Chapter 24

The Jet Propulsion Laboratory and Southern California

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Southern California, as any of its inhabitants will attest, is a rather particular—if not unique—place. Over the course of the twentieth century it evolved from irrigated agriculture, through an oil boom and the emergence of Hollywood, to its present status as a sprawling, high-tech nexus on the Pacific Rim. The central factor in this evolution, especially in the last half-century, has been the aerospace industry. The aerospace complex started with a few aircraft builders around World War I, vastly expanded in the mobilization for World War II, and then continued and broadened in the cold war to encompass a wide range of activities, including military and civilian aircraft, reconnaissance and communications satellites, and strategic missiles in addition to space exploration. By the 1980s about 40 percent of the American missiles and space business resided in southern California, as did about one-third of the aerospace engineers, and the industry as a whole there employed close to a half-million people. Southern California as we know it would not exist without aerospace, and, if one is looking for the societal impact of space exploration, one need look no further than the transformation of southern California in the twentieth century from sunbelt orange groves to high-tech metropolis.[1]

1. See Kevin Starr, *Americans and the California Dream, 1850–1915* (New York: Oxford University Press, 2002); Kevin Starr, *Inventing the Dream: California Through the Progressive Era* (New York: Oxford University Press, 1986); Kevin Starr, *Material Dreams: Southern California Through the 1920s* (New York: Oxford University Press, 1991); Kevin Starr, *Endangered Dreams: The Great Depression in California* (New York: Oxford University Press, 1997); Kevin Starr, *The Dream Endures: California Enters the 1940s* (New York: Oxford University Press, 2002); Kevin Starr, *Embattled Dreams: California in War and Peace, 1940–1950* (New York: Oxford University Press, 2003); Mike Davis, *City of Quartz: Excavating the Future in Los Angeles* (New York: Verso, 1990), pp. 120–121; Ann Markusen et al., *Rise of the Gunbelt: The Military Remapping of Industrial America* (New York: Oxford University Press, 1991). Statistics from Allen J. Scott, *Technopolis: High-Technology Industry and Regional Development in Southern California* (Berkeley, CA: University of California Press, 1993), p. 129. The total employment figure includes aircraft, electronics components, search and navigation equipment, and other aerospace-related categories. Scott, *Technopolis*, pp. 12–16. The author is helping launch an initiative to document the history of the regional aerospace industry in a project under the Institute for California and the West at USC and the Huntington Library; see the institute's Web site at *http://www.usc.edu/icw* (accessed 28 March 2007). Throughout the notes, citations to material from the JPL archives follow the form: JPL collection number, box/folder. All interviews by author unless otherwise noted.

Several thousand of these aerospace engineers worked at the Jet Propulsion Laboratory (JPL) in Pasadena. JPL worked with and spun off local aerospace firms, and experienced with them the ups and downs of federal support, but also competed with them in the local labor pool; it attracted publicity to the local community but also a backlash because of environmental pollution; and it intersected the Hollywood movie business in surprising ways. This paper examines a few of these evolving interactions to demonstrate how space programs both reflected and shaped southern California.

Origins and the Aerospace Industry

It was no accident that JPL sat at the geographic epicenter of the aerospace industry. Caltech's aeronautics programs had close ties from the 1920s to nearby aircraft firms, and its research and graduates helped fuel the pre-World War II growth of the local aircraft industry. At the time, Caltech was already a center for science and engineering in the United States, fostered by philanthropic funding. This included money from the Guggenheim family for an aeronautics program, which in 1930 helped Caltech lure Theodore von Kármán, a leading authority on aerodynamics in Germany, to become director of the Guggenheim Aeronautical Laboratory at Caltech (GALCIT). In addition to promoting GALCIT's collaboration with local aircraft firms on wind tunnel and other research programs, von Kármán supported research on rockets, which eventually led to Army support and, during World War II, the formal creation of JPL.[2]

The symbiosis continued in the cold war, and JPL's evolution from rockets to spacecraft resonated with the diversification of local industry from aircraft to aerospace. Caltech continued to manage JPL, first under an Army contract and then under NASA. JPL differs from the other NASA Centers in its association with a university—one well-connected with local aerospace industry. Caltech (through GALCIT and JPL) provided to the industry both research underpinning technological advances and also a steady supply of science and engineering graduates, such as Simon Ramo and Dean Wooldridge—the R and W in TRW. These links may be measured by the many aerospace executives on Caltech's board of trustees, several of whom also served on a special committee overseeing JPL and hence injected industrial perspectives. Although Caltech and JPL had exceptionally well-developed connections, they were by no means unique in southern California: Convair engineers helped establish the science and engineering departments at the University of California at San Diego; Boeing similarly cultivated Cal-State Long

2. Judith R. Goodstein, *Millikan's School: A History of the California Institute of Technology* (New York: W. W. Norton & Company, 1991), pp. 156–177; Clayton R. Koppes, *JPL and the American Space Program: A History of the Jet Propulsion Laboratory* (New Haven, CT: Yale University Press, 1982), pp. 1–7.

