HYBRID PRACTICES

Art in Collaboration with Science and Technology in the Long 1960s

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FALLOUT AND SPINOFF

Commercializing the Art-Technology Nexus

PREAMBLE

This essay explores the intersections of artist and technologist communities of the 1960s through the lens of commercialization and engagement with the corporate world. It is part of my larger interest in the experiences of engineers and scientists who participated in formal collaborations like Experiments in Art and Technology (E.A.T.) and the Art and Technology (A&T) program at the Los Angeles County Museum of Art. My larger goal is a consideration of the emergence and maturation of what C.P. Snow in 1963 called the "third culture," in which hybridized professionals closed traditional gaps separating artists, engineers, and scientists.[1] Most recently, a version of this sentiment has surfaced in calls for a "STEM to STEAM" movement in which art and design are integrated with education in science, technology, and medicine.[2]

I originally intended this essay as a modest historical intervention. In the 1960s and 1970s, contemporary art critics and theorists writing about the "art and technology" movement (a label that I think is fair, given the scale, scope, and duration of these formal artist-engineer collaborations) gave very little, if any, consideration to the engineers who contributed time, technical expertise, and sometimes aesthetic input to their artist colleagues. They were, to most observers from the art world, simply "invisible technicians."[3] While the art and technology movement has received little attention in traditional historiography, the contributions to it by engineers and scientists remain even less examined, with barely any consideration given to their experiences or motivations.[4]

When contemporary art critics responded to the art and technology movement, their focus was primarily the *products* of artist-engineer collaborations. Here, the view was evaluative, considering whether the art produced was innovative and aesthetically pleasing: that is, whether the artist-engineer/scientist collaboration was "successful" on the basis of what they made. My point is not to condemn this perspective—art critics and theorists, not surprisingly, directed their gaze to the outcome and the object. But fifty years later we are not obliged to take the same approach, and we can expand our frame accordingly. We can instead shift our focus of inquiry to the *processes* and *practices* inherent in interdisciplinary efforts like E.A.T.'s *Pavilion* or a journal like *Leonardo.* The "E" in E.A.T. stood for "experiments." For example, what if we actually approached artist-engineer collaborations *as experiments* and adopted ideas from the history of science to treat them thus?

Obviously, historians of science and technology have a good deal of expertise on topics such as the nature of experiment, the "goodness" of research results, and the evaluation of technologies as successes or failures. Starting with these sorts of perspectives, I wish to see how perspectives from the histories of science and technology will contribute to new ways of thinking about the interactions and exchanges between artistic and engineering communities. I'm hoping that this essay might serve as an experiment in its own right—a sounding rocket, if you will—to explore these hybrid practices from a different vantage point and spark discussion about how the histories of technology, art, and science might better inform each other.

SEEING THE INVISIBLE TECHNICIAN

In June 1958, Frank J. Malina, an American living in Paris, requested patent protection for an invention he had made in France. Requesting a patent was nothing new for Malina. As one of the founders of Aerojet, a pioneering aerospace company, and then the Jet Propulsion Laboratory, Malina already had his name on several patents. This time, however, Malian's patent application was not about aerospace but art. Titled "Tableau d'aspect changeant"—the American version read "Lighted, Animated, and Everchanging Picture Arrangement"—it described the use of "illuminated stationary and movable transparent elements" that could "produce a pleasant and always changing composition of shapes and colors."[5]

A rocket engineer with degrees from Caltech, Malina had lived in Paris since 1947. His Aeroject stock, its value enhanced by Cold War tensions, gave him financial independence. In 1953, he began to transition from engineer to professional artist, a process further catalyzed by McCarthy-era harassment. A sketcher since boyhood, Malina quickly tired of the "nudes, flowers, landscapes, and dead fish" he found in Parisian galleries.[6] In 1955, he began to experiment with electric light as a medium in conjunction with moving parts to produce electro-kinetic paintings. Eventually, he began to refer to the technique he developed as his "Lumidyne system." His patent application represents just one of the outcomes of his engineering/art experimentation.

I had long been familiar with Malina's work as an aerospace engineer. Doubtless, Malina's earlier career as an engineer had taught him the importance of protecting one's intellectual property. However, while examining his papers at the Library of Congress, I was startled to discover his attempts to patent his *aesthetic* experiments. Further archival digging revealed some reasons why he chose this path. At about the same time as he sought patent protection, Malina also launched a start-up company. Electra Lumidyne International was based in Paris. Malina's goal was to adapt his art system to create displays for shop windows and airport terminals. Despite some interest from General Electric in the early 1960s, the effort didn't pan out, and Malina closed the company a few years later.[7]

Moreover, as he was refining what became his Lumidyne system, Malina learned "around 1957" through a friend about the "lumia" works made by the Danish-born artist Thomas Wilfred.[8] Although he didn't see have the opportunity to see one of Wilfred's works until 1959—Malina's passport was suspended by the State Department for much of the 1950s, rendering him unable to leave France—he could have sought out articles and other descriptions of them. The engineering-as-art techniques Wilfred developed well before World War II startled Malina with their similarity to his own work. Malina eventually learned of Wilfred's patents, and it's likely that this furthered his interest in seeking his own intellectual property protection.

Malina's experiences—this was several years before he founded the seminal art-science-technology journal *Leonardo*—offer us a one instance of engineers' engagement with artists during "the long 1960s." This time period, from roughly 1957 until 1974, coincided with engineers' growing concerns about the changing nature of their profession and their complicity in helping build the modern technological world, with all of its promise and peril.[9] The diverse practices reflected in the artist-engineer collaborations of this era, as well as people's reactions to them, have to be understood in light of this era's optimism and ambivalence about technology.

A constructive unit of analysis for thinking about the hybrid practices found in artist-engineer collaborations is that of *technological communities*. By this, I mean an assembly of people larger than a lab group yet smaller than a professional society. Frequently interdisciplinary in its outlook and practice, a technological community is often oriented around a particular project, instrument, or technique. Such communities possess distinct forms of knowledge, expertise, and objectives, be they aesthetic or technical or both.[10] Narrowing the focus further, we can think of artists and engineers forming hybridized *techno-aesthetic* communities that stabilize, dissolve, or persist over time. My special interest in these techno-aesthetic communities is experiences and motivations of the often-unrecognized engineers and scientists—what one historian, in a different context, called "invisible technicians"—who were nonetheless essential to the collaboration.

