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THE THOR-AGENA STORY

draft prepared by

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Contents:

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Chapter 1

INTRODUCTION

Since the close of the Second World War American military services have been activiay interested in earth-circling satellites. Pertinant German reasearch came to the attention of American military personnel and under the sponsorship of the Army Air Forces, the RAND Corporation undertook feasibility studies of earth satellites. In September 1947, an Air Force preliminary study + evaluation of RAND reports revealed that a satellite was technically feasible,[1] and in 1948 the Air Force, as an independent service, requested RAND to establish a program for the further investigation of possible satellite development.[2] During the next few years, RAND studied the problem under the code name Feedback. By 1954 the compnay had reported that a space vehicle could be placed in an earth orbit by a rockbt powered booster. RAND personnel recognized that numerous system component development problemms existed but such hardware development would not require radically new technology or enourmous costs

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1. Ltr, TSEON (TSEON-9) circa Dec 1947 from Ch Engr Div Brig Gen Allen R Crawford to CofS ...

2. Ltr 1 May 48 Crawford to Douglas Aircraft Co, 17 Feb 1948, subj: Satellite Project

[redacted]

[redacted]

About the time RAND was completing its study, the Air Force established a research and development program on an advanced reconnaissance system, ~~[illegible]~~ ~~The~~ Wright Air Development Center, Dayton, Ohio, was responsible for managing the program.called Project 1115. Air Force personnel made ~~intensive feasibility studies~~ including such critical component developmmat areas as satellite-born electrical power for equipment operation and component reliability in a satellite enviornment.

By 1955 the Air Force had obtained sufficient data to insure that the problems were surmountable. which permitted system design studies to begin. Consequently, in that year, ~~[illegible]~~ Wright center awarded ~~1st~~ design study contracts to Radio Corporation of America, Glenn L. Martin Company, and Lockheed Aircraft Corporation.for the purpose of determining if a [illegible] recomnaisance ~~xtx~~ satellite system could be developed within a [illegible] time span which would warrent a full scale development effort. These "Pied Piper" studies [illegible] ~~[illegible]~~ submitted by all three contractors showed that the systam could be developed.

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With these positive reports, the Air Force felt that it could begin hardware development under the title WS 117L. The Air Reseack and Development Command beleived that it would be best for Western Development Division located in the Los Angeles area to manage the program. The Los Angeles division managed the ballistic missile top national priority program, and since the WS 117L system would have to use a missile as the first stage booster and the change of location was an attempt to remove potenteial military satellite areas of conflict between the two programs. During 1956, management functions passed from the Wright center to the missile division.

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Personnel from both Wright center and the ~~[illegible]~~ *Los Angeles* division combined their ~~[illegible]~~ talents in the preparation of a WS 117L development plan. ~~[illegible]~~ *In May 1956 Washington authorities including* ~~to Air Force agencies and to~~ Secretary of the Air Force Donald A Quarles, and the Predidnat's Science Advisory Committee *generally approved the plan.* ** approved 24 Jul 56*

The ~~[illegible]~~ plan called for a two stage vehicle which could be launched from United States territory. The booster or first stage would be an intercontinental ballistic missile which would fall away when the engine burned out at about 3,000 miles from the [illegible] pad. The second stage would be the orbiting vehicle, which would have a ~~[illegible]~~ propulsion system to supply the necessary power to propel the vehicle into a speed necessary for orbit. The vehicle would ~~[illegible]~~ ascend to an altitude of about [illegible] miles where an orbit would be assumed, and internal controls would orient the vehicle in the proper attitude.

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** from WADC History*

Typed Data [illegible] same as Rocket history

[redacted]

[redacted]

Meanwhile im March 1956, an Air Force board convened at Wright center to study the Pied Piper designs and to recommend a contractor for hardware development. The board recommended Lockheed as the prime systems contractor and this action was subsequently approved by the Department of Defense. The Air Force formally awarded the contract to Lockheed's Missile and Space Division at Sunnyvale, California on 29 October 1956.

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[redacted]

~~Despite [illegible]~~ [redacted]

The development plan had specified $32.1 million for fiscal 1957. However, despite the program's high national priority, there was a chronic shortage of funds during the ensuing twelve months. The defense department had already planned its fiscal 1957 budget and consequently there was a time lag while the budget was juggled. ~~But of even greater importance was the extremely conservative approach of Assistant Secretary of Defense Quarles to the entire program.~~ The first funds finally arrived on the West Coast in December 1956, but only in the amount of $3 million. Subsequently, during 1957, this amount was incrementally increased to a total of $13.9 million. The Western Development Division made repeated efforts to relieve the situation with no appreciable results.

Of greater importance was the extremely conservative approach of Assistant Secretary of Defense Quarles to the entire program. He would not authorize the fabrication of mock-ups or experimental vehicles. He wanted the development to continue at a slow pace, to be conducted along conventional lines, ~~with an initial flight target date~~ some time after 1 January 1960. Aside [illegible] about the usefulness of a military satellite, there was concern over the possible political repercussions arising from the use of a military

[redacted]

[redacted]

space vehicle.

~~As a matter of policy no mock-up or experimental vehicle was to be finished without Quarles' permission. During this time period [illegible]~~

The fund limitation and the defense department's general attitude caused WS 117L program activity to be channeled into component rather than total system development. On a short supply of funds, ~~During the pre-Sputnick~~ ~~era~~ Lockheed began satellite airframe design studies, investigated sources ~~mfx~~ for satellite-born auxilary power and attitude contol systems, and selected a ~~searched for~~ satellite propulsion systems which would be available at an early date. Indeed some technical progress was made but of equal ~~same~~ impprtance a contractor team had been ~~mxkx~~ assembled and a broad base established from which rapid expansion could grow.

(based largely on hist rpt, WS 117L, Jan-Dec 56; short hist & chronology WS 117L, 1946-1959)

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Acceleration

In July 1957 the division (renamed Air Force Ballistic Missile Division on 1 June 1957) submitted a new development plan which specified that if the current level of funding continued, September 1959 would be a realistic target date for the first launch. However, a more desirable level of funding—$47 million for fiscal 1958 and $142.5 million for fiscal 1959—would enable a first launch in March 1959. The Air Force Council recommended the "desirable level" of funds, but before the Department of Defense gave approval, the Soviet Union launched Sputnik I on 4 October causing political and emotional repercussions.

A few days later, the "desirable level" and Air Force secretary James H Douglas' approval, Air Force headquarters released part of the 1958 funds to the division. When the new defense secretary Neil McElroy was briefed on 29 October 1957, he was so enthusiastic that he directed the immediate release of the balance of the 1958 funds and that the [illegible] program proceed as rapidly as good management would permit.

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Also during the crisis atmosphere following the first Sputnik, both RAND and the Department of the Air Force urged that Thor boosters be used in conjuction with the planned Lockheed 117L upperstage to provide an early space demonstration. In addition two special advisory groups created to consider steps for reviving United States prestige arrived independently at the same conclusion.

In February the Secretary of the Air Force asked for approval of a program acceleration based on expanded use of Thor-boosted satellites, but a decision was delayed pending the Department of Defense's activation of the new Advanced Research Projects Agency. The overall management of the WS 117L program was to be one of the task of the new agency. On 28 February, the new agency's director Roy Johnson approved the Thor-117L combination for early flight tests and as a means of conducting biomedical experiments.

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The principal obstacle to WS 117L acceleration remained funding. Not until June 1958 were the various proposals and counterproposals reduced to an approved program. At that point, the Thor-WS 117L phase

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received enough money to support the fabrication of the first 12 vehicles. By this time, thetotal 117L effort was under the new agency's control, the Secretary of Defense gradually making the shift between February and June.

During December 1958, the Advanced Research Projects Agency divided the original WS 117L program into three specialized projects, two of these include the Atlas as a booster and the other retain the Thor. The Thor boosted program involved space engineering test functions, biomedical experimentation, development of recovery techniques, and associated military support activities. Eleven months later, on 17 November 1959, the Secretary of Defense transferred the Thor-Agena (as the second stage began to be called) to the Air Force. However, for any program changed, the Air Force Ballistic Missile Division would have to receive approval from the Department of Defense Director of Development, Research and Engineering.

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The Thor-Agena, booster-satellite combination representdd an early and major Air Force achievement in that it was the first hardware combination to progress to almost routine launchings and payload recoveryes. Although each stage was used with other space hardware combinations, the AirForce used the two stages together for flight tests more freqeuntly than any other combination. The original Thor-Agena flight proposal was 5 in January 1958, increased to 10, 13, 15, 19, and then 25 flights by 30 April 1959. Shortly after the first complete flight sucesses, --launch, orbit, and capsule recovery--a new production growth began in August 1960. The approved total moved upward from 35 to 41, then to 44, 60, and 65 by July 1962. Of comparable or greater importance, Director of Defense? Research and Engineering in October 1961 had authorized indefinite continuation of production to provide adequate numbers of Thors and Agenas for a variety of space projects.

(based largely on USAF Space Programs, 1945-1962)

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Chapter 2 [redacted]

THOR ADAPTATION

In November 1955 the Department of Defense assigned the development of the Thor 1,500 mile intermediate range ballistic missile to the Air Force. By the end of the year the Air Force's Western Development Division ~~had solicited Ramo-Wooldridge to perform system engineering and technical direction and~~ had let a letter contract with Douglas Aircraft Company to development the airframe, assemble the various systems, and test the entire package under the technical direction of Ramo-Wooldridge. With the backlog of experience gained during the early development of the intercontinental ballistic missile, and with the decision to use components and facilities under development for the longer range missiles, the Thor development time was greatly lessened. In fact, just fourteen months after the contract award, flight tests began at Cape Canaveral, and they continued until February 1960 after 48 Thors had been expended perfecting the [illegible] component parts. Actually the [illegible] which eventually came to be used in the Thor booster had gained considerable early experience in special reentry vehicle tests and satellite launches.

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Guidance

~~[illegible]~~

For intercontinental ballistic missiles the Air Force had let two 1955 contracts for development guidance systems. AC Spark Plug Company--a subsidary of General Motors--was to develop an all-inertial system and Western Electric's Bell Telephone Laboratories was to develop a radio-inertial system. ~~Following the decision to to develop the Then there was~~

After the Thor became part of the Air Force missile development program, there was no immediate decison on which guidance sys tem to apply to the short (IRBM) range missile. However, after a series of program changes ending in May 1958, the Air Force Ballistic Missile Division definitely assigned the AC Spark Plug to the Thor and the Bell system to the early Titan combat squadrons.

However, the AC Spark Plug system would not be ready for flight tests until November, while Air Force planners had scheduled some Thor development flights between June and October to carry the Bell system.

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[redacted]

The necessary ground equipment for the radio-guidance would be ready at Cape Canaveral and ~~xxxx~~ since there was no interference with the AC Spark Plug system development, the Air Force allowed the schedule to ~~dxx~~ stand.

Beginning in July 1958 there was a series of three ~~space~~ lunar probes ~~launches~~ from Cape Canaveral using the Thor as the first stage booster.but without a guidance system. All three were failures ~~but~~ primarily due to instability in ~~the propulsion system~~ Thor engines rather than due to ~~xxxx~~q inadequate guidance.

In the meantime, the Air Force Ballistic Missile Division was making plans for the first Thor-117L launches from Cooke Air Force Base -- later Vandenberg Air Force Base. By September 1958, the division had definitely decided not to use any of the unproven guidance systems and to rely on the Thor's autopilot and electronic programmer. (contr -65, sup 15, amend 1, 29 Sep 58)

~~During 1959 the development of the AC Spark Plug system continued ... and after all improvements ..., the system weighed 1,800 pounds.~~

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But when this decision was made, the guidance systems were still under development. Developers gradually decreased the missile-borne weight of the radio-guidance system, while the inherently heavier all-inertial system gained more weight. By the end of 1959 the operationally configured Thor guidance system weighed 1,800 pounds. Bell had reduced the radio-inertial systems weight to 140 pounds for use in four successfully guided reentry vehicle tests during first half of 1959. The same configured system was used in Titan flight tests beginning in February 1960. The Bell system also contributed to the successful launch of a Thor boosted satellite from Cape Canaveral on 1 April 1960.

At Vandenberg, as part of the Titan program, the Air Force had established launch installations with one radio antenna and computer. However, by January 1960 one of these installations was abandoned and consequently, the ground guidance equipment was available for other programs.

During 1960, Bell had made additional improvements [redacted] in the airborne guidance components consisted of two canisters weighing a total 80 pounds. In order to improve and increase the reliability of the booster's programmed trajectory, the division decided to use the system in the Thor

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Propulsion

For the Atlas ~~xxxxxx~~ missile, the Rocketdyne Division of North American Aviation Company was develåping two ~~xxxxxxxxxxxxx~~ booster and two vernier engines with thrusts of 150,000 pounds and higher for ~~the~~ each booster and 1,000 pounds for each vernier. In early 1956, the Air Force directed Rocetdyne to adapt one of the booster engines and ~~xxxxxx~~ the two vernier engines for use in the Thor missile. Rocketdyne was/to deliver the required engines to Douglas, who was responsible for their installation in the ~~missile~~frame. For flight tests Douglas received the first 150,000 pound thrust engine in January 1957. During the following ~~year~~ twenty months Rocetdyne made improvements including an integrated start system and made extensive tests. Douglas received ~~xxxxxx~~ The ~~final operationally configured engine -LR-79-NA-7 as~~ ~~xxxxx~~ for flight tests in November 1958.

