Precision Paper Space Models

GEMINI TITAN 2 LAUNCH VEHICLE

This 1/96 scale Precision Paper Space Model represents the Titan 2/Gemini 8 combination (GT8) that launched U.S. astronauts Neil Armstrong and David Scott on the world's first orbital docking mission.

The model can be assembled as a single unit, or as two separable Titan stages and a separable Gemini spacecraft.

To assemble, you will need a pair of scissors and/or a hobby knife, rubber cement, a toothpick or narrow strip of paper, a dowel rod or a round pen or pencil, and some cardstock (ie, several 3 x 5 cards). For best results, print model pages on 20-24 pound paper.

Use dowel/pen/pencil to apply cementing pressure from inside of paper tubes, etc. Assemble using rubber cement, rather than white glue, to minimize stains and wrinkles.

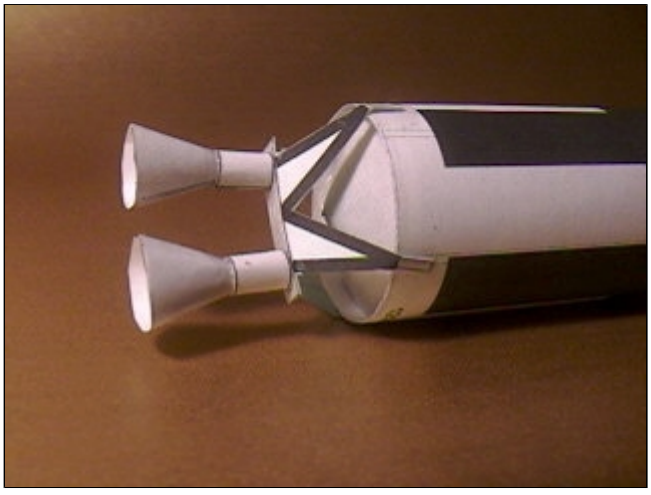
MODEL ASSEMBLY INSTRUCTIONS

FIRST STAGE

1. Cut out Titan 2 first stage body, forward bulkhead mount, and aft bulkhead mount (Parts 1, 2, and 3) from Page 1. Trace bulkhead mount gray area outlines on back, nonprinted side of paper. Cement adapter mounts to inside of body underfold onto trace boxes on NONPRINTED side of page, OPPOSITE gray areas.

2. Without applying cement, roll Titan 2 first stage body into a double-layered tube. While holding tube, apply rubber cement SPARINGLY with toothpick or small strip of paper to small area beneath seam only. Finish by cementing loose underfold sections to body tube ends using toothpick or small strip of paper to insert cement.

3. Cut out Titan 2 first stage forward and aft bulkheads (Parts 4 and 5 on Page 2) and cement to a single layer of cardstock. When dry, cut out bulkheads again and cement into cone shape.
When dry, insert bulkheads into top and bottom of first stage body tube down to bulkhead mounts. You may need to trim or sand the bulkhead slightly to get a good fit. With the bulkhead in place, apply cement to fix in place.



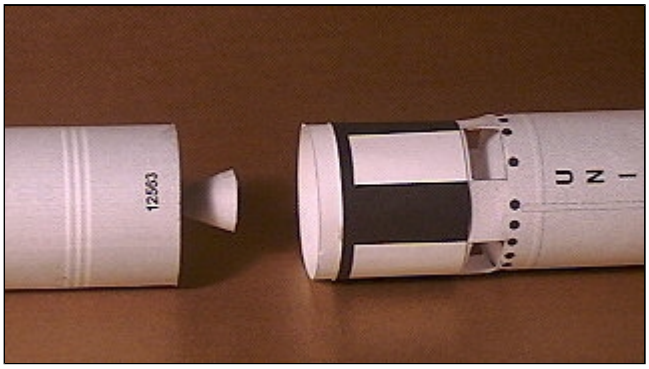
4. Cut out first stage rocket motor mount (Part 6 on Page 2) and cement to cardstock. When dry, cut out. Do not cut out triangular white portion between thrust beam trusses. Bend at base of each thrust longeron attachment and where the eight thrust beam trusses attach to the rectangular engine mount structure. Attach to first stage by cementing the four thrust longeron attachments to the thrust longeron attach points on the outside base of the first stage body. Attach so the words "United States" line up with the LONG side of the rectangular

engine mount structure.

5. Cut out two first stage rocket motor nozzles (Parts 7 and 8 on Page 2). Roll into truncated cone by underfolding the white portions. Cement at seam. Set aside to dry.

