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First Mission to Pluto: Policy, Politics, Science, and Technology in the Origins of New Horizons, 1989–2003

ABSTRACT

The complex and contested origins of the New Horizons mission to Pluto, launched by NASA in 2006, provides a window on how space science policy has been formulated in the United States before and after the turn of the twenty-first century, and how the shifting network of institutions that support and shape space science have changed since 1989. Those decades have so far been little studied except by policy scholars seeking lessons from the NASA Administrator Daniel Goldin's attempt to force a small-spacecraft technological revolution on space science in the 1990s. The New Horizons case study reveals a shift in the balance of power around 2000 among the important players in the field, increasing the influence of non-NASA actors—notably Congress, science groups, and planetary-exploration lobbies. In addition, the

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The following abbreviations are used: AO, Announcement of Opportunity; APL, Applied Physics Laboratory, Johns Hopkins University, Laurel, MD; BMDO, Ballistic Missile Defense Organization; CIW, Carnegie Institution of Washington, Washington, D.C.; CONTOUR, Comet Nucleus Tour; CRAF, Comet Rendezvous/Asteroid Flyby; DPS, Division of Planetary Sciences, American Astronomical Society; EO, Europa Orbiter; FY, Fiscal Year; IAA, International Academy of Astronautics; IKI, Institute of Cosmic Research, Moscow; IR, infrared; ISS, International Space Station; JIMO, Jupiter Icy Moons Orbiter; JPL, Jet Propulsion Laboratory, Pasadena, CA; MESSENGER, Mercury Surface, Space Environment, Geochemistry and Ranging; NACP, National Archives College Park, MD; NASA, National Aeronautics and Space Administration; NASA HO, National Aeronautics and Space Administration History Office, Washington, DC; NAS/SSB, National Academy of Sciences, Space Studies Board; NEAR, Near Earth Asteroid Rendezvous; OMB, Office of Management and Budget; OPSWG, Outer Planets Science Working Group; OSS, Office of Space Science, NASA; OSSA, Office of Space Science and Applications, NASA; PFF, Pluto Fast Flyby; PKE, Pluto Kuiper Express; RSA, Russian Space Agency; RTG, radioisotope thermal generator; SMKP/APL, Stamatios M. Krimigis Papers, Applied Physics Laboratory, Johns Hopkins University, Baltimore, MD; SwRI, Southwest Research Institute; UV, ultraviolet.

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origins of New Horizons reveal how contingent the emergence of a particular space science mission can be.

KEY WORDS: Pluto, New Horizons, NASA, JPL, APL, Alan Stern, Daniel Goldin, Robert Staehle

Contemporary space science, Arturo Russo has written, "is not a scientific discipline . . . defined by a coherent set of scientific goals, theoretical foundations, and experimental techniques." It is an interdisciplinary field "defined by its technological tools" such as launch vehicles, spacecraft, and communications systems—tools that require national or multinational investments in the billions of dollars. These investments are not primarily made for scientific reasons, although science informs the choice of instruments and targets; they are driven largely by national prestige, international diplomacy, or the maintenance of personnel and technological capability in the often huge organizations needed to carry out spaceflight.[1]

All of these factors come into play in the origins of New Horizons, which the National Aeronautics and Space Administration (NASA) launched on January 19, 2006. That spacecraft is the first, and so far only, attempt to reach the dwarf planet Pluto, with a flyby set for July 14, 2015. Behind its launch stood nearly two decades of mission proposals and development, several cancellations and revivals, and a competition that led to a dramatic shift in the developing organizations: from the Jet Propulsion Laboratory (JPL), which the California Institute of Technology manages for NASA, to the Applied Physics Laboratory (APL) of Johns Hopkins University, paired with the Southwest Research Institute (SwRI). That shift, which took place after NASA cancelled JPL's Pluto project in September 2000, splits the story into two distinct phases: the JPL era of the 1990s and the APL/SwRI period since 2001.

During the first phase, NASA's leadership had the dominant role in shaping the shifting and unstable set of projects that JPL aimed at Pluto, although

1. Arturo Russo, "Europe's Path to Mars: The European Space Agency's Mars Express Mission," *HSNS* 41 no. 2 (2011), 123–78, on 175. For the origins of space science in America, see David H. DeVorkin, *Science with a Vengeance: How the Military Created the US Space Sciences after World War II* (New York: Springer-Verlag, 1992); for an introduction to the history of space science at NASA, see John E. Naugle and John M. Logsdon, "Space Science: Origins, Evolution, and Organization," in *Exploring the Unknown: Volume V: Exploring the Cosmos,* ed. John M. Logsdon (Washington, DC: NASA, 2001), 1–15. For a key study of how space science has operated in a giant program, see Robert W. Smith et al., *The Space Telescope: A Study of NASA, Science, Technology and Politics* (Cambridge: Cambridge University Press, 1989).

advice from the scientific community certainly played a role. But space science took a backseat to technology policy after Daniel Goldin became NASA Administrator in April 1992, with an agenda to push through a small-spacecraft revolution in science missions under the rubric "faster, better, cheaper." One program that was particularly impacted was the Pluto mission, which went through several changes in direction due to his intervention.

After Goldin's revolution petered out due to the embarrassing failures of two Mars probes in 1999, widespread protest by scientists, lobby groups, and the public over the 2000 Pluto cancellation empowered outside organizations in the second phase, shifting the balance of forces in the planetary program. A critical factor became the ability of non-NASA actors to mobilize political support in Congress to revive or sustain a mission, a pattern that appears roughly every decade in NASA space-science history, when the agency is politically weak or in conflict with the scientific community, providing an opening for congressional intervention.[2] The result was that external organizations forced a change in NASA's space science policy, and Pluto was put back on its agenda despite three agency and administration attempts to cancel it.

To date, only New Horizons Principal Investigator (PI) S. Alan Stern of SwRI has discussed the long and complicated Pluto mission story, but his factually rich accounts are naturally the memoirs of a key participant first.[3] Insofar as social scientists and historians have treated planetary exploration after 1990, they have mostly attempted to explain, or draw policy lessons from, the rise and fall of Goldin's revolution.[4] Scholars have scarcely touched the first

2. One noteworthy example is the incoming Reagan Administration's attempt to cancel NASA's planetary program in 1981, which provoked scientific protest and Congressional intervention. See John M. Logsdon, "The Survival Crisis of the US Solar System Exploration Program in the 1980s," in *Exploring the Solar System: The History and Science of Planetary Exploration*, ed. Roger D. Launius (New York: Palgrave Macmillan, 2013), 45–76. In his introduction to the volume, Launius also discusses an earlier crisis that provoked intervention, leading to the cancellation of the Voyager Mars landing program in 1967. It was revived in less ambitious form as Viking. Ibid., 3–4.

3. Alan Stern and Jacqueline Mitton, *Pluto and Charon: Ice Worlds on the Ragged Edge of the Solar System,* 2nd ed. (Weinheim, Ger.: Wiley-VCH, 2006), chaps. 7–8; S. Alan Stern, "The New Horizons Pluto Kuiper Belt Mission: An Overview with Historical Context," in *New Horizons: Reconnaissance of the Pluto-Charon System and the Kuiper Belt*, ed. C. T. Russell (n.p.: Springer, 2009), 3–21. See also Richard J. Terrile et al., "Spacecraft Missions to Pluto and Charon," in *Pluto and Charon*, ed. S. Alan Stern and David J. Tholen (Tucson: University of Arizona Press, 1997), 103–24.

4. Stephanie A. Roy, "The Origin of the Smaller, Faster, Cheaper Approach in NASA's Solar System Exploration Program," *Space Policy* 14 (1998): 153–71; Howard E. McCurdy, *Faster, Better,*

decade of the twenty-first century because it is so recent and because it lacks the clear test of space policy effectiveness that the 1990s affords. Examining the Pluto exploration story thus provides a window on how space science policy was formulated in the United States before and after the turn of the twenty-first century, but also how the shifting network of institutions that support and shape space science have changed since 1989. In addition, the origins of New Horizons reveal how contingent and complex the emergence of a particular space science mission can be. Several times the Pluto program hung in the balance, showing that however much one tries to analyze space policy as a rational process among organizational actors, the actions of particular individuals may change the course of history.

FROM PLUTO-350 TO PLUTO FAST FLYBY, 1989–1993

The first proposals to send a spacecraft to the then-ninth planet go back to the late 1960s. JPL scientists pointed out that the alignment of Jupiter, Saturn, Uranus, Neptune, and Pluto in the late 1970s and 1980s, relative to the Earth, would allow launching two or more spacecraft in about 1977 on a "Grand Tour" of the outer solar system. What came of that idea was the Voyager program, which spectacularly explored the first four between 1979 and 1989. But the opportunity to send one of the two Voyagers to Pluto was dropped in 1979/80 because Saturn's major moon Titan, the only satellite in the solar system with a substantial atmosphere, was both a higher scientific priority and lower risk target. Very little was known about Pluto then, Titan was potentially exciting as a site for pre-biotic organic chemistry, and the Voyager 1 spacecraft

Cheaper: Low-Cost Innovation in the U.S. Space Program (Baltimore, MD: Johns Hopkins University Press, 2001); Howard E. McCurdy, "Learning from History: Low-Cost Project Innovation in the U.S. National Aeronautics and Space Administration," *International Journal of Project Management* 31 (2013): 705–11; Amy Page Kaminski, "Faster, Better, Cheaper: A Sociotechnical Perspective on Programmatic Choice, Success, and Failure in NASA's Solar System Exploration Program," in Launius, *Exploring the Solar System* (ref. 2), 77–101. The best historical work on planetary exploration in the period is Peter J. Westwick's *Into the Black: JPL and the American Space Program, 1976–2004* (New Haven, CT: Yale University Press, 2007), but as a history of JPL, it inevitably touches only lightly on other organizations and national policy dimensions of the program. There are also a few NASA project histories, such as: Howard E. McCurdy, *Low-Cost Innovation in Spaceflight: The Near Earth Asteroid Rendezvous (NEAR) Shoemaker Mission,* NASA Monographs in Aerospace History, no. 36 (Washington, DC: NASA, 2005); and Michael Melzer, *Mission to Jupiter: A History of the Galileo Project* (Washington, DC: NASA, 2007).

was more likely to survive through the Saturn/Titan encounter than it was during the decade or so it would take to get from Saturn to Pluto. The trajectory options were such that it could not do both. Once the Titan flyby succeeded, Voyager 2 was directed to fly from Saturn to Uranus and Neptune, a path that similarly precluded a Pluto flyby.[5]

Between the 1977 launch of the Voyagers and their Jupiter encounters in 1979, astronomers at the US Naval Observatory discovered a major satellite around Pluto, soon dubbed Charon (pronounced both "Shar-on" and "Kar-on"). Once its orbital characteristics were known, it was possible to calculate the two bodies' masses. Pluto was even tinier than had earlier been supposed—only about 0.2% of the mass of the Earth. By an extraordinary stroke of astronomical luck, the plane of the system was such that only seven years later, in 1985, Charon began to pass in front of and behind Pluto as viewed from Earth—something that happens only every 124 years. The "mutual events," as they were called, allowed further refinements of the masses and diameters of what amounted to a double planet—the satellite being fully half the 2400-km diameter of the primary. They also revealed important information about large differences in albedo between light and dark areas on the surface of Pluto, and about its large, if very thin atmosphere with an high escape rate, putting it somewhere between a comet and a planet. Moreover, astronomers could determine that there are stark differences in surface composition between the two bodies, leading to the theory that a giant impact during the formation of the solar system had knocked off a portion of Pluto's icy mantle, forming Charon—analogous to the favored theory of Earth-Moon formation. Pluto had thus turned from a little-understood planetary oddball into a scientifically important subject for research during the 1980s.[6]

5. Henry C. Dethloff and Ronald A. Schorn, *Voyager's Grand Tour: To the Outer Planets and Beyond* (Washington, DC: Smithsonian Books, 2003), 34, 47; Alan Stern interview by author, 2 May 2013, 1–2; Richard Terrile interview by author, 14 Mar 2013, 1–3; Stern and Mitton, *Pluto and Charon*, 183 (ref. 3); Stern, "New Horizons," in Russell, *New Horizons* (ref. 3), 4–5. Stamatios Krimigis of APL also remembers NASA proposing, ca. 1975, a third Voyager mission, to Pluto via Jupiter. This idea must have been short-lived, as it not mentioned in Dethloff and Schorn. Krimigis interview by author, 6 Jul 2012, 1; and Krimigis presentation viewgraphs: "Realizing an Elusive Goal: The (Torturous Path to the) Exploration of Pluto with New Horizons," 22 Jul 2013, PDF file courtesy S. M. Krimigis.

