The Pioneer Rocket

by Gideon Marcus

On 4 October 1957, the Soviet Union orbited the first artificial satellite. Within just one year, the United States designed, built, and launched the first lunar probes. This early series of missions is scarcely documented today, but those first months of the space race showed the world what could be done in an incredibly short time when the stakes were high enough. This article is Part I of a series on the United States's first lunar probe—the story of the inception, creation, and flight of the rocket that would ultimately propel not just lunar spacecraft, but dozens of other space probes.

Space Technology Laboratories

It is a fitting start to begin with the corporation that would ultimately oversee the construction and launch of the new rocket. The Ramo-Wooldridge (R-W) corporation was founded in 1953 by Simon Ramo and Dean Wooldridge for the express purpose of designing specialized electronic components for the U.S. military.[1] They scoured the universities for talent on the assumption that anyone with a PhD must be reasonably intelligent and therefore a potential asset. Additionally, R-W recruited a number of Hughes Aircraft expatriates. In this manner, R-W accumulated one of the most impressive pools of talent in the nation. Within one year of incorporation, R-W became the U.S. Air Force's (USAF) contractor for systems engineering and technical direction for the Atlas intercontinental ballistic missile (ICBM)[2]. In November 1957, seizing the opportunity afforded by the Soviet launch of *Sputnik*, Si Ramo changed the name of R-W's Guided Missile Research Division to Space Technology Laboratories (STL), heralding a new direction for the company.

The Memo

Paul Degarabedian was a young PhD who went to work for R-W in late 1954. His job was to crunch numbers on the room-filling, vacuum-tube circuited IBM 701 to predict the performance of the Atlas, Titan, and Minuteman missiles. Eventually, his group became known as the Systems Development Department. It was a sort of brain trust whose job was to develop a proliferation of innovative ideas. Degarabedian was associate manager of the department and de facto head when, in October 1957, *Sputnik* made its beeping path across the sky. Without external prompting, he ran a few calculations and came up with an exciting proposition.

At the time, two-stage, orbital, liquid-fuel rockets were still a thing of the future. Coordinating a midair ignition was considered too finicky an operation to depend on. This is why Atlas, the first U.S. ICBM, was designed as an ingenious stage-and-a-half missile with all three engines firing at liftoff, two being jettisoned after their fuel was exhausted. The first booster to employ two liquid stages was the Vanguard, then being developed as a civilian space booster with considerable assistance from the Navy. As of October, the Vanguard had not even flown yet, but it was the only liquid-fuel second stage then in existence.

Just for the sake of spinning ideas, Degarabedian ran some numbers on the hypothetical combination of the Thor intermediate range ballistic missile (IRBM), then currently in testing, and the Vanguard second stage, coupled with a solid-fuel third stage. He distributed his findings in a memo to Simon Ramo but not before he solicited the signature of his coworker, Jack Irving, who enjoyed close relations with the company president. The relevant portions of the memo, written in a typically understated manner, are as follows[3]:

> ***Escape Vehicles Using Thor and Vanguard Components. 1 November 1957***
>
> *The last two stages of Vanguard are responsible for adding about 21,500 ft/sec to the total Vanguard velocity [with] a 21.5 [lbs] payload . . . When the Thor is fired with a control system but no guidance, and when the nose cone is replaced by the second and third stage Vanguard . . . the total velocity at burnout for the three stage missile would be 36,200 ft/sec. When fired eastward from Cape Canaveral this missile would achieve a velocity of 37,500 ft/sec. and this is about 1000 ft/sec. more than is required to get to Mars or Venus.*

This new launch system was too attractive to be ignored. While the original proposal suggested that the vehicle be used to loft probes to the planets, the Thor-Vanguard was to prove more immediately useful in resolving a pressing military conundrum.