6. Cut out two first stage rocket motor thrust chambers (Parts 9 and 10 on Page 2). Roll into cylinders by underfolding white portions. Cement at seam. When dry, cement thrust chambers to first stage motor mount at white circles.

7. Set rocket motor nozzles into thrust chambers and cement.



8. Cut out interstage body, interstage/first stage adapter, and interstage/second stage adapters (Parts 11, 12, and 13 on Page 3). Without applying cement, roll interstage body into a double-layered tube. While holding tube, apply rubber cement SPARINGLY with toothpick or small strip of paper to small area beneath seam only. Finish by cementing loose underfold sections at body tube ends with toothpick or small strip of paper to insert cement.

9. Cement first stage/interstage adapter to inside base of interstage (roll bars "point" down), lining up exhaust port cutouts with white sections. Only four panels should extend below interstage body when complete.

10. Cement widest portion of second stage/interstage adapter to inside top of interstage.

11. When dry, insert first stage/interstage adapter into top of first stage cylinder, lining up exhaust port cutouts and body seams.

SECOND STAGE

12. Cut out second stage body and bulkhead adapters (Parts 14, 15, and 16 on Page 3). Trace bulkhead mount gray area outlines on back, nonprinted side of paper. Cement adapter mounts to inside of body underfold trace boxes on NONPRINTED side of page, OPPOSITE gray areas.

13. Without applying cement, roll second stage body into a double-layered tube. While holding tube, apply rubber cement SPARINGLY with toothpick or small strip of paper to small area beneath seam only. Finish by cementing loose underfold sections at body tube ends with toothpick or small strip of paper to insert cement.

14. Cut out second stage forward and aft bulkheads (Parts 17 and 18 on Page 3) and cement to card stock. When dry, cut out bulkheads again and cement into cone shape. When dry, insert bulkheads into top and bottom of

second stage body tube down to bulkhead mounts. You may need to trim or sand the bulkheads slightly to get a good fit. With the bulkheads in place, apply cement to fix in place.

15. Cut out second stage/Gemini spacecraft adapter (Part 19 on Page 3). Cement the non-notched half to the inside of the top of the second stage cylinder.

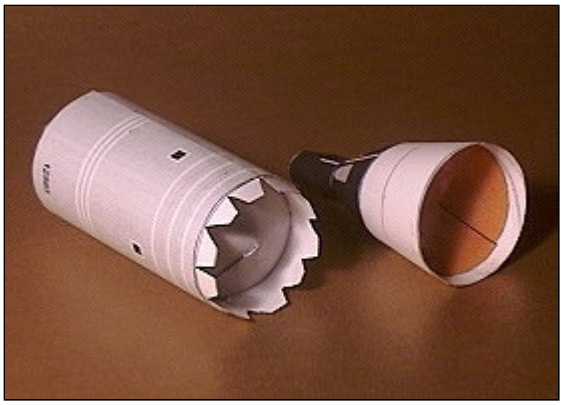
16. Cut out the second stage rocket motor nozzles (Parts 20 on Page 2). Roll into truncated cone by underfolding the white portion. Cement at seam. When dry, attach to center of second stage aft bulkhead.

GEMINI SPACECRAFT

17. Cut out Gemini Reentry Module Cabin Section (Part 21 on Page 4). Roll into truncated cone by underfolding the white portion. Cement at seam.

18. Cut out Cabin Section Forward Adapter (Part 22 on Page 4). Roll and cement into inside top of Cabin Section, leaving cut/strip portion extending from top of Cabin Section.

19. Cut out Gemini Reentry Module Reentry Control System (RCS) section (Part 23 on Page 4). Roll into cylinder, underfolding white section, and cement. When dry, attach to top of Cabin Section, cementing to cut/strip portion of Forward Adapter.



20. Cut out Gemini Reentry Module Rendezvous and Recovery Section (Part 24 on Page 4). Roll into tapered cylinder, underfolding white section, and cement. When dry, attach at the widest end to the top of the Reentry Control System section, cementing to triangular attachment strips.

21. Cut out Gemini Reentry Module Nose (Part 25 on Page 4) and cement to card stock. When dry, cement to top of Rendezvous and Recovery Section by pressing against triangular attachment strips.

22. Cut out Gemini Adapter Module (Part 26 on Page 4, comprising the combined Equipment and Retrograde Sections). Roll into truncated cone, underfolding all-white section, and cement at seam only. When dry, attach to triangular attachment strips at base of Cabin Section.

