The Mighty Titan. The Rocket family that put the US on the path to the moon… but was really the best launch vehicle for large objects in space. Until It wasn't.

This will be a series of articles covering the entire Titan family, flown and in cases we have good data, un-flown variants. Now as the Titan family is partially shadowed in secrecy due to its work as a nuclear missile and as a launch platform for NRO satellites, sometimes I will have to use conjecture to describe certain rockets. This conjecture is based in interconnected facts even if the conjecture itself is a guess. I am not the first person who has summarized the Titan family and I won't be the last. One of my sources is the SpaceLaunchReport.com website by Ed Kyle. While I do not rely on his research and summation, It is a good starting place for people interested in Titan, Atlas, Thor/Delta Launch vehicles.

The Titan Missile; Genesis from a backup to the long arm of SAC:

Early in the USAF's attempts to build an ICBM, they hired Ramo-Wooldridge corporation to investigate and study the then current plans for the USAF's intercontinental ballistic missiles as well as to help the USAF bring said missile into service. One of the first things that the Ramo-Wooldridge corporation discussed with the USAF was that they were putting all their eggs in a presently "untested" Balloon tank weapon system. The Atlas B-65 (latter SM-65). If this "pressurized" rocket failed to stay together, as the engineers at the corporation surmised, then the USAF would be without a nuclear Deterrent other than the Strategic Bombers the USAF was trying to replace/reduce. This caused the USAF to decide to order a "conservative" belt and braces backup program. While the star effort was still with Consolidated Vultee aka Convair and shortly latter General Dynamics, and their Atlas missile, the USAF would not be caught with a lemon if they ordered an alternative that did not use any of the advanced technologies that were suspect… Those being the stage and a half design as well as the Balloon Tanks. Instead, the new Missile, ordered from the Glenn L Martin company, would be built with a conservative structure, with individual internal tanks with no conjoined bulkheads. Due to its larger mass, it would require two stages to match the performance of the Atlas… but the extra complication and cost was considered a fair trade-off vs the risks of the balloon tank and stage and a half flight. The Glenn L Martin company was even instructed to design and build two full up rockets powered by two separate engine systems. So, if the main engine choice (the Aerojet General LR87) failed, there was the NAA-Rocketdyne E-1 to replace it with already designed missile components for the E-1.

Oh, and if Ramo-Wooldridge corporation sounds familiar, it should. It was the predecessor to TRW or Thompson-Ramo-Wooldridge.

Now I have already covered the development of the E-1 engine and the fact that it was tested under a Glenn L Martin company Titan 1st stage. The E-1 (and the associated S-4 upper stage engines) exist in this document only as a what if at this point. Neither engine was ever completely developed for the Titan I rocket, and as history will show, a smaller version of the S-4 would be used as the LR105 for the Atlas that preceded the Titan. But we should mention

WHY the E-1 was started here. Early in the Titan design process Ramo-Wooldridge would step in again and state that they did not like the two separate engines being conjoined as a single dual bell engine as Aerojet was then proposing for the future LR87. Since they were closely co-located and interlinked the failure of one engine would result in the failure of the other, it was believed. The E-1 was a SINGLE engine that RW corp thought would be more reliable. When the E-1 test articles started exploding that theory was quickly changed. Aerojet General did have problems with the development of their AJ-23 family (what became the LR87 and LR91 in USAF use.) But those problems were small when compared to the E-1's combustion chamber instability and explosions.

Now the Guidance system for the new Titan rocket would be the only state of the art portion of the entire rocket, well other than it's payload which is an entirely different discussion. The Titan was designed to fly with a self-contained Inertial Guidance system. This is important because a self-contained system did not communicate with the outside world and therefor could not be jammed or interfered with. Due to the complexity of the system, not enough units could be made to equip both Titan and Atlas until well after the Titan I was canceled from service. In the interim, a Radio-Command Inertial system would be used on Titan I, since the Titan I was better protected in the silo than Atlas was in its armored 'coffin.' The Radio Command update Inertial system used on Titan I, was jammable, but a far less complex system than the self-contained system used on Atlas. The system utilized a combination of Radar measurements over the first 700 nautical miles of the missiles flight and Pulse Radio communications through the radar signal from launch to update the rocket on it's initial performance including direction and speed, again, up to 700 nautical miles away from the Launch site. By the way that is just over 800 "standard" miles. This provided a weight savings on the Titan I and even thought it, in theory could be jammed if "Enemy Agents" were able to get close to the launch site… It was reliable enough for 1959. The self-contained Inertial system would be used on the Atlas E and F production standards instead of Titan I due to safety and security of the Atlas launch sites. The latter Titan II had an improved guidance system, that was less complicated than the proposed for Titan I/Atlas self-contained Inertial system. An Inertial system works by measuring several gyroscopes movement to determine the flight path, acceleration, and rate of pitch, roll and yaw of the rocket/missile. The system compares the data it expects to get with the data the gyroscopes are providing and makes adjustments to how the rocket flies based on these comparisons. The advantage of the self-contained Inertial system is more than one launch can happen at once at a missile base. The Radio control uplink was limited to a single missile at a time in the days of Titan I and significantly slowed the launch program at a missile base. In the case of Titan I, only one missile could be launched at a time and a 2nd missile could begin fueling while one was being controlled by the Command network. This is just one of the many reasons Titan I had a short life.

