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California Dreamin'

Defense projects made the West Coast the promised land for US physicists after World War II—until the projects dried up.

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The Cold War decisively shifted the US physics community's center of gravity west, from the elite universities, corporate research laboratories, and high-tech firms in the Northeast and Midwest industrial corridors to the emerging centers of aerospace and defense electronics on the West Coast, particularly in Southern California. Even though universities in New England and mid-Atlantic states continued to award far more PhDs in physics than schools on the Pacific coast, those new physicists increasingly went west to work. (See the article by L. R. Harmon, *PHYSICS TODAY*, October 1962, page 21.) By 1960, the tipping point, California already employed more physicists than New York, Pennsylvania, and New Jersey combined. Los Angeles, Orange, and San Diego Counties alone employed nearly as many physicists as New York, the leader among the other states.

Aerospace, the quintessential Cold War industry and Southern California's largest single employer, drove the westward tilt in physics. During World War II, Southern California's aircraft companies were magnets for tens of thousands of job seekers. Among them were a large number of women—ultimately 42% of the industry's local wartime workforce—who were drawn to skilled and semiskilled manufacturing jobs for the first time.¹

At its wartime peak, the aircraft industry employed a quarter million workers in Southern California. Scientists and engineers generally made up less than 5% of the workforce.

By the early 1960s, aerospace rather than aircraft had become the major market. Companies originally built on manufacturing know-how became increasingly dependent on scientific expertise to design and build rocket engines and inertial guidance systems for intercontinental ballistic missiles, aircraft and antiaircraft radar systems, ground-to-air and air-to-air missiles, and other high-tech instruments.² Established firms such as Northrop and North American Aviation (NAA) added new electronics and aerospace

divisions, whereas newcomers that included Hughes Aircraft Company and Thompson Ramo Wooldridge (shortened to TRW in 1965), with their heavy emphasis on R&D, added manufacturing facilities to their laboratories.

To facilitate their transition to aerospace, Southern California's big five—NAA, Lockheed, Northrop, Douglas Aircraft Company, and Convair Astronautics—hired scientists, engineers, and



Hughes Research Laboratories in Malibu, California. (Courtesy of HRL Laboratories.)

technical personnel by the tens of thousands. The new employees accounted for close to a quarter of the companies' total workforce in the mid 1960s. By 1962 Southern California aerospace companies had been awarded a quarter of the nation's prime defense contracts and employed 380 000 workers (although far fewer of them were women or people of color than during World War II). That buildup led to what would be the world's largest concentration of high-technology industry up to the end of the Cold War.³

To give themselves an edge in recruiting, hiring, and retaining young physicists and engineers, Southern California's aerospace companies had to project the right image. In their advertisements, they highlighted bold architecture, brilliant colleagues, challenging problems, and "California living at its finest." The companies gave a distinctly Californian flair to what David Kaiser has called "the suburbanization of American physics."⁴ As aerospace companies relocated their R&D laboratories and high-tech manufacturing divisions to new research campuses in the emerging "edge cities" of greater Los Angeles, they created aerospace suburbs. Those enclaves of privilege for white, white-collar, and predominantly male workforces reinforced a regional pattern of socially stratified and racially segregated communities.⁵

Shangri-la for deep thinkers

During World War II, the reclusive billionaire Howard Hughes purchased a large tract of land in Culver City, just north of the Los Angeles airport. There he constructed an industrial complex where Hughes Aircraft built planes under contract with other airframe manufacturers. The ensuing Cold War pushed the company's focus from aircraft manufacturing to sophisticated radar and guided missiles. It faced formidable competition for the military electronics market, especially from established eastern firms such as General Electric, Westinghouse, RCA, and Raytheon, all of which were major wartime radar contractors with enormous research laboratories.

In 1946 Hughes Aircraft hired Simon Ramo and Dean Wooldridge as the brain trust for its aerospace group. The two were graduate school classmates in physics at Caltech in the late 1930s. After graduation they had headed east—Ramo to General Electric's research laboratories and Wooldridge to Bell Labs. Though small, the company's aerospace group had one decisive advantage: the essentially unlimited capital of its sole shareholder, Hughes. Ramo and Wooldridge also had the confidence of former air force officers who were in charge of the avionics and missile programs. The company's leaders felt that neither traditional airframe manufacturers, whom they dismissed as Rosie the Riveter-type operations, nor established electronics companies

such as General Electric could attract and hold truly top-notch scientists and engineers.

