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☐ 222E END OF TOUR REPORT
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☐ 224C [illegible]
☐ 226Q CORRESPONDENCE
☐ 228Z PAPERS
☐ 227[illegible]

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300 TOTAL PAGES ________

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AIR FORCE SYSTEMS COMMAND

UNITED STATES AIR FORCE

PRELIMINARY DEVELOPMENT PLAN

FOR

HYBALINE-FUELED AGENA SPACE VEHICLE

System No. SS-01-B

26 July 1963

00920409

3-6806-39

...FIED

[redacted]

DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

FOREWORD

This document presents a proposed development program for a Hybaline fueled Agena Space Vehicle in response to Hq USAF message AFRSTD 76993, dated 9 July 1963.

The program is based on the results of research efforts by Union Carbide Chemicals Company, South Charleston, West Virginia, and the Rocket Propulsion Laboratory, RTD, AFSC, Edwards AFB, California, and results of a feasibility demonstration program conducted by the Lockheed Missiles & Space Company, Sunnyvale, California, and the Bell Aerosystems Company, Buffalo, New York.

TABLE OF CONTENTS

SECTION 1

PROGRAM SUMMARY

Hybaline (A-5) is a new high-energy rocket fuel developed by the Union Carbide Chemicals Company which can provide significant increases in performance of the Agena space vehicle with only minor modifications to the present design, with the exception of the engine.

Typical missions have been calculated to illustrate the performance gains (See Figures 6.1, 6.2 and 6.3). Increments of 500 to 750 pounds in burnout weight, which can be interpreted as increments in payload and mission peculiar equipment, are available using the Improved Thor launch vehicle. Using the Atlas launch vehicle, typical increments in burnout weight are 500 to 900 pounds. The increased performance can also be used to increase orbit altitude. For example, Program A (Figure 6.3), using an Atlas launch vehicle, could increase orbit altitude from 2000 to 3500 miles.

The modified engine will have 18,000 pounds thrust using IRFNA as the oxidizer. It will have multi-start capability with a simplified start system, and a maximum burn time of from 225 to 250 sec, depending on which of the propellant tank configurations is selected. Engine specific impluse (Isp) is estimated to be 325 sec under vacuum exit conditions with an expansion ratio of 45. This exceeds the present UDMH/IRFNA performance by more than 30 sec.

Configuration No. 1 for vehicle structure is based on a [illegible] minimum modification concept. The only changes are structural beef-up to carry the higher payload and a minor relocation of the inner bulkhead in the propellant tank to provide the proper ratio of fuel and oxidizer with no increase in total volume.

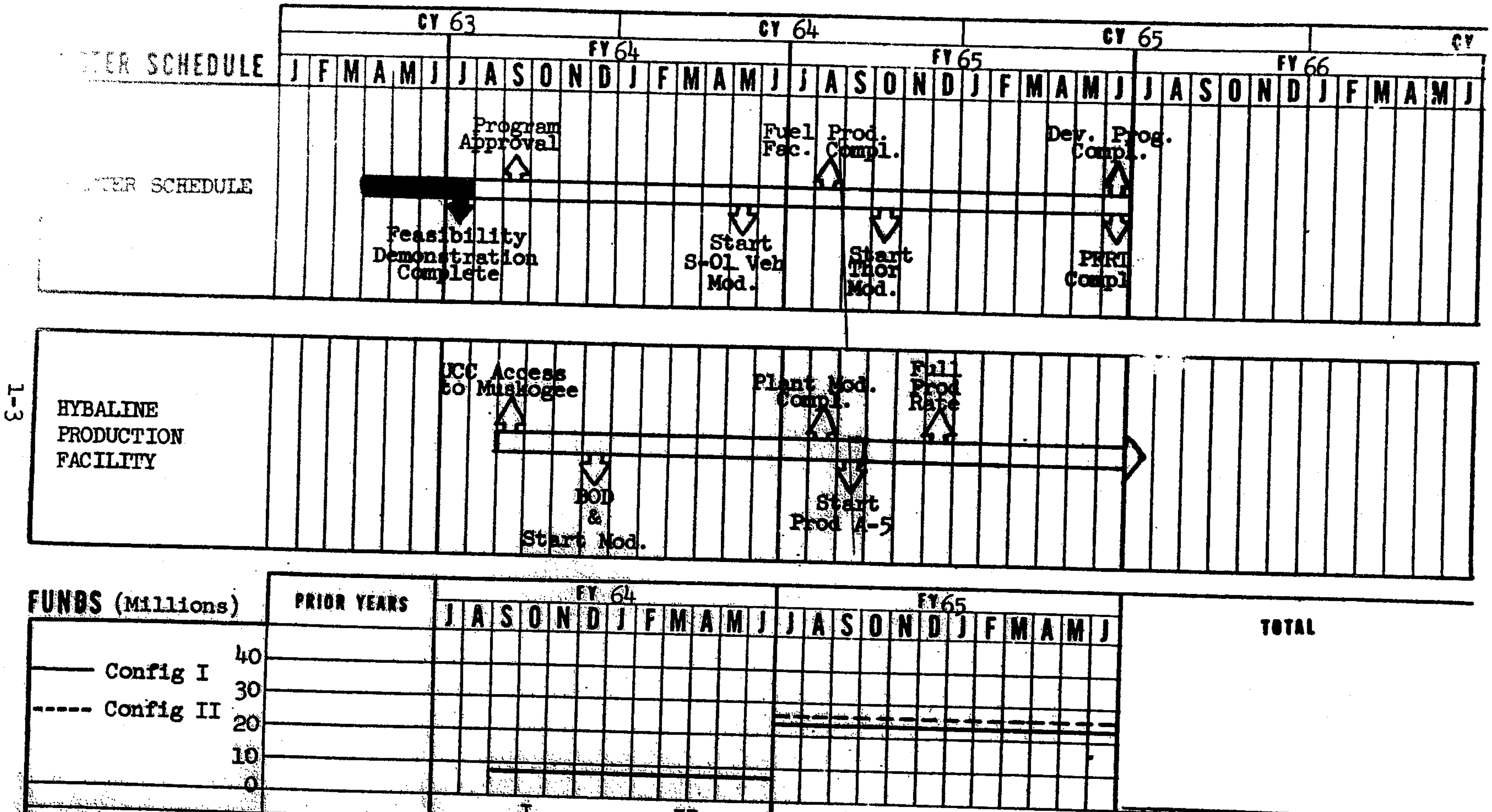
Configuration No. 2 is based on a near minimum modification concept. In addition to structural beef-up, the propellant tank volume is increased by approximately 15% in order to increase the propellant load and thereby achieve increased performance gains within the constraint of a minimum change concept. This increase in volume is achieved by increasing the tank diameter from 60" to 63" without changing the length. [illegible] increase in diameter does not cause any change in handling [illegible]

[illegible] change in AGE (for either alternative structure) [illegible] and fuel system. This change would involve the [illegible] pressurization system, which is not expected to [illegible]ities.

DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

The pacing item in this proposed program is the availability of sufficient quantities of Hybaline fuel for engine development. The lead time for a full scale production facility is approximately 12 months. Prior to that time, the only fuel available is from a small pilot plant which has a capacity of only 1200 pounds per month.

