7 Plucking the Golden Gate Bridge

The April 25, 1985, edition of the *San Francisco Chronicle* featured a story on the terrific success of the Yamaha DX7. A picture alongside the story showed Niels Reimers, the Stanford OTL director, next to the CCRMA-facilitated instrument. The headline, however, read "Why U.S. Inventions Profit Foreigners."[1] Far from unabashed praise for the instrument and the CCRMA–Yamaha relationship that gave rise to it, the article questioned why a foreign company was profiting—handsomely—from a US invention.

An important part of the Bayh–Dole Act of 1980, the legislation that eased patenting of federally funded university research, is that preference is given to US-based and small companies. This preference was directly tied to US worries about technology competitiveness with the Japanese. In the 1970s and 1980s, US policy makers and businesspeople alike noted with apprehension the growing Japanese dominance in consumer electronics and other transistor- and semiconductor-related goods. Although US-based research had led to many of the initial breakthroughs in these fields, it appeared that Japanese industry was reaping the primary rewards.[2]

US observers tied Japanese business success to Japanese industrial policy. Chalmer Johnson's influential book, *MITI and the Japanese Miracle*, reflected the dominant belief that Japanese government planners and their resultant policies had positioned that country for dominance.[3] Thus, US policy needed to react, observers argued, to spur the commercialization of US research by US companies.[4]

The 1980s also witnessed the explosive growth of the biotechnology industry, which was based in large part on university-conducted research. Most notably, perhaps, Stanley Cohen at Stanford and Herb Boyer at UC San Francisco developed recombinant DNA (rDNA) in 1973. rDNA enables the connection of genetic material from different sources, and scientists have used the technique to create human insulin, human growth hormone, herbicide- and insect-resistant crops, and other products. Starting in 1980, Stanford licensed the technique on behalf of both universities and the license ultimately netted $255 million for Stanford and UCSF.[5]

Stanford's leadership and, indeed, university leaders around the country took notice of the tremendous financial success and of the booming biotechnology industry. In the face of uncertain federal funding, the potential of hundreds of millions of dollars in unrestricted cash held obvious allure. Given both international competitiveness and significant profit tied to university research, the backdrop behind technology licensing in the 1980s was rather different, therefore, from the environment that Chowning and Reimers encountered in the 1970s as they worked to commercialize FM.[6]

Against this backdrop, CCRMA researchers developed another breakthrough technology: physical modeling synthesis. Physical modeling synthesis rests on the observation that physical actions, such as the vibration of a string, can be represented as mathematical equations. In turn, an instrument such as a violin can be "broken down" into a series of equations that account for the strings, bridge, resonating body, and other characteristics.

In the early 1980s, Stanford computer science graduate students Kevin Karplus and Alexander Strong developed a simple, dynamically modified wavetable synthesis algorithm that sounded surprisingly close to a plucked or struck string. At the same time, David A. Jaffe, who had arrived at CCRMA as a graduate student in the 1970s, was working on a composition for mezzo-soprano, eight guitars, and computer-generated tape. Jaffe's composition, *May All Your Children Be Acrobats* (1981), blends text reflecting the backgrounds of a wide range of Americans (excerpted from Carl Sandburg's "The People, Yes") with music representing a wide variety of styles, including bluegrass, Irish, Jewish, and African-American music, as well as American popular and European classical styles.[7]

For the tape part, Jaffe was attempting to use Chowning's FM technique to simulate plucked strings, but with limited success. Fortunately, Jaffe played violin in a string quartet with Strong, who played viola. As Jaffe recalled:

> It was the Mozart piano quartet. … The violist was Alex Strong, who I didn't know. We just started talking and he was kind of a technical computer science-y kind of guy. I said something about how I was trying to synthesize guitars and he said, "Oh, you know, we just discovered this really great way of synthesizing guitars and I'd

love to show it to you, but you have to sign a nondisclosure." And I said, "Okay, I'd love to do that." So, we got together and they showed me what they had done. I thought it sounded really great and I got their permission to implement it on the Samson Box.[8]

Working with Julius Smith, who quickly recognized that the Karplus–Strong algorithm could be interpreted as an extremely simplified physical model, Jaffe extended and refined the algorithm. He used it in *May All Your Children Be Acrobats*, making this composition the first piece to use physical modeling.[9]

Smith, too, had a strong interest in synthesizing string sounds. In describing his dissertation work in the late 1970s, Smith recalled:

Mostly I was aiming for violin modeling. My mission was to learn everything I could find in the world of signal processing that might be useful in making a virtual violin, a really good violin synthesizer. Or more generally, bowed strings. The reason for that was in my home studio I had some synthesizers, and you could not buy for any amount of money a good bowed string synthesizer. So that was why I chose it. It was a really important family of instruments and they could not be synthesized. I thought that was an important problem.[10]

In other words, Smith's concern with a "real world" musical problem drove his choice of a dissertation topic in electrical engineering.