Leaning on its Pentagon connections and the reputation of its technical staff, Hughes Aircraft cornered the market for airborne electronics for all air force interceptors. By 1952 Hughes had air force contracts worth \$200 million and 15 000 employees, including 1000 scientists and engineers. Despite the defection of Ramo and Wooldridge to form Ramo-Wooldridge Corp (later TRW) in 1953, Hughes Aircraft became the largest military electronics firm, and perhaps the most innovative, in Southern California.

Ramo and Wooldridge set out to build the Bell Labs of the West, but at one-tenth the size. They offered top salaries, compelling technical challenges, and, as the recruiting posters promised, "luxury living in California," poolside beneath the palms. To give the scientists their own space, literally and intellectually, Hughes built Hughes Research Laboratories (HRL), a stunning complex in Malibu perched on a hill overlooking the beach. The facility, shown in the opening image on page 36, boasted unrivaled views of the Pacific Ocean to one side and the Santa Monica Mountains to the other. Entirely sheathed in glass and with a cantilevered canopy for shade from the intense Malibu sun, the building featured an enormous fieldstone wall near the entrance and a bridge of interlocking concrete slabs crossing a large, landscaped pond. The lobby, furnished with chairs, tables, and couches in the Danish modern style, looked like the entrance to an exclusive country club.

Hughes's namesake lab could be as secretive, glamorous, and seductive as the reclusive billionaire himself. It's no wonder comic master Stan Lee modeled the original Iron Man,



FIGURE 1. A YOUNG AEROSPACE ENGINEER AND HIS FAMILY look for a house in Orange County, California. Autonetics drew physicists and engineers to work at its nearby facility by promising beautiful homes and neighborhoods, good schools, and other amenities. (Courtesy of the City of Huntington Beach Historical Collection.)