MASTER PROGRAM CHART



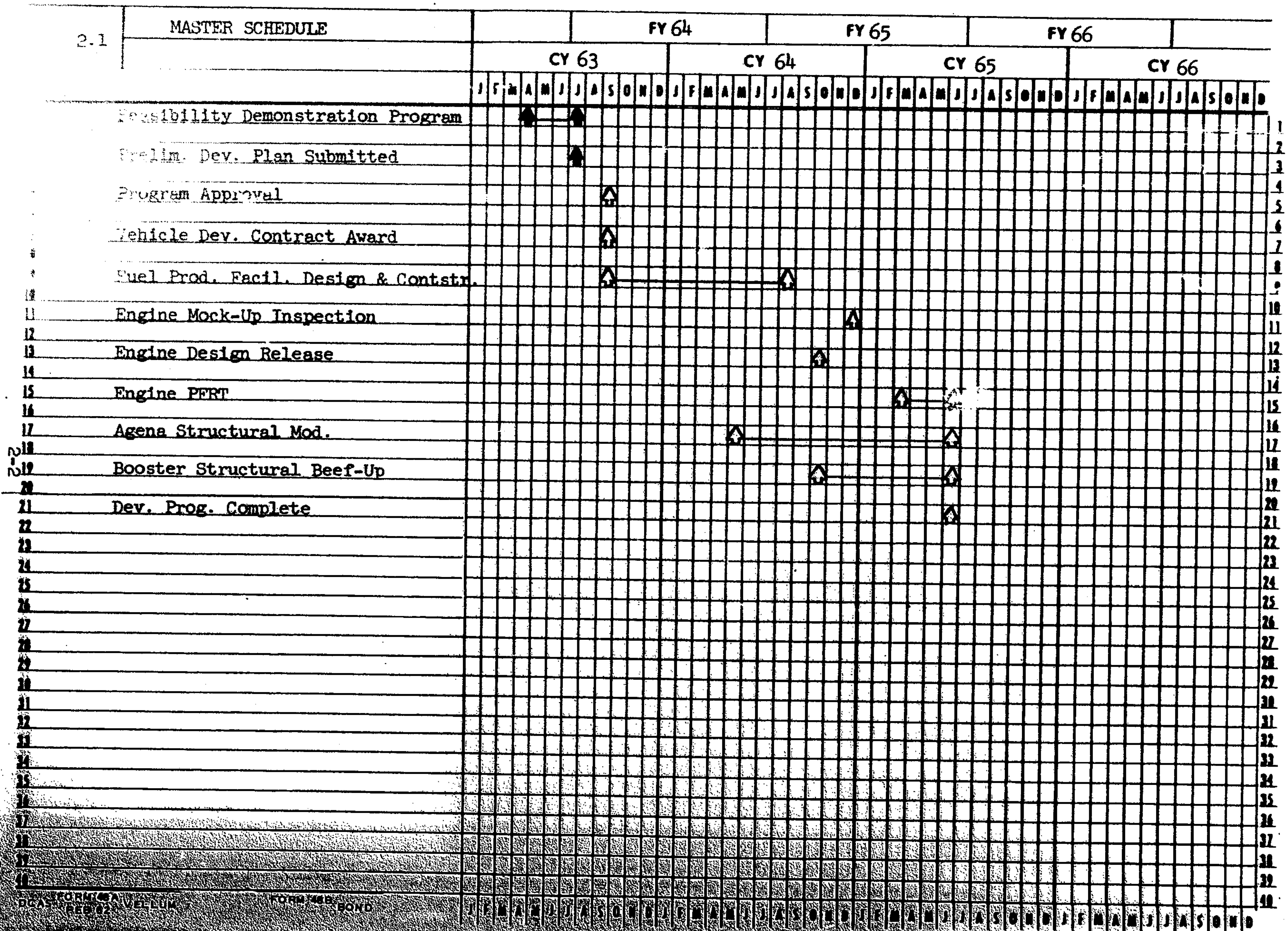
	PRIOR YEARS	FY 64 I	FY 64 II	FY 65 I	FY 65 II	TOTAL I	TOTAL II
RDT & E		5.4	5.4	22.4	24.9	27.8	30.3
Industrial Fac.		2.0	2.0	0.7	0.7	2.7	2.7
Total		7.4	7.4	23.1	25.6	30.5	33.0

SECTION 2

SCHEDULES

PROGRAM SCHEDULE - FOUR YEAR

2.1 MASTER SCHEDULE



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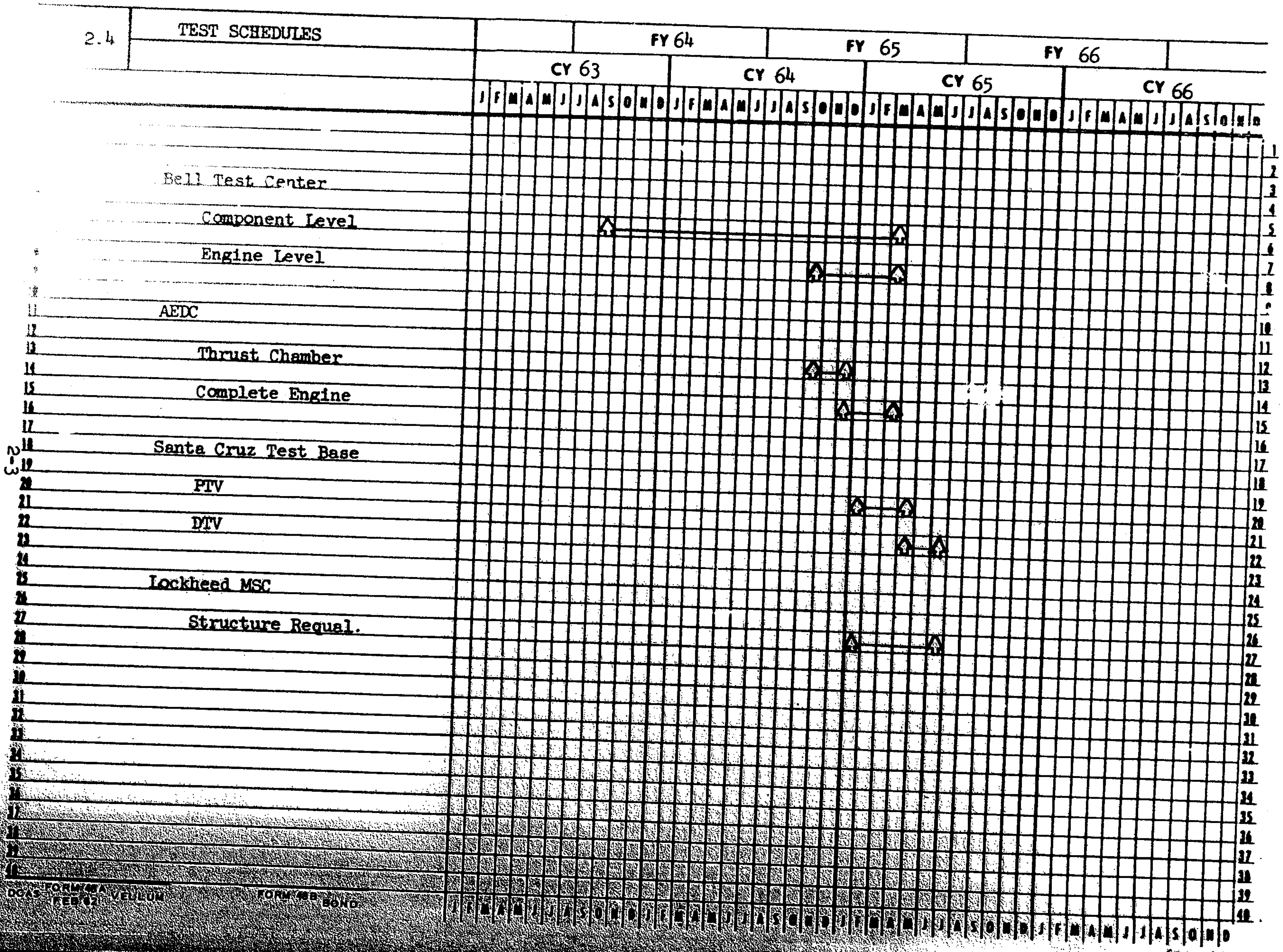
DCASPP (L.A. Calif.) 62-3550

PROGRAM SCHEDULE – FOUR YEAR

2.4 TEST SCHEDULES



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DCASPP (L.A. Calif.) 62-3550

