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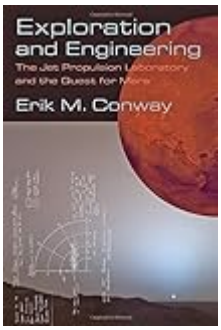

Erik M. Conway. *Exploration and Engineering: The Jet Propulsion Laboratory and the Quest for Mars.* New Series in NASA History. Baltimore: Johns Hopkins University Press, 2015. Illustrations. viii + 405 pp. $34.95 (cloth), ISBN 978-1-4214-1604-5.

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Mission to Mars: Engineering at the Jet Propulsion Laboratory

Since the beginning of the Cold War, the United States has continually pushed further into space. John Glenn became the first American in space and Neil Armstrong and Edwin âBuzzâ Aldrin became the first humans on the moon. For many in the space community, Mars is the next step. Erik M. Conway, the historian of the National Aeronautics and Space Administration (NASA) and California Institute of Technologyâs Jet Propulsion Laboratory (JPL), presents a history of Mars exploration from the two Viking spacecraft launched in the 1970s to the Mars Phoenix proposal in 2007 and also addresses ongoing projects at JPL, drawing on documentation primarily from within NASA and JPL. As a historian at NASA and JPL, he gained access to people and documentation that those outside these institutions would have a far more difficult time obtaining. Thus, Conway acknowledges early in the book that he presents JPL from an insiderâs perspective. The author also had access to funding to conduct oral histories with JPL engineers and scientists. He collected records from individuals involved with Mars projects and created the Historianâs Mars Exploration Collection. Conway also drew from publicly available online sources from the NASA Technical Information Server.

Exploration and Engineering traces the history of Mars exploration through the various missions and vehicles that have reached Mars, including orbiters, landers, and rovers. The first five chapters follow the Mars Global Surveyor and Mars Pathfinder projects, both of which were considered to be operationally and financially successful. As a result, NASA expected JPL to perform under tighter budgeting. In the next few chapters, Conway examines the failures that began to plague the various Mars missions which drew out public derision. The author presents an irony that success led to a loss in funds and higher acceptance of risk. Public perception of NASA as an agency was at stake. By the ninth and tenth chapters, he shows how the âFaster, Better, Cheaperâ low-cost funding regime dissolved.[1] The space agency, JPL included, returned to larger projects with greater âscientific ambitionâ (p. 272). The tragedy of the *Columbia* orbiter grounded the shuttle fleet and placed JPL at cen-

ter stage of spaceflight. President George W. Bush also called for expanded space exploration in 2004. In the final chapters, Conway demonstrates how testing, an emphasis on planetary geology through rovers, and reengineering shaped Mars exploration in the 2000s. The author makes clear that public interest in Mars exploration grew despite fluctuating budgets and mission setbacks. Conway finishes the book by describing the Obama administrationâs announcement of funding cuts to Mars exploration.

Exploration and Engineering makes the case that sweeping changes in NASA management, which emphasized contracting and low-cost missions, âthreatened the survival of JPLâs spacecraft engineering cultureâ (p. 3). JPL had become accustomed to large, in-house projects, such as Viking and Galileo, but NASA pressured JPLâs leaders to subcontract its workload to aerospace companies, such as Lockheed and RCA. Subcontracting ran counter to JPLâs spacecraft engineering culture that was less focused on cost as a result of its operations being based in a university-run nonprofit organization. Conwayâs book is a welcome addition to the history of spaceflight and supplements a trend in the history of technology. Historians of spaceflight and of NASA have studied the consequences of uneven federal funding to the agency and the effects of its missions. After the Apollo years, NASAâs funding dropped off, only to resurge during the Ronald Reagan years. Conwayâs book begins during the âFaster, Better, Cheaperâ years, when NASA used smaller teams and conducted less complex projects.[2] Historians of spaceflight might also take interest in Conwayâs emphasis on NASAâs drive to commercialize its research, development, and operations against the present backdrop of increasing commercial activity in the space industry. Historians of technology have considered how knowledge flows within and among agencies and the difficulties of facilitating such transfer, especially in nuclear physics and spaceflight.[3] According to Conway, JPL transferred knowledge from one Mars project to another by sustaining relationships with its subcontractors, keeping teams of engineers together, and holding onto project managers. JPL preferred to pay for more expertise and experience by keeping its longer-tenured engineering managers who had learned from past projects about spaceflight to Mars rather than bringing in less-experienced staff with lower salaries.