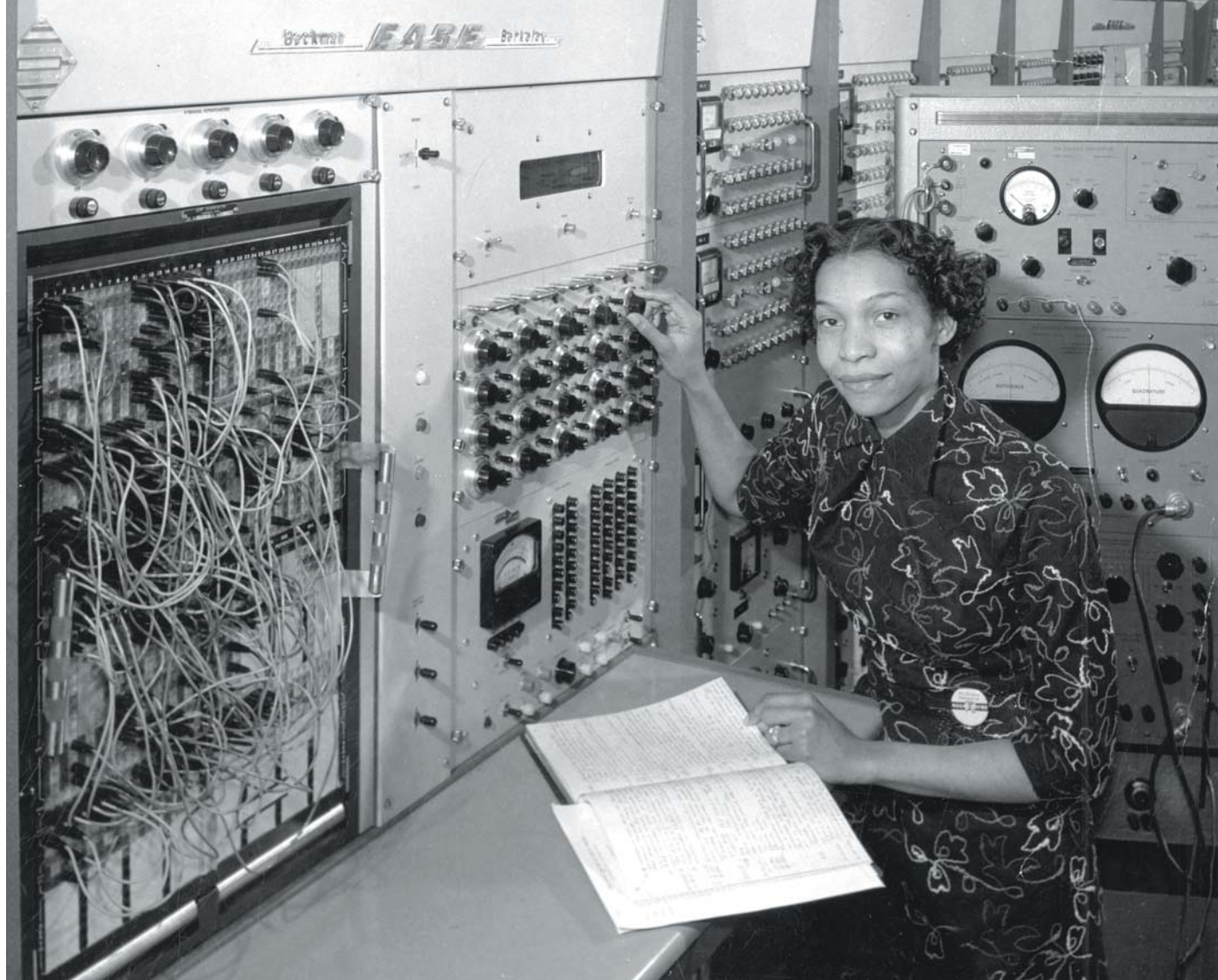


FIGURE 2. PHYSICIST NASIRA WILKINS was a member of Rocketdyne's scientific staff in 1959. Women, particularly women of color, were "hidden figures" at most aerospace companies in the 1950s. (Courtesy of the Valley Times Collection, Los Angeles Public Library.)

Tony Stark, on Hughes. The 2008 film version set Iron Man's clandestine laboratory in the basement of a Malibu mansion that freely borrowed from some of architect John Lautner's futuristic mansions. Hughes, a connoisseur of midcentury modern, surely would have approved.

HRL moved into its new home in early 1960. The facility housed research groups for theoretical physics, quantum physics, computing, and materials science. "Sure it's a long haul," one scientist complained about the commute to HRL in a 1962 *Westways* magazine article. "But it's such a darn pleasant place to work I actually look forward to the drive every morning." HRL repaid the company's investment almost immediately. Theodore Maiman fired up the world's first functioning laser there that May, beating out Bell Labs and its high-powered team of future Nobel laureates and bringing the new laboratory instant international recognition.

The company sought to provide a university atmosphere even though it was a highly classified laboratory. It recruited heavily from Caltech, especially at the PhD level, and many of those alumni moved to its upper ranks. To keep some of that freewheeling graduate-school spirit alive, HRL brought in Richard Feynman to consult and to give a series of popular weekly lectures to the staff. The company advertised for researchers fascinated by "far out" ideas and attracted more than its share. Physicist Robert Forward, for example, spent three decades there working on gravity-wave and gravity mass detectors, ground-based lasers for interstellar propulsion, space tethers, antimatter, and smart

structures. He wrote popular science fiction on the side.

HRL became the public face of a company with a reputation for keeping a low profile. It was a place everybody—generals, executives from other companies, even scientific dignitaries—wanted to see for themselves. In 1965 the European press corps was invited to cover the launch of *Intelsat 1*, the first geosynchronous communications satellite. The company's management made sure the journalists saw two Southern California landmarks: Disneyland, with a personalized tour by multilingual guides, and HRL, whose own "imagineers" talked about lasers, ion propulsion, and other real-life science fiction.

