C-141 Starlifter

(January 1959-June 1971)

NARRATIVE

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USAF C-141 STARLIFTER

FOREWORD

C-141 Starlifter is a study in three parts: Requirement and Acquisition, Management and Testing, and Deficiencies and Modifications. Together they span the years 1959 through the first half of 1971--from the time modernization of the strategic airlift force was seen as a military necessity, through the development, testing, and operation of the C-141, MAC's first jet cargo craft.

Part I discusses the need for a modern, jet-powered airlifter and its culmination in the C-141. Part II covers MAC participation as a functional manager and using command in the C-141A System Management Program, while part III concentrates upon deficiencies discovered in the components of the operational aircraft and efforts toward improvement and solution.

Parts I and II, written by Mr. Walter L. Kraus and published originally as volumes I and II, are reprinted here with minor changes in organization of material. Part III was completed by Mr. Jose M. Matheson upon the transfer of Mr. Kraus to AFSC. Supporting documents for this study are contained in four volumes; one copy is on file in the Office of MAC History and another at The Albert F. Simpson Historical Research Center, Maxwell AFB, Alabama. Supplements to part III are on file in the Office of MAC History.

PREFACE

As fiscal year 1971 drew to a close the Starlifter force had flown 2,862,968 flying hours since its entry into the MAC inventory in October 1964. No other USAF weapon system had ever achieved that mark in a like timeframe. The figure demonstrates the value of MAC's "workhorse" to USAF and DOD and, in essence, tells the story of this prodigious aircraft, which has been the command's prime mover from the mid-1960s to the present (July 1972). The C-141 has been the backbone of MAC operations and cannot be separated from the command's global mission effort after 1964. Hence, the history of MAC operations is the history of the Starlifter.

The Starlifter has been a good aircraft, a forgiving aircraft, and one that has presented the command with a minimum of problems. At this writing the aircraft has no planned phaseout date and most assuredly will be the strategic airlift workhorse well into the 1980s. One of the program's pioneers, still involved deeply with the materiel aspects of Starlifter life, stated:*

> I feel that despite the concurrent production and operational concept and the numerous problems I have enumerated with regard to the various systems, let's face the facts--this aircraft has undoubtedly been the best weapon system to have entered the Air Force inventory. When I say this, I would like to include the bombers, the fighters--you name it--it's been a fantastic workhorse. You can go back in history and place it in the same category as the C-47 which has had a terrific record in the Air Force.

*Morris Intvw, pp 25-26.

Although the Gooney Bird proved itself to be a worthy aircraft, it is doubtful that it could have:*

> sustained upwards of 10-hour-a-day utilization for an extended period of time . . . had the diversified mission capability of aeromed, paratroop, heavy cargo, out-sized cargo, passenger . . . had the 90% plus on mission departure reliability and en route mechanical reliability.

Nor did the Gooney Bird possess the Starlifter's range, speed (loaded), or its cargo capacity. Until the event of the C-141, no true strategic airlifter had entered the USAF inventory.

In the future, reams of C-141 history may be written; however, none will contain more fitting praise than that given by another of the program's pioneers, who stated, "We always had excess performance in the C-141."**

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*Ibid, p 26.

**Spillers/Chambers Intvw, p 35.

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PART I

REQUIREMENT AND ACQUISITION

(January 1959-June 1968)

"The C-141 obviates many of the historic [airlift productivity] constraints by virtue of its high speed (above 425 knots) and its range/payload options. . .Requiring only some 4000 feet of runway for take-off or landing, it can use about 1850 airports around the world, which greatly enhances its flexibility of employment . . . ."

PART I
The Starlifter

So General Howell M. Estes, Jr., Commander of the Military Airlift Command, described MAC's new aircraft in the spring of 1966.[1] However, while extolling its considerable capabilities, the MAC Commander placed the C-141 in proper perspective, unlike many of the contemporary newspaper and periodical accounts. He explained that the ". . .C-141, when fully operational in force, represents the beginning transition to the second phase. The real [airlift] revolution. . ." he then postulated ". . .is attendant upon production of the giant C-5A."[2]

Even the C-5A, the General went on to explain, did not ". . .radically breach the state of the aeronautical art. . . ." Hence, it must be surmised that the C-141 was, as defined in its Specific Operational Requirement (SOR), ". . .well within the state-of-the-art of aircraft design. . . ."[3] for the period 1960/1961. In fact, the Starlifter fell short of some of the characteristics and capabilities of the then available contemporary transports.

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1. General Howell M. Estes, Jr., "The Revolution in Airlift," in Air University Review, XVII, No. 3, March-April 1966, p. 9.
2. Ibid.
3. SOR No. 182, AFORQ, subj: SOR For A Cargo Transport Aircraft Support System, 4 May 60, p. 7 (hereinafter cited as SOR 182/182-1), SD I-1.

For instance, the C-141 had a shorter fuselage than the C-133 and DC-8F; its maximum payload of 34 tons[4] was less than the Boeing 707-300 series (44.9 tons) or the Douglas DC-8F (38.7 tons); its economy cruise speed fell 35 miles per hour (MPH) and 64 MPH below the 707-320B and DC-8F, respectively; while its maximum range with maximum payload was some 500 miles less than that of either the 707 or DC-8F. In addition to the above, the C-141 was incapable of carrying the out-sized cargo that the C-124 or C-133 could.

What then, one might validly ask, was the need for the C-141 and what could it contribute to the national airlift posture? The answer is rather simple in that the C-141 gave to the United States arsenal a pure cargo aircraft that traded the near 500 MPH speed for the lesser cargo envelope (outsized capability) then available in both the C-124's and C-133's. On the other hand, it accepted range, speed, and payload penalties in order to carry considerably more outsized cargo than did either the Boeing 707 or DC-8. The C-141 was, in fact, the cargo work-horse long requested by MAC.

When accurately viewed as a fast cargo aircraft, with a troop carrying capability, the Starlifter adequately answered the need for a ". . .military cargo transport aircraft developed for use in the strategic airlift mission."[5] This mission, by the late 1950's and early 1960's, had come to

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4. The Starlifter minuteman configuration has a higher payload capacity.
5. US House of Representatives, 86 Cong., 2 Session, Hearings Before Special Subcommittee on National Military Airlift, Committee on Armed Services (hereinafter cited as Nat'l Alft Committee Hearings), Testimony of Maj Gen Bruce K. Holloway, Dir of Operational Requirements, DCS/O, Hq USAF, 17 Mar 60, p. 4303.

mean not only long range support for the United States Nuclear Forces but also rapid response to limited conflagrations. The latter concept, developed by the Army, called for ". . .small, heavily armed, quick moving combat forces to meet aggression in its incipient stages, seizing the initiative before an enemy had time to build up strong forces in the objective area."[6] This "flexible response," as it later came to be known, was predicated on rapid deployment of the forces by air, hence, calling for a transport capability not adequately possessed by MATS until the C-141 was available in force.

A Cargo Aircraft

While the espousal of the "flexible response" strategy, with its attendant requirement for rapid airlift, gave the final impetus to the development of the C-141, the need for a cargo aircraft was one of long standing. Ideas concerning the development of a modern pure cargo aircraft were well over a decade old on 13 March 1961 when President John F. Kennedy announced the initiation of the C-141 Program. The demands for the cargo aircraft seemed to be myriad, especially during the 1950's. Lt General William H. Tunner, in fact, states in his autobiography, that there was discussion of ". . . the perfect transport plane," during the "Hump" days.[7] By 1948 this requirement took a more concrete form

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6. Roland D. Hinds, MAC Historian, The Development of Strategic Airlift for the Armed Forces of the United States, 1941-1965, Hq MAC, July 1968, p. 16 (hereinafter cited as Devel of Strat Alft).
7. General Tunner is considered by many to be an air transport pioneer -- for his impressions of the development of air transport see his autobiography, Over the Hump, Duell, Sloan and Pearce, New York, 1964, p. 301.

when Major General Laurence S. Kuter (MATS Commander, 1 June 1948-15 November 1951) stated: "The relatively inefficient system of adapting personnel transport for cargo transport should be replaced by the development of a prototype cargo aircraft intended primarily for commercial use, but adaptable also for emergency military service."[8] In a 1952 letter the MATS Chief of Maintenance-Engineering informed the Commanding General of the Wright Air Development Center, Wright-Patterson Air Force Base, of the characteristics required of a cargo transport and a jet transport.[9] The following year saw a number of articles concerning the configuration and characteristics of the ideal "air freighter." Undoubtedly, the lessons learned from the Korean War played an important part in this demonstrated interest.[10] Many defense officials listed among the lessons learned from the Korean War the need for "large aircraft. . ., both for inter-theater and intra-theater airlift, provided they were properly configured and equipped."[11]

People from both the military and commercial interests gave at least lip service to the idea of the need for the development of an "air freighter."

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8. Hist, MATS, 1949, (citing Maj Gen Kuter's presentation before the Eberstadt Committee, 7 Oct 48, p. 18), p. 271.
9. Ltr, Col Robert J. Koster - Chief, MATS Maintenance-Engineering, to Commanding General, Wright Air Development Center, Wright-Patterson AFB, Ohio, subj: Aircraft Characteristics (Unclas), 9 April 1952, w/2 atchs (1. General Characteristics, MATS Aircraft; 2. Characteristics of Jet Transport) in MAFOIH files.
10. Interesting proposals can be found in the following articles -- Maj Gen Hugh J. Knerr (USAF-Ret), "Design Features for Tomorrow's Transports," Aviation Age, July 1953, pp. 28-29; Lt Gen Joseph Smith (MATS Comdr), "The Jet Transport," National Defense Transportation Journal, Mar-Apr 1953.
11. Hinds, Devel of Strat Alft, p. 12.

However, most commentators regarded the proposed cargo aircraft as a vehicle to develop a commercial freight capability, often with little regard for the military requirements.[12] Hence, the general opinion tended to hamper any program to modernize MATS. In fact, the need for the command was vituperatively questioned by the press and even members of Congress. Especially formidable to MATS plans was the frontal assault by Representative Daniel Flood (Dem-Pa), who objected to the modernization on the basis that the airlines could handle the traffic better, and by Senator A. S. (Mike) Monroney (Dem-Okla) who urged the Senate Defense Appropriations Committee to limit MATS to a small fleet designed to carry only outsized cargo or to carry cargo to remote areas. In addition, Monroney favored government-guaranteed loans to commercial carriers to build a cargo fleet so that they could handle most of the Department of Defense's (DOD) needs.[13]

In late 1958 and early 1959 with MATS under heavy fire, measured by both the volume and caliber of the artillery employed, the prospect for the development of a new mainstay cargo aircraft seemed dismal, at least until a definite national airlift policy could be established.[14] It was in this atmosphere that Lt General William H. Tunner (MATS Commander, 1 July 1958-31 May 1960), as he later recollected, ". . .lit the match to an all-out program to increase. . . (airlift capability)."[15] His idea of the cargo aircraft was as follows:

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12. See articles listed in footnote #10.
13. Aviation Daily, 6 May 1959, 15 Jun 1959, 31 July 1959.
14. Frederick C. Thayer, Jr., Air Transport Policy and National Security, The University of North Carolina Press, Chapel Hill, 1965, pp. 114-226.
15. Lt General William H. Tunner, Over the Hump, Duell, Sloan, and Pearce, New York, 1964, pp. 301-302.

1. A big plane that could carry heavy as well as bulky loads.
   Because ". . .in both the Hump and Berlin Airlift we had to cut up heavy equipment in order to get it on the airplane, and loading could only be done by hand."
2. Straight-in loading from the front or the rear.
   Because "the whole envelope should be available for a maximum-size object, such as our biggest missile."
3. The cargo floor would be at truck bed height.
   ". . . so that it can be loaded directly from standard commercial trucks, thus eliminating the need for high-lift trucks and fork-lifts."
4. The above (3) would require a high-wing design.
   Because ". . .the fuselage is closer to the ground; this, then, would be preferable."
5. Optimum range/payload trade off.
   ". . .maximum range of seven thousand miles. For shorter ranges, cargo would be substituted proportionately for gasoline. Thus the plane. . .would be able to carry an appreciable load from California nonstop to the Orient and much heavier load to Hawaii."
6. Speed was not a criterion.
   Because ". . .by using air instead of surface transportation, we are able to cut time in transit from weeks to hours. After such a reduction, the additional saving of an hour or two through more expensive engines, burning up fuel at a greater rate seemed pointless."

7. Turboprop or turbojet engine.

   Because ". . .no piston-type engine would provide sufficient horsepower for the eighty thousand-pound capacity we hoped for."

8. Low cost operation.

   "Highly efficient operation with full loads both ways might bring the cost down to eleven cents."

In closing, the General stated: "This was our major requirement -- a work-horse plane, cheap to operate, of indifferent speed, relatively large and easy to load. It would be the backbone of the fleet. . . ."[16] Tunner's counterattack, coupled with the Army's refinement of its airlift requirements plus a Congressional Committee's objective, if not sympathetic stand, led to the powerful coalition that gave birth to the Starlifter.[17]

SOR 182

Officially, the MATS position was established on 16 February 1959 with the submission of a Qualitative Operational Requirement (QOR) for a Logistic Aircraft Support System to Headquarters USAF. This QOR, signed by General Tunner, closely followed his above-mentioned recollections. While promoting a fleet mainstay the QOR did not ". . .negate requirements for outsized lift and fast reaction time. . . ."[18] The document explained that the C-133 would fulfill the outsized requirement until the 1970's, but it also noted that a requirement still existed for a turbojet which could provide the Strategic Air Command with support.

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16. Ibid.
17. Thayer, Air Transport Policy and National Security, pp. 149-226.
18. Ltr, MAORD to Director of Requirements - Hq USAF, subj: Qualitative Operational Requirements for Logistic Aircraft Support System, 16 February 1959, SD I-2.

The QOR delineated the proposed design as:[19]

> . . .one of medium size, [which] will insure reasonable frequency of service and not only be capable of performing local airlift missions within the Zone of Interior[20] and overseas theaters but would have the capability for transoceanic operations.

In addition, the writers of the QOR found it necessary to make the following statement regarding contemporary aircraft designs:[21]

> Present designs of large, high-speed, long range intercontinental aircraft will not afford the flexibility of operation necessary. This equipment must be available to handle general war requirements. . .the world-wide short-field and terrain difficulties would seriously limit its value in limited war. For example -- studies concerning the usability of the VC-137A indicate that this aircraft can operate from only about 30 percent of the world-wide airfields now being used by the 1254th Air Transport Group (SM),[22] at Washington National Airport.

Major General James Ferguson, the Headquarters USAF Director of Requirements, in reply stated that the MATS letter was welcome because "The subject of a suitable aircraft to satisfy airlift requirements during both general and local war situations currently is a matter of much concern within the Air Staff.[23] General Ferguson further indicated that the Air Force had in preparation a draft proposed for a very large long range transport but because of the current funding situation only a small fleet of the large transports could be obtained. He, therefore, felt the MATS

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19. Ibid.
20. Zone of Interior (ZD) meant roughly the Continental United States and near off-shore islands -- today this area is commonly called the Continental United States (CONUS).
21. Ltr, MATS to USAF, subj: QOR, 16 Feb 1959.
22. In January 1966 this unit became the 89th Military Airlift Wing.
23. Ltr, Major General James Ferguson, Director of Requirements USAF, to Commander MATS, subj: Qualitative Operational Requirement for Logistic Aircraft Support System, 5 Mar 59, SD I-3.

requirement for a medium transport was a very timely alternative. USAF's Director of Requirements admitted that a combination structure of both the medium and heavy transports ". . .would provide optimum flexibility;" but felt that simultaneous development was unrealistic. Also of interest was Ferguson's statement that "It is possible that a liaison could be effected between the Air Force and commercial interests for a joint development program."[24] However, he further stated, perhaps a bit prophetically, that "in the meantime, it appears more reasonable to plan for transport development within Air Force resources." After the last remark General Ferguson stated that the situation was such that it might become necessary to limit support to a single system; hence, he requested MATS comments and recommendations relative to the merits of a heavy versus a medium system development.

In answer to General Ferguson's request, the Commander of MATS, on 23 March 1959, stated that ". . .deletion or omission of either the heavy or the medium transport will sooner or later compromise the airlift logistic system."[25] However, Tunner restated his opinion that the C-133 could handle the heavy and outsized lift into the 1970 period. Therefore, he reasoned that "the medium 'work-horse' transport must be programmed for immediate development. . . .[26]

In the following June, Headquarters USAF completed a General Operational Requirement (GOR) for a medium transport and by 1 December 1959 had refined

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24. Ibid.
25. Ltr, Lt Gen William H. Tunner, to Director of Requirements USAF, subj: Ltr, AFDRQ, Hq USAF, 5 Mar 59, subj: Qualitative Operational Requirement for Logistic Aircraft Support System, 23 Mar 59, SD I-4.
26. Ibid.

it into a draft Specific Operational Requirement (SOR) for a "work-horse" aircraft. MATS was then requested to coordinate on the latter plan. By 21 December the MATS Staff had completed its coordination and advised General Tunner that "the aircraft as specified by Hq USAF meets or surpasses all MATS requirements as set forth in the MATS QOR dated 16 February 59. . . ."[27] Nevertheless, in the MATS reply to Air Force, on 31 December 1959,[28] some additional suggestions were made. Most of the additive recommendations were included in the final SOR prepared by Headquarters USAF. As noticed in Table I, the USAF General Operational Requirement (GOR) and SOR characteristics were indeed comparable to or better than the original MATS QOR.

As the Air Force's design criteria for a new "work-horse" medium cargo aircraft was unfolding, two developments led to the final stage of the C-141's conception. The first of these developments was a concrete plan developed by General Elwood R. Quesada (FAA Administrator), which he presented before Congress. The second was an agreement between General Lyman L. Lemnitzer (Army Chief of Staff) and General Thomas D. White (Air Force Chief of Staff) which refined the Army's mobility airlift requirements.[29]

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27. Memo, DCS/O/R&D to MATS Commander, subj: Draft Specific Operational Requirement for Cargo Transport Aircraft Support System, 29 December 59, SD I-5.
28. Ltr, Lt Gen William H. Tunner, to Hq USAF (AFORQ), subj: Draft Specific Operational Requirement for Cargo Aircraft Support System, 31 Dec 59, SD I-6.
29. A good background source is Thayer's book cited in footnote 14.

TABLE I*

Performance Characteristics	MATS QOR - Feb 1959	USAF GOR - Jun 1959	USAF Draft SOR - Dec 1959	USAF SOR - Jun 1960
1)	Range: 2,000-3,000 NM	4,000-5,000 NM	4,000-5,500 NM	
2)	Payload: 35,000-60,000 lbs	20,000 lbs/5,500 NM 40,000 lbs/4,000 NM	same	60,000 lbs/3,000 NM (w/CAR fuel reserves for commercial)
3)	Speed: Power plant by product	Min 325 knots [440 hand-written]		Product of design
4)	Take off & landing distance: 4,000-5,000 ft ground roll	4,000 ft over 50 ft obstacle	5,000 ft over 50 ft obstacle for long range operations; 3,000 ft over 50 ft obstacle for short range operations; 4,000 ft landing	6,000 ft CAR (Civil Air Requirement) runway length
5)	Power plant: turbo prop or fan	same	turbo fan	
6)	Structural limit			

(continued on following page)

Table I (cont'd) ---

Design Features

MATS QOR - Feb 1959	USAF GOR - Jun 1959	USAF Draft SOR - Dec 1959	USAF SOR - Jun 1960
1) Gross weight:	Max 210,000 lbs		
2) Cargo Envelope: 50'x10'x12' (6,000 cu ft)	Pending AMC's** requirement but not less than MATS Specs	(to carry Minuteman) 5,400 cu ft	70'x10'x9' min
3) Loadability: straight in truck bed height	same	same	same w/forward side door and compatible w/463L
4) Upswept tail undesirable	Upswept tail acceptable	Alternate tail design for TAC airdrop requirement	
5) Cost per ton mile: 4¢ at 10 hr utilization; 8-9¢ at 5 hr utilization	4-5¢		
6) Interior Accom: troop, cargo, air evac	same	Max troop capability - 80	80 troops & 42 litters

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*Table developed from the MATS QOR and USAF GOR (Jun 59, Draft SOR (Dec 59) and USAF SOR (Jun 60). Memo, MAORD to Cmdr MATS, subj: General Operational Requirement for Medium Transport Aircraft, 2 July 1959.

**AMC (Air Materiel Command) is now the Air Force Logistics Command (AFLC).

> Congress built its own military airlift program in 1960, a task performed. . . with dispatch, logic, and reasonableness. . .The new program probably was the best available under the circumstances, and it was an unusual accomplishment for Congress. . . .[30]

The Congressional Hearings

It is true that the subcommittee on National Military Airlift of the House of Representatives Armed Forces Committee initiated the 1960 program for the modernization of the national strategic military airlift force. However, several factors had developed by February-April 1960 that changed the climate of opinion and allowed the subcommittee to establish their findings in an atmosphere that was not as highly charged as it had been a few years prior. Probably ranked first among these factors was Tunner's oblique attack on the MATS detractors. Secondly, the success of Operation "Big Slam/Puerto Pine", which coincided with the hearings, showed, as MATS personnel hoped it would, that the nation's strategic airlift was woefully inadequate.[31] Thirdly, and probably as a consequence of the above, the more vociferous of the opponents of MATS, Flood and Monroney, became advocates of modernization. In addition to this reversal, General Quesada removed some of his objections to "certain transports." Lastly, the closer understanding between the Army and Air Force, with the White/Lemnitzer Agreement, placed modernization on a more solid basis.

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30. Thayer, Air Transport Policy and National Security, p. 196.
31. Thayer's book gives the background as does Hist, MATS, Jan-Jun 60 and Jul-Dec 60.

Unquestionably, the above ferment aided the airlift cause as did the impressive aid received from both the legislative and the executive branches of the government. Nevertheless, much of the credit for the final resolution of the controversy must be given to Chairman L. Mendel Rivers and the members of the subcommittee. By and large, these men approached the questions of the national airlift policy objectively, in the realistic atmosphere of national defense needs. Hence, it can be said that the Rivers Committee accomplished ". . .a political tour de force incorporating the best characteristics of executive decision making and Congressional investigating. . . ."[32]

Congress Chooses an Airplane

The Rivers Committee Hearings (8 March-22 April 1960) overlapped the period of Operation "Big Slam/Puerto Pine" (14-28 March 1960). This timing certainly aided the cause of the military airlifters, especially since most of the modernization antagonists were unheeded after "Big Slam/Puerto Pine" demonstrated that MATS equipment was obsolete and inadequate for the strategic role expected of the command. During the hearings, the Air Force, of course, stood by the, as yet, unpublished SOR 182.[33] Major General Bruce K. Holloway, the Air Force Director of Operational Requirements, succinctly stated the rationale for the Air Force Program on 17 March 1960. In explanation of program choice he used the following three reasons:[34]

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32. Thayer, Air Transport Policy and National Security, p. 197.
33. SOR 182 was published 4 May 1960.
34. Nat'l Mil Alft Committee Hearings, pp. 4304-4305.

> Considering existing and expected funding limitations, it is unlikely that more than one cargo aircraft development of this magnitude could be concurrently funded. In recognition of this factor, every effort has been made to evolve aircraft specifications that would meet the military requirements and, additionally, assure an aircraft possessing a high degree of commercial compatibility.
>
> Secondly, considering the recognized obsolescence within both the military and civil airlift fleets, the factor of early availability was given considerable weight. As a result, our specific operational requirement stipulates a state-of-the-art aircraft.
>
> Lastly, and most important, is the effective capability of the aircraft to be developed. The design of the aircraft must encompass performance and reliability features which will not only assure its effective utilization under widely varying conditions but also assure the continued effectiveness of this aircraft in order to preclude early obsolescence.

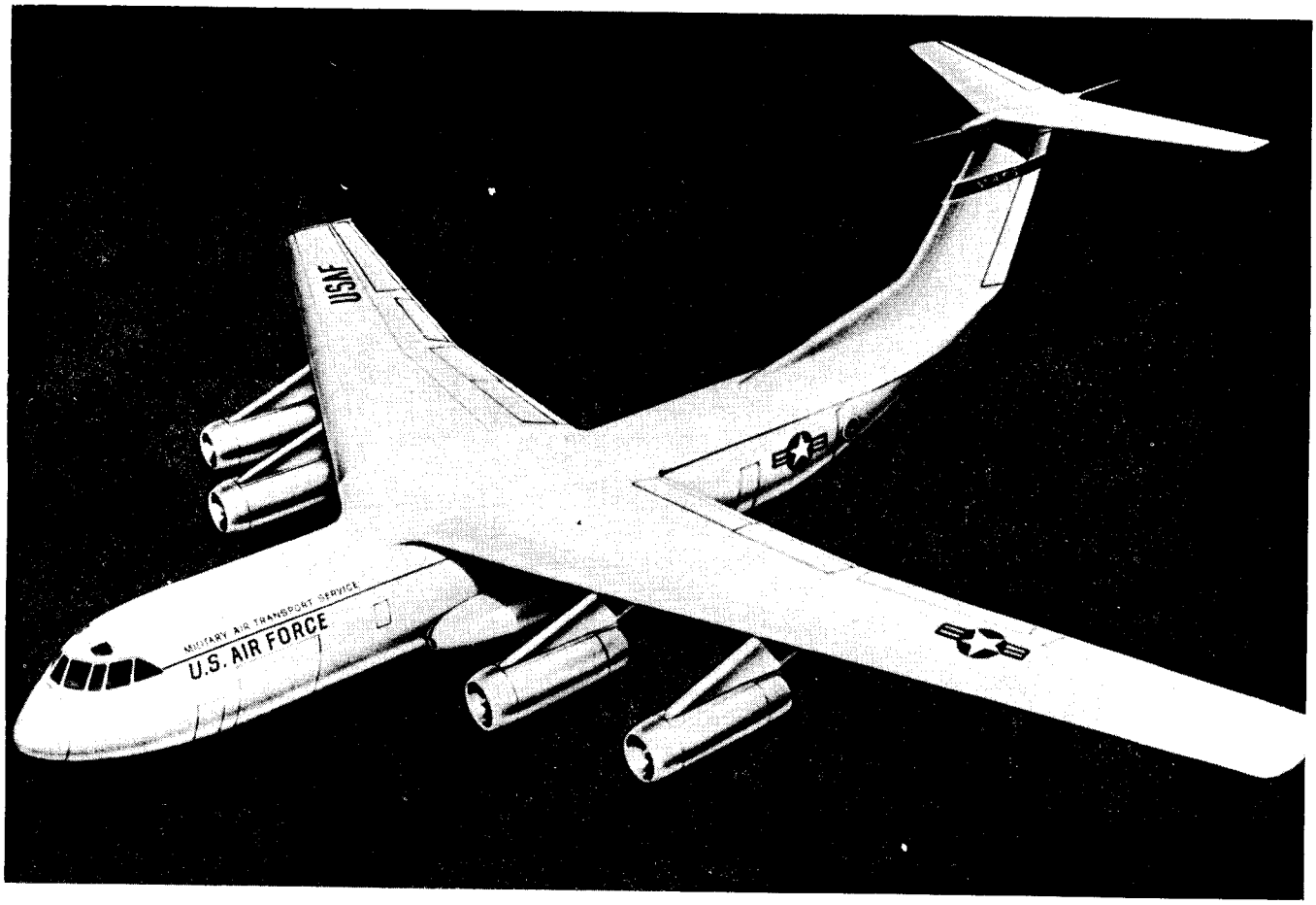
General Holloway further explained that in making its choice the Air Force was faced with three possible courses of action, which were:[35]

> (1) Off-the-shelf procurement of either existing cargo aircraft or cargo modified versions of the jet transport aircraft now in operation by both military and civil agencies. (2) The procurement of certain projected turboprop aircraft which required a relatively high degree of development funding; and (3) the pure development of an optimum cargo aircraft.

Holloway then explained that the off-the-shelf procurement would give the Air Force much less than optimum aircraft. He further stated that the turboprop designs were only slightly more attractive from the financial standpoint. Hence, he explained after examining the three proposals from the view of ". . .fundamental factors of aircraft cost, availability and capability. . ." only course number three ". . .effected the airlift modernization required.[36]

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35. Ibid., p. 4305.
36. Ibid., p. 4305.


USAF
MILITARY AIR TRANSPORT SERVICE
U.S. AIR FORCE

While the Air Force pressed for a new "optimum" transport, the Army favored the C-130. Basically, the Army's discussion centered around the tactical lift role but in their testimony before the committee the Army Generals infringed on the strategic area.[37] In these discussions the Army appraised the C-130 as . . . the best all around aircraft which is available to us."[38]

Unexpected aid came to the Air Force, on 28 March 1960, the official last day of BIG SLAM/PUERTO PINE, when General Elwood R. Quesada, the Administrator of the Federal Aviation Agency (FAA), changed his former position[39] somewhat.[40] In his opening remarks he emphatically stated:

> I want to make it crystal clear that I am a strong supporter of the concept that the Military Air Transport Service should be a modern, basic weapons system in support of military missions. . .my concept of a highly trained, instantly ready MATS, equipped with truly modern equipment, is confined to a fleet designed expressly and solely for effective performance of a clearly defined, hardcore military mission.

While agreeing to MATS' need for modern equipment, however, he still disputed most of the command's claims. Nevertheless, he reversed his announced preference for the CL 44 turboprop aircraft,[41] thereby giving credence to the Air Force position of the need for an optimum aircraft.

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37. Ibid., pp. 4219-4267.
38. Ibid., p. 4223 (Testimony of Maj Gen Ben Harrell, USA).
39. Quesada was a strong supporter of a National Air Cargo Fleet operated by Civil Companies, in the 1959 congressional hearings.
40. Nat'l Military Alft Committee Hearings, p. 4406.
41. In the 1959 hearings he strongly supported the Canadair CL-44 as the needed cargo aircraft.

He further aided the USAF proposal by stating before the committee that "if we compromise the military fleet now, it will be compromised for the next decade at least."[42] Following this line, Quesada discouraged an interim purchase of the Boeing 707 and Douglas DC-8 but did suggest purchase of a suitably modified C-130B for interim purposes.[43]

Stuart Tipton, the president of the Air Transport Association (ATA), when asked by Congressman L. Mendel Rivers what kind of new equipment MATS should get, stated:[44]

> The kind of equipment that is now being worked on by the military, the FAA, and with comments up to this point from the airlines, in determining what kind of a cargo airplane. . . .

When Chairman Rivers pressed Tipton further, by asking how long he thought MATS could wait for new equipment, the ATA president stated:[45]

> They are available - equipment of the kind I referred to is available for purchase.
>
> For example, the C-130 is available now, if they need more equipment. That was designed for air movement of troops and their supplies.

After this statement, Tipton quickly agreed with the chairman that a business lobby should not advocate particular types of military aircraft.

Hence, among the main figures in the controversy, three, the Army, General Elwood Quesada, and Stuart Tipton, favored the Lockheed manufactured C-130, while the Air Force held to the optimum equipment (SOR 182). However,

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42. Ibid., p.4410.
43. Ibid., p.4408.
44. Ibid., p.4534.
45. Ibid.

the Army, considering the C-130 the best available aircraft, did not discourage the development of SOR 182, while General Quesada encouraged its development but suggested the C-130 (properly modified) only as an interim aircraft. In fact, when perusing the testimonies, it appears that only the ATA took the firm view that the C-130 was an adequate aircraft for the MATS mission.

Most of the 1960 debate centered around the SOR, C-130, and suggested available turbine interim types (DC-8 and B 707). However, at this juncture it is interesting to note that among the annexes of the Hearings are several letters recommending a cargo development of "Lifting-Body" aircraft.[46] Of course, the subcommittee was not entertaining testimony on theoretical aircraft design and, in fact, even the SOR, which promoted a new aircraft, stipulated that it must be a state-of-the-art vehicle.

Upon completion of the hearings Rivers recommended funds for the development program. These recommendations eventually became part of the House bill. As the bill passed to the Senate Appropriations Committee, a changed climate was encountered. Senator Monroney, who formerly opposed MATS modernization, promised General Tunner all the support ". . .humanly possible. . . ."[47] Hence, the Senate bill accepted most of the principles of the Rivers subcommittee, including funds for the SOR.

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46. Nat'l Mil Alft Committee Hearings - Statements inserted, subj: Lifting Body Acft -- Letters from B/Gen Ray A. Dunn (USAF-Ret); Lt Col Richard T. Cella (USAF Reserve -- president R. T. Cella Corp); M/Gen Hugh Johnston Knerr (USAF-Ret); M/Gen Leigh Wade (USAF-Ret); Col Robert W. Johnson (USAF Reserve); Jay E. Brandt (Captain TWA); and Paul F.Zimmer (Co-owner Air Supply Int.), pp. 4945-4964.
47. U.S. Congress, Senate, Committee on Appropriations, Department of Defense Appropriations for 1961, Hearings before Subcommittee, 86th Congress, 2nd Session. p. 818.

Events progressed rapidly from this point. On 1 July 1960, Public Law 86-601 was enacted which allocated $310,788,000 for the Air Force to develop, construct, procure and modify transport aircraft, provided none of the aircraft would be used for regular passenger service. Of this amount, $50,000,000 was earmarked for development purposes. By 10 August 1960 the SOR Development Plan, which included proposals for both turboprop and jet propulsion systems, was issued by the Air Force.[48] Five days later SOR 182-1 was issued, adding pertinent design criteria to the original SOR.[49]

Among the additions and/or changes, to SOR 182, was the landing and take off distance (6,000 feet with 50,000 pound payload), a capability for 3-engine take-off over a 35 foot obstacle, provisions for plug in seats over the entire cabin floor, and identification of communications and navigation systems by type (and often by specific system). Shortly thereafter a combined SOR 182/182-1 was issued incorporating the provisions of both. This combined document then became the official SOR.[50]

On 23 November Headquarters Air Force released Development Directive Number 415.[51] Included in the provisions of this directive was the assignment of USAF Importance Category II to the project, a completion target date of mid 1964, a $44,000,000 fund program for Fiscal Year 1961, and the

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48. Hist, C-141 System Program Office -- ASD, Wright-Patterson AFB, subj: C-141A System Program History (hereinafter cited as C-141 System Hist), Aug 65, p. A-1.
49. SOR 182-1, Hq USAF, subj: Amendment to Specific Operational Requirement -- SOR No. 182, dated 4 May 60, for "A Cargo Transport Aircraft Support System," 15 Aug 60, SD I-7.
50. SOR 182, & SOR 182-1, Hq USAF, subj: SOR For a Cargo Transport Aircraft Support System, 4 May and 15 Aug 60, SD I-8.
51. Development Directive -- DD 415, Hq USAF, subj: Development Directive for the Cargo Aircraft Support System, 23 Nov 60, SD I-9.

specification that a turbofan engine would be the aircraft's propulsion unit. The document also established the following development criteria, in order of importance:

a. Ease of maintenance
b. Low unit cost
c. Early availability
d. Payload capacity--4,000 NM range
e. Low operation costs (1960 Air Transport Association formula)

Development Directive 415 also stated that the source selection could be expected in December 1960. On 19 December USAF issued Development Directive Number 415-1.[52] This document established the 463L Materials Handling System as the loading/unloading equipment for the new aircraft. Two days later Headquarters Air Force forwarded a "Statement of Work" and "Request for Proposal" to Boeing, Douglas, Convair and Lockheed, the competing contractors.[53] The last official action of 1960 was the "Contractors Query Meeting" which was held on 30 December. Before the end of the year all that remained of the design/development preliminaries was model and contractor selection.

Nevertheless, many skeptics remained. For instance, a contemporary aviation periodical reported:[54]

> Opinions among many spectators at the IAS air logistics meeting. . .were that "warmed-over" conversions of passenger aircraft would continue as the mainstay of the air cargo industry for many years. . . .

More important, however, were the speeches made by the presidential candidates in this important presidential election year. Both of the

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52. Development Directive 415-1, USAF, subj: Amendment to Development Directive for the Cargo Transport Aircraft Support System, 19 Dec 60, SD I-10.
53. C-141 System Hist, p. A-1.
54. Erwin J. Bulban, "MATS Aims at Turbofan Airlift by 1964," Aviation Week and Space Technology, McGraw-Hill, New York, Vol 73, No 15, 10 Oct 60, p. 41.


MATS
U.S. AIR FORCE

candidates supported the program. Richard M. Nixon, of course, subscribed to the then evolving administration program. John F. Kennedy, on the other hand, severely criticized the Eisenhower Administration's airlift policy. Among his more salient comments was the assertion that more jet transports were needed. . .because. . .it doesn't do any good to have seventeen divisions here if you can't move them around the world within 24 or 48 hours. . . .[55] The Kennedy statements seemed to underscore the skepticism and create a situation somewhat akin to the more famous Missile Gap.

Whether or not the Kennedy campaign stance aided the implementation of the new airlift policy is not the subject matter of this paper. However, it is clear that the outgoing Eisenhower Administration initiated the airlift program designed by the 86th Congress. It is also equally clear that the new president meant to carry out his campaign promises. In his first State of the Union Message, while explaining his defense program to Congress, he listed additional airlift capacity first:[56]

> First, I have directed prompt attention to increase our airlift capacity. Obtaining additional air transport mobility -- and obtaining it now -- will better assure the ability of our conventional forces to respond, with discrimination and speed, to any problem at any spot on the globe at any moment's notice.

To men like General Tunner the announcement by the new president ". . .was far more than a personal vindication; this was the vital strengthening of

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55. Speech, John F. Kennedy, to American Legion, Miami Beach, Florida, 18 Oct 60 -- in Selected Statements of President Kennedy on Defense Topics, December 1957-August 1, 1962, prepared by Research and Analysis Div, SAFAA, 15 August 1962.
56. Pres. John F Kennedy, -- in Selected Statements of President Kennedy on Defense Topics, December 1957-August 1, 1962, prepared by Research and Analysis Div, SAFAA, 15 Aug 62.

America in the very area where it was most needed."[57] The Kennedy announcement, however, did not indicate that the contractor proposal had been selected. During January, February, and early March 1961, the SOR 182 Source Selection Working Group, and Evaluation Teams were established by the Office of the Secretary of Defense (OSD) and these groups made recommendations. On 8 February the Warner-Robins Air Materiel Area (WRAMA), Robins AFB, Georgia, was designated the Logistics Support Manager (LSM)[58] by Headquarters Air Materiel Command (AMC).[59]

Birth of an Airplane

On 13 March 1961, the President, in a press release, announced that the Lockheed Company's Proposal Model Number GL-207-45, Super Hercules, was the winner of the SOR design competition.[60] The release stated that the new aircraft could transport troops or heavy cargo at speeds of 440 to 500 nautical miles per hour for distances ranging up to 5,550 nautical miles. It further stated that the aircraft would have a pressurized cabin, a rear loading ramp, and that it would be powered by fan jet engines.

The SOR aircraft had grown from the basic medium transport to more of an all purpose aircraft by early 1961, as noted by Thayer:[61]

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57. Tunner, Over the Hump, p. 320.
58. C-141 System History, p. A1.
59. AMC later became the Air Force Logistics Command (AFLC).
60. Press Release, Associated Press, subj: Jet Transport, 14 March 1961, in MATS Newsclips, Vol III, No. 49, SD I-11.
61. Thayer, Air Transport Policy and National Security, p. 223.

> As various agencies added new specifications, the proposed aircraft became more of an all-purpose aircraft than originally planned. The new transport was to fly at 440 miles per hour, but also at speeds low enough to permit the dropping of paratroopers. It was to use runways of intermediate length, i.e., 5,000 feet. The fuselage was to be close enough to the ground to permit drive-on loading and cargo handling in areas not having loading equipment.

Of course, the aircraft also had some design compromises. Nevertheless, as noted by General Tunner "although compromised in some particulars, for commercial use, it had most all the features I wanted."[62] In fact, General Tunner, the architect of the SOR 182 program, hailed the C-141 as the vehicle for a new national airlift policy.[63] He said:

> The C-141 is more than just a plane. It signifies the return of our entire military program from almost sole emphasis on all-out nuclear war to the more practical preparation. . .for localized conflicts the free world constantly faces all over the globe.

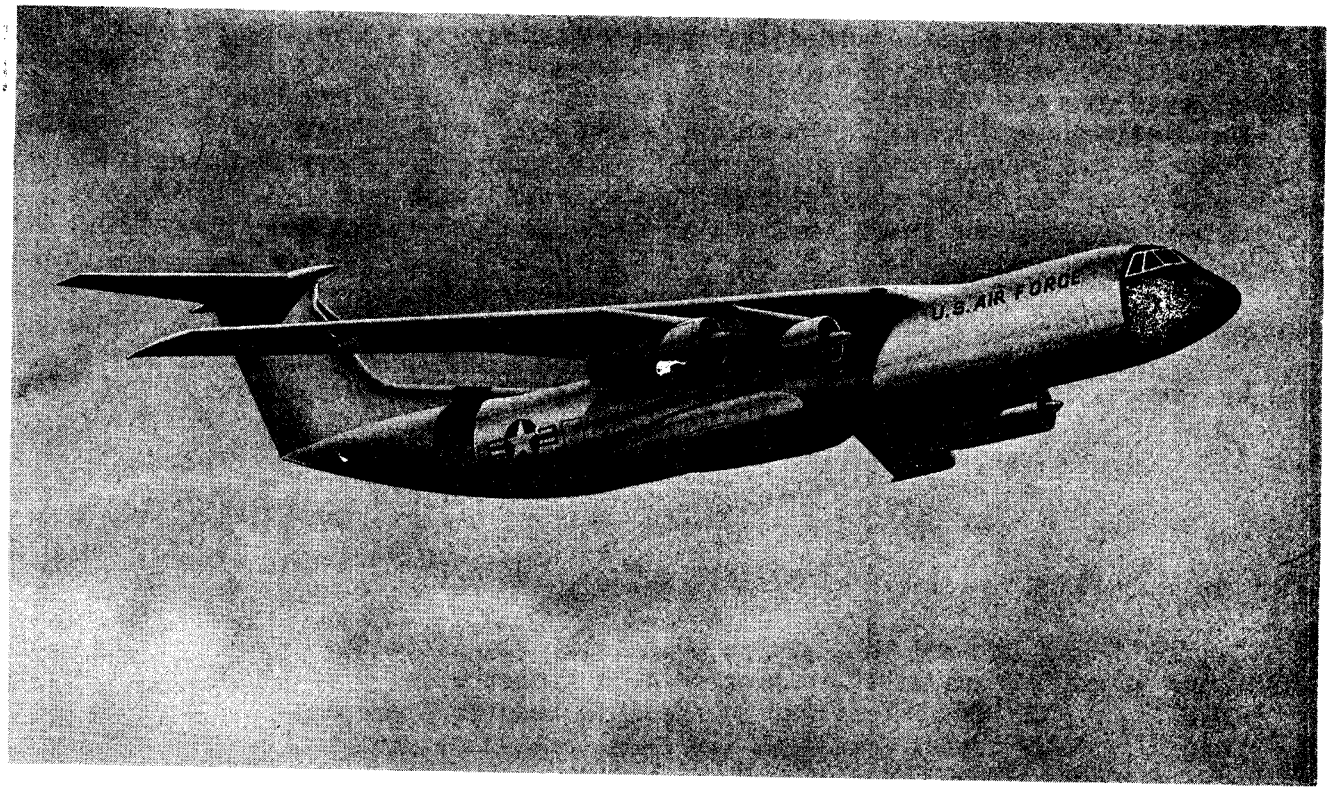
As noted in the following Lockheed published C-141 Characteristics and Performance Data, the aircraft as envisioned in 1962 was very close to the Headquarters MATS developed QOR of 23 March 1959 and the Headquarters USAF SOR of 4 May 1960. In fact, the following 1966 version of the Lockheed published C-141 Performance and Characteristics Data also showed that the operational C-141 did not deviate much from the original plan.

Commercial Worth Questioned

This design concept, however, encountered opposition from the airlines soon after its characteristics were set. One of the desires of many of the

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62. Tunner, Over the Hump, p. 320.
63. Ibid.



LOCKHEED C-141 A

The Lockheed C-141A is a modern, high speed aircraft which was designed for and meets all of the Air Force requirements for a logistics support system. Its capacity, loadability, and air-drop capability have not compromised its ability to maintain high subsonic cruise speeds. Four modern, turbofan, pod-mounted engines on a 25° sweep wing provide cruise speeds in the 500 knot class. A uniquely faired afterbody plus a T-tail combine to provide high aerodynamic efficiency in flight with ease of loading and unloading on the ground.

The high wing configuration and fuselage-mounted landing gear provide a low truckbed-level, cargo compartment. In flight, both cargo compartment and flight station are pressurized for 8000-foot cabin altitude at 40,000 feet or sea level cabin up to 21,000 feet: The cargo cube envelope is 109 inches high, 123 inches wide, and 70 feet long which allows a clear cube volume of 6,531 cubic feet plus 826 cubic feet on the ramp for a total of 7,357 cubic feet. The Air Force loading system 463L is included as an integral part of the design. The rollers and restraining rails for the pallets can be quickly retracted into recesses to provide a flat, smooth floor which is suitable for bulk loading, rolling stock, troops, and litter patients.

PERFORMANCE

Maximum cruise speed	485 knots
Long range cruise speed	440 knots
Aerial delivery drop speed	115-200 knots
Rate of climb (S.L., std. day) 4-engines, normal power at 316,100 pounds	3330 ft/min
Take-off distance over 50 feet at 316,100 pounds	5,330 ft
Landing distance from 50 feet at 257,500 pounds	3,700 ft
Maximum range with 80,000 pound payload	3,240 n.m.
Payload with maximum fuel	33,360 lb
Range with maximum fuel and payload	5,440 n.m.
Ferry range	6,220 n.m.

AIRPLANE CHARACTERISTICS

DIMENSIONS

Length		143.0 ft
Height	Approx.	39.0 ft
Wing span		160.1 ft
Wing area		3,228 sq ft
Wing sweep		25°

WEIGHTS

Maximum ramp	318,000 lb
Maximum flight	316,100 lb
Maximum landing	257,500 lb
Equipped weight empty	134,600 lb
Maximum payload	94,000 lb

POWER PLANT

Manufacturer	Pratt & Whitney
No. and model	(4) TF-33P-7
Thrust rating	21,000 lb
S.F.C.	0.605

FUEL SYSTEM

JP-4

Capacity	23,080 U.S. Gallons	(150,020 lb)
SPR rate	900 U.S. Gal/Min	(5,850 lb/min)
Jettison rate	700 U.S. Gal/Min	(4,550 lb/min)

CARGO COMPARTMENT

Length (exclusive of ramp)	70.0 ft
Height	9.1 ft
Width	10.25 ft

CARGO CAPACITY

Clear cube volume (incl. ramp)	7,357 cu ft
Palletized volume (incl. ramp)	5,484 cu ft
Number of pallets	10

PARATROOP DOORS

Number	2
Height	6.0 ft
Width	3.0 ft
Height from ground	50 in.

PERSONNEL CAPACITY

Crew	4
Troops	154
Paratroops	127
Litters plus 8 attendants	80
16g aft facing seats	138

LOADING OPENING

Height	9.1 ft
Width	10.25 ft
Height from ground	50 in.

LANDING GEAR

Dual wheel, NLG	
Four wheel bogey, MLG	
Tread MLG	17.5 ft
Wheel base	53.1 ft
UCI @ landing weight of 200,000 lb	38

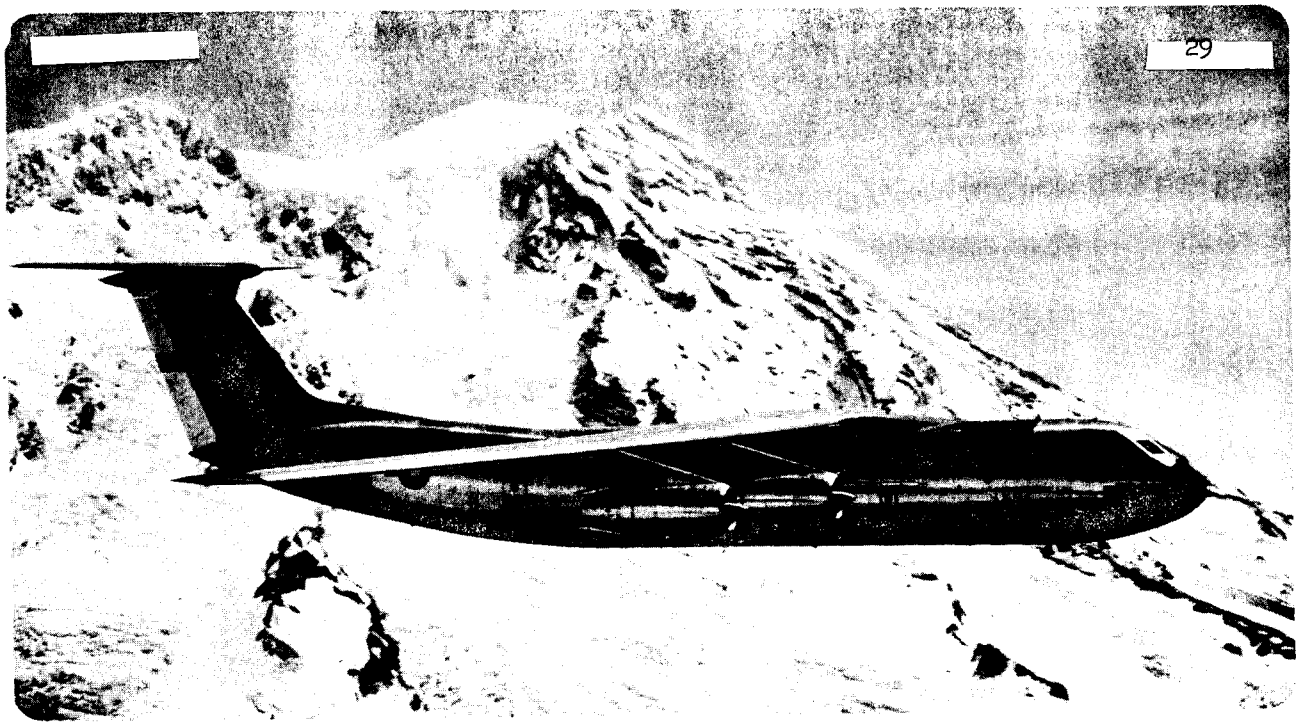
Note: All data subject to change pending final specification approval.

LOCKHEED-GEORGIA COMPANY / MARIETTA, GEORGIA

leading personages in the airlift controversy (1956-1960) was to develop an aircraft that would be compatible for commercial usage. Hence, much effort was expended in soliciting airline opinion concerning the performance and characteristics of the new aircraft. However, by 1961, due in part to the new President's insistence on mobility, "the military indicated it would try to make any changes suggested by airlines to enhance civil cargo use, but stressed that the C-141 was essentially a MATS plane."[64] Before long the commercial partners in the development decided that the new aircraft would not satisfy commercial needs because the C-141 was ". . .compromised toward a basic military purpose." Robert Prescott, the president of The Flying Tiger Line, then further stated that commercial industry ". . .should make it clear that the government i s n't doing us any favors. . ." by developing the C-141.[65] On 16 October 1961 Mr. William B. Becker, the ATA Director of Operation and Engineering, informed N. E. Halaby, the FAA Administrator, that it had been made ". . .quite clear that any basic changes to ". . .specifications to afford commercial utilization of the airplane [C-141] are not acceptable to the military."[66] Mr. Becker went on to state that the airlines felt that no benefits could be gained by joint airline/FAA/military discussions concerning the aircraft's characteristics. In addition, the letter suggested that the ". . .FAA's continued interest in the C-141 airplane need only entail assurance that the airplane will meet the CAR's" (Civil Airline Requirements).[67] Administrator Halaby, in the following November,

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64. "Carrier Recommendations Sought on C-141", Aviation Daily, 10 April 1961, in Newsclips, Hq MATS, Vol III, No 70, 12 April, SD I-12.
65. "Commercial Worth of C-141 Questioned", Extraction from Aviation Daily, undated (circa Oct 1961), SD I-13.
66. Ltr, William B. Becker, ATA Director of Operations and Engineering, to N. E. Halaby, FAA Administrator, 16 October 1961, SD I-14.
67. Ibid.



U.S. AIR FORCE C-141A STARLIFTER

DESCRIPTION

The U. S. Air Force C-141A is a long-range logistics transport designed to airlift personnel, supplies (either palletized or in bulk), and outsize objects, and to airdrop men and equipment. Four turbofan engines, pod-mounted on a 25-degree swept wing, provide cruise speeds up to 488 knots. A uniquely faired afterbody plus a T-tail combine to provide high aerodynamic efficiency in flight with ease of loading and unloading on the ground.

The high wing configuration and fuselage-mounted landing gear provide a low truckbed-level, cargo compartment. In flight both cargo compartment and flight station are pressurized for 8000-foot cabin altitude at 40,000 feet or sea level cabin up to 21,000 feet. The interior is basically 109 inches high, 123 inches wide, and 70 feet long which allows a clear cube volume of 6,514 cubic feet plus 826 cubic feet on the ramp for a total of 7,340 cubic feet. The Air Force loading system 463L is included as an integral part of the design. The rollers and restraining rails for the pallets can be quickly retracted into recesses to provide a flat, smooth floor which is suitable for bulk loading, rolling stock, troops, and litter patients.

PERFORMANCE

In Accordance with MIL-C-5011A

Maximum cruise speed	488 knots
Normal cruise speed	440 knots
Aerial delivery drop speed	130-150 knots
Rate of climb (S.L., std. day) 4-engines, normal power at 300,000 pounds	3200 fpm
Take-off distance over 50 feet at 316,100 pounds	5650 ft
Landing distance from 50 feet at 257,500 pounds	3680 ft
Range with 70,847 pound payload	3450 nmi
Payload with maximum fuel	30,877 lb
Range with maximum fuel (153,350 lb) and payload (30,877 lb)	5250 nmi
Ferry range	5925 nmi

C-141A AIRPLANE CHARACTERISTICS

DIMENSIONS

Length	145.0 ft
Height	Approx. 39.3 ft
Wing span	160.0 ft
Wing area	3,228 sq ft
Wing sweep	25 °

POWER PLANT

Manufacturer	Pratt & Whitney
No. and model	(4) TF 33-P-7
Thrust rating	21,000 lb
S.F.C. @ takeoff	0.605

CARGO COMPARTMENT

Length (exclusive of ramp)	70.0 ft
Height	9.1 ft
Width	10.25 ft

PARATROOP DOORS

Number	2
Height	6.00 ft
Width	3.0 ft
Height from ground	50 in

LOADING OPENING

Height	9.1 ft
Width	10.25 ft
Height from ground	Approx. 50 in

WEIGHTS

Maximum ramp	318,000 lb
Maximum flight	316,100 lb
Maximum landing @ 10 ft per sec. sink rate	257,500 lb
Maximum landing @ 6 ft per sec sink rate	316,100 lb
Equipped weight empty	133,773 lb
Design payload	70,847 lb

FUEL SYSTEM

Capacity	23,592 Gal*	153,350 lb
SPR rate	900 Gal/Min*	5,850 lb/min
Jettison rate	700 Gal/Min*	4,550 lb/min

* U. S.

CARGO CAPACITY

Clear cube volume (plus ramp)	7,340 cu ft
Palletized volume (incl. ramp)	5,241 cu ft
Number of pallets	10

PERSONNEL CAPACITY

Crew	4
Alternate crew	4
Troops (without comfort pallet)	154
Paratroops (without comfort pallet)	123
Litters plus 8 attendants	80
16g aft facing seats (without comfort pallets)	138

LANDING GEAR

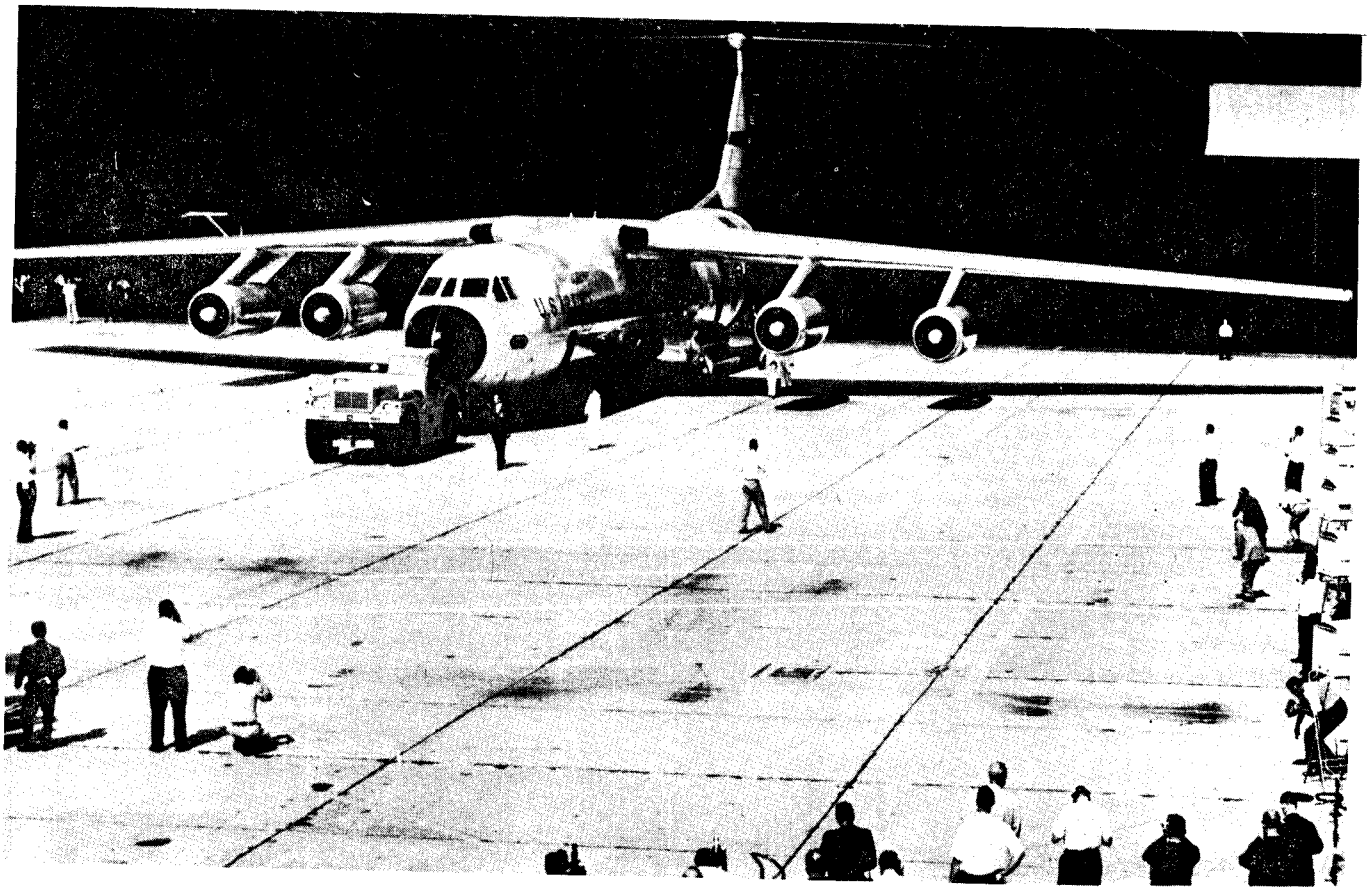
Dual wheel, NLG
Four-wheel bogey, MLG

Tread MLG	17.5 ft
Wheel base	53.0 ft

in answer stated that while ". . .no basic changes in the aircraft specifications would be acceptable to the Air Force. . .[the]. . .airline views were thoroughly considered by the Air Force in the preparation of the specifications which led to the selection of the C-141 design."[68] Halaby in answer to Mr. Becker's suggestion concerning FAA's role in the project stated: "As you probably know, civil certification is a condition of the Air Force contract with Lockheed."[69] Despite the FAA's argument the ATA did not continue to participate in the program and Lockheed was never able to sell a C-141 to a commercial line.[70] So the C-141 became what it began as [MATS QOR]: a medium-sized, fast, cargo workhorse, with a troop carrying and cargo and troop drop capability.

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68. Ltr, N. E. Halaby, FAA Administrator, to William B. Becker, ATA Director Operations and Engineering, 2 Nov 1961, SD I-15.
69. Ibid.
70. Interview, C. E. Curnane - Lockheed Representative to Hq MAC, by W. L. Kraus, Historian, 2 Dec 1968.



C-141A ROLLOUT - AUG 1963

Birth to Maturity

After the momentous events of 1959 through 1961 the development, production and acquisition of the C-141 seemed rather undramatic. Nevertheless, the following period saw the definitization of the aircraft's characteristics and capabilities, its production, as well as its roll-out and first flight. Following the 17 December 1963 first flight came the aircraft tests, its acceptance by Headquarters USAF and its assimilation into operational units. Hence, while the period January 1962 through 17 December 1963[71] lacked the glamour and perhaps the excitement of the preceeding and following periods, it constituted a vital phase of C-141 history.

Foremost among these numerous milestones was the publication of the last revision of SOR 182. This revision refined many of the provisions of the former SOR, as well as consolidated Amendments 182-1 and 182-2 into the body of the document. Among the major changes was the direction that the traffic pattern speed should approximate the speeds of the C-118 and C-124, which the C-141 was programmed to replace. In addition, a requirement for a runway length of no more than 6,000 feet was added, as well as a capability to make 180 degree turns on a runway that was only 150 feet wide.[72]

Other major events included the first airplane assembly, on 19 June 1962, and the completion of the cargo floor bulkhead. Following these

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71. On 22 August 1963 the first C-141 was rolled out at the Lockheed Aircraft Corporation Plant at Marietta, Georgia.
72. SOR No. 182, AFORQ, subj: SOR for a Cargo Transport Aircraft Support System, 15 June 1962, SD I-16.

milestones, in September the first subcontracted assemblies arrived at Lockheed. These assemblies were the cargo floor plates manufactured by Bell Aerosystems of Buffalo, New York. In January of 1963 Lockheed accomplished the first fuselage mating on schedule. Two months later the first wing, built by AVCO of Nashville, Tennessee, was received by Lockheed and in May 1963 the first airplane entered final assembly.[73] By 15 July 1963, Lockheed was able to present the Air Force with a price proposal for 127 aircraft.[74]

Finally on 22 August 1963, amid much fanfare,[75] the C-141 Roll Out Ceremonies were conducted at Lockheed-Georgia. Six days later the Air Force accepted the first Starlifter, and by 30 October the Air Force had accepted production aircraft number 2 on an interim basis.[76] Hence, both aircraft numbers 1 and 2 were accepted prior to the first flight of the Starlifter.

On 17 December 1963, the culmination of the C-141's design and development phase came to an end. The event that closed this period was the first flight of a C-141, by aircraft SN 61-2775. This flight, which lasted 55 minutes, was accomplished at the planned altitude of 7,800 feet. Significant to the history of the C-141 and aircraft development was the fact that this first airplane was not a prototype but a production model, thereby deviating somewhat from standard aircraft test policy.[76] As 1963 closed, the C-141

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73. News Release, News Bureau - Lockheed-Georgia Co, subj: Highlights in Development of C-141 Starlifter, undated (circa August 1963), SD I-17.
74. C-141 System Hist, p. A-17.
75. Including an electro telegraphic system whereby President John F. Kennedy pressed a button on his desk in the White House which opened the C-141's hangar doors at the Lockheed-Georgia Plant.
76. Progress Report No. 6, Lockheed-Georgia Co, Marietta, Georgia, subj: C-141A Starlifter, undated (circa Dec 1963), SD I-18.

design was in final form. As noted in a Lockheed publication, the aircraft remained ". . .a high speed cargo transport. . .which was. . .required to provide air drop capability for both cargo and paratroops. . . ."[77]

Flight Test To Operations

After the first flight all organizations engaged in C-141 development were busy with the aircraft's Category I, II, and III Tests, as well as preparing the Starlifter for squadron service. OSD's approval of the design was attested by the 22 May signing of the multi-year definitive production contract for 127 C-141's bringing the total buy to 132 (5 initial production).[78] In June production aircraft number 6 was flown across the country (the first time a C-141 accomplished this feat) to the Air Force Flight Test Center (AFFTC) at Edwards AFB, California. This aircraft was designated as the first Category II Test aircraft. On 19 August, the first production aircraft (AFSN 61-2775) was also deployed to Edwards AFB for engine performance tests.[79]

Finally, on 19 October 1964, another major milestone was reached when production aircraft number 9 (AFSN 63-8078) was delivered to the MATS Transitional Training Unit, the 1707 Air Transport Wing,[80] at Tinker AFB, Oklahoma. This event marked the command's first acquisition of a Starlifter. Hence, with appropriate ceremonies General Howell M. Estes, the MATS

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77. Configuration Description, Lockheed-Georgia Company, subj: C-141A, Jan 1963, p. 2, SD I-19.
78. C-141 System History, p. A-28.
79. Ibid.
80. On 8 January 1966, the 1707th became the 443 Military Airlift Wing (MAWg).

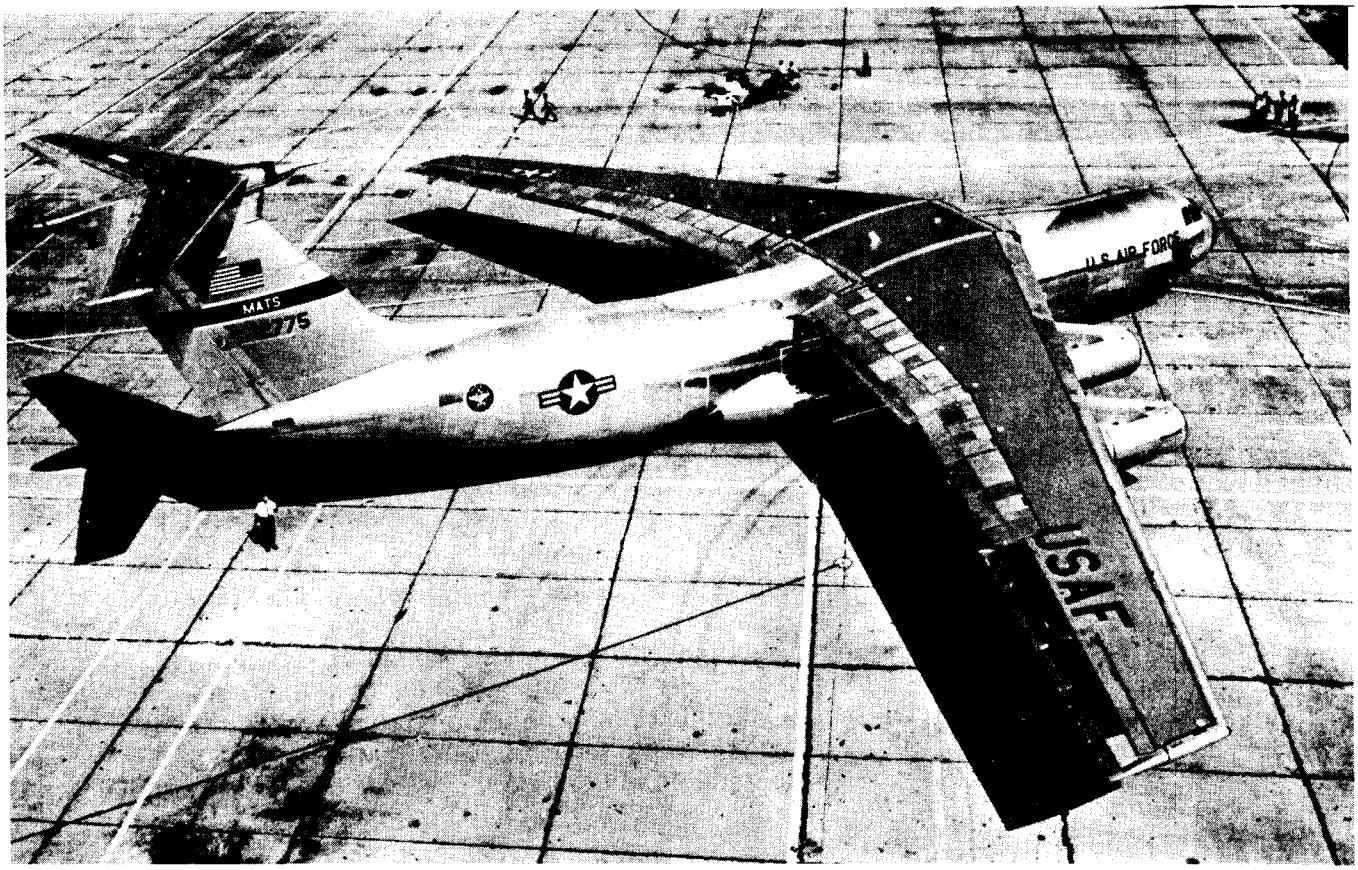
Commander, accepted SN 63-8078, which had been dubbed the "Spirit of Oklahoma City," from Major General C. H. Terhune, Jr., who was the Commander of Aeronautical Systems Division (ASD) of the Air Force Systems Command (AFSC). At the ceremonies, Air Force Under Secretary Brockway McMillan stated that ". . .it is remarkable that this cargo airplane was developed within three years and stayed within its cost."[81] General Estes also, in recognizing this major milestone, stated that the ". . .Arrival of the C-141 heralds a completely new era in which we can look to a better reliability and far more flexibility." From this point MATS began to actively train the C-141 air and ground crews needed for the Starlifter operations.

Shortly thereafter, on 23 April 1965, the first of the new fan-jet transports entered operational squadron service. On this date General Estes delivered a Starlifter to the Western Transport Air Force (WESTAF).[82] This aircraft, SN 63-8088 -- assigned to the 1501 Air Transport Wing (ATW)[83] -- was nicknamed the "Golden Bear" in honor of the State of California. By 25 May 1965, the "Golden Bear" had flown nonstop from Travis AFB to Japan in nine hours and twenty minutes,[85] marking the first operational C-141 flight to the Pacific.

Gaining more publicity in the following month, between the period 10 June through 21 June, the Air Force showed the world its new aircraft.

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81. Progress Rpt No. 9, Lockheed-Georgia Co, Marietta, Georgia, subj: C-141A Starlifter - First Delivery, 30 Oct 64, SD I-20.
82. WESTAF became the 22 Air Force on 1 Jan 66.
83. The 1501 Air Transport Wing became the 60 Military Airlift Wing (MAW3) on 1 Jan 66.
84. Hist, 1501 ATW, Jan-Jun 65, Vol IV, Tabs 36-40.
85. Theodore P. Wagner, "New Cargo Jet Spans Pacific Nonstop in 9 Hours, 20 Minutes," St Louis Post Dispatch, 1 Jun 65, SD I-21.



C-141A ROLLOUT - AUG 1963

A C-141 from the 1501 ATW was placed on display at the 26th Paris International Air and Space Salon at Le Bourget Airport, Paris, France. This Starlifter proved to be one of the stars of the show when it demonstrated some of its performance capabilities in an aerial demonstration. The cargo aircraft also drew large interested crowds while on static display.[86]

The Operational Environment

Having already proven itself in the test environment the C-141 and its crews now faced the acid test of war when on 5 August 1965 a C-141 and crew from the 1501 ATW initiated regular service to Saigon, Vietnam. Laden with 50,000 pounds of general purpose cargo, the aircraft completed the outbound trip to Saigon in 18 hours and 15 minutes of elapsed flying time. This event marked the beginning of regular Starlifter resupply missions to the Pacific area; aeromedical evacuation on some return flights was soon initiated.[87]

On 14 August the 1608 ATW,[88] Charleston AFB, S.C., received its first C-141, thereby bringing the new jet into the Eastern Transport Air Force.[89] Following that event, on 18 August, the 1611 ATW[90] based at Dover AFB, Delaware, received its first C-141.[91] By 31 December 1965 MATS had received its 65th Starlifter.

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86. C-141 System Hist, P. A-44. The aircraft displayed was SN 63-8089.
87. Highlights and Accomplishments - C-141 Program, W. L. Kraus, Historian, undated (circa Dec 66), (hereinafter cited as C-141 Highlights).
88. The 1608 ATW became the 437 MAWg on 8 Jan 66.
89. Eastern Transport Air Force (EASTAF) became the 21 AF on 8 Jan 66.
90. The 1611 ATW became the 436 MAWg on 8 Jan 66.
91. C-141 Highlights.

Two more major milestones were passed in the waning months of 1965. The first of these events was the 14 December publication of Amendment 1 to SOR 182. Amendment 1 provided for the addition of an automatic landing system when weather precluded visual landings. This All Weather Landing System (AWLS)[92] also had ". . .provisions for installation of de-crab and rollout functions for landings under Category III weather minimums."[93] The second proved to be the first large scale operation in which the C-141 performed in the rapid deployment stage of the "flexible response" strategy. Utilizing C-133's and Starlifters MATS moved the U. S. Army's Third Brigade, 25th Division, from Honolulu, Oahu, Hawaii, to Pleiku, South Vietnam. This operation, which was initiated on 24 December for the advanced party, began for the main party on 27 December and ended on 28 January 1966. Dubbed Operation "Blue Light" this mission called for the movement of 2,952 troops and 4,749 tons of equipment for a distance of 6,000 miles. Starlifter missions consisted of the movement of 2,216 troops and 1,802 tons of equipment.[94] While not a mission that tested C-141 overall capabilities, it did prove that C-141's could efficiently operate in deployment phases of a military movements.

Immediately following Operation "Blue Light," on 31 January 1966, Hq Air Force accepted the first of the Minuteman missile-carrying C-141s.[95]

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92. Later this system was redesignated the Adverse Weather Landing System.
93. SOR 182-1, AFRDQ, subj: Amendment to Specific Operational Requirement SOR 182, dated 4 May 1960, revised 15 June 1962, for "A Cargo Transport Aircraft Support System," 14 Dec 64, SD I-22.
94. Hist, 61 MAWg, Jan-Jun 66, Vol I, pp. 124-189.
95. C-141 Mgt Sum, A/O 4 Feb 66, p. 5-1.

This event gave to MAC the vehicle for the fast SAC support missions identified as a national defense requisite in the Rivers Committee Hearings of 1960. Early in 1966, C-141s were assigned to the Embassy Run[96] and designated the European aeromedical evacuation vehicle. Both services were initiated on 1 April.[97]

Including the new mission assignments, seven more milestones were past in April. The third of these was a 14 April three-air drop sequence of jeep-sized loads, made at the Fort Bragg North Carolina drop zone, from an altitude of 700 feet. This event marked the first time that the C-141 dropped equipment from a normal combat drop altitude.[98] On 21 and 22 April the first loading/unloading test of a Minuteman missile was successfully completed. In addition, production Starlifter number 100 was accepted on the twenty-second[99] and the Category I Test for the AWLS was initiated on 27 April.[100] Lastly, the month saw the end of MAC's first year of operation with the C-141's. Commemorating the occasion a Lockheed Aircraft Company's Progress Report stated that in one year the aircraft had become an operationally-tested vehicle.[101]

On 30 June, another major milestone was reached when the final contract was definitized for the last buy of Starlifters. This contract called for a follow-on purchase of 134 aircraft, bringing the total procured to 284

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96. A mission which circles the globe periodically, primarily to service world-wide U. S. Embassies.
97. C-141 Highlights.
98. Mgt Summary - RCS: 13-AFSC-R32, C-141 SPO, subj: Program C-141A, A/O 22 April 1966, p. 5-1 (Complete set in MAFOIH files)(hereinafter cited as C-141 Mgt Sum).
99. Ibid., pp. 5-1-2.
100. C-141 Mgt Sum, A/O 29 Apr 66, p. 5-1.
101. Progress Rpt No. 13, Lockheed-Georgia Company, subj: U.S. Air Force C-141A Starlifter, undated (circa April 1965), SD I-23.



FIRST PRODUCTION C-141, SN 61-2775,
IN FLIGHT TEST

airplanes,[102] including the 18 aircraft which were authorized on 23 March 1965.[103]

In early July a Starlifter entered the record books when an aircraft from the 443 MAWg flew nonstop from Yokota Air Base, Japan, to Tinker AFB, Oklahoma. This 5,948-mile trip, which required a 12-hour 50 minute flight time, demonstrated the feasibility of logistics transportation from inland ports.[104] July also saw the completion of the Category III Tests with the submission of the Test Final Report to General Estes on 5 July 1966.[105] Before 1966 ended the C-141 garnered still another first when an aircraft flew to McMurdo Sound, Antarctica, thereby in November becoming the first fan-jet transport to land in the South Polar Region.[106] However, much more important was the fact that by 31 December 1966 the aircraft had assumed its position as the backbone of the MAC Force. At this time a total of 164 were in the possession of MAC units.[107]

The early operational years were not without disasters. The first of these occurred to the C-141 force at 0630 Pacific Standard Time on 7 September 1966 when aircraft SN 65-281 was totally destroyed by fire while parked on the ramp at McChord AFB, Washington. Primary cause of this accident was ascertained, by an investigation team, as a material/design deficiency in

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102. C-141 Highlights.
103. C-141 Mgt Sum, 26 Mar 65, p. 5-1.
104. "Plane Sets Record," The Oklahoma Journal, 7 July 1966, SD I-24.
105. C-141 Mgt Sum, A/O 8 July 1966, p. 5-1.
106. C-141 Mgt Sum, A/O 18 November 1966, p. 5-1.
107. Photostat of the MAC Aircraft Force Inventory Board, MACOAS, A/O 31 Dec 66.

the MD-2A tester with adapter. A contributing factor was inadequate instructions, which made possible the introduction of 115 volts of alternating current into the aircraft tankage system. This accident led to the issuance of more precise instructions and a modification of the adapter.[108]

Disasters again came in March and April 1967 in almost a rapid-fire succession. On 23 March 1967 a Starlifter (SN 65-9407) from the 62 MAWg was struck by a U.S. Marine Corps A-6 "Intruder" (BUNO 152608) at DaNang Air Base, South Vietnam. Apparently the C-141 had been waved across a runway from which the "Intruder" was negotiating its takeoff roll. Fortunately, the Marines saw the C-141 in time and were able to "punch-out" of their aircraft before it struck the MAC airplane. The ensuing collision demolished both aircraft and allowed only the C-141's Loadmaster to survive. The Investigating Team classified the accident as C-141 operator error because apparently the Starlifter crew followed the Vietnamese Traffic Director's instructions without first visually inspecting the runway.[109] The second accident, of 12 April 1967, was also classified as operator error because the crew attempted to takeoff with the aircraft's spoilers deployed. This accident, at Cam Ranh Bay, South Vietnam, completely destroyed aircraft SN 66-127.[110] However, as a result of the accident, the C-141 SPO requested Lockheed to develop a takeoff warning system to

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108. C-141 Mgt Sum, A/O 23 Sep 66, p. 5-1.
109. Hist, 62 MAWg, 1 Jan-30 Jun 67, Vol I, pp. 51-55.
110. C-141 Mgt Sum, A/O 21 Apr 67, p. 5-1.



C-141A, SN 63-8078, "SPIRIT OF OKLAHOMA CITY", ACCEPTED BY GENERAL HOWELL M. ESTES, JR., FOR MATS, AT TINKER AFB, OKLAHOMA. THIS 19 OCTOBER 1964 EVENT MARKED THE FIRST ACCEPTANCE OF A STARLIFTER BY MATS.

alert the pilot and copilot of a spoiler deployment condition. This new safety device was approved and scheduled as an aircraft modification in June.[111]

As 1967 continued to run its course, Starlifters became the main element of the MAC force. By 30 June there were 220 of them in the inventory, see Table II.[112] C-141's comprised about one quarter of the inventory, the only other aircraft nearly that numerous being the obsolete C-124's (188) which the Starlifters were replacing. As noticed in Table III,[113] the inventory value of the C-141 airlift aircraft was $1,142,000,000, while the value of the 20 Starlifters possessed by the 443 MAWg (TTU) were valued at $114,200,000. Hence, the combined value of the Total MAC C-141 Force was $1,256,200,000 at the end of FY 1967. This force value was to rise to $1,723,742,286 by 30 June 1968, as noticed in Table IV.[114]

The Starlifter's evaluation and testing continued in 1967 and into 1968. A major achievement resulting from the tests was the granting of a FAA certification of the AWLS for Category II weather minimums on 6 October 1967. The only other aircraft system to achieve this milestone was Boeing's 707-720 series of airplanes. Basically, this certificate recognized the Starlifter's ability to land automatically within 12 feet (plus or minus) of an airport localizer beam and within 300 feet (plus or minus) of the nominal touchdown point (under manual-visual execution).[115] During the last

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111. C-141 Mgt Sum, A/O 16 Jun 67.
112. Table II is p. 4.08 of the FY 1967 MAC Airlift Data Summary.
113. Table III is p. 2.51 of the FY 1967 MAC Airlift Data Summary.
114. Table IV is p. 2.51 of the FY 1968 MAC Airlift Data Summary.
115. C-141 Mgt Sum, A/O 13 Oct 67, pp. 5-1 - 5-2.

