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THE  
THOR-AGENA  
STORY

draft prepared by

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DOWNGRADED AT 12 YEAR  
INTERVALS; NOT AUTOMATICALLY  
DECLASSIFIED. DOD DIR 5200.10

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Chapter 1

INTRODUCTION

Since the close of the Second World War American military services have been actively interested in earth-circling satellites. Pertinent German research came to the attention of American military personnel and under the sponsorship of the

Army Air Corps, the RAND Corporation undertook feasibility studies of earth satellites. In September 1947, ~~the~~ <sup>an Air Force preliminary study + evaluation of RAND reports</sup> reported that a <sup>revealed</sup>

satellite was technically feasible, and in 1948 the Air Force, as

~~an~~ independent service, requested ~~that~~ <sup>P2</sup> RAND to establish a

program for the further investigation of possible satellite development.

During the next few years, RAND studied the problem under the code

name ~~XXXX~~ Feedback. <sup>By 1954 had</sup> The company reported that a space vehicle could

be placed in an <sup>earth</sup> orbit around the ~~earth~~ by a rocket powered booster.

RAND personnel recognized that numerous system component development

problems existed but such hardware development would not require

radically new technology or enormous costs

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1. Ltr. TSEON (TSEON-9) ~~8-11-47~~  
circa Dec 1947 from Ch Engr Dir  
Brig Gen Allen R Crawford to CofS  
21.4.11

2. Ltr 1 maj Gen Crawford to Douglas Air Corps, 1948, re: Satellite Project

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[REDACTED]

About the time RAND was completing its study, the Air Force established a research and development program on an advanced reconnaissance system, ~~the program was called Project 1115~~

The Wright Air Development Center, Dayton, Ohio, was responsible for managing the program called Project 1115. <sup>P 3</sup> Air Force personnel made intensive feasibility studies including such critical component development areas as satellite-born electrical power for equipment operation and component reliability in a satellite environment.

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 ~~the summer of 1955~~ <sup>that year</sup>, Wright center <sup>awarded</sup> design study contracts to Radio Corporation of America, Glenn L. Martin Company, and Lockheed Aircraft Corporation for the purpose of determining if a reconnaissance ~~satellite~~ satellite system could be developed within a ~~reasonable~~ time span which would warrant a full scale development effort.

These "Pied Piper" studies ~~submitted~~ <sup>submitted</sup> by all three contractors showed that the system could be developed.

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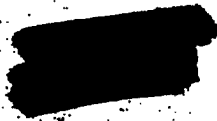


With these positive reports, the Air Force felt that it could begin hardware development under the title WS 117L.

The Air Research and Development Command believed 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 program, top national priority program, and since the <sup>WS</sup> 117L system would have to use a missile as ~~the~~ the first stage booster and ~~the~~ <sup>the change of location was an attempt to remove</sup> ~~the~~ <sup>potential</sup> 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 <sup>Los Angeles</sup> ~~development~~ division

combined their ~~own~~ talents in the preparation of a WS 117L

development plan. In May 1958 ~~The WS 117L~~ <sup>Washington authorities including</sup>

~~to Air Force agencies and to~~ Secretary of the Air Force Donald A.

<sup>Quarles,</sup> and the President's Science Advisory <sup>Committee</sup> <sup>generally</sup> ~~approved the plan.~~

The ~~plan~~ 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 ~~launch~~ pad.

The second stage would be the orbiting vehicle, which would have a

~~propulsion~~ propulsion system to supply the necessary power

to propel the vehicle into a speed necessary for orbit.

The vehicle would ~~then~~ ascend to an altitude of about 300 miles

where an orbit would be assumed, and internal controls would orient

the vehicle in the proper attitude.

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\* from War History



*about  
typed as  
same as rocket motor*

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Meanwhile in 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 <sup>the</sup> 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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~~SECRET~~

~~Department of Defense~~ [redacted] 6

The development plan had specified \$32.1 million for fiscal 1957. However, despite the program's high national priority, there was a chronic <sup>low</sup> 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~~ <sup>appreciation of</sup> ~~extreme conservatism of the Secretary of Defense~~ <sup>finally</sup> Quarles to the entire program. The first \$7 funds arrived on the West Coast in December 1956, but ~~that~~ only in the amount of \$3 million. Subsequently, <sup>1957</sup> during the year, this amount was incrementally increased to a total of \$18.9 million. The Western Development Division made repeated efforts to relieve the situation with no appreciable results.

Of greater importance was the extremely conservative approach 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 from the danger of ~~the~~ <sup>the</sup> ~~program~~ <sup>the</sup> ~~was~~ <sup>the</sup> ~~of~~ <sup>the</sup> about the usefulness of a military satellite, ~~was~~ there was concern over the possible political repercussions arising from the use of a military [redacted]

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space vehicle.

~~As a matter of policy, no model or experimental vehicle was to be fabricated without Guggenheim's permission. During this time period, the program was suspended.~~

The fund limitation and the defense department's general attitude caused <sup>US</sup> 117L program activity to be channeled into component

rather than total system development. *On a short supply of funds,* During the pre-Sputnik

Lockheed began satellite airframe design studies, investigated sources ~~for~~ for satellite-borne auxiliary power and attitude control systems,

*selected a* and searched for ~~proper~~ satellite propulsion systems which would be

available at an early date. Indeed some technical progress was

equal made but of ~~some~~ importance a contractor team had been ~~well~~ 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) ~~presented~~ <sup>two a</sup> submitted new development plans ~~during~~ 1957.

~~The development plan was submitted by~~

*which specified*

~~that if the~~ current level of

funding continued, ~~the~~ September 1959 would be a realistic target

date for the first launch. However, a more desirable level of funding--

\$7 million for fiscal 1958 and \$14.5 million for fiscal 1959--

would enable a first launch in March 1959. The Air Force Council

~~recommended~~ recommended the "desirable level" of funds, but before

~~the Department of Defense would approve,~~ *gave* approval *Soviet Union launched* the Russian Sputnik J on 4 October *causing political and emotional repercussions.*

~~would have been launched under a new Secretary of Defense.~~

*A few days later,* ~~the~~ *the "desirable level" and* ~~the~~ *the* Air Force secretary James H Douglas' approval, ~~the~~ *the* Air Force

headquarters released ~~the~~ part of the 1958 funds to the

division. When the new defense secretary Neil McElroy was briefed

on 29 October 1957, he was so enthused <sup>*isitic*</sup> that he directed the immediate

release of the balance of the 1958 funds and that the <sup>*we*</sup> program

proceed as rapidly as good management would permit.

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Also during the crisis atmosphere following ~~the~~ the first Sputnik, both RAND and the Department of the Air Force urged that Thor boosters be used in conjunction with the <sup>planned</sup> 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 ~~the~~ expanded use of Thor-boosted satellites, but <sup>a</sup> decision <sup>was</sup> ~~was~~ delayed pending the/activation of the new Advanced Research Projects Agency. The overall management of the

*W-117*

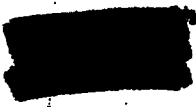
WS 117L program was <sup>to be</sup> ~~going to~~ one of the tasks of the new agency.

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.

The principal obstacle to WS 117L acceleration remained funding. Not until June 1958 were the various ~~and~~ 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, the total 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 <sup>three</sup> specialized projects, two of these ~~would~~ included the Atlas as a booster and the other ~~would~~ retain the ~~the~~ Thor ~~boosters~~.

The Thor boosted program and involved space engineering test functions, biomedical experimentation, of development/recovery techniques, and associated military support activities.

Eleven months later, on 17 November 1959, the Secretary of Defense transferred the Thor-Agana (as the second stage began to be called) to the Air Force. ~~However~~ However, for any program changed, ~~Los Angeles~~ 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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*memo*





The Thor-Agena, booster-satellite combination represented an early and ~~major~~ major Air Force achievement in that it was the first hardware combination to progress to almost routine launchings and payload ~~recovery~~ recoveries. Although each stage was used with other space hardware combinations, the Air Force used ~~the~~ <sup>for flight tests</sup> ~~two~~ stages together ~~more~~ more frequently than any other ~~combination~~ combination. The original Thor-Agena flight proposal was ~~five~~ <sup>5</sup> in January 1958, increased to 10, 13, 15, 19, and then 25 flights by 30 April 1959. Shortly after the first complete flight successes, --launch, orbit, and capsule recovery-- ~~in~~ 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 ~~these~~ comparable or greater <sup>Defense?</sup> importance, Director of Development, Research and Engineering in October 1961 had authorized <sup>production</sup> indefinite continuation of ~~launches~~ to provide ~~adequate~~ 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

THOR ADAPTATION

In November 1955 the Department of Defense assigned the development of the Thor 1,500 mile intermediate <sup>RANGE</sup> 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 back log 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 long 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 ~~the~~ ~~system~~ ~~is~~ ~~a~~ ~~whole~~ ~~and~~ ~~its~~ ~~component~~ ~~parts~~.

Actually the ~~the~~ ~~system~~ which eventually came to be used in the

Thor booster had gained considerable early experience in ~~many~~

special reentry vehicle tests and other satellite launches.

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Guidance



~~Ballistic Missile Development Program~~

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

After the Thor became part of the Air Force missile development program, there was no immediate decision on which guidance system to apply to the <sup>(short)</sup> short range missile. However, after a series of program changes ending in May 1958, the Air Force Ballistic Missile Division definitel~~y~~ assigned ~~decision that~~ the AC Spark Plug <sup>to</sup> ~~would be used in~~ the Thor and the Bell <sup>to</sup> system ~~in~~ the early Titan combat squadrons.

However, the AC Spark Plug system would not be ready for <sup>until</sup> 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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The necessary ground equipment for the radio-guidance would be ready at Cape Canaveral and ~~was~~ since there was no interference with the AC Spark Plug system development, the Air Force allowed the schedule to ~~not~~ stand.

Beginning in July 1958 there was a series of three *luna probes* ~~space~~ 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 ~~the~~ 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 until and after all improvements were incorporated, the system weighed 1,800 pounds.~~

~~REDACTED~~

**ROUGH DRAFT**



But when this decision was made, the guidance systems were still under development. Developers gradually decreased the missile-borne weight of the ~~radio~~ 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 systems weight to 1,400 pounds <sup>radio-inertial</sup> ~~for use in four~~ <sup>and ok AF installation</sup> successfully guided reentry vehicle tests during the 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~~ <sup>As</sup> part of the Titan program, ~~the~~ the Air Force had ~~established two~~ <sup>launch</sup> installations each with one radio antenna and computer. However, by January 1960 one of these installations was abandoned and consequently, the ground guidance equipment was ~~therefore~~ available for other ~~programs~~ programs.

<sup>During</sup> By July 1960, Bell had made additional improvements

<sup>in the airborne/computer</sup> in the airborne/computer ~~consisted of~~ <sup>two</sup> two canisters weighing a total of 80 ~~pounds~~ pounds. In order to improve and increase the reliability of the ~~Thor~~ booster's programmed trajectory, the division ~~had~~ decided to use the system ~~in~~ in the Thor

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*Handwritten notes:*  
 The committee  
 is to be  
 at Vandenberg





Propulsion

For the Atlas ~~missile~~ missile, the Rocketdyne Division of North American Aviation Company was developing ~~two~~ two 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 Rocketdyne to adapt one of the booster engines and ~~transfer~~ 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~~ tenety months Rocketdyne made improvements including an integrated start system and made extensive

Douglas received ~~the~~ parts. The final operationally configured engine - ~~SR-79-N-722~~ SR-79-N-722.

~~was~~ flight tests in November 1958.

static and difficulties However, ~~during~~ previous flight tests revealed ~~serious~~ difficulties

particularly ~~the~~ in the turbopump. Rocketdyne found solutions and incorporated them into another designed engine - ~~SR-79-N-722~~

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 ~~terminated~~ with

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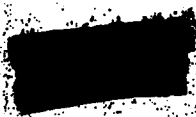
Contractors had proposed further engine development with a goal of increasing the thrust to 165,000 pounds.

Although these 150,000 pound booster engines met the requirements

of the Thor weapon system program, space program were interested in a higher thrust engine. By April 1959 the Air Force Ballistic Missiles Division established a requirement for a higher pound thrust engine. Following static tests and three successful flight tests during January and February 1960, the improved engine-- IR 79-NA-11-- was available for use in Thor space boosters.

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 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 IR79-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 the Thor-Agena Launchers and Rocketdyne Ballistic IR79-NA-11 engines for RJ-1 consumption.

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~~#~~ Just prior to Sputnik, the Air Force <sup>Missile Production</sup> headquarters had authorized a total

production of 175 Thor missiles at a rate of two ~~xxx~~ per month. If this program~~ed~~

~~xxx~~ had been followed, the first operational~~y~~/configured missile would

not have been ready before November 1960. (STL final rpt) (TWX 11 Aug 58)<sup>o</sup>

However, following Sputnik, the Air Force <sup>triple</sup> planned production

rate, reduced the number of research and development type missiles, and

set a goal of June 1958 ~~xxx~~ for the delivery of the first operationally

configured missile. ~~Repealing~~ <sup>in</sup> making these revisions the Air Force

cut the number of missiles to be produced back to the bare essentials

for the Thor program, a total of 147. (STL final rpt; TWX 2 Dec 57)<sup>o</sup>

On 6 January 1958, General Schriever appealed to the Air Force Chief of

**ROUGH DRAFT**



Staff to reinstate 24 missiles [redacted] program in order to accomplish

objectives not directly related to the Thor weapon system program.  
Stc

(ltr 6 Jan 58) Such objectives included tests of re-entry 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 had 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

beginning in February 1960. <sup>1960</sup> (STL final rpt)  
*through October when the last missile*

*would roll off the assembly line.*

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, the 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, the Air Force

headquarters cancelled their commitment, but not until after most of the

missiles had started 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 <sup>Thor</sup> ~~the~~ development ~~phase~~ at the end of 1959 (except for engines), the ~~Ballistic~~ Air Research and Development Command transferred the executive management responsibility ~~from~~ to the Air Materiel Command. The Air Force Ballistic Missile Division cancelled the system engineering and technical direction role held by Space Technology Laboratories, a subsidiary of Ramo-Wooldredge, and contracted with Douglas for system engineering, and ~~retained~~ retained ~~the~~ technical direction for itself. (Wky Digests, 3 Sep 59, 29 Oct 59)

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[REDACTED] [REDACTED]

For these early ~~inter~~space launches, the Air Force had Douglas take a missile off the assembly line and ~~make~~ <sup>modify</sup> as necessary to meet the required program. However ~~beginning~~ in November 1959, technicians ~~had~~ established a specification for ~~the~~ <sup>a</sup> ~~Thor~~ <sup>booster</sup> which would be used. ~~All operational missiles that have been produced.~~

<sup>called</sup>  
~~This was known as the DM-21 missile frame.~~ The principle difference between ~~this~~ <sup>the booster</sup> frame and that of the operational configuration was that ~~latter's~~ <sup>latter's</sup> transition section where the AC Spark Plug Guidance System ~~was~~ <sup>was</sup> located was ~~shortened~~ <sup>by five feet.</sup> The space programmers were not using a ~~guidance~~ <sup>section(?)</sup> so a long body was not needed and it improved the aerodynamic capability of the combined launch system. Since Rocketdyne's IR79-NA-9 and IR79-NA-11 engines were interchangeable ~~with~~ <sup>from</sup> one missile frame to another, the contractor could install the 165,000 pound thrust engine in DM-21s ~~when the engine was available.~~ <sup>to meet program requirements.</sup>

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In February 1960, the Secretary of Defense approved the  
fiscal year 1960 research and development program. ~~xx~~ and ~~yy~~

Air Force headquarters directed the Air Force Ballistic Missile  
Division to produce fourteen more <sup>Thor</sup> ~~Thor~~ to boost Agenas into orbit.

(TWX 27 Feb 60, justify 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, ~~thus~~ so the contract specified  
production would begin ~~at~~ 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 perhaps in larger degree than during the previous year.

By December 1960, Washington had increased the number of Thor-Agena  
missiles 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 procurement (TWX 27 Oct 60) Indeed Washington responded  
with an authorization for four more ~~DM-21 boosters~~ DM-21 boosters.

(TWX 28 Nov 60) After the ~~Space~~ the Thor office had made presentations  
to ~~the staff~~ the Air Research and Development Command headquarters  
the Air Materiel Command headquarters and the Air Staff, ~~was~~

(ltr 12 Dec 60)  
asking for permission to procure 48 more missiles, Washington approved  
an additional procurement of 12 at a continued production rate of two  
per month. This December authorization ~~would keep the Thor assembly~~  
would keep the Thor assembly

~~work~~ line busy through February 1962. (TWX 30 Dec 60)

[REDACTED]

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During the ensuing months there was a constant struggle between the Space Systems Division and Washington authorities over the ~~acceleration~~ continued production of Thor boosters. ~~The~~ <sup>to</sup> At first the division objected the low production rate of boosters, ~~but~~ <sup>principally</sup> 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 production rate but the real difficulty lay in ~~the~~ obtaining approval from

early enough Washington approval ~~on the continued production~~ so as not cause a break in the production line. Otherwise the division feared that it would be costly in time and money to start ~~the~~ <sup>the</sup> production line ~~again~~. For orderly production and contract negotiation the ~~division~~ <sup>division</sup> needed ~~a minimum~~ of 15 months in advance of the

~~fix~~ when the first booster would be ~~sent~~ delivered. In practice however, this lead time was more nearly ten months due to the late approval of Washington authorities.

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Washington ~~in~~ <sup>did not</sup> want to approve the procurement of more boosters ~~than~~ <sup>there was</sup> ~~reason~~ <sup>of</sup> using ~~them~~ <sup>had a</sup> Often the ~~program~~ <sup>program</sup> office in the space division could ~~not~~ <sup>Washington</sup> difficult time obtaining program approval ~~and adequate~~ <sup>and adequate</sup> in Washington including funds. (TWX 11 Aug 61)





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

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

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After urgent requests from the Space Systems Division,

on 13 March 1961, the Air Force headquarters authorized the procurement  
of four additional boosters, on 30 March, six more, in July, four more,  
more, in October, five more, ~~and~~ in December, eight more  
boosters  
~~extending the production schedule~~

at the rate of two per month  
continuing booster production ~~through~~ well into the middle of 1963.

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

**ROUGH DRAFT**

Standardization

When the San Bernardino Air Materiel Area assumed executive management responsibility, the material area also assumed responsibility

Thru weapon system

for the configuration control board. (20 Jan 1960) Since during

~~the period 1958 and 1959, the Air Force was~~ pulling missiles off the Douglas assembly line and modifying them

to configure to the desired requirement, a standard was not appropriate.

But there was already the beginnings of standardization 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/reliability. An example of standardized

efforts was the control electronics assembly which consisted of an

autopilot and programmer.

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The booster control electronics assembly had essentially been a modified

missile flight controller, which required ~~many~~ modifications for the various

space booster configurations. (ltr 25 May 62)




In May 1961 the division determined that the electronics assembly needed standardization. ~~xxxxxx~~ and in response to the division's request, Douglas provide the Air Force with a prototype. The ~~xxxx~~ contractor then modified the assemblies in stock ~~xxx~~ before undertaking the manufacturing of any new ones. (ltr 20 Jul 61; contr 9887, amend 1, 24 Jul 61; contr-887-80, 5 June 62)

By mid-1962 the division had completed standardizing most of the ~~xxxxxx~~ subsystems which the division thought should be changed.

Even after these <sup>changes</sup> modifications were incorporated into the standard ~~xxxx~~ booster, some differences would continue to exist. These result from the use of various second stages <sup>which differ</sup> in their dimensions, and methods of firing and separating, and the location

**ROUGH DRAFT**

of the guidance system. (hist rpt 26 Feb 62)

However, the idea was to ~~be~~ <sup>have</sup> able to support as many programs as feasible with as few changes as possible. 



~~XXXXXXXXXX~~, The Space Systems Division felt that in order to <sup>retain</sup> develop  
\* standardized <sup>components</sup> ~~launch vehicle~~, a configuration control board was necessary.

<sup>1962</sup> In April of ~~that year~~, the division established such a board ~~consisting~~  
~~XXXXXXXXXX~~ chaired by <sup>representative</sup> a Thor booster office ~~XXXXXXXXXX~~ officer and  
consisting of representatives from ~~the~~ National Aeronautical and Space  
Administration, each <sup>S</sup> Space Systems Directorate ~~and~~ having a direct  
interest in Thor space booster configuration, and appropriate Air Force  
Plant Representatives. (ltr, 2 Apr 62)

**ROUGH DRAFT**



From Missiles to Boosters  
Originally the ~~in~~ intermediate range ballistic ~~missiles~~

19

was developed and deployed as an interim solution until the longer range intercontinental 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 <sup>be</sup> gradually withdrawn from England.

DDR&E directed that these SM-52 75 missiles be converted into DM-21 boosters

at Douglas' 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. <sup>1962</sup> 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 1962. Space Systems Division estimated

that ~~the~~ <sup>price</sup> modification of each booster would be \$275,000.

(notes, fSSD program review, 11 Nov 62)

The Space Systems Division had estimated the average price of <sup>a</sup> 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 <sup>paid</sup> to

Douglas at Santa Monica ~~and~~ <sup>does not include</sup> ~~the~~ engines, BTL

guidance units, or Douglas launch services.)

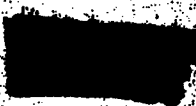
**ROUGH DRAFT**





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 ~~next~~ horizon. In retrospect/the transfer of executive management responsibility from ~~Los Angeles~~ Los Angeles to San Bernardino may be considered a watershed in Thor history. Before that date <sup>Thors</sup> 160 were under contract for development tests, operational squadrons, and crew training launches, while only 64 had been earmarked for use as first stage boosters <sup>for</sup> ~~in~~ reentry vehicle tests and space launches. During ~~this~~ <sup>the</sup> early period, the Air Force had the ~~missile~~ <sup>missile</sup> frames modified for what was <sup>was</sup> at that time "special purposes", but Beginning in 1960, all Thors placed on contract were assembled as a booster, in most instances ~~not~~ meeting the specifications of the DM-21, ~~and~~ sometimes called ~~the~~ Standard Launch Vehicle. II

**ROUGH DRAFT**





Chapter 3

AGENDA DEVELOPMENT

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 component parts including entire subsystems from capable and experienced firms who performed tests on their product before ~~that~~ delivering it to Lockheed. These subcontractors were to deliver ~~the~~ the tested hardware to Lockheed which in turn would integrate the components, subassemblies 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~~ ~~reached~~ ~~completion~~, someone conceived of the idea of acceptance firing of ~~each~~ vehicle there, thus requiring additional equipment and instrumentation. (ltr 11 Apr 60)

**ROUGH DRAFT**

Lockheed produced the early flight test vehicle in various locations.

The contractor fabricated components at ~~the~~ <sup>the</sup> Van Nuys plant,

assembled the vehicle at Sunnyvale, <sup>modified</sup> installed and checked out

subsystems at Palo Alto, <sup>then</sup> before shipping the vehicle for

engine firing and system checkout <sup>to</sup> Santa Cruz. (Prog rpt 31 May 58)

(Mar 59 Q)

*Small*

The Air Force planned that Lockheed's 4000 acre tract

north of Santa Cruz be used for static firing and a complete

systems checkout of the entire vehicle. (Presented on Santa Cruz)

(Dev Plan Mar 58)

*The Air Force allocated \$400,000 in industrial equipment.*

Workers completed the components test laboratory in April 1958

and finished the two static firing test stands and blackhouses

in time for testing of the first flight vehicle in August 1958.

(Prog Status rpts, 15 Apr 58, 30 Aug 58)

# ROUGH DRAFT

*Removal*

Early in planning for the program, a decision made to fabricate two

propulsion test vehicle assemblies (PTVA).



~~Two failures occurred in September, 1958, minor ones (to pg 30)~~

3  
~~xxx~~ For the first flights, ~~the xxx~~ Lockheed ~~xxxx~~ vehicles  
to Sunnyvale for further checkout, then to Vandenberg where in  
an assembly building the vehicle ~~was~~ went further checks, and  
then still further checks on the pad prior to launch. During 1960,  
the Air Force Ballistic Missile Division made an effort to cut down on  
some of these ~~xxx~~ checks and consequently expenses.

~~The division attempted to reduce the need for xxx checkout xxx procedures at~~

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

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

## ROUGH DRAFT

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

In addition the ~~xxx~~ extensive checkout of the vehicle at the Vandenberg  
assembly building was eliminated. ((16 June 1961))

The various Air Force program offices usually installed their payloads  
in the Agena in the assembly building. ~~xxxx~~

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

The Bell Aircraft Company had been developing a turbo-pump rocket engine for the air-to-ground missile which would be carried by B-58 Hustler aircraft then under development. By March 1957, Lockheed with the concurrence of the Air Force, selected Bell's IR-81 engine as the basic propulsion unit for the 117L's second stage. (Spc Proj (Wkly Diary, 28 Mar 1957) X)

Later, during the year <sup>and following preliminary flight testing</sup> the Air Force cancelled ~~the~~ the missile portion of the B-58 program, so consequently ~~the~~ about \$570,000

**ROUGH DRAFT**

worth of hardware ~~in~~ 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)

ROB Project Card, DD Form 613,

Propulsion for Gyrotron for AAS, WS 117L, Project No 1756, Encl. No. 2-117, 2 Apr 1957



~~██████████~~  
 The <sup>LR-81</sup> engine consisted of a single thrust chamber, gas generator, including starting solid propellant charge<sup>s</sup> (ullage rockets), turbine driven pumps, propellant control valves, and auxiliary equipment to start operate and shut down. (L Jul-Sep 56 pp 17-20; TW 3 Apr 58?)

← Without interfering with the ballistic missile program, the <sup>only</sup> selected engine was the <sup>only</sup> available with a turbopump feed system and within the required thrust range. The LR-81 engine had a thrust rating of about 15,000 pounds. ~~Engineers estimated the control system~~

~~without an additional system.~~ The engine burned JP-4 fuel when combined with <sup>an</sup> oxidizer <sup>of</sup> inhibited red fuming nitric acid. (RDB Proj Card, DD Form 613 Propulsion Subsystem, 2 Apr 57)

From the B-58 design, ~~For the B-2 engine,~~ the ~~engine~~ engineers made only <sup>a</sup> minor change <sup>which</sup> increase ~~the~~ propellant burning time from 65 to 100 seconds.

**ROUGH DRAFT**





During 1958, Washington changed some of the flight objectives, although the principal ones, satellite vehicle and ground communications. The secondary objective, remained the same. The development of visual reconnaissance including film recovery, was replaced with the development of a recoverable capsule and the collection of geophysical 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 maneuver with a heavier load than had been originally planned.

*July 58*  
 (30 Jun 58; Dec 58 Q)  
*July 58*

**ROUGH DRAFT**



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

*Lockheed* Engineers recommended a slightly heavier and higher energy fuel, Technicals decided to use unsymmetrical dimethyl hydrazine.

In addition the relative sized ~~parts~~ <sup>engine</sup> of the combustion throat and ~~nozzle~~ <sup>nozzle extension</sup> 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)(15 Apr/rpt) <sup>58</sup>

A slight increase in the size of the <sup>aluminum</sup> standard propellant tanks and

a rearrangement of the plumbing resulted in a slight lengthening of the overall airframe. (Jun 58 rpt; L Apr-Jun 58, p 2-25)

**ROUGH DRAFT**

[REDACTED]

For ground tests, Bell delivered two engines to Lockheed in March 1958. By June, technicians had mounted them on the <sup>two</sup> newly completed propulsion test assemblies <sup>at Santa Cruz.</sup> 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. <sup>firing</sup> These tests 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 result, the first two flight test vehicles were accepted at Santa Cruz, and shipped to Vandenberg for final adjustments before flight, hopefully before the end of the year.

Weekly diary at base 1st 31 Oct 58  
24 26 Nov

**ROUGH DRAFT**

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

[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 dimethyl hydrazine flight engine and delivered it to Lockheed in September 1958. <sup>(5/10/58)</sup> Although propellant temperature variations were initially troublesome, Bell solved this difficulty and then began rating tests. The new engine designated IR81-Ba-5 was rated at 15,600 pounds of thrust compared to the JP-4 engine with 15,150

In addition, pounds. The new engine could burn almost twice as long, 120 seconds compared to 64 for the old. <sup>LC Apr-Jun 58 p 2-25</sup> <sup>14 Dec 58; Mar 59 + one more</sup>

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

*These were in turn shipped to*  
At Santa Cruz, pre-acceptance testing of ~~satellite vehicles~~ continued with *for* which included hot engine firings, inspections, and functional component checks.

After incorporating any engineering changes, the Air Force <sup>would then</sup> accept the vehicle. (Sep 59)

**ROUGH DRAFT**

Agena B

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 <sup>useless</sup> dead 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 <sup>booster</sup> than the current Thor-Agena combination <sup>were</sup> capable. (when a program needed a higher orbit <sup>capability</sup>. In addition such an

engine would permit the change from one established orbit to one which is lower or higher. (Mr Feb 59, AFAND 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. (Mr 15 Jan 59 memo 6 Mar 59) The Advanced Research Projects Agency approved the

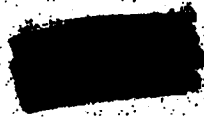
development on **ROUGH DRAFT** also directed that the propellant capacity be increased. (ARPA order 17-59, Amend 4, 10 Apr 59) By August engineers had decided that tanks

with double the Agena A capacity would be the best with both Thor and

In order to accommodate the new capacity, designers added six feet to the length of the cylindrical mid-section of the Agena. When applicable Atlas boosted flights. /Engineers used components and materials proved

in the Agena A and subjected the new design to similar ground tests

such as including vibration and centrifuge tests. In addition Lockheed build a new propulsion test tank at Santa Cruz incorporating the new design.



Early in the year the Air Force 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 high altitude chamber. (Hr 15 Jan 59)

Necessary testing on the new engine called IR81-Ba-7 had already begun by the time the Advanced Research Projects Agency issued formal approval and in September 1959 Bell shipped one engine to Lockheed for test 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 <sup>new</sup> propellant tank design, and had shipped the first assembled Agena B to Santa Cruz for tests. During the Santa Cruz tests certain difficulties had

**ROUGH DRAFT**

to be overcome including the design of the generator propellant valve. Before Air Force acceptance, technicians had to rework three engines and repeat the systems tests. (Jan Feb (or Mar 60) Under different circumstances, Bell

begin an extensive series of reliability tests <sup>at its own plant,</sup> would have ensued, but due to the limited number of flights which would employ this particular engine model,

1960  
by June, the Air Force ~~had~~ <sup>in June 1960,</sup> decided to ~~terminate~~ <sup>halt</sup> further testing, ~~by Bell.~~

Nevertheless, tests had confirmed that the IR81-Ba-7 had the same thrust as the previous Agena A model--the IR81-Ba-5--but with twice the burn time--four minutes. (NSP Memo)



The limited number of flights scheduled for this radically <sup>maneuverable,</sup> new model was that engineers had been concurrently improving the capability of the Bell engine by another approach. The approach was to increase the relative size differences between the throat and the mouth. In July 1959, the Air Force Ballistic Missile Division authorized Lockheed to proceed with such improvements in the IR81-Ba-5; <sup>(ltr 31 Jul 59, TWX 28 Jul 59)</sup> however, in March 1960, the first dual restart engine--IR81-Ba-7--was undergoing acceptance testing. At that time the Air Force directed that no further effort be expended 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 <sup>the</sup> of the new model that mouth (should be 45 times larger than the throat. <sup>(ltr 18 Feb 60; contr-297 CCN36 25 Mar 60)</sup> 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 <sup>center</sup> technicians tested nozzle

extensions made of graphite, steel, and titanium. <sup>(MSP Dec 59, 31 Mar 60)</sup> Titanium proved successful for the <sup>erosion</sup> ~~erosion~~ <sup>abrasive</sup> ~~erosion~~ <sup>abrasive</sup> The erosion

**ROUGH DRAFT**

was curtailed by ~~the~~ coating the throat with hard materials such as

<sup>MSP</sup> (31 Apr 60) Zirconia Testing and evaluation of throat coatings continued into June.



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 ~~the~~ a restart capability. (AFBMD Space Apr 61)

Earlier in the year, Beal had shipped an "expanded nozzle" engine to Lockheed for testing in the propellant test assembly at Santa Cruz.

Hot firings ~~of the Ba-9 were in progress~~ <sup>ed</sup> during February and March 1960, ~~at Santa Cruz~~. This series consisted of nine firings

including several restarts. ~~One of the prime objectives 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 gimbaled engine would ~~be~~ propel the vehicle into another flight path.*

**ROUGH DRAFT**

Although technicians were not completely satisfied with test results, <sup>for flight vehicle</sup> Bell shipped the initial "expanded nozzle" engine to Lockheed.

(June 60)  
In June 1960, 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 reliability, technicians continued tests at Bell's facilities and at Arnold.

operated  
At Bell the engine was fired 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 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**

Chapter 4

LAUNCH, FLIGHT, AND RECOVERY

America's military services were using Cape Canaveral for missile flight tests and space programs and the Air Force had originally planned to launch 117L satellites from there. Following Sputnik, not only did the Department of Defense authorize the use of Thor as a booster in the 117L program, but also approved peacetime ~~xxxx~~ 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 ~~xxx~~ with permission for peacetime launches the Air Force could use the base also for completed integrated weapon system tests and combat training launches of both intermediate and intercontinental range. Also, early in 1958 the Air Force decided that if Thor boosted 117L satellites should be launched into polar orbit, and considering overflight hazards, a southward launch from Cooke would be the best procedure.

**ROUGH DRAFT**

[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 WDI 28 Feb 59)  
25 Apr 58

The Air Force designed the first two complexes for test and training activities including the launch of missiles in a westerly direction. The third complex was designed to launch the two stage combination southward in 162 degree azimuth.

As the Air Force's construction agent the Corps of Engineers had begun work on the first Thor launch facilities in the fall of 1957 and as decisions were made in regard to the other facilities, the

corps activities expanded. Like the 117L program the Thor ~~missile~~ weapon system program required

a West Coast launch emplacement at ~~the~~ Point Mugu at Soesterling

**ROUGH DRAFT**

efforts were made to have at least one pad at the test complex and one at the 117L complex by the needed date and other installations

could be completed later. (17 Apr 58) The ~~first~~ Air Force accepted ~~the~~ pad 1 and

the blockhouse from [REDACTED] 21 August 1958, and ground ~~ed~~ (WKly Diary WDI Installation) 22 Aug 58



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

~~\_\_\_\_\_~~  
~~\_\_\_\_\_~~  
support facilities and the Air Force contractors began installing  
necessary equipment in them.

About the same time the corps had completed ~~\_\_\_\_\_~~ separate facilities

Thors ~~\_\_\_\_\_~~ after their arrival at  
designed to house the ~~\_\_\_\_\_~~ and second stage vehicles upon their  
the base until their emplacement on the launch pad.  
*And Technicians mated them together*  
~~arrival at the base. Air Force contractors began to install equipment.~~

In these facilities inspection,  
Air Force contractors ~~\_\_\_\_\_~~ installed ~~\_\_\_\_\_~~ 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**



In the meantime, Air Force teams were <sup>G</sup>wandering around the

the United States and the Pacific Ocean choosing sites for <sup>satellite</sup> tracking

*and data acquisition*

stations. The Air Force chose sites and had <sup>established</sup> ~~temporary~~ temporary

facilities and equipment at points in Hawaii, and Alaska by August

1958 (Terhune files, installations) 22 Aug 58)

The ~~The Air Force selected additional sites - a time period, such~~

~~as one in Ft. Belknap, Montana, and another in the western United States, and~~

~~one at Columbus, Naval Air Station, Iowa.~~

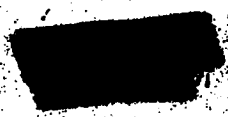
The Air Force decided that ~~six~~ data and tracking stations were needed

in the areas of the United States, northwest, central, and northeast

*These stations gradually came into operation*  
Font Stevens was approved for the northwest, Ottumwa Naval Air Station, Iowa

for the central, and for the northeast at New Boston, New Hampshire.

**ROUGH DRAFT**



To gain as much information as possible about ~~the~~ hardware behavior

on each flight, the Air Force utilized one ~~of~~ two ships equipped with special telemetry equipment. ~~The ships were assigned to locations where~~

m (L vol 2)

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

~~Later the Air Force was more~~

~~After~~ After orbital injection seemed to be mastered, the Air Force became increasingly concerned over the ejection of the recovery capsule and

To gather information on orbital ascent, a ship ~~was located above~~ *moved to a position*

~~at a~~ downrange about 1,000 miles. To gather information

on ejection and reentry procedures, ships were ~~located~~ located between

Alaska and Hawaii

**ROUGH DRAFT**



Due the many tasks that needed to be preformed, contractors began preparing for a launch ~~several~~ ~~days~~ prior the scheduled liftoff.

Among these tasks were the transporting of the first and second stages from their respective ~~fix~~ checkout facilities to the launch emplacement.

They were mated together in a horizontal position, but ~~as~~ ~~the~~ crew did

*no work* *since then until the day of the launch*

At best procedures for a launch lasted ~~from~~ more than seven

hours. Preparations for the launch usually began in the pre-dawn

hours when the crew mated the recovery capsule to the Agena and raised

*It took several hours to*

the Thor-Agena to an erect position. For several hours the crew checks the radio

frequencies, makes umbilical connections including the propellant lines,

warms up electronic equipment, loads the propellant tanks with fuel,

checkout guidance and flight control systems

The last 15 minutes were devoted almost exclusively to the Thor.

*Then*

When the missile automatically passes through a sequence of fueling,

**ROUGH DRAFT**

calibration, arming, ~~gating~~ and ~~initialization~~. However,

~~any case of a technical malfunction or~~

*the count* *down* *is* *held* *up* *until*

However, ~~any case~~, a countdown may be held up until the the last

five seconds, ~~before liftoff~~ *the crew might hold either for*

technical reasons, to allow a train to pass, or due to ~~inclement~~ *over* weather.

(L 401 1)



*condition*

Workers had readied 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 occurred in the Agena

~~and~~ *and crew* ~~the~~ *of* Launch ~~power~~ *cut off* the power ~~immediately~~ *immediately*. ~~Ground power~~ caused ignition of the ullage rockets inadvertently and safety circuit failed.

*Apparently*  
The ullage rockets had accidentally fired and triggered off internal mechanisms causing serious damage to both the first and second stages.

Following removal of the hardware from the pad, technicians determined that the Thor could be ~~rehabilitated~~ *repaired* for a future launch but the Agena was not worth rehabilitating. Technicians investigated the accident to determine in detail the causes so corrective ~~and~~ measures could be taken prior to the next countdown. (mo rpt Jan 59; L vol 1)

~~For program purposes~~ ~~should be considered~~ ~~the~~ ~~most~~ ~~important~~

**ROUGH DRAFT**

Two weeks later,



Technicians gave the next Agena a completed systems check test in the assembly building on 4 February, and then transported the vehicle to the launch pad. The launch crew mated the Agena to the Thor and conducted a practice countdown on 19 February.

The crew made an attempt to launch the combination on 25 February but after twelve hours of countdown procedures, the managers

~~decided~~ decided to postpone the launch so that

Thor's corrections could be made in the liquid oxygen tank pressurization

system. A second attempt was successful on 28 February.

when the Thor-Agena combination zoomed off into the mid-day

the Thor rolled into a southerly direction, sky. As programmed, the Agena separated from the booster and began

coasting in orbit. Radar at Vandenberg and Point Mugu and telemetry

tracking equipment at Vandenberg received signals from the Agena for

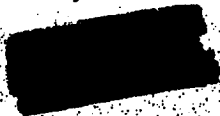
more than eight minutes after ~~litter~~ liftoff. Although

ground equipment ~~did not~~ <sup>north</sup> confirm the Agena's orbit over the

Pacific area, sporadic signals acquired on later passes showed that

the vehicle was in orbit. The Air Force considered this launch a

success. (no rpt Feb 59; L vol 1)



**ROUGH DRAFT**

9

[REDACTED]

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

In order to align flight with the current Thor-Agena program, the Air Force decided to consider the January abortive (mo rpt Feb 59) countdown as the first flight test. Since the program specified without recovery capsules, only two JPelapropelled Agenas the next flight would ~~also~~ include a second stage ~~propellant~~ which ~~would~~ burn unsymmetrical and carry a recovery capsule. dimethyl hydrazine/(Q rpt Mar 59) This time the crew launched an Agena into orbit ~~the Agena~~ 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 180 degrees the vehicle to turn/in a horizontal plane and that the satellite was floating in orbit with engine in the forward position and the recovery capsule <sup>pointing toward</sup> ~~pointing toward~~ the earth. The new position was in preparation for the seventeenth pass ~~was~~ <sup>upon command</sup> from the earth the satellite nose would tilt 60 degrees downward ~~from the~~ to permit the ejection of the reentry ~~reentry~~ capsule. Telemetry data showed that that control and ejection equipment operated properly.

[REDACTED]

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

However, the Agena had gone into an orbit <sup>at</sup> a low velocity which caused ~~the orbital period~~ 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 ~~it~~ 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 calculated that the capsule would impact ~~in the recovery circle,~~

**ROUGH DRAFT**

near the Norwegian coast of ~~the~~ <sup>the</sup> effort by both air and ground American and Norwegian forces failed to find the capsule although local observers had sighted ~~what~~ <sup>the US Air Force interpreted as</sup> ~~was thought to be~~ descending parachute and foil chaff.



11

~~XXXXXXXXXX~~

Telemetry and radar ~~operations~~ installations in the satellite continued to operate extremely well through the twenty-fifth pass which was about one and half days after launch. A continuous <sup>emitted?</sup> beacon imeted signals for another week and ~~failed~~ ~~signals~~ sightings reports of visual sighting continued until 25 April when the Air Force estimated that the satellite reentered the earth's atmosphere and burned ~~up~~ up.

In the meantime, the Air Force took steps to prevent ~~reentry~~ an ejection from taking place ~~in~~ above the wrong geographic area. Tracking procedures were revised ~~beginning with the fourth flight~~ and the vehicle timer was replaced by ~~the~~ more sophisticated one

manufactured by Fairchild. (Q rpt Jun 59) ~~no rpt Apr~~

**ROUGH DRAFT**

~~XXXXXXXXXX~~

12

~~XXXXXXXXXX~~

On 7 May 1959 the first and second stages were moved from their respective ~~XXXXXXXXXX~~ housing and checkout facilities to the launching pad ~~XXXX~~ where mating and complete systems checkout occurred. 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 ~~the~~ several abortive countdown sequences. Three delays were caused by technical difficulties, two in the Agena and one in the Thor.

(I 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 ~~is~~ coast, and engine boost were accomplished as planned. However, <sup>Agena's</sup> the ~~IR81-Ba-5~~ IR81-Ba-5 engine shut down prematurely causing the <sup>vehicle</sup> Agena to fail to achieve the required orbital velocity.

The second stage fell into the Pacific south of the equator.

Three ~~months~~ <sup>on 27 June</sup> later the Agena ~~was~~ <sup>launched</sup> a similarly configured combination ~~with~~ <sup>with</sup> ~~the~~ <sup>the</sup> ~~same~~ <sup>same</sup> ~~result~~ <sup>result</sup> ~~as~~ <sup>as</sup> ~~the~~ <sup>the</sup> ~~previous~~ <sup>previous</sup> ~~one~~ <sup>one</sup>.  
**ROUGH DRAFT**

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 ~~XXXXXX~~ <sup>XXXXXX</sup> and time, the Air Force

Ballistic Missile Division postponed the ~~subsequent~~ next scheduled flight

and initiated an investigation of the failures. ~~Studies showed that~~

~~and~~ ~~an~~ ~~improved~~ ~~performance~~ ~~could~~ ~~be~~ ~~obtained~~ ~~by~~ ~~an~~ ~~increase~~ ~~in~~ ~~increase~~ ~~in~~ ~~thrust~~ ~~and~~ ~~decrease~~ ~~in~~ ~~satellite~~ ~~weight~~.

~~Studies~~ ~~confirmed~~ ~~that~~ ~~the~~ ~~last~~ ~~two~~ ~~flights~~ ~~did~~ ~~not~~ ~~achieve~~ ~~sufficient~~ ~~velocity~~ ~~at~~ ~~the~~ ~~time~~ ~~of~~ ~~second~~ ~~stage~~ ~~burnout~~ ~~to~~ ~~obtain~~ ~~orbit~~.

~~Technicians~~ ~~had~~ ~~first~~ ~~believed~~ ~~that~~ ~~the~~ ~~engine~~ ~~had~~ ~~shut~~ ~~down~~ ~~prematurely~~;

however, ~~the~~ ~~subsequent~~ this postmortem investigation revealed that

in both flights that the satellites had not achieved sufficient

velocity at the time of second stage burnout to obtain orbit.

The Air Force approved

~~Several~~ ~~actions~~ ~~recommended~~ taken in order to improve the situation.

Lockheed reduced the ~~weight~~ weight of the Agena by 48 pounds by removing

desirable but not essential equipment and instrumentation. Space System ~~was~~ ~~hoping~~ ~~that~~

the Thor velocity could be improved by ~~increasing~~ ~~the~~ ~~thrust~~ ~~to~~ ~~200~~ ~~feet~~ ~~per~~ ~~second~~

with the use of RP-1 fuel instead of the standard RJ-1. In addition, ~~was~~

the Air Force directed that the launch azimuth be ~~changed~~ ~~from~~ ~~175~~ ~~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~~

**ROUGH DRAFT**

~~personnel~~ equipment (no rpt Jul 59) Launch pads had be be

adjusted for the new direction. Launch emplacement number 5

~~was~~ <sup>completed</sup> had been used for the fourth flight, launch, so ~~with~~ <sup>there were</sup>

two pads available for space launches .

~~The sixth flight was scheduled for~~

The Thor-Agena combination had been waiting on launch pad (4) for several weeks before final launch on 13 August. There

were a total of <sup>five</sup> ~~six~~ postponements, ~~four~~ four times due to poor

and a weather conditions. ~~sixth~~ fifth due to a Thor engine ignition

failure. Finally on 13 August the crew launched the Thor-Agena

into the sky and after separation the second stage achieved an orbit.

Tracking and data acquisition at all ground stations was excellent

this time

*long flight*

A Thor-Agena had been installed on pad (4) and the <sup>launch</sup> crew did not

~~experience~~ <sup>such</sup> such bad luck, only one ~~six~~ postponement , the

~~six~~ sixth flight <sup>and achieving orbit</sup> ~~was~~ off the pad on 13 August, only

six days following the order. Tracking and data acquisition was

generally good at all ground stations except Point Mugu and Vandenberg

where radar interference was experienced .

**ROUGH DRAFT**



On both of the August flights all objectives were achieved except capsule recovery. ~~On both flights~~ Kodiak and Hawaiian data from tracking stations indicated that capsule ejection occurred between the two; therefore near the planned point. However telemetry from the fifth flight indicated that the <sup>low</sup> capsule temperature was lower than expected and ~~effect~~ prevented the ~~mechanism~~ parachute-opening mechanism from operating.