Technological achievement through novelty also plays a role in *Exploration and Engineering*. In the same way that Naomi Oreskes argues that new forms of measurement assisted with the discovery of plate tectonics by American geologists in *The Rejection of Continental Drift: Theory and Method in American Earth Science* (1999), Conway demonstrates how novel engineering on rovers and landers led to discoveries on the Martian surface. He argues that NASA and the National Science Foundation âsought technological achievement through scientific researchâ (p. 335). Conway also suggests that technological novelties, such as the Mars rovers and landings, stimulated public interest since they were tangible scientific breakthroughs, which he refers to as âtechnospectacles.â

From both a political and technical standpoint, NASA plays two broad roles: as a setting and as an actor. As a setting, it serves as the focal point of Mars exploration research, development, and operations, but also as a backdrop for intra-agency politics. NASAâs organizational structure is a critical component of the Mars exploration story. Conway explains that âoutsiders often see the space agency as a monolith, and NASA officials often try to foster that appearance.... But the agency is structured into relatively independent directoratesâ (p. 6). The interaction between the Science Mission Directorate, formerly the Office of Space Science, and the Human Exploration and Operations Directorate plays a key role in Conwayâs narrative.

NASA provides the setting as a research and development and operational center situated at the agencyâs Jet Propulsion Laboratory in Pasadena, California. NASA oversees JPL jointly with CalTech. NASAâs headquarters, located in Washington, DC, was often the setting in which the agencyâs administrators, deputies, and key scientists met to formulate Mars exploration policy. NASA is one among several key actors that played a role in decision making with regard to Mars exploration. NASAâs policy is heavily dictated by the White House and the Office of Management and Budget (OMB) on matters of human exploration, meanwhile the National Academy of Sciences influences, but does not dictate, the Science Mission Directorate. The Science Mission Directorate has more independence in its decision making but still must request funds from the White House and OMB.

Accordingly, Conway tells the Martian exploration tale from the perspective of JPL. As mentioned, he draws his sources exclusively from JPL archives and NASA sources. For more depth on the politics of mission funding, Conway may have benefited from also using the Congressional Record and records from presidential libraries. Also, at several points Conway mentions the role of the National Academies, which maintains an archive in Washington, DC; more thorough research into the docu-

ments housed at this archive may have shed more light on JPLâs role.

Throughout the book, Conway includes useful photographs, organizational and funding charts, and design schematics of the various Mars spacecraft, rovers, and landing devices. The book is an excellent case study of JPL, organizational culture, and planetary exploration. Given its emphasis on Pasadena, a reader looking for a broader study of NASA or its relationship with other sectors of government will find it less useful. Conwayâs work can be read alongside W. Henry Lambrightâs *Why Mars: NASA and the Politics of Space Exploration* (2014), which is a more policy-centered analysis of NASAâs efforts to organize, prioritize, and fund its various missions to explore Mars. Conway and Lambright cover the politics and technical aspects of Mars exploration in great depth. They provide an excellent blueprint for institutional histories of other NASA installations, such as the Kennedy or Goddard Spaceflight Centers, among others. Conway points out that NASA had international competition to reach the red planet, but does not address other programs in any detail. The author also does not delve into reasons why NASA or JPL faced restricted budgets on a broader scale. The Reagan administration, his OMB directors, and Congress attempted to reign in government spending more generally, and NASA was no exception. Congress passed two Balanced Budget acts in 1985 and 1987 which curtailed sections of the federal budget, making it harder for NASA to procure funding. These political motivations might have enlightened the reader further as to why JPL was under such pressure to perform within its budgeting. Despite these minor concerns, Conway displays masterful command of JPL and NASA records.

Conway gives us a well-researched book rich in both political and technical details, an analysis of JPLâs problem-solving approach to engineering, NASA project-management structure, and insight into the challenges faced by the brilliant scientists and engineers at JPL. Despite the political rhetoric and public discussion of human visitation of Mars, no humans have set foot on Mars nor does there appear to be any significant political commitment in Washington or elsewhere to make that happen in the near future. On all these fronts, Conwayâs analysis gives us an enlightened view of where JPL has gone and offers thoughts on where it may go next.

Notes

[1]. Howard McCurdy, *Faster, Better, Cheaper: Low-Cost Innovation in the U.S. Space Program* (Baltimore, MD: Johns Hopkins University Press, 2001).

[2]. Ibid.

[3]. For a debate about knowledge transfer in rocketry, see John Krige, âEmbedding the National in the Global: US-French Relationships in Space Science and Rocketry in the 1960s,â in *Science and Technology in the Global Cold War*, ed. Naomi Oreskes and John Krige (Boston, MA: MIT Press, 2014), 227-250; and Asif Siddiqi, âCompeting Technologies, National(ist) Narratives, and Universal Claims: Toward a Global History of Space Exploration,â *Technology and Culture* 51, no. 2 (April 2010): 425-443.