At the same time, however, Smith kept his musical motivations quiet:

Having a fellowship really made it possible to work on that. But I kind of kept it quiet. For the first three years or so, you wouldn't know I was working on the violin. It looked like I was studying system identification and digital filter design, which I was. I really was studying that stuff. But I had in my mind one application.[11]

Smith's lack of public attention to the applied musical aspects of his work lay in his perception that these aspects would detract from his standing as an electrical engineer. As he explained:

I just felt like I would be a second-class citizen in my department if I made it known that I was seriously interested in music applications. I also wanted to be a full-fledged one-hundred percent through-and-through EE [electrical engineering] signal processing guy. I did not want to compromise my EE. I wanted to get a hard-core PhD in electrical engineering. And the music stuff in that context would just be an application example. Just like saying, "Let's let X be a 440 Hertz sinusoid" [the frequency of the "concert A" pitch to which orchestras tune]. It's just, I could pick any example I want. So I'll pick this music example. [Laughter] … There was this sort of secret filtering going on where I wasn't interested in anything that [didn't] seem like it was going to be useful.[12]

Although Smith does not draw the direct comparison to Chowning's tenure denial, he nonetheless expresses acute awareness that a musically focused electrical engineer might not be perceived as a "genuine" electrical engineer; interdisciplinarity could dilute one's disciplinary standing. Moreover, as Smith notes, a focus on something "useful," like music, was not in line with the hard-core theoretical work for which electrical engineers in academia were rewarded. Smith's commentary, therefore, reminds us that CCRMA's ability to balance such activities remained unique, even within Stanford.

At the same time, Jaffe's compositions were demonstrating that physical modeling technology could prove to be *extremely* useful. Impressed with the results of *May All Your Children Be Acrobats*, Jaffe next began work on a four-channel physical modeling piece. *Silicon Valley Breakdown* (1982) would become a classic of the genre, performed in over 25 countries. The piece, in Jaffe's words,

> is a spatial multi-stylistic work scored for a symphony of imaginary plucked stringed instruments. These range from a tiny "piccolo mandolin" to an immense bass "plucked Golden Gate Bridge."[13]

The image of "plucking" the cables of the Golden Gate Bridge like a string instrument would resonate with other composers, illustrating the power of physical modeling to produce entirely new kinds of sound and music.

In reflecting on the development of physical modeling synthesis and these early compositions, Jaffe explained how:

> The refinement of the algorithm was driven by the composition. In *May All Your Children Be Acrobats*, a lot of the problems hadn't been solved yet … for example, the tuning wasn't solved at that point—or if it was solved, it was solved using the low-pass filter rather than the all-pass filter. I know that we didn't have pick position at that point. … There were also effects like very high notes we couldn't do.[14]

In turn, continued refinements of the algorithm, "things like up and down picking, … the pick position and an all-pass filter for tuning," were driven by Jaffe's desire to realize compositions. As with Mike McNabb's description of "losing track" of whether engineers or musicians drove creativity, Jaffe's reflections highlight the intricate interplay between compositional and technical activities: Jaffe's musical desires suggested the specific technical refinements that he implemented.

One particular set of developments around the physical modeling algorithms would prove to be especially important. A major challenge in physical modeling lay in the computational requirements: a brute force approach of solving the equations for each sound required tremendous processing power and thus limited real-time applications of the technique. In the mid-1980s, Smith proposed another approach: using waveguides. In a "real" instrument, the waveguide is the medium along which the sound wave travels, such as the instrument bore or string. In a digital environment, these waveguides can be simulated with digital delay lines, which are computationally efficient. In short, Smith found a way to use waveguides to dramatically decrease the computational requirements of physical modeling synthesis, which in turn opened up a number of new applications for the technology.