TABLE II

AIRCRAFT, UNIT EQUIPPED AND ASSIGNED (MAC BY SUBCOMMAND)

30 JUN 67

	21 AF		22 AF		1370 PM Wg		ARRS		AWS		89 Mil Aleft Wg		375 Aeromed Aleft Wg		443 Mil Aleft Wg		Total	
	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd
U-3A	7	7	5	5									4	4			16	16
CH-3					7	4											7	4
HH-3							28	22									28	22
U-4											4	4					4	4
VC-6A											1	1					1	1
HU-16							30	37									30	37
T-29	4	4	11	11									4	4			19	19
T-33			4	4													4	4
T-39			2	2									5	5			7	7
HH-43							150	144									150	144
C-47	2	2							1	1							3	3
WB-47									24	25							24	25
HH-53							6	3									6	3
C-54	3	3	5	5									4	4			12	12
RB-57C									6	6							6	6
RB-57F									15	14							15	14
C-118	5	5	2	2	3	3					3	3	8	9			21	22
C-121											4	4					4	4
C-124	48	54	114	126											8	8	170	188
C-130	32	35															32	35
HC-130							54	60									54	60
RC-130					15	16											15	16
WC-130									14	14							14	14
C-131	5	5									4	4	14	16			23	25
C-133	23	25	15	14													38	39
C-135	9	10			4	2			10	10	3	3					26	25
C-137											4	4					4	4
C-140											11	11					11	11
C-141	92	100	96	100											18	20	206	220
TOTAL	230	250	254	269	29	25	268	266	70	70	34	34	39	42	26	28	950	984
MONTHLY SUMMARY																		
31 Jul 66	265	286	275	284	23	24	257	260	65	66	33	35	41	44	26	27	985	1026
31 Aug 66	265	288	275	284	23	24	257	260	65	65	33	35	41	44	26	29	985	1029
30 Sep 66	264	286	277	291	23	23	257	263	65	65	33	35	41	44	26	30	986	1037
31 Oct 66	273	291	275	281	26	23	257	254	65	65	33	35	38	41	26	30	993	1020
30 Nov 66	273	292	273	279	26	24	261	255	65	64	33	34	38	41	26	29	995	1018
31 Dec 66	273	282	272	289	26	24	261	261	65	63	33	34	38	41	26	29	994	1023
31 Jan 67	269	269	254	278	27	25	263	266	67	64	33	34	38	41	26	29	977	1006
28 Feb 67	239	257	254	274	27	26	265	266	67	65	33	34	38	41	26	28	949	991
31 Mar 67	240	261	254	275	27	26	261	266	67	67	33	34	39	42	26	28	947	999
30 Apr 67	231	243	254	270	29	25	268	268	70	67	34	34	39	42	26	28	951	977
31 May 67	230	247	254	267	29	25	268	265	70	69	34	34	39	42	26	28	950	977
30 Jun 67	230	250	254	269	29	25	268	266	70	70	34	34	39	42	26	28	950	984

Asgd - Assigned UE - Unit Equipped

Source: DCS/O Acft allocation and TEC services Division

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TABLE III

INVENTORY VALUE OF ASSIGNED AIRCRAFT

30 JUNE 1967

INDUSTRIAL FUND AIRCRAFT

MISSION, DESIGN AND SERIES AIRCRAFT	UNIT COST	NO. ASGD AIRCRAFT	INVENTORY COST
AIRLIFT FORCE			
C-124C	$ 1,646,406	148	$ 243,668,088
C-130E	2,287,895	35	80,076,325
C-133A	9,788,469	25	244,711,725
C-133B	6,605,730	14	92,480,220
C-135A	2,620,000	2	5,240,000
C-135B	2,938,533	8	23,508,264
C-141A	5,710,000	200	1,142,000,000
TOTAL		432	$ 1,831,684,622
AEROMED EVAC			
375 Aeromed Airlift Wg			
C-118	$ 1,179,976	7	$ 8,259,832
C-131A	970,412	16	15,526,592
TOTAL		23	$ 23,786,424
55 Mil Airlift Sq			
C-118	$ 1,179,976	5	$ 5,899,880
C-131A	970,412	5	4,852,060
TOTAL		10	$ 10,751,940
SPECIAL AIR MISSION			
89 Mil Airlift Wg			
U-4	$ 98,750	4	$ 395,000
VC-6A	340,100	1	340,100
C-118A	1,179,976	1	1,179,976
VC-118A	1,179,976	2	2,359,952
C-121A	2,533,770	4	10,135,080
C-131H	1,342,514	4	5,370,056
C-135B	2,938,533	3	8,815,599
VC-137B	6,460,000	3	19,380,000
VC-137C	8,396,662	1	8,396,662
C-140B	1,602,463	5	8,012,315
VC-140B	1,602,463	6	9,614,778
TOTAL		34	$ 73,999,518
TOTAL IF		499	$ 1,940,222,504

NON-INDUSTRIAL FUND AIRCRAFT

MISSION, DESIGN, AND SERIES AIRCRAFT	UNIT COST	NO. ASGD AIRCRAFT	INVENTORY COST
U-3A	53,200	16	$ 851,200
HU-16B	744,129	37	27,532,773
T/VT-29A	643,273	4	2,573,092
T/VT-29B	891,816	8	7,134,528
T-29C	781,991	3	2,345,973
T-29D	994,222	4	3,976,888
T-33A	122,810	4	491,240
HH-43B	304,000	136	41,344,000
HH-43F	286,000	8	2,288,000
HH-53	150,470	3	451,410
C-47	95,466	3	286,398
W-47	2,449,456	25	61,236,400
C-54	382,779	12	4,593,348
RB-57C	1,211,955	6	7,271,730
RB-57F	9,019,780	14	126,276,920
C-118	1,179,976	7	8,259,832
C-124	1,646,406	40	65,856,240
CH-3	771,384	4	3,085,536
HH-3	771,384	22	16,970,448
C-141A	5,710,000	20	114,200,000
C-135B	2,938,533	10	29,385,330
RC-135A	10,331,000	2	20,662,000
T-39A	960,216	7	6,721,512
WC-130	2,747,654	14	38,467,156
RC-130A	2,616,645	16	41,866,320
HC-130H	2,607,142	60	156,428,520
TOTAL		485	$ 790,556,794
AGGREGATE		984	$ 2,730,779,298

1/ Used unit cost for the VC-53(per TO-00-25-30) no other cost available as of this date.

(Published Monthly)

Source: MAOCOA

Prepared by MABIFS

TABLE IV

INVENTORY VALUE OF ASSIGNED AIRCRAFT
30 JUNE 1968

INDUSTRIAL FUND AIRCRAFT

MISSION, DESIGN AND SERIES AIRCRAFT	UNIT COST	NO. ASGD AIRCRAFT	INVENTORY COST
AIRLIFT FORCE			
C-124C	$ 1,646,406	146	$ 240,375,276
C-130E	2,395,206	34	81,437,004
C-133A	9,788,469	25	244,711,725
C-133B	6,605,730	14	92,480,220
C-141A	6,245,443	256	1,598,833,408
TOTAL		475	$2,257,837,633
AEROMED EVAC			
375 Aeromed Alft Wg			
C-118	$ 1,195,597	6	$ 7,173,582
C-121G	1,811,826	8	14,494,608
C-131A	970,412	16	15,526,592
		30	$ 37,194,782
55 Mil Alft Sq			
C-118	$ 1,195,597	6	$ 7,173,582
C-131A	970,412	5	4,852,060
TOTAL		11	$ 12,025,642
SPECIAL AIR MISSION			
89 Mil Alft Wg			
U-4	$ 98,750	4	395,000
VC-6A	436,200	1	$ 436,200
C-118A	1,195,597	3	3,586,791
C-131H	1,342,514	3	4,027,542
C-135B	2,938,533	5	14,692,665
VC-137B	6,850,000	3	20,550,000
VC-137C	8,396,662	1	8,396,662
C-140B	1,970,000	5	9,850,000
VC-140B	1,970,000	6	11,820,000
TOTAL		31	$ 73,754,860
TOTAL IF		547	$2,380,812,917

NON-INDUSTRIAL FUND AIRCRAFT

MISSION, DESIGN, AND SERIES AIRCRAFT	UNIT COST	NO. ASGD AIRCRAFT	INVENTORY COST
U-3A	$ 53,200	13	$ 691,600
HU-16B	744,129	6	4,464,774
T/VT-29A	643,273	4	2,573,092
T/VT-29B	891,816	7	6,242,712
T-29C	781,991	3	2,345,973
T-29D	994,222	3	2,982,666
T-33A	147,810	4	591,240
HH-43B	304,000	138	41,952,000
HH-43F	286,000	8	2,288,000
HH-53	1,819,000	8	14,552,000
C-47	95,466	3	286,398
W-47	1,869,667	24	44,872,008
C-54	409,559	9	3,686,031
RB-57C	1,211,955	6	7,271,730
RB-57F	9,019,780	16	144,316,480
C-118	1,195,597	7	8,369,179
C-124	1,646,406	37	60,917,022
CH-3	766,925	9	6,902,325
HH-3	999,308	27	26,981,316
C-141A	6,245,443	20	124,908,860
C-135B	2,938,533	10	29,385,330
RC-135A	10,331,000	4	41,324,000
T-39A	960,216	7	6,721,512
WC-130	2,395,206	14	33,532,884
RC-130A	2,797,251	16	44,756,016
HC-130H	2,668,877	59	157,463,743
HC-97	1,132,781	9	10,195,029
		471	$ 830,573,920
AGGREGATE		1,018	$ 3,211,386,837

(Published Monthly)
SOURCE: MAOCOA
Prepared by: MABIFS

days of 1967, the SPO was engaged in establishing landing gear flotation tests for the C-141's[116] -- tests that were completed during 1968. These tests were established to evaluate the C-141's ability to land on relatively unprepared fields.

On 27 February 1968, the last C-141 left the Lockheed production line. This event marked the completion of the USAF 284 aircraft buy program, as well as the research and development phase of the C-141 Program. Shortly thereafter, on 1 March, ASD relinquished executive management of the weapon system to the Air Force Logistics Command. Since the Warner-Robins Air Materiel Area (WRAMA) had already been designated as Support System Manager (SSM), control passed to it.[117] With this transfer the Starlifter officially became a recognized fully operational weapon system.

Maturity

With the acceptance of the weapon system by AFLC and MAC, the cargo transport entered into another phase of C-141 operations. Due to a thorough management program,[118] MAC personnel were not entirely unfamiliar with the necessary requisites of this phase. Throughout the various phases of the program, after aircraft became available, MAC operated under the relatively new concept, "Concurrent Acquisition and Test." Unlike the old system of "test first", the concept called for aircraft operating in squadron service before the completion of the Category II and III Tests. The basic rationale for this new program was to enable the using command to

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116. C-141 Mgt Sum, A/O 9 Nov 67, p. 5-1.
117. C-141 Mgt Sum, A/O 15 Mar 68.
118. C-141 Management Program is the topic of part II, this study.

have production vehicles shortly after they had been proven air-worthy. This, of course, enhanced MAC's airlift productivity, while aiding the subsystem test process, since the subsystems were realistically tested in the operational environment.[119] In practice, this meant that most of the planned for C-141's were in squadron service or engaged in transitional training prior to the completion of the Category II Tests.[120] In fact, on 31 June 1968, as noticed in Table V, the total programmed 276 Starlifters were assigned to MAC while the Landing Gear Flotation Tests were still in progress.[121]

More important, Starlifter acquisition gave MAC a highly versatile aircraft. The C-141's 123-inch width, 109-inch height, and 70-foot length can accommodate 19 configurations which range from a pure passenger or aeromedical evacuation form to pure cargo pallet or mixed troop/cargo forms. These configurations further varied from the ability to carry 127 troops or 80 litters to 10 cargo pallets or mixes ranging from 6 seats to 65 seats and cargo space. In addition, one variant can provide for the airdrop of paratroops and another for a Minuteman missile-carrying capability. Most of the forms require only a few hours to accomplish; only the VIP configuration requires 24 hours to install. Nevertheless, the Starlifter remains a basic cargo

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119. Hist, MAC, 1 Jul 65-30 Jun 66, Vol I, pp. 161-162.
120. Category III Tests were completed by 30 Jun 66.
121. Table V is p. 4.08 of the FY 1968 MAC Airlift Data Summary.

TABLE V

AIRCRAFT UNIT EQUIPPED AND ASSIGNED (MAC BY SUBCOMMAND)

30 JUN 68

	ARRS		AWS		1370 PM Wg		89TH		375TH		443D		21 AF		22 AF		TOTAL	
	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd	UE	Asgd
U-3A									4	4			6	6	3	3	13	13
CH-3	4	3			7	6											11	9
HH-3	31	27					4	4									31	27
U-4							1	1									4	4
VC-6A																	1	1
HH-16	12	6							4	4			3	3	10	10	12	6
T-29															4	4	17	17
T-33									5	5					2	2	4	4
T-39																	7	7
HH-43	150	146															150	146
C-47			1	1									2	2			3	3
WB-47			24	24													24	24
HH-53	8	8															8	8
C-54									4	4			3	3	2	2	9	9
RB-57 C/F			22	22													22	22
HC-97	8	9															8	9
C-118					3	3	3	3	8	8			5	6	2	2	21	22
C-121									8	8							8	8
C-124											5	5	64	68	106	110	175	183
C-130													32	34			32	34
HC-130	55	59															55	59
RC-130					15	16											15	16
WC-130																	14	14
C-131			14	14									5	5			22	24
C-133							3	3	14	16			24	25	14	14	38	39
C-135																	19	19
C-137			10	10	4	4	5	5									4	4
C-140							4	4									11	11
C-141							11	11									242	276
TOTAL	268	258	71	71	29	29	31	31	47	49	18 23	20 25	112 256	128 280	112 255	128 275	980	1,018

MONTHLY SUMMARY

31 Jul 67	260	267	68	69	29	26	34	34	39	42	23	25	239	252	247	259	939	974
31 Aug 67	260	264	68	69	29	28	34	34	39	41	23	25	239	258	247	257	939	976
30 Sep 67	260	262	70	69	29	28	34	34	39	42	23	25	239	260	247	262	941	982
31 Oct 67	259	265	70	70	29	28	34	35	39	42	23	25	246	262	250	266	950	993
30 Nov 67	259	265	70	71	29	28	34	35	39	42	23	25	246	264	250	269	950	999
31 Dec 67	259	259	70	72	29	29	34	36	39	42	23	25	246	266	248	271	948	1,000
31 Jan 68	267	264	71	71	29	29	32	36	39	42	23	24	257	284	272	296	990	1,046
29 Feb 68	267	262	71	70	29	29	32	36	39	42	23	24	257	285	272	296	990	1,044
31 Mar 68	267	266	71	70	29	29	32	35	39	42	23	25	257	283	271	294	989	1,044
30 Apr 68	268	261	71	71	29	29	32	33	39	42	23	25	257	282	255	286	974	1,029
31 May 68	268	260	71	71	29	29	31	32	47	50	23	25	257	282	255	275	981	1,024
30 Jun 68	268	258	71	71	29	29	31	31	47	49	23	25	256	280	255	275	980	1,018

Asgd - Assigned UE - Unit Equipped

Source DCS/O Acft allocation and tec services division

4.08

aircraft; eight of its configurations are for cargo or cargo/passenger mixes, three are aeromedical, three are paratroop, and five are designed for passengers or troops.[122]

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122. Manual MM 55-4, Hq MAC, subj: C-141 Cargo Compartment Configuration/ Mission Planning Manual, 21 Jun 67, SD I-25.

Conclusion

The value of the C-141 to the deployment phase of the "flexible response" strategy was dramatically illustrated in four deployments during 1967 and 1968. These troop movements were operations "Eagle Thrust", "Combat Fox", "Bonny Jack", and "Reforger".[123] In each case the Starlifters showed that they were well adapted to rapid deployments. However, in retrospect it should be noted that the C-141's major contributions to the national defense posture since August 1965 has been in the resupply facet of the new strategy. Perhaps this fact is best illustrated by the Fiscal Year (FY) 1968 channel traffic cargo movement statistics. They show that of the 2,724,473,575 ton miles of cargo flown during the year Starlifters accomplished about 82.3 percent of the total.[124] These statistics become even better evidence of the aircraft's role when the MAC operational transport inventory is considered. Fiscal Year 1968 ended with 256 of the fan jets in squadron service (20 were assigned to the TTU), a total which was slightly more than one-half of the MAC transport force (475 aircraft) used in basic airlift.[125]

A further testimony to the Starlifter's versatility was the rapid accumulation of flight hours since the "Spirit of Oklahoma City" entered the MATS Inventory on 19 October 1964. In approximately three years and eight months after this event and about four months after the last of the Starlifters rolled off Lockheed's production lines, a C-141 passed the

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123. MAC Histories for the appropriate periods cover these operations.
124. Interview, George Graf, MABIFS, by W. L. Kraus, Historian, 17 Dec 68.
125. Airlift Service Mgt Rpt, Hq MAC, Jul 67-Jun 68, p. 28.

one millionth flight hour of MAC Starlifter operations. This milestone, commemorated in ceremonies at Scott AFB, Illinois, on 18 June 1968, was accomplished during a period when the demands of the Southeast Asia Conflict's logistic movements negated much of MAC's normal training operations and exercises.[126]

Unquestionably MAC's achievements during the 1965-1968 period, especially the airlift to Southeast Asia, could not have been accomplished without the development of SOR 182.[127] In both the deployment and resupply missions the C-141's have proven themselves to be the "medium sized, fast, workhorse, general purpose cargo transport" that General William H. Tunner requested some 10 years prior to the time that ASD relinquished the C-141 management reins to WRAMA.

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126. "C-141 Hits Million Hour Mark," Release No. 26 June 24-539, MAC News Service, 24 June 1968, p. 5.
127. Specific Operational Requirement (SOR) 182 - is the C-141 development requirements, see page 7.

PART II

MANAGEMENT AND TESTING

(January 1959-June 1968)

"In today's complex times,
improvements in management are
essential in every sphere of our activity.
There will be no lessening of this
need in the future."

PART II

INTRODUCTION

(U) This premise stated by General Howell M. Estes, Jr., the Commander of the Military Airlift Command, is, of course, corollary to the current almost incomprehensible explosion in scientific and technological knowledge and practice.[1] Since the management of a program must keep abreast of developments, it is safe to surmise that the C-141 Program as we view it today (1969) is almost unidentifiable with its original course. Why then is it necessary for a historian to evaluate a program that had its genesis in a period when system management was in its infancy? The answer to this question is "How did we get there?" or, to borrow from an English Historical Writer:[2]

> History, military or otherwise should never be viewed, as it so often is, in the light of what has since happened, for this is like surveying a mountain range and its problems only from the side one has descended and forgetting the very different slopes which had to be negotiated before reaching the summit.

Hence, a study such as this assumes importance if for no other reason than it may spare some future manager the pitfalls inherent in a growing managerial program.

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1. Speech, General Howell M. Estes, Jr., USAF Worldwide Management Analysis Symposium, Bolling AFB, D.C., "A Major Commander Looks at Management Analysis," 15 Feb 66, p. 8.
2. Lifetime Speakers Encyclopedia, Vol I, quoting Arthur Bryant, p. 366.

"Different motivations
of functional managers and project
managers are in fact essential
and complementary features
of. . .management."[3]

PROGRAM MANAGEMENT

(U) Essentially the history of the MAC C-141 Management Program is one of negotiations, compromises, and resolutions which contributed to the end result of a general purpose work-horse cargo transport. But beyond this it is also the story of men and how they met the challenges and resolved the proglems in training, deficit facilities, aircraft deficiencies, airframe and subsystem evaluation and assimilation of the aircraft into the operational environment.

(U) The Starlifter Systems Program was initiated by Headquarters USAF message AFDDC-94696 to the Air Research and Development Command (ARDC),[4] which was later quoted in a Headquarters ARDC message to the Wright Air Development Division (WADD).[5] Hq USAF pointed out that the authority to initiate the C-141A program was contained in Procurement Authorization 61-AL-13 dated 16 March 1961. It further designated ARDC as the overall program manager in accordance with Air Force Regulation (AFR) 375-1. ARDC also directed WADD to implement the acquisition of the C-141, designated Colonel Mahlon B. Hammond as the System Program Director (SPD), and

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3. Integrated Logistics Support Guide for DOD Systems and Equipment, DOD (Ref DOD Directive 4100.35), 15 Oct 68, p. 3.
4. ARDC in 1961 was renamed the Air Force Systems Command (AFSC).
5. WADD in 1961 was renamed the Aeronautical Systems Division (AD) of AFSC.

stipulated that Starlifter documentation would be accomplished as a complete package as outlined in the AFR 375 series of regulations.[6]

Management Organization

(U) The broad policies of system management are delineated in AFR 375-1. The first of the 375-1 regulations to guide the C-141 program was dated 23 January 1961; however, approximately 11 months after the initiation of the program, this regulation was superseded by a revised AFR 375-1.[7] By a 25 November 1963 revision the regulation was updated again and as of February 1969 remained the basic weapon system management guide.[8]

(U) AFR 375-1 is based on the one manager concept, that is, ". . .one manager and one control."[9] This concept, as illustrated in Chart I, superimposes the top management echelons over functional agencies, drawing contributions from them. System Manager functions include overall planning, organization, direction, control, and the coordination of all of the activities generated by a system program.

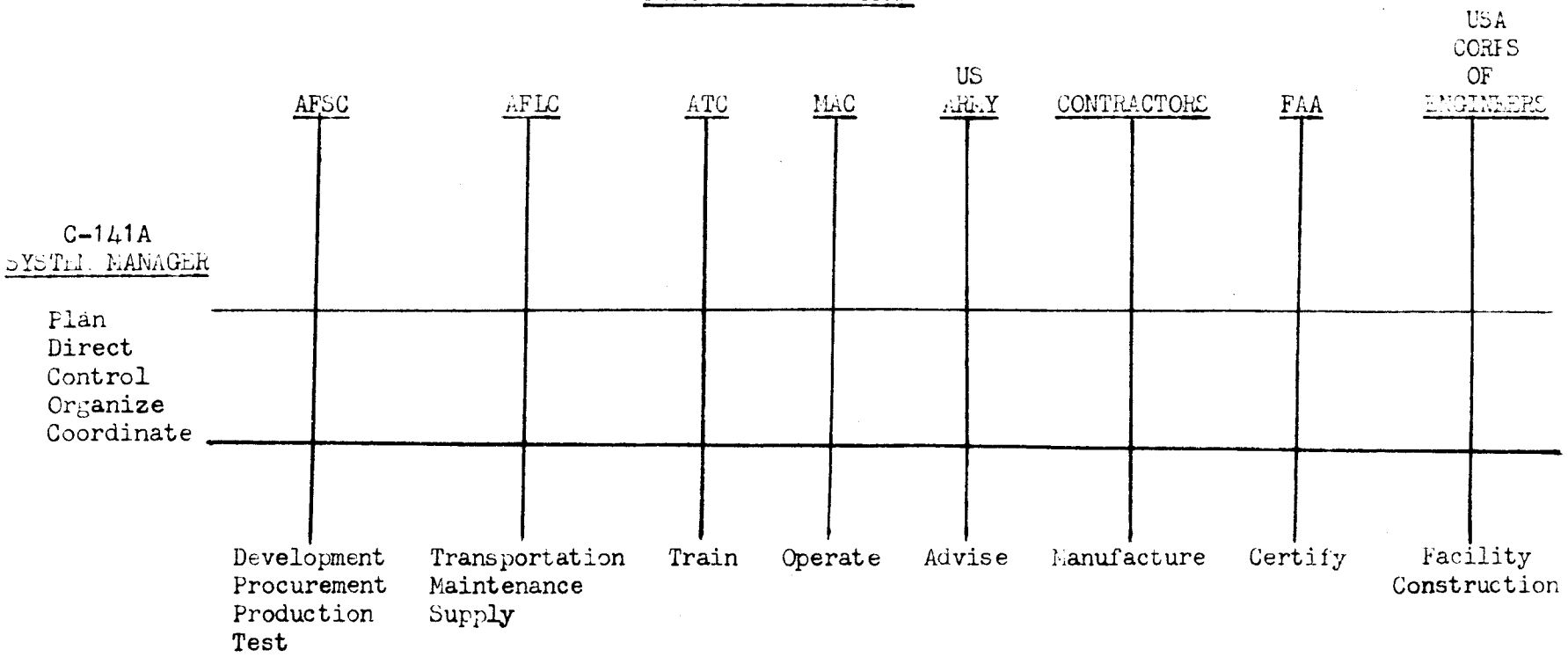
While AFR 375-1 management affirms the one manager concept, it also eliminates the rigidity inherent in a single manager. Inflexibility is alleviated by the transition of the single management from one USAF organization to another, and through the delegation of specific authorities

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6. Msg, RDRAS 2135, Hq ARDC to WADD, subj: Hq USAF Msg AFDDC-94696, 21 Mar 61, p. 13-11 of System Package Program, AFSC, subj: C-141A Cargo Transport - System 476L, Nov 61, as revised Jun 67. (SECRET, material used unclassified)(subsequently cited as C-141 SPP), SD II-1.
7. AFR 375-1, "Systems Management - Management of System Programs," 12 Feb 62, SD II-2.
8. Ibid., 25 Nov 63, SD II-3.
9. C-141 SPP, p. 3-3.

CHART I

ONE MANAGER CONCEPT



as the system passes from one life cycle phase to another. This basic organization remained until 17 June 1966, when revised AFR 57-1[10] modified the structure somewhat. Prior to that date, as illustrated in Chart II, a major air command cited the need for new or improved capabilities by submitting a Qualitative Operational Requirement (QOR) to Headquarters USAF. This document initiated the Conceptual Phase of Weapons System Management. During this initial phase, the single manager was the Headquarters USAF Deputy Chief of Staff, Operations (DCS/O). The phase was terminated with the publication of a Specific Operational Requirement (SOR) by Headquarters USAF. With the move into the second phase, the Acquisition Phase, single managership was invested in the Headquarters USAF DCS Systems and Logistics (DCS/S&L) for Air Staff matters while in the field the Air Force Systems Command (AFSC) System Project Office (SPO) became the functional manager.[11] When the system passed into the Operational Phase, the manager for Air Staff matters became the Headquarters USAF DCS/O, and the Air Force Logistics Command (AFLC) delegated functional management to a Support System Manager (SSM).[12]

(U) The modifications to managerial organization and procedures delineated in AFR 57-1 are illustrated in Chart III. As indicated

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10. AFR 57-1, "Operational Requirements - Policies, Responsibilities, and Procedures for Obtaining New and Improved Operational Capabilities," 17 Jun 66 (subsequently cited as AFR 57-1), SD II-4.
11. For theC-141 program the SPO was a unit of the Aeronautical Systems Division (ASD).
12. For the C-141 the SSM is a component of the Warner-Robins Air Materiel Area (WRAMA).

CHART II

ONE MANAGER CONCEPT PRIOR TO 17 JUNE 1966

DURING THE PHASE OF C-141A LIFE

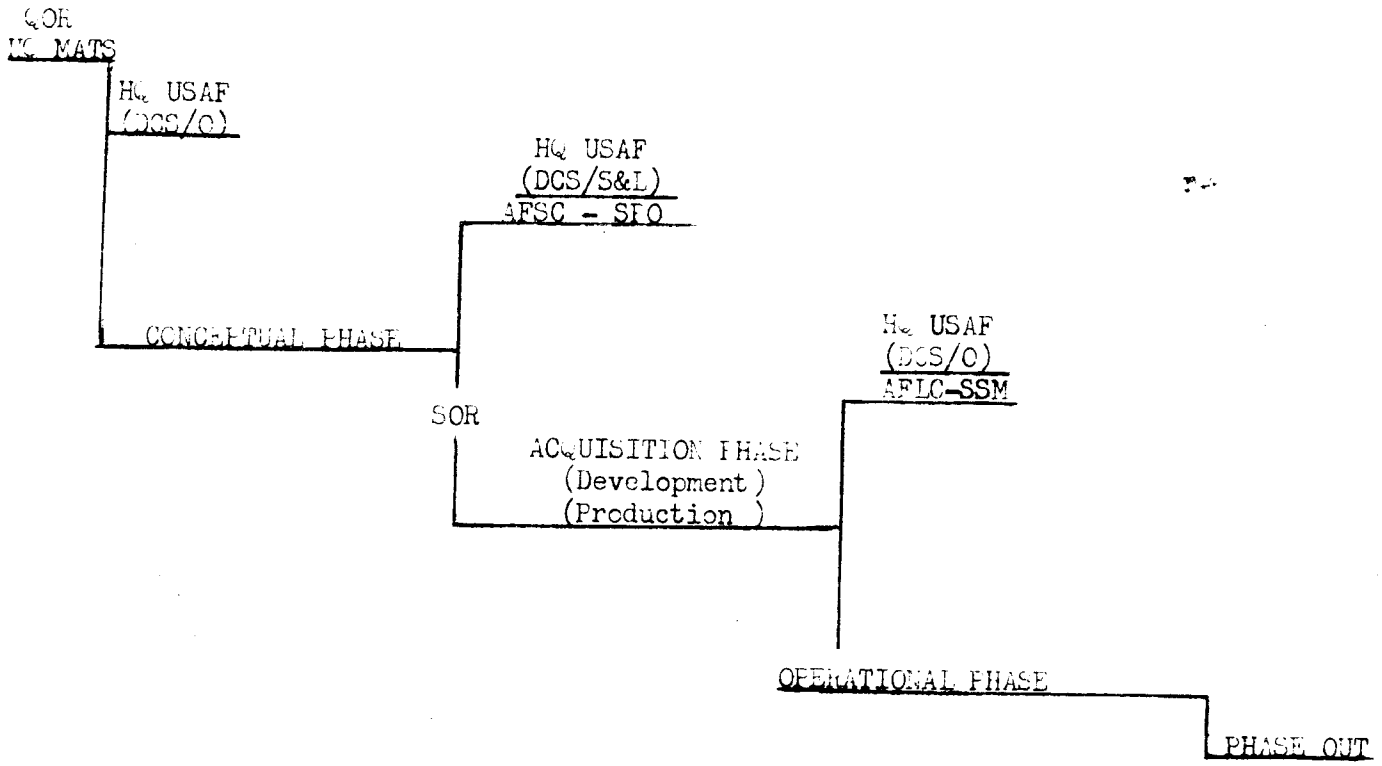
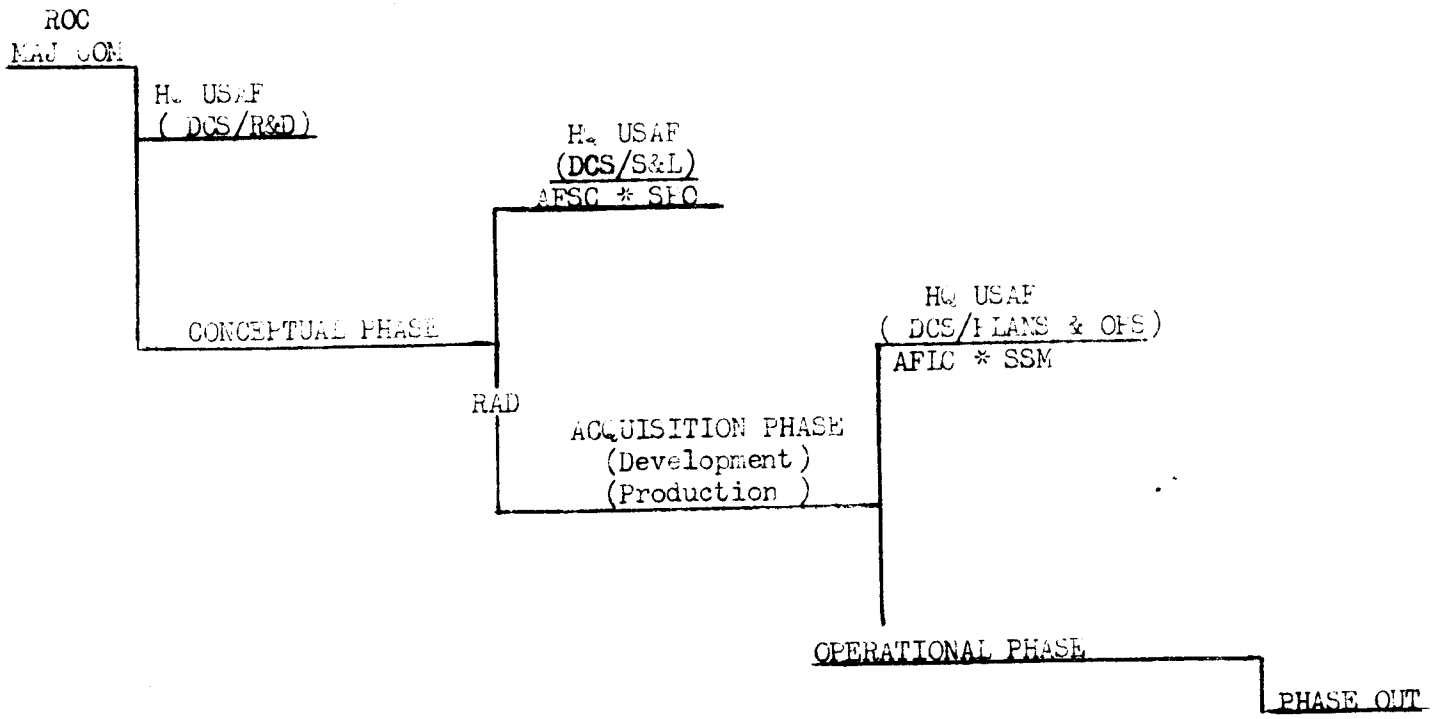


CHART III

ONE MANAGER CONCEPT AFTER 16 JUNE 1966

DURING AIRCRAFT LIFE PHASES



the QOR is replaced by a Required Operational Capability Document (ROC).

The ROC is standardized to cover the full range of answers to questions such as:[13]

I. Deficiencies/Needs

II. Required Operational Capability

III. Determination of Deficiencies/Needs and the Required Operational Capability

IV. Solutions

V. Class V Modifications (if needed)

VI. Harmonizations (suggested coordination with other commands and services in order to insure cooperation; interoperability, interface or interchangeability of equipment; and to increase the effectiveness of overall national and international logistics through greater standardization)

VII. Quantitites involved

VIII. Aircraft and Munitions/Stores Compatibility

IX. Special Comments (such as: maintainability, reliability, supportability, transportability, availability, survivability, vulnerability, crew comfort, crew safety, system safety and supporting equipment)

Another document change was the replacement of the SOR with Requirements Action Directive (RAD). The RAD, using Air Force (AF) Form 71, directs and guides:[14]

1. Studies related to the analysis of required operational capability or requirement.

2. Initiation of development of technological alternatives for future decision or for satisfying the identified requirement. (cont'd)

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13. AFR 57-1, pp. 7-8.
14. Ibid., pp. 10-11.



Operational C-141

(cont'd)

3. Submission of a Class V modification feasibility study by AFSC or AFLC.

4. Submission of proposed technical or operational solutions.

5. All requirements action leading to contract definition, except those directed by the Systems Management Directive (SMD), when appropriate.

6. Submission of preliminary technical development plans and final prerequisite studies. Normally this included the latest system or equipment characteristics and performance envelopes.

7. New aircraft and munitions and stores compatibility requirements for inventory munitions and stores and for nonproductive (in-service) aircraft when other documents, such as the Modification Requirement (MR), the System Management Directive (SMD), the Preliminary Technical Development Plan (PTDP), the System Package Program (SPP), and the Development Directive (DD) do not apply.

8. Describing and disseminating significant decisions about requirement proposal (including approval/disapproval, amalgamation, reorientation, etc.).

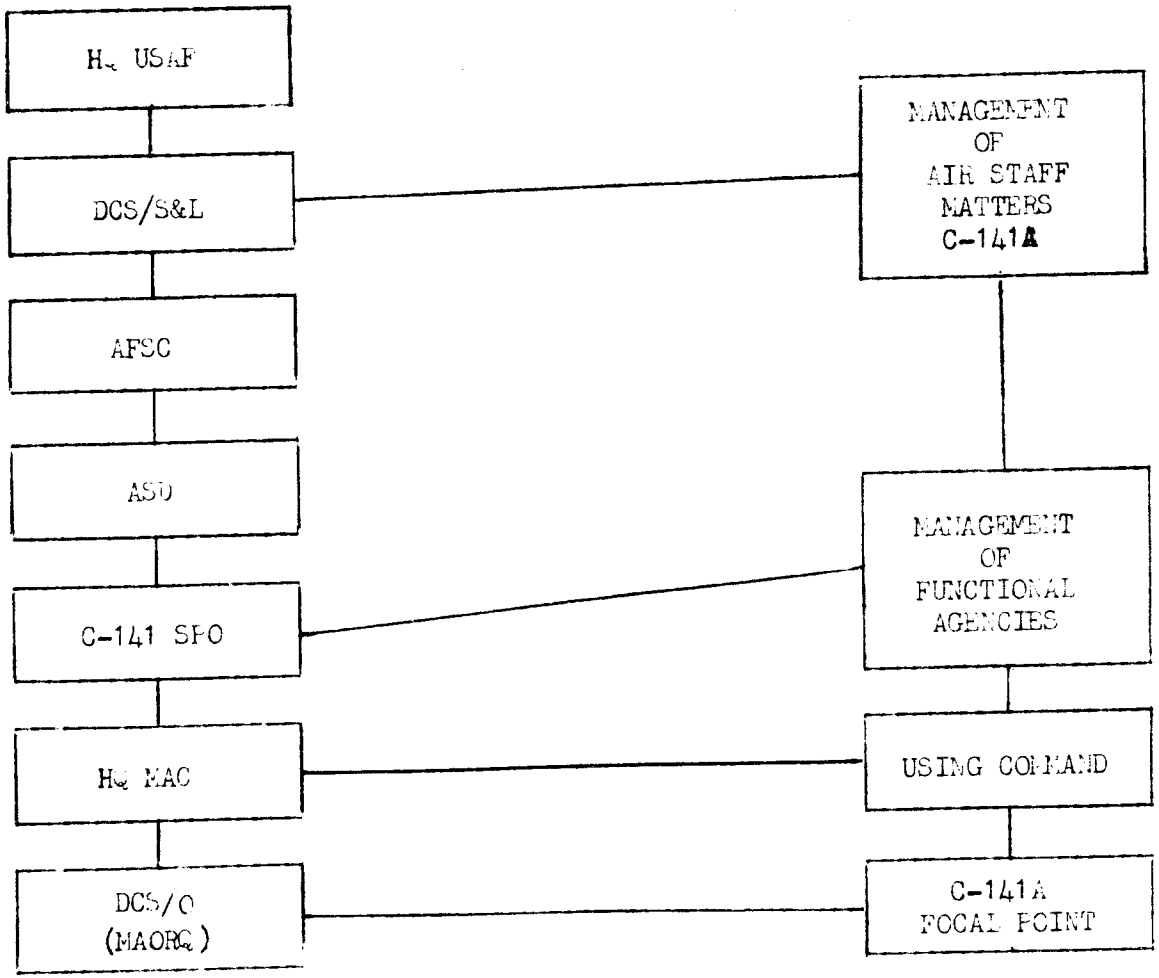
(U) Air Staff reorganization also became involved in the new managerial approach. The conceptual phase now was guided by the Headquarters USAF DCS/Requirements and Development (R&D) and, during the operational phase, overall management came from Headquarters USAF DCS/Plans and Operations.

(U) As noted in Chart IV, during the C-141 Acquisition Phase, the MAC Office of Primary Responsibility (OPR) was the Directorate of Operational Requirements (MAORQ) of the DCS/Operations. MAC Headquarters Operating Instruction (HOI) 375-1 states that the OPR's management responsibility ". . .spans the conceptual, definition, and acquisition phases of system development and that part of the operational phase which includes the processing of Class V modifications and the administration of testing. . . of operational systems in the operational environment to determine system

CHART IV

C-141 MANAGEMENT

ACQUISITION PHASE



reliability, capability and/or tactics."[15] During this phase of system life, MAORQ was one of the functional agencies responsive to the C-141 SPO, a constituted office of the Aeronautical Systems Division (ASD).

(U) During the operational phase, the focal point for the weapon system shifted at Headquarters MAC to the Directorate of Maintenance Engineering (MAMME) of the Headquarters MAC DCS/Materiel (MAMDC). Its major guidelines are AFR 57-1 and HOI 57-1[16] and 57-1A.[17] At the major command level maintenance-engineering is charged with the responsibility to "Modify existing or in-production systems or equipment,"[18] as a functional agency supervised by the System Support Manager (SSM) of AFLC. This is opposed to the requirement to "Develop and acquire new systems and equipment,"[19] which is partially the function of the SPO and, at the functional agency level, MAORQ. As noted in Chart V, the SSM for the C-141 is a component of the Warner-Robins Air Materiel Area (WRAMA).

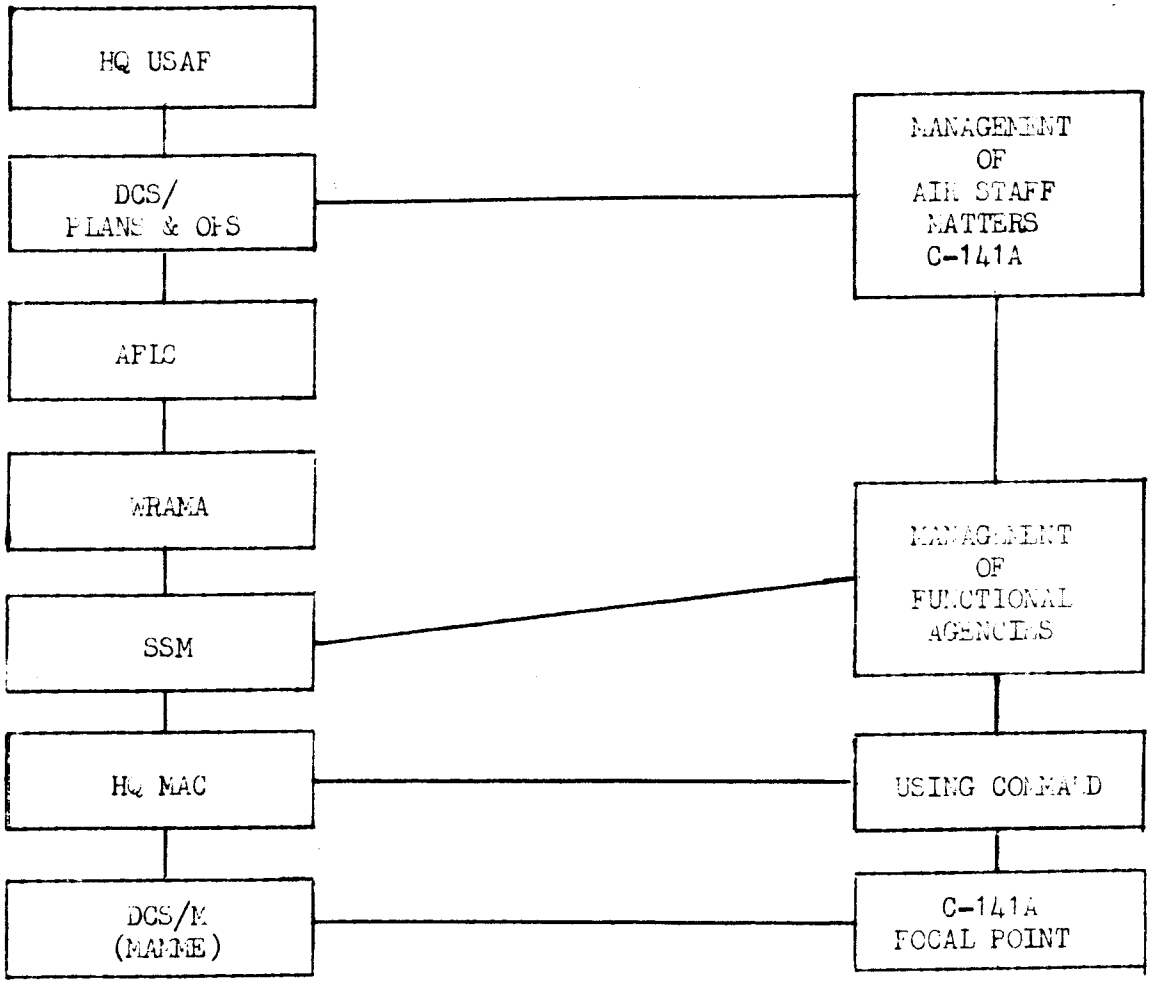
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15. HOI 375-1, Hq MAC, "System Management - Management of System Programs," 2 Jun 67, p. 1 (subsequently cited as HOI 375-1), SD II-5.
16. HOI 57-1, MATS, "Operational Requirements - Modification of Systems and Equipment," 27 Jul 65, (subsequently cited as HOI 57-1), SD II-6.
17. HOI 57-1A, MAC, "Operational Requirements - Modification/Modernization of Systems and Equipment," 5 Jul 66 (subsequently cited as HOI 57-1A), SD II-7.
18. AFR 57-1, p. 2.
19. Ibid.

CHART V

C-141 MANAGEMENT

OPERATIONAL PHASE



> "Future programming for MATS is aimed primarily at fulfilling logistic support requirements in the event of general war, a situation involving the highest possible speeds and extreme ranges. The possibility of general war cannot by any means be overlooked; however, international events of the past decade indicate that a limited war or a series of tense situations bordering on limited war are likely to continue. These challenges which occur at any moment in any part of the world, in isolated areas under extreme climatic and geographical conditions, must be met."

THE CONCEPTUAL PHASE

(U) So the Qualitative Operational Requirement (QOR) for the logistic aircraft support system stated the USAF requirement for the aircraft which became the C-141.[20] The QOR went on to say that the:[21]

> "Present designs of large, high-speed, long range intercontinental aircraft will not afford the flexibility of operation necessary. This equipment must be available to handle general war requirements, but the world-wide short-field and terrain difficulties would seriously limit its value in limited war."

In answer to the Headquarters MATS QOR, Headquarters USAF stated that the QOR was welcome because that headquarters was preparing a General Operational Requirement (GOR) for a very large long range transport and the MATS QOR provided an alternative.[22] Due in part to Lieutenant General William H.

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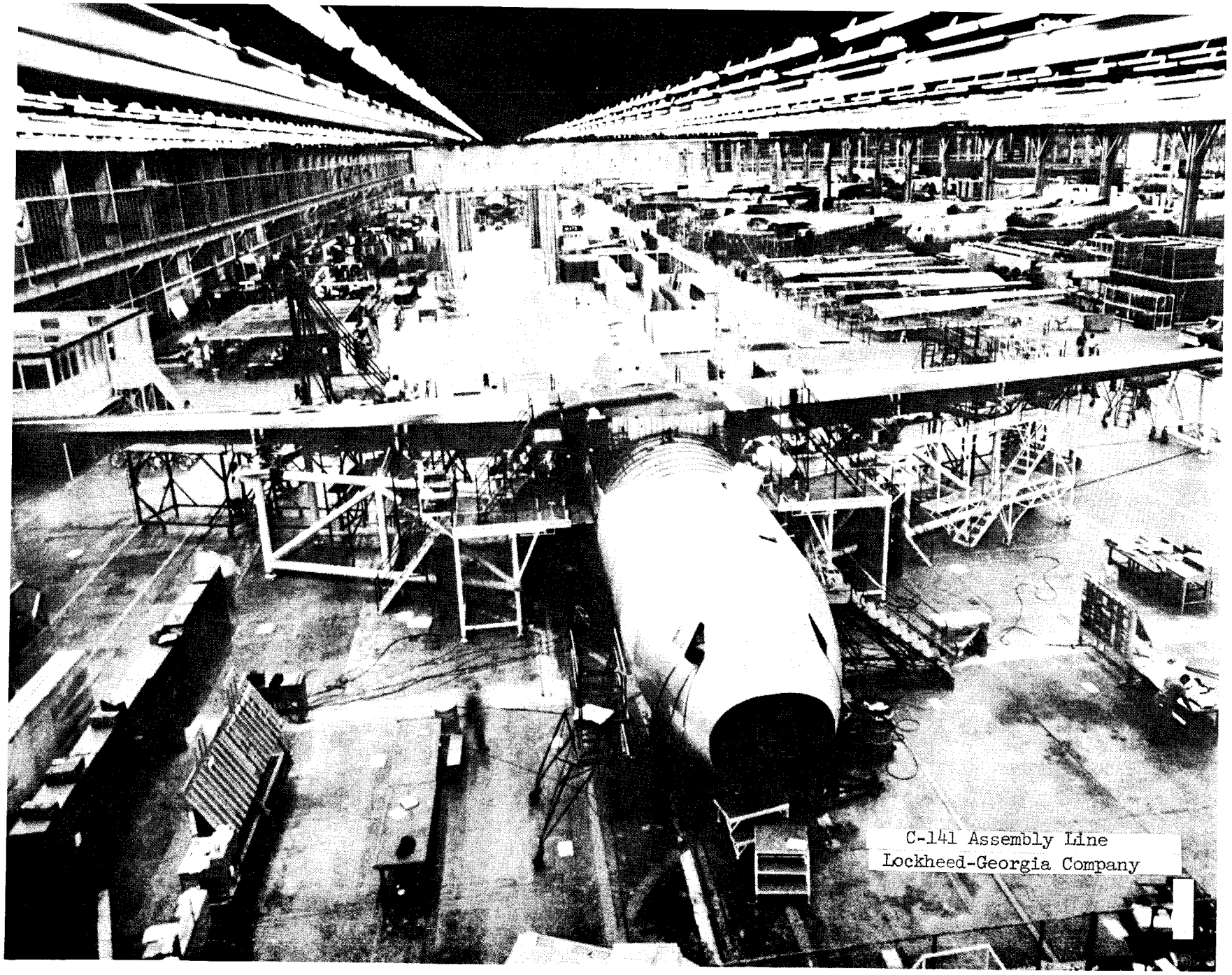
20. Ltr, MAORD to Director of Requirements - Hq USAF, subj: Qualitative Operational Requirement for Logistic Aircraft Support System, 16 Feb 59, p. 2 (subsequently cited as C-141 QOR), SD I-2 to Hist, MAC, Jul 67-Jun 68, I, (Study, MAFOIH, subj: C-141 Starlifter, Jan 59-Jun 68, I, (subsequently cited as C-141 Study, I).
21. Ibid.
22. Ltr, AFDRQ to Commander MATS, subj: Qualitative Operational Requirement for Logistic Aircraft Support System, 5 Mar 59, SD I-3, to C-141 Study, I.

Tunner's (MATS Commander, 1 July 1958-31 May 1960) recommendation, Headquarters USAF decided that the MATS position, that of the need for a medium transport, was the best choice and began preparing a General Operational Requirement (GOR) for such an aircraft.[23] By 1 December the Headquarters USAF Director of Requirements dispatched a draft Specific Operational Requirement (SOR) for a medium cargo transport to Headquarters MATS for comments and by 4 May 1960 the official SOR 182 for a "Cargo Transport Aircraft Support System" was published.[24]

(U) MATS participation in the C-141 Program did not stop with the development of the QOR. In fact, the command coordinated on the SOR, and General Tunner and members of his staff twice appeared before the Rivers Committee in order to establish the MATS' need. Also the spectacular success/failure of Operation "Big Slam/Puerto Pine," which coincided with the hearings, backed up the findings of the Rivers Committee.[25] Events moved rapidly after the 22 April 1960 close of the Rivers Committee hearings. On 4 May, SOR 182 was published and on 1 July Public Law 86-601, which provided funds for the C-141 development, was enacted by Congress.

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23. For details, see pp. 7-12, C-141 Study, I.
24. SD I-1, C-141 Study, I.
25. For details see pp. 9-24, C-141 Study, I.



C-141 Assembly Line
Lockheed-Georgia Company

"In order to provide your command
with the best possible results in terms
of qualitative systems in the most timely manner,
it is mandatory that all participants involved
in systems acquisition work together
as a team beginning with the
early operational phases
of each program."

ACQUISITION PHASE

(U) Certainly the above mentioned teamwork called for by General Schriever[26] was a hallmark of both the Acquisition and Operational Phases of the C-141 Life Cycle. In the latter part of June 1960, WADD initiated the C-141 Acquisition Phase by beginning work on the SOR 182 Development Plan. Coincident with the WADD action, Headquarters MATS, on 30 June 1960, established a rudimentary management organization by the establishment of the "Cargo Aircraft Development Panel." This panel, which was chaired by the Chief of the Requirements and Development Division of the Headquarters DCS/Operations, was first established to follow SOR 182 progress. "The committee members were to be involved in many staff actions to see that MATS got the best aircraft possible. . . ."[27] This panel, which later grew into the C-141 Development Panel did not assume, however, the

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26. Ltr, Lt Gen B. A. Schriever (Commander ARDC) to MATS (Lt Gen J. W. Kelly), subj: Weapon System Management Under Regulations 375-1, -2, and -3, 10 Oct 60, SD II-8.
27. Hist, MATS, 1 Jan-30 Jun 61, I, pp. 249-250.

position of the MATS Requirements and Development Division (R&D) of the DCS/Operations which, following AFR 375 series regulations, was made ". . .responsible for the overall project. . ."[28] about the same time.

(U) Later, a sequence of letters between the Air Research and Development Command (ARDC) and Headquarters MATS officially established the R and D Division as the MATS focal point for weapon systems development.[29] On 10 October 1960 Lieutenant General Joe W. Kelly[30] (MATS Commander, 1 June 1960-18 July 1964) received a letter from Lieutenant General Bernard A. Schriever[31] requesting that Headquarters MATS establish a single point of contact for new system acquisition.[32] In an answering letter General Kelly advised ARDC that the R and D Division of the Headquarters MATS DCS/Operations would be the focal point for new system development.[33] Also during the latter months of 1960, Air Force attempted to clarify AFR 375 series management through a series of letters to the major air commands. MATS disseminated these letters and a series of questions and answers to the Headquarters Staff and subordinate commands in order to familiarize key personnel with the provisions of the regulations.[34]

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28. Ibid.
29. These ARDC letters were for all major commands.
30. Became General, 6 June 1963.
31. He became a General on 6 June 1963.
32. Ltr, Lt Gen B. A. Schriever (ARDC) to MATS (Lt Gen J. W. Kelly), subj: Weapon System Management Under Regulations 375-1, -2, and -3, 10 Oct 60.
33. Ltr, Lt Gen Joe W. Kelly to Lt Gen B. A. Schriever, subj: Weapon System Management Under Air Force Regulation 375-1, -2, and -3, 21 Oct 60, SD II-9.
34. Key Questions and Answers on the 375 Series AFR, undated (circa Dec 60), SD II-10.

(U) Meanwhile WADD of the Aeronautical Systems Center (ASC) prepared by 10 August 1960 a cargo aircraft development plan, and five days later published SOR 182-1.[35] By 23 November, Development Directive 415[37] was issued by USAF and five days later, on 28 November, Headquarters USAF directed that the source selection procedures should begin. On 19 December Amendment Number 415-1 to the Development Directive[38] was issued, and, on 21 December a Statement of Work was prepared and a Request for Proposal (RFP) was forwarded to the eligible contractors: Boeing, Douglas, Convair, and Lockheed. A contractor's query meeting was held with the eligible contractors to close out the eventful conception year on 30 December 1960.[39]

(U) During the final month of 1960, Major General J. R. Holzapple, Chairman of the SOR 182 Source Selection Board, requested that General Kelly furnish the WADD Source Selection Board Recorder with the names of four senior board members and four alternates from MATS.[40] One of the board members was appointed to an Ad Hoc Committee, formed by ARDC, which was charged with the preparation of working papers for the Source Selection

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35. C-141 Study, I, p. 62.
36. SD I-7 of C-141 Study, I.
37. SD I-9 of C-141 Study, I.
38. SD I-10 of C-141 Study, I.
39. C-141 Study, I, p. 62.
40. Senior Board members selected from the MATS Staff were: Maj Gen Glen R. Birchard; Col Tracy J. Peterson; Col Hugh E. Wild; and Col Gilbert L. Curtis. Alternates selected were: Col Lionel F. Johnson; Col Ward E. Cory; Col Roland J. Barnick; and Col Lenard Sherman.

Board.[41] This committee was chaired by Mr. J. A. Boykin, who was the WADD Technical Advisor; the MATS member was Colonel Hugh E. Wild.[42]

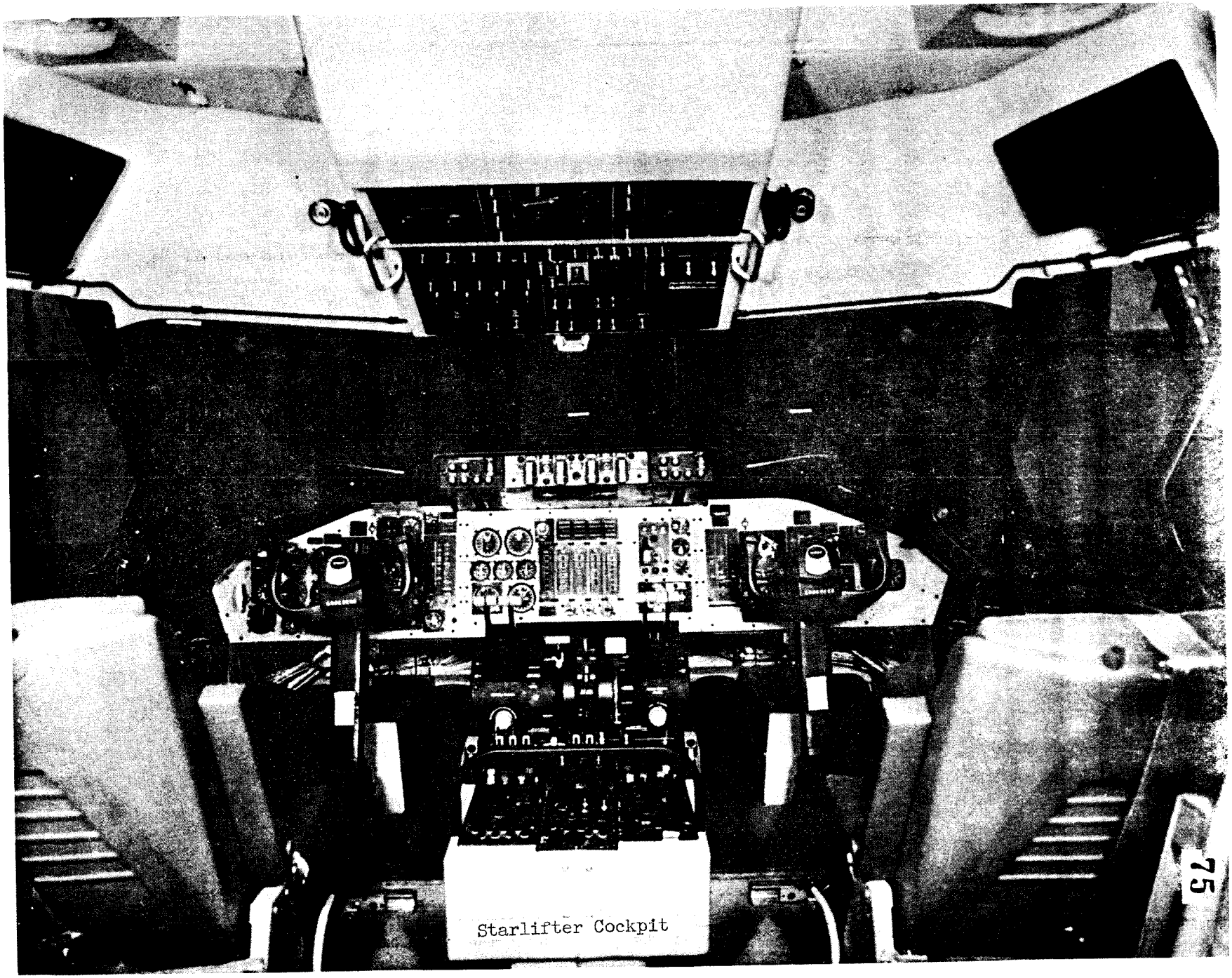
(U) The primary objective of the source selection board is and was ". . .the impartial, equitable, and comprehensive evaluation of competitors and their proposals to insure selection of that source which will provide optimum satisfaction of the Government's basic objectives. . . ."[43] After the organization of the Source Selection Board in December 1960, the contractors were asked to submit their proposals by 27 December 1960.[44] One month later on 31 January 1961 the contractors made their oral presentations to the Air Force.[45] During the January-March 1961 period, the Source Selection Board studied the proposals and on 9 March 1961 submitted its report to the Air Council. These actions culminated in the announcement that the Lockheed Aircraft Company's proposal Number ETP 250, Model Number GL-207-45 "Super Hercules" was the SOR design competition winner.[46]

System Project Office (SPO)

(U) Although the source selection had been completed, the appointment of Colonel Mahlon B. Hammond[47] as the C-141 SPD and authorization for the SPO did not come until 21 March 1961.[48] Losing no time, WADD directed the

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41. Hist, MATS, 1 Jan-30 Jun 61, I, pp. 250-252. (SECRET, material used Unclassified).
42. Telecon, Interview, Walter L. Kraus, MAFOIH (subsequently cited as WLK) with Mr. J. A. Boykin, Hq ASD, 5 Mar 69.
43. AFR 70-15, "Proposal Evaluation and Source Selection Procedures," 17 May 68 (subsequently cited as AFR 70-15), SD II-11.
44. Hist, MATS, 1 Jan-30 Jun 61, I, p. 252 (SECRET, material used Unclassified).
45. C-141 Study, I, p. 62.
46. Ibid., p. 24.
47. Col M. B. Hammond headed the Evaluation Group of the Source Selection Board prior to being appointed the SPD. Ltr, Mahlon B. Hammond to W. L. Kraus, 9 Feb 69, WLK personal files.
48. For details, see pp. 2-3, this volume.



Starlifter Cockpit

establishment of the SPO on the following day through its Operations Order Number 1-61. The operations order also delineated the mission of the SPO and set its manning requirements.[49] The SPO's mission was and is that of ". . .the only overall field systems management organization during the Definition and Acquisition Phases of a system life cycle. . . ."[50] It is charged with the responsibility of providing a focal point for planning, guidance, and instructions to the functional agencies. It also has several specific duties, including the overall coordination of management actions, program progress evaluation, recommendation of program changes, and the maintenance of permanent records.[51] The SPD was and is:[52]

> ". . .a field manager with authority to speak for the Air Force, within the confines of the approved system program. Participating field organizations will look to him as the one individual responsible for determining how the actions of all organizations should fit together. When consistent with the approved system program his decisions are directive and may not be changed by any organization participating in the system program except Hq USAF. . . ."

(U) Aware, as noted above, that the AFR 375 series would be applicable to the C-141 program, Headquarters MATS initiated command support of the still embryonic SPO on 6 January 1961. On that date, Brigadier General James C. Sherrill, the MATS Chief of Staff, distributed a memorandum among

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49. C-141 Study, I, p. 62.
50. AFR 375-2, "Systems Management - System Program Office (SPO)," 25 Nov 63, SD II-12.
51. Ibid.
52. AFR 375-3, "Systems Management - System Program Director (SPD)," 25 Nov 63, SD II-13.

the MATS staff agencies. This correspondence was designed to alert the staff to the pending C-141 management structure and command responsibilities in the program. The Chief of Staff, in his memorandum, reiterated that MATS had been designated the primary using command for System 476L (SOR 182) and as such it would have to provide representatives to the SPO. The memorandum further stated that while it was not known ". . .how many MATS representatives will be required to properly administer the Using Command activities in the Systems Program Office. . . only the most qualified personnel. . .were to be. . .selected and assigned. . . ."[53] The Chief of Staff also stated that the Requirements and Development Division of DCS/Operations (DCS/O/R&D) had already been designated the C-141 single point of contact in the Headquarters and that it would have the management responsibility during the development and operational testing phases of program life. He then directed that each staff agency establish a contact point in its organization and advise DCS/O/R&D of the individual's name, rank and telephone number.[54] Lastly, General Sherrill emphasized that:

> "This is the first opportunity afforded MATS to participate in the entire development of a Strategic Airlift System. It is incumbant upon us to insure the program is efficiently managed within this Headquarters, so that the end result will be the most effective Support System. . . ."

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53. Memo, MACCS, to MATS Staff, subj: Headquarters MATS Implementation of AFR 375-1, 2, and 3, 6 Jan 61, SD II-14.
54. Ibid.

(U) This embryonic organization set the basis for the MATS management structure until it was formalized through the 9 June 1961 Headquarters Operating Instruction (HOI) 375-1. This HOI officially established DCS/O/R&D as the office to which all other Headquarters Staff Agency C-141 efforts were responsible. It further designated the following responsibilities for other agencies:[55]

1. DCS/Materiel - Reliability Program for Weapon Support and Command and Control Systems
2. DCS/Plans - manning authorizations for MATS SPO representatives
3. DCS/Personnel - staffing of the MATS SPO contingent
4. DCS/Comptroller - budget for MATS program participation

(U) Shortly after the publication of the HOI a C-141 Development Panel was formed. Its members were those officers who had been previously designated under the provisions of the HOI. The purpose of the panel was to provide a means of coordinating the command's inputs to the C-141 Development Program. In a DCS/O memorandum informing the MATS Staff of the panel's existence and the identification of the original members, the staff was also directed to submit to DCS/O/R&D all copies of correspondence, trip reports, and memorandums for record pertaining to C-141 development.[56] On 16 August the C-141 Development Panel membership was revised by the addition of some new members.[57] Of course, as necessary, most of the MATS Staff agencies became involved in C-141 actions.

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55. HOI 375-1, Hq MATS, "Systems Management - Weapon, Support Systems Management," 9 Jun 61, SD II-15.
56. Memo (Quickom), DCS/O/R&D to DOI/PPD, subj: C-141 Development Panel, 24 Jul 61, w/1 atch, List of C-141 Development Panel, SD II-16.
57. List, Hq MATS, subj: C-141 Development Panel, 16 Aug 61, SD II-17.

(U) In November 1961, AFSC issued the first C-141A System Package Program which formalized the various management organizations.[58] As noted in Chart VI,[59] the MATS C-141 Development Panel was directly responsible to DCS/O/R&D.* In addition, Detachment 42, stationed at the Air Force Flight Test Center (AFFTC) at Edwards AFB, California, and Detachment 18 stationed at the SPO at Wright-Patterson AFB, Ohio, also reported directly to MAORD. This structure did not change throughout the Acquisition Phase of the Program.[60]

Program Documentation

(U) One of the primary tasks of the C-141 SPO and the functional managers was the development of System Program Documentation. During the Acquisition Phase, AFSC was charged with the development of the System Package Program (SPP). That command first prepared a Proposed System Package Plan (PSPP), which had to be ". . .suitably definitive in terms of System description, cost estimates, resource requirements, performance specifications, schedules, and related information for each alternative proposed to permit negotiation of incentive contracts (or fixed price, if practical) for the development portion of the Acquisition Phase. . . ."[61] This action was initiated for the C-141 Program on 10 April 1961 when the

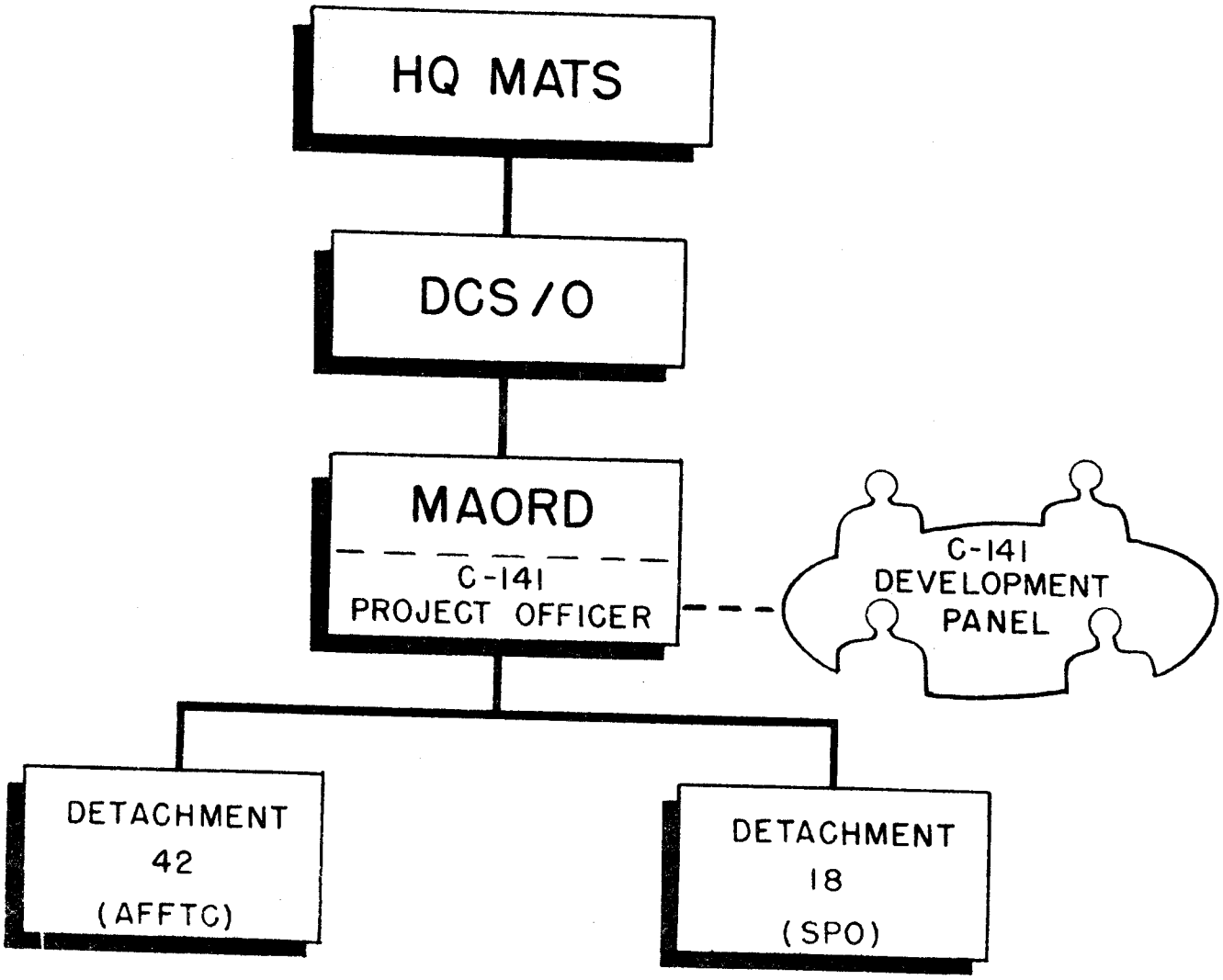
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58. For details of the initial organizations see C-141 SPP, November 1961, in MAFOIH files. For the final C-141 organizational structure see C-141 SPP, as revised June 1967. SD II-1 of this history.
59. Chart VI is p. 3-10a of C-141 SPP, Nov 1961.
    * The Requirements and Developments Division was later redesignated the Directorate of Requirements and Developments (MAORD) and still later the Directorate of Operational Requirements (MAORQ).
60. For details see C-141 SPP, June 1967, pp. 3-1 - 3-28; SD II-1 this history.
61. AFR 375-4, "Systems Management - System Program Documentation, 25 Nov 63, p. 2, SD II-18.

CHART VI

UNCLASSIFIED

3.2.2.4. The headquarters MATS organizational structure for efficiency of operations is shown below. The C-141A project officer is assigned the responsibility of chairing a development panel composed of staff members. The SPO and Test Flight detachments report to the Requirements and Developments Division to assure timely command coordination and decision. (UNCLASSIFIED)





Troop Movement

SPO issued a plan for the preparation of the SPP.[62] From this date until the final approval of the SPP by the USAF Air Council on 1 February 1962[63] the documentation remained a primary SPO task.

(U) MATS, as a functional manager, was involved in the development of the SPP right from the start. One of the first command actions was the establishment of an operations and a personnel plan for the C-141 program. A SPO letter of 10 April requested that MATS submit a personnel plan by 15 May 1961,[64] and an operations plan by 28 April.[65] The command's staffs, however, lamented that the plans could not be completed until exact specifications for the C-141 Program (number of crew positions, maintenance requirements, delivery dates, etc) were received from Headquarters USAF. MATS was not the only command that was unable to meet these original stiff schedules. Soon after the MATS Staff discussion of the tight schedules, it was learned that the Air Training Command (ATC) had slipped their project from 11-12 May to 4 August 1961.[66] Nevertheless, by 31 May 1961 the Operational Plan for the C-141 was completed and circulated throughout the various command staff agencies.[67] The plan was staffed and submitted to the SPO by 15 June,

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62. C-141 Study, I, p. 63.
63. This Air Council approval was the first ever given to an ASD-managed SPP. ASD approved the package on 11 December 61 and AFSC approved it on 4 January 62.
64. Memo for the Record, MAPPP, subj: C-141 Proposed Systems Package Program, 2 May 61, SD II-19.
65. Memo for the DCS/Personnel, MAPPP, subj: C-141 Proposed Systems Package Program, 12 May 61, SD II-20.
66. Ibid.
67. Memo for the Record, MAPPP, subj: C-141 Operational Plan, 5 Jun 61, SD II-21.

and on 13 July, Headquarters USAF approved it. This operational plan became part of the SPP and remained, with a few changes, the same basic instrument throughout the program.[68] A very concise mission statement was the crux of the plan. It was often separated from the SSP and received wide dissemination;[69] in part, it delcared that the C-141 mission was:

> ". . .to provide long-range airlift capability in support of Department of Defense world-wide airlift requirements, to include the global airlift of cargo, troops, military equipment, the aerial delivery of cargo, the paradrop of troops and equipment, and the evacuation of patients;
>
> Aircraft will be employed on a world-wide basis to provide airlift for DOD combat forces in connection with war readiness training, cold war, contingency, limited war and general requirements in accordance with the priorities established by the Joint Chiefs of Staff. . . ."

(U) The Personnel Plan, however, required more time and hence was not submitted to the SPO until 6 September 1961.[70] In fact, as late as 4 August the MATS Staff had not received the personnel requirements guidance. This stymied the command because AFR 375-4 specified that the requirements ". . .depended upon guidance from AFSC, AFLC, Hq USAF and ATC. . . ."[71] By

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68. For a comparison of the changes see C-141 SPP, Nov 61, and C-141 SPP, as revised Jun 67 (See fn 6)
69. Msg, 142152, Asst Dir Information - MATS, to Mr. Lee Rogers - Lockheed Acft Corp, subj: Official MATS Mission Statement for the C-141, 14 Dec 61, hist, MATS, 1 Jan-30 Jun 61, IV, SD VI-6.
70. Ltr, MAPPP to Mr. Gentit - C-141 SPO, subj: C-141 Aircraft Personnel Support Plan (Proposed)(U), 6 Sep 61, SD II-22.
71. Memo, DCS/P/PPD to DCS/O/R&D, subj: Status of C-141 Package Program, 4 Aug 61, SD II-23.

14 August the Staff was able to establish the responsible offices for the personnel input to PSPP.[72] They were as follows:

Requirement	Responsible Agency
Personnel Planning Data	Manpower and Organization
Time Phased Total Personnel Requirements	Manpower and Organization
Trained Personnel Requirements (Individual Training)	Utilization and Training Division
Trained Personnel Requirements (ORT, Crew and Unit)	Officers Division
Typical Unit Manning Document	Manpower and Organization
Typical Organizational Charts Schedule	Manpower and Organization Personnel Plans Division Requirements and Development Division

The information that these offices developed was also incorporated into the Qualitative, Quantitative Personnel Requirements Information (QQPRI), which was approved by the SPO, in part, on 28 June 1962.[73]

(U) While the command was engaged in the various C-141 actions, it also was establishing its representation on the SPO. MATS, as the C-141 using command and a functional agency of the program, had a vital interest in the daily activities of the major C-141 focal point. The responsibilities for this representation were also established by the SPP. These MATS/MAC

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72. Memo for Record, MAPPP, subj: C-141 Package Program, 14 Aug 61, SD II-24.
73. Hist, C-141 System Program Office -- ASD, Wright-Patterson AFB, subj: System Program History (subsequently cited as C-141 System Hist), Aug 65, p. A-10, SD II-25.

representatives to the C-141 SPO had very important positions being responsible to both the operational using command and to the C-141 Program. Basically, their overall responsibilities were identified in 1961 as:[74]

> "With the assistance of the C-141A System Program Director (SPD), the MATS representative maintains cognizance of activities which are directly related to the design, development, test, production, performance, reliability, maintainability, and training for the C-141A including its components and advises the SPD and MATS Headquarters of any reprogramming actions relating to areas of MATS interest. Within policies and directives of MATS, he participates in SPO activities and is responsive to the SPD."

In addition, the resident representation to the SPO assured ". . .that the C-141A System receives continuous MATS attention during the acquisition phase. All correspondence between the SPO and MATS will be forwarded through the MATS representative."[75] These responsibilities did not change throughout the acquisition phase of the Program.[76]

MATS/MAC C-141 Documentation

(U) MATS too needed guidelines for the C-141 Program. The SPP, it must be understood, was the AFSC published overall program document. Therefore, because of its general requirements, MATS found it necessary to develop a programming plan for its own use. Initially, the operational plans fitted this niche, but, as the time for command acceptance of the weapon

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74. C-141 SPP, Nov 61, p. 3-10 (SECRET, material used unclassified).
75. Ibid., (SECRET, material used unclassified).
76. C-141 SPP, as revised Jun 67, p. 3-10 (SECRET, material used unclassified).

system drew near, MATS needed a more detailed programming plan in order to more efficiently transition the aircraft into service. With the impending initiation of aircrew transitional training for the Starlifter in October 1964[77] and the programmed C-141 entry into operational squadron service in April 1965,[78] the early months of 1964 were not premature for publication of such a guide.

(U) The initial MATS C-141 Programming Plan was issued on 15 April 1964 and superseded MATS C-141 Operations Plan of 15 October 1963. This document contained planning and programming information for the subjects noted below:[79]

I. Basic Plan

II. Training Requirements

a. C-141 Test Program

b. C-141 Pilot/FET Training Requirements and Output

c. C-141 Flight Simulator Equipping and C-141 MTD Schedules

III. Production and Allocation Schedule

IV. Conversion and Capability Phasing Schedule

V. Channels of Command and Communication

VI. Logistics

a. Supply

b. Maintenance

c. Civil Engineering

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77. The Transitional Unit (TTU) - the 1707 Air Transport Wing (ATW) - which on 8 Jan 66 became the 443 Military Airlift Wing (MAW), received its first two C-141s on 19 Oct 64.
78. The Starlifter entered squadron service with the 1501 ATW (on 8 Jan 66 it became the 60 MAW) on 23 April 65.
79. Programming Plan, MAXDC, subj: MATS C-141 Programming Plan, 15 April 64, SD II-5, hist, MATS, 1 Jan-30 Jun 64, Vol VI (SECRET, material used unclassified).

This initial plan was soon superseded by the more detailed MAC C-141 Programming Plan of 15 June 1966. This latter document differed from the former plan by an amplification of subjects and through a more detailed approach.[80] It contained the following:

I. Basic Plan

II. C-141 Concept of Operations

III. C-141 Production and Conversion Schedule

IV. Operations

- A. C-141 Training Requirements
  - a. C-141 Pilot/FET Training Requirements and Output
  - b. C-141 Flight Simulator Equipping Schedule/C-141 FTD Schedule
- B. Flight Test Program
- C. Operational Capabilities
- D. C-141 Conversion and Capability Phasing Schedule

V. Communications

VI. Logistics

- A. Supply
  - a. Supply and Equipment
- B. Maintenance
- C. Transportation

VII. Personnel

VIII. Safety

(cont'd)

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80. Programming Plan, Hq MAC, subj: C-141 Programming Plan, 15 Jun 66 (subsequently cited as C-141 Program) (SECRET, material used unclassified), SD II-26.

IX. Program Management, Control and Evaluation

X. Civil Engineering

A. Real Property Facility Requirements

B. Factors Affecting Real Property Facility Requirements

a. General Arrangement

b. Minimum Ground Clearances

c. Turning Radius

d. Permanent Runway Requirements

e. Footprint Geometry

f. Operation from Metal Mats

g. Power Plant Exhaust Danger Areas

h. External Noise Levels

(U) The relatively smooth transition of the turbofan transport into MATS/MAC transitional training and squadron service is due in a large measure to the detailed approach of the programming plans. However, one other ingredient was applied to enhance program management capability. This ingredient was a management tool which enabled managers to easily ascertain project status, as well as overall program status. The tool was at once a document and an aid to project/program evaluation and review technique.

(U) Program Evaluation and Review Technique (PERT), a form of logic diagramming, was the name of this tool. It was a system which combined field inputs, a computer, and a visual display. The function of the network and its printed documents was to allow managers to be cognizant of the progress of C-141 events and projects in detail and hence enabled them to realistically schedule future events or, if necessary, to reschedule objectives not met.

Perhaps the greatest benefit of such a system is that it keeps key personnel aware of problems or pending problems, thereby allowing them to take the necessary actions or apply the necessary resources to alleviate difficulties before the project or program becomes bogged down.

(U) In November 1960 Colonel Hammond (the SPD) directed that a requirement for PERT be inserted in the Requests for Proposal (RFP) to the eligible contractors.[81] While this relatively new technique had proven itself in other areas, it had not, as yet, been used in an aircraft management program. This employment of the management technique soon justified Colonel Hammond's belief in it.[82] In fact, it has been said of the C-141 Program that:

> "Successful application of PERT on the C-141A program is significant from a program management standpoint. This was the first truly integrated program effort, under the System Package Program Concept, to employ PERT from the proposal stage through the delivery of hardware. It was deliberately planned for and implemented, and information from PERT analysis was effectively used by top management. Because total program impact was the primary use of the PERT system, the SPO never got bogged down in unrelated details."

(U) The success of PERT at the SPO level encouraged its use by MATS. On 27 October 1964, the command staff made the decision to implement PERT in the C-141 Conversion Program.[83] MATS personnel were familiar with the applications of PERT because they had worked with the technique since February 1963 as representatives to the SPO and through command inputs to the SPO network.[84]

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81. Maj Hans H. Driessnack, USAF, "How PERT Paid Its Way In The C-141A Starlifter Program," Armed Forces Management - In the NewsClips - MATS DOI, Vol 7, No. 8, 19 Feb 65, pp. 1-2, SD II-27.
82. Ibid., p. 2.
83. Hist, MATS, 1 Jul 64-30 Jun 65, I, p. 162.
84. A MATS PERT team became part of the Development Panel in February 1963. This team developed and kept current the MATS Networks for personnel, training, facilities, and AGE/Spares under SPO direction.

