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THE GENESIS OF PROJECT GEMINI : THE IDEA OF ORBITAL RENDEZVOUS, 1929-1961

Three related but distinct lines of development lay behind the United States'decision in 1961 to undertake Project Gemini. The most direct was strictly technical. The Gemini spacecraft began its career as an advanced version of the Mercury capsule used in the first U.S. manned space flight program. The effort to improve and refine the Mercury capsule was pursued chiefly by elements of Space Task Group, the organization within the U.S. National Aeronautics and Space Administration (NASA) responsible for directing Project Mercury. Improvement meant increased weight, and thus a more powerful launch vehicle was needed. Such a vehicle was available in the Titan II, which was being developed during 1961 at the same time that the spacecraft improvement was being planned ([1]). Technical feasibility, however, while necessary, was not sufficient.

The justification for Project Gemini came from another source. This second line of development was oriented toward the goal of manned flight to the Moon, now being carried out as Project Apollo. While Space Task Group engineers concentrated on Project Mercury, other NASA planners concerned themselves with outlining a program to land Americans on the Moon. By 1961 NASA had come to realize that some form of orbital rendezvous was the key to achieving this goal with dispatch and economy. NASA's growing recognition of the crucial role of rendezvous in the human exploration of space beyond the immediate vicinity of the Earth stimulated the demand for a program to develop orbital techniques and to determine their feasibility. Although Project Gemini officially began with three major objectives, including long-duration flight and controlled landing as well as rendezvous, NASA officials persistently emphasized rendezvous in justifying the program ([2]).

During 1961 Space Task Group's efforts to improve the Mercury capsule merged with NASA's growing awareness of the importance of orbital techniques. The result was a rendezvous development program, Project Gemini, drawing on the technological capital laid up by Project Mercury, but chiefly justified as a preliminary phase of Project Apollo. Gemini owed its existence to both its predecessor and its successor.

But there was a third, more general, line of development leading to Project Gemini. NASA's grasp of the significance of orbital rendezvous was surprisingly late in coming. As a scientific speculation it was half a century old when NASA adopted it; its literary antecedents were even a little older. NASA, of course, had only been created in 1958. The point, though, is that for some three years NASA's planning for a manned lunar mission assumed a direct flight from the Earth's surface to the Moon, an approach toi nterplanetary travel long since discretited among knowledgeable space flight enthusiasts.

Until the late 1940's rendezvous was an incidental, and often neglected, aspect of speculation on the role of the space station in interplanetary travel. The origin and growth of the space-station concept in astronautical thought, and of the complementary idea of the significance of orbital rendezvous, may be traced through the works of the Russian pioneers of astronautics — Tsiolkovskii, Kondratyuk, and Tsander — as well as in the writings of their Central European counterparts — Oberth, Hohmann, Pirquet, and " Noordung ". Although a fascinating story, it is unfortunately beyond the scope of this paper ([3]).

Their essential conclusions were that chemically fueled rockets were only marginally capable of interplanetary flight, or even of flight to the Moon. Some form of intermediate stopover point in orbit offered the chance of alleviating this problem. By 1929 the orbital space station had been generally accepted as a necessary prelude to interplanetary travel. With the theoretical foundations of space flight well established, investigators turned their attention during the next decade and a half to the development of practical rockets ([4]). Rocketry began very quickly to move from the realm of theory to the realm of technique, as most spectacularly exemplified in the German V-2 program ([5]). During the 1930's and early 1940's, rocketry and astronautics thus temporarily parted company. Rocket science was well on its way to becoming rocket engineering while space travel remained a purely theoretical exercise.