6. Stern and Mitton, *Pluto and Charon* (ref. 3), 49–175; Richard Binzel phone interview by author, 2 Jul 2013. For a scientific synthesis ca. 1996, see Stern and Tholen, eds., *Pluto and Charon* (ref. 3); for an historical survey of Pluto as an astronomical anomaly through to its demotion, see David H. DeVorkin, "Pluto: The Problem Planet and Its Scientists," in Launius, *Exploring the*

In 1989, the confluence of that scientific context and Voyager 2's Neptune encounter in August led NASA to once again consider a Pluto flyby. The initiator was Alan Stern, then a graduate student finishing his dissertation on comets around other stars at the University of Colorado. He had worked on Pluto with his advisor at the University of Texas in the early 1980s and remained fascinated both by the science and by the prospect of exploring new frontiers. Cognizant of the upcoming milestone, which marked the end of Voyager's primary mission, on May 4 he visited Geoffrey Briggs, head of the Solar System Exploration Division at NASA Headquarters in Washington, DC. After they watched the space shuttle launch with the Magellan Venus radar spacecraft, Stern told him: "I want to know why we don't have a mission to Pluto. There's a bunch of us that would like to see that." Briggs replied: "No one's ever asked that question of me before. I think we should study it."[7] During the American Geophysical Union conference in Baltimore the next week, Stern and other young colleagues organized a "Pluto Underground" over dinner at an Italian restaurant after a special session on the planet at the conference. The informal group would be dedicated to advocating such a mission to the scientific community and NASA.[8]

The "Underground" was scarcely alone. A flyby of Pluto would "complete the reconnaissance of the solar system"—so states a document generated during the June 1989 New Hampshire workshop of Briggs's scientific advisory committee.[9] But it is noteworthy that this conception of a mission rested on Pluto's status as the ninth planet and the *end* of the system. The Kuiper Belt—a region of icy bodies beyond Neptune once proposed by Dutch-American astronomer Gerard Kuiper—had yet to be confirmed. When it was a few years later, and astronomers discovered many objects of significant size, including one about the same size as Pluto (soon named Eris), it would revolutionize the concept of the outer solar system and bring

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Solar System (ref. 2), 323–62. See also Alan Stern, "The Pluto Reconnaissance Flyby Mission," *Eos* 74, no. 7 (1993): 73, 76–80, esp. 73, 76.

7. Stern interview by author (ref. 5), 2–5.

8. Stern and Mitton, *Pluto and Charon* (ref. 3), 182–84; Terrile interview by author (ref. 5), 4–5; Richard Binzel phone interview by author, 2 Jul 2013; Stern PowerPoint slides from Jan 2006 lecture at Kennedy Space Center, courtesy Alan Stern.

9. "Mission Questionnaire Results, Blue Team, Durham Workshop, June 26, 1989," in SMKP/APL, Box Krimigis Committees (SSEC-SSAAC), Folder Solar System Exploration Subcommittee.

Pluto's planetary status into question.[10] But in 1989, all that lay in the future, and for many planetary scientists and others, the fact that the United States had magnificently explored eight planets, but not the ninth, was almost argument enough in itself.

When Voyager did fly by Neptune on August 24, there was a bonus. The planet's large moon Triton, about the same size as Pluto, turned out to be remarkably geologically active despite being extremely cold. Geysers spouted from an icy surface forty degrees above absolute zero. A likely captured Kuiper Belt object, it was thus a possible Pluto analogue, given the recent observations of the latter's dynamic atmosphere. According to JPL astronomer Richard Terrile, another member of the Pluto Underground, the Triton encounter "had a phenomenal impact." Stern calls it "a sexy scientific surprise."[11]

One more factor made Stern's intervention opportune: it occurred while Briggs was trying to get a small spacecraft initiative started. A sense of crisis prevailed in solar system exploration at the time, notwithstanding the budget prospects. The program had fallen into a cycle of large "flagship" spacecraft so expensive that NASA could only afford one about every half decade or longer. The gap in launches in the eighties had been made even worse by the shuttle *Challenger* accident in 1986—Magellan was the first US planetary mission off the pad since 1978. Moreover, overruns and delays in the Mars Observer orbiter program, an attempt to lower spacecraft costs, had created skepticism that cheaper planetary spacecraft were even feasible. But helped by APL's Stamatios "Tom" Krimigis, who energetically defended the idea of small planetary missions at the June 1989 meeting in New Hampshire, Briggs was able to launch the Discovery Program that fall. He created a science working group to study possible low-cost missions and named Robert Farquhar, a Goddard Space Flight Center orbital mechanics expert, to be part-time program manager. Farquhar was famous for using lunar gravity assists to divert the International Sun-Earth Explorer 3 spacecraft, which had been in orbit around Sun-Earth Lagrangian point L-1, to a comet flyby in 1985 (Fig. 1).[12]

10. For a compelling memoir by the discoverer of Eris and several other Kuiper Belt objects, see Mike Brown, *How I Killed Pluto and Why It Had It Coming* (New York: Spiegel & Grau, 2012).

11. Terrile interview by author (ref. 5), 4–5; Stern and Mitton, *Pluto and Charon* (ref. 3), 184.

12. Michael J. Neufeld, "Transforming Solar System Exploration: The Origins of the Discovery Program, 1989-1993," *Space Policy* 30, no. 1 (2014): 1–8. See also the literature cited in n. 1; and Stamatios M. Krimigis and Joseph Veverka, "Foreword: Genesis of Discovery," *Journal of the Astronautical Sciences* 43 (1995): 345–47.

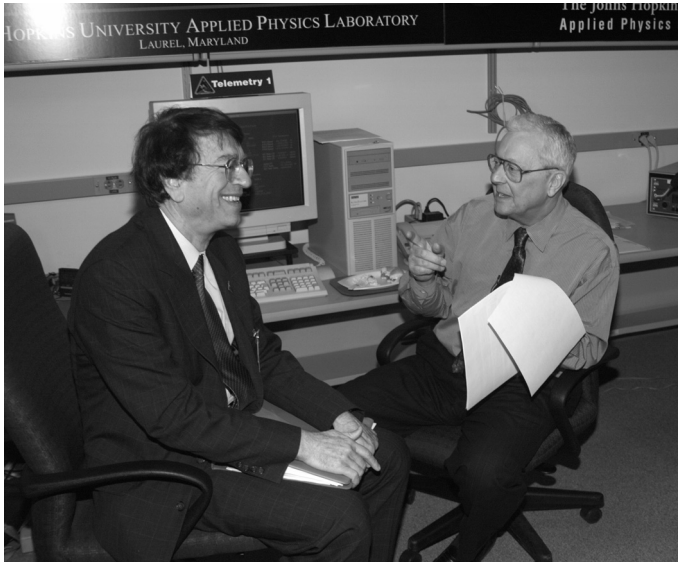

FIG. 1. Stamatios "Tom" Krimigis and Robert Farquhar at APL in 2001. Farquhar worked with Alan Stern on the "Pluto-350" proposal early on, and later headed trajectory design for New Horizons. As APL Space Dept. Head, Krimigis was critical to the emergence of the New Horizons proposal in 2000–2001 and its subsequent political survival in Congress. *Source*: APL. Courtesy of APL.

Farquhar was excited by the idea of a Pluto mission. Immediately after the Neptune encounter, he got some public attention for advocating a dual launch of a Pluto spacecraft and Solar Probe, a mission to come very close to the Sun. They would both use a Jupiter gravity assist to go off in opposite directions. Stern, enlisted for the Pluto mission study, coined the clever label "Fire and Ice" to describe this mission. But Farquhar's idea went nowhere, perhaps because Solar Probe still was nothing but a paper project too. He says, however, that it was because he dropped the dual launch for "an even better plan."[13]

To keep the Pluto mission small, and thus perhaps under the Discovery target of $150 million for the spacecraft, Farquhar proposed using Earth and Jupiter gravity assists and only a medium-size booster, the Delta II. That

13. Robert W. Farquhar, *Fifty Years on the Space Frontier: Halo Orbits, Comets, Asteroids and More* (Denver, CO: Outskirts Press, 2010), 241–42, on 242; Alan Dye, "Maverick Scientist Casts an Eye on Pluto," *Los Angeles Times,* 5 Sep 1989, 18–19 ("Fire and Ice," 18); Stern and Mitton, *Pluto and Charon* (ref. 3), 185–86.

eliminated the huge and expensive rocket that would be required (probably a Titan IV/Centaur) for the daunting energy necessary to make either a two-spacecraft mission by Jupiter or a direct launch to Pluto. Even though the latter was then at its perihelion of 30 astronomical units (1 AU (Astronomical Unit) = the Earth-Sun distance), significantly closer than in other parts of its orbit (aphelion is 49 AU), Pluto was such a difficult target that Stern called a mission to it the "Everest" of planetary exploration. Farquhar's gravity-assist design was a clever solution to the problem, but the spacecraft could not launch until late 2001, as the first opportunity to use Jupiter to accelerate it did not occur again until about 2004. And it would take until 2015 to get there—a quarter century into the future, beyond the time horizon of many senior scientists and managers, let alone the politicians who would have to vote for it.[14]

Alan Stern and Frances Bagenal, one of the few women in the Pluto Underground, were responsible to the Discovery Program Science Working Group for the scientific dimensions of the Pluto mission study, but the money (probably about one or two hundred thousand dollars) went primarily to JPL for the design. The proposal that emerged in 1990 was named Pluto-350, for its approximate dry (unfueled) mass target of 350 kg. Thanks to improved technology, it managed to pack much of the multi-instrument capability of a Voyager into a package under half the weight of that spacecraft. But it never gained much traction. Even under the most optimistic assumptions, it did not fit under the cost ceiling of the Discovery Program, which soon began moving toward a less ambitious inner solar system mission, such as an asteroid rendezvous. Pluto-350 did not appeal to JPL management either, in the view of Andrew Cheng, an APL space physicist and later a key New Horizons team member: "The mission was too small and inexpensive, and people didn't believe it could be done. It just went nowhere."[15]

The JPL leadership was more interested in the possibility of an elaborate flagship spacecraft in the Mariner Mark II series, even larger than Voyager. The Office of Space Science and Applications (OSSA) under Associate Administrator

14. Farquhar, *Fifty Years* (ref. 13), 242–43; Stern and Mitton, *Pluto and Charon* (ref. 3), 186–87.

15. Robert Farquhar and S. Alan Stern, "Pushing Back the Frontier: A Mission to the Pluto-Charon System," *Planetary Report* 10, no. 4 (1990): 18–23; Farquhar, *Fifty Years* (ref. 13), 242–43; Stern and Mitton, *Pluto and Charon* (ref. 3), 187–89; Andrew Cheng interview by author, 1 Feb 2013, 9. The 1990 article and other secondary references constitute almost the only material I was able to find on Pluto-350. I turned up nothing at the JPL Archives or the NASA History Office on it, which confirms that it remained a paper study that was little read or saved. A bit of further detail is found in early documents of the Pluto Fast Flyby project described below.

Lennard Fisk had proposed that series in the late 1980s, a flush period for NASA. Congress passed it in 1990 with two projects: a Saturn orbiter/Titan probe mission called Cassini (the European Space Agency took on the probe as Huygens), and Comet Rendezvous/Asteroid Flyby (CRAF). A year earlier, before Stern's initiative, JPL scientists had floated the idea of a Mariner Mark II Pluto flyby, with impact probes for Pluto and Charon. It would fly an Earth-Jupiter gravity assist trajectory similar to Pluto-350, but would require a Titan IV/Centaur, a vehicle that cost at least a quarter of a billion dollars. But such an ambitious mission fit the engineering culture of JPL at the time, and would be of a size that could sustain an institution of over five thousand people.[16]

In August 1990, Wesley Huntress, a distinguished former JPL scientist, and most recently deputy division director for Earth sciences at NASA Headquarters, took over the Solar System Exploration Division from Briggs. He had three priorities: (1) reenergize the Discovery Program for small spacecraft, which he thought had languished over the preceding year; (2) support the astronomical search for extra-solar planets, then gathering momentum; and (3) a Pluto mission, again with the rationale of completing the reconnaissance of the solar system.[17]

Huntress quickly settled on the Mariner Mark II proposal and incorporated it into the strategic planning process initiated by Fisk, which was to produce a comprehensive space sciences and applications plan in 1991. According to Stern, by then at the Southwest Research Institute in San Antonio, Texas, the planetary division chief told him that "I need to get it done with the Mariner Mark II because I need to keep that line open." Following a workshop in San Diego in late February 1991—Stern remembers it coinciding with the hundred-hour, ground-combat phase of the Gulf War—Huntress created an Outer Planets Science Working Group (OPSWG) chaired by Stern to work out the scientific rationale and conceptual instrument suite for Pluto, or alternately, for a Neptune Orbiter. (Stern remembers being somewhat taken aback by Huntress's jokey acronym PorNO: Pluto or Neptune Orbiter.)[18]

16. "Outer Planet Missions, JPL, La Jolla, March 6–10, 1989," viewgraphs 10–11; "Mission Questionnaire Results, Blue Team, Durham Workshop, June 26, 1989," and "Outer Planets Mission, FY 93 Moderate, JPL, Pluto/Charon Flyby, Stuart Kerridge, 26 June 1989," in SMKP/APL, Box Krimigis Committees (SSEC-SSAAC), Folder Solar System Exploration Subcommittee; Westwick, *Into the Black* (ref. 4), 222–26.