(U) A short time after the implementation decision, Headquarters MATS conducted a PERT Workshop (19-20 November 1964) at Scott AFB, with representatives from the Eastern Transport Air Force (EASTAF),[85] Western Transport Air Force (WESTAF),[86] Air Training Command (ATC), AFSC, and AFLC attending. The objective of this workshop was to develop and construct a PERT Network for the first MATS squadron that was to convert to C-141's. This preliminary network was later refined and served as a general model for other squadron conversions.[87]

(U) The plan that evolved established the Management Systems Division of the Directorate of Management Analysis of the MATS DCS/Comptroller as the PERT focal point. Basically, the plan had a three-layer organization with the squadrons, wings, and Air Forces reporting to the Headquarters, where their input information was to be processed through the computer, displayed, and the resultant update information fed back to the subordinate units. Some of this information would also channel to the SPO as the MATS input to the major SPO PERT effort. These inputs were planned to generally identify significant milestones and detailed time-phased actions.[88]

(U) However, before the plan could be implemented, MATS had to establish a PERT Center, which was designated as the focal point of the command network. The center was designed to aid managers through analytical, consultant and advisory services that it could provide. Another of its functions was to

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85. EASTAF became the 21 Air Force on 8 Jan 66.
86. WESTAF became the 22 Air Force on 8 Jan 66.
87. Hist, MATS, 1 Jul 64-30 Jun 65, I, p. 162.
88. Ibid., p. 163.

update the networks and other management displays for all MATS Projects, as well as those delineated by the C-141 Programming Plans.[89]

(U) The initial major action involved in setting up this center was its manpower requirements. As per MATS Management Review Action Item #3-CO-1, the establishment of the center was to be developed in two phases. Phase I covered the ". . .actions to set up and staff an office for indoctrination and implementation of management systems, display of PERT networks, preparation and submission of manpower and organization package."[90] By 17 September 1965 this first phase was completed with a minimum of difficulties.

(U) Phase II of the program covered the next six months, in which the center development actions were to be completed with the center becoming fully operational. Both phase met the pre-set schedules and by the end of FY 1966 MAC had a functioning, command-wide PERT network. At first the network was used only for C-141 squadron conversion; however, before long the successful center and network was used for numerous other command projects.[91]

(U) More important, however, for the purposes of this study was the success of the C-141 PERT Program. This was what enabled the Starlifter manager to realistically document and implement the provisions of the program events from the SPO level through the using command level.

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89. Pamphlet, DCS/Comptroller, subj: Honeywell 800/200 PERT Application, undated, (circa 1963-1964), SD II-28.
90. Ltr, MARMAR to MAXMO, subj: Manpower and Organization Requirements for the PERT Center, 27 Jul 65, w/1 atch, SD II-29.
91. Hist, MAC, 1 Jul 65-30 Jun 66, I, pp. 53-54.



C-141 Aeromedical Evacuation

> "The aircraft. . .should be well within the state-of-the-art of aircraft design. . .For design purposes, aircraft performance will be based upon power plants which will be qualified or type certificated by July 1963. Additionally, the aircraft should be of a relatively simple, conventional design, devoid insofar as possible of special systems to accomplish design goals. Emphasis should be placed upon efficiency of design in order to minimize operating costs. Commercially available components will be utilized wherever feasible."

The Starlifter Design

(U) With the above military design philosophy[92] C-141 management was faced with a task that deviated from the normal military aircraft development situation. The aircraft, unlike most developmental types, was not to be built with advanced state-of-the-art theory and components. This posture was possible because, unlike the normal military aircraft, it was not to be designed for specific high performance missions in an intense combat environment. The Starlifter's design philosophy, on the contrary, called for a highly cost effective and reliable aircraft that could be used for varying airlift missions.

(U) However, while the airplane was not to be a specialized weapon system to be used in direct combat missions, it did, as noted below, have a combat mission.[93]

> "Operational Mission. This support system will provide a rapid, reliable, efficient means of airlifting:
>
> a. Combat or support units of all Services under General or Limited Emergency conditions.
>
> b. Military logistic supplies.
>
> c. Commercial cargo and mail.

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92. SOR 182, 4 May 60, SD I-1, C-141 Study, I.
93. SOR 182, as revised 15 Jun 62, C-141 SPP, p. 13-2, SD II-1, this history.

This mission, therefore, required certain capabilities that precluded the purchase of a "warmed over" commercial transport. This was true because commercial transport aircraft, available or planned (1961), lacked the outsized capability needed for military logistics movement, as well as the troop and cargo airdrop facilities required by the mission statement. In addition, no available commercial aircraft could be readily adapted for the mixed troop/equipment version that was necessary for a true strategic airlifter.

(U) Hence, the C-141, as envisioned through its design philosophy and mission employment requirement, was in fact an aircraft type theretofore never developed. It was a new type that borrowed concepts from the available aircraft types. In short, it was designed to be ". . .an airplane that is more mule than race horse (but with race horse speed), more truck than limousine (but designed with a degree of troop comfort). . .". However, while incorporating these characteristics, it also had to be ". . .easy and inexpensive to maintain. . .as well as. . .reliable and economical in the air."[94] Hence, the functional combinations required by the Starlifter concept predicated a new type of aircraft, which challenged designers and managers alike.

(U) Specifically, the Starlifter was described as a ". . .conventional, subsonic, high-wing cargo transport airplane designed for a cargo payload of over 60,000 pounds and a maximum gross ramp weight of 318,000 pounds."[95]

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94. News Release, Lockheed Newsbureau, subj: "C-141 Design Philosophy" by F.A. Cleveland, Asst Chief Engineer -- in charge of the C-141 Engineering Program, Lockheed-Georgia Co., Aug 63, SD II-30.
95. C-141 SPP, as revised Jun 67, p. 6-4.

In addition, the aircraft was to be designed to use four Pratt and Whitney TF 33-P-7 engines, which would be pylon mounted under the wing. Its wing, horizontal stabilizer, and vertical fin were to be swept back, and a trimmable horizontal stabilizer would be mounted on top of the fin. Its tricycle undercarriage would include a main landing gear that would retract into the wheel-well pods on the fuselage. The Starlifter would also have a high fuselage afterbody, high stabilizer, tail loading doors, and a ramp that would enable "straight in" cargo loading from ground level, or truck-bed height. Integral struts would be provided in order to stabilize the airplane during loading and unloading operations, and the cargo loading and stowage arrangements were to be compatible with Materials Handling System 463L.[96] Other programmed features were:

1. A flight deck with four crew seats, and accommodations for crew augmentation up to a total of eight.
2. Cargo airdrop capability.
3. Conversion capabilities to personnel carrying missions, paratroop drop, and aeromedical evacuation, either ambulatory or litter or a mix.
4. Portable lavatory and latrine and a portable galley.
5. Ground air conditioning and ventilation using the auxiliary power unit for heat and energy.
6. In flight pressurization system, including air conditioning, that maintained a cabin altitude of 8,000 feet up to 40,000 feet.

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96. Ibid., pp. 6-4, through 6-10.

7. An auxiliary power unit which would supply power for the pneumatic, electrical, and starting systems.

8. Component ability to use standard fuels and lubricants.

9. Capability to land or take-off from flexible pavement and landing mats.

10. Communications and navigation equipment that would be compatible with ground installations to be used in the 1965-1975 time period.

As early as 23 May 1961 Hq MATS was able to report that the C-141 would have a guaranteed performance of:[97]

1. Cruising true airspeed of 475 knots at 30,000 feet at normal power, with a 240,000 pound gross weight.

2. Payload of 50,000 pounds at 4,000 mile range.

3. Design gross weight of 315,000 pounds.

(U) Equally as important were the Reliability/Maintainability provisions of the C-141 Program. Perhaps these aspects were the most difficult to attain because while:[98]

> "The C-141A support system will not require extensive research and development or the application of techniques beyond the state-of-the-art. . .a major engineering program will be required to apply existing knowledge and proven techniques to component development, integration of components, and subsystems to meet system requirements."

Programmed Reliability

(U) The Reliability Program for the C-141 was based on stringent criteria. The numerical contractual goal was .90 for a five-hour mission without system performance degradation.[99] Basically, this formula meant

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97. Memo, MAPPP to Asst DCS/Personnel, subj: C-141 Aircraft, 23 May 61, SD II-31.
98. C-141 SPP, as revised Jun 67, p. 6-4.
99. C-141 SPP, as revised Jun 67, p. 6-11.

that if 100 aircraft were dispatched on a five-hour mission, 90 would arrive at their destinations without any system degradation. The lack of system degradation was defined as all systems and subsystems operating satisfactorily at destination arrival.[100]

(U) The reliability program criteria for the first five aircraft were based on Military Reliability Specification (MIL-R)-26674, which called for the review of each detailed design in order to predict reliability. Hence, all subcontractor and vendor proposals and alternate proposals were evaluated from the standpoint of reliability. Mathematical techniques were established to describe the reliability of the aircraft by means of an analytical model. Based on the .90 reliability rate for a five-hour mission the failures were computed at 21,076 per million flight hours. These failures were then arithmetically allocated down through the various subsystem, systems and component levels. Concurrently, failure rate from known experience with similar application of the same components in commercial aircraft, C-130, and other military aircraft were used to predict component, subsystem, system and total aircraft reliability.

(U) Then a comparison of the allocated and predicted failure rates was made in order to more specifically identify the critical and marginal reliability components. From the comparison evaluation a monitoring list of the marginal and critical components was developed, which was then used

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100. Interview, WLK with Mr. Wendel Wall, C-141 SPO Engineering, 20 Mar 69.

A Starlifter Loading

to provide a basis for evaluation concentration on identified items during the component test phases. This comprehensive test program also incorporated the use of component and system simulators which were developed for the program. Initially, this test program established the preliminary failure modes and indicated needed corrective actions on major systems. Later the SPO was able to augment the mathematical approach with failure data collected during the Category I, II, and III flight tests and hence pinpoint potential problems on both the contractor - furnished equipment (CFE) and government - furnished aerospace equipment (GFAE).

(U) The requirement to establish and verify the C-141's reliability parameters was established for all phases of the test program. For the follow-on production aircraft the program was based on MIL-R-27542, which included demonstration tests and the establishment of a minimum acceptable requirement for 30 critical items selected from the monitoring list established for the first five aircraft.[101] Generally, this approach eliminated many problems and allowed the aircraft to enter the operational inventory without an extensive test period.

Programmed Maintainability

(U) The maintainability goal established for the Starlifter was 12.5 direct maintenance manhours per flight hour. In addition, the goal established a requirement to reduce aircraft down time, special skills, and special maintenance equipment to absolute minimums. Another goal

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101. C-141 SPP, as revised Jun 67, p. 6-11.

was to reduce reliability difficulties to the point where the aircraft could be operated, in an emergency, from bases where virtually no support facilities existed. Throughout the program compliance with MIL-M (Military Maintenance Specification) 26512A was maintained. This specification required continuing analysis, maintainability predictions, evaluations, and verifications.[102]

(U) In addition, engineering surveillances were continuously made in order to ". . .insure technical excellence of the system and contract compliances. . . ."[103] Among the engineering programs developed to insure system reliability were aerodynamic fitness, fatigue evaluation, safety engineering, and corrosion prevention, as well as engineering evaluation programs for all the aircraft subsystems.[104]

MATS/MAC Participation

(U) The earliest command participation in the C-141 Program was in a technical advisory capacity to the Source Selection Board. After the formal program was established, MATS, as a program functional manager, continued its technical advice to the SPO, specifically on such matters as model specifications and technical evaluation of the aircraft and its components. As early as July 1961 MATS personnel participated in the review of components and equipment and made recommendations as applicable.

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102. Ibid., p. 6-13.
103. Ibid., p. 6-47.
104. Ibid., pp. 6-17 - 6-50.

Concurrently, the MATS representatives to the SPO became members of the C-141 Configuration Control Board (CCB), which reviewd all engineering changed proposals (ECP's). This board would either recommend concurrence or non-concurrence with a proposal; however, the final decision was made by the SPD. If a decision contrary to the MATS position was made, the command was notified through the SPO representatives and was given a chance to reclama the SPO position. In some cases, if the MATS argument was strong enough, the CCB was reopened for a further review of the change.[105] When the decision was made to give Headquarters USAF the final authority for model specification changes,[106] in the summer of 1961, the CCB assumed a high degree of importance.[107] Hence, throughout the program MATS/MAC personnel were actively engaged in the Preliminary Design Reviews (PDR's), Critical Design Reviews (CDR's), and in the Design Engineering Inspections (DEI's). This task was a difficult one and often resulted in painstaking negotiations with the SPO, the contractor, and other functional agencies.

C-141 Test and Evaluation Program

(U) The Starlifter Test and Evaluation Program was made up of ten elements.[108] These elements were:

1. Federal Aviation Agency (FAA) Certification
2. Qualification and Environmental Tests
3. Reliability and Maintainability Tests

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105. Telecon, WLK with William Linklater, ASD Configuration Control Board, 7 Apr 69.
106. Both USAF and The Federal Aviation Agency (FAA) were under consideration for this authority.
107. Memo for the Record, MAPPP, subj: C-141 System Package Program, 17 July 1961, SD II-32.
108. C-141 SPP, as revised Jun 67, p. 6-52.

4. Structural Static Tests

5. Fatigue Tests (including sonic testing)

6. Wind Tunnel Tests

7. Engine Development Tests

8. System Development Tests

9. Flight Tests

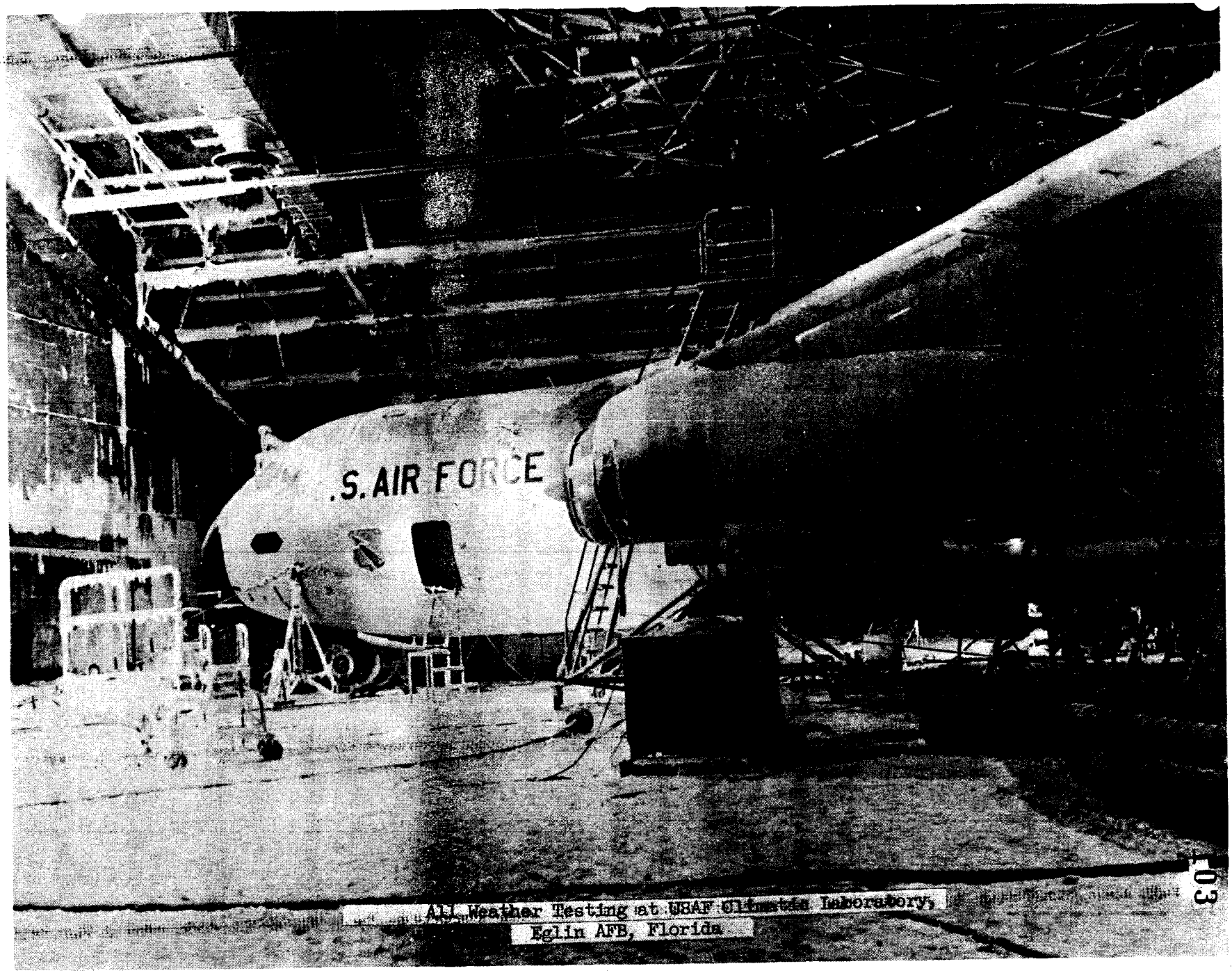
10. Follow-on Development Flight Test

(U) MATS/MAC personnel participated in all of the test elements; however, it was not until the flight testing that the command participated with large commitments of its hardware, effort, expertise, and manpower.

(U) Nevertheless, the command monitored and/or sat on the CCB for all of the elements.[109] Noteworthy among these elements was the requirement for FAA Type Certification of the aircraft system. This requirement was first stated in SOR 182, which under paragraph seven, section f stated that ". . .The aircraft shall be designed and shown to comply with Civil Air Regulations, transport category, at the civil payload, range, and field size specified."[110] In fact, FAA certification was a program requisite for the beginning. This factor had been discussed in the Rivers Committee Hearings[111] and hence was a well known stipulation of the cargo aircraft program. Attesting to this popular knowledge was Najeeb E. Halaby's (FAA Administrator, 1961-1965) letter to the Air Transport Association's (ATA)

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109. Ibid., pp. 6-53 - 6-56.
110. Ibid., p. 13-9.
111. C-141 Study, I, pp. 13-19.



All Weather Testing at USAF Climatic Laboratory, Eglin AFB, Florida

Director of Operations and Engineering, which stated, "As you probably know, civil certification is a condition of the Air Force contract with Lockheed."[112]

(U) Still more binding was Air Force Regulation (AFR) 80-36, which stipulated that:[113]

> "Transport aircraft that the Air Force procures or develops must be designed to comply with civil airworthiness standards when their intended usage is generally consistent with civil operations. This does not preclude the use of military specifications and standards in designing an aircraft when necessary to assure that the aircraft will perform its military role properly under intended operating conditions."

Since this regulation defined transport aircraft as "An aircraft whose primary purpose is to transport personnel or cargo. . .", the C-141 design project had to be governed by the regulation. Hence, C-141 planners were required to contractually stipulate which type of FAA Certification would be required. In the Starlifter's case USAF requested "Type Certification", which directed that the aircraft design must meet the Federal Aviation Agency's "civil airworthiness standards."

(U) In order to insure that these requirements were met, the Director of Systems Management, WADD, and the FAA signed a "Memorandum of Understanding" on 29 March 1961 at Forth Worth, Texas.[114] This memorandum provided for a

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112. Ltr, N.E. Halaby, FAA Administrator, to William B. Becker, ATA Director, Operations and Engineering, 2 Nov 61, SD I-15, Vol I, this history.
113. AFR 80-36, "Research and Development Civil Airworthiness Standards for USAF Transport Aircraft," 28 Jul 66, SD II-33.
114. Memo of Understanding, WADD and FAA, subj: Cargo Aircraft C-141, 29 Mar 61, pp. 14-4 - 14-8, C-141 SPR, as revised Jun 67.

permanent FAA representative to the SPO as the primary point of contact for that Program Functional Agency. Further the memorandum tacitly directed adherence to AFR 80-36 but also established the position that if ". . .the military and civil mission requirements lead to design conflicts, first emphasis will be placed on meeting the military mission requirements."[115]

(U) In its position as a program functional agency the FAA continually monitored and evaluated the aircraft and its subsystems in order to insure compliance with the civil airworthiness standards. These evaluations culminated in flight demonstrations for the FAA in January 1965. On 27 January the agency convened its "Type" Board to consider the results of the contractor flight demonstrations. Two days later the FAA announced that the C-141 had met certification requirements and later that day appropriate ceremonies were held at Dulles International Airport, Washington, D.C., in order to award FAA "Type Certification" to the Starlifter System.[116] This event marked a major milestone in the C-141 Program.

(U) General Joe W. Kelly also signed a memorandum of agreement with FAA's Halaby on 25 July 1963. This document established the mutually agreed upon arrangements for working relationships between Headquarters MATS and its Transport Air Force (TAF)[117] Headquarters, and the FAA. This new liaison greatly enhanced the relationships between the two agencies during the C-141 Flight Test Program.[118]

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115. Ibid., p. 14-4.
116. Mgt Summary - RCS: 13-AFSC-R32, C-141 SPO, subj: Program C-141A, (subsequently cited as C-141 Mgt Sum), A/O 29 Jan 65, p. 5-1 (Complete set in MAFOIH files).
117. See fn 85 and 86.
118. MATS Staff Digest, No. 107, 9 Aug 63, para 2.

"It occurred to me,
very simply, that there
wasn't a damn reason in the
world not to fly.
So we flew."

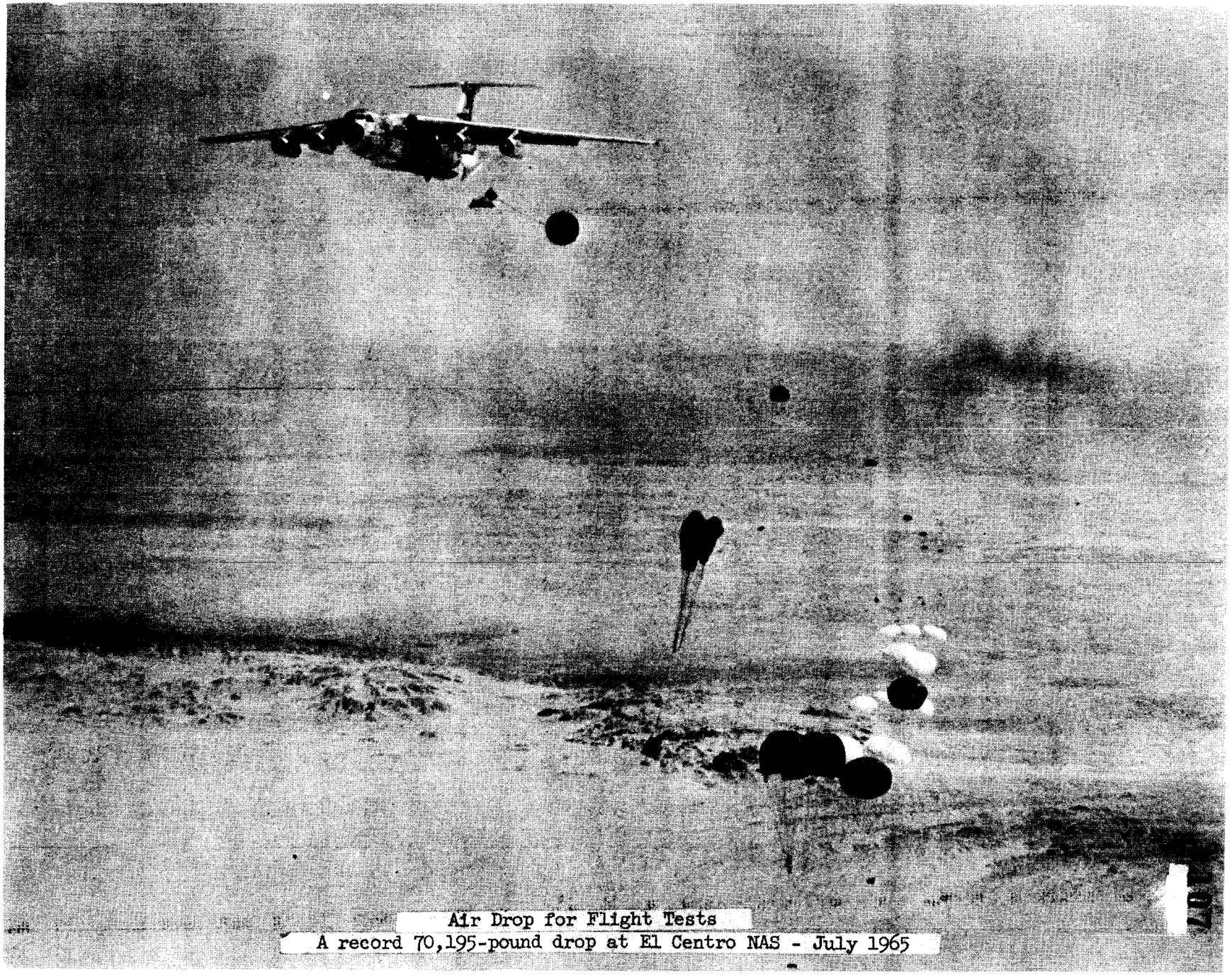
Flight Test

(U) So Leo Sullivan, the Chief Engineering Test Pilot for the Lockheed-Georgia Company, tells us that the decision was made to initiate the C-141 maiden flight.[119] More important than the glamour associated with a first flight was the fact that this 17 December 1963 event marked the beginning of the Starlifter Test Flight Program, a program that was still not completed on 30 June 1968. The Flight Test Program was based on AFR 80-14 and AFR 80-36.[120] AFR 80-14 delineates the general objectives of an Air Force Research and Development Program as:[121]

1. Measure and assess the accomplishment of development objectives.
2. Insure that systems and equipment meet program requirements.
3. Obtain true indication, forecast, or verification of actual performance capabilities of any system, subsystem, or equipment item in as real an operational environment as practicable.
4. Identify operational and engineering deficiencies in time for changes to be incorporated before significant production buildup. Insure that the changes meet the required objectives, or that any necessary trade-offs are identified.

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119. Leo Sullivan, "First Flight of the Starlifter," Atlanta Magazine, reprinted in C-141 Service, No. 2, Lockheed-Georgia Company, (April Quarter 1965), p. 18.
120. C-141 SPP, as revised June 1967, p. 6-54.
121. AFR 80-14, "Research and Development Test and Evaluation of Systems, Subsystems, and Equipment," 24 Feb 67, p. 2, SD II-34.



Air Drop for Flight Tests
A record 70,195-pound drop at El Centro NAS - July 1965

5. Provide data for operational analyses and for application to current and future systems and system studies.

6. Verify the over-all logistic capability, scope and effectiveness as prescribed by the support procedures, plans and planning factors, which have been developed concurrently with system evolution.

7. Assess identified manpower spaces and personnel resources necessary to support the systems and equipment.

8. Validate training and training programs.

9. Evaluate vulnerability/survivability including electronic countermeasures (ECM) and electronic counter countermeasures (ECCM) in the predicted hostile combat environment.

10. Obtain data and evaluate safety and reliability of systems, subsystems, or items of equipment in severe and abnormal environments such as aircraft crash, fire, lightning strike, explosion, severe impact, extreme pressure or temperature changes, radiation, electromagnetic radiation, or combinations of these conditions.

(U) The above objectives (as detailed in AFR 80-14 of 24 February 1967) were much more comprehensive than those of the earlier AFR 80-14's. For instance, the first of these regulations to guide the C-141 Program (AFR 80-14 of 19 August 1958)[122] lacked the comprehensive delineation of program objectives that is found in the later regulation. This, of course, is partly attributable to the experience gained by the Air Force, in new system acquisition during the 1960's. Certainly this evolutionary process was enhanced by the seven systems[123] gained by MATS/MAC during the period. More important for MAC, however, was the experience it gained from the C-141 Program. This expertise

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122. Ibid., 19 Aug 58, SD II-35.
123. During the period 1960-69, MATS/MAC acquired or was in the process of acquiring seven (C-141A, C-5A, C-9A, HC-130H/P, HH-3, HH-53, and RC-135) systems.

unquestionably helped in the system acquisition programs that followed the Starlifter Program.

(U) Basically, Acquisition Flight Test evolved into the following categories:[124]

Category I - Consists of development, testing and evaluation of individual components, subsystems and sometimes the total systems. Category I test is conducted under the aegis of the Air Force Systems Command (AFSC) but is primarily accomplished by the aircraft contractor.

Category II - Consists of the test and evaluation of the integration of the subsystems into the complete system, as well as a test of the complete system in as near an operational configuration as practicable. This category is primarily an Air Force effort with contractor participation. AFSC directs and controls the projects but active participation by the using and supporting commands is mandatory.

Category III - This category normally completed the test phase of the SPP. It is conducted by the using command with technical support provided by AFSC and the Air Force Logistics Command (AFLC). Basically, test objectives are as follows:

1. Determine capabilities of the system/equipment in terms of operational tactics, techniques, doctrines, and standards.

2. Determine deficiencies and/or limitations; provide quantitative and qualitative data for product improvement programs in order to suggest development tests, operational employment tests and evaluations.

3. Obtain supplemental data on operational and support requirements.

4. Evaluate the logistic system capability and supplemental logistical data.

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124. AFR 80-14, 24 Feb 67, pp. 5-6.

5. Determine training adequacy in the operational environment.

6. Determine technical data for operational usage.

7. Determine health protection, life support, and medical and safety procedures, directives, and equipment.

8. Supplement and refine the reliability data and insure that the program reliability factors are attained.

9. Supplement and refine maintainability data and insure that acceptable maintainability factors are attained.

10. Verify the mechanized configuration status and reporting system between AFLC and the support command.

11. Determine vulnerability and survivability of system/equipment throughout the mission profile.

As noted, the above parts of the Category II Test Program and the total Category III Program required active using command participation. Hence, basically the MATS/MAC active participation in the C-141 Flight Test Program began with the Category II Program.

Concurrent Acquisition and Test

(U) The basic flight test program (Categories I, II, III) were completed toward the end of Calendar Year 1966, but when they ended the Starlifter had been in the MATS/MAC operational inventory and performing in its planned operational mode over two years. Hence, with the entry of the C-141 into the MATS Force the command embarked on a relatively new concept of acquisition testing. Under previous Air Force policy an aircraft would not enter an operational force until the standard Category I and II Test were all but completed. However, the

concurrent acquisition test philosophy used in the Starlifter program called for the entry of the C-141 into the operational force prior to end of the Category II Test Program. As depicted in Chart VII, the Category II Program began in June 1964 and continued through November 1966 while the first C-141 entered the MATS Transitional Training Unit on 19 October 1964 and the first operational Starlifter entered the Command inventory on 23 April 1965. The rationale for these circumstances was that the weapon system force could become productive sooner and that the use of aircraft in the operational environment would enhance the system evaluation processes.

(U) Employment of the aircraft prior to the amplified subsystem test evaluations (Category II) naturally led to a myriad of operational force modification and update projects because of the breakdown of many unqualified systems. However, the SPO, MATS, and other C-141 management organizations decided to pursue this course because of the obvious advantages that could be accrued by MATS in its mission responsibilities and the Joint Test Forces in its evaluation programs.[125]

Category II Flight Test

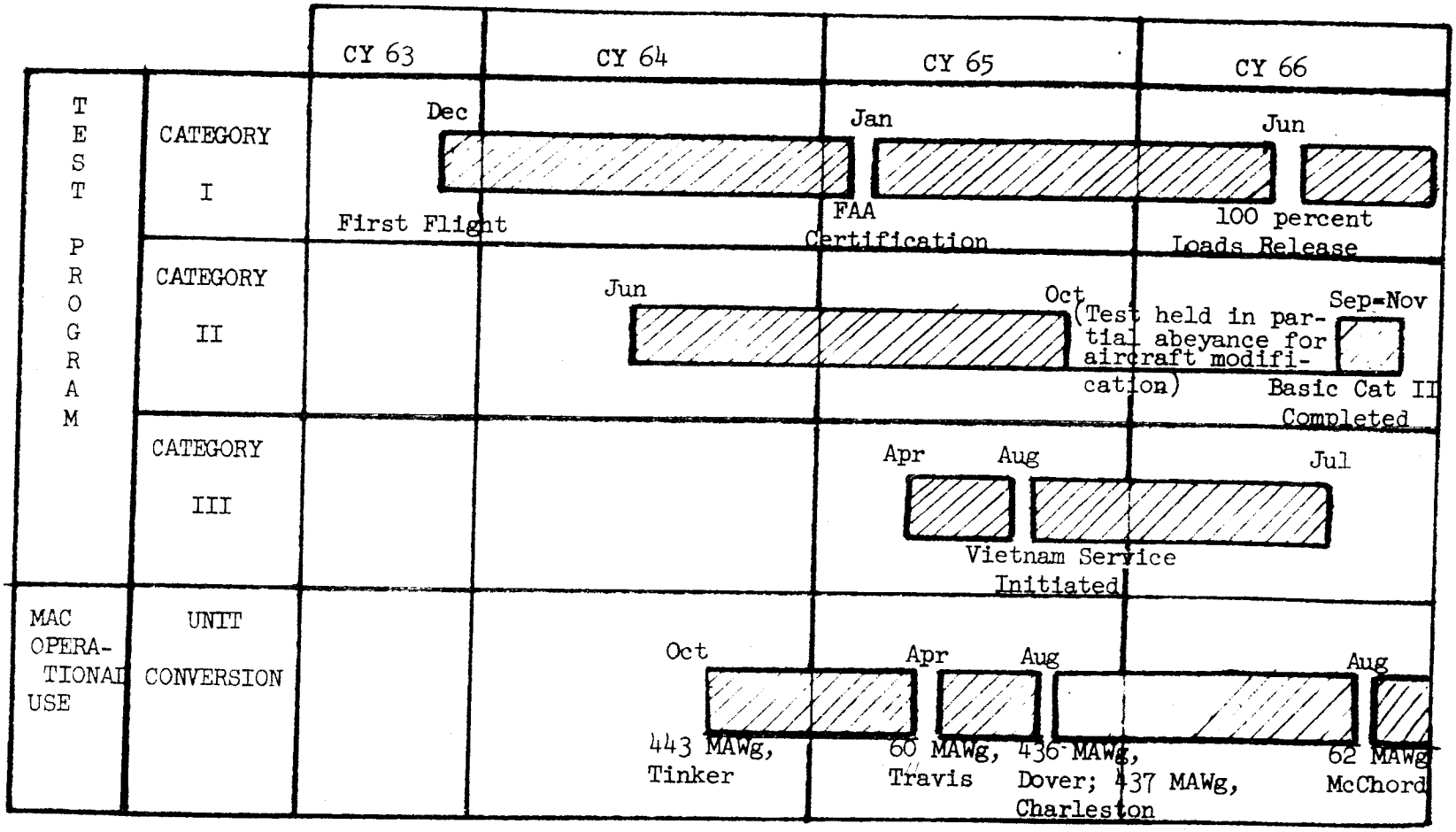
(U) Flight Test for the C-141 was planned and programmed early in the aircraft's Acquisition Phase. As early as April 1961 the SPO solicited flight test proposals from diverse Air Force commands and other governmental

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125. Hist, MAC, 1 Jul 65-30 Jun 66, I, pp. 161-162.

CHART VII

C-141 CONCURRENCY



agencies.[126] After analyzing these proposals, the SPO called a meeting of the functional managers at Wright-Patterson AFB, to discuss plans for the tests. In preparation for this conference, the MATS Staff was informed that the command would be primarily concerned with the Category II and Category III tests, because, for the former, MATS would be required to provide all the maintenance support and some aircrews, while the latter was planned as an all MATS program.[127] On 19 May the command's representatives to the conference reported that a tentative test schedule had been recommended to the SPO.[128]

(U) From these preliminary discussions, events moved rapidly. By September planning had progressed to the point where the Air Force Flight Test Center (AFFTC), Edwards AFB, California, could submit to MATS a list of the maintenance personnel requirements needed for the Category II Test Program. AFFTC based these requirements on the experience it had gathered through the B-52H Test Program. This list provided for a three shift operation in support of two aircraft. AFFTC also indicated the number of additional personnel that would be needed for a three aircraft operation. On 13-14 December 1961 a meeting was held at the Flight Test Center for AFFTC, SPO, ATC and MATS

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126. Memo, DCS/P, subj: Weapon/Support Systems, 5 Jul 61, SD II-36.
127. Memo For Record, MAPPP, subj: C-141 Proposed Systems Package Program, 9 May 61, SD II-37.
128. Trip Report, Lt Col William M. Best, MATS Personnel Plans Div, Subj: To represent DCS/Personnel at a C-141 Test Schedule Meeting at the AFLC Headquarters, Wright-Patterson AFB, 19 May 61, SD II-38.

Onload Demonstration at Tinker AFB, Oklahoma -- 19 October 1964

personnel. This meeting resulted in a modified list of personnel that was agreeable to both AFFTC and MATS.[129]

(U) During the summer of 1962, MATS refined these requirements, and identified its position in the Category II Tests with the draft of a Category II Test Support Plan. In order to review the MATS plan another meeting was held at the Flight Test Center for AFFTC, SPO and MATS personnel in September 1962. This meeting officially established the needed personnel requirements and the command's position in the test.

(U) Hence, on 18 October 1962, MATS published its Annex F to Air Force Flight Test Center C-141A Category II Test Plan.[130] This plan pointed out that all participating personnel would be integrated into the Category Joint Test Force. MATS personnel were to be assigned to the Test Center to:

1. Obtain early training of aircrew and maintenance personnel.
2. Augment the AFFTC Test Team.
3. Provide a maximum interchange of information so that the C-141 could be rapidly integrated into the MATS Force.
4. Gain background and experience so that MATS could properly assume its responsibilities for the TTU and Category III Test Program.

Further, MATS would be required to establish a Joint Test Force Staff Team, whose personnel were to be assigned permanent change of station (PCS) to a command detachment at Edwards. However, the MATS flight crews and maintenance

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129. Minutes, AFFTC-MATS C-141 Conference, 13-14 Dec 1961, w/2 Atchs, Atch 1 - Roster of Attenders; Atch 2 - MATS Maintenance Personnel for Support of Category II Test of C-141 Aircraft, SD II-39.
130. C-141A Category II Test Support Plan, MATS, subj: Annex F to Air Force Flight Test Center, C-141A Category II Test Plan, 18 Oct 62, SD II-40.

and supply people were to be assigned on a temporary duty (TDY) status. Basically, the plan called for the phasing of four aircrew and three support groups through the Category II Program.[131] As seen in Chart VII, the phasing plan required that the first, second, and fourth groups of aircrew members were to be transferred to the TTU as instructors after Test Force experience. The third aircrew group was destined to be transferred to the Category III Program. Of the three groups of support personnel, only the first was to be transferred to the TTU, while the second was destined to enter the Category III Program and the third was to be integrated into the new C-141 squadrons.

(U) In order to implement this plan the MATS C-141 Panel held a Category II Test personnel meeting on 15 February 1963, at Scott AFB, Illinois. These conferees first considered the status of the permanent staff of MATS Detachment 42, which was to be attached to the AFFTC. The panel agreed that all of these personnel would be selected by 1 March 1963 and by the following September the staff would be in place at Edwards and fully manned. As for the TDY support personnel, the panel decided that the first group would be selected from the 1707 Air Transport Wing[132] and other MAC units. The second group was to be selected from WESTAF units and the third from EASTAF units. While recommending the maximum use of experienced C-135 airframe and engine specialists, the panel, however, cautioned the selectors against stripping the MATS C-135 resources.[133]

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131. Ibid., p. F 4.
132. On 8 Jan 66, the 1707 became the 443 MAWg. This unit is the MAC TTU, and the first MATS unit programmed for the C-141.
133. Ltr, MAORD to MADIX, subj: Minutes of C-141 Category II Test Personnel Selection Meeting, 15 Feb 63, 26 Feb 63, SD II-41.

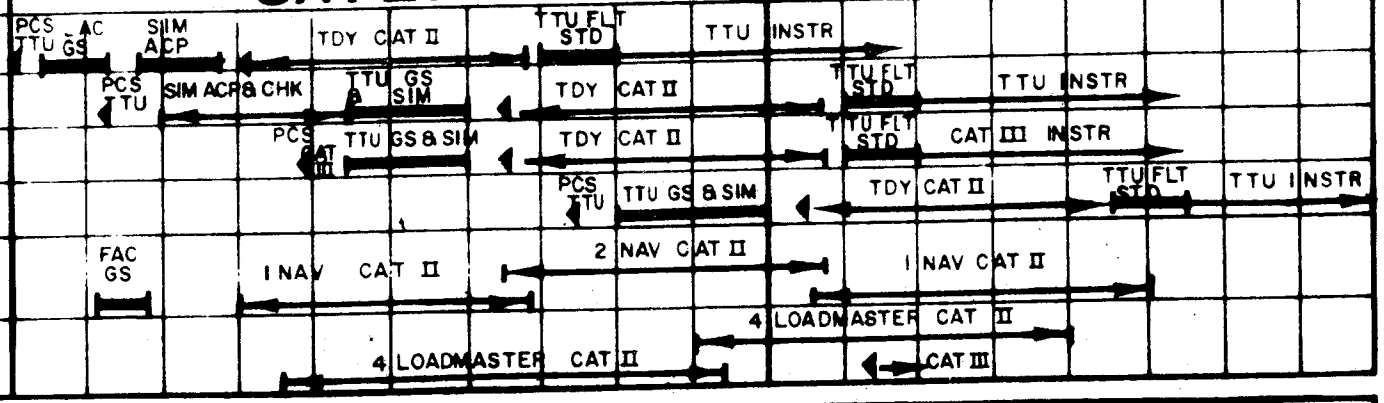
CHART VIII

C-141 CAT II MATS SUPPORT TIME PHASING

	1964										1965							
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Production A/C								1	1	1	2	2	3	3	4	4	5	5
Accumulative								1	2	3	5	7	10	13	17	21	26	31
Test Return A/C													2			3		
TTU A/C								1	2	3	5	7	10	10	10	10	13	14
Cat III Sq													2	5	9	16	16	16
2nd Sq A/C																	2	6
TTU Plt Input / Per Month									10	12	18	20	24	24	28	32	32	40
TTU Plt Input \ Cumulative									10	22	40	60	84	108	136	168	200	240

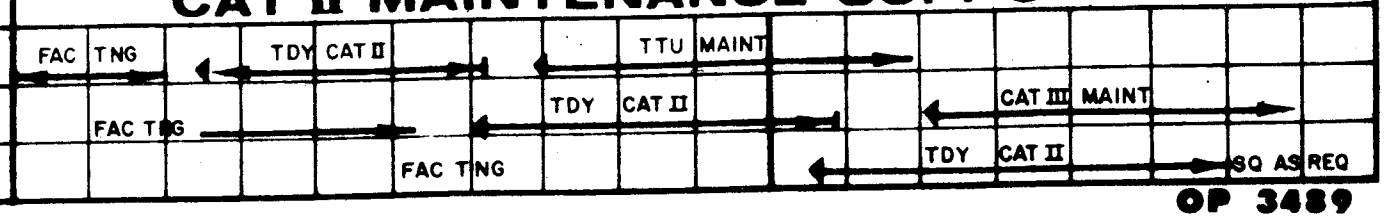
CAT II AIR CREW SUPPORT

Gp	Plts	Eng
I	8	8
II	2	2
III	2	2
IV	4	4
Navigator		4
Load Master		8



CAT II MAINTENANCE SUPPORT

Gp	No
I	108
II	151
III	151



OP 3489

(U) On 17 December 1964 the AFFTC was able to announce that 1,195 flight test hours were completed in the Category II Program.[134] In fact, by October of 1965 the basic Category II Program was complete. The only remaining tests were those that required aircraft modification. The last of these, the light-weight stability and control testing, were completed in October of 1966.[135]

(U) Generally, the Category II Tests were successful in that the subsystem testing was accomplished and MAC acquired the necessary training for its personnel. However, as in any joint enterprise, a few problems developed in the operation of the Joint Test Force (JTF). In a critique of the Category II Tests, the MAC Chief of the Operations Division of the C-141 JTF pointed out that in the administrative, supply, and maintenance areas cooperation between the Test Center and MATS personnel was good and, hence, these facets of the operation were successful. However, he lamented that initially command aircrews did not accrue adequate flying time, but he pointed out that later, with the extension of the original program, MATS crews received adequate flying hour allocations. Another difficulty, as seen by the command contingent chief, was that not enough ". . .MAC type missions had been flown. . . ."[136] He reasoned that if more of this type

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134. C-141 Study, I, p. 87.
135. Ibid., p. 97.
136. Ltr, 22 JTO to MAC (MAORD/Col Thomas), subj: Critique of MAC Participation in the C-141 Category II Test Program, 11 Apr 66, w/1 Atch, subj: C-141 Category II Test Program, Jun 1964-June 1965, 15 Feb 66, p. 1, SD II-42.

of mission configuration had been flown and had the C-141 been subjected more " . . . to rainy weather, cold weather, heavier weights, loading and unloading with 463L equipment, formation flying, and long range over water flights. . ." the following deficiencies could have been detected:[137]

1. Petal doors
2. Pressure doors
3. Tie down fittings
4. Rails
5. Air conditioning
6. Comfort pallets
7. Landing gear operation
8. Formation lights
9. Stabilizer struts
10. Crew rest facilities

The MAC analysis of the Category II Tests further suggested that less emphasis should have been placed on FAA Certification, because the quest for this certification delayed many Air Force high importance tests. In addition, he felt that a manual or regulation governing Joint Test Force program would be helpful. Lastly, the MAC Joint Test Force (JTF) Contingent Operations Chief suggested that the JTF be operated under a single manager concept and that MAC ". . .have more than adequate representation to insure all facets are covered as we desire."[138]

(U) From this juncture the critique covered the positive and negative points in the following areas:[139]

1. Administration
2. Budget
3. Billeting/Housing
4. Messing
5. Personnel (cont'd)

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137. Ibid., p. 1.
138. Ibid., p. 3.
139. Ibid., pp. 3-12.

(cont'd)

6. Engineering
7. Operations
8. Logistics
9. Maintenance

Basically, the suggestions of the critique were sound and will probably form a basis for MAC participation in future amplified service testing.

"Operational test and evaluation (OT&E) including Category III and Category III - Equivalent is conducted under the control and direction of the appropriate operating command."

Category III Flight Test

(U) Following the above regulatory direction[140] MATS in February 1963 announced that ". . .Category III Testing will be assigned to the first operational squadron to be activated at Travis AFB."[141] This announcement came in a briefing to the C-141 Executive Council, which declared that the tests were to be conducted ". . .over world-wide routes and will provide system evaluation in the operational environment." At this time it was reported that the MATS Staff was preparing the specific details for the Category III operational environment tests.

(U) By the summer of that year the details were presented in a preliminary test plan.[142] This plan pointed out that "The C-141A Cat III test program is essentially a continuation of the Category II test but utilizing an operationally significant test force and in a true operational environment."[143] Emphasis, the plan stated, would be directed toward

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140. AFR 55-31,"Operations - Operational Test and Evaluation," 20 Dec 66, p. 1, SD II-43.
141. Ltr, MAORD to MADIX, subj: Presentation to the C-141 Executive Council, 15 Feb 63, w/1 Atch, subj: MATS C-141 Development Participation, p. 6, SD II-44.
142. Plan, Hq MAC, subj: MATS C-141A Category III Test Plan System Operational Test and Evaluation Program, undated (circa - Summer 1963), SD II-45.
143. Ibid., p. 1.

determining the system's operational usefulness, maintainability and reliability, and the development of the most effective operational tactics, techniques, doctrines, and standards for system employment. The program was to be conducted primarily at Travis AFB; however, selected portions of the program were programmed to be accomplished at test sites along the MATS routes on a temporary duty (TDY) basis. In addition, the TTU was charged with the accumulation of certain data beginning in October 1964, although officially Category III Tests were not to begin until the receipt of the first operational aircraft. Further directions stipulated that "all test missions will be as productive as possible, i.e. transporting troops and cargo or meeting MATS training requirements." However, the preliminary plan cautioned the ". . .the meeting of test requirements will be given priority over any other operation of the C-141 during the test period."[144]

(U) Mission Objectives for the Category III test program were as follows:

A. Evaluation by MATS, with AFSC and AFLC participation, of operational systems; including all components, support items, personnel skills, technical data, and previously established procedures. Specific activities were established as:

1. Determine and improve the operational capabilities of the system and develop the most effective operational tactics, techniques, doctrine and standards.

2. Determine any operational deficiencies and limitations and provide quantitative and qualitative data for product improvement programs.

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144. Ibid., pp 1-2.

3. Evaluate the C-141 logistic system and capability and acquire supplemental logistic data on the following:

   a. The rate of parts consumption, maintenance, and support facility requirements obtained during previous tests.

   b. Adequacy of off-the-shelf equipment.

   c. Supportability of commercial equipment incorporated in the system.

   d. Compatibility of equipment and components with transportation equipment planned for use in support of the equipment.

4. Determine the adequacy of trained personnel who will operate and maintain the system in the operational environment.

5. Obtain supplemental data relative to operational and support requirements in terms of personnel, maintenance, supply, transportation, packaging and materials handling, training, special tools, test and support equipment, special facilities, and general performance standards.

6. Determine the adequacy of technical data and provide information for early corrections or additions to problem areas.

7. Supplement and refine reliability data.

8. Determine the adequacy of health protection, life support, and medical and safety procedures, directives, and equipment.

9. Verify configuration status and reporting system between AFLC and support command (Air Materiel Area) where mechanized system of accounting was to be used.

10. Insure that acceptable reliability factors were attained.[145]

In order to implement these tests, the 44th Air Transport Squadron (ATS)[146] of the 1501 Air Transport Wing (ATW),[147] Travis AFB, California, was

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145. Ibid., pp. 2-3.
146. On 8 Jan 66, the 44 ATS became the 44 Military Airlift Squadron (MAS)
147. On 8 Jan 66, the 1501 ATW became the 60 Military Airlift Wing (MAW).



Acceptance of the "Golden Bear"
Travis AFB, California -- 23 April 1965

designated as the Category III Test Squadron. Lastly, the plan stated that the C-141 Category III Joint Test Force was to be ". . .established in accordance with AFR 80-14"[148] and to have a USAF Importance Category of II. This category was ". . .considered an essential element of the Nation's military strength. . .and was. . .required to eliminate major deficiencies in AF operational capabilities."[149]

(U) With this auspicious plan MATS embarked on its C-141 Category III program. The next step was to coordinate the plan with the various C-141 Functional Agencies and the operating agencies within the MATS structure. On 9 June 1964, a coordination meeting was called at Headquarters MATS for this purpose. At this meeting the Category III Test plan was reviewed page by page, with each agency coordinating and approving or recommending changes by page. Among the suggested changes was a request for the change of administrative procedures to insure more rapid reaction than was available under AFR 66-1.[150] Another question presented by the conferees concerned the funding of the updating changes to the C-141. MATS also requested a "highly qualified" Lockheed engineer on the Category III test site ". . .to provide technical assistance and liaison between the test force, Lockheed, and the SPO."[151] The conferees agreed to the following target dates:[152]

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148. See SD 's 33 and 35, this study.
149. AFR 80-11, "Research and Development Importance Categories," 15 Jun 65, p. 2, SD II-46.
150. AFR 66-1 governed and guided USAF Maintenance Management.
151. Ltr, MAORD/D to All Attendees, subj: Minutes of the C-141 Cat III Coordination Meeting, undated (circa June 64), pp. 1-2, SD II-47.
152. Ibid., p. 2.

1. Final draft distributed for coordination - 1 July 1964.

2. Final coordination with each major command's annex returned to Headquarters MATS - 15 August 1964.

3. Final publication - 1 September 1964.

(U) Despite these efforts, the final C-141 Category III Test Plan was not published until January 1965. The reason for the slippage was the inability to acquire the necessary information and coordination from all the interested agencies. Nevertheless, the plan was published in ample time to enable MATS to initiate the program in April 1965. In answer to the questions presented at the coordination meeting the revised plan stipulated that:[153]

1. "Maintenance Data will be collected by utilizing the procedures outlined in AFM 66-1 and AFM 65-110."[154]

2. The Lockheed-Georgia Company would support the program with a Liaison Engineer whose ". . .function. . .would be. . .to provide technical assistance and liaison between the Joint Test Force and the Lockheed-Georgia Company.

3. Commander AFSC would "insure that a quick updating/modification kit installation exists for those kits the installation of which is beyond the capability of WRAMA[155] or the 1501 ATW."

(U) In addition, the final plan also augmented the stated test objectives with the following requirements:[156]

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153. C-141A Category III Test Plan, Hq MATS, subj: System Operational Test and Evaluation Program, Jan 65, p. G-1, 7, 6, SD II-48.
154. Air Force Manual (AFM) 66-1 covers maintenance management, while AFM 65-110 is the Standard Aerospace Vehicle and Equipment Status Reporting Procedure.
155. WRAMA refers to the Warner-Robins Air Materiel Area - a sub organization of AFLC.
156. C-141 Cat III Test Plan, Jan 65, pp. 2-3.

1. Evaluate the logistic system and capability. Acquire supplemental data on the:

    a. Adequacy and utility of the Aerospace Ground Equipment (AGE) as authorized in the applicable Table of Allowances (TA's).
    b. Adequacy of MM 28-2.[157]

2. Further validate the C-141 Qualitative and Quantitative Personnel Requirements Index (QQPRI) with maintenance data generated in accordance with AFM 66-1.

3. Determine the adequacy of health protection, life support, and medical procedures, directives, and equipment.

4. Determine the adequacy of safety standards and directives.

5. Evaluate the system reliability being obtained and compare that with the primary goals. Provide data to measure reliability factors.

6. Analyze all performance data recorded on long range missions for validating published data.

7. Determine standard aeromedical configuration(s) and procedures, standard patient loads and combinations, compatibility of standard aeromedical evacuation equipment with aircraft electrical and oxygen systems. Recommend revisions to applicable MATS directives as appropriate.

8. Verify composition and adequacy of WRM kits.

9. Provide for analytical overhaul of new systems or components, as provided for in AFLCR 65-25.[158] The purpose of analytical overhaul is to identify new systems and/or components whose failure could generate NORS or critical item situations in the C-141 aircraft. Criteria for selecting these type items are state of the art development, suspected design weakness, lack of previous experience, or experience in the application involved.

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157. MM 28-2 is titled "The Development, Reporting, and Publication of Wartime Activity Planning" (FOUO).
158. AFLCR refers to Air Force Logistics Command Regulation.

Category III Flotation Tests

In order to implement the details of the Category III Plan, WESTAF also published a supplement to the Headquarters plan.[159] This WESTAF Plan spelled out the operating details for the C-141A Category III Joint Test Force (JTF).

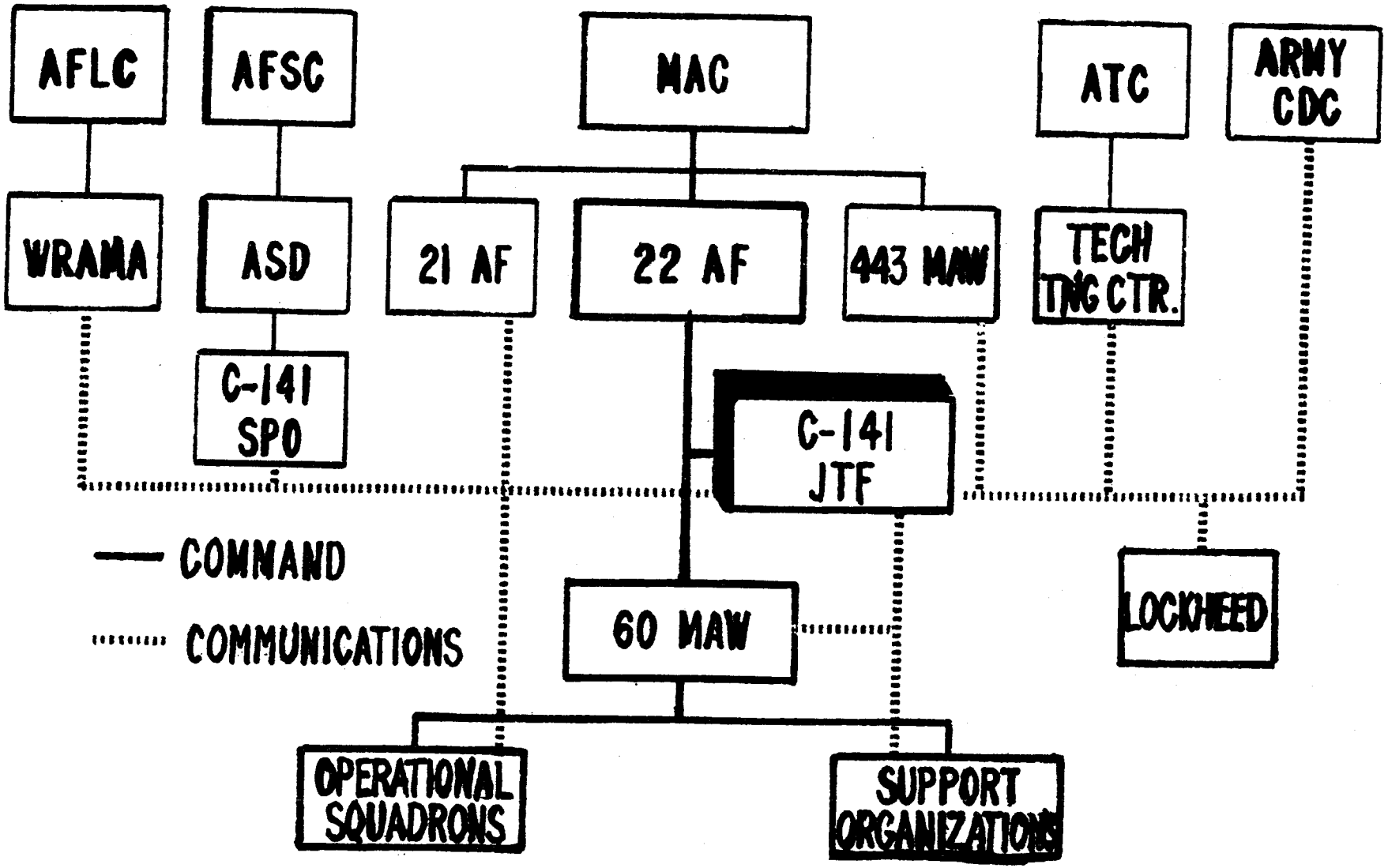
(U) In order to implement the test and evaluation MATS established a C-141A Joint Test Force (JTF) and assigned it to Headquarters WESTAF. Since the JTF was subordinate to WESTAF, all requirements generated by the JTF were coordinated by the WESTAF Staff and mission directives were issued through normal command channels. However, important to the success of the operation was an authorized direct communication between the JTF and operating organizations,[160] in order to furnish guidance and clarify data collection. As noted in Chart IX, these direct communication lines were with WRAMA, the logistic support command; the SPO; EASTAF, and its operational squadrons, the TTU; the Air Training Command's (ATC) Technical Training Center; the Army; Lockheed; and the 60 MAWg and its squadrons. These direct lines speeded up the functional processes by eliminating the necessity for following command channels in purely test matters.

(U) After developing the organization of the JTF and operating agencies, the next step was to man the organization. This was done by assigning thirty-two people directly to the force. Nine of these were representatives of commands and agencies other than MATS. They were required in orier to provide a direct liaison between the JTF and their parent organizations.

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159. Test Plan, Hq WESTAF, subj: C-141A Category III Detailed Test Plan System Operational Test and Evaluation Program, 15 Apr 65, SD II-49.
160. Briefing, Cat III JTF Chief to MAC Staff, subj: Category III Evaluation, undated, circa Jun 66 (subsequently cited as Cat III JTF Briefing), SD II-50.

CHART IX
C-141 CATEGORY III TEST
ORGANIZATION AND COMMUNICATIONS



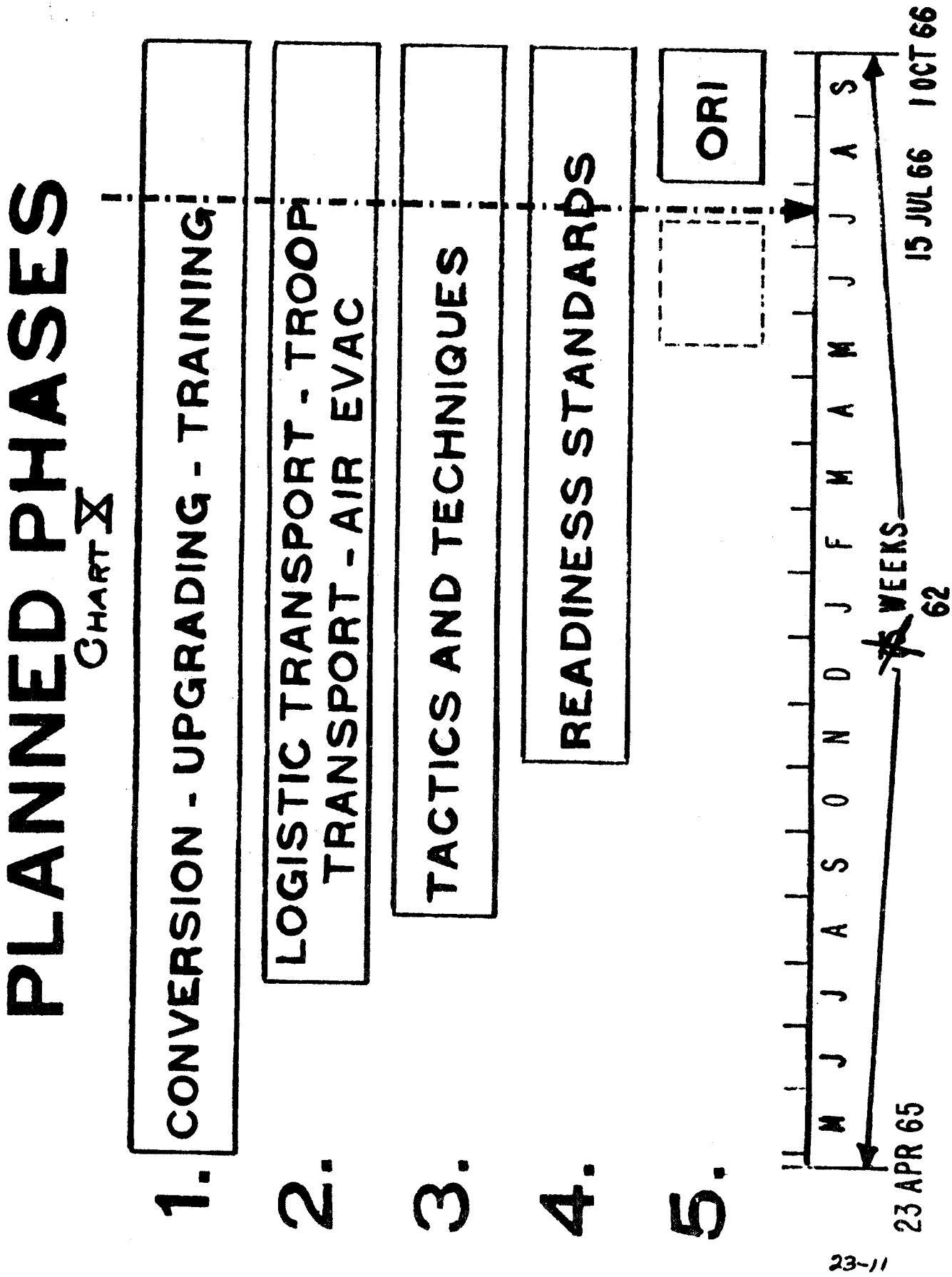
Also very important to the Category III mission was the fact that almost all of the people assigned to the JTF had a long association with the Starlifter Program. Not only did the JTF team personnel administer the program but many were also selected for their various skills which allowed them to directly participate in test missions.[161] By 23 April 1965, when MATS accepted the first operational C-141, the JTF had been assigned and many of its personnel were in place at Travis AFB, California.

(U) With the acceptance of the first C-141 by an operational unit the Category III Tests began for the Starlifter.[162] Originally the test and evaluation was scheduled to continue through August 1966 and in addition another month was allowed to write the final C-141 Category III Test Report. However, with the exception of the squadron Operational Readiness Inspections (ORI) all phases of the test and evaluation were completed in June 1966 and the C-141A Category III Test and Evaluation Summary Report[163] was published on 15 July 1966. As noted in Chart X, this feat was accomplished in 62 weeks although the test plans called for a 75-week test and evaluation period.

(U) While the test and evaluation program proved to be highly successful, three major factors adversely impacted the program.[164] These factors were:

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161. Cat II JTF Briefing.
162. This event occurred on 23 April 1965 when the 1501 ATW accepted the Starlifter the "Golden Bear".
163. Report, C-141 Category III Joint Test Force, subj: C-141A Category III Test and Evaluation Summary Report, 15 Jul 66 (subsequently cited as C-141A Cat III Test Report), SD II-51.
164. Cat III JTF Briefing.


PLANNED PHASES
CHART X
1. CONVERSION - UPGRADING - TRAINING
2. LOGISTIC TRANSPORT - TROOP TRANSPORT - AIR EVAC
3. TACTICS AND TECHNIQUES
4. READINESS STANDARDS
5. ORI
M J J A S O N D J F M A M J J A S
23 APR 65
15 JUL 66
1 OCT 66
62 WEEKS
23-11

1. The South East Asia (SEA) situation
2. Project Fast Fly[165]
3. The Production Increase

The demand for increased airlift to SEA, specifically Vietnam, required high utilization of all of MATS/MAC airlift vehicles. Hence, the Category III evaluations and data collection became secondary to this mission. While this factor was not detrimental in all respects, because ". . .the best way to determine system suitability is under actual operating conditions," it did require significant changes in operating methods. The last two factors both impacted the spare stockage and replenishment programs. Accelerated airframe utilization for Project "Fast Fly" increased spare consumption and, of course, depleted the preplanned stockage levels. Lastly, the production increase, from seven to nine aircraft per month,[166] severely cut into the spares procurement program without allowing vendor production adjustments.[167] In addition, spare parts and equipment were naturally consumed at high rates because many of the sub-systems and components were still in the qualification and certification processes and, hence, many had deficiencies that had to be corrected, which in turn levied heavy requirements on supply.

(U) The C-141A Category III Test and Evaluation Summary Report of 15 July 1966, which concluded the Category III Program, reported that the

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165. Project Fast Fly was a program to increase aircraft utilization to 8 hours per day. C-141's came under this program in October 1966.
166. Increased production began in April 1966.
167. Cat III JTF Briefing.

Starlifter ". . .does a good job on all missions."[168] Nevertheless, this Cat III JTF report had many recommendations for future programs. The general recommendations were as follows:[169]

1. Manning in the administrative and engineering sections was felt to be deficient. In the former, the paperwork workload exceeded the available manhours. In the latter, the JTF felt that there was a need for more AFSC on-site engineers in order to more rapidly resolve engineering problems. Also needed was a draftsman so that engineering recommendations could more expeditiously be displayed.
2. For the top management level, it was recommended that the Test Force Director be relieved of all other duties because his full attention was required by the program.
3. For Test Force organization and manning the report writers felt that the JTF should be fully manned by the program's initiation date. In the C-141 program the JTF was not fully manned until two months after the program began, which hampered initial operations.
4. The JTF felt that blanket approval for Class I and II modifications should be granted from program initiation. The C-141 program did not receive this authority until October 1965.
5. More active participation by MAC Headquarters Staff Agencies was also suggested.

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168. C-141 Cat III Test Report, p. 57.
169. Ibid., pp. 56-57.



Offload, Operation Deep Freeze '68

6. An exclusively allocated block time such as 50 hours per month for test missions was also considered desirable. The impact of SEA airlift motivated this suggestion.
7. A quick fix procedure for Engineering Change Proposals (ECP's) was recommended for future programs because of the lengthy time intervals needed to process and install ECP's under the regular procedure.
8. The urgent need for Category II data was also a problem because of the lack of a final Category II Test report, by July 1966, and the fact that the Category II Test data came to the Category III JTF in dribbles.
9. Deviations from normal operational procedures in order to establish better standards were also suggested. The JTF report suggested that this situation could be corrected by a published command policy concerning test missions.
10. Lastly, the JTF suggested that the squadrons be given an operational readiness inspection after being declared operationally ready (C-1) and that this inspection require some joint airborne experience for the units.

(U) From this juncture the report covered the Starlifter's Category III Test operational, engineering, materiel, and management evaluations. Some of the operational problems encountered were:[170]

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170. Ibid., pp. 58-59.

1. Restrictions imposed by the MAC Aircrew Standardization Division often hampered test operations. Hence, the JTF suggested that it should have full authority and responsibility for the tests. Specifically, they suggested that the JTF, or at least the AF Commander, have waiver authority for test purposes.
2. Approval of engineering changes prior to JTF review also worked hardships on the test force. It was felt that had the ECP's been coordinated with the JTF many unnecessary test restrictions could have been avoided.

The engineering section of the force also encountered various problem areas.[171] Among these were:

1. The lack of MAC orientation of the SPO engineering personnel. Orientation was considered essential because at times it was difficult to convince engineering personnel of the need for an ECP. Since the criteria for system changes were mission essential, safety of flight, and monetary savings, the engineering personnel's lack of acquaintance with MAC operations worked hardships for MAC personnel suggesting changes for the first two categories.
2. Engineering personnel also suggested that funds for manufacture of proposed equipment or modification should be included in the JTF budget.

The materiel and administrative management problems areas were generally incorporated into the general program recommendations noted above.

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171. Ibid., p. 123.

Operational Evaluation Staff/Maintenance Evaluation Division

(U) The C-141 Category III JTF "hardware" problem evaluation and resolution technique was continued after the completion of the tests. This task was taken over on 15 July 1966 by the Operational Evaluation/Lead the Force Staff (OES/LTF). OES/LTF was organized and in place by 1 July 1966[172] so that it would have approximately 15 days of familiarization with the C-141 Program. Its basic mission was to continue to report on problem areas, both Category III carryovers and new ones, and the progress of problem resolutions. Since the "comments received during the tenure of the JTF. . .indicated that the information presented. . .was adequate and satisfying. . .the OES intended to follow the same format."[173] The OES continued to function as a unit until 5 March 1968, when it was disbanded. However, actually only the name was discontinued because, in consonance with the C-141 Program's movement into the Operational Phase of the aircraft's life cycle and program control passing to AFLC and MAC Maintenance Engineering, the name of the evaluation staff changed to Maintenance Evaluation Division (MED). The functions of MED remained the same as the functions of its predecessor. In fact, the March copy of the monthly report succinctly noted the change as follows:[174]

> "The OES passed into history on 15 March 1968, but in name only; we're now the C-141 Maintenance Evaluation Division (MED), still based at Travis."

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172. S.O. G-91, Hq MAC, 27 May 66, SD I-2, Hist MAC, 1 Jul 65-30 Jun 66, III.
173. Report, OES/LTF, subj: Monthly Activities Rpt, June/July 1966.
174. Rpt, MED/LTF, subj: Monthly Activities Rpt, Vol 2, Number 9, March 68, p. ii.

Lead The Force

(U) During October 1964, the Secretary of the Air Force and the Air Staff Board recommended that a Lead the Force (LTF)[175] program be evaluated for use in the C-141 program. Apparently, the germ of this recommendation was the LTF program developed by the Oklahoma City Air Materiel Area (OCAMA) and the Strategic Air Command (SAC) for the latter command's B-52 and B-47 fleets.[176] Basically, their program consisted of:

> ". . .ageing selected SAC aircraft prematurely by accelerating their flight time beyond normal by a predetermined amount. It was hoped that this process would reveal premature structural fatigue, determine the effectiveness of modifications, and provide more accurate statistical data regarding fleet service life. . .If service life failures could be uncovered early enough in the Lead-the-Fleet aircraft, AFLC and the contractors could design and install correct modifications in the fleet before general failure."

The OCAMA Commander, the B-52 Weapon System Manager, stated the case for a program more succinctly by stating "I agree that the B-52 Lead-The-Fleet Program will provide us the best answer to 'Where will the airplane fail next?'"[177] In fact, the program seemed to satisfy SAC's needs so well that eventually not only the B-52s and B-47s were assigned an LTF but also the B-58s and KC-135s came under such a program.[178]

(U) In order to investigate a C-141 program, a Lead-The-Fleet meeting was called at WRAMA for Hq USAF, MATS, SPO, FAA, and WRAMA personnel on

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175. Originally this concept was termed Lead the Fleet.
176. Hist, SAC, Jul-Dec 64, p. 301.
177. Msg, DM 103453, Cmdr OCAMA to SAC, subj: B-52 Lead-The-Fleet Program, 21 Nov 63, SD II-52.
178. Hists, SAC, Jul-Dec 63, pp. 278-281; Jul-Dec 64, pp. 301-304; Jan-Jun 66, pp. 35-37.



An LTF Bird

20 October 1964. At this meeting the conferees defined a Lead-The-Fleet Program as:[179]

> ". . .a program to provide early intelligence from actual fleet operations on structural and systems reliability which will provide engineering and procurement leadtime for orderly updating changes and modifications to in-service and/or production aircraft."

This definition deviated from the SAC/OCAMA concept in two ways. The first of these was the fact that updating as well as modification was considered an end result. More important, however, was the inclusion of a systems evaluation along with the structural analysis.

(U) This meeting also prepared the basic background for a requested briefing to the Air Staff on 20 November 1964. By 13 November MATS had agreed with AFLC and AFSC that, despite the rigorous C-141 program static and fatigue tests, a program for the Starlifter was desirable. Therefore, on 20 November a joing AFLC/AFSC/MATS presentation was given to the Air Staff and preliminary approval was granted. On 25 November General Estes directed the MATS DCS/Operations to prepare a Lead-The-Force Plan and on 11 December Headquarters USAF assigned the C-141 LTF operational responsibility to MATS and directed the command, in conjunction with AFSC and AFLC, to prepare an implementation plan.[180]

(U) While events moved rapidly in late 1964 it should be noted that not all MATS personnel agreed that such a program was necessary. To some it seemed like "overdoing a good thing." Among the objections to the program was the fact that the contractor testing had already been labelled, by the Air Force and FAA, the most thorough given to a jet transport. Further, the objectors

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179. Minutes, C-141 Lead-The-Fleet Meeting, 20 Oct 64, SD II-53.
180. Hist, MATS, 1 Jul 64-30 Jun 65, I, pp. 155-157.

pointed out that aircraft number 6 was actually flying a diminutive LTF. At first the views of these dissenters ranged from restrained skepticism to actual non-concurrence. However, these debates soon dissolved into agreement that an LTF would provide lasting benefits.

(U) On 27 January 1965 Headquarters MATS distributed a draft LTF Plan to interested C-141-responsible personnel for comment.[182] The objectives as stated in the draft were as follows:

"1. Identify structure fatigue deficiencies, sonic impact, reliability and maintainability requirements, scope of organizational field maintenance and IRAN.

2. To identify deficiencies, either structural or system, that long-term operation determines necessary for updating or modification.

3. To supplement the contractor static, dynamic, and fatigue testing programs, particularly as regards low level flight profiles, take-offs and landings, reverse thrust operations, braking, etc.

4. To provide rapid analysis of failure data and facilitate early decision in procurement of follow-on spares.

5. To prevent prolonged down time for incorporation of fixes in the event major deficiencies occur.

6. To determine the adequacy of system and component performance on a cycle or an airframe time basis by correlation of actual experience with qualification requirements.

7. To gain high operational time experience on engines APU's on a serialized basis. Other systems may be considered if deemed appropriate. These selected systems when removed for cause will be reinstalled on LTF A/C at the earliest opportunity.

8. Flying time on "Lead-the-Force" aircraft will be approximately 2 years in advance of the remainder of the operational force. This objective should be reached at the earliest possible date.

9. Validate MATS manpower requirements to support C-141 in its worldwide operational environment."

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181. Ibid., pp. 157-158.
182. Plan (Draft), MAORD, subj: Lead-the-Force, 27 Jan 65, pp. 3-4, SD II-54.

(U) By May 1965 MATS was able to publish a final "C-141A Lead-The-Force Program Plan." A comparison between the official plan and the draft plan shows relatively minor changes; however, the latter carried an additional objective.[183] This objective was:

> "Provide a follow-on capability to the Cat III JTF to complete evaluations and analysis not completed during the Cat III test program."

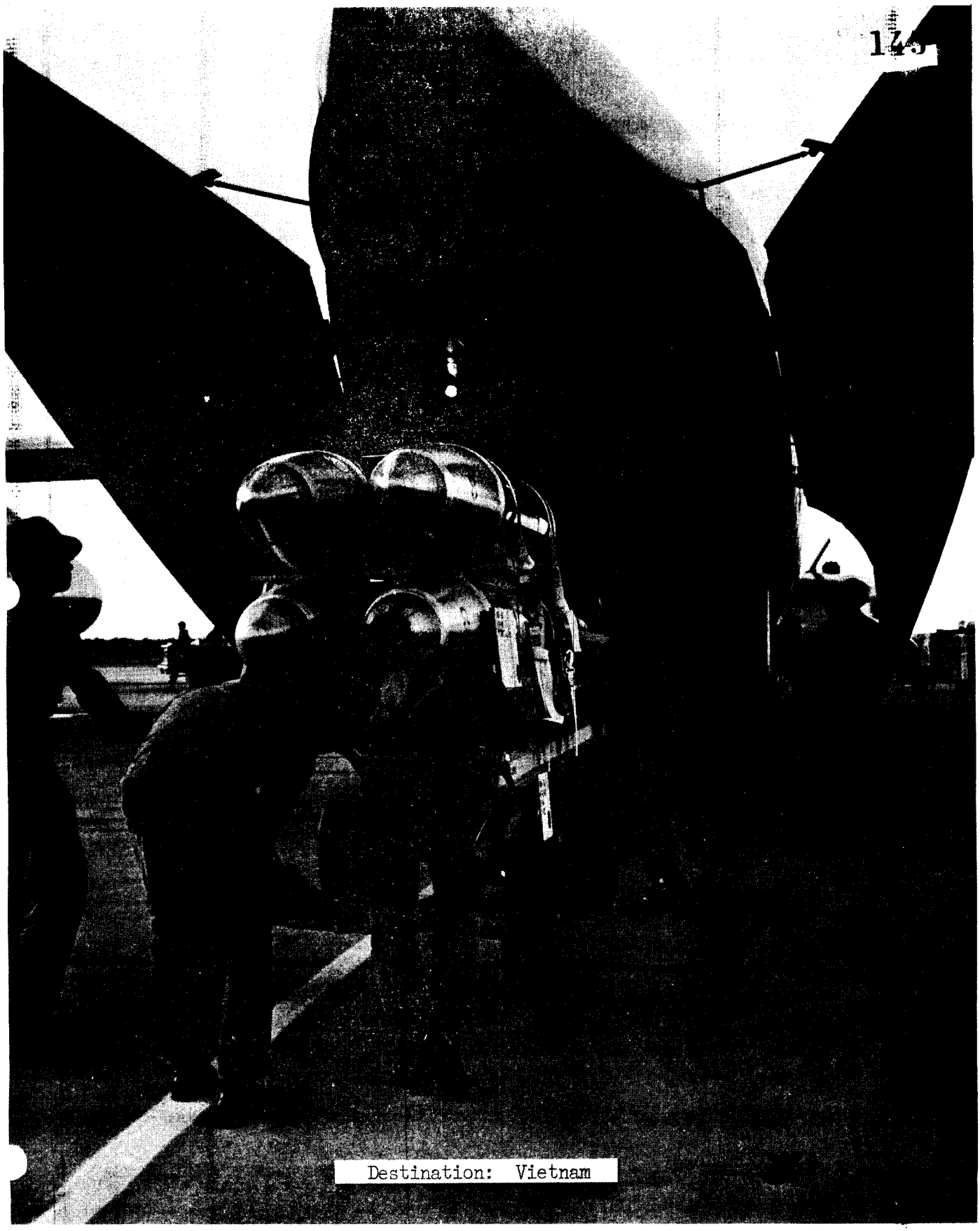
(U) Officially the MATS LTF Program began on 1 June 1965; however, the Transitional Training Unit (TTU) aircraft and test aircraft had actually been accumulating LTF type data before that date. The program from the beginning showed the promise that it would meet its flying hour and landing goals. Unquestionably, this program did provide important and necessary information to the Category III JTF, OES, and later the MED. Much of its raw data led to system update and modification. Actually, only one factor seriously impacted this program. This was the accelerated airframe utilization under Project "Fast Fly" and its follow on program Project "Combat Pacer". These higher utilization programs forced an even higher flying hour program for the LTF aircraft so that the 2 year leadtime in flying hours and landings goal could be reached by 1 July 1970. Despite the fact that the program initially fell behind the program, MAC personnel and aircrews were equal to the task. In October 1968 the LTF program was officially terminated. LTF aircraft had achieved the flying hour objective on 10 September and the landings goal sometime earlier.[184]

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183. Plan, Hq MATS, subj: C-141 Lead The Force Plan, May 65, pp. 2-3, SD II-55.
184. Msg, R00122342, 21 AF to AIG 7209, subj: Lead-The-Force Program, 2 Nov 68, SD II-56.

Other Acquisition Phase Activities

(U) The major acquisition phase activities, of course, did not tell the complete story of the C-141 Weapon System Management Program. Many other activities comprised the total program. Among these facets were: The Category II and Category III Equivalent evaluations; facility construction or improvements for new system use; training of aircrews and maintenance personnel for the new system; squadron conversions and the attendant required on the job training; and the striving of the various squadrons to obtain an operational readiness. While there is no intent to minimize the importance of the considerable planning, programming, and labor involved in these projects, it is not felt that they can add to the weapons system program management narrative. The main developments of the acquisition phase have been recounted and constitute the outline upon which the other developments were founded. The facets, such as the Category II and Category III Adverse Weather Landing System and the flotation tests will be addressed in the third volume of this study but only insofar as the deficiencies developed in the program impacted the MATS/MAC operations and materiel functions.