As I began to explore the archives that document formal artist-engineer-scientist collaborations—E.A.T., LACMA's Art and Technology program, and so forth—I started to notice more and more ventures like Frank Malina's—experiments not just in art but in entrepreneurship. Maybe this isn't surprising—why *shouldn't* artists or musicians try to patent or commercialize their ideas just as engineers do? But these activities suggested a framework in which to consider the intersections of the artists and engineers who made up these techno-aesthetic communities. One way to approach the question of mutual engagement is to be aware of shared practices. Direct engagement with the marketplace as evidenced by commercialization and patenting is one such practice.[11]

Actors from this period used some curious words to describe these interactions. One term, ominous given the era's thermonuclear threats, alluded to the technological fruits one might gather if the tree of artist-engineer collaborations was shaken—*fallout*. At a speech in 1966, some months before he cofounded E.A.T., Bell Telephone Laboratories engineer Billy Klüver observed that for too long "art has only been interested in the fallout . . . of science and technology."[12] Artists, in other words, had benefited from the research done by engineers and scientists. However, after *9 Evenings: Theatre & Engineering* debuted in October 1966, Klüver reversed the equation. Now he highlighted the "technical 'fallout'" that artist-engineer collaborations could generate.[13] In the words of John R. Pierce, Klüver's boss and a research director of communication sciences at Bell Labs, it was now industry's turn "to gain from the arts." Pierce noted that artist-engineer collaborations weren't just about burnishing the "public image" of corporations but extended toward imagining "new products." E.A.T. cofounder and fellow Bell Labs engineer Fred Waldhauer expressed similar thoughts, calling artists an "underdeveloped resource." The main payoff for industry would be "new ways of looking at and doing things."[14] Likewise, on the West Coast, LACMA curator Maurice Tuchman predicted that "collaborating personnel" (i.e., engineers and other technicians working with artists) could "gain experience directly valuable to the corporation."[15]

Another term—*spinoff*—that was part of the vernacular in the 1960s also speaks to the commercialization of the artist-engineer nexus. Popularized as larger corporate entities gave rise to new smaller companies, it soon became associated with the space race. For example, in 1962, NASA's head, James E. Webb, lauded the "spinoff benefits" that the Apollo program would generate for the American economy and society.[16] New business enterprises offered one such spinoff. Together, *fallout* and *spinoff*, two linguistic products of the Cold War, reflected some of the aims expressed by the art and technology movement and its supporters. Engineers could help introduce artists to the possibilities, processes, and products of modern industry while the experimental collaborations that resulted might prove profitable.[17]

This essay considers, using two examples, how the hybrid practices of the art and technology movement encountered the market, produced patents, and catalyzed the creation of new companies. Issues such as industrial sponsorship, funding sources, commercialization, and intellectual property have long engaged the attention of historians of modern science, while art historians have thoroughly investigated questions of patronage. My metapoint here is that practitioners' direct engagement with industry and the marketplace offers a useful vehicle for understanding collaborations between artists and engineers in the long 1960s. At the same time, it also suggests a patch of common ground for historians of art and science.

"ALL WE DID WAS SELL A CLOUD . . ."

Both examples explored here have a common origin—E.A.T.'s commitment to building a multimedia experimental art environment for PepsiCo as part of the Expo '70 fair in Osaka. Better known simply as the Pavilion, this was the apogee of the era's art and technology movement.[18] For the Pavilion building itself, Klüver and his E.A.T. colleagues had inherited an architectural design they disliked: a crumpled, false-geodesic dome.[19] Displeased with its appearance, they felt that the next best alternative was to try to artfully conceal it. To realize the effect of a "pavilion that could disappear," Klüver turned to Japanese artist Fujiko Nakaya.[20]

Born in Sapporo, Nakaya was the daughter of Japanese physicist Ukichiro Nakaya. During the mid-twentieth century, the elder Nakaya achieved prominence for his scientific investigations of snow. His research blended careful laboratory experiments in which he made artificial snowflakes with an aesthetic sensibility toward classifying their structure.[21] His daughter Fujiko came to the United States in the late 1950s to attend Northwestern University. She went on to study at the Sorbonne, where her interest was initially painting—she was especially fond of capturing the look of clouds. Around 1966, she met Klüver when she participated in the *9 Evenings* show. For the Osaka exhibition, besides handling logistics and smoothing over Japanese-American interactions, she designed the remarkable fog sculpture that would surround the building.[22]

For aesthetic as well as safety reasons, Nakaya insisted the fog be generated using pure water instead of some type of chemical.[23] Producing fog from pure water isn't easy, however. In nature, fog can occur when the temperature drops until the air is saturated with water and droplets condense. This could be done by dramatically cooling the Pavilion's roof. Another way to generate fog would be to heat water, which, when surrounded by cooler air, condenses. This is what gives rise to the fog that forms on a cold morning over a warm body of water. Both of these approaches, however, would require huge amounts of energy. But there was a third method. Fog can also be made by atomizing water—basically spraying tiny droplets of water into the atmosphere. In 1969, Nakaya learned of a scientist based near Pasadena who might be able to do this on the scale she wanted.

Thomas R. Mee was born in 1931 and grew up in Louisiana, where he received a bachelor's degree in physics. After a short stint as a naval aviator, he returned to Louisiana State University in 1957 for an advanced degree in physics. He was especially interested in oceanography and atmospheric science. Three years later, the Cornell Aeronautical Laboratory recruited him to work on a variety of projects related to weather modification.[24] In 1964, he accepted a research position at Meteorological Research Inc., a small company based in nearby Altadena, where he continued investigating ways to modify and control meteorological phenomena.[25] In 1969, Mee set out to start his own company, initially planning to make niche instrumentation for weather and pollution studies.