Beach as a labor source; and Hughes supported the engineering program at the University of Southern California.[3]

JPL also intersected local industry as a competitor in the labor market. JPL managers viewed southern California as a more competitive labor market than that of other NASA Centers, since JPL engineers could jump to any number of industry firms without the hassle of relocating; lab managers consistently worried about losing top talent. As JPL grew to be the largest employer in Pasadena, its evolving mission shaped its ability to recruit and retain staff. After the lab shifted to NASA it gradually relinquished secret defense work, which made it particularly attractive to aerospace engineers who did not want to work in a classified environment. Since many (if not most) local aerospace jobs required a security clearance, this could provide a substantial recruiting inducement, not only for those morally opposed to military work but also those—such as homosexuals—who feared an intrusive clearance process. This became an issue when JPL resumed substantial military work in the 1980s, amid a general remilitarization of the space program.[4]

JPL more generally capitalized (with the rest of local industry) on the southern California climate as a recruiting tool. A number of JPL staff went job hunting in southern California at least in part because of the weather, especially those who started in the early years of the 1950s and 1960s, and even more especially those from colder climes. As one engineer put it, "The Chamber of Commerce sent me this booklet that showed beautiful mountains, no smog, snow on the top, and orange trees," and that was all the inducement necessary to head west.[5]

JPL also reflected the ethnic composition of the local labor pool. Like the rest of NASA, lab staff was very largely white and male, following the national demographic of science and engineering disciplines, but JPL generally had almost twice the proportion of minorities on the staff than did NASA, and Asian ethnic groups made up the largest fraction of minorities, followed by Hispanics and African

3. On Convair engineers and San Diego colleges: Marvin Stern, interview by Finn Aaserud, 1 May 1987, American Institute of Physics.

4. Pete Lyman interview, 1 April 2004; U.S. Government Accountability Office, "Security Clearances: Consideration of Sexual Orientation in the Clearance Process," 24 March 1995 (Washington, DC: GAO, GAO/NSIAD-95-21, 1995); Barbara Spector, "Security Clearance Delays Hamper Gays' Careers," *The Scientist* 6/5 (2 March 1992); *High Tech Gays v. Defense Industrial Security Clearance Office*, U.S. Court of Appeals, Ninth Circuit, 895 F.2d 563, 2 February 1990; Gary Libman, "Scientists Confront Homophobia in their Ranks," *Los Angeles Times*, 2 February 1990; Peter J. Westwick, *Into the Black: JPL and the American Space Program, 1976–2004* (New Haven, CT: Yale University Press, 2006), p. 100. See also M. G. Lord, *Astro-Turf: The Private Life of Rocket Science* (New York: Walker and Co., 2005), pp. 188–195.

5. Charles Kohlhase interview, 2 July 2002; see also John Casani interview, 21 November 2003, and Pete Lyman interview, 26 March 2004.

Americans.[6] Affirmative action policies and the increasing number of minority scientists and engineers nationwide almost doubled minority representation from the 1970s to the 1990s (from 13 percent in 1976 to 25 percent in 1994), although upper management remained a mostly white male province. Hispanics and especially Asian Americans continued to constitute most of the minorities (8 percent and 11 percent, respectively), in particular among scientists and engineers (14 percent Asian), so that whites, Asians, and Hispanics held better views of JPL's diversity than did African Americans.[7]

JPL's connections to local industry extended to spinoffs—from major defense contractor Aerojet, spun off during World War II, to more recent smaller startups such as ViaSpace and Photobit—and of course to local contractors. Many local firms made their living in part off JPL contracts, in what economists would explain as a high-tech, post-Fordist example of earlier concentrations of craft industry (such as Lyon silks or Alsatian calico), where mutually independent producers capitalize on a common labor market and on a network of suppliers and services.[8] About one-third of JPL's subcontracting currently goes to southern California firms, and even for contracts that went to other aerospace hotbeds, such as to Lockheed Martin in Colorado, some of the subcontracts for those programs ended up in southern California as well.[9]

On the other hand, big aerospace firms could view JPL projects as contributing a mere pittance to company balance sheets. For groups such as the Hughes Space Division, which might have sales of several hundred million dollars a year, a JPL contract for $50 million or $100 million spread out over several years provided a very small fraction of business.[10] That did not keep them from competing for contracts or from complaining that JPL kept work in-house instead of contracting it to industry. As firms such as TRW and Hughes developed extensive satellite expertise (most of it through spacecraft for military reconnaissance and commercial communications), JPL faced competition from aerospace firms both near and distant, and NASA and Congress consistently pressured the lab to farm out more work.[11] Periodic downturns in civil and military space spending increased the competition from aerospace firms. The end of the cold war, in particular, marked a turning point for JPL, the aerospace industry, and southern California itself. JPL contemplated

6. T. G. Meikle, "Ethnic Staffing by Job Categories, 28 October 1976 (JPL 142, 16/265); "Advisory Council on Minority Affairs Minutes," 5 October 1977 (JPL 142, 16/258); Employment Comparison in Advisory Council Material," February 1979 (JPL 8, 5/79).

7. JPL, "Response to the NASA Federal Laboratory Task Force Subcommittee Questions," 31 October 1994 (JPL 259, 20/231), and Kirk Dawson, "JPL Institutional Overview," 7 November 1994 (JPL 259, 20/229); JPL Employee Survey, June 1995 (JPL 259, 89/1296).

8. Scott, *Technopolis*, pp. 25–26.

9. Data courtesy of Martin Ramirez in the JPL Legislative Affairs Office.

10. Albert Wheelon interview, 13 June 2002.

11. Westwick, *Into the Black*.

the grim prospect that the lab itself might shut down and, as the aerospace industry hemorrhaged jobs, Caltech's president declared that "This is a time of triage—[the] only question is what is going to die."[12] JPL's response, known as the "employee displacement strategy" or "right-sizing"—or, more bluntly, downsizing—produced staff cuts of 30 percent over the next several years. Though not as deep as the cuts suffered by the aerospace business in general, they represented and contributed to the general malaise of the early 1990s in southern California.[13]

JPL survived because it found new justifications (besides the pork-barrel political support it received as a large local enterprise.) One response to the end of the cold war was to celebrate the triumph of the private sector and, as military threats receded, the federal government shifted emphasis to economic concerns. Clinton's presidential campaign catchphrase of 1992—"It's the economy, stupid"—infected NASA and JPL, which channeled the entrepreneurial buzz into efforts to transfer space technologies to the civilian economy. The usual approach involved licensing and patents, but JPL also spun off people and their ideas in small startup companies. Caltech encouraged the spinoffs by providing startup capital through a "grubstake" grant program, with an equity stake retained by the university. The startups also capitalized, literally, on the thriving venture capital business in California in the 1990s, which quickly learned to target the people and ideas emerging from JPL.

These spinoff companies supported new justifications for the space program based on high technology for economic growth. The clustering of offshoots such as Photobit and ViaSpace around the lab helped the local economy rebound from aerospace cutbacks, but they also demonstrated some resistance to the commercial spirit at JPL. Lab managers worried that engineers constantly on the lookout for business opportunities might not stay focused on the job of building spacecraft. Lab managers also feared the loss of key staff. In 1998, for example, Carl Kukkonen, the architect of JPL's microelectronics program, left to start ViaSpace, and he sought to bring a number of JPL staff with him. Caltech agreed but asked that he keep his recruiting within reasonable bounds—as Kukkonen put it, "retail rather than wholesale."[14] Lab managers also anticipated that NASA auditors, despite the Bayh-Dole Act promoting technology transfer, would charge that individuals were profiting from government-funded research. In some cases the Caltech president and trustees had to intervene to overcome JPL's and NASA's concern about the private–public divide, which continued to dampen the embrace of entrepreneurialism.[15]

12. Stone, "Notes on Trustees' Committee on JPL," 10 March 1992 (JPL 259, 32/323).

13. "JPL's Institutional Strategy," ca. January 1993, and "Executive Council Meeting Agenda," 1 March 1993 (JPL 165, 2/11); Stone presentation to Trustees Committee on JPL, 30 October 1998 (JPL 259, 35/343); Stone to Edward Weiler, 7 March 2000 (JPL 259, 7/101).

14. Carl Kukkonen interview, 3 June 2003.

15. Lawrence Gilbert telephone interview, 15 March 2005.

THE ENVIRONMENT AND THE LOCAL COMMUNITY

JPL has always interacted with the local geography and environment. The lab itself sits in the Arroyo Seco, a dry wash three miles above the Rose Bowl in Pasadena. The isolated spot was chosen for initial rocket tests in the 1930s, not so much for safety as because no campus facilities were available. The wisdom of using a remote site was confirmed, however, when subsequent tests on the Caltech campus misfired, one explosively. When the Army Air Corps then stepped up wartime funding, the rocketeers returned to the Arroyo, but only after the city of Pasadena, protecting the interests of nearby high-end homeowners, insisted that the site would serve only for the duration of the war. By war's end, the growth of apparently permanent structures alarmed city managers, but when the Army threatened to invoke eminent domain the city gave in and signed a long-term lease.[16] JPL remains in the Arroyo today, although it had to seek a more remote site for rocket tests in the Mojave desert near Edwards Air Force Base. The California high desert provided isolation of a different sort necessary for deep-space tracking and communication, removed from radio noise, and the cornerstone of what would become the Deep Space Network was laid in the late 1950s on a dry lake bed at Goldstone in the Mojave.[17]

Despite the rocky start with the city of Pasadena, for the local community JPL largely represented a boon. The lab and Caltech came to enjoy substantial influence with local media and city government, by virtue of their size and prestige—enough to squash the occasional protest from neighbors over the construction of new buildings. With more than 4,000 staff by the mid-1970s, JPL at that time was the largest employer in Pasadena.[18] This statistic relied on the fact that JPL staff were Caltech employees; JPL itself was not located in Pasadena. It lay outside the city limits on land annexed by the neighboring town of La Cañada-Flintridge when it incorporated in 1976. After much squabbling between rival city boosters, including the Pasadena city manager's declaration that "to see it end up in some other corporate limits would be like losing the Rose Bowl," the U.S. Postal Service left the decision up to the lab and JPL chose Pasadena. La Cañada-Flintridge residents were still stewing about the episode 20 years later.[19]

16. Koppes, *JPL and the American Space Program,* pp. 11, 21.

17. Ibid., p. 95; Douglas J. Mudgway, *Uplink-Downlink: A History of the Deep Space Network, 1957–1997* (Washington, DC: NASA-SP-2001-4227, 2001), pp. 2–12.

18. JPL Institutional Background and Overview, 3 October 1975 (JPL 142, 27/483).

19. "JPL is in Pasadena" [quote, editorial], *Pasadena Star News*, 19 March 1976; Harold Brown to Mortimer Mathews, 2 December 1975, and D. R. Fowler to A. T. Burke, 2 January 1976 (JPL 142, 24/420); "Pasadena to Ask JPL Land Annexation," *Pasadena Star News*, 1 January 1976; Jackie Knowles, "Pasadena Fails in JPL Annex" *Pasadena Star News*, 11 March 1976; "The Great Battle for JPL," [editorial] *La Canada Valley Sun*, 18 March 1976; Dick Lloyd, "JPL Faces an Identity Crisis Following Incorporation Vote," *Pasadena Star News*, 15 November 1976; see additional clippings in JPL files, folder 4649, NASA History Office.

Pasadena city leaders soon had cause to regret JPL's proximity. Increasing public sensitivity in the United States to environmental pollution resulted, among other things, in the Safe Drinking Water Act of 1976 and testing of water supplies. In 1980 state health authorities began testing water wells in Pasadena and found a number of them contaminated with toxic carcinogens, including four wells in the Arroyo Seco east of JPL. The lab had developed formal control of hazardous waste in the early 1960s; before that, JPL had used cesspools, dumping pits, and an incinerator to dispose of wastes at the east end of the lab.[20]

Pasadena officials assumed the contamination came from JPL's early rocket research. The lab initially denied blame, noting that the contaminants—trichloroethylene, carbon tetrachloride, and tetrachlorethylene—were common industrial solvents; 30 other wells throughout the San Gabriel Valley had also turned up excessive traces. JPL nevertheless agreed in 1985 to fund jointly with Pasadena an engineering study, in the spirit of a "good neighbor" and without admitting liability. An outside consultant subsequently concluded that JPL was the "most probable source" and recommended construction of a water treatment plant.[21] NASA agreed to pay for the plant, built in 1990 at a cost of $1.3 million, and JPL planned to commit about $1 million a year for several years for cleaning up the contamination. In 1992 JPL was named a "Superfund" site, one of more than 1,000 polluted places identified by the federal government for environmental remediation.[22]

In this respect JPL differed little from many other aerospace sites, not to mention nuclear labs and other enterprises, that had raced to beat the Soviets in the cold war—at a time of more cavalier attitudes toward waste disposal and the environment—and then faced the consequences decades later. The concentration of aerospace business in southern California, however, has made the cold war environmental legacy more acute there. This, too, is one of the societal impacts of space exploration.

Environmental liability would be a major issue in contract negotiations with NASA. Caltech feared exposing its endowment to lawsuits, while NASA found itself paying for damage likely incurred under the previous Army contract.[23] This was not just splitting hairs: JPL was shortly slapped with a lawsuit alleging that pollution caused the death of one local woman and Hodgkin's disease in two others;

20. Beverly Place, "Foothill Water Wells Checked for Chemicals," *Montrose Ledger*, 19 January 1980; Fred Felberg to speakers' bureau, with attached fact sheet, 26 November 1986 (JPL 230, 26/246).

21. Felberg to speakers' bureau, 1986; W. E. Rains, memo to the record, 20 August 1986 (JPL 230, 26/241). The "good neighbor" phrase appears in both documents.

22. Management plan for remedial investigation/feasibility study, January 1992 (JPL 239, 3/18); "Environmental Cleanup Review," JPL fact sheet, April 1991 (JPL 239, 1/5); E. C. Stone to senior staff, 22 October 1991 (JPL 239, 2/11); Marla Cone, "Jet Propulsion Lab Added to Superfund list," *Los Angeles Times*, 15 October 1992.

23. Tom Sauret interview, 25 April 2001.

31 other local residents petitioned to join the case. A groundwater study by the federal Health and Human Services Department in 1998 found no current threat and judged past hazards "unlikely," but JPL continued to grapple with lawsuits into the new century.[24]

JPL's response to the groundwater problem is instructive. Despite the lawsuits, JPL avoided the much more active environmental controversies that plagued some other government labs. Brookhaven National Lab, to take one example, encountered an uproar after revelations in the 1990s that a plume of groundwater near a nuclear reactor contained tritium. Hundreds of community activists packed public hearings and vented their anger. Brookhaven scientists could not understand the fuss over what they saw as a negligible hazard, but local residents resented what they viewed as evasions and patronizing reassurances based on statistical risk analysis. Brookhaven learned a hard lesson in community relations: the lab director was effectively pressured out of his job and the contractor, which had run Brookhaven for 50 years, saw its contract summarily terminated by the Department of Energy in 1997.[25]

The JPL case differed in that it dealt with common industrial chemicals, whereas Brookhaven and other nuclear labs involved radioactivity, with its popular associations of danger and secrecy.[26] Another prime difference from labs such as Brookhaven was that JPL, like NASA as a whole, had a finely tuned public relations organization and decades of experience with operating in the media glare, including highly exposed failures. Brookhaven scientists, by contrast, admitted their lack of public relations expertise. At the outset of the controversy at JPL, lab managers emphasized to staff that any public comments "will not underestimate the important nature of the problem. For example, we will not cite statistics in an effort to demonstrate that chances of getting cancer from Pasadena drinking water are low."[27] Another internal memo stressed that JPL and NASA should "maintain a positive, cooperative attitude in dealing with the city. The contribution of a substantial part of the construction cost of a treatment plant is preferable to the consequences of sensational adverse

24. Robin Lloyd, "11 to Join Toxic Suit against JPL," *Pasadena Star-News*, 18 June 1997; "Study Clears NASA Lab of Alleged Threat to Public Health," *San Diego Union-Tribune*, 23 August 1998; Patti Paniccia, "The Devil's Advocate," *Los Angeles Times Magazine* (25 July 2004): p. 16.

25. Colin Macilwain, "Brookhaven Contractor is Sacked over Tritium Leak," *Nature* 387 (8 May 1997): p. 114; Andrew Lawler, "Meltdown on Long Island," *Science* 287 (25 February 2000): pp. 1382–1388; Robert P. Crease, "Anxious History: The High Flux Beam Reactor and Brookhaven National Laboratory," *Historical Studies in the Physical and Biological Sciences*, 32/1 (2001): pp. 41–56; Jack M. Holl, *Argonne National Laboratory, 1946–96* (Urbana, IL: University of Illinois Press, 1997), pp. 485–488; Leland Johnson and Daniel Schaffer, *Oak Ridge National Laboratory: The First Fifty Years* (Knoxville, TN: University of Tennessee Press, 1994), pp. 225–229.

26. Spencer Weart, *Nuclear Fear: A History of Images* (Cambridge, MA: Harvard University Press, 1988).

27. Lawler, "Meltdown"; Felberg to speakers' bureau, 1986.

press coverage of the situation."[28] JPL's public relations experience, well-honed by the civil space program, helped it largely avoid the antagonistic community reaction that could characterize environmental cleanup at other cold war labs.

Hooray for Hollywood

The lab also forged links with another prominent local industry, namely, show business. Hollywood knows a spectacle when it sees one, and celebrities often descended on JPL for planetary encounters. This included not only actors and actresses, but also writers with studio connections—especially local science-fiction writers, who had a natural interest in JPL's work. In the lab's earliest days, two of its founders, Frank Malina and Jack Parsons, tried to sell a story about their rocket group to Metro-Goldwyn-Mayer to raise money for their research; Parsons later hobnobbed with L. Ron Hubbard and Robert Heinlein and lost his life in an explosion while working on pyrotechnic special effects for Hollywood.[29] By the 1970s sci-fi writers were a strong presence around JPL for planetary encounters, including such luminaries as Arthur C. Clarke, Ray Bradbury, and Heinlein. As with aerospace, Caltech helped nourish JPL's Hollywood ties with its own elite connections, including trustees (and JPL overseers) such as mogul Lew Wasserman.

Movie trends revealed Hollywood's periodic fascination with space exploration, such as in the late 1970s, when the first *Star Trek* movie featured a mysterious, nearly sentient object known as V-GER. The trend revived in the late 1990s, when the discovery of a Martian meteorite with possible life-forms, the Shoemaker-Levy comet impact on Jupiter, and Mars Pathfinder were followed by blockbuster movies including *Deep Impact* and *Armageddon*, about meteor impacts on Earth, and *Mission to Mars* and *Red Planet*, about mysterious life-forms on Mars, not to mention several new installments of the *Star Wars* saga. JPL's executive council in 1999 noted the surprising interest in "space movies and the merging of entertainment and realities." The merging included a new mission, approved that year, which planned to fire a 1,000-lb (500-kg) projectile into the comet P/Tempel-1 and observe the resultant crater; JPL's project manager had to insist that the mission's name, Deep Impact, was in fact selected prior to the movie.[30]

There are more substantial connections between JPL and the movie business in the lab's technical program. In the early 1960s JPL engineers had pioneered

28. Rains memo, 20 August 1986.

29. George Pendle, *Strange Angel: The Otherworldly Life of Rocket Scientist John Whiteside Parsons* (New York: Harcourt, 2005), and Davis, *City of Quartz*, pp. 54–62.

30. Gael Squibb notes on EC retreat, 11 March 1999 (JPL 259, 64/758); James Graf quoted in Matthew Fordahl, "Deep Impact," AP newswire, 9 July 1999; Andrew Murr and Jeff Giles, "The Red Planet takes a Bow," *Newsweek* (6 December 1999).

the use of digital image processing, first to clean up pictures returned from the Ranger missions to the Moon, and later on other planetary spacecraft images. The first techniques corrected distortions and removed signal noise, such as a particular frequency superimposed on an image by vibration of the camera, and grew to encompass algorithms for contrast enhancement, cartographic projection, motion compensation, and so on (in short, many of the techniques now available through such software packages as Photoshop).[31] By the mid-1970s, what was known as the Image Processing Laboratory at JPL had perhaps the most advanced capability in the country.

Meanwhile, JPL had also supported important early work on computer animation. In the late 1970s JPL hired a young programmer from Utah named James Blinn, a student of Ivan Sutherland (who was now at Caltech). Blinn was making a name as a guru of computer graphics; Sutherland, himself no slouch, would say, "There are only a dozen great people in computer graphics, and Jim Blinn is six of them." Blinn went to work with Charles Kohlhase on the Voyager project, generating three-dimensional animations simulating Voyager's flight past Saturn, at each point calculating the relative appearance of planets and stars. The three-dimensional (3-D) movies—in which the viewer rode along with Voyager as the spacecraft swooped over Saturn's rings and satellites—proved a hit with TV news editors and viewers. Similar graphics sequences from Blinn enlivened the *Cosmos* television series of Carl Sagan.[32]

Although Blinn was not a part of the Image Processing Lab, his computer animations for Voyager and *Cosmos* used similar techniques, such as reconstructing viewing geometries and surface reflectance.[33] The Image Processing Lab had also produced its own motion pictures by combining still photos, such as those from the Ranger and Mariner spacecraft. Around the time of Blinn's work on Voyager, Kevin Hussey was doing some crude 3-D animation for atmospheric scientists, including modeling the smog distribution in the Los Angeles basin. Hussey heard about Blinn's work and approached him for help, but lacked the budget to hire him. So Hussey used in-house code written by Mike Kobrick in the Image Processing Lab and, with the help of a young programmer named Bob Mortensen, tweaked it for his purposes. The result, in 1987, was *L.A. the Movie*, which projected topographic data from Landsat to simulate the 3-D view from an aircraft swooping through the Los Angeles basin. By that time Hussey's group had grown from 2 to 14 and

31. Caltech/JPL Conference on Image Processing Technology, *Proceedings*, 3–5 November 1976 (JPL report SP-43-30).

32. Natalie Angier, "It Was Love at First Byte," *Discover* (March 1981); David Salisbury, "Computer Art Takes Off into Space," *Christian Science Monitor*, 20 July 1979; Frank Colella interview, 26 February 2002; Charles Kohlhase interview, 20 July 2002.

33. William B. Green interview, 12 February 2002. On shared techniques, see Kenneth R. Castleman, *Digital Image Processing* (Englewood Cliffs, NJ: John Wiley & Sons, 1979), pp. 371–377.

had formally organized as the Digital Image Animation Lab (DIAL), alongside and overlapping the original Image Processing Lab.[34]

Blinn had meanwhile gotten several offers from the movie business and in 1981 accepted one from George Lucas to establish a special effects studio for *The Empire Strikes Back*, the first *Star Wars* sequel. At the Lucas studio Blinn teamed up with Alvy Ray Smith, who had himself worked briefly with Blinn at JPL. Blinn's work at JPL had already had some influence: the sequence that persuaded Lucas of the potential of computer graphics was developed by Smith's team for *Start Trek II: The Wrath of Khan*, which showed the view from a spacecraft flying past a dead, Moon-like planet which then is transformed by a fiery cataclysm into an Earth-like environment. In creating this "Genesis" shot, Smith declared, he "was still under the influence of Blinn's Voyager flybys of the planets at the Jet Propulsion Laboratory." After joining Smith for a stint at Lucasfilm, Blinn returned to the Caltech campus and later became a "graphics fellow" at Microsoft; Smith would go on to help found Pixar.[35]

Hussey had also intersected Hollywood through work on digital color correcting, starting with a CBS television special on the *Mona Lisa* and then on color correction of old *Star Trek* backgrounds. He had then helped William Shatner with a zoom shot from the galaxy down to Yosemite Valley for another of the *Star Trek* movies and digitally erased telephone wires from the Egyptian skyline for *Raiders of the Lost Ark*. He had also developed a technique to interpolate between still images, from work for ocean scientists creating continuous animation of ocean circulation from satellite images taken 12 hours apart; he applied this on work for Whitney/Demos Productions, one of the leading graphics studios, to morph images into one another—an early example of the technique popularized by *Terminator 2* and Michael Jackson's *Black and White* video in 1992. Hussey soon had a stream of movie producers coming through his door for what he called "demo after demo" of VICAR (Video Image Communication and Retrieval) and other JPL digital processing software.[36]

Hollywood was hooked, and in the mid to late 1980s began to pour money into digital techniques, aided by the emergence of commercial software packages such as Photoshop. Disney soon hired away Hussey and several others from the DIAL to help build its own digital animation studio, including work with Pixar's movies. By the mid-1990s Hollywood's vastly greater resources allowed it to outstrip the

34. Kevin Hussey phone interview, 11 September 2006; Green interview, 12 February 2002; Kevin Hussey, Bob Mortensen, and Jeff Hall, *L.A. the Movie*, 1987 (JPL audiovisual collection).

35. Natalie Angier, "It Was Love at First Byte"; David Salisbury, "Computer Art Takes Off into Space"; Alvy Ray Smith, "George Lucas Discovers Computer Graphics," *IEEE Annals of the History of Computing* 20/2 (1998): pp. 48–49.