Destination: Vietnam

OPERATIONAL PHASE

(U) On 28 February 1968 MAC accepted the last of the 284 C-141s purchased by the Air Force. This aircraft, like the first received by MATS, was assigned to the 443 MAWg (TTU), located at Tinker AFB, Oklahoma.[185] With this acceptance, the C-141 entered the Operational Phase of its Life Cycle.[186] Officially, however, the Operational Phase did not begin until the C-141 SPO transferred the managerial function to the Support System Manager (SSM). Assignment of the Warner-Robins Air Materiel Area (WRAMA) as the SSM had been made as early as 8 February 1961[187] and WRAMA had participated in the program since that date. Hence, on 1 March 1968[188] when the transfer officially took place, the C-141's management responsibility went to a well versed organization.

Transition Agreements

(U) The specific guidelines for the transfer of responsibility were delineated in two combined Air Force Systems Command (AFSC) and Air Force Logistic Command (AFLC) Regulations. The first of these was AFSCR 375-4/AFLCR 375-3,[189] which established:

> "policy and assigns AFSC/AFLC responsibilities for accomplishing a transition in management at the end of system acquisition. It augments the 375-series Air Force Regulations. . . ."

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185. C-141 Study, I, p. 102.
186. For Life Cycle details see pp. 5-12, this volume.
187. C-141 Study, I, p. 62.
188. Ibid., p. 102.
189. AFSCR 375-4/AFLCR 375-3, AFSC/AFLC, "Systems Management - Transition Agreements," 18 Sep 65, SD II-57.

The objective of the regulation was:

> "To accomplish an orderly transition in management whereby AFSC terminates responsibility to Hq USAF for overall systems management and concurrently AFLC assumes responsibility for support of the operational system."

Further, this regulation listed the following elements of management functions as typical transfers:

1. System documentation and records.
2. Configuration management.
3. Engineering.
4. Technical Order data
5. Materiel support
6. Transportation and packaging
7. Security
8. Budgeting and funding summary
9. Other subjects

Specifically delineated were engineering responsibilities for which AFSC was to support the AFLC efforts. These responsibilities were identified in the combined regulation AFSCR 80-17/AFLCR 80-5.[190] The stated objective of this regulation was:

> "To provide competent and responsive engineering support to Air Force systems and equipment, and to accomplish an orderly transfer and realignment of engineering responsibility between AFSC and AFLC."

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190. AFSCR 80-17/AFLCR 80-5, AFSC/AFLC, "Research and Development - Engineering Responsibility for Air Force Systems and Equipment," 18 Oct 66, SD II-58.

The C-141 Transition Agreement

(U) On 25 October 1967 the Air Force Logistics Command announced its approval of the "Transition Agreement Between AFSC and AFLC for the C-141A Weapon System."[191] This document's stated purpose constituted:

> "the sole agreement to accomplish the phased transition of primary Air Force system responsibility for the C-141A from AFSC (ASD) to AFLC (WRAMA) coincident with the completion of Air Force acquisition of the current series."

The agreement covered the following responsibility transfers:[192]

1. Documentation and Records
2. Configuration Management
3. Engineering
4. Engineering Data
5. Technical Order Data
6. Material Support
7. Transportation and Packaging
8. Security Classification
9. Funding
10. Procurement

Specifically delineated in the transfer agreement were two responsibilities no explicitly identified in AFSCR 375-4/AFLCR 375-3.[193] These were:

1. Engineering Data
2. Procurement

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191. Ltr, Hq AFLC to ASD, subj: C-141 Transition Plan Between AFSC and AFLC, 25 Oct 67, w/1 atch, subj: Transition Agreement Between AFSC and AFLC for the C-141A Weapon System, 1967, (subsequently cited as C-141 Transition Agreement), SD II-59.
192. Ibid.
193. Ibid.

Further the agreement established the method of the transfer and identified what specifically was needed to provide program continuity.

(U) While the effective date for the transfer from AFSC to AFLC was 1 March 1968, the confirmation of the transfer and the realignment of responsibility at the Headquarters USAF level did not come until 5 March 1968. On that date Headquarters USAF issued a System Management Directive, Directive Control Number SMD 8-206-476L(4)-(C-141A),[194] which had a stated purpose to:[195]

1. Terminate ". . .the applicability of the AFR 375 series of regulations for the development and acquisition of the C-141A system program."

2. Direct ". . .the phased transition of primary Air Force systems responsibility for the C-141A from AFSC (ASD) to AFLC (WRAMA) effective 1 March 1968, in accordance with the AFSC/AFLC Transition Agreement for theC-141A Weapon System."

3. Confirm ". . .the system management and engineering responsibilities identified in the AFSC/AFLC Transition Agreement and Engineering Transfer Package."

The directive further established 2 April 1968 as the transfer date of primary C-141 responsibility from the DCS/Systems and Logistics to the DCS/Plans and Operations at Headquarters USAF.

MAC Function Transfer

(U) With the above actions the C-141 management responsibility for the Operational Phase of the system Life Cycle was completed except for the

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194. SMD, DAF, subj: SMD 8-206-476L(4)-(C-141A), 5 Mar 68, SD II-60.
195. Ibid., p. 1.

Headquarters MAC (using command) functions.[196] At Headquarters MAC, in accordance with Headquarters Operating Instruction (HOI) 375-1,[197] the C-141 management responsibility was transferred to the DCS/Materiel. Specifically, and in line with the transfer to Headquarters USAF DCS/Plans and Operations and AFLC's Warner-Robins Air Materiel Area, the responsibility was transferred to the DCS/Materiel's Directorate of Maintenance Engineering (MAMME). This transfer was accomplished by letter between the Headquarters DCS/Operations Directorate of Operational Requirements (MAORQ) and MAMME.[198] As it was in the case of the WRAMA personnel, the MAMME personnel also had long been associated with the C-141 Program; hence, the management continuity at Headquarters MAC was also not broken. From the 1 March date through 30 June 1968 little was perceptible that would indicate that major changes had been made in the C-141 Management Program. This fact reflected well on the USAF system management programs and the implementation of the C-141 program at the working levels of the SPO and MAC.

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196. For details of the realignment of functions for the Operational Phase see pp. 5-12, this volume.
197. HOI 375-1 is SD II-15, this volume.
198. Memo of Agreement, MAODC and MAMDC, subj: Transfer of Responsibility for C-141 Program, undated (circa Mar 68), SD II-61

CONCLUSION

(U) The C-141 has been operationally proven for the mission for which it was designed. Its value to the national defense posture, especially during the Southeast Asia Contingency, is certainly that which was envisioned by its early proponents. These facts alone give testimony to the sufficiency of the Starlifter developmental program. For it was this program which assiduously demanded high standards of performance through arduous test, update, and correction of the weapon system and its subsystem. Further, this program tested all the components and the system in the endeavor to prove design soundness, airworthiness, subsystem adequacy, and finally operational suitability. At all stages a myriad of problems were encountered and as many solutions were devised and incorporated into the aircraft. Hence, today, as the Starlifter performs in the stellar role as the backbone of the Military Airlift Command, it is the result of the men and their intellects, perseverance, and certainly travail that provided MAC with a sound aircraft.

(U) If one accepts the premise that the Starlifter itself is the proof of the adequacy of its development program, then what more can be said about the program? The answer lies not in the fact that the program was sufficient, but more in the challenges met and surmounted by the personnel actively engaged in each program phase. One must ask how did they meet their challenges? With our hindsight can we develop a better way to resolve these problems?

(U) The material to answer these questions is contained in Part I of this study and the foregoing portion. Part II especially is a historical

synthesis; that is, it depicts the major elements or phases of the C-141 Program and pulls them together in one section of this study, along with major program documents, so that the reader may observe the program as a whole. Thus, it should enable him to realize the impact of each phase, or phase grouping, upon that whole.

PART III

DEFICIENCIES AND MODIFICATIONS

(1965-1971)

> "I think a concurrent system, if you're not pushing the state of the art as far as the weapon system is concerned, is the only way to go. . . . This does not mean that you're not going to have to live with your NORM, NORS, and cannibalization rates (and we're experiencing the same kinds of thing now in the C-5); but if you have a concurrent program, you can put the weapon system into operational use, I would say, two to three years faster than you can by going the prototype route."[1]

INTRODUCTION

(U) The above positive viewpoint depicts the so-called Concurrent Acquisition and Test philosophy, which was applied to the C-141 program. This philosophy called for the entry of the aircraft into the operational force prior to the end of the category II test program[2]

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1. Transcript, Tape Intvw with Col George M. Wentsch, Cmdr, 443 MAWg (HQ MAC C-141 Program Mgr, 1963-1965), by Walter L. Kraus, Historian, HQ MAC (subsequently cited as WLK), subj: C-141 Program, 16 Mar 72, p 15 (CSEH Tape Intvw #4, USAFCHO Oral History Program) (subsequently cited as Wentsch Intvw), Sup Doc III-1; briefing slide, HQ MAC, subj: C-141 Concurrency [circa 1965], Sup Doc III-2.
2. For details of the category II test program, see study (U), MAC, The C-141 Starlifter (subsequently cited as C-141 Study), II, May 69 pp 57-66.

and the beginning of the category III test program.[3] "The rationale for these circumstances was that the weapon system force could become productive sooner and that the use of aircraft in the operational environment would enhance the system evaluation processes."[4] Of course, placing the aircraft into the operational environment prior to full component test and certification led to many component failures during the operational phase of its life cycle. Since application of this philosophy placed a strain on the logistic systems (because many untested or incompletely tested components failed prior to the programmed mean-time-between-failures), the philosophy had as many opponents as it had adherents. For instance, in contrast to Colonel George M. Wentsch's laudatory statement,[5] Colonel Willum H. Spillers, the first MATS[6] C-141 Program Manager stated:[7]

> It hurts us from the standpoint that we have a very expensive retrofit-type program, because you are going to find problems with the system. We just don't have that clear crystal ball to design an airplane perfectly from the start. We bet on rolling sevens or elevens every time we pick up the dice and we know that just doesn't happen. So when we have a problem, it takes about two years to crank in a fix and get it retrofitted into the fleet, or in a lot of cases, even have it available.

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3. For details, see C-141 Study, II, pp 67-83.
4. Ibid., p 57; hist (S) , MAC, 1 Jul 65-30 Jun 66, I, pp 161-162.
5. Opening quotation, this chap.
6. MATS renamed MAC on 1 Jan 66.
7. Transcript, Tape Intvw with Col Willum H. Spillers, Cmdr, C-5 Joint Task Force (C-141 Program Manager from 1959-1963) and Lt Col Everret A. Chambers, C-5 Program Officer, JTF (formerly asst to Col Wentsch in the C-141 Program), by WLK, subj: C-141 Program, 1 Mar 72, p 20 (CSEH #1, USAFCHO Oral History Program) (subsequently cited as Spillers-Chambers Intvw), Sup Doc III-3.

THE DEFICIENCIES

(U) The deficiency volume was large and consequently the attendant maintenance man-hour costs were also large. By the end of Fiscal Year 1971 (approximately seven years after the aircraft was assigned to MATS),[8] the C-141's had 1,300 time compliance technical orders (TCTOs) issued to ascertain, stabilize, or correct deficiencies. While this volume was large, it was comparable to those of other aircraft programs. Experience has shown that most "hardware" development programs encounter a similar phenomenon. For instance, by 15 July 1969 the B-52 program (A through H models), after 14 years of operation, had 2,000 TCTOs issued against its material problems,[9] while the C/KC-135 program issued 1,084 TCTOs after 13 years of operation (by 15 June 1969).[10]

(U) Although the TCTO level was not extraordinary, the fact that the C-141 program accumulated the 1300 plus TCTOs in such a short time (October 1964 to 30 June 1971) was extraordinary. The rapid accumulation is certainly attributable to the concurrent philosophy.

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8. The C-141 first entered a MATS unit on 19 Oct 64. This unit was the 443 MAWg, which is the MAC Transitional Training Unit. The first operational unit to receive the C-141 was the 60 MAWg, which received its C-141 on 23 Apr 65.
9. Intvw with Harry James, CH B-52 Tech Services, Directorate of Materiel Management, Oklahoma City Air Materiel Area (OCAMA), Air Force Logistics Command (AFLC) by Kenneth L. Patchin, OCAMA Historian, 15 Jul 69 (by request from WLK).
10. Rpt, RCS: DO 47-221-Ji, OCAMA, subj: Tech Order Status Rpt C-KC-135, 14 Jun 69.

However, the intense use of the Starlifter should also be considered since the force had accumulated 2,862,968 flying hours by 30 June 1971, a figure that far exceeded those acquired by other USAF aircraft in a similar timeframe.

(U) The above was not the only problem that afflicted the C-141 development program. Some of the problems, especially the aircraft's landing gear and airframe defects, were caused by inherent design weaknesses. Unlike commercial passenger transports " . . . the military aircraft has to accommodate great size, as well as great weight."[11] In addition, the military transport often " . . . must also incorporate characteristics and features not consistent with optimum aerodynamic design."[12] A typical example of the latter, in the C-141 system, was the incorporation of the troop and cargo aerial delivery system.[13] Not only did the aerial delivery system (ADS) develop difficulties, its use also contributed to airframe problems, specifically stresses and strains on the petal doors and aft fuselage. Nevertheless, the addition of the ADS also gave the aircraft an enhanced capability. This capability was not necessarily requested by MATS and " . . . it was not the passionate demand of the Army that got it there . . .",[14]

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11. Student Research Rpt No. 155, Stringer, Lt. Col Elbert G. and Wentsch, Lt Col George M. (Industrial College of the Armed Forces - Resident School, Class of 67), The C-141 Aircraft: A Case Study in Decision Making from Conception through Selection, 31 Mar 67, p 8, Supplement III-1.
12. Ibid., p 8.
13. Ibid.; also see pamphlet, Lockheed Corp, subj: C-141 General Arrangement (subsequently cited as C-141 Arrangement), [circa 1963], Supplement III-2.
14. Hist Summary, HQ USAF, subj: History of the C-141 (SOR 182) Project [circa 1963], p 14, Sup Doc III-4.

but apparently the Army considered the airdrop capability as an enhancement of the aircraft's capability. In addition, " . . . they were convinced that it was a by-product of the design which called for truck bed height and straight-in loading."[15]

(U) Whether it was more important to have a weapon system two years earlier or whether it took two years to incorporate a fix into the aircraft is not germane to this study; the C-141 did encounter myriad difficulties that probably would not have occurred if the aircraft had been fully tested. This study examines these difficulties, that is, subsystem and component failures, with the attendant deficiency correction and fix development. The problem and problem-resolution approach to the C-141 system, the third part of the C-141 trilogy,[16] is believed to be the proper course in depicting the complete history of a USAF weapon system.

(U) One further note--it should be understood by the reader that despite its difficulties, the C-141 is considered a good aircraft by the Military Airlift Command (MAC) aircrews and support personnel. In retrospect, we find C-141 program pioneers such as Colonel Willum H. Spillers stating, "I think that the airplane performs extremely well and meets all criteria. It was the first time we really had an airplane that had all the thrust and power that it required."[17] Further, Lieutenant Colonel Everret A. Chambers, another early C-141 program

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15. Ibid.
16. Part I of the C-141 study covers a summary history of the aircraft, while part II describes the weapon system's management program.
17. Spillers-Chambers Intvw, p 9.

participant, said, "I think it's proven that we have got a good airplane,"[18] and Colonel George M. Wentsch remarked that the C-141 is " . . . very, very successful as far as the cargo and the people are concerned for the airborne division."[19] The former MAC C-141 Program Manager, however, further state, " . . . the only real deficiency that the 141 had was that it was not the right size," which he qualified by stating, " . . . as far as the general cargo use of the aircraft . . . ."[20]

(U) To be sure, after Fiscal Year 1968, very little can be found in the MAC histories concerning C-141 system achievements or failures. While in previous MAC histories many deficiencies are recounted, they are always tempered with facts indicating that the C-141 did indeed perform well. In fact, it can be safely stated that MAC's contribution to the war effort and other Department of Defense airlift tasks during the 1965-1971 period could not have been achieved without the rapid acquisition of the C-141 Starlifter.

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18. Ibid., p 16.
19. Wentsch Intvw, p 21.
20. Ibid., pp 20-21. For aircraft configurations, see MAC Manual 55-4, MAC DCS/Ops, subj: C-141 Configuration/Mission Planning Manual, 17 Sep 1971, Supplement III-3.



Lt General William H. Tunner
MATS Commander 1958-1960
Tunner was a "key figure" in
C-141 development.

"There are two major factors which govern the structural life of an aircraft: exposure to stresses, which induce fatigue damage, and corrosion."[21]

STRUCTURAL PROBLEMS

(U) Cognizant of the above, the planners for the C-141 program used existing programs and designed new procedures to test the aircraft's ability to meet its design criteria. Therefore, the " . . . structural test program [included] alternate load testing on the complete airplane and all major components such as landing gears, radomes, and pressure doors."[22] Generally the above comments by Lockheed's Assistant Chief Engineer referred to the Air Force Aircraft Structural Integrity Program (ASIP), which had its roots in a USAF directive to the Air Research and Development Command (ARDC).[23] This

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21. Background Paper (U), MAC DCS/Ops, subj: Expected Service Life of C-141, 18 Feb 71, p 1, Sup Doc III-5.
22. News Release (U), F.A. Cleveland, Engineer in Charge of C-141 Engineering Program, Lockheed-Georgia Company, subj: C-141 Design Philosophy - All Technological Advances of Starlifter Thoroughly Proven During Aircraft's Development, p 3, Sup Doc III-6.
23. Now the Air Force Systems Command (AFSC).

directive called for a program that was designed to obviate a rash of fatigue failures that plagued the B-47 and B-52 fleets during the late 1950s. The program was given impetus by a February 1959 message from General Curtis E. LeMay,[24] Commander Strategic Air Command (SAC), to ARDC, which called for the following three-point program:[25]

1. Control structural fatigue in the operational aircraft force.
2. Develop methods to accurately predict aircraft service life.
3. Provide the design knowledge and test techniques to avoid structural and sonic fatigue problems in future weapon systems.

(U) The C-141 program consequently included an ASIP which was based on the 30,000 flight-hour, 12,000 landing, and 20,000 pressure-cycle design-life of the aircraft (later reduced to 8,000 cycles). In order to verify these criteria, the C-141's ASIP called for a test factor of four lifetimes. The sections to be tested (or test articles) were as follows:[26]

1. Wing and fuselage section.
2. Wing and mid fuselage.
3. Aft fuselage and empennage.
4. Main landing gear (MLG) support structure.
5. Nose landing gear (NLG) support structure.

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24. General LeMay was the Air Force Chief of Staff from 30 Jun 61 to 31 Jan 65.
25. Background Paper (U), HQ MAC, subj: Aircraft Structural Integrity Program (ASIP) [circa Apr-May-or Jun 1966], Sup Doc III-7.
26. Study (U), HQ MAC, subj: C-141A Fatigue Test and Service Life History Program, pp 1-2, Sup Doc III-8.

Originally the C-141 ASIP program was not so ambitious; it called for only a test factor of two lifetimes. However, major failures experienced during that first test showed the necessity to establish a program for a test factor of four lifetimes. Hence, in 1965 the C-141 System Program Office (SPO) requested a four-lifetime program citing the test failures and noting, "It has been found over a period of years that service fatigue failures may occur much earlier than predicted by the fatigue test."[27]

(U) Systems Management Directive 7-138-476L (3) - C-141A, dated 5 April 1967, authorized the four lifetime factor test, which was to include the following:[28]

Test Article	Life Cycles
Complete fuselage & wing less tail and landing gear	4
Wing and mid fuselage section	2
Tail section and aft fuselage	4
Main landing gear and center fuselage	4
Nose landing gear	4

The program was carried out successfully and by February 1971 it was established that, with the incorporation of certain TCTOs and the

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27. Ltr (U), C-141 SPO to AFSC, subj: Program Change - Extension of C-141A Fatigue Testing to a Factor of Four (4), 4 Nov 65, w/1 atch, Study, Sup Doc III-9. For definition of SPO as understood in the early 1960s, see C-141 Study, II, p 22.
28. Ltr (U), C-141 SPO to AFSC, subj: C-141 Fatigue Test Program Funding Requirements, 20 Aug 68, w/1 atch, Prog Chg Study, Sup Doc III-10. (The program is scheduled to continue through 1975.)

lowering of daily aircraft utilization rates during 1971,[29] the aircraft had a remaining life of 13.4 years and would remain effective through 1983.[30]

(U) A sub-program of the ASIP was the Lead-the-Force (LTF) program. The concept of this program was to fly some aircraft the equivalent of two years of flying hours in advance of the force. Other aircraft were to be exposed to landings and takeoffs in advance of the force. This flying hour and landing acceleration was to pinpoint fatigue problems prior to occurrence on the main force and hence allow time for preventive retrofit.

(U) Apparently, at first, neither the SPO nor MAC had a Lead-the-Force plan; however, after a briefing to the Air Staff on the total C-141 program, MAC personnel devised a Lead-the-Force plan. One MAC officer recalled the program genesis as follows:[31]

> Initially . . . the original requirement for Lead-the-Force was a reaction to a briefing of the Air Council or the Air Staff before briefing one of the Secretaries of the Air Force on the C-141 program and a young two-star general named Catton asked, "Do you have any plans in your 141 program similar to the B-52 Lead-the-Force Program?" We very ashamedly said, "No," and a week later we had one. That's where it started.[32]

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29. At one point during the Southeast Asia (SEA) Conflict the C-141s were flying an eight-hour utilization rate. During FY 71 the utilization rate was dropped to 4.75 hours, primarily because of SEA Conflict phasedown.
30. Talking Paper (U), MAC DCS/Ops, subj: Expected Service Life of C-141, 18 Feb 71, Supplement III-4.
31. Spillers-Chambers Intvw, p 15.
32. General Jack J. Catton has been the MAC Commander since 1 Aug 69; however, during the above events he was a major general and assigned to HQ USAF as DCS Programs and Requirements.

(U) The circumstances recounted above seem to be substantially correct because in a letter commenting on the LTF section of C-141 Study, part II, a former C-141 SPO[33] stated:[34]

> It is not believed that the initial LTF investigation was called at WRAMA as stated in the last two lines of page 85. In reality, subsequent to General Catton's request during a DSMG, your Major Wentsch (now Col) prepared (at the SPO's request) an initial draft plan with the assistance of Mr. Vic Morris, MAC Maintenance Engineering. This draft was then reviewed and revised within the C-141 SPO, subsequent to which all other concerned agencies were called in.

(U) Despite the above comments, apparently at least one MAC officer thought a Lead-the-Force plan would be requested at the briefing to the Air Staff. Colonel Charles D. Craig, commander of the MATS detachment assigned to the C-141 SPO, in a 16 October 1964 memorandum to MATS stated,[35] "There is little doubt that MATS and the C-141 SPO will receive instructions from the Air Staff to prepare a plan and conduct a 'Lead-the-Fleet' program as was conducted on the B-52 aircraft by SAC." From this juncture Colonel Craig recommended an LTF program for the C-141. The concept, however, was not accepted by all MAC staff personnel without opposition. Some staff officers felt

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33. Colonel Elbert M. Stringer was the C-141A Systems Staff Officer in HQ USAF. See p 1, Teaching Notes (following p 44) of Supplement III-1.
34. Ltr (U), C-141/C-130 SPO to MAC, subj: C-141 Study - Vol II, 22 Sep 69, Sup Doc III-11.
35. Memo (U), Col Charles D. Craig, Jr., Cmdr Det 18 (MATS) C-141/463L Materials Handling SPO to Col William W. Thomas, Requirements Div, MATS, DCS/Ops, subj: Thoughts on "Lead-the-Fleet," 16 Oct 64, Sup Doc III-12.

that the C-141 was being overtested; hence, they objected to the acceleration program. One of these officers commented in the following manner:[36]

> In summation, we feel that the current static fatigue testing, category I, II, and III testing and the normal field and depot maintenance programs will give us sufficient data to maintain the C-141. We also feel that a planned LTF program will be difficult to manage and the results may be less than desired.

Later events, of course, proved that at least some of the negative comments, especially those concerning the difficulties in administering such a program, were correct.[37]

(U) At the 20-21 October 1964 SPO/MATS/Air Force Logistics Command (AFLC) Conference, held at the Warner Robins Air Materiel Area (WRAMA), the conferees decided to initiate an LTF feasibility study. Later, on 29 October 1964, HQ USAF requested that the Air Force Systems Command (AFSC) conduct this study.[38] However, prior to the USAF request, Colonel Mahlon (Max) B. Hammond, the C-141 SPO, had been informed that Air Force was very interested in an LTF plan for the C-141. Hence, the SPO had already initiated an analysis of LTF in the total program structure.[39] By 13 November 1964, the

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36. Draft Position Paper (U) [attributed to Maj M. J. Ansboro, a knowledgeable former HQ MAC Materiel officer, by his contemporaries], subj: LTF Program [circa Nov 64], Sup Doc III-13.
37. See C-141 Study, II, pp 85-89.
38. Msg (U), CSAF to AFSC, 282339Z Oct 64, Sup Doc III-14.
39. Memo (U), Col M. B. Hammond to Aeronautical Systems Div (ASD) Organizations, MATS, and WRAMA, subj: Discussion with Don Bussey and Col Christenson Relative to "Lead the Fleet" Planning, 26 Oct 64, w/1 atch, Agenda for "Lead-the-Fleet" Conference, WRAMA, 20-22 Oct 64, Sup Doc III-15.

program participants agreed to conduct an LTF program; the Air Staff was so briefed on 20 November; and on 25 November 1965 General Howell M. Estes, Jr., MATS Commander, directed MATS DCS/Operations to prepare an LTF plan.[40]

(U) In addition to the static fatigue tests and the LTF program, the C-141's airframe was closely scrutinized during the category I, II, and III tests. Therefore, the C-141 structure became one of the most thoroughly tested in the history of the United States Air Force. The stated goal of this rigorous testing schedule was to provide MATS with " . . . a highly refined transport aircraft requiring little maintenance . . . ."[41] These test programs and operational experience brought to light several difficult Starlifter structural problems. While some of these difficulties bordered on catastrophic failures or engendered strongly diverse opinions among the participants, others were discovered routinely and corrected prior to becoming difficult problems.

(U) Probably the most dramatic and also the most serious of the Starlifter's deficiencies was the explosive decompressions caused by the failures of the cargo ramp, pressure, and petal doors. These failures and the ensuing explosive decompressions created serious incidents.[42]

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40. C-141 Study, II, p 87.
41. News Release (U), HQ MATS, subj: MATS C-141 Receiving Rigorous Tests, 3 Jun 65, Sup Doc III-16.
42. Three C-141s were lost due to accidents on 7 Sep 66, 23 Mar 67, and 12 Apr 67. The first was caused by aircraft design deficiency, while the other two were caused by operator error. No other Starlifters became total losses. For details of above, see C-141 Study, I, pp 42-43.

CARGO RAMP, PRESSURE AND PETAL DOORS

(U) Loss of pressurization or the threat of the loss of pressurization created much consternation and a large workload for MAC and other personnel assigned to the C-141 program. The defect that caused the most concern was the inflight, explosive opening of the large pressure door in the aft cargo compartment. This large square door, when it opened or leaked, would release the pressurization from the cabin, which subsequently could and sometimes did cause an explosion from the outrush of the pressurized air. When this happened, the pressure door could break loose and smash against the petal doors, breaking them open.[43] This of course would create a great outrush of air which could possibly suck equipment and even personnel out of the aircraft. In addition, the loss of pressurization would create an immediate need for oxygen, further endangering personnel.

(U) The first problem that was noted concerning the aft door complex occurred in August 1963 (on aircraft 6000) after the beginning of static fatigue tests. During pressurization test, " . . . to ultimate pressure . . .," the ramp door hinge failed.[44] Repairs were made and in October the test was satisfactorily completed. A pressure door-to-ramp attachment point on the Fatigue Test Specimen C (the aft fuselage and empennage) failed during fatigue tests in October

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43. For illustration of Cargo Ramp, Pressure and Petal Door Complex, see C-141 Arrangement, Supplement III-2, p 7.
44. Hist (S), MATS, Jul-Dec 63, p 42.

C-141 petal door opened, showing cargo ramp and pressure door.

1965. This failure of the 3F41616 hook support fitting occurred at 11,257 cycles of a 40,000 cycle program.[45] Subsequently, repairs were made and the tests were continued.

(U) Since the above defects were either corrected or occurred beyond one simulated lifetime and fixes were in preparation, the first pressure door explosive decompression was unexpected. This first incident occurred on 10 July 1966 while a 437 MAWg crew from Charleston AFB, South Carolina, was performing a local training flight on C-141 serial number (SN) 65-220. As the aircraft climbed through 19,000 feet at 280 knots indicated air speed, an explosive decompression occurred.[46] The decompression resulted from an

> inadvertant release of the pressure door as a result of failure of the pressure door ramp latches. The door rotated about its upper hinge line and slammed into the loft structure. Immediately following the pressure door movement, all petal door hinge fittings tore loose from their positions on the sloping longerons and the petal doors left the aircraft.

Along with the loss of the petal doors, considerable damage to the secondary structure in the loft area[47] was experienced. Despite the obvious danger of 300 pounds of metal doors dropping 19,000 feet to the ground which could have resulted in unfavorable publicity, local newspaper coverage was helpful in the search for the doors.[48]

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45. Rpt (U), RCS: 13-AFSC-R32, C-141/Materials Handling SPO, subj: Management Summary - C-141 Program (subsequently cited as C-141 Mgt Sum), 22 Oct 65, p 5-1.
46. C-141 Mgt Sum, 15 Jul 66, pp 5-1 thru 5-2, Sup Doc III-17.
47. Loft area: structure on ceiling aft of the pressure doors popularly called the "hay loft."
48. "CAFB Starlifter Loses Two Doors on Local Flight," Charleston News Courier, 11 Jul 66, p 1-B, Sup Doc III-18.

(U) As a result of the decompression incident, TCTO 1C-141A-1111 was issued five days later. This TCTO called for the inspection and the correct alignment of pressure door hooks. In addition, an operational supplement was issued to TO 1C-141A-72-21, which gave instructions for alignment checks of the pressure door hooks. TO 1C-141A-2-2 was developed in the spring of 1966 after an extensive SPO/Lockheed-Georgia study of door rigging procedures. This study was undertaken because of several unsatisfactory reports (URs) and other reports citing failure of latch mechanisms. Nevertheless, an inflight incident did not occur until the aforementioned 10 July 1966 explosive decompression.[49]

(U) By August 1966 evaluations led to the issuance of three more TCTOs. The first of these was TCTO 1C-141-1130, which required the redesign of the cargo door mechanism and indication system;[50] the second, TCTO 1C-141A-1146, was the installation of visual inspection windows for the pressure door seals.[51] The third, TCTO 1C-141A-1131, was a redesign of the pressure door actuation and indicator system.[52] The kits for these TCTOs were scheduled for delivery to the field organizations commencing in January 1967, and production aircraft

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49. Rpt (U), RCS: LOG D-20, HQ WRAMA, subj: C-141A System Support Program (subsequently cited as Log D-20 Rpt), 15 Aug 66, pp VII, VIII-14.
50. Log D-20 Rpt, 15 Sep 66, pp VII, VIII-8.
51. Ibid., 10 Oct 66, pp VII, VIII-8.
52. Ibid.

SN 66-126, delivered in November 1966, had the modifications incorporated. By November 1966 the problems seemed identified and corrected; nevertheless, as a precautionary measure, MAC issued Safety Supplement 1C-141A-2-2SS-5 which clarified rigging instructions.[53]

(U) This safety supplement proved to be a harbinger of the difficulties that lay ahead. The next incident occurred on 15 January 1967 when SN 65-230 experienced an explosive decompression while climbing to its assigned altitude. This aircraft, carrying 96 soldiers to Southeast Asia, experienced the incident 30 minutes after takeoff from the Wake Island refueling stop.[54]

(U) Accident investigations showed that the pressure door had rotated into the aft loft area and the petal doors were missing. Also noted was that nine of the 13 latching hooks were loose; hence, the investigators deduced that either the latches had broken or that they had not been secure. This latest accident brought attention to the real possibility that people or cargo could be sucked out of an aircraft; the first preventive action was to develop and install a net in front of the pressure door. In addition, all passengers were informed that seat belts would remain buckled. Other operational instructions were:[55]

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53. Hist (S), MAC, Jul-Dec 66, I, p 87.
54. The pressure and petal doors had not been opened during refueling stop because the aft pallet was loaded.
55. Hist (S), MAC, Jul 68-Jun 69, II, pp 66-68; hist (S), MAC, Jan-Jun 67, I, pp 149-150.

1. Pressure differential was not to rise above 7.3 pounds per square inch (PSI). The former allowance had been 8.6 PSI.

2. Personnel transportation mission aircraft could not fly above 33,000 feet.

3. For aeromedical evacuation missions 29,000 was the limit.

4. Cargo missions were not to exceed 39,000 feet.

The incident prompted an intensified concern over these pressure door openings. The problem appeared so important that it was discussed at a MAC Commanders Conference, as follows:[56]

> The aft door system is intolerant of less than perfect adjustment. The complexity of this system coupled with the lack of fail-safe features results in incompatability with flying safety and maintainability standards.

At this conference the MAC Materiel people further stated that it was believed that the following remedies would help:[57]

1. Establish . . . sufficient redundancy to the existing latches to guarantee that the system is fail safe.

2. A shoe-tree device has been developed and is being produced for use as an interim expedient to apply aft force on the pressure door and assure pressure door hook contact with the stirrups. This should assure that the hooks remain locked during taxi, takeoff and climb.

3. Several proposals for pressure latching devices are being considered.

4. In addition to the interim actions, an engineering review of the entire aft door latching system is being conducted. The objective of this review is to provide a system that will preclude the possibility of inflight failure. Simplicity for maintenance and operation are important considerations in the modification of this system.

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56. Talking and Background Papers to MAC Commander's Conference (U), COLD TEA, 1-4 Mar 67, DCS/Mat, subj: Background Paper on C-141 Pressure Door System, pp 2-56 - 2-57.
57. Ibid.

Pressure Door Fixes

(U) The second incident led to intensified efforts to identify the problem areas. Studies in search of a structural modification were being conducted by Lockheed-Georgia, the Air Force Systems Command (AFSC), and Air Force Logistics Command (AFLC) engineering personnel. In addition, a MAC C-141 Operational Evaluation Staff (OES)[58] reported that there were " . . . nineteen (19) separate delaminations . . ." on the pressure doors which required replacement at WRAMA.[59] In fact, during the first five years of operation, MAC " . . . had considerable problems with honeycomb delamination."[60] However, a change of door manufacturer and better quality control eventually corrected the problem.[61]

Pressure Door Lock Modifications

(U) The major effort, however, was expended in interim fixes " . . . to insure safety until a redesigned latching system [could] be formulated and incorporated."[62] These four Engineering Change Proposals (ECP) were as follows:[63]

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58. The OES was the C-141 Operational Evaluation Staff, Detachment 12, HQ MAC, stationed at Travis AFB, CA. This organization was formed on 15 Jul 66 to monitor problem areas identified during Cat III testing.
59. Rpt (U), OES, subj: OES/LTF Monthly Activities Rpt (subsequently cited as OES/LTF Rpt), Jul 67, p 2.
60. Transcript, Tape Intvw with Mr. Victor E. Morris, Ch, Jet Engine Br, Dir Maintenance-Engineering, DCS/Logistics, HQ MAC, subj: C-141 Program, 23 May 72, p 24 (CSEH Tape #6, USAFCHO Oral History Program) (subsequently cited as Morris Intvw), Sup Doc III-19.
61. For details see hist (S), MAC, 1 Jul 65-30 Jun 66, p 173.
62. OES/LTF Rpt, Mar 67, pp 21-22.
63. Ibid.

1. ECP-729 (TCTO 1C-141A-1146). Installation of a visual means to inspect pressure door seals.

2. ECP-780-1 (TCTO 1C-141A-1185). Installation of camjacks (which had been designed by the 437 MAWg). The jacks were designed to hold the pressure door in the aft position with hooks engaged to the stirrups until the aircraft was pressurized.

3. ECP 780-2 (TCTO 1C-141A-1186). Redesign and installation of the pressure door electrical control circuit with an additional relay, relay socket, and diode. A second part of the ECP replaced the pressure door actuator attach fitting with one having thicker lugs.

4. ECP 780-3 (TCTO 1C-141A-1186). Installation of a set of seven restraint links mounted on the forward side of the door which attach to the aft row of cargo ramp tie-down fittings. These links were to function as a secondary lock system to restrain the door in the event the primary latching failed in flight.

Lockheed field teams completed ECPs 780-2 and 780-3 in the spring of 1967, while MAC maintenance units installed the first two ECPs.

(U) Meanwhile, WRAMA was investigating the pressure door seals. They found that the seal could double back under the door and cause the latches to hook on the seal and, hence, not lock. Therefore, a 22 May 1967 message (WRNHTA 73073) cited adjustment of the lower pressure door seal as a necessary door closing function.[64]

(U) By mid-1967 the WRAMA weapon system manager (WSM) was able to report that, "Due to the modification of the pressure door locking system plus the incorporation of auxiliary restraint latches, an acceptable level of reliability and maintainability has been attained."[65]

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64. OES/LTF Rpt, May 67, p 22.
65. Log D-20 Rpt, 15 Jun 67, p VII & VIII-8.

However, the above statement was premature, because by the end of Calendar Year (CY) 1967, WSM reported that, "Interim changes have been made to the system and in addition a back up strap locking device has been incorporated on all aircraft."[66] As noted in Tables I and II, the interim fix provided an in-depth redundancy.[67]

Pressure Door Final Fix

(U) After the January 1967 decompression the SPO, WSM, MAC, and Lockheed began directing efforts toward developing a final fix for the problem. A strong impetus was given to the development of a final fix by the January accident report. It read, in part: "This accident was clearly due to a design deficiency. Many USAF agencies share responsibility for the primary cause."[68] By July 1967 Lockheed had developed the final fix (ECP 780-4) and it had been staffed by MAC and WRAMA. However, due to a controversy between Lockheed and the Air Force over responsibility for the modification and subsequent reimbursement to Lockheed, the fix was held in abeyance.

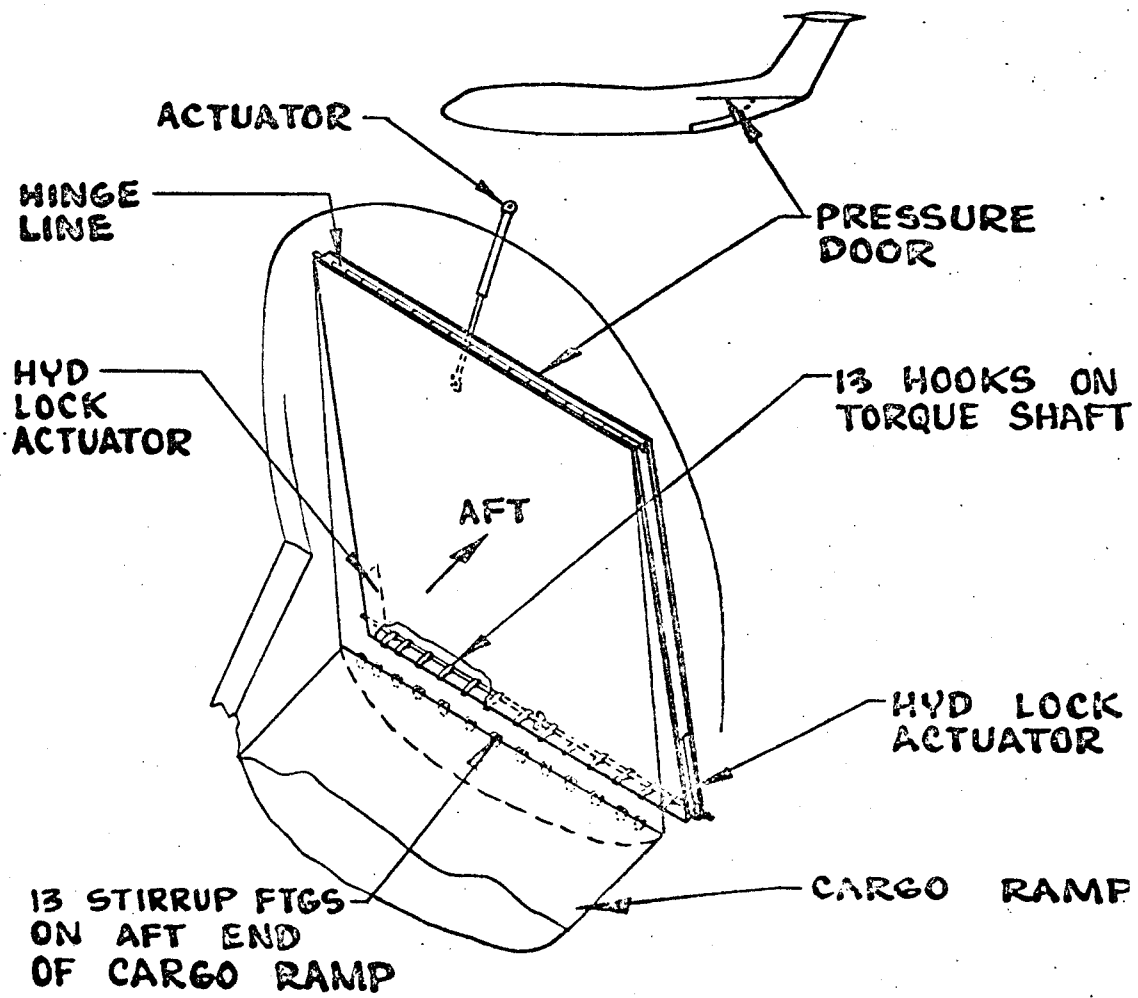
(U) The final fix, however, did show promise; it consisted of:[69]

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66. Ibid., 31 Dec 67, p 52.
67. Tables I and II provided by MAC DCS/Logistics.
68. 5th Ind to MAC IG ltr, 3 Feb 67, subj: Report of Major Aircraft Accident, C-141A, SN 65-230, 16 Jan 67.
69. Log D-20 Rpt, 26 Jan 68, p 52.

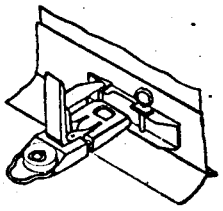
TABLE I

PRESSURE DOOR SYSTEM ORIENTATION



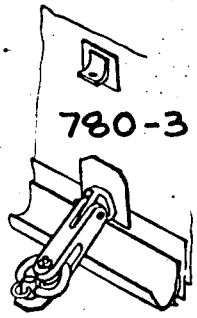
REVIEW OF THE INTERIM ECP 780-1,-2,-3 FUNCTIONS

1. 780-1 CAM JACKS POSITION & RESTRAIN PRESSURE DOOR IN AFT LATCHED POSITION WHENEVER CABIN IS NOT PRESSURIZED



2. 780-2 HYDRAULIC/ELECTRIC CHANGE ACTUATES PRESSURE DOOR AFT & RETAINS LATCHES IN LATCHED POSITION PRIOR TO INSTALLATION OF CAM JACKS (GROUND ONLY)

3. 780-3 SECONDARY RESTRAINT LINKS PROVIDE A NORMALLY UNLOADED SECOND LOAD PATH FOR PRESSURE DOOR PRESSURIZATION LOADS



1. Viewer in the seal.

2. A new hydraulic actuator locking mechanism.

3. A spring cartridge which maintains pressure on the torque shaft toward the locked position and provides a visual inspection for locked condition.

4. An improved torque shaft.

5. Redesigned hooks.

6. Improved stirrup installation.

7. A ramp guard.

The estimated cost for the engineering, kits, and installation was $4,600,000 and would require about 960 man-hours and 10 days' down time per aircraft.[70] Table III depicts the schedule programmed for the development and installation of the ECP.[71]

(U) Due to the problems and the high cost, long leadtime, aircraft downtime, and improvements provided by the interim fix in late CY 1968, WRAMA requested MAC to re-evaluate the need for ECP 780-4. A MAC analysis of the system indicated that the interim fix was adequate, safe, and reliable. In addition, the maintainability experience on the interim system showed that its reliability was such that it exceeded the projected 70 percent reduction for the final fix.[72] In lieu of the findings MAC Deputy Chief of Staff/Logistics (DCS/Log)

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70. Ibid.
71. Table III is p 53 of Log D-20 Rpt, 31 Dec 67.
72. Background Paper, MAC DCS/Log, subj: C-141 Pressure Door Locking Mechanism [circa 1969], Supplement III-6.

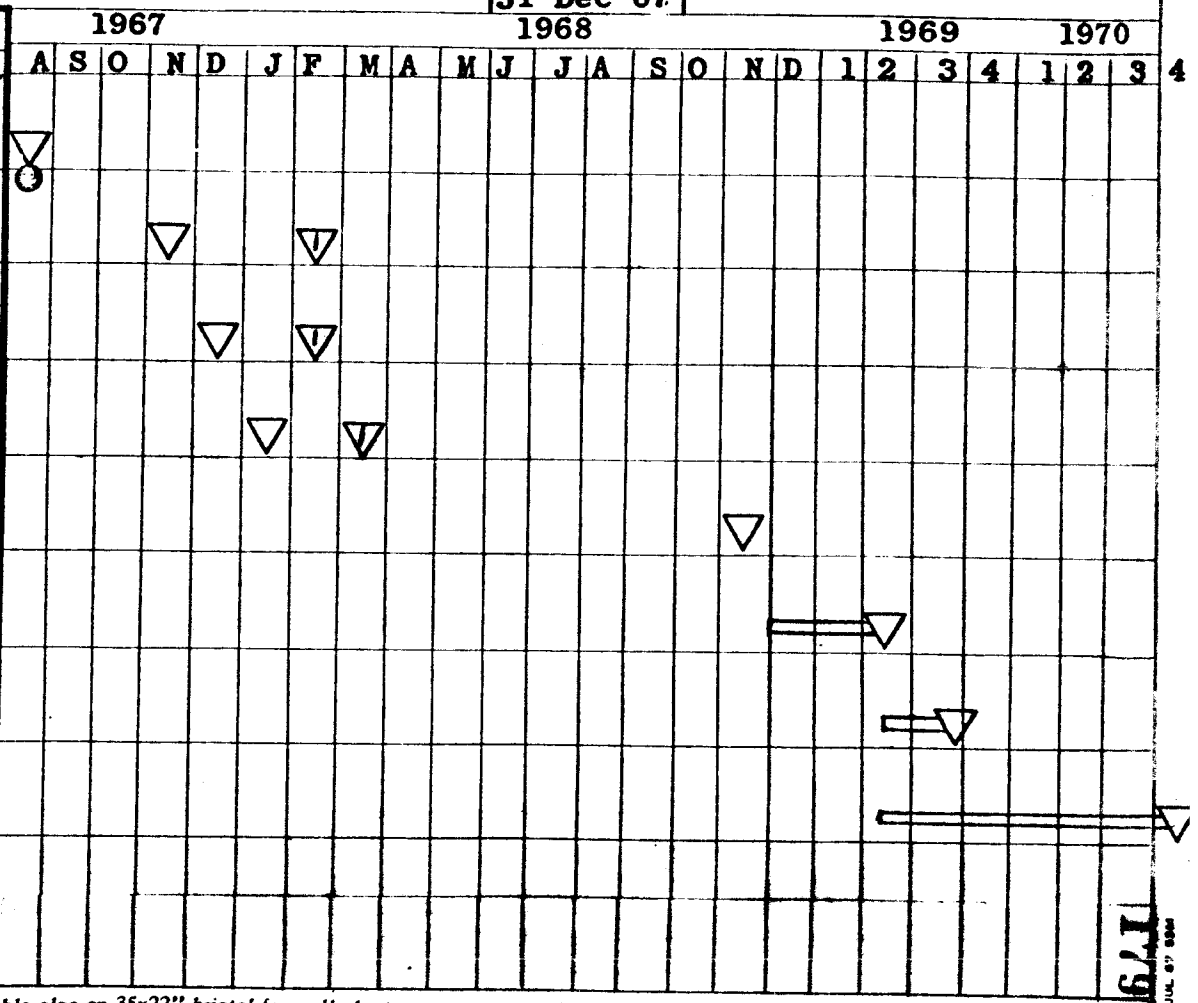
SUBJECT UNDER REVIEW

TABLE III **PRESSURE DOOR**

DATE REVIEWED: 31 Dec 67

REPORTING AGENCY & PROJECT MONITOR

NO.	MILESTONE ACTIVITIES AND EVENTS	PCT PROGRAM ACCOMPLISHED FCST	PCT PROGRAM ACCOMPLISHED ACT
1	ECP TO SPO		
2	PCR APPROVAL		
3	ECP APPROVAL		
4	CONTRACT AWARD		
5	DELIVER TEST KITS		
6	PERFORM TEST		
7	DELIVER RETROFIT KITS		
8	INSTALLATION		
9			
12			



LEGEND: *(Colors indicated for attention attraction)* *(Identical format available also on 35x22" bristol for wall chart or presentation (AFLC Form 280A).)*

ACTIVITY PLAN — EVENT TARGET *(Black outline)*

1 *(Red outline)* 2 TARGET SLIPPAGES

(Black fill-in of activity plan bar) PERCENTAGE OF ACTIVITY PLAN COMPLETED AS OF DATE OF REVIEW *(Portrays "Actual" column within heavy bordered frame above.)*

(Green) DATE COMPLETED 53 *(Place at point of event completion. Overlap triangle if necessary.)*

INSTRUCTIONS: *On the reverse side, by line number, capsule in each instance the cause for event slippage.*

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recommended that General Jack J. Catton advise WRAMA to drop further action.[73] On 29 October 1969 General Catton concurred with the DCS' recommendation and WRAMA was so advised. The WSM then agreed to allow Lockheed to complete Phase "A", consisting of two and one-half ship sets. After 19 January 1970 MAC was to install the sets and evaluate them, with the proviso that the pressure door ECP could be reopened if necessary.[74]

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73. Talking Paper, DCS/Log, subj: C-141 Pressure Door Latching Mechanism [circa 1969], Sup Doc III-20.
74. Memo, DCS/Log, subj: ECP 780-4 [circa Jan 70], Sup Doc III-21.

FUSELAGE PROBLEMS

(U) Some fuselage difficulties also plagued the Starlifter during its developmental and operational years. Among the first of these failures was the aft fuselage during ASIP testing in 1964. This section failed at 120 percent of load limits or 80 percent of the total testing.[75] Repairs were made and testing was continued without further test slippage.[76]

(U) Two other failures, however, proved to be difficult problems. These were fatigue failures at fuselage stations 351 and 1058. Each of these required extensive inspections and repairs.

Cracks Fuselage Station (FS) 351

(U) In March 1970 fatigue cracks were discovered in the FS 351 ring cap and in the pilots and copilots side windshield post number two. The failed area was approximately 13 inches above the cockpit floor in the ring cap at FS 330 in the windshield sill. Since the aircraft that sustained the original crack had not been pressurized as many times as had other in-service aircraft, the WSM issued urgent Time Compliance Technical Order (TCTO) 1C-141A-1342. This TCTO directed the immediate inspection of all C-141s with over 2,000 full-stop landings.

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75. C-141 Mgt Sum, 17 Jul 64, p 1.
76. Ibid., 24 Jul 64, p 1.

(U) Lockheed-Georgia Company (LGC) and WRAMA immediately began the development of a fix-modification kit. Prototyping was completed in June, after delays caused by changes to the original drawings; and the prototype was installed in September 1970. This kit proved successful; hence, WRAMA elected to manufacture the kits in-house, and kit installation began in March 1971 as aircraft were transferred to the depot for inspection and repair as necessary (IRAN).[77]

(U) The initial inspection efforts under TCTO 1C-141A-1342 revealed that seven of the C-141s were afflicted with the fatigue problem; hence, MAC queried WRAMA about the advisability of placing restrictions on aircraft with a high number of full-stop landings. However, WRAMA's engineering evaluation showed that a catastrophic failure was remote provided that an afflicted aircraft was not operated for an extended period.[78]

(U) Despite in-being programs to correct the problem, the recurring inspections indicated that a high-incident trend was developing. These circumstances prompted the MAC commander to establish an accelerated program of repair. This stepped-up program was to be accomplished through the added support of depot and contract field teams, which were to concentrate on the aircraft having a high number of full-stop landings. As FY 1971 drew to an end, two more of the C-141s developed cracks at FS 351, bringing the total to 28 afflicted aircraft.[79]

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77. Hist (S), MAC, Jul 70-Jun 71, I, pp 148-150.
78. Sup Doc III-7 of MAC hist, Jul 70-Jun 71, VIII.
79. Sup Doc III-8 of MAC hist, Jul 70-Jun 71, VIII.

Cracks Fuselage Station 1058

(U) During 1966 some of the older C-141s began exhibiting fatigue crackage at fuselage frame station (FFS) 1058. Concern for the development of an adverse trend began when a third aircraft developed cracks at FFS 1058.[80] This aircraft, SN 63-8075, was an LTF airplane. On 17 November 1966 MAC requested depot assistance from WRAMA. The WSM agreed and a 60 Military Airlift Wing crew with a wheels-down flight delivered the aircraft to the depot on 19 November 1966.[81] The first two aircraft, SN 63-8081 and SN 63-8083, to develop FFS 1058 problems, both assigned to the 443 Military Airlift Wing, were also placed in an investigation and corrective action status.[82]

(U) By January 1967 two more aircraft experienced FFS 1058 cracks. The first was SN 63-8079 which was at WRAMA for a landing gear pod repair, and the second, SN 63-8090, was assigned to the 436 Military Airlift Wing. Headquarters MAC then requested (message, Unclassified, MAMMEA 15617, Jan 67) expedite action " . . . to develop and incorporate a permanent fix to correct this deficiency."[83] WRAMA's evaluation of the broken parts revealed that the failures were due to stress corrosion. "The excessive stress [was] being induced by

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80. Previously two 443 MAWg-assigned C-141s developed FFS 1058 cracks.
81. Memo (U), Daily Activities Rpt, Dir Maintenance Engineering to DCS Materiel (subsequently cited as Daily Act Rpt), subj: Fuselage Frame Crack - C-141A, 18 Nov 66; Daily Act Rpt, subj: Fuselage Frame Crack - C-141A, 22 Nov 66, both Sup Doc III-22.
82. OES/LTF, Nov 66, p 25.
83. Ibid., Jan 67, pp 26-27.

the force fit of the bushing."[84] Lockheed prepared a Technical Order (TO) which was designed to reduce interference. Hence, the test program to determine stress loads was cancelled because of WRAMA's findings.[85]

(U) The January findings led to the development of ECP 773 which eliminated the interference caused by the force fit of bushing LS 3859-12-24 in the main landing gear support of the 3F 31033 frame. This ECP required the increase of the diameter of the bushing holes in the lug frame, shot peening of the inside surface of the bushing holes, and application of MIL-S-8802 sealant to the inside surface of the bushing holes before installation of the bushings.[86] Prior to closing the action on this problem another airplane, SN 63-8088 (LTF), experienced FFS 1058 cracks. This aircraft had accrued 5,943 flying hours and 2,337 landings. The latest development caused the SPO to urge Lockheed to expedite kit delivery.[87]

WING PROBLEMS

(U) Starlifter wings also presented problems during the period. Foremost among the problems were wing leading edge buckles, skin separation of flight surface trailing edges, upper wing surface corrosion, and wing center pressure shift. However, during the static tests, other problems appeared that were corrected before the aircraft entered service.

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84. Ibid.
85. Ibid.
86. OES/LTF, Feb 67, p 28.
87. Ibid., Apr 67, p 22.

(U) Among the first problems noted was excessive stress in some diagonal members in the wing and pylon. These stresses were found by static testing during the upending mode test at 120 percent of design limit load. Following the appearance of this failure during December 1964, a minor structural beefup was made and tests continued at month's end.[88] Seven months later another fatigue problem occurred in test specimen B after 9,280 simulated flight hours and 3,745 simulated landings (1,545 full-stop landings and 2,200 touch-and-go landings). These cracks appeared in the center wing section planks at the center wing/inner wing splice. The third and fifth planks from the rear spar experienced the cracks--one about one and one-half inches long and the other three-quarter inches long.[89]

(U) Since C-141s had been assigned to the MAC operational force for several months,[90] the SPO issued a recurring inspection TCTO. The TO was to begin when an aircraft reached 500 flight hours and continue at every hourly post flight inspection (every 100 hours) thereafter.[91] By October 1965 a design change was developed for the wing center section cracking problem and the repairs were made on the

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88. C-141 Mgt Sum, 31 Dec 64, p 5-2.
89. Ibid., 30 Jul 65, p 5-1.
90. The 60 MAWg (then the 1501 ATWg) received its first C-141 on 23 Apr 65. The first Starlifter in the MAC force was received by the 443 MAWg (then the 1707 ATWg), MAC's transitional training unit on 19 Oct 64.
91. C-141 Mgt Sum, 13 Aug 65, p 5-1.

test speciments. Plans were formulated for force-wide incorporation of the change.[92] On 20 November 1965 the critical wing/fuselage static test program was completed and the 150 percent of load limit was attained.[93] In fact, on 1 June 1966 the C-141 received its 100 percent structural release.[94]

(U) Nevertheless, structural testing continued and nine days later a wing plank failed on specimen B at the fuel boost pump cut-out at wing station (WS) 395.[95] Further inspection of the test specimen revealed small cracks in wing planks at five fuel probe access holes. The C-141 had 33 such access holes distributed over the upper surface of each wing.[96] Hence, the SPO, WRAMA, and MAC established procedures whereby inspection criteria would find the cracks in a timely manner.

Wing Leading Edge Buckling

(U) Flight test brought another problem which required prompt attention. This problem was the buckling of the wing leading edge between WS 238 and 410 on both of the wings. This condition, which was discovered on 25 February 1965, was found to have resulted from the use of the wing anti-icing system.[97] Lockheed proposed a fix,

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92. Ibid., 22 Oct 65, p 5-1.
93. Ibid., 3 Dec 65, p 5-2.
94. Ibid., 3 Jun 66, p 5-1.
95. Ibid., 10 Jun 66, p 5-1.
96. Ibid., 17 Jun 66, p 5-1.
97. Hist (S), MAC, Jul 64-Jun 65, I, p 139.

which increased the clearance of the leading edge segments and incorporated floating nut plates to allow the leading edge to "float" during thermal expansion.[98] In addition, Operational Supplement TO 1C-141A-35-1 was issued on 14 November 1966. This TO provided information relative to allowable/negligible damage to skin panels and honeycomb face sheets. Further, WRAMA message (WRNATA 20116, February 1967) explained that the buckling and cracking was caused by the large temperature changes encountered when an aircraft descended from altitude after prolonged cold soaking. The message further stated that this problem would be minimized if pilots turned off the wing anti-icing system prior to landing.[99] On 26 July 1967 the problem was resolved by TO 1C-141A-1197, which called for an increase in the gap tolerance between the wing leading edge assemblies and the trimming of the leading edge inner skin.[100]

Wing Center Pressure Shift

(U) In October 1966 the Starlifter's testing programs uncovered another problem that had the earmarks of a major aerodynamic deficiency. Lockheed's flight test data revealed that a shift of pressure had occurred aft of center on the aircraft's wing at Mach .82 to .85 speeds.[101] This development resulted in a slippage in the rest

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98. OES/LTF, Aug 66, p 18.
99. Ibid., Jan 67, p 27.
100. Ibid., Aug 67, p 14.
101. C-141 Mgt Sum, 10 Nov 65, p A-5.

of the test program toward release of the C-141 to 100 percent flight load capability and the establishment of a specification aircraft. As noted by the solid line in Chart I, the pressure had shifted considerably aft from the analytical (wind tunnel) indications. This shift placed stresses in a weaker section of the wing than was desired. The shift, as shown in Chart II, created the real possibility that the new aircraft needed structural beefups in the wing and rear fuselage areas. Therefore, as an immediate preventive measure, the aircraft was restricted to a flight speed schedule as seen in Chart III.[102]

(U) However, Lockheed proposed a relatively simple correction. This suggestion was that of rerigging the elevator "Q Feel" setting 2 degrees downward and rerigging the ailerons 3 degrees upward. The elevator change was expected to relieve the load on the aft fuselage, while the aileron rerigging was designed to move the aft center wing loading inboard, where the wing was stronger. The SPO, therefore, authorized the contractor to flight test the new configuration and to prove the fix in static tests.[103]

(U) On 5 November Lockheed conducted tests for the theoretical critical loads for the aft fuselage and horizontal tail. These structures withstood 150 percent design limit loads for positive pitch

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102. Charts I, II. and III from Mgt Review Summary, MATS, 10 Nov 65, pp A-40, 42, 43.
103. Ltr (U), DCS/Ops to EASTAF, WESTAF, 1707 ATWg, subj: C-141 Status Report for October, 1 Dec 65, p 3.

CHART I

COMPARSION OF CENTER OF PRESSURE M=.82

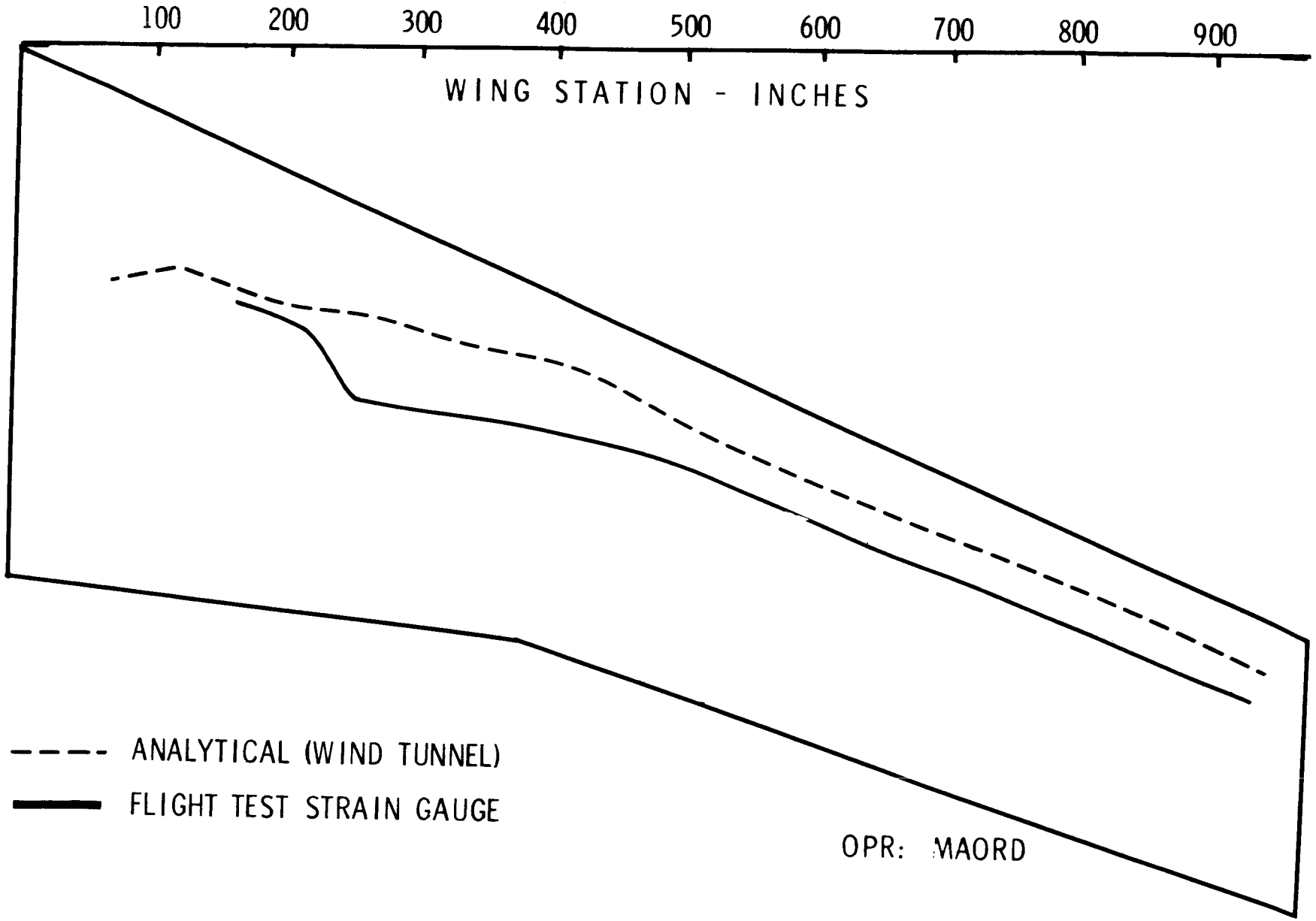
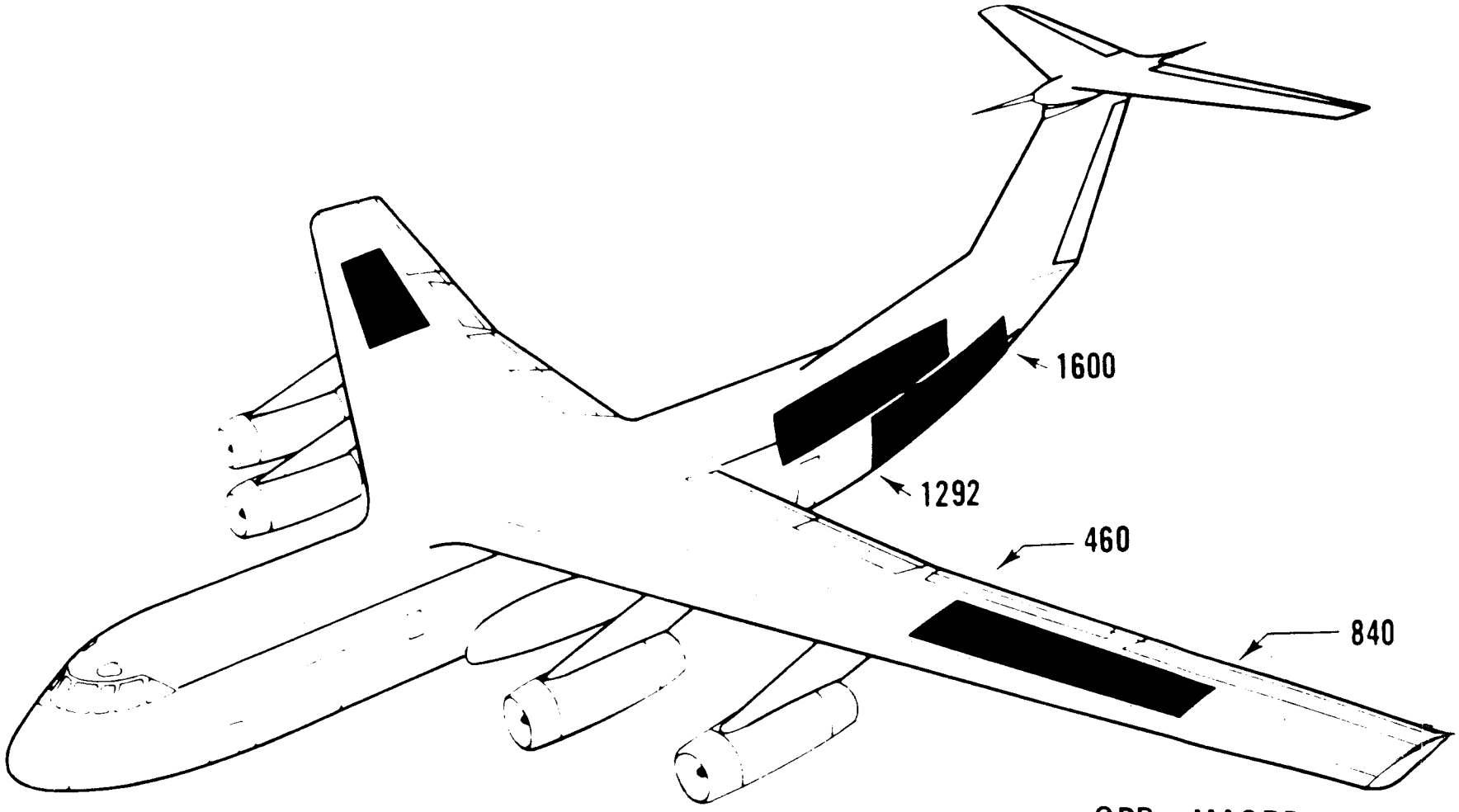


CHART II

POSSIBLE AREAS OF STRUCTURAL BEEF-UP

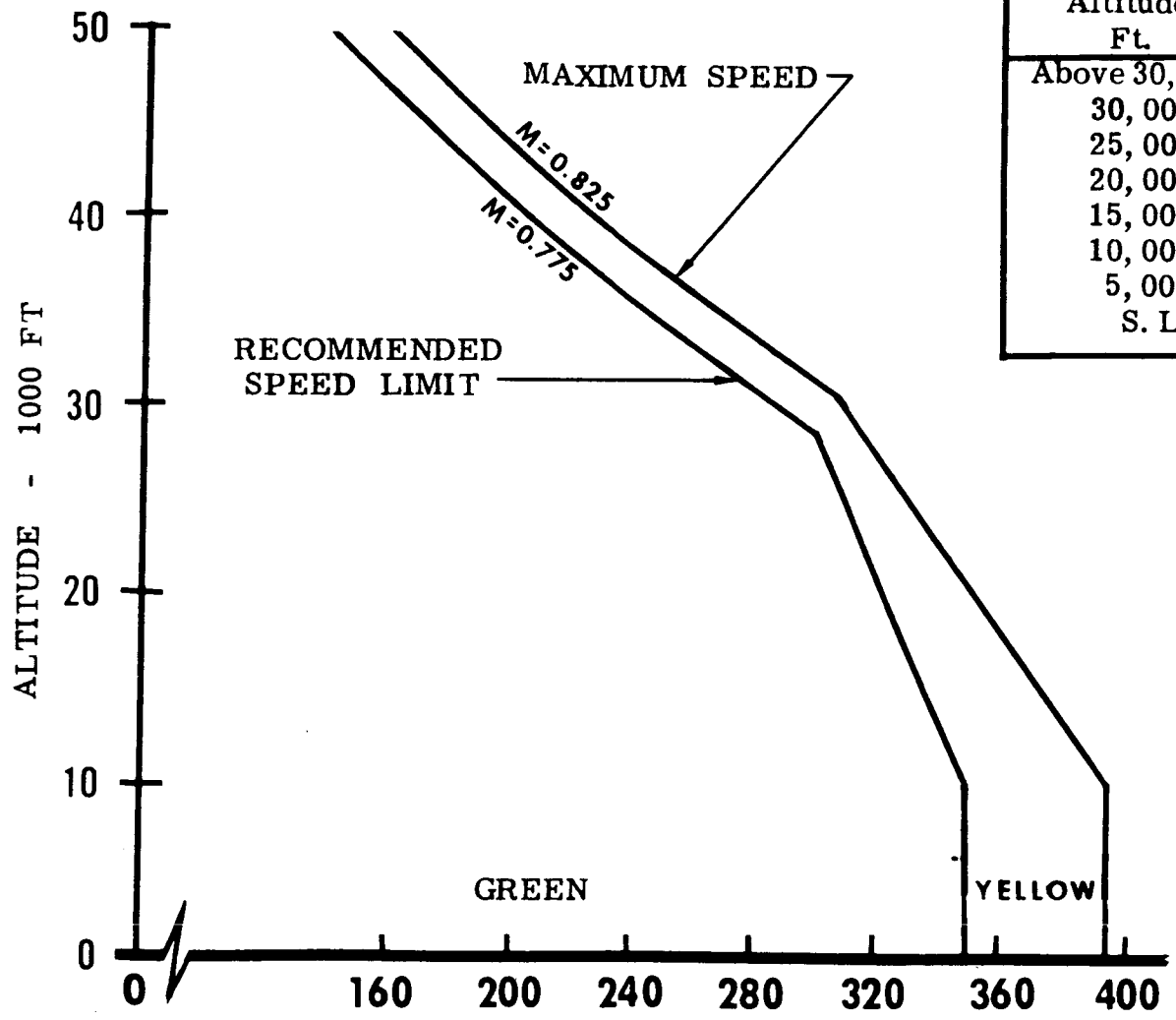


OPR: MAORD

CHART III

C-141A

SPEED SCHEDULE		
Altitude Ft.	Recommended Speed-KCAS	Maximum Speed-KCAS
Above 30,300	M=0.775	M=0.825
30,000	293	313
25,000	312	332
20,000	325	351
15,000	339	369
10,000	350	388
5,000	350	394
S. L.	350	394



entry. On 20 November the wing center section was tested for 2.5g symmetrical pullup and the wing outer panel was tested for 2.0g roll. These tests were for unrigged ailerons, no aileron hinge movement limit and elevator rerigging to 2.0 degrees down. At that time a MAC report stated:[104]

> it appears at this time from analysis of all existing flight test data, stress analysis, static test, etc., that only rerigging of the elevator will be required to permit 100 percent specification airspeeds and "g" load for symmetrical flight maneuvers. . . the rolling maneuvers are still questionable; however, the additional strength discovered during static tests will give a reasonable rolling load factor capability within the specification speed-altitude diagram . . . .[105]

The report further stated that:

> it appears that up to the high speed level flight (350 KTS/M - .825) a roll load factor of 2.0g is within reach without aileron changes. Above $M_H V_H$ (350 KTS/ M - .825) a possible load factor reduction may be necessary, but it should not be less than 1.67g which is the present capability of existing commercial cargo and transport aircraft. . . .

However, final justification of the fix depended upon additional flight and static test.

(U) On 21 February 1966 the abrupt pushdown and pullout maneuvers were demonstrated to 100 percent design load factor. Flight tests of the normal uncoordinated rolling pullout maneuver were attempted on 23 February 1966 and 100 percent of the design load factor of 2.0g

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104. Ltr (U), DCS/Ops, to EASTAF, WESTAF, 1707 ATWg, subj: C-141 Status Report for Month of November, 30 Dec 65, p 3.
105. Ibid., p 4.

was reached.[106] These demonstrations completed the 100 Percent Flight Loads Program, leaving only the 2.0g rolling pullout, which required stretching the wing strength envelopes by static test.

(U) On 23 April 1966 Lockheed successfully conducted a 150 percent of limit load which combined the 2.0g rolling pullout at M = 0.85 for the C-141A and the 2.5g symmetrical maneuver at M = 0.85 for the C-141A Minuteman (missile) configuration. This evaluation, the most critical for the wing and center fuselage, concluded the Static Test Program, except for some miscellaneous component evaluations.[107] Complete qualification was granted after the completion of the full component tests.

Honeycomb Flight Control Surfaces

(U) The C-141's flight control surfaces (ailerons, elevators, and rudders) presented the command with another difficult problem. Since the aircraft entered the force, unsatisfactory reports (URs) reported the separation of the skin, which covered the surfaces, from the honeycomb trailing edges. The peeling was due to water seepage into the honeycomb cells which froze when the aircraft was at high altitudes, thereby expanding. In addition, the frozen water also broke the skin away from the honeycomb core.[108]

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106. C-141 Mgt Sum, 25 Feb 66, p 5-1.
107. Ibid., 29 Apr 66, p 5-1.
108. Hist (S), MAC, Jul 68-Jun 69, II, pp 79-81.

(U) During 1966 the MAC C-141 operators used radiographic X-ray to search for entrapped water. Thirty-one Starlifters had been X-rayed by August 1966, and 21 of them had water trapped in the honeycomb edges. Therefore, to rid the aircraft of the water, holes were drilled in the edges and the water drained. The trail edges were then heated and vacuumed to dry out the honeycomb structure; the holes were then plugged with rivets dipped in a sealant (MIL-S-8802).[109]

(U) In April 1967 TCTO 1C-141A-1197 was issued requiring an X-ray inspection, drainage of water, and the sealing of butt joints to prevent further water entry. This inspection was established as a recurring one, required at every fifth major inspection. However, because of the major man-hour expenditures required of the inspections and drainage, MAC requested a better solution.

Fiberglass Trailing Edges

(U) In response to the MAC request the Aeronautical Systems Division (ASD),[110] in September 1967, procured ECP 774-1P to provide the engineering and prototype installation of fiberglass trailing edges. By August 1968 the one-trial installation was completed satisfactorily. In December 1967 ECP 1018 was submitted for the retrofit of the fleet, and in April 1968 Headquarters AFLC approved the retrofit. By August 1968 WRAMA completed contract coverage for the

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109. Ibid., p 80.
110. ASD is a component of the Air Force Systems Command (AFSC).

retrofit, and a service evaluation of ECP 774-1P prototype fiberglass trailing edges was begun.

(U) Retrofit under ECP 1018 (TCTO 1C-141A-1261) was scheduled to begin in January 1969, with a completion date for the third quarter CY 1970, as noted in Chart IV.[111] [112] This project was programmed to cost $2,000,000 and to require 700 man-hours of work for each C-141. The project was initiated in February 1969 and completed during CY 1971.[113]

Wing Spoiler Quadrants

(U) Spoiler quadrant failures also plagued the aircraft during the early operational years. Initially the lower quadrant failures were attributed to inadequate rigging, so interim TCTO 1C-141A-882 was issued to provide supplemental rigging instructions. However, the quadrants continued to fail, and ECP 574 (TCTO 1C-141A-993) was issued to correct the problem. This ECP called for installation of a reinforcing strut on aircraft production number 19 through 56, and a stronger quadrant was to be installed on production aircraft number 57. In addition, ECP 550-92 (TCTO 1C-141A-1049) was approved; it was designed to change the flap rigging to relieve the interference between the flaps and spoilers.[114]

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111. Log D-20 Rpt, 31 Oct 68, p 11.
112. Chart IV extracted from Log D-20 Rpt, 31 Oct 68, p 12.
113. Hist (S), MAC, Jul 68-Jun 69, II, p 81.
114. Log D-20 Rpt, May 66, p VII & VIII-5.

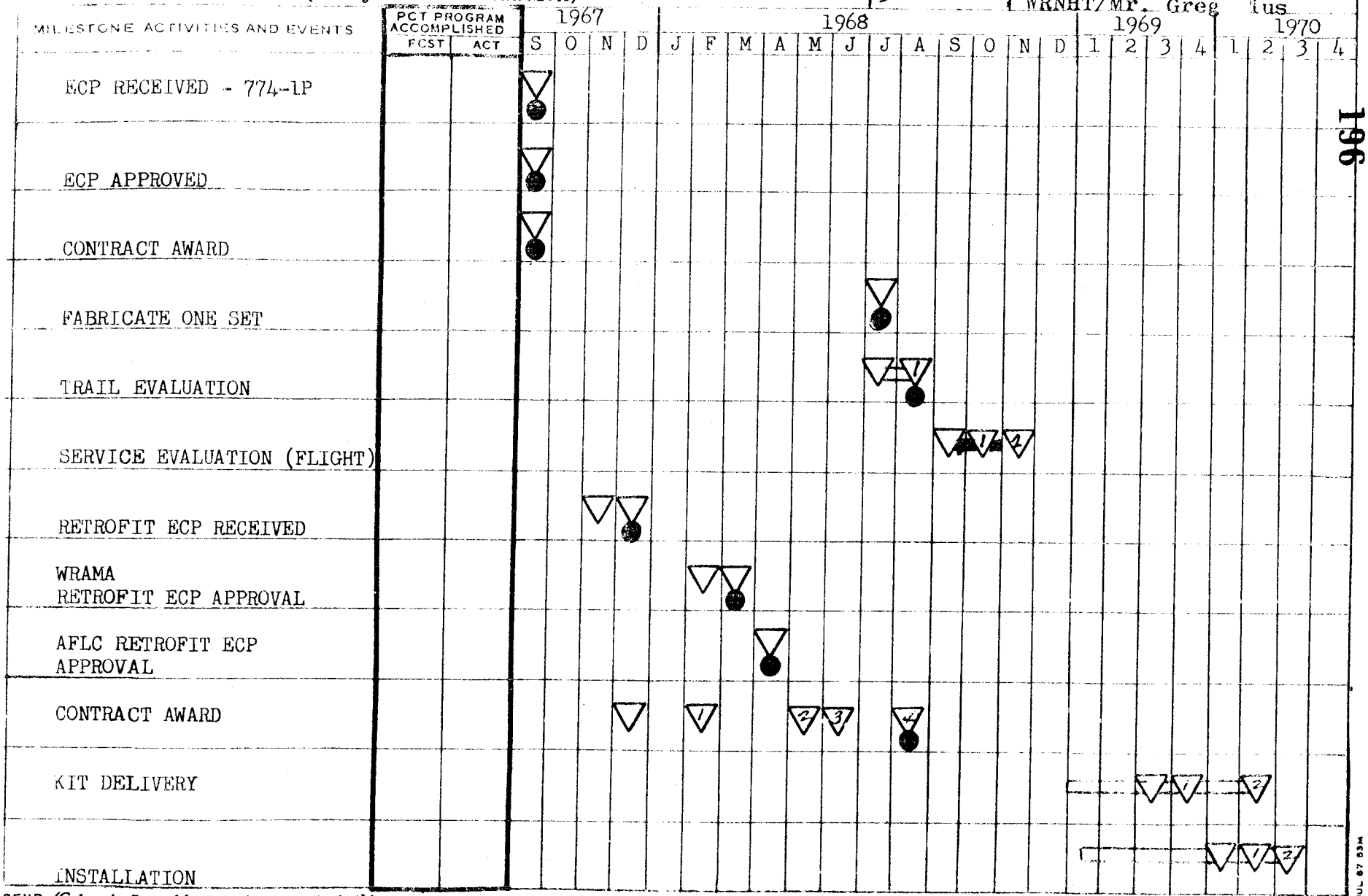
ITEM UNDER REVIEW

TRAILING EDGES (Honeycomb delamination) CHART IV

DATE REVIEWED: 31 Oct 68

REPORTING AGENCY & PROJECT MONITOR: WRNHT/Mr. Greg Ius

MILESTONE ACTIVITIES AND EVENTS	PCT PROGRAM ACCOMPLISHED FCST	PCT PROGRAM ACCOMPLISHED ACT
ECP RECEIVED - 774-1P		
ECP APPROVED		
CONTRACT AWARD		
FABRICATE ONE SET		
TRAIL EVALUATION		
SERVICE EVALUATION (FLIGHT)		
RETROFIT ECP RECEIVED		
WRAMA RETROFIT ECP APPROVAL		
AFLC RETROFIT ECP APPROVAL		
CONTRACT AWARD		
KIT DELIVERY		
INSTALLATION		



196

LEGEND: (Colors indicated for attention attraction) (Identical format available also on 35x22" bristol for wall chart or presentation (AFLC Form 280A).)