17. Wesley T. Huntress interview by author, 13 Feb 2013, 1.

18. Stern interview by author (ref. 5), 9, 12, 13, 14 (quote); Huntress interview by author (ref. 17), 5–6. Stern PowerPoint slides from Jan 2006 lecture at Kennedy Space Center, courtesy Alan

Pluto won priority in the scientific discussions of OPSWG by the beginning of 1992, no doubt because of the forceful advocacy of Stern and other colleagues about the importance of Pluto to understanding the outer solar system and the Kuiper Belt. But also important were two arguments coming out of the new science: (1) the atmosphere might snow out on the surface as Pluto moved away from the Sun (computer models suggested that "atmospheric collapse" might happen as early as the 2010s); and (2) as the highly inclined north pole of the system turned more and more toward the Sun, an increasing proportion of the southern hemispheres of Pluto and Charon would disappear into a night that would last decades. Neptune would always be there, but the longer it took to get to Pluto, the less there would be to observe.[19]

Huntress incorporated both the Pluto and Neptune Orbiter options as major components of the solar system exploration strategic plan in July 1991, with a projected "new start" in the Fiscal Year (FY) 1996 budget, and launches in 2001 and 2002 respectively. But this highly optimistic scenario quickly collided with a NASA budget no longer projected to be growing quickly. The US economic downturn that began in 1991, combined with budget deficits, the savings-and-loan crisis, the end of the Cold War, and several embarrassing NASA setbacks (notably the mirror problem on the Hubble Space Telescope), resulted in sudden cutbacks in the projected space budget. At the turn of 1991/92, as the result of relentless cost growth in the Cassini project and a decrease in the FY 1993 budget and those beyond, Fisk and Huntress were forced to cancel the CRAF portion of the Mariner Mark II program and demand reductions in Cassini's capabilities to save money—to inevitable protest in the scientific community. It turned out to be the only Mariner Mark II ever launched.[20]

In early 1992, the majority of Stern's science working group voted to return to the Pluto-350 concept, but it was quickly challenged by a much more radical proposal: a micro-spacecraft concept developed by Robert L. Staehle and his small group at JPL. An engineer, Staehle had been working on the laboratory's team advising the Space Station Freedom project, until JPL decided that it was

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Stern, show that OPSWG originally had the even longer name of Neptune Pluto Outer Planets Science Working Group.

19. Stern and Mitton, *Pluto and Charon* (ref. 3), 189–91; on the science, see chaps. 3–4. See also Stern, "Pluto Reconnaissance Flyby Mission" (ref. 6), 76.

20. Solar System Exploration Division Strategic Plan, Jul 1991 (Volume III: PF/NO; Pluto Flyby/Neptune Orbiter), copy courtesy David H. Smith, NAS/SSB; Huntress interview by author (ref. 17), 5–6; Stern interview by author (ref. 5), 14–15; Stern and Mitton, *Pluto and Charon* (ref. 3), 191–93; L. Fisk phone interview by author, 16 Jul 2012.

a waste of time. Already someone predisposed to be skeptical of the laboratory's conservative and costly engineering culture, and frustrated with the waste of money in the human program, he was assigned to a project at JPL looking at cost reduction. On October 1, 1991, he attended the unveiling at JPL of a new US postage stamp set for planetary exploration. Included was a Pluto stamp with the label "Not Yet Explored." Staehle, who was unaware of the ongoing discussions in the science and policy communities, took it as a personal challenge. Afterward he happened to be walking in the hallway of the advanced projects office and ran into a friend, Stacy Weinstein, who was working on the Mariner Mark II Pluto study. Staehle recalls her calling it "this stupid mission" because it would take forever and cost so much that it would never happen. Soon thereafter he was able to get a little money from management to form a team that included Weinstein, who in October/November 1989 had done a trajectory study at JPL on how to launch two 18-kg micro-spacecraft to Pluto.[21]

Influenced by that proposal, Staehle's first idea was radical: a tiny Pluto orbiter that was only tens of kilograms in weight. Orbiting was soon dropped as unrealistic, but the team's early concept was for a 35–50 kg vehicle integrated around a spare antenna in storage. If possible, it would be launched directly to Pluto on a Titan IV/Centaur booster, allowing arrival only seven or eight years after launch. Called Pluto Fast Flyby (PFF), its only science instrument would be a miniature camera. Yet even this concept was beyond the state-of-the-art then and perhaps even now. Soon the spacecraft grew to about 140 kg but its science payload remained only 5 kg, half the weight of one Cassini instrument.[22]

PFF's meager scientific return was a nonstarter in Stern's working group, but it did provoke a useful debate on what the minimum goals would be for a Pluto flyby. In early 1992 meetings, science objectives were sorted into three categories, and only three objectives were made category Ia (mandatory): (1) global mapping of Pluto and Charon's geology and geomorphology at 1-km resolution, (2) compositional mapping of the two bodies at 10-km

21. Stern, "New Horizons," in Russell, *New Horizons* (ref. 3), 69; Robert L. Staehle interview by author, 3 May 2012, 16–27; Stacy Weinstein-Weiss interview by author, 12 Jul 2012, 1–4; JPL press release, 23 Sep 1991, on stamp ceremony, electronic copy courtesy Staehle; Weinstein-Weiss e-mails to author, 17 Sep 2013.

22. D. Abraham memo to Staehle, 9 Dec 1991, in JPL Archives, electronic document D-49472; Stern and Mitton, *Pluto and Charon* (ref. 3), 193–96; Stern, "New Horizons," in Russell, *New Horizons* (ref. 3), 6–7.

FIG. 2. Alan Stern, the driving force behind a Pluto mission from 1989 until today, is second from the left in the front row. Around him are many scientists who were in the "Pluto Underground" and/or the Outer Planets Science Working Group at the time the photo was taken. Also present are the two young engineers who started the Pluto Fast Flyby project, Robert Staehle and Stacy Weinstein. *Source*: Robert L. Staehle. Courtesy NASA/JPL-Caltech. This figure is in the public domain.

resolution, and (3) characterization of the composition and dynamics of the atmosphere of Pluto. To do this, the minimum payload set would be visible-light imager plus ultraviolet (UV) and infrared (IR) imaging spectrometers, plus a radio experiment to measure the atmosphere as the spacecraft passed behind the planet. But the tiny payload allotment meant creating a very miniaturized, highly integrated UV/visible/IR instrument, rather than three separate ones. Some space scientists active in the community considered it unrealistic, or at least too small an optical system to make the effort worthwhile (Fig. 2).[23]

Any debate over which proposal NASA Headquarters would support became moot when Rob Staehle met the new Administrator, Daniel Goldin, on May 27, 1992. The occasion was the return of an Oscar flown on the space

23. Terrile et al., "Spacecraft Missions" (ref. 3), 107–10; Staehle interview by author (ref. 21), 33–36; Terrile interview by author (ref. 5), 15–16, 18–20; Krimigis interview by author (ref. 5), 5–6; Cheng interview by author (ref. 15), 12–13, 15–16.

shuttle for the awards broadcast that year. The ceremony was staged at the Academy of Motion Picture Arts and Sciences research facility in Beverly Hills, California. Alerted to this event by a friend at the Academy, Staehle received permission from his manager to attempt to meet Goldin and present his PFF concept. The JPL engineer well knew that the George H. W. Bush administration had hired the former vice president from defense contractor TRW to shake up NASA's bureaucratic ways, in part by importing technologies and management methods from the Strategic Defense Initiative and private industry. Goldin had extensive experience managing the construction of classified spacecraft and agreed with the need for post–Cold War defense reconversion to civilian uses. He arrived in office convinced that the agency's space-science directorate was ponderous, slow, and wedded to huge and expensive "Battlestar Galactica" spacecraft (a name he took from a TV science fiction show). NASA needed to adopt accelerated development methods and miniaturization technologies pioneered in the Strategic Defense Initiative, a program soon labeled "faster, better, cheaper."[24]

As Staehle remembers it, he stood patiently in a receiving line carrying the viewgraphs from the OPSWG meeting approved by Huntress's planetary division. When it was his turn:

> I said, "I'm Rob Staehle. I'm from JPL and I'm working on a mission to Pluto."
>
> He says, "How much does it weigh?" . . .
>
> And I said, "Well, we think we can do it for about 100 kilograms."
>
> And he goes, "Really?" And then he starts asking me a bunch of questions, and I've got this thing with me, and he gets to a trajectory question. How do you answer a trajectory question in just words? So I got the package out and opened that page and started pointing to him and explaining what was going on, and he got really engaged and he said, "May I have this?"
>
> And I said, "Sure," and gave it to him and [Goldin] said, "Thanks for the time."

Staehle went back to JPL and immediately briefed higher-level managers about what happened, including Charles Elachi, then head of space science and missions (since 2001, JPL Director). Clearing the meeting with his immediate

24. Richard memo, 26 May 1992, and attached Academy press release, in NACP, RG 255, E. 110 (Goldin files), FRC Box 1, Folder 73035 LA Trip 5/26/27; McCurdy, *Faster, Better, Cheaper* (ref. 4), 48–52; Roy, "Origin" (ref. 4); Kaminski, "Faster, Better, Cheaper" (ref. 4).

supervisor beforehand turned out to be crucial, as a couple of JPL managers wanted him fired for violating all channels.[25] Goldin apparently had looked into a Pluto mission before, as Wes Huntress found out at their first meeting, shortly after the Administrator's arrival at Headquarters on April 1:

> He [Goldin] had this way of looking at you, his eyes would get big, kind of penetrating, and he put his finger in my chest. He said, "You're the guy."
>
> I thought, "Oh, what's this? What's coming?"
>
> He says, "I want you to send a spacecraft to Pluto and bring a sample back, and to do it within ten years for 100 million bucks."
>
> And I was just aghast. Of course, it's impossible. But I'm sure it was his way of making a point. I probably still maintained my job because I didn't tell him, "Well, that's stupid." I said, "Well, that's challenging. That's sort of interesting. We'll have to look at that."[26]

In any case, Staehle had successfully engaged the Administrator in his quest, and followed it up with a long letter written May 28 about the state of the project. He stated that he wanted to launch a spacecraft by 1997, regardless of much of the skepticism that he had received about getting approval to launch nuclear material in that time—like other outer-planets explorers, PFF had to use a RTG fueled with plutonium-238 to supply electrical power so far from the Sun. [27]

The most revealing passage in Staehle's letter is about OPSWG: "Many of the relevant science advisory group members are still in shock from the fact that about a year ago, they were planning to have a grand, 14-instrument, Cassini-based 'flagship' Pluto flyby. With CRAF's cancellation, reality is beginning to set in and we are making some progress with the group, but we still have a lot of skepticism, and a little bitterness, to overcome to win their support."[28] The resisters supported Pluto-350, but in July Stern's working group voted 3:1 for Fast Flyby. The dramatically changed budget context at

25. Staehle interview by author (ref. 21), 39–41, on 41. Four months after the event, Goldin remembered Staehle interrupting him during a TV interview, but some of what he said aligns with the engineer's account. See Goldin speech, "Remarks to the Aeronautics and Space Engineering Board," 1 Oct 1992, 4–5, in APL/SMKP, Box 1993–1995 SMK Chron/Calendars, Folder Chronological File (1992).

26. Huntress interview by author (ref. 17), 7. In the Goldin "Remarks" cited in the previous note, he claims he challenged Staehle to do with 62 kg and five years, and said: "I know you can do it because I've already looked at that mission."

27. Staehle to Goldin, 28 May 1992, NACP, RG 255, E.110, FRC Box 60, File 71441 Pluto.

28. Ibid.

Headquarters, Dan Goldin's personal interest, and his "faster, better, cheaper" space technology policy made it look inevitable that only a smaller and more innovative concept would be funded.[29]

On July 31 Staehle and his team presented the results of further study of the options and tradeoffs by telephone to NASA Headquarters. Included was the possibility of two PFF spacecraft, because Pluto and Charon are in locked rotation and orbit at 6.4 days, meaning a second spacecraft would be needed to scan the hemispheres unseen by the first flyby. Two spacecraft would also reduce risk for such a daring new concept. On the following Monday, Huntress endorsed the effort to his boss, Len Fisk, with the only reservation being the amount of study money needed for FY 1993, which began on October 1. Total mission cost he estimated at "less than $400M[illion] in FY92$," as compared to almost a billion for Mariner Mark II. But both figures excluded launch vehicle expense, which was unspecified and could be significant. Huntress mentioned two possibilities, the Titan IV/Centaur with two solid-propellant kick stages, and the Russian Proton, with similar add-on stages—a reflection of the unfolding post–Cold War discussions with Russia about further cooperation, mostly in human spaceflight and robotic Mars exploration.[30]

All signs were that Pluto Fast Flyby had become a real project, not a paper one, and a favorite of Dan Goldin in his attempt to force NASA to embrace his space technology policy. When Staehle presented his team's paper comparing PFF and Pluto-350 concepts to the World Space Congress in Washington, DC, in late August or early September, the Administrator singled out PFF at a lunch with the National Academy of Sciences' Space Studies Board and in a session of space agency heads at the congress. He did mention the huge cost that providing two Titan IVs would entail, driving the total cost to over a billion dollars, but "promised to prevent the small mission's 'dream' from becoming a 'nightmare,' 'crushed' by the 'bureaucracy.'" Staehle sent him a letter of thanks afterwards "for your public encouragement." In fiscal 1993, the project got five

29. Stern and Mitton, *Pluto and Charon* (ref. 3), 196; John Noble Wilford, "NASA Plans an Economy Flight to the Solar System's Last Stop," *New York Times,* 8 Sep 1992.