PROGRAM SCHEDULE – FOUR YEAR

FACILITIES

Military Construction

None

Industrial Facilities

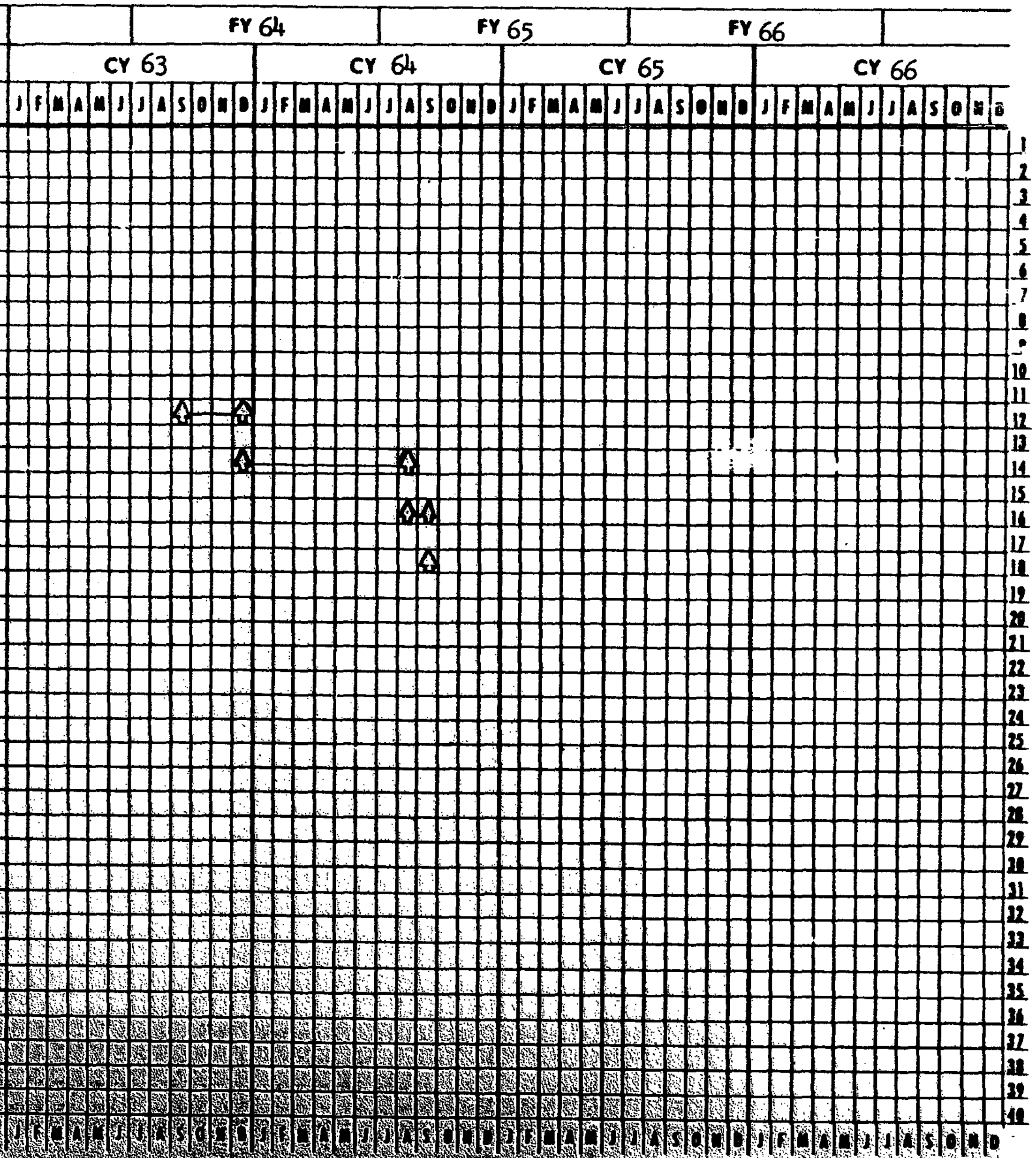
Hybaline Production Facility

Design

Construction/Modification*

Plant Checkout

Initial Production



*Assumes conversion of Muskogee plant. Add 2 months for augmentation of UCC plant.

SECTION 3

PROGRAM MANAGEMENT

No changes are anticipated to the existing Agena management structure. Primary responsibility for program management rests with the Agena Program Office (SSVA) within Hq Space Systems Division (AFSC). The prime contractor is Lockheed Missiles and Space Company, Sunnyvale, California. LMSC subcontracts rocket engine development and production for the Agena program to the Bell Aerosystems Company, Buffalo, New York.

Management procedures, including configuration control, have been fully implemented during the acquisition of SS-01-A and SS-01-B and no changes are anticipated.

SECTION 6

ACQUISITION

6.1 System Description and Performance

The Agena space vehicle is a versatile standardized vehicle which can carry a wide variety of payloads into space, either as a second stage booster or as an orbital vehicle. Approximately thirty optional kits are available for tailoring the Agena to specific missions.

First stage boost is provided by either Atlas or Improved Thor standard launch vehicles. Launch facilities are available for both the Atlantic Missile Range and the Pacific Missile Range.

Two configurations are presented for consideration. Both are based on an 18,000 pound thrust Hybaline/IRFNA rocket engine which is a minimum-change adaptation of the present Agena engine. The minimum change concept has been applied even more stringently to the other subsystems of the vehicle in order to avoid changes, insofar as possible, in factory tooling, AGE, spares, launch equipment, and test equipment.

Configuration No. 1 is essentially the same as the present Agena except that the vehicle structure must be strengthened slightly to carry the higher payloads, and the inner bulkhead of the propellant tank is relocated to optimize the oxidizer/fuel ratio.

Configuration No. 2 is a near-minimum change configuration, but one important concession is made in order to increase performance -- the propellant tank is enlarged by approximately 15%.

Adaptation of the Agena vehicle for use with Hybaline fuel will not change the operational concept. It will, however, provide a substantial increase in performance which is illustrated in Figures 6.1, [illegible] This increase in performance can be used to increase [illegible] and or payload, or, in some cases, it will allow [illegible] smaller and less expensive Thor launch vehicle [illegible].

[illegible] Agena vehicle for use with Hybaline rocket fuel [illegible] structural redesign in order to accommodate the [illegible] and increased thrust. The degree of redesign [illegible] performance increase desired.

Configuration No. 1, being the same size and shape as the present Agena, requires only a modest increase in strength, generally by increasing thickness of material, with very little impact on tooling and test equipment. In many cases structural components can be requalified by similarity. It will be necessary, however, to investigate the requirement for additional thermal shielding in the vicinity of the engine in order to cope with the higher combustion temperature.

Configuration No. 2 requires the same structural redesign as No. 1 plus redesign of the propellant tank. In order to obtain the additional volume without impact on vehicle length or handling equipment, the tank diameter is increased from 60 inches to 63 inches. While the tank redesign and qualification is simple and straightforward, it does require additional engineering, testing, and tooling as reflected in the increased vehicle development costs. In addition, the increased propellant weight will require some increase in skin guage on the booster adapter.

A preliminary investigation of the impact of increased payload and/or increased propellant weight on the launch vehicle indicates that the Improved Thor will have to be strengthened in either case. This effort is estimated at $1,900,000 and will probably require eight months. Atlas, on the other hand, can carry the increased load provided a low-g trajectory is used for Configuration No. 2. (See Figure 6.4).

6.2.2 Propulsion

Based on the favorable results of the feasibility program at BAC, we strongly recommend the immediate initiation of an engine development program. A prime design objective in this program will be the use of YLR81-BA-11 and XLR81-BA-13 design requirements and hardware configuration to insure interchangeability with these engines. This development program will consist of the following:

a. Thrust Chamber

[illegible] scale and full scale evaluation of thrust chamber [illegible] to optimize parameters of mixture ratio, combus- [illegible]), thrust coefficient (C_F), and chamber film coolant.

[illegible] the optimum thrust chamber and nozzle extension

[illegible] performance and durability at sea level (at [illegible] Arnold Engineering and Development Center).

b. Gas Generator

(1) Develop a Hybaline/IRFNA injector suitable for use in the gas generator (GG).

(2) Determine injector performance, operating temperature, solids buildup, duration, and restart capability.

c. Turbine Pump

(1) Determine the effect of mixture ratio on the propellant pumps.

(2) Determine the effect of solids in the GG exhaust on the turbine blades.

(3) Evaluate a new pump-inducer combination capable of operating at a lower net positive suction head.

(4) Evaluate a power take-off pad to drive the hydraulic actuators.

d. Valves and Controls

(1) Develop simplified and more reliable gas generator propellant valve.

(2) Evaluate faster opening and closing main propellant valves to reduce propellant pre- and post-flow losses and associated start-up and tail-off total impulses.

e. Engine Assembly

(1) Fabricate engine mock-up.

(2) Evaluate complete engine performance and durability at sea level (at BAC) and at altitude (at AEDC).

[illegible] theoretical engine and propellant performance.

[illegible] Power Unit

[illegible] an auxiliary power unit to drive the turbine [illegible] the Hybaline/IRFNA gas generator proves to be [illegible] that in the eighth to tenth month of the program, a decision will be made as to which type [illegible] Hybaline/IRFNA or some other) would be carried to [illegible].

The schedule for the above engine development program (Figure 6.5) is predicated upon the present production capability of Hybaline (Figure 6.7). The schedule calls for completion of PFRT in twenty-one months from go-ahead. It should be noted that the engine development program could be completed in fourteen months if adequate quantities of fuel were available.

6.3 Background, Difficulties and Approach

The family of storable liquid rocket fuels known as the Hybalines were developed by the Union Carbide Chemicals Company during the period of late 1960 to 1962. This new class of propellants consisting of aluminum borohydride adducts of organic nitrogen compounds, such as primary and secondary amines, has the desirable characteristics of relatively high performance, along with the physical properties required of an earth or space storable fuel. On the basis of small (100# thrust) motor firings at the Air Force Rocket Propulsion Laboratory in late 1961 and early 1962, the Hybaline A5 material evolved as the best candidate from the standpoint of high performance and optimum physical properties. The characteristics and properties of Hybaline A5 are shown in Figure 6.6.

Because of the relatively new nature of Hybaline A5, an experimental evaluation of its characteristics was essential to determine its actual performance and operational behavior. To accomplish this task, the Air Force Rocket Propulsion Laboratory at Edwards AFB, in November 1962, procured a quantity of this material sufficient to permit thrust chamber testing at a thrust level of approximately 5000 pounds and to conduct supporting laboratory work in the areas of stability, chemical analysis, and material compatibility. The A5 that was procured was [illegible] intended to represent a final fuel but was considered a prototype material which, if the experimental data was promising, would be further developed into a well characterized propellant. Therefore, it was anticipated that some problems would arise concerning the purity and physical properties.

The AFRPL program consisted of a performance testing program, a combustion stability program, and laboratory tests. The testing was intended to identify any operational problems such as safety, handling, transfer [illegible] of the Hybaline as well as providing specific performance data on the Hybaline A5-N204 combination.

[illegible] testing program, which began in December 1962, was [illegible] phase consisting of mixture ratio and injector [illegible] establish performance trends, and a determination of [illegible] pressure upon combustion efficiency. The second [illegible] performance based on the trends established during the first part of the program and would provide data on heat flux and nozzle efficiency. In the initial phase of this program, over 96 tests have been conducted at the 2000 pound thrust level using Hybaline A5 and N204. These tests have served to evaluate twelve different injector patterns. The results of these tests show that the best efficiency obtained at the present time has been approximately 89% Isp which is equivalent to a delivered Isp of 257 sec at 500 psia chamber pressure and sea level exit pressure or 275 sec at 1000 psia chamber pressure and sea level exit pressure. Mixture ratio traverses have indicated lower performance efficiencies at the fuel rich mixture ratios, with the drop off in efficiency occurring around a mixture ratio of 1.0 to 1.2. Varying the chamber pressure over levels of 300, 500, and 1000 psia did not appreciably affect the performance efficiency for a given injector. Comparative tests between N204 and IRFNA with hybaline using the same injector pattern have shown essentially equal performance efficiencies for both combinations. This indicates that it should be possible to extrapolate the trends established with the A5-N204 combination to the A5-IRFNA combination.

A measure of the relative stability for the A5-N204 combustion process was accomplished by firing the propellants in a pulse motor. This is a combustion chamber into which calibrated pulses can be introduced. The size of the pulse required to initiate combustion instalability provides a relative measurement of the stability of the combination and the injector pattern involved. The hardware utilized in these tests had previously been used to test the N204-50/50 combination so that a baseline for comparison was available. The results of the tests indicated the stability of A5-N204 is considerably better than N204-50/50 for the conditions tested. The testing covered a chamber pressure range between 300-800 psia and a mixture ratio between 2.2 to 4.1 using an injector pattern with a performance of approximately 85-87% Isp. Thus the injector performance was fairly good compared to the best injector tested so far at 87% Isp.

The laboratory tests and operational experience gained from the Hybaline tests have demonstrated that the A5 is relatively easy to work with and presents no major problems as far as operating a test system is concerned. Handling and transfer of the Hybaline A5 on the test stand has been accomplished on a routine basis with no difficulty. The [illegible] offers no hazard from toxicity or danger of [illegible] the exhaust produced with either N204 or IRFNA contains n[illegible] undesirable products. Hybaline A5 has been [illegible] with most of the commonly used materials in [illegible] though Hybaline A5 is sensitive to moisture and reacts violently with water, there has been no operational difficulty from this aspect providing proper precautions are observed. Several incidents have occurred where impurities in several batches of the A5 have resulted in problems in the test system, but it appears that modifications in the production process can eliminate these difficulties.

On the basis of the promising results from early testing at AFRPL, an interest was generated in applying the Hybaline A5 fuel to the Agena propulsion system. This interest was further stimulated by the apparent suitability of Hybaline A5 in Agena with IRFNA as an oxidizer. The chemical and physical properties of A5 make it well suited for application to a system such as Agena. The theoretical performance with IRFNA offers a considerable improvement over the existing IRFNA-UDMH propellants. In addition, the density of A5 is similar to UDMH, the chemical nature in terms of compatibility is reasonably similar to UDMH and the mixture ratio for Hybaline A5-IRFNA is in the proper range to make a substitution of A5-IRFNA into the Agena system appear quite attractive. Besides the chemical and density similarities between A5 and UDMH, the retention of IRFNA as the oxidizer might permit the use of IRFNA as a coolant in the same manner as it is used in the present Agena engine.

In January 1963, discussions between AFSSD, AFRPL, Lockheed Missile and Space Company, and Bell Aerosystems Company were held to explore the possibility of test work with Hybaline A5-IRFNA directed towards an Agena application. These preliminary studies and discussions led to a program initiated on 20 March 1963 to demonstrate the feasibility of utilizing Hybaline in the YLR81-BA-11 engine with minimum changes to the present hardware. The program was organized into five parts to investigate the areas of combustion evaluation, gas generator and turbine pump evaluation, thermal transport properties, chemical analysis, and design changes to the engine.

The task on Combustion Evaluation had several objectives: First of all was to determine the combustion efficiency of the A5-IRFNA propellant using Agena type hardware. The present results indicate a C* efficiency of [illegible] can be obtained from Agena type injectors in existing water cooled chambers. The heat rejection rates were also [illegible] water cooled chambers. This was an important area [illegible] rates that are too high would preclude the possibility [illegible] with IRFNA using the present Agena type aluminium [illegible] of the work showed that heat rejection valves were [illegible] values and were approximately the same for [illegible] values obtained indicate that cooling with IRFNA [illegible] the same margin of safety as presently obtained.

The presence of solids in the exhaust posed a potential loss in nozzle efficiency. To investigate this area tests were performed in a diffuser with an Agena thrust chamber using a fully expanded nozzle to an area ratio of 45 to 1. The average C_f delivered from three tests 97.4% of theoretical. C_f for the UDMH-IRFNA engine is 97.1%. This is an encouraging result which apparently indicates no appreciable losses are occurring during expansion through the nozzle. The overall results from the thrust chamber performance tests have indicated it is possible to operate an existing Agena type chamber using A5-IRFNA with the IRFNA acting as a regenerative coolant and to deliver thrust chamber impulse at attitude of over 327 sec.

The purpose of the gas generator and turbopump work was to identify problem areas involved in operating a gas generator using A5-IRFNA as propellants and in driving a turbopump with an exhaust containing an appreciable amount of solids. The choices of either oxidizer rich gas generator operation or fuel rich gas generator operation were possible. Oxidizer rich operation produces less solids than fuel rich operation, but results in a more severe environment for the turbine materials because of the hot oxidizing gases. The results of testing under both conditions indicated the turbine and pump could operate satisfactorily for durations of over 30 seconds with no evidence of harmful effects. This was originally considered to be a critical area and it had been predicted that either the solids or the oxidizing exhaust would have an adverse effect on the turbine. Although the turbopump itself caused no problems, a problem was encountered with burnouts of the gas generator under both oxidizer rich and fuel rich conditions. The problem appears to be one of injector design and it is believed that the burnouts would be eliminated by utilizing a different injector pattern.

In summary, it appears possible to operate a turbopump with either a fuel rich gas generator or an oxidizer rich gas generator provided a satisfactory gas generator can be developed.

The [illegible] on thermal transparent properties was undertaken to investigate the thermal stability of A5 under conditions of heat input such as [illegible] encountered in injector manifolds or coolant passages. In addition [illegible] feasibility of using A5 as a regenerative coolant was examined. [illegible] showed A5 would decompose under both static conditions [illegible] conditions with the evolution of gases and production of [illegible] resolved whether this thermal decomposition was [illegible] impurities present in the A5, but is believed [illegible] would reduce the decomposition rate. The [illegible] a marginal regenerative coolant with a [illegible] equivalent to that of IRFNA.

The effort on chemical analysis was undertaken to determine the "quality of the fuel", to establish quick analytical techniques for determining quality, and to determine physical properties. The study indicated that existing analytical technique need to be improved to accurately determine quality control of A5. The work effort in this area is still in progress.

"Difficulties and Approach"

The experimental data and experience obtained from the BAC feasibility program and from the AFRPL studies with Hybaline A5 indicate that the development program to incorporate the Hybaline A5-IRFNA propellants into the Agena system is feasible. Certainly no problems have been encountered to date which would rule out the possibility of such a system. On the other hand, the evidence is strong that Hybaline can be incorporated into an Agena system with a minimum of major design change. In summary, it can be stated that the characteristics of Hybaline A5 in terms of physical properties, handling data, operating experience, thrust chamber performance, combustion stability, and heat transfer have been experimentally investigated and the results are encouraging for an Agena development program.

Some additional work is required in several areas to support a development program. These areas consist of analytical procedures on the Hybaline A5 propellant to more fully define "quality" of the propellant and to check consistency from batch to batch and run to run. Other areas concerning the fuel are to more accurately establish theoretical performance values, to develop more complete physical property data, and to optimize the manufacturing process. Further test work is required in the engine area to optimize thrust chamber performance, achieve durability of the hardware, develop an A5-IRFNA GG injector, and demonstrate integrated engine operation.

6.4 Test and Evaluation

Category I and II testing, as defined by AFR 80-14, will not be required for this program. However, development testing requirements include tests at AEDC and Santa Cruz Test Base.

Testing [illegible] required to demonstrate the altitude performance of the [illegible] later, of the complete propulsion subsystem. Previous [illegible] upper stage propulsion systems has shown that alti[illegible] performance problems which cannot otherwise be [illegible] AEDC will provide the most reliable data for [illegible] subsystem performance.

Testing at the Lockheed Santa Cruz Test Base is required to demonstrate integration of the propulsion subsystem into the complete Agena vehicle. It will also serve as a training program for LMSC launch base crews and as a verification program for operating and handling procedures. This is particularly important for handling and storage of Hybaline fuel because of the necessary modification to the ground fuel system.

The schedules for these tests are shown in Figure 2.4.

6.5 Hybaline Production Data

The only additional facilities required for this program are production facilities for Hybaline fuel. A survey of existing facilities indicates that the USAF Pentaborane Plant (Installation No. 8699) at Moskogee, Oklahoma, is the only existing plant which could be converted for Hybaline production at reasonable cost. The availability of Hybaline fuel is the pacing item for the development schedule of a Hybaline fueled Agena. The pacing item for conversion of the Muskogee plant is physical access for Union Carbide facility design engineers to the Muskogee plant and to the necessary detailed design data on the Muskogee plant. The generalized data currently available to them is sufficient to assure feasibility of the conversion, but is not sufficient to allow them to start detailed design work.