ACTIVITY PLAN — EVENT TARGET (Black outline)

1 (Red outline) 2 — TARGET SLIPPAGES

(Black fill-in of activity plan bar) — PERCENTAGE OF ACTIVITY PLAN COMPLETED AS OF DATE OF REVIEW (Portrays "Actual" column within heavy bordered frame above.)

(Green) — DATE COMPLETED (Place at point of event completion. Overlap triangle if necessary.)

12

[illegible] reverse side, by line number, capsule in each instance the cause for [illegible]

AFLC-WPAFB-JUL 67 53M

(U) Relief was gained for a short time, but in May 1966 the quadrant failures reoccurred. The problem became critical when spares reached a critical low level, resulting in G-NORS conditions.[115] To correct the problem TO 1C-141A-1218 was issued, which called for the trimming of the sharp edges and shot peening of the hub area. There were 69 right and 27 left wing number four quadrants furnished to the MAC bases to use as rotatables for accomplishment of the TO.[116]

(U) In another action to correct the problem TCTO 1C-141A-98897-476L-1050-1 was approved and placed on order in August 1967. This TO provided thicker material around the hub area and a positive bearing retaining device. By December 1967 engineering, tooling, and drawings were completed and plans were drawn to replace quadrants on an attrition basis. By 30 January, 81 left and 117 right quadrant spares became available and the problem resolution was at hand.[117] (The program progress is noted in Table IV.)[118]

Upper Wing Corrosion

(U) During FY 1968 corrosion was discovered in the upper wing fuel tank access door area. An inspection revealed that the corrosion was caused by water and moisture that entered the flange and dome nuts underneath the access cover. The problem, of course, had

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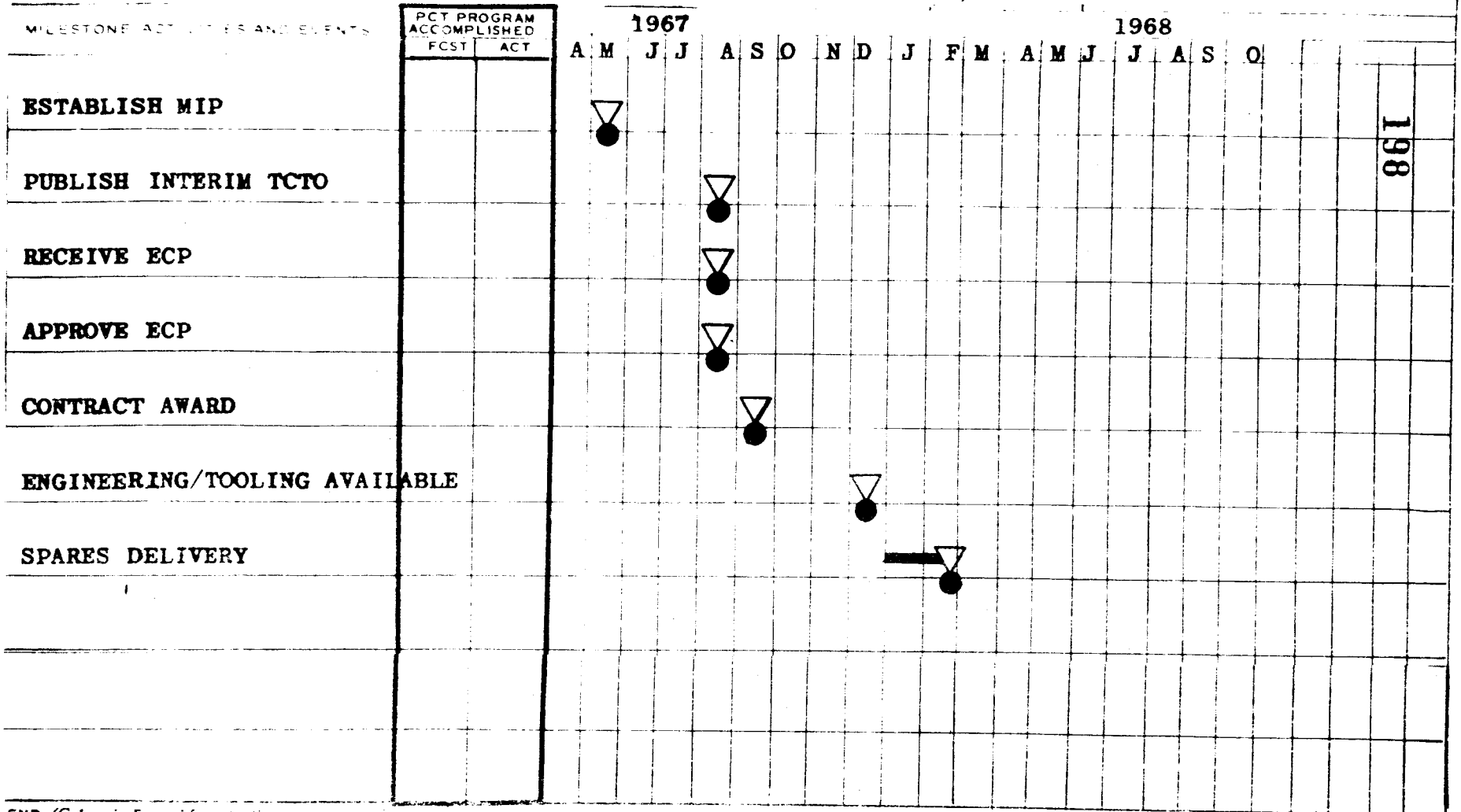
115. G-NORS - grounded not operationally ready because of supply.
116. Log D-20 Rpt, 29 Feb 68, p 21.
117. Ibid.
118. Table IV is p 22 of Log D-20 Rpt, 29 Feb 68.

SPOILER QUADRANT TABLE IV

DATE REVIEWED: 29 Feb 68

REPORTING AGENCY & PROJECT MONITOR

MILESTONE ACTIVITIES AND EVENTS	PCT PROGRAM ACCOMPLISHED FCST	PCT PROGRAM ACCOMPLISHED ACT
ESTABLISH MIP		
PUBLISH INTERIM TCTO		
RECEIVE ECP		
APPROVE ECP		
CONTRACT AWARD		
ENGINEERING/TOOLING AVAILABLE		
SPARES DELIVERY		



LEGEND: (Colors indicated for orientation attraction. Will change for presentation. AFLC Form 280A.)

ACTIVITY (Black outline)

EVENT TARGET

Built-in of plan bar)

PERCENTAGE OF ACTIVITY PLAN COMPLETED AS OF DATE OF REVIEW. Portrays "Actual" column within heavy bordered frame above.)

(Green)

DATE COMPLETED. Place at point of event completion. Overlap triangle if necessary.)

INSTRUCTIONS: On the re

serious implications because some of the corrosion had progressed to the intergranular stage, which would further develop into stress fatigue[119] in the wing planks. At any rate, the need for expensive repair and large amounts of aircraft downtime was apparent.[120]

(U) In order to combat the difficulty WRAMA issued instructions authorizing inspection of the afflicted area and the application of a faying surface seal under the access doors during IRAN. In addition, the WSM issued similar instructions (TO 1C-141A-1226) for field level compliance. The TCTO also called for environmental sealant in the wing upper surface access doors and flange areas. While the temporary fix was in development, Lockheed was in the process of developing a permanent fix which would implement the use of a sleeved dome

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119. "If a specimen is corroded, there is a general roughening effect on the surface which will influence the fatigue strength in much the same manner as any other surface damage. Also pitting caused by corrosion, results in a reduced cross-section area, thus increasing stress amplitude. Even if only small areas are involved, the results are harmful, since the first crack will almost always occur in the corroded area. . . . A more serious type of damaging effect occurs when continuous corrosion is acting simultaneously with repeated stressing. In this case, corrosion occurs not only on the surface but also in the crack after its formation. The corrosive medium attacks the walls and base of the crack, and the corroded particles, which separate and lodge in the crack, form wedge which forces the crack to deepen under the closing action--thus hastening failure. This type of behavior is known as 'corrosion fatigue' and is high deleterious." (The Fatigue of Metals and Structures, NAVWEPS 00-25-534, Revised 1 Jun 60, pp 138-319)

120. Log D-20 Rpt, 31 Dec 67, p 78.

nut in the corroded area. In addition, a tapered bushing was designed for the fatigue that developed in the corner fastener holes of the access openings.[121]

(U) At first MAC did not concur with the TO because the estimated 60 man-hour expenditure would have severely impacted the field maintenance units.[122] By 27 August 1968 the supplemental (field level) TCTO 1C-141A-1226C was released and required inspection and rework of all the wing openings. Further, the permanent fix, ECP-1013, was revised to include the requirement of ECP-746, which was the retrofit installation of swaged collars in the wing upper surface skin panels.

(U) By 30 June 1971 ECP C-141A-98897-476L-1013PR was approved and incrementally funded. In addition, TCTO 1C-141A-1319 was assigned to modify the force. In January 1971 part delivery began, the retrofit beginning at Norton AFB in March and WRAMA in May 1971.[123] At the end of FY 1971 the program status was as noted on Table V.[124]

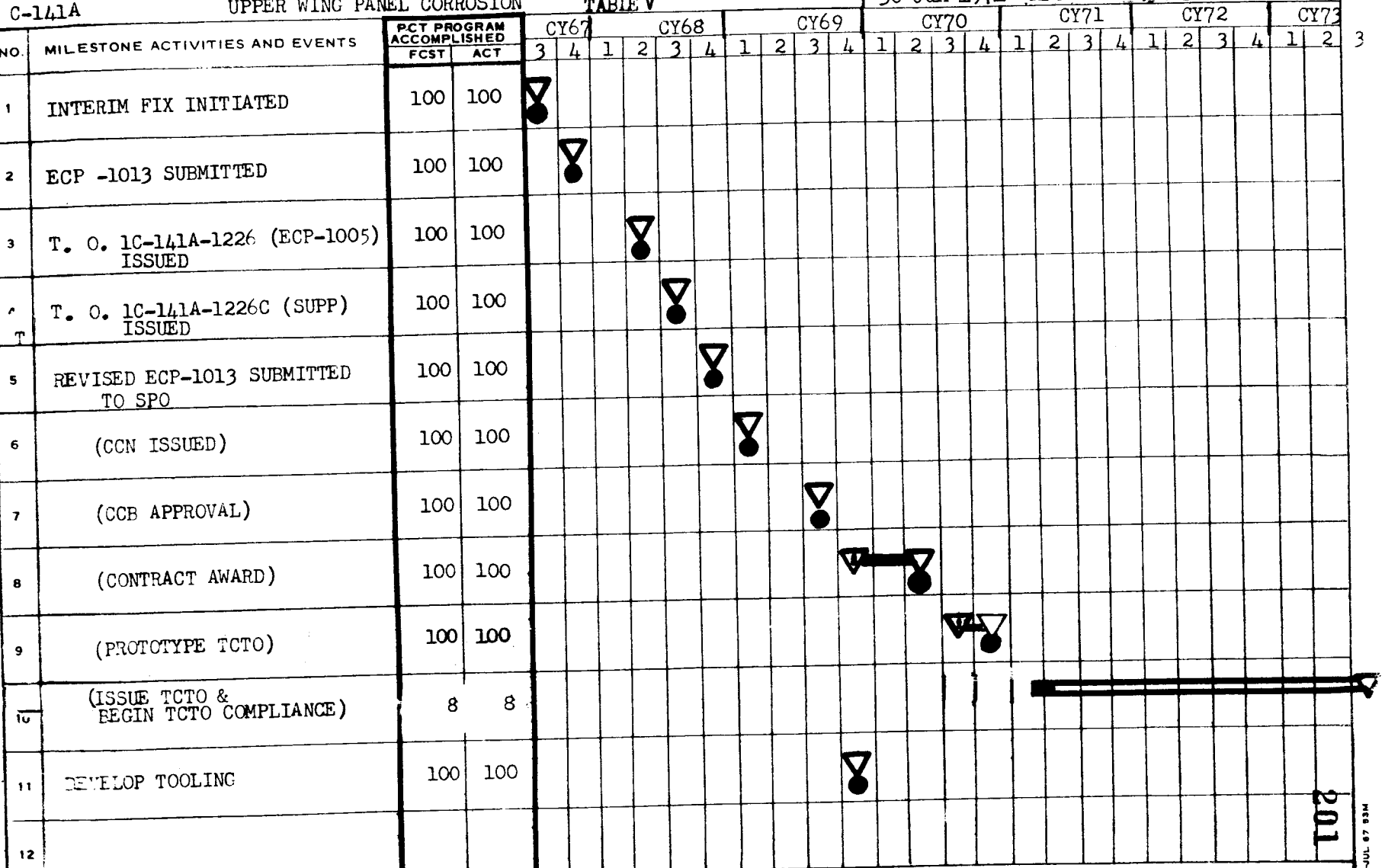
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121. Ibid.
122. Ibid., 31 Mar 68, p 43.
123. Ibid., 30 Jun 71, pp 10-10a.
124. Table V is p 11 of Log D-20 Rpt, 30 Jun 71.

SUBJECT UNDER REVIEW: C-141A — UPPER WING PANEL CORROSION — TABLE V

DATE REVIEWED: 30 Jun 1971 | REPORTING AGENCY & PROJECT MONITOR: Mr. Bowers/MMCPA-1/6494

NO.	MILESTONE ACTIVITIES AND EVENTS	PCT PROGRAM ACCOMPLISHED FCST	PCT PROGRAM ACCOMPLISHED ACT
1	INTERIM FIX INITIATED	100	100
2	ECP -1013 SUBMITTED	100	100
3	T. O. 1C-141A-1226 (ECP-1005) ISSUED	100	100
4	T. O. 1C-141A-1226C (SUPP) ISSUED	100	100
5	REVISED ECP-1013 SUBMITTED TO SPO	100	100
6	(CCN ISSUED)	100	100
7	(CCB APPROVAL)	100	100
8	(CONTRACT AWARD)	100	100
9	(PROTOTYPE TCTO)	100	100
10	(ISSUE TCTO & BEGIN TCTO COMPLIANCE)	8	8
11	DEVELOP TOOLING	100	100
12			



LEGEND:

- ACTIVITY PLAN (Black outline) — EVENT TARGET
- 1 (Red outline) 2 — TARGET SLIPPAGES
- (Black fill-in of activity plan bar) — PERCENTAGE OF ACTIVITY PLAN COMPLETED AS OF DATE OF REVIEW (Portrays "Actual" column within heavy bordered frame above.)
- DATE COMPLETED (Place at point of event completion. Overlap triangle if necessary.)

INSTRUCTIONS: On the reverse side, by line number, capsule in each instance the cause for event slippage.

201

AFLC-WPAFB-JUL 67 83M

TAIL DEFICIENCIES

(U) The tail section of the Starlifter presented MAC with very few difficulties. However, a series of horizontal stabilizer tie box stringer cracks did present some problems. Cracks first appeared during the ASIP when the vertical stabilizer failed near its root under static pressures, simulating a side load condition in an overswing yaw. This break came with pressures equalling 130 percent of design strength. In order to correct the deficiency, modifications were made which included local reinforcement and redesign of the vertical fin stringers and aft fuselage. Installation of this beefed-up fin enabled the tail and aft section to successfully withstand the required 150 percent of strength test pressures.[125]

Horizontal Stabilizer Tie Box Stringer Cracks

(U) The major tail problem was not noticed until 16 November 1967 when the 60 Military Airlift Wing reported a one-half inch crack in the horizontal stabilizer panel tie box. Reacting immediately, WRAMA issued urgent action TO 1C-141A-1241 for the inspection of the MAC force. By 1 December 1967 the force inspection was completed and revealed that 47 of the aircraft had 56 cracked stringers.[126]

(U) In January 1968 WRAMA, ASD, and Lockheed issued TCTO 1C-141A-1246 which required a more detailed inspection of the stringers.

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125. Hist (S) MATS, 1 Jan-30 Jun 64, I - Part I, pp 113-114.
126. Log D-20 Rpt, 31 Dec 67, p 76.

This TCTO was prototyped by MAC's 58th Military Airlift Squadron (MASq).[127] The 58th's findings showed that the inspections under TCTO 1C-141A-1246 would require 22 clock-hours. Hence, MAC requested that the TO be changed to depot compliance; however, WRAMA did not concur and forwarded a letter to MAC on 12 June 1968 requesting concurrence for the field compliance. MAC eventually concurred; the TCTO was scheduled for field compliance in November 1968, and the inspection was performed and repairs made.[128] MAC then requested that TCTO 1C-141A-1246 be made applicable to all aircraft[129] and strongly recommended to WRAMA that they concur. After WRAMA had agreed, TCTO 1C-141A-1246D was issued to affect all aircraft and follow-on inspection procedures were outlined.[130]

WINDSHIELDS

(U) Windshield difficulties causing replacement and an ensuing NORS condition appeared during late 1966. The S-15[131] reports took notice of C-141 windshield NORS in December 1966, January 1967, and again in February 1967. In July 1967 part of the problem was identified when MAC field units reported that windshield shattering was caused by overheating of defrosters. Further, the field units complained that an estimated 32 man-hours were needed to change a panel

127. Ibid., 29 Feb 68, p 42.
128. Ibid., 31 Jul 68, p 32.
129. Ibid., 31 Oct 68, p 23.
130. Ibid., 31 Dec 69, p 6.
131. Supply inventory condition reports.

and that aircraft out-of-service time was approximately one and one-half days. Because of the time factor and the high cost of the panels (center panel $800.00 and the pilot or copilot panels $1,600.00 each), the MAC Operational Evaluation Staff (OES) recommended an engineering study.[132]

(U) By the end of CY 1967 the causes of the cracking and delamination had been identified; they were:[133]

1. Inadequate aerodynamic seal around the windshield.
2. Poor heat control and normal heat cycle.
3. Poor quality control at vendor facility.
4. Inadequate flight manual and maintenance handbooks.

As a result of the many problems ASD, with MAC cooperation, initiated special reporting procedures which supplemented the regular UR reporting for the temperature and control relay. In addition, ASD and Lockheed engineers visited MAC bases to observe the damaged windshields and the removal/replacement procedures. WRAMA then issued an operational supplement to TO 1C-141A-2S-12 on 28 February 1968 to provide additional guidance for repair of the aerodynamic seals around the windshields. ASD began working with the vendors on the quality control problem and initiated a service test to correct the high temperature trip point of the windshield overheat control.[134]

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132. OES/LTF Rpt, Jun 67, p 21.
133. Log D-20 Rpt, 31 Dec 67, p 75.
134. Ibid.

(U) Basically the problems were due to moisture filtering through the layers of plastic and glass used in the windshield construction. Therefore, a method was devised, by thorough testing, for sealing the layers of plastic and glass. This sealing process reduced failure incidents by 60 percent and allowed the windshield problems to fall to a manageable maintenance level.[135] The TCTO that authorized the inspection and application of improved sealant was TCTO 1C-141A-1247 of March 1968.[136]

CORROSION CONTROL

(U) From the beginning of the C-141 program all participants agreed that a sound corrosion control program was a necessity. MAC strongly supported this thesis by suggesting that the aircraft be supplied with the latest state-of-the-art in corrosion protection.[137] MAC, however, envisioned a complete interior painting, but exterior painting only in the nonclad areas.[138] MAC substantiated its thinking after an SPO, Lockheed, AFLC, and MAC trip to the east coast MAC units. During this trip, maintenance personnel at all levels were queried about the feasibility of exterior painting, and the consensus was negative. Most of the field maintenance people felt

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135. Morris Intvw, Sup Doc III-19, this study.
136. Log D-20 Rpt, 31 Mar 68, p 40.
137. Memo, DCS/Materiel to Commander MAC, subj: Corrosion Control - C-141 Aircraft (subsequently cited as MAC Corrosion Memo), w/16 atch, [circa 1963], Sup Doc III-23.
138. Ibid., Atch #2.

that painting " . . . would be a major task and a hinderance in accomplishing exterior skin repairs. A good washing program was offered as the most effective method for control of corrosion."[139]

(U) Further, MAC substantiated the nonpaint position by pointing out the high cost of maintenance and the lack of in-house IRAN facilities for maintaining exterior paint.[140] MAC and the SPO maintained this position and eventually the commander of AFLC, General Mark E. Bradley, concurred with the nonpaint faction.[141]

(U) However, during 1966 a HQ MAC, SPO, WRAMA, Air Force Materials Laboratory, and Lockheed team inspected eight Starlifters for corrosion. This inspection revealed that the aluminized lacquer was superior to the paint in the nonclad areas. The paint had peeled and cracked, causing rust in the fastener areas, and had worn off in the landing gear and on latrine floors, causing rust and leaks.[142]

(U) Among the corrosion problems encountered was the wing corrosion/fatigue problem noted previously in this chapter. By 1968 widespread pitting began to appear on unfinished surfaces; and at a MAC, Lockheed, and AFLC meeting it was decided that complete painting was the corrective measure to be used. Hence, after a review of paint possibilities, a paint test program, Project Order A-0-8087 WR,

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139. Ibid., p 2.
140. Ibid., Atch #5.
141. Ibid., p 3.
142. See Sup Docs V-69 thru V-73, hist, MAC, 1 Jul 68-30 Jun 69, XIV.

was implemented on 4 November 1969 to determine which paint should be used.[143] Twelve aircraft were painted: one with acrylic-nitrocellulose and another with a water-base paint, while ten were painted with three different types of polyurethane prime coats. The project programmed for completion in June 1970 was progressing satisfactorily and producing the desired results by January 1970.[144]

(U) However, in March 1970, USAF made the decision to adopt the US Navy specifications for polyurethane paint. MAC was then authorized to initiate its C-141 paint program on 1 July 1970. By year's end plans called for the painting of 132 aircraft by FY 1971 and the remainder of the force in FY 1972.[145]

(U) The initial contract awards were made to the Aero Corporation, Lake City, Florida, and the Space Corporation, Ardmore, Oklahoma, in September 1970, as noted in Chart V.[146] By the end of FY 1971 the project was well established and a multi-year contract was awarded to the Aero Corporation to paint 56 C-141s in FY 71[147] and 84 in FY 72.[148] In addition, the 20 aircraft contract awarded to the Space Corporation was completed and WRAMA Maintenance agreed to paint 20 more

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143. Hist rpt (U), DCS/Log, subj: Weapon System Branch, 5 Nov 69, Sup Doc III-24.
144. Trip Rpt, DCS/Log, subj: Trip Rpt - Charleston and Travis AFBs, 22 Jan 70, Sup Doc III-25.
145. See Sup Doc III-20, hist, MAC, 1 Jul 69-30 Jun 70, VII.
146. Log D-20 Rpt, 31 Jan 71, p 29.
147. Chart V is p 30 of Log D-20 Rpt, 31 Jan 71.
148. Completed on schedule, see Chart VI.

CHART V

C-141 PAINT PROGRAM

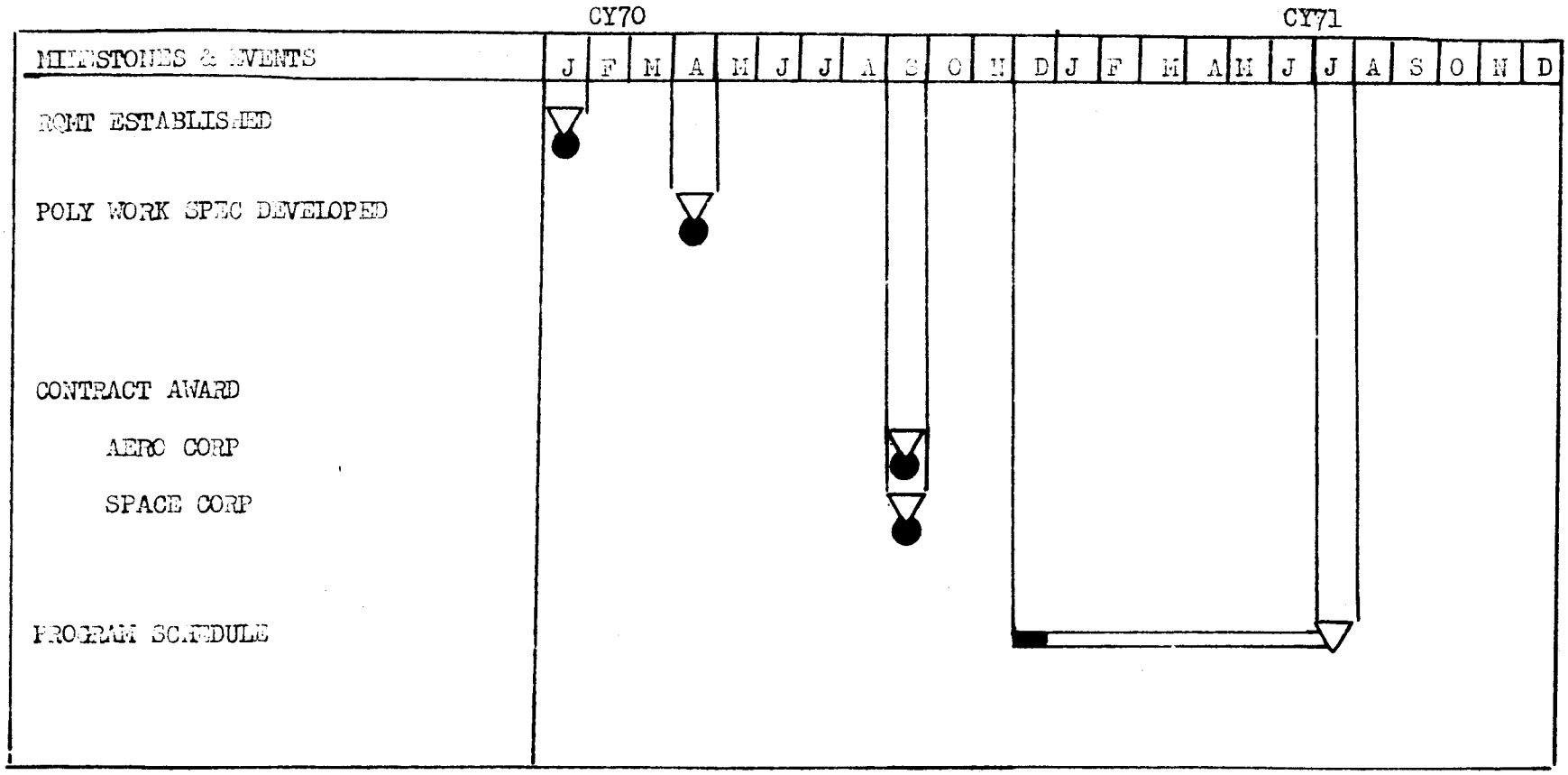
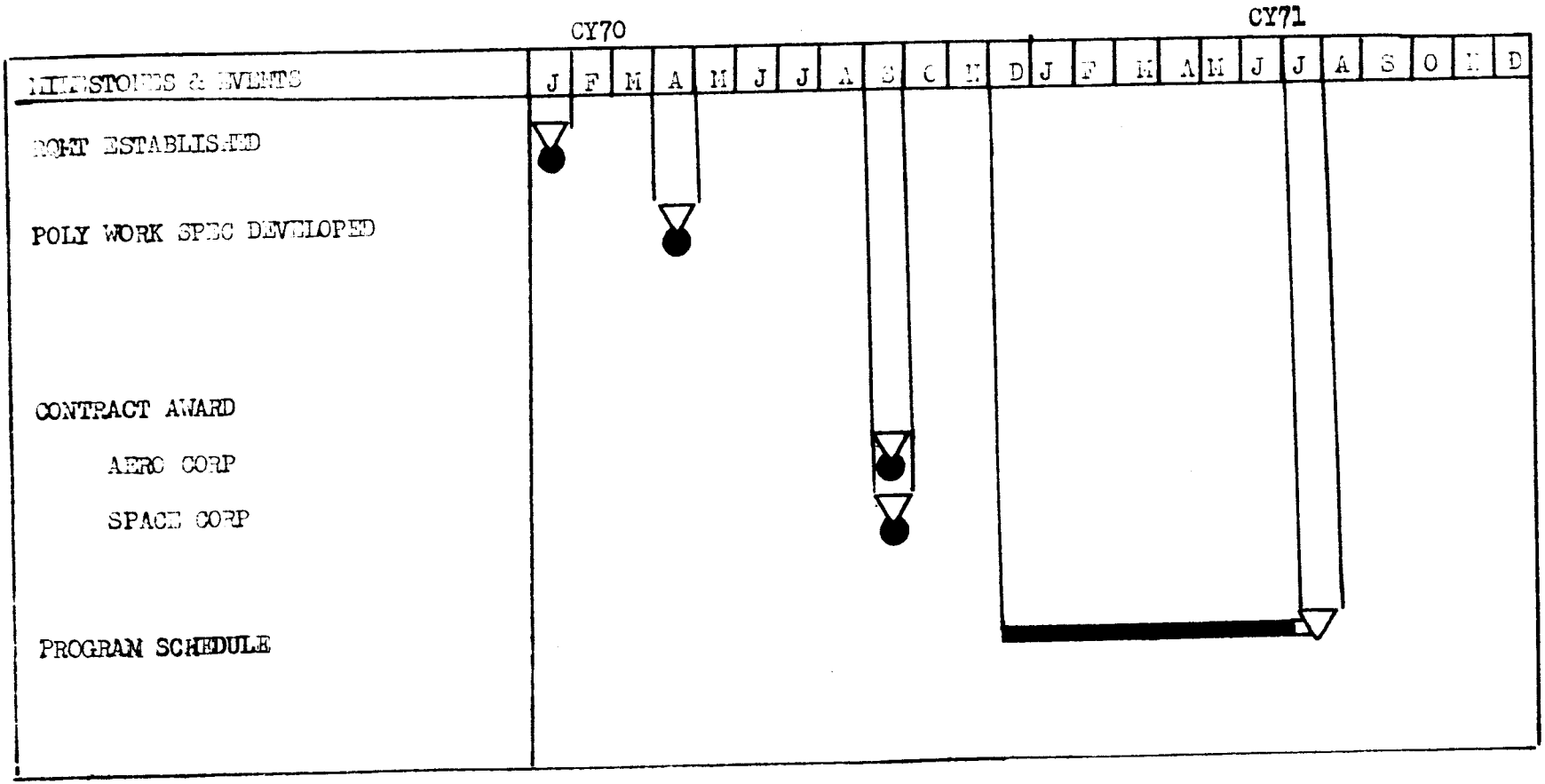


CHART VI

C-141 PAINT PROGRAM



ACTIVITY PLAN — EVENT TARGET

TARGET SLIPPAGE

COMPLETE

during FY 1972, while Lear Siegler, Inc., contracted to paint 50 aircraft during FY 1972.[149]

149. Log D-20 Rpt, 30 Jun 71, p 29.

> "I would have to place the landing gear at the head of the list in that we have now been through seven separate swap out programs of landing gear components. Even though this has not necessarily been a burden on MAC maintenance, it has been a burden on Air Force Logistics Command who have the responsibility for overhauling the landing gear."[150]

LANDING GEAR PROBLEMS

AT THE HEAD OF THE LIST

(U) Asked what component of the C-141 had been the most difficult from the maintenance standpoint, MAC's Chief of the Airlift Aircraft Branch, Directorate of Maintenance Engineering, felt no hesitation in giving his answer. The C-141's landing gear system represented the same tricycle arrangement used on other large transports of the time, such as the Boeing 707 and the DC-8, except that, because of its high-wing configuration, the C-141 retracted its main gear into pods on the fuselage. It was within the state of the art; but without being new or innovative, it managed to cause more problems

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150. Morris Intvw, p 18, Sup Doc III-19.

than any other subsystem in the aircraft's development and early operational use.

(U) During its first year in the MAC operational environment, the C-141 chalked up a total of 30 aircraft incidents, six involving the landing gear. As additional C-141s entered the inventory and gained more practical experience, the number of incidents related to this aircraft type increased significantly, reaching 271 in 1967 and more than double that figure in 1971. The share ascribed to landing gear failures was a source of mounting concern to aircrew and flying safety as well as maintenance personnel. Landing an aircraft, considered " . . . the most dangerous phase of flight . . . accounting for 29.5 percent of all operator-factor accidents. . . ,"[151] was certainly hazardous enough without the complication of a material factor. Maintenance data compiled on man-hour consumption showed the landing gear second only to the propulsion system during nine months of 1966; during the other three months it was the top man-hour consumer. Eventually, it settled down into fourth place, where it apparently belonged.[152] By October 1971 over a hundred modification and inspection directives had been issued, over a half million man-hours had been expended, and over half a dozen "swapout" projects

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151. Lt Col Richard L. Anderson, "How to Land an Aircraft," The MAC Flyer, Nov 68, p 19.
152. OES/LTF Rpts, Jan 66-Dec 67.

had been accomplished to improve the C-141 landing gear, which had become " . . . historically . . . one of the most troublesome systems on the C-141. . . ."[153]

(U) At MAC, the importance of correcting deficiencies before they were "built into" the aircraft was recognized long before the first C-141 emerged from the factory.[154] As the Lockheed production line shifted into high gear to meet user requirements, the machinery to improve the product in every possible way had also been set in motion; thus by the time the aircraft started flying regular airlift missions, improving it and using it had become analogous functions. This accounted for much of the maintenance work lavished on the C-141 weapon system, which was on a scale compatible with the "buy before fly" concept of procurement. As early as June 1966 the backlog of organizational/field level time compliance technical orders (TCTOs) had reached unmanageable proportions; to reduce it, routine TCTOs requiring more than 35 man-hours had to be marked for accomplishment at depot level, although safety TCTOs remained a field responsibility.[155] More than 1,100 engineering change proposals (ECPs) had been submitted; approximately 850 were approved. Most of those submitted were from

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153. Background Paper, MAC DCS/Materiel, subj: C-141 Landing Gear Improvements, 8 Oct 71, Sup Doc III-26.
154. Memo, MAC DCS/Materiel, subj: Minutes of C-141A Panel Meeting (3 Jan 1963), 7 Jan 63, Sup Doc III-27.
155. C-141 Status Report for June 1966 (Atch 2 to MAC DCS/Ops ltr, subj: PERT Report--C-141 Management Summary, 28 Jul 66) (subsequently cited as C-141 Status Rpt).

Lockheed (949, of which 673 were approved); 50 were a result of FAA certification; 100 were Class II modification changes; the remainder were "fixes" for deficiencies uncovered in the testing process.[156]

Fatigue Endurance Tests

(U) Project Long Life, the fatigue testing at Lockheed, was extended to record successfully twice the number of simulated landings programmed for the C-141 (from 12,000 to 24,000 for the main gear and double that for the nose gear), prompting the following observation in the official MAC safety publication shortly after MAC had received the last of 284 C-141s purchased by the Air Force: "The landing gear proved adequate and should exceed the safe life goal set by the Air Force." However, reference was made to the proper handling and care of the C-141 and the importance of corrosion protection to assure landing gear fatigue endurance.[157]

(U) MAC's own Lead-the-Force (LTF) program monitored vital components of the landing gear as well as other subsystems. The first main landing gear fatigue failure reported under this program occurred in October 1966;[158] another was recorded the following month, after the third C-141 purchased by the Air Force had made its 2,874th

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156. Ltr, MAC DCS/Materiel to 21 AF, et al., subj: C-141 Status Report April 1966, 2 Jun 66, Sup Doc III-28. For details of the C-141 test program (categories I through III), see Vol II, pp 45-89, this study.
157. "Project Long Life II," The MAC Flyer, Apr 68, pp 8-11.
158. OES/LTF Rpt, Oct 66, p ii.

landing.[159] But the LTF program was still just another test program, and as one MAC official commented, not enough " . . . MAC type missions had been flown . . ." that might have helped to bring to the surface other latent deficiencies.[160] The high landing phase of the LTF program was terminated on 12 September 1968 after attaining 2,252 days leadtime.[161]

The Weight Factor

(U) The fact that the C-141's landing gear turned out to be difficult to maintain came as no surprise to those at MAC who from the beginning had strived to give the aircraft the landing gear that it deserved,[162] as the following testimony revealed:

> During the development phase . . . we (MAC) were given the opportunity of developing specific design criteria as pertains to maintainability; however, despite our recommendations, based on previous weapons system's experience in the field of reliability and maintainability, all our suggested design recommendations were not bought . . . .

(U) A crucial factor in determining design and performance characteristics was the aircraft basic weight. At first, the requirement was for a C-141 basic airplane weight of 122,679 pounds; Lockheed declared this could not be met and requested a basic weight of

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159. OES/LTF Rpt, Nov 66, p ii.
160. See pp 64-65, Vol II of this study.
161. Rpt, Maintenance Evaluation Div, Det 12, HQ MAC, subj: MED/LTF Monthly Activity Report (subsequently cited as MED/LTF Rpt), Sep 68, p 1. In 1968 the Operational Evaluation Staff (OES), Det 12, HQ MAC, was redesignated Maintenance Evaluation Division (MED).
162. Morris Intvw, p 2.

132,773 pounds. Depending on the point of view, what appeared as a weight increase might be regarded otherwise. The dilemma that the manufacturer had to cope with concerned the varied roles of weight in aircraft design:[163]

> an optimum operational performance of aircraft had to be achieved by the manufacturer; therefore, to achieve this optimum in performance . . . it was necessary for him to take action to reduce the aircraft basic weight. Unfortunately, from a maintenance man's viewpoint, this really hurt. It has had a terrific impact on systems reliability and an extraordinary burden on maintenance to keep the airplane going. I think one of the prime examples of this is the design of the landing gear. Many of the components of the gear were scaled down in size and weight to a point where the great abuse that the gear is subjected to resulted in low reliability and high failure rate of components . . . .

(U) The landing gear, including tires, weighed a total of 8,700 pounds: 900 for the nose gear and 3,900 for each of the main gears. It was meant to support a maximum weight of 318,000 pounds.[164] To give the landing gear strength and durability inherent in a heavier, sturdier frame, it was reinforced in ways that only served to accentuate its limitations and further complicate the corrective process. However, whatever might be said of C-141 landing gear deficiencies, these were at least logically consistent, making swapout or replacement programs a feasible solution. The " . . . swapout program to end all swapouts . . .," Pacer Gear 495, was said to just about give

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163. Ibid., pp 15-16.
164. C-141A Starlifter Loading & Airport Operations Data Book, Lockheed-Georgia Company, 31 Aug 64, p 4.

the C-141 " . . . a brand new undercarriage . . ."[165]; yet, even before it had been completed the need was recognized for more swap-outs.[166] Pacer Gear 495 was planned to replace all main landing gear (MLG) bogie beams plus whatever other MLG components which OOAMA and WRAMA could support. The nose landing gear (NLG) was known to have problems, but none of these were supportable during Pacer Gear 495.

PROBLEMS AND SOLUTIONS

(U) Inevitably, the sins committed in the C-141's conception were reaped in its production; and this was nowhere more evident than in the landing gear whose parts bore the brunt of the inborn defects: the bogie beam, axles, pistons, braces and links, actuators and trunnions, bearings and seals, not to mention tires and wheels. Usually a MLG malfunction was considered a graver matter than a NLG problem. Paradoxically, a precarious parts situation partly induced by the swapout business made the latter a risky proposition when the replacement also had to be replaced. The subcontractor for the main gear was the Menasco Manufacturing Company of Forth Worth, Texas. A strike by employees of this company in October 1966 lasted only three days; had it gone beyond six days, it was expected to cause a three-day production slippage for each day of strike.[167] At a

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165. "Pacer Gear 495," The MAC Flyer, Nov 71, pp 22-23.
166. See Footnote 153.
167. C-141 Mgt Sum, 30 Sep 66.

meeting on 3 June 1966 to discuss maintenance problems, in which the MLG figured prominently, the Lockheed management told the C-141 SPO that material shortages at vendor facilities were a major delaying factor in production and retrofit actions. The SPO volunteered to " . . . coordinate necessary priorities through Air Force channels to government and industry . . . ." The meeting resulted in the approval of ECPs on corrosion control and the redesign of some defective parts.[168]

Stress Corrosion and Cracking

Bogie Beam

(U) With aircraft landing gear there was no failure like a fracture; none were more perilous than those affecting the bogie beam, the main gear part which held the two axles and supported the strut and the whole aircraft. A broken bogie beam during the take-off or landing roll could spell disaster. Fortunately, none occurred during this critical moment. The recorded failures--23 as of November 1971--happened while the aircraft was either stationary or taxiing. Those who had experienced a broken bogie beam remembered it for "that sinking feeling." A bogie beam failure at Hickam AFB on 27 November 1970, while the C-141 was static on the ground undergoing engine maintenance, was preceded by a "bang" that fairly caused the mechanics

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168. C-141 Status Rpt for Jun 1966.

to jump out of their skins, a condition not abated by the sight of the aircraft's left wing settling slightly. At the time the gross aircraft weight was 308,665 pounds, and the faulty beam had been installed only 10 months before the incident. The report suspected fatigue failure and stated that the problem had been "fully identified previously" with "corrective actions deferred to higher headquarters."[169] The bogie beam was the main gear's "primary problem area."[170]

(U) The bogie beam problem was identified early in 1968. In May of that year OOAMA issued an interim supplement reclassifying MLG axle and beam corrosion to release all aircraft listed as NORS-G as a result of a TCTO compliance. An earlier TCTO had directed the retrofit of all bogie beam assemblies with certified reworked assemblies which had been chrome plated. At this time MAC devised a "drop-in" program for the beam assembly swapout, the first of its kind, contingent upon WRAMA's capability to provide sufficient reworked spares.[171] The finding that bogie beam corrosion was caused by improper rework procedures during overhaul led to the overhaul of the overhaul system itself, and it was thought that the problem had been solved by the chrome plating of the bogie beams (80 aircraft were involved). In February 1969 the Maintenance Evaluation Division of Detachment 12, HQ MAC, at Travis AFB reported that the swapout program was

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169. Msg, 61 MASWg to MAC, et al., subj: MAC Acft Incident Message Report, 280232Z Nov 70, Sup Doc III-29.
170. See Footnote 153.
171. MED/LTF Rpt, May 68, p 14.

progressing well ahead of schedule, and the original estimated completion date of 30 June 1969 was moved to 31 March 1969,[172] but shortly thereafter more bogie beam failures were reported. It was discovered that chrome-plated beams (75 of which had been produced and 59 installed in 37 aircraft) were really bad beams. Cracks were developing in the axle lug area. The chrome plating was actually abetting corrosion. MAC was advised that chrome plating of the beam lug was detrimental to the beam's service life, and the rework process was discarded in favor of a protective zinc chromate application. A depot level TCTO (1C-141A-1311) was issued to replace the chrome-plated beams through another WRAMA drop-in project.[173]

(U) The new swapout replaced the chrome plating inside the beam axle lugs with zinc chromate-coated steel sleeves for corrosion protection. The project, involving 40 aircraft, was completed by September 1969, but before the year was over more beam failures occurred. Deterioration of the new protective coating, which was "elastomeric" (elastic), allowed moisture to enter the beam; the resulting corrosion caused stress cracks and "catastrophic" failures (complete beam fractures). One such failure at Travis AFB in November 1969 was attributed to a crack at a corroded area without protective coating.[174]

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172. Rpt, MED, Det 12, HQ MAC, subj: C-141/MED Report (subsequently cited as C-141/MED Rpt), Feb 69, p 20.
173. C-141/MED Rpt, May 69, p 24.
174. Msg, 60 MAWg to CSAF, et al., subj: USAF Aircraft Incident Final Message Report, 040155Z Nov 69, Sup Doc III-30.

Another incident at Travis the same month indicated that the grease used to lubricate the pivot bearings and the solvent used to wash the aircraft caused the protective coating on the inner surface of the bogie beam to deteriorate, causing material failure due to corrosion pitting. Since the last TCTO compliance, the aircraft had made 486 landings and flown 1,265 hours.[175]

(U) It was evident that inadequate corrosion protection had been provided the bogie beam's inner surface. The beam failures at Travis prompted the issuance of an inspection TCTO (1C-141A-1328) on 10 C-141s stationed there. The findings necessitated the following actions:[176]

1. TCTO 1C-141-1330, dated 30 December 1969, required immediate ultransonic inspection of all beams. Suspect beams were flown to WRAMA for further metallurgical analysis.

2. TCTO 1C-141A-1331, dated 4 December 1969, required a visual field inspection to determine the condition of the elastomeric coating on all installed beams.

3. A new, "improved" corrosion prevention procedure was developed consisting of a combination of aluminum flame spray and polyurethane paint coating.

4. TCTO 1C-141A-1333, dated 30 January 1970, required the installation of bogie beams incorporating the new, "improved" anticorrosion technique on all C-141s. This project again involved flying the aircraft to WRAMA for beam retrofit.

(U) By the end of March 1970 the latest beam swapout was 35 percent complete. The expected "get well" date was in July 1970

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175. Msg, 60 MAWg to MAC, et al., subj: MAC Acft Incident, 012208Z Dec 69, Sup Doc III-31.
176. Log D-20 Rpt, subj: MLG Bogie Beam, 31 Mar 70.

but was achieved on 2 September 1970 (including rework of spare beams).[177] By that time the bogie beam had started failing again. Analysis showed the same old stress corrosion cracking in the lug area. Its confidence in the bogie beam seriously corroded, especially since there was no way of detecting an impending failure, MAC insisted on more positive action to solve the bogie beam problem. This time the overhaul procedure was not overhauled again but thrown out the window. When landing gear experts from the Air Force and industry gathered to compare notes, it was decided that what was needed was a new, redesigned, "beefed-up" bogie beam.[178] The original beam had been reworked "to a point where the design safety margin has been seriously reduced" and was no longer tolerant of "any surface or subsurface imperfections." AFLC felt that another rework cycle would be detrimental to the service life of the beam, particularly in the lug area, so the decision was made for a redesigned beam for complete force retrofit. The new beam would be made of improved steel and would have a greater margin of safety designed in the lug area and a titanimum cadmium plating for corrosion protection. A purchase request was submitted on 29 August 1970 (a few days before the completion of the latest swapout) for enough beams to retrofit the C-141 force plus 31 spares. Total estimated cost was $5 million with deliveries during May-December 1971.[179] AFLC initiated procurement action in October 1970. The

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177. Log D-20 Rpt, subj: MLG Bogie Beam, 31 Aug 70.
178. See Footnote 153.
179. Historical Report, MAC DCS/Materiel, subj: C-141 MLG Bogie Beam Failures, undated, Sup Doc III-32.

swapout was incorporated in a package retrofit which included eight other items. Known as Pacer Gear 495, it was the major cure that was to enable the C-141 landing gear to get well by December 1971.[180]

(U) Pacer Gear 495 was completed 1 January 1972, just barely behind schedule. Although support problems had caused some work specification inconsistencies in that AFLC support on the eight other items was inadequate, the project was considered " . . . generally successful in providing a serviceable and reliable landing gear . . . ." It was perhaps too soon to rejoice; a " . . . follow-on fly-in project . . ." was programmed sometime in October 1972 to improve the nose gear and " . . . flame spray remaining main landing gear piston/bogie beam attaching lugs . . . ."[181] In any case, a projected service life between overhaul of 48 months had been identified for the bogie beam. (See Table VI.)

(U) The bogie beam experience highlighted the dual role of maintenance in material support. The attribution of deficiencies to " . . . improper rework procedures during overhaul . . ." was tantamount to the solution creating the problem it was meant to correct. In a related instance it conjured visions of " . . . misaligned functions . . ." as the principal cause for delay in the resolution of material deficiencies. This was that situation wherein the management and engineering responsibility was located several thousand

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180. See Footnote 153.
181. Msg, Dir Mat Mgt Hill AFB to MAC DCS/Log, 19 Jan 72, no subject.

TABLE VI

C-141 LANDING GEAR SERVICE LIFE

MLG Piston	48 mo
MLG Outer Cylinder	48 mo
MLG Bogie Beam Assy	48 mo
MLG Axle	36 mo
MLG Forward Brace	36 mo
MLG Aft Brace	48 mo
MLG Upper Torque Arm	48 mo
MLG Lower Torque Arm	60 mo
MLG Upper Drag Brace (with lug)	Indef
MLG Upper Drag Brace (without lug)	Indef
MLG Unlock Actuator	24 mo
MLG Piston	48 mo
NLG Oleo Trunnion	60 mo
NLG Axle	Indef
NLG Upper Torque Arm	48 mo
NLG Lower Torque Arm	48 mo
NLG Upper Drag Brace Aft	36 mo
NLG Trunnion Drag Brace	36 mo

NOTE: All of the above service lives were strictly engineering estimates without benefit of analytical condition inspection (ACI) evaluation of the new gear components. As such, on the basis of previous experience with the problems inherent in the exotic high heat treat metals used in the C-141 gear, these estimations were subject to dramatic changes.

miles from the actual overhaul and rework facility, resulting in " . . . inadequate IM/SRA coordination and/or lack of attention to end-item support requirements . . . ."[182] The exposure had a salutary effect. By 31 January 1971 WRAMA could say without fear of incriminating itself that cracks on bogie beam axle lugs were caused by "stress corrosion" and "hydrogen embrittlement," and it had developed an overhaul procedure that was the ultimate in corrosion prevention.[183] Metallurgical analysis of a bogie beam failure at McGuire AFB had revealed initial cracking caused by hydrogen embrittlement; an eight-hour bake period for hydrogen release was prescribed, with replacement of the axle lug bushings by a flame-sprayed material.[184] Corrosion was a reality that existed apart from WRAMA's imperfections; it was not a WRAMA invention but a legitimate concern that lay at the core of the total maintenance support problem. A MAC Corrosion Task Group was organized in February 1969 with two members each from HQ MAC, HQ 21 Air Force, and HQ 22 Air Force and one member each from the 443 Military Airlift Wing and WRAMA.

Others

(U) Other areas susceptible to corrosion and cracking were the inner cylinder walls and pistons of the main and nose gear struts,

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182. Background Paper, MAC DCS/Materiel, subj: C-141 MLG Actuator Failure Problem, 7 Apr 71. See Sup Doc III-40.
183. Log D-20 Rpt, subj: MLG Bogie Beam, 31 Jan 71.
184. Msg, Dir Mat Mgt Hill AFB to 438 MAWg, et al., subj: Failure of C-141 MLG Bogie Beam Assy P/N SG10010-103, EUMR 610MASS E 70-90, (23 Nov 70), 271540Z Nov 70, Sup Doc III-33.

the trunnion lugs, axles, drag braces, actuator cylinders and wheel flanges. (See Supplements III-7 and 8.) A strut failure was recorded as early as 23 October 1964. This was at a static test of an MLG specimen for a simulated life of 2,400 landings.[185] The nose gear strut was a fertile place for cracks. Like the bogie beam, it was especially vulnerable in the axle lug area. A C-141 pilot of the 436 Military Airlift Wing provided the following first-person account of a strut failure at Incirlik AB, Turkey, on 8 August 1969:[186]

> I initiated a hard right out of the parking spot with absolutely no difficulty. At the taxiway I commenced another hard turn to the left. After the turn was established I felt a rather sharp thump thru the airframe. As I straightened out the aircraft on the taxiway I felt another milder thump and observed the aircraft's nose slowly settle on the concrete. I applied the brakes, stopped and shut down engines . . . .

(U) By September 1969 the count indicated 22 aircraft with bad nose struts. The purging of struts with a "thin wall condition" in the axle lug web was followed by failures caused by " . . . an off-center process during overhaul . . .," necessitating a revision of depot rework procedures.[187] Cracks in the strut outer cylinder led to loss of hydraulic fluid and "operation with a hard strut." The cracks were attributed to "high stress concentrations" and were

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185. C-141 Mgt Sum, 23 Oct 64.
186. Msg, ACP MAC Incirlik to MAC, et al., subj: Preliminary Acft Incident Report, 080849Z Aug 69, Sup Doc III-34.
187. CMSgt John T. Kossakoski, "C-141 Landing Gear Malfunctions, Part II," The MAC Flyer, Jan 71, pp 8-12.

the result of a design deficiency. A "fix" was implemented in IRAN aircraft in 1969.[188] In February 1971 a nose strut failure at Travis prompted OOAMA to suspect that WRAMA had not adequately inspected the aircraft during IRAN in October 1970; accordingly, WRAMA's overhaul procedure for nose struts was changed on 15 January 1971 to preclude a recurrence. It involved the use of "low embrittlement" cadmium plating in lieu of a zinc-rich coating. OOAMA and WRAMA got together and worked out improved rework procedures to embrace all struts processed for Pacer Gear 495.[189]

(U) The strut stood conspicuously in the list of items monitored by the LTF program, which testified to the early importance attached to the strut. Also attached to it were the trunnions. The nose landing gear had more trunnion trouble than the main gear because the former not only had a strut trunnion that was subject to stress corrosion cracking, but also a drag link trunnion with a basic design deficiency. Failure of either trunnion caused collapse of the nose gear assembly. To deal with a stress-corroded trunnion, a depot rework procedure was used which involved shot peening for tensile stress relief (bombarding the surface with small steel beads at high velocity to allow the afflicted area to "relax"--a form of metal massage) and "hard anodizing" the interior for corrosion protection.

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188. Ibid.
189. Ltr, MAC DCS/Materiel to Col Jens, subj: Failure of Nose Strut--C-141 Acft 64-653, Travis, 24 Feb 71, Sup Doc III-35.

Besides being shot peened, drag link trunnions were provided with end bushings with less interference fit, for there was a high concentration of stress corrosion in this area. This rework process was implemented on IRAN aircraft starting January 1970 with estimated completion by January 1973. Spare drag link trunnions of the future were to be made of a material with a greater "toughness factor," would be more resistant to stress corrosion, and would have end bushings with less interference fit. The retrofit was delayed by a defect in the shot peening equipment.[190]

(U) Among the major stress corrosion problems persisting after Pacer Gear 495 were those affecting the NLG oleo and drag link trunnions along with the NLG outer cylinders, the MLG strut piston and unlock actuator, and the MLG axle. At a joint MAC/WRAMA/OOAMA conference on 8 February 1972, trunnions made from T-6 aluminum alloy were pronounced inferior to the newer T-73 aluminum alloy trunnions. OOAMA expressed the opinion that rework was no remedy for trunnion trouble and recommended outright replacement with T-73 aluminum trunnions of a new design.[191] In March 1972 the C-141 system manager completed negotiations with OOAMA for the installation of NLG struts and drag link trunnions and MLG axles, downlock actuators, and flame-sprayed pistons. The swapout would place approximately 204 aircraft on the depot fly-in program, the work requirements calling for total

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190. See Footnote 187.
191. Ltr, MAC DCS/Log, subj: Trip Report--Joint MAC/WRAMA/OOAMA Conference, 8 Feb 72, Hill AFB, 22 Feb 72, Sup Doc III-36.

replacement of the nose struts, drag link trunnion and downlock actuator, while approximately 180 aircraft required replacement of the MLG piston and 79 needed new axles.[192]

(U) The last two items, the MLG piston and axle, had had a history of stress corrosion failure dating back to 1965 when the first cracks were noted on the MLG fatigue test specimen at Lockheed's Project Long Life facility. In February of that year the piston failed at only 2,600 landings, prompting a modification that was tested to satisfy the 12,000 landings requirement and used to replace the original piston.[193] Continued cracking was attributed primarily to the bushing design. OOAMA recommended rework of the lug ID (inner diameter) with a stainless steel flame spray and installation of spiral-grooved, copper-beryllium lug bushings.[194] The piston had a projected service life between overhaul of 48 months; it was 36 months for the main gear axle and "indefinite" for the nose gear axle. (See Table VI.) Investigation of a broken MLG axle found on 17 August 1970 during preflight inspection of a C-141 revealed that the axle had been installed by WRAMA cnly 30 days before. It was of the latest configuration, was made from high tensile strength steel, and had never been reworked. Fracture analysis by WRAMA and Menasco metallurgists indicated that the fracture occurred " . . . because of a crack that had not been

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192. Msg, Dir Mat Mgt Robins AFB to Dir Mat Mgt Hill AFB, subj: C-141 NLG Swap-Out Program, 22 Mar 72.
193. C-141 Mgt Sum, 19 Feb 65.
194. See Footnote 191.

completely worked out during manufacture . . . ." Four other such axles had already been installed; the C-141s involved were traced and grounded temporarily for axle replacement.[195]

(U) Early in 1966 attention was focused on the drag brace as a result of the first known failure of this gear component. It had not been determined whether the failure could be associated with the number of landings. The 443 Military Airlift Wing was directed to inspect by nondestructive inspection all drag braces on aircraft with more than 1,800 landings; the 60 Military Airlift Wing was for doing it on aircraft with over 1,100 landings.[196] Both WRAMA and Lockheed looked into the "practicability" of such a process; the alternative was removal of the brace during periodic inspection.[197] The possibility of the incident being an isolated one (i.e., not indicative of a trend) gained credence after a 1,800 landings inspection at Tinker showed "negative findings of discontinuities or cracks."[198]

(U) In December 1970 (almost five years later) drag brace failures were identified as stress corrosion cracking due to high stress concentration in the area of the lock bolt hole, preventing gear retraction/extension. A change in depot overhaul procedures required roll burnishing of the bolt hole (reaming or cleaning out), shot peening, and then bringing the hole back to its original state by

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195. Background Paper, MAC DCS/Materiel, subj: C-141 MLG Axle Failure, 21 Aug 70, Sup Doc III-37.
196. Daily Act Rpt, subj: C-141A Incident, 10 Feb 66, Sup Doc III-38.
197. Daily Act Rpt, subj: C-141A Incident, 15 Feb 66, Sup Doc III-39.
198. Daily Act Rpt, subj: C-141A Incident, 16 Feb 66.

insertion of a steel sleeve. Estimated get-well date would be in January 1973. Meanwhile, units in the field were to continue with the inspection of unmodified braces to insure replacement of cracked ones.[199]

(U) A component that not only affected gear retraction/extension but also the operation of other systems was the actuator cylinder. A ruptured actuator cylinder spilled hydraulic fluid into the gear pod, creating a fire hazard in addition to rendering the entire number two hydraulic system impotent, which necessitated the use of emergency operating procedures on gears since none of the other two hydraulic systems could be used as an alternate except on the wheel brakes. (The number two hydraulic system also operated the aircraft aileron, rudder, flaps, spoilers, etc., but with numbers one and three hydraulic systems as back-up.) In 1967 WRAMA's diagnosis of what ailed the actuator pointed to corrosion fatigue as the culprit. The rework criteria for the actuator cylinder assembly was established and published in a technical order supplement on 7 June of that year. It involved "machining" of the cylinder inner wall to remove defects, shot peening, and hard anodizing. This treatment was expected to result in reduced corrosion, "cocking of piston during extension," and improved actuator service life.[200]

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199. CMSgt John T. Kossakoski, "C-141 Landing Gear Malfunctions, Part I," The MAC Flyer, Dec 70, pp 4-7.
200. Log D-20 Rpt, Jul 67.

(U) Two instances of actuator cylinder cracking--one at Kelly AFB involving the left MLG and another at Altus AFB involving the right MLG--gave ample proof that, whatever good the 1967 rework might have done to the actuator, it was not in the best of health in 1970. Both incidents produced identical recommendations to OCAMA[201] and WRAMA[202] for "a study to determine cause of failure." Actually, an actuator test had been concluded in May of that year with "highly favorable results."[203] The tested modification was said to relieve stress concentrations in the cylinder barrel without recourse to shot peening. Its main selling point was the refinishing of the barrel interior with chrome oxide, which supposedly increased the actuator's service life to as much as 64,000 pressure pulse cycles (compared to only 20,000 pressure pulse cycles for the original actuators). Implementation was set to commence in August 1970 but slipped to January 1971 and then to February. As of 7 April 1971 nothing had been done. When asked why actuators were not provided for swapout as scheduled, WRAMA referred to " . . . delays in obtaining bits and pieces for actuator build-up . . ." and recommended that AFLC " . . . consider the feasibility of relocating the MLG actuator SRA to OCAMA . . . ."[204] The tantalizing dream of a world without actuator

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201. Msg, Det 1, 63 MAWg to OCAMA, subj: EUMR Submitted IAW TO 00-35D-54, 101900Z Jul 70.
202. Msg, 443 MAWg to WRAMA, no subject, 242012Z Sep 70.
203. See Footnote 199.
204. Background Paper, MAC DCS/Materiel, subj: C-141 MLG Actuator Failure Problem, 7 Apr 71, Sup Doc III-40.

failure prevailed over WRAMA's inscrutable behavior, and by 9 August 1971 over a hundred C-141s were fitted with the "improved" fixture. On that fateful day McChord AFB reported three aircraft with number two hydraulic system contamination. The cause: flaking chrome oxide in the actuator cylinder barrel. The actuator swapout, which was being accomplished as part of Pacer Gear 495, was brought to a grinding halt, but by this time it had run out of unreworked actuators anyway. A frantic demand followed for the discarded original actuators that had been refashioned into the now unwanted replacement. It was a scene that was becoming all too familiar in the C-141 improvement story. An order for 242 original actuators had to be placed with ABEX Corporation, Canada, with OCAMA " . . . pressing ABEX for earliest possible delivery . . . ."[205]

Seal Leakage and Bearing Slippage

(U) Among the trio of troubles that bedeviled the C-141 landing gear--breakage, leakage and slippage--the last two were perhaps not as dramatic but were quite as capable of damage. Leaking seals or slipping bearings generally resulted in a malfunction of the whole gear by adversely affecting the retraction or extension process. The up-and-down movement of the landing gear depended upon adequate lubrication and bearings in good condition. In December 1966 the

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205. Background Paper, MAC DCS/Materiel, subj: C-141 MLG Actuators, 9 Aug 71, Sup Doc III-41.

first was considered a major problem area.[206] A month later, the second was also an object of primary attention;[207] TCTO 1C-141A-1161, one of the earliest steps towards improving the free-fall characteristics of the MLG by replacing existing drag braces with drag braces containing beryllium copper or aluminum bronze bearings, was published and distributed. Possible methods and materials for repairing MLG upper strut bearings were investigated. The surface roughness of steel mating, it was found, complicated and limited the choice of materials, which must:

1. have good bearing properties;
2. withstand the abrasive effect of the outer cylinder, and
3. not have a detrimental effect on the steel.

Selected for testing were bearings with flame-sprayed aluminum bronze and flame-sprayed tungsten carbide.[208]

(U) Meanwhile, the replacement of seals at off-shore stations under less than ideal conditions was causing too many MLG struts to leak. The 60 Military Airlift Wing alone repaired six struts during a three-day period and told of "rolled, twisted, scored and eroded" packing.[209] The incidence of strut leakage, seal failure, and bearing deterioration called for "action to improve the reliability of the strut and its components." A new Greene-Tweed seal and backups

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206. MAC C-141 Status Rpt for December 1966.
207. MAC C-141 Status Rpt for January 1967.
208. Ibid.
209. OES/LTF Rpt, Jan 67, p 18.

were included in the service test on the aluminum bronze-coated upper bearing,[210] two of which were forwarded to the C-141 SPO by the Systems Support Branch of the Air Force Materials Laboratory. Theoretically, the bearing's coating would enable it to resist steel mating surface roughness and withstand the abrasive effects of the outer cylinder. At this time the known causes of strut cylinder seal failures were "spiral rolling" and metal particles embedded in the seal. Three months of testing with no leakage led to tentative acceptance of the Greene-Tweed seal with its inclusion in retorfit kits to be used on an attrition basis.[211] On the basis of 398 leak-free landings, a depot level TO supplement was prepared, for accomplishment at overhaul, requiring rework of the original bearing to remove defects and then flame-spraying with bronze aluminum. A design change would be incorporated in future procurement while in-service bearings were being modified on an attrition basis. At Travis the service test on the aluminum bronze bearing and Greene-Tweed seal proceeded smoothly.[212] With no strut seal or bearing discrepancies reported by June 1968, TO 1C-141A-1256 was issued directing replacement of the upper strut bearing and dynamic piston seals with the redesigned configuration of aluminum bronze bearings and Greene-Tweed seals.[213]

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210. Ibid.
211. OES/LTF Rpt, Apr 67, pp 21-22.
212. OES/LTF Rpt, Jul 67, pp 18-19.
213. MED/LTF Rpt, Jun 68, p 5.

(U) In another area, the bearing problem was developing some complications. MAC had to nonconcur on 28 May 1968 with OOAMA's closing action on MLG trunnion bearing slippage, pointing out that the issuance of a TO had not reduced the problem. After a strut change, two bearings slipped, one after only a single landing. MAC called for " . . . accelerated action . . . to identify cause(s) . . . and initiate corrective action that will qualify as a permanent fix . . . ." The C-141 Maintenance Evaluation Division of Detachment 12, HQ MAC, at Travis agreed with the 22 Air Force that the closing action by OOAMA was "not warranted" and declared that expedited action by OOAMA was " . . . urgently required to prevent mission degradation and potential flying safety hazard . . . ."[214] Continued trunnion bearing slippage prompted OOAMA to modify four struts and eight drag braces for a service test of trunnion bearings with increased internal diameter tolerance.[215] The modification directed side loads to the drag braces instead of the trunnion lug, even when the trunnion rotated. Inspection of the edges of the flame-sprayed surface on drag braces five months later revealed no chapping, cracking, or flaking and showed no signs of trunnion bearing rotation. On the other hand, NLG trunnion bearings were showing excessive wear and failure; WRAMA investigated, procured a new NLG trunnion bearing to be made available starting January 1969 for

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214. MED/LTF Rpt, May 68, p 12.
215. C-141/MED Rpt, Dec 68, p 16.

replacement on an attrition basis.[216] An incident near Clark AB on 31 August 1969, attributed to failure of the lower strut bearing presumably as a result of insufficient lubrication, drew a recommendation emphasizing the necessity of properly lubricating trunnions and bearings "at required intervals."[217]

(U) While the trunnion bearing slippage problem was not serious enough to warrant anything more urgent than "replacement on an attrition basis," it did cause aircraft gross weight restriction and related annoyances. For one thing, bearing slippage on unmodified assemblies had to be corrected by replacing the strut and side drag braces to preclude gross weight restrictions.[218] Moreover, an NLG trunnion bearing failure, while not seriously affecting the safe operation of the aircraft, could create nose shimmy and place undue stress on the aircraft structure. It also heavily taxed the maintenance capability with the requirement to jack the aircraft. Like most of the other landing gear deficiencies, it was the result of unproven design: a nongrease type of bearing with a fabroid lining which deteriorated and slipped when subjected to high load forces. The "improved" bearing deleted the fabroid lining but required periodic grease servicing. This modification was accomplished in the field through TCTO

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216. Ibid.
217. Msg, 69 MASGp to CSAF, et al., subj: USAF Aircraft Incident Report, 1 Sep 69.
218. CMSgt John T. Kossakoski, "C-141 Landing Gear Malfunction, Part I," The MAC Flyer, Dec 70, pp 4-7.

action.[219] However, the outer race of this bearing proved too soft and made installation critical. Consequently, MAC found itself service testing fourth generation fabroid-lined bearings which were considered far superior to first generation fabroid bearings.

The Shimmy

(U) Besides the common ills landing gears were heir to, the C-141 NLG was susceptible to a unique abnormality known simply as the shimmy. During the first half of 1966, investigation by both the C-141 SPO and Lockheed into the high frequency of nose wheel shimmy incidents indicated that the disorder occurred "only at light gross weights during landing deceleration from 70 to 20 knots" and could not be duplicated in high-speed taxi tests. No specific cause could be determined. Procedures tried at Travis failed to identify the cause or correct the problem. Two Lockheed engineers dispatched to the base on 25 June 1966 remarked that it was possibly caused by "looseness of the wheels on the axle" due to such factors as excessive clearance between wheel bearing and axle, miscellaneous galling and pitting, etc., etc. Their recommendations stressed the importance of "proper rigging and servicing" of the nose gear.[220]

(U) On 6 July 1966 a C-141 of the 443 Military Airlift Wing landed at Yokota, Travis, and McChord after a Southeast Asia mission,

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219. CMSgt John T. Kossakoski, "C-141 Landing Gear Malfunction, Part II, The MAC Flyer, Jan 71, pp 8-12.
220. C-141 Status Rpt for June 1966.

each time with nose wheel shimmy. Maintenance was performed at each base, yet when the aircraft landed at Tinker AFB, there was that old nose wheel shimmy again. The SPO sent Lockheed and WRAMA engineers to Tinker to tinker with the problem.[221] They stayed during 8-10 July, changed the C-141's nose wheels and when the aircraft checked out perfectly during a 10 July test flight decided that "wheel out of balance" was the possible cause and they considered their job done and went home. The next day the aircraft was flown, and after nine landings, there was that old nose wheel shimmy again.[222] This time the people at Tinker decided to do their own tinkering, replaced the nose gear piston and axle assembly on 11 July, and after 23 landings without a shimmy, the aircraft was sent home to Altus AFB.[223]

(U) More shimmy reports were received; many more were said to be unreported. The Operations Evaluation Staff/Lead-the-Force (OES/LTF) monthly activity report for August 1966 stated that the nose shimmy problem was "not yet clearly defined." This did not mean that causes were not identified; among these were: bad tires, water in one tire, use of incorrect wheel bearings and improper wheel installation.[224] By the end of November 1966 the number of shimmy

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221. Daily Act Rpt, subj: C-141A 63-8080, Nose Wheel Shimmy Problem, 8 Jul 66, Sup Doc III-42.
222. Daily Act Rpt, subj: C-141A 63-8080, Nose Wheel Shimmy Problem, 12 Jul 66, Sup Doc III-43.
223. Daily Act Rpt, subj: Items of Interest--C-141A, 13 Jul 66, Sup Doc III-44.
224. OES/LTF Rpt, Aug 66, pp 12, 16.

incidents reported since the start of the year totalled 357. With experience came expertise. It was observed that the application of nose steering seemed to arrest the shimmy. Again, it was not necessarily due to many hours use; a C-141 fresh from the factory with only 28 hours flying time and eight landings shimmied.[225] Trouble-shooting for shimmy consumed 25.4 percent of total man-hours expended on the landing gear.[226]

(U) On 28 October 1966 the Aerospace Systems Division (ASD) said about the shimmy:[227]

> On-site investigations and analysis of shimmy problems reported indicate that while there have been numerous shimmy incidents, maintenance variations appear to be the major contributing factor. Engineering analysis of design and test data have not as yet detected a design deficiency. However, a reduction in total accumulative tolerance build-up in gear may be possible.

(U) The following month, preliminary test results of Project 3-A, the formal shimmy inquiry, indicated that the primary cause was "air cavitation in the steering system" due to "fluid shrinkage" resulting from cold temperatures during high flight. As an interim remedy the SPO proposed a technique developed by Lockheed pilots, who were well versed in living with Lockheed problems. This consisted of turning the steering system five to ten degrees in each direction prior to landing.[228] Meanwhile, a two-month service test

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225. OES/LTF Rpt, Nov 66, pp 24-25.
226. Ibid., p 43.
227. C-141 Mgt Sum, 28 Oct 66.
228. C-141 Status Rpt for November 1966.

was initiated on a permanent fix which required installation of a check valve to keep steering cylinders supplied with oil.[229] Lockheed was able to get six C-141s (two LTF) into the service test. The fix specified the addition of tubing into the number two hydraulic system return line to bypass the nose wheel steering system compensator valve. This allowed a constant circulation of number two system fluid through the nose wheel steering system, keeping the fluid warm and avoiding the shrinking problem. Test kits were due on 13 January 1967 at Travis where the test was being conducted and monitored by the Operational Evaluation Staff for 60 days.[230] The test verified that cavitation in the steering system was indeed the primary cause of nose gear shimmy; further, that the condition could be corrected by the use of a check valve bypassing the number two hydraulic system return pressure to the nose wheel steering selector valve.[231]

(U) On 9 December 1966 ASD reported:[232]

> Preliminary results of laboratory and instrumented aircraft testing indicate that a cavitation condition occurring in the steering actuation cylinders under certain conditions is the primary cause of nose gear shimmy.

(U) After 303 landings with no shimmy the decision was made that the SPO should initiate action to include the new check valve

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229. C-141 Status Rpt for December 1966.
230. OES/LTF Rpt, Dec 66, pp 15-16.
231. Ibid., p 24.
232. C-141 Mgt Sum, 9 Dec 66.

in aircraft production and fleet retrofit.[233] Up to 1,032 landings with still no discrepancies reported provided added incentive to TCTO action in process.[234] ECP-769 for installation of the new check valve was approved by the SPO in April 1967.[235] At about this time an aircraft with installed shimmy test kit experienced a shimmy. It was found to have defective nose steering actuator valves.[236] With TO 1C-141A-1200 in effect, kit delivery was completed in September 1967, and MAC directed modification accomplishment on all C-141s by 15 November 1967.[237]

(U) The nose wheel shimmy did not fade entirely into history. From time to time it reappeared, but never again to cause such concern. On 8 January 1970 a C-141 of the 437 Military Airlift Wing at Charleston AFB, South Carolina, while on takeoff roll at Corpus Christi Naval Air Station, Texas, experienced severe vibration caused by NLG shimmy resulting from material failure of the NLG steering actuator.[238] On 27 April 1970 a C-141 experienced severe NLG shimmy 5,500 feet down the runway on an otherwise normal landing at Torrejon AB, Spain; cause: number two hydraulic system failure.[239] On 4

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233. C-141 Mgt Sum, 24 Feb 67.
234. OES/LTF Rpt, Mar 67, p 21.
235. C-141 Mgt Sum, 14 Apr 67.
236. OES/LTF Rpt, Apr 67, p 25.
237. Hist Rpt, MAC DCS/Materiel, subj: C-141 NLG Shimmy Service Test, 1 Sep 67, Sup Doc III-45.
238. Msg, 437 MAWg to CSAF, et al., subj: USAF Acft Incident Message Rpt, 152200Z Jan 70.
239. Msg, 625 MASq to WRAMA, et al., subj: EUMR, 271510Z Apr 70.

February 1971, after a normal landing on a wet runway at Norton AFB, California, a C-141 experienced a shimmy when the NLG upper torque arm failed at 80 knots. The incident was attributed to "an over-serviced strut" and suspected excessive loads on the torque arms during takeoff.[240]

Extension/Retraction Difficulties

(U) A landing gear system was as good as its ability to be where it was needed: up for flight and down for landing--otherwise it created an unacceptable situation. An unretractable gear was sufficient ground for flight abortion; an unextendable one was worse than none, an invitation to all kinds of unpleasant possibilities. As more C-141s entered the inventory, there was increasing concern over the likelihood of a gear-up landing. Some difficulty with the downlock mechanism was recognized and reported by the Category III Joint Test Force as early as November 1965. Practice attempts by the 443 Military Airlift Wing at manual extension of the main landing gear into the locked position met with repeated failure (eight out of eight). The 60 Military Airlift Wing reported 137 failures out of 152 functional check flights, which represented a 90 percent failure rate; three of the aircraft involved had less than 100 flying hours.

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240. Msg, 61 MASWg to CSAF, et al., subj: USAF Acft Incident Message Report, 100158Z Feb 71.

Of 32 aircraft with recurring uplock/downlock difficulties, the mean time between failures (MTBF) averaged 248 hours.[241]

(U) According to a 1 February 1966 report by the MAC Director of Maintenance Engineering, TCTO 1C-141A-618, "Relocation of the Landing Gear Manual Downlock Engagement Mechanism," was not being completely complied with by Lockheed during production.[242] Later that year there was the problem of the MLG that would not lock down by means of the normal emergency extension method. The proposed solution involved modification of MLG drag braces and redesign of MLG bearings to relieve galling of the rotating joint bushings. Aluminum bronze or copper beryllium bushings replaced the original steel bushings, and lubricating grooves were added where required "to assure proper lubrication to all contact surfaces." Command emphasis was provided by a statement made 20 December 1966 saying that "the present situation is unacceptable." Because of the "exhibited seizing tendency of MLG bearings," it was decided that the inflight free-fall check was not reliable, since it might bring about the situation it was meant to avoid. Maintenance personnel had to perform the MLG free-fall check with the aircraft on jacks, but this procedure increased the likelihood of a serious accident due to a problem with jack failures. Under the circumstances, an expedited bearing retrofit program was in order. However, WRAMA

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241. OES/LTF Rpt, Nov 66, p 26.
242. Daily Act Rpt, subj: MLG Emergency Extension--C-141A Acft, 1 Feb 66, Sup Doc III-46.

claimed that the drag brace problem was dragging because MAC and OOAMA were not making the braces available to WRAMA for modification.[243]

(U) While WRAMA, OOAMA, and MAC thus wrestled with the problem, C-141 aircrews on occasion were obliged to resort to unorthodox methods with hardly a moment to spare. One such incident happened on 11 February 1969. A C-141 bound for Norton from McChord with 36 passengers on board couldn't get its nose wheels down despite the use of all published procedures. A hole finally had to be cut in the bulkhead with an axe and pliers and a loop made from wing streamers slipped over the disconnected actuating rod to free the gear.[244]

(U) A similar incident on 14 January 1971 credited the success of the axe operation to training in "emergency cut-through/NLG extension procedures" and prompted the recommendation that such training "be considered for inclusion in simulator courses . . . at all C-141 operating wings if it is not already so included." Another suggestion was the development of an extender handle of the NLG emergency handle assembly.[245] Actually, TCTO action had been taken to install a manual nose gear release bar for inflight use (which could also be used by ground maintenance crews to check the NLG release mechanism for binding conditions) but it was not easily reached by personnel with short

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243. OES/LTF Rpt, Dec 66, pp 18, 24-25.
244. "C-141 Inflight Emergency Creates Anxious Moments for Crew," McChord Airlifter, 20 Feb 69, p 2; "Lame Starlifter Lands Safely," The Sun Inland Empire, 14 Feb 69, p B-4.
245. Msg, 61 MASWg to CSAF, MAC, et al., subj: USAF Acft Incident Message Report, 140245Z Jan 71.

arms. All C-141s reportedly had a manual release bar installed by October 1970. Along with this modification was the installation of an easily removable door to permit inflight emergency access to the manual release bar.[246]

(U) At the start of 1971 the NLG uplock release mechanism was listed as one of the continuing problems of the C-141 landing gear system. This was because it had too many components that could fail and render the system inoperable, in which case there would be no way to release the uplock mechanism except manually.[247] Unlike the main gear, the nose gear had two hydraulic systems dedicated to it--one a small emergency unit called the number four hydraulic system. The two hydraulic systems plus the manual system made it almost impossible for the C-141 to land with its nose gear up, since the extension process merely induced the gear to fall freely once released from the uplocked position. New ways of doing this were continually being developed. Interim Operational Supplement, TO 1C-141A-1S-87, "Nose Gear Emergency Extension," 29 October 1969, provided the following additional information for emergency NLG extension:[248]

> In the event a manual gear extension is attempted and the nose gear will not extend with pressure from hydraulic system Nr. 4, turn off hydraulic system Nr. 2 to deplete

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246. CMSgt John T. Kossakoski, "C-141 Landing Gear Malfunction, Part II," The MAC Flyer, Jan 71, pp 8-12.
247. Ibid.
248. Msg, WRAMA to OCAMA, et al., subj: Operational Supplement TO 1C-141A-1S-87, 291800Z Oct 69.

the pressure, and attempt to lower the nose gear using the manual nose gear extension procedure. Return the hydraulic system Nr. 2 to normal operation after the nose gear is down and locked.

(U) In July 1970 WRAMA modified the NLG unlock procedure. Hand pumping the unlock actuator to unlock the nose gear released a microswitch and pressure from the number two hydraulic system, locked the uplock again, and kept the gear from extending. The new instruction provided relief to hydraulic pressure prior to hand pumping the unlock actuator. This allowed the nose gear to unlock and check the pressure required to operate the uplock mechanism.[249]

(U) A ruptured nose wheel steering pressure line (flex hose) could cause a leak in the number two hydraulic system and incapacitate the nose gear. This was what happened at McChord AFB on 9 July 1967 when a hose with 6,000 hours failed. As a result, a nose wheel pressure line change was recommended every 5,000 hours.[250]

(U) When hydraulic failure prevented normal extension of the MLG, the following procedure was recommended:[251]

1. Gear handle down.
2. All Nr. 2 flight control switches off including elevator power switch.
3. Position scanner at hydraulic interconnect valve with Nr. 3 pumps off interconnect closed.

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249. Msg, Dir Mat Mgt Robins to DMM Hill, subj: Emergency AFTO Form 21, 101921Z Jul 70.
250. Msg, 62 MAWg to MAC, et al., subj: MAC Acft Incident, 101800Z Jul 69.
251. Msg, 61 MASWg to MAC, et al., subj: MAC Acft Preliminary Message Report, 092301Z Feb 71.

4. Simultaneously turn on Nr. 3 pumps, open interconnect, and scan Nr. 3 reservoir for rapid fluid drop which would be cause for immediate closing of interconnect.

(U) There was also the maintenance factor in gear retraction/extension failures, as in the case of a C-141 whose right main gear had to be extended manually at Elmendorf AFB on 21 November 1970 because the uplock required lubrication.[252] When a malfunction could not be duplicated it was placed in the "undetermined" category, as when a nose gear failed to retract following touch-and-go takeoff at Tinker in February 1970.[253]

Wheel and Tire Troubles

(U) Like anything with wheels and tires, the C-141 had its share of problems with these components--primarily wheel cracks attributed to design deficiency, tire tread separation, and brake deterioration. Due to the military requirement to enhance the versatility of the C-141, the possibilities of tire deflation techniques for landing on unprepared runways were investigated in conjunction with flotation tests.

(U) A classic case of wheel failure occurred on 21 July 1969 when a C-141 on the way to Da Nang, Republic of Vietnam, from Cubi Naval Air Station, Philippines, found itself with a flat tire after retraction indicated an unsafe MLG. The flight was diverted to Clark

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252. Msg, ACP MAC Elmendorf to MAC, et al., subj: MAC Acft Incident, 290628Z Nov 70.
253. Msg, 443 MAWg to MAC, et al., subj: MAC Acft Incident, 042300Z Mar 70.