70:17 Seventy test launches, including production standard Titan I missiles vs 17 launch failures. Like most early rockets, the Titan I rocket had a large string of failed or partially failed launches. With Titan I much of these seemed to have to do with Stage 2 separation. To keep the rocket as simple as possible the Martin company (after 1957 name change) decided to dispense with ullage motors to settle the propellants of the 2nd Stage before and during stage separation, and instead light up the LR91 second stage engine as soon as the first stage was given thrust termination commands (but before the LR87 first stage engine had fully shut off.) This is called “fire in the hole” staging by NASA and others. This means that the LR87 powered first stage was still thrusting forward when the 2nd stage started up and the stage separation explosive bolts were cut. To be clear Aerojet only started the 4x verniers that are external to the interstage when the MECO command was sent to the 1st stage’s LR87 engine. Approximately seven seconds later the separation bolts would be fired, and a further 4 seconds after that the main combustion chamber would finally come online and the separation SRMs would likewise be fired. There are three major and many minor problems resulted from this. First off as the LR91 was starting up the first stage may still be providing full thrust. That means the lower thrust 2nd stage might not separate cleanly or may in fact be hit by the first stage immediately after stage separation. But it turns out there was an even bigger problem. Starting the LR91, verniers while the main bell was still in the enclosed space of the interstage could lead to an overpressure event that would damage the interstage before separation preventing said stage separation… or worse… the interstage structure would crumple around the LR91 engine destroying it through the nearly un-heard of Coandă effect. It is this reason why the Titan II has big open holes between the stages. One form of damage from this style of separation, was the Interstage blowing apart when the LR91’s main combustion chamber came online. Early in the full production standard Titan I rocket, blow out panels were added to the Interstage Structure to reduce or prevent this. Even with these blow out panels, or the specific chain of timed events through separation, the Titan I was less than ideally reliable at stage separation.

The Titan I would have serious attacks on the entire concept of the backup ICBM, no less than 3 times before the first all up rocket was even built. It took the “Sputnik crisis” of 1957 to “kick start” the Titan Program to that of a fully funded weapon system. Had the Soviet’s not successfully launched the Sputnik family of satellites… Titan might never have flown!

The Titan I in detail:

The First stage consists of a Kerosene, latter RP-1, and Liquid Oxygen tanks to fuel the Aerojet General AJ-23 (the LR87-AJ-3) The diameter is 3.05m which at KSP scale is approximately 1.952m. Rounded down to meet the 0.125 multiplier diameter of 1.875m.

The second stage is 2.3m which scales nicely to 1.5m. The second stage is KeroLOx fueled and powered by the Aerojet General LR91-AJ-3, also a member of the AJ-23 family. Both stages were designed for strength and simplicity, eliminating many features found on other then current rockets as un-needed or experimental. At the time of it’s design, the Glenn L Martin corporation had a reputation as producing products with conservative engineering that were always stronger than needed to be. This is a large part of why they were approached to make this rocket vs many other companies in the aeronautical world.

101 production Titan I missiles were made but only 54 (plus 6 spare) Titan Is were ever deployed to Launch Silos. The reason is twofold. First the Titan I had the sub-standard Command-Inertial guidance and with manual tracking only one missile could be launched at a time. This was because the manufacture of the fully self-contained Inertial guidance system could not make them fast enough, and the Atlas was the preferred launch vehicle to receive this due to it’s lower costs as well as the significantly lower standard of protection for the Atlas missiles. The second reason is that because by the time the 101 production Titans were built,

the USAF had to redesign and rebuild the Titan Silos twice. Once due to a major design flaw in the elevator system, costing an all-up Titan Rocket in it's failure. The second design of the silo was to handle the older Radio-Command Inertial guidance system "temporarily" installed on the Titan I. Each Missile silo complex of 9 missiles had a "hanger queen" fully functional Titan I rocket stored, with no fuel or warhead, in a nearby hanger, in case there was a major failure on one of the 9 missiles in a silo, but the silo itself was "ok." So 60 total Titan I missiles were deployed to 6 sites with 9 armed and ready Missiles, and a 10th that was a spare in everything except the warhead.