HRL set the tone for the company's manufacturing divisions. Hughes's ground systems division built an enormous complex for its ground radar systems in Fullerton, located in Orange County. The ultramodern T-shaped complex featured a glass curtain wall and fieldstone accents on the facade. Fullerton offered the first-rate housing, schools, and lifestyle HRL envisioned for its predominantly male workers, most of whom had stay-at-home wives with young children.

Bolstered by a huge backlog of military contracts for ground-based air defense systems, Hughes continued expanding. The

company hired physicists, engineers, and technicians as fast as it could sign them up. By 1961 the Fullerton site had 7000 employees and had essentially become a self-contained city within a city. "With its broad lawns and stands of towering trees, the sprawling Hughes Aircraft aerospace complex looks more like a college campus than an industrial outpost of the Cold War," according to a 1994 *Los Angeles Times* article. Fullerton's mayor made no apologies for saying, "Hughes is Fullerton, and Fullerton is Hughes."

Space-age workers find "home"

Like its competitors, NAA decided after World War II that its future would be in aerospace, not aircraft. Southern California's biggest wartime aircraft manufacturer moved aggressively into missiles, space, and related technologies. In 1955 it established three new aerospace divisions: Rocketdyne for rocket engines, Atomics International for nuclear reactors, and Autonetics for missile guidance and control. All three depended heavily on physicists.

When NAA's original plants became severely overcrowded, it relocated Rocketdyne and Atomics International to Canoga Park in the San Fernando Valley and built a new complex for Autonetics in Anaheim, in Orange County. When the structure was completed in the mid 1960s, it was the nation's largest single military electronics facility, with 3.3 million square feet of floor space and 36000 workers. The 20-building complex contained everything needed to design, fabricate, assemble, and test complete inertial guidance and flight control systems for a new generation of intercontinental ballistic missiles and advanced jet fighters.

When it came to new facilities, NAA followed Hughes's lead and designed Autonetics like a university campus so its PhD recruits would feel more at home. The main research laboratory included such touches as tropical gardens in the lobby, lava rock walls, and glass entries screened with artful tile and metal designs. Like its competitors, Autonetics provided its engineers with high salaries, paid postgraduate study, and enviable neighborhoods in which to raise their families (see figure 1). It also built a 20-acre recreation center with a three-section swimming pool, exercise rooms, a steam bath, baseball fields, tennis courts, and a pitch-and-putt golf course that together could have passed for a private country club.

The Rocketdyne and Atomics International facilities in Canoga Park transformed a sleepy San Fernando Valley suburb into a thriving hub of the military-industrial complex. With 10 000 employees, Rocketdyne built rocket engines for the military and for NASA, including the gigantic F-1 engines that powered the first stage of the Saturn V. Atomics International, with 9000 employees, designed experimental sodium-cooled nuclear reactors for electric power stations and compact SNAP (Systems for Nuclear Auxiliary Power) reactors. In 1965, one SNAP reactor, SNAP-10A, was placed in orbit to power a satellite. It remains the only fission reactor power system that the US has launched into space.