AB where a second tire failed during the landing roll. Unknown to all, number seven wheel had failed on takeoff at Cubi, leaving a large chunk of its outer rim on the runway. Total cost for replacement of wheels and tires was $1,032. The 69 Military Airlift Support Group at Clark recommended that the "recent increase of C-141 main landing gear wheel failures be made a subject of special briefings for all flight crew personnel, with emphasis on critical preflight of this item." The number of tire changes was a suspected factor in wheel failures.[254]

(U) The 69th at Clark was not joking when it said that there was an increase of C-141 MLG wheel failures. At McGuire a wheel failure caused a number three tire blow out on 29 July 1969 and three days later at Elmendorf another C-141 experienced deflation of number seven tire as a result of wheel failure. Both aircraft were taxiing and a loud "thump" or "thud" was heard in each case. Earlier that month, while a C-141 was taxiing at Norton, its number three wheel failed and caused the number three tire to go flat, inducing a sympathetic flat in number four tire which could not support the added weight. (A standard numbering system for MLG wheels and tires was established by the C-141 Operational Evaluation Staff in 1967; the front wheels and tires, left to right, were numbered one through four in the same way as the engines, and the rear wheels and tires were numbered five through eight.)

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254. Msg, 69 MASGp to CSAF, et al., subj: USAF C-141 Incident, 230915Z Jul 69.

(U) On 14 November 1969, another wheel failure while taxiing caused another flat tire at Clark; evidence of stress corrosion in the radius of the wheel's rim flange was noted. Another wheel rim failure, this time involving the number seven wheel, occurred at McGuire in January 1970 while a C-141 was taxiing to the parking area after a normal smooth touchdown with little braking. It was recalled that two 90-degree turns were made during the taxiing. On 8 February 1970 a C-141 emitted a loud "bang" at Cam Ranh Bay, Republic of Vietnam, while taxiing to the parking ramp after making a 90-degree turn; the number three wheel rim was found cracked with a 26-inch wide section separated from the wheel assembly. A C-141 at Altus AFB, on 14 July 1970 also suffered a 24-inch separation of the rim circumference at the bead seat area of the number three wheel while taxiing. A loud noise was also heard, although it was not specified whether it was a "bang," "thud," or "thump." The wheel in question had been overhauled, placed back in service in February 1970 and had had two tire counter changes. It was installed on the aircraft on 2 July 1970 and was checked ten days before failure. The 443 Military Airlift Wing at Altus strongly recommended that a reinforced, stronger wheel be used in the field, and that all wheels made during or before 1965 be condemned.[255]

(U) There had been an earlier recommendation on the C-141 main wheel in January 1970 after two front tires blew out during takeoff

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255. Msg, 443 MAWg to WRAMA, subj: 443 MAW, E70-343 Mission Failure, 142048Z Jul 70.

roll at Yokota AB, Japan. The tires were found shredded and the wheel rims worn. An emergency unsatisfactory report was submitted to WRAMA which resulted in the redesign of the wheel and the requirement for an eddy current inspection at each tire change. Further, an ultrasonic inspection was required at each minor inspection on built-up wheels to "enable detection and replacement of wheels prior to failure."[256]

(U) On 22 July 1970, a C-141 at Robins AFB while taxiing experienced a wheel failure which damaged three tires. In view of the continuing wheel failures during taxiing, MAC issued guidelines regarding this aspect of the C-141 operation which was intended to minimize wheel failures resulting from improper taxiing techniques. The taxi speed was to be "the minimum acceptable, not to exceed 15 knots." Taxi routes were to be preplanned, smooth turns made and sharp ones avoided. The aircraft must move forward before making a turn. It must brake smoothly, and there was to be no braking during turns "except when absolutely necessary."[257] There was an additional directive on turns a few days later:[258]

> Turns will be as gradual as conditions allow. Do not use nose wheel deflections in excess of 60 degrees except in extreme conditions.

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256. Msg, 65 MASGp to MAC, et al., subj: MAC Acft Special Interest Incident Message Rpt, 200130Z Jan 70.
257. Msg, MAC DCS/Ops to 21 AF, et al., subj: C-141 Taxi/Towing Techniques, 292200Z Oct 70, Sup Doc III-47.
258. Msg, MAC DCS/Ops to 21 AF, et al., subj: C-141 Taxi/Towing Techniques, 031425Z Nov 70, Sup Doc III-48.

(U) A wheel failure on 18 February 1971 at Travis illustrated the impact of recommendations and the continuing faith of those who made them. After a C-141 takeoff, approximately 30 percent of an MLG wheel rim was found on the taxiway. The aircraft was notified and the mission aborted. The separated rim section was from wheel number two, which had failed as a result of metal fatigue. The tire was flat but fortunately held on landing. The wheel was manufactured in July 1965, had had eight tire changes but no overhauls, and its last non-destructive inspection (NDI) was on 6 February 1971. Wheel and tire were installed on the aircraft on 18 February 1971 and had five landings before failure. The 60 Military Airlift Wing at Travis recommended that all wheel assemblies be replaced with the reinforced stronger model.[259] The fact was that NDI eddy current checks instituted in 1970 for checking installed wheels during minor/major and home station checks had reduced installed wheel failures to almost zero.

(U) When it was not related to the wheel problem, the tire problem usually concerned tread separation. This problem was reported in September 1966 and referred to WRAMA the following month. The B F Goodrich Company's solution to tread separation was itself a form of separation, a preventive surgery consisting of the removal of the "outer tread land and groove on each side of the tire mold . . . ." It was not considered a serious problem and was a closed item in March 1967. This was because of the relative ease with which retreads could

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259. OES/LTF Rpt, Oct 66, p 16.

be obtained. The object was to have a tire retreaded before it had a chance to start falling apart. Early in 1968, a technical order change authorized unlimited retreading of C-141 main tires. All reparable tires were returned to OOAMA for retreading. However, as the C-141's mission expanded, the problem reappeared in mid-1970 in a less propitious perspective. It was noted that there were five more tire tread separation cases during January-June 1970 than there were during the same period the previous year. It was mainly a question of management hinging on the difficulty of sending "exhibits" to OOAMA from offshore locations. When reparable tires were sent to the primary supply point at Norton, they somehow lost their identity as exhibits and were "lost in normal supply channels." Maintenance data showed that during a 15-month period new tires averaged 180 landings while retread tires averaged 154 landings. Average landings per retread cycle were as follows:

First retread. . . . . .174 landings

Second retread . . . . . .145 landings

Third retread. . . . . .129 landings

Fourth retread . . . . . .105 landings

Fifth retread. . . . . .121 landings

No limit was imposed on the number of retreads that could be applied since this was determined by the serviceability of the tire casings. What OOAMA needed was accurate and complete maintenance data documentation to enable it to disseminate usable and meaningful data for effective management of the tire program.[260] Increased emphasis on tire

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260. Background Paper, MAC DCS/Materiel, subj: C-141 MLG Retread Tires, 5 Jun 70.

inflation, started in 1970, had almost eliminated tire tread separations. Specific tire inflation criteria were established in the preflight/throughflight work cards and in TO 1C-141A-2-2. Meanwhile, OOAMA had been conducting a tire reliability test at Altus since 1969 to compare the service life of different manufacturers' tires--both new and retreads--for purposes of future procurements. The results of the new main tire tests by the 443 Military Airlift Wing which terminated on 14 July 1970 revealed the following average landings per new tire:

B F Goodrich 412

Goodyear 293

Schenuit 289

Uniroyal 257

On the basis of the results of previous test programs, OOAMA reported the following documented savings for new and retread tire buys:[261]

	New Tires	Retread Tires
FY 1969	$722,467	$1,371,177
FY 1970	$568,828	$1,375,287
FY 1971	$678,162	$1,375,287 (Projected)

(U) Besides normal wear and tear, C-141 tires were subjected to experimental usage. Formal discussions on the subject of inflight tire deflation and various alternatives took place on 21 March 1966. A tire deflation system developed by the Foster-Miller Corporation was demonstrated on 9 June 1966. Attached directly to the anti-skid

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261. MAC Mgt Info Sum, subj: Materiel, 5 Aug 70, pp ii-iii.

mechanism, it involved hand-setting of the desired deflated tire pressure on each tire prior to takeoff; later that year the C-141 SPO recommended discontinuance of "efforts toward installation of an inflight tire deflation device . . . ." A meeting at HQ USAF on 8 December 1966 discussed the C-141 off-runway capability improvement program and identified areas to be investigated. An SPO briefing at HQ USAF on 5 January 1967 concerning the results of "high speed taxi tests" and "possibly a few takeoffs and landings" on mat runways was postponed due to "insufficient data." A meeting held on 12 January resulted in the decision to hold another meeting.[262] A flotation test conducted during June-August 1968 met similar difficulties mainly due to delays in accomplishing mat runway repairs at Dyess AFB, Texas.[263]

(U) Last but not least were the brake problems which troubled both main and nose wheels. However, these were not serious enough to retard the C-141's progress. Deficiencies in the hydraulic brake swivel fitting and the NLG spin brake led to corrective design changes. Tests in March-June 1968 on a redesigned fitting were sufficiently successful to prompt a SAAMA request for sole-source procurement of the item.[264] Elimination of eight rivets from the nose wheel spin brake where it came in contact with the tire allowed use of the brake until the lining was worn through to the neoprene strap without damage to the tire, resulting in considerable savings.[265]

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262. C-141 Mgt Sum, 20 Jan 67.
263. C-141 Mgt Sum, 15 Feb 68. LGC reports re flotation test proposal and results available in CSAH files.
264. WRAMA Log D-20 Rpt, 31 Dec 69.
265. C-141/MED Rpt, May 69, p 20.

> "The navigation system on the C-141 was envisioned as the most sophisticated and the most accurate system ever to be installed on a transport aircraft. The heart of the system would be the ASN-24 digital navigation computer. Inputs to this computer would include the AVN-2 astrotracker, . . . LORAN C . . . TACAN, Doppler, TAS, and the C-12 Compass . . . . Limited IFR airdrop capability was to become a reality with the airdrop mode of the computer. This, then, was to be a truly all-weather, global transport capable of combat operations anywhere in the world at any time."[266]

AVIONIC DIFFICULTIES

(U) From the beginning of the program there were many difficulties with the avionic equipment, especially the series of navigation aids. For instance, "The AVN-2 astrotracker was cancelled when the contractor was unable to meet specifications. The planned LORAN C coverage did not materialize. The C-12 compass did not live up to expectations; the only radar available was the unreliable APN-59, and the other equipment which materialized had many deficiencies

266. Sup Doc II-51 of Study, CSEH, subj: C-141 Starlifter, II, p 95.

to correct."[267] In addition, difficulties with the Central Air Data Computer (CADC), ARC-90, autopilot, flight director, MD-1 Gyro, and Adverse Weather Landing System (AWLS) also created problems for the command.

NAVIGATION SYSTEMS COMPUTER ASN-24

(U) During November 1963 serious consideration was given to the cancellation of the Starlifter's ASN-24 requirement. The reasons a faction wanted the requirement cancelled were as follows:[268]

1. Vertical navigation
   a. 1.0 monitoring
   b. Auto-monitoring
   c. Two-way data links capability not incorporated (removed for cost reasons)
2. Pressure pattern not possible (programs on great circle)
3. MATS would not delete second navigator
4. Present system limited to mach 1.0 (no growth potential due to programmer speed)
5. Auto airdrop capability not automatic, but only a light at navigator's panel--aircraft pitches up 500-1200 feet and loses wind data
6. No navigation program for latitudes above 67° N-S. Must be reprogrammed every 3-6 years due to variation shift

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267. Ibid., p 96.
268. Memo for Record (U), AFORQC, subj: ASN-24 Study ANSER, 6 Nov 63, Sup Doc III-49.

7. System would not permit use of TACAN stations above 67° latitude (i.e., Thule)

8. Polar navigation, using ASN-24, not feasible

9. Program costs were approximately $95,000/copy

(U) While the program participants were discussing reasons for elimination, the following reasons for retention were given:[269]

1. The system without the ASN-24 would only integrate the LORAN C, Astro-Tracker, Doppler and program great circle courses below 67° latitude

2. Production and engineering costs to remove the system and provide read-out for Astro-Tracker, LORAN C, and dual C-2 was as follows:

   a. Astro-Tracker - $90,000

   b. LORAN C/C-12 - $10,000

3. Astro-Tracker problems (eventually it was dropped)

4. ASN-24 Program was programmed to cost $25,000,000 plus spares. A cancellation would cost $3,000,000 to $4,000,000. Re-engineering in late 1963 was planned to cost $100,000 plus read-out parts. In addition, a periscopic sextant would have to be installed.

5. If cancelled the on-hand $3,000,000 worth of assets could not be applied to an existing program

6. ANSER (Analytical Service Test) was in being and promised a complete program study

With the above questions in mind the Chief of Staff Air Force queried the involved commands concerning their thoughts on the ASN-24 program.[270] Perhaps the clinching argument for program retention was

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269. Ibid., p 2.
270. Msg, CSAF to MATS and AFSC, subj: C-141 Navigation System Computer ASN-24 Revalidation, AFORQC 71192, 14 Nov 63, Sup Doc III-50.

proposed by the SPO in a memorandum to Air Force. Colonel Hammond pointed out that the SPO had " . . . always considered the items in question as growth functions . . . ."[271] At any rate, the ASN-24 was retained in the C-141 program, with some program alterations.

Early Difficulties

(U) After the Starlifter entered the MAC force[272] some serious problems still remained. Probably the most serious was a compatibility problem. For instance, the ASN-24 had a programmed accuracy based on zero error, while components feeding into the computer had no such planned accuracy. Hence, it was that the zero error inputs were " . . . unobtainable since some error [existed] in all the systems being fed into the computer."[273] Apparently the long distance missions were adequately computed; however, shorter missions produced gross errors from the computer.

System Qualification

(U) Many of the early deficiencies were uncovered and corrected through the manufacturer's attempts to qualify the system. As a consequence of the contractor's difficulties in qualifying the system and because of the need for the systems, unqualified ASN-24's were

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271. Memo, Col M. B. Hammond to Col Lionel Johnson, 13 Dec 63, Sup Doc III-51.
272. The first aircraft to enter the MAC force was production aircraft #9 which entered the Transitional Training Unit's (443 MAWg) inventory on 19 Oct 64. The first operational unit to receive a Starlifter was the 60 MAWg. The aircraft was received on 23 Apr 65.
273. Ltr, FTTC to ASD (C-141 SPO), subj: Deficiencies in C-141 Navigation Equipment, 6 Apr 65, Sup Doc III-52.

delivered for the category I and II programs. Subsequently, both the continuing manufacturer laboratory tests and the flight tests aided in the discovery of many deficiencies that had to be corrected before this component could be qualified.[274] By the end of FY 1965, after a number of design deficiencies had been corrected, satisfactory operation was achieved and the production schedule was adjusted for the newly qualified computer.[275]

(U) By October 1965 the computer was installed on production C-141 number 19 and following aircraft, except number 20. Operational Starlifters received field modifications. However, the category I and II tests had shown the need for further modifications.

(U) The first modification, which qualified the set, called for a revision to the computer program to eliminate errors and to correct a radar transfer initiation problem. The second step fix, which became available in December 1965, provided the following:[276]

1. Development of best available heading.
2. Changing of LORAN C coordinate locations from permanent to temporary storage.
3. Development of a method of presenting arrival over destination on horizontal situation indicator.
4. Reformulation of wind-finding between two fixes.
5. Reformulation of computer program to prevent errors introduced during aircraft turns.

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274. Log D-20 Rpt, 15 Jan 67, p 16.
275. Stewardship Report for FY 1965 and Objectives for FY 66, MAC DCS/Mat, Sect A-2.
276. Log D-20 Rpt, 15 Nov 65, p VII-16.

During the remainder of the year the ASN-24 underwent extensive field testing. Originally, this program was to have ended on 15 April, but various support problems precluded its completion date.

(U) Along with the slipping tests the computer developed other problems, specifically switch failures in the internal gear train and in seven of the system's indicators. Assets, also, were not available to replace the switches without resorting to stripping the MAC inventories.[277] To alleviate the critical situation the contractor proposed 15 ECPs and the command established an update program nicknamed "Applecore." The program was implemented to control the processing and transportation of the 815 control indicators that were scheduled for modification. By 11 April 1966 the first installation of the modified indicators was completed at Travis AFB, but the program completion date remained FY 1967.[278]

(U) The update program progressed satisfactorily until the contract with Kearfott Products Division of the General Precision, Inc., San Marcus, California, the vendor, expired on 16 June 1966. By the time the contract had been extended, in late July, the overall program had slipped more than 30 days.[279] By October 1966 the

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277. Daily Activities Rpt, MAC DCS/Mat, subj: Update/Modification ASN-24 Control Indicators, 9 Mar 66, Sup Doc III-53.
278. Historical Report, MAC DCS/Mat, subj: Project "Applecore," 30 Apr 66, Sup Doc III-54.
279. Daily Activities Rpt, MAC DCS/Mat, subj: Project Applecore Status, 21 Jul 66, Sup Doc III-55.

the AN/ASN-24 update program (Project Applecore) was completed on all aircraft spares, at Travis AFB, including all of the spares assigned to the 22AF forward supply points. The program's next cycle was initiated in November 1966, but further delay was incurred due to the late funding of federal supply class (FSC) 6605 following transfer of this responsibility from the Middletown Air Materiel Area (MAAMA) to the Oklahoma City Air Materiel Area (OCAMA).

(U) Despite these problems considerable headway had been made. The unqualified field level AGE was replaced with qualified equipment at the organizational and field level maintenance organizations, the computer program was in the process of update, the compatibility tests for the ASM-300 flight line test set and the MX 7443 adapter tray were planned,[280] and the ASM-300 was scheduled for delivery.

(U) Furthermore, by 31 December 1966 the modification projects were in the process of resolution. Project Applecore at Dover AFB was scheduled for completion on 17 January 1967, and the next cycle was to begin shortly thereafter.[281] The ASM-300 flight line test sets were scheduled for delivery in late January and TCTO-1C-141A-1141 actions, test adapter modification, were scheduled to begin on 1 January 1967.[282]

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280. Hist Rpt, MAC DCS/Mat, subj: C-141A AN/ASN-24 Navigation Computer System, 31 Oct 66, Sup Doc III-56.
281. Daily Activities Rpt, MAC DCS/Mat, subj: Status of Project Applecore, 21 Jan 67, Sup Doc III-57.
282. Daily Activities Rpt, MAC DCS/Mat, subj: ASN-24/C-141 Navigation Computer Test Adapter, 9 Jan 67, Sup Doc III-58.

(U) Project Applecore, however, brought to light a new problem. Test set AN/ASM-300 caused this problem; hence, the ASN-24 could not be tested. Since a defective test set could nullify all the gains by false readings, a crash project was established to correct its deficiencies.[283] By 1 May 1968 Air Force approved the new test sets and Kearfott began shipping them to the field units.

(U) During 1968 substantially all of the modifications were made or progressing satisfactorily when further improvements were suggested for the computers.[284] These improvements (termed Revision F) were:

1. Deletion of the earth rate correction to the C-12 Compass to permit use of compass latitude control.
2. Update of magnetic variation tables to 1970.
3. Update of star data tables to 1973.
4. Modification of celestial routine for true azimuth of the celestial bodies on C-6214/ASN-24(V) Control Indicator.
5. Modification of program to permit polar grid display of:
   a. Celestial Azimuth
   b. Heading
   c. Bearing (input/output)
   d. Wind Direction (input/output)
   e. Ground Track

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283. Sup Docs V-122 through V-124 of hist, MAC, 1 Jul 68-30 Jun 69, XV.
284. Operational Test Order 1-2-69, DCS/Ops, subj: Operational Test and Evaluation of ASN-24 Revision F, Nov 69, pp 1-2, Sup Doc III-59.

A spare switch was incorporated on the LORAN station counter switch in order to select normal or grid display. A polar grid chart convergence factor of one (1) was used. When the switch for grid was activated the grid reading was to be displayed on the following control indicators:

a. Celestial aximuth on C-3965/ASN-24(V) Control Indicator.

b. Celestial azimuth on C-6214/ASN-24(V) Control Indicator.

c. True heading on C-3965/ASN-24(V) Control Indicator.

d. Bearing, wing direction or ground track on C-3963/ASN-24(V) Control Indicator.

6. Program revision to preclude abrupt heading alterations when ASN-24 was coupled to the autopilot and the Cross Track Deviation and/or Track Angle Error was suddenly changed. The revision would cause the autopilot to disconnect and then go smoothly in Heading Hold mode without undesirable control transients.

The test of the modifications was conducted during November and December 1969. This " . . . overall test and evaluation revealed a substantial improvement of Revision F over Revision D."[285] However, one problem remained which caused a re-evaluation of the system. This problem was a cross track error on the range and bearing panel.[286] When the correction was made a new test order was published (Operational Test Order 1-4-70).[287] This test was designed to:

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285. Rpt, 63 MAWg, subj: Operational Test and Evaluation of ASN-24 Revision F, Nov-Dec 69, p 2, Sup Doc III-60.
286. Ibid., p 14.
287. Operational Test Order 1-4-70, DCS/Ops, subj: Operational Test and Evaluation of ASN-24 - Revision F, Jun 70, p 1, Sup Doc III-61.

1. Verify new modifications to software to preclude cross track jumps.

2. Verify that the fast IP update (Cruise Operator) feature was deleted.

3. Verify that TACAN fix routine was revised so that it was possible to update computer when only a range and bearing signal was available.

4. Determine that chart convergence angles .31137, .78535, and .39565, when used with appropriate charts, would perform grid navigation in subpolar areas.

The latter test proved the adequacy of the modifications and the ASN-24 emerged as a much improved Starlifter subsystem.[288]

APN-157 LORAN C

(U) The long-range navigation radio (LORAN C) utilized for the C-141 was also a new system. It evolved from the APN-151 used by the US Coast Guard, and was capable of automatically tracking ground stations and reporting stations 3,000 miles away at night and 1,000 miles away during the day. Originally the C-141 planners wanted the new micro-miniaturized ARN-78 made by the Sperry Corporation. However, this request was denied since this system was so new that testing was still in primary stages. Therefore, APN-157, which was still not completely tested, was selected for the Starlifter. Initially this system figured in the ASN-24 incompatibility problems; however, by FY 1968 the problems were all but corrected.

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288. Intvw, WLK with Maj John N. Rosa, Dir of Requirements, MAC DCS/Ops, 11 Jul 72.

APN-157 LORAN C Problems

(U) APN-157 LORAN C problems developed early in the C-141 program. First, the qualification and reliability tests were delayed because of difficulties encountered during the LORAN development program. Foremost among the problems at that time was incompatibility with the navigation computer. Eventually, during October 1965, these tests were completed, only to lead into more difficult problems during the flight test phase of the component. During this phase the contractor encountered excessive radio frequency interference and an antenna problem. These deficiencies were resolved by the installation of a new coaxial cable (Tri-ax) and by removing the anti-static coating of the antenna.[289]

(U) During the category III test period one further difficulty developed. The tests revealed that the aircraft navigator was having a problem in utilizing the LORAN Receiver because it was set at a poor angle. Therefore, ECP 108 was issued to tilt the receiver at a 45 degree angle. This modification was incorporated in production aircraft number 37, and by 30 June 1966 update kits (TO 1C-141A-513) were available.[290]

(U) During the period 1 July 1966 - 31 December 1966 two problems still plagued the system, but both were substantially resolved by

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289. For the FY 1966 APN-175 LORAN C problems, see MAC hist, 1 Jul 65-30 Jun 66, I, pp 181-182.
290. Log D-20 Rpt, 15 Jan 67, p 14.

the period's end. The first of these difficulties was the lack of aerospace ground equipment (AGE). Foremost among the problems generated by the lack of this equipment was the inability of maintenance personnel to fully utilize the flight line tester until the aircraft was modified to provide test point adapters. The Travis AFB LORAN maintenance was most hampered by this need because the LORAN's on its aircraft developed a trend of improper LORAN reception from ground stations. Since a bench check was the only available means to check the components, the 60 Military Airlift Wing was unable to correct this deficiency. Therefore, the SPO issued TCTO 1C-141A-685 in order to provide this needed maintenance capability. Travis immediately complied with the TO and by 28 December 1966 had only three more aircraft to modify. C-141 aircraft at other MAC bases would be modified during phase III update, IRAN, and organizational/field maintenance.[291]

(U) The last of the APN-157 problems consisted of two limiting factors. The first of these was insufficient ground station coverage while the second was poor sensitivity of the airborne antenna system. The latter was corrected by coaxial cable replacement and the former by the installation of an active antenna coupler. This coupler was expected to double the range of ground station coverage

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291. Daily Activities Rpt, MAC DCS/Mat, subj: AN/APN-157 LORAN "C" System, C-141A Aircraft, 28 Dec 66, Sup Doc III-62.

and improve signal to noise ratio.[292] This modification was initiated by TCTO 1C-141A-1046, dated 25 November 1966. Service tests produced excellent results and retrofit began with kit availability. During FY 1969 the complete C-141 force had received this modification.[293]

C-12 COMPASS

(U) The C-12 gyro-magnetic compass issues primary directional information to other navigation components; hence, it is a highly important item for the Starlifter. However, it remained a problem throughout the C-141 program and was one of the major components that gave poor information to the ASN-24. As early as 1965 the command complained about the compass as follows:[294]

> The C-12 Compass system performance in DG or free gyro mode is unpredictable. Drift rates are random and rates as high as 5°/hour have been measured--thus Polar (GRID) navigation is nearly impossible without reliable heading inputs for positive fixing capability.

C-12 Deficiencies

(U) The excessive drift errors, revealed in FY 1965, and continuing rejects of newly delivered equipment disenchanted C-141 managers.[295] Moreover, the Starlifter operations were not alone in

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292. Daily Activities Rpt, MAC DCS/Mat, subj: AN/APN-157 C LORAN "C" Extended Range, 4 Jan 67, Sup Doc III-63.
293. Log D-20 Rpt, 30 Jun 68, p 28.
294. Agenda Items (S), Comdrs Conf, 29-30 Nov 65, p 203.
295. Ltr, MAC DCS OPS to EASTAF, WESTAF and 1707 ATW, subj: C-141 Status Rpt for Month of May, 2 Jul 65, p 4.

experiencing the massive errors because HC-130H and RB-57F test programs and operational aircraft were also being plagued by these problems.[296]

(U) Specifically, the compass persisted in producing the following problems:

1. Excessive heading errors at completion of a turn when operating in magnetic mode with errors up to 4 degrees.
2. Excessive errors due to gyro drift when operating in DG mode (2 to 3 degrees per hour).
3. Excessive man-hours required to swing the compass system (approximately 6 hours per compass, 12 hours for both systems).
4. Lack of adequate AGE and technical data.

These deficiencies, identified during category II/III testing, prompted C-141 Safety Supplement 1C-141A-1SS-38 which restricted the compass to magnetic mode only and aircraft operations between 70 degrees north latitude and 70 degrees south latitude.[297]

(U) In order to improve the compass Sperry proposed ECP-8 which was designed to provide a fast swing capability and a turn rate cut-out provision for the magnetic mode. The modification was prototyped and tested by FY 1965 and proved to be suitable. However, due to the gyro drift problem, the SPO established a flight test evaluation program at Lockheed with Sperry participation; and ECP-8 was held in abeyance, pending final evaluation.

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296. Ltr, DCS/Mat to ASD and SEG, subj: C-12 Compass System, 2 Jun 65.
297. Memo, DCS/Mat, subj: C-12 Compass System, 4 Nov 65.

(U) The test program, conducted from 1 June through 5 October 1965, prompted Sperry to make three proposals for drift correction. They were as follows:

1. Application of anti-friction torque on the outer (azimuth) axis.

2. Installation of roterace on aximuth axis.

3. Installation of a roll stabilization device.

On 6 and 7 October, the C-141 SPO held a meeting to evaluate the flight tests and proposals. The conclusions reached by MATS/SPO representatives were that the modifications did not significantly improve the gyro drift problem. Furthermore, they ascertained that continuing tests were of no avail. Therefore, the following actions were taken:[298]

1. The C-12 would continue to be operated in the magnetic mode and the restrictions would continue to be applied.

2. ECP-8, for providing a fast swing capability and the turn rate cut-out provision, would be approved.

3. Finalized AGE would be scheduled for all stations.

4. A blue line copy of the Sperry Field Maintenance Manual would be delivered with each field bench test set. The technical data for components, except for the amplifier power supply, would be published approximately in Jan 1966. The TO for the amplifier power supply would require updating to include the ECP-8 change.

5. The user and SPO agreed that the C-141 would wait for further improvements until the C-5A equipments were definitized. However, consideration was given to a system compatible with SOR-216 (adverse weather aerial delivery system) such as a two-heading gyro reference which could be available in 16 months.

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298. Ibid.

(U) By December 1966 planning called for modified C-12 compass equipment with ECP-8R incorporated. Installation was scheduled for March 1966, while aircraft wiring changes were delayed until 1 June 1966.[299] However, toward the end of the year the vendor slipped C-12 component production. In an effort to alleviate the problems caused by the lagging production, a "last ditch" installation of the amplifier, the most critical item, was made on 20 May 1966 and appeared to satisfy immediate requirements.[300] The modifications were subsequently made with little or no improvement.

(U) By 1968 MAC concluded that a further modification would be too costly, so it was decided to attempt to replace the compass with a new one for the C-141. Hence, ROC 18-68 was submitted to Air Force, but due to increasing money restrictions MAC still had the C-12 at the close of FY 1971. The situation had not improved and the C-12 compass was still requiring much maintenance attention.[301]

APN 147 DOPPLER

(U) The doppler radar selected for the C-141 was the APN-147 which was manufactured by the Canadian Marconi Corporation. Initially the major doppler concern was the development of aerospace ground

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299. Ltr, MAC DCS/Ops to 21AF, 22AF, and 433 MAWg, subj: C-141 Status Report for December 1965, 31 Jan 66, p 6.
300. C-141 Mgt Sum, 20 May 66, p 5-1.
301. A random selection of URs is as follows: msg, 437 MAWg, subj: Repeat EUMR submitted iaw para 2-13, TO-00-35D-54, 232201Z Mar 71; msg, 437 MAWg, subj: EUMR submitted iaw TO-00-35D-54, 232202Z Mar 71, both Sup Doc III-64.

equipment to test it. By 1964, however, the necessary equipment was in development and became available to field units shortly thereafter.[302]

(U) The equipment deficiency encountered early in the Starlifter program involved the doppler's TD-505 sequential timer. Since the timers were deemed insufficient, the SPO initiated action to purchase updated TD-505 timers. However, immediately upon installation the newly procured articles began failing. An inspection of these timers revealed that the reed-type relays were the malfunctioning components;[303] hence, a request was made to correct the defective timers. Marconi then developed a new one utilizing solid-state principles throughout the system and eliminated the relays. In January 1966 a 60-day service test was made on 16 timers, utilizing 16 aircraft.[304]

(U) These solid-state sequential timer assemblies also lacked reliability. In March when they were bench checked, 11 of the 16 were malfunctioning. Canadian Marconi stated that each assembly had been tested 100 hours prior to leaving their facility and requested further test with one of their engineers evaluating the deficiency.[305] During

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302. Trip Rpt, MAC DCS/Log, subj: Trip Rpt - Montreal, Quebec, Canada, 30 Nov 1964, Sup Doc III-65.
303. Hist Rpt, MAC DCS/Log, subj: Service Test of Solid State Timer in APN-147 Doppler, 31 Jan 66, Sup Doc III-66.
304. Ibid.
305. Daily Activities Rpt, MAC DCS/Log, subj: Service Test of Modified TD 505A Timer Assembly in AN/APN 147 Doppler System, 23 Mar 66, Sup Doc III-67.

the ensuing tests, the Marconi engineer located the deficiency and the timers were returned for modification.

(U) By December 1966 the updated solid-state timers were submitted for field test. The final test report showed that only eight failures occurred in 6,292.4 hours, a factor which amounted to a mean time between failures (MTBF) of 786.6 hours. The new timer resolved the problem and it was approved for installation on the aircraft.[306]

ARC-90

(U) Among the other major problem units was the ARC-90, which was the Starlifter's ultra high frequency (UHF) communications system. Some of these systems had been delivered prior to contractor (Magnavox) qualification testing, in order to preclude category I and II program delays. This action was taken as an interim measure with the understanding that all accepted equipment would be updated to qualification standards.[307] Therefore, most of the set's improvements developed from operational experience.

(U) During category II tests the ARC-90 proved to be bulky, but, prior to 16 February 1965, there were only three reported failures, all crystal oscillator oven burn outs. After that date, however, the sets developed major problems which ranged from loud background noises

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306. Daily Activities Rpt, MAC DCS/Log, subj: Service Test ST-124-WTJTF-C-141 Solid State Timer, 21 Dec 66, Sup Doc III-68.
307. Log D-20 Rpt, 15 Nov 65, p VII-8.

to complete failures.[308] Constant contractor upgrade actions improved the units and by early FY 1966 they began to approach the contract required MTBF of 250 hours. On 20 October 1965 the ARC-90 first article configuration inspection (FACI) was held and the set was accepted. The contractor also, at that time, agreed to update prior delivered equipment at the rate of ten sets per month, starting in November 1965.[309] By the end of FY 1966 the ARC-90 problems appeared to be resolved.

FLIGHT DIRECTOR

(U) Initially, the C-141 SPO planned to use the CPU-27/A as the flight director for the aircraft. However, this system, also utilized in other aircraft, required modification so that it could monitor the installed ASN-24 and insure that the flight direction flags would operate in case the ASN-24 doppler failed. In addition, the CPU-27A did not provide the capability, requested by MAC, of capturing the aircraft's glide slope from above or below. Therefore, in order to fulfill some of the using command's requests, the CPU-27/A received extensive modifications and was redesignated the CPU-65/A. However, it still lacked VOR TACAN intercept and far out tracking ability, desired by MAC, mainly because it had been optimized for VOR TACAN approach only.[310]

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308. Cat II Monthly Progress Rpt, C-141 JTF, AFFTC, Edwards AFB, AFSC, Rpt Nr. 9, 11 Feb 65 to 10 Mar 65, p 22.
309. Log D-20 Rpt, 15 Nov 65, p VII-8.
310. VOR--Visual Omnirange; TACAN--Tactical Air Navigation.

(U) In order to pursue the full MAC desired capability, the SPO directed that a study be made by the Logistics Command. The approach taken by that command was an analysis to see if the new computer could be integrated into an all weather landing system (AWLS).

(U) In the meantime, all the changes required to assure CPU-65 compatibility with other standard aircraft systems were included in ECP-64 and ECP-218 (TCTO 1C-141A-562) and incorporated into production aircraft, starting with number 19. It was also included in the update program for prior delivered aircraft.

(U) One of the benefits derived from CPU-65 use was the fact that it did not upset the AGE inlay program, because only minor circuit changes had to be made on the CPU-27/A AGE.[311] Furthermore, the test sets for the initial computer also required only field modifications to be compatible with the new computer.[312] In fact, the only CPU equipment problem encountered during FY 1966 was AGE shortages at Charleston and Dover AFBs. These shortages required the bases to reschedule their training programs; however, most of the problems were resolved by year's end.

APN-59B

(U) The weather search radar allocated to the Starlifter was one that had been developed in 1950. This radar, located in the

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311. Log D-20 Rpt, 15 Nov 65, p VII-9.
312. Daily Activities Rpt, MAC DCS/Log, subj: Shortages of AGE for Flight Director Computer CPU-65, C-141 Acft, 11 Apr 66.

nose radome, had so many failures of its intricate components that, during the mid-1960's, the C-141's APN-59s were removed for maintenance on an average of every 35 hours of use.[313] Of course, this radar was used by many Air Force aircraft and its poor reliability was well known. Hence, in 1967 Air Force approved the development of a new search radar (for specific aircraft)--the APQ-122. In addition, ASD concluded that attempting further modifications on the APN-59B would be too expensive.[314]

(U) Nevertheless, during FY 1968 AFLC alloted some money to make a study of the system, as well as some minor system changes. The results of the study showed the system to be so unreliable that the investigators urged AFLC not to make any changes. Despite this warning, WRAMA directed some of the modifications at the field level. After the MAC units made the corrections, during CY 1969, some improvements were realized.[315]

Poor Scope Resolution

(U) For MAC, perhaps, the most bothersome problem was poor scope resolution. This situation created a dilemma because of the plans to use the APN-59B in consonance with the ASN-24 for the pilot visual

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313. For APN-59B early deficiencies, see documents in Supplement III-9.
314. Sup Doc V-127 of hist, MAC, 1 Jul 68-30 Jun 69, XV; hist, MAC, Jan-Jun 67, XII, pp 211-212, 306-307; hist, MATS, 1 Jul 64-30 Jun 65, I, p 132.
315. Hist (S), MAC, Jul 68-Jun 69, II, pp 127-128.

cargo parachute release capability. In order to evaluate the system at low levels (prior to modification) cameras were procured to photograph the scope. The tests indicated that the scope was dark enough for the cargo release capability; hence, the modification was authorized. However, while authorizing the ASN-24/APN-59 coupling, AFLC engineering noted that the APN-59B had many electronic deficiencies causing poor scope resolution.[316]

CENTRAL AIR DATA COMPUTER (CADC)

(U) Another problem system was the CADC, which was a unit consisting of two computers, two airspeed vertical side indicators, two altitude vertical scale indicators, two airspeed amplifiers, two altitude amplifiers, and one true airspeed indicator. In addition to providing input to the indicators, this system was designed to be utilized by other systems such as the autopilot and artificial feel systems.

(U) The category II and III tests revealed that this system was a high man-hour consumer. Part of this low reliability problem stemmed from the fact that the original components were purchased from the Bendix Corporation but follow-on vertical scale indicators were purchased from the Kollsman Instrument Company. This mixed component posture caused technical data and AGE incompatibilities.

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316. Ibid., p 129.

(U) Most critical of the problems, however, were component failures; therefore, several product improvement programs were developed in FY 1966. The most prominent of ECPs were:

1. ECP 650--rework of the rudder pressure control switch to eliminate failure of the Qc-7 switch.

2. ECP 108P--replacement of the pitot static and hydraulic lines to preclude interference with the use of the CADC simulator.

3. ECP 19315-3771-1361--replacement of the transistor in the SH 327A1 and GE 43B1 cards.

In addition, ECPs for the improvement of the Kollsman and Bendix indicators were in the approval process by the end of FY 1966.[317]

(U) Despite all of the above actions, maintenance requirements and computer failures increased by 50 percent during December 1966. In order to correct the increasing problems, the C-141A Operational Evaluation Staff made a comprehensive study of the system in late CY 1966. By January 1967, the report of these investigations, which identified the deficient components and recommended corrective actions, had been forwarded to the prime AMAs and to the Aeronautical Systems Division (ASD). Warner Robins Air Materiel Area (WRAMA), the Weapons System Manager (WSM), after receiving the report, recommended that the SPO convene a meeting during February 1967 so that the problems and recommendations could be reviewed and a course of action developed.[318]

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317. Hist Rpt, MAC DCS/Log, subj: CADC System, C-141 Aircraft, 29 Jul 66, Sup Doc III-69.
318. Daily Activities Rpt, MAC DCS/Log, subj: Central Air Data Computer, C-141 Aircraft, 27 Jan 67.

(U) Among the problems which the conferees wanted fixed was a deficient control valve solenoid in the rudder hydraulic system. This solenoid surged the electric current which overloaded the Qc7 switch and caused it to fail. Another problem area was the routing of hydraulic and static lines in the hydraulic system. This poor design caused problems because it would not allow the connection of test equipment to the CADC test outlet.[319]

(U) In still another area it was found that many of the CADC failures occurred when the "approach" mode was used by the crews. Therefore, in August 1967 MAC requested the USAF System Safety Review Board to develop engineering changes that would improve the CADC. As a result of the request, MAC was directed to use only the "normal" flight mode until it could be ascertained whether the "approach" mode was indeed the culprit.[320]

(U) The "approach" mode proved to be the problem area, for when it was not used, the average CADC removal rate dropped by more than 50 percent from the previous average of 173 per month.[321] As a result of the test, AFLC directed MAC to remove the cross-monitor switch from the computer in order to preclude inadvertent use of the switch. In addition, better maintenance instructions and improved test AGE were provided for personnel servicing the computer. After these

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319. Sup Docs V-104 through V-108 of hist, MAC, Jul 68-Jun 69, XV.
320. Sup Doc V-109 of hist, MAC, Jul 68-Jun 69, XV; OES/LTF, Feb 67, p 29.
321. Sup Doc V-110 of hist, MAC, Jul 68-Jun 69, XV; OES/LTF, Feb 68, p 12.

actions MAC was able to report that the CADC's MTBF had risen from 200 hours in 1967 to 400 hours in 1969.[322]

AUTOPILOT

(U) The Starlifter's autopilot was also beset with problems during its test period. During the category I testing, Lockheed and the subcontractor (Bendix) encountered deficiencies which involved the dynamics of the aircraft and the autopilot closed-loop system when it was tied into the aircraft system. As a result, modifications were made in the elevator "Q" feel spring, pitch, roll, and yaw axis computer amplifiers and in the aircraft wiring. In addition, the dynamic vertical sensor was deleted.[323]

(U) After the corrective actions were completed ASD accepted the system and production began in August 1965. However, these modifications resulted in the need to rework the AGE and to update all technical data. By December the Eclipse-Pioneer Co. (the AGE contractor) completed the changes to the field bench sets but the TO definitization was still lagging. This condition did not improve; therefore, on 28-29 April 1966 a meeting was called at ASD for the purpose of expediting technical data publication and to establish further corrective actions for the bench sets, which had developed some additional discrepancies. By 4 June the TOs had been published

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322. Sup Doc V-111 of hist, MAC, Jul 68-Jun 69, XV.
323. Log D-20 Rpt, 14 Jan 66, p VII-12.

but ASD continued to monitor the test set deficiencies as well as autopilot defects that had developed during the year. Among problems noted in the finalized system was an MTBF of approximately 100 hours--a condition that was unacceptable to the command. At year's end the AFLC Inventory Manager (IM) established several maintenance improvement programs (MIP's) on the system's high failure items for contractor evaluation and defect rectification.[324]

(U) As the fiscal year ended the SPO stated:[325]

> High failure rates (83 hour MTBF) of the autopilot components, inadequate AGE, and the lack of technical data have been the major problems with this system. Fixes have been established for the AGE but have not been incorporated. However, fixes will not overcome the AGE design deficiencies . . . .

From the end of FY 1966 the autopilot's reliability regressed. In an effort to reach a practical reliability goal the MAC Operations Evaluation Staff made a study to identify the deficient components. This study revealed that six components accounted for 91 percent of the failures.[326] These components were:

Component	Percentage Contribution to Failure Statistics
1. Elevator Computer	23.9
2. Yaw Damper Computer	20.2
3. Aileron Computer	18.4
4. Vertical Gyro	10.6
5. Single Axis Gyro	9.4
6. Two Axis Gyro	8.6

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324. Sup Doc II-5 of hist, MAC, Jul 65-Jun 66, VI.
325. OES/LTF, Jun/Jul 66, p 15.
326. Ibid., Oct 66, p 45.

(U) Through a tedious process of removal and replacement of modules[327] and the replacement or repair of items after a bench check, MAC was able to identify the offending parts of the components.[328] The PB-60 Autopilot Reliability Study[329] was published in June 1967 and provided the base for the corrective actions.

(U) After a series of modifications only one problem remained. This problem was a matter of compatibility between the modified PB-60 vertical gyros, new MD-1 gyro, and test programmer logic computer with the all weather landing system (AWLS). During FY 1969 OCAMA requested that MAC conduct service tests on the gyros and the computers with the AWLS. These tests were programmed for 1000 flying hours and were begun on 18 February 1969, with completion on 15 August 1969. However, the service test was extended to test a new proposed fix of the vertical gyros. Two of the gyros were installed in 437 Military Airlift Wing aircraft for the tests. Tests showed that the vertical gyros were not sufficient, so in November 1969 the PB-60 vertical gyros were included in the MD-1 gyro service tests.[330] At the end of FY 1971 the problem still had not been resolved.[331]

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327. Module - a one package assembly of functionally associated parts, usually a plug-in unit; a black box.
328. OES/LTF, Oct 66, p 45.
329. OES Study, Autopilot System, PB-60 Reliability Study, inclosure of OES/LTF Rpt, Jun 67, Supplement 10.
330. Log D-20 Rpt, 31 Jul 70.
331. Ibid., 30 Jun 71.

ALL WEATHER LANDING SYSTEM (AWLS)

(U) Among the subsystems added after production of the C-141 had begun was the AWLS. On 11 November 1965 Headquarters USAF approved a program for incorporation in the Starlifter. Therefore, on 14 December 1965 SOR Nr. 182 was amended to require an all weather landing system for the aircraft. Included in the new system were vertical tape, flight instruments, a flight director system, a radar altimeter, auto-pilot, auto-throttles, and other required components. The specifications called for responsiveness to safely position aircraft for landings under category II weather minimums (100' decision height and 1,200' runway visual range [RVR], as well as be capable of demonstrating touchdowns under category II weather criteria). It was also to have prcvisions for decrab and roll out functions for landings under category III weather minimums (150' RVR). The test program was established as follows:[332]

Cat II Test -

1. Aircraft Modification - Jan-Mar 1966.
2. Subsystem, Integration and Development Test, Apr-Sep 1966.
3. Production Tests and Demonstration - May-Sep 1967.

Cat III B Test -

1. Aircraft Modification, Feb-Apr 1967.

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332. Daily Activities Rpt, DCS/Log, subj: All Weather Landing System (AWLS) on C-141A Aircraft, 15 Feb 1966.

2. Installation Checkout, Mar-May 1967.

3. Subsystem, Integration and Development Tests, May-Sep 1967.

(U) Planning called for installation of the AWLS in all production aircraft in CY 1/68. This provided for 128 production installations. For operational aircraft an update program was scheduled to begin in CY 1/67.[333] By August 1966 the SPO had received a firm price proposal for AWLS installation from a contractor. The total price of this proposal was well above the amount originally programmed; therefore, the SPO reviewed the contractor's bid in order to determine those items which could be reduced in scope so that the project would remain within the funding.

(U) By September the difficulty was resolved and plans were being made for the receipt of the first AWLS configured aircraft in November of 1966. Before installation, however, major equipment changes had to be made to the auto flight control system (AFCS). These changes included modifications to the elevator, aileron and yaw damper computers, as well as the installation of a new AFCS coupler. AWLS equipment to be installed was as follows:

1. Control Panel
2. Flare Computer
3. Vertical Navigation Computer
4. Flight Director System
5. Rotational Go-Around Computer
6. Auto Throttle System
7. Test Program Logic Computer

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333. Ibid.

(U) Also at this time it was recognized that the delivery of the first six interim configured AWLS aircraft (all in November) would present support problems because of the lack of peculiar AGE for the vehicles. However, the command felt that this problem would be alleviated by the replacement of the line replaceable units (LRU's) that were shown to be defective by the aircraft built-in-test equipment (BITE). In fact this action was to be the maintenance posture until the programmed AN/GSM-133 automatic test equipment became available in April 1967.[334] On 21 November 1966 the first of these interim AWLS configured aircraft, SN 66-132, was accepted by the Air Force and immediately prepared for a 29 November delivery to Tinker AFB, Oklahoma.[335]

(U) While the interim configuration appeared to move smoothly, the fully qualified and certified AWLS was apparently destined to develop difficulties. At an AWLS management meeting, convened at the Lockheed-Georgia Company on 1 December 1966, the contractor stated that possibly the schedule for a qualified system would slip from the February 1967 delivery date to sometime in March. The reason for this possible delay was due to technical problems being experienced with the autopilot. The conferees were informed that two major milestones had to be met before firm delivery dates would be known; they were:

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334. Hist Rpt, DCS/Log, subj: C-141 All Weather Landing System (AWLS), 30 Sep 66.
335. C-141 Mgt Sum, 25 Nov 66, p 1.

1. To identify and correct the autopilot malfunctions, which was accomplished in December.

2. To establish a firm AWLS configuration, which had a tentative date of late December or early January 1967.

During the meeting the SPO offered to expedite the programs.[336] However, at a 27 December 1966 follow-on meeting at Lockheed it was ascertained that it was not possible to attain a certified system by February 1967 because of the above problems, and program rescheduling was initiated by the SPO.[337]

(U) During the last half of the fiscal year (January-June 1967), the major problem that was encountered was contractor delivery slippages.[338] The problem was so critical that it caused unit installations to slip from production aircraft number 184 to production aircraft number 251. Therefore, the SPO was forced to direct that production aircraft numbers 157 through 250 would be accepted with only the AWLS wiring and mounts installed.[339] In addition to the production aircraft difficulties, the slippages delayed the entry of the first AWLS update aircraft entry into Lockheed until May 1967 and the Federal Aviation Agency's conformity inspection until 8 May 1967.[340]

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336. Ibid., 9 Dec 66, p 2.
337. Ibid., 30 Dec 66, p 2.
338. Ibid., 6 Jan 67, p 1.
339. Ibid., 20 Jan 67, p 1.
340. Ibid., 12 May 67, p 1.

(U) By 18-19 April 1967 the SPO established the AWLS demonstration and certification tests for July 1967. The tests were to be accomplished at the Atlantic City Federal Aviation Agency (FAA) facility. However, by 30 June the flight test had also been slipped four weeks because of pitch disconnects and enroute test problems; therefore, it was necessary to reschedule the relocation of the test aircraft, SN 6001, to FAA until 8 July 1967.[341]

(U) Another snag in the production of the AWLS subsystems occurred during August 1967 and consequently the tests were held in abeyance. Among the problems were faulty air conditioning ducts, while the test programmer, logic computer, and automatic flight control subsystems developed interface problems. After modification of the air conditioner and correction of the interface, the tests again began and were completed during September 1967.[342]

(U) On 6 October 1967, the FAA certified the AWLS for the C-141. This certification was long awaited by Air Force officials. The C-141 Weapons System Manager (WSM) said, "This is a major accomplishment and provides the Air Force with its first FAA accepted system which will control the aircraft to touchdown."[343] Also, during October 1967, Lockheed installed the complete AWLS on the 261st C-141.

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341. Ibid., 30 Jun 67, p 1.
342. Hist (S), ASD, AFSC, Jan 67-Jun 68, I, p 134.
343. Log D-20 Rpt, 31 Dec 67.

At the same time, installation of the rest of the AWLS equipment on 103 C-141s that had been delivered with partial systems began.[344]

(U) Despite the FAA certification, MAC officials foresaw still another AWLS problem because no military air bases had AWLS ground equipment. This matter was serious since that equipment had to be in place if crews were to operate the AWLS airborne equipment. The needed ground equipment included more lights for the runways, touchdown zones, and centerlines, as well as more accurate instrument landing systems. MAC Operations personnel noted that although 23 bases had been listed to receive this ground equipment between June 1969 through 1971, "due to the latest cutback in funding, these dates may not be realized."[345]

(U) This concern proved well founded. On 1 December 1967, the Office of the Secretary of Defense (OSD) disapproved the MAC program change request (PCR) that requested AWLS ground equipment on 23 bases. As a result, on 20 February 1968 General Estes asked General John P. McConnell, Air Force Chief of Staff (CSAF), to appeal the OSD decision. General Estes indicated that 17 bases needed the equipment, and he placed each of those bases in priority order in case General McConnell had to delete some from the list. The selected bases were: Travis, McGuire, Yokota, Mildenhall, Elmendorf, Dover, McChord, Norton,

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344. Background paper, MAC Commander's Conference, COLD MILK: Talking Papers (S), 20-22 November 1967, subj: AWLS C-141 Aircraft (subsequently cited AWLS Background Paper, Nov 67), p 2.13; Log D-20 Rpt, 31 Dec 67, p 79.
345. AWLS Background Paper, Nov 67, pp 2.22-2.23.

Charleston, Andrews, Kelly, Tinker, Robins, Goose, Hill, Torrejon and Wright-Patterson.[346]

(U) The appeal was made and it worked. On 16 July 1968, the OSD approved buying and installing the ground equipment at the 17 bases; the first five bases were programmed during FY 1970, the next five in FY 1971, and the last seven during FY 1972. HQ MAC explained, "Approval by OSD insures the funds requested will be included in the military construction program (MCP) for each fiscal year and forwarded to the Congress for approval."[347] Subsequently, HQ AFSC ordered the traffic control, navigation, and landing system (TRACALS) office in the ASD to manage that part of the program. Soon after that action, General McConnell requested that the ground equipment for the Andrews AFB runway be installed at both ends. The FAA agreed.[348]

(U) In addition to installation of the airborne and ground equipment, HQ MAC made sure that aircrews and mechanics were programmed for AWLS training. Shortly after the FAA had certified the AWLS, cadre pilots began training on the system at the Lockheed Marietta plant. During February 1968 the 443d Military Airlift Wing took

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346. Background paper, MAC Commander's Conference, COLD MILK II: Talking Papers (S), 9-13 April 1968, subj: Category II Adverse Weather Landing System Ground Environment, p 2.77.
347. Background paper, MAC Commander's Conference, COLD APPLE: Talking Papers (S), 3-8 March 1969, subj: Category II All Weather Landing System (AWLS) Ground Environment (subsequently cited as AWLS background paper, Feb 69), p 3.47.
348. Ibid., pp 3.47-3.48.

over the pilot training, which consisted of 12 hours of academic courses and two transition flights--all accomplished in four training days.[349]

(U) By September 1968, MAC had 100 pilots qualified to use the AWLS.[350] A few months before that training detachments from the Air Training Command (ATC) began instructing MAC flightline maintenance men on the repair of the AWLS. Three courses were offered: a six-week course for the repair of the automatic flight control subsystem, a two-week course for the repair of the flight director, and a two-week course for the repair of the radar altimeter. Also, MAC directed a complete field shop maintenance course which lasted 14 weeks.[351] By March 1969 the maintenance training program for the AWLS equipment repair was completed, and each MAC C-141 home station had enough trained men to take care of the AWLS maintenance.[352]

(U) Meanwhile, during September 1968, a project to install an AWLS in all eight MAC C-141 flight simulators began; and on 7 November 1969 the project was finished. MAC officials noted that all C-141

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349. Background Paper, MAC Commander's Conference, COLD JUICE: Talking Papers (S), 9-11 October 1968, subj: C-141 TTU/MAC AWLS and Category III Training Program, pp 2.19-2.20.
350. Background Paper, MAC Commander's Conference, COLD JUICE: Talking Papers (S), 9-11 October 1968, subj: C-141 AWLS and Interfly Capability, p 2.6.
351. Sup Doc V-47 of hist, MAC, Jul 68-Jun 69, XII.
352. Presentation, MAC Commander's Conference, COLD APPLE: Items (S), 3-8 March 1969, subj: C-141A AWLS Deficiency and Support (subsequently cited as AWLS Presentation, Mar 69), pp 22.1-22.14.

flight simulators could now perform "complete manual and automatic AWLS approaches and landings in addition to a wide range of malfunctions and failures."[353]

(U) During 1969 MAC maintenance personnel had trouble with other AWLS equipment. The most troublesome was another test device, the test programmer and logic computer (TPLC). The TPLC, after undergoing six major electronic design changes, passed the qualification tests during January 1969. Nevertheless, after MAC received and used it, they found that its circuitry was incorrect; more serious, however, was the suspicion that the computer was falsely reporting good parts as defective and in need of overhaul after less than 500 hours of use. Another troublesome problem was the autopilot/AWLS interface. The autopilot often failed, causing the pitch and roll accuracy to be off more than five percent. Furthermore, the AWLS vertical gyroscope and the flight director MD-1 gyroscope had a low MTBF average.

(U) Because of these persistent AWLS problems, in February 1969 a command working group was formed to oversee the AWLS performance. It was hoped that the group could obtain a 1,000 flying hour MTBF for the TPLC, autopilot, and two gyroscopes; they also hoped that the group could define all the faults of the AWLS, "and through analysis, recommend specific corrective actions. The efforts and recommendations of this group are geared toward improving system performance and reliability."[354]

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353. Sup Doc V-48 of hist, MAC, Jun 68-Jul 69, XIII.
354. AWLS presentation, Mar 69, pp 22.1-22.3.

(U) Toward the end of November 1970 the C-141 AWLS intermediate maintenance level aerospace ground equipment had been delivered to all C-141 stations. However, due to late delivery,[355] the Aeronautical Systems Division (ASD) of the Air Force Systems Command (AFSC) authorized six more months of contractor support in order for MAC personnel to gain experience operating the equipment.[356] This new equipment was capable of providing component testing, which could allow a 45-minute average mean time to repair (MTTR) by the replacement of deficient modules of the AWLS components. Twelve of the C-141 AWLS components were conducive to this type of testing, as were other aircraft avionic components.[357] By year's end the AGE proved to be invaluable to MAC units.

(U) The AWLS also required 14 follow-on modifications to the basic equipment. Nine of the modifications were completed prior to and during FY 1970; and during the fiscal year one was being updated on a swap-out basis, while another was scheduled for fix on an attrition basis. In addition, by year's end the modifications for the rotation/go-around computer (R/GA), radar altimeter receiver/transmitter, and the automatic throttle computer (ATS) were all but completed. With the completion of these technical modification programs, the command now became concerned with pilot AWLS training

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355. This equipment had been scheduled for delivery in early FY 70.
356. Hist rpt, DCS/Log, subj: C-141 All Weather Landing System Intermediate Level AGE, 28 Nov 69.
357. Sup Doc III-15 of hist, MAC, Jul 69-Jun 70, VII.

and runway updates. For the former all assigned pilots were scheduled for training completion on 30 May 1971, while the runway update completions were projected from 1971 to 1973.[358]

(U) In another major AWLS action the Air Force terminated the supply portion of Lockheed-Georgia Company contract on 1 January 1970 and assigned it to WRAMA and MAC. Therefore, WRAMA and MAC completed an agreement with Lockheed concerning the transfer of supply assets to AF accountability and an agreement among themselves for C-141 support for the initial six-month period.[359] By the end of the fiscal year another agreement had been negotiated with WRAMA for the remainder of CY 1970. Basically, the latter document extended the 1 January 1970 agreement; however, some procedural changes were made.[360]

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358. Sup Doc III-16 of hist, MAC, Jul 69-Jun 70, VII.
360. Sup Doc III-17 of hist, MAC, Jul 69-Jun 70, VII.
361. Sup Doc III-18 of hist, MAC, Jul 69-Jun 70, VII.

"The next system that has given us considerable difficulty . . . is flight control. We experienced many inflight incidents which could not be duplicated when the airplane landed. We have been chasing ghosts, so to speak, for the last six years, and it was only during the past year (1971) that we recognized that many of these deficiencies were due to hydraulic system contamination."[361]

FLIGHT CONTROLS

(U) As noted above, flight control deficiencies proved to be difficult to identify and more stubborn to correct. Among the more troublesome systems were the spoiler system, elevator artificial feel system, the pitch trim system, and a flap asymmetry problem. However, the most puzzling problems were those of the "ghosts," or airborne malfunctions that could not be duplicated on the ground, seriously hampering system trouble analysis.

(U) When it was discovered that many of the Starlifter's control problems could be attributed to improper hydraulic fluid cleansing, the major thrust of identification and resolution shifted to filter

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361. Morris Intvw, p 20.

development. Nevertheless, before the above development the major thrust was that of "hardware" problem identification and defect correction. The approach to this chapter will be chronological as were the previous chapters. The overall hydraulic analysis will be discussed in its proper time sequence.

SPOILER SYSTEM

(U) Early in the Starlifter's operational years a series of spoiler problems emerged. In fact, during the category I and II flight tests, a number of failures caused excessive, unscheduled spoiler component replacement.[362] In order to negate the extensive maintenance and operational problems encountered in this complex system, the C-141 SPO initiated a Spoiler Technical Study Group for deficiency investigation. The group members--representing MAC, WRAMA, Lockheed and the SPO--met in October, November, and December 1965. On 22 December they verbally presented their preliminary findings and recommendations to the SPO Director. After some discussion, the members were directed to review the information and provide final recommendations.[363] During February 1966 the group submitted its recommendations, which prompted the SPO Director to request the proposed ECP's from the contractor.[364] These proposals included fixes for the:

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362. Log D-20 Rpt, 15 Nov 65, p 11.
363. Hist Rpt, DCS/Log, subj: Spoiler Groups, 4 Feb 66.
364. Ltr, MAC to 21AF, 22AF, 443 MAWg, subj: C-141 Status Rpt for February 1966, 1 Apr 66, p 2.

1. Rigging

2. Spoiler-flap interlock

3. Pilot operation

(U) Even before the Study Group's recommendations were received, several ECPs had been established for this system:[365]

ECP 231-1 (TCTO 1C-141A-863) provided landing gear wheel spin-up, automatic spoiler actuation, spoiler mode selector switch redesign, and spoiler handle detent changes. It was effective on production aircraft starting with number 37 and Lockheed provided the retrofit for the remainder of the force.

ECP 231-2 rectified deficiency by improving switch position identification and maintainability. TCTO 1C-141A-964 applied in this case and was incorporated on aircraft number 84 and following production aircraft. Previously delivered airplanes were scheduled for retrofit.

ECP 411 P (TCTO 1C-141A-825) modified the spoiler actuator. Incorporated on production aircraft number 95; all other aircraft received changes through a contractor turnaround program.

ECP 583 P (TCTO 1C-141A-933) provided revised touchdown control boxes in production aircraft number 87. Also with production aircraft 100, some circuit wiring was relocated. A retrofit program was scheduled in April 1966 when kits became available for previously produced airplanes.

(U) Later in the fiscal year the proposals of the study group were incorporated into ECP 574 and ECP 550-92.[366] By year's end these ECPs, and a few additional ones, were in various states of completion.

(U) The switch, latch, and wiring changes, however, did not stop the inadvertent spoiler releases. This fact came to the attention of Starlifter managers in April 1967 when a C-141 crashed one

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365. Log D-20 Rpt, 15 Feb 66, p 49.
366. Log D-20 Rpt, 16 May 66, p 9.

mile from the end of a runway at Cam Ranh Bay Air Base (AB), Republic of Vietnam. As a result of this accident, the proper spoiler control configuration setting for takeoff was incorporated into the takeoff light circuitry. The SPO approved Lockheed ECP 790 that explained how to change the wiring of the spoiler selector switch, making the switch tie in better with the takeoff warning-light circuitry.[367]

(U) Despite the changes throughout 1967 and 1968, C-141 crews continued to report that the spoilers sometimes released to the ground position while the plane was in the air. Then, during 1969 the 443 Military Airlift Wing reported mishaps and accidents because of the spoiler switches. As a result, HQ MAC reviewed the matter and decided that the trouble was the complex operations that C-141 pilots used to operate the spoiler selector switch. For instance, during a C-141 transitional training flight, an instructor pilot had to move the switch about 30 times. "Should he become distracted and fail to position the switch properly just once," MAC safety personnel said, "the aircraft could sustain extensive damage."[368]

(U) Consequently, early in June 1969, HQ MAC and WRAMA met to search for a better spoiler system design for the C-141s--a design that would prevent a pilot from accidently releasing the spoiler during a flight. As a result of that meeting, Lockheed was directed to devise a way that would allow the pilot to release the spoilers

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367. Hist (S), ASD, AFSC, Jan 67-Jun 68, I, p 135; Log D-20 Rpt, 30 Jun 67, p 2.
368. Sup Doc V-83 of hist, MAC, Jul 68-Jun 69, XIV.

only when he had the landing gear down and the throttle retarded. The design was soon developed and on 15 July 1969 Air Force approved the new design. WRAMA then announced that Lockheed would build and install a prototype of the new spoiler release system in a C-141 during August and flight tests would follow shortly thereafter.[369] The corrective action proved to be effective and kits were installed.

ELEVATOR ARTIFICIAL FEEL SYSTEM

(U) Another system that consistently showed a poor MTBF in the early years was the Artificial Feel System. For instance, from 1 July 1965 to 30 November 1966 the MTBF was 470 hours based on 86,087 flying hours. During the 1 January 1966 to 30 November 1966 period, the MTBF fell to 449 hours based on 74,076 flying hours. An SPO system evaluation stated that the " . . . poor performance of this system has resulted in excessive delays throughout the Pacific area of operation. . . . The average delay time per month was 126.4 hours, which equated to a loss of approximately four round trips to SEA. . . ."[370]

(U) At first the system's defective component was found to be the 3C91003-111 Artificial Feel Servo Actuator, which had not been constructed in accordance with design specifications and test requirements. As an interim measure, the command modified the actuator by removing its controller and locating it remotely. In the meantime,

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369. Ibid., p 9.4.
370. Sup Doc III-11 of hist, MAC, 1 Jan-30 Jun 67, VI.

the contractor programmed a newly designed actuator, the -113, for installation on production aircraft. TCTO 1C-141A-1096 was to cover the field retrofit with kit delivery beginning in February 1967.

(U) When production aircraft, with the -113's installed, began entering the field, more problems developed. Basically, this difficulty stemmed from system unfamiliarity, the lack of technical data, and lack of qualified AGE. This situation prompted the headquarters to include interim checkout troubleshooting procedures in the maintenance handbooks. At the end of FY 1966, problem correction still was not in sight; in fact, the command did not anticipate delivery of the needed AGE before August 1967. Therefore, as another interim measure, the blue line[371] copies of the actuator maintenance and overhaul technical data were furnished to the field.[372] The servo actuator problem was substantially resolved when kits became available and were installed.

(U) Then, however, further problems developed. The principal problems which now plagued the system were electrical incompatibility and electro/mechanical failure of components. The SPO pointed out that accumulated system tolerances prohibited the normal maintenance practice of removal and replacement of defective components, because the various system interfaces could negate the functioning

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371. Blue Line Technical Data - a draft for review or pre TO publication technical instructions for interim usage.
372. Log D-20 Rpt, 15 Aug 66, p 8.

of a replacement component. This technical evaluation pointed out and analyzed the many difficulties inherent in the system and made recommendations, which included the following:[373]

1. Evaluate the tolerances within and among equipment components.
2. Review TO 5F5-4-8-2 for accuracy and adequacy. More frequent tests of the QC5 pot and a decrease of its tolerances.
3. Central Air Data Computer (CADC) mach rate output and technical data should be provided to field activities.
4. Action should be taken so that the CADC would be loaded as required by Military Specification Mil-C-38037A.
5. Essentiality of the Pitch Rate Adapter should be ascertained, since indications pointed to the fact that it introduced more problems than it solved.
6. Technical data for the Pitch Rate Adapter should be provided to field maintenance.
7. AGE or appropriate alternatives should be provided for the Pitch Rate Adapter bench test capability.
8. Provide adequate AGE for the positive isolation of a given single line replaceable unit (LRU) on an aircraft.
9. Provisions should be made to instruct personnel not to reduce the R-11 resistance to zero ohms. This information should be included in TO 1C-141A-2-9, Section VI.
10. Expedite action on the Electro-mechanical Linear Actuator to insure (a) a longer lasting brake, (b) staking of bearings, (c) provisions for positive locking of the jack screw retaining nut.
11. Provide final technical data for the actuator to the field.
12. The preliminary TO 16CL-7-10-3 tolerance for the follow-up pot should be reduced.

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373. Sup Doc III-11 of hist, MAC, 1 Jan-30 Jun 67, VI.

13. Deficiencies of the field shop servo-adapter cable for testing of the actuator should be corrected.

14. As an interim measure, the comparator trip level should be increased.

15. TO 1C-141A-2-9 requires correction and improvement.

With the above actions, the system was able to perform acceptably.

WING FLAP PROBLEMS

(U) Several wing flap problems also plagued the aircraft. Among these difficulties were a flap asymmetry, flap asymmetry brake system, and a flap jackscrew actuator problem. The first of these to occur was the flap asymmetry, which prompted MAC to establish a 90-day reporting period--1 November 1966 to 31 January 1967. This close-watch period indicated that there were no actual asymmetries.

False Asymmetry Indications

(U) As noted above, no actual asymmetry conditions were reported, but 82 malfunctions were reported and classed as false indications. These were attributed to possible transient voltages, broken cable detect switch assemblies, or the flap asymmetry detect transmitter (P.N. 3890085-1390).[374] Therefore, on 21 March 1967 AIRESEARCH Corporation's (the vendor) engineering personnel initiated a field service test, at McChord AFB on 21 March 1967, for the purpose of resolving the false indications.[375]

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374. OES/LTF Rpt, subj: Wing Flap Asymmetry, Jan 1967, p 25.
375. C-141 Mgt Sum, subj: C-141 Flap Asymmetry, 24 Mar 67, p 5-4.

(U) Utilizing new troubleshooting procedures, mechanical changes, and improved quality control procedures, the vendor, SPO, and contractor identified intermittent and instantaneous malfunctions of the transmitter synchros as the major source of the problem. The synchros were found to be contaminated with plastic dust and paper fibers in the "hair fine" brush area. The findings indicated that the dust originated from the plastic end-cap machining and the paper fibers from the brush resistance test when the brushes were isolated by writing paper. In addition, it was noted that the brushes were distorted by the close fit installation of the plastic end cap.

(U) Hence, the interim fix required that all the synchros be cleaned and the brush contact force increased. The final fix, however, required newly designed synchro parts and, on some test units, the elimination of "O" rings. "O" ring deletion, it was hoped, would aid in moisture exclusion. This retrofit, which also included a time delay in the transmitter, was service tested in April and May 1967.[376] By the end of May the service test (#180-60-C-141-147F) was successfully concluded by the 62 Military Airlift Wing. The modification was considered satisfactory because no further asymmetry malfunctions were encountered. By year's end the SPO was engaged in preparing modification instructions for force retrofit.[377]

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376. OES/LTF Rpt, subj: False Flap Asymmetry, April 1967, pp 23-24.
377. OES/LTF Rpt, subj: Wing Flap Asymmetry System, May 1967, p 22.

(U) Starting with production aircraft serial number 67-010 the modified flap position indicators were incorporated. In addition, a vendor team visited all the bases, modified the available equipment, and left instructions and parts to rework the remaining components when they became available. Further, WRAMA issued TO 1C-141A-1213 which documented and required the modification.[378]

Flap Asymmetry Brake System

(U) After the above modification the flap asymmetry brake system continued to plague aircrews. Therefore, a new brake system was procured and installed on the C-141s. However, the problems continued and the new brake system was evaluated. C-141 engineering concluded, by mid-1968, that the new system was also poor and that it failed because of close part tolerances which produced too much heat.

(U) Hence, in the first six months of 1969 the San Antonio Air Materiel Area (SAAMA) tested a third flap asymmetry brake system. This system proved itself and was approved by the SAAMA Configuration Control Board (CCB). In July 1969 MAC announced that the field units would install the brake. The work began in February 1970 and continued into FY 1972.[379]

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378. Briefing, DCS/Log, subj: C-141 Problems, circa Spring 1967, p 15, Supplement III-11.
379. OES/LTF Rpt, Apr 67, p 23; Log D-20 Rpt, 31 Jul 68, p 38; Log D-20 Rpt, 30 Apr 69, p 23.

Wing Flap Jackscrew Actuator Problem

(U) In September 1969, MAC concurred with a SAAMA request to remove these actuators on 20 high time aircraft for analytical condition inspection. The inspections identified "wear patterns between the grooves of the ballnut and jackscrew on the assemblies which eventually would result in excessive side play (jackknifing) which could cause the actuator to bind or jam." A swapout retrofit program was initiated 25 July 1971 to be accomplished during depot IRAN. When MAC requested an increase in overhaul capacity to speed up the program, SAAMA advised that their maximum swapout support must remain at eight ship sets per month; force retrofit would be completed by July 1974.[380]

AILERON HINGE PLATE STRESS

(U) Five incidents involving aileron hinge plate stress occurred between February 1970 and May 1971. OCAMA determined that the cause of these incidents was total failure of hairline stress cracks when the hinge plates were under load. This discovery led to the issue of TCTO 1C-141A-1379 and a modification/retrofit program.[381]

PITCH TRIM SYSTEM

(U) Problems with the pitch trim system came to light on 8 February 1967 when a C-141 crew noticed the nose of their aircraft rapidly rise as they took off from Robins AFB, Georgia. Seeing the nose rise, both

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380. See Supplement III-12.
381. See Supplement III-13.

pilots of that C-141, SN 66-151, immediately pushed the yoke forward and pressed the trim disconnect buttons. That action increased the airspeed; and when SN 66-151 was about 300 feet off the ground, the pilots banked 60 degrees to get the nose down. With the nose down, they reduced the power and used a manual hydraulic, back-up trim system to recover and land. Afterwards, since SN 66-151 belonged to the 58 Military Airlift Squadron located on Robins AFB, MAC asked WRAMA to evaluate the aircraft.

(U) Complying, WRAMA technicians checked the electrical wiring and connectors in the pitch trim system, looking for evidence of binding or wearing of the parts. They also pulled all the circuit breakers to see whether the electrical system was arcing. Finally, they checked the indicator and stabilizer movements. They reported that they could not find the cause of the incident.[382]

(U) However, during the next few months, C-141 crews continued to report pitch trim incidents. Mainly, the system was apparently activating without being activated. As a result, during April 1967, delegates from HQ MAC, Lockheed, WRAMA, and Dover AFB reviewed the matter. Although the conferees could not pinpoint the causes for all the incidents, they decided that failures of the mach trim compensator (MTC) and transmitter were causing some of the incidents. The delegates noted that at times, when pilots activated the MTC during flight, the stabilizer began going through a test cycle, either because the flight

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382. Sup Docs 94 and 95 of hist, MAC, Jul 68-Jun 69, XV.

engineer had turned off the MTC before finishing a test during preflight operations or because power losses had occurred during the tests.[383]

(U) Consequently, on 7 June 1967 HQ MAC ordered C-141 pilots to leave the mach trim system switch off during flights and to open the direct currect (DC) circuit breaker. In addition, the C-141 flight engineers were directed not to give the MTC preflight checks. A month later the officials said, "This action eliminates the MTC system as a cause of the pitch trim problems. . . . ASD is evaluating the entire pitch trim system."[384] The procedure worked for the rest of the year, so on 4 December 1967 the C-141 SPO approved removing the MTC from the C-141s.[385]

(U) Meanwhile, during 1967 maintenance officials decided that another part of the pitch trim system was faulty. That part was the horizontal stabilizer actuator assembly, which investigators felt was causing many incidents; also, maintenance personnel were complaining that specialists were spending too much time repairing the actuators. On 25 October 1967 personnel from Lockheed and the C-141 SPO met with SAAMA people and made a teardown inspection of some actuators at the SAAMA depot. They decided that the manufacturer had built them with poor materials.

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383. Sup Doc 96 of hist, MAC, Jul 68-Jun 69, XV.
384. Background Paper, Commander's Conference: COLD TEA II: Talking Papers (S), 19-22 Jul 1967, subj: C-141 Pitch Trim Problems, p 2.63.
385. Log D-20 Rpt, 31 Dec 67, p 46.

(U) Early in 1968 attempts were made to develop a better actuator.[386] As that year progressed, increasing complaints about the existing actuator filtered to the headquarters. Its motor burned out and its shaft, mating spline, and screw-nut wore out rapidly. (See Chart VII.) At times missions were aborted because of the faulty actuators.[387]

(U) A nearly disastrous accident occurred on 1 August 1968 and sped efforts to find a better pitch trim actuator. On that day the pilot of a C-141 was climbing out of Cam Ranh Bay AB when the nose of the plane suddenly pitched downward. The pilot turned on the electric-hydraulic pitch trim only to feel a vibration; this action had no effect on the trim or attitude of the plane. He then pressed the hydraulic pitch trim lever, still obtaining no effects. Se he retarded the throttles and released the spoilers and, together with the copilot, applied back-pressure to the yoke. Pressing against the column with all their strength, the pilots leveled the plane at 9,000 feet, even though the pitch trim indicator showed a full nose-down position. They had to keep pressing the column until they landed.

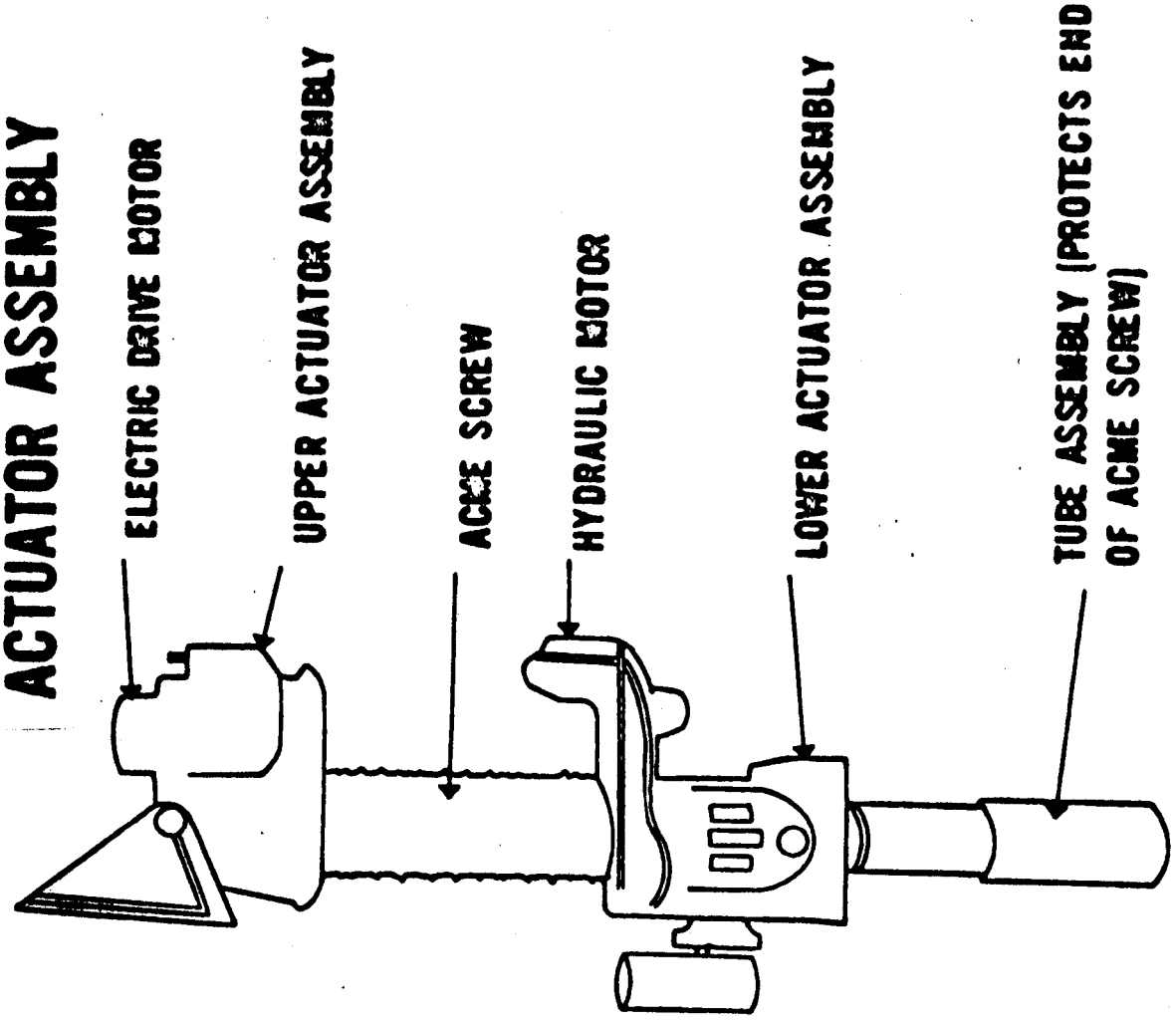
(U) A complete investigation of that incident soon took place and the accident board determined that the pitch trim actuator was made of bad materials, causing a series of events. The events occurred because a bronze acme rotating nut had stripped its threads. The nut was an important part of the actuator assembly, because it rotated down a jackscrew to operate the stabilizer. The board members said that because

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386. Sup Docs 97 and 98 of hist, MAC, Jul 68-Jun 69, XV.
387. Log D-20 Rpt, 31 Aug 68, p 44.

CHART VII

SIDE VIEW OF HORIZONTAL STABILIZER ACTUATOR ASSEMBLY



the nut had stripped, it had slid on the jackscrew to the extreme nose-down position, owing to an off-balance weight distribution of the stabilizer.

(U) Later, SAAMA engineers studied the actuator assembly that had caused the incident and noted that the nut had worked for 6,000 hours before failing. The MTBF of the actuator, however, was 9,362 hours. On 14 August 1968, people from HQ MAC, WRAMA, Lockheed, Western Gear, and the C-141 SPO met at SAAMA and conducted a teardown inspection of that actuator. They soon saw that it was not greased. Its dryness brought about wearing in the parts and the subsequent stripping of the nut. HQ MAC conferees reported, "A poorly designed actuator requiring extraordinary lube servicing, coupled with inadequate handbook servicing instructions, was found to be the primary cause factor."[388]

(U) On 17 August 1968 MAC issued new lubricating instructions to C-141 units for the pitch trim actuator. At the same time, WRAMA and SAAMA were asked to evaluate whether timed changes of the nut might help. In addition, to gain facts for a study, officials in the two agencies ordered inspections of all C-141 actuators. By 28 August MAC maintenance had found 11 bad rotating nuts in the actuators of 243 C-141s.

(U) Analyses of the pitch trim actuator assembly continued throughout 1968; at the end of the year it was concluded that the actuators were failing for reasons other than just poor lubrication. Motor drive shaft splines were stripping and the clutch drives were breaking.

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388. Sup Docs 99 and 100 of hist, MAC, Jul 68-Jun 69, XV.

About the same time Lockheed engineers sent to SAAMA an ECP for a better actuator.