On the sixth flight difficulties with the command-timer-adjustment sequence delayed the capsule ~~in~~ ejection 360 miles south of the planned point. <sup>sea and air</sup> During ~~the~~ both flight the/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~~ revised impact areas. ~~within~~ before the capsule would normally sink ~~in~~ beneath the ocean waves. ~~The~~ ~~aircraft~~ The forces only received scattered radar signals from the fifth flight's ~~recovery~~ capsule and nothing from the sixth flight's. (no rpt 31 Aug 59)

**ROUGH DRAFT**





August

Due to the failures of these two/recovery attempts,

the Air Force postponed additional flight until an detailed evaluation and testing of the entire recovery system could be made.

In order to allow for ~~impr~~ improved retro-rockets to be incorporated in the next flight/configuration, the Air Force ~~was~~ delayed the launch until 3 November. (~~is~~ no rpt, Oct 59)

*on pad 4* four

However, ~~the~~ abortive countdowns delayed a launch ~~until~~ for <sup>actual</sup> four days. The/launch and orbit acquisition was a complete success

but between that time and the first pass over ~~the~~ Alaska, the Agena's battery ~~the~~ auxiliary power ~~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

Crews also found it impossible to activate the vehicle began to tumble. ~~By the second pass~~ ~~the~~ the recovery capsule ejection sequence.

~~the~~ <sup>small</sup> ~~the~~ ~~to~~ ~~stabilize~~

**ROUGH DRAFT**

(L vol 1)

*from pad 5*  
a Two weeks later on ~~the~~ ~~neighboring~~ ~~pad~~ technicians ~~successfully~~ placed an Agena into orbit ~~without~~ the launched the eight Agena. This attempt was not ~~made~~ ~~with~~ any abortive countdowns. *(MBP Q Dec 59)*

~~the~~ ~~Agena~~ ~~was~~ ~~launched~~ ~~on~~ ~~pad~~ ~~5~~

However, the Agena ascended into orbit at a greater speed than  
 programmed. Lockheed had installed a mechanism, ~~called the accelerometer-integrator~~  
~~designed to cut the engines off when the~~  
 vehicle had reached its program speed. <sup>ed.</sup> In this instance the  
 accelerometer failed to perform the ~~desired~~ required task.

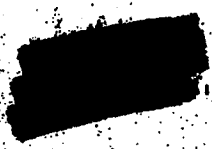
~~The result was an eccentric orbit and exceptionally~~

The result was that the Agena followed an eccentric path and took  
 an exceptionally long ~~time~~ <sup>about 1 1/2</sup> time to circle the earth, ~~103.7~~ minutes, to  
~~be exact~~. The 104-minute period exceeded the vehicle's ~~borne~~ timer's  
 capabilities to ~~make~~ react to earth bound adjustment commands. (L vol 1)

In addition, the ~~greatly increased~~ eccentric orbit confused the  
 vehicle's guidance and control system resulting in the premature  
 exhaustion of the control gas. The ~~result~~ result was that the  
 vehicle was in an improper attitude at the time of capsule ejection.

(MSP Q Dec 59)

**ROUGH DRAFT**



Some improvements in the vehicle components delayed the launching of the next Agena for over a month. (MSP Q Dec 59)

The actual liftoff was ~~another week~~ <sup>another week</sup> ~~delayed~~ <sup>by several abortive</sup>

~~countdowns~~ <sup>an pad 4.</sup> <sup>1960</sup> Finally on 4 February the Thor-Agena ~~soared~~ <sup>soared</sup> upward

and arced ~~southward~~ southward, but the Thor's main engine prematurely shut

down resulting 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 because of a ~~malfunction~~ <sup>malfunction</sup> in the helium pressurization system.

~~at the time of liftoff, the Thor's main engine prematurely shut down~~

~~the vehicle's main engine prematurely shut down~~

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

<sup>within two weeks</sup> Undaunted, the Douglas crew ~~launched~~ <sup>launched</sup>

launched another Thor-Agena, this time from pad 5. The countdown

was smooth and the launch ~~ended~~ <sup>ended</sup> on the first ~~attempt~~ <sup>attempt</sup> however,

immediately after ~~liftoff~~ <sup>lift</sup> liftoff the Thor began ~~to~~ <sup>to</sup> oscillate and

~~the range safety officer~~ when the ~~soaring~~ <sup>soaring</sup> hardware began

to deviate from its program ~~flight~~ <sup>flight</sup> path, the range safety officer

pushed the electronic destruct button. (MSP Q Feb 60; L vol 2)

**ROUGH DRAFT**





Two simultaneous explosions occurred ~~within~~ <sup>flying</sup> within the hardware verifying that both the Thor and the Agena destruction systems were operating. (L vol 2) ~~\_\_\_\_\_~~

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 ~~fix~~ the flight for a month in order ~~to conduct a survey~~ to survey the situation. Again from pad 5,

the Douglas crew launched a Thor-Agena combination into the sky, <sup>15 April 60</sup>  ~~Agena ~~was~~ ~~not~~ ~~recovered~~~~ at the climax of only one countdown.

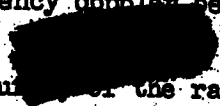
but this time the Agena went into a very satisfactory orbit.

The battery auxiliary power ~~system~~ supply lasted through the twenty-sixth orbit and attitude and control system functioned extremely well,

resulting in excellent satellite stabilization. Telemetry indicated that the recovery capsule ~~was~~ ~~not~~ ~~recovered~~ on the seventeenth pass.

**ROUGH DRAFT**

but that the re-entry trajectory was probably too high since spin rocket firing was not verified. This was the first orbiting Agena to carry a dual-frequency doppler beacon and four optical tracking lights. The ~~accuracy~~ ~~of~~ the radar system could be tested



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 initiated a program to test ~~the~~ the components. (MSP Q May 60)

An attempt to launch the Thor-Agena space system from pad 4

~~the twelfth time~~ <sup>occurred</sup> on 29 June 1960. After ~~some~~ <sup>count down</sup> minor technical delays

~~the~~ ~~Thor~~ ~~hardware~~ blasted off ~~into~~ the afternoon sky. The Thor and then the Agena ~~xxx~~ operational sequences were normal.

through the cutoff of the second stage engine. Nevertheless, ~~the~~ the

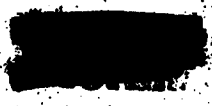
~~vehicle~~ <sup>vehicle</sup> failed to achieve orbit. Telemetry and ~~subsequent~~

investigation <sup>indicated</sup> showed that the vehicle was in an ~~improper~~ <sup>pitch down</sup> attitude

during engine operation causing the vehicle to reenter the atmosphere. ~~due to a malfunction in the horizon scanner.~~ (no rpt June 60)

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

**ROUGH DRAFT**



~~██████████~~ Littlefield, Agena <sup>21</sup>  
STORY  
May 63

The thirteenth liftoff from Vandenberg occurred on 10 August 1960

as the climax of one countdown attempt.

All programmed events ~~occurred~~ <sup>occurred nearly as programmed.</sup>

The trajectory and speed were ~~within~~ within the limits of toleration and the Agena performance was very ~~close~~ close to that which was programmed.

Following the ~~burn~~ burn out of the Agena engine, the vehicle reoriented itself into a nose aft ~~attitude~~ attitude. On the seventeenth ~~pass~~ pass over

~~northern~~ ~~the~~ ~~Pacific~~

orbit, 26 1/2 hours after launch, the Alaska tracking station verified ~~the~~ that the satellite had ~~pitched~~ pitched down, and ~~capsule had~~ ~~performed~~

~~the~~ ~~capsule~~ ~~pitched~~ ~~down~~, ~~that~~ ~~is~~, ~~the~~ ~~satellite~~ ~~pitched~~ ~~down~~,

~~the~~ ~~capsule~~ ~~ejected~~.

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 ~~picked~~ <sup>picked up</sup> ~~up~~

the capsule's radar beacon began ~~moving~~ moving toward the signal.

One ~~aircraft~~ <sup>air</sup> C-119 saw the capsule hit the water ~~and~~ <sup>and relayed</sup> the information

to a nearby ship, who dispatched a helicopter to ~~retrieval~~ <sup>the scene</sup> ~~the~~ ~~capsule~~.

~~That~~ With the help of ~~a~~ ~~frogman~~ ~~██████████~~ helicopter was able to retrieve



the capsule ~~from~~ from the choppy waters and returned 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 sustained period in orbit. (mo rpt, Aug 60; ESE Q Aug 60)

After this exhilarating experience, the launch crew threw another <sup>Agema</sup> ~~Thor~~ into orbit. Actually ~~the countdown~~ at one point the ~~countdown~~ <sup>previously launched</sup> countdown stopped for fifteen minutes while the ~~satellite~~ vehicle passed through the projected flight area. The Thor and Agena's performance were as programmed until on the first pass over the Alaskan station, telemetry data indicated that the satellite was in an ~~abnormal~~ abnormal attitude. However, the satellite ~~had~~ stabilized itself on subsequent passes. While on the seventeenth ~~pass~~ orbit the satellite programmer automatically initiated the recovery sequence

**ROUGH DRAFT**

~~over~~ over the north pole ~~and~~ and the capsule ~~re-entered~~ re-entered the atmosphere over the Pacific and deployed ~~its~~ its parachute. A C-119 aircraft, one of the recovery force's, homed in on the capsule's CW beacon signal and in the afternoon sky. visually sighted the capsule. On the third pass under the capsule as it <sup>plumbed</sup> ~~drifted~~ toward earth, the rear hooks of the spacelift air-recovery gear snagged the nylon ~~line~~ <sup>line</sup> the crew carefully reeled in the chute and



capsules and stored them aboard the aircraft for return to the states.

~~On the evening of August 23, 1960,~~

The recovery of these capsules gave the contractor, General Electric, a chance to examine the effects of an actual ~~reentry~~ reentry.

(mo rpt, Aug 50; MSP Q Aug 60)

After a month's <sup>pause</sup> ~~recovery~~ another Thor-Agena soared

into the ~~sky~~ mid-afternoon sky, rolled to the south, the Agena separated and ascended into ~~orbit~~ a polar orbit. This launch was the sixth consecutive 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 <sup>gas</sup> depletion, ~~the gas of the control~~

~~gas~~ the vehicle's ~~pit~~ downward path did not occur. As a result, the capsule reentered the earth's atmosphere and descended into the

**ROUGH DRAFT**

choppy waters of the Pacific ~~about~~ about 1,000 miles south of the planned impact point. Nevertheless, recovery forces were able to reach the ~~xxx~~ scene.

~~XXXXXXXXXX~~

~~XXXXXXXXXX~~  
The Hawaiian station tracked the capsule until ~~XXXXXXXXXX~~

~~XXXXXXXXXX~~ the atmosphere's ionization particles enveloped it.

From the ~~XXXXXX~~ tracked path,  
NA computed ~~XXXXXXXXXXXXXXXXXXXX~~ revised the ~~XXXX~~ predicted impact point

and ~~XXXXXXXXXXXXXXXXXXXX~~ aircraft and one recovery ship rushed <sup>toward</sup> the

<sup>point.</sup> first  
~~scene.~~ The aircraft ~~XXXXXXXXXXXX~~ in the area picked up the capsule's

thirty minutes later  
radio signals and a second aircraft sighted ~~XXXX~~ 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 because of rough seas.

<sup>Because</sup>  
~~and because~~ of the worsening sea and weather conditions plans were abandoned

to drop ~~XXXX~~ parachutists and a raft. ~~XXXXXXXXXXXXXXXXXXXX~~

The capsule began to list and ride low in the water. <sup>and by</sup> ~~XXXX~~ afternoon

disappeared from sight. (MEP Q Aug 60; no rpt Aug 60)

**ROUGH DRAFT**

~~XXXXXXXXXX~~

DM-21 Thor-Agena B



~~By October 1960, Douglas and Lockheed had improved their  
respective products and ~~intended to~~ subjected ~~them~~ the  
~~new~~ designs to flight tests beginning on 26 October 1960.~~

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

*Countdown*  
Prior to ~~launch~~ workers had to modify some of the ground  
support equipment, particularly for the Agena. <sup>new</sup> The Agena ~~was~~ <sup>B</sup> was  
six feet longer while the new Thor was five feet shorter, som making  
the combined length a foot longer than the old combination.

