Computers in Spaceflight: The NASA Experience

- Chapter One -

The Gemini Digital Computer: First Machine in Orbit

[10] Project Mercury was America’s first man-in-space effort. The McDonnell-Douglas Corporation developed the Mercury spacecraft in the familiar bell shape. It was barely large enough for its single occupant and had no independent maneuvering capability save attitude control jets. Its orbital path was completely dependent on the accuracy of the guidance of the Atlas booster rocket. Re-entry was calculated by a realtime computing center on the ground, with retrofire times and firing attitude transmitted to the spacecraft while in flight. Therefore, it was unnecessary for the Mercury spacecraft to have a computer, as all functions required for its limited flight objectives were handled by other systems.

Gemini both continued the objectives of the Mercury program and served as a test bed for the development of rendezvous techniques critical to lunar missions[1]. At first glance, the Mercury and Gemini spacecraft are quite similar. They share the bell shape and other characteristics, partially because Gemini was designed as an enlarged Mercury and because the prime contractor was the same for both craft. The obvious difference is the presence of a second crew member and an orbital maneuvering system attached to the rear of the main cabin. The presence of a second crewman meant that more instrumentation could be placed in Gemini and that more experiments could be performed, as an extra set of eyes and hands would be available. Gemini’s maneuvering capability made it possible to practice rendezvous techniques. The main rendezvous target was planned to be the Agena, an upper stage rocket with a restartable liquid propellant engine that could be launched by an Atlas booster. After rendezvous with an Agena, the Gemini would have greatly increased maneuvering capability because it could use the rocket on the Agena to raise its orbit.

Successful rendezvous required accurate orbital insertion, complex catch-up maneuvering, finely tuned movements while making the final approach to the target, and guidance during maneuvers with the Agena. Safety during the critical powered ascent phase demanded some backup to the ascent guidance system on the Titan II booster vehicle. The Gemini designers also wanted to add accuracy to re-entry and to automate some of the preflight checkout functions. These varied requirements dictated that the spacecraft carry some sort of active, on-board computing capability. The resulting device was the Gemini digital computer.

The Gemini computer functioned in six mission phases: prelaunch, ascent backup, insertion, catch-up, rendezvous, and re-entry. These requirements demanded a very reliable, fairly sophisticated digital computer with simple crew interfaces. IBM built such a machine for the Gemini spacecraft.

(MISSING PICTURE)
Figure 1-1. First orbital rendezvous: Gemini VI keeps station after using its on- board computer to maneuver to position near Gemini VII. (NASA photo S-65-63 l 75)

By the early 1960s, engineers were searching for ways to automate checkout procedures and reduce the number of discrete test lines connected to launch vehicles and spacecraft. Gemini's computer [11] did its own self checks under software control during the prelaunch phase. It also accepted parameters needed for the flight during the last 150 minutes before launch[2]. During ascent, the computer received information about the velocity and course of the booster so that it would be ready to take over from the Titan's computers if they failed. Switch-over could either be automatic or manual. The computer could then issue steering and booster cutoff commands to the Titan[3]. Even if the updated parameters were not necessary to boost guidance, they were useful in the calculation of additional velocity needed after the Titan's second-stage cutoff to achieve the proper orbit. That velocity difference was displayed to the crew so that they could use the spacecraft's own propulsion system to reach insertion velocity[4].

[12] Rendezvous operations required an on-board computer because the ground tracking network did not cover all parts of the Gemini orbital paths. Thus, it would be impossible to provide the sort of continuous updates needed for rendezvous maneuvers. For example, Gemini XI was planned as a first-orbit Agena rendezvous, with some of the critical maneuvers conducted outside of telemetry range[5]. That same mission also featured a fully computer-controlled re-entry, which resulted in a splashdown 4.6 kilometers from the target[6]. In computer-controlled descents, the roll attitude and rate are handled by the computer to affect the point of touchdown and re-entry heating. The Gemini spacecraft had sufficient lift capability to adjust the landing point up to 500 miles on the line of flight and 40 miles laterally respective to the line of flight. Five minutes before retrofire, the computer was placed in re-entry mode and began to collect data. It displayed velocity changes during and after the retrofire. During the time the spacecraft traveled from an altitude of 400,000 feet to when it reached 90,000 feet, the computer controlled actual attitude[7].

INDEX PAGE