(U) During July 1969, HQ MAC announced that the Air Force had approved a new actuator for the C-141s. It was noted that, "This new actuator will have stronger internal parts to make it more reliable in the electrical mode of operation."[389] At the same time MAC requested Air Force to approve a grease-loaded cartridge which maintenance men could insert in the actuator. The cartridge would automatically begin greasing the actuator when the pilot turned on the number two hydraulic system. If approved, the cartridge would only have to be changed every 45 days, eliminating the need for weekly lubrication. MAC officials also requested a redesigned motor shaft, cam sets, bearing retainers, and improved water drainage points in the pitch trim actuation.[390]

TASK GROUP C-141-14

(U) In 1968 the above problems and many other unresolved flight control incidents led to the formation of an investigation/evaluation group. On 16 August 1968 WRAMA issued a contract to the Lockheed-Georgia Company which called for the investigation and evaluation

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389. Hist rpt, DCS/Log, subj: C-141 Pitch Trim Problem, circa Aug 68; hist rpt, DCS/Log, subj: C-141 Pitch Trim Actuator Malfunctions, circa Feb 69; presentation, Commander's Conference, COLD JUICE: Items, 9-11 October 1968, subj: C-141 Maintenance Management, pp 24.4-24.5.

390. "Flight Control Malfunctions in the C-141," MAC Flyer, Aug 69, p 7.

of the C-141 Primary Flight Control System problems. This group, named "Task Group 18," was also charged with the responsibility of identifying problems and recommending corrective actions. This group initiated 24 projects which generated 11 TCTOs, nine handbook changes, three instrumented flight tests, and one component swapout program. Despite this prodigious effort, flight control system incidents rose dramatically in CY 1970 over those of CY 1969.[391]

(U) During CY 1970, MAC C-141s experienced 69 flight control incidents--a figure that showed an undesirable trend when compared to the 55 incidents accrued during CY 1969. In all, for CY 1970 and January-February 1971, 83 incidents were reported in the following areas:[392]

1. Nineteen in the aileron system. Although several malfunctions showed similar symptoms, the causes were determined to be unrelated.

2. Twenty-one in the elevator system. For three of these the cause could not be determined. In each case multiple components were changed and teardown investigations were conducted on removed components.

3. Seventeen rudder system malfunctions. In four of these malfunctions the cause was not determined although extensive troubleshooting and teardown analysis of removed parts was performed.

4. Twenty-six incidents occurred in the pitch trim system. In eight of these incidents the problem could not be identified despite stringent efforts by the maintenance teams.

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391. Log D-20 Rpt, 12 Jul 72, p 12.
392. Sup Doc III-11 of hist, MAC, FY 1971, VIII.

(U) In addition to the above, since 27 June 1970, MAC had followed a policy of impounding the aircraft when a discrepancy could not be identified. Despite specialist team (AFLC/Industry/MAC) efforts on the impounded aircraft, only the most probable cause of the deficiency could be identified in 12 out of 15 aircraft. Since no resolution for the problems appeared feasible, MAC recommended the following:[393]

1. Continue high priority task group approach.

2. Pursue actions to insure AFLC recognition of possible hydraulic contamination and teardown inspection deficiencies.

3. Continue intensive investigations and followups as incidents occur.

(U) As a result of the rise in incidents and MAC's recommendation, WRAMA called a Preliminary Flight Control System Task Group Conference at Robins AFB, Georgia, on 22 September 1970. The purpose of the meeting was to organize " . . . a follow-on Task Group for continuation of the C-141 Primary Flight Control Task Group 18 Agenda."[394] The name selected for the new group was "Task Group C-141-14" and the conferees deemed it " . . . necessary that all aspects of the system continue to be explored in an effort to obtain increased reliability."[395] The membership of the new group consisted of designees from the following commands:[396]

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393. Ibid.
394. Minutes, C-141 Flight Control System Preliminary Conference - WRAMA, 22 Sep 1970, p 1, Sup Doc III-70.
395. Ibid.
396. Ibid.

COMMAND	OFFICE
WRAMA	Chairman
MAC	Cochairman
SAAMA	Member
OCAMA	Member
WRAMA	Member
WRAMA	Member
AFSC	Member
ASD	Member

Officers were chosen from the various commands as noted above. Meetings were scheduled quarterly, with the first meeting held on 21 October 1970.

(U) The agenda for the new group was formulated from open Task Group 18 items and new items submitted at the preliminary conference. Therefore, the new group started with 20 action items; however, after the first meeting, two items were closed, several interrelated projects consolidated, and new ones were added, making a total of 17 action items.[397] The group met as planned and was seemingly successful.

(U) MAC admitted that it was difficult to evaluate the efforts of the group; however, the command's personnel felt " . . . if frequency of in-flight control incidents can be used as an indicator, it appears we are on the right track "[398] As noted below, during

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397. Ibid.
398. Background Paper, DCS/Materiel, subj: Task Group C-141-14, Flight Control Systems Study Group, C-141 Aircraft, 24 Sep 71, Sup Doc III-71.

two like time periods, reductions occurred in flight incidents. In fact, only the rudder showed a higher incident rate in the 1971 period than in the 1970 period.

	Aileron	Rudder	Elevator	Pitch Trim	Totals
1 Jan-23 Sep 70	15	12	22	25	74
1 Jan-23 Sep 71	6	22	6	10	44
TOTALS	21	34	28	35	118

Unexplained Malfunctions

(U) Among the tasks that the group began evaluating was the inability of AFLC's AMAs to isolate inflight malfunctions during depot teardown inspections and repairs. Therefore, some of the conferees indicated that they felt this phenomenon was due to:[399]

> two distinct possibilities: either the tear down inspection specifications are inadequate, or the deficiency is transitory in nature, i.e., hydraulic system contamination.

At the October 1970 Task Group C-141-14 meeting the Flight Dynamics Laboratory of ASD was directed to review OCAMA's hydraulic actuator overhaul and TDR specifications. This investigation revealed that the specifications were acceptable.[400] Nevertheless, OCAMA modified their rudder power control unit test stand to incorporate a feature that simulated flight loads.[401]

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399. Background Paper, DCS/Log, subj: Overhaul/Teardown Inspection of C-141 Flight Control System Components, Tinker AFB, 16 Dec 70, Sup Doc III-72.
400. Ibid.
401. Background Paper, DCS/Log, subj: Simulation of Aerodynamic Flight Loads During SRA Teardown Investigation Testing of C-141 Rudder Power Control Actuator Materiel Deficiency Exhibits, 7 Apr 71, Sup Doc III-73.

(U) Hydraulic system contamination also remained a strong candidate for the malfunction-inducing agent. Therefore, MAC, WRAMA, and OCAMA initiated a stringent program,[402] which included:

1. Flight test of 3-5 micron disposable filter elements.
2. Improve flushing procedures.
3. Develop new fluid sampling procedures.
4. Improve servicing procedure.
5. Expand the training program.
6. Establish time change for hydraulic pump.
7. Establish a chemical cleaning process.
8. Initiate a study for the development of a case drain flow monitoring device.

During the fall of 1971, most of the above remedial actions were accomplished and the tests showed that " . . . at least a 5-micron filtering system was essential to keep the hydraulic system clean."[403] In early 1972 some successes were gained; however, the various projects were still in operation and the final evaluations had not been made.[404]

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402. Background Paper, DCS/Log, subj: Hydraulic System Fluid Contamination, 29 Sep 71, Sup Doc III-74.
403. Morris Intvw, p 21.
404. For further details on flight problems see Supplement 14.

> "Our aerial delivery system has been a burden on maintenance. This is an area where I feel five-and-dime type hardware was used. It just would not withstand the heavy loads imposed during cargo drops, as well as during normal loading and unloading operations."[405]

UTILITY SYSTEMS

(U) Among the so-called utility systems of the C-141, perhaps the most critical from the standpoint of reliability and maintainability was the aerial delivery system (ADS). Its problems had a direct bearing on the strategic airlift mission and were peculiar to the development of the C-141 as a MAC workhorse aircraft. On the other hand, there was nothing unique about the problems that plagued the air conditioning system and the fire warning system. These were typical, normal aberrations which any new aircraft might be expected to experience. The pressurization problem was something else (it was really an airframe problem), and problems of the hydraulic system could be regarded as hydraulic problems of the other systems. The life support system presented nothing more serious to worry about than where to

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405. Morris Intvw, p 22.

stow the life rafts, a question beclouded by the fact that thus far there had been no occasion to use the C-141 life rafts.

AERIAL DELIVERY SYSTEM PROBLEMS

(U) The C-141's "capacity for straight-in, end-loading" also gave it a capacity in reverse that was ideal for aerial delivery operations.[406] Theoretically, by this means the C-141 could while airborne discharge its entire load of cargo in one momentous expulsion, but a malfunction of the ADS could also turn airdropped matter into waste.

Early Problems

(U) In the beginning one of the main problems of the ADS was the tendency to release cargo inadvertently, dropping it in the wrong place. Early in 1967, after "mission aborts, delays, and excessive expenditures of maintenance manhours," grave doubts were expressed concerning the reliability of the system. In September 1967, delegates from HQ MAC, the C-141 SPO, Lockheed and WRAMA met and identified 21 problems of the ADS. WRAMA subsequently set up a materiel improvement project to find 21 solutions. However, WRAMA's efforts did not suffice to solve all the ADS problems during 1968. The original 21 problems identified in 1967 were solved, but new problems took their place. One reason for this was that Lockheed had delivered the C-141s to MAC with ADS equipment incompletely installed. Even by November 1968 the C-141s

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406. Lockheed-Georgia Company, C-141A Starlifter Loading and Airport Operations Data Book (Marietta, Georgia, 1964), p 1.

still did not have all their ADS equipment, although MAC had "in the past brought this deficiency to the attention of the ASD and the AWADS [Adverse Weather Aerial Delivery System] SPO."[407]

(U) The continuing ADS problems necessitated a review during October and November 1968. It was found that not only was the ADS handicapped by faulty parts--weak lashing webs for the aft restraint subsystem and weak floor roller conveyors--but it also needed additional equipment: a 28-foot extraction parachute and a device that could mechanically transfer the force exerted on the extraction parachute to the main parachute after a load left the plane.

Weak Lashing Webs

(U) The question of weak lashing webs arose during ADS testing in 1968 when vehicles prepared for parachuting from the C-141s tore off their platforms after the webs broke. The lashing webs were restraint straps made of cotton and had been incorporated into the C-141 ADS after their use was successfully evaluated in C-130 aircraft. During the 1968 tests, however, it was learned that although loads airdropped from a C-130 produced 5,400 pounds of force, the same loads with the same parachute produced 9,100 pounds of force when released from a C-141. Moreover, the rails on the cargo floor did not release the platform easily when the extraction parachute pulled the load out of the plane. As a result, the webs broke. A recommendation was made to

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407. Hist, MAC, 1 Jul 68-30 Jun 69, II, pp 48-50.

raise the Air Force criterion for the strength of the lashing webs from two measures of gravity (2Gs) to three (a 200-pound package under a pressure of 3Gs exerted the force of a 600-pound package). Since the aerial delivery missions usually involved joint operations with the Army and the loads for such missions were prepared by Army personnel, the Air Force asked the Army to approve the use of nylon webs instead of cotton ones (nylon webs could take pressures of 3Gs). Accustomed to packing loads for C-130 missions, the Army at first declined, feeling that the use of different webs for packing C-130 and C-141 loads would complicate the procedure. To resolve the matter, Air Force and Army representatives met on 31 October 1968 and agreed that they should find out whether nylon, dacron, or doubled cotton webs would hold loads better on the platforms than did the single-ply cotton webs. Tests established that all three types of webs could hold loads with pressures of 4Gs at the front of the cargo compartment, 3Gs at the back, 1.5Gs from side-to-side, and 2Gs along the length. These were the maximum pressures that an extraction parachute exerted when it pulled a load out of a C-141 flying at the fastest airdrop speed. After a review of the reports, the dacron lashing webs were selected, and the Army began buying them late in 1968.[408]

Weak Roller Conveyors

(U) The floor roller conveyors, which were part of the cargo loading system developed for the C-141 ADS in the early 1960s, proved too

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408. Hist, MAC, 1 Jul 68-30 Jun 69, II, pp 50-52.

weak for the heavy airdrop loads that the C-141 carried; furthermore, the conveyors allowed the loads to exert uneven pressures on the cargo floor. This problem was identified in 1967 during ADS testing with some Army equipment that turned out to be too heavy for the conveyors. As a result, the C-141 SPO restricted the paradrop of such heavy equipment. Subsequently, the Air Force started looking for a way to distribute weight more evenly on the conveyors and on the floor of the C-141. During May 1968 the Air Force contracted with the Brooks and Perkins Corporation for a two-month test of a new instrumented floor roller distribution system, beginning 8 June 1969 at Fort Bragg, North Carolina.[409] By 1 July 1969, MAC was able to report:

> The floor roller weight distribution test is progressing satisfactorily. It is expected that data gathered to date will allow a clear release for Division Ready Force (DRF) loads.

Additional Equipment Needed

(U) In 1967 it was learned that the original extraction parachute could not pull out loads weighing more than 15,500 pounds when a C-141 traveled faster than 140 knots; therefore, a 28-foot extraction parachute was obtained in 1968 for testing. The ADS also needed a device to transfer pressures from the extraction parachute to the main parachute for loads that weighed between 25,000 and 35,000 pounds. MAC and WRAMA worked jointly to develop such a device during 1968 and 1969.[410]

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409. Hist, MAC, 1 Jul 68-30 Jun 69, II, pp 52-53.
410. Ibid., p 53. HQ MAC Operational Test Order 11-1-69, subj: Support of C-141 Aerial Delivery Extraction Parachute Tests, Aug 69, Sup Doc III-75.

Maintenance Team Field Survey

(U) The review of ADS problems in late 1968 produced two important results: First, HQ USAF formed an interservice ad hoc committee; the AWADS SPO was designated chairman of this committee composed of delegates from MAC, Air Force Systems Command, Tactical Air Command, and Army agencies. Second, a MAC/WRAMA maintenance team was formed to visit C-141 units and develop solutions by studying the ADS problems firsthand.

(U) The joint MAC/WRAMA team visited C-141 units during December 1968 through February 1969 and reported in March 1969 a total of 41 findings (13 design defects, 18 instances of inadequate technical information in the ADS manuals, and 10 management problems), including the following list of serious ADS deficiencies:

1. Exposed and weak rail locks and rollers.
2. Easily breakable remote control housings. (Each C-141 unit used up ten a week.)
3. Loose-fitting restraint rails which were difficult to adjust.
4. Complicated lock sears that had to be adjusted to a thousandth of an inch.
5. Cracking of the ramp pickup bearings.
6. Loose ramp locks.
7. Buckling petal doors.
8. Locking of the petal doors before they fully opened.
9. Fragile troop door spoiler parts.
10. An extraction mechanism that allowed premature releases.

(U) Of the problems listed, the last one was considered the most serious. At first it was thought that the premature releases were caused by the tension regulator, but further investigation revealed that the extraction mechanism itself was to blame. The MAC/WRAMA team reported:[411]

> We found that some aircraft, even if rigged properly, would experience an early release when armed by the loadmaster because of the way the system is built. We determined that by modifying components of the extraction mechanism . . . we could separate the mechanical and electric release system and provide a completely reliable system in each mode. Prototypes were developed at two wings and eight inflight drops and more than thirty ground tests were successfully accomplished.

The modification, which was approved by WRAMA, reduced the number of parts needed and lessened the weight of the system. It replaced a straight cable with a tension regulator cable and freed the loadmaster from the requirement to arm the circuit mechanically. With regard to improving the performance of the petal doors in ADS operations, the MAC/WRAMA team recommended the development of a device to reinforce the microswitch strike-plates. The 437 Military Airlift Wing came up with such a device, WRAMA approved it, and MAC announced that all C-141s would get it.

(U) By July 1969, only seven problems remained. It was noted at HQ MAC that the solutions thus far had been highly effective. The C-141 ADS performed remarkably well during the Focus Retina exercise early in 1969, wherein MAC aircraft transported troops and equipment of the

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411. Hist, MAC, 1 Jul 68-30 Jun 69, II, pp 55-56.

82 Airborne Division from Pope AFB, North Carolina, and airdropped them into Korea. Altogether, the number of incidents attributed to malfunctioning ADS equipment dropped from a high of 26 in December 1968 to two in July 1969, at which time HQ MAC commented that:[412]

> It is our objective to continue the task group approach of interest; we are continuing our efforts to provide an adequate rail cover to protect the rail mechanisms and improved visual lock indicator.

1969 ADS Review

(U) The ADS malfunction rate dropped even lower in August 1969 with only one incident reported for the entire month. Of the 41 problems originally identified by the joint MAC/WRAMA maintenance team, there remained but two still unresolved; these were in the areas of restraint rail covers and microswitches. The modifications that had been incorporated thus far had proven successful. Then in October 1969, during the Deep Furrow exercise, something happened to upset the seemingly favorable trend: out of 15 equipment drops there were two ADS malfunctions. This unreliability was definitely "unacceptable and clearly indicated the need for positive action." A meeting was held at Charleston on 12 November 1969 for the purpose of conducting "an in-depth review of the complete ADS from both a maintenance and operations standpoint." In addition to representatives from HQ MAC, WRAMA, Lockheed-Georgia Company, and Brooks and Perkins (ADS contractor),

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12. Hist, MAC, 1 Jul 68-30 Jun 69, II, pp 56-58.

each MAC C-141 wing was represented by "a qualified ADS maintenance technician and the wing combat tactics loadmaster" at this meeting, during which the following were discussed:

1. Status and effectiveness of actions taken by the previous ADS task group.
2. ADS maintenance policies and procedures.
3. New problem areas.
4. ADS malfunction analysis.
5. Recommended improvement areas and new agenda items.

As a result of the discussions, five new problem areas were added to the two remaining open items. It was also decided that nine of the original 41 problems identified by the previous ADS task group required "additional action in order to achieve maximum effectiveness of the system." Revised estimates of completion dates for corrective action reflected extensions of from two to ten months.[413]

Corrective Progress

(U) Although corrective progress was made on known ADS materiel deficiencies, much work remained to be done to achieve a 100 percent system reliability. During November and December 1969, the command-wide reliability for equipment drops was 97.2 and 94.7 percent, respectively; in January 1970 it dropped to a low 88 percent. Analysis

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413. Background Paper, MAC DCS/Mat, subj: 100% Mechanical Reliability, C-141 Aerial Delivery System, 13 Jan 70, Sup Doc III-76.

of airdrop malfunctions clearly indicated that the majority of the malfunctions should have been detected during preflight inspections. To reverse the adverse trend, the MAC Director of Maintenance Engineering called upon maintenance supervisors for aggressive action "to insure that thorough preflights are performed on the complete Aerial Delivery System."[414]

(U) In addition to the 16 open items already identified by the revitalized ADS task group, three new problems were uncovered concerning failures of the extraction parachute holder cable, the cargo ramp actuator bracket attach rivets, and the retriever cable retainers. The first was identified by the ADS task group in 1968 and was thought to have been corrected by replacing the existing 1/16-inch cable with a 3/32-inch cable, but the appropriate technical data had not been revised to reflect the change. Corrective action specified necessary revision by WRAMA of all drawings and technical data to show the preference for the larger cable by May 1970, at which time it was hoped the replacement of the smaller cables would have been completed. Correction of the other two deficiencies also called for replacement of the defective part, either by a larger part or one made of a better material. In the case of the attach rivets, retrofit would be completed by August 1970 on the basis of a 180-day field level TCTO issued by WRAMA in March 1970. The retriever cable retainers or spring clips

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414. Ltr, MAC DCS/Mat to MAC Units, subj: C-141 Aerial Delivery System, 6 Feb 70, Sup Doc III-77.

would have their lower lip made from a material with "sufficient elasticity to insure retention of the cable." With the WRAMA evaluation of this proposal completed by April 1970, it was expected that retrofit, if required, would be accomplished within five months.[415]

(U) Units were encouraged to share their ADS malfunction experience which might be "of value to other C-141 units in reducing/eliminating similar malfunctions."[416] Placing special emphasis on achieving an objective of 100 percent ADS reliability paid off. In a year's time, of the 19 problems which required modification, revised procedures, or additional instruction, 16 had been solved, increasing the overall reliability to 98.7 percent. To expedite resolution of the remaining problems, AFLC assistance was considered necessary "in order to maintain high reliability without the expenditure of excessive maintenance man-hours."[417] Three ADS problems remained: restraint rail cover/walkways, microswitches, and loadmaster trainers.

Restraint Rail Covers/Walkways

(U) The requirement for restraint rail covers or walkways was integral to the design of the C-141 aerial delivery system and was considered the top ADS problem by the MAC/WRAMA maintenance team late in 1968. It ranked first among the open items listed by the second

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415. Ibid.
416. Msg, MAC DCS/Mat to 21AF, et al., subj: C-141 Aerial Delivery System Reliability, 272146Z Feb 70, Sup Doc III-78.
417. Background Paper, MAC DCS/Mat, subj: C-141 Aerial Delivery System (ADS), 6 Nov 70, Sup Doc III-79.

ADS task group a year later. Early in 1970 MAC/WRAMA representatives reviewed three preliminary rail cover proposals by the Brooks and Perkins Company preparatory to the submission of a formal proposal on the final selection before 1 March 1970. No slippage was anticipated on the originally established March 1971 target date.[418] Restraint rail covers/walkways prevented rail damage caused by the shoes of aircrew and support personnel, provided a safe passageway in the cargo compartment, and eliminated the continual replacement of existing wooden or honeycomb walkways. A Class IVB modification for restraint rail covers/walkways was certified by MAC on 20 October 1970 as "essential and an overriding operational necessity." At this time the restraint rail system had a reliability of 99.1 percent, a rate achieved and maintained "by extremely close scrutiny of the system," which meant "expending excessive man-hours to inspect and repair rails" damaged by personnel stepping on them. The high reliability of the restraint rail system was apparently not a very effective stimulus for the development of improved rail covers/walkways, for in February 1972 it was one of the ADS projects still being monitored for feasibility determination.[419] By August 1972, however, this modification had been successfully prototyped and was in procurement for force retrofit.

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418. Background Paper, MAC DCS/Mat, subj: 100% Mechanical Reliability, C-141 Aerial Delivery System, 13 Jan 70, Sup Doc III-76.
419. Ltr, MAC DCS/Log to DCS/Ops, subj: 1971 Airdrop Malfunction Analysis, 14 Feb 72, Sup Doc III-80.

Microswitches

(U) Microswitch problems were first brought to light by the joint ADS task group which visited C-141 units in early 1969. It was found that maintenance personnel had been having considerable difficulty adjusting mechanical microswitches on C-141 aircraft, particularly those on the ramp, petal doors, and pressure door. The resultant excessive maintenance and aircraft downtime prompted a request to WRAMA in May 1969 for an engineering review of all microswitch installations in the aerial delivery system "to determine the scope of the problem and make recommendation to correct all known deficiencies." WRAMA's report, forwarded the following month, pointed out that the microswitches "varied in the pretravel dimensions, overtravel dimensions, actuating force and release force," although they were all made by the same vendor. Other possible contributing factors were the rigging procedures used, weak mounting brackets, and lack of a definite reference point for adjustment of the switches. The recommended remedies included "standardizing switches, beefing up mount brackets, revising rigging procedures and the procurement of switches with a longer plunger and additional overtravel to permit ease of adjustment." MAC's concurrence with the recommendations and urgent request for "expeditious action" led to WRAMA's investigation of the microswitch problem under two separate engineering projects scheduled for completion by 1 December 1969. Actually, an answer was already available in the solid state proximity switches that were being used on the C-5 aircraft landing gear doors,

flaps, and slats in lieu of mechanical microswitches. One drawback was the cost of the proximity switches, but according to information supplied by Lockheed early in 1969 to visiting 437 Military Airlift Wing personnel, a cost effectiveness study had shown that the reduced downtime of the proximity switches more than justified their increased cost. It was estimated that their use over a 10-year period would mean a $30 million savings per hundred aircraft. In answer to a request from the 437th, MAC initiated a study which confirmed that "solid state switch systems would be beneficial on C-141 aircraft." Since the proximity switch systems had no moving parts, needed no adjustment and could be replaced without recalibration, they were immune to the most common failure modes of mechanical switches. The guarantee provided by the manufacturer--up to 250,000 hours--expressed their supreme confidence in the product. In early August 1969 representatives of the proximity switch manufacturer, WRAMA, and HQ MAC met at Charleston AFB to further discuss the excellent qualities of proximity switches preliminary to hatching plans for a service test later in the year which would determine the "preferred method of modifying the C-141 aircraft, using either proximity switches or modified microswitches."[420]

(U) The year 1969 elapsed and the plan to hold a service test on the proximity switches was, at least, still a plan. By 6 February 1970, a test program had been established, MAC had identified 27 microswitches within the aft door system for reconfiguration to proximity

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420. Briefing, HQ MAC, subj: Microswitch Problems--C-141 Aircraft, undated, Sup Doc III-81.

switches, and the manufacturer had agreed to support a three-aircraft test without cost to the US Air Force, with WRAMA supplying the engineering drawings and installation instructions. The test was scheduled to start on 1 August 1970 and last for 120 days. A successful test would lead to WRAMA procurement action on a competitive basis in January 1971 for possible force retrofit in December 1971.[421]

(U) Two C-141 aircraft were assigned finally to the test during the week 15-20 September 1970,[422] and by 6 November 1970 had accumulated over 330 hours, including three successful heavy equipment airdrops, without an incident.[423] But more than a year later WRAMA was still evaluating the test.[424] A clue to one of the causes of the delay might be deduced from the following MAC Malfunction Review Panel agenda item on proximity switches:[425]

> MAC project (MAC CCB Control #710159) concerning "Installation of Proximity Switches in Aft Door Control and Indicator Circuitry" deferred due to excessive cost ($850,000).

Loadmaster Trainers

(U) Lastly, there was the urgent need for C-141 loadmasters to become proficient in the aerial delivery system in the shortest possible

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421. Ltr, MAC DCS/Mat to MAC Units, subj: C-141 Aerial Delivery System, 6 Feb 70, Sup Doc III-77.
422. Status Rpt No 11, MAC DCS/Mat, subj: 100% Mechanical Reliability, C-141 Aerial Delivery, 28 Sep 70, Sup Doc III-82.
423. Background Paper, MAC DCS/Mat, subj: C-141 Aerial Delivery System (ADS), 6 Nov 70, Sup Doc III-79.
424. Ltr, MAC DCS/Log to DCS/Ops, subj: 1971 Airdrop Malfunction Analysis, 14 Feb 72, Sup Doc III-80.
425. Agenda Item 4 (MAC Malfunction Review Panel), MAC DCS/Log, subj: Proximity Switches, undated.

time. This was a new item added to the list of ADS problems in late 1969 and was one of three items set up for a long term solution.[426] The requirement for seven complete sets of restraint rails and rollers to be used in fabricating training simulators was forwarded to WRAMA for procurement action in January 1970. It was learned that leadtime for procurement of the rails would be approximately 12 months,[427] but partial approval of the request alone took 11 months; in November 1970 word was received that two of the seven trainers requested were approved with the recommendation to utilize one set within each MAC numbered air force.[428] While awaiting the outcome of the request for trainers, HQ MAC undertook an ADS orientation program, particularly at bases which did not have an ADS repair shop or training capability.[429]

100% Reliability

(U) The attainment of a 98.7 percent reliability in June 1970 inspired the MAC Deputy Chief of Staff, Materiel, to issue a commendatory message to all concerned, wherein he said:[430]

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426. Background Paper, MAC DCS/Mat, subj: 100% Mechanical Reliability, C-141 Aerial Delivery System, 13 Jan 70, Sup Doc III-76.
427. Ltr, MAC DCS/Mat to MAC Units, subj: C-141 Aerial Delivery System, 6 Feb 70, Sup Doc III-77.
428. Background Paper, MAC DCS/Mat, subj: C-141 Aerial Delivery System (ADS), 6 Nov 70, Sup Doc III-79.
429. Ltr, MAC DCS/Mat, Dir of Maint Eng, to General Cruikshank, DCS/Mat, subj: C-141 Aerial Delivery System (ADS), 7 Nov 69, Sup Doc III-83.
430. Msg, MAC DCS/Mat to 60 MAWg et al., subj: C-141 ADS Reliability, 091930Z Jun 70, Sup Doc III-84.

> Although many actions have been taken to acquire 100 percent ADS reliability, perhaps the most important contribution to improve our performance is the emphasis you have applied and the expertise developed in maintaining the associated system hardware. I solicit your continued assistance . . . in emphasizing supervision, adherence to tech data, inspection and adjustment procedures to achieve our ultimate objective of 100 per cent ADS equipment reliability.

AIR CONDITIONING DEFICIENCIES

(U) The status of air conditioning maintenance in April 1966 indicated a vigorous improvement program in progress. Six engineering change proposals (ECPs) were being incorporated into the production process and one was under evaluation:[431]

> ECP 297 (TCTO 1C-141A-636) provided an improved control box to correct temperature control instability in the heat exchanger. Effective in production aircraft No. 19; retrofit of aircraft No. 9 through 18 to be accomplished during phase II update.
>
> ECP 398 (TCTO 1C-141A-796) provided underfloor heating during auxiliary power unit operation to eliminate severe temperature stratification in the cargo compartment and condensation and icing on the floor (revealed during category II tests). Effective in production aircraft No. 67; retrofit did not require kits.
>
> ECP 400P (TCTO 1C-141A-820) provided plastic debris catchers in the hot air outlets along the fuselage floor. Effective in production aircraft No. 91; retrofit kits were available as early as February 1966.
>
> ECP 455 (TCTO 1C-141A-1028) provided a water trap in the cargo compartment segment of the flight station gasper air supply ducts. Effective in production aircraft No. 171 with kit availability in August 1966.

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431. Log D-20 Rpt, 15 Jun 66, p 7.

ECP 622 (TCTO 1C-141A-1025) provided an improved water separator assembly. Effective in production aircraft No. 134; no kits were needed.

ECP 623 (TCTO 1C-141A-1027) provided a redesigned cargo compartment overhead duct. Effective in production aircraft No. 185 with kit availability in August 1966.

ECP 647, a modification of the turbine to allow it to discharge accumulated water through air vents instead of into the bearing oil sump, was under evaluation.

Cooling Turbine Troubles

(U) Although service life testing of the cooling turbine and water separator bag formally ended with the transfer of two test aircraft from Travis to Dover AFB in August 1966, continued evaluation of the project was pursued by means of a request from the C-141 SPO to the 436 Military Airlift Wing at Dover for information concerning the date of replacement of the left-hand cooling turbine on either aircraft, including the reason for removal and airframe hours, and a request to 22 Air Force for the installation of water separator test bags in 60 Military Airlift Wing aircraft.[432] Service test JTF-C-141-41144B was conducted on one C-141 at Dover. On 10 February 1967 AFLC reported that two modified turbines had been installed in accordance with TCTO 1C-141A-1128 which had been issued on 11 January 1967. Starting that month, modified turbines with an expected life of 2400 hours mean time between failures (MTBF) were available at the rate of 25 turbines per month.[433]

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432. OES/LTF Rpt, Aug 66, p 17.
433. Ltr, MAC DCS/Ops to 21AF, et al., subj: PERT Report--C-141 Management Summary (Report No. 12), 14 Apr 67, p 3-2.

(U) During a conference at OCAMA on 25 October 1966, ASD, Lockheed, MAC, the Inventory Manager, and the System Support Manager decided to let the System Project Officer initiate a contract with Lockheed to modify all turbines in the field, starting with aircraft units with the highest time. On 17 December 1966, a hundred reparable turbines were airlifted to the vendor for overhaul. During January and February 1967, 86 modified units were delivered; subsequent deliveries, however, were affected by a shortage of required parts.[434]

(U) ECP 647 called for a modification of the refrigeration cooling turbine to enable it to discharge accumulated water through its air vents. It was necessary to eliminate the accumulated water because water entering the bearing oil sump diluted the oil and caused bearing failure. During the period 12 September to 24 October 1966, 14 turbines were replaced due to premature bearing failure. At that time, the reliability experience indicated that the average MTBF was 1084 hours, but some turbines failed with as little as 284 to 300 hours of operation. To help alleviate the problem, MAC reiterated a directive requiring the air conditioners' oil to be changed at 50-hour intervals.[435]

(U) In March 1967, some apprehension was expressed that water that would otherwise have accumulated in the oil sump, when ejected into the air conditioning compartment, might accelerate corrosion in the surrounding structure. A review of the ECP 647 design revealed

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434. Log D-20 Rpt, 15 May 67, p 24.
435. OES/LTF Rpt, Oct 66, pp 21-22.

that although there was water ejection into the air conditioning compartment, this did not occur when the turbines were operating, but probably "only during ground or low altitude operation on humid days." In any case, it was noted that water condensation occurred in the vented air conditioning compartment each time the aircraft descended from a cold, high altitude environment to a warm, humid low altitude or ground level. Hence, water in the air conditioning compartment could be regarded as "a very frequent, almost normal, occurrence." It was concluded that additional water as a result of modified turbine operation was not likely to cause any more of a corrosion problem than water from other sources.[436]

(U) Cooling turbines remained a hot topic and on 29 January 1968 a conference was convened at Air Research Corporation in Los Angeles to discuss it and discover why some turbines failed early in their service life while others continued to operate satisfactorily even after 5000 hours. Two 300-hour turbines from 60 Military Airlift Wing were disassembled to determine wear rate. Both were still well within manufacturing tolerances and might easily have operated satisfactorily for many more hours. The disassembly of two very low time failed turbines led the conferees (representing MAC, the SPO, OCAMA, 22 Air Force and Air Research) to the conclusion that low time cooling turbine failures were "generally precipitated by system component malfunctions

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436. Ltr, MAC DCS/Ops to 21AF, et al., subj: PERT Report--C-141 Management Summary (Report No. 11), 15 Mar 67.

which cause overheating, over-speeding, loading and unloading of the turbine." It was noted that turbine teardowns showed essentially the same failure mode: overheating or over-speeding with subsequent failure of the heavy end bearing located on the compressor end. Identified as having caused many turbine failures in the past were the following difficulties and/or malfunctioning components:[437]

1. Misalignment of the turbine in the cooling pack.
2. Flow control valve.
3. Pressure regulating valve.
4. Primary heat exchanger high limit sensor.
5. Primary heat exchanger louver doors.
6. Turbine bypass valve.

A clean and properly operating water separator assembly (relief valve and coalescer bag) was considered essential to long turbine life. A thorough check of this assembly and the items in the foregoing list were recommended after each cooling turbine failure.[438]

(U) The Maintenance Evaluation Division of Detachment 12, HQ MAC (formerly the C-141 Operations Evaluation Staff) at Travis reported in September 1969 that a review of air conditioning system work unit codes for the period January-August 1969, using 60 Military Airlift Wing's base maintenance statistical data, showed 15 items out of 89 as reflecting sufficient replacement/maintenance actions to warrant

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437. OES/LTF Rpt, Jan 68, pp 20-21.
438. Ibid.

presentation. That the number of water separator failures (three, requiring two replacements) was among the items mentioned was a measure of the effectiveness of C-141 air conditioning maintenance at this time. For the month of July, WRAMA reported a total of 11 water separator failures MAC-wide, with an MTBF of 30121 against a minimum acceptable reliability of 38240.[439]

Sensor Malfunctions

(U) Repeated malfunctions of the primary heat exchanger sensors had prompted an investigation to determine causes and necessary corrective action.[440] Shrinkage of the epoxy potting compound was found to be the source of the difficulty. By October 1966 sensors with ceramic potting had been developed and were undergoing reliability tests.[441] On 1-2 March 1967, a conference at Lockheed on temperature control and sensor problems resulted in an agreement by the vendor to dispatch a field team to all bases concerned to update its particular brand of flightline and bench temperature test equipment.[442] The meeting discussed the reliability of sensors and what might be done to improve the design and manufacturing techniques. Failure data reflected approximately 2000 hours MTBF whereas the desired reliability was near 5000 hours MTBF. Since commercial aircraft were not experiencing

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439. C-141/MED Rpt, Sep 69, p 24.
440. Log D-20 Rpt, 15 Aug 66, p 9.
441. Log D-20 Rpt, 15 Dec 66, p 15.
442. Log D-20 Rpt, 15 May 67, p 24.

problems in this area, SPO engineering suspected the design and/or manufacturing techniques used.[443]

Burned Insulation Blankets

(U) On 2 August 1966 the 436 Military Airlift Wing reported finding charred and burned air conditioning insulation blankets near the hot air ducts during a special investigation of selected aircraft. The condition was evidently the result of using low temperature insulation (300 degrees F) blankets in a high temperature area. According to Lockheed, temperatures in excess of 300 degrees F were not anticipated in the affected area at the time of the initial design, hence the selection of the 300 degree F blanket. Lockheed proposed an engineering change which called for blankets capable of withstanding temperatures up to 450 degrees F.[444] The insulation blanket was one of 15 items that required attention among 89 work unit codes in air conditioning maintenance during January-August 1969. A total of 62 replacement actions placed it as the second highest consumption component of the C-141 air conditioning system.[445]

FIRE WARNING SYSTEM DEFECTS

(U) While the C-141's air conditioning system might have on occasion caused men to sweat and swear, there was one system whose function

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443. Ltr, MAC DCS/Ops to 21AF, et al., subj: PERT Report--C-141 Management Summary (Report No. 12), 14 Apr 67, p 3-2.
444. Ibid.
445. C-141/MED Rpt, Sep 69, p 24.

or malfunction invariably caused men's blood to turn cold, namely: the fire warning system. As early as 1965 a major effort was made to eliminate the fire warning system's defects. For a while it seemed that the only way to do this was to eliminate the fire warning system.

(U) The major deficiency encountered was false fire warnings due to overheating in the auxiliary power unit compartment during taxi, chafing of cowl mounted fire warning sensor wires, and corrosion of the electrical connectors at the pylon electrical panel and in the sensor loops.[446] Initially, Lockheed's special proposal 1140-35 was designed to improve the cooling air flow on production aircraft. From this proposal TCTO 1C-141A-786 was issued to modify previously delivered aircraft. The problem, however, persisted and led to other ECPs. TCTO 1C-141A-896, the upshot of ECP 514, was then approved and authorized. It called for:

1. Relocation of the fire detection sensing element on the aft cowl door.
2. Installation of heat shields.
3. Application of corrosion deterrent on the aft cowl door to prevent chafing.

These changes were effective on production aircraft No. 5 and retrofit kit delivery was scheduled for February 1966.[447] Later, however, Aeronautical Systems Division directed AFLC to resubmit and revise

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446. Log D-20 Rpt, 31 Jul 65-30 Jun 66.
447. Log D-20 Rpt, 15 Nov 65, p 9.

the ECP by preparing a separate ECP for relocation of the sensing element and other changes. This new ECP, 550-31, was approved and made effective on production aircraft No. 73. Retrofit kits were not considered necessary.[448]

(U) However, even after Lockheed had instituted the recommended production improvements designed to correct malfunctions of the fire detection system, false indications of engine trouble continued to bedevil flight crews. At best, these indications were annoying; usually the trouble light came on unexpectedly and a horn blew as though announcing doomsday, prompting immediate action to discharge a fire extinguishing agent into the engine involved. If this did not turn off the light and the horn, the flight engineer pulled the cannon plug transmitter to disconnect the system. An emergency landing then had to be made at the nearest base, where maintenance personnel usually found that the wires had chafed, activating the system.[449]

(U) During 1967 the C-141 Operations Evaluation Staff (OES) at Travis AFB studied the problem and noted the fire detection system's faults: the wires broke, the fire warning loop and sensing elements chafed, clamps loosened, and moisture got into the system to create corrosion. The OES recommended that a better system be designed. WRAMA, on the other hand, was inclined to ascribe the malfunctions to improper installation or bad maintenance work.[450]

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448. Log D-20 Rpt, Dec 65 and Apr 66.
449. Msg, 61 MAWg to MAC/IG, et al., subj: MAC Acft Incident, 240020Z Sep 68.
450. OES/LTF Rpt, May 67, pp 22, 73-75.

(U) As a result, the problem lingered throughout 1968 and 1969. During the latter year, however, another study of the problem was conducted by HQ MAC. It was determined that improper maintenance caused 80 percent of the incidents, while corrosion caused by moisture in the sensing elements was responsible for the other 20 percent. In September 1969, WRAMA proposed an improvement by again relocating the sensing elements and using a watertight, corrosion resistant sensor connector for the fire detection system. Meanwhile, HQ MAC directed that a more effective maintenance effort be made, noting that "inspection and instructions are adequately covered in the existing handbooks."[451] When in October 1969 the MAC commander ordered a full review of the fire warning system of all MAC aircraft, the problem had become more or less academic.[452]

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451. Hist Rpt, MAC DCS/Mat, subj: C-141 Overheat and Fire Warning, circa Sep 69, Sup Doc V-103 of hist, MAC, 1 Jul 68-30 Jun 69.
452. Rpt, MAC DCS/Compt to MAC Staff, subj: MAC Management Review Items and Staff Reminders, 6 Oct 69, p 4.

"It was the first time we really had an airplane that had all the thrust and power that it required. In fact, it probably was a little bit excessive if you compare it with older airplanes . . . "[453]

PROPULSION SYSTEM

THE TF33-P7 ENGINE

(U) The engine chosen to propel the US strategic airlift force finally into the jet age was described in August 1963 as "the nation's most powerful turbofan."[454] With its 21,000-pound thrust the TF33-P7 clearly had no equal at the time and made possible a unique transport aircraft in the C-141. By the time the Military Air Transport Service had acquired a new name on 1 January 1966 as the Military Airlift Command it had also acquired a new image as a vigorous and progressive command.

(U) It eventually became apparent that the most remarkable thing about the C-141's wonderful turbofan was not its tremendous

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453. Spillers Intvw, p 9.
454. News Release, Pratt & Whitney Aircraft, "The TF33-P7, Powerplant for the C-141," 22 Aug 63, Sup Doc III-85.

power but its durability. An engine growth program to determine its maximum time between overhauls (TBO) resulted in extension after extension of its service life, to the increasing amazement of all concerned. Never had a military aircraft engine shown such endurance. Naturally, a number of "bugs" had to be ironed out in the process of defining the limits of the engine's capabilities, but this did not pose any insurmountable difficulties. The lengthened intervals between maintenance also entailed some support problems which, however, were readily resolved. A significant innovation induced by the TF33-P7 was the vertical JEFM (jet engine field maintenance) concept; before that the only vertical jet engine maintenance had been those accomplished in depots and commercial facilites.

Costs

(U) A total of 1,468 TF33-P7 engines were bought from Pratt and Whitney Aircraft in East Hartford, Connecticut (a division of United Aircraft Corporation), at a unit acquisition cost of $266,336 or $390,981,284 for the whole quantity. Of these, 1,136 were to be installed on 284 C-141 aircraft and 332 set aside as spare engines: 11 for the training squadrons; 196 for 14 MAC flying squadrons (14 engines per squadron); 12 for AFSC, IRAN, and special projects; 106 for repair and depot stock, and seven for ATC. Other than the number for the training squadrons, the spare engines actually deployed varied from allocation figures as follows: 258 for MAC; five for

AFSC, IRAN, and special projects; 58 for repair and depot stock, and three for ATC. In March 1971 the engine inventory showed 1,120 installed with 335 spares.[455]

(U) A series of provisioning conferences were held to determine TF33-P7 support requirements. The first was at Pratt and Whitney Aircraft on 9-27 July 1962. The scope of this meeting covered the full range of parts and accessories with 5,827 items reviewed, of which 3,769 worth $1,402,525 were procured for FY 1962 and 2,451 worth $1,499,432 were procured for FY 1963. The second conference, held at SAAMA on 3-8 March 1963, afforded a supplemental review of peculiar items only; 247 of 502 items reviewed were procured for $33,583. The third and fourth conferences, held 28 January-20 February 1964 and 7-23 September 1966, both at Pratt and Whitney Aircraft, were follow-on provisioning conferences for a complete review of factors, usage data, source codes, procurement actions, and update of records. Procurement for FY 1964 onward totalled $5,661,720 for that fiscal year, $664,000 for FY 1965, $112,470 for FY 1966, and $156,826 for FY 1967. Follow-on provisioning procurement amounted to $664,326 for FY 1964, $1,933,913 for FY 1965, $5,895,186 for FY 1966, $9,675,000 for FY 1967 and $8,100,000 for FY 1968. Provisioning costs through February 1968 totalled $35,635,513, leaving a procurement balance of $6,324,280 for the remainder of FY 1968. In

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455. Briefing, OCAMA, subj: TF33 Series Engines, 31 Mar 71.

addition, modification costs for FY 1964 through FY 1968, involving 24 TCTOs, amounted to $1,337,268.

(U) In August 1964, Aeronautical Systems Division reported as a "significant event" a price increase of $16,351 per TF33-P7 engine as a result of negotiations with Pratt and Whitney for a "price redetermination for engines." The price increase required Department of Defense approval.[456] On 18 May 1965 Pratt and Whitney representatives visited the C-141 System Project Officer (SPO) to advise the latter "informally" that the TF33-P7's thrust could be increased to 22,500 pounds. It meant an engine weight increase of approximately 300 pounds and an estimated cost of $2 million for 1965, $5 million for 1966 and $7 million for 1967. It raised the question of interchangeability of engines. The fact that the C-141 had been designed on the basis of the TF33-P7 as a 21,000-pound thrust engine also held significant implications.[457]

(U) At the time, however, TF33-P7 engine growth in terms of thrust increase, with its attendant weight and cost increases, appeared farthest from the minds of those responsible for its procurement and utilization. The main concern then was meeting the immediate airlift needs of an escalated Southeast Asia conflict in which the C-141 was predestined to play a vital support role. Rather than expend additional time and resources on a more powerful engine, the focus

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456. C-141 Mgt Sum, 14 Aug 64.
457. Ltr, MAC to EASTAF, et al., subj: C-141 Status Report for Month of May, 2 Jul 65.

was placed on getting the most out of what was already available. From this effort evolved a more relevant engine growth program, one involving the extension of the TF33-P7's service life. As it turned out, the TF33-P7 proved to be one of the most durable and reliable jet engines ever made.

ENGINE GROWTH PROGRAM

(U) The goal of the TF33-P7 engine life growth program was to "establish optimum maximum engine service life based on operational experience and analytical TDR inspections." The service life of an engine was its maximum time between overhaul, with a reconditioning cycle at midpoint. The longer the TBO, the more useful an engine. The initial TBO for the TF33-P7 was set at 2400 hours in 1964. Its engine life growth might be summarized by the following authorized maximum TBO progressions:

FY 4/64	FY 1/66	FY 4/67	FY 2/68	FY 2/69	FY 2/70
2400	3200	4000	4800	6000	8000

As each subsequent analytical teardown deficiency report (TDR) showed favorable findings, the TBOs were advanced at first by increments of 800 hours and then more confidently by as much as 2000 hours. The program was expected to extend through calendar year 1973.[458] By then an ultimate progression to 12,000 hours between overhauls was anticipated.[459] The interval between the first and second engine

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458. Briefing, OCAMA, subj: Logistic Support Briefing--TF33 Series Engines, 31 Mar 71.
459. Briefing, MAC/OCAMA Commanders Conference, 13 Apr 71.

growth milestones was not as long as the interval between the second and the third; however, the next milestone, the last 800-hour extension, was the shortest. After that, the 2000-hour extensions came at regular intervals, indicating that the program had reached a degree of stability.

(U) The first engine to reach an extended reconditioning cycle of 2000 hours was disassembled and inspected at Travis AFB on 4-5 May 1966 and found to be in excellent condition with no adverse effects of the extended cycle, and official approval of the extended reconditioning cycle was anticipated.[460] Authority to operate six Lead-the-Force (LTF) engines to 4000 hours was not granted until January 1967, after teardown findings had shown that the engine could operate beyond the 3200 hours prescribed at the time. Formal extension of the TBO to 4000 hours occurred a few months later. MAC stressed the importance of minimizing "overhaul pipeline status" to realize the "maximum benefits from the increased operating time and teardown report findings."[461]

(U) With the maximum TBO at 4000 hours MAC lost no time authorizing its extension to 4800 hours on seven engines. Upon reaching 4800 hours the engines were to be shipped immediately to the overhaul facility for "expeditious" analytical inspection. The Operational

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460. Daily Activity Report, MAC DCS/Mat, subj: Extended Reconditioning Cycle, TF33-P7 Engine (C-141A Aircraft), 6 May 66.
461. OES/LTF Rpt, Jan 67, p 28.

Evaluation Staff proposed that the engines be service tested in LTF aircraft equipped with performance recorders. At this stage of the program the objective was a maximum service life of 6000-8000 hours, provided the performance "remained satisfactory."[462] Another OES proposal was the reduction or deletion of separate hot section inspections for C-141 engines. An analysis of jet engine maintenance man-hours during a nine-month period showed that 31.5 percent were devoted to hot section inspections. Since only "minor" discrepancies--i.e., those not detrimental to continued engine operation--had been noted during these inspections, the effort was considered nonproductive and unnecessary. Moreover, degradation of engine condition could be readily detected in the engine performance before reaching serious proportions. As proof of this, commercial users were operating equivalent engines up to 8000 hours without inspection.[463] Separate hot section inspections were subsequently discontinued and made a part of the general reconditioning inspection.

(U) The TF33-P7's performance remained outstanding and by August 1968 a total of 28 test engines had designated maximum TBOs of from 6000 to 10,000 hours. A joint MAC/SAAMA team was constituted to conduct special reconditioning inspections when the engines were halfway to their overhaul date.[464] By this time the engine growth program had clearly outgrown the confines of the LTF engine program

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462. OES/LTF Rpt, May 67, p 21.
463. Ibid.
464. MED/LTF Rpt, Aug 68, p 17.

and the latter was reported a month later to have been discontinued in favor of the former.[465] (The high flying and landing phase of the LTF program was reaching its projected two-year lead; and the LTF program was reported terminated in October 1968, although the LTF aircraft continued to be monitored to maintain their two-year lead.) By November two 6000-hour and three 8000-hour engines had reached their goals and were scheduled for teardown inspection at OCAMA, the specialized repair activity (SRA), where the "viewing" by representatives from SAAMA and MAC was set for 20 January 1969;[466] when MAC and SAAMA representatives got together at Kelly AFB on 18 March 1969, the authorized maximum TBO was increased from 4800 to 6000 hours.[467]

(U) The engine growth program also grew. By March 1969 it had expanded to include the operation of 120 test engines beyond the 6000 hour TBO authorization: 60 were marked for overhaul at 8000 hours and reconditioning at 4000 hours; the other 60 were marked for overhaul at 12,000 hours and reconditioning at 4000 and 8000 hours.[468] On 8 August 1969 MAC advised its units to extend the 3000-hour hot section inspection to 4000 hours, the training wing to conduct it in accordance with TO 1C-141A-6WC-2PE and all other units per TO 1C-141A-6WC-3PE.[469]

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465. MED/LTF Rpt, Sep 68, p 1.
466. C-141/MED Rpt, Nov 68, p 4.
467. Background Paper, MAC DCS/Mat, subj: TF33-P7 Engine Support (C-141 Aircraft), 7 Oct 71.
468. C-141/MED Rpt, Mar 69, p 1.
469. Msg, MAC DCS/Mat to 21AF, et al., subj: TF33-P7 Engine Inspection Interval, 082257Z Aug 69, Sup Doc III-86.

(U) Just when everything seemed to be going great, the engine overhaul program ran into difficulties. The forecasted SRA output for FY 1970 was 50 engines per month, but only 31 engines were overhauled during the first month of this fiscal year. The shortage of 19 engines was attributed mainly to "lack of logistic support." MAC was afraid it would be "without sufficient spare engines to continue our high standard of mission capability" if the situation continued to deteriorate. There appeared little hope for improved support but there was no question that the reduced SRA output would have to be balanced by a reduced input. A solution to the problem was seen in a 20 percent (1200-hour) overfly of the 6000-hour TBO. MAC noted that "TBO increases must be attained through systematic steps based on results of analytical teardown inspections and continued engine reliability." With over 6,000,000 operating hours and a depot removal rate of only .032 engines per thousand, the TF33-P7 was "capable of safe reliable operation with a TBO of 12,000 hours." On 15 August 1969 MAC told OCAMA (who besides being the TF33-P7 SRA also replaced SAAMA as the AFLC engine item manager in June 1969) that a 20 percent overfly would "alleviate" the problem caused by "engine shortage at SRA." The overfly would be applied to only 50 percent of engines reaching 6000 hours; for each 6000-hour engine shipped to the SRA for overhaul one would be operated to 7200 hours.[470]

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470. Msg, MAC DCS/Mat to OCAMA, subj: TF33-P7 TBO Interval, 151705Z Aug 69, Sup Doc III-87.

(U) A MAC background paper dated 7 October 1969 credited the engine growth program with successfully achieving "periodic decreases in depot production requirements." During May-July 1969 MAC's scheduled overhaul removals had exceeded OCAMA's production capability. An optimum depot production was necessary to maintain required levels. MAC's spare engine "asset position" on 5 August 1969 was 78 percent of the objective. On 25 August OCAMA agreed to the 20 percent TBO overfly, and by 1 October 1969 the SRA production had improved to a point where all but six of MAC's current spare engine authorizations were either on hand or en route to C-141 bases.[471]

(U) By the end of the month the engine growth program boasted 130 engines plus five alternates: 65 at 8000 hours, three at 9000 hours, four at 10,000 hours, another four at 11,000 hours, and 59 at 12,000 hours. OCAMA noted that available data on engines reconditioned at 4000 hours showed no "appreciable increase or decrease" in the demand for parts replaced at 3000 hours "for which support was previously initiated." This encouraging sign inspired OCAMA to anticipate "recommending a TBO of 8000 hours" for consideration by the Aerospace Engine Life Expectancy Committee, the official approving body on matters pertaining to aircraft engines used by the Armed Forces, during its meeting in December 1969. (Composed of representatives from the major commands and other interested agencies in

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471. Background Paper, MAC DCS/Mat, subj: TF33-P7 Engine Support (C-141 Aircraft), 7 Oct 69.

the government, the committee had consented to MAC's latest requested TBO increase, from 4800 to 6000 hours, in March 1969.) OCAMA anticipations relative to its 8000-hour engine TBO recommendation were that the increase would "not adversely affect parts support posture" and "conversely reduced overhaul generations" would "offset added JEBM demands."[472]

(U) With the approval of the 8000-hour TBO as recommended, the 20 percent overfly requirement ceased to be a requirement. In issuing instructions to implement the change, MAC advised C-141 units:[473]

> Your management efforts toward reducing peak time change period and to insure a continuous flow of engines to SRA are necessary. This action is to insure that required spare engine resources are maintained and the maximum utilization of jet engine base maintenance capabilities are realized.

Monitoring of the 8000-hour engines "within Service Test 258" (the engine growth program), however, was continued until 12 June 1970.[474]

(U) OCAMA's optimistic prognostications notwithstanding, the overhaul program continued to have a hard time keeping abreast of the engine growth program. The 8000-hour TBO had brought but temporary relief to the sorely pressed overhaul program. On 1 April 1970 OCAMA informed MAC that an unprecedented number of C-141 engines

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472. Msg, OCAMA to AFLC, info MAC, subj: TF33-P7 Parts Support of TBO Growth Program, 311636Z Oct 69.
473. Msg, MAC DCS/Mat to 21AF, et al., subj: TF33P7 Time Between Overhaul (TB) Interval, 172116Z Dec 69, Sup Doc III-88.
474. Msg, MAC DCS/Mat to 21AF, et al., subj: TF33-P7 TBO Growth Program MAC Service Test 258, 122144Z Jun 70, Sup Doc III-89.

would reach 8000 hours during FY 1971 which, combined with normal usage removals, would require a considerable increase in overhaul production. Needed was MAC's plan for accomplishing removals and projected "monthly need" schedule to assist OCAMA in overhaul scheduling and in preventing any deterioration of support.[475]

(U) MAC explained that its projected engine removals were based on "aircraft flying program and actuarial engine removal tables furnished by AFLC." While engine removals were projected on a command-wide basis, the programming of scheduled removals at each base was accomplished locally in accordance with established aircraft inspection intervals and the existing workload to allow an even flow of engines through the shops. When 1969 ended, 330 engines had 4800 or more hours and therefore, except for those in the engine growth program, required removal in 1970. MAC assured OCAMA that upon receipt of actuarial tables based on 8000 hours maximum time, engine removal projections would be recomputed accordingly.[476]

Life Limiting Factors

(U) An increased maximum TBO was attained during October 1969 through September 1970 despite the increasing number of components that were beginning to fail. OCAMA reported to AFLC that "failures

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475. Msg, OCAMA to MAC, subj: TF33-P7 Engines (C-141 Acft), 011739Z Apr 70, Sup Doc III-90.
476. Msg, MAC DCS/Mat to OCAMA, subj: TF33-P7 Engines (C-141 Acft), 071749Z Apr 70, Sup Doc III-91.

in first stage fan and turbine blades and numbers one and three bearings have been limiting factors to higher time between overhaul." The low cycle fatigue limits applied to the compressor and turbine disk also restricted engine growth. OCAMA urged that greater emphasis be placed on the Product Support Program (PSP) and organic engineering programs to improve the durability of "life-limited" components. Improved first stage turbine blades were procured through ECP 265178. Meanwhile, selected engines were earmarked for operation beyond the current maximum time, and surveillance was maintained with intermediate inspections at 4000-hour intervals to determine whether further extensions were feasible.[477]

(U) Combustion chamber outlet ducts joined the list of problem parts the following month. Due to the growing number of components that were "life limited by materials and/or operating environment," no further extension of the TBO beyond the set goal of 12,000 hours was envisioned for the "immediate future." During a visit to OCAMA in November 1970 the MAC commander was briefed about actions taken to introduce improved components into the system which had been procured for installation on an attrition basis.[478]

(U) By March 1971 the TF33-P7 engine had accumulated over 10 million operating hours. One of the best premature removal rates

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477. Ltr, OCAMA to AFLC, subj: Logistics Performance Measurement and Evaluation System (LPMES), 28 Oct 70.

478. Discussion Item, OCAMA for MAC Commander's Visit, 20 Nov 1970, subj: TF33-P7 Engine Life Growth Program, 19 Nov 70.

in the Air Force--.26 premature removals per thousand operating hours--a rate maintained while operating at the highest TBO (8000 hours) of any military engine, demonstrated beyond question the TF33-P7's superior reliability. Attainment of a 12,000-hour TBO was anticipated by mid-1973, although teardown analysis of 9000-10,000 hour engines revealed deficiencies in carbon seals, transition ducts, and first stage turbine wheel blades, which could cause a "slippage" in projected TBO increase. Fixes had been developed to resolve these deficiencies, but austere funding, manufacturing leadtime, and the time required for retrofit made an across-the-board TBO increase by FY 1973 somewhat doubtful. Once the fixes had been incorporated, the engines could have their TBO extended to 12,000 hours.[479]

Number Three Bearing Carbon Seals

(U) As early as 1966, number three bearing carbon seals were replaced during "hot section" or reconditioning inspections which at that time came after 2000 hours. The hot section figured prominently as a maintenance man-hour consumer and was then the most critical component being monitored under the LTF program.[480] The previous year, 13 engines had been removed for high oil consumption. Teardown analysis indicated number three bearing seal failure resulting from excessive wear of the carbon seal surface. Although all bearing

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479. Briefing, MAC/OCAMA Commanders' Conference, 13 Apr 71.
480. OES/LTF Rpt, Jun-Jul 66, pp 8, 13; Aug 66, p 3.

compartments on the TF33-P7 engine had carbon seals, the number three area was the only one which had indicated a problem.[481] Preliminary investigation by Pratt and Whitney identified as the most probable cause of seal failure the titanate additives in MIL-L-7808E oils (Sinclair 1032, Hatco 611-17B, and Royal 11B).[482] Within three weeks TO 43B2-1-617, which identified and condemned the oils containing titanate additives, was in the process of being published.[483] Subsequent findings of a more thorough investigation by Pratt and Whitney and a SAAMA "Quick Fix" team confirmed the earlier indictment against 7808 oils containing titanate additives, which included the oil used by Lockheed. Most early installed engines were therefore affected. It was not considered appropriate to improve the seal, so steps were taken to remove the condemned oils from Air Force stocks and C-141 engines. Procedures were developed for flushing and reservicing engines and determining carbon seal condition.[484]

First Stage Fan Blades

(U) The first known failure of the TF33-P7's first stage fan blades was noted in November 1964. Investigations showed no correlation

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481. Memo, MAC DCS/Mat (Dir of Maint Eng to DCS), subj: Failure of Nr 3 Bearing Carbon Seal--TF33-P7 Engine C-141 Aircraft, 28 Jan 65, Sup Doc III-92.
482. Ltr, MAC DCS/Mat (Dir of Maint Eng to DCS), subj: Trip Report, Pratt & Whitney Aircraft, East Hartford, Connecticut, 13 Jan 65, Sup Doc III-93.
483. Memo, MAC DCS/Mat (Dir of Maint Eng to DCS), subj: HiBreather Pressure, TF33-P7 Engines, C-141 Aircraft, 6 Jan 65, Sup Doc III-94.
484. Ltr, MAC DCS/Mat to DCS/Ops, subj: High Engine Oil Consumption, C-141 Aircraft, 29 Mar 65, Sup Doc III-95.

between operating time, operating condition, or environment and fan blade failure. In September 1967 Pratt and Whitney assigned a high priority to the failures; however, it was not until a year later, in September 1968, that the vendor indicated a forging defect as a possible contributing factor. Defects were detected by the Zyglo process and confirmed by ultrasonic inspection. A one-time ultrasonic inspection of fan blades was issued the following month. However, the ultrasonic inspection was found to be "totally unreliable" and was held in abeyance until it could be improved. Another year passed before this was done with the release to the field on 30 September 1969 of a revision to TCTO 2J-TF33-628.[485]

(U) Due to differences in design and application, engineering authorization for weld repair of the TF33-P7 engine blades was not included in an engineering change permitting weld repair of the leading edge of TF33-P3, P5, P9, and P11 engine blades. Since engineering approval for weld repair of the TF33-P7 engine blades was made contingent on the results of an instrumented flight test proposed by Pratt and Whitney to identify the cause of blade failure, blades held for weld repair were discounted as reparable assets so that replacement blades could be procured. By October 1969 a total of 18 fan blade failures had been recorded, but six of these had occurred since the preceding July.[486] The increasing failure trend was considered

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485. Background Paper, MAC DCS/Mat, subj: First Stage Fan Blade Failure, TF33-P7 Engines, C-141 Aircraft, 21 Oct 69.

486. Memo, OCAMA TF33 Engine Unit, subj: Status of EB Weld Repair for TF33 Engine Fan Blades, 3 Oct 69.

serious enough to warrant a conference at OCAMA on 14 April 1970 to review proposals for resolving the problem. Pratt and Whitney insisted on a flight test to determine the cause of failure on the ground that the ground test being conducted was unrealistic. The conference recommended: a review of the existing ultrasonic inspection method used, glass bead peening of the fan blades as soon as possible, a flight test program, and immediate engineering efforts towards a redesigned blade. The last recommendation was expected to incur a two-year leadtime.[487]

Primary Exhaust Nozzles

(U) Primary exhaust nozzle problems were encountered early in the C-141 program. The first failure was reported in October 1965. By August 1966 the C-141 Operations Evaluation Staff could refer to an "improved" nozzle that was being installed on an attrition basis.[488] Force retrofit was completed in 1967, and for a while it looked as though exhaust nozzle trouble had become a thing of the past. Service reliability remained reassuringly high until approximately 4000 hours operational time had been accumulated, then a dramatic decline of the component's MTBF took place--from 41,078 hours in June 1968 to 3,885 hours in July 1969. The number of failures

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487. Ltr, MAC DCS/Mat (Weapon Systems Div to Dir of Maint Eng), subj: Trip Report--OCAMA, Tinker AFB, Oklahoma, 15 Apr 70, Sup Doc III-96.

488. OES/LTF Rpt, Aug 66, p 12.

shot up from 31 during January through June 1968 to 389 in the first six months of 1969. With no new nozzles coming in, MAC's serviceable assets position became "extremely critical" in October of that year. Sixty-eight nozzles were placed on order and 341 more were contracted from the manufacturer, but until new nozzles arrived the total Air Force support would come from base and depot repair outputs. Fifty-two reparable nozzles were on hand at the SRA, but from these no more than a 15-20 percent recovery was expected, or ten nozzles at best. All MAC units were advised of the need for extraordinary efforts to repair nozzles at base level. Nozzles that could not be repaired at base level were to be shipped to the SRA by priority transportation; these included those nozzles that had been condemned and placed in the redistribution and marketing activity for disposal.[489] There was to be no condemnation of nozzles at unit level "until further notice."[490]

(U) One irony of the exhaust nozzle crisis was that it came not long after WRAMA, the Inventory Manager, had assured MAC that sufficient quantities of nozzle components were being procured to support the C-141 program. MAC at the time was beginning to worry over cracks which WRAMA said nozzles could have so long as they did not grow and were repaired no later than the next isochronal inspection.[491]

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489. Msg, MAC DCS/Mat to 21AF, et al., subj: Primary Exhaust Nozzles Applicable TF33-P7 Engine C-141 Aircraft, 142201Z Oct 69.
490. Msg, MAC DCS/Mat to 21AF and 22AF (from Cruikshank for Kelly and Fredrickson), subj: Primary Exhaust Nozzles TF33-P7 Engine, 151805Z Oct 69, Sup Doc III-97.
491. C-141/MED Rpt, May 69, p 19.

(U) The primary exhaust nozzle consisted of a honeycombed material sandwiched between two sheets of metal. The sheet that was directly exposed to the exhaust heat was subject to cracking and delamination. Corrective actions taken included decreasing the size of the honeycombed core for added bonding strength and increasing the thickness of the silver-nickle brazing material to enhance its pliability, as well as replacing the honeycombed core material with a nonperforated type to preclude moisture and oxygen damage to the nozzle assembly. The welding and brazing of the honeycombed panels were accomplished in an inert atmosphere. WRAMA established the inspection interval for detection of nozzle delamination at each preflight and minor/major isochronal inspection and provided instructions for repairing minor cracks and delamination. MAC considered these interim efforts "band-aid" fixes and urged WRAMA to establish an hourly time replacement interval and increase procurement to support replacement requirements. The idea of a solid tailpipe, rejected during the early development stages due to overriding weight-saving considerations, was revived for the considerable increase in reliability that it entailed and the promise it offered of eliminating the hazard of aircraft damage caused by delamination. While recognizing the signal merits of the solid tailpipe proposal, WRAMA issued expanded inspection criteria to accommodate the new nozzles which began coming in three weeks earlier than the anticipated date of delivery. The

procurement program for 872 nozzles provided for a complete force retrofit within three years.[492]

Low Cycle Fatigue Problem

(U) In April 1969 MAC provided the following elucidation of the low cycle fatigue problem after observing that it was not receiving proper emphasis:

> An engine cycle is a measurement of low cycle fatigue which affects compressor and disk life. Low cycle fatigue is a phenomenon which can cause catastrophic damage if ignored. Each time the engine is started and accelerated to power, the disk is subjected to large centrifugal loads from the high rotational speed. At the same time, large thermal gradients can be imposed on the disk. Rims, relatively thin and exposed to the hot gas flow, heat rapidly and want to grow. Bores, thicker and sheltered from the hot gases, heat much more slowly and therefore grow slowly thermally. This causes high tensile stresses in the disk bore and web from the resulting tug of war. These thermal stresses combine with the centrifugal stresses. On shut-down and cool-off, the thermal fight reverses. Thus, with each lift-off, acceleration to power, shut-down and cool-off the disk experiences a large stress excursion from very high tensile to very low, or, in some cases, compressive stresses.

Accurate engine recordkeeping and cycle recording, MAC pointed out, was the key to managing a low cycle program and controlling it.[493]

(U) MAC took the position that the "accumulation of cycles/time" on components within the engine was the most significant factor in determining and controlling engine life, and relegated the conventional emphasis on accumulated operational hours to a secondary

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492. Background Paper, MAC DCS/Mat, subj: TF33-P7 Engine Primary Exhaust Nozzle (General), 12 Jan 70.
493. C-141/MED Rpt, Apr 69, p 17.

importance. It meant that an engine was as old as its oldest component. In this sense components controlled the operating life of the engines in which they were installed. An overhauled engine was considered to have zero time only if its components also had zero time. MAC sought to prevent such problems as those which developed when an engine supposedly having zero time from overhaul had components with previous operating time or components that had already exceeded their cycle/time limits. This misconception of engine operating life had caused MAC to experience mission degradation. Moreover, partial life engines incurred unprojected workloads at the SRA and in the field. Said MAC to OCAMA in July 1969:

> It is foreseeable that the present management of components could result in degradation of engine life to the extent that the engine will be returning to SRA at an unmanageable rate regardless of established maximum operational hours. At the present time it is estimated that 29 percent of all installed engines will require premature removals due to component cycle/hour limits. This percentage will increase as a larger percentage of new engines are processed through overhaul. . . .

MAC proposed the management of components removed from overhauled engines to assure that their reinstallation afforded maximum engine operational life, and stressed the need to reflect component cycle/time limits as a determining factor of engine life in all publications.[494]

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494. Msg, MAC DCS/Mat to OCAMA, subj: Updating TF33-P7 Engine Operational Life Criteria, 022045Z Jul 69, Sup Doc III-98.

(U) In response, OCAMA:

a. Noted that MAC's concept of engine component cycle/time management posed "numerous maintenance, supply and procurement implications."[495]

b. Issued a TO supplement to prevent installation of compressors or turbine disks at overhaul with less than 6000 hours or 2000 cycles remaining. Front hubs were replaced at overhaul regardless of cycle/hours. This action insured that overhauled engines would have compatible components for maximum operational life.[496]

c. Revised the spare parts procurement program to support an engine maintenance program based on cycles. (No TO revision to reflect engine component cycle limits was considered necessary as these could be deduced from the engine operating hours.)[497]

Rotation of Airlift and Training Engines

(U) MAC was particularly concerned with insuring the maximum utilization of both hours and cycle service life of the TF33-P7 engine prior to overhaul. In sharp contrast to the one cycle per three operating hours accumulated by engines assigned to the airlift wings, engines assigned to the training wing accumulated two cycles per operating hour (touch-and-go landings naturally generated more cycles),

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495. Ltr, OCAMA, subj: Updating TF33-P7 Engine Operational Life Criteria, 8 Jul 69, Sup Doc III-99.
496. Msg, OCAMA to MAC, subj: Updating TF33-P7 Engine Operational Life Criteria, 051754Z Aug 69, Sup Doc III-100.
497. Ibid.

curtailing engine life to 2750 maximum operating hours before overhaul. The increase of cycle limits to 7000 was verified in July 1969, more than ever underscoring the need to rotate high-cycle engines.[498] Procedures were developed at HQ MAC to prevent the recurrence of engine cycle problems at the training wing. To preclude premature return to overhaul, effective 1 September 1969 training engines with high cycles and low hours were to be exchanged on a one-for-one basis for airlift engines with low cycles and high time. Close scrutiny of engine historical data was required to insure that rotated engines did not degrade the gaining activity's mission capability. Engines shipped to the training wing were to have a minimum of 1800 hours and 3500 cycles remaining on the controlling components; engines shipped to the airlift wing, a minimum of 4000 hours and 1500 cycles remaining.[499]

VERTICAL JEFM CONCEPT

(U) Prior to the TF33-P7, MAC jet engines undergoing field maintenance took it lying down. The horizontal method was the old, accepted way entrenched by tradition and established habits. However, when the TF33-P7 arrived, its size, strength, and complexity aroused second thoughts about the continuing validity of the horizontal maintenance position in the field. After all, all USAF depots as well

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498. Msg, MAC DCS/Mat to 21AF, et al., subj: TF33-P7 Engine Rotation Program, 201351Z Aug 69, Sup Doc III-101.
499. Msg, MAC DCS/Mat to 443 MAWg, subj: TF33-P7 Low Cycle Fatigue Program, 141400Z Aug 69, Sup Doc III-102.

as commercial operators were using the vertical or standing position for major and minor repair of TF type engines. Delegates to a TF33-P7 engine handling conference at Wright-Patterson AFB, Ohio, on 29 April 1964 voted unanimously in favor of the vertical JEFM and arrived at the following conclusions:[500]

1. JEFM (minor and major repair of cold section) required an entirely different approach from horizontal buildup (QEC kit installation), teardown (QEC kit removal), and 1600-hour periodic inspection (hot section), which were completely acceptable and appropriate as such.

2. Accurate leveling of the engine on the air logistics horizontal stand was extremely difficult if not impossible.

3. This problem was compounded by the requirement for leveling for each engine installation. The removal and reinstallation of an engine on the test stand negated previous leveling.

4. Horizontal stands could not be reserved and maintained in one position while waiting for one specific engine to complete cold section vertical maintenance.

5. Obtaining accurate torque on internal and external components was relatively easy with the engine vertical and very difficult with the engine horizontal. There was equal distribution of weight with the engine vertical; the engine tended to droop in the center when horizontal.

6. The vertical position provided the "surest, fastest, most trouble-free, and reliable method for field maintenance activities."

In addition, it was generally acknowledged that vertical JEFM produced far superior results than did horizontal JEFM. For example, the monthly rejection rates for excessive vibration with horizontal

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500. Ltr, 1501 FMSq to MATS, subj: Vertical JEFM Concept, TF33-P7 Engine, 8 Jun 64, Sup Doc III-103.

JEFM was in excess of 40 percent; with vertical JEFM the rejection rate dropped down to less than 25 percent.[501]

(U) On 25 September 1964 the MATS DCS/Material asked his director of maintenance engineering how MATS stood vis-a-vis the vertical concept and received the following enlightenment:[502]

a. All tooling purchased was for the horizontal JEFM. However, shop equipment and special tools for horizontal JEFM were used at Travis for vertical JEFM.

b. The vertical position:

(1) Used less work area.

(2) During the installation of vital parts, was less conducive to misalignment of cases and damage to carbon seals and bearings.

(3) Was used by all airlines and depots.

(4) Was suitable for the size of jet engines being developed.

c. Work stands, dollies, and tooling procured for horizontal work would have to be used for "buildup of the QEC" and for hot section inspection; the vertical position would be used for JEFM only.

(U) The MATS DCS/Material on 23 November 1964 forwarded the vertical JEFM concept to SAAMA for approval, citing the foregoing

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501. Ibid.
502. Ltr, MATS DCS/Mat (Dir of Maint Eng to DCS), subj: JEFM for the -7 Engine, 11 Oct 64, Sup Doc III-104.

rationale and the information that vertical JEFM required no more training than was already being accomplished for horizontal JEFM.[503]

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503. Ltr, MATS DCS/Mat to SAAMA, subj: Vertical JEFM for TF33-P7 Engine, 23 Nov 64, Sup Doc III-105.

Chronology Items developed from:

1. MATS/MAC Chronologies, FY 1959-FY 1971.
2. MATS/MAC Histories, FY 1958-FY 1971.
3. Monthly Activities Reports, OES (MED)/LTF, 1965-1969.
4. C-141 Management Summaries, SPO, 1963-Feb 1968.
5. C-141A System Program History, ASD, August 1965.
6. Log-D-20 Reports, WRAMA, 1966-1971.
7. Various documents consulted in the writing of this study.

1956-1960	Airlift controversy.
1959	
16 Feb	MATS Qualitative Operational Requirement (QOR) for a medium-sized Logistic Aircraft Support System was submitted to USAF.
5 Mar	USAF letter to MATS noted MATS alternative to the USAF planned very large, long-range transport.
23 Mar	MATS rationale for a medium-sized transport was submitted to USAF.
1 Jun	USAF General Operational Requirement (GOR) for a medium-sized transport was published.
1 Dec	USAF Specific Operational Requirement (SOR) Proposal was submitted to Hq MATS for review.
31 Dec	MATS concurrence with the SOR Proposal was submitted to USAF.
1960	
4 Mar	General Lyman L. Lemnitzer and General Thomas D. White letter to TAC and USCONARC defined the Army's airlift needs. Later it became known as the White/Lemnitzer Agreement.
8 Mar-22 Apr	Hearings of the Subcommittee on National Military Airlift of the House of Representatives' Armed Forces Committee were held. Subcommittee was later known as the Rivers Committee.
11 Mar	Testimony of General William H. Tunner, MATS Commander, and MATS Presentation were given before the National Military Airlift Subcommittee.
14-28 Mar	Operation "BIG SLAM/PUERTO PINE" was conducted.
17 Mar	Major General Bruce K. Holloway (Air Force Director of Operational Requirements) gave testimony, concerning SOR 182, before the National Military Airlift Subcommittee.
28 Mar	Testimony of General Elwood R. Quesada, FAA Administrator, was given before the National Military Airlift Subcommittee.
1 Apr	Testimony of Stuart Tipton, President of the Air Transport Association was given, before the Nat'l Military Airlift Subcommittee.
20-21 Apr	General Tunner appeared for second time before National Military Airlift Subcommittee.

1960 (cont'd)

4 May	USAF issued Specific Operational Requirement (SOR) 182 for a cargo Transport Support System.
1 Jul	Public Law 86-601 was enacted by Congress. The law provided for $310,788,000 for the Air Force to develop, construct, procure and modify transport aircraft.
10 Aug	Development Plan was prepared by Hq Wright Air Development Division (WADD)/Aeronautical Systems Center (ASC) and included proposals for both turboprop and jet propulsion systems.
15 Aug	SOR 182-1, "Amendment to Specific Operational Requirement," was issued by Hq USAF.
23 Nov	Development Directive No. 415 was issued by Hq USAF.
28 Nov	Source Selection was directed by Hq USAF.
19 Dec	Amendment No. 415-1 to Development Directive was issued.
21 Dec	Statement of Work was prepared and Request for Proposal forwarded to eligible contractors: Boeing, Douglas, Convair, and Lockheed.
30 Dec	Contractors' query meeting was held with eligible contractors.

1961

31 Jan	Contractors' oral presentations were made to AF.
Jan-Mar	Source Selection Board, Working Group and Evaluation Teams were established and source recommendations made.
8 Feb	WRAMA was designated LSM (Logistics Support Manager) by Hq AMC.
13 Mar	White House made the winner announcement - Lockheed, Proposal No. ETP 250, Model No. GL-207-45, Super Hercules.
17 Mar	Type and model designation C-141 approved for System 476L by Hq Air Research and Development Command (ARDC) and Hq WADD.
21 Mar	Authority directed to initiate development of the C-141 (476L) System per acquisition directive PA 61AL-13 dated 16 Mar 61. System Package Program documentation to be accomplished as a complete package per AFR 375-1 and -4 series regulations.
22 Mar	WADD Operations Order No. 1-61 was issued delineating Systems Program Office (SPO) mission and manning requirements.
	System Program Office (SPO) was established.

27-29 Mar — Memorandum of Understanding between the Federal Aviation Agency (FAA) and AF was prepared.

1 Apr — C-141 Budget Estimate/Financial Plan was submitted to Hq USAF for FY 61 thru FY 66 -- $1.079 billion total program.

5 Apr — Engine, Turbofan, TF 33-P-7, Model designation was approved.

Contract AF33(600)-42941 bilaterally executed and released to Lockheed for fabircation of five RDT&E aircraft -- $29.9M obligated; $100,000 committed for spares and Aerospace Ground Equipment (AGE).

6 Apr — Civil Airline meeting with FAA and SPO was held regarding C-141 development.

10 Apr — Plan for preparation of System Package Program (SPP) was issued to all agencies.

27 Apr — Pratt & Whitney (P&W) proposal specification No. A-1783 for TF 33-P-7 engine was received.

10 May — AGE guidance meeting was held at Lockheed Aircraft Corp (GELAC).

15 May — Subcontract structure submitted to AFSC -- 61% AMPR, 44% dollars. Presentation also given at Hq USAF level.

16 May — P&W authorized go-ahead on JT3D-8A (TF33-P-7) engine based on Product Improvement Program.

Air Force Systems Command (AFSC) advised that the Structural Integrity Program would include static test; fatigue and dynamic response survey was included in contract program.

16 May — SPO Meeting with MATS rendered decision not to install automatic landing capability.

18 May — Decision was made to delete requirement for aerial refueling. Deletion of forward cargo door also confirmed.

25 May — 9G versus 16G seat configuration study resulted in disclosure that design strength of cargo floor is based on 20,000 lb axle load. Therefore, structure for 16G seats inherent in the design.

The possibility of lengthening the cargo compartment for increased capacity was unfavorably considered since such action would necessitate complete redesign and extensive additional wind tunnel testing with attendant increased costs.

1961 (cont'd)

5-10 Jun	First detailed review of model specification with MATS and FAA was conducted.
8 Jun	SPO requested three Mobile Training Units (MTU's) and three Flight Simulators be placed on WTD schedule.
9 Jun	C-141 proposed flight test program was prepared to include five aircraft. The first three production aircraft were selected for AF evaluation.
14 Jun	Subcontract "Make or Buy" Plan was approved by Hq USAF.
	Decision was made to include Reliability Program in Contract -- $2.6M added requirements.
21 Jun	MATS proposed Operational Plan dated 15 Jun 61 was received and distributed.
23 Jun	Maintainability Program approach was approved.
27 Jun	C-141 certification and program status, plus data relative to the Lockheed commercial version Model 300, was presented to the Administrator of FAA.
28 Jun	Master Scheduling conference held to firm test and initial production deliveries -- roll-out of first test article in Aug 63 with first flight in Dec 63.
	Decision made to utilize numerical control tooling during manufacture.
29 Jun	First detailed review of engine model spec with FAA was conducted.
11 Jul	PA 62AL-SC-2 issued citing FY 62 funds of $98M.
13 Jul	MATS Operational Plan approved by Hq USAF.
25 Jul	Initial Government Furnished Aerospace Equipment (GFAE) networks were processed into integrated PERT networks.
Jul	Amendment #1 to the contract was prepared to provide for structural integrity program to include a 100% design load limit, static test program, complete flight loads survey program, and a fatigue test program based on a life cycle of 30,000 flight hours and 12,000 landings.
1 Aug	Model Specification ER-6100M received from Contractor and SPO review begun.
	Lockheed Model Number changed from GL-207-45 to 300-50A-01.