36. Hussey interview, 11 September 2006. For history of Whitney/Demos, see Gary Demos, "My Personal History in the Early Explorations of Computer Graphics," *Visual Computer* 21/12 (2005): pp. 961–978.

capabilities at JPL—even though most of DIAL's funding came from outside NASA, with IMAX as the largest sponsor.[37] As a result, the influence began to run mostly in the opposite direction, from Hollywood to JPL. Hussey himself returned to JPL after several years at Disney, bringing with him the latest from Hollywood studios. These included 3-D gaming techniques, which JPL applied not only for outreach efforts (allowing kids to play online games of planetary exploration), but also to help mission managers visualize what their spacecraft are doing in space, by transforming raw telemetry into real-time animations.[38] Such techniques have closed the loop from JPL to Hollywood, and from popular interest to technical capability.

CONCLUSION

JPL's impact on southern California has ranged from the local aerospace industry and labor pool, to its environmental legacy, to Hollywood studios. But the influence throughout has run both ways. We might ask not only about the societal impact of space programs, but also whether southern California left a particular stamp on the enterprise of space exploration. What were the consequences of the concentration of aerospace for the space program? California historian Kevin Starr has long described the state as a land of dreamers; did the blue-sky California environment encourage dreams of soaring beyond the sky, in the attitude captured by a California-ism from that other local industry, "imagineering"?[39] Or did California's recreation and leisure culture—all that sun and sand and surf—instead distract space engineers from their work, as it can also distract space historians?

Or could one go even further and ask whether there is a distinctive southern California type of spacecraft. Perhaps not, although those Mars Rover airbags look suspiciously like beach balls bouncing across the sand. But one could speculate that southern California attracted or nurtured a particular mindset or sensibility, one attuned to the imaginative possibilities and the public appeal of spaceflight. JPL managers identified two general categories of staff: the benchtop engineers building hardware (or software), and the mission designers.[40] It was the mission designers who were perhaps more susceptible to the context. Consider Bruce Murray, for example, who as JPL director would emphasize missions with popular appeal over strictly scientific goals. In the 1970s Murray released the "purple pigeons," a group of proposed missions with razzle-dazzle for the public (such as a solar sail to Halley's

37. James A. Evans, "The Reimbursable Program," 28 February 1995 (JPL 259, 50/553).

38. Hussey interview, 11 September 2006.

39. See the several volumes in the series by Kevin Starr, *Americans and the California Dream*. See also David Beers, *Blue Sky Dream: A Memoir of America's Fall From Grace* (Garden City, NY: Doubleday and Co., 1996).

40. Felberg et al., "JPL Futures Study," July 1980 (JPL 142, 20/325).

comet); he would continue to push such flights of fancy as an interstellar probe, Mars airplanes, and Venus submarines in the planetary program and in the civil space program in general. Such attitudes were not confined to southern California—but it might be no accident that Murray had grown up just across town in Santa Monica. (It might also be no accident that he has been the only one to wear shorts and sandals behind the JPL Director's desk.)[41]

One might speculate further that JPL, by virtue of its location, attracted more than the usual share of Bruce Murrays. And an attitude like Murray's did in fact influence spacecraft design. Emphasizing popular appeal often meant imaging—that is, spacecraft that returned pictures instead of just reams of numerical data. And imaging cameras in turn meant three-axis-stabilized spacecraft instead of the spin-stabilized spacecraft preferred for particles-and-field experiments. This preference shows up in JPL's long tradition of three-axis-stabilized craft. (For the Galileo spacecraft, JPL review boards and Murray himself recommended dumping a complicated spun/despun design, which combined a spin-stabilized section with a three-axis-stabilized platform, for a straight three-axis spacecraft.) A 1987 proposal from the nearby Planetary Society for a robotic Mars spacecraft captured the people-pleasing sensibility and the sense that planetary missions were all about entertaining the public. The proposal stressed that "Science should be given a low priority on this mission, if it is given any direct participation at all . . . . Imaging, imaging, and more imaging is the name of the game . . . . The aim here is to obtain images that are shameless crowd-pleasers and show Mars from a human perspective. If that's not good science, well then tough."[42] A Hollywood flack couldn't have said it any better. If one considers that the entertainment industry passed aerospace in 1995 as the main employer in California, it may indeed be appropriate to view JPL itself as a subset of the entertainment business.

41. Westwick, *Into the Black*; Bruce Murray, *Journey into Space: The First Three Decades of Space Exploration* (New York: W. W. Norton & Co., 1989).

42. E. J. Gaidos, "Project Precedent," 31 July 1987 (JPL 198, 36/528).