For several months in early 1969, Nakaya collected weather data at the Osaka site and carried out fog-generating experiments in Japan. Unsatisfied with her results, in June Nakaya contacted Mee at his brand-new company, Mee Industries Inc. He had never heard of E.A.T. but was "impressed by her knowledge of cloud physics." Moreover, he had met Nakaya's father at scientific conferences and was well aware of his snow research.

Mee was initially skeptical about generating enough fog to create an environmental sculpture that would envelop the entire 120-foot diameter Pavilion. But he agreed to experiment with Nakaya on a method to spray pure water under high pressure through very narrow nozzles and produce dense clouds of tiny water droplets. Mee took into consideration Nakaya's aesthetic preference for a "dense, bubbling out fog . . . [something] to walk in, to feel and smell, and disappear in."[26] A few months later, she and Mee met again and set up the equipment in his Altadena backyard. The heart of Mee's system consisted of stainless steel nozzles with openings about 160 microns wide (1 micron is a millionth of a meter). Pumps moved water through the system and kept it compressed at high pressure throughout a network of copper lines. At the tip of each nozzle was a tiny pin that broke up the water into an ultrafine cloud of water particles and created, to Mee and Nakaya's delight, a large cloud of fog that partially obscured Mee's house when they first tested it.

Wind-tunnel tests with a scale model of the Pavilion building followed to optimize placement of the system on the building's roof. In March 1970, Mee met Nakaya in Osaka to help supervise installation of a full-scale system. Ultimately, 2,520 of Mee's specially crafted nozzles atomizing some eleven thousand gallons of water an hour could enshroud the entire Pavilion in an ever-changing fog sculpture. The pure white fog that Mee's system generated poured down over the structure's irregularly angled and faceted roof and out over the fairground A control system allowed Nakaya to vary its density, with wind and humidity further varying the effect.

Nakaya and Mee's fog became the Pavilion's most visually striking exterior feature, the "symbolic guide" to the entire concept of the Pavilion.[27] One Pepsi executive observed that the "quietness, the fog around the dome" was "like the cloud that hovers near the top of Fujiyama."[28] Others more familiar with art history might have drawn comparisons to the mist and clouds commonly found in pre-eighteenth-century Japanese landscape paintings.

Mee had originally planned for his nascent company to make instrumentation for meteorological applications. However, his collaboration with Nakaya and the success of the Osaka system prompted him to think about other directions. The era's utopian and ecological leanings also drove Mee's interest in commercializing his fog system. As he told one interviewer in December 1969, "I'm totally involved in this environmental thing now. . . . It opens up a possibility of farming the desert, literally."[29] Nilo Lindgren, a writer from *IEEE Spectrum* who was documenting the Pavilion collaboration, asked Mee if he had signed away his patent rights to Pepsi. Mee brushed the concern aside, stating that "all we did was sell a cloud." Meanwhile, he said, "some attorneys" were exploring whether he had a "patentable product."[30] After Expo '70 ended, Mee filed for patent protection to cover an "Environmental Control Method and Apparatus" derived from his Pavilion work.[31] The system, he imagined, had many possible uses. His patent application cited the possibility of using it for agricultural purposes, either for cooling farm areas or for preventing frost, as well as for producing a "visible cloud" that gave a "highly decorative and entertaining effect."[32]

Artist Nakaya also pursued protection for her intellectual property. In the late 1980s, she applied for a patent in Japan covering a "system/apparatus for making a cloud sculpture from water-fog." But whereas Mee's interests were directed toward his commercial interests, Nakaya was more interested in having the patent serve as a record of her experimental techniques. As she later explained, this was an opportunity to describe and define the "seemingly amorphous fog sculpture in the hardest language of law." She worked with a Japanese scientist and a patent lawyer from Sony to develop language that would express "the structure and physical properties of this visually ephemeral phenomenon."[33] Unlike Mee, Nakaya never realized any profit from her patent.

Mee's patents directly resulted from his collaboration with Fujiko Nakaya. In 1971, Mee took his small company public and moved his manufacturing operations from his garage to a larger building in San Gabriel, employing some thirty people. By 1985, sales by Mee Industries were approaching $2 million. After some rough financial times, the company rebounded when Mee's children took over the business and secured a controlling interest in the firm. Originally providing equipment for environmental applications, the company saw a big expansion in 1997 when the Tennessee Valley Authority decided to install fog systems on its electric power turbines to improve their efficiency. Similar orders followed, and the company expanded into other areas such as providing cooling for data server installations. By 2014, some eighty people worked for the company and sales were over $10 million annually.[34]

Even as his company gradually grew, Thomas Mee continued his collaborations with Nakaya. These interactions continued after his death in 1998. Mee Industries contributed hardware to installations Nakaya designed for sites like the Guggenheim Museum in Bilbao. More recently, her *Fog Bridge* was integrated into the new site for the Exploratorium in San Francisco. Although most of the company's hardware was used for industrial purposes, Nakaya's environmental sculptures allowed "millions of people around the world to appreciate fog's natural beauty" and perhaps sense what the many visitors to the Pavilion had once experienced.[35]

"THE VISUAL ART OF THE FUTURE"

Although Klüver and E.A.T. were based in New York City, a good deal of the work that went into making the Pavilion a reality happened in Los Angeles, where there was a strong local E.A.T. chapter. One of its most active members was Elsa M. Garmire. Originally trained at MIT, where she received her doctorate in physics, she moved to California in 1966 for a postdoctoral position at Caltech. Caring for two young children and unimpressed by the school's treatment of women faculty, Garmire began to consider other career paths. The possibility of using technology "in a non-logical, artistic way" intrigued her, and, in the summer of 1968 she approached E.A.T. about serving as the "part-time technical director" for the group's West Coast efforts.[36] Klüver, impressed by her research credentials and enthusiasm, invited her to participate in a panel on art and science at the American Association for the Advancement of Science's annual meeting. Over the next several months, Garmire also became increasingly involved with E.A.T.'s Pavilion project.