Active interest in space flight, as opposed to rocketry, revived after World War II. In the West, the late 1940's saw the focus of this activity migrate from Germany to Britain and the United States. Early postwar U.S. work was secret ([6]), but between 1949 and 1951 the British Interplenetary Society provided, in its *Journal*, a forum for the introduction and dissemination of an important new concept in astronautics. The idea, variously termed " orbital technique " or " orbital operations ", was suggested independently by two members of the B.I.S. in papers submitted to the Society's editorial committee in October 1948 ([7]). The first of the two to be published was Harry E. Ross, on " Orbital Bases ", in the January 1949 issue of the *Journal* ([8]). Kenneth W. Gatland's paper, " Rockets in Circular Orbits ", followed in March ([9]). Both pointed out that the advantages of orbital staging need not depend on establishing a space station. The interplanetary traveler had merely to rendezvous in orbit with a separately launched fuel supply or, alternatively, with a specialized interplanetary spacecraft constructed in orbit. This meant, in effect, that the interplanetary voyage would be launched from orbit, rather than from the ground, and thus launched with the greater proportion of escape velocity already achieved.

The publication of these two papers lifted rendezvous to a new prominence in astronautical thought. Like the space station itself, orbital technique wad proposed as an answer to the basic limitations of chemically fueled rockets. But while rendezvous had been an incidental consideration in thinking about space stations, it was a fundamental characteristic of orbital technique. Thus the rapid and universal acceptance of the utility of orbital technique directly stimulated work on the problems of rendezvous.

That acceptance was indeed rapid. When the Second International Congress of Astronautics met in London, September 3-8, 1951, the process was already complete. In its report on the Congress, the B.I.S. noted as the outstanding point " the unanimity of opinion shown by the technical representatives from all countries regarding the significance of the ' Earth-Satellite-Vehicle '... All the contributors believed that interplanetary flight must, or at least should, involve refuelling at some sort of orbital base, whether it be a , space station ' in the usually accepted sense, or simply a rendezvous position for a fleet of tanker rockets " ([10]). The new status of rendezvous as a field of study in its own right won a sort of formal ratification at the London Congress itself. On September 7, 1951, R. A. Smith, another B.I.S. member, presented the first paper speciafically addressed to the problem of " Establishing Contact Between Orbiting Vehicles " ([11]).

The pioneering, and largely qualitative, suggestions of Ross, Gatland, and Smith were followed, during the early and middle 1950's, by renewed interest in the fundamental problems of orbital mechanics, an area relatively neglected since the publication in 1925 of Walter Hohmann's seminal investigations in *Die Erreichbarkeit der Himmelskörper* ([12]). The major new work was by Derek F. Lawden, another B.I.S. member, but several others contributed significantly to establishing a quantitative basis for the consideration of orbital and inter-orbital maneuvers ([13]).

Rendezvous, however, was a relatively advanced space flight technique. During the early and middle 1950's, it was the minimum, unmanned satellite vehicle which attracted the most interest, since it was the obvious opening move in the assault on space. Once that move had been made, however, rendezvous was clearly the next logical step. The effect was immediate. From 1952 through 1957, some four or five articles related to rendezvous were published each year. But 1958 produced almost as many rendezvous studies as the preceding six years combined, and 1959 came close to tripling the 1958 total. This literature was distinctly different from the seminal, but largely intuitive, formulations of the early postwar period.

Firmly based on the capabilities of existing operational, or developmental, launch vehicles, it was highly quantitative and narrowly focused. It was also largely the product of work sponsored by large organizations, either industrial corporations or the U.S. Government. For the scene had also shifted. The major focus of activity had, by 1958, become the United States, where the money and the skills to turn theory into practice were available.

For a long time, however, practice outran theory. Formed in 1958 from the 40-year-old National Advisory Committee on Aeronautics (NACA), NASA began its career with aeronautical engineers. This had its advantages. In the relatively straightforward engineering job demanded in Project Mercury, for example, solid experience in aerodynamics and other aspects of high-speed flight and rocketry stood NASA in good stead, while a lack of familiarity with advanced astronautical thought was, in the main, irrelevant ([14]). But in long-term planning, engineering skill was no substitute for theoretical sophistication. NASA was therefore condemned to recapitulate (though in a much compressed span of time) the history of astronautical thought. NASA's plan for a lunar mission began with the long-since-rejected notion of direct ascent from the Earth's surface ([15]). Such attention as it paid to rendezvous was entirely in the context of the space station ([16]). Only by degrees over a period of some three years did NASA come to recognize (presumably because its personnel became educated to astronautical, rather than aeronautical, thinking) the striking advantages of orbital rendezvous in interplanetary flight. It was only in 1961, a decade and more after the idea had been fully accepted elsewhere, that NASA began seriously to consider orbital rendezvous for a lunar mission and to recognize that rendezvous was a desirable capability in its own right ([17]). By the end of 1961, both concepts had, however, been accepted. Rendezvous was incorporated into Project Apollo in 1962, while Project Gemini was initiated in 1961 to develop rendezvous techniques.

