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Chapter 8

The Ranger Project's Legacy for Emerging Space Programs*

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Abstract

Ranger was the first American project to send science data from the surface of the Moon. Today, with a revival of lunar activity worldwide, the technical and management lessons of Ranger give a relevant historical background. Planning for Ranger began at JPL in 1958, while JPL and the von Braun group in Alabama were US Army institutions. The transition to NASA occasioned management chaos. Every known precept of orderly project governance was violated, not only amid the NASA and science-community participants but also among NASA, the US Air Force, and its contractors. Despite these early troubles the project was able to launch nine spacecraft on Atlas-Agena B vehicles between 1961 and 1965, with six failures followed by three complete successes returning thousands of high-resolution lunar images. Ranger's ultimate success is due to the perseverance of people who put devotion and skill ahead of interagency rivalry and scientific disputes. Beginning in an atmosphere of challenge from the Soviet Union and ending during preparations for Apollo, Ranger pioneered technical and managerial methods that can be applied worldwide to enable lunar and planetary achievements today.

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I. Introduction

This chapter gives an account of NASA's Ranger lunar exploration project, showing how its progress from failure to triumph laid groundwork for the Jet Propulsion Laboratory's later lunar and planetary missions.* Ranger began in 1960 in an atmosphere of management confusion and conflict, but by the time of its last flight in 1965 most of the troubles had been sorted out, and NASA-JPL relations and methods had settled into the well-understood arrangement that continues to deliver success today.

Ranger was the first US attempt to deliver scientific and engineering information from the lunar surface. What follows is a review of Ranger's origin and the political background, technical experience, management relationships, and in-flight events that characterized the project and created its legacy.

The definitive book about the project is *Lunar Impact.*[1] Other insights about Ranger can be drawn from *Spaceflight*[2] and *Ambassadors from Earth,*[3] written many years after the end of the project and so reflecting its longer-term historical significance. At its outset, the project's priorities were driven by the post-Sputnik urgency of competition with the Soviet Union. *Seven Years to Luna Nine*[4] describes what the United States knew about the Soviet lunar and planetary program in the 1960s. An authoritative account of the Soviet program, including some of its management troubles, is given in *Soviet Robots in the Solar System.*[5]

During 1958 and 1959, JPL's central goals in deep space exploration were the same as they are today. Recognizing that Earth satellite programs were to become a huge business and a complex array of scientific and applications activities in a crowded field, JPL's leaders chose to concentrate the lab's efforts mainly beyond Earth orbit. For missions to the Moon, rough landings were selected because at the time it was still thought possible that the US Air Force's Atlas-Able lunar orbiters (Atlas-Able missions 4A, 4, 5A, and 5B) might succeed. (They did not.) When JPL and the Wernher von Braun team were transferred from US Army auspices to those of the newly formed National Aeronautics and Space Administration, these decisions were accepted as defining JPL's role in the new civilian space agency.

All deep-space mission planners knew then that an October 1960 launch window offered the first chance in human history for a mission to Mars. Briefly studied at JPL as a goal for a large spacecraft to be named Mariner A, the prospect of a 1960 mission to Mars was soon abandoned as too ambitious. A smaller craft called Mariner R, to be derived from Ranger, was chosen for a mission to

* Some text is taken from a NASA book to be published, noting the 50th anniversary of the first Mariner and Ranger flights.

Venus during the 1962 launch window. Ranger had always been considered a precursor to planetary spacecraft, so it had solar panels and a high-gain antenna, features not necessary for lunar missions but essential for flights beyond the Moon.

On 10 and 14 October 1960, two Soviet launch vehicles departed for Mars. Both failed, but they proved that the Soviet Union was committed to planetary exploration, providing a blowtorch stimulus to people at JPL.

II. The Ranger Flights

The two Ranger test spacecraft, launched 23 August and 18 November 1961, were intended to demonstrate Sun and Earth attitude information systems, solar power, and high-gain communications from high-apogee orbits not aimed at the Moon. Because of Agena upper-stage failures, these two spacecraft were stranded in low Earth orbit and unable to return any useful science data. Both spacecraft did appear to be fully functional during their brief lives in orbit.