Garmire's research specialty—like Klüver's—was laser physics. The first optical laser had been demonstrated only in 1960. Garmire's adviser at MIT was Charles H. Townes, who shared the 1964 Nobel for research leading to the invention of the laser. When she arrived at Caltech, lasers were still expensive, delicate, laboratory-based devices that required experts to build and operate. Working with lasers in the 1960s was cutting-edge science that had a hint of glamour and a high-tech futuristic sheen.[37] Press releases and newspaper articles about Klüver, for example, often highlighted his field of expertise at Bell Labs.[38] The relative novelty of the laser, Garmire's position as a woman in a male-dominated field, and the high visibility of her graduate adviser all put her in a unique position circa 1968 when E.A.T.'s involvement with the Pavilion got started.

An active member of the E.A.T. branch in Los Angeles, Garmire organized a "Cybernetic Moon Landing Celebration" in mid-July 1969 at Caltech.[39] In addition to dance performances and multimedia demonstrations, Garmire helped build a "laser wall" in which a low-power argon laser beam was spread out into multiple lines of color that people could walk through.[40] A broader goal of the festival was to directly involve the "industrial community in the collaborative process of art and technology."[41] A short piece Garmire wrote for her local E.A.T. chapter's newsletter expresses her thoughts on the relationship between technology and art. "Technological art," she explained, "is the first step toward eliminating this divinity of technological wonders. . . . The technological artist approaches and utilizes the incomprehensible for his own ends in ways often irrelevant to the original 'purpose' of the device."[42] Her modification of the laser for artistic purposes was an extension of this idea.

For the Pepsi Pavilion, Garmire's main contribution was helping design the giant spherical mirror that nestled inside the building's crumpled exterior. Besides helping oversee its construction and testing in California, she traveled to Japan to oversee its installation.[43] Back in Pasadena, though, she was becoming more interested in lasers as an artistic medium. Initially, Garmire created what she called "lasergrams"—photographs of images made by shining blue and red laser lights through diffraction media. A variation on this was a live laser show she made using a helium-neon laser, which produced a red beam of light, and rotating diffraction wheels. Caltech's public relations department stirred up attention for her artwork. Unfortunately, the San Fernando earthquake of February 1971 overshadowed Garmire's opening at a local gallery and also damaged some of her pieces.

However, Garmire's live laser show—she displayed it at a conference on art and technology at the University of Southern California in May 1970—caught the attention of Ivan Dryer. A Los Angeles–based filmmaker, Dryer was also an "astronomy freak" but one more interested in the "mystiques of space . . . not the mechanics of it."[44] Before moving into the film industry, Dryer also worked as a guide at Griffith Observatory in Los Angeles. After seeing Garmire's presentation, Dryer and his colleague Dale Pelton visited her Caltech lab and filmed the "marvelous shapes and forms" that Garmire's laser system generated.[45]

Dryer soon realized that filming Garmire's laser images was aesthetically inferior to seeing the intensity and purity of their colors in person. In the fall of 1970, he arranged for a live and—to his eyes—captivating demonstration of Garmire's system, accompanied by classical music, for Griffith staff in the observatory's planetarium dome. The observatory management—seeing entertainment, not education—was less enchanted. Undaunted, Dryer, Pelton, and Garmire cofounded a company in February 1971 called Laser Images Inc. Riffing on the popularity of planetarium shows, they called their product "Laserium."[46]

For the next few years, Dryer and Garmire worked intermittently to perfect their laser show and attract interest. A representative from Spectra-Physics, a Southern California company that made some of the first commercial lasers, loaned them a krypton laser system that could produce multiple colors.[47] In June 1973, they invited Griffith Observatory's new director, William Kaufmann III, to see an improved demonstration. Kauffmann, then in his early thirties, had a more liberal view of what the public might want to see at the observatory, and he arranged for Dryer and McDonald to have access to the planetarium dome.

In mid-November 1973, spurred by Dryer's appearance on a morning television show, some seven hundred people showed up at Griffith for the debut of what became known simply as Laserium. Classical music and art rock provided the soundtrack for watching multicolor laser images projected in real time on the planetarium's starry background. For a few dollars, attendees received a stimulating audio and visual experience. For many of them, it was likely the first time they had seen a laser's light effects. With its multisensory nature, one might compare Laserium to other projects like Stan VanDerBeek's earlier experiments with his Movie-Drome.[48] VanDerBeek had a loose affiliation with E.A.T. and even gave a presentation of his work to artists and engineers in 1968.[49] While no evidence in the historical record suggests that Garmire and company were aware of his work, we might think of Laserium and Movie-Drome as parallel attempts to create a multimedia experience for an audience.

After Laserium's debut, word of mouth helped expand the audience, and, by the time the initial four-week engagement ended, hundreds of people were being turned away for laser shows at Griffith. A year after it opened, Los Angeles's mayor proclaimed "Laserium month."[50] Around this time, Garmire began shifting her creative energies back to science and left Laser Images Inc. amicably. Before doing this, however, Garmire contributed technical input and imagery to a short film, filled with "hallucinogenic visuals," that Pelton created called *Death of the Red Planet*.[51] After leaving Caltech and overcoming the sexism young women scientists encountered, Garmire went on to have a very successful scientific career in laser science and physics at the University of Southern California (1974) and then Dartmouth College (1995), eventually becoming a dean of engineering at Dartmouth and president of the Optical Society of America.

By 1977, Dryer's growing team of live laser performers was putting on shows in more than fifteen cities and Laserium was a registered trademark. After starting with custom-designed equipment, eventually Dryer and his colleagues based Laserium around a standard system. The details of this are preserved in the patent application Dryer and two colleagues filed in July 1975. It described a "laser light image generator" that can create a "plurality of light images in different colors from a single laser light."[52] The heart of the system was a one-watt krypton gas laser that would be split by prisms into four colors. Other optics, scanners, and oscillators allowed for rapid image movement, closed linear shapes, Lissajous figures, and so on. An operator sat at a console where she could access the variety of switches and joysticks used play the laser "instrument." A four-track tape deck had music in stereo as well as audio for the show's introduction and narration synched to the visuals. For new operators, a "teach track" could help them learn the system and the best timing for performances. The basic format of each show was preprogrammed by the "laserist," but this person had considerable opportunity to vary and change the tempo and image sequences. Since Laserium shows were live performances, their quality, as well as the audience's response, depended on the skill and imagination of the system operator.

