Gemini IV results, Hacker, op. cit. , and Aldrin, Men From Earth

In the spacecraft, McDivitt and White had no doubts about liftoff, as they felt their vehicle pick up speed. There was very little noise. The hush was broken only when the launch vehicle bounced like a pogo stick for a few seconds. Then everything smoothed into near silence again. Pyrotechnics shattered the illusion of quiet at stage 1 and, later, at stage 2 separation. The spacecraft entered an elliptical orbit of 163 kilometers at the low point (perigee) and 282 kilometers at the high point (apogee).[39]

As *Gemini IV* separated from its booster, McDivitt turned the spacecraft around to look for the trailing vehicle. White saw the rocket venting, with propellant streaming from its nozzle. How far was it, and where was it going? McDivitt estimated the distance as 120 meters; White guessed it was closer to 75 meters.

McDivitt braked the spacecraft, aimed it, and thrusted toward the target. After two bursts from his thrusters, the booster seemed to move away and downward. A few minutes later, McDivitt pitched the spacecraft nose down and the crew again saw the rocket, which seemed to be traveling on a different track. He thrusted toward it—no success—and stopped. McDivitt repeated this sequence several times with the same luck.[40]

As night approached McDivitt spotted the booster's flashing lights. He estimated that the distance to the target had stretched to perhaps 600 meters. He knew he had to catch the booster quickly if they were going to stationkeep and do extravehicular activity as planned. For a while, *Gemini IV* seemed to hold its own and even to close with the other vehicle. McDivitt thought they got to within 60 meters, but White estimated it at 200 to 300 meters. The target's running lights soon grew dim in the gray streaks of dawn and vanished with the sunrise. When the target hove into view about three to five kilometers away, McDivitt again tried to close the distance. Additional thrusting did not seem to bring it any closer. Well aware that he was a pioneer in orbital rendezvous and that choosing the right maneuvers might not be as easy as it seemed, McDivitt had previously asked Mission Director Kraft which was more important, rendezvous or EVA. The space walk, said Kraft. McDivitt knew he had to stop spending fuel chasing the elusive target by the "eyeball" method.

As GPO engineer André Meyer later remarked, "There is a good explanation [for] what went wrong with rendezvous." The crew, like everyone else at MSC, "just didn't understand or reason out the orbital mechanics involved. As a result, we all got a whole lot smarter and really perfected rendezvous maneuvers, which Apollo now uses." Catching a target in orbit is a game played in a different ball park than chasing something down on Earth's essentially two-dimensional surface. Speed and motion in orbit do not conform to Earth-based habit, except at very close ranges. To catch something on the ground, one simply moves as quickly as possible in a straight line to the place where the object will be at the right time. As *Gemini IV* showed, that will not work in orbit. Adding speed also raises altitude, moving the spacecraft into a higher orbit than its target. The paradoxical result is that the faster moving spacecraft has actually slowed relative to the target, since its orbital period, which is a direct function of its distance from the center of gravity, has also increased. As the *Gemini IV* crew observed, the target seemed to gradually pull in front of and away from the spacecraft. The proper technique is for the spacecraft to reduce its speed, dropping to a lower and thus shorter orbit, which will allow it to gain on the target. At the correct moment, a burst of speed lifts the spacecraft to the target's orbit close enough to the target to eliminate virtually all relative motion between them. Now on station, the paradoxical effects vanish, and the spacecraft can approach the target directly. *Gemini IV's* problem was compounded by its limited fuel supply; the Spacecraft 4 tanks were only half the size of later models, and the fuel had to be conserved for the fail-safe maneuvers. When McDivitt and White broke off their futile chase, they had exhausted nearly half their load of propellants.[41]

[39] "Preliminary Debriefing," Part I, pp. 17-18, 20-21, 23-25, 31; "Gemini IV Mission Report," p. 4-1.

[40] "Preliminary Debriefing," Part I, pp. 38, 50-57.

[41] Ibid., pp. 54-55, 58-69, 72; Gemini 4 mission commentary, tape 7, p. 1; Meyer, comments on draft chapter of Gemini narrative history, 28 Feb. 1969.

MEN FROM EARTH, Buzz Aldrin, Bantam Books

Liftoff came after a brief delay when the launch pad gantry stuck, but the ascent was flawless. Television coverage of the blast-off was broadcast to Europe via Early Bird satellite, another first for NASA (which the Soviets in their determination to be secretive could never do). There were some unpleasant longitudinal "pogo" booster oscillations, which were smoothed out, and *Gemini IV* was in orbit five minutes later. Unfortunately, McDivitt's awkward attempts at an "eyeball rendezvous" with the spent second stage were an utter failure. He tried to *fly* the spacecraft toward the slowly tumbling Titan booster shell, and naturally, he ran into the predictable paradoxes as the target alternately seemed to speed away and then drop behind. McDivitt had never grasped much rendezvous theory during his Houston training, and after the mission, one of the Gemini engineers, André Meyer, commented that McDivitt "just didn't understand or reason out the orbital mechanics involved."[16] I certainly knew what Andy was saying, having once hoped to interest a bunch of white-scarf astronauts in rendezvous techniques. Unfortunately McDivitt's abortive rendezvous wasted half their thruster propellant.

<u>MEN FROM EARTH</u>, Buzz Aldrin, Bantam Books, New York, 1989, pp. 70-1

I chose my thesis subject carefully. Hoping to work for either NASA or the Air Force after completing my doctorate, I wanted to make a positive contribution. Manned orbital rendezvous was a vital field, because any way you cut it, if we were going to assemble large interplanetary spacecraft, we'd have to master the techniques of space rendezvous—bringing two or more separately launched spacecraft together in orbit. With computers we could reduce the blizzard of spherical geometry and calculus equations down to automated rendezvous procedures. But I'd seen enough autopilots malfunction during my flying career to realize that the spacecraft NASA planned to use for Earth orbital and lunar spaceflight would need some kind of manual backup.

An astronaut "flying" a spacecraft just isn't the same as throwing a Super Sabre through a dogfight. There's no true up or down in space, nor is there lift in the traditional sense of the term. And orbital rendezvous is very complicated, but can appear deceptively simple. For example, an astronaut in a lower orbit—closer to Earth—might want to catch *up* with his partner in a higher orbit. The fighter pilot's instinct is to fire his engine and increase velocity. But speed and centrifugal energy are intertwined and this maneuver would loop the lower spacecraft above the target, placing him in a still higher orbit. He would also slow down, so that his partner would appear to drop below and speed away. They call this "orbital paradox," and it definitely can be puzzling. In short, the instincts an astronaut had that kept him alive flying jet fighters could easily betray him in space.

The problem becomes much more complex when the astronaut cannot see his rendezvous target or have radar contact with it. There is, however, one important link between standard aviation and manned spaceflight. Through the hand controller, the astronaut can operate the spacecraft reaction control system (RCS) thrusters, which act like the jet fighter's stick and rudder. When a pair of thrusters fires, the spacecraft pitches, rolls, or yaws. Firing a larger thruster propels the spacecraft in one direction—a process known as "translation," which is like opening the throttle of a jet plane. Relative to the direction the spacecraft is pointing, this can change velocity right or left, up or down, forward or aft.

My challenge was figuring out a way of putting these complex orbital mechanics into an exact sequence of maneuvers an astronaut could follow with the spacecraft's attitude and thrust hand controllers. Military flight instructors had done basically the same thing when they transformed theoretical aerodynamics into standard flight maneuvers using a plane's stick and throttle. By December 1962, my graduate work was almost complete and the Mercury program was in full swing. I sweated through my oral and written doctoral exams and emerged with only some finishing touches to put on my thesis. I dedicated it "To the men in the astronaut program, oh, that I were one of them." But I wasn't optimistic. NASA was still requiring that test pilot's diploma.

<u>MEN FROM EARTH</u>, Buzz Aldrin, Bantam Books, New York, 1989, pp.

Following NASA practice, the astronauts in my group were given specialty assignments outside our standard training courses. Some of the ex-test pilots concentrated on Gemini spacecraft hardware, such as the life-support and recovery systems or the retrorockets, while others focused on the Gemini's Titan launch booster. I worked on mission planning, specifically on orbital rendezvous flight plans. I finally felt my years at MIT had not been wasted. I was helping develop a concept of space rendezvous eventually known as the "concentric orbit flight plan," in which spacecraft number two (the chaser) would be premaneuvered into an inner matching orbit uniformly below and overtaking spacecraft number one (the target), and then initiate the intercept transfer, maintaining this collision course with small jet corrections to final closure and docking. I knew this approach was the best chance we had for a successful, practical rendezvous and docking for both Project Gemini and the Apollo LOR mission plan, because the concentric orbit concept would give the astronaut crew a second chance at completing the rendezvous if a computer or radar malfunctioned.

It wasn't easy translating these complex orbital mechanics into relatively simple flight plans for my colleagues. After a few months of trying to promote the intricate mechanics of the actual maneuvers at cocktail parties, I saw that most of these guys weren't really interested. Many were hard-core stick-and-rudder fighter jocks who had no appetite for astronautical theory. All they wanted to know was where to point the spacecraft and what thruster to fire to make it maneuver. They started calling me "Dr. Rendezvous"—some out of respect, others sarcastically—when I gave them a hard time for being so intellectually lazy.

The program managers, on the other hand, did appreciate my work in the rendezvous trenches. After I had spent two years in mission planning, Chris Kraft, the assistant director of MSC for flight operations, wrote a memo to Deke Slayton that focused on my contribution to Project Gemini's success and to the planned lunar orbital rendezvous for Apollo. "In the early stages of the development of the Gemini rendezvous mission plan," Kraft wrote, "Major Aldrin almost single-handedly conceived and pressed through certain basic concepts which were incorporated in this operation, without which the probability of mission success would have unquestionably been considerably reduced." Kraft added that I was "... currently exerting a similar influence on the Apollo program in which the rendezvous exercise is not only a primary mission objective but rather a mandatory operation for the safe return of the flight crew from the moon."[1]

Those months in mission planning were among the most demanding and most rewarding of my life. I was enthralled with Gemini. There's no other way to describe my feelings for the program. Gemini was the realization of all the obscure astronautical theory I'd absorbed at MIT. Gemini was also the proving ground for Apollo.