30. Huntress to Fisk, 3 Aug 1992, plus viewgraphs and spreadsheets, in electronic documents "Len-Pluto Study," "Pluto VSS [Very Small Spacecraft] Flyby," "Pluto Flyby Costs," and "Pluto-Proton Level Requirements," courtesy Wes Huntress. The name and acronym Very Small Spacecraft (VSS) is used in these documents, but quickly disappears thereafter. For a more detailed discussion of trajectories and booster options, see S. S. Weinstein, "Pluto Flyby Design Concepts for Very Small and Moderate Spacecraft," ca. Aug 1992, paper AIAA-92-4372-CP, courtesy Stacy Weinstein-Weiss.

million dollars for Advanced Technology Insertion (ATI—at NASA everything had to have an acronym) to develop new lightweight instruments, avionics, and spacecraft equipment to meet the ambitious weight goals of Pluto Fast Flyby.[31]

Although Stern and OPSWG had gotten onboard with PFF, neither Goldin's campaign nor his advocacy of a radically smaller Pluto spacecraft went over easily in the larger scientific community. There were naturally competing interests groups for different targets, and many scientists viewed the concept as too technologically risky and an unwelcome intruder to the space science policy laid out in OSSA's 1991 strategic plan. The dissatisfaction boiled over into media attacks following Goldin's move on October 15, 1992, to break up OSSA by splitting off earth sciences and applications, in the process kicking Len Fisk upstairs to the empty title of Chief Scientist. Wes Huntress was to become the head of a smaller Office of Space Sciences (OSS). But this move was forestalled by political intervention because of the imminent presidential election. George Bush then lost to Bill Clinton, followed by months of uncertainty whether Goldin would be staying on as Administrator. Fisk fought a rearguard action to get him fired. When Clinton finally confirmed Goldin in summer 1993, Fisk quit. Throughout the public battle, Goldin's scientific opponents had used PFF as an example of the kind of "sketchy project" that he had promoted.[32]

Yet in the end it would ironically be Dan Goldin, not the external critics, who would derail PFF's seemingly inevitable drive toward a launch in the late 1990s. In August 1993, Goldin told the team that he could not afford two Titan IVs. Support for Pluto was further undermined by other factors. Later that month, Mars Observer disappeared shortly before it was to reach orbit around the Red Planet, probably due to an explosion in the main propulsion system.

31. Staehle et al., "Exploration of Pluto," World Space Congress paper IAF-92-0558, and letter to NAS/SSB, 4 Sep 1992, courtesy of David Smith, NAS/SSB ("promised . . . "); Staehle to Goldin, 16 Sep 1992, copy in NASA HO file 05397; James R. Asker, "Pluto Fast Flyby Scheduled for 2006," and "Flyby Seeks Low Cost with New Technology," *Aviation Week and Space Technology,* 15 Feb 1993, 46–47, 49, 51, and Staehle and Weinstein letter to the editor, in same, "Pluto Mission a Bargain," 5 Jul 1993, 6. Much of the money went to the scientific community for instrument development.

32. "Space Scientists Get the Jitters," *Science* 298 (1992): 1296–97; "NASA Turks Eye Probes to Pluto," *Washington Times,* 15 Feb 1993 (copy in NASA HO, file 05397); Liz Tucci, "NASA to Adopt Higher Risk Science Philosophy," *Space News* 4, no. 11 (1993): 9; Liz Tucci, "Researchers Question NASA's Science Strategy," *Space News* 4, no. 16 (1993): 3, 29; and Stern letter to editor "Pluto Support," *Space News* 4, no. 28 (1993): 24; Fisk phone interview by author, 16 Jul 2012.

It provoked much criticism of NASA; Goldin had to ask Congress and the Administration for a Mars orbiter replacement. Simultaneously, there was a fight in Congress over the Discovery Program, a marquee project for his technology policy. The preceding year a new concept for a Mars Pathfinder lander using airbags had emerged, and Huntress, with Goldin and Fisk's support, had put that JPL mission first in line for Discovery funding, displacing the Near Earth Asteroid Rendezvous (NEAR) mission awarded to APL. Neither Tom Krimigis, by then Head of the Space Department at that institution, nor Sen. Barbara Mikulski of Maryland were willing to accept demotion to second and a launch delay to 1998. In fall 1993, Mikulski succeeded in getting Congress to fund both. Goldin, who was under pressure from Congress and the Clinton Administration to cut budgets and personnel, was furious at being dictated to. Huntress, now confirmed as Associate Administrator for Space Science, was however pleased at the increased Discovery funding, but in his first full budget he felt he could not pick Pluto as another "new start." He did not want to appear biased toward planetary exploration, as compared to his other major units, astrophysics and heliophysics. Two major astrophysics projects were also better developed than PFF and got priority.[33]

The Mars Observer failure and the budget situation had an immediate impact on Pluto Fast Flyby. Stern says: "Huntress pretty much told me, 'This means you're not going to get a start for a while. You are the back of the bus. You were the front and now you're at the back because Dan has other priorities.'" The only other launch options were a space shuttle, but that entailed a slow trajectory and many costs for man-rating the vehicle and upper stages, or the Russian alternative, which had been discussed for more than a year but never really pursued. Now it became the best hope for PFF.[34]

THE RUSSIAN INTERLUDE AND PLUTO EXPRESS, 1994–97

Frustrated by the lack of official progress, Stern went to Moscow in January 1994 despite NASA attempts to stop him from acting as a free agent in

33. Liz Tucci, "NASA Seeks Cheaper Vehicle to Launch Spacecraft to Pluto," *Space News* 4, no. 43 (1993): 17; "Will Goldin Wave Bye-Bye to Pluto Flyby?," *Science* 262 (1993): 979; Huntress interview by author, 9; "Cuts Leave NASA 'in Chaos,' Director Says," *Washington Post,* 17 Nov 1993; McCurdy, *Low-Cost Innovation* (ref. 4), 14–15. The two were the SOFIA airborne observatory and SIRTF, which became the Spitzer Space Telescope.

34. Stern interview by author (ref. 5), 19; Tucci, "NASA Seeks Cheaper Vehicle" (ref. 33).

international space policy. He traveled at a time when Russian-American space collaboration was reaching a peak. In September 1993 Vice President Albert Gore, Jr., and Prime Minister Victor Chernomyrdin signed an agreement to merge their nations' space station programs; in early February 1994, the first cosmonaut to ride a US space shuttle went into orbit, leading off several years of joint missions; in April 1994, the heads of all of the agencies involved in the International Space Station (ISS) Project met in Washington, DC. In addition, NASA's space science directorate had a long-standing cooperative arrangement with Russia in Mars exploration, including its next launch. Although trouble was on the horizon—the Russians had just delayed its large and ambitious Mars '94 spacecraft to 1996 due to a lack of money—in general it was an opportune moment politically for Stern to ask for collaboration on Pluto.[35]

After briefing space scientists at Moscow University and the Institute of Cosmic Research (Russian acronym IKI), Stern went to see Albert Galeev, the head of IKI, the closest equivalent to JPL. Galeev was not at first sympathetic about the possibility of supplying Protons, as it simply meant Russia paying to launch a purely American mission. Then "Stern asked him whether IKI and the Russian space science community might be more interested if PFF carried a Russian-built probe designed to enter Pluto's atmosphere. Galeev sat up in his chair, smiled, and said, '*This* is an interesting idea.'" It would provide an independent space first and trove of data, and it would help Russia move out into the outer solar system, where it had never sent a spacecraft.[36]

The positive answer set off a flurry of activity. In March, the Planetary Society, an independent space enthusiast organization and lobbying group, delivered a Russian Pluto study to Wes Huntress. How much earlier Louis Friedman, the Executive Director, had been working on the possibility of a Proton launch is unclear, but the Planetary Society had been promoting cooperation with Russia for years. In early April, Huntress went to Moscow himself to carry out discussions with the Russian Space Agency (RSA) on Mars Together (as future collaboration was labeled), Pluto Fast Flyby, Solar Probe,

35. Stern and Mitton, *Pluto and Charon* (ref. 3), 202; Matthew J. Von Bencke, *The Politics of Space: A History of U.S.–Soviet/Russian Competition and Cooperation in Space* (Boulder, CO: Westview Press, 1997), 101–07; Angelina Long Callahan, "Russian American Cooperation in Space: Privatization, Remuneration, and Collective Security," in *NASA in the World: Fifty Years of International Collaboration in Space*, by John Krige, Angelina Long Callahan and Ashok Maharaj (New York: Palgrave Macmillan, 2013), chap. 8, esp. 175–77 on ISS.

36. Stern and Mitton, *Pluto and Charon* (ref. 3), 202–03, on 202; Stern interview by author (ref. 5), 34–35.

and other activities. He found a very receptive audience. The label "Fire and Ice" was revived for Pluto and Solar Probe, with the argument that they would use similar spacecraft and Jupiter flybys, as per Bob Farquhar's earlier proposal, only with separate launches. Huntress saw that Russian space scientists were more interested in the solar mission than Pluto, although "Drop Zonds" (Zond is the Russian word for probe) on each PFF spacecraft met with favor. Soon thereafter Stern, Staehle, and Richard Terrile, the JPL chief scientist for the Pluto project, all went to meetings in Russia, where they found their counterparts enthusiastic and easy to work with. But the contrast in working conditions was stark. Russian institutes were rundown and shabby, reflecting Soviet-era buildings made worse by the post-Soviet economic crash; members of the same institutes often looked exhausted from having to work second jobs to compensate for their meager, inconsistently paid salaries.[37]

The Fire and Ice and Mars groups held joint meetings in Moscow, Hamburg, and Pasadena in 1994, and exchange visits and conferences continued until 1996. But by the end of 1994, there were warning signs. The RSA stated that it could not afford to give away the Proton, which was valuable on the commercial satellite market. It asked to be paid for the Pluto launches, but Stern was told that it was illegal under American law. Then it withdrew the Proton and offered the Molniya, a medium-size booster based on the R-7 missile, like the Soyuz rocket from the human program. That meant long, Earth- and/or Venus-gravity-assist trajectories to send PFF to Jupiter for another velocity boost.[38]

Earlier in 1994, Stern and Terrile had made a tour of Western European space institutes looking to internationalize the mission further, and found considerable scientific interest, but little willingness to commit money. No doubt the Huygens probe on Cassini, to be launched in 1997, and other projects, meant that European Space Agency support was unlikely. Wing Ip

37. Huntress letter to Friedman, ca. Mar 1994, "Potential Cooperative Program with Russian [sic] in Space Sciences," ca. Apr. 1994, "Opening Comments," ca. 7 Apr 1994, "Summary of Discussion US/Russia Space Science Meeting Moscow, Russia, April 7–9, 1994," and draft memo to Associate Administrator for Policy Coordination and International Relations, ca. Apr 1994, Huntress electronic documents "TPS-Pluto," "OSS-RSA ideas," "NASA-RKA Apr. 94," "Protocol 4-9-94," and "RC-RSA trip," courtesy W. Huntress; Stern and Mitton, *Pluto and Charon* (ref. 3), 203–04; L. Friedman interview by author, 13 Jul 2012, 13, 32–33; Staehle interview by author, 4 May 2012, 5–12; Terrile interview by author (ref. 5), 27–30; Stern interview by author (ref. 5), 34–35.

38. Stern and Mitton, *Pluto and Charon* (ref. 3), 203–04; summaries, presentations and results of 1994 "Fire and Ice" meetings in JPL Archives electronic document D-65909.

and his colleagues at the Max Planck Institute for Aeronomy did get onboard, and in return for asking the German government to pay for the boosters, wanted a probe to impact the volcanically active Jovian moon Io during the flyby. That idea lingered through 1995, without result.[39]

Hope for the international alternative deflated slowly. In late 1996, the deterioration in Russian space science capability was confirmed with the disastrous outcome of the Mars '96 (formerly Mars '94) launch, in which the upper stage failed.[40] What money and resources the Russian government had for space had to go primarily to the space station programs Mir and ISS, which were more important to the Russian space industry and diplomatic relations with the United States. For NASA, the priorities were identical; space science collaborations could be eliminated if they did not work, but the success of the ISS was critical.