However, ~~during~~ previous/static and flight tests revealed ~~xxxxxxxxxxxxxx~~ difficeinties particularlyk ~~the~~ in the turbopump. Reocetdyne found solutions and [redacted] incprporated them ~~and~~ into another desinged engine --[redacted] which was ready for flight tests beginning in April 1959. As part of available Thor Missiles, both these engines helped boost Agenas into orbit.
~~Although the Thor weapon system program office was concerned with~~

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contractors had proposed further engine development with a goal 6

of increasing the thrust to 165,000 pounds. [redacted]

Although these 150,000 pound engines met the requirements of the Thor weapon system, space programs were interested in a higher thrust engine. By April 1959 the Air Force Ballistic Missile Division established a requirement for a the higher pound thrust engine. Following static and three succesful flight tests during January and February 1960, the improved engine—LR 79-NA-11— was available for use in Thor space boosters.

15 The Thor engines had been calibrated to burn RP-1 fuel, but in an effort to increase the payload capacity of the Thor-Agena, the division in mid-1959 decided to switch to the RJ-1 fuel. This fuel Rocketdyne had developed the fuel for the Navaho ramjet engine. RJ-1 was quite similar to RP-1 except that it was denser and had higher energy qualities. Captive tests using the LR79-NA-9 engine had indicated that the fuel would increase the velocity of the booster by a matter of seconds, but a study of flight data in January 1961 showed that there had been no significant advantage in using the RJ-1 fuel. Nevertheless, the Air Force continued to use the denser fuel for Thor-Age[...]s and R[...] LR79-NA-11 engines for RJ-1 consumption. [redacted]

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Misssile Production

Just prior to Sputnik, the Air Force heqdquarters had authrized a total proudction of 175 Thor missales at a rate of two per month. If this programmed had been followed, the first operationally configured missile would not have been ready before November 1960. (STL final rpt)(TWX 14 Aug 58). However, following Sputnik, the Air Force tripled the planned production rate, reduced the number of research and development type missiles, and set a goal of June 1958 for the delivery of the first operationally configured missile. In making these revisions the Air Force cut the number of missiles to be produced back to the bare essentialls for the Thor program, a total of 147. (STL final rpt; TWX 2 Dec 57). On 6 January 1958, General Schriver appealed to the Air Force Chief of

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[redacted]

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Staff to reinstate 24 missiles [redacted]ram in order to accomplish objectives not directedy related to the Thor weapon system program. (ltr 6 Jan 58) Such objectives included tests of reentry vehicles, early demonstrations of an intercontinental ballistic missile capability and possible space launches. Under Secretary of the Air Force Malcolm A. MacIntyre approved the additional missiles and authorized an increased production rate of eight per month beginning in November 1958. (memo 31 Jan 58; TWX, 7 Feb 58)

Within another year and half, Washington authorities allocated a total of 64 Thors for "special purposes." and had authorized a production rate of nine missiles per month beginning in February 1959, extending through September 1959, and then tapering off to four per month from February through October 1960 when the last missile would roll off the assembly line. (STL final rpt)

Since February 1958, the Air Force had planned on activating four Thor squadrons of 15 missiles each in the United Kingdom. In addition, late in 1959, Washington had directed the Air Force Ballistic Missile Division to protect the capability of activating a fifth squadron with ten missiles. On 23 February 1960, Air Force headquarters canceled the requirement, but not until after most of the missiles had started through the assembly line. The division had to allow

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a minimum of twelve months for a Thor to pass through the line. So, the division had another ten missiles that [could be modified] ~~were~~ available for space programs.

With the termination of ~~the~~ Thor development ~~phase~~ at the end of 1959 (except for engines), the ~~Air Force Ballistic~~ Air Research and Development Command transfered the executive management responsiblity ~~from~~ to the Air Material Command. The Air Force Ballsitic Missile Division ~~x~~cancelled the system engineering and technical direction role held by Space Technology Laboratories, a subsidary of Ramo-Woolridge, ~~and~~ contracted with Douglas for system engineering, and ~~xxxxxxx~~ retained ~~the~~ technical direction for itself. (Wky D[illegible] ies, 3 Sep 59, 29Oct 59)

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For these early space launhces, the Air Force had Douglas take a missile off the assembly line and modify as neccessary to meet the required program. However beginning in November 1959, technicans had established specifications for a Thor booster which would be used. All operational missiles had been produced. Called the DM-21 missiles frame. The principle difference between the booster frame and that of the operational configuration was that latter's its transition section where the AC Spark Plug guicance Sytem would have located was shortened by five feet. The space prgrammers were not using a guidance section(?) so a long body was not needed and it improved the aerodynamic capability of the combined launch system. Since Rocketdyne's LR79-NA-9 and LR79-NA-11 engines were interchanegable from one missile frame to another, the contractor could install the 165,000 pound thrust engine in DM-21s to meet program requirements. when the engine was available.

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[redacted]

[redacted]

In Februayy 1960, the Secretary of Defense approved the fiseâl year 1960 reasearch and development program. xx and the Air Force headequarters directed the Air Force Ballistic Missile Division to produce fourteen more Thors to boost Agenas inbd orbit. (TWX 27 Feb 60, justifyx 16 Mar 60; TWX 28 Sep 60) Consequently the division was able to contract with Douglas to begin production of the DM-21s. However, the authority limited the production to two per month, thmsx so the con tract specified production would begin xx following the last missile configured Thor and extend through May 1961. (contr -24)

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[redacted]

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[redacted]

During 1960, space program requirements continued at to exist perhpas in larger degree than during the previous year. By December 1960, Washington had increased thernumber of Thor-Agena flight from 24 in late 1959 to 41. In the meantime, if the Air Force production line was to continue, Washington would have to authorize additional procuemtnxx (TWX 27 Oct 60) Indeed Washington responded with an authorization ofr four more DMxxxxxxxxx DM-21 boosters. (TWX 28 Nov 60) After the Spxxxx the Thor office had made presentations to the Air Research and Development Command headquarters the Air Materiel Command headquarters and the Air Staff, Wxxxx asking for permission to procure 48 more missiles, (ltr 12 Dec 60) Washington approved an additional procurement of 12 at a continued production rate of two per month. This December authorization would keep the Thor assembly xxxxx line busy through February 1962. (TWX 30 Dec 60)

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[redacted]

During the ensuing months ~~where~~ was a constant struggle between ~~the~~ Space Systems Division and Wahiggton authorities over the continued production of Thor boosters. ~~The division~~ At first the division objected to the low production rate of boosters, principally because the unit cost would be higher and the confidence that there would be a demand for the product. The division learned to live with the low ppoduction rate but the real difficulty lay in ~~the~~ obtaining ~~approval from~~ Washington approval early enough so as not buase a break in the production line. Otherwise the division feared that it would be costly in time and money to have to start ~~the~~ production line going again. For orderly production and contract degotiations the division needed to know ~~a minimum of~~ 15 months in adavnce of ~~the~~ when the first booster would be delivered. In practice however, this lead time was more nearly ten months due to the late approval of Washington authorities.

Washi[illegible] did not want to approve the procuemant fo more boosters [illegible] of using. Often the using program office in the space division ~~could~~ had a difficutl time obtaining Washington program approval ~~in Washington including~~ and adequate funds. (TWX 11 Aug 61) [redacted]

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[redacted]

The space division usually procured the boosters with reimbursable funds; that is, the Thor booster office had an alloted fund for direct procurement and the using program offices would pay the Thor office at an establihsed rate. (Maj Young interveiew 29 Jan 63)

The net result of this continuous dialogue between Los Angeles and Washington was that upon each request for authority to continue the production line there was a minimum authorization. (TWX, 31 May 1961)

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[redacted]

[redacted] [redacted]

After urgent re quests from the Space Systems Division, on 13 March 1961, the Air Force headquarters authorized the procurment of four additional boosters, on 30 Marhh, six more, in July, four more, in September, three more, in October, five more, ~~xxxx~~ and in December, eight more booster ~~extending the production~~

continuing booster production ~~xxxxxx~~ at the rate of two per mehhh well into the middle of 1963.

(ltr 14 Mar 61; TWX 30 Mar 61; TWX 30 May 61; TWX 6 Oct 1961; ltr 13 Nov 61; ~~xxxxxx~~ contrs- 55 and -80)

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[redacted]

Standardization [redacted]

When the San Bernardino Air Materiel Area assumed/ Thor weapon system executive management responsibility, the material area also assumed responsibility for the configuration control board. in November 1959./ (ltr 28 Jan 1960) Since during xxxxxxxxxxxxxxxxxxxxxxxx 1958 and 1959, xxxxxx the Air Force was pulling missiles off the Douglas assembly line and modyfying them to configure to the desired requriement, a standard was not appropriate.

But there was already the beginnings of standardisation with the design of the DM-21 late in 1959. In August 1961, the Air Force approved a new acceptance specification applicable to those boosters coming off the assembly line beginning in March 1962. (hist rpt 26 Feb 62; contr -887)

The advent of the acceptance specification coincided with an effort to standardize the internal subsystems of the Thor booster. The Space Systems Division felt that standardization would reduce production costs, and increase/ systems reliability. An example of standardized efforts was the control electronics assembly which consisted of an autopilot and a programmer.

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The booster control electronics assembly had essentially been a ~~modified~~ missile flight controller, which required xxxxxx modifications for the various space booster configurations. (ltr 25 May 62) [redacted]

[redacted]

In May 1961 the division determined that the electronics assembly needed standardization. xxxxxxxx an in response to the division's request, Douglas provide, the Air Force with a prototype. Thexxx contractor then modified the assemblies in stock xxx before undertaking the manufacturing of any new onws. (ltr 20 Jul 61; contr 0887, amend 1, 24 Jul 61; contr-887-80, 5 June 62)

By mid-1962 the division had compltedx standardizing most of the xxxxxxxxxxxxx subsystems which the division thought should be changed.

Even after these ~~modifications~~ changes were incorpated into the stanadrard xxxx booster, some differences would continue to exist. These result from the use of various second stages whcih differ in their dimensions, and methods of firing and seprating, and the location of the guidance sys[illegible] (hist rpt 26 Feb 62)

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However, the idea was to xx able to support as many programs as feasible with as few changes as possible. [redacted]

[redacted]

~~[illegible]~~, The Space Systems Division ~~feat~~ felt that in order to ~~develop~~ retain ~~a~~ standardized ~~launch vehicle~~ components a configuration control board was necessary. In April ~~of that year~~ 1962, the division established such a board ~~consisting~~ ~~xxxxxxx~~ chaired by a representative Thor booster office ~~xxxxxxxxxx officer~~ and consisting of representatives from ~~Xxx~~ National Aernoutical and Space Administration, each Space Systems Directorate having a direct interest in Thor space booster configuration, and appropriate Air Force Plant Representatives. (ltr, 2 Apr 62)

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From Missiles to Boosters

Originally the ~~xx intermediate range ballis~~ [redacted] was developed and deployed as an interim solution until the longer range intercontiental missiles could be readied for combat within the United States. ~~In~~ Washington authorities publicly announced that Thor ~~missiles~~ intermediate range ballistic missiles were no longer needed and would be gradaully withdrawn from England.

DDR&E directed that these SM-~~52~~ 75 missiles be converted into DM-21 boosters at Douglas's inactive plant at Tulsa. Space Systems Division negotiated a contract with Douglas for the conversion of the first squadron (15 missiles) and work began in November 1962. San Bernardino Air Materiel Area was responsible for the refurbishing of the ~~the~~ MB-3, Block I engines. The boosters were to be converted at the rate of two per month with the first completed late in February 1963. Space Systems Division estimated that ~~xxxxxx~~ the modification price of each booster would be $275,000.

(notes, fSSD program review, 14 Nov 62)

The Space Systems Division had estimated the average price of new boosters procured under ~~the~~ Air Force letter contracts since 1 January 1960 at $192,000 (based on ltr 30 July 1962: this is the price payed to Douglas at Santa Monica and does not include Rocketdyne engines, BTL guidance units, or Douglas launch services.)

[redacted]

[redacted]

This announcement was the beginning of the end of the Thor as a ballistic missile and the future use of Thor exclusively for space purposes was on the horizon. In retrospect, the transfer 1 January 1960 -- of executive management responsibility from Los Angeles to San Bernardino may be considered a watershed in Thor history. Before that date 160 Thors were under contract for development tests, operational squadrons, and crew training launches, while only 64 had been earmarked for use as first stage boosters for reentry vehicle tests and space launches. During this early period, the Air Force had the missile frames modified for what were at that time "special purposes", but beginning in 1960, all Thors placed on contract were assembled as a booster, in most instances meeting the specifications of the DM-21, sometimes called the Standard Launch Vehicle.[7]

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Chapter 3

AGENA DEVELOPMENT [redacted]

The fact that the Air Force had designated Lockheed Aircraft Company as prime contractor for the 117L program did not mean that Lockheed was to perform research and development, design, manufacture and test of the many system components. On the contrary, the Air Force expected Lockheed to procure most of the component parts including entire subsystems from capable and experienced firms who performed tests on their product before delivering it to Lockheed.
These subcontractors were to dleiver the tested hardware to Lockheed which in turn would integrate the components, subassembleis and subsystems into an integrated upper stage and would be responsible for the system tests together with those of the subcontractors. (ltr 23 Sep 57)

During 1957 someone conceived of the Santa Cruz Test Base, a Lockheed property for research and development vehicle, propulsion and component testing. When the facilities neared completion, someonce conceived of the idesa of acceptance firi[redacted]cile there, thus requireng additional equipment and instrumentation. (ltr 11 Apr 60)

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Lockheed produced the early flight test vehicle in various locations. The contractor fabricated components at the Van Nuys plant, assembled the vehicle at Sunnyvale, modified and checked out subsystems at Palo Alto, then shipped the vehicle for engine firing and system checkout to Santa Cruz. (Prog rpt 31 May58) (Mar 59 Q)

The Air Force planned that Lockheed's 4,000 acre tract north of Santa Cruz be used for static firing and a complete systems checkout of the entire vehicle. (Presentation on Santa Cruz) (Dev Plan Mar 58) The Air Force invested $400,000 in industrial equipment there. Workers completed the components test laboratory in April 1958 and finished the two static firing test stands and blockhouses in time for testing of the first flight vehicle in August 1958. (Prog Status rpts, 15 Apr 58, 30 Aug 58)

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Early in planning fo the program, a deicison made to fabricate two propulsion test vehicle assembles (PTVA). [redacted]

~~Two failures occured in September, 1958, minor ones (S p6-58)~~

xxx For the first flights, xxxxxxx Lockheed [redacted] vehicles to Sunnyvale for further checkout, then to Vandanberg where in an assembly building the vehicle under went furhter chnecks, and then still further checks onthe pad prior to laucnh. During 1960, the Air Foec Ballistic Missile Division made an effort to cut down on some of these xxx chenks and consequently expenses.