A New Type of Nose Cone

In the beginning of 1956, the USAF began high speed reentry tests using the Lockheed X-17, a rocket that consisted of three solid-fuel stages. Ramo-Wooldridge was responsible for the technical management of the X-17 reentry program, and prevailing wisdom at the time suggested that the most promising way to avoid the prohibitive problem of nose cone overheat on reentry was to achieve as close to laminar (nonturbulent) flow of air over the nose of the missile. To this end, the X-17 nose cone was designed as a nickel-plated, copper, spherical shape with a 2 micro-inch finish to prevent transition to turbulence[4]. However, the X-solid nose cone was heavy, and even the super-smooth nickel plating could not achieve nonturbulent flow. Ultimately, the idea of using ablative materials instead of solid construction was conceived, apparently in many agencies simultaneously. Ablation works much like the burning of a book. Essentially, each page burns individually and sloughs off, removing the fire from the rest of the volume. In a similar fashion, heated outer layers of an ablative nose cone combust and come off before the rest of the nose can become superheated. This method of heat management was later used in projects Mercury, Gemini, and Apollo.

The U.S. Army demonstrated an ablative nose cone on the Jupiter IRBM in August 1957, and the Navy intended to test one on its Polaris ship-launched missile. At the time, however, no one knew whether or not an ablative cone could survive the rigors of an ICBM range reentry. As the first full range Atlas flight was not scheduled until late 1958, the USAF needed an alternative in the interim to test the concept[5].

Project Able

On 1 November 1957, Degarabedian submitted his two-stage Thor-Vanguard proposal, which he called the Thor A or Able. The Douglas Thor IRBM was a USAF project with similar characteristics to its competitor, the Jupiter, and represented the current state of the art in booster technology. Therefore, it was the natural selection for the first stage of the nose-cone test vehicle. Although there was some suggestion that the solid propelled X-17, a proven stage that would later see service incorporated into the Scout booster, might be used, in the end, the Aerojet second stage on the Vanguard won out[6]. Though a flight test of the stage had never been conducted, this stage's weight and performance characteristics recommended it for the job. The X-17 simply was not powerful enough[7].

There was no question at the time but that STL, which was already working on the Thor and had a symbiotic relationship with the USAF, would be chosen to develop the reentry vehicle. Phase 1 in a long series of projected roles for the Thor Able involved a flight path that would propel the missile 5,500 nautical miles from the coast of Florida to the vicinity of Ascension Island, propelling its ablative nose cone through the atmosphere at ICBM velocity. In this role, the Thor Able was dubbed the Able Reentry Test Vehicle or ARTV. On 26-November, STL sent a delegation, including propulsion experts George Gleghorn and George Solomon, to the Martin assembly plant in Middle River, Maryland, to procure several Aerojet stages. Gleghorn, a Korean War veteran and R-W's hundredth employee, was the most knowledgeable Thor integrations and test person there was. Solomon was his superior. They placed a special order with Aerojet purchasing several Vanguard second stages. The rocket company was to ship a set of tanks and an engine but strip the boosters of all guidance and control mechanisms. The STL team wasn't interested in putting a payload into a particular orbit. Rather, they aimed to slam the nose cone into the ocean as fast as possible. Thus, the Thor Able's second stage would fly open-loop, or based on a preplanned trajectory with no in-flight course correction. This configuration saved a good deal of weight, and weight was always a paramount concern.

Paul Degarabedian at his home in April 2006
Photo: Gideon Marcus

Gleghorn immediately began work on constructing actuators and a new forward compartment for fitting with a payload. Douglas provided the standard autopilot, amplifiers, and gyros[8]. Gleghorn was also responsible for ballasting the vehicle—essentially weighing the rocket down such that even after all the fuel had been burned, the missile would not hit the coast of Africa. He eventually settled on a weight of 185 pounds as sufficient to prevent the Thor Able from becoming the first ICBM to hit a foreign nation[9].

In December, work on the Thor Able began in earnest. STL's role in the project became a subject of controversy requiring clarification. At the time, Douglas was quite proprietary about its booster business and did not relish the idea of creating its own competition. This friction was one of the main reasons R-W (and later Thompson Ramo Wooldridge—TRW) segued away from boosters and into the space probe business. On 13 December, R-W and Douglas reached the agreement that STL would be in charge of all propulsion operations, including the starting and stopping of the countdown, and on 24-December, R-W took on the responsibility of all cabling, except for inside the propulsion unit[10].