Laserium represents an extreme form of commercialization that began with Elsa Garmire's involvement with E.A.T. and her personal desire to connect her scientific research to art and aesthetics. Just as planetarium shows helped popularize astronomy in the twentieth century, Laserium can be interpreted as a public display of laser technology, its roots traceable back to nineteenth-century displays of electricity and electrical effects.[53] Unconventional to be sure, Laserium was not without some aesthetic admirers. One art writer, for example, referred to experiments with laser projection as the "seeds of what will become the high, universally acclaimed visual art of the future."[54] Given Laserium's penchant for attracting attendees whose appreciation of choreographed laser light was chemically enhanced, "high" visual art assumes another meaning as well.

After peaking in the late 1970s, when some seventy people worked for the company, Laserium slowly faded in popularity.[55] Often lampooned as the preferred entertainment of potheads and LSD trippers, we can understand Laserium as the somewhat disreputable cousin of the venerable planetarium show.[56] Nonetheless, by 2002, some twenty million people around the world had seen a Laserium show—its run at Griffith lasted some twenty-eight years—and its idiosyncratic blend of music and spectacle had become part of popular culture. Was Laserium art?[57] It's debatable but not germane to the argument here. While maybe not quite the "technical fallout" that laser scientist Klüver had imagined, Laserium, like Mee's fog, was a commercially successful result from the productive artist-engineer collaborations of the late 1960s.

IS ART WHAT ARTISTS DO?

Like engineers and scientists, artists in the 1960s struggled to fathom societal changes catalyzed by new, more pervasive, and more powerful technologies.[58] Both communities were repositioning and redefining themselves in the midst of great technological change as well as reevaluating their place in society and their relevance to it. Like their engineering counterparts, they looked to writers like Lewis Mumford, Jacques Ellul, Herbert Marcuse, C.P. Snow, and Thomas Kuhn for ideas, critiques, and explanations. And, like engineers, artists in the 1960s faced the opportunity and challenge of satisfying new patrons with their work. Corporate sponsors, state arts programs, and the federal government all helped create a "new paradigm" for funding, making, and collecting art.[59] E.A.T. and LACMA's A&T program both stand out as formal efforts to link artists not just to engineers but also to corporate sponsors.

Since the 1980s, historians of science have developed a robust historiography that explores the relationships between scientists, engineers, and the patrons—military, industrial, governmental, and academic—that supported so much of their work. A classic perspective on this relation, familiar to historians of science but perhaps not of art, was formulated by Paul Forman in the 1980s as the Cold War newly intensified. Refined, affirmed, and occasionally challenged by scores of scholars since, Forman's argument was that the Cold War distorted the very nature of technical and scientific knowledge that researchers produced. Scientists and engineers increasingly oriented their research and projects to conform with the interests of their patrons. As Forman provocatively claimed, scientists lost control of their disciplines, sacrificed autonomy, and made ethical and intellectual compromises.[60] Those scientists and engineers who maintained otherwise were self-deluded.[61]

We can find parallels to this historical interpretation in the contemporaneous negative reactions of art critics to both artist-engineer collaborations and the corporate sponsorship that underwrote the art and technology movement in general.[62] Articles in major art magazines excoriated, as one vociferous critic labeled it, the "multimillion dollar art boondoggle" that this "experiment in patronage" had produced.[63] While this invective focused specifically on LACMA's A&T program, it spilled over to stain artist-engineer collaborations in general.

In these critiques, if not outright condemnations, of partnerships underwritten by corporate patrons, one detects a sense that writers lamented a loss of purity on the part of the artist. At the very least, writers like David Antin, Amy Goldin, and Max Kozloff described artists as morally and aesthetically compromised by their encounters with engineers and the corporate world. Kozloff, in the heated language common to the Vietnam protest era, charged artists with not hesitating "to freeload at the trough of that techno-fascism that had inspired them." Abetted by their engineer collaborators, artists were nothing but "would-be magi, con-men, fledgling technocrats, acting out mad science fiction fantasies."[64] What resulted, in other words, was impure art.

Historians of science have devoted much attention to the question of "pure science"—the illusory idea that certain research might be free of commercial interest, corporate sponsorship, military ties, or even practical applications.[65] "Pure science" is primarily an actors' category, not a fixed historical entity. But, while art critics of the early 1970s were not so naive as to speak of "pure art," when we look past the florid language, critiques about art and technology around 1971 bear more than a passing resemblance to Forman's thesis. Just as historians castigated certain forms of Cold War science, critics and artists asked whether art was being diverted from a truer, purer path by corporate patrons and their engineer employees. Of course, this interpretation is limited by the assumption that there is some *natural* path that science in its pursuit of Truth, or Art in its pursuit of Beauty, should develop along.

But there were, of course, other ways of reading the evidence that Forman and others used to buttress their Cold War–driven "distortion thesis." Daniel J. Kevles, then a historian at Caltech, rejected claims that military largesse and patronage had somehow "seduced" researchers. Alliances that new patrons and accommodation of military needs gave scientists expanded opportunities and opened new research paths. Kevles came to the somewhat opaque conclusion that "physics is what physicists do."[66] Given that artist-engineer collaborations blossomed in the same Cold War environment that yielded missiles, MIRVs, transistors, and Telstar, perhaps we could make the symmetrical claim that "art is what artists and their engineer collaborators did."[67]

Artists collaborated with engineers and accepted corporate patronage with open eyes; they were neither duped or deluded. Moreover, the partnerships with industry that LACMA and E.A.T. encouraged *did* offer artists new opportunities and access to new technologies. Instead of thinking about concepts like purity and distortion, maybe one can ask a different question—does the *history* of a particular technology (such as lasers, computers, artificial fog) matter for how we think about the *artistic* ends it was used for?[68]

Frank Malina's short-lived Electra Lumidyne International, Mee Industries, and Laser Images Inc. are just three instances where the intermingling of art and engineering led to the marketplace. Examples like these—and there are many more—offer potentially valuable entry points for exploring the mutual interests that artists and engineers shared.[69] In these commercial activities, we also find the planting of seeds that would flower into a new "third culture" of even more market-minded hybrid artist/technologists in the late 1980s and 1990s.[70] Then and now, the desirable outcomes of fallout and spinoff helped drive art-technology collaborations and inspire the formation of new techno-aesthetic communities.