~~The [illegible]~~

These procedures were not ~~only expensive but also costly~~. The division attempted to reduce or eliminate the need for xxxxxxx checkout xxxx procedures at Vandenberg assembly building and at Santa Cruz.

During this period of time, the biggest oblstacle in accomplishing a cut back in testing and chetkout procedure was the simple fact that no two vehible were alike. However, during this period Lockheed was able to produce a series of vheicles which were alike, therefore only the first

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of a series needed to be tested at Santa Cruz. (ltr 12 Dec 60)

In addtion the xxx extensive chekcout of the vehicle at the Wandenber assembly buidling was eliminated. ((16 June 1961)

The various Air Force program offices usually installed their payloads in the Agena in the assembly builidng. [redacted]

Following the award of the 117L contract to Lockheed Aircraft Corporation, the prime contractor began making design studies for the second stage seatellite vehicle. including the necessary subsystems. and casting about for ~~xxxx~~ possible subcontractors to develop these subsystems. Lockheed concluded that perhaps a pump-fed propulsion system would ~~xx~~ technically be thebest, but type of propulsion ... ~~xxxxxxxx~~/ other factors such as the ~~xx~~ availability of a particular engine and the competance of the particular firms producing the engine. should be considered.
(L 31 Jan 57, p 5-6)

The Bell Aircraft Company had been ~~xxx~~ developing a turbo-pump rocket engine for ~~the~~ air-to-ground missile which would be carried by B-58 Hustler ~~aircraft~~ then underdevelopment. By March 1957, Lockheed with the concurrace of the Air Force, selected Bell's LR-81 engine as the basic propulsion unit for the 117L's second stage. (Wkly Diary, 28 Mar 1957) (Spc Proj) X
Later, during the year, and following the engine's preliminary flight rating tests, the Air Force cancelled ~~xxxx~~ the missile portion of the B-58 program, so consequently ~~xxxxxxx~~ about $570,000 worth of hardware ... was transferred to the 117L program. *(

*(As part of the B-58 development program, Bell had been a subcontractor under Convair at Ft. Worth)
(Wkly Diary, 117L, 22 Aug 57)and 14 Nov 57)

ROUGH DRAFT

ROB Project Card, DD Form 613, Propulsion Sub-System for ARS, WS 117L, Project Nr 1756, Ind. Nr. 2-117, 2 Apr 1957

[redacted]

[redacted]

The LR-81 engine consisted of a single thrust chamber, gas generator, inluding starting solid propellant charges (ullage rockets), turbine driven pumps, propellant control valves, and auxiliary equipment to start operate and shut down. (L Jul-Sep 56 pp 17-20; TWX 3 Apr 58?)

the ballistic missile program, engine was the only turbopump feed system and within the required thrust range. The LR-81 engine had a thrust rating of about 15,000 pounds. The engine burned JP-4 fuel when combined with an oxidizer of inhibited red fuming nitiro acid. (RDB Proj Card, DD Form 613 Propulstion Subsystem, 2Apr 57)

From the B-58 design, the engineers made only a minor change which increased propellant burning time from 65 to 100 seconds.

ROUGH DRAFT

[redacted]

[redacted]

During 1958, Washington changed some of the flight objectives although the principal ones, satellite vehicle and ground communications remained the same. The secondary objective, The development of visual reconnaisance including film recovery, was replaced with the development of a recoverable capsule and the collection of geophyscical data for research purposes. In March, the directive said that the new requirement would become effective with the fifth flight, however, before the end of the year it had been changed to be effective beginning with the third flight. In order to meet the new objectives, the satellite vehicle would have to manuever with a heavier load than had been originally planned.

(30 Jun 58; July 58 Dec 58 Q)

ROUGH DRAFT

[redacted]

[redacted]

Meanwhile, contractor engineers had been study the possibility of improving the propulstion system in order to cayyy a heaveier payload in flight. (L Jan-Mar 58, p 1-9) In March the Air Force directed Lockheed to proceed with the nexxary work to changexxxx tye propulsion system design and the fuel.

Lockheed Engineers recommended ~~Technicals diecided to use~~ a slightly heaveir and higher energy fuel, unsyemtrical deimthal hydraznie.

In addition the relative sized ~~faxxx~~ of the engine ~~combustion~~ throat and nozzle extension ~~injection~~ mouth ~~would be~~ increased from approximately 1 to 15 to 1 to 20. (L Apr-June 58, p 2-39; Wkly Diary, 27 Mar 58) TWX 3 Apr 58 (15 Apr 58 rpt)

A Slight increase in the size of the aluminum propellant tanks and a rearangement of the plumbing resulted in a slight lenghtening of the overall airframe. (Jun 58 rpt; L Apr-Jun 58, p 2-25)

ROUGH DRAFT

[redacted] [redacted]

[redacted]

For ground tests, Bell delivered two engines to Lockheed in March 1958. By June, technicians had mounted them on the two newly completed propulsion test assemblies at Santa Cruz. The entire propulsion system composed of prototype components underwent generally successful hot firing tests. At the same time Bell was conducting a series of flight rating tests at its own plant. The firing at both locations were completed by August, but Lockheed continued testing the propulsion assembly's plumbing with the fuel and oxidizer throughout the remainder of the year.

L J-1758 p 2-32

In June 1958, Bell shipped the first two flight test engines to Lockheed at Sunnyvale. Lockheed assembled these engines with the other subsystems and components to form the first two flight test vehicles. Following modification and checkout, the two vehicles arrived at Santa Cruz. At the base the two vehicles successfully passed the hot firing tests with all flight equipment installed and operating. As a [illegible] accepted both vehicles at Santa Cruz, and shipped [illegible] for final adjustments before flight, hopefully before the end of the year.

Wkly Diary [illegible] 1 at 31 Oct 58, 2 at 26 Nov

L Apr-Jun 58 pp 2-39, 2-40
117L Prgst Jul 58
Sep 58

[redacted]

[redacted]

Technicians erected a prototype propulsion system and began flow tests with the new fuel. Performance was within specifications and therefore Bell completed assembling the first unsymmetrical dimethal hydrazine flight engine and delivered it to Lockheed in September 1958. (Sept 58) Although propellant temperature variations were initially troublesome, Bell solved the difficulty and then began rating tests. The new engine designated LR81-Ba-5 was rated at 15,600 pounds of thrust compared to the JP-4 engine with 15,000 pounds. In addition, the new engine could burn almost twice as long, 120 seconds compared to 64 for the old. (LC-Apr-Jun 58 p 2-25; 14 Dec 58; Mar 59 + one more

By September 1959, Lockheed had incorporated the new engine into fourteen flight vehicles.

These were in turn shipped to Santa Cruz, for pre-acceptance testing ~~of satellit vehicles continued with~~ which included hot engine firings, inspections, and functional component checks. After incorporating any engineering changes, the ~~Air~~ Force accepts the vehicle. (Sep 59)

ROUGH DRAFT

[redacted]

16

Agena B [redacted]

Early in 1959 developers began changing the satellite propulsion system to such a degree that the end product was known as the Agena B and the previous configurations, by way of contrast, the Agena A. In flight Agena A engines were ~~dead~~ useless once the propellant was extinguished, but technicians began working on a scheme whereby an engine could be restarted in response to a signal from the ground. The concept originated when a program needed a higher orbit ~~capability~~ than the current booster Thor-Agena combinations ~~was~~ were capable. In addition such an engine would permit ~~the change~~ from one established orbit to one which is lower or higher. (ltr Feb 59, AFBMD Space Apr 61)

By the first of March 1959, the Air Force Ballistic Missile Division had set July 1960 as the goal for the new engine's first flight test. (ltr 15 Jan 59, memo 6 Mar 59) The Advanced Research Projects Agency approved the development on [illegible] also directed that the propellant capacity be increased. (ARPA order 17-59, Amend 4, 10 Apr 59) By August engineers had decided that tanks with double the Agena A capacity would be the best with both Thor and Atlas boosted flights. In order to accomodate the new capacity, designers added six feet to the length cylindrical mid-section of the Agena. When applicable Engineers used components and materials proved in the Agena A and subjected the new tank design to similar ground tests such as including vibration and centrifuge tests. ~~In addition~~ Lockheed build a new proplusion te[redacted]t Santa Cruz incorporating the new design.

ROUGH DRAFT

1 Aug Sand [illegible]

[redacted]

Early in the year the AirForce Ballistic Missile Division had determined that the restart engine ~~tests~~ would be conducted at Arnold Engineering Development Center as well as at Bell's facilities. Tests at Arnold would include those in the hightaltitude chamber. (Hr 15 Jan 59) Necessary testing on the new engine called LR81-Ba-7 had already begune by the time the Advanced Research Projects Agency issueded formal approval and ~~in~~ September 1959 Bell shipped one engine to Lockheed for ~~tests in the new~~ propulsion test assembly.

By 1 March 1960, Lockheed had received all flight engines of the new configuration, had completed tests of the new propellant ~~tanks~~ design, and ~~had~~ shipped the first assembled Agena B to Santa Cruz for tests. During the Santa Cruz tests certain difficulties had to be overcome inclu[illegible] propellant valve. Before Air Fo[illegible]eptance, technicians had to rework three engines and repeat the systems tests. (Jan Feb '31 Mar 60) ~~Under different circumstances~~, Bell began ~~an extensive~~ series of reliability tests at its own plant, ~~would have insued~~, but due to the limited number of flights which would employ this particular engine model, ~~by June~~ 1960 the Air Force ~~had~~ decided in June 1960, to ~~terminate~~ [redacted] further testing ~~by Bell~~.

ROUGH DRAFT

Nevertheless, tests had confirmed that the LR81-Ba-7 had the same thrust as the previous Agena A model--the LR81-Ba-5--, but ~~with~~ twice the burn time ---four minutes. (MSD Men...)

[redacted]

~~The limited number of flights scheduled for this radically new model was that~~ meanwhile, engineers had been concurrently improveing the capability of the Bell engine by another approach. The appro ch was to increase the relative size difference between the throat and the mouth. In July 1959, the Air Force Ballistic Missile Division authorized L$_o$ckheed to proceed with such improvements in the LR81-Ba-5; (ltr 31 Jul 59; TWX 28 Jul 59) however, in March 1960, the first dual restart engine--LR81-Ba-7-- was undergoing acceptance testing. At that time the AirForce directed that no futher effort be expanded on improving the Agena A model, but apply that work toward improving the new restart engine.

After several months of testing, the Air Force specified that the mouth of the new model should be 45 times larger than the throat. (ltr 18 Feb 60; contr -397 CCN 36 25 Mar 60) The greater the size differences, the greater the speed across the throat and the greater the force exerted against the nozzle extension.

At both Bell's facilities and at the Arnold center technicians tested nozzle extensions made of graphite, steel, and titanium. (MSP Dec 59, 31 Mar 60) Titanium proved successful for the extensions but the throat eroded. The erosion was curtailed by ~~xxx~~ coating the throat with abrasive ~~hard~~ materials such as Zirconia. (MSP 31 Apr 60) Testing and evalua[redacted] throat coatings continued into June.

ROUGH DRAFT

[redacted]

In September, technicians completed the preliminary flight rating tests without appreciable nozzle throat erosion (MSP Q Nov 60). The new LR81-Ba-9 combined an increased thrust---16,000 pounds with ~~thm~~ a restart capability. (AFBMD Space Apr 61)

Earlier in the year, Beal had shipped an "expanded nozzle" engine to Lockheed for testing in the propplant test assembly at Santa Curz. Hot firings ~~of the Ba-9 were in~~ progressed during Feburay and March 1960~~, at Santa Cruz.~~ This series consisted of nine firings inclding several restarts. One of the prime objectives was ~~[illegible] Parts of the program was~~ the testing of a fuel-powered hydraulic system to gimbal the engine which performed satisfactorily (Feb 60; Mar 60)

In orbit the restart of a gimballed engine would ~~[illegible]~~ propel the vehicle into another flight path.