23. Cut out Gemini Adapter Module Aft Cover (Part 27 on Page 4) and cement to card stock. When dry, cut out and form into a cone with the gold side on the inwardly tapered face. Cement by attaching a small strip of paper across the seam on the white side of the cone. When dry, press Aft Cover evenly and into the base of the Adapter Module, gold side out, and cement into place.

24. Congratulations! Your Gemini Titan 2 is complete.

GEMINI TITAN 8 STORY

NASA's Gemini 8 astronauts Neil Armstrong and David Scott performed the world's first orbital docking on March 16, 1966. Their historic flight was cut short, however, by a stuck Gemini maneuvering thruster that put their spacecraft into a hazardous, accelerating "Dutch Roll". To regain control, Armstrong and Scott were forced to use Gemini's Reentry Control System (RCS). Mission rules required that a mission be aborted once the RCS was activated, so Gemini 8 landed in the western Pacific Ocean after 6.5 revolutions, only 10 hours 41

minutes after liftoff.

Gemini Titan 8 (GT-8) was the sixth manned launch of the program. The mission used the eighth two stage Titan 2 Gemini Launch Vehicle (GLV-8) and the second Gemini Agena Target Vehicle (GATV-5003), boosted by an Atlas Agena D. It was the first successful GATV launch, following the failure of GATV-5002 during its October 25, 1965 GT-6 mission attempt.

The Equipment

Titan 2, a U.S. Air Force ICBM built by the Martin Company in Baltimore, Maryland, was "man rated" for Gemini. Fully fueled with a Gemini payload, the 3.05 meter diameter rocket stood 33.2 meters tall and weighed 185,000 kg. Both stages carried nitrogen tetroxide oxidizer in a forward tank and Aerozine 50 (a hydrazine-unsymmetrical dimethyl hydrazine (UDMH) mix) fuel in an aft tank.

The first stage was powered by an Aerojet LR87-AJ-7 engine consisting of two gimbaled, independent gas generator cycle, turbopump-fed engines that together produced a total 195,010 kgf of sea level thrust for about 150 seconds. A single turbopump-fed Aerojet LR91-AJ-7 powered the second stage, producing 45,350 kgf thrust in vacuum for about three minutes. The second stage engine could gimbal for yaw and pitch control. Turbine exhaust gas ejected through a roll control nozzle provided roll vectoring.

Solid fuel cartridges started Titan's engine turbopumps, creating a distinctive shriek just before the main thrust chambers roared to life. While starting, the second stage engine fired through blow ports in the Titan 2 interstage for about one second before the stages separated.

Gemini, built by McDonnell of St. Louis, Missouri, consisted of a black Reentry Module atop a white Adapter Module. The conical Gemini spacecraft was 5.79 meters tall and 3.05 meters wide at the base. Mass varied from mission to mission. Gemini 8 weighed 3,788 kg.

The Reentry Module included three sections. The conical crew cabin was topped by a cylindrical Reentry Control System (RCS) and a tapered Rendezvous and Recovery (R&R) section. The R&R section housed a rendezvous radar and a parachute system. It was jettisoned when the pilot parachute deployed. The RCS section housed two independent RCS thruster rings, each consisting of eight 11.3 kgf thrust bipropellant thrusters. These thrusters were meant to control the spacecraft during reentry. The crew section consisted of a pressurized crew compartment surrounded by unpressurized equipment bays, backed by an ablative heat shield. Two hatches provided access to the cramped compartment. Two teardrop shaped windows provided forward vision. Each astronaut sat in an ejection seat, with the Command Pilot seated on the right.

The Adapter Module was composed of two sections: a forward Retrograde Section and an aft Equipment Section. The Retrograde Section housed four 1,134 kgf thrust Thiokol solid motors, mounted in a square pattern. It also housed four 45.4 kgf thrust lateral translation thrusters and two forward facing 38.5 kgf thrust reversing thrusters of the bipropellant Orbit Attitude and Maneuver System (OAMS). The Equipment Section held six OAMS propellant and pressurization tanks, the astronaut's oxygen supply, batteries, fuel cells, water, eight 11.3 kgf thrust roll thrusters, and two aft facing 45.5 kgf forward thrusters.

The Equipment Section would separate just before the reentry phase of the mission. The retrograde motors would fire sequentially for about 5.5 seconds each, then the Retrograde Section would separate from the Reentry Module.