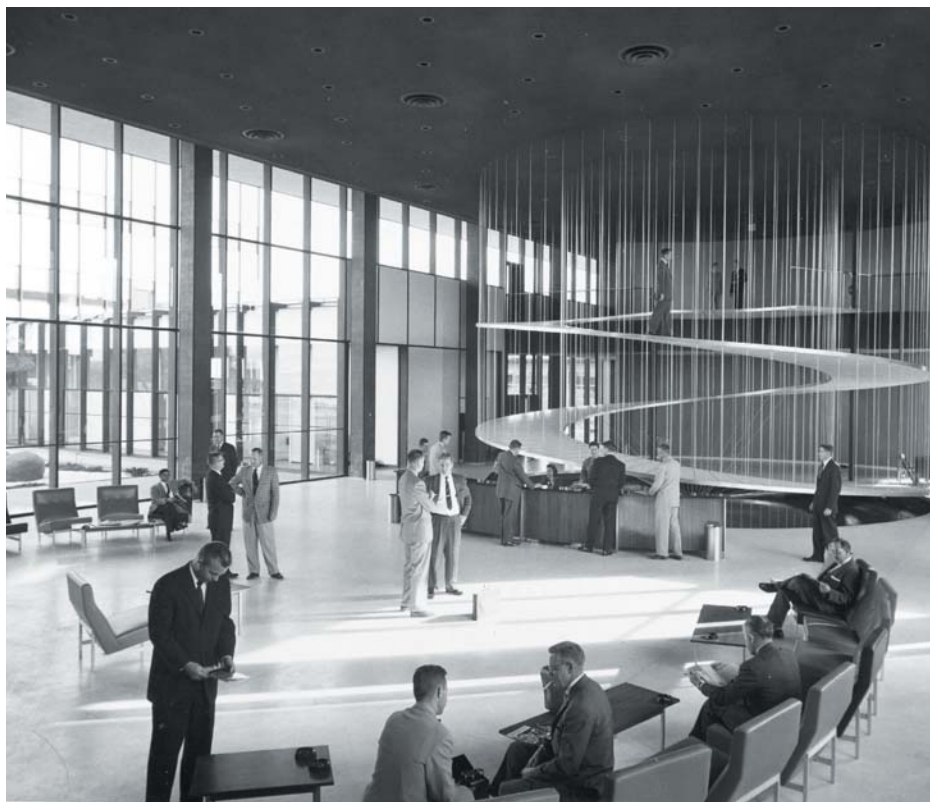


FIGURE 3. THE SUSPENDED ALUMINUM RAMP AT CONVAIR ASTRONAUTICS connected the lobby with the executive offices upstairs. Given that the photo was surely posed, missiles were clearly considered a man's game. (Courtesy of the San Diego Air & Space Museum.)

Rocketdyne opened in 1955, and within four years it employed 2260 women, a number of whom were scientists and engineers with graduate degrees in mechanical, electrical, and chemical engineering. One of them, Nasira Wilkins (see figure 2), was a bona fide rocket scientist with a physics degree from Howard University. As a Black woman, she was a trailblazer; Rocketdyne's parent company, NAA, refused to hire African Americans for any skilled positions until forced to by federal law in 1941, and then it did so only reluctantly. Predictably, Rocketdyne could not resist calling its female employees "Rockettes." The press release for the opening of its 15-acre Atomics Club featured two model-worthy employees in revealing swimsuits, "setting stage for summer splashing" in the new pool.⁶

An established firm, NAA had a reputation for being a somewhat undesirable place for scientists to work. To change that, the company followed Hughes and built its own basic research laboratory, known as the Science Center. The founding director, Howard Reiss, was the former head of research for Atomics International. He had spent almost a decade at Bell Labs and set out to re-create a smaller-scale version for aerospace. Rather than organizing the Science Center around research themes of direct relevance to NAA's manufacturing divisions—atomic power, guidance and control, propulsion, and aerodynamics—Reiss proposed something modeled after a university with departments of physics, chemistry, physical metallurgy, and mathematics.



Reiss was convinced that an academic style would most appeal to the kind of scientist he hoped to recruit. He thought something like 50 PhDs would be sufficient to start, but as he noted in a memo to corporate officers, each one had to be first rate: “It should be reiterated that such personnel will be attracted to the corporate research center only if the proper image can be created. Everything must be done to produce and maintain this image. Once we acquire outstanding personnel and are provided with proper funding and adequate working conditions, the rest will take care of itself. The essence of this image is the company’s display of enthusiasm for good science and the establishment of a permissive atmosphere in which creativity can flourish.”

What could convey the right image more forcefully than architecture? Reiss considered Bell Labs’ facility claustrophobic, with scientists sequestered like monks in identical 8-by-10-foot cells. He hired Albert Martin Jr to design something contemporary and chic for the Science Center. Martin had recently conceived stunning new corporate campuses for TRW, the Aerospace Corp, and Atomics International.⁷ He and Reiss chose a spectacular 66-acre site in Thousand Oaks overlooking a dry creek and adjoining the residential community. Given a generous budget, Martin came up with a laboratory worthy of the site. To blend into its suburban surroundings, he kept the laboratory one story, with tapered concrete stilts in soft white with exposed brown aggregate from a nearby quarry.

The Science Center’s architecture and location became an important recruiting tool for Reiss. In a remarkably short time, he pulled together an organization that could compete with Hughes, although not necessarily with the best East Coast laboratories, many of which were 10 or 20 times as big as the Science Center. In one memorable year, the Science Center staff published 600 papers, more than Bell Labs—a rare accomplishment indeed.

Beyond its scientific achievements, the Science Center became a port of entry for bright young scientists who eventually moved into management positions in other parts of NAA. Reiss correctly estimated that perhaps three-quarters of his staff would choose to relocate to Thousand Oaks or nearby suburban communities. Restrictive racial housing covenants meant that no African Americans could live there or in places such as Canoga Park, which had just two Black residents in 1960. Nonwhite employees would have to commute from Pacoima, a town 20 miles to the northeast that had suburban homes for sale to nonwhite residents. In the late 1960s, the town’s population was 79% African American.

Atoms for peace, and for profit

Founded in 1955 by defense conglomerate General Dynamics, General Atomics aspired to do for the nuclear age what General Electric had done for an earlier era. Its sister company Convair Astronautics constructed a \$20 million self-contained missile factory north of San Diego. There, 20,000 scientists, engineers, and technicians—the vast majority of them white and white collar—designed, manufactured, and tested the Atlas missile. The stunning lobby, the work of architect William Pereira, featured a suspended aluminum ramp rising out of the pool below, shown in figure 3, and epitomized aerospace modernism. Although an iconic image of the lobby depicts a couple

ascending the ramp, few women, aside from the secretarial staff, actually worked there.

General Dynamics considered atomic energy a key emerging market and backed its commitment with cash: \$10 million in startup funds to make General Atomics a world-class center for studying nuclear power. On the advice of Edward Teller, General Dynamics hired Frederic de Hoffmann to organize and staff its newest division. Along with many of the brightest physicists of his generation, de Hoffmann had spent the war in Los Alamos. After completing his doctorate at Harvard University, he returned to Los Alamos as Teller’s assistant on the hydrogen bomb project and was responsible for some of the trickier numerical computations. But it was nuclear power—the quest “to bring the sun down to the earth,” as he often put it—that truly captivated de Hoffmann.

With his inside contacts at Los Alamos and the Atomic Energy Commission (now the Department of Energy), de Hoffmann already knew virtually everyone in the field worth knowing. Now he had the money to make them offers they could hardly refuse. Hoping to recapture some of the magic of Los Alamos, de Hoffmann recruited heavily among its veterans. He lined up an all-star team of advisers, including Hans

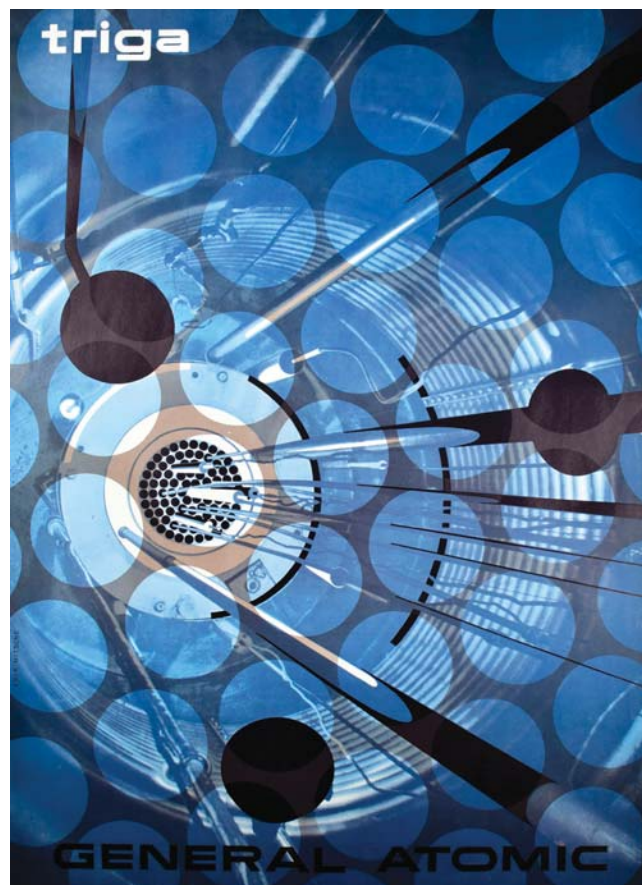


FIGURE 4. ERIK NITSCHKE’S ATOMS FOR PEACE POSTERS are now considered design classics. The Swiss graphic artist created this poster of General Atomics’ TRIGA reactor for the Second International Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland, in 1958. (Image from © The Museum of Modern Art/Licensed by SCALA/Art Resource, NY.)



