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CLIMATIC TESTING OF THE C-5A: LESSONS LEARNED FOR FUTURE CLIMATIC TESTING OF AERONAUTICAL SYSTEMS

STUDY REPORT

PMC 73-1

Alba John Hurlbut
LtCol USAF

CLIMATIC TESTING OF THE C-5A: LESSONS LEARNED FOR FUTURE CLIMATIC TESTING OF AERONAUTICAL SYSTEMS

An Executive Summary
of a
Study Report
by

Alba J. Hurlbut
LtCol USAF

May 1973

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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE:

CLIMATIC TESTING OF THE C-5A: LESSONS LEARNED FOR FUTURE CLIMATIC TESTING OF AERONAUTICAL SYSTEMS

STUDY PROBLEM/QUESTION:

To show how future aeronautical systems programs can avoid repeating the mistakes and failures of the C-5A Climatic Test Program.

STUDY REPORT ABSTRACT:

The C-5A Climatic Test evaluation program met with two major failures: the forced cancellation of a tropic test and an inadequate arctic evaluation. This study analyzes the C-5A Climatic Laboratory Test program to determine how and why those subsequent failures came about. In addition, the report analyzes the relative value and need for a formal desert test, and recommends its deletion from climatic testing.

Student, Rank Service	Class	Date
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CLIMATIC TESTING OF THE C-5A: LESSONS LEARNED FOR FUTURE CLIMATIC TESTING OF AERONAUTICAL SYSTEMS

STUDY REPORT

Presented to the Faculty

of the

Defense Systems Management School

in Partial Fulfillment of the

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Class 73-1

by

Alba John Hurlbut
LtCol USAF

May 1973

EXECUTIVE SUMMARY

This report analyzes the C-5A Climatic Test Program in order to determine what lessons can be learned from the results of that program, and applied to future test programs.

A climatic test program normally includes an extensive static systems operation test in the huge Climatic Laboratory at Eglin AFB, Florida; a tropic test at Howard AFB, C.Z.; an arctic test at Eielson AFB, Alaska; and a desert test at MCAS Yuma, Arizona or NAF El Centro, California. The tropic test is constrained to the October-mid December time period; the arctic test to the mid December to 1 March time period; and the desert test to the late June to early August time period. The arctic test is historically the most critical and the most severe test; however, the Climatic Laboratory is the most crucial to the overall success of the test program. For one thing, it clears the system for safe conduct of the arctic test.

The C-5A Climatic Laboratory evaluation met more than the usual number of difficulties, but this is to be expected for any large, complex weapon system during development. System problems, a tight schedule and the

eventual schedule slips, and an overly ambitious test program resulted in the forced cancellation of the tropic test. In addition, the aircraft was about one month late in deploying to the arctic site; this fact, coupled with an unusually mild February, resulted in a totally inadequate arctic evaluation.

Based upon an extensive analysis of the C-5A test program, the following recommendations are made to preclude a recurrence of the C-5A experience for future systems:

1. The following Laboratory Test activities should be candidates for trade-off, in order of preference, to preclude jeopardizing an arctic test or tropic test:

    a. Hot temperature (simulated desert) tests.

    b. 85° F/high humidity tests.

    c. Simulated tropic rainfall tests.

    d. Cold temperature tests not required to insure the safe conduct of the Arctic Test.

    e. Correction of climatic deficiencies, unless related to safe system operation.

    f. Updating the aircraft to the "latest configuration," unless without the update the entire arctic or tropic test would be virtually meaningless (a rare instance).

2. No extensive instrumentation and data recording package other than a simple photopanel set-up, is required or desired for the article under test. The type of system

deficiencies found are of the gross go-no go type. The inclusion of sophisticated instrumentation and recording systems overly complicates the testing, "gets in the way," and is costly in terms of equipment, installation, maintenance, and data processing.

3. Along with the "no instrumentation" philosophy, the conduct of tests should be simplified to maximum extent possible; while every subsystem should be exercised for go-no go operation, it is not necessary to exercise every possible capability of the subsystem.

This report also discusses the cost effectiveness of a formal desert test. Historically, aeronautical systems perform relatively free of trouble in hot desert environments; the C-5A was no exception. It is recommended that formal desert testing be deleted in favor of opportune, "piggy-back" basis with other tests at AFFTC, Edwards AFB, California.

ACKNOWLEDGEMENT

The author is indebted to Mr. Ronald B. Stanford, GS-13, of the 4950 Test Wing, Aeronautical Systems Division, Wright-Patterson AFB, Ohio. As Test Director for the C-5A Climatic Test, Mr. Stanford planned, directed, participated in and reported on the test program.

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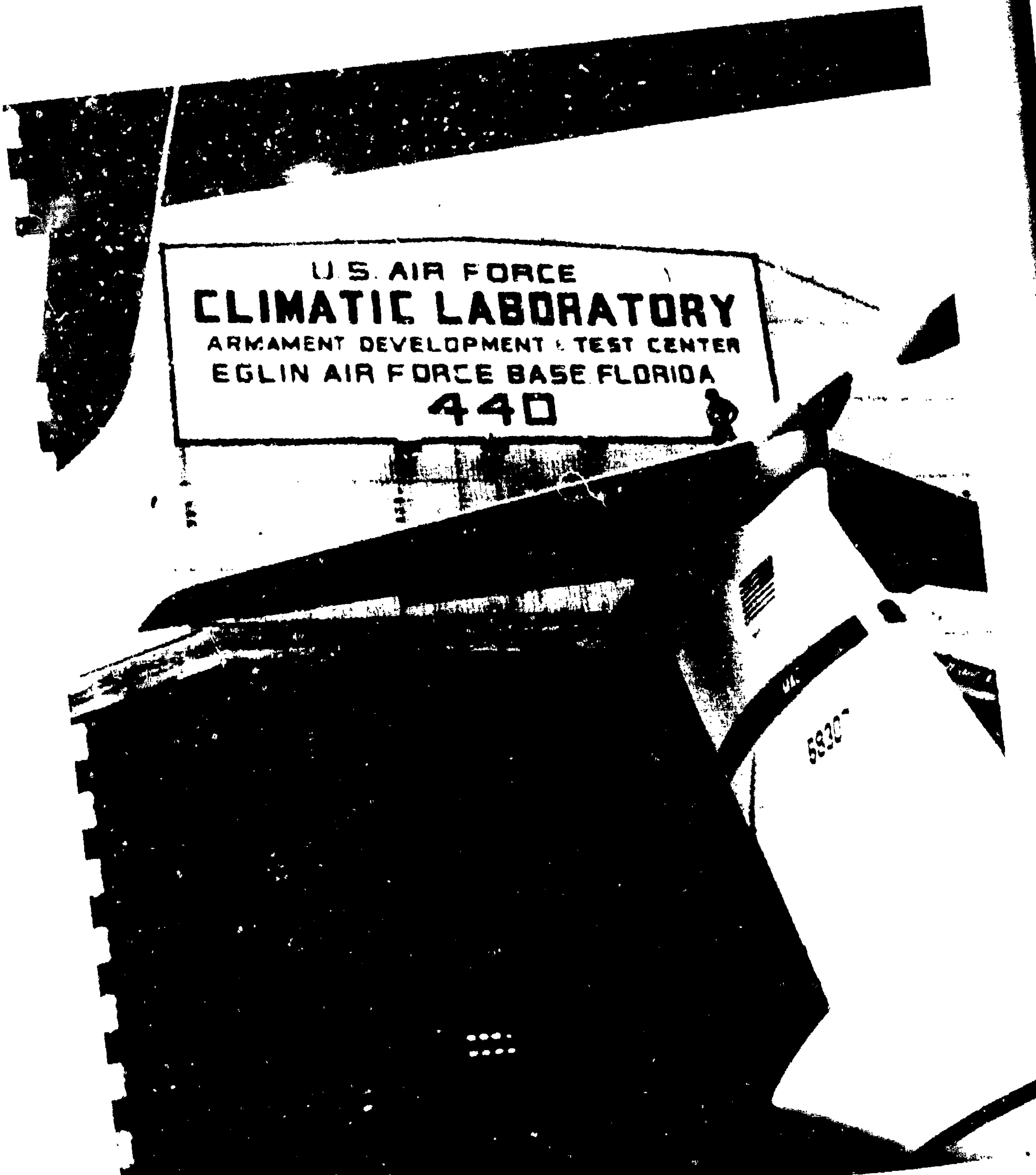
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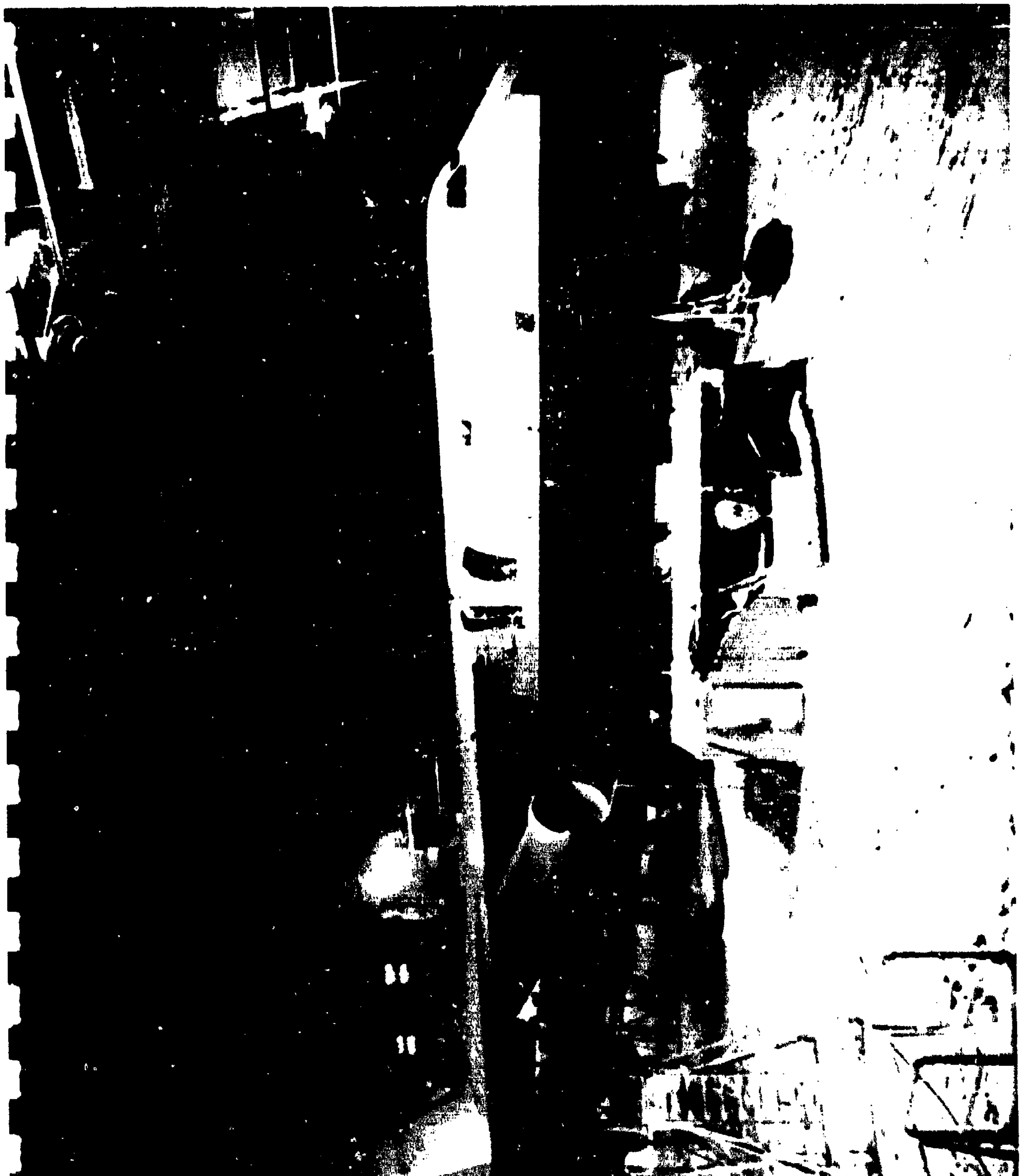

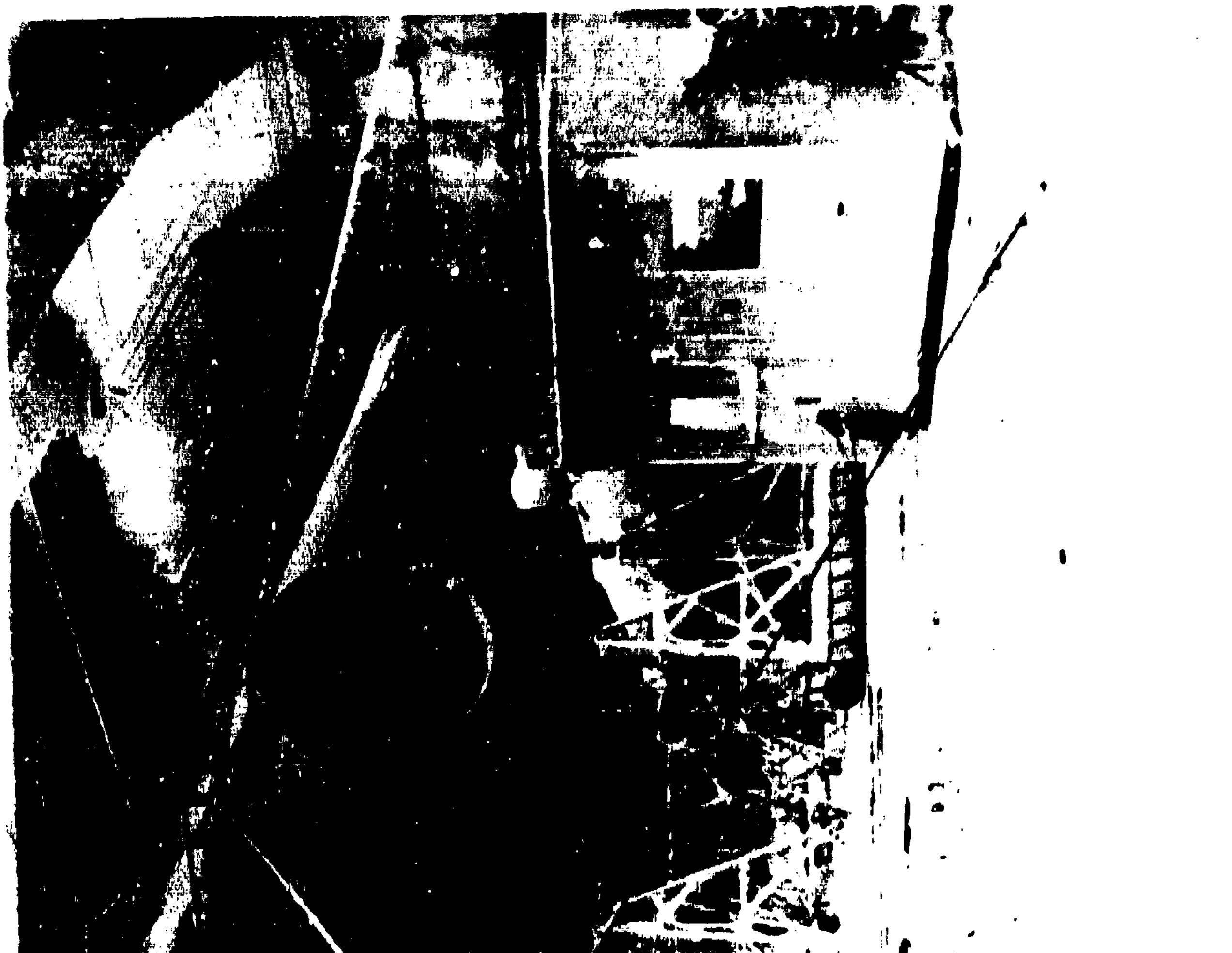

CLIMATIC TESTING OF THE C-5A:
LESSONS LEARNED FOR FUTURE CLIMATIC
TESTING OF AERONAUTICAL SYSTEMS*

Introduction

The C-5A Climatic Test was conducted by the Aeronautical Systems Division, Deputy for Flight Test (now the 4950th Test Wing), Wright-Patterson AFB, Ohio, from June 1969 to August 1970. The responsibility for climatic testing of aeronautical systems was transferred in late 1970 to the Air Force Flight Test Center (AFFTC), Edwards AFB, California. Climatic testing normally consists of (1) an extensive static systems operation test in the Air Force Climatic Laboratory (Hangar) at Eglin AFB, Florida, (2) a Tropic Test at Howard AFB, Panama Canal Zone, (3) an Arctic Test at Eielson AFB, Alaska, and (4) a Desert Test at NAF El Centro, California (or equivalent site). For reasons explained in this study report, the Air Force failed to conduct a Tropic Test; a late Arctic Test start coupled with an unusually mild February combined to result in an inadequate Arctic Test.

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*ABSTAINER

This study represents the views, conclusions and recommendations of the author and does not necessarily reflect the official opinion of the Defense Systems Management School nor the Department of Defense.

The author was Task Force Commander of the C-5A and A-7D Climatic and Adverse Weather Test Task Force. The task force consisted of a Climatic Test Director, an Adverse Weather Test Director, the C-5A flight crew and ground crew, test engineers, technicians, a complete maintenance, and technical support personnel (a total of approximately 60 personnel). (Ref. 9)

Purpose of Study

The purpose of this study is to show through analysis of the C-5A Climatic Test Program how climatic testing of major aeronautical systems can be accomplished at significantly reduced expense, with improved efficiency, and still meet climatic test objectives. The C-5A Climatic Test was planned and conducted based on traditional test concepts evolved from the experience of previous tests of earlier systems. As a result of each successive program adding to the list of "requirements" for a climatic test program, the C-5A test was handicapped by over-ambitious test objectives and an overly sophisticated test instrumentation system. It is hoped that future climatic test programs can benefit from the lessons learned from the C-5A test. In order to reduce the expense and compress the schedule for climatic testing, the Program Office must have an understanding of (1) what types of external constraints (seasonal, laboratory limitations) limit the test program objectives and (2) what can and should be cut from a program. Without this understanding, the program office is at the mercy of the testing organization, and the failures of the C-5A program could be repeated.

For the purposes of this study, discussion of the C-5A Climatic Test Program will focus primarily on the Climatic Laboratory phase of the program. This is not to slight the remainder of the program; it is because the planning and conduct of that phase is extremely critical to the success or failure of all that follows. A separate but related topic is also addressed: the need for and importance of a formal Desert Test - is it cost effective?

Background

Air Force Requirements

The Air Force requirements governing climatic testing are derived primarily from AFR80-14, AFR80-31, and MIL-STD-210A (Ref. 2, 1, and 12). AFR80-14 states that one of the "major objectives" of test and evaluations is to:

> establish actual performance capabilities in an environment which simulates the actual operating environment including the climatological and other extremes as closely as possible. (Ref. 2:5)

AFR80-31 states that "normally," climatic testing is conducted in artificial environments such as the climatic hangar (Air Force Climatic Laboratory) at Eglin Air Force, Florida (phase 1), and at "cold weather, desert, and tropic bases as required" (phase 2) (Ref. 2:2). It also states that the data on climatic extremes contained in MIL-STD-210A (Ref. 12:4-11) will be used as a guide.

It should be noted that Program Directors can adapt the above broad guidance to their own programs as appropriate, even to the point of obtaining waivers if required. This fact is important to keep in mind, particularly in discussions concerning formal desert testing, later in this report.

C-5A Climatic Test Objectives

The C-5A, like most aeronautical systems, is required to be "capable of executing the system missions in all conditions of weather and climate of any area of the world" (Ref. C-5A System Specification SS400013, para. 3.1.3.4). The fundamental objective of the Climatic Test Program is to test the system for that capability, as stated in reference 10:

> The objectives of the Climatic Evaluations of the C-5A were:
>
> a. To determine the adequacy of the aircraft, its subsystems, components, and special AGE for proper operation under laboratory simulated as well as actual extreme climatic environments, e.g., arctic, desert, and tropic.
>
> b. To analyze deficiencies uncovered and make recommendations for corrective action.
>
> c. To determine the adequacy of available improvements intended to remedy known deficiencies.
>
> d. To define special protective, maintenance, and operational techniques necessary in the extreme environments for inclusion in the appropriate airplane manuals.
>
> e. To compile environmental data for future design purposes.

It should be noted that the aircraft individual components, and in some cases entire subsystems, undergo tests of varying severity (and quality) in environmental chambers. Although these tests are an important part of the design and development process, they do not verify that the component or subsystem will perform when integrated into the total system, where interface and synergistic effects come into play.

Seasonal Constraints

System testing under severe climatic conditions can be accomplished to a great degree in the Climatic Laboratory at Eglin AFB. (The Laboratory is large enough to accommodate the C-5A). However, due to limitations of the Laboratory and the inherent limitations of static testing, it becomes necessary to complete the climatic testing at geographical locations where extreme climatic conditions (Ref. 12) can be found. Because of the high cost of conducting these tests, there must be a very high probability of encountering the severe conditions on an almost daily basis for an extended period of time (5-7 weeks). In addition, adequate facilities must be available to support testing. No location in the continental United States meets these criteria for arctic and tropic testing; for desert testing, the criteria are met at Yuma MCAS, Arizona, NAF El Centro, California, and Luke AFB, Arizona. Edwards AFB falls short of the "extended period - high probability" criteria; however, sufficiently severe test conditions are encountered on a less frequent and shorter term basis.

The following is a summary of the locations where adequate test conditions can be found, along with the time periods of the year:

Type of Test	Location	Time Period
Tropic	Howard AFB, C.Z.	October to mid December (11 weeks)
Arctic	Eielson AFB, Alaska	Late December through February (10 weeks)
Desert	(3 U.S. Bases, S.W.)	Mid June through early August (7 weeks)

Note that no natural climatic testing is practical for the 3 1/2 month period from March through mid June. (March and April are good months for adverse weather testing in the U.S.; e.g., natural icing, thunderstorm, and instrument flight conditions. Although these tests are not a part of climatic testing, they are often conducted with the same aircraft.) Ideally, then, Climatic Laboratory testing should be scheduled during those months. If the decision is made to eliminate formal desert tests (see "Desert Test") in favor of accumulating opportune "piggy back" testing at Edwards AFB, then the ideal months for Climatic Laboratory testing are March through September.

C-5A Climatic Test Schedule

The C-5A Climatic Test schedule proposed by the Deputy for Flight Test was designed to take advantage of the above considerations:

Delivery of Test Vehicle	27 June 1969
Climatic Laboratory Test	30 June - 31 October 1969 (18 weeks)
Updating at Lockheed	3-28 November 1969
Adverse Weather Testing (WPAFB)	1-26 December 1969 (4 weeks)
Arctic Test	29 December 1969 - 27 February 1970 (9 weeks)
Adverse Weather Testing (WPAFB)	2 March - 12 June 1970 (15 weeks)
Desert Test	15 June - 31 July 1970 (7 weeks)
Adverse Weather Testing (WPAFB)	3 August - 25 September 1970 (8 weeks)
Tropic Test	28 September - 13 November 1970 (7 weeks)

(Ref. 7)

The proposed schedule was unacceptably lengthy to the C-5A SPO; accordingly, the SPO directed (1) that the Climatic Laboratory test be shortened to allow for a Tropic Test in the fall of 1969 and (2) that all testing be complete by 31 July 1970. The schedule was compressed as follows:

a.	Climatic Laboratory Test	30 June - 10 October 1969 (3 weeks less)
b.	Updating at Lockheed	10 October - 31 October 1969 (1 week less)
c.	Tropic Test	1 November - 7 December 1969 (2 weeks less)
d.	Preparation for Arctic Test and Adverse Weather Test at WPAFB	8 December - 29 December 1969 (1 week less)
e.	All Testing Terminated	31 July 1970

The total compression for items (a) through (d) was 5 weeks, with the resultant addition of a 5-week Tropic Test (two weeks less than desired).

Neither the SPO nor the Director of Test made any serious attempt to reduce the scope of the Climatic Laboratory test program to allow for the schedule compression. The failure to do this eventually contributed to (1) the failure to accomplish a tropic test and (2) a late Arctic test start. The latter factor, coupled with an unusually mild February at Eielson AFB, Alaska, resulted in an inadequate arctic test.

In the next section, the Climatic Laboratory Test program and its results will be critically examined to determine how these failures could have been prevented, and how a similar situation can be avoided in future programs.

Climatic Laboratory Test Program

Background

Laboratory Capabilities. The Climatic Laboratory has the capability of simulating actual climatic environments from about -90° F to +140° F, very dry to very humid atmospheric conditions, and continuous rainfall up to about 24 inches per hour rate. Thus the MIL-STD-210 arctic, tropic, and desert environmental conditions required for climatic evaluation can be closely duplicated.

Limitations of Laboratory Tests. Most aircraft systems can be operated in the Laboratory, including the landing gear (with the aircraft on jacks). However, only very limited engine operation is possible in the Laboratory; therefore, most systems operation is limited to that available from auxiliary power units (APU's) and Aerospace Ground Equipment (AGE). One reason for the limitation is the following: running two C-5A engines at idle, and ducting the hot engine core exhaust to outside the building causes the Laboratory temperature to rise from -70° F to about 0° F in approximately 15 minutes. In effect, the cold air is used up by the engines faster than it can be replenished.

Another limitation of Laboratory testing is the immobility of the airplane; i.e., taxi, takeoff, ice fog visibility, etc. cannot be duplicated. Also, long term climatic effects such as tropical fungus and corrosion are impractical to duplicate. Climatic-related flight problems, such as heavy fog condensation in the cockpit occurring during descent from high altitude into a tropical environment, cannot be duplicated in the Laboratory.

Laboratory Test Schedule. The Laboratory Test schedule is depicted in Table 1 (Ref. 10:5). A full week was required at each temperature level in Part I because of the concurrent testing of the A-7D in the Laboratory (a typical situation, given the heavy service demands on the Laboratory). The C-5A and A-7D tests could not be run simultaneously, and extended (1 - 1 1/2 day) temperature soak periods were required between tests. (The A-7D was not present during Part IV.)

It is the author's contention, in retrospect, that the 0° F, -25° F, and -45° F tests of Part II could have been combined to a single -35° F test (saving 2 weeks); the 0° F and -25° F tests of Part IV could have been eliminated (saving 1 week); in addition, all testing could have been simplified to a "bare bones," minimum instrumentation

TABLE I

C-5A CLIMATIC LABORATORY TEST SCHEDULE
(15 weeks)

	EVENT	DATES-1969	DURATION (WEEKS)
I	Installation	28 Jun - 13 Jul	2
II	Engine Runs, L.G. Tests (on jacks)		
	Shakedown and 70° F Tests	14 Jul - 18 Jul	
	0° F	21 Jul - 25 Jul	
	-25° F	28 Jul - 1 Aug	
	-45° F	4 Aug - 8 Aug	
	-65° F	11 Aug - 15 Aug	7
	105° F & 125° F	18 Aug - 22 Aug	
	Rain Soaks, 85° F-high humidity tests, repeat 70° F tests	25 Aug - 29 Aug	
III	Change Set-up for Kneeling Tests, etc.	1 Sep - 3 Sep	1/2
IV	L.G. Kneeling, L.G. Strut Integrity, Cargo Handling Tests		
	70° F Tests	4 Sep - 5 Sep	
	0° F, -25° F Tests	8 Sep - 12 Sep	3
	-45° F, -65° F Tests	15 Sep - 19 Sep	
	Repeat 70° F Tests	22 Sep - 23 Sep	
V	Dismantle Test Set-Up, Remove from Laboratory	24 Sep - 26 Sep	1/2
VI	Post-Test Maintenance necessary for flight to LGC	27 Sep - 10 Oct	2

Note: Low temperatures established preceding Friday evening, with extended soaks through Sat-Sun-early Monday.

philosophy to reduce actual test time and allow for more time for maintenance and correction of deficiencies. The total reduction would have been about four weeks, which probably would have allowed time for a tropic test. As it turned out (see Laboratory Test Results), the total Lab program required five weeks longer than planned (Ref. 4). Another week probably could have been pared by postponing some of the less critical cold weather tests, such as cargo handling, until the Arctic Test; but by the end of August 1969, the Tropic Test had already been written off (Ref. 6).

Scope of Tests

Instrumentation. An extensive network of instrumentation was built into the test airplane for the purpose of obtaining climatic test data. A list of 310 test parameters to be instrumented were agreed upon by the Air Force and the Contractor as being "required" or "desired" for evaluation of system performance under climatic test conditions. Some of the test parameters being measured were: temperatures in cargo, crew, and equipment compartments (using thermocouples); oil, hydraulic, and Environmental Control System (ECS) temperatures and pressures; engine, auxiliary power unit, and air turbine motor speed (rpm) and vibration measurements. Signals from these 310 instrumentation pickups were routed to a common test station installed in the forward crew compartment. At this test station, the Air Force installed a four-channel multiplexed data recording system, incorporating an electronic clock with direct readout. For the Climatic Laboratory Test, the test station was located in a remote "shirtsleeve environment" control booth; this of course required additional electrical cables routed from the airplane to the remote control booth. In addition to the 310-parameter instrumentation system, a photopanel was set up with selected repeater instruments from the pilot and flight engineer stations.

Data Processing. To process all the data recorded by this complex instrumentation system, the test force had a truck mounted air conditioned van with a limited data processing system for fast response capability. For full data processing, however, the tapes were sent to an IBM 7094 computer center.

Instrumentation Personnel. To maintain and operate the instrumentation system, recording system, and data processing equipment, and to review and analyze the data, the test force included two full-time technicians and one mathmetician.

Purpose of Instrumentation. The purpose of incorporating the system described above was to provide the test engineer a capability for detailed analysis of subsystem and component performance under climatic test conditions. For example, an exact time history of an APU start could be obtained, including temperature changes, pressure buildups, and shaft rpm. Or, for example, the exact time required for wing flap operation or landing gear extension, retraction or kneeling could be obtained and analyzed. As it turned out (see "Laboratory Test Results," next section), the actual types of system climatic problems found were: APU's could not be started without external heat; wing flap bearings froze; landing gear operation was grossly unsatisfactory at extreme cold temperatures; and hydraulic systems leaked fluid by the bucketful at cold temperatures. It is the author's opinion, having participated in the entire test program including almost all laboratory test sessions and subsequent test flights, that the entire instrumentation and recording system (with the exception of the simple photopanel) could have been dispensed with; saving dollars, complexity, test time and data processing. It should be noted that this kind of data from climatic tests is usually reproduced in bulky volumes that are rarely (if ever) used.

Conduct of Tests. Individual tests were patterned after typical Military Air Command (MAC) ground crew and aircrew procedures, starting with powering up an APU to exercising every system which could be operated. For example, with APU's supplying power to aircraft systems, the landing gear was cycled up and down (on jacks), control surfaces and flaps were exercised, aircraft heating and airconditioning systems were exercised, cargo loading and unloading operations were performed (aircraft off jacks), engines were started and run at idle, and virtually all hydraulic, pneumatic, electrical and electronic systems were operated. The tests were generally excessively lengthy, partially due to the over-use of and reliance on the instrumentation and data recording system. The schedule impact of the over-use and reliance on instrumentation was (1) reduced time available for maintenance and correction of deficiencies and (2) delayed temperature soak periods for subsequent test sessions. Both of these factors contributed to a stretch-out of the Laboratory test program.

Laboratory Test Results

Major Deficiencies Found. One important value of any test program lies in the discovery and, if possible, correction of system deficiencies before the system is deployed. From the standpoint of discovering deficiencies, the C-5A Laboratory Test Program must be classified a resounding success. Deficiencies were found in the following areas (most of which were corrected):

1. APU's. At temperatures of -45° F and below, the APU's could not be started without external heat being applied. A variety of mechanical and hydraulic accumulator problems contributed to this, including one instance when the dual accumulator installation literally blew apart in the cargo compartment during start-up (fortunately no one was hurt).

2. Air Turbine Motors (ATM's). Once the APU's were started, the ATM's (which work off the APU's) could not be started without external heat (at 0° F and colder).

3. Wing Flap Bearings. The wing flap bearings "froze" and would not operate at -45° F and below.

4. Landing Gear Struts. At -25° F and below the landing gear struts leaked hydraulic fluid profusely. Operation of landing gear doors and the crosswind control system was progressively more unsatisfactory at temperatures below -25° F.

5. Landing Gear Kneeling System. (For cargo loading and unloading.) Kneeling system operation was either extremely slow or out of synchronization (among the four

main landing gear bogies) at -25° F and below. In one instance, the jackcrews went out of control, exceeding mechanical stops, resulting in major subsystem damage.

6. Hydraulic Couplings and Seals. The hydraulic system literally bled by the bucketful at temperatures of -45° F and below, all throughout the aircraft.

7. Nose Gear Retraction. Nose gear retraction after an extensive -65° F cold soak required 30 minutes. After removing the pressure reducer from the subsystem (a safety device to prevent overspeed at normal temperatures), the time was reduced to 3 minutes 5 seconds (the MILSPEC requirement is 30 seconds). The reason for this deficiency was never found during the Laboratory Test; those low temperatures were not encountered during the Arctic Test because the start of the Arctic Test was delayed beyond the period when extreme cold temperatures were present. (During the time of the actual test, an unusually mild February prevailed. The lowest temperature encountered was -37° F; usual temperatures were from -10° F to +15° F.)

8. Stability Augmentation System. The yaw axis failed to function after -45° F and -65° F cold soaks.

9. Miscellaneous. A variety of lesser temperature-related malfunctions, any of which could be potentially serious or at least delay a flight, occurred at cold temperatures: inoperative starter valves, frozen fire control handles, inoperative Ram Turbine extension/retraction,

pump cavitation, etc. (Ref. 6 and 8)

The simulated tropic rainfall test resulted in major water leaks around the overhead escape hatches, air refueling panel, overhead panel above flight deck center console, and aircraft nose visor and radome. (Ref. 2, number 10:10-11)

The high temperature (simulated desert) test uncovered no major climatic-related deficiencies (Ref. 5).

Evaluation of Test Philosophy

The main point to be made in reviewing the list of problems and deficiencies above is: none of them required any elaborate test instrumentation or procedures to discover or analyze. Thus any un-instrumented test aircraft would have easily been adequate for the Climatic Laboratory Test, saving costs, manpower, complexity, test time, and subsequently, processing of reams of never-to-be-used data.

The test philosophy of exercising every subsystem which could be exercised proved to be a valid philosophy; however, time could have been saved by simply testing for "go-no go" operation, rather than testing for every possible function, and taking the time to acquire and record all the detailed data available via the sophisticated instrumentation and recording system. The time required for each test session could have been reduced significantly.

Schedule Trade-offs Available

It should be apparent from a review of the problems encountered that the cold temperature phase of any Climatic Laboratory Test will inevitably require more time than the schedule allocates. Even relatively simple maintenance tasks become complicated and time consuming at extreme cold temperatures. To avoid the serious potential consequences of missing a Tropic Test and/or obtaining an inadequate Arctic Test (as happened with the C-5A), it is imperative that the overall program schedule be given top priority (next to safety of flight considerations, of course). In the case of the C-5A Laboratory Test, the test requirements spelled out in the test plan became sacred, and the only mechanism used to make up schedule slips was the use of overtime and seven-day weeks. The following activities should be candidates for elimination from the Laboratory Test if the overall schedule is in jeopardy: (in order of priority)

1. Hot temperature (simulated desert) tests.
2. 85° F/high humidity tests.
3. Simulated tropic rainfall tests.
4. Cold temperature tests not required to insure the safe conduct of the Arctic Test.
5. Correction of climatic deficiencies, unless related to safe system operation.

6. Updating the aircraft to the "latest configuration," unless without the update, the entire Tropic or Arctic test would be virtually meaningless. (This could be the case, but only in rare instances.)

If these trades had been made (they were not even considered) for the C-5A program, both the Tropic Test and the Arctic Test could have been successfully accomplished.

It should further be noted that the Arctic Test should take priority over the Tropic Test, if further trades have to be made.

Desert Test Program

Relative Importance. Long before the C-5A Climatic Test Program was actually begun, it was tacitly recognized that the Arctic Test would be the severest and most critical test to pass, both from operational safety considerations and from the difficulty of meeting requirements. It was also generally recognized that the Tropic Test was critical mainly to the performance of the avionics components, and not very much to system safety. Last of all, no one seriously believed that the Desert Test would pose a problem to the C-5A; historically, airplanes experience little difficulty operating in a hot dry environment. The C-5A proved, as expected, to be no exception to the rule.

Results of Desert Test. Only one subsystem deficiency related to the hot desert environment, was found in the course of the Desert Test. This was the failure of the doppler Signal Data Converter (SDC) caused by high avionics bay temperatures during engine starts, when cooling air is not available. (Ref. 5) Even in this case, the SDC was operational during flight, after re-setting. Other than this minor deficiency, and several minor problems not related to the desert environment, the Desert Test was accomplished with very little difficulty and on schedule, at a total cost (personnel, TDY, use of a C-5A, its operational costs and base support) estimated to be $500,000 - not counting the "opportunity cost" of tying up one C-5A and 50 personnel for five weeks. The obvious question is, is it worth doing? The author's opinion is that it is not, and Program Managers for aircraft systems should seriously consider dropping the formal Desert Test requirement from their programs. An alternative is to "piggyback" hot temperature tests on an opportunity basis at Edwards AFB (AFFTC) whenever favorable test conditions occur. For specific, high priority hot weather tests, the use of the Climatic Laboratory should suffice.

Conclusions and Recommendations

1. The Climatic Test Program for any weapon system is governed by the tight non-controllable constraints of season and geographical location. Given that a Climatic Laboratory Test should precede actual climatic tests, both for safety and efficient use of test resources and time, this fact virtually dictates that the Climatic Laboratory Test be planned for completion no later than the end of August of the test year.

2. The type of problems encountered in climatic testing are almost certainly to be of a very gross nature, not requiring any elaborate instrumentation or data accumulation. Any un-instrumented representative airplane would be totally adequate for climatic testing.

3. The schedule trades listed under Climatic Laboratory Test, Schedule Trade-offs Available, this report, should be seriously considered by the Program Office. (p. 21)

4. There is no real requirement to conduct a formal desert test; any hot weather testing should be obtained on an opportune basis during the course of other tests conducted at AFFTC, Edwards AFB.

Annotated Bibliography

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   A comprehensive record of the daily activities of the Arctic Test. In addition to the daily log, each report contains a summary section for its own period of coverage.

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6. Deputy for Flight Test, Aeronautical Systems Division, Air Force Systems Command. C-5A Tropic and Arctic Test Meeting Minutes at Eglin AFB, Fla., 29 October 1969.

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A detailed test plan for the Climatic Laboratory evaluation of the C-5A.

11. Naval Air Facility El Centro, DOD Joint Parachute Test Facility, and Aeronautical Systems Division (AFSC). Memorandum of Agreement for C-5A and A-7D Category II Desert Tests, 8 April 1970.

A good example of the comprehensive, detail and planning required to prepare the support of a climatic test.

12. United States Government Printing Office. Climatic Extremes for Military Equipment (MIL-STD-210A), 2 August 1957.

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