The USAF plant at Muskogee, Oklahoma, is presently being maintained in a stand-by status by Callery Chemical Corporation under ASD Contract No. 33(600)-41757. The decision has been made, however, to deactivate the plant in October 1963. A portion of this plant, acquired in 1962 at a cost of approximately $32,500,000, could be converted to an initial production capacity of 2,000,000 pounds per year at a cost of approximately $2,700,000. The relative cost of conversion of this plant as compared to augmentation of one of the U.C.C. plants is misleading. That part of the Muskogee plant not used for production of Hybaline has the peculiar capability of being easily converted for production of sodium borohydride, which is the critical raw material for production of Hybaline. The current national capacity for production of sodium borohydride is sufficient for no more than 2,000,000 pounds [illegible] per year. Construction of a new sodium borohydride plant would be much more expensive than conversion of the Muskogee plant. A[illegible] requirement for Hybaline for the Agena program [illegible] pounds per year, it is reasonable to assume that [illegible] of this new fuel will stimulate usage on other [illegible] the capability for future expansion should not

Union Carbide Chemicals Company, developer for Hybaline fuel, has made a study which indicates that they could augment facilities at either of two existing plants in south Texas (Seadrift and Brownsville) to produce up to 2,000,000 pounds of Hybaline per year. Both land and major utilities are available at these sites. Cost of this augmentation is estimated at $3,700,000 and would take about 14 months from go-ahead to initial production delivery.

Consideration of the above factors leads to the obvious conclusion that the Muskogee plant conversion is preferable to augmentation of one of the U.C.C. plants. This choice, however, demands access as soon as possible to the detailed design data on the Muskogee plant. In addition, it is also concluded that a full go-ahead on conversion of the Muskogee plant must be given at the very beginning of any further development effort, however limited, unless we are prepared to accept a day for day slippage of the over-all program.

Production capability in either the converted Muskogee plant or an augmented U.C.C. plant builds up rapidly after completion of the facility, as shown in Figure 6.7. After three months, production capability exceeds requirements for testing. At that time it is anticipated that production would level off at about 50% of maximum for a few months and then drop back to about 25% of maximum. Fortunately, the production process is largely automated so that these large fluctuations in production rate can be economically accommodated.

The cost of Hybaline is strongly affected by production rate, as shown in Figure 6.8. Manpower costs are essentially a function of time rather than rate, due to the high degree of automation. In addition, raw materials, particularly sodium borohydride, are subject to quantity discounts. However, since the national capacity for production of sodium borohydride is only sufficient for 2,000,000 pounds of Hybaline per year, there is a discontinuity in Figure 6.8 at this point.

Above 2,000,000 pounds per year, it would be necessary to obtain additional production facilities for sodium borohydride. This can be accomplished easily at the Muskogee plant with only minor modification to existing facilities. Construction of new facilities would be quite expensive. Production costs in Figure 6.8 are therefore based on production of sodium borohydride at Muskogee for Hybaline rates in excess of 2,000,000 pounds per year.

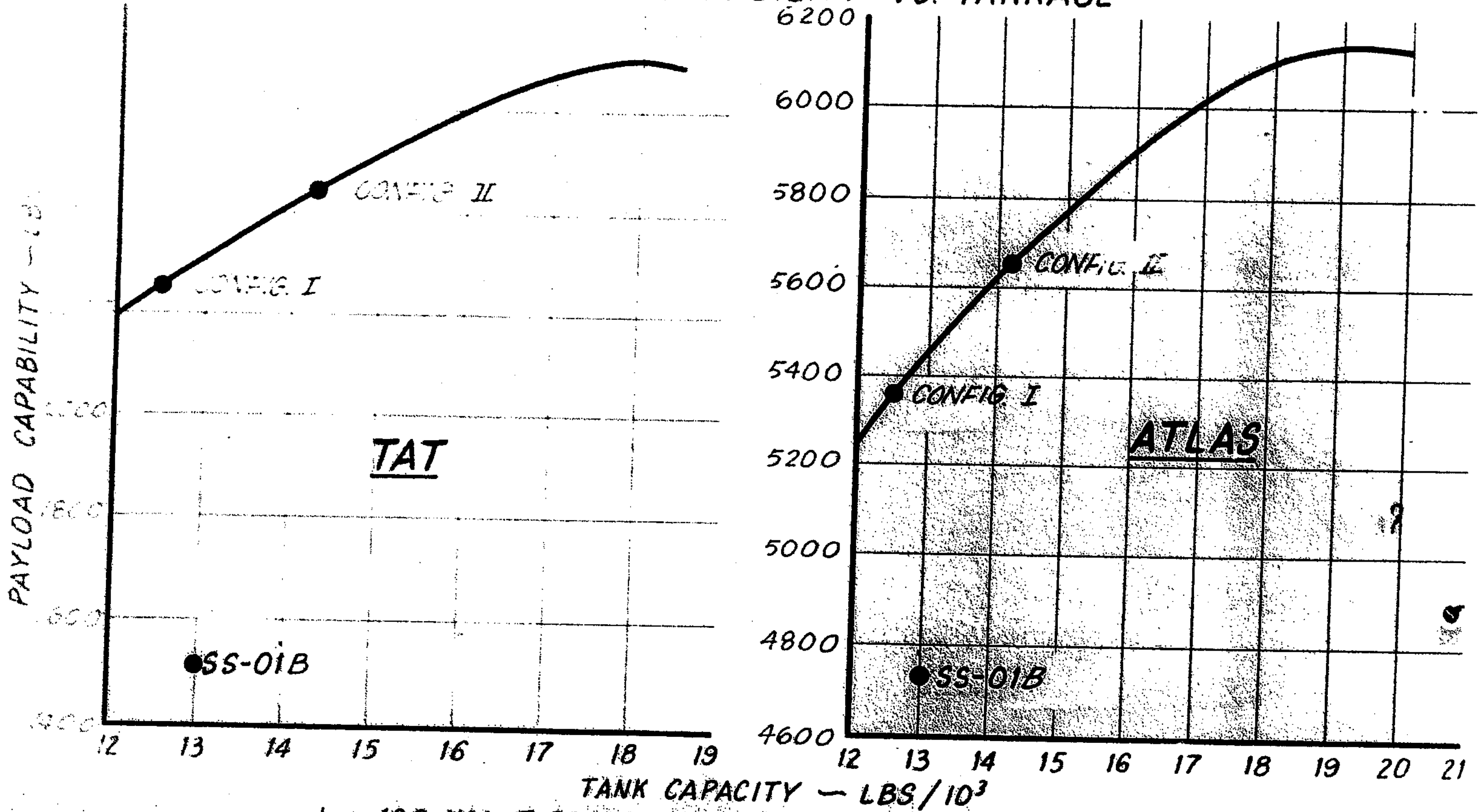
[illegible] of the Hybaline production facility, the only source [illegible] a small pilot plant operated by Union Carbide at [illegible] Virginia. This pilot plant, originally designed for [illegible] per month, is currently operating at 1200 [illegible] development plan is based on the 1200 pound rate in the pilot plant, it is estimated that this output could be further expanded to 1800 pounds per month at a cost of approximately $30,000. Lead time for this modification would be four months. Production at the 1200 pound rate could continue for 3½ months, at which time the plant would have to be shut down for two weeks for installation of the new reactors. The increased output would be more efficient, thereby reducing the cost of Hybaline from $80 per pound to $70. The net gain in production capability prior to completion of the full scale production facility would be 4200 pounds, which would accelerate the engine development effort by about one month at a net cost of $170,000.

In constrast to expansion of the pilot plant, acceleration of the construction schedule for the full scale production facility would result in a direct saving of $74,000 per month due to decreased cost of Hybaline and at the same time allow earlier completion of the over-all program by an amount almost equal to the acceleration of the Hybaline production facility. Management attention should therefore be directed toward expediting completion of this facility. There is also the possibility of a favorable trade-off between premium construction costs (overtime) and the reduced cost of fuel, although this trade-off is complicated by administrative problems because two different categories of funds are involved.

S-01A

SS-OIB/A-5 IMPROVEMENT PROGRAM

PAYLOAD CAPABILITY VS. TANKAGE



hp = 100 NM, T = 91 MIN, PMR, 85° INCLINATION, I_{sp} = 325 SEC,
THRUST = 18 K, INERT WT = 1999 LBS - NOMINAL PERFORMANCE

~~CONFIDENTIAL~~

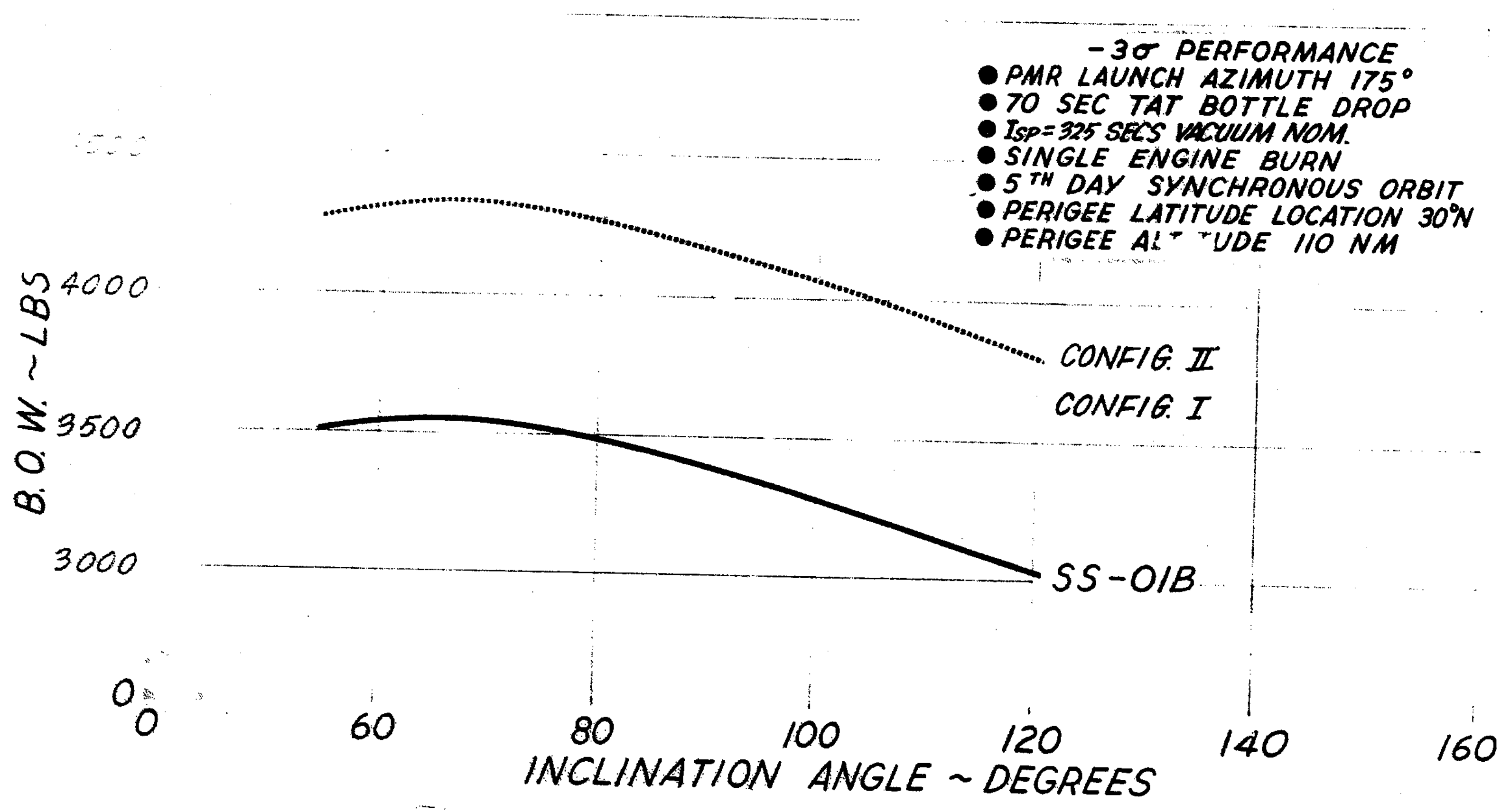
Fig. 6.1

~~CONFIDENTIAL~~

S-01A

SS-01B/A-5 IMPROVEMENT PROGRAM (U)

PERFORMANCE CAPABILITIES FOR PROG 162



P-16338 "S-01A" 7-19-63
LMSC A382916 CY S-1

~~CONFIDENTIAL~~

Fig 6.2

SS-01B/A5 IMPROVEMENT PROGRAM (U)

PERFORMANCE CAPABILITIES FOR SAMPLE PROGRAMS

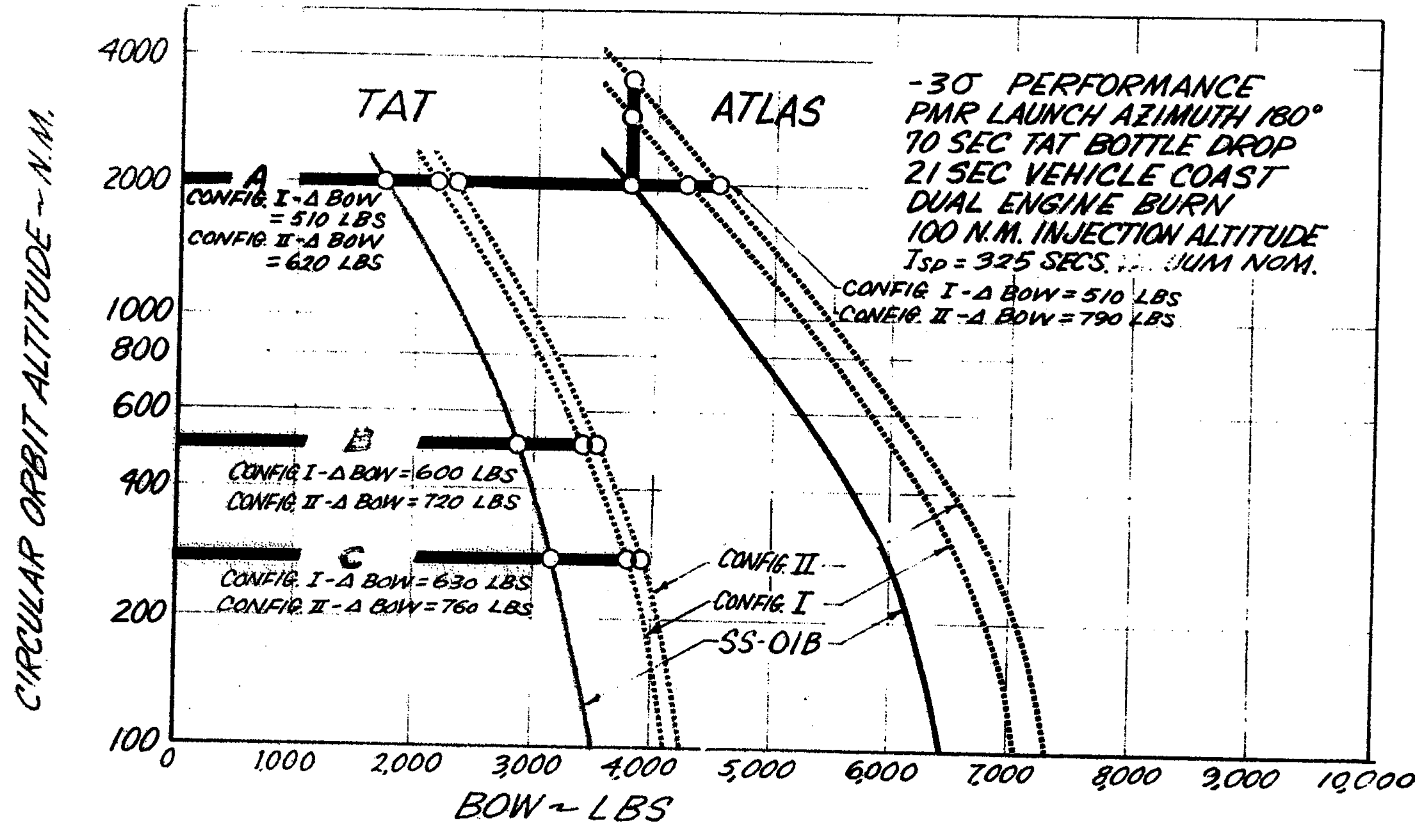


Fig. 6.3

SS-OIB/A-5 IMPROVEMENT PROGRAM

BOOSTER AXIAL STRENGTH

- TAT REQUIRES STRUCTURAL MODIFICATION FOR MAXIMUM LONGITUDINAL LOAD CONDITION
- ATLAS STRUCTURALLY ADEQUATE AT ADJUSTED TRAJECTORY LOAD FACTORS

BOOSTER	ALTERNATE CONFIGURATION	LOAD FACTORS	LIMIT AXIAL LOAD (LBS)	LIMIT ALLOWABLE AXIAL LOAD (LBS)
TAT	I II	6 g's 6 "	188,000 200,000	165,000 164,000
ATLAS	I	5 " 7 "	95,000 135,000	146,000 143,000
	II	5 " 7 "	108,000 154,000	145,000 142,000