To Stanford personnel searching for another moneymaker like FM and recombinant DNA, Smith's digital waveguide developments seemed like a future blockbuster. A 1988 memo from Joe Koepnick in Stanford's Office of Technology Licensing (OTL) to Anna Ranieri in the Office of Development summarizes Stanford's hopes for Smith's waveguide development:

> We think this technology rivals the FM synthesis technology that is exclusively licensed to Yamaha from Stanford. The FM synthesis technique is the basis of all of Yamaha's synthesizers. The FM license has been very fruitful for both Stanford and Yamaha; and we hope to conclude a similarly fruitful agreement with Yamaha regarding the DWT [Digital Waveguide Technology]. By the way, the FM patent will expire in the early 1990s [and revenues to Stanford will cease].[15]

One looming concern for Stanford, as Koepnick's memo indicates, was the approaching end of FM patent royalties. Yet Stanford foresaw an even larger "fiscal cliff," to use contemporary parlance: The lucrative rDNA patents, which ultimately netted ten times the revenue of FM, would expire in 1997.[16] Thus, two major revenue streams were due to disappear within a few years of one another. Technology licensing revenue was very much on the minds of Stanford administrators.

Stanford's initial plan was to sign an agreement with Yamaha for DWT that was similar to the FM agreement. As the licensing associate, Joe Koepnick, noted:

> It's a classic case of 90 percent of the cases that we license are repeat customers. Yamaha's already had great success with the FM. We get something in the music department, we send it to them: "What do you think?" They were interested.[17]

But Yamaha still had reservations. They took an "option" to DWT—basically, a right to investigate it further and then to take a license if they desired—that would expire at the end of 1988. In an August 1988 letter to Yamaha, Koepnick inquired whether they intended to take a license.[18] Yamaha responded that they intended to do so, subject to royalty conditions, but they also conceived of DWT as a different kind of technology:

> We consider DWT is not so basic or principal technology as the FM tone synthesis. For example, FM is capable of producing tones of every tone color while DWT is applicable to a specific tone color or colors. Therefore an electronic musical instrument can not [*sic*] be implemented by DWT only.[19]

Though no one at Stanford recognized it at the time, DWT would not prove to be simply another FM.[20]

In early 1989, a contingent from Stanford traveled to Japan to negotiate licensing terms with Yamaha.[21] A key feature of the FM license was worldwide exclusivity for Yamaha. This exclusivity motivated Yamaha to dedicate significant resources to the development of FM. As discussed in chapter 5, however, this exclusivity also presented challenges for Stanford, as other companies desired to access a Stanford-invented technology that Yamaha controlled. Sandelin, the licensing associate who worked closely with FM, recalled that

> there was a lot of bickering with US companies. How come Yamaha has this exclusive right and it's developed by a US university? That shaped some provisions. … The big change was that we would not grant Yamaha [an] exclusive [license]. … There were a number of adaptations that were made … to make sure that North American companies had access.[22]

Thus, Stanford's DWT licensing strategy responded to criticisms of its FM license strategy.

In the DWT case, Stanford agreed to give Yamaha an exclusive license outside of North America; but, companies within North America could still license the technology from Stanford. In addition to insulating the university from the political objections that accompanied FM, Stanford's hope was that this arrangement would develop interest among more companies—in turn, further establishing the technology and ultimately increasing Stanford's royalties on related products. By 1993, the OTL had signed Sierra Semiconductor, Crystal Semiconductor, Media Vision, and Atari as licensees, bringing the total number of licensees to five.[23]

The nonexclusive license was structured to allow companies to experiment with potential applications of the DWT technology. The license terms clearly draw from Stanford's rDNA experience. With rDNA, Stanford took a wholly nonexclusive approach. In turn, initial rDNA adopters ranged from breweries to cosmetic companies, until the specific drug development applications of the technique grew clear.[24] In the DWT case, Stanford personnel themselves seemed a bit unclear as to all of the potential applications. As a 1992 OTL newsletter relayed:

> The waveguide technology's most immediate applications are in electronic synthesizers and personal computers. But Koepnick and these companies are also looking forward to what they predict will be the next consumer electronics boom: multi-media. Koepnick envisions a 4′ × 4′ × 3′ flat panel display on the living room wall, controlled by computer and synthesizer keyboards. The owner will be able to compose music using a myriad of sounds and also have access to everything from music to movies to banking and groceries. "It would be your video phone and answering machine as well," Koepnick adds. The multi-media system would also be educational, he says, making education "interactive, so it's fun for kids to learn."[25]

Koepnick's vision was prescient, though perhaps twenty years too early. But the role of DWT in this system was less than clear. As Stanford would discover, there were other ways to produce sound for multimedia systems.