NOTES

I've benefited from suggestions by Michael D. Gordin, Anne Collins Goodyear, Douglas Kahn, and Roger Malina. I would also like to thank the organizers and sponsors of the Hybrid Practices Conference for inviting me to the conversation.

1. Charles Percy Snow, *The Two Cultures and a Second Look* (Cambridge: Cambridge University Press, 1969).

2. See, for example, ideas presented at "Stem to Steam," n.d., accessed June 2015, http://stemtosteam.org/.

3. Steven Shapin, "The Invisible Technician," *American Scientist* 77 (1989): 554–63. For example, when critic Barbara Rose—who was generally sympathetic to art-technology collaborations—wrote about artist Robert Whitman's work in 1974, she neglected any mention of Whitman's frequent collaborator, engineer John F. Forkner; Barbara Rose, "Considering Robert Whitman," in *Projected Images: Peter Campus, Rockne Krebs, Paul Sharits, Michael Snow, Ted Victoria, Robert Whitman* (Minneapolis: Walker Art Center, 1974), 38–45.

4. Edward A. Shanken, "Historicizing Art and Technology: Forging a Method and Firing a Canon," in *MediaArtHistories,* ed. Oliver Grau (Cambridge, MA: MIT Press, 2007), 43–70.

5. Quotes from the US version. Malina received the French patent on June 29, 1959. Malina also applied for and received similar legal protection in the United States (requested on December 11, 1961; received December 15, 1964) and the United Kingdom (received 1962) as well. Folder 6, box 41, Frank J. Malina Papers (MSS61793), Manuscript Division, Library of Congress, Washington, DC (hereafter, FJM).

6. Frank J. Malina, "Electric Light as a Medium in the Visual Fine Arts: A Memoir," *Leonardo* 8 (1975): 109–19.

7. Malina's correspondence shows that he was starting to think about founding the company around October 1958; folder 13, box 22, FJM; see also Malina, "Electric Light," 115–17.

8. Malina to Martin Summerfield, May 25, 1962, folder 7, box 39, FJM.

9. Matthew Wisnioski, *Engineers for Change: Competing Visions of Technology in 1960s America* (Cambridge, MA: MIT Press, 2012).

10. Ann Johnson, "Revisiting Technology as Knowledge," *Perspectives on Science* 13 (2005): 554–73.

11. A corollary to this, although beyond the scope of this essay, is the question of how the art market and patronage opportunities for artists were themselves changing in this period.

12. Billy Klüver, "The Great Northeastern Power Failure," talk given January 28, 1966, Experiments in Art and Technology, 1966–77 collection, Archive of American Art, Smithsonian Institution (hereafter E.A.T./AAA).

13. Billy Klüver to E.A.T. board members with general note to E.A.T. members, Billy Klüver, "Interface: Artist/Engineer," talk presented at MIT, April 21, 1967, and Billy Klüver, "Theatre and Engineering: An Experiment. 2. Notes by an Engineer," *Artforum* 5, no. 6 (February 1967): 31–33, all in E.A.T./AAA. In the introduction for the *9 Evenings* program that accompanied the show, Klüver, in discussing the show's equipment, noted "commercial potential of discoveries made as a result of its development."

14. John Pierce, statement, n.d. but ca. early 1967, folder 18, box 4, Experiments in Art and Technology Records, Getty Research Institute, Los Angeles (hereafter E.A.T./Getty). Also, Fred Waldhauer to Emmanuel Piore, draft letter, June 12, 1967, folder 18, box 4, E.A.T./Getty.

15. The language appeared in the original promotional brochure for the LACMA program that was distributed to industry executives; the excerpt from this is on p. 11 of Maurice Tuchman's *Art and Technology: A Report on the Art and Technology Program of the Los Angeles County Museum of Art, 1967–1971* (New York: Viking Press, 1971). However, even as artists were seen as new sources of corporate creativity, with the supposed benefits of artist-engineer collaborations flowing in both directions, according to E.A.T.'s policy at least, any "patents and commercial ideas" would still "belong to the industrial laboratory." *E.A.T. News* 1, no. 1 (1967): 2, folder 6, box 138, E.A.T./Getty.

16. James E. Webb, "The Role of Government in Scientific Exploration," in "Proceedings of the Second National Conference on the Peaceful Uses of Space, May 8–10, 1962," 21, NASA Technical Report, https://ntrs.nasa.gov/search.jsp?R=19630001263. In that same year, NASA started an "Industrial Applications Program," later renamed the NASA Technology Utilization Program. Its goal was

to “increase the return on national investment in aerospace research” by encouraging “additional use” of the knowledge and experience gained. In 1976, the reports from this program were named *Spinoff.*

17. Christopher R. De Fay, “Art, Enterprise, and Collaboration: Richard Serra, Robert Irwin, James Turrell, and Claes Oldenburg at the Art and Technology Program of the Los Angeles County Museum of Art, 1967–1971” (PhD diss., University of Michigan, 2005).

18. The Pavilion’s history—its origins in 1967, the effort by scores of E.A.T.-coordinated artists and engineers to build it, its debut in March 1970, and its ignominious denouement when Pepsi terminated its relationship with E.A.T. just weeks later—is preserved in several boxes at the Getty Research Institute and is well documented by art historians. Three key references are Billy Klüver, Julie Martin, and Barbara Rose, *Pavilion* (New York: E.P. Dutton, 1972); Norma Loewen, “Experiments in Art and Technology: A Descriptive History of the Organization” (PhD diss., New York University, 1975); and Anne Collins Goodyear, “The Relationship of Art to Science and Technology in the United States, 1957–91: Five Case Studies” (PhD. diss., University of Texas at Austin, 2002).

19. Frosty Meyers, interview by Nilo Lindgren, December 4, 1969, box 140, E.A.T./Getty.

20. John Pearce, “An Architect’s View,” in Klüver, Martin, and Rose, *Pavilion*, 256.

21. Snowflakes, he wrote, were “hieroglyphs sent from the sky.” The quote comes from the September 1962 obituary of Nakaya in *Arctic*. See also Ukichiro Nakaya, *Snow Crystals: Natural and Artificial* (Cambridge, MA: Harvard University Press, 1954).

22. Anne-Marie Duguet, ed., *Fujiko Nakaya—Fog* (Paris: Éditions Anarchive, 2012).

23. Dry ice, for example, was considered but was ruled out by the Expo Association’s Health Department on the grounds that the excess CO2 produced would attract mosquitoes to the fair grounds. Fujiko Nakaya, “Making of ‘Fog’ or Low-Hanging Stratus Clouds,” in Klüver, Martin, and Rose, *Pavilion*, 207–23. Also, Marina McDougall, “Learning to Love the Fog,” in Exploratorium, *Over the Water: Fujiko Nakaya* (San Francisco: Exploratorium, 2013), 8–19.

24. A number of these projects were funded by the Department of Defense; these included Project Whiteout, an army-funded effort in the early 1960s to see if it was possible to dissipate blizzard whiteouts in Arctic conditions.

25. This company was started in 1951 by Paul MacCready (1925–2007), a Caltech graduate who later became famous for designing and building the Gossamer Condor, a human-powered aircraft. MacCready later started another company, AeroVironment, which today is one of the largest manufacturers of unmanned aerial vehicles (“drones”).

26. Nakaya’s experimental approach is well documented in her “Making of ‘Fog’” essay. Also, see Nilo Lindgren’s essay “Into the Collaboration” in Klüver, Martin, and Rose, *Pavilion*, 40–48.

27. Pearce, “Architect’s View,” 257.

28. Lindgren, “Into the Collaboration,” 48.

29. Tom Mee Jr., interview by Nilo Lindgren, December 10, 1969, folder 5, box 140, E.A.T./Getty.

30. Ibid.

31. Thomas R. Mee, “Environmental Control Method and Apparatus,” US Patent 3,788,542, filed December 31, 1970, issued January 29, 1974.

32. Thomas R. Mee, "Nozzle for Producing Small Droplets of Controlled Size," US Patent 3,894,691, filed January 7, 1974, issued July 15, 1975. In 1974, when his initial patent was awarded, Mee applied for another to specifically cover the design of his system's nozzles.

33. Fujiko Nakaya to author, pers. comm., December 12, 2014. Nakaya noted that she had considered applying for a US patent but had found the process too expensive.

34. "The Histories of Mee Industries Inc.," unpublished document, n.d., in author's personal files; Brian Keppel, "Cools, Humidifies: Tom Mee's Fog Machine Winning Place on the Farm," *Los Angeles Times,* May 2, 1985, H1; D'Arcy Sloan to author, pers. comm., November 11, 2014.

35. Mee Industries Inc., *MeeFog™ Sculpture Welcomes Visitors to New San Francisco Exploratorium*, 2013 promotional brochure, 2013, www.meefog.com/wp-content/uploads/Exploratorium_Web-2.pdf.

36. Else Garmire, "Resume," July 1968, folder 14, box 124, E.A.T./Getty.

37. This was an abrupt change for optical science, a field of physics that before the laser had relatively moribund. Joan Lisa Bromberg, *The Laser in America, 1950–1970* (Cambridge, MA: MIT Press, 1991).

38. The very first article about Klüver in the *New York Times* described how, "hunched over a big aluminum table, he does modulation experiments with lasers"; Grace Glueck, "Scientist Brings Art to His Work," *New York Times,* December 17, 1965, 48.

39. Materials on the Moon Landing Celebration are in folders 12 and 13, box 29, E.A.T./Getty.

40. Elsa Garmire, "Elsa Garmire and Art," unpublished document, August 2013, copy in author's personal papers.

41. "E.A.T. Report 1970: Los Angeles," September 18, 1970, folder "Documents 6/1/70–5/30/71," Experiments in Art and Technology Records, 1966–77, Archives of American Art, Smithsonian Institution, Washington, DC (hereafter AAA/DC).

42. Elsa Garmire, "Art and Technology: Ruminations of an Engineer," *E.A.T.L.A.*, no. 1 (January 1970): 5.

43. Garmire also wrote an excellent technical overview of the entire Pavilion; this essay appeared in Klüver, Martin, and Rose, *Pavilion*, 173–206.

44. "It's 2001 and a "Drugless High' as Ivan Dryer Sets Laser Beams to Music," *People,* January 26, 1976, www.people.com/people/archive/article/0,,20066089,00.html.

45. Ivan Dryer, "Applications Pioneer Interview: Ivan Dryer," *Laser and Applications,* October 1986, 53–58.

46. The idea of live laser shows did not originate with Dryer et al. Cross, a multimedia artist, claims to have performed the first "public multi-color laser light show" in May 1969 at Mills College. Cross would go on to collaborate with Berkeley physicist Carson D. Jeffries and composer David Tudor to create a laser light show for the Pepsi Pavilion; see Lowell Cross, "The Laser Systems: Timeline," 2005, www.lowellcross.com/timeline/laser/, as well as material in Klüver, Martin, and Rose, *Pavilion.*

47. Dryer, "Applications Pioneer Interview," 54. For spectra-physics, see Bromberg, *Laser in America*, 119–21.

48. Gloria Sutton, *The Experience Machine: Stan VanDerBeek's Movie-Drome and Expanded Cinema* (Cambridge, MA: MIT Press, 2015).

49. Box 128 of E.A.T./Getty contains materials for this and the other technical presentations the organization sponsored.

50. “Mayor Proclaims ‘Laserium Month,’” *Los Angeles Times,* December 25, 1974, F17.