Back in America, things had not gone very well for PFF either. No doubt due to Goldin's request, in late 1993 or early 1994 Huntress formed a Technology Challenge Team of engineers and managers largely from military organizations and laboratories (including APL, which was mostly funded by the Navy). The panel reflected the Administrator's program for importing miniaturized technology and streamlined management methods from missile defense projects. The Team report, sent to JPL on June 17, suggested various methods for cutting costs, but enthusiastically endorsed Pluto Fast Flyby: "One unanimous conclusion of the Challenge Team is that the time for studying the options is over! The PFF team needs to be focused by NASA on a single approach, and enjoy the savings of both time and funds that solid mission definition offers." A month later, Goldin scrawled on his copy: "Wes[:] I disagree with basic conclusions of report. Fix design and press on! I believe we need to explore for 2 more years with substantial tech investment 7.5M/yr. Then let's relook. I also believe JPL didn't get message on—software . . . [,]—mission ops . . . [,] etc[.] etc[.] Let's talk."[41] He picked on the few sections that had

39. Stern and Mitton, *Pluto and Charon* (ref. 3), 204; Stern interview by author (ref. 5), 35–36; Pluto Express FY 95 report, 26 Sep 1995, JPL Archives electronic document D-12931. Further discussions from 1995–96 on Russian launch options can be found in JPL Archives electronic documents D-49409, D-47189, D-46409, and D-66836.

40. "Main Points of Conversation with Milov, September 27, 1995," and "Summary of Joint RSA/NASA Space Science Executive September 27–28, 1995" in Huntress electronic document "RSA-Sept. 95," courtesy W. Huntress; Huntress interview by author (ref. 17), 12–16.

41. "Technology Challenge Team," late 1993?, Huntress electronic document "Tech Challenge," courtesy W. Huntress; photocopy of "Report by Technology Challenge Team on Pluto

suggested improvements. It seems likely that Goldin actually believed what he said, but it also seems convenient. At a time when NASA's inflation-adjusted budget continued to decline, he may have felt he did not have any money for a new start and more study was a useful way to stall.

Goldin's message reached the team in early fall, provoking Stern to write in protest as a member of the science working group. He noted that Staehle's team had met Goldin's cost goals with a $580 million, two-spacecraft mission, including "$200M in reserves and HQ taxes." PFF beat other planetary missions on weight, power consumption, and total cost. "Now, however, after that success has been achieved, you have set a goal of a $200M, 50 kg mission. In all honesty, Pluto cannot be explored with two spacecraft for the cost of a Discovery mission. And, sadly, there is now the strong perception that you are moving the goalposts just as people succeed." Other scientists chimed in, in part because Goldin's new goal seemed unrealistic by any measure. Richard Terrile thought it might be reduced to a one-spacecraft mission for $300 million to $380 million, but that increased the risk of a single failure resulting in no data at all.[42]

Faced, however, with a directive, Rob Staehle's JPL team put forward their most radical weight- and cost-saving proposals to try to meet Goldin's objective. By December 1994, they had repackaged the mission as Pluto Express. All electronics and instrumentation would be combined into a single, integrated package, rather than having separate electronics boxes and an integrated UV/visible/IR instrument. The new concept was called a "sciencecraft," a term adopted from another mission proposal: Pluto Express would not be a spacecraft on which science instruments are hung, but rather a sciencecraft that would more fully integrate the instruments into the spacecraft architecture. (Stern asserts that he and many other team members saw this as window-dressing for Goldin.) Another key concept, originated by five JPL members of the team, was "beacon cruise." In order to reduce the operations cost of having to employ hundreds of people twenty-four hours a day to monitor and command the spacecraft, as had been true in Voyager and other large missions, PFF had already gone down to a plan for twenty-five operations staff and one weekly message during the decade-long cruise phase. Express would take that

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Fast Flyby Review," 17 Jun 1994, with cover letter Dwight Dustin/BMDO to Charles Elachi, and handwritten Goldin note to Huntress on latter, 18 Jul 1994, in NASA HO file 05397.

42. Stern to Goldin, 7 Oct 1994, copy in NASA HO file 05397; Tony Reichhardt, "Space Scientists Protest at Decision to Scrap Plans for Pluto Mission," *Nature* 372 (1994): 117; Staehle email to author, 3 Apr 2014.

down to ten people and simple tones emitted by the spacecraft, which might be coded green, yellow, or red, indicating whether everything was working normally or required intervention. Further studies would be made about getting rid of the expense and problems of the plutonium-fueled RTG or developing a more advanced and efficient radioisotope power source—something already studied in 1993–94.[43]

The net result was that by 1995, the JPL team was projecting two spacecraft of 75 kg dry weight each (and 105 kg with propellant and a Drop Zond) costing about a quarter billion dollars together—but excluding the operations cost and the price for RTGs, which would put it back over $300 million. Later estimates put the dry weight at more like 90 or 100 kg, indicating the challenges of getting that light for a mission to go that deep into the outer solar system. But at 75 kg it was possible to imagine two "sciencecraft" on one large booster, or two launchers in the Molniya/Delta medium class with various gravity assist options.[44]

When one steps back from the myriad details of the mid-nineties, what emerges is a pattern driven almost entirely by Dan Goldin's space technology policy and personality, magnified by budget problems. The space science case for Pluto had scarcely changed, although the discovery of the first Kuiper Belt objects beginning in 1992 was beginning to modify the rhetoric of the science team for Pluto Express, which now placed the planet in the larger context of a new region of the solar system. Pluto was not, however, universally popular in the planetary science community: the 1994 report of the Committee on Planetary and Lunar Exploration of the Space Science Board virtually ignored the ninth planet, which was effectively a dissent from NASA's Pluto mission, which anti-Goldin scientists saw as his baby. Indeed, he had forcefully promoted it up to that time. But space science policy, whether coming from Huntress's OSS or the National Academy of Sciences, was not setting NASA's agenda, and there was no decadal survey as yet for the planetary sciences, as was

43. "New Paradigms for Pluto Mission," viewgraphs for meeting (of Goldin?) with Elachi, Huntress, Piotrowski, and Appleby, 7 Dec 1994, in NACP, RG 255, E. 110, FRC Box 46, Folder 73942; Pluto Express Preliminary Program Plan, Feb. 1995, in same, FRC Box 85, Folder 72194 DOE/RTG Related Info 95; Diaz memo to Goldin, "RTGs for Pluto," Mar 1995?, in same, FRC, Box 79, Folder 72026 Pluto Fast Flyby 94; Diaz to Goldin, 28 Apr 1995, white papers on space science missions for meetings with reporters, including Pluto Express, in same, FRC Box 79, Folder 71990, Space Science, Wes Huntress, 94, 95; Staehle interview by author, 4 May 2012, 17–24, 34–36; Stern comments on manuscript, attached to e-mail to author, 1 Sep 2013.

44. Pluto Express summary from 1995 Flight Project Data Book, in NASA HO file 05397; Pluto Express FY 95 report, 26 Sep 1995, JPL Archives electronic document D-12931.

the case for astronomy and astrophysics. Goldin's drive for "faster, better, cheaper" missions was in full flower, and as a result the papers and viewgraphs produced by the JPL team emphasized the innovative concepts that the pre-project group was producing, not so much the science.[45]

When combined with the endless uncertainty about whether the Russian option was viable, and would the Germans be part of the solution, and what booster would be used, the repeated studies naturally produced frustration in the Pluto Express team. Alan Stern asserts: "My connecting of the dots is that Goldin decided that it was too popular to kill, but he was just going to keep it in study mode forever." Goldin's demands for new options were nothing but a series of make-work "errands" for Staehle's team. Richard Terrile's explanation is personality driven: "he was a very, very eccentric person who had this short and changing attention span, and once you impressed him on something, you had to find something else to impress him with, we had to keep doing that, and this was part of that marketing process" that resulted in multiple iterations and two changes in name. Huntress recognized that Goldin was an explosive and erratic personality who liked to manage by intimidation, but sees the failure to deliver Pluto, one of his three priorities from 1990, as driven more by budget. Other space science missions came to the top in the context of declining money for NASA after 1993, which suffered from the Clinton Administration's disinterest, exacerbated after the November 1994 mid-term election by the new Republican-controlled House of Representatives, which wished to further slash spending.[46] Even before that happened, the budget situation had been a crucial context for Goldin's July decision to send Pluto Fast Flyby back to the drawing board. Thus, while his personality certainly influenced the way he dealt with the JPL team, who he sometimes micro-managed from Washington, ultimately it was his desire to push through

45. "Pluto Express: Report of the Science Definition Team," Sep 1995, copy in NASA HO file 05397; "An Integrated Strategy for Planetary Sciences 1995–2010," National Research Council report, 1994, on *The Space Studies Board 1958–2011: Compilation of Reports* DVD produced by the National Academies, copy courtesy David H. Smith, NAS/SSB; H. W. Price et al., "Pluto Sciencecraft System Design," Apr 1996 paper for the Second IAA Conference on Low-Cost Planetary Missions, held at APL, copy from same; "Pluto Express Technology Flow," NACP, RG 255, E.110, FRC Box 52, Folder 74289 6/19/96 Pluto Team Briefing; Huntress Pluto bullet points likely for Goldin, 1996, Huntress electronic document "DG-Pluto-96," courtesy W. Huntress.

46. Stern interview by author (ref. 5), 9; Terrile interview by author (ref. 5), 34; Huntress interview by Rebecca Wright, 9 Jan 2003, 27–28, NASA HO file 18948; Huntress, "Recollections on Developing a Flight Mission to Pluto," 8 Feb 2013, Huntress electronic document.

a radical technology policy combined with budget pressures that led him to string PFF and Pluto Express along for years.

FROM PLUTO KUIPER EXPRESS TO CANCELLATION

On August 7, 1996, NASA Headquarters held an historic press conference, one that announced that extremely tiny fossils of bacteria *may* have been discovered in a Martian meteorite found in Antarctica. In hindsight the whole affair appears overblown—the claim ultimately lost favor in the scientific community—but the immense publicity had an immediate impact on NASA space science. Even before the announcement, Huntress and Goldin went to the White House and briefed President Clinton and Vice President Gore. Money was found for an Origins Program, to look into the origins of life, the solar system, and the universe—a clever repackaging of existing projects. OSS's budget stopped declining, and even began rising a little, making possible yet another version of the mission to Pluto.[47]

The "Mars rock," as it was usually called, was not the only stimulus for Origins. After the Galileo spacecraft went into orbit around Jupiter in December 1995, its flybys of the satellite Europa provided magnetometer and imaging evidence that its nearly uncratered icy surface hid a salty ocean, as had been suspected since Voyager. NASA naturally was not averse to promoting the idea of exotic forms of life in that ocean, as some scientists had speculated. Goldin became enthused about Europa, so Wes Huntress was able to get the budget authority to fund a new Outer Planets line that would include both it and Pluto.[48] The mission to the latter was soon renamed Pluto Kuiper Express (PKE) to incorporate the new bodies discovered beyond Neptune.

But PKE was a tough sell at the Office of Management and Budget (OMB), according to Huntress:

> And we constantly had this battle with OMB. My counterpart at OMB was a guy named Steve Isakowitz, who was very good, very, very good. I wish he was there now. Steve was a smart guy, and he constantly questioned us about, "Why is Pluto in there? What's that got to do with origins of

47. Huntress interview by Wright (ref. 46), 23–25, 33–35; Huntress, handwritten notes on speech to Caltech Management Association, 17 Apr 1997, in Huntress Papers, Carnegie Institution of Washington.

48. Melzer, *Mission to Jupiter* (ref. 4), 261–63; Stern comments on manuscript, attached to e-mail to author, 1 Sep 2013.

> anything? Europa, I get, because there may be an ocean there and there might be some life in it. I get that. But what is Pluto doing in here?"
>
> So my response was, well, it's all about the origin of the solar system. It's out there where this Kuiper Belt is, and that had a big effect on the origin of the solar system. So the Pluto mission kind of tailgated on Europa in that mission line. It's kind of the weak sister, actually, but it was the way that I could keep it on the burners.[49]

With "new start" funding in fiscal year 1998, Huntress created a joint project office at JPL called Outer Planets/Solar Probe, with the familiar rationale that the Europa Orbiter, PKE, and Solar Probe would all have to encounter Jupiter. This packaging of related missions on the argument of saving money was a familiar one for JPL, although recent attempts (Planetary Observer and Mariner Mark II) had failed to reduce cost and had each resulted in only one mission. All three were also tied to an advanced electronics package to be produced by the X-2000 program, which was to create a new generation of integrated, radiation-hardened computers and avionics in line with Goldin's technology policy. Wrapping Europa, Pluto, Solar Probe, and X-2000 together made for an appealing political package in Washington and at JPL, but it was to prove the program's downfall in fairly short order.[50]

In spring 1998 laboratory managers named John McNamee, who managed the two Mars missions to launch that year, to head the office (he would transition out of those after launch). Staehle was passed over as too junior, but became his deputy. An early document pays lip service to the sciencecraft idea, but the ultra-miniaturized PKE went out the window under McNamee; at the end of 1998 the spacecraft was listed as 250 kg, but still with only 7 kg of instruments. Weight would nearly double again in 1999. Preferred launch date was December 2004 with a single spacecraft using a Space Shuttle or a larger Delta or Atlas launch vehicle capable of sending it directly to a Jupiter gravity assist. PKE would go second after Europa Orbiter, which was to launch in November 2003. Solar Probe was put off to 2007—an indication both that there was not enough money for all three and that a mission that came out of the heliophysics community, and was funded by that division at Headquarters, was a stepchild in the planetary program. Europa had top priority because it

49. Huntress interview by author (ref. 17), 18–20, on 18.

50. Staehle interview by author (ref. 33), 53–57; Staehle-Pulrich e-mails, 13 Sep 1996, in JPL electronic document D-47146; R. L. Staehle et al., "Outer Planets/Solar Probe: Solar System Exploration Annual Report NASA Office of Space Science," 20 May 1998, in JPL electronic document D-65912.

was politically popular in NASA and the Administration as a result of its speculative connection to extraterrestrial life. Noting that popularity, the scientific advisory committee to the Solar System Exploration Division explicitly endorsed Europa as first.[51]

The year 1999 saw significant advances for PKE, in that NASA formed a Science Definition Team for Pluto and initiated a competition for instrument selection, but in 2000 the larger Outer Planets/Solar Probe program fell apart. At fault were spiraling costs and the collapse of the technological optimism behind X-2000 and the Europa Orbiter. The latter mission was inherently the most difficult of the three, as the severe radiation environment near Jupiter made the long-term survival of the spacecraft challenging. Neither PKE nor Solar Probe needed as much radiation protection for their swingbys farther out; the solar mission had the additional challenge that solar heating would become a major problem as it plunged into the inner solar system, which meant a completely different thermal design. A metal-lined vault could be built around Europa Orbiter's electronics for radiation protection, but even if the metal plates were left off PKE, extra weight remained for the mounting hardware. The X-2000 program itself ran into development delays, weight increases, and rising costs, which put Margaret "Peggy" Easter, the chief acquisitions officer for both it and Outer Planets/Solar Probe, in an awkward position: "I have never felt so torn apart, because I had great respect for all the managers on these projects, . . . but it was very difficult because X-2000 could not meet their commitments." To add to the troubles, the price tags were escalating and the dates slipping for the advanced radioisotope power system needed for Europa and for the new Atlas V and Delta IV vehicles the Air Force was developing, bringing all cost assumptions and launch dates into question.[52]

Early warning signs came in February 2000, when McNamee reported to the Solar System Exploration's scientific advisory committee that Europa

51. Staehle interview by author (ref. 33), 60–67, and 13 Jul 2012, 4–9; Krimigis interview by author (ref. 5); J. Ludwinski, "Outer Planets/Solar Probe: Pluto-Kuiper Express Preliminary Mission Plan," 15.12.1998, in JPL electronic document D-47148; J. T. Bergstahl, "Outer Planets Program, Briefing to COMPLEX September 16, 1998," copy courtesy of David H. Smith, NAS/SSB; S. Squyres to C. Pilcher, 5 Mar 1998, copy in SMKP/APL, Box Krimigis Committees (SSEC-SSAAC), Folder Solar System Exploration Subcommittee; Krimigis interview by author (ref. 5), 37.

52. Staehle interview by author (ref. 51), 10–16; H. Price interview by author, 15 Mar 2013, 17–20; M. Easter interview by author, 15 Mar 2013, 20 (quote); Krimigis notes on "SSES meeting, NASA Hdqtrs 2/15/00," in SMKP/APL, Committees (IAGA-SSES), Box 2, File SSES Meeting NASA HQ, 15–16 Feb 2000.

Orbiter would have to be delayed to 2006. It might be possible to launch to Pluto via Jupiter in 2003, but "it will be a challenge to fit PKE and EO under the present program profile"—i.e., the multi-year budget. To save money and time the PKE spacecraft would drop the common design with EO, use a left-over Cassini RTG, and downsize from 447 to 377 kg (with propellants). Pluto Kuiper Express had been saddled with development costs and delays for advanced power systems and electronics it did not need, but it was the easier target for cancellation because it was less politically popular in Washington. At the next meeting of the committee in June, McNamee painted a bleak picture of cost overruns and delays. NASA space science administrators warned that cancellation of Pluto was a likely solution to the budget crisis.[53]

Burned out by dealing with Goldin and Congress, Huntress had left NASA in fall 1998 for the Carnegie Institution of Washington, so the decision fell on his successor as Associate Administrator, Edward J. Weiler, formerly Chief Scientist for the Hubble Space Telescope. Weiler already had reason to distrust JPL, as both Mars missions launched in 1998 ignominiously ended in failure the next year: Mars Polar Lander crashed and Mars Climate Orbiter burned up in the atmosphere because of a navigation mistake. He had to take the heat for programs he had not started. Goldin also endured a wave of criticism for pushing his "faster, better, cheaper" policy too far, with the result that the technology pendulum lurched back in the other direction and the Administrator became risk-averse. At JPL, engineering managers who had always been skeptical of Goldin's mantra felt vindicated. Design and testing became more conservative and spacecraft became heavier and more expensive. To what extent that impacted McNamee's Outer Planets/Solar Probe program is unknown—he had after all been the project manager for the underfunded Mars missions—but it is hard to believe that it did not have some effect.[54]

When Weiler got the reports from the June meeting from Colleen Hartman, who held the outer planets portfolio and would soon become planetary division director, he was upset that the combined multi-year cost of Europa and Pluto had gone from the 1998 figure of $654 million to nearly $1.5 billion.

53. Krimigis notes on "SSES meeting, NASA Hdqtrs 2/15/00" (quote), in SMKP/APL, Committees (IAGA-SSES), Box 2, File SSES Meeting NASA HQ, 15–16 Feb 2000; Krimigis notes, "SSES Meeting NASA Hdqtrs 6/28/00," and McNamee "SSES Presentation," 6/29/00, in Box 2, File SSES Meeting Washington, DC 6/28–29/00.

54. Huntress interview by Wright (ref. 46), 27–30; C. Hartman and E. Weiler interview by author, 7 Mar 2013, 2–3; Huntress, "Recollections on . . . Pluto" (ref. 46); Westwick, *Into the Black* (ref. 4), chap. 18.

In July he dressed down the project team at JPL, something Rob Staehle describes as the most unpleasant meeting he has ever been in. According to Staehle, Weiler said he would not cancel now but might the following March. But for whatever budget reasons, on September 12, 2000, he issued a "stop work order" for PKE—all activity was to be terminated immediately. A new cheaper mission was to be studied that would get a spacecraft to the planet by 2020, but that scarcely convinced anyone that the gesture was sincere.[55]

Already in July, the Planetary Society had attempted to mobilize its members over a projected cancellation, and now it did so again. By October Executive Director Lou Friedman was able to deliver ten thousand letters to Congress—half each to the chairs of the House and Senate subcommittees responsible for space. Simultaneously a seventeen-year-old student, Ted Nichols II, launched a save-the-Pluto-mission website that drew a fair bit of attention that fall and in subsequent years. From those campaigns and from the uproar six years later, when the International Astronomical Union demoted Pluto from major planet status, it is clear the heavenly body had a lot of popular appeal, perhaps most of all to Americans because it had an American discoverer, Clyde Tombaugh. The space enthusiasts, and members of the informed public, were sympathetic to the old argument that the United States should complete the reconnaissance of the solar system by going to the last known planet; they were activated further by interviews that angry Pluto scientists gave to the press. It is very hard to measure how much impact the Planetary Society's lobbying, popular activism, and media stories had, but they may have influenced the votes of members of Congress in the battles that would follow in 2001 and 2002.[56]

Weiler, however, asserts that the public campaign had no effect on his decision making in 2000—only science mattered. So it was critical that

55. Weiler memo fax to JPL Director Stone, 12 Sep 2000, electronic copy courtesy R. Staehle; Hartman and Weiler interview by author (ref. 54), 4–5; Staehle interview by author, 13 Jul 2012, 23–28; Weiler-Hartmann e-mails, 14 Sep 2000, in Huntress electronic document "000914_EW re Pluto."

56. Friedman interview by author (ref. 37), 15–19; Stern interview by author (ref. 5), 40; Stern and Mitton, *Pluto and Charon* (ref. 3), 213–14; Planetary Society press releases, 29 Jul and 22 Sep 2000, from SpaceRef.com, and "NASA Stops Work on Pluto Mission," *Florida Today* website, copies in NASA HO file 05397; "Mr. Friedman Goes to Washington," *Aviation Week and Space Technology,* 23 Oct 2000, 29; Jennifer Vaughn, "Odd Planet Out: What's Up with Pluto Exploration," *Planetary Report* 21, no. 2 (2001): 18–19; DeVorkin, "Pluto" (ref. 6), 351–55; Neil DeGrasse Tyson, *The Pluto Files: The Rise and Fall of America's Favorite Planet* (New York: W. W. Norton, 2009).

a rebellion broke out in the planetary science community over the stop-work order. The Division for Planetary Sciences (DPS) of the American Astronomical Society issued a press release on September 21 noting the time-critical character of a Pluto launch: more delays would lose the Jupiter-gravity-assist possibility of a December 2004 launch (the fact that there was a last chance in January 2006 was then little known). Missing that, the DPS argued, made it very unlikely that a spacecraft could reach Pluto before its atmosphere collapsed, often predicted to happen by 2020 (hence the date in Weiler's order). The press release did not mention the other timeliness argument, that the planet was turning its north pole toward the Sun, meaning that every year of delay meant a larger fraction of the southern hemispheres of Pluto and Charon would disappear into a darkness lasting decades. But it certainly figured in the next meeting of NASA's Solar System Exploration advisory committee on October 30–31, which immediately followed the DPS annual conference on JPL's home turf of Pasadena, California.[57]

Weiler opened the committee session speaking by telephone from Washington. He discussed the more than doubling of the outer planets budget and "noted that he had clear direction and authority from the Administration that Europa was the priority. Therefore he issued the stop work order on Pluto. This leaves NASA with a Europa mission, however, it is not clear that the Agency can even afford" it. He also mentioned that Goldin had given him "until the end of the year to 'fix' the Outer Planets Program." JPL was ordered to show how to lower costs for Europa and Pluto by the end of November, otherwise he "will starting making decisions on competition." Above all he had "to re-establish OSS's credibility with OMB."[58]

Later that day John McNamee briefed the committee, noting in passing that Solar Probe had been split off from the office, leaving him effectively only with Europa, although he inevitably talked about Pluto. According to Stern, "all hell broke loose when it became obvious how JPL had F'ed that mission up. JPL's project manager stood in front of that committee and made a ridiculous faux pas. He revealed through a series of viewgraphs that the reason Pluto had gotten out of control on cost was because it was saddled with all of the costs for

57. Hartman and Weiler interview by author (ref. 54), 14–15; DPS press release, embedded in e-mail to DPS members, 21 Sep 2000, courtesy David H. Smith, NAS/SSB; Bergstrahl and Drake, SSES "Meeting Report," 30–31 Oct 2000, SMKP/APL, Committees (IAGA-SSES), Box 2, File SSES Meeting JPL, Oct 30–31, 2000.

58. Bergstrahl and Drake, SSES "Meeting Report," 30–31 Oct 2000, SMKP/APL, Committees (IAGA-SSES), Box 2, File SSES Meeting JPL, Oct 30–31, 2000, 2.

radiation hardening on Europa." Tom Krimigis remembers McNamee passing around an example of the X-2000 hardware, which seemed very heavy. Knowing well the Jovian environment as principal investigator on a Voyager experiment, he saw how unnecessary radiation hardening was for a Pluto flyby mission that would not come that close to Jupiter. Immediately afterward there were two presentations on Pluto science, by Jonathan Lunine of the University of Arizona, head of the PKE Science Definition Team, and Alan Stern, head of the SwRI space science department (relocated in 1994 to Boulder, Colorado), the most energetic and consistent voice for a Pluto mission. Both strongly emphasized the new perspective on Pluto and Charon as relatively large and close members of the Kuiper Belt. The new understanding of that region constituted "an intellectual revolution in how planetary system[s] form" (Lunine), in that it showed that massive numbers of icy bodies were created in the outer regions of new systems, and are subsequently disturbed by the migration of the orbits of the major planets. Stern underlined the scientific importance of Pluto-Charon as a means to understanding the Kuiper Belt, and explicated the atmospheric collapse and polar aspect arguments as to why Pluto mission had to be done now. The next day, a Lockheed-Martin representative outlined how his industrial firm had already scoped out a low-cost approach to that mission, and argued that it should be allowed to develop the spacecraft.[59]

By the end of the meeting, the consensus was clear. No one was against a Europa program, but it was challenging and not time-critical: a direct launch opportunity to Jupiter existed every thirteen months. A Pluto mission needed to be done first and through competition, otherwise an historic opportunity might be lost. Krimigis took on the task of writing a resolution supporting the competitive approach.[60]

THE COMPETITION AND THE BATTLES OVER NEW HORIZONS

The scientific and popular reaction to the cancellation of Pluto Kuiper Express initiated a new era where NASA no longer dominated planetary science policy

59. Ibid., 7–10; Stern interview by author (ref. 5), 44–45 (quote); Lunine and Stern handouts with Krimigis notes in SMKP/APL, Committees (IAGA-SSES), Box 2, File SSES Meeting JPL, 30–31 Oct 2000.

60. Krimigis notes on SSES meeting, 30–31 Oct 2000, and Krimigis to Drake e-mail, 2 Nov 2000, with attached draft statement in SMKP/APL, Committees (IAGA-SSES), Box 2, File SSES Meeting JPL, 30–31 Oct 2000.

formation and outside organizations played a central role. In the early nineties, the OSS and its Associate Administrators controlled NASA's space science policy—Huntress made a Mariner Mark II mission to Pluto a priority whether everyone in the science community agreed or not. (There were occasional exceptions; Sen. Mikulski pushing through early funding for NEAR is the most noteworthy.) Goldin's 1992 arrival resulted in the ascendancy of a NASA technology policy of smaller, cheaper missions with more experimental technology, notably as expressed in Pluto Express and PKE. But that era came to a crashing halt in 1999/2000. The Discovery Program, which had begun before Goldin, but which he certainly supported strongly, had survived the transition and demonstrated the virtues of a competitive approach. Discovery also fostered the rise of non-NASA organizations that might challenge JPL in planetary exploration—primarily Johns Hopkins APL—bringing with them new sources of Congressional support. Moreover, the planetary science community had begun to organize itself more effectively at the turn of the twenty-first century, leading to the rebellion over Pluto and to the first National Academy of Sciences decadal survey in that discipline in 2002. As a result, in the subsequent battles over Pluto, it was non-NASA organizations, Congress, the scientific community, and perhaps the public that ended up determining what would be done.

Credit for initiating the competitive approach for Pluto has to be given to NASA's Edward Weiler, however, a fact that may be difficult for key Pluto advocates like Alan Stern to accept. From his point of view, the Associate Administrator was mostly the Pluto program's nemesis after 2000. Weiler had not only cancelled PKE, and defended the cancellation to the media and Congress, but he also was the public face of two subsequent cancellations by the incoming George W. Bush Administration in 2001 and 2002. Yet at least as early as October 13, one month after the first cancellation, Weiler raised the possibility of a competitive Pluto procurement with Krimigis, during a discussion of "the NASA budget markup of the Senate Appropriations Subcommittee." He asked Krimigis: "Would you be interested in an AO or an RFP [Request for Proposal] for a Pluto mission?" The AO was the legal form that allowed the greatest participation by the scientific community, the APL Space Department head pointed out.[61]

61. Stern interview by author (ref. 5), 23–24, 27–30; Krimigis interview by author (ref. 5), 3. The October 13 date and the Weiler question are from Krimigis's notebook on the meeting, which he quoted in our interview. These personal notebooks have not yet been deposited in his APL papers.

Weiler then essentially threatened JPL with a competition in his talk to the Pasadena meeting on October 30, either to get better estimates from that organization, or to float competition as a trial balloon. According to Krimigis, on November 20, "he called me and he said, 'I don't have any money, but would you guys be able to do a very quick study to tell me how you would do a Pluto mission a là NEAR?'" APL's spacecraft was then successfully orbiting the asteroid Eros, giving the laboratory a lot of credibility with NASA, notably for its low-cost approach.

> So I got three or four people together, including Tom Coughlin, who was the program manager on NEAR, and Andy Cheng, and the program scientist on NEAR, Ralph McNutt . . . [and] Glen Fountain and John Appelby. I said to them, "Okay, here's the challenge. . . . "
>
> . . . we all worked through the Thanksgiving holiday and, I think, the following week. I think it was Wednesday [November 29, 2000] maybe. I had an appointment with Weiler.
>
> . . . he did not place this appointment on the Headquarters calendar. It was sort of secret, if you like. He didn't want a subject and he didn't want anybody to know what's Weiler up to. . . .
>
> . . . when I got there, he invited in Colleen Hartman, who was then the director of planetary. He trusted her. So we had this discussion and I went through the design that we proposed, and we had concluded that, with reserves, it would be less than $500 million.[62]

Weiler has only the vaguest recollection of such a meeting, but says that he made similar inquiries with other organizations, although he is constrained by the rules governing procurement from mentioning any names. Certainly he would have asked JPL. The objective was to find out whether there were any credible competitors for a half-billion-dollar Pluto mission before Hartman and her staff wasted weeks working over the Christmas holidays turning out an AO, which is a legally precise document of tens of pages in length requiring an extensive internal NASA review.[63]

With that in mind, on December 11 he wrote a memo to Dan Goldin proposing: "Pluto launches first in 2004 (arrival in 2012), Europa put on a directed technology program and launches in ~2011 (Europa launch determined by $ available)." He listed a series of pros for Pluto first and only a few

62. Krimigis interview by author (ref. 5), 4, 11–12; Krimigis, "Reaching an Elusive Goal" viewgraphs, 22 Jul 2013, which includes 4 viewgraphs for Weiler, 29 Nov 2000, courtesy S. M. Krimigis. One such viewgraph gives an estimated cost of $379 million.

63. Hartman and Weiler interview by author (ref. 54), 10–14.

cons, notably "Europa is the clear Administration and OMB priority, NOT Pluto." But earlier he noted: "I don't feel a 2008 launch of Europa (by killing Pluto) is guaranteed. There is still some unobtainium in the system that must be 'discovered.'" Goldin told him to go ahead, as on the twentieth, NASA gave notice that the AO would be released in a month, a very short deadline. Normally, Hartman and Weiler explain, it could take up to a year to clear such a document through channels. But the very hard deadline set by the Jupiter-gravity-assist opportunity in late 2004 meant that a highly accelerated process was critical. Weiler gives Colleen Hartman full credit for pulling it off.[64]

The December 20 announcement immediately set in motion a flurry of team-building activity. Krimigis called Jonathan Lunine and Alan Stern about the possibility of becoming the Principal Investigator for an APL spacecraft, but Lunine was committed to another team. Alan Stern had already been contacted by Charles Elachi, the incoming JPL Director on January 1.

> Elachi called me up and said, "Would you be PI?" And Ralph McNutt got . . . Krimigis to call me up too. . . . I didn't know Krimigis then except to shake his hand.
>
> I asked Elachi for two things. I said, "I'll go with JPL, but I want two things: That we're the only Pluto proposal you'll turn in. I want all your eggs in our basket, and I want you to promise me that if we win it, that you will never let it be cancelled."
>
> And he said, "Let me think about those two things."
>
> The phone rang from Krimigis probably the same day, December 20th, the day after Weiler's announcement. I posed the same questions. Krimigis said, "Absolutely" to both.
>
> Elachi called me back the next day and gave me a bunch of reasons why he couldn't do either. He said, "I'm going to support you, but I have to write multiple proposals, and I don't know which one will work. They'll be very different approaches, we'll firewall the teams, and I can't make political promises like you want to fight for the mission if it is cancelled." . . .
>
> Charles completely lost it to me that day, and that's why we went with APL.[65]

64. Weiler to Goldin, "Pluto and Europa[:] An Objective View (I hope)," 11 Dec 2000, NACP, RG 255, E.110, FRC Box 187, Folder 78006 "12/11/00 Weiler Notes on Pluto & Europa"; NASA press release on Pluto AO, 20 Dec 2000, in NASA HO file 05397; Hartman and Weiler interview by author (ref. 54), 20–22, 26–27.

65. Krimigis interview by author (ref. 5), 14–16; Stern interview by author (ref. 5), 25–26; Krimigis file on New Horizons team formation, 20 Dec 2000–26 Feb 2001 in SMKP/APL, Box Krimigis Papers and Correspondence, File New Horizons Preliminaries. Krimigis made the deal

The answers to Stern's questions well illustrate the differences between the two institutions. APL Space Department was one-tenth the size of JPL and could only mount one proposal, but Tom Krimigis would not want to divide his department's efforts in any case. JPL was large enough that Elachi apparently felt that he would create problems if he stopped the formation of more than one—in the end he would support two. As for the political promise, JPL may have been part of Caltech but was *de facto* another NASA field center, and did not have much political independence from Headquarters. Nor did it attract that much attention from California's congressional delegation in a big state with more powerful aerospace institutions. By contrast, APL was effectively a free agent in a smaller state with a powerful senator on its side.

When Weiler and Hartman did release the AO on January 19, 2001, the last full day of the Clinton Administration, APL's political connections immediately saved the day. In February the Bush Administration released its first budget, cancelling the Pluto mission, asserting that the program had greatly overrun its budget—an excuse that did not even apply to the new competition. NASA then halted the AO. OMB political appointees barely on the job probably had little to say in the Pluto decision, which would have been made by the budget official responsible for NASA, Steve Isakowitz. He had repeatedly stated a preference for Europa. Stern was naturally upset that his dream could once again be derailed. He called Tom Krimigis about the disingenuous rationale and "Tom said to me, in his very deep gravelly voice, . . . 'Alan, it's time to break some legs.'" He called Sen. Mikulski's office immediately. Shortly afterward, as chair of the Senate Appropriations subcommittee responsible for space, she sent a letter to NASA instructing it to continue the AO review process so as not to exclude any options from Congressional consideration. If JPL had still been the only center involved in Pluto, the mission likely would have died right then, as the center's lack of political independence and access would have obliged Elachi to accept Headquarters' orders.[66]

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with Stern on 22 Dec: Krimigis interview by author (ref. 5), 15–16; Stern, "New Horizons," in Russell, *New Horizons* (ref. 3), 8.

66. Pluto–Kuiper Belt Mission AO, 19 Jan 2001, draft of 20 Dec 2000, JPL Archives electronic document D-47172; Stern interview by author (ref. 5), 26 (quote); Krimigis interview by author (ref. 5), 22–23; Stern, "New Horizons," in Russell, *New Horizons* (ref. 3), 8; "Action Alert for Planetary Society Members—Help Save the Pluto Mission," after 10 Apr 2001, copy in NASA HO file 05397 (likely insert into *Planetary Report,* May/Jun 2001). The Stern article gives a 6 Feb 2001 date for the Bush budget cancellation, whereas the Planetary Society insert dates it 28 Feb; Stern's date may refer to a draft budget document.

The interruption in the AO process caused NASA to delay the submission deadline to early April. Five teams "survived the grueling pace to put together" proposals the size of phone books: New Horizons from APL and the Southwest Research Institute, the two allied to JPL, and two others that have not become public. On June 6 Weiler's office announced that, as planned, two were selected to receive $450,000 each for Phase A studies: the Stern-led New Horizons and one of the JPL-based proposals, POSSE (Pluto Outer Solar System Explorer), with Lawrence Esposito of the University of Colorado as principal investigator and Lockheed Martin as spacecraft builder. It was the more technologically conservative JPL proposal, with the most engineering continuity from the late-nineties version of PKE.[67]

For New Horizons, the continuity was almost entirely in the science payload. Stern brought his integrated UV/Visible/IR instrument, which had been developed for Pluto Express and PKE, and induced Leonard Tyler of Stanford University to sign up his radio-science experiment as well. Both Stern and Tyler had won in the 2000 PKE instrument selection process, but that had never been announced due to the budget turmoil. Stern at first thought of adding a "daughter probe," a small deployable spacecraft to image the side of the planet not seen during the single flyby, but went with a long-range telescopic camera instead. The team added particles and fields experiments not on the old PKE, and a solid-state memory twenty-four times as large, reflecting the ongoing revolution in integrated chip technology. For the 400-kg New Horizons, APL drew on experience with NEAR and two Discovery missions recently won but not yet launched: CONTOUR (Comet Nucleus Tour) and the MESSENGER Mercury orbiter. CONTOUR, then under construction at APL, provided a baseline for the design, which lowered costs and schedule risk (Fig. 3).[68]

After another due-date delay caused by the September 11 terrorist attacks, the two teams submitted their proposals and on November 29 NASA announced the selection of New Horizons. The year 2001 had been ideal for

67. Stern and Mitton, *Pluto and Charon* (ref. 3), 216–17, on 216; Hartman "Pluto" chronology, ca. 7 Mar 2013, supplied by C. Hartmann; Krimigis e-mail with APL press release, 8 Jun 2001, in SMKP/APL, Box Krimigis Papers and Correspondence, File New Horizons Preliminaries; Stern, "New Horizons," in Russell, *New Horizons* (ref. 3), 8–11.

68. Stern interview by author (ref. 5), 65–68; Krimigis notes on phone call with Stern, 27 Dec 2000, and team e-mails and agendas, 5–12 Jan 2001, in SMKP/APL, Box Krimigis Papers and Correspondence, File New Horizons Preliminaries; Stern, "New Horizons," in Russell, *New Horizons* (ref. 3), 9–11.

FIG. 3. An artist's concept of the New Horizons spacecraft encountering Pluto and Charon on July 14, 2015. *Source*: http://pluto.jhuapl.edu/gallery/artistConcepts/artistConcepts_01.html Courtesy: APL/SwRI.