The Flight

Gemini 8 lifted off from Cape Canaveral Launch Complex (LC) 19 at 11:41 EDT on March 16, 1966, only 111 minutes after an Atlas Agena D launched GATV-5003 from LC 14 a few miles to the south. The planned three-day mission required dual countdowns, with Armstrong and Scott in their spacecraft when GATV-5003 lifted off.

The 8,097 kg Agena entered a circular 298.7 km orbit inclined 28.91 degrees from the equator. At liftoff, Gemini 8 trailed by 2,035 km, but it began to catch up from its quicker 160 x 272 km initial orbit. Gemini then caught Agena on the fourth revolution using the "coelliptic maneuver" approach, wherein Gemini switched to a circular orbit in the same plane as Agena, but several tens of kilometers lower. In this orbit, Gemini would gradually catch and pass Agena. Gemini would then vertically "translate" to Agena's altitude, where the crew would gradually cancel the final velocity difference to effect a rendezvous.

At the 1 hour 34 minute mark near first perigee, Armstrong performed a retro burn with his two forward OAMS

thrusters to reduce apogee slightly. At second apogee, 2 hours 18 minutes into the mission, Gemini 8 performed an apogee burn to move to a 248 x 273 km orbit. The crew performed two unplanned plane change maneuvers during the next orbit. At third apogee, 3 hours 47 minutes into the flight, Armstrong performed a final coelliptic maneuver burn to circularize the orbit at 273 km. Gemini 8 closed in on GATV-5003 for another orbit before the crew conducted the first of a series of terminal phase maneuvers, moving to Agena's orbit.

Gemini 8 moved in to dock with Agena during the fourth orbit, 6 hours 33 minutes after launch. The docking was uneventful. Gemini's docking mast slid into a V-notch on Agena's docking adapter, then three docking adapter spring loaded mooring latch hooks snapped into place to "rigidize" the mated vehicles.

The crew proceeded to perform a 90 degree yaw maneuver test using Agena's attitude control system (ACS). The spacecraft entered the earth's shadow and passed out of ground station radio range. Less than 30 minutes after docking, while the crew was busy sending commands to Agena, an intermittent short circuit in a relay valve driver caused Gemini 8's No. 8 OAMS roll thruster to fire for three seconds, shut off for three seconds, and then fire continuously for 3 minutes. One pound of propellant jetted out of the thruster each second, pushing the docked Gemini-Agena into a wobbly roll.

Gemini 8 did not have an OAMS thruster crew display, so some time passed before Scott noticed the ball indicator showed the spacecraft in a roll. Armstrong used his OAMS controller to slow the roll while Scott shut off Agena's RCS. For four minutes, the No. 8 thruster did not fire, but then it fired again, this time without stopping for eight minutes. Armstrong compensated with OAMS again, but now 70% of the OAMS propellant was gone and the roll continued. The roll was stressing the GATV docking adapter.

If OAMS fuel depleted, Gemini 8 would not be able to undock, so Armstrong and Scott had little choice but to backed away from Agena. Now Gemini began to roll and wobble at up to one revolution per second. Both astronauts became dizzy, their vision blurring. Finally, Gemini 8 came within range of tracking ship Coastal Sentry Quebec, but by then Armstrong and Scott had decided to cut out OAMS and switch to RCS.

Once RCS was activated, Houston ground controllers had no choice but to order a contingency landing. Gemini 8 reentered during the seventh revolution, landing in the Pacific 800 km east of Okinawa.

Postscript

Gemini 8 achieved one of its primary mission objectives, the first orbital docking, but the crew was not able to use Agena's main engine to change the docked vehicle's orbit and David Scott did not get to perform his planned space walk. The mission did, however, prove beyond doubt the toughness of the Agena and Gemini spacecraft. After recovering from its tumble/roll, in fact, GATV-5003 performed multiple engine firings and remained in orbit long enough for the Gemini 10 crew to rendezvous with it later that year.

Gemini 8 also showed how good Armstrong and Scott were, as they coolly handled an unexpected failure. Both men would later walk on the moon. Armstrong, of course, become the first on Apollo 11. Scott flew to earth orbit on Apollo 9 and to a lunar landing on Apollo 15.

After the landing, McDonnell crews poured over the Gemini 8 Reentry Module, but never found an electrical short, probably because most of the OAMS system was in the discarded Adapter Module. NASA documents had claimed that OAMS would "fail safe" in the event of "electrical malfunction of any kind", so astronauts were not trained to handle such an event. Subsequent spacecraft were equipped with an OAMS thruster display and crews began to train to handle stuck thruster failures.

Today, the Gemini 8 Reentry Module is on display at the Neil Armstrong Museum in Ohio.

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