ROUGH DRAFT

[redacted]

9 [redacted]

Although technicians were not completly satisfied with test results, for flight vehicle Bell shipped the initial "expanded nozzle" engine to Lockheed in June 1960. (June 60) After being assembled with the other airborne components and hot-fired at Santa Cruz, the Air Force accepted the vehicle in August 1960. (Aug 60)

In order to further test the engine's reliability, technicians continued tests at Bell's facilities and at Arnold. At Bell the engine operated in various positions and under unusual vibration frequencies. (Oct 60) The use of a fuel with a high solid content tested the skin temperature of the thrust chamber.

At Arnold, tests simulated altitude and temperature conditions in which the engine would operate in orbit. (Jan 61, Feb 61) The Air Force considered the reliability tests--60 in all--to have been completed in April 1961. The tests demonstrated an engine operational life far in excess of the specified requirements. (Apr 61) MSP Q May 61)

ROUGH DRAFT

[redacted]

[redacted]

Chapter 4

LAUNCH, FLIGHT, AND RECOVERY

America's military services were using Cape Canaveral for missile flight tests and spade programs and the Air Force had orginally planned to launch 117L satellites from there. Following Sputnick, not in only did the Department of Defense authorize the use of Thor as a booster in the 117L program, but also approved peacetime iaaax missile launches from the West Coast at Cooke Air Force Base (later renamed Vandenberg) (TWX 23 Nov 57) The Air Force had selected the base for the first operational intercontinental ballistic missile force, but iak with permission for peacetime launches the Air Force could use the base also for completex integrated weapon system tests and combat training launches of both intermediate and intercontinental range. Also, early in 1958 the Air Force decided that the Thor boosted 117L satellite should be launched into polar orbit, and considering overflight hazards, a southward launch from Cooke would be the best procedure.

ROUGH DRAFT

[redacted]

[redacted]

At Cooke the Air Force had reserved an area near the ocean for Thor launch installations. ~~At first~~ the Air Force planned for only one launch complex consisting of a launch control blockhouse and two launch emplacements or pads. As program requirements increased, the Air Force added a second complex, and then upon the "polar orbit" decision, a third complex was added for the 117L. (Wkly Diary WD1 28 Feb 58, 25 Apr 58)

The Air Force dsigned the first two complexes for test and training activities including the launch of missiles in a westerly direction. The thrid complex was designed to launch the two stage combination southward in 182 degree azimuth.

As the Air Force's construction agent the Corps of Engineers had begun work on the first Thor launch faciltíes in the fall of 1957 and as decisions were made in regard to the other facilitíes, the corps' activities expanded. Like the 117L program the Thor ~~xxxx~~ weapon system program required a West Coast launch emplacement [illegible] 1958. So stringent efforts were made [illegible] at least one [illegible] at the test complex and one at the 117L complex by the needed date. Other installations could be completed later. (ltr 9 Jul 58)

The ~~xxxx~~ Air Force accepted ~~xxx~~ pad 4 and the blockhouse from [redacted] 21 August 1958, ~~and ground eq~~ (Wkly Diary WD Installation 22 Au. 58)

ROUGH DRAFT

[redacted]

[illegible]

In the meantime ground equipment for pad 4 had been arriving at Vam Cooke since May and workers began emplacing the equipment as soon as the area was clear. (Wkly Diary 22 May 58)

About the same time the corps had completed technical support facilities and Air Force contractors began installing necessary equipment in them.

About the same time the corps had completed separate facilities to house Thors and second stage vehciles after their arrival on the base until their empłacement on the launch pad. and technicians mated them together

In these facilities Air Force contractors installed inspection, maintenance, and checkout equipment. The first vehicle arrived from Lockheed in November 1958. and Thors began to arrive from Douglas for both missile program purposes and space launches.

ROUGH DRAFT

[redacted]

[redacted]

In the meahtime, Air Force teams were wondering around the Max United Sates and the Pacific Ocean choosing sites for satellite tracking and data acquisition stations. The Air Force chose sites and had [illegible] established temporary facilities and equipment at points in Hawaii, And Alaska by August 1958 (Terhune files, installations) 22 Aug 58) -

Th
~~The Air Force selected additional sites a time [illegible] such as one xxx Ft Stevens [illegible] United States and one Ottumwa, Naval Air Station, Iowa.~~

The Air Force decided that xxx data and tracking stations were needed in the areas of the United States, northwest, central, and northeast. These stations gradually came into operation.

Font Stevens was approved for the northwest, OttumwaNaval Air Station, Iowa ffor the central, and for the northeast at New Boston, New Hampshire.

ROUGH DRAFT

[redacted]

To gain as much information as possible about ~~the~~ hardware behavior [redacted] on each flight, the Air Force utilized one or two ships equipped with special telemetry equipment. ^ m (L vol 2) ~~The ships were moved to locations where~~

The need for certain type of information was greater on some flights than on others and the ships maneuvered to the locations where the the ~~greatest~~ need was greatest. On the early flights the Air Forfe was ~~mainly~~ primarily concerned ~~with~~ about getting an Agnea into a suitable orbit.

~~Later the Air Force was more~~

~~then~~ After orbital injection seemed to be masterdd, the Air Force became increasing concerned over the ejection of the recovery capsule, and

---

To gather information on orbital ascent, a ship ~~was located about~~ moved to a position ~~1,000 miles~~ downrange about 1,000 miles. To gather information on ejection and reetry procedures, ships were/located between Alaska and Hawaii.

ROUGH DRAFT

[redacted]

Due the many takks that needed to be preformed, contracsors began preparing for a launch se[redacted]befor the shheduledliftoff. Among these tasks were the tmansporting of the first and second stages from their respctive fax checkout facilities to the launch emplacement. They were mated together in a horizontal position, butxbefore the crew did

At best procedures for a launch lasted form more than severn hours. Preaparations for the launch usually began in the pre-dawn hours when the crew mated the recovery capsule to the Agena and raised the Thor-Agena to an erect position. ~~It took several hours for~~ For several hours the crew checks the radio freqencies, makes umbilical connections including the propellant lines, warms up electronic equipment , loads the propellant tanks wath fuel, checkout guidance and flight control systems

The last 15 minutes were devoted almost excludively to the Thor. Then When the missile automatically passes through a sequence of fueling, calibration, arm... and ... However,

~~any case of a technical malfunction or~~

However, ~~any case, a countdwon may be held~~ pp until the the last five seconds before ~~liftoff~~, the countdwon may be held for technical reasons, to allow a train to pass, or due to inclement weather.

((vol 1) [redacted]

ROUGH DRAFT

[redacted]

Workers had r[redacted]ed pad 4 for the first launch and had assembled a modified Thor and Agena for a launch on 21 January. During countdown procedures smoke began to rise while explosions occureed in the Agnea ~~and~~ and Launch ~~personnal~~ crew cut~~off~~ the power off ~~immediatex~~ immediately. ~~Ground power cuasad inginition of the ullage rockets inavertently and safety circuit failed.~~

Apparently The ullage rockets had accidently fired and triggered ~~off~~ internal mechanisms causing serious damage to both the first and second stages. Follwing removal of the hardware from the pad, technicians determined that the Thor could be ~~rehabilitatedy~~ repaired for a future launch. but the Agena was not worth rehabilitating. Technicians investigated the accident to determine in detail the causes so corrective ~~mxt~~ measures could be taken prior to the nest countdown. (mo rpt Jan 59; L vol 1)

~~For program purposes ... The Air Force decided to consider ... flight test.~~

ROUGH DRAFT

[redacted]

[redacted]

Two weeks later Tecnicians gava the next Agena a completed systems check test in the assembly building on 4 Feburay and then transproted the vehcile to the launch pad. The launch crew mated the Agena to the Thor and conducted a practice countdown on 19 Feburary. The crew made an attempt to launch the combination on 25 February, but after twelve hours of countdwon procedures, the managers decided to postpone the launch so that corrections could be made in the Thor's liquid oxygen tank pressurization system. A second attempt was successful on 28 February when the Thor-Agena combination zoomed off into the mid-day sky. As programmed the Thor rolled into a southernly direction; the Agena separted from the booster and began coasting in polar orbit. Radar at Vandenberg and Point Mugu and telemetry tracking equipment at Vandneberg received signals from the Agena for more than eight minutes after liftoff. Although ground equipmen [illegible] northward pass over the Pacific area, sporodic signals acquired on later passes showed that the vehicla was in orbit. The Air Force considered this launch a success. (mo rpt Feb 59; L vol 1)

ROUGH DRAFT

[redacted]

By Feburary, the Hawaiian control center was prepared and combination air and sea forces were ready for recovery operations. (mo rpt Feb 59; 1 vol 1)

In order to aligne flight with the current Thor-Agena program, the Air Force decided to consider the January abortive countdown as the first flight test. (mo rpt Feb 59) Since the program specified only two JP-2 propelled Agenas without recovery capsules, the next flight would include a second stage which would burn unsymetrical dimethal hydrazine and carry a recovery capsule. (Q rpt Mah 59) This time the crew launced an Agena into orbit at the end of the first countdown.

Immediately after Agena engine burnout the satellite stabilization and guidance system operated a series of small gas jets which caused the vehcile to turn 180 degrees in a horizontal plane so that the satellite was floating in orbit with engine in the forward position and the recovery capsule pointing toward the rear. The new position was in preparation for the seventeenth pass when upon command from the earth the satellite nose would tilt 60 degress downward to permit the ejection of the reentry capsule. Telemetry data showed that that control and ejection equipment operated properlyl

ROUGH DRAFT

[redacted]

[redacted]

The Air Force has established a ground-communication system so that after computing the orbital period around the earth a northern tracking station could adjust the vehicle-born timer so that ~~the timer would activate~~ on the seventeenth pass the timer would react at the correct moment so that the recovery capsule would be injected a predicted area. ~~could on a later pass and from a ground signal could be activated.~~

However, the Agena had gone into orbit at a low velocity which caused the orbital period to much shorter than what was expected. There resulted some confusion in the ground tracking station and the ground command made an error in resetting the timer.

(L vol 1) The reset error, introduced into the satellite timer from the ground, made it impossible to adjust capsule ejection to permit impact within the planned recovery area.

~~Automatic ejection took place. Based on the automatic ejection~~

Technicians ca[illegible] that the capsule would impact [illegible] ~~the arctic circle~~.

near the Norwe[illegible] of Spitsbergen. [illegible] effort by ~~both~~ American and Norwegian air and ground forces failed to find the capsule although local observers had sighted what the US Air Force interpreted as ~~what was thought~~ to be a decending parachute and foil chaff.

[redacted]

[redacted]

Telemetry and radar installtions in the satellite continued to operate extremely well through the twenty-fifth pass which was about one and half days after launch. A continuous wave beacon emitted? imetted signals for another week and reports of visual sighting continued until 25 April when the Air Force estimated that the satellite reentered the earth's atomphere and burned up.

In the meantime, the Air Force took steps to prevent an ejection from taking place above the wrong geographic area. Tracking procedures were revised and/the vehicle timer was repalced by a more sophisticated one manifactured by Fairchild. (Q rpt Jun 59) no rpt Apr)

ROUGH DRAFT

[redacted]

[redacted]

On 7 May 1959 the first and second stages were moved from their respective housing and checkout facilities to the launching pad where mating and complete systems checkout occured. In addition the Air Force installed a Mark I recovery capsule on the top of the Agena. However the combination was on the pad for several weeks due to several abortive countdown sequences. Three delays were cuased by technical difficulties, two in the Agena and one in the Thor. (L vol 1)

Finally on 3 June the crew completed a countdown with a launch which was to end in dismal failure. The launch itself, ascent, vehicle separation, Agena coast, and engine boost were accomplished as planned. However, the Agena's LR81-Ba-5 engine shut down prematurely causing the vehicle to fail to acheive the required orbital velocity. The second stage fell into the Pacific south of the equator.

ROUGH DRAFT

Thre[illegible] launched a similarly configured comb[illegible] with only one abortive countdown. However, the results were as heartbreaking as the previous one. Due to two seemingly similar failures of the Agena and the result loss of thousands of dollars [redacted]ment and time, the Air Force

[redacted]

Ballistic Missile Division postponed the xxxxxxxx next scheduled flight and initiaqd and investigation of the failures. Studies showed that

and

an xxxxxxxxbetter performance [illegible]

increase [illegible] weight.

showed

Studies [illegible]

velocity [illegible]

In [illegible]

[illegible]

Technicians had first believed that the engine had shutdown prematurely; however, thexxxxxxxx this postmortum investigation revealed that in both flights that the satellites had not acheived sufficient velocity at the time of second stage burnout. to obtain xorbit.

The Air Force approved

Thus Several actions xxxxxxxxxxxx taken in order to improve the situation.

Lockheed reduceed thw xxxx weight of the Agena by 48 pounds by removing

desirable but not essentail

equipment and instrumentation. Space Systems Division was hoping that the Thor velocity could be improved by as much as 100 feet per second with the use of RP-1 fuel instead of the standard RJ-1. In addition, xxxx the Air Force directed that the launch azimuth be changed from 175 moved to 170 degrees. This slightly more easterly direction would take advantage of the earth's rotation and was expected to provide an additional 100 feet increase the Agena's speed

[redacted]

[redacted]

~~personnel and security~~. (mo rpt Jul 59) Launch equipment ~~pads~~ had be adjusted for the new direction. Launch emplacement number 5 had been completed ~~used~~ for the fourth flight ~~launch~~, so there were ~~with~~ two pads available for space launches.

~~The fifth flight~~

The Thor-Agena combination had been wating on launch pad (4) for several weeks before final launch on 13 August. There were a total of five ~~six~~ postponements, four times due to poor weather conditions and a fifth due to a Thor engine ingnition failure. Finally on 13 August the crew launched the Thor-Agena into the sky and after separtaion the second stage achieved an orbit. Tracking and data acquisition at all ground stations was excellent this time.

A Thor-Agena had been installed on pad (4) and the launch crews did not encounter such bad luck, only one postponement, the sixth flight off the pad and achieving orbit on 19 August, only six days following the other. Tracking and data acquistion was generally good at all ground stations except Point Mugu and Vandenberg wherer radar interference was experienced. [redacted]

ROUGH DRAFT

[redacted]

On both of the August flights all objectives were acheived except capsuel recovery. ~~On both flights~~ Data from Kodiak and Hawaiian tracking stations indicated that capsule ejection occured between the two; therefore near the planned point. However teaemetry from the fifth flight indicated that the low capsule temperature was lower than expected and prevented the parachute-opening mecanism from operating. On the sixth flight difficulties with the command-timer-adjustment sequence delayed the capsule ejection 360 miles sough of the planned point. During both flight the sea and air recovery forces were deployed properly in relation to the expected impact point. But due to the last minute changes only aircraft were able to reach the revised impact areas. beforethe capsule would normally sink beneath theocean wanes. The forces only received scattered radar signals from the fifth flight's capsule and nothing from the sixth flight's. (mo rpt 31 Aug 59)

ROUGH DRAFT

[redacted]

[redacted]

Due to the failures of these two/August recovery attempts, the Air Force postponed additional flight until am detailed evaluation and testing of the entire rdcovery system could be made. In order to allow for ~~imppx~~ improved retro-rockets to be incorporated in the next flight configuration, the Air Force ~~pwww~~ delayed the launch unitl 3 November. (~~xx~~ mo rpt, Oct 59)

However, on pad 4 four ~~threexxaxx~~ abortive countdowns delayed a launch~~xxxxx~~ for four days. The actual launch and orbit acquisition was a complete success but between that time and the first pass over ~~thexPacificx~~Alaska, the Agena's battery ~~the~~ auxilary power~~x~~ ~~supply~~ failed, ~~inactivating the guidance system~~ ~~The power failure.~~ The operation of the guidance system, the horizon scanner and gyro stabilizers, depended on that power, so consequently the yehcile began to tumble. ~~By the second pass~~ Crews also found it impossible to activate ~~xxxxx~~ the revovery capsule ejection sequence.

~~the small jets which stabilize~~

ROUGH DRAFT

(L vol 1)

a Two weeks later from pad 5, technicians placed an Agena into orbit without the [illegible] ~~launched the eighth Thor Agena. This attempt was not mared with~~ any abortive countdowns. (MBP Q Dec 59)

~~However, the Agena~~ [redacted]

[redacted]

However, the Agena ascended into orbit ah a greater speed than programed. Lockheed had installed a mechanism, called the accelerometer-integrator designed to cut the eingine off when the vehicle had reached its programed speed. I^n this instance the accelorometer failed to perform the required task.

~~The result was an eccentric orbit and exceptionally~~

The result was that the Agena followed an eccentric path and took an exceptionally long time to circle the earth, ~~103.7~~ about 104 minutes ~~to be exact~~. The 104-minute period exceeded the vehicle borne timer's capabilites. to react to earth bound ajustment commands. (L vol 1) In addition, the eccentric orbit confused the vehicle's guidance and cotrol system resulting in the premature exhustion of the control gas. The result was that the vehicle was in an improper attitude at the time of capsule ejection. (MSP Q Dec 59)

ROUGH DRAFT

[redacted]

[redacted]

Some improvments in the vehicle components delayed the launching of the next Agena for over a month. (MSP Q Dec 59) The actual liftoff was ~~further~~ delayed another week by several aborthive countdowns on pad 4. Finally on 4 Feruary 1960 the Thor-Agnea ~~xxxxxx~~ soared upward and arced ~~xxxxxxx~~ southward, but the Thor's main engine prematuraly shut down resultigng in the booster velocity being 4,000 feet per second less than normal at the time of Agena separation. In addition, the Agena's engine shutdown prematurely becuase of a ~~[illegible]~~ ~~than at the time of lift off the Agena's~~ malfunction in the helium pressurization system.

~~at the [illegible] umbilical cube connects the vehicle [illegible]~~

Either of these ~~xxxxxxxx~~ mishaps would have prevented the vehicle from achieving orbit.

Undaunted within two weeks the Douglas crew ~~[illegible]~~ launched another Thor-Agena, this time from pad 5. The countdown was smooth and the la[illegible] fi[illegible] However, immdiately after ~~xx~~ ~~flight~~ liftoff the Thor began ~~xx~~ to oscillate and ~~[illegible]~~ when the ~~xxxxxx~~ soaring hardware began to deviate from its program[redacted] flight path, the range safety officer pushed the electronic destruct button. (MSP Q Feb 60; L vol 2)

ROUGH DRAFT

[redacted]

Two simultaneous explosions occured ~~xxxxxxxx~~ within the flying hardware verifying that both the Thor and the Agena destruction systems were operating~~xxxx~~ (L vol 2) ~~[illegible]~~ Some of the resulting debris fell ~~xxx~~ close enough for recovery and examination. (MSP Q Feb 60)

The next launch had been scheduled for mid-March but the Air Force delayed ~~xxxx~~ the flight for a month in order ~~xxxxxxxxxxxxxx~~ to survey the situation. Again from pad 5, the Douglas crew launched a Thor-Agena combination into the sky, 15 April 60 again ~~xxxxxxxxxxxxxxxx~~ at the climax of only one countdown. but this time the Agena went into a very satisfactory orbit. The battery auxilary power ~~xxxxxx~~ supply lasted through the twenty-sixth orbit and attitude and control system functioned extremely well, resulting in excellent satellite stablisation. Telemetry indicated that the recovery cap[illegible] the seventeenth pass. but that the re-entry trajectory was probably too hight. since spin rocket firing was not verified. This was the first orbiting Agena to carry a dual-freqency [redacted] beacon and four optical tracking lights. The ~~xxxxxx~~ accu[redacted] the radar system could be tested

ROUGH DRAFT

[redacted] [redacted]

in comparison.

As a result of the recovery failure, the Air Force made a greater effort in the testing of the re entry system. The Air Force was intiated a program to test ~~xxx~~the components. (MSP Q May 60).

An attempt to launch the Thor-Agena space system ~~from~~ pad 4 ~~the twelfth time~~ occured on 29 June 1960. ~~After some minor technical~~ countdown delays the ~~xxxx~~ hardware blasted off ~~xxxxx~~ into the afternoon sky. The Thor and then the Agena ~~xxx~~ operational sequences were normal through the cutoff of the second stage engine. ~~However~~ Nevertheless, the ~~Agena bird~~ vehicle failed to achieve orbit. Telemetry ~~and subsequent investigation~~ ~~showed~~ indicated that the vehicle was in ~~an improper~~ pithh down attitude during engine operation causing the vehicle to reenter the atmosphere. ~~due to a malfunction in the horizon scanner~~ (mo rpt June 60)

Subsequent investigation ~~xxxx~~ showed that the satellite telmeter transmitter interfered with RF and prevented the horizon scanner to perform properly. (MSP Q Aug 60)

ROUGH DRAFT

[redacted]

Littlefield, Agena Story May 63

[redacted]

The thirteenth liftoff from Vandenberg occured on 10 August 1960 at the climax of one countdown attempt.

All ~~programmed~~ events ~~xx~~ occured ~~[illegible]~~ nearly as programmed.

Thor trajectory and speed were ~~xxxxx~~ within the limits of toleration and the Agena performance was very ~~xxxx~~ close to that which was programmed. Following the ~~Agena~~ burn out of the Agena engine, the vehicle reoriented itself into a nose aft ~~xxxxxxx~~ attitude. On the seventeenth ~~[illegible] the Pacific~~ orbit, 26½ hours after launch, the Alaska tracking station verified that the satellite had ~~xxxxx~~ pitched down, and ~~[illegible]~~ that is there was a capsule ejection, spin, retro firing, capsule de-spin, and thrust cone ejection.

ROUGH DRAFT

All aircraft and ships of the recovery force that ~~xxxxxxx~~ picked up the capsule's radar beacon began ~~xxxxx~~ moving toward the signal. One ~~xxxxxxxx~~ C-119 saw the capsule hit the water ~~xxxxxx~~ and relayed the information to a nearby ship, who dispatched a helicopter to ~~[illegible]~~ the scene.

~~Thex~~ With the help of ~~a~~ frogm[redacted]elicopter was able to retrieve

[redacted]

the capsule from the chopy waters and return it safely to the mother ship. Subsequently, the capsule was delivered to Washington for public view as a historic object, the first man-made object recovered after a sustanined period in orbit. (mo rpt, Aug 60; ESP Q Aug 60)

After this exhilerating experince, the launch crew threw another Agena into orbit on 18 August. Actually at one point the countdown stopped for fifteen minutes while the previously launched vehicle passed through the projected flight area. The Thor and Agena performed as programmed until on the first pass over the Alaskan station, telemetry data indicated that the satellite was in an abnormal attitude. However, the satellite stabilized itself on subsequent passes. While on the seventeenth orbit the satellite programmer automatically intitated the recovery sequence over the north pole and the capsule re-entered the atmosphere oner the Pacific and deployed its parachute. A C-119 aircraft, one of the recovery force's, homed in on the capsule's CW beacon signal and visually sighted the capsule in the afternoon sky. On the third pass under the capsule as it plumbed toward earth, the rear hooks of the special air-recovery gear snagged the nylon [redacted]e crew carefully rewlded in the chute and

[redacted]

capsuxxx ans stored them aboard the aircraft. for retumn to the states.

The recovery of these capsules gave the contractor, General Electricx a chance to examine the effects of an actual xxxxxxx reentry. (mo rpt, Aug 60; MSP Q Aug 60)

After a month's ~~xxxxxxxxx~~ pause another Thor-Agena soared into the xxxx mid-afternoon sky, rolled to the wouth, the Agena separated and ascended into xxxxx a polar orbit. This launch was the sixth consequetive one to require only a single countdown. (L vol 2) Telemetry data on the first pass over the Pacific indicated that the vehicle was stable and in the programmed attitude but that the control gas consumption was excessive. On the seventeenth pass the vehicle ejected the capsule, but because of the gas depletion, ~~xxxxxxxxxxx~~ the vehicle's xxx downward pitch did not occur. As a result, the capsule reentered the earth's atmosphere and decended into the choppy waters of the Pacific xxxxx about 1,000 miles south of the planned impact point. Nevertheless, recovery forces were able to reach the xxx scene.

ROUGH DRAFT

[redacted]

The Hawaiian station tracked the capsule until the atmoshere's ionization particles enveloped it. From the tracked path, a computer revised the predicted impact point and aircraft and one recovery ship rushed ~~to~~ toward the ~~seene~~ point. The first aircraft in the area picked up the capsule's radio signals and thirty minutes later a second airfraft sighted the capsule bobbing up and down in the water. The aircraft dopped marker beacons, strobe lights, smoke bombs, and aluminum dye to mark the area. The next morning a Coast Guard amphibian arrived but did not land becuase of rough seas. ~~and becuse~~ Because of the worsening sea and weather conditions plans were abandoned to drop parachutists and a raft. The capsule began to list and ride low in the water and by afternoon disappeared from sight. (MEP Q Aug 60; mo rpt Aug 60)

ROUGH DRAFT

[redacted]

DM-21 Thor-Agena B

~~By October 1960 [illegible] Douglas and Lockheed [illegible] making~~

~~[illegible]~~

During 1960 both Douglas and Lockheed had improved their respective products. and ~~[illegible]~~ subjected the new designs to flight tests beginning on 26 October 1960.

Prior to countdown ~~[illegible]~~ workers had to modify some of the ground support equipment, particularly for the Agena. The new Agena B was six feet longer while the new Thor was five feet shorter, so making the combined length a foot longer than the old combination.

The morning countdown was normal and the new combination lifted off the pad at noon and rolled southward as programmed, but instead of separting from the Thor and ascending into orbit the Agena plunged back to earth with the booster.

~~[illegible]~~

Telemetry data showed that a malfunction in the Agena timer prevented separation mechanisms from operating properly.

ROUGH DRAFT

[redacted]

[redacted]

A chance to dispel the gloom cast by the ignominious fate of the first Agena B flight was at hand on 12 November. ~~Problems with xx/Ground xx equipment at the pad forced a launch cancellation for the previous day.~~ After a one day delay due to technical difficulties with pad equipment, the Dm-21-Agena B combination zoomed into the upper reaches of the atmosphere, and after turning ~~xxxxxxxxxxxxxxxxxxxxxx~~ southward, ~~xxxxxxxxxx~~ the Agena successfully separated itself from ~~thxx~~ booster and ascended into ~~x~~ orbit. The ascent was satisfactory except that the orbit injection altitude was slightly lower than programmed and the orbital period was ~~would~~ consequently $2\frac{1}{2}$ minutes longer than planned. ¶ Extra batteries for auxiliary power and additional ~~xxxxxx~~ gas for attitude control in the Agena B design enabled the Air Force to ~~xxxx~~ plan for delayed recovery operations. ~~Withxxxxx~~ Previously, all capsule recovery attempts ~~operations~~ were planned not later than the following the launch ~~within a~~ day ~~of~~ launch. Now, ~~xxx~~ attempts could be made after waiting ~~xxxxx~~ considered ~~for as~~ long a delay ~~as four days~~. Consequently, the flight plan called for a recovery on the thirty-second ~~first pass~~ orbit which would occur in daylight hours over the de[illegible] the Pacific.