In other ways, too, Stanford shaped its approach to DWT in response to their experiences and "lessons learned" from FM. One of their primary lessons lay in the limited patent life—and, therefore, the limited revenue timespan. As figure 5.2 (chapter 5) illustrates, Stanford's FM patent expired in 1994, just as revenues were accelerating. As an experiment, in 1993 the OTL thus proposed a trademark plan designed around DWT. Reimers had contemplated trademarks as early as 1983. In a Telex to Yamaha that year, he inquired:

> Have you considered strategy of Dolby (noise reduction technology)? That is, to develop FM as industry sound synthesis "standard." This would involve FM trademark license to permit buyer to advertise that his product uses "FM" sound synthesis. If FM of highest quality, and that becomes known to buyers, a new market entrant for an alternative sound synthesis technology to FM will have greater marketing difficulty.[26]

Dolby had experienced great success with its trademark that signaled a special noise reduction technology. Even consumers with no understanding of signal-to-noise ratios and various technical schemes for improving them were willing to pay more for tape recorders that featured the Dolby trademark. Yamaha, however, did not pursue the strategy, reasoning that a trademark was unnecessary since most synthesizer purchasers either judged on the basis of sound alone or were technically savvy enough to understand which products featured FM, regardless of the presence of a trademark. The trademark idea, however, stuck around the OTL.

The OTL modeled its 1993 trademark plan explicitly on Dolby's program. As the introduction of the plan states:

> While the same FM patent licensing strategy could be applied [to DWT], cumulative royalty revenues can be increased dramatically by licensing the patents together with a trademark and software as a complete package. The Plan proposed herein will allow the worldwide licensing of waveguide indefinitely. The model for this Trademark Plan is based on Dolby Laboratories' licensing program, whereby several consumer electronic technologies are licensed internationally along with Dolby trademarks. Dolby's program generates around $15 million annually in royalty income at an annual expense of about $2 million. It is anticipated that the waveguide program will have a similar income-to-expense ratio.[27]

Stanford settled on the name "Sondius" for the trademark.

To add value to the trademark, Stanford needed patents tied to sound technologies. Thus, the trademark program was associated with a flurry of patenting activity. Julius Smith alone filed eight patents between 1992 and 1994. As he described the motivation:

> The flurry of additional patents that I did was in the spirit of "Let's fill up the boat as big as we can." There was sort of this, "Yamaha had taken out a big license. Music was on a roll. Let's just, anything we can think of, let's just throw it in there and make our patent portfolio big and strong. Get the students involved. Every CCRMA student in my group should graduate with a PhD and a patent!" [Laughter.] That was just kind of the thinking of the time.[28]

While commercial interests had long played a role at CCRMA, patenting in connection with the Sondius program dramatically raised its profile and marked an increased emphasis on formal patent-linked technology transfer efforts managed through the OTL.

The patent flurry focused on quantity more than strategy. Thus, it collected a number of unrelated patents under a single umbrella. As Smith noted:

> All of the Stanford music technology people were sucked into the Sondius program. It lumped together irrelevant patents, such as clipped signal restoration that has nothing to do with synthesis. [Clipped signal restoration fixes recordings in which the signal level was too high and caused a harsh audio artifact known as "clipping."] Stanford took out lots of patents—invested in them due to the big buzz. The trademark program wanted to have as many patents as possible.[29]

While the Sondius trademark represented a means to extend Stanford's revenue indefinitely, the university also worked to reduce the time-to-market for waveguide technology. The seven-year commercial development period for FM—from the 1975 license to the 1982 product release—was simply too long from the university's perspective. As Mary Watanabe, the licensing associate who managed the Sondius program, noted, "Looking at FM is what caused us to try this experiment because we saw that the revenue hit its peak when the patent expired. So we thought we'd try to address the situation by setting up this program."[30]