FIGURE 5. AUTONETICS' NEO-BABYLONIAN ZIGGURAT in Laguna Niguel, California, was designed by William Pereira and completed in 1971. However, the company never occupied the 1-million-square-foot megastructure; instead, they swapped properties with the General Services Administration which placed federal agencies in the building. (Image from © J. Paul Getty Trust/Getty Research Institute, Los Angeles, 2004.R.10.)

Bethe, Richard Courant, Frederick Seitz, and Teller.

For the laboratory's director, he brought in Edward Creutz, a group leader at Los Alamos who had worked on the design of nuclear fuel elements. Creutz had gone on to head the physics department at Carnegie Institute of Technology (now Carnegie Mellon University) and build its synchrocyclotron. Together, Creutz and de Hoffmann would create one of the country's biggest and best physics departments, which boasted the highest percentage of PhD physicists of any corporate laboratory. They envisioned General Atomics as a university without students and without pressure to bring in outside grants.

The city of San Diego donated 320 acres of land on Torrey Pines for the General Atomics laboratory; the site overlooked sandy beaches and the Pacific Ocean. Creutz turned to Pereira to design a one-of-a-kind laboratory for a one-of-a-kind company. Based on his prior experience at universities and national laboratories, Creutz firmly believed that developing complicated new technologies would require interdisciplinary collaboration. Traditional campuses reinforced disciplinary isolation, so he encouraged Pereira to think outside the box. Pereira's hub-and-wheel laboratory ring design looked more like a tethered space station than a corporate laboratory. The central hub housed common areas—the cafeteria, executive dining room, and library—and the main laboratory buildings nearly encircled the hub. With their sky-blue spider leg motif, the laboratories looked like they had just touched down from the future.

Pereira's guiding aesthetic for the General Atomics commission might be dubbed California country club. The facility included tennis courts and an outdoor swimming pool, and the landscaping would have looked right at home at Torrey Pines Golf Course, which opened just west of the General Atomics

campus in 1957. The difference between an old-style eastern corporate laboratory and its upstart western rival was epitomized in the contrast between General Electric's red-brick industrial research laboratory in Schenectady, New York, and Pereira's space-age design for General Atomics in San Diego.

Its civilian projects got the press, but General Atomics' defense contracts made the money. The TRIGA (Training, Research, Isotopes, General Atomics) reactor, designed by Los Alamos veteran Ted Taylor and consultant Freeman Dyson, found a large market as a small, safe reactor for universities and hospitals (see figure 4). General Atomics also developed the HTGR (High-Temperature Gas-Cooled Reactor) with funding from a utilities consortium, although it failed to work out all the bugs before orders for nuclear power plants collapsed. A group of Texas utility companies put up \$10 million for research on fusion reactors, but nothing commercial came out of that effort either. For pure audacity, it would be hard to match Project Orion, the hydrogen-bomb-powered spacecraft envisioned by Taylor and Dyson for a mission to Mars.⁸

As fascinating as those projects may sound, General Atomics' viability, financially and otherwise, depended solely on US Air Force and Advanced Research Projects Agency funding for ballistic missile defense and other weapons studies. Its reputation was out of proportion to its size—fewer than 600 total employees in its early years and just 1350 by 1962. But the com-

pany set a high standard for laboratory architecture in San Diego, against which later icons, such as the Salk Institute, would measure themselves.