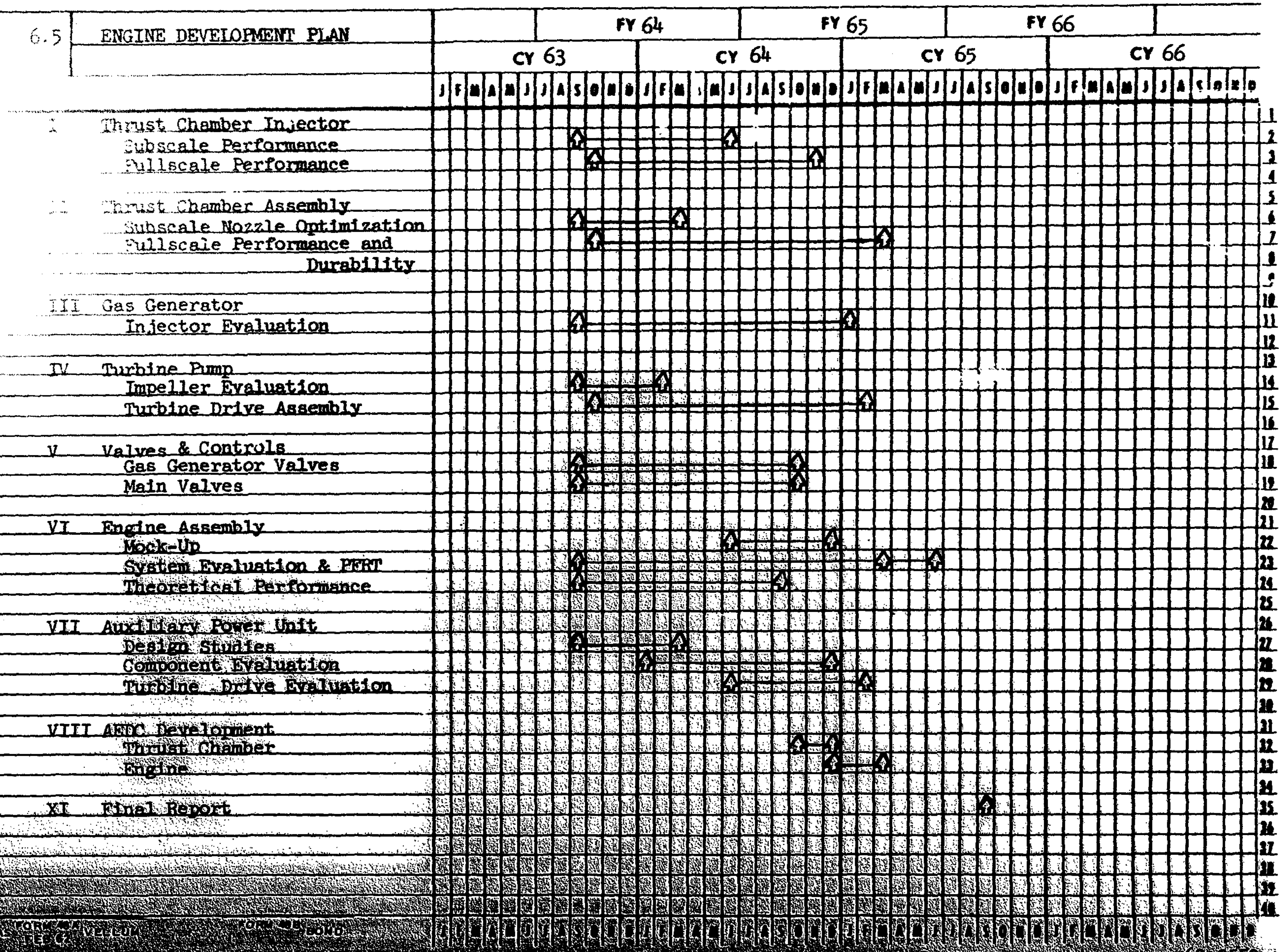
NOTE: (1) MECO(-)8 SEC FOR TAT, MECO FOR ATLAS
(2) INCLUDES RIGID & ELASTIC CONSIDERATIONS
(3) CRITICAL CONDITION AT BOOSTER INTERFACE

UNCLASSIFIED

FIG. 6.7

PROGRAM SCHEDULE - FOUR YEAR

6.5 ENGINE DEVELOPMENT PLAN



DCAS FORM [illegible] VELLUM FORM [illegible] BOND

DCASR [illegible] 62-3550

~~CONFIDENTIAL~~

PHYSICAL PROPERTIES OF HYBALINE A_5

Name	Mixed methylamine-dimethylamine monoaluminum borohydride
Structural Formula	$CH_3NH_2 \cdot Al(BH_4)_3$ 53% by wt $(CH_3)_2NH \cdot Al(BH_4)_3$ 47% by wt
Empirical Formula	$C_{1.47}NH_{17.94}AlB_3$
Molecular Weight	109.19
Density, gm/ml 20°C	0.736
Vapor Pressure, mm Hg 25°C	3 (a)
Freezing Point, °C	-50.0 (b)
Boiling Point, °C	263
Viscosity, cp 20°C	6.78
Thermal Stability, °C	90-100 (c)
Shock-Sensitivity, Kg/cm	120.0 (d)
Air-Sensitivity	Oxidizes slowly in air without ignition
Heat of Formation, Kcal/gm-mole	+11.0 (e)
Surface Tension, dynes cm	48
Auto-combustion Temperature, °F	298
Enthalpy, cal/gm, 10°C	6.0
Specific Heat, cal/gm, 20°C	0.621
Critical Temperature, °C	350 to 500
Heat of Vaporization, 25°C cal/mol	4990
Thermal Conductivity, cal/sec. cm °C at 20°C	340×10^{-6}

(a) Vapor [illegible] of pure compound.

(b) Sets [illegible] below -50°C.

(c) [illegible], 5.7 per cent decomposed after 5.5 hours at 215°C.

(d) [illegible] Olin Mathieson drop weight tester.

(e) [illegible] +17.7 ΔH_f° for aluminum borohydride, and the [illegible] amine ligands.

[illegible] empirical method.

DOWNGRADED AT 3 YEAR INTERVA
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