ROUGH DRAFT

The ~~extended~~ satellite period had little effect on satellite

[redacted]

operation or the recovery except to make the ~~xxx~~ alternate pass, the thirty first more desirable than the following one.

[redacted]

After nearly 51 hours in orbit, capsule ejection sequence was near normal and recovery forces were scattered in the predicted impact area. A C-119J aircraft made initial contact with the capsule's transmitter and a few minutes later another Pelican II craft spotted the parachute and capsule decending through the air. On the second pass under the falling aperatus an aircraft successfully snaged the payload. (mo rpt Nov 60; MSP Q Nov 60)

Although the two flights tested the new configured harware provided by Douglas and Lockheed, neither the DM-21 nor the Agena B had higher thrust engines. The Air Force had planned flights using the higher thrust engines, following four flight tests with the less adavanced models. However, by December 1960 the higher thrust configurations were available and due to payload considerations, a desire to save the remaining two fortnon-recoverable payloads flights on a... the program director decided to intermingle the use of the higher thrust configurations with the lower thrust ones. So, 7 December the contractor's crew launched the first space mission propelled by the high thrust Rocketdyne's MB-3, Block II and Bell's engines.

ROUGH DRAFT

[redacted]

[redacted]

Lockheed considered the first high-thrust flight the most successful operation to date. (L vol 3) Liftoff and booster operation was normal. The main engine cutoff when the configration was travelling southward at 11,080 feet per senond. 46 miles above the earth. The Agena engine ignited as programmed and burned for almast 235 seconds, providing a velocity of 25,900 feet per second as it went into orbit. The resulting orbit had a 380 mile apogee and 133 mile perigee and a period of almost 94 minutes. All systems operated satisfactorily, and after a lapase of three days and on the fourty-eighth orbit, the satellite successfully ejected the capsule. All elements of the recovery force were at their prescribed locations when the parachute opened. and a C-119J aircraft snagged the falling package on the first attempt. Subsequent to capsule ejection, the ground signals reoriented the Agena to the normal orbital attitude. Telemetry recorded a stable attitude-on-orbit for the next two days until the Agena electrical power source no longer had the energy to keep the attitude control mechanisms operating. (MSP Q Fe

ROUGH DRAFT

[redacted]

Both non-recoverable paylaod flights had successful ~~xxx~~ laucnhes on 20 Decmeber 1960 and 18 February 1961. However, on the first flight telemetry indicated that the gas ~~attitude~~ control mechanism ~~which turned the vehicle 180 degrees around~~ had lost all of ~~xxxx~~ its gas before completion of the first orbit and that the vehciles had become unstable. The contractor took action to correct the malfunction for future flights. The second ~~xxxxxxx~~ non-recoverable ~~xx~~ flight was more successful.

ONe of the objectives of the February flight was ~~xxxxxxx~~ to perform the first engine restart in orbit. Consequently, the usual ~~xxx~~ 180 deggree yaw turn immediately after orbital infection was delayed until after the first pass over Alaska. ~~station. [illegible]~~ The Alaska station signaled and the engine reignited, burning ~~for~~ about one second ~~xxx~~ which increased the satellite velocity about 350 feet per second and increased the orbital period by about four minutes. (MSP a Feb 60 mo rpts ___)

(Mins of 54th AFBMC 15 July 1960) dtd 4 Oct 1960

The two non-recoverable payload flights had been ~~were~~ interspersed between ~~thxx~~ recoverable flights propelled by the higher thrust engines.

ROUGH DRAFT

[redacted] [redacted]

[redacted]

The flight launched on 17 February 1961 was not only significant because it was propelled by the high thrust engines but also because it was the first launch using a Bell Telephone Laboratories guidance system in a space launch from Vandenberg. At the pad, Technicians installed the guidance cannisters in the transition section of the Thor, and used a radio antenna and computer installed originally for use in the Titan I testing intstallation at Vandneberg. Since then the Titan program personnel had abandoned the installation and Bell had improved their antenna ground system so that it could serve launches several miles away as wall as those within a matter of yards. On this launch, technicans provided an open loop circuit for the radio-guidance system. (AFBM Q Mar 61 p29) Until, this time booster trajectory had depended on the Thor's autopilot and programmer. When the technicans establihsed the closied circuit, any slight deviation from the desired path could be corrected.

ROUGH DRAFT

This launch and flight was satisfactory through until the fourth day in orbit. However, technicans determined that a recovery on the sixty-second pass was more desir[redacted]an the sixty-third,

[redacted]

and a ~~signal~~ tracking station sent a signal for the change. Normally, the command would be stored and halfway through the succeeding orbit the programmer would skip an orbital sycle. However, the programmer apparently malfunctioned and prevented capsule recovery.

On 30 March 1961 Technicans launched for the first time a Thor-Agena combination guided by the closed-loop Bell Telephone Laboratories radio-guidane system. ~~Until the guidance system~~

The Thor had used an autopilot and programmer to perform trajectory movements. With the Bell guidance system a more accurate trajecotry could be had. In addition the cannister in the Thor connected by wire to tha Agena which controlled the second stage engine ignition, and other mechanisms.

The booster performance and Agena separation and engine ignition performed normally, but 20 seconds prior to engine shutoff a rapid drop in hydraulic pressure caused the loss of engine control resulting in Agena velocity being less than required to attain an orbit.

ROUGH DRAFT

[redacted]

A week later xx on [redacted] Douglas crew launched another Thor-Agnea combination. The ascent was satasfacotry and the Agena was injected into xxxxxx an orbit approximating the one programmed, and reoriented itself with the engine end in the forward position. However, by the tenth orbit the vehicle become unstable dueto the anxxx exhaustion of control gas. Nevertheless, the vehicles continued to recive siggals from the ground.stations. ~~ground stations were able to continue to tra~~

Prggram managers decided to attempt a recovery during the second dayx in orbit rather than the fourth. xx Upon xxxxxxx ground command, xxxxxxxxxx the vehicle ejected the capsule, but into a new and higher orbit, due to xxxxx the vehicle's attitude.wxxxxxxxx

Analysis of telemetry data indicated that xxxx temperatures beyound the Agena's experience had caused erratic operation of the gas jet control valves xxxxxxxxxx which resulted in the rapid expenditure of control gas. To prevent such a reoccurance technicians were ~~to~~ coated the valvesx with a heat abosrbne material and wrapped them with thermostatically controlled electric blankets. (MSP Q May 61)
(AFBM Q Sep 61 p32)

[redacted] ROUGH DRAFT

[redacted]

Exxxxxx Exactly two months following the April launch,

technicahs launched antohser Thor-Agena. The combination appeared

to soar off into the sky and curve southward in the usual pattern,
but the Agena failed to ~~attain~~ develop sufficient ~~velocity boost~~ thrust for orbitatl boost.

~~but 147 seconds after lift off, telemetry indicated~~

~~however far beyond the [illegible] the California coast line,~~

~~however, the Agena failed to [illegible] from the [illegible] and plunged back~~

~~to earth in a [illegible] trajectory. Telemetry indicated that~~

~~there was a fire in the Agena's aft area~~
~~a [illegible]~~

~~Txxx~~ After studying available data technicians believed that

~~a xxx~~ the Agena's fuel lines leaked and caused a fire to break out in

the the aft section. Measures were taken to ~~prxxx~~prevent this

from reoccuring. (MSP 9 May61)

ROUGH DRAFT

[redacted]

Increasing Launch Rate

[redacted]

During the past two and halff years, all Thor-Agena combinations had blated off from one of two launch pads. These flights were becoming

~~During the past year Thor-Agena launches had been becoming~~

more frequent and the Air Forde beleived that the launch rate would gradually increase in the future. The last Thor training launch occured from Complex 1 in January 1960 and the Strategic Air Command had agreed that the Air Force Ballistic Missile Division could use the installation for space projects. However, the complex would have to be modified to accomodate ~~the~~ space launches and the Air Force Ballistic Missiles Commitee did not approve any ~~second~~ modification until June 1960. At that time the committee authorized the modification of the blockhouse and Pad 1. The estimated conversion cost was $2 million. (AFBMC 51st Mtg, dtd Oct 60)

During the ensuing twelve months, Douglas in conjuction with Lockheed altered the the equipment as necessary including the reorientation of the Pad so launches could be made in a 172 degree azimuth(contr-347, a mend 50) (ltr 26 Jul 60)

ROUGH DRAFT

[redacted]

[redacted]

~~Finally~~ On 16 June 1961, ~~the first~~ Thor-Agena ~~was launched~~

~~fxxxx~~ from ~~the~~ pad 1, ~~of Complex I.~~ (MSP Q May 61)

the ~~Agena being injected into a polar orbit.~~

The launch, roll and ascent into orbit ~~xxxxxxxxxxxx~~ occured in the usual manner as ~~xxxxx~~ planned. IN orbit the Agena ~~was~~ oriented ~~oritated~~ and stabilized itself in the usual programmed manner. ~~Capsule recovery began as planned~~

Capsule ejection occured ~~as planned~~ on the second day follwoing the thirty-third orbit as planned, but due to a miscalculation the recovery forces were in the wrong location. ~~Nevertheless, the capsule's electronic beacon signal the location and aircraft rushed to the scene~~

Nevertheless, the ~~xxx~~ force picked up the capsule's electronic ~~xxx~~ signal and aircraft rushed toward it. ~~to the scene.~~ Late in the afternoon An aircraft spotted the capsule floating in the water. ~~Para-rescue men inflated their rubber life raft~~ Within a few hours Para-rescue men reached the scene, ~~wit xxxx~~ jumped into the water, inflated a raft, and by nightfall the capsule was safely aboard their raft. The next morning a ship picked up the rescue team and the capsule for delivery back to the states.

(MSP Q Aug 61) [redacted] ROUGH DRAFT

Chapter 5 [redacted]

AGENA D

Since 1959 the Agena appeared in different configurations in order to meet different program requirements. As erarly as September 1959 Lockheed at Sunnyvale and the Air Force in Los Angeles have discussed the feasibility of standaridizing the vehilce. (ltr 29 Sep 59) ~~At the first the~~

The diffiulty in establishing a stanadrad second stage behicle was the diverstiy of requirements demanded of the using programs. In early 1960, Lockheed noted "six groosly dissimilar operational functions at three different altitudes on orbits varying from polar to equatorial. Additionally, the versateil Agena must accomodate boosters of radically ~~diff.~~

different capabilities and permit adapatations for widely differing control refinements." ~~Rather than attempting to design one absolute structure~~ The very scope of the programs precluded the single do-all vehicle as an ideal solution, yet Lockheed agreed that the vehicle should be simplified . (ltr 4 March 60)

At first the best that seemed feasible was them fabrication of three or four identical [redacted]ries.

ROUGH DRAFT

By 1961 the Air Force determined that it had much to gain by a basic

[redacted]

redesign of the Agena B and regid configuration control therdafter.

in view of the program

So Lockheed initiated a design study ~~in~~ toward achieving ~~e~~

a standard Agena vehicle ~~for ascent into orbit~~ to serve all known

requirements. (ltr6 Nov 61)

As the prelimianry design (~~study~~) progreesed, two sailient points emerged:

It appeared feasible and desirable to design the structure so as to

acept opeional equipment which could be ~~xxxx~~ installed for specific

missions. Secondly, ~~the~~ in order to ~~obtain~~ improve

reliability and maintainability as well as receive economic bennefits,

~~it appeared feasible and desirable to improve~~ the product should be improved during the

the manufacture of the first few. (ltr 6 Nov 61)

Following its presentation in Washington

~~In September~~ Sept - October, the Air ~~Staff~~ staff, Under Secretary of the Air Force Charyk,

~~and the~~

and the ~~xxxxx~~ Deputy Director of Defense Research and Engineering,

Rubel approved this standardization concept.

~~Reubal.~~ [~~Reubel~~ Rubel paace a further qualification that the concpet be

reviewed further after ~~xxxxx~~ Lockheed completed the design.]

(ltr ~~2~~ 6 Nov 61)

[redacted] ROUGH DRAFT

Meanwhile The Space Systems Division ~~proceeded to~~ let a CPFF letter contract [redacted] Lockheed

for the design, development, and production of 12 Agena D ~~[struck]~~ vehicles which would be standard in nature and capable of being used with a minimum degree of change in the various programs. Thesfirst ~~one~~ Agena D ~~mmxxflight should~~ was to be ready for a launch flight in January1963. (Agena D stauts rpt, Aug 62) (Hr 18 Sep 61) (contr -21)

However, this schedule was soon to change.

On 17 October 1961, Charyk appointed a fourtman committee headed by Clarence L Johnson, Vice Predident of Lockheed to"investigate ways and means for improving the reliability of the Agena vehicle and recommend improved procedures for getting the standard Agena D into earlier operation." A week later the committee reported its findings to ~~Dr~~ Charyk. It proposed ~~a~~ procedures which it thought would result in a June 1962 first launch, and the possibilty of starting a standard prduction of five per month beginning in January 1962.

ROUGH DRAFT

The committee found the organization structure of the company at Sunnyvale and the method of subcontractors ~~acceptance testing of subsystem~~ equipment ~~at Sunnyvale rather than at the subcontractors plant~~ militated ? seriuslyimediatedagainst a reliable vehicle.

[redacted]

The commitee belived that the June 1962 launch date could be [redacted]

the Air Force met
if fifteen conditions. ~~xxxx~~ These were:

1. A DX priority should be assigned the Agena "D" program.

2. The engineering system should be similar to that of the U-2, requiring only engugh drawings to tool, build and serfice the vahicles.

3. An early and final configuration freeze is necessary.

4. The engineers should be located in a secure area immediatly adjacent to the tooling and manufacturing area.

5. A rapid drawing release system (24 hours maximum) from the project engineer's approval to the manufacturing groups is necessary.

6. Fundigg should be ~~xxxxxxxx~~ adequate and timely.

7. Delete technical directive meetings invoaving large groups. Have Air Force personnel working close engough with the LMSC /Lockheed Missile and Space Company/ project engineer so that formal meetings are not required. Keep extraneaous visitors away.

8. Reasonable overtime ~~will~~ should be approved. In some cases, this may come after and not prior to its use.

9. Air Force approval of vendor selection ~~will~~ should be furnished on the spot at Sunnyvale. When single source procurement is necessary, a short written record of why this was done must be kept on file.

10. Tooling should be of the simplest type that will give interchangeabiaity, as stated in the basic Agena "D" specification. No tool drawings or outside approval of tooling should be required.

11. Interchangeability on the first four Agena "D's" will be limited to major structural and equipment items. Doors, for instance, may require trim to fit.

12. No engineering analysis reports should be required. Revert to the old system of using the basic engineering reports, which furnsih comparable data.

13. Another pad should be made avaiaable at Vandenberg (Pad #2 - Complex 75-1).

14. The WSPO /weapon system project office/ and LMSC /Lockheed Missile and Space Company/ should review the specification problem togetaher and agree at the configuration conference to reduce the number of specifications involved to the minimum compatible with the Agena "D" mission. It should also be noted that many items common with the Agena "B" will be used on the "D", and have already been qualified to exisiting specifications.

15. The /Air Force/ Program Director should be responsible for, and delegated authority for, all Agena "D" functions, including C&C /communications and control/ flight hardware. No C&C T-D's /technical directives/ should be required.

[redacted] ROUGH DRAFT

[redacted]

Knowledgeable persons with the Space Systems Division were dubious about the proposed program. For one, if the Air Force was to pursue a fixed prise contract following the initial standarization, it would be necessary to have formal model specifications, drawings and documentation for both the vehicles themselves and any specialized tools. (Blum 6 Nov 61) The drastically compressed time schedule would make it difficult it not impossible for the necessary doucumentation to be accomplished on the vehicle, and according to the recommendations, formal tool design would not be required. (Evens 6 Nov 61)

Nevertheless on 7 November 1961, Charyk approved the Johnson committee proposals, called the "skunk works" procedures. (9 Nov 1961) (Prog Plan 22 Dec 61)

ROUGH DRAFT

[redacted]

[redacted]

In pursance to these new guidelines, Air Force headquarters directed the Space Systems Division to prepare an Agena D program plan to be presented in Washington. (TWX 30 Nov 61) The divsion's plan included the initial development of 12 flight vehicles and the continued production of more. The division estimated that the program would cost $48.9 million for fiscal year 1962 and $88.5 million for 1963. (abbreviated plan, dtd 22 Dec 61) The Air Force Systems Command headquarters approved the plan on 2 January 1962 and Charyk approved it the next day. (memo 5 Jan 62)

It was the intention of the Director of Defense Research and Engineering that the Agena D program be budgeted as a separate line item. However, principally because the using programs had previously been funded for fiscal 1962 (including Agena procurement), it was not unitl 31 May 1962 that Air Force headquarters converted funds to cover the Agena D development, engineering, and industrial facility requirements as a separate budgeted program. Until that time, Agena D buyers were operating on a system of reimbursable funds whereby the using program would pay the Agena D program for procuring services & hardware. (TWX 8 Dec 61; ltr 19 Dec 61; ltr 2 Apr 62; ~~TWX 1 Jun 62~~, ltr 11 Jan 62; ltr 30 Apr 62; TWX 1 Jun 62)

[redacted] ROUGH DRA

[redacted]

On 27 November 1961, Chark had directed that contract work proceed on a cost plus incentive fee basis ~~xxxxxxxxxxxxxxxxxxxxxxxxxx~~ ~~xxxxx~~ for the initial 12 Agena Ds ~~xxxx~~ the remaining one be procured on either a fixed price contract or a fixed price incentive fee one. (memo 27 Nov 61) So the Space Systems Division began to negotiate ~~xx~~ to change the letter contract, cost-plus-fixed-fee to the new type.

Lockheed's made first proposal on 15 December 1961 which the Air Force would not ~~xxxxxxx~~ accept.

Negotiations dragged on between the Space Systems Division and Lockheed concerning the development contract as a result of proposals and counter propasals revolving around a formula for incentive fees (memo 14 Feb 62) (ltr 22 Mar 62)

Finally in April, a defintive ~~xxxxxxxx~~ agreement was reached between the contractor and the government which specified a target fee of 7-2/3 per cent of cost with overall target price of $34 million. (contr -21)

ROUGH DRAFT

By this time over half of the vehciles were in process of being manufactured. (TWX, Mar 62) The fact that ~~Since~~ ~~xx~~ as a matter of policy the division would ~~had determined~~ not ~~be~~ obligate ~~xxx~~ more than 60 per cent of approparated funds on a letter contract, may have influenced the conclusion of negotiations.

(ltr 25 Apr 62)
(ltr 14 May 62)

[redacted]

[redacted] 8

The division determined it practival to issue a straight fixed price for 39 follow on vehicles con fact since the only cost data available would be derived from the first 12 standard vehicle contract. which inclueded a large portion of non-recrruing costs of design, tooling and test equipment, plus changes in the development process. (ltr 22 Mar 62)

In April Ritland worte to Schriver stating that a clarification was needed as to the Air Force position on whether or not the origianl 15 rule used to develop the first twelver Agenas D were to be continued inoto the productin phases. Johnson and Ritland understood this, but apprently instruction have gone through normal AF channels negating this appraocha. (ltr 25 Arp 62)

Perhaps Kelly also

AF accepted first standard chassis on schedule (ltr 25 Arp 62)

Following the December 1961 issuance of the letter contract for the follow-on production of the 39 vehicles, the contractor and the government negotiate ROUGH DRAFT price redeterminable contract, a reavaluation would occur at thetime of delivery of the twelfth chassis. (TWX 10 Aug 62; TWX 24 Aug 62) However, in

[redacted] Systems Division agreed that

a fixed price incentive type contra t would be best (TWX 13 Sept 62to OSAF; TWX 13 Sep 62 to AFSC) and nggotiation were completed shortl/y thereafter establisheing [redacted] as the target price. (ltr 14 Nov 62)

ROUGH DRAFT

[redacted]

Organization

Due to the highx priority that Washington placed on the Agena D program, the entire orgranizational concept was to stremline proecedures and to limit the number of people directly participating in the program. In November General Schriver directed General Ritland to establishx within the Space Systems Division a spparate Agena D program office, directly responsible to Ritland. The office should include engineering and contract administrative functions. With Shhriver's approval, Ritland chose Colonel H B Kucheman to be the program director. In addition Schriver authorized direct communication between Kucheman's office and General Holzapple's office at Air Force headquarters for contact at that command level or higher. (ltr 24 Nov 61; ltr 20 Nov 61)

Lockheed Missile and Space Company established a separate organization for the Agena D porgram headed by Fred O'Green and physcially located apart from the rest of the Sunnyvale plant. O'Green had broad comprehensive authority including control over operations normally organized on a plant-wide functional basis. (S-01A staus rpt, Aug 6[redacted]

ROUGH DRAFT

[redacted]

Personnel of the Space Systems Division's program office established what amonnted to temporary residence at Lockheed Agend B's fabrication facility. These officers particiapted with D!Greenr[illegible]tor's and his personnel in all meetings, discussions, evaluations and decisions at the contractor's facility. In addition to the Space System Division personnel, a selected few specilists from the Air Force Plant Representatives office particpated in contractural arrangements under Colonel Kucheman's direction. In this kind of relationship, the Air Force program director was actually involved in what amounted to a continuing fact finding operation with the contractor's program manager. (ltr 13 Aug 62)

ONly the few people from the Space Systems Division, Air Force Plant Representativess office, and Lockheed who were had responsible roles in the day to day operation of the Agena D program had access to a restricted area ajacent to the Agena D assembly line.

In order to help Air Force and Lockheed engineers determine a suitable design, the contractor fabricated several test vehicles and mockups. [redacted]

ROUGH DRAFT

[redacted]

Since reliability improvemant as well as standardization were objectives of the Agena D development phase, Lockheed fabricated several test vehicles and mockups.

~~as the~~ A propulsion test vehicle was used to proof test ~~the~~ a new orifice pressurization system and ~~the~~ dual start capability of the rocket engine, ~~the~~ A structural test vehicle was used to ~~concurrently~~ qualify forward equipment rack and aft structure, ~~a and~~

~~the~~ A thermal test vehicle ~~which~~ was used to verify environmental acceptability of the design. (ltr 13 Jun 62)

An "development test vehicle" was completed on 31 March 1962 and Lockheed ~~completed its first~~ hot fired it for the first time at Santa Cruz on 23 May 1962. (ltr 13 Jun 62)

The development test vehicle might be used for installing, qualifyigg, ans where necessary, hot firing, ~~(program peculiar and component improvement~~ potential improvements ~~modifications)~~ in supprot ~~amx~~of all using programs. (ltr 13 Jun 62)

As part of the standardization, Air Force intended that automatic checkout equipment would be developed and could be used beginnigg with the nineteanth chassis. For all vehciles prior to that one, Lockheed used manual checkout equipment. However, the automatic equipment only applied to the standardi[redacted]xxxx

ROUGH DRAFT

[redacted]

A flyable Agena D consisted of the standard chassis, ~~and~~ plus certain optional equipment, ~~and~~ In addition ~~most~~ programs would have hardware peculiar to their mission ~~which they would add~~.

The objective of the development contbact was to perfect ane standard chassis. According to plan, Lockheed would checkout standard component parts, assemble the parts into a chassis, checkout the entire chassis and present ~~deliver~~ this ~~to~~ item to Air Force/Agena personnel for accetpance. ~~Then~~ Lockheed would move the chassis to an adjacent building and install ~~and~~ optional and ~~peculiar~~ mission peculiar equipment. ~~in adjacent building~~ The contractor would then manually checkout the entire vehicle for acceptance by the using program personnel. (ltr 28 Dec 61.)

Thus, as Geneal Ritland correctly observed, ~~that~~ in order to have a usable vehicle, ~~it was necessary to have~~ two checkout and acceptanne procedures were necessary.

(memo 25 Apr 62)

ROUGH DRAFT

[redacted]

[redacted]

14

For the first twelve ~~[illegible]~~ A ena D chassis, O'Green, the Lockhhed program manger, was responsible for controlling the configuration. However, Airf Force managers promulgated overall guidelines. In order to Allowing ~~xf~~ for some experimentation in design, ~~thexfx~~ all the parts of the first several chassis were not interchangeable. In April, Colonel Kuchechman ~~Kuchechanox~~ asked O'Green to standardize the configuration beginning with the sixth chassis to be deliverd to the Air Force for acceptance. ~~The colonel wanted to [illegible] to avoid structural changes in the design beyond the streghenting the forward and aft equipment racks and~~

(memo 18 Apr 62; prog rpt 13 Jul 62)

Lockheed had albeady redesigned the intial "standard" configuration at least twice. (memo 26 Feb 62) and the colonel wanted to make sure that a sutiable engineering drawings, specifications, and documentation ~~procedures~~ would be accompany the 13th chassis when delivered to the AF for acceptance ~~ready for the acceptance of the thirteenth vehicle, the first to be fabricated under the productinn contract.~~

Effective 1 July 1962, the The Space Systems Division established a configuration control board ~~fmrxthm~~ [redacted] representatives from using Air Force and

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NASA programs. ~~The xxxxxxxxxxxx~~ and headed by an offiwer in the Agena program office. The board was responsibile for the acdeptance of all vehicles produced under the production contract and for the determination of any future configuration chagges. (mo prog rpt 13 Jul 62) (ltr 11 July 62; ltr 9 July 62; ltr 25 Sep 62)

A team from of the board ~~The first article configuration inspection team~~ examined the thirtheenth ~~xxxxx~~ chassis Agena D, ~~or~~ the first of the production contractxxx in September 1962. Documentation presented to the team by Lockheed was not entirely adequate to define a configuration "baseline," but the team agreed to accept this chassis and the next five with the documentation as presented. ~~The acceptance of the first six production vehicle would be based on specifications which xx the the team gave interim approval.~~

Lockheed took action to make the necessary corrections as recommended by the team and in November the team inspected the ~~ninth~~ nineteenth chassis ~~production unit~~ and determined that the doumentation was adequate to ~~xxxx~~ define a "baseline" configuration. ~~xxxxxxxx~~ The team then directed the office of the Air Force plant representative to began accepting the units with the approved ~~to the improved~~ doucumentation ~~specifications~~. In addition ... of the inspection the each team inspected/optional kit [redacted] ... ce. By

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[redacted]

[illegible]

[illegible]

Sinne the ridgid configuation control procedures were not applied before the thirteenth chassis, the Agnea office planned that any marginal performance on first flights during June and July would be idetified so that Lcokheed could modify the production package accordingly. (mo prog rpt 13 Jul 62)

In the opinion of General Ritland, the final proof of the Agena D effort would be shown in the flights (ltr 25 Apr 62)

According to the Agena D program plan, using programs would have flown thirteen vehicles from June through December 1962. In reality only five were used and at the end of the year there was no immdediate prospect for an increase in the demand.

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In October 1962, the division made contractural arrangements with Lockheed to store the chassis and associatdd equipment while were not in use. They were to be stored in a suituable enviornment on a first-in-first-out basis in order to medigate against aging and weathering. (TWX 12 Oct 62; ltr 2 Nov 62; hist rpt Jul-Dec 62).

~~The division [illegible] the guidance modules were safe in storage but asked Lockheed to determine the life expectancy~~

Storage costs were [redacted] per bird in January 1963 and Air Force headquarters directed the production rate be cut back to three birds per month. (pro review 26 Jan 63)

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[redacted]

Component Improvement

One phylosophy of the Agena D program was the segration of the 39-vehicle production effort from any technical support and component improvement contract. (ltr 21 May 62) Although under the development contract continued provided for some product improvement the rapidity in which the design was frozen caused the division to have use most of the Agena B qualified components merely in a repackaged form. (ltr 24 Jan 62) The division belived that the componets needed to be developed further in order to better serve current and future program requirements. Following a presentation in Washington by the Space Systems Division, Charyk approved on 25 June 1962 an advanced development program as a line item in the budget. The division estimated costs of $5.5 million for fiscal 1963, which the Air Force headquarters approved. (ltrs 25 June 62; ltr 27 June 62)

Nevertheless However, the division was obligated to defend plans to improve particular components before the Air Staff. (TWX 30 Nov 62)

One of the most important advanced development reqirements was for the improvement of the Bell engine for the Gemini program. (TWX 28 Sep 62)

SECRET ROUGH DRAFT [redacted]

The first flight [redacted] Agena D used the

For the standard Agena D configuration, engineers had adapted the 16,000 pound thrust dual start engine which had propelled most of the Agena Bs in flight. Except for a change in the turbine exhaust duct the improved Agena B and the first Agena D engines were essentially the same. However, in order to insure positive identification the Air Force designated the new model LR81-Ba-11. (ltr, 20 Jul 62; ltr 3 Aug 62)

During 1962 the National Aeronautics and Space Administration expressed the need for a multiple start engine in the Agena. The civiliain space agency wanted to use the Agena as a rendezvous vehicle in the Gemini program but in order to rendezvous with another orbiting vehicle, the Agena would have to be able to make adjustments in its flight path. The Space Systems Division directed Bell, through Lockheed, to make the necessary improvements to meet the Gemini requirements but at the same time design the engine to be campatable with the Agena D. After the 1963 tests, the division might adopt the multiple start engine as the standard one for the Agena D. The principal task at hand was to simplify the starting system by removing the solid ullage rockets and controlling the flow of fuel and oxidizer into the gas generator by valves alone. (ltr 20 Jul 62; ltr 25 Jul 62; TWX 2 Aug 62)

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Chapter 6

THRUST AUGMENTED THOR

During 1959 and 1960, Douglas Aircraft Company was analyzing the basic Thor booster to determine how ~~its capacity for placing~~ heavaer objects into orbit and ~~outer space~~ at higher altitudes might be achieved. From these studies came at least two unsolicited proposals. One involved an engine with greater thrust and propellant tankage with increased capacity. However, since the Air Force would have to develop a new engine, the pursuits of such a concept would have been relatively expensive. In June 1961, Douglas revealed a more expedient way of incresing booster capability. This method would be by the use of the standard DM-21 booster with three solid propellant rocket motors strapped on the sides of the booster engine section frame. These EM-33-E2 rockets were available from Thiokol having been used as the second stage of the Air Force's Blue Scout launch vehicle & originally developed as ~~and other programs~~ for Army. (D rpt, June 1961) ~~(Eight months later Thiokol reported that all static tests and flight tests had been successful, a total of 52.) (Ltr, 8 Feb 62)~~

Each of the solid rockets had a thrust rating of 54,000 pounds; these three rockets combined with the DM-21 propuslsion system would give about 300,000 pounds of thrust.

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[redacted]

Agena payleads were getting heavier and heavier until it became clear that many future program requirments would be beyond the capability of the 170,000 pound thrust of a single Thor booster. (memo, 15 May 62 atch to ltr 4 May 62) On 27 February 1962, a program director asked that Douglas make a two month study and in coordination with Lockheed, define more precisely, the performance and design of the propesde thrust augmented Thor. (ltr 27 Feb 62) Following the detailed study, the program director felt that since additional thrust would be needed in the immediate future, the propesed appreach was the only one feasible. On 26 April, he requested the Space Systems Division's Thor booster office to provide the envisioned hardware combination ready for for the first flight seven months hence and for nine similar flights during the following year. (ltr 26 Apr 62)

[redacted]

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The requesting program office was providing the necessary funds estimated to amount to $3.35 million. For budget purposes, the Space Systems Division estimated that after the first unit, each thrust augmented Thor would cost $700,000 or $250,000 more than the standard DM-21. (ltr 9 May 62) Launch costs would be another $700,000 or $100,000 more than a DM-21 launch. (hist rpt,

Tests

In early July 1962, the Thor booster office asked Aerospace Corporation to be technical consultants for the thrust augmented Thor integration. (ltr 24 Sep 62) Operating under an extremely short lead time,

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[redacted]

the booster office ~~Space Systems Division~~ procured the solid motors directly from Thiokol (contr - 148) and negotiated an agreement with Douglas. The Thor airframe contractor ~~whereby the firm would~~ provided a prototype thrust augmented configuration by modifying a DM-21 booster, attaching the solid motors to it, and testing the new combination at the Army's Redstone Arsenal. (contr -152) Douglas modified the DM-21's flight control system, increased the ... instrumentation, and installed brackets on the aft section of the booster frame. Each set of bracakts was to hold in place one of Thiokol's 7,500 pound motors. Douglas demonstrated the capacity of the Thor to support such weights and verified the suitability of the booster modifiaations by a series of vibration and load tests.

In connection with the aft brackets there were a number of explosive bolts designed to sever the rockets from the booster frame upon a programmed signal. Static firings at the arsenal showed that this severance mechanism needed to be refined. In additon from scale model tests, engineers were able to improve the timing of the severance. ~~By ...~~

ROUGH DRAFT

By waiting a minute after the ... burnout the Thor's attitude would be in a better position to avoid contact with ~~miss the dropping of the~~ empty cases as they would fall away. [redacted]

[redacted]

The Space Systems Division was also concerned about the performance of the engines and the effects of their exhausts in the new enviornment. In order to reduce the probability of combustion instability in the main engine, the divisinn directed Rocketdyne to install a baffled injector in the MB-3, Block II engine. The modification had been successful in similar engines used by the Atlas bboster. (TWX 1 Aug 62)

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[redacted]

Production, Delivery and Launch

Space Systems Division planned to have Douglas produce the neceesary modified DM-21 boosters with the modified design in a normal assembly line fashion. Howeger, the new engineering design package generated from testing package would not be ready immeidately and in order to expedite early delivery of the first three, the division contracted with directed Douglas to produce three standard DM-21 boosters and then modify them after they came off the assembly line.*

(* In addition, two Ablestar configured Thor boosters were to be similarly modified.)

(ltr 11 July 62; contr - 186)

In the past Douglas and Leokheed shipped to Vandneberg the first and second stages from Santa Monica and Sunnyvale respectively. Now, ThioKol was obligated to ship motors in monthly increments beginning in September 1962. (contr -148) to be tempo rarily stored and then mated together with the other airborne hardware at the launching pad.

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[redacted]

[redacted]

4 Lack of a firmm decision on the Class of explsives, by the Armed Force Explosive Safety Board preluded the completion of a storage facilities for the solid rockets in time for xxx the first launches. Air Force personnel had to wait for the board to rule whether the rockets could inadvertently exploded or burn. This would determine the nature of the storage building as well as the distance from the pad. (ltr13 Jul 62) In the meantime, managers made arragnements to hosue these rockets temporarily in an iglooo type construc ton used by the Blue Scout program.

The first of the cylindriaal rockets, 2½ feet in diameter and 21 feet long, weighing 7300 pounds, were scheduled to arrive at Vandanberg in September. (TWX, 1 June 62; memo 11 June 62; memo 13 Aug 62)

Finally in October the safety board ruled that these rockets would not inadvertenly explode and in February construction began on a prefabricated metal building near the Thor launch pads. (interview with Capt J B Rauhut, SSNF, 6 Mar 63)

Douglas [redacted] provided additional ground equipment to accomodate [redacted] t configu... existing Thor launch complexes and readied Pad 5 ...

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The first modified DM-[redacted] finally arrived at Vandnsberg in December./ (hist rpt, Jul-Dec 62) and the programm director hoped for a launch ~~in~~ ~~during the~~ within ~~following~~ another month. Technical difficulties cuased delays including several postponements on the pad. Finally ~~in~~ on 28 Feburay, 1963, the new ~~xxxxxx~~ booster combination rose off its pad pushing an Agena D into the sky. However, the vehicle veered off course and the Pacific Missile Range ~~xxxx~~ safety officer ~~xxxxxxx~~ pushed the button to destroy ~~it~~ the flying hardware. ~~As the Rocketdyne engine~~ On the pad when ~~xxxxx~~ the ~~Rxxxx~~ Rocketdyne engine appreached liftoff thrust, a current passing through installed circuits was designed to ignite the three solid motors. However, in this case , there was an improper connection which cuased one solid motor not to ignite. Thus an Agena was inadvertantly lost on what was in essence the first flight test of this particular ~~xxxxx~~ hardware combination.

Despite the initial setback, undoubtedly the thrust augmented Thor would be used as a booster for future space flights requiring thrustx ratings between that of the DM-21 and the more powerful, but more expensive Atlas/. (info frm SSE) These launches will be the only known ones utilizing a combina tion of liquid and solid propellant motors. (hist rpt Jan-Jun 62)

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Chapter 7

CONCLUSIONS

---1956 through 1962, in the Los Angeles area

During the span of seven years, the Western Development Division, renamed the Air Force Ballistic Missile Division, and reorganized as the Space Systems Division, was responsible for the day-to-day management of the Air Force statellite development. However, during the entire time the purse strings were held tightly in Washington and all major technical and managerial decisions were were approved by the Department of Defense, or during 1958 and 1959, by the Advanced Research Projects Agency. These administrative arrangements were demonstrated in the go-slow attitude typified by Assistant Secretary of Defense Quarles in 1956 and 1957, the reams of numerical orders published by the special defense agency, during 1958 and 1959, and the continual dialogue between the Los Angeles project personnel and the Defense Directorate of Research and Engineering, from 1960 through 1962.

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[redacted]

Los Angeles space program managers approached the satellite systems development by determining what components were available and which ones needed to be developed. By this method the managers could shorten overall development time and reduce costs. However, some component development was inherent in the purposes behind the early satellite concepts. Early objectives included the establishment of ground-satellite communications and data processing techniques, and the development of a recovery system. The outer shell of the early recovery capsules were the by-products of reentry vehicle tests; but another area which had to be developed was in the satellite attitude control system.

ROUGH DRAFT

[redacted]

[redacted]

Nevertheless, Air Force satellites owe a great debt to other programs because of the components and systems which were made available in various stages of development. Of all the systems which were available to Lockheed the most important was the satellite engine which Bell Aircraft Company had been developing for the B-58 program. This fact is not to say that many refinements had to made and that improvements were desirable. Bell redesignedd theaengine for a higher energy fuel, later increased the fuel burn time and established a restart capability, and then went on to increase the thrust.

Following Sputnik, the decision to use the Thor as a booster was predicated on the fact that the missile would be available before the other Air Force alternative, the Atlas. Nevertheless, space project managers were not satisfied with the Thor missile and so consequdly redesigned the frame and increased the engine thrust, and selected what they thought was an improved fuel.developed in the Navaho program. In a further effort to increase the first stage booster capacity, the space program managers selected the Thor with solid rockets used by the Air Force [illegible] [redacted]

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[redacted]

the Air Force Blue Scout program and the National Aeronautics and Space Administration and developed by the Army.

~~[illegible] selecting equipment [illegible] guidance system.~~

Both the airborne cannisters and the ground antennas and computers of the Bell Telephone Laboratories radio-guidance system had proven themselves before a space program manager requested, in July 1960, ~~that~~ that the guidance system be used to provide greater trajectory accuracy on the Thor-Agena launches from Vandenberg Air Force Base. The system had successfully guided early Titan and Thor missile test flights and Thor boosted reentry vehicle test flights and there was available ground equipment at Vandenberg installed by the Titan program.

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[redacted]

In great part due to the engineering and managerial skills of Air Force space program personnel in Los Angeles, the Thor-Agena flights have become gradually more successful. At first the primary concern was for the Agena to achieve a polar orbit, later there were difficulties in the the ground-satellite communcications, and still ~~later~~ in the attitude control, and ~~recovery procedures.~~ capsule ejection and reentry system.

From February 1959 through December 1962, ~~During the six years~~ the Air Force ~~had~~ launched ~~satellites~~, 60 ~~were~~ Thor-Agenas ~~flights~~. Althoghgh either the first or second stage may be flown in combination with anohter configuration, by far the most Air Force satellite launches have been with the Thor- Agena combination. The Thor-Agena combination has proved the back bone of the Air Force space program.

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