The plan was to build on the NeXT MusicKit software—the same software that CCRMA maintained and distributed with Steve Jobs's permission, as relayed in chapter 6—to make it easy for potential licensees to implement DWT. In 1989, Michael Minnick, a NeXT employee, developed an application to create MusicKit patches graphically, by arranging and connecting modules on a computer screen. He called the prototype SynthEdit and presented a paper at the 1990 International Computer Music Conference.[31] In 1992, Princeton University student Eric Jordan created a similar application called GraSP (Graphical Synth Patch), with assistance from David A. Jaffe. (Recall that Jaffe was the physical modeling whiz and *Silicon Valley Breakdown* composer. He was teaching at Princeton at the time of Jordan's work.[32])

Nick Porcaro, a visiting scholar at CCRMA, continued work on GraSP, with assistance from Jaffe and Julius Smith, and he started integrating it more deeply with the NeXT's Draw program and the MusicKit. In September 1993, Porcaro and Smith obtained funding from the Stanford OTL for Porcaro to further develop the application, which eventually became known as SynthBuilder.

SynthBuilder, was a core element in Stanford's plan to develop waveguide sounds in order to increase the value of the trademark. The program also represented a major shift for the Stanford OTL in that they invested directly in technology development, alongside CCRMA. Thus, CCRMA ultimately invested $1.35 million from the FM royalty account, using it to hire two developers to work on DWT: Jaffe and Porcaro.[33] One year later, Porcaro contacted his colleague Pat Scandalis and Scandalis joined the development team.[34]

Jaffe, Porcaro, and Scandalis were paid an hourly wage and took up positions alongside regular university researchers—professors and graduate students—at CCRMA. Their mission was to "increase the value of the university's patents" in order to attract additional licensees. Much of the effort was put into the development of SynthBuilder, which was a first step toward creating a sound library to demonstrate DWT technology.

In turn, the sound library itself was another goal. As Pat Scandalis, one of the developers, recalled, "The original charter was to deliver a whole General MIDI set done with physical modeling, which was an extremely ambitious goal."[35] (General MIDI is a set of 128 standardized patches.) To assist with creating the sound library, two CCRMA graduate students, Tim Stilson and Scott Van Duyne, joined the development team as paid employees.

The OTL supported these efforts, in part, through funds that the OTL had earned from previous licenses and that it administered as research grants. For example, the OTL awarded Chowning $23,500 for a related project in 1991; they awarded another $25,000 to Chowning and Smith in June 1992; and in February 1994, the OTL officially turned down a CCRMA-wide funding proposal, but still offered the group $20,000 from another set of funds.[36] An important point concerns the justification for these research proposals. As Chowning explained in applying for the 1991 grant:

> This [project] is an outgrowth of Professor Julius Smith's work in closed waveguide networks for which a patent has been issued. Yamaha has licensed the waveguide work and this research would not only increase its value to them but may attract other interests in speech-related activities as well.[37]

Again, the 1992 funding application notes:

> CCRMA is approaching the end of the patent life in 1994 of the FM synthesis patent. Our future rests upon our ability to produce continuing income. This collection of interdependent projects is one that has real prospects for both intellectual and financial payoff.[38]

Thus, the OTL's research grants were clearly tied to projects that might yield financial benefits for Stanford. In turn, CCRMA worked to position its proposals accordingly.

The SynthBuilder project, however, raised a number of issues for CCRMA tied to open innovation. Since SynthBuilder was related to the MusicKit, which was freely distributed (recall the announcement from the previous chapter), one core issue concerned whether the development team would share sounds they had created with SynthBuilder. The issue came to a head in 1996, as developer Pat Scandalis outlined in an email to Mary Watanabe:

The Sondius voices could be ported to CLM [the sound synthesis package in use at CCRMA and freely distributed around the world]. That is what Bill [Schottstaedt] is asking for.

[In original email from Watanabe]: What are some of the issues here?

[Reply]: Sondius instruments ported to CLM will drift through the academic community around the world. The algorithms that we use will be freely available (but in a very cryptic form, CLM Lisp). One question would be, what does Sondius define as its intellectual property. Is it purely patents, or is it also the expertise that we build into the algorithms? Do we have the concept of trade secrets as well as patents? I feel that since the Sondius program is a trademark program, the value of the mark is drived [*sic*] both from the patent portfolio, and the expertise archived in the program, in the form of algorithms.