*The morning*  
The countdown was normal and the new combination lifted off the pad at  
noon and rolled ~~in~~ southward as programmed, ~~but for the Agena failed to~~ <sup>ascend</sup>  
The DM-21 performed but instead of separating from the Thor and ascending into orbit the Agena  
plunged back to earth with the booster. satisfactorily except the vernier engines shut down when the main engine

~~Normally the vernier engines burn for a long time  
main engine to down out any attitude error~~

*data* a malfunction in  
Telemetry showed that the Agena timer failure prevented separation  
mechanisms <sup>from</sup> to operate properly.



**ROUGH DRAFT**



A chance to dispel the gloom cast by the ignominious fate

Problems with Ground

of the first Agena B flight was at hand on 12 November.

~~xx~~ equipment at the pad forced a launch cancellation on 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

and after turning atmosphere, ~~in a ballistic trajectory~~ southward, ~~xx~~

the Agena successfully separated itself from ~~the~~ booster and ascended

into ~~a~~ orbit. The ascent was satisfactory except that the ~~injection~~ orbit

altitude was slightly lower than programmed and the orbital period

was ~~was~~ consequently 2 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 ~~make~~ plan for delayed

recovery operations. ~~With this~~ Previously, capsule attempts ~~recovery operations~~

were planned ~~within a day of~~ launch. *not later than the following day by delay* Now, ~~the~~ attempts could be

*after waiting* considered for ~~as~~ long a delay as ~~four~~ days. Consequently, the flight

plan called for a recovery on the thirty-~~first~~ <sup>second</sup> orbit which would

occur in daylight hours over the ~~desired~~ ~~area~~ ~~in~~ ~~the~~ ~~vicinity~~

**ROUGH DRAFT**

The extended satellite period had little effect on satellite

operation or the recovery except to make the ~~last~~ alternate pass, the

thirty first more desirable than the following one.



After nearly 51 hours in orbit,  
Capsule ejection sequence was near normal and redcovery  
behaviour satisfactory

forces were scattered in the predicted impact area. A C-119J  
aircraft made initial contact with the capsule's transmitter

Pelican II  
and a few minutes later another craft spotted the parachute  
and capsule descending through the air. On the second pass  
under the falling apparatus an aircraft successfully snagged the  
the payload. (no rpt Nov 60; MSP Q Nov 60)

Although the two flights tested the new configured  
hardware provided by Douglas and Lockheed, neither the F105 nor  
the Agena B had the ~~most advanced~~ higher thrust engines. The Air Force planned

flights using the higher thrust engines, following four flight tests  
with the older models. However, by December 1960 the higher thrust

configurations were available and due to payload considerations, the  
program director decided to intermingle the use of the higher thrust  
engines with the lower thrust ones. So, on 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 RL10-A-9 engines.

**ROUGH DRAFT**



Lockheed considered the ~~flight~~ first high-thrust flight the most successful operation ~~to date~~ to date. (L vol 3)

Liftoff and booster operation ~~was~~ normal. The main engine cutoff when the ~~boost~~ configuration was travelling ~~southward~~ southward at 11,080 feet per second. 16 miles above the earth. The Agena engine ignited as programmed and burned for almost 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 ~~three~~ a lapse of three days and on the forty-eighth orbit, the ~~capsule~~ satellite successfully ejected the capsule. All elements of the recovery force ~~at their~~ <sup>were at their</sup> prescribed locations ~~at the time of ejection~~ when the parachute opened, and 4 C-119J aircraft snagged the falling package on the first attempt.

Subsequent to capsule ejection, the ground signals reoriented ~~the~~ <sup>the</sup> Agena to the normal ~~orbit~~ orbital attitude. ~~Telemetry~~ Telemetry recorded a stable attitude-on-orbit for the next two days ~~when~~ until the Agena electrical power source no longer had the energy to keep the attitude control mechanisms operating. (MSP Q Feb)

**ROUGH DRAFT**



Both non-recoverable payload flights had successful ~~xxx~~ launches on 20 December 1960 and 18 February 1961. However, on the first flight telemetry indicated that the <sup>gas</sup> ~~altitude~~ control mechanism ~~which~~ ~~rotated~~ ~~the vehicle 180 degrees around~~ had lost all of ~~xxx~~ its ~~gas~~ before completion of the first orbit. The contractor took action to correct the malfunction for future flights. The second ~~xxxx~~ non-recoverable ~~xx~~ flight was more successful.

One of the objectives of the February flight was ~~xxxxxx~~ to perform the first engine restart in orbit. Consequently, the usual ~~xxx~~ 180 degree orbital yaw turn immediately after/injection was delayed until after the first pass over Alaska. ~~The Alaska station signaled the engine to restart~~

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 <sup>about</sup> four minutes. (MSP Q Feb 60)

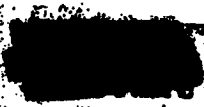
(Mins of SATN 2FBMC 15 July 1960) dtd 4 Oct 1960

MAKPTS \_\_\_\_\_ )

The <sup>two</sup> non-recoverable payload flights <sup>had been</sup> interspersed

between ~~the~~ recoverable flights propelled by the higher thrust engines.

**ROUGH DRAFT**



The flight ~~was~~ launched on 17 February 1961 was not only significant because it was ~~the~~ propelled by the high thrust engines but also because it was the first launch using a Bell Telephone Laboratories guidance system in ~~the~~ a space launch from Vandenberg. ~~Thor~~ ~~at Vandenberg~~ At the pad, <sup>guidance</sup> Technicians installed the/cannisters in the transition section of the Thor, and used ~~the~~ a ~~Thor~~ radio antenna and computer installed originally for use in the Titan I ~~testing~~ installation at Vandenberg. Since then the Titan program personnel had abandoned the installation and Bell had improved their antenna ground system so that it could ~~handle~~ ~~launches~~ <sup>serve</sup> launches several miles away as well as those within a matter of yards.

On this launch, technicians <sup>provided</sup> ~~used~~ an open loop circuit for the radio-guidance system. <sup>(AFBM Q Mar 61 p29)</sup> Until, this time booster trajectory had depended on the Thor's autopilot and programmer. When ~~the~~ the technicians established the closed circuit, ~~any~~ any slight deviation from the desired path could be corrected.

# ROUGH DRAFT

This ~~flight~~ launch and flight <sup>was</sup> satisfactory through <sup>until the fourth day in orbit</sup> ~~the~~ ~~fourth~~ ~~day~~ of orbit. However, technicians determined that a recovery <sup>second</sup> on the sixty-~~third~~ pass was more desirable ~~than~~ ~~on~~ the sixty-~~third~~ <sup>th</sup>id.

[redacted] and a ~~signal~~ tracking station sent a signal for <sup>the</sup> a change. Normally, the command would be stored and halfway through the succeeding orbit the programmer would skip an orbital cycle. However, the programmer apparently malfunctioned and prevented <sup>capsule</sup> recovery.

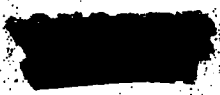
On 30 March 1961

Technicians launched for the first time a Thor-Agena combination guided by the <sup>closed-loop</sup> Bell Telephone Laboratories radio-guidance 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 trajectory could be had. In addition the ~~the~~ cannister in the Thor connected by wire to the Agena which controlled the second stage engine ~~ing~~ ignition, and ~~was connected to~~ other <sup>mechanisms.</sup>

The booster performance and Agena separation and engine ignition performed normally, but 20 seconds prior to engine shut <sup>off</sup> ~~down~~ 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**

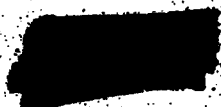


A week later ~~on~~ ~~the~~ Douglas crew launched another Thor-Agena combination. The ascent was satisfactory and the Agena was injected into ~~xxxxxx~~ an orbit approximating the one programmed, and reoriented itself with the engine end in the forward position. However, by the tenth orbit the vehicle became unstable ~~due to~~ <sup>the</sup> ~~anxxx~~ exhaustion of control gas. Nevertheless, the vehicle continued to receive signals from the ground stations. ~~ground stations were able to continue to~~

Program managers decided to attempt a recovery during the second day in orbit rather than the fourth. ~~On~~ Upon ~~the~~ ground command, ~~the~~ the vehicle ejected the capsule, but into a new and higher orbit, ~~due to~~ <sup>due to</sup> the vehicle's attitude. ~~was~~

Analysis of telemetry data indicated that ~~xxx~~ temperatures beyond the Agena's experience had caused erratic operation of the gas jet control valves ~~xxxxxxx~~ which resulted in the rapid expenditure of control gas. To prevent such a recurrence technicians were ~~to~~ <sup>ed</sup> coat the valves with a heat absorbent material and wrap ~~them~~ <sup>them</sup> with thermostatically controlled electric blankets. (MSP Q May 61)  
(AFBM Q Sep 61 p32)

~~██████████~~ **ROUGH DRAFT**



~~Exactly~~ Exactly two months following the April launch,

technicians launched another Thor-Agena. The combination appeared

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

but 147 seconds after ~~lift-off~~ <sup>develop</sup> ~~take-off~~ <sup>thrust</sup>

however far beyond the ~~range of the California coast line~~ <sup>the California coast line</sup>.

however, the Agena failed to ~~escape from the tube~~ and plunged back to earth in a ballistic trajectory. Telemetry ~~indicated~~ indicated that there was a fire in the Agena's aft area. ~~a fire had broken out in the aft area.~~

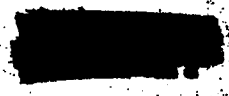
~~After~~ After studying available data technicians believed that

~~a~~ the Agena's fuel <sup>lines</sup> leaked and caused a fire to break out in

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

from reoccurring. (MSP @ 11/2/61)

**ROUGH DRAFT**



Increasing Launch Rate

24

During the past two and half 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 Force believed that the launch rate would gradually increase in the future. The last Thor training launch occurred 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 <sup>be</sup> modified to accommodate ~~the~~ space launches and the Air Force Ballistic Missiles Committee did not approve any ~~needed~~ 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.

(AFBMD 51st Mtg, Ctd: Oct 60)

During the ensuing twelve months, Douglas in conjunction 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**



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

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

~~the~~ ~~Agna~~ ~~being~~ ~~injected~~ ~~into~~ ~~a~~ ~~proper~~ ~~orbit~~.

~~The~~ launch, roll and ascent ~~xxxxxxxxxxxx~~ ~~occured~~ ~~in~~ ~~the~~ ~~usual~~ ~~manner~~

as ~~planned~~ planned. <sup>oriented</sup> IN orbit the Agena was ~~oritated~~ and stabilized

itself in the usual programmed manner. ~~Capsule~~ ~~was~~ ~~begin~~ ~~as~~

~~planned~~

Capsule ejection occurred as ~~planned~~ on the second day following 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~~ ~~signals~~ ~~the~~ ~~location~~ ~~and~~ ~~aircraft~~

~~rushed~~ ~~to~~ ~~the~~ ~~scene~~

Nevertheless, the ~~xxx~~ force picked up the capsule's electronic

~~xxx~~ signal and aircraft <sup>toward it</sup> rushed to ~~the~~ ~~scene~~. <sup>An</sup> aircraft spotted

the capsule floating in the water. ~~Para-rescue~~ ~~men~~ ~~inflated~~ ~~their~~

<sup>within a few hours</sup> ~~rubber~~ ~~life~~ ~~raft~~ <sup>Para-rescue</sup> men reached the scene ~~with~~

~~xxx~~ 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)

**ROUGH DRAFT**

Chapter 5

AGENA D

*Following flow orbital*  
 Since 1959 the Agena appeared in different configurations ~~in~~ in order  
 to meet different program requirements. *to an effort to cut down costs,*  
 As early as September 1959,  
 Lockheed at Sunnyvale and the Air Force in Los Angeles have discussed  
 the feasibility of standardizing the vehicle. *(ltr 29 Sep 59)*  
 At ~~the start~~ the

The difficulty in establishing a standard second stage vehicle was

~~due~~ the diversity of requirements demanded of the using programs.

*In early 1960,*  
 Lockheed noted ~~six~~ "six grossly dissimilar operational functions at three  
 different altitudes on orbits varying from polar to equatorial."

Additionally, the versatile Agena must accommodate boosters of radically

~~diff~~

different ~~max~~ capabilities and permit adaptations 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 ~~agreed~~ Lockheed

agreed that the vehicle should be ~~max~~ simplified. (ltr 4 March 60)

*At first the*  
 best that seemed feasible was the fabrication of three or four

identical ~~gun~~ ~~series~~ ~~ries~~.

**ROUGH DRAFT**

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

2

~~SECRET~~

redesign of the Agena B and rigid configuration control thereafter.

*in June of 1961*  
So Lockheed initiated <sup>a</sup> design study ~~in June 1961~~ <sup>toward</sup> ~~to~~ achieve

a standard Agena vehicle for ~~ascent into orbit~~ to serve all known requirements. (ltr 6 Nov 61)

As the preliminary design (study) progressed, two salient points emerged:

It appeared feasible and desirable to design the structure so as to accept optional equipment which could be ~~was~~ installed for specific

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

reliability and maintainability as well as receive economic benefits,

~~it appeared feasible and desirable to improve~~ the product <sup>should be improved</sup> during the

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

*Followed by presentation in Washington October*  
In September, the Air ~~Force~~ staff, Under Secretary of the Air Force Chayrk, ~~and the~~

and the <sup>Deputy</sup> ~~Director~~ Director of Defense Research and Engineering,

Rubel *approved this standardization concept*  
Raubal. <sup>Rubel</sup> [Raubal place a further qualification that the concept be

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

(ltr 4 6 Nov 61)

~~SECRET~~  
**ROUGH DRAFT**

Meanwhile

CFFF

letter

The Space Systems Division proceeded to let a contract with Lockheed

for the design, development, and production of 12 Agena D

vehicles which would be standard in nature and capable of being used

with a minimum degree of change in the various programs. The first one

was to a launch ~~was to~~ flight should be ready for flight in January 1963.

Agena D (status rpt, Aug 62) (Tr 18 Sep 61) (Contr - 21)

However, this schedule was soon to change.

On 17 October 1961, Charyk appointed a four-man committee headed by Clarence L Johnson, Vice President 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 Charyk. It proposed a procedure which it thought would result in a June 1962 first launch, and the possibility of starting a standard production of five per month beginning in January 1963.

ROUGH DRAFT

The committee found the organization structure of the company at Sunnyvale and the ~~method of subcontractors~~ <sup>method of subcontractors</sup> ~~acceptance testing of subsystem equipment at Sunnyvale~~ <sup>rather than at the subcontractors' plants</sup> ~~seriously~~ <sup>militated?</sup> ~~immediately~~ <sup>immediately</sup> ~~against~~ <sup>against</sup> a reliable vehicle.

The committee believed that the June 1962 launch date could be met

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 enough drawings to tool, build and service the vehicles.
3. An early and final configuration freeze is necessary. ~~Adjacent to the tooling and manufacturing area.~~
4. The engineers should be located in a secure area immediately 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 group is necessary.
6. Funding should be ~~adequate~~ adequate and timely.
7. Delete technical directive meetings involving large groups. Have Air Force personnel working close enough with the LMSC /Lockheed Missile and Space Company/ project engineer so that formal meetings are not required. Keep extraneous 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 interchangeability, 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 furnish comparable data.
13. Another pad should be made available 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 together 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 existing 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.

**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 <sup>price</sup> ~~pr~~ contract following the initial standardization,  
it would be necessary to have <sup>formal</sup> model specifications, drawings and  
documentation for both the vehicles themselves and any specialized  
tools. (Blum 6 Nov 61) The ~~contract~~ drastically compressed time  
schedule would ~~make~~ make it difficult if not impossible for  
the necessary documentation to be accomplished on the vehicles, and  
according to the recommendations, formal tool design would not be  
required. (Evens 6 Nov 61)

Nevertheless on 7 November 1961, Gharyk approved the Johnson

committee proposals, which called the "skunk <sup>works</sup> procedures. (9 Nov 1961)

(Prog Plan 22 Dec 61)

**ROUGH DRAFT**

[REDACTED]

6

[REDACTED]

# In pursuance to these new guidelines, the Air Force headquarters directed the Space Systems Division to prepare an Agena D program (TWX 30 Nov 61) plan to be presented in Washington. / The division's plan included both <sup>the</sup> initial development of 12 <sup>flight</sup> 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 <sup>headquarters</sup> 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 <sup>as</sup> a separate line item. However, principally because the using programs had previously been funded for fiscal 1962 (including Agena program), it was not until 31 May 1962 that the Air Force headquarters converted funds to cover the Agena D ~~initial~~ 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 <sup>for procuring services & hardware.</sup> (TWX 8 Dec 61; ltr 19 Dec 61; ltr 2 Apr 62; ~~ltr 19 Jun 62~~; ltr 11 Jan 62; ltr 30 Apr 62; TWX 1 Jun 62)

[REDACTED]

**ROUGH DRAFT**

On 27 November 1961, Chark had directed that <sup>contract</sup> work proceed

on a cost plus incentive fee basis ~~with a fixed fee~~  
~~under~~ for the initial 12 Agena Ds ~~and~~ 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  
to change the letter contract, cost-plus-fixed-fee to a new  
type.

Lockheed's ~~made first~~ proposal on 15 December <sup>1961</sup> which the Air Force would  
not ~~accept~~ accept.  
Negotiations dragged on between the Space Systems Division and

Lockheed concerning the development contract as a result of proposals  
a formula for (memo 14 Feb 62)  
and counter proposals revolving around/incentive fee (ltr 22 Mar 62)

Finally in April, a tentative ~~contract~~ agreement was reached between  
the contractor and the government which specified a target fee of 7-2/3

per cent of cost ~~with a~~ target fee of \$3 million. (contr -21)

**ROUGH DRAFT**

By this time over half of the vehicles were in process of <sup>being</sup> manufactured.

(TWX, Mar 62) <sup>The fact that</sup> Since ~~it~~ as a matter of policy the division <sup>had</sup> ~~determined~~ <sup>would</sup>

not ~~be~~ obligate ~~for~~ more than 60 per cent of appropriated funds on a

letter contract, may have influenced the conclusion of negotiations.

(ltr 25 Apr 62)  
(ltr 11 May 62)



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

In April Ritland wrote to Schriver stating that a clarification was needed as to the Air Force position on whether or not the original 15 rule used to develop the first twelve Aenas D were to be continued into the production phases. ~~John~~ Johnson and Ritland understood this, but apparently instruction have ~~gone~~ gone through ~~normal~~ normal AF channels negating this approach. (ltr 25 Apr 62) *perhaps Kelly also*  
AF accepted first standard chassis on schedule (ltr 25 Apr 62)

Following the December 1961 issuance of the letter contract for the follow-on production of the 19 vehicles, the contractor and the government negotiated a ~~price~~ **ROUGH DRAFT** redeterminable contract, a reevaluation would occur at the time of delivery of the twelfth chassis. (TWX 10 Aug 62; TWX 24 Aug 62) However, in

[REDACTED]

a fixed price incentive type contract would be best (TWX 13 Sept 62 to OSAF;  
TWX 13 Sep 62 to AFSC) and negotiation were completed shortly  
thereafter establishing [REDACTED] as the target price. (ltr 14 Nov 62)

**ROUGH DRAFT**

[REDACTED]

10

[REDACTED]

Organization

Due to the high priority that Washington placed on the Agena D program, the entire organizational concept was to streamline procedures and to limit the number of people directly participating in the program. In November General Schriever directed General Ritland to establish within the Space Systems Division a separate Agena D program office, directly responsible to Ritland. The office should include engineering and contract administrative functions. With Schriever's approval, Ritland chose Colonel H B Kucheman to be the program director. In addition Schriever 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 program headed by Fred O'Green and physically located far 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-OLA stans rpt, Aug 61)

[REDACTED] **ROUGH DRAFT**

19

[REDACTED]

Personnel of the Space Systems Division's program office established what amounted to temporary residence at Lockheed Agena B's fabrication facility. These officers participated with OIGreenractor'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 specialists from the Air Force Plant Representatives office participated in contractual 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 Representatives 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 adjacent 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]

**CONFIDENTIAL**

12

[REDACTED]

improvement  
Since reliability/as well as standardization were objectives

of the Agena D development phase, Lockheed fabricated several test vehicles and mockups.

<sup>A</sup> as the propulsion test vehicle <sup>was</sup> used to proof test <sup>a new</sup> the <sup>new</sup> orifice pressurization system and the dual start capability of the rocket engine.

<sup>A</sup> the structural test vehicle <sup>was</sup> used to concurrently qualify forward equipment rack and aft structure, and

<sup>A</sup> the 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

<sup>Lockheed</sup> and ~~completed the first~~ hot fire <sup>at Santa Cruz on 23 May 1962.</sup> <sup>it for the first time</sup> (ltr 13 Jun 62)

The development test vehicle might be used for installing, qualifying,

and when necessary, hot firing, ~~(program propulsion and component improvement)~~

<sup>Potential</sup>  
<sup>A</sup> <sup>improvements</sup> ~~made~~ in support ~~and~~ of all using programs. (ltr 13 Jun 62)

<sup>A</sup> As part of the standardization, Air Force intended that automatic checkout

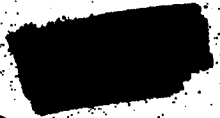
equipment would be developed and could be used beginning with the nineteenth

chassis. For all vehicles prior to that one, Lockheed used manual

checkout equipment. However, the automatic equipment only applied to

the standard ~~XXXXXXXX~~

**ROUCH DATA**



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 contract was to perfect one standard chassis. According to plan, Lockheed would checkout standard component parts, assemble the parts into a chassis,

present checkout the entire chassis and ~~submit this~~ <sup>move the chassis to an adjacent</sup> item to Air Force/personnel for acceptance. ~~Then~~ Lockheed would ~~be~~ <sup>building</sup>

and install ~~and~~ optional and ~~per~~ mission peculiar equipment. ~~incorporation~~

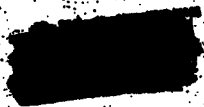
~~initially~~ manually The contractor would then/checkout the entire vehicle for acceptance by the using program personnel. (17r 28 Dec 61)

Thus, <sup>as</sup> General Rita ~~and~~ correctly observed, ~~that~~ in order to have a usable vehicle, ~~it was necessary to have~~ <sup>and acceptance</sup> two checkout/procedures were necessary.

(memo 25 Apr 62)

**NOUVEAU DIVA I**





For the first twelve ~~units~~ A<sup>U</sup>ena D chassis, O'Green, the Lockheed program manager, was responsible for controlling the configuration. However, Air Force managers promulgated overall guidelines. *In order to* ~~allowing~~ <sup>allowing</sup> ~~it~~ for some experimentation in design, ~~therefor~~ all the parts of the first several chassis were not interchangeable. In April, Colonel Kucheche~~nox~~ <sup>van</sup> asked O'Green to standardize the configuration beginning with the sixth chassis to be delivered to the Air Force for acceptance. ~~The colonel wanted to standardize the configuration beginning with the sixth chassis to avoid structural changes in the design beyond the strengthening the forward and aft equipment racks and~~

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

Lockheed had already redesigned the initial "standard" configuration at least twice. (memo 26 Feb 62) and the colonel wanted to <sup>engineer</sup> make sure that suitable drawings, specifications, and <sup>documentation</sup> procedures ~~would be ready for the acceptance of the thirteenth vehicle, the first to be fabricated under the production contract.~~ *accompany the 13th chassis when received by the AF for U.C. copy on it*

*Effective July 1962,*  
 1) The Space Systems Division established a configuration control

board ~~functions~~  representatives from using Air Force and

**ROUGH DRAFT**



NASA programs. ~~The board was composed of~~ and headed by an officer in  
 the Agena program office. The board was responsible for the  
 acceptance of all vehicles produced under the production contract  
 and <sup>for</sup> the determination of any future configuration changes.

(no pros ret 13 Jul 62)  
 (ltr 11 July 62; ltr 9 July 62; ltr 25 Sep 62)

*A team from the board*  
 The first article configuration inspection team examined the thirteenth

*Chassis*  
 Agena D, ~~the~~ the first of the production contracts in

September 1962. <sup>D</sup> Documentation presented to the team by Lockheed

was not <sup>entirely</sup> adequate to define a configuration "baseline" but the team

*agreed to accept the chassis and the next five with the*  
~~The acceptance of the first six production vehicles would be based~~  
 documentation as presented.

~~on specifications which the team gave <sup>interim</sup> approval.~~

Lockheed took action to make the necessary corrections as recommended

by the team and in November the team inspected the <sup>nineteenth</sup> ~~ninth~~ production unit *chassis*

and determined that the documentation was adequate to ~~next~~ define

a "baseline" configuration. ~~The team then directed~~ <sup>the office of the</sup> Air Force

plant representative to begin accepting the units <sup>with the approval</sup> ~~to the inspection~~

documentation specifications. In addition to the inspection

<sup>the</sup> each team inspected optional kits ~~for~~ <sup>presented</sup> ~~to~~ <sup>the</sup> office. By

**ROUGH DRAFT**





~~Standard~~

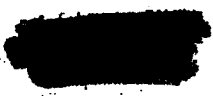
~~Standard~~

Since the rigid configuration control procedures were not applied before the thirteenth chassis, the Agnea office planned that any marginal performance on <sup>first</sup> ~~these~~ flights during June and July would be identified so that Lockheed could modify the production ~~program~~ package accordingly. (mo prog rpt 13 Jul 62)

In the opinion of General <sup>R</sup>itland, the final proof of the Agnea D effort would be shown in the flights (ltr 25 Apr 62)

According to the ~~program~~ Agnea 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 immediate prospect for an increase in the demand.

**ROUGH DRAFT**



17

[REDACTED]

In October 1962, the division made contractual arrangements with Lockheed to store the chassis and associated equipment which were not in use. They were to be stored in a suitable environment on a first-in-first-out basis in order to mitigate against aging and weathering. (TWX 12 Oct 62; ltr 2 Nov 62; hist rpt Jul-Dec 62)

~~The distribution of the chassis and associated equipment were safe in storage but asked Lockheed to determine the life expectancy.~~

Storage costs were [REDACTED] per bird and Air Force headquarters in January 1963 directed the production rate be cut back to three birds per month.

(pro review 26 Jan 62)

[REDACTED]

**ROUGH DRAFT**

18

~~XXXXXXXXXX~~  
Component Improvement

One philosophy of the Agena D program was the segregation of the 39-vehicle production effort from any technical support and component improvement contract. (ltr 21 May 62) Although ~~under~~ the development contract ~~contract~~ provided for some product improvement, the rapidity <sup>use</sup> in which the design was frozen, ~~caused~~ caused the division to have most of the Agena B qualified components merely in a repackaged form. (ltr 24 Jan 62)

The division believed that the components 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 requirements was for the improvement of the Bell engine for the Gemini program. (TWX 28 Sep 62)

SECRET ROOM DRAFT ~~XXXXXXXXXX~~

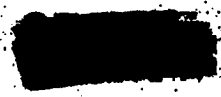
The first flight ~~was~~ <sup>standard</sup> for the Agena D configuration, ~~was~~ <sup>had</sup> engineers adapted

the 16,000 pound thrust dual start engine which <sup>had</sup> propelled most of the Agenas 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 IR81-Ba-11. (ltr, 29 Jul 62; ltr 3 Aug 62)

During 1962 <sup>the</sup> National Aeronautics and Space Administration expressed the need for a multiple start engine in the Agena. The civilian space agency wanted to use the Agena as <sup>a</sup> ~~one of~~ the rendezvous vehicles in the Gemini program <sup>or</sup> but in order to be able to rendezvous with another orbiting vehicle, the Agena would have to be able to make ~~it~~ 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 compatible with the Agena D. After the 1963 tests, the division might adopt the multiple start engine as the standard <sup>one</sup> for the Agena D.

The principal task at hand was to simplify the starting system by removing the solid ullage rockets and ~~control~~ <sup>the</sup> gas generator by valves alone (ltr 20 Jul 62; ltr 25 Jul 62; ltr 2 Aug 62)

**ROUGH DRAFT**  
**SECRET**



Chapter 6

THRUST AUGMENTED THOR

During 1959 and 1960, Douglas Aircraft Company was ~~analyzing~~ <sup>analyzing</sup> ~~the basic Thor booster to determine how ~~its~~ its capacity for ~~lifting~~ <sup>orbit and</sup> heavier objects into ~~space~~ <sup>space</sup> at higher altitudes might be achieved. From these studies came ~~in~~ <sup>at</sup> 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 pursuite of such a concept would have been~~

In June 1961, Douglas revealed a relatively expensive, <sup>a</sup> more expedient way of increasing booster capability.

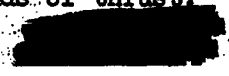
This method would be by the use of the standard DM-21 booster with three solid propellant rocket motors strapped on the <sup>engine section</sup> sides of the booster <sup>frame</sup>.

EM-33-E2 from Thiokol These ~~solid~~ rockets were available <sup>having</sup> been used as the second stage of the Air Force's Blue Scout launch vehicle <sup>& originally developed as well as other programs.</sup>

(D rpt, June 1961) ~~Eight months later, Douglas reported that all static and flight tests had been successful, a detail of 52, 111, 8 Feb 62~~

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

**ROUGH DRAFT**



2

[REDACTED]

Agna payloads were getting heavier and heavier until it became clear that many future program requirements 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, 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 proposed 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 proposed approach was the only one feasible. On 26 April, he requested the Space Systems Division's the envisioned Thor booster office to provide 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]

**ROUGH DRAFT**

3

[REDACTED]

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 ~~the~~ 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,

**ROUGH DRAFT**

[REDACTED]

The booster office  
Space Systems Division procured the solid motors directly

from Thiokol (contr - 148) and negotiated an agreement with Douglas.

*The Thor <sup>airframe</sup> contractor*  
whereby the firm would provide 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 brackets was to hold in place one of Thiokol's

7500-pound motors. Douglas demonstrated the capacity of the Thor

to support such weights and verified the suitability of the booster

modifications 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 addition

from scale model tests, engineers were able to improve the timing of

the severance. By determining the timing of the severance mechanism

By waiting a minute after the solid motors were burned out the Thor

attitude would be in a better position to *avoid contact with* miss the dropping of the empty

cases as they fall away.

**ROUGH DRAFT**

*from an - 82 - forward*



5

[REDACTED]

The Space Systems Division was also concerned about the performance of the engines and the effects of their exhausts in the new environment. In order to reduce the probability of combustion instability in the main engine, the division 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 booster. (TWX 1 Aug 62)

[REDACTED]

**ROUGH DRAFT**

[REDACTED]

6

~~██████████~~

## Production, Delivery and Launch

Space Systems Division planned to have Douglas produce

the necessary <sup>modified DM-21</sup> boosters ~~with the modified design~~ in a normal

assembly line fashion. However, the new engineering design <sup>package</sup> ~~generated from~~ <sup>tests</sup>

package would not be ready immediately and in order to expedite early

delivery <sup>FC</sup> ~~of the first three~~; the division <sup>contracted with</sup> directed Douglas to ~~DM-21~~

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 Lockheed~~ <sup>to Vandneberg</sup> shipped 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 temporarily

stored and <sup>then</sup> mated ~~together~~ with the other airborne hardware at the

launching pad.

**ROUGH DRAFT**

~~██████████~~

~~4~~ Lack of a firm decision on the Class of explosives, by the Armed Force Explosive Safety Board <sup>wait</sup> precluded the <sup>rule whether</sup> completion of a storage facilities for the solid rockets in time for ~~xxx~~ the first launches.

Air Force personnel had to ~~wait~~ <sup>wait</sup> for the board to ~~determine if~~ <sup>rule whether</sup> the rockets ~~might~~ <sup>could inadvertently</sup> explode or burn, ~~by accident~~. This would determine the nature of the <sup>storage</sup> building <sup>as well as the distance from the pad.</sup> in ~~which they would be housed in.~~ (ltr 13 Jul 62)

In the meantime, ~~management~~ managers made arrangements to house these rockets temporarily in an igloo type construction used by the Blue Scout program.

The first of the cylindrical rockets, 2 1/2 feet in diameter and 21 feet long, ~~xxx~~ weighing 7300 pounds, were scheduled to arrive at Vandenberg 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 inadvertently 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 ~~XXXXXXXXXX~~ <sup>additional</sup> provided ~~new~~ ground equipment

to accommodate ~~the~~ <sup>at</sup> configuration of existing Thor launch complexes and readied Pad 5 ~~of the~~ <sup>for the</sup> Thor launch complex.

**ROUGH DRAFT**

The first modified DM-21 finally arrived at Vandenberg in

(hist rpt, Jul-Dec 62)

December/ and the program director hoped for a launch <sup>within</sup> during the

~~following~~ <sup>another</sup> month. Technical difficulties caused delays including

several postponements on the pad. Finally ~~in~~ <sup>1963,</sup> on 28 February, the

new ~~combination~~ booster combination rose off its pad pushing an

Agena D into the sky. However, the vehicle veered off course and

the Pacific Missile Range ~~safety~~ safety officer ~~destroyed~~ pushed the

button to destroy ~~it~~ <sup>the flying hardware.</sup> As the ~~Rocketdyne~~ engine <sup>when</sup> on the pad ~~started~~

the ~~Rocketdyne~~ Rocketdyne engine approached liftoff thrust, a current <sup>passing</sup>

through installed circuits was designed to ignite the three solid

motors. However, in this case, there was an improper connection

which caused one solid motor not to ignite. Thus an Agena was

inadvertantly lost on what was in essence the first flight test

of this particular ~~hardware~~ hardware combination.

Despite the initial setback, undoubtedly the thrust augmented

Thor would be used as a booster for future space flights requiring

thrust ratings between that of the DM-21 and the more powerful, but

(info frm SSE)

more expensive Atlas. These launches will be the only ones <sup>utilizing</sup>

utilizing a combination of liquid and solid ~~propellant~~ <sup>propellant</sup> motors (hist rpt

Jan-Jun 62)

**ROUGH DRAFT**

[REDACTED]

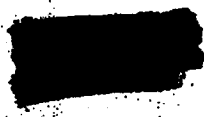
Chapter 7

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 satellite development.  
However, during the entire time the purse strings were held tightly  
in Washington and all major technical and managerial decisions 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.

**ROUGH DRAFT**

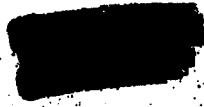
[REDACTED]



Los Angeles space program managers approached the satellite systems development by determining what ~~was~~ available and ~~was~~ needed components were which ones to be developed. ~~ix~~ 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





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 <sup>were</sup> available to Lockheed the most important was the satellite engine which Bell Aircraft Company had been developing for the B-50 program. This fact is not to say that many refinements had to be made and that improvements were desirable. Bell redesigned the engine 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 consequently 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 augmented the Thor with solid rockets used by

the Air Force Miss... [Redacted]

**ROUGH DRAFT**

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

~~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 the guidance system be used to provide greater trajectory accuracy on the Thor-Agena launches from Vandenberg Air Force Base.~~

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 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 <sup>missile</sup> test flights and Thor boosted reentry vehicle test flights and there was available ground equipment at Vandenberg installed by the Titan program.

**ROUGH DRAFT**



5

[REDACTED]

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

*From February 1959 through December 1962,*  
During the ~~six years~~ the Air Force ~~had~~ launched satellites,  
60 were Thor-Agena ~~flights~~. Although ~~in~~ <sup>either</sup> each the first or second  
stage may be ~~used~~ <sup>flown</sup> in combination with another 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.

[REDACTED]

**ROUGH DRAFT**

[REDACTED]