George Mueller, director of the STL Electronics Laboratory and a PhD from Ohio State, was officially made project manager early in the month. Dick Morrison was then put in charge of booster development, and Solomon went to the Cape to handle data and support requirements at the launch site, the Air Force Missile Test Center (AFMTC) at Patrick Air Force Base in Florida. All the subcontractors were signed off on 20 December. Control Systems Division was responsible for the accelerometer. A Vanguard type was preferred for the mission but took an uneasy three weeks to procure. Radio Corporation of America (RCA) was contracted to provide the autopilot. Though contingency plans were drawn up to develop the autopilot in house to save money and weight, in the end the schedule was too tight to allow it. Hallamore provided the Ground Support Equipment (GSE) trailers. All told, the original cost for the program was estimated at $1,550,000. This number naturally increased as development proceeded, perhaps to around $2 million—still a bargain by 2006 standards, though it was considered profligate at the time. On 2 January 1958, all material pertaining to RCA and Hallamore was unclassified. The rest would remain classified for more than a year. By the end of December, a preliminary telemetry scheme had been set up and a projected first flight was expected no later than mid

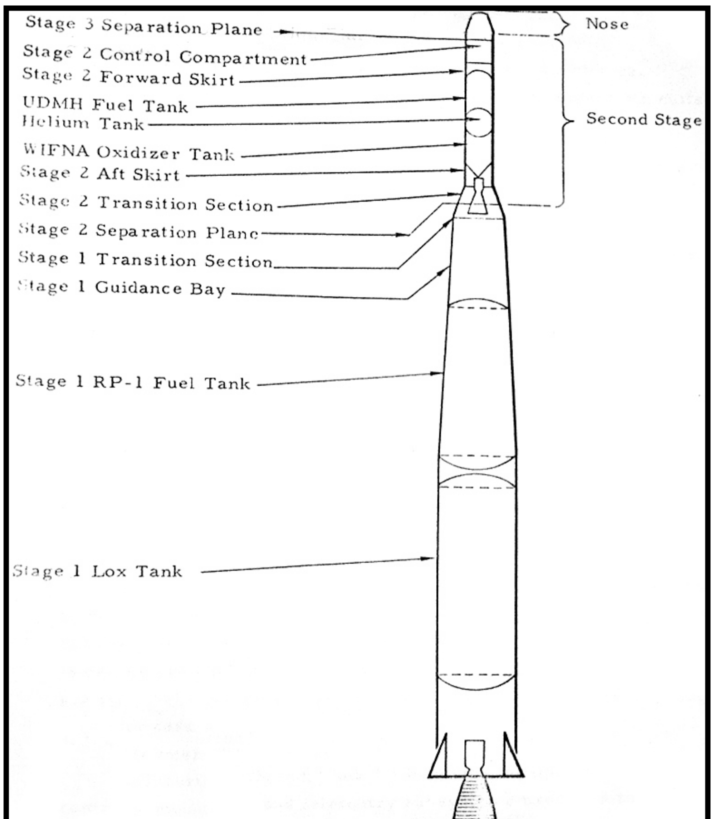
Paul Degarabedian in the late 1960s.
Photo: Gideon Marcus

May with a late April launch a reasonable possibility[11].

A Busy New Year

January was marked by intense discussions between STL and the USAF on their roles in the development and launch of the new booster. On 6-January, Mueller met with Colonel Henry H. (Hank) Eichel, assistant commander of the Office for Missile Tests, to discuss telemetry requirements. In particular, Mueller insisted that means for telemetry to be gathered from launch to separation and from 15,000 feet to impact be provided. He also considered a search-and-recovery beacon essential. STL wanted to use S-Band (2-4 GHz) frequencies for the telemetry, but AFMTC favored C-band (4-6 GHz). C-band was ruled out on 17-January as its tracking range was only 200 nautical miles. Still, the USAF continued to advocate its use in the weeks to come[12]. Major General Donald Yates, commander of AFMTC, suggested that the Thor Able use the Azusa electronic guidance system, which had performed satisfactorily at White Sands and elsewhere. Yates had also argued for Azusa to be used for the Vanguard[13] project in 1956, not happy at the prospect of additional tracking hardware "clobbering up his range," but had been overruled in the end. Louis Dunn, president of STL, rejected the suggestion the next day, probably for the same reason the Vanguard people had rejected it—Azusa required a heavy airborne transmitter. Thus Thor Able either used homegrown tracking, no tracking, or the Army-Navy Fixed, Radar, Search (AN/FPS)-16 high precision radar developed for Vanguard. Dick Booton was given the task of coordinating all tracking and communications concerns. His role enlarged greatly in scope in subsequent stages of the project, beyond the scope of this first article.

February began with the inauspicious TV-3BU all-up Vanguard launch. Fifty-seven seconds after liftoff on 5 February, the rocket lost attitude control capability and broke up. Along with the 6 December 1957 failed TV-3 launch, this meant that Able second stage still had not been tested in flight[14]. It was beginning to look as if the first successful Able flight might be begun from the shoulders of a Thor first stage. The next day, on 6-February, STL was informed by the USAF that the Navy would take no part in the recovery of the nose cone[15]. This would prove to be a fateful decision.



The original 2-stage ARTV configuration. (Reconstructed from existing data)
Image: Gideon Marcus

The first in a series of covers-off tests of the Able stage was scheduled for 21-February. Covers off was a term coined by Douglas referring to the test firing of a rocket with all its equipment accessible for modification and plugging in diagnostic volt/ammeters. George Mueller went to the hangar, specially built at Los Angeles Airport (LAX) for the assembly of the Able, to personally supervise the effort. He did more than just supervise. Mueller loved to get his hands dirty and assisted where he could, screwdriver always in hand. He would even plug in a soldering iron on the launch stand, even though such activities were forbidden due to the danger of static discharge.

According to Gleghorn, things went pretty smoothly, but partway through the first covers off test, the sequencer, responsible for the timing of engine, shut down and other booster functions, broke down. George Hatches had built the sequencer box like people used to build hi-fi sets—with all the current running through 18-gauge wire. Inevitably, the wire fused under such a load. The crew had to do a complete reanalysis of the power system to ensure that such an event didn't happen again[16].

Just two days behind schedule, on 28-February, the covers-on test of the Able was successfully conducted at 5:30 p.m. The rocket was closed up as if for flight, accessible only through the command receiver and telemetry—and a switch to turn it off if things got out of hand! This test marked the end of the week of testing for booster 1 [17].

Home Stretch

On 4 March, the first Thor stage was shipped from Douglas just one day behind schedule. Development proceeded at a breakneck pace and Mueller moved the launch date up several times based on Douglas's accelerated readiness expectations. More encouraging news came on 16-March, when TV-4 successfully orbited the first civilian satellite, Vanguard 1. At last, the Vanguard second stage had been proved in flight.

Covers-off and covers-on tests were conducted on booster 2, during which a faulty yaw gyro was discovered and interference from the beacon was noted. One test failed because an operator had neglected to move a switch into the on position. Still, booster 2 was declared sound on 26-March, and booster 1's first flight was scheduled for mid-April[18].

Also on 26-March, STL employee Herb Latham, whom Gleghorn had worked with at Hughes, arrived at Mueller's office with two men from Lockheed. He was interested in attaching an instrument package to boosters 2 and 3 to investigate some sort of atmospheric effect. It might seem strange that such a straightforward military test vehicle might be used for science, but at the time, few satellites had been launched. The flight plan of the ARTV, arcing out and back into the atmosphere at high speeds, made it a sort of high-powered sounding rocket, and a preliminary designer like Latham found the prospect of adding an experiment to the rocket irresistible. The next day, however, the proposal was vetoed by Dunn who was advised by Mueller that the effect would not be significant, and Dunn didn't want to worry about the balancing and frequency coordination of a superfluous device attached to the untried Able stage[19]. The first Thor Able flights would fly strictly for military purposes. Well, mostly . . .