Scandalis's email raises genuine questions about the extent to which the fruits of commercially oriented labor in an academic environment should be shared, and the ways in which intellectual property considerations may shape the group's approach. Continuing, he writes:

One could argue that everyone should get the algorithms, just give them away, because any commercial product would have to come to Stanford to license the patents. But what about companies in countries that have been historically bad about recognizing and paying for patents? They could have free access to the technology though [*sic*] the algorithms. So one perspective might be that the Sondius instruments should not be freely available to the whole world.

One middle ground position that Bill S. talked to me about was to port the Sondius instruments, but only as precomiled [*sic*] instruments, so that composers could use them, but not see their implementation. [Such an approach is akin to giving a painter new premixed colors, but not sharing how the colors were created or enabling them to be changed.] It raises hard questions.[39]

In other words, the Sondius development effort rubbed against the open sharing that had characterized CCRMA. As Bill Schottstaedt, the CCRMA researcher referenced in Scandalis's email, recalled the situation:

There was one time here at CCRMA where the Sondius group was working on sound synthesis. I wanted to take part of the physical modeling of this research, but they felt they couldn't tell anyone outside of their group. It pissed me off.[40]

To be sure, academic pursuits, too, can result in secrecy; as academic researchers race to be the first to discover something new, they can withhold information tied to intermediate steps.[41] The difference in the Sondius case, however, is that the relative secrecy was motivated by commercial considerations rather than academic desires. In turn, that motivation reordered sharing relationships, since protecting commercial interests suggested secrecy even within CCRMA.

The Sondius effort also raised conflict-of-interest issues. Specifically, because Julius Smith had a financial interest in waveguide physical modeling, Stanford's Conflict of Interest policy prevented him from overseeing the work of the developers who were hired into CCRMA to further develop the technology. The rationale of the policy is that a professor should not be able to leverage university resources to his or her direct financial benefit. Since Smith would receive royalties from licenses related to the development effort, the university reasoned that he should not simultaneously oversee the university's investment in this effort. The result, as noted by Scott Van Duyne, one of the graduate students on the project, was that, "The guy with the knowledge, the best résumé, for overseeing our work [Smith] wasn't allowed to oversee our work."[42] In turn, the project sometimes suffered from a lack of engineering leadership and from a lack of integration between marketing and engineering, since the licensing associate in charge of marketing had limited technical understanding.

Graduate students also faced conflicts between their academic work and their commercial development work through Sondius. As Koepnick recalled:

> We had a couple of conflict things that we had to be careful about. … You want to make sure that the student is not distracted from his research and that he's not doing research that's not benefiting him, that's benefiting the university or the company. In this case, if you weren't careful, somebody could argue that we were distracting Tim [Stilson, another graduate student] from getting his thesis. Tim is there three years and his advisor's going, "You should be out of here." And Tim says, "Well, I'm spending all this time on Sondius."

Thus, the situation of these student-developers in the university context meant that they were placed at the nexus of two competing demands—personal academic achievement and development for the sake of commercial gain. While CCRMA had earlier leveraged such differences to generate novelty and acquire resources, the enhanced emphasis placed on commercial activities appeared to throw these intertwined relationships out of balance.

At the same time, Stanford grew concerned about other companies infringing the DWT patents. For example, in 1995, Perry Cook sent an email to Watanabe and Smith to alert them that Invision, a Palo Alto-based music software company, was introducing a new product called CyberSynth. Cook wrote:

> It's a software-only synthesizer, like Seer Systems' synthesizer. [Seer was a Sondius licensee.] I've seen mock-ups of the boxes and they clearly state the types of synthe-

sis used, including Physical Modeling. The chief architect on this project is Steve O'Connell (Yep, the author of the SynthKit patent), ex-Korg, ex-Yamaha, DSP guy who arguably knows the most about physical modeling of anyone outside of Stanford or Yamaha.

In the same email, Cook shares that

> Steve gave a pretty negative talk at the S.F. AES [Audio Engineering Society] meeting, basically saying that physical modeling has been around so long that no patents on this topic were valid. Julius [Smith] was at that talk as well.[43]

As Cook's email highlights, Stanford's desire to enforce its intellectual property around DWT in order to generate revenue placed it in conflict with firms that did not necessarily respect Stanford's claims.

Stanford also had a conflict with Korg, which had received a patