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GECART

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21 June 1962

NRO REVIEW COMPLETED

MEMORANDUM FOR : The Record

SUBJECT : Status - GECART Engine Program

REFERENCE : GEC-3480 dated 10 May 1962 titled "Status - GECART Engine Program"

1. This report describes significant highlights of subject program since the release of reference memorandum as surfaced during recent visits to [redacted] Lockheed, Pratt and Whitney Florida, Pratt and Whitney Hartford, and [redacted]

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2. Development Status:

(a) Engine

(1) Test Status:

Although no additional full scale 50 hour engine endurance tests have been completed since April, engine testing is progressing at a higher than average rate. Total engine time now stands at 4137 hours reflecting an increase of 1% hours during the past month. Five engines are currently on test status including engine FX-115 which is on shakedown for endurance at Mach 3.2 inlet temperature, max afterburning, with fully integrated main control and latest "E" configuration hydraulic pump with 300°F fuel without oil additive. Three engines now in assembly are targeting test by 30 June; one for performance calibration, one for sea level endurance, and the other depending upon FX-115 results for Mach 3.2 mission cycle endurance at altitude.

(2) Limited Flightworthiness:

Progress made in known major critical problems in the areas of compressor durability, hydraulic pump durability, controls durability, turbine inlet temperature profile, plumbing durability, afterburner durability, and full scale engine durability test time is now felt to be sufficient for release of the initial delivery engines as suitable for Mach 2 limited flight. This is not tantamount to saying that these problems are resolved, warrant reduction in effort, are all suitable for Mach 3.2 operation, will not

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recur during test or flight, nor does it mean that each individual delivery engine will not develope certain peculiar problems of a flight safety nature.

(3) New Immediate Problems:

Recently surfaced problems include one of thrust discontinuity during refueling or landing approach power settings and one of thermal shock fuel leakage at the afterburner fuel manifold coupling. A fix for the thrust discontinuity problem has been demonstrated on engine test and is expected to be incorporated on delivery engines prior to flight. Fixes for the thermal shock leakage (a fine spray leak of 15 seconds duration) are being demonstrated now on engine test and pending final results are expected to be incorporated on delivery engines prior to flight.

(4) Mach 3.2 Preliminary Flight Rating Test Prerequisites:

It is expected that the Mach 3.2 engine Preliminary Flight Rating Test will take place in July. Prerequisite to this engine PFRT is successful completion of the Mach 3.2 bench PFRT for the main fuel control and repeatable demonstration on engine test of a fix for a burner can center tube burning problem resulting from inlet velocity profile upset at Mach 2.3 at 65,000 feet altitude.

(5) Additional Considerations:

No less important to the mission than the Mach 3.2 engine PFRT will be the engine altitude performance calibrations and the continuing maximum development effort to improve performance, improve durability, and correct the multitude of presently unsurfaced but anticipated problems resulting from engine/aircraft installed flight test operation.

(b) Controls

(1) Mach 3.2 Bench Qualification Status:

Better than expected progress at [redacted] has resulted in Mach 3.2 50 hour bench test qualification for all of the seven engine control system components except the main fuel control which suffered a broken speed servo piston ring at 35 hours. This failure is attributed to insufficient piston to bore clearance. The unit is now rebuilding with appropriate fixes and is expected to rerun the test 30 June

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1962. Since a previous test at the same conditions was terminated at 92 hours successfully, the chances for a successful rerun appear good. High temperature bench test time now stands as follows:

	Hours @ M2 Mission Cycle Environment	Hours @ M3.2 Mission Cycle Environment
Main Control	337	255
Afterburner Control	448	257
Exhaust Nozzle Control	314	103

In summary, excepting the main control, all system components have demonstrated acceptable bench operational durability at the Mach 3.2 environment but need further refinement in the area of specification accuracy.

(2) Additional Considerations:

It should be recalled that bench qualification is a first step only and that many new problems and old problems too should be anticipated as progression is made to full scale engine mission environment endurance and then to aircraft installation. Although engine test operation with fully integrated controls now stands at 415 hours reflecting 391 hours increase since 31 January 1962, only five of these hours were at engine control environmental temperatures above Mach 3.

(e) Hydraulic Pumps

(1) Bench Test Status:

Since February 1962, thirteen 60 hour bench mission cycle endurance tests have been completed successfully reflecting an accumulation of 1260 hours. Five of these tests involved "D" configuration pumps requiring 3% oil additive, three of which were run at the 200° fuel temperature cycle and the other two at the 350° fuel temperature cycle. Eight of the thirteen tests involved "E" configuration pumps requiring no oil additive and were run at the 350° fuel temperature cycle. Five of these eight "E" pumps exceeded 60 hours at the following test conditions:

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Item No.	Fuel Temp. °F	Ambient Temp. °F	Hours	Remarks/Condition
7437-6A	350	Accel	217	30 hrs @ 750° ambient. Shaft seal wear.
7433-0	350	700	202	Included cesium additive. Shaft bearing spalled.
7434-0	350	750	150	Shaft bearing failed.
7435-0	350	750	150	None.
7431-0	350	500 accel	79	Running shaft seal test.

(2) P3.2 Bench Qualification Status:

Although the above test results place the "F" pump very close to being P3.2 bench qualified, this judgment should be withheld pending investigation results of delivery program test trouble described in paragraph 3(c).

(d) Development Accelerations:

Since February 1962 the contractor has been authorized to proceed with accelerations in the following areas:

1. Hydraulic Pump.
2. Mod. III Turbine (durability).
3. Altitude Test Facilities.
4. Alternate Backup Main Control.
5. Afterburner Performance.
6. Addition of XD-3 Development Engine.
7. Long Lead Time Hardware Procurement.
8. Compressor Test Rig (performance).
9. Mod. IV Turbine (performance).

In addition to the above accelerations, DO/CSA actions have been taken to insure continued maximum effort in the area of controls and the hydraulic pump. The only area which has not been accelerated to date is a weight reduction program reflecting a possible engine weight reduction of 90 lbs. at a development cost of [redacted]

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3. Delivery Status:

(a) Engine:

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(1) Schedule:

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Engine Number	Estimated Shipment	Scheduled Shipment
[illegible]-1	Shipped 6/11/62	6/30/62
[illegible]-2	6/30/62	7/31/62
[illegible]-3	7/31/62	7/31/62
[illegible]-4	8/31/62	8/31/62

It is anticipated that the maximum delivery rate of five engines per month scheduled to start in November 1962 will be difficult to meet because of raw material availability involving basic engine parts such as turbine blades and discs. Contractor action is underway to improve this situation.

(2) Limited Engines:

The first three delivery engines are limited to Mach 2.0 operation. The significant limiting factors are:

1. Mach 2 controls which have special cams cut to the Mach 2 schedule in order to permit this limited operation until the main control has been bench qualified to Mach 3.2 (requiring a different cam) and the system has been engine qualified on the full scale M3.2 engine PFRT.

2. "B" configuration hydraulic pumps which require the 3X oil additive known to be thermally unstable at temperatures above Mach 2.

3. The burner can center tube burning problem described in paragraph 2(a)(4).

(3) Engine [illegible]-1 Discrepancies:

Engine [illegible]-1 now undergoing aircraft fit check at Burbank was shipped at Lockheed's request for aircraft scheduling purposes prior to final clean-up of two discrepancies noted on final engine acceptance test. These discrepancies which are in addition to the thrust discontinuity problem cited in paragraph 2(a)(3), consist of an afterburner coupling thermal shock leakage cited in paragraph 2(a)(3) and main fuel control "lean-out" at high power setting. It is expected that these discrepancies will be corrected on test stand running at [redacted] The control "lean-out" appears peculiar to this one control and in itself is not a flight safety item. Fuel/air ratio goes slightly lean at maximum power reducing thrust from 28,700 lbs. to 27,600 lbs. The concern registered by

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Pratt and Whitney is that the reason for the "lean-out" is not yet defined and may be indicative of sensitivity to abnormally low fuel inlet pressure which could become serious in the event of aircraft fuel boost pump failure. Boost failure is relatively remote since two boost pumps supply each engine at all times. Repeatability of this condition without improvement may warrant control replacement prior to flight, a not uncommon situation for an initial delivery engine.

(b) Controls:

Because of improved manufacturing techniques and incorporation of engineering changes which have helped reduce calibration time from 400 to 200 hours, five complete control systems were delivered in May meeting the schedule commitment and reflecting a total of nine Mach 2 systems delivered to date. It is doubtful, however, that more than three of the five systems scheduled for June will be delivered in June due to engineering change impact in going to Mach 3.2 hardware. The third June delivery system is the first Mach 3.2 system for Florida. The first Mach 3.2 system for Hartford is scheduled for July. The initial three delivery engines have their controls delivered. Contractor actions which have been taken in the past and covered in previous reports are expected to markedly improve deliveries by September in addition to the more immediate factors cited above which have so far at least maintained compatibility with engine requirements.