APL, as the NEAR Shoemaker spacecraft had just triumphantly completed its mission with an asteroid landing not officially in the program, and CONTOUR's failure due to a flawed solid-rocket motor was two years away. The Laurel, Maryland, laboratory had a reputation of being low-cost and reliable. The cloud of the 1999 failures still hung over JPL, to the point that Goldin asked APL in mid-2001 to enter the Mars program. Krimigis rebuffed that idea as being too big for his Space Department to take on and too much of an incursion on JPL's turf. A space physicist, he was happy to get Solar Probe from JPL instead. Still, both Weiler and Rich Terrile agree that New Horizons ultimately won because Alan Stern wrote the better proposal. The science rationale for the mission and its suite of instruments was number one in the selection criteria and that was Stern's responsibility.[69]

69. NASA press release, 29 Nov 2001, in NASA HO file 05397; Weiler, Krimigis, and Elachi, "Collaborative Understanding Between NASA OSS, JPL and APL," 2 Oct 2001, electronic copy from S. Krimigis; Krimigis interview by author (ref. 5), 32–33; Hartman and Weiler interview by author (ref. 54), 14; Terrile interview by author (ref. 5), 53–54; Pluto AO, draft of 20 Dec 2000, JPL Archives electronic document D-47172.

Weiler's Pluto award letter was, however, one of most challenging that any mission leader has ever received. Even though the Associate Administrator delayed the launch to the January 2006 Jupiter-gravity-assist opportunity to gain time, he listed several conditions before that could become a reality. Budget was absolutely critical. Although Mikulski had put $30 million in the NASA appropriation for FY 2002, covering phase B of spacecraft development, that was done against the will of the Bush Administration. It was only a small down payment on the half billion dollars needed to actually build the spacecraft and buy the booster. Number two challenge was meeting the launch vehicle requirements at a time when the Atlas V and Delta IV were only just coming into operation. In particular the federal environmental clearance to launch nuclear material—the plutonium in the RTG—was far from easy. And finally, the spacecraft and mission had to pass a "confirmation review" after one year to receive any more support. Stern saw the message of the letter as: "'You won, but you didn't win, and you're going to have to do these five things' . . . there were a whole series. . . . And I literally sat in my chair and said, 'I have to make all these tumblers work.' Any one of them is hard, you know, because these are things that involve nuclear launch on a tight schedule and a budget cap."[70]

The award happened days after Dan Goldin made his exit as Administrator, ending a record-breaking term of nearly a decade. President Bush appointed Sean O'Keefe, the Deputy Director of the Office of Management and Budget, as his replacement, but that only worsened New Horizons' budget prospects. OMB was angry that Congress had rammed Pluto down its throat. On November 15, Steve Isakowitz and his deputy Brant Sponberg had spoken by phone to planetary scientists working on the first National Research Council decadal survey of the field, something Weiler had specifically requested because of the disarray caused by the Pluto versus Europa policy fight. Isakowitz and Sponberg told the committee: "It would be very easy for this Administration to walk away from the planetary program." The "fractured" community and the "lack of a clear vision . . . makes you guys very, very vulnerable." Until the decadal was finished and the community came to a consensus, OMB would continue its policy. Predictably, when the FY 2003 presidential budget came out in early 2002, Pluto was cancelled again,

70. Weiler to Stern, 29 Nov 2001, electronic copy from A. Stern; Andrew Lawler, "Planetary Science's Defining Moment," *Science* 295 (2002): 32–37, here 32; Stern interview by author (ref. 5), 26 (quote).

with O'Keefe's full support. The old Europa mission died too, but it would soon be resurrected in the Administrator's push for space nuclear power; the grandiose Jupiter Icy Moons Orbiter (JIMO) mission would use ion rocket engines powered by a nuclear reactor that spewed even more radiation. Billions were wasted on nuclear power before O'Keefe's exit from NASA in 2005 killed it, taking JIMO and the Europa mission down with it. But the FY 2003 budget did contain one proposal coming from Colleen Hartman's division that became essential to New Horizons: a New Frontiers line for competitive outer–solar system missions on the Discovery and Pluto models.[71]

Krimigis, Stern, and the Planetary Society girded for yet another Pluto fight. Sen. Mikulski announced that she would again try to insert the money into the budget, but earmarking a whole program on a year-to-year basis meant getting the Senate and House to agree each time, making rational planning nearly impossible. New Horizons would need $122 million in FY 2003 as it moved into Phase C/D, building and buying hardware. One way to do it would be to call the Pluto mission the first New Frontiers one and increase the budget from the planned $15 million to cover it. The best and really only hope was that the decadal survey would put a Pluto Kuiper Belt mission at the top of the list. The year before Weiler had told Stern: "You can get Mikulski to force this through and continue to keep you in study . . . but unless the decadal survey ranks this mission number one, not just on the A list, but number one on the A list, it will die after Phase B in 2003." So Stern and his scientific colleagues mounted all the arguments for exploring Pluto and Charon that they had mounted in the 1990s, and in 2000 and 2001: a remarkably diverse double-planet system that held the key to the Kuiper Belt and the formation processes of the outer solar system. When the committee for the decadal survey announced its priorities in mid-July 2002, New Horizons was number one on the medium-sized missions list. The Kuiper Belt argument was primary, not only for Pluto-Charon, but also for the possibility that the spacecraft might make another encounter afterward, if a body in an appropriate orbit could be found (so far that has proven difficult). The argument for Pluto as the last unexplored planet was, at least for the scientific community, pretty much dead; rather, that body

71. Lawler, "Planetary Science's Defining Moment" (ref. 70), 32–34, on 32; Sponberg-Huntress e-mails, 24 Jan 2002, in Huntress electronic document "020124_Sponberg on Pluto"; Krimigis interview by author24–25; Terrile interview by author (ref. 5), 46–49; Hartman and Weiler interview by author (ref. 54), 26, 30–32, 38–42.

was the key to understanding a whole new region of planets, or at least dwarf planets, as the International Astronomical Union would call Pluto in 2006.[72]

With the budget prospects for New Horizons looking much brighter in summer 2002, Stern and APL had one last problem: Weiler and Hartman's skepticism of the program actually meeting the challenges of launching to Jupiter in three-and-a-half years, notably the nuclear clearance for a new booster. Weiler in particular seems not to have believed in New Horizons as it was formulated. By Stern's account, he got a call from the Associate Administrator "very early one morning" in Boulder congratulating him on the decadal survey victory and then telling him: "But we're bringing JPL in because APL doesn't know what they're doing, and this is going to be a solar electric mission." He meant that solar panels and an electric (ion) rocket engine would have to added to shorten the cruise time since the Jupiter-gravity-assist opportunity would be missed. Stern's point of view is that "Elachi just wanted APL to fail at everything. And why solar electric, you're going to drive the price up through the roof and get us cancelled for that. That's a carte blanche to JPL to layer on a billion dollars onto what is a $500 million class mission." Further evidence that Weiler was actually considering electric propulsion comes from e-mail exchanges with Wes Huntress, by then President of the Planetary Society. But Stern and APL only pretended to investigate this option, the New Horizons principal investigator says, and they "just ran the clock out on" Weiler. When Wes Huntress sat on the program's confirmation review at APL on October 22, he and the board were convinced that the laboratory did know what it was doing. At the same time, Congress, thanks above all to Mikulski, placed it in the FY 2003 budget as the first New Frontiers mission, so that even O'Keefe and OMB begrudgingly had to accept it.[73]

NASA Headquarters issued its final mission confirmation in March 2003. While there would be several project-threatening crises with the RTGs and the

72. Stern interview by author (ref. 5), 56–57; Frank D. Roylance, "Cuts Threaten Mission to Pluto," *Baltimore Sun,* 4 Mar 2002, and Lee McFarling, "US May Still Get a Shot at Pluto Mission Budget," *Los Angeles Times,* 4 May 2002, both copies of web articles in NASA HO file 05397; Warren E. Leary, "NASA Urged to Give Pluto a Priority in Exploration," *New York Times,* 12 Jul 2002; NAS/SSB, *New Frontiers in the Solar System: An Integrated Exploration Strategy* (Washington, DC: National Academies Press, 2003), 4–5, on *Space Studies Board* DVD (ref. 45).

73. Stern interview by author (ref. 5), 29–30; Huntress-Weiler e-mails, 22 Oct 2002, in Huntress electronic document "021022_EW on NH" and Huntress to Hartman and Weiler, 22 Oct 2002, in Huntress electronic document "021022 for OSS."

booster before launch came on January 19, 2006, a fully funded Pluto expedition was at last on NASA's program.[74]

CONCLUSIONS

No one factor can be singled out as decisive in the above result—so fragile and contingent was the emergence of New Horizons that everything had to line up to make it possible.[75] It was, as the Duke of Wellington described his victory at Waterloo, "the nearest run thing you ever saw in your life." The win required a fundamental shift in the scientific argument; an endorsement by the scientific community through the National Academy of Sciences; public enthusiasm; lobbying by the Planetary Society; fourteen years of vision and persistence through multiple setbacks on the part of Pluto advocates like Stern, Staehle, Terrile, and several others; leadership at NASA headquarters by Huntress, Goldin, Weiler, and Hartman; political intervention by Mikulski only made possible by the entry of Applied Physics Laboratory into the planetary exploration field; and APL Space Department's competence as the builder of low-cost, reliable, scientific spacecraft under the leadership of Tom Krimigis.

A tortured birth lasting more than a decade is, however, not that unusual a story in the NASA robotic space program; the Galileo Jupiter orbiter is a case in point, with its multiple changes of booster, spacecraft design, and trajectory.[76] Congressional interventions are not new in NASA's science program either, although major ones that change its path of development tend to occur only at intervals of a decade or more, generally when the agency's political position is weak. What the Pluto mission story does provide is a window on the formulation of space science and technology policy in the United States during the 1990s and 2000s, decades that have so far been little studied except by scholars seeking lessons from the Goldin "faster, better, cheaper" era. It reveals a shift in the balance of power that took place around 2000 among the important players: NASA senior management, the planetary science

74. Mission confirmation date from Stern comments on manuscript, attached to e-mail to author, 1 Sep 2013. The crises involved the availability of sufficient plutonium for the RTGs and the failure of an Atlas V tank in a ground test only months before the launch: Glen Fountain interview by author, 22 Jun 2012. Fountain became the project manager in 2006.

75. Stern argued this to me in our oral history: Sterniinterview by author (ref. 5), 59.

76. Melzer, *Mission to Jupiter* (ref. 4).

community, the space technology community and industry, Congress, the sitting Administration, and public advocates and lobbies.

In the late 1980s and early 1990s, NASA space-science administrators Len Fisk and Wes Huntress had the upper hand in determining which solar system missions got funded, albeit with advice from their scientific committees. There were no decadal surveys in the planetary sciences yet and the Space Studies Board was not always effective with NASA leadership. Dan Goldin's arrival in office, which reflected political disillusionment with the agency's bureaucracy, subordinated science policy to technology policy in an attempt to force a revolution in spacecraft design on JPL, industry, and the scientific community. Goldin's campaign petered out after the 1999 Mars failures, but it left some important legacies for the Pluto story: notably the rise of competitions for Principal Investigator–led small and medium missions, which stimulated, and were stimulated by, the entry of APL into the planetary spacecraft business, bringing with it the laboratory's unusual political clout.

By 2000, Goldin's revolution had run its course, but the underlying science behind the Pluto-Charon system and the Kuiper Belt, and its implications for understanding the history of solar system formation, had produced an "intellectual revolution" in the planetary sciences. When combined with the arguments for the urgency of a Pluto launch because of the fleeting Jupiter-gravity-assist opportunities, possible atmospheric collapse, and the increasing loss of visible territory on Pluto and Charon, it produced a rebellion in the planetary science community that was critical to Weiler's reversal on the cancellation of Pluto. OMB quickly restored Europa's priority, reigniting protest. The ongoing fight caused Ed Weiler to request that the National Academy of Sciences do a decadal survey, which further empowered the scientific community and shifted its relationship to NASA. In parallel, the cancellations sparked a popular campaign driven in particular by the Planetary Society, which, if it did not much influence NASA leadership, may have aided Mikulski in her search for votes in the Senate and House, although that remains to be proven. Even the NASA space science leadership—Weiler and Hartman—had an important role, although they were required by their jobs to advocate the sitting administration's cancellations, making them appear as enemies of Pluto to the advocates. But they were instrumental to the idea of Discovery-like competition for Pluto and then created the New Frontiers line, both of which were essential to the victory and survival of New Horizons. Yet the balance of power had shifted, and those cancellations were overridden by Congress, drawing on arguments of the scientific community, the public, and APL.

To what degree that NASA's science policy has been determined by external groups outside planetary exploration and beyond 2003 remains to be determined, but the post-1990 environment of a greater number of smaller, PI-led missions, combined with competitive mission selection from a larger number of space science institutions, many of them outside NASA, has created an environment where political lobbying and external intervention are more likely. Meanwhile, New Horizons continues to fly outward to its target, and may well become one of humankind's signature achievements in space exploration, which might be reason enough to understand its history.

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