51. Dale Pelton, “‘Death of the Red Planet’ Filmed in Laser Images,” *American Cinematographer* 54, no. 7 (July 1973): 842–43, 902.

52. Dan Slater, Ivan M. Dryer, and Charles W. McDonald, “Laser Light Image Generator,” U.S. Patent 4,006,970, filed July 14, 1975, issued February 8, 1977.

53. Iwan Rhys Morus, *Frankenstein’s Children: Electricity, Exhibition, and Experiment in Early-Nineteenth Century London* (Princeton, NJ: Princeton University Press, 1998); Jordan D. Marché, *Theatres of Time and Space: American Planetaria, 1930–1970* (New Brunswick, NJ: Rutgers University Press, 2005).

54. Andrew Kagan, “Laserium: New Light on an Ancient Vision,” *Arts Magazine,* March 1978, n.p., www.laserium.com/laserium_origins/pr-ArtsMagazine197803.pdf. This article describes Laserium with references to Thomas Wilfred’s Lumia works, Moholy-Nagy’s light-based art, and so forth.

55. The figure of seventy people comes from a 1975 brochure, *Experience Laserium: The Cosmic Light Concert,* copy in author’s possession.

56. A point acknowledged on the Web page of the Laserium company, www.laserium.com/culture/index.html (accessed December 15, 2014).

57. Brian Wirthlin, one of the early operators of Laserium, wrote in 2002: “The term Laserist used to bother me. Laser Artist, how pretentious can you be? It was just technology—wasn’t it? I loved Laserium, but it wasn’t Art. I mean Art is . . . well of course I mean Real Art, not some modern self indulgent crap . . . but on the other hand, I’ve seen self-indulgent crappy Laser Shows. . . . They definitely weren’t Art. . . . Of course the first Laserium Show’s technology was lightyears (pardon the pun) behind even Laserium II, but I’d travel to see it again . . . Hell what is Art anyway?” Brian Wirthlin, “Digital Graphics and Laserium Remembrances,” post to Laserist List mailing list, July 9, 2002, www.famous-company.com/pm_laseristlist-histories.htm#bw_digital-laserium. While Laserium was certainly a pop application of laser light for entertainment purposes, there were several “serious” efforts to make laser-based art in the 1960s and 1970s, including notable work by artist Rockne Krebs that LACMA featured in its 1971 Art and Technology show. According to the 1971 catalog, at least four other artists considered using lasers in some fashion, and, of course, lasers were central to the emerging art form of holography.

58. Wisnioski, *Engineers for Change*; Kelly Moore, *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, 1945–1975* (Princeton, NJ: Princeton University Press, 2008).

59. Discussed in De Fay, “Art, Enterprise, and Collaboration,” 64–66; see also chap. 2 of Mark W. Rectanus, *Culture Incorporated: Museums, Artists, and Corporate Sponsorship* (Minneapolis: University of Minnesota Press, 2002).

60. This argument is stated in Paul Forman, “Behind Quantum Electronics: National Security as Basis for Physical Research in the United States, 1940–1960,” *Historical Studies in the Physical and Biological Sciences* 18 (1987): 149–229.

61. There is some ironic symmetry here. In a 1992 article, Forman also decried scientists' efforts to pursue patents and commercialization in the postwar era. The object of his opprobrium was Charles Townes, Elsa Garmire's adviser and a co-inventor of the laser. Paul Forman, "Inventing the Maser in Postwar America," *Osiris* 7 (1992): 105–34.

62. Some historical context for this backlash appears in Goodyear's "Relationship of Art," but there is room for further examination.

63. Max Kozloff, "The Multimillion Dollar Art Boondoggle," *Artforum* 10 (1971): 72–76. Critics' reaction is well covered in chap. 6 of Goodyear, "Relationship of Art."

64. Kozloff, "Multimillion Dollar Art Boondoggle." One wonders, however, to what degree these critiques were aimed specifically against artist-engineer collaborations and to what degree they served more as proxies for larger critiques of corporate power, militarism, and so forth.

65. Steven Shapin, *Never Pure: Historical Studies of Science as If It Was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority* (Baltimore: Johns Hopkins University Press, 2010). More recently, the "Focus" section in the September 2012 issue of *Isis* examined the issue of "applied" versus "basic" science.

66. Daniel J. Kevles, "Cold War and Hot Physics: Science, Security, and the American State," *Historical Studies in the Physical and Biological Sciences* 20 (1990): 239–64.

67. Obviously, there is much more complexity and nuance than these two positions, staked out twenty-five years or more by historians of science, suggest. Forman's position is limited in its assumptions of a natural trajectory, while Kevles's tautological rejoinder ultimately fails to satisfy or explain.

68. On this point, I've benefited a great deal from suggestions from my colleague Michael Gordin.

69. Two obviously important areas beyond the scope of this essay are the use of computer to make art and electronic music. For example. Ken Knowlton patented the language BEFLIX that he developed at Bell Labs (filed 1965, granted 1971) and that he and Lillian Schwartz used to make a series of computer artworks in the late 1960s. The literature here is quite large; one point of reference is the recent but flawed book by Tom Sito, *Moving Innovation: A History of Computer Animation* (Cambridge, MA: MIT Press, 2013). Meanwhile, Andrew Nelson's recent book notes how profitable computer music patents were for Stanford University; *The Sound of Innovation: Stanford and the Computer Music Revolution* (Cambridge, MA: MIT Press, 2015). Likewise, Peter Sachs Collopy notes that it was artist/engineer efforts to make video synthesizers that led to patents and commercialization; see his "Video Synthesizers: From Analog Computing to Digital Art," *IEEE Annals of the History of Computing* 36 (2014): 74–86.

70. What I have in mind here are ventures like MIT's Media Lab, Xerox PARC's PAIR program, and Interval Research. The term *third culture* comes from C.P. Snow when he revisited his "two cultures" idea in 1963; Snow, *Two Cultures*. In more recent years, the idea of a "third culture" has been promoted by people such as editor-publisher John Brockman, cyber-libertarian Kevin Kelly, and artist Victoria Vesna.