When it came time to build Satellite launchers, the expense of converting the Titan I was deemed too expensive as the entire control system would have to be replaced for "reliable" space launches of "optimal" flight attitude. This is because the Command/Inertial system was designed for what would be an optimal flight profile for longest distance traveled, not greatest altitude or efficient flight to an altitude. You know, the thing needed to get objects actually IN SPACE! Even so, assuming a new control system was installed, the as built truncated conic structure of the GCU only allowed for a 48" payload. This is the same size of payload as the Juno II (Jupiter) launch vehicle so it could have been used. However, the Titan missile would have payload capability to spare and few new satellites were being designed for 48" maximum diameter before launch.

Except for the guidance and control Warhead bus and the warhead itself, an All-up Titan I is fully possible to build in BDB. With the use of the hypothetical HOSS from the Delta Rockets we can get a BDB made "replacement" for the Titan I Guidance and Control Unit (GCU.) The shape of the HOSS GCU is almost correct for a Titan I GCU. The major differences between the HOSS GCU and Titan I GCU being in the shape of the truncated conic structure. Also, the Titan I GCU was designed with two large, removable doors. These doors served one or two purposes in addition to the "easy to maintain" feature. They provided a large access portal for potentially upgrading the Titan I GCU to full design spec. They may also have provided storage space for "Pen-Aids." Pen-Aids or more formally, penetration aiding devices, being decoys, chaff and the like used to confuse enemy radar during a nuclear attack. We know with certainty that inflatable mylar balloons were used on the Titan I as a RCS mimic for the actual warhead. They may have been ejected from these doors.

Using the SMART-PARTS mod in conjunction with BDB to bring about the proper staging of the Titan I 1st and 2nd stage:

https://forum.kerbalspaceprogram.com/index.php?/topic/151340-19x-smart-parts-continued/

https://spacedock.info/mod/614/SmartParts

1. Use a single, Drainex fuel drain sensor from the SmartParts mod on Stage 1. Set this to 7%. Set it to Activate any single Action Group.

2. Add a AGT-Timer Timed Action Group Trigger to the 2nd stage again from the SmartParts mod

3. Add a SECOND AGT-Timer Timed Action Group Trigger to the 2nd Stage. This can NOT be in symmetry (as in placed) with the one in step 2 above they must be unique and seperate

4. In the Action group listed in the Drainex sensor placed in step one, you will need the following actions: "Activate Engine" that is at the BOTTOM of the LR91-AJ-3 (there are 2 activate engine buttons on the LR91!) and start one of the two AGT-Timer Timed Action Group Trigger, above set to 7 seconds.

5. The 7 second AGT-Timer Timed Action Group Trigger, will activate another Action group. In this 2nd action group, you will activate the 2nd AGT-Timer Timed Action Group Trigger added above but it needs to be set to 4 second. In this new ActionGroup, in addition to activating the next AGT, you will Stage the interstage between the first and second stages. Also, to ensure proper Main engine cut off, I also shut down the 1st stage main engine at this time as this is the proper point for MECO.

6. The 4 second timer will activate The UPPER LR91-AJ-3 "Activate engine" as it's only action.

So hypothetical Titan I space launchers:

It is easy to not put a conic GCU on the Titan I's 2nd stage and instead just place a 1.5m fairing and rely on the payload in the fairing for control of Titan. This option works in KSP but would not work in the Titan I time frame in real life… as the GCU to control Titan would need to be rather large. I tend to use Tweakscale to make a 1.5m pancake (flat cylindrical) GCU for Titan (often from the 1.875m MOL Control module,) and then place a 1.5m fairing on top of that.

USAF MISS launcher: This is an interesting side note. As part of the USAF MISS (Man in Space Soonest) program that predated the start of NASA, both Martin Corporation and AVCO separately suggested the Titan I as the launch vehicle to get a man in space. In this case the GCU would have been replaced with a new system allowing for both piloted and ground controlled flight. Unlike NASA the USAF was looking for ways for astronauts to actually fly from the outset, their spacecraft.

An alternative B9PS option to the ATLAS-Mercury interstage that performs the same function but to the 1.5m Diameter of the Titan I 2nd stage would be a welcome addition to BDB. While project Mercury and MISS had little in common, they would both have used a similar sized command module to orbit the astronaut in space. This same interstage could be used on a Jupiter/Juno II launch of the Mercury as was originally proposed when Project Mercury started.

Lastly, and probably the best known alternative/hypothetical use of the Titan I.. The X-20 sub orbital test launcher. Starting with Well's X-20 Moroz mod, build a full up X-20 including an adapter to match the 1.5m Titan I 2nd stage. Then build a Titan I underneath it in the VAB. Lastly add 4 large wing/fins that have control surfaces. The X-20 provides so much lift it can topple the Titan I rocket rather quickly in stock Aero (and in whatever replacement Aerodynamics you might use it will topple the rocket… just slightly slower.)

https://spacedock.info/mod/2149/%D0%96-20%20%22Moroz%22%20Spaceplane

https://forum.kerbalspaceprogram.com/index.php?/topic/184435-110-%D0%B6-20-moroz-spaceplane/&tab=comments#comment-3597842