Between them, Convair Astronautics and General Atomics employed 224 physicists in 1960, along with some 7000 other scientists and engineers. Virtually all of them chose to live in new suburban developments in Kearny Mesa and La Jolla. Those neighborhoods were worlds (if not miles) away from older working-class neighborhoods like Linda Vista, which was once the largest public-housing complex in Southern California. During World War II, 3000 homes and 750 dormitories were built in Linda Vista for San Diego's aircraft and shipyard workers. After, it was home to 20 000 residents, and it was one of the few neighborhoods in San Diego County where African Americans could buy single-family homes.⁹

The crash of blue-sky California

As the Vietnam War heated up in the early 1970s, the space race wound down and demand shifted from strategic weapons back to conventional ones. California's aerospace industry lost 160 000 jobs, 80% of those in greater Los Angeles. The end of the Cold War brought an even more devastating downturn: Southern California lost 150 000 aerospace jobs from 1988 to 1996, then another 130 000 in the following decade as companies shut down or sold off entire divisions. Household names like Douglas, NAA, and Northrop disappeared in a wave of mergers, and with them entire aerospace complexes.

Many scientists and engineers suddenly found themselves confounded by a world where "Work Close to Home," Rocketdyne's slogan for luring employees to the suburbs of the San Fernando Valley, seemed a cruel irony. In 1995 Hughes closed down its modern-day company town in Fullerton, a place that for four decades had delivered on the promise of "the American dream—a large home with a yard and a pool, nice cars, a stable environment in which to raise children, and some money in the bank," according to a 1994 *Los Angeles Times* article. A real estate developer replaced the Hughes campus with a community of single-family homes and a shopping center.

California has fewer physicists now than it did at the height of the Cold War—still more than any other state, but scarcely more than runners-up Maryland and New Mexico.¹⁰ Boeing bought what was left of the Autonetics complex in 1996 and closed it a decade later; all that remains today is a monument to aerospace workers that was erected by Boeing in 2009. HRL outlived the company that created it and is now a jointly owned venture of General Motors and Boeing. It still attracts top talent for the same reasons as in the past: world-class science and a great location. Almost everyone mentions the ocean views and gorgeous sunsets, although the occasional killjoy rips HRL as an old aerospace company run like it was still 1965.

The NAA Science Center carries on as a division of Tele-dyne. General Atomics continues to thrive as a scientific workplace, with its midcentury modern style frozen in time and its idealistic founding mission of turning "atoms for peace" into "atoms for profit" long since supplanted by a more pragmatic business plan. Today General Atomics makes its money from Predator drones and their offspring and remains on the cutting edge of Southern California aerospace.

Fittingly, perhaps, no physicists or engineers ever got to occupy the biggest "aerospace" ever built in Southern California. In 1968 Autonetics purchased 1320 acres in Laguna Niguel, in southern Orange County, in preparation for a planned expansion. The company hired Pereira to produce a master plan for its \$20 million facility. Instead of a campus, Pereira designed a seven-tiered ziggurat in neo-Babylonian brutalism, the perfect metaphor for the Vietnam War-era bunker mentality of the military-industrial complex (see figure 5).

The building's facade stood as massive, forbidding, and unapproachable as a medieval castle. But with the collapse of its defense contracts, Autonetics found itself with the quintessential white elephant and traded it to the federal government, which found the ideal tenants for such a structure: the Internal Revenue Service and, later, the Department of Homeland Security and its Immigration and Customs Enforcement. Despite the loss of Autonetics, Laguna Niguel flourished as one of the largest and fastest-growing cities in Southern California in the 1980s. Its population was 84% white and less than 2% Black.

Symbolically, Pereira's ziggurat marked the end of the golden age of aerospace in Southern California. Hunter Thompson's 1971 elegy for the radical 1960s, *Fear and Loathing in Las Vegas*, applies just as well to the forgotten cold warriors who believed the sky was the limit and whose scientific contributions, many still classified, have never been fully acknowledged:

We had all the momentum; we were riding the crest of a high and beautiful wave.

So now, less than five years later, you can go up on a steep hill . . . and look West, and with the right kind of eyes you can almost see the high-water mark—that place where the wave finally broke and rolled back.

As the aerospace wave receded, it left behind a unique suburban geography with divisions of labor, class, race, and gender that will long outlast the industry that spawned it.¹¹

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