Ranger 3, launched 26 January 1962, had an Atlas guidance-system fault, but the spacecraft did get off to a reasonable start, acquiring Sun and Earth attitude references and executing a midcourse burn. But the midcourse maneuver vector, due to an undetected double sign inversion in ground testing, was the mirror image of the planned one, so the spacecraft missed the Moon.

Ranger 4, launched 23 April 1962, had our first perfect launch and the spacecraft hit the Moon, but the spacecraft's main power system was shorted out at separation from the Agena, probably by a floating conductive particle bridging two pins in the separation connector. If the spacecraft side of the connector had been female, this could not have happened.

Ranger 5, launched 18 October 1962, again started off well, acquiring attitude references and preparing to maneuver, but then its main power system gradually failed due to overheating of a small screw in one logic unit.

Ranger 6, launched 30 January 1964, the first Ranger mission after the project's reorganization, had a perfect flight to the Moon but then, due to a subtle and peculiar cause, returned no approach images. At staging off of the Atlas booster engines, a hot plasma cloud enveloped the launch vehicle, bridging pins in an Agena umbilical connector and burning out the spacecraft's two high-powered TV transmitters. Redesigning the umbilical receptacle eliminated the possibility of this failure occurring in future missions. Rangers 7, 8, and 9 were completely successful, returning thousands of high-resolution images.

III. The Ranger Legacy

Management Lessons and Cautions

At its outset, Ranger was subject to vexed management problems stemming from the chaotic interagency atmosphere after the Sputnik shock. JPL and the von Braun team at the Army Ballistic Missile Agency had a well-established relationship with their US Army customers. When they were transferred to the newly formed NASA, several bad things happened simultaneously. First, launch services procurement was upended. The US Air Force had contracts with the suppliers of Atlas and Agena, but NASA people wanted to insert the Agency into the process, believing that the USAF method did not offer close enough control of the vehicles. This placed the von Braun team in an impossible position. A fumbling organ called the Agena-B Coordination Board did nothing to improve the situation during its brief existence. Second, there was disagreement over Ranger's priorities. JPL engineers and managers, driven by the evidence of serious and urgent Soviet intentions, advocated fast schedules while scientists associated with NASA were not so persuaded.

An atrocious episode, violating every principle of good management, happened in 1962. Responding to pressure from non-lunar scientists whose experiments had been voided by the failures of Rangers 1 and 2, NASA Headquarters people unilaterally directed the JPL Project to add eight magnetospheric instruments to each spacecraft in the next flight series. After the failure of Ranger 5, this order was rescinded, but while it existed it had a devastating effect. Hall's book [Ref. 1] shows how these and other management faults bedeviled Ranger in its early days.

The post-Sputnik situation will not recur, but managerial disagreements are a perennial hazard and Ranger's lesson is that they are a risk in planning and executing any project. Choosing achievable goals and holding them steady over time are keys to success.

Technical Legacy

The causes of the six Ranger failures may seem so diverse that no clear lesson can be drawn from them, but in fact certain common elements do exist. First, attitude-stabilized craft, unlike spinning satellites, are vulnerable to floating conductive particles that can cause short circuits. Second, the initial Ranger policy of requiring uninterrupted telemetry is violated at risk. Many years later, other JPL missions were lost due to causes that will never be known. Third, rigorous analysis of possible failure chains, with associated testing to the extent possible, is essential. The Ranger failures occurred at interfaces hard or impossible to test.

Ranger lessons were applied in fault-protection design of the Voyagers, with the result that they each survived many in-flight failures.

IV. Conclusions and Recommendations

The purpose of this chapter has been to give a brief summary, for the benefit of a new generation of space mission designers, builders, and operators, of some of the main lessons of Ranger, a project that pioneered a class of space efforts much more complicated and risky than any that had gone before.

Plan thoroughly, set and retain goals, test to the maximum achievable under constraints, think creatively about human-to-machine trouble sources and hold back reserves for contingencies. The balance among time, resources and risk is the essence of a successful project.

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