3 Aug	Eglin test personnel advised of C-141A system requirements including need for climatic testing of the complete airplane during September, October, November 1964 and cold weather start tests for TF33-P-7 during November and December 1963.
9 Aug	"A" series designation approved by Hq USAF (C-141A-LM).
10 Aug	AGE Operations Plan received from Contractor for SPO review.
16 Aug	P&W made application for FAA Type Certification for TF33-P-7.
23 Aug	TF33-P-7 engine classified "Tentative Standard." (Form 81 and 81A)
25 Aug	Status classification of "development" approved for C-141A.
28 Aug	Extra crew compartment configuration approved by Hq USAF.
31 Aug	Impact study in support of approved MATS Operational Plan forwarded to Hq USAF.
8 Sep	Received USAF approval of automatic flight control system and weight and space provisions for automatic landing capability.
18-19 Sep	Detailed facilities and service requirements to support Contractor Category I tests at the Edwards AFB Air Force Flight Test Center (AFFTC) were provided in Lockheed ER 5482 for AFFTC approval.
20 Sep	Contractor AGE Maintenance Plan was submitted for review by SPO.
22 Sep	Engine production network processed into the PERT network.
25 Sep	Contractor authorized to instrument aircraft #6 as back-up for the #3 airloads aircraft.
26 Sep	Subcontractor selections announced by USAF -- Main Landing Gear, Bendix; Nose Landing Gear, Cleveland Pneumatic; Empennage, General Dynamics.
25 Oct	Tech Data Conference with contractor. Preliminary Tech Manuals required prior to first flight reduced from 16 to 4.
26 Oct	Development Engineering Inspection (DEI) conducted on general cockpit configuration and visibility.
28 Oct	Metal engine mock-up shipped from P&W to Rohr.
1 Nov	Staff study completed on Lockheed proposal for TF33-P-7 engine installation testing. Recommendations: (1) Contractor request for C-135 test bed aircraft be revised. (2) A dual engine test stand program be approved.

1961 (cont'd)

9 Nov	C-141A Military Construction Program for FY 63 was submitted to Hq USAF by Hq MATS.
10 Nov	Contractor proposed 43 changes in an effort to reduce the operating weight empty.
27 Nov	Contractor test program for contractual purposes submitted to SPO for approval.
Nov	USAF-directed program change required earlier delivery of first operational aircraft and a faster build-up to peak production rate.
4 Dec	Exhibit "E" to contact AF33(600)-42941 established requirements for Engineering Qualification Approval Procedures, Parts I & II.
11 Dec	ASD approved System Package Program following presentations to Generals Davis and Culbertson.
13-14 Dec	During conference at Edwards, AFFTC, MATS, ATC and SPO firmed up personnel requirements (115 maintenance and supply personnel) for MATS Support of category II testing.
15 Dec	Flight simulator specification received from Lockheed for SPO review.
20 Dec	Flutter model investigation begun at the Langley wind tunnel.
27 Dec	Source selection recommendations forwarded to Hq USAF on the wing box beam, automatic flight control system and an environmental system.
Dec	Airplane model specification approved, which became baseline configuration.

1962

4 Jan	Hq AFSC approval of the C-141A SPP received.
5 Jan	Integral fuel tank corrosion protection with FR 1560 polyurethane approved.
12 Jan	SOR 182-2 issued as amendment.
16-19 Jan	C-141A mock-up inspection conducted at Lockheed-Georgia Co, Marietta, Georgia. 127 Requests For Approval (RFAs) reviewed, with 98 approved for further action.
30 Jan	Alternate mission capability -- paratroop, life raft, litters, etc., approved.

Jan — Major subcontractors announced were: Wing Box Beam, Avco; Automatic Flight Control System, Eclipse-Pioneer; Aircraft Environmental System, AiResearch.

The Lockheed price proposal for definitizing Contract AF33(600)-42941 for five DT&E C-141A received.

1 Feb — Air Council review and approval of C-141A SPP. First formal approval ever given an ASD-managed SPP.

8 Feb — Provisions for automatic landing capability approved.

12 Feb — Formal negotiations on Contract AF33(600)-42941 began.

Feb — FAA review of the C-141 mock-up conducted at Lockheed. Eleven (11) major U.S. and foreign airlines reviewed the mock-up.

20 Mar — New MATS C-141A Operational Plan received.

Mar — Requests For Proposal (RFPs) for the first flight simulator issued to 78 prospective bidders.

A parametric evaluation of the airdrop capabilities of the C-141A received from Lockheed. The study evaluated the dropping in incremental loads up to 70,000 lbs including individual drops of 35,000 lbs.

23 Apr — Report prepared on all-weather airdrop capability.

25 Apr — Design Engineering Inspection (DEI) completed on wing front beam and empennage.

Apr — Contract AF33(600)-42941 negotiations completed on an FPIF with a firm target from outset. Target cost and target price negotiated at $132.5M and $143.1M respectively. Performance incentives on aircraft weight, payload-range, takeoff and landing distances included.

Twin Industries Corp., Buffalo, New York, selected as subcontractor for the wing trailing edge.

Recommendations to increase the scope of the fatigue test program submitted to AFSC. An additional $10M required if recommendation to double the test cycle was approved.

1962 (cont'd)

1 May	Memo of Agreement for configuration control prepared and approved between SPO and WRAMA.
2 May	RDT&E Contract AF33(600)=42941 definitizwd effective 2 May. Value Engineering program requirement established in Contract AF33(600)-43941.
4 May	FAA Preliminary Type Certification Board Meeting conducted.
7 May	Action completed on first AGE Figure 1.
	SPO Avionics Plan prepared.
8 May	Type II interior corrosion prevention approved.
9 May	DEI completed on engine/nacelle - Rohr.
18 May	Letter Contract AF33(657)-8835 issued for advance buy (16 aircraft).
21 May	Structural Design Criteria Report ER-5053 approved.
22 May	An impact study on a 337 aircraft program submitted to AFSC. The aircraft were to be delivered by 1st quarter FY 69 as opposed to 4th quarter FY 68 for the approved 252 aircraft program.
	An Executive Council Meeting was conducted at Lockheed, Marietta, Georgia.
23 May	DEI completed on outer wing panel.
29 May	Flight Control Design Criteria Report ER 5113 approved.
4 Jun	An impact study was submitted to AFSC on a proposed 287 aircraft program.
12 Jun	Study initiated to evaluate the capability of the C-141 to transport the SM-80 (Minuteman).
18 Jun	C-141A Flight Simulator Letter Contract AF33(657)-9523 awarded to Curtiss-Wright.
20 Jun	DEI completed on cargo floor.
	DEI completed on cockpit lighting.
25 Jun	Engine tests were started at Lockheed.
26 Jun	C-141A Mobile Training Unit Letter Contract AF33(657)-8957 awarded to Lockheed.

1962 (cont'd)

28 Jun	USAF/AFSC granted approval to double (2 cycle) fatigue test program.
	Approximately 50 GFAE peculiar items have been placed on contract in support of the C-141.
	Nine pieces of numerical control tooling were placed in the Lockheed plant. A total of 20 numerical control machines were planned.
30 Jun	Final action on all RFAs from mock-up inspection, except one, completed.
Jun	The last PERT analysis in June indicated the power package delivery was the most critical item. Possible eight week delay in roll-out of first aircraft. Corrective action was continuing. PERT networks consisted of over 6500 activities covering all aspects of the program. The PERT office developed a summarization technique to process the large amount of data without exceeding computer capacity limitations.
	Proposed Lockheed static, fatigue and flight test programs approved.
Jul	First XTF33-P-7 engine delivered to Lockheed.
3 Jul	FY 63 PA 63-ASD-1-C141 RDT&E #1 issued in the amount of $6M.
11 Jul	FY 63 PA 63-ASD-8-C141A #2, issued in the amount of $167.1M for production.
13 Jul	Main/nose landing gear DEI.
25 Jul	Auxiliary Power Unit (APU) DEI conducted.
28 Jul	First major structural assembly; i.e., nose landing gear, box housing completed.
Aug	Engine test time on Lockheed test stand was 28:27 hours.
Aug	Second reliability analysis of C-141A aircraft completed. Predicted reliability on 1 Aug was .82 for five hour mission.
7-8 Aug	Paratroop and Aerial Delivery System DEI. Fifty-three (53) RFAs submitted. A follow-up DEI was scheduled.
14-17 Aug	Technical Manuals for the C-141A established (C-141 Exhibit 1-1).
28-31 Aug	Definitive negotiations on the C-141A Flight Simulator Contract AF33(657)-9523 accomplished.

1962 (cont'd)

Sep	Removal of Verson Wheelon press under consideration at Hq USAF. Possible slippage in C-141A empennage schedule. Subsequently resolved with no program slippage.
5 Sep	Purchase Request for FY 63 buy of two flight simulators initiated.
10-14 Sep	Flight Simulator layout inspection.
12-14 Sep	AGE pre-guidance meeting at WRAMA established provisioning policy and technical guidance for initial provisioning for first 16 production aircraft.
18 Sep	SPO requested authorization and fund augmentation to undertake a C-141A/SM-80 compatibility study.
18-20 Sep	C-141A Technical Manual Verification Plan developed and published.
19-20 Sep	Airdrop demonstration at Ft Bragg was witnessed by SPO personnel.
24-28 Sep	Mobile Training Unit (MTU) -1 specification reviewed and approved.
Oct	Flight simulator performance incentive contract provisions were approved by Hq USAF.
	Transitional Training Unit (TTU) location changed to Tinker AFB.
	Second XTF33-P-7 engine delivered to Lockheed Test time on the first engine totaled 42 hours.
	Increase in P&W engine prices impacts budget.
Oct	Modifications underway to the Air Proving Grounds Center (APGC) Climatic Laboratory Engine Test Chambers and control room to accommodate C-141 engine environmental testing.
2 Nov	The MATS new Operations Plan submitted.
7 Nov	Aerospace Systems Division (ASD) included the FY 63 flight simulator procurement in the DOD Labor Surplus Area Procurement Program.
9 Nov	SPO and Lockheed authorized to proceed on C-141A/SM-80 study.
12-16 Nov	Conference at LGC to resolve terms and conditions of Letter Contract AF33(657)-8835.
27 Nov	TF33-P-7 engine climatic tests begun at Eglin AFB.

1962 (cont'd)

Dec	Assembly of fuselage sections underway. Major assembly components from subcontractors arrived at Lockheed.
11 Dec	Definitive contract for the initial flight simulator forwarded to Curtiss-Wright Corp. for signature.
13 Dec	FY 63 C-141A Flight Simulator Specification GS-141A-63 received from Lockheed.
20 Dec	Lockheed study and associated ECP for C-141A transport of SM-80 received in SPO and necessary evaluation and coordination began.
21 Dec	Environmental tests of the TF33-P-7 engine at Eglin AFB proved the necessity of adding a fuel enrichment device on all production engines for cold weather starting assistance. Engineering Change Proposal (ECP) approved to incorporate the change.
21 Dec	DOD approval received to contract for 127 C-141A flyaway aircraft using the multi-year contracting technique. (Included GFAE, spares and six flight simulators.)

1963

4 Jan	Completed study and prepared Program Change Proposal (PCP) to transport the SM-80 Minuteman in the C-141A.
11 Jan	Mating of the forward, mid and aft sections of the first fuselage occurred.
15 Jan	Completed price negotiations for the first C-141A MTU.
29 Jan	Completed the 150 hour engine endurance test.
8 Feb	Started Logistic Program to support Project "Dixie Belle" GFAE requirements on RDT&E aircraft.
15 Feb	The first wing box beam shipped from Avco.
20 Feb	Hq USAF was presented a Program Change Request (PCR) for incorporating the capability to transport the Minuteman in the C-141A.
1 Mar	The revised C-141 SPP was published and released.
6 Mar	A PCR to provide aircrew trainers for the TTU was forwarded to Hq AFSC for approval.
14 Mar	The #1 aircraft fuselage pressure tested by Lockheed.

1963 (cont'd)

18 Mar — Letter Contract issued for 127 C-141A aircraft utilizing multiple-year techniques.

The sea level low and high temperature starting and acceleration tests of the P&W TF33-P-7 engine were completed.

21 Mar — A PCR to update the flight test schedule was prepared and forwarded to Hq AFSC for approval.

26 Mar — Ceremonies at P&W resulted in the formal military qualification and FAA Type Certification of the TF33-P-7 engine.

28 Mar — The first production engines were delivered to Rohr for build-up and installation of cowling.

The first empennage for the static test vehicle received by LGC.

1 Apr — The wing and fuselage of the first aircraft were mated. Landing gear and cargo ramp assemblies were installed on schedule.

4 Apr — Hq USAF approved the PCR to transport the SM-80.

15 Apr — Completed pressure test of static article.

18 Apr — Established Central Management Engineering Depository at Lockheed (later changed to Lockheed Engineering Data Depository - LEDD) for reprocurement purposes.

25 Apr — Hq AFSC approved a follow-on reliability program.

26 Apr — Pesco delivered the first ship set of thrust reverser components (prop, filter, etc.) to Rohr.

May — Trailing edges and functional subsystems were installed in the #1 aircraft.

The first empennage was installed on the static test article.

The third fuselage was mated and pressure tested.

3 May — A firm fixed price definitive contract AF33(657)-10383 for six C-141A flight simulators was awarded to Link Division for a total amount of $6,989,613. This is the first Air Force negotiated definitive contract awarded utilizing the multi-year procurement technique.

6 May — The Corrosion Preventive Program to paint major assemblies on site was approved.

10 May — PCP #C-141A 63-2 "Alternate Program" portraying an increased C-141 force was submitted to Hq AFSC.

PCP #63-1 "Budget Revision" portraying three proposals was submitted to Hq AFSC.

Jun	Deutsche Lufthansa and the German Air Force queried LGC with respect to buying a C-141 during CY 1965.
3 Jun	LGC's proposed "Make or Buy" Program for multi-year procurement of MTUs was approved with 53% buy from three other vendors.
4-5 Jun	Type I (Factory) Training requirements in support of C-141A Cat II Test Program finalized for all commands at conference conducted at LGC.
13 Jun	C-141 upgraded to a designated system by Hq USAF.
20 Jun	Revised budget information for alternate mission equipment PCR submitted per guidance from Hq USAF.
25-27 Jun	Cargo compartment (installations) DEI completed.
15 Jul	Lockheed price proposal for 127 aircraft was received.
17 Jul	Static test article Aircraft #6000 was delivered to Engineering Research Lab.
27 Jul	Amendment #10 to the production contract AF33(657)-8835 included approval to fabricate four MTUs and one set of resident trainers.
5 Aug	Procurement data for the Auxiliary Power Unit (APU) was released.
14 Aug	The compatibility test procedure for the taped flight instruments was approved to assure that any potential vendors' equipments could be used in the C-141A aircraft.
22 Aug	Roll-out of the first C-141 occurred one week ahead of schedule.
28 Aug	The first C-141 aircraft was accepted by the AF on schedule.
31 Aug	The first peculiar and non-standard AGE list for Contract AF33 (657)-8835 was approved and released by ASD to LGC.
Sep	C-141A updating change requirements in accordance with AFSCM 375-1 have been approved and PA 64-ASD-32 authorized $8.2M for updating changes under funds account 1159-9000.
Sep	PA 64-ASD-33 was released for $150M, which was an increase of $35M over previous Procurement Authority (PA). The new PA authorized procurement in quantities to support the WA 63-3 production schedule.

Sep — A failure occurred in the static tests in the ramp door hinge area during the fuselage test to ultimate pressure on Aircraft #6000. Repairs were accomplished and adjustments to the schedule were made to permit continuation of testing of other phases of the static program. The pressure tests to ultimate were rescheduled to mid-October 1963.

20 Sep — Hq USAF message was received by ASD approving the PCR dated 21 Mar 63 for extension of C-141 test program.

24 Sep — AFSC message was received approving the intent of the PCR dated 1 Mar 63 for an aircrew trainer. Funds in the amount of $.5M will be included in the FY 65 C-141A program requirements to cover the acquisition of the aircrew trainer to support TTU at Tinker AFB.

27 Sep — ASD completed the fact finding portion of negotiations for the 127 aircraft multi-year buy.

Oct — C-141 Test Force met at El Centro Naval Air Field (NAF) to finalize plans for the Cat I airdrop program.

The C-141A Configuration Management Program progressed to the point of defining and approving the work statement for Exhibits II, III, IV and VIII of AFSCM 375-1 and ANA Bulletin 445. The LGC work statement was approved by SPO letter, 9 Oct 63. The firm cost proposal for the above work was received and was analyzed by the AF; however, contractual action was withheld pending funds release.

Oct — All of the GFAE spare parts required by Lockheed for C-141 Flight Test Program were on procurement. Deliveries started in Sep 63 and completion was anticipated by Apr 64.

4 Oct — Representatives of the C-141 SPO accomplished a facilities check of the Technical Training Center (ATC) at Sheppard AFB, Texas.

12 Oct — The failure in the pressure door and ramp area of the static aircraft was corrected. Also, Lockheed successfully concluded pressure testing on the static test aircraft to the ultimate pressure differential of 17.2 psi.

14 Oct — Two T-38 chase/pace aircraft were delivered to LGC from ATC. AFFTC pilots who delivered the aircraft conducted the required training and checkout of the LGC pilots.

The engine pressure ratio system was delivered to LGC. The transmitters and indicators passed LGC bench test and on 16 Oct 63 were released for installation on the first C-141 aircraft.

1963 (cont'd)

21 Oct — AF/FAA approved the LGC 2G taxi test procedure.

22 Oct — LGC presented to representatives from MATS, FAA and the SPO a proposed means of conducting an R&D program to improve the C-141A capability for lower approach minimums and automatic landing. FAA evaluated for type certification and compatibility with features developed by FAA. Other evaluations were made by MATS and the SPO.

23 Oct — Goodyear delivered a qualified brake assembly to LGC.

29 Oct — PA 63A-ASD-126 was received for $1.7M covering increased engine costs per Redline PRESTO TWX.

30 Oct — The Air Force accepted aircraft #2 Serial No. 61-2776 on an interim basis.

31 Oct — Competitive reprocurement resulted in a change of contractors for the C-141 engine pressure ratio system. Contract was awarded to AiResearch for the FY 64-65 multi-year procurement with Lear Siegler Co. as a subcontractor for the Engine Pressure Ratio (EPR) indicator. The FY 63 requirements for this system were procured from Minneapolis Honeywell with Eclipse Pioneer as the subcontractor.

11-22 Nov — A MATS, SPO and Lockheed team of nine personnel visited MATS Support Squadrons and other interested commands in the Pacific Theater to present status of the C-141/463L Systems and determine adequacy of base facilities in support of these programs. Clark, Kadena, Tachikawa and Elmendorf did not have sufficient ramp space and refueling hydrants in proper locations to support efficient C-141 turnaround. Operationally, the runway at Tachikawa was too short to support hot day conditions with maximum payload. MCP requirements had to be formalized by MATS.

12 Nov — The C-141 SPO received DOD Format "B" dated 17 Oct 63 which approved C-141 PCP 63-151 except for a reduction of $7.4M for ECO and $8.9M for configuration management and its related reporting system. FY 64 approved increase of $24.6M was subject to Congressional approval.

19 Nov — Contract AF33(657)-9523 with Curtiss-Wright Corp. for the C-141A-1 flight simulator was definitized and distributed.

Failure of the 998 main fuselage frame occurred during the conduct of the 2.0G taxi static load test.

1963 (cont'd)

3-4 Dec	Air Force approved the specification for fabrication of a set of C-141 resident trainers. Conference was conducted at LGC with personnel from ATC, OOAMA, ASD, LGC, and the LGC AFPRO in attendance.
5 Dec	Government Furnished Aerospace Equipment (GFAE) Aerospace Ground Equipment (AGE) for TF33-P-7 engine training for Chanute's FMO Maintenance Course ATS 43250-66 and Sheppard's -3 MTU were defined in a SPO-chaired Air Force/P&W Conference held at Weathersfield, Conn.
9 Dec	The corrosion prevention presentation requested by the DSMG was given to AFSC. The decision was made that insufficient data existed from a cost effectiveness standpoint. Therefore, briefings to higher headquarters were postponed. No dates were rescheduled.
9-13 Dec	Air Force acceptance of MTU-1 was accomplished at Lockheed Aircraft Services, Ontario, California.
16 Dec	MPR AS 4-92 issued to effect contractual coverage of TF33-P-7 engine training AGE.
17 Dec	The C-141A took off for first flight. It flew for 35 minutes and encountered no significant problems.
20 Dec	The AF accepted aircraft #4 Serial No. 61-2778 on an interim basis.
31 Dec	All preliminary aircraft Technical Orders were printed and distributed (on an as required basis) to AF activities for review and comment.
Dec	The Value Engineering clause for Contract AF33(657)-8835 was acceptable to LGC; however, contractor did not concur with value engineering hours being treated as indirect charges.

1964

7 Jan	C-141A flap control system fault analysis meeting conducted at Lockheed.
8 Jan	Qualification approval was granted for the C-141 Engine Pressure Ratio indicating system, A24J-33, supplied by the Minneapolis Honeywell Co.
10 Jan	The fuselage up-bending test, a part of the static test program, was completed.

23 Jan — A contract was awarded to REF Dynamics Corp. for the buffet-lavatory.

Feb — Squadron level AGE for engine instrument system, Central Air Data Computer (CADC) and Vertical Scale Flight Instrument (VSFI) system was identified to the contracting officer for procurement of FY 63 and 64 program requirements.

Flutter excitation equipment and additional instrumentation were installed in C-141 #1 test aircraft.

5 Feb — The first half of the field survey on corrosion control was completed. Information was needed to determine the advisability of using wet rivets on the C-141 in clad areas.

6 Feb — An official request to have WRAMA, the SSM, perform configuration status accounting was forwarded to Hq AFSC.

11 Feb — A team including personnel from Hq MATS, C-141 SPO, ASD Civil Engineers, WRAMA and Lockheed returned from inspecting facilities and presenting program status for C-141/463L at the following Atlantic Theater bases: Azores, Chateauroux, Orly Field, Rhein-Main, Wiesbaden, Torrejon, Mildenhall, Prestwick, Harmon, Goose Bay, Thule and Sondrestrom. The team found that most bases were in need of hangar or door modification to accept the high T-tail.

19 Feb — A conference was held at LGC to determine a method of improving the maintainability of the APU. The contractor was authorized to submit an ECP to reduce installation time.

21 Feb — The seventh major C-141 static test, designed to evaluate certain maneuver loads on the pressurized fuselage, successfully reached 150% of design limit load.

29 Feb — Flights 3 and 4 for the #1 C-141 aircraft totaled 4 hours and 11 minutes. An AFFTC pilot was aboard for the fourth flight, marking initial AF participation in the flight test program.

Mar — FY 63/64 funds were received by the C-141 SPO and PAs were released in support of the C-141A aircraft.

Librascope was having difficulty with environmental testing of ASN-24 digital computer equipment. ASD worked with Librascope engineers to assess the extent of difficulty and determine solutions to problem areas. Unqualified equipment was accepted and delivered to Lockheed for use in the C-141 test programs.

1964 (cont'd)

3-4 Mar — MTU production and preparation for FACI were reviewed at Reflectone Electronics Corp., Stamford, Conn. Relfectone fabricated 50% of the MTUs for Lockheed Air Services in accordance with the "Make or Buy" Program.

6 Mar — The P&W engine TF33-P-7 for the C-141 completed 12,210 hours of full scale testing, 100 hours using an RB-45 aircraft as the test bed and 114 1/2 hours in an RB-66. All testing was satisfactorily accomplished with no significant problems reported. Sixty-four (64) production engines were delivered to the Air Force.

The first flight of the #2 aircraft occurred and lasted for approximately one hour. This was the initial shake-down flight and no significant problems were encountered.

The cost effectiveness study prepared by the SPO to improve corrosion control by the use of wet fasteners was completed and handcarried to Hq AFSC. AFLC, MATS and RTD correspondence confirming their concurrence in the recommendation was forwarded on 19 Mar 64.

6-11 Mar — The #1 aircraft conducted three additional flights which marked the beginning of the flight flutter program. During these flights, the speed envelope of the aircraft was extended to 310 knots at 18,500 feet.

12 Mar — SPO met with Hq MATS Plans, R&D, Capability and Facilities personnel to review latest operational planning with respect to new base activation, etc. As a result of this meeting, Hq MATS proceeded to formalize a new operational plan in support of the latest Hq USAF "P" series programming documents.

13 Mar — A Memorandum of Understanding relative to the "Category II Test Aircraft" was agreed upon by the SPO and LGC regarding expedited procedures for incorporation of updating changes.

18 Mar — Amendment #15 to Letter Contract AF33(657)-8835 obligating $14.4M as a partial funding was released from distribution.

20 Mar — The #1 aircraft had flown eight missions for a total of 17 hours and 15 minutes. The #2 aircraft had flown three missions and logged 8 hours and 41 minutes.

23-24 Mar — Representatives from the C-141 SPO, Hq MATS, EASTAF and Middletown AMA attended a mock-up inspection of the buffet-lavatory at REF Dynamics Corp.

26 Mar — Hq USAF released a System Program Directive calling for an increased force of C-141's.

27 Mar — The ASD Commander and the SPD briefed officials at Hq AFSC and Hq USAF on the results of the negotiations with Lockheed for definitization of the 127 aircraft multi-year contract.

31 Mar — The #3 C-141 made its initial shake-down flight. The #1 aircraft flew to the Ft Bragg airdrop area where dummy drops were made through the emergency escape system.

Apr — AFSC approved the expenditure of $450,000 to buy new equipment to support fatigue testing at Lockheed.

Reliability requirements for the C-12 gyro compass were definitized and a 600 hour Mean Time Before Failure (MTBF) was negotiated for this equipment, with full reliability requirements and demonstrations thereto.

Slick Airways entered into a contract to procure four C-141A aircraft. The agreement was contingent upon government requirements for and the development of an extended fuselage version of the C-141.

Work was begun by the SPO to assist Hq AFLC in formulation of a machine program for Configuration Status Accounting. Initial data inputs for the status accounting system were provided to Hq AFLC.

Kollsman Instrument Co. was awarded a multi-year procurement contract for Vertical Scale Flight Instruments.

1 Apr — A contract for modification of Shaw-Eston engine test stand was released to Spence Corp. This modification was required to accommodate the TF33-P-7 engine.

The FAA, Atlanta, Ga., issued a Type Inspection Authorization (TIA) for the C-141, which permits FAA crews to join AF and Lockheed in flight testing the aircraft.

2 Apr — PA 64-ASD-93 reduced authorized funds for updating FY 64 program funds from $28.3M to $2.3M.

8 Apr — Hq AFSC and Hq AFLC made a formal agreement for WRAMA to machine-process C-141 configuration status accounting reports.

The first step of a two-step procurement for the aircrew trainer was released to industry.

1964 (cont'd)

14 Apr — AFSC PA for FY 64 Updating (OQTD) Funds was received by ASD.

15-17 Apr — The final airplane DEI on aircraft #5 was held at LGC.

15 Apr — The 127 aircraft multi-year contract was written.

17 Apr — Aircraft #6 made its first flight.

20 Apr — The first AFFTC test pilot assigned to the C-141 test program was checked out in the aircraft.

21 Apr — An Aircrew Trainer Bidders' Conference was held at ASD.

23-24 Apr — A follow-on mock-up inspection was held on the buffet-lavatory and final configuration was established.

24 Apr — The Cost Effectiveness Study for the incorporation of wet fasteners in all clad areas was approved, and the SPO was advised to incorporate wet fasteners in production aircraft as soon as possible.

May — Final strain surveys were completed on the first fatigue specimen C-141.

Initial airspeed calibration using pacer aircraft from ASD was conducted.

A simulation of approximately 500 flying hours accomplished in the cyclic testing of the main landing gear/center fuselage specimen.

Proposal received from LGC to implement Configuration Status Accounting on the C-141 Program.

The Flying Tiger Airline placed an order for eight commercial versions of the C-141. This order was contingent upon government requirements for an extended fuselage configuration.

The C-141 Technical Manual Management Group meeting with the Joint Test Force at AFFTC to better define TO verification procedure and responsibilities applicable to Category II testing.

The C-141 fatigue tests were resumed with the successful completion of the final pylon test and wing transient gust test to 150% of limit load.

1 May — Final order for Contractor Furnished Equipment (CFE) AGE FY 63/64 was released to Lockheed.

11 May — Information received to the effect that SMK-43 visual equipment (one each) was to be procured for one of the flight simulators.

15 May — Category II Test Plan was approved.

SPO was notified by Hq USAF that two East Coast operational bases were to be activated simultaneously and earlier than originally planned.

20 May — Cyclic testing began on the main landing specimen.

22 May — The SPO contracting officer and the contractor signed the multi-year definitive production contract for 127 C-141A aircraft.

25 May — DEI for the Curtiss-Wright flight simulator began at the contractor's facility.

26 May — Re-testing of the empennage with the beefed-up vertical fin for the overswing yaw condition was accomplished to 100% of design limit load.

A meeting was held to determine Type I depot-overhaul training courses required to support AFLC. Depot training will be conducted at the specialized repair activity (WRAMA).

27 May — Aircraft #6 was accepted by the Air Force.

29 May — The definitive contract for 127 aircraft was reviewed and manual approval accomplished at AFSC.

Jun — Facts analyzed during re-test of the overswing yaw condition to 100% of design limit load indicated that additional structural beef-up was required in the aft fuselage.

The C-141 reached maximum test dive Mach number M_D 875 and maximum dive velocity V_D of 410 KCAS at 20,000 feet altitude.

7 Jun — Aircraft #7 made its initial flight.

11 Jun — The vertical stabilizer was successfully static tested to 150% design limit load with the fuselage pressurized.

15 Jun — Aircraft #6, the first of Category II test aircraft, was delivered to AFFTC. This was the first cross country flight conducted.

1964 (cont'd)

24 Jun	Configuration Status Accounting was contractually covered with LGC.
2 Jul	Representatives from MATS, FAA and the SPO attended a demonstration of the C-141 jet blast rain removal system.
6 Jul	The equilibrium yaw, petal doors open condition was successfully completed to 150% of design limit load.
7 Jul	The first night flight on aircraft #5, AF Serial #61-2779, was successfully conducted at Edwards AFB.
8 Jul	Final assembly of aircraft #10, AF Serial #63-8079, was completed.
11 Jul	Curtiss-Wright Corp. began shipment of the flight simulator to Tinker AFB.
12 Jul	During the positive pitch entry test, the aft fuselage, at 120% of limit load (30% of ultimate), failed.
16 Jul	Aircraft #6, AF Serial #63-8075, while conducting a test mission, was flown to Scott AFB for static display to MATS Commanders and key staff personnel.
17 Jul	The aircraft flutter test program was completed, with the exception of the full flap investigation.
20 Jul	Air Force Acceptance Inspection of MTU-2 accomplished at Lockheed Air Services.
	Interim acceptance of aircraft #7, serial #63-8076, by Air Force.
23 Jul	Representatives from Hq USAF, MATS, WRAMA and the SPO attended a conference at Hq AFLC to review spare engine (TF33-P-7) requirements for the C-141A. It was agreed to retain 25% engine spares.
24 Jul	Interim acceptance of aircraft #8, AF Serial #63-8077, by AF.
27 Jul	The strain survey was begun on the nose gear, Specimen "E", in preparation for the beginning of cyclic testing.
28-29 Jul	The Facilities Inspection (FACI) was completed on MTU-2 and it established the baseline configuration for follow-on MTUs.
31 Jul	The total flight time on all test aircraft has exceeded 600 hours.

Aug — The SPO received a price proposal for the 18 additional aircraft from LGC, for which the SPO has FY 65 procurement authority.

Six technical proposals were received for the aircrew trainer.

The Curtiss-Wright flight simulator was delivered and installed at Tinker AFB.

3 Aug — The 23 trainer panels which comprise the -2 MTU were shipped to Tinker AFB.

The first 300 hour maintenance inspection was completed in the programmed span of time on aircraft #6, Serial #63-8075.

13 Aug — Final on-site engineering tests were completed on the Curtiss-Wright flight simulator, and it was conditionally accepted. Training of the initial MATS CADRE of instructor pilots and flight engineers was begun.

13 Aug — The wing negative accelerated roll test was satisfactorily completed to 150% of design limit.

Aug — The -2 Mobile Training Unit (MTU) was installed at Tinker AFB.

19 Aug — Aircraft #1, AF Serial #61-2775, was deployed to Edwards AFB for engine performance tests and airspeed calibrations.

24 Aug — A C-141 coordination meeting was held at Charleston AFB with representatives from MATS, AFLC, LGC, FAA and the SPO to discuss operational, logistic and training support requirements associated with C-141 squadron activation.

26 Aug — The SPO met with representatives from LGC, FAA, AFFTC and MATS and reviewed the pitch trim redesign proposed by the contractor. The contractor was told to proceed with the fix.

Contract terms and conditions conference on the 18 aircraft buy was completed.

27-28 Aug — A DEI was held at LGC on the rails, rollers, tie-downs, and associated cargo and aerial delivery equipment on the C-141.

28 Aug — Total flight time on test aircraft exceeded 800 hours.

Technical evaluation of the proposals for the aircrew trainer was completed.

1964 (cont'd)

31 Aug-1 Sep	Aircraft #5 made its first flight.
31 Aug-1 Sep	SPO, WRAMA and LGC personnel visited Hq MATS and Tinker AFB to review, brief and discuss activation of the 1707th ATW at Tinker AFB.
1 Sep	A "Provisioning Order" was issued for communications and electronics level AGE development for AN/ASN-24 (V).
8-9 Sep	Special flight test data submitted by LGC on the CADC during a coordination meeting with FAA, SPO, MATS, Eclipse-Pioneer and Rosemount Engineering Co. representatives were found adequate for final configuration.
10 Sep	The AF price pre-negotiation conference on 18 aircraft buy began.
11 Sep	The first fatigue test spectra on the nose landing gear and support structure was completed.
13 Sep	Aircraft #9 made a five hour first flight.
15 Sep	Aircraft #7 was put into the climatic hangar at APGC.
	Negotiations on Supplemental Agreement #17 (18 aircraft buy) began with LGC.
17-19 Sep	Alternate mission kits were demonstrated.
24 Sep	Representatives of the SPO and RTD met with LGC to investigate the steel rivet head corrosion found during AF inspection of aircraft #7. Corrective action was being taken to improve production and quality control techniques and procedures.
25 Sep	Total flight time on test aircraft exceeded 1127 hours.
1 Oct	Re-test of the positive checked pitch maneuver (entry) condition which had previously resulted in failure of the aft fuselage at 120% of limit load during static test was successfully conducted to 150% of limit load.
	DEI on the following C-141 alternate mission kits: paratroop, litter and maximum troop configurations was accomplished at Travis AFB and board review action on RFAs was completed.
7 Oct	Canadian Aviation Electronics Limited of Canada was awarded the contract for the development of one C-141A aircrew trainer.

12 Oct — Representatives of MATS, OOAMA, LGC and the SPO began an in-plant inspection of the first Link flight simulator.

16 Oct — The first buffet-lavatory unit was shipped to Tinker AFB for display during formal delivery of the first C-141 to MATS.

19 Oct — The first aircraft was delivered to the 1707th (TTU) ATW at Tinker AFB. Maj Gen Terhune, ASD Commander, turned the aircraft over to MATS Commander, General Estes. The aircraft, dubbed "The Spirit of Oklahoma City" was production aircraft number 9.

20-21 Oct — The SPO participated in IRAN planning conference at WRAMA.

21 Oct — A joint SPO, MATS, AFLC conference was held at Travis AFB to discuss all aspects of support for the Category III test squadron.

The production version of the revised pitch trip actuator system was flight tested in aircraft #1 with very satisfactory results. This flight also included a test of the revised yaw damper washout system with good results.

20-23 Oct — The buffet-lavatory unit was shipped to Edwards AFB for fit and function tests; essentially all test objectives were realized.

23 Oct — The main landing gear fatigue specimen experienced a failure of the forging which supports the basic beam at the lower end of the strut at a simulated life of 2400 landings.

Oct — 98.7% of the common AGE delivered to Tinker AFB in support of TTU activities.

29-30 Oct — An endurance mission of 18 hours and 20 minutes was flown by AFFTC on aircraft #6.

29 Oct — Tests to 150% design limit load were successfully completed for the horizontal stabilizer checked maneuver upload condition.

30 Oct — Total flight time on test aircraft has now exceeded 1516 hours.

2 Nov — Representatives from FAA Washington, Southern Region FAA, WRAMA, RTD, MATS and the SPO discussed preparation of a program proposal for installation of an all-weather landing system in the C-141.

Specimen "D", the main landing gear fatigue test specimen, experienced a failure of the station 998 frame.

1964 (cont'd)

9 Nov — A meeting was held with representatives of MATS, FAA, WRAMA, and the SPO to discuss preparation of a study for Hq USAF on "Lead-the-Force."

9-10 Nov — Representatives from Canadian Commercial Corp., Canadian Aviation Electronics Limited, MATS and the SPO held a management meeting to discuss milestones for timely delivery of theC-141A aircrew trainer.

10 Nov — The climatic hanger evaluation of aircraft #7 was completed at Eglin AFB and no major problems were encountered.

12 Nov — Representatives of Hq AFLC, WRAMA, LGC and SPO attended a conference at ASD to establish procedures for a phased provisioning program. LGC was given adequate information for preparation of a proposal which was forecasted to be complete 25 Jan 65.

16 Nov — Four Central Air Data Computers (CADCs) modified to the final configuration were delivered to Lockheed for installation in flight test aircraft.

20-24 Nov — In-plant engineering inspection of the first Link flight simulator and the follow-on interim FACI were completed.

23 Nov — The flap ultimate load static test was completed. All tests required for FAA Type Certification for the C-141A have been completed.

23-24 Nov — Lead-the-Force and the "stretch" C-141 Program studies requested by Hq USAF were presented to Hq AFSC and Hq USAF.

Nov — Flight testing of the pitch trip system was satisfactorily completed.

A study regarding the installation of a Crash Position Indicator/ Recorder was forwarded to Hq AFSC per Hq USAF request.

The redesign pitch trip system production hardware has been installed in aircraft #6 for flight evaluation.

WRAMA reported that the C-141A is 84.5% O.R. and an 0% NORS (Not Operationally Ready Status).

Dec — Aircraft #6, the AF accelerated service test aircraft, was placed on a 15 hour per day flying schedule. This demanding schedule was needed to reach the goal of 2400 flying hours within one year of testing.

2 Dec — The last of the C-141 stress analyses was technically approved.

3-4 Dec — A conference was held to define and coordinate the SPO study effort on all-weather landing system (AWLS) with all concerned agencies represented.

7-14 Dec — Air Force acceptance inspection of MTU-3 was accomplished at Lockheed Aircraft Services.

10 Dec — Hq MATS personnel presented the latest operational (C-1 acceleration) plans for the C-141A to AFLC and SPO personnel.

15 Dec — Aircraft #6, the accelerated service test aircraft, reached the 1000 hour flight test milestone in six months time.

The static test article was successfully tested to 120% of design limit load in the wing upbending mode.

15-16 Dec — Personnel from LGC, AFPRO, MATS, WRAMA, SPO and Cat II test attended a conference at Edwards to conclude the Air Force verification program for the preliminary Technical Manuals.

17 Dec — The first anniversary of the initial flight of the C-141A. During the first year of operations, the eight test aircraft accrued 2265 hours (1070 on the Cat I aircraft and 1195 on the Cat II aircraft). An additional total of 515 hours were flown by the five production aircraft.

Aircraft #1 was flown from Edwards AFB to Lockheed for continuation of FAA demonstrations required for Type Certification.

24-27 Dec — Aircraft #7, the environmental test aircraft, was flown from Marietta to Wright-Patterson AFB (WPAFB) and then on to Eielson AFB to begin the cold weather flight test program.

29 Dec — The first class of 16 pilots and flight engineers completed their flight training in the C-141. They were MATS qualified as aircraft commanders or first engineers and remained at Tinker to serve as instructors for future students.

30 Dec — The wing and pylon were successfully static tested in the up-bending mode to 142 1/2% of design limit load.

31 Dec — Total flight time on test aircraft exceeded 2387 hours.

Total flight time on C-141's assigned to the 1707 ATW at Tinker AFB exceeded 588 hours.

1965 (cont'd)

4 Jan	Aircraft #6 flew a 6 hour and 20 minute mission to evaluate the LORAN Navigation Unit (APN-151).
5-6 Jan	A flight test management meeting was held at Lockheed-Georgia Co. to review the status of the test program.
6 Jan	A Contractor Change Notice (CCN) was issued to cover updating aircraft #9 thru #36.
	Aircraft #6 was flown from Edwards AFB to Ramey AFB, Puerto Rico with Gen Schriever aboard.
9 Jan	Aircraft #7 was re-deployed from Wright-Patterson AFB to Alaska to continue cold weather testing.
12 Jan	A management meeting was held at Tinker AFB where SPO and Lockheed personnel briefed 1707 ATW and Hq MATS on AGE and Reliability Status.
14 Jan	The AN/ASN-24(V) computer set met qualification tests. The qualified item was installed in production aircraft #19 and on.
	The #7 aircraft flew a navigation mission up to 80° N latitude. All navigation equipment operated satisfactorily.
25 Jan	A management meeting was held with the 1707ATW. Representatives from Hq MATS, ATC, WRAMA, AFPRO, LGC and SPO discussed logistics, configuration management problems and responsibilities for the C-141 Program.
26 Jan	The SPO and AFLC reviewed the initial draft of the implementing plan for Lead-the-Force.
27-29 Jan	A DEI was held at Lockheed covering the paratroop cargo anchor installation, spoiler doors, and jump platform.
29 Jan	Configuration Identification Index and Status Accounting Reports were officially published and distributed to using agencies.
	Type Certification was granted by FAA.
	Total flight time on test aircraft exceeded 3077 hours. MATS accumulated 933 hours on aircraft assigned to the TTU at Tinker.
5 Feb	Distribution was made of the FAA C-141 Flight Manual.
	Cold weather evaluation of #7 aircraft was completed.
	SPO personnel met with Kollsman Instrument Corp. representatives to determine the availability status of the Vertical Scale Flight Instruments.

6 Feb — Aircraft #6 flew a non-stop round trip from Edwards AFB to Hickam AFB, evaluating the over-water navigation capability of C-141 equipment.

11 Feb — SPO, MATS, WRAMA and ASD personnel met with ITT Federal Laboratories personnel to provide guidance in the preparation of technical orders for the LORAN Navigation Set AN/APN-157.

The SPO received System Program Directive No. C-141A-65-1 dated 4 Feb 65, covering installation of a Crash Position Indicator in all C-141 aircraft.

12 Feb — Aircraft #2 was transferred from Lockheed to AFFTC to begin AF Category II performance evaluation.

Request for Proposal (RFP) for the C-141A follow-on buy of 115 aircraft was released to Lockheed.

16 Feb — SPO, MATS and ASD representatives met with Canadian Avionics Electronics personnel to resolve a design concept for the Aircrew Trainer.

17 Feb — Failure of the axle occurred during the fatigue cyclic testing on the main landing gear test specimen.

18 Feb — Official direction was received to accelerate changes; i.e., one year early, necessary to support the Minuteman Mission. SPO held a management meeting with representatives of ASD, BSD, Lockheed, Boeing and MATS.

19 Feb — Aircraft #9, the first assigned to Tinker, achieved 1000 landings in four months.

23 Feb — Aircraft #15 was accepted by the Air Force.

24-25 Feb — A First Article Configuration Inspection was held at Eclipse-Pioneer Division of Bendix Corp. on the Central Air Data Computer.

Feb — The #8 aircraft was deployed to El Centro NAS for initiation of the Category I Airdrop Program.

Failure occurred in the main landing gear back-up structure at approximately 97% of ultimate load during static test for the tail-down spring-back condition.

4 Mar — Aircraft #6 was accepted by the Air Force.

1965 (cont'd)

8 Mar — An extraction parachute failed during an airdrop test at El Centro NAS and caused minor skin damage to the #8 aircraft.

23 Mar — Negotiations were completed for the C-141A follow-on buy of 18 aircraft.

23-26 Mar — A joint Air Force/Contractor team conducted a compatibility test of Bendix AGE and Lear-Siegler prime equipment for the Engine Instrument System at Tinker AFB. The testing included compatibility for both flight line and shop level maintenance.

31 Mar — Total flight time on all test aircraft exceeded 4006 hours. MATS aircraft at Tinker flew a total of 2244 hours.

Mar — At approximately 6000 hours of simulated aircraft live, fatigue failures of the aircraft skin around the aft escape hatch and in the cargo ramp occurred on the aft fuselage/empennage specimen.

Air Force Acceptance Inspection was conducted on the C-141A Resident Trainer at Lockheed Aircraft Services, Ontario, Calif.

The SPO approved ECPs to incorporate Type II painting of thin clad areas, sealing of faying surfaces and painting of plumbing to improve corrosion prevention.

Authority was granted to the DOD AIMS SPO to proceed with procurement of 23 each Transponder Test Set AN/APN-123A to meet C-141A requirements.

1 Apr — SPO and contractor personnel met and reviewed all active flight restrictions on the C-141A.

The first actual airdrop was made at El Centro. It consisted of a single 6000 lb load dropped from 5000 ft at an airspeed of 150 knots.

8 Apr — The 80% airloads demonstrations were completed on #3 aircraft.

15-16 Apr — Lockheed, MATS, WRAMA, AFFTC and SPO personnel met and reviewed flight restrictions on the C-141A. Flight restrictions were reduced from 75 to 35 on Travis aircraft. Safety of flight supplements were reduced from 18 to 7.

16 Apr — A firm cost proposal for the FY 66-67 C-141A aircraft procurement was received by the AFPRO for review and analysis.

19-21 Apr — Category I airdrops #11 and #12 were successfully completed by aircraft #8 at El Centro.

23 Apr — General Estes, Commander MATS, delivered the first C-141A to Travis AFB and Maj Gen Dany, Commander WESTAF. Aircraft dubbed the "Golden Bear" was assigned to the 1501 ATW. This was MATS' first operational C-141.

28 Apr — SPO and the 1707th ATW personnel met and developed an Air Force Verification Plan for Flight Simulator Tech Order.

30 Apr — Fourteen (14) cargo airdrops have been accomplished at El Centro with no significant aircraft problems.

Total time on all flight test aircraft exceeded 4556 hours. MATS aircraft at Tinker AFB have flown over 3051 hours.

Apr — Aircraft #8 made a 10,500 lb airdrop at an airspeed of 140 knots with no problems encountered.

Aircraft #7 completed the final artificial icing test with satisfactory results.

2 May — Aircraft #3 lost a petal door while conducting a flight loads survey mission. The aircraft was flying at 7000 ft at 190 knots with the petal door in full in-flight open position when the forward hinge gave way and the door fell out and down. The other door was closed and the aircraft returned to Dobbins AFB with no further difficulty. No injury to personnel occurred and minor property damage resulted.

4 May — A coordination meeting was held to definitize the update work package for test aircraft #4 thru #8 and to coordinate the update program on #9 through #36.

6 May — A single platform load of 32,000 lbs was successfully airdropped at El Centro.

4-7 May — Representatives of the SPO and ATC inspected and accepted ten training panels of the updated MTU-1.

10 May — The first 35,000 lb single load was successfully airdropped at El Centro.

14 May — Supplemental Agreement for the procurement of 18 additional FY 65 C-141A aircraft and related items was distributed.

The Air Force in-plant inspection of the #3 Link Simulator was completed.

1965 (cont'd)

16 May — The accelerated service test aircraft #6 reached its goal of 2500 flight test hours in 11 months. The original goal was 1000 hours in 12 months.

17 May — An engineering procurement clearance package, including ASD Form 170 clearances, quantities, delivery, GFE, reliability and maintainability requirements, was proposed and transmitted for procurement action for the AGE for LORAN receiving set.

18 May — Aircraft #5 was deployed to Ft Bragg for Category II ADS testing.

25-31 May — Aircraft #19, assigned to Travis AFB, flew to Wake, Kadena, Okinawa and Yokota. The C-141 capability performance characteristics were presented to Army, Navy, Marines and foreign nationals at each stop.

26 May — A post flight inspection revealed a failure in the upper wing attach bolt in the right hand aft beam. All C-141 aircraft were called down for inspection of wing bolts.

26-28 May — All Weather Landing System meetings were held to clarify engineering requirements for ECP revision and identify the work statement necessary for CCN action.

May — Emergency ground evacuation testing was conducted on #5 aircraft at Ft Bragg with no significant problems encountered.

2-3 Jun — Towing and jacking demonstrations were made in 12 to 14 knot winds at WPAFB. No problems were encountered.

3 Jun — A 24,000 lb cargo airdrop was made at El Centro NAS using the standard Army Type 10 extraction line lengths.

7-9 Jun — A demonstration loading of the Minuteman and SSCBM in the C-141A was successfully conducted at Lockheed.

8 Jun — Aircraft #1, while flying an autopilot development test mission, lost an 18x24" section of the honeycomb tail pipe cone. It struck the left wing flap and damaged two flap panels.

9 Jun — The first 35,000 lb armored airborne assault vehicle mockup (General Sherman Tank) was dropped at El Centro. The extraction chute was inadvertently cut free from mockup during extraction resulting in loss of the mockup.

10-21 Jun — A C-141 aircraft was on static display and participated in aerial demonstrations at the 26th Paris International Air & Space Salon at Le Bourget Airport, Paris, France.

16 Jun Minuteman shake tests were successfully completed.

18 Jun Strike at AVCO, manufacturer of the wing box beam, was settled.

21 Jun High altitude takeoff and landing tests began at Mexico City.

22 Jun A fatigue failure occurred in F.S. 1398 pressure bulkhead after 9504 pressure cycles, approximately 23% of the present requirement.

28 Jun Lockheed conducted an inflight rain repellent system performance test in very heavy rain with satisfactory results.

2 Jul First trans-Pacific aeromedical evacuation flight from Clark AB, Philippines, to Travis AFB, California.

3 Aug Flew first aeromedical evacuation modified polar route from Vietnam to Andrews AFB, Maryland.

5 Aug First transport flight to Saigon, Vietnam, was completed 18 hours 15 minutes elapsed flying time. The total flying time was just under 24 hours; the aircraft made two en route refueling stops. This Travis-based aircraft carried over 50,000 pounds of general purpose cargo. This flight initiated regular C-141 service to the Pacific area, including aeromedical flights.

7 Aug Aircraft #7 completed the hot weather test and encountered no significant problems.

14 Aug Charleston AFB received its first operational C-141, which was the first assigned to EASTAF.

14-15 Aug A C-141 from the 1707 ATWg (TTU) participated in the Third Annual Air Show at Abbotsford, British Columbia.

16 Aug A Category II Test aircraft dropped 85 paratroops. The mission was accomplished in five passes at a speed of 130 knots and 1,500 feet altitude. This was believed to be the largest paradrop of troops from a jet aircraft.

17 Aug A Category II Test C-141 paradropped eight 8-foot, 3,200-lb pallets. This feat was believed to be the largest sequential cargo drop from a jet aircraft.

18 Aug Dover AFB received its first operational C-141.

2 Sep A Category II Test aircraft dropped two 35,000-pound loads.

7 Dec The Red Ball Express mission was initiated. These missions basically required the C-141's speed.

1965 (cont'd)

24 Dec — C-141's and C-133's began the airlift of the Army's Third Brigade, 25th Division's advance party from Honolulu to Pleiku, South Vietnam.

27 Dec — Starlifter's and Cargo Master's initiated the airlift of the main body of the Army's Third Brigade, 25th Division, to South Vietnam. The first strategic lift in which C-141's were used.

30 Dec — MATS received a total of 65 C-141's by year's end.

1966

18 Jan — Successful tests with a minuteman missile, in a locked position, were completed.

28 Jan — MAC C-141's and C-133's completed the airlift of the Army's Third Brigade, 25th Division, to South Vietnam.

31 Jan — USAF accepted the first Starlifter with a minuteman capability.

Feb — C-141 designated to make Embassy Run sometime after 1 April 1966.

27 Feb — Lead-the-Force aircraft completed a total of 9,890 flying hours and 13,501 landings.

Mar — USAF designated the C-141 to make aeromedical evacuation flights from Europe starting April 1966. USAF approved the sale of the 110th production aircraft to the Lockheed Company for demonstration purposes.

20 Mar — Lead-the-Force Program Accomplishments:

Total Flying Hours	Total Landings
10,676	14,047

31 Mar — Approval received to install and test a tire deflation/inflation device on one test aircraft.

Apr — Category II Test C-141 performance estimates:

Speed-Cruise (4,000NM)	431 KIAS
Payload (4,000NM)	57,500 lbs.
Payload (5,500 NM)	20,000 lbs.
Takeoff (at 316,000 lbs. gross) (wt. over 50ft.)	5,640 ft.
Landing (4,000NM, over 50 ft.)	3,480 ft.
Range (Ferry)	5,960 NM
Ceiling (100 FPM-Normal power) (TO-wt)	38,200 ft.

1966 (cont'd)

1 Apr	Accelerated aircraft production from 7 to 9 per month.
1 Apr	Aeromedical flights from Europe were initiated.
1 Apr	Embassy Run by C-141 aircraft was initiated.
14 Apr	Three air drops of "jeep size" loads were successfully made, from an altitude of 700 feet, during a Category III Joint Test Force/Army exercise at Ft Bragg, N.C. This was the first time that the Starlifter made drops below 1,200 feet.
21-22 Apr	First loading/unloading test of a minuteman missile was made.
22 Apr	The 100th C-141 was accepted by USAF.
27 Apr	The first Category I Test flight for the qualification of the All Weather Landing System (AWLS) was made. The radar altimeter, rotation go-around, auto-throttle, accelerometer, test programmer and logic computer and flight directional systems were evaluated.
11 May	2.0g rolling pull-out at MACH .85 successfully demonstrated during static wing tests, qualifying Lockheed fix of the aft cf center pressure shift on the C-141 wings.
17 May	C-141 nose landing gear and support structure test was completed. This test was the equivalent of 49,972 failure-free landings.
19 May	Supplemental Agreement to Contract AF 33(657) 8835, which allowed Lockheed to purchase the 110th production aircraft, was executed.
31 May	Lead-the-Force program accomplishments:

Total Flying Hours	Total Landings
13,275	16,161

1 Jun	The Starlifter received its 100 percent and interim structural release.
30 Jun	Final contract definitization of the additional 134 aircraft buy executed.
Jul	Two major failures, at FS 998 main frame and fuel boost pump cut-out at WS 395 encountered during the fatigue test program.
1 Jul	C-141 carrying 34 litter and 27 ambulatory patients initiated direct aeromedical evacuation from Vietnam to the U.S.
5 Jul	Category III Joint Test Force terminated. On this date the final test report was submitted to Gen H.M. Estes, Jr., MAC Commander.

1966 (cont'd)

10 Jul — Aircraft SN 65-220, assigned to the 437th MAWg, experienced an explosive decompression while on a local training flight. The incident occurred, while the aircraft was climbing through 19,000 feet at 280 knots indicated airspeed, because of an inadvertant release of the pressure door as result of ramp latch failure.

11 Jul — Lead-the-Force milestones were:

Total Hours	Total Landings
15,263	17,237

14 Jul — A C-141 from the 22 AF landed at Ban-U-Tapao, Thailand, on the partially completed Sattahip Airfield. This event marked the first time a heavy transport landed there.

21 Jul — TCTO 1C-141A-1112 was issued as a result of the 10 July pressure door incident. The TO was designed to insure proper rigging of the pressure door latching mechanism.

Jul — Aircraft SN 63-8080 of the 443 MAWg experienced nose wheel shimmies while on a SEA mission.

The SPO received full release of the authorized FY 67 funds.

8 Aug — The 62 MAWg, McChord AFB, Washington, received its first two C-141's.

Aug — A firm price proposal was received from Lockheed for AWLS installation.

The SSM (WRAMA) initiated project "Fast Flow," which was designed to reduce downtime for depot maintenance (MOD/IRAN). The program required $1,350,000 of additional developmental AGE.

7 Sep — At 0630 Pacific Coast Time, aircraft SN 65-281 was totally destroyed by fire while parked on the ramp at McChord AFB, WA.

29 Sep — Hq USAF briefed on the requirements for project "FAST FLOW."

Sep — An investigating team ascertained that the 7 September C-141 accident was due to material/design deficiency in the MD-2A. tester, with adapter. This was compounded by inadequate operating instructions, which made it possible to introduce 115 volts AC current into the tankage system. Operator error was considered a factor.

Sep — Recorders installed in the Lead-the-Force (LTF) aircraft were declared operational.

The SSM inaugurated a quarterly "System Critical Items" review. Starting in October 1966 this review included high NORS, critical items, hi-value management, WRM, FSS stockage, etc.

Cracks were found in Fuselage Station 1058 on aircraft SN 63-8084 during IRAN. Cracks were attributed to residual stress.

10 Oct — Aircraft SN 61-277 was flown to Hill AFB, Utah, to pick up a Minuteman Missile and container for the Minuteman structural flight testing.

15 Oct — End of successful tests, which demonstrated the feasibility of opening the flap asymmetry limits from three to five degrees.

19 Oct — SPO authorized to use existing C-141 funds for the project "Fast Flow" AGE requirements.

Oct — The Air Force Flight Test Center (AFFTC) at Edwards AFB, Calif, completed the remaining Category II lightweight stability and control testing. These tests completed the basic Category II Test requirements.

An LTF C-141 based at Travis AFB, Calif., reached the 5,000-hour milestone while returning from a SEA mission.

6 Nov — At 1039 Pacific Standard Time, C-141 SN 65-233, assigned to the 60 MAWg, collided with a Cessna 150 (civilian) while on a training mission. No injuries were incurred by the Cessna people or the C-141 crew.

7 Nov — A C-141 from the 60 MAWg made the first all jet aerial flight to Antarctica.

21 Nov — Contract negotiations on Letter Contract AF 33(657)-14820 began.

23 Nov — The C-141A Aeromedical Training device was accepted at Brooks AFB, Texas.

Nov — The SPO received a Requirements Action Directive (RAD) from Hq USAF cancelling any further effort towards the installation of UHF/DF equipment in the C-141A aircraft.

1966 (Cont'd)

1 Dec — At an AWLS meeting at Lockheed-Georgia Company, Marietta, Georgia, the contractor expressed concern about meeting the contractual requirements to deliver a fully qualified and certified AWLS in February 1967.

7 Dec — MAC completed one year of support to the RED BALL EXPRESS program with the departure of a C-141.

16 Dec — A C-141 of the 60 MAWg airlifted the Bob Hope Christmas Show from Los Angeles to SEA.

Dec — It was discovered by WRAMA that Lockheed had included clauses in their contracts with subcontractors which prohibited the vendor from selling C-141 parts to anyone but Lockheed. It was thought that Lockheed intended to negotiate a license agreement with the vendors which would provide Lockheed a fee on any items produced for the Air Force.

Seventy-nine percent of the contractor-furnished developmental AGE was transferred to the AFLC inventory managers.

1967

1 Jan — Lead-the-Force progress was:

Total Hours	Total Landings
21,542	21,267

9 Jan — The 58 MASq at Robins AFB, Georgia, received its first C-141.

15 Jan — C-141 SN 65-230 experienced an explosive decompression, over Wake Island, because of pressure door latch failure.

17 Jan — A C-141 of the 44th MASq, Travis AFB, Calif., claimed a transpacific speed record from Japan to U.S. mainland. The aircraft flew the 5,400-mile distance in eight hours and seventeen minutes with speeds averaging 630 mph. Pilot of the C-141 was Squadron Leader Barry C. Mills, an RAF exchange officer.

First flight to determine C-141 capability to accomplish airdrop of the A-22 Container Delivery System was completed.

Jan — Hq USAF approved the release of FY 68 through FY 70 RDT and E funds for the purpose of increasing the C-141 Fatigue Test Program to a Factor of Four.

A tentative fix was established for the nose gear shimmy by installing a new check valve in the steering mechanism.

1 Feb — Tests on a back-up latch system for the pressure door was successfully completed.

7 Feb — The revised AWLS Engineering Change Proposal was delivered to the SPO by Lockheed.

16 Feb — 22 AF completed the airlift of a complete satellite tracking station to Clark AB, in the Philippines, using C-133's and C-141's.

Feb — The APN 157 LORAN C became a critical item for production installation at Lockheed.

The decision was made to deliver all production aircraft starting with numbers 6185, 6187, and up, and SN 66-159, 66-161 and up, with the following pressure door engineering changes:

1. ECP 780-1, Cam Jack Installation, which placed pressure on the hooks so that they would stay firm in the stirrups.

2. ECP 780-2, Electrical Change, to put hydraulic pressure on the aft door and locks until cabin pressure is exerted.

3. ECP 780-3, Restraint Link Installation, which gave the system a redundant restraint.

1 Mar — Lockheed accepted the Government's final offer, including all terms and conditions and price, of a fixed price proposal.

21 Mar — AiResearch, Inc., engineering personnel initiated a field test at McChord AFB, Washington, for the purpose of resolving C-141 flap asymmetries.

22 Mar — A C-141 taxiing across a runway at DaNang AB, S. Vietnam, was struck by a U.S. Marines A6 "Intruder" which was negotiating its takeoff roll. Both Marines and the C-141 Loadmaster survived the accident. Both aircraft were total losses. The investigation team charged the accident to C-141 operator error because, despite the fact he had been waved across the runway, apparently the C-141 pilot did not visually inspect the runway.

1967(cont'd)

31 Mar	C-141 SN 63-8075 based at Travis AFB established a new daily utilization rate of 15.1 hours for the month.
1 Apr	A schedule of two C-141 aeromedical evacuation flights from both DaNang and Cam Ranh Bay, S. Vietnam, to the U.S. was initiated.
8 Apr	The 63 MAWg at Norton AFB, Calif., received its first C-141's. The first of these was dubbed the "Inland Empire" and the second the "City of San Bernadino."
8-30 Apr	Exercise Clove Hitch III conducted in the Caribbean. This was the first major exercise in which C-141 dropped paratroops.
12 Apr	C-141 SN 66-127 with 9 persons aboard crashed on takeoff one mile from the end of the runway at Cam Ranh Bay, S. Vietnam. Cause of the accident was classed as operator error because the aircraft crew negotiated the takeoff with spoilers deployed. The SPO later approved the incorporation of spoiler deployment condition light in C-141's.
18-19 Apr	AWLS Flight Test Conference was held at the C-141 SPO.
Apr	EDP-769 was approved by the SPO for the installation of a check valve in the Nose Landing Gear Steering Actuator to eliminate cavitation and hence the shimmies.
14 May	A C-141 airlifted a replica of the Lindberg airplane "Spirit of St. Louis" to the Paris Air Show.
17 May	ECP 780-4K, the Pressure Door Final Fix, was received by the SPO.
26 May	The C-141 was again placed on display at the Paris Air Show.
31 May	The overall C-141 Program funds was 96.3 percent obligated and 83.9 percent expended.
6 Jun	The most patients ever moved on a C-141 were airlifted from DaNang AB, S. Vietnam, to Yokota AB, Japan. The 66 litter and 11 ambulatory patient load was in contrast to the normal 60 litter or 27 litter and 42 ambulatory patient loads.
16 Jun	Aircraft SN 65-254 enroute from Wake Island to Clark AB, the Philippines, experienced a rapid decompression. It was determined that the left ramp hooks failed.
Jun	The SPO received from Lockheed and approved ECP-790 which wired the spoiler selector switch to the takeoff warning system.

24 Jul	AWLS flight test, using C-141 6001, initiated.
27 Jul	AFSC received the determination and findings concerning continuation of test on the R&D contract.
8 Aug	The 438 MAW at McGuire AFB, N.J., received its first C-141. Ceremonies, marking the receipt of the C-141's by the last MAC unit programmed to use Starlifters, were held.
14 Aug	AWLS flight demonstrations suspended because air conditioning duct problems.
25 Aug	The last AF production C-141 received the fuselage center wing mate.
31 Aug	General Thomas S. Jeffrey, Jr., AF Director of Production and Programming, presented the "Outstanding Award" to the C-141/C-130 SPO for meritorious achievement in the execution of the FY 1967 C-141 Program.
	The overall C-141 Program funds were 95.7 percent obligated and 86.6 percent expended.
16 Sep	Flying demonstration of Category II AWLS for FAA was initiated.
25 Sep	Ground training for the C-141 AWLS began.
6 Oct	The C-141 AWLS received the FAA Category II weather minimum certificate. This milestone marked only the second time that an aircraft received this certification. Only the Boeing 707-720 series had acquired Category weather minimum AWLS certification.
Oct	FY 1968 funds, in the amount of $230,000 were received for the C-141 flotation tests.
	Fund approval to retrofit the entire C-141 Force with the Pressure Door final fix (ECP 780-4) was received.
9 Nov	C-141's began support missions for the Apollo Space Program.
Nov	During a routine inspection, a cracked elevator forging was discovered. Ten-day Urgent Action TCTO 1C-141A-1240 to inspect the force was issued. During the inspection, 31 elevators were replaced.

1967 (cont'd)

12 Dec	The 10,000th landing of C-141's was made at Elmendorf AFB, Alaska.
12-29 Dec	During Operation "Eagle Thrust", MAC, using C-141's and C-133's, moved two brigades of the 101st Airborne Division from Ft Campbell, Ky, to Bien Hoa AB, S. Vietnam. 10,356 paratroops and 5,118 tons of equipment were moved 10,000 miles.

1968

14 Jan	MAC increased C-141 cargo flights in the Mediterranean and Middle Eastern areas from six to nine per week.
23 Jan	C-141's were used in the build up of troops in Korea following the USS Pueblo incident.
23 Feb	MAC received the last of the 284 C-141's purchased by the Air Force. This aircraft, like the first C-141 received by MAC, was assigned to 443 MAWg, Tinker AFB, Oklahoma.
Feb	A C-141 from the 86 MASq, Travis AFB, California, was used in the 2,000th "Red Ball Express" mission.
1 Mar	The C-141 SPO (and ASD) transferred executive management of the C-141 weapon system to AFLC (WRAMA).
15 Mar	The C-141 Operational Evaluation Staff's (OES) name changed to C-141 Maintenance Evaluation Division.
25 Mar	The 944the MAGp (Associate) was formed at Norton AFB, California. This group is associated with the 63 MAWg in the operation and maintenance of the wing's C-141s.
Apr-Jun	MAC, using C-141s, airlifted two brigades of the 24th Division from Munich, Germany, to Forbes AFB, Kansas.
25 May	The 20,000th C-141 landing at Yokota AB, Japan.
28 May	Thirty-six C-141s, from the 21 and 22 AF's, were used in the largest C-141 airdrop formation during exercise "Cold Mass II".
31 May	LTF C-141 SN 63-8079 of the 436 MAWg achieved a 21.25 hour utilization rate for the month of May.
18 Jun	Commemoration of the one millionth flight hour of C-141 operations at Scott AFB, Illinois.

1968

5 Jul — Aircraft accident highlighted pressure door problem.

16 Jul — Secretary of Defense approved the purchase and installation of All Weather Landing System ground equipment at 17 bases.

20 Jul — The 939 MAGp (Associate) was activated at McChord AFB to integrate reservists into MAC's modern jet force. This was MAC's second associate unit to be activated. The first was 944 MAGp (Associate) at Norton AFB in April 1968.

6-14 Aug — In the first deployment by C-141s of a complete Strike Command Joint Task Force, 450 personnel and 500 tons of equipment were lifted from MacDill AFB, Florida, to Robins and Lawson AFBs, Georgia. Exercise Bronze Plate demonstrated the capability of USSTRICOM's Communications Support Element to support joint task forces under field conditions.

16 Aug — Task Group 18 was formed to study C-141 primary flight control system problems and make recommendations on corrective actions.

24 Aug — The 903 MAGp (Associate) was activated at McGuire AFB, New Jersey, for C-141 training and operations.

15-25 Aug — For the first time C-141s were used in employing troops during a European exercise, as MAC participated in the NATO Exercise Deep Furrow 68 conducted in Northern Greece.

12-13 Sep — C-141s participated in Joint Airborne Training Exercise Bold Shot/Brim Fire 1-69. During the exercise, an airborne infantry rifle company and door bundles were airdropped at Fort Campbell, Kentucky.

25 Sep — The 912 MAGp (Associate) (formerly 912 Tactical Airlift Group (AFRes)) was established at Dover AFB, Delaware, for training in flying and maintaining C-141s.

Oct — C-141 aircraft demonstrated their capability to take off from and land on aluminum mats serving as temporary runways in rugged areas. Tests were made at Dyess AFB, Texas, and Edwards AFB, California.

1968 (cont'd)

Oct — C-141s supported Apollo 7 project.

22 Oct — Fourteen C-141s were used during Exercise Linebacker, a combat training airdrop of paratroops and cargo at Ft Bragg, which tested MAC's operational readiness and reaction capability and the MAC Wing-Army Division Affiliation Program.

31 Oct — Thirty-six C-141s flew in formation and dropped heavy equipment over Ft Riley's drop zone during Exercise Cold Mass III which provided training in large scale formation and simulated combat airdrop procedures for MAC aircrews.

1 Nov — The MAC C-141 Lead-the-Force Program ended this month, almost two years ahead of schedule. Six aircraft, operating out of Dover, Tinker, and Travis AFBs, had been flown at accelerated rates in order to identify mechanical problems before the rest of the fleet was affected.

Dec — Replacing PACAF C-130s, MAC C-141s and contracted Boeing 727s flew more than 200 channel missions into Korean bases from Kadena, Yokota, and Itazuke ABs.

1969

Jan — Six C-141 missions were flown in support of Apollo 8, December 68-January 69.

Jan — Following their release by the North Koreans, the 82 crewmen of the USS Pueblo were transported by two C-141s from Yokota AB, Japan, to the United States.

8-16 Jan — C-141s participated in Bold Shot/Brim Fire 2-69, an exercise designed to test the operational readiness and capabilities of US Strike Command tactical air/ground forces for contingency actions.

Feb — Retrofit of the entire C-141 force began in order to solve problem of skin delamination on flight control surfaces. Delamination, caused by infiltration of water followed by freezing and expansion at altitude, was corrected by replacing honeycomb trailing edges with fiberglass.

5 Jan-4 Feb — C-141s participated in Reforger I/Crested Cap I, an exercise in support of NATO commitments.

1969 (cont'd)

8-10 Mar — Four C-141s moved nearly 200 airmen and 35 tons of equipment from the United States to Rygee AB, Norway, in support of Exercise Big Boy 69.

9-26 Mar — C-141s participated in Joint Combined Exercise Focus Retina conducted in Korea.

1 Apr — Testing of the Satellite Forward Supply System concept began at Lajes Field and Torrejon AB.

31 Mar-2 Apr — Six C-141s airdropped 2,151 troops of the 82 Airborne Division on drop zones at Fort Bragg, North Carolina, and airlanded 300 more at Pope AFB in Field Training Exercise Caretan.

22 Apr — The 25,000th C-141 Combat Pacer mission transited Elmendorf AFB, Alaska. C-141 flights bound for Southeast Asia were dubbed "Combat Pacer" when they were established in October 1965 to provide a faster means of airlifting cargoes to SEA than mid-Pacific routes.

27 May — A C-141 of the 63 MAWg flew the Apollo 10 astronauts from Pago Pago in American Samoa to Ellington AFB, Texas, after completion of the Apollo mission.

27 May-16 Jun — MAC C-141s and C-133s provided airlift during Exercise Olympic Express in Europe.

24-29 Jun — C-141s participated in USSTRICOM Exercise Bold Shot/Brim Fire 5-69 held at Fort Campbell, Kentucky.

10 Jul — A 60 MAWg C-141 was diverted from a routine mission in the Pacific to Midway Island to pick up a sailor who had been critically burned on the Russian trawler Barabinsk. The C-141 flew the sailor from Midway to Hickam AFB for treatment at a civilian hospital.

Jul-Aug — Three C-141s of the 438 MAWg transported 35,000 blankets on 29 July and 9 August from Brunswick NAS, Maine, to La Mesa International Airport, San Pedro, Sula, Honduras, for the relief of flood victims.

1969 (cont'd)

Sep — Five C-141s airlifted food and equipment to aid Guatemala after Hurricane Francelia. Cargo included 215,000 pounds of food airlifted from Dobbins AFB, Georgia, to Guatemala City.

8 Oct — New C-141 forward supply points (FSPs) were opened at Ramey AFB, Puerto Rico, and Patrick AFB, Florida, and placed under the operational control of the primary supply point (PSP) at Charleston AFB, South Carolina.

7 Nov — Installation of an All Weather Landing System in all eight MAC C-141 flight simulators was completed.

Dec — A C-141 en route to Hickam AFB from Yokota was diverted to pick up a Russian woman who had taken ill on a Russian trawler off Midway Island. The C-141 flew her to Honolulu for admittance to a civilian hospital.

17 Dec — Maximum time before overhaul of the TF33-P7 engine was increased from 6,000 hours to 8,000 hours. The increase had been authorized at the semiannual Aerospace Engine Committee meeting at SAAMA, Kelly AFB, Texas.

1970

Jan — Three C-141 flights operated from Tinker and Travis AFBs to McChord to airlift three 750 KW generators. Subsequent movement was by surface to Ketchican, Alaska, in support of landslide relief.

1 Jan — Air Force terminated the supply portion of Lockheed-Georgia Company contract on All Weather Landing System (AWLS) equipment and assigned supply responsibility to WRAMA and MAC. AWLS assets were transferred to Air Force accountability, 29 December 1969-5 January 1970.

20 Jan — One C-141 airlifted 540 blankets and 35 tents from Nurnburg and Aviano to Sale Airport, Rabat, Morocco, for flood victims.

Apr — Nine C-141s and one C-133 were provided in support of Apollo 13. Four C-141s supported the AF ETR-ARIA EC-135, the voice relay/telemetry data aircraft; the other five airlifted support equipment and components to their positions; and the C-133 airlifted the Command Module from Hickam AFB to Ellington AFB, Texas.

1970 (cont'd)

Jun — Two MAC C-141s airlifted 15,000 pounds of arms and ammunition to Trinidad in support of the local government after a revolt.

25 Sep — The 701 MASq (Associate) was established at Charleston AFB, South Carolina. This action established the second C-141 associate airlift squadron at this location.

6-11 Oct — MAC aircrews flew 143 C-141 missions and 12 C-133 missions in support of Exercise Reforger II, the movement of Army dual-based forces to Europe and back. More than 11,400 troops and 550 tons of cargo were airlifted from the CONUS to Germany. Closure was made eight hours ahead of planned closure. Reforger II aircraft were then interfaced with three different exercises: Crested Cap II redeployment, Flintlock III redeployment, and Deep Express deployment.

Nov-Dec — C-141s airlifted relief supplies from Pope AFB, North Carolina, to Dacca, East Pakistan, following massive floods.

6-14 Dec — During Exercise Acid Test III, C-141s deployed Army and Air Force personnel and equipment to Allen AAF, Alaska. During the combat airlift phase of this Canadian-US exercise, 12 C-141s from McChord dropped, in two increments, 590 members of the Canadian Airborne Regiment and 39 tons of supplies and heavy equipment into the exercise area near Ft Greely, Alaska.

1 Oct-31 Dec — In support of Operation Deep Freeze 71, 11 MAC aircraft operated from the CONUS to Christchurch, New Zealand; two C-141s shuttled between Christchurch and McMurdo Sound, Antarctica.

1971

8 Jan — Crew members of 8 MASq, McChord AFB, Washington, airlifted emergency pumps to a merchant marine freighter in distress off Midway Island. The C-141 crew interrupted its scheduled mission in the Pacific to fly the emergency equipment from Hickam AFB to Midway to save the sinking vessel.

1971 (cont'd)

19 Feb A C-141 carrying the 500,000th aeromedical evacuation patient to be moved within the Pacific by MAC arrived at Hickam AFB en route to the CONUS from Vietnam. The patient, Army Specialist 5 Thomas P. Wilson of Orange, California, had been injured in a mine explosion.

27 Mar A MAC C-141 flew back to the United States an American agricultural advisor who had been held captive for months by Uruguayan rebels and recently released because of a heart condition. Dr. Claude Fly was flown from Montevideo, Uruguay, to Charleston AFB by a 437 MAWg crew.

Jun A 438 MAWg C-141 transported the one-millionth Southeast Asia-bound pint of whole blood from the Armed Forces Whole Blood Processing Laboratory at McGuire AFB, New Jersey.

Jun Pacer Gear 495, a total rework program, was initiated to resolve bogie beam and other landing gear problems.

17 Jun Six C-141s airlifted communications, maintenance, and aerial port equipment in support of USAF aircraft relocating East Pakistani refugees from the crowded Indian state of Tripura to less crowded Assam, following the flight of the refugees from their politically torn country.

30 Jun Total cumulative C-141 flying hours: 2,862,968.

GLOSSARY OF TERMS AND ABBREVIATIONS

AB	air base
ACI	analytical condition inspection
ADS	aerial delivery system
AFCS	auto flight control system
AFLC	Air Force Logistics Command
AFSC	Air Force Systems Command
AGE	aerospace ground equipment
AMA	air materiel area
ANSER	analytical service test
ARDC	Air Research and Development Command
ASD	Aeronautical Systems Division
ASIP	aircraft structural integrity program
ATC	Air Training Command
atch	attachment
ATWg	air transport wing
AWLS	adverse weather landing system
BITE	built-in test equipment
br	branch
CADC	central air data computer
cat	category
CCB	Configuration Control Board

ch	chief
CY	calendar year
DC	direct current
DCS/Log	Deputy Chief of Staff for Logistics, HQ MAC
DCS/Mat	Deputy Chief of Staff for Materiel, HQ MAC (redesignated DCS/Logistics on 1 Jan 72)
dir	directorate
DSMG	Designated Systems Management Group
EASTAF	Eastern Transport Air Force
EB	engine blade
ECP	engineering change proposal
eng	engineering
EUMR	emergency unsatisfactory materiel report
FAA	Federal Aviation Agency
FFS	fuselage frame station
FM	field maintenance
FS	fuselage station
FSC	Federal Supply Class
FY	fiscal year
G-NORS	grounded not operationally ready because of supply
iaw	in accordance with
ibid.	the same place

ID	inner diameter
IG	Inspector General
IM	inventory manager
ind	indorsement
intvw	interview
IRAN	inspection and repair as necessary
JEFM	jet engine field maintenance
JTF	joint task force
KIAS	knots indicated air speed
LGC	Lockheed-Georgia Company
log	logistics
LORAN	long-range navigation
LRU	line replaceable unit
LTF	lead the force
ltr	letter
MAAMA	Middletown Air Materiel Area
maint	maintenance
MASq	military airlift squadron
MASWg	military airlift support wing
mat	materiel
MAWg	military airlift wing
MCP	military construction program

MED	Maintenance Evaluation Division, Det 12, HQ MAC
mgt	management
MIP	maintenance improvement program
MLG	main landing gear
msg	message
MTBF	mean time between failures
MTC	mach trim compensator
MTTR	mean time to repair
NDI	nondestructive inspection
NLG	nose landing gear
NORS	not operationally ready because of supply
OCAMA	Oklahoma City Air Materiel Area
OES	Operational Evaluation Staff, Det 12, HQ MAC
OOAMA	Ogden Air Materiel Area
ops	operations
OSD	Office of Secretary of Defense
PCR	program change request
PE	periodic inspection
PSI	pounds per square inch
PSP	product support program
QEC	quick engine change
RCS	reports control symbol

ROC	required operational capability
rpt	report
RVR	runway visual range
(S)	Secret
SAAMA	San Antonio Air Materiel Area
SAC	Strategic Air Command
SN	serial number
SOR	specific operational requirement
SPO	Air Force System Program Office under the direction of AFSC; the System Program Officer
SRA	specialized repair activity
subj	subject
sum	summary
sup doc	supporting document
TACAN	tactical air navigation
TBO	time between overhauls
TCTO	time compliance technical order
TDR	teardown deficiency report
TO	technical order
TPLC	test programmer and logic computer
TRACALS	traffic control, navigation, and landing system
(U)	Unclassified
UHF	ultra high frequency
UR	unsatisfactory report

USAFCHO	Office of Air Force History
w/	with
WESTAF	Western Transport Air Force
WRAMA	Warner Robins Air Materiel Area
WS	wing station
WSM	weapons system manager

GLOSSARY OF HEADQUARTERS ORGANIZATIONAL SYMBOLS

DCS/O/R&D	Directorate of Requirements and Development, Deputy Chief of Staff, Operations
DCS/P	Deputy Chief of Staff, Personnel
DCS/P/PPD	Directorate of Plans and Programs, Deputy Chief of Staff, Personnel
DM	Deputy Chief of Staff, Materiel
DOI/PPD	Plans and Programs Division, Directorate of Information
MABIFS	Systems and Analysis Division, Directorate of Industrial Fund, Deputy Chief of Staff, Comptroller
MABMAR	Reports Branch, Directorate of Management Analysis, Deputy Chief of Staff, Comptroller
MACCS	Office of Chief of Staff
MADIX	Plans and Programs Division, Directorate of Information
MAFOIH	Historical Services and Research Division, Directorate of Information
MAMDC	Depty Chief of Staff, Materiel
MAODC	Deputy Chief of Staff, Operations
MAORD	Directorate of Requirements and Development, Deputy Chief of Staff, Operations
MAPPP	Directorate of Personnel Plans, Deputy Chief of Staff, Personnel
MAXDC	Deputy Chief of Staff, Plans
MAXMO	Directorate of Manpower and Organization, Deputy Chief of Staff, Plans

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