NOTES

([1]) On the technical background of Project Gemini, see James M. GRIMWOOD and Barton C. HACKER, with Peter J. VORZIMMER, *Project Gemini: Technology and Operations*, Part I, " Concept and Design " (Washington : NASA SP-4002, 1969).

([2]) See, for example, the testimony of James E. WEBB (NASA Administrator), Robert C. SEAMANS, Jr. (NASA Associate Administrator), and D. Brainerd HOLMES (Director of NASA's office of Manned Space Flight) before the U.S. House of Representatives, Committee on Science and Astronautics, Subcommittee on Manned Space Flight, Hearings, on H.R. 10100 (superseded by H.R. 11737), *1963 NASA Authorization*, 87th Cong., 2nd Sess. Feb. 27, 28, Mar. 6, 26, 1962, p. 4-5, 102-103, 250-51, 460-62. For a brief account of the current place of rendezvous in Apollo planning, see Wernher von BRAUN and Frederick I. ORDWAY III, *History of Rocketry & Space Travel* (New York, Thomas Y. Crowell Company, 1966), p. 215-20.

(3) For a fully documented account, see my "The Idea of Rendezvous", the first chapter of a projected history of the Gemini program, especially p. 4-19.

(4) On Soviet experimental work, see I.A. MERKULOV, "A Contribution to the History of the Development of Soviet Jet Engineering During the 1930's," in A.A. BLAGONRAVOV *et al.* (eds.), *Soviet Rocketry: Some Contributions to Its History*, trans. and ed. H.I. NEEDLER (Jerusalem, Israel Program for Scientific Translations, 1966), pp. 41-67; and E.K. MOSHKIN, "F.A. Tsander's Engineering Contributions to Rocketry", *ibid.*, pp. 156-70. Less useful is G.A. TOKATY, "Soviet Rocket Technology", *Spaceflight*, V (1963), reprinted in Eugene M. EMME (ed.), *The History of Rocket Technology: Essays on Research, Development, and Utility* (Detroit, Wayne State University Press, in cooperation with the Society for the History of Technology, 1964), pp. 271-84. American rocketry is briefly surveyed, with selected references to the work of Robert H. Goddard and of the American Rocket Society, in G. Edward PENDRAY, "Pioneer Rocket Development in the United States", *ibid.*, pp. 19-28. For German rocketry, see Willy LEY, *Rockets, Missiles, and Space Travel* (2nd rev. ed.; New York, The Viking Press, 1961). Von BRAUN and ORDWAY, *History of Rocketry & Space Travel*, cover French, Italian, and British rocket experiments (as well as Soviet, American, and German) in Chapter 4, "The Legacy of the Pioneers", pp. 60-85.

(5) *Ibid.*, pp. 86-119, sketches the international development of military rocketry during World War II. On the V-2 specifically, see also Walter DORNBERGER, *V-2*, trans. James CLEUGH and Geoffrey HALLIDAY (New York, The Viking Press, 1954); and the same author's "The German V-2", in EMME (ed.), *The History of Rocket Technology*, pp. 29-45.

(6) See R. Cargill HALL, "Early U.S. Satellite Proposals", in EMME (ed.), *The History of Rocket Technology*, pp. 67-93.

(7) Kenneth W. GATLAND, *Development of Guided Missiles* (2nd ed.; London, Published for *Flight* by Iliffe and Sons, Ltd., 1954), p. 218.

(8) H.E. ROSS, "Orbital Bases", *Journal of the British Interplanetary Society*, VIII (Jan. 1949), 1-19. This journal will hereafter be cited as *JBIS*.