The Special Payload

For various reasons, it was deemed desirable to have a biomedical payload on the Thor Able. As early as 7 February, the plan was to install a small compartment in the nose cone big enough to accommodate a small white mouse. The rodent was called *MIA*, or Mouse in Able, and telemetry developed by the Navy would monitor her heartbeat throughout the flight to determine her reaction to g-forces and weightlessness. Called the Cook Recovery Package after its assembler, the nose cone payload was top secret. When J. Rittersbacher of the Thor program office included reference to MIA in the circulated memo, "Revisions to DTO [Development Test Objectives] for 116, 118, 119 [the Thor booster numbers]," there were heated discussions as to the propriety of such an action. Though he claimed he had the permission of Dunn and Dolph Thiel, director of the Thor Weapon System Program Office, neither seem to have approved the action. While the issue has become clouded with the passage of time, the concern at the time was probably that the inclusion of the Cook Recovery Package might in some way compromise the primary mission, and widespread circulation of the inclusion of package might unduly compromise Douglas or the Air Force. Mueller reassured the upset parties that the modified nose cone would most likely not affect the overall flight test objectives[20].

Things didn't quite work out that way. *MIA* had a secret companion stowed away in her compartment. The STL team had included a 2-ounce bottle of *Old Granddad* bourbon with the label "aged in space" affixed to it. An irate USAF project manager discovered the liquor during the countdown and ordered it removed[21]. George Mueller makes terse reference to the incident in his log: "Inadvertent arming of the Cook Recovery Package during installation in the nose cone resulted in having to replace the recovery package with a spare, which caused some delay in countdown[22]." America's first rodent in space would fly dry.

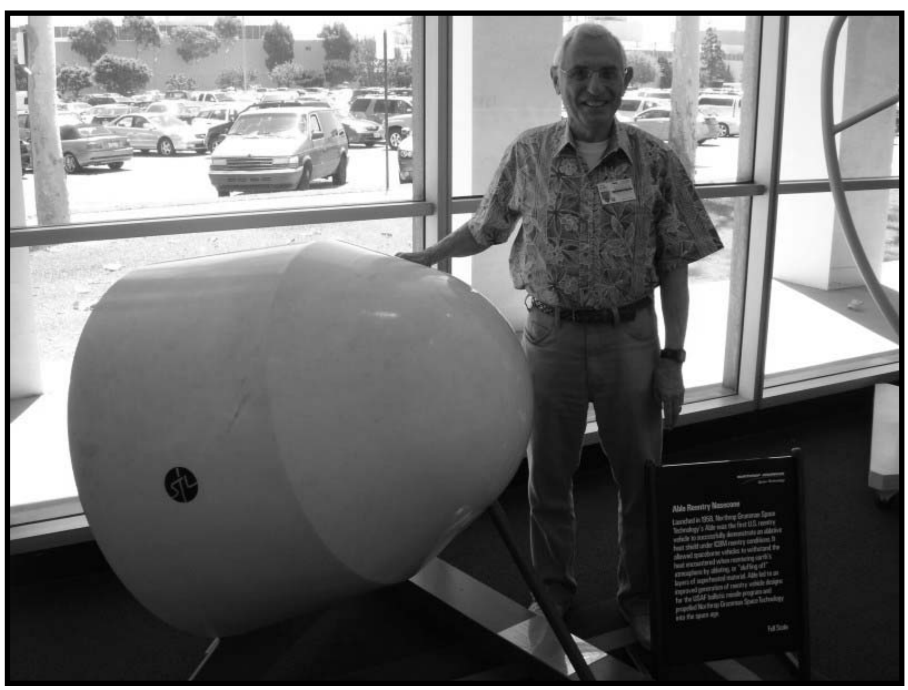
The Able Flies

The first Thor Able was erected on the firing stand in the beginning of April. On 3-April, preparations were made for the mock firing exercise the next day. On 4-April, it was discovered that there was still some interference from the beacon, but the problem was either fixed or was not problematic enough to be fixed. Countdown revisions and procedures were completed on 6-April. On 10-April, the STL crew reviewed the TV-4 launch and concluded that the performance of the second stage was within expectations and the recovery fleet deployment did not need to be modified. On Saturday, 12-April, the flight readiness firing, essentially a covers-on test in launch position with only restraints preventing the rocket from flying away, was successfully conducted. There was some trouble noted with the Radiation Inc. RF Amplifier (again, either fixed or compensated for by launch time)[23].