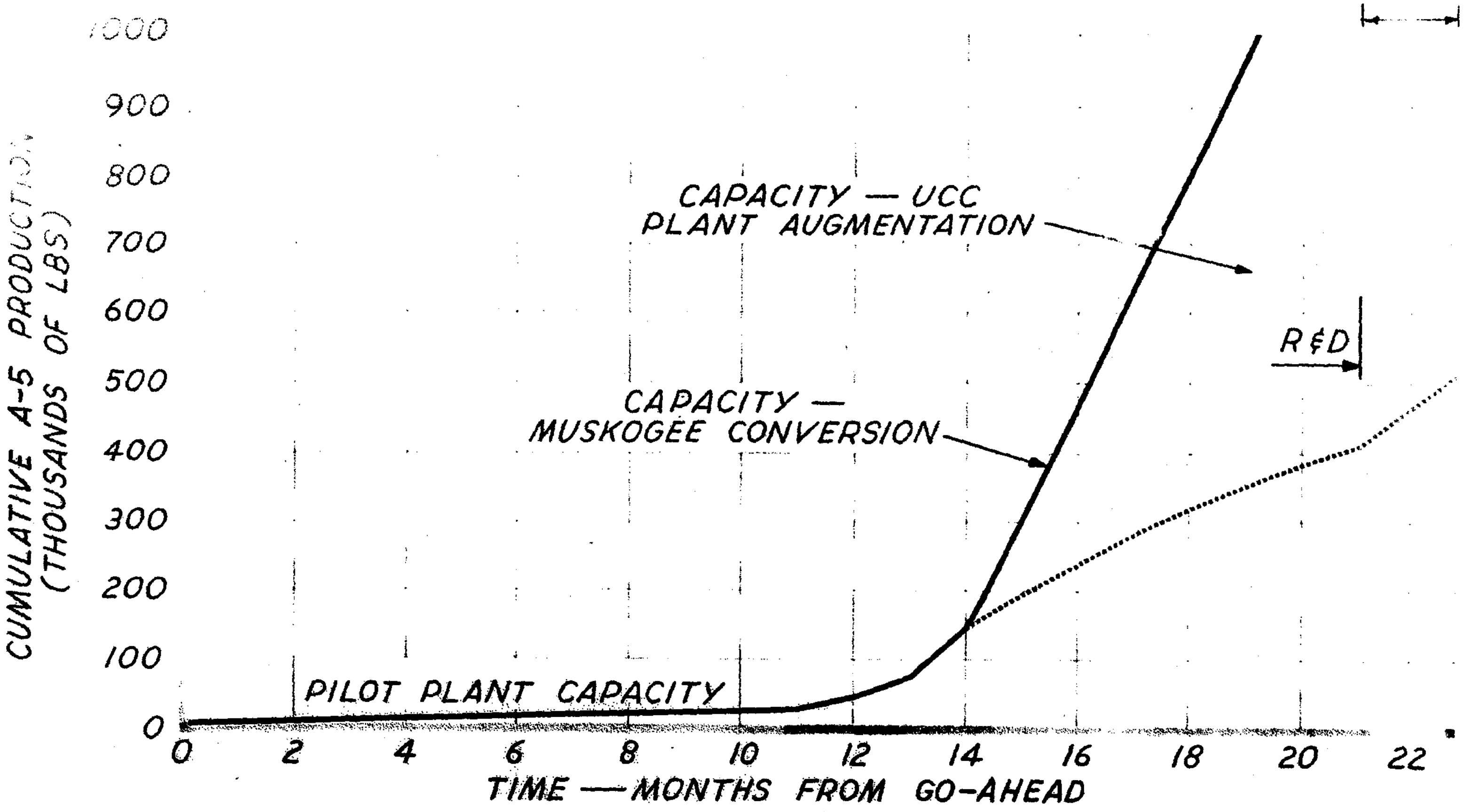
~~NFIDENTIAL~~

Fig. 6.6

S-01A

SS-01B/A-5 IMPROVEMENT PROGRAM

A-5 PRODUCTION CAPABILITY



P-16334 "S-01A" 7-19-63
CY S-1

Fig. 6.7

SS-01B/A-5 IMPROVEMENT PROGRAM

COST VS. QUANTITY OF A-5

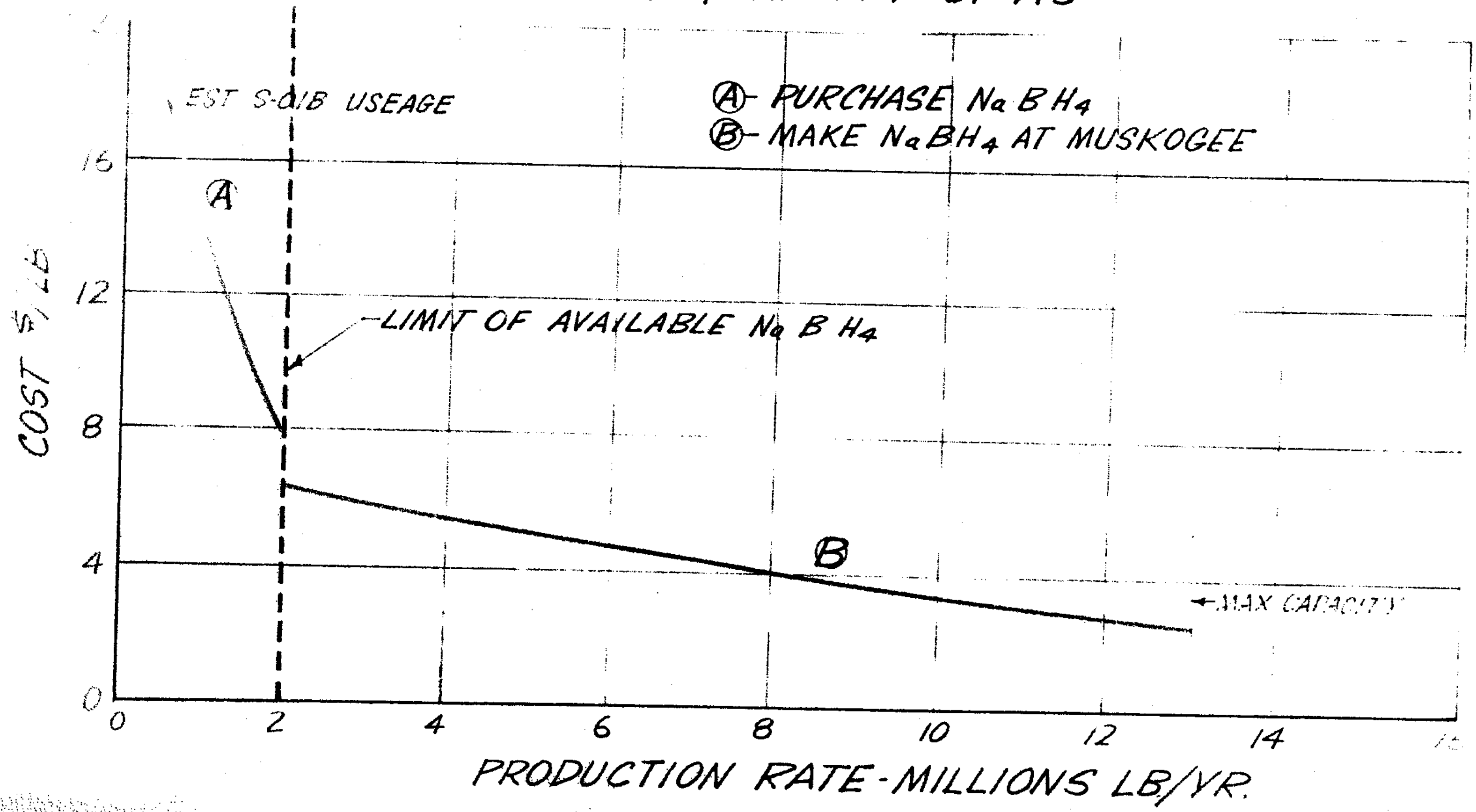


Fig. 6.8

SECTION 11

FINANCIAL

CONFIGURATION I

ITEM	FY 64	FY 65	FY 66	TOTAL
RDT&E				
Airframe				
LMSC	0.5	3.1		3.6
DAC		1.9		1.9
Propulsion				
LMSC	0.2	0.4		0.6
BAC	3.7	9.3		13.0
Fuel	1.0	7.6		8.6
Reliability Demonstration		1.0	4.0	5.0
AGE		0.1		0.1
Total RDT&E	5.4	23.4	4.0	32.8
Industrial Facilities				
Hybaline Production Plant	2.0	0.7		2.7
GRAND TOTAL	7.4	24.1	4.0	35.5

CONFIGURATION II

ITEM	FY 64	FY 65	FY 66	TOTAL
RDT&E				
Airframe				
LMSC	0.5	5.6		6.1
DAC		1.9		1.9
Propulsion				
LMSC	0.2	0.4		0.6
BAC	3.7	9.3		13.0
Fuel	1.0	7.6		8.6
Reliability Demonstration		1.0	4.0	5.0
AGE		0.1		0.1
Total RDT&E	5.4	25.9	4.0	35.3
Industrial Facilities				
Hybaline Production Plant	2.0	0.7		2.7
GRAND TOTAL	7.4	26.6	4.0	38.0

SECTION 12

REQUIREMENTS

Directors of Program 162 and SAFSP programs have expressed great interest in performance increases of the order of magnitude of the increased proposed in this plan. Justification of requirements will be left to the program directors concerned.

SECTION 13

AUTHORIZATIONS

FM HQ USAF WASH DC
TO RUE AFF/AFSC ANDREWS AFB MD
INFO RUEAFF/AFSC (SCSB) (COLONEL CRISTRADORO) ANDREWS AFB MD
RUWHBK/SSD (SSZA (LT COLONEL LEBECK) LOS ANGELES CALIF
RUWHBF/ROCKET PROPULSION LAB (DGGD) EDWARDS AFB CALIF
AF GRNC
NT
UNCLAS FROM AFRSTD 76993
SUBJECT: HYBALINE PROGRAM. REFERENCE OUR MESSAGE 75215, 1 JULY 1963, SAME SUBJECT. UNDER SECRETARY MCMILLAN HAS CLARIFIED HIS REQUEST FOR INFORMATION ON THE HYBALINE PROGRAM. HE WOULD LIKE A PRELIMINARY DEVELOPMENT PLAN PUT TOGETHER FOR A HYBALINE FUELED AGENA WHICH INDICATES THE QUANTITIES AND TIME PHASING OF HYBALINE REQUIRED. HE HAS STATED THAT THIS PLANNING DOES NOT NECESSARILY INDICATE THAT WE WILL PROCEED WITH AN ENGINE DEVELOPMENT PROGRAM EVEN IF THE PRESENT BELL EFFORT IS SUCCESSFUL. DR. MCMILLAN HAS ASKED FOR A BRIEFING ON THE PRELIMINARY DEVELOPMENT PLAN AROUND THE END OF JULY. PLEASE CONFIRM DATE THIS BRIEFING WILL BE AVAILABLE.

P 1520457
FM DCMSF ANDREWS AFB MD
TO RUWHBK/SSD LOS ANGELES CALIF
RUEABL/RTD BOLLING AFB WASH DC
INFO RUWHBF/ROCKET PROPULSION LABORATORY EDWARDS AFB CALIF
BI
UNCLAS MSFA 15-7-22
FOR SSV (COL BLUM). RTD FOR RTNP; RPL FOR DGGD. THIS CONFIRMS 12 JULY 1963 TELECON BETWEEN COL BLUM (SSV) AND MSFAM PERSONNEL. REQUEST SSD COMPLY WITH USAF MESSAGE AFRSTD 76993. FURTHER REQUEST RTD ASSIST SSD IN PREPARATION AND PRESENTATION OF THE REQUIRED PLAN. THIS OFFICE UN[illegible] [illegible] THE BRIEFING WILL BE AVAILABLE WEEK OF 29 JULY. WE WILL [illegible] ACCORDINGLY AND ADVISE OF PRESENTATION SCHEDULE AS SOON [illegible]

SECTION 15

SECURITY

The chemical formula, detailed physical properties, and detailed performance data on Hybaline (A5) rocket fuel are confidential.

The performance characteristics of the Agena Space Vehicle, in general, are confidential. When the performance of the Agena with specific payloads is presented, the security classification of their combined performance is controlled by the security classification of the using program except that it will never be less than confidential.