(9) Kenneth W. GATLAND, "Rockets in Circular Orbits", *JBIS*, VIII (Mar. 1949), 52-59.

(10) "Second International Astronautical Congress, London, 1951", Annual Report of the B.I.S., in *JBIS*, X (Nov. 1951), 326.

(11) R.A. SMITH, "Establishing Contact Between Orbiting Vehicles", *JBIS*, X (Nov. 1951), 295-99.

(12) Walter HOHMANN, *Die Erreichbarkeit der Himmelskörper: Untersuchungen über das Raumfahrtproblem* (Munich and Berlin, R. Oldenbourg, 1925).

(13) Among the most frequently cited of LAWDEN's paper: "Entry into Circular Orbits, I," *JBIS*, X (1951); "Inter-Orbital Transfer of a Rocket", *JBIS* XI (1952), 321-33; "The Determination of Minimal Orbits", *ibid.*, pp. 216-24; "Orbital Transfer Via Tangential Ellipses", *ibid.*, pp. 278-89; "Minimal Rocket Trajectories", *Journal of the American Rocket Society*, XXIII (1953), 360-67; "Correction of Interplanetary Orbits", *JBIS*, XIII (1954), 215-23; and "Transfer Between Circular Orbits", *Jet Propulsion*, XXVI (1956), 551-58. Other significant papers include: Lyman SPITZER, Jr., "Interplanetary Travel Between Satellite Orbits", *JBIS*, X (1951), 249-57; H. PRESTON-THOMAS, "Generalized Interplanetary Orbits", *JBIS*, XI (1952, 76-85; H. PRESTON-THOMAS, "Interorbital Transport Techniques", *ibid.*, pp. 173-93; H.S. TSIEN, "Take-off from Satellite Orbit", *Journal of the American Rocket Society*, XXIII (1953), 233-36; and B.H. PAIEWONSKY, "Transfer Between Vehicles in Circular Orbits", *Jet Propulsion*, XXVIII (1958), 121-23+. For a more complete bibliography on this subject, see Gary P. HERRING, "Orbital Transfer and Rendezvous: A Bibliography", Chrysler Corp., Space Div., Huntsville Operations, Tech. Note HSM-N42-67 May 30, 1967.

(14) On NACA's orientation and its metamorphosis into NASA, see Loyd S. SWENSON, Jr., James M. GRIMWOOD, and Charles C. ALEXANDER, *This New Ocean: A History of Project Mercury* (Washington, NACA SP-4201, 1966), pp. 55-106, See also Robert L. Ro-

SHOLT, *An Administrative History of NASA, 1958-1963* (Washington, NASA SP-4101, 1966), pp. 19-36.

(15) See NASA Propulsion Staff, „A National Space Vehicle Program : A Report to the President", Jan. 27, 1959, an unclassified version of which was published as "The National Space Vehicle Program" in U.S. Senate, Committee on Aeronautical and Space Sciences, Subcommittee on Governmental Organization for Space Activities, *Hearings, Investigation of Governmental Organization for Space Activities*, 86th Cong., 1st Sess., 1959, pp. 17-24. The persistence of this approach is reflected in NASA Office of Program Planning and Evaluation, "The Ten Year Plan of the National Aeronautics and Space Administration", Dec. 18, 1959; and Ad Hoc Task Group for Manned Lunar Landing Study, "A Feasible Approach for an Early Manned Lunar Landing, Part I: Summary Report", June 16, 1961.

(16) This is clearly evident, for example, in NASA formal justification for requesting funds in fiscal year 1960 for rendezvous studies, reprinted in U.S. House of Representatives, Committee on Appropriations, Subcommittee on Independent Offices, Hearings, *NASA Appropriations*, 86th Cong., 1st Sess., Apr. 29-30, 1959, pp. 166-67.

(17) The best guide to these events is the documented chronology by Ivan D. ERTEL and Mary Louise MORSE, "The Apollo Spacecraft : A Chronology ", Vol. I : "Through November 7, 1962" (Washington : NASA SP-4009, 1969).