ARTV 1 was, at last, ready to fly. At 7:10 p.m. EST on 23 April 1958, the slim two-stage rocket ascended into the night sky. However, 146 seconds into the flight, shortly before the first stage would have exhausted its fuel and sent the Able stage toward the coast of Africa, Thor 116 exploded spectacularly in the darkness. This catastrophe proved a blessing in disguise. Many other Thors had met similar ends, and it was this flight that finally explained the gremlin responsible. As it turned out, the main bearing of the turbopump simply could not handle the terrific 21,000 rpm speed of its shaft. The bearing walked itself right out of its housing, destroying the turbopump and the Thor rocket[24]. The problem was fixed and the delays incurred did not unduly affect this or subsequent phases of the program.

Less than two months later, Thor Able took off on 9-July at 9:30 p.m. EST, reaching an altitude of almost 1,000 miles, and flying 6,063 miles to land, half an hour later, in the vicinity of its target in the south Atlantic Ocean near Ascension Island. Its non-parabolic course was specially designed to ram the nose cone into the ocean at ICBM speeds, and telemetry suggested it had done just that[25]. Two ships and two aircraft were involved in the recovery effort, but the nose cone's dye marker could not be found and the beacon's signals were too sporadic and weak to be triangulated. The ablated nose cone was designed to float, but only for a limited time as a precaution against seizure by foreign parties. After 36 hours, the first U.S. nose cone to travel at intercontinental range sank beneath the waves taking with it its occupant, the mouse MIA II. However, telemetry data seemed to confirm the concept of nose cone ablation[26].

On 23 July 1958, the Thor Able flew for a third time from the Missile Test Center. Onboard was another little white mouse. The press refused to call her MIA III, so she was named Wickie, after a local female journalist who had covered the project for some time. Sadly for the test mouse, she



Budd Cohen with ARTV prototype/back-up nosecone.
Taken at Northrop Grumman in July 2006
Photo: Gideon Marcus

George Gleghorn taken in March 2006 at his home
Photo: Gideon Marcus

really did end up missing in action after the recovery team failed again to locate the nose cone and package[27]. However, the nose cone telemetry successfully transmitted Wickie's heartbeat from launch to splashdown. Her heartbeat served as a living accelerometer, matching the rocket's telemetry to 1/1000 of a second[28]. General Yates, the test center commander, felt that despite the failed recovery, the telemetry results were sufficient to answer most biomedical questions regarding the flight[29].

With the flight of Thor 119, the official round of nose cone tests was complete. As early as February, there had been suggestion of a possible upgrade for higher velocity tests. There was even a plan to convert the ARTV into an ICBM. The latter option was dubbed Thoric, the "ic" standing for intercontinental. While there is little doubt that the Thor Able was up to the task, the progress on the Titan and Atlas missiles made the idea a moot one. The Thor would never serve as the first stage on an intercontinental missile[30].

Epilogue for a Nose Cone

A surviving example of the fiberglass nose cone, a backup and probably the prototype, is on display at the 13-story Northrop-Grumman building at Space Park in Redondo Beach, California. Painted white with an old-style STL logo on its side, the hollow fiberglass chassis ranges from 2 inches in thickness at the sides to 6 inches at the front. The story of how the nose cone ended up back at TRW is comical. Some years back, Budd Cohen, an STL employee since 1957 and later manager of the Aerodynamics Department, received a phone call at his office from an irate fellow who had purchased the item at a surplus sale and was highly dissatisfied. The purchaser had been assured that he was buying a missile nose cone, which was guaranteed to withstand 3,000 degree temperatures. Naturally, he assumed he was buying a symmetrical hunk of copper, which he could use as a crucible for home metallurgy projects. Instead, he got a worthless hunk of fiberglass. Angrily, the man demanded his $10 back. Budd was only too happy to comply. In this manner, he became the proud owner of an ARTV nose cone. Eventually the item worked its way from his lab to its current resting place in the building's lobby, nestled between models of TRW spacecraft.[31]

Able-1

The Thor Able proved a dramatic success and a testament to the resourcefulness of engineers. Only six months elapsed between conception and first flight for the two-stage vehicle, an amazing accomplishment. But even as the STL team feverishly labored to complete the nose cone test vehicle, work began on an ambitious new project. Much as the Thor Able depended on the untested Vanguard second stage, so would this new project depend on an untested Thor Able. This new phase was given the name Baker as it was a logical successor to Able. The project's ambitious goal was to launch the first lunar probe. Part II of this article will detail the story of the first program under the nominal control of the civilian space agency, NASA. The reader may be more familiar with it by the name NASA gave it: Pioneer.

About the Author

Gideon Marcus is a graduate of the University of California San Diego history department. Until last year, his interest in space history was largely recreational. A short sting in post-graduate work reinforced his desire to pursue active research. He currently is working on a comprehensive recounting of the almost forgotten first days of the American unmanned space program, particularly the Space Technology Lab missions. This work has the advantage that many of the key players are still alive, but the time sensitivity of the materials and interviewees lends a somber urgency to the project. The opportunity to do this valuable research at such a critical time is truly a blessing.

Notes

1 Davis Dyer, *TRW Pioneering Technology and Innovation Since 1900* (Boston: Harvard Business School Press, 1998), 170.

2 Dyer, *TRW Pioneering Technology*, 184.

3 Paul Degarabedian, Interview by Gideon Marcus, 10 May 2006.

4 M. Richard Denison, "My Experiences with Reentry Technology," 2005. http://www.aerowebspace.com/Reentry-Story.shtml. Accessed 11 March 2006.

5 Dyer, *TRW Pioneering Technology*, 199.

6 *Aviation Week* (20 October 1958):26.

7 George Gleghorn, Interview by Gideon Marcus, 8 March 2006.

8 George Gleghorn, Interview by Gideon Marcus, 8 March 2006.

9 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 1-18-58; 2-3-58.

10 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 12-13, 24-57.

11 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 12-10, 14, 17, 19, 31-57; 1-2-58.

12 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 1-6, 17, 26, 27-58.

13 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives. Constance Green and Milton Lomask, *Vanguard: A History* (Washington, DC: NASA, 1970), 141, 146.

14 Green and Lomask, *Vanguard*, 283.

15 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 2-6-58.

16 George Gleghorn, Interview by Gideon Marcus, 8 March 2006.

17 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 2-28-58.

18 George Mueller, "Daily log, 12-10-57 to 4-23-58," from STL archives, 3-4, 11, 16, 17, 19, 20, 26-58.

19 George Mueller, "Daily log, 12-10-57 to 4-23-58," from STL archives, 3-26, 27, 31-58. George Gleghorn, Interview by Gideon Marcus, 8 March 2006.

20 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 2-7; 3-25-58.

21 Dyer, *TRW Pioneering Technology*, 199.

22 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 4-23-58.

23 George Mueller, "Daily Log, 12-10-57 to 4-23-58," from STL archives, 4-3, 4, 6, 10, 12-58.

24 George Gleghorn, Interview by Gideon Marcus, 8 March 2006.

25 Budd Cohen, Interview by Gideon Marcus, 1 February 2006.

26 Julian Hartt, The Mighty Thor (New York. Van Rees Press, 1961), 192–193. Dyer, *TRW Pioneering Technology*, 199–200.

27 Hartt, Thor, 195.

28 *Aviation Week* (25 August 1958):15.

29 Hartt, Thor, 195.

30 Hartt, Thor, 195.

31 Budd Cohen, Interview by Gideon Marcus, 1 February 2006.