(c) Hydraulic Pumps:

Delivery of production units is running one week behind schedule due to green test trouble cited below. The total of four "F" pumps have been delivered. The first "F" pump is scheduled for delivery to Hartford 6/25/62, to be followed by two more in July. In addition to the above three "F" pumps, five more are scheduled for delivery to Florida by mid July. Major fabrication problems are not anticipated at this time, however, very recently two production "F" pumps have failed initial green break-in test with cold fuel within one hour. These pumps showed evidence of severe wear which in no way is reflective of recent development test experience. [redacted] attributes these failures to contaminated fuel as supplied by Pratt and Whitney. A joint investigation including fuel sample analysis is underway to determine the exact cause of this unique situation.

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4. Engine Flight Test:

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(a) Engine Control Support:

[redacted] engine utilization program for planned engine core tests

[redacted]

procurement for overhaul was prepared by USAF and coordinated with the engine contractor. This program is based upon USAF flight test experience and present aircraft and engine delivery schedules. It provides for a maximum flight time level of 15 hours per month per article. This is at variance with Lockheed's admittedly optimistic target of 25 hours per month per article. It is the writer's recommendation that the USAF program be followed for engine overhaul planning purposes at least initially for the following reasons:

1. Orders for engine overhaul parts sets are placed each quarter for usage in the same quarter the following year. If early flight experience indicates a level of operation higher than 15 hours per month, the quarterly orders may be increased appropriately.

2. To plan now for the 25 hour per month per article level would more than double the size of each quarterly order of overhaul parts sets many of which undoubtedly will become partially unusable because of obsolescence.

3. Sizing each quarterly order now for the 25 hour level would dictate disproportionately high fiscal 1963 funding.

The recommended USAF plan, as does every other plan, indicates clearly that the available in-house spare engine level will drop to three spare engines in May 1964 only at which time 18 articles will be flying. This means that three spare engines only will be available to cover 36 installed operating engines. This ratio of 3 spares/36 installed increases slightly to 5 spares/36 installed for the period from November 1963 to July 1964, still a narrow margin. The only way to improve this margin is to increase the current number of 57 delivery engines on order.

(b) Senior Engineering Representatives:

25X1A [redacted] Pratt and Whitney Senior Project Engineer, who spearheaded the early phase of engine development and more recently the transfer to and initiation of the delivery effort at Hartford has been assigned as senior engineering representative 25X1A [redacted] DD effort is currently underway to establish a much needed secure verbal communication link between his office 25X1A and [redacted] in Florida. 25X1A

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(c) Ground Service Equipment:

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All initial major engine GSE items have been shipped [redacted] The engine test stand has been through shakedown with a J75 engine. Coordination is underway between Pratt and Whitney and Lockheed for establishing test methods and procedures for the airframe remote gearbox.

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(d) Anticipated Flight Test Problems:

Although no known rule of thumb is applicable in forecasting anticipated propulsion flight problems, past experience dictates that problems will occur. Compatibility problems are sure to arise with installation of an unflown engine into an airframe particularly with a complex and relatively untried inlet system. A few of the harnessing problems known to have occurred on other programs and soon the less expected here will be:

1. Plumbing leaks.
2. Turbine thermocouple durability.
3. Engine and inlet control matching.
4. Afterburner spraybar coking.
5. Nozzle actuator seal life.
6. Foreign object damage (FOD).
7. Performance.
8. Engine controls.

5. Altitude Facilities Activation:

(a) J-A Altitude Stand - Florida:

As reflected by the large number of personnel, equipment, and activity on site progress toward completion is on schedule. The operational readiness target of 30 November quoted in April now stands at 15 November.

Progress as of 15 June is as follows:

1. Of the total of 107 vendor items of work involved, 77 have been completed. The work reflected by the balance of 30 incomplete items is mainly in "on site" construction.

2. Pacing items have been reduced from a total of 30 in April to 16 comprising only 4 delivery and 12 construction items. Acceleration of some of the previously pacing items has reduced lead times by varying increments of 3 to 43 days.

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3. Potentially pacing items have been reduced from a total of 43 in April to 10, all 10 delivery items.

4. Present status of work falls in the area of final delivery cleanup with intense effort in construction and installation.

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(b) [redacted] Altitude Stand - Hartford

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Adaptation of the Williams 4-209 stand has progressed to the point of engine readiness on 7 June. The pacing item is engine [redacted] now on sea level calibration in Florida and targeted to [redacted] 30 June. At least two weeks will be required after receipt of the engine for installation, instrumentation, and shakedown prior to performance calibration.

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Development Division
OSA-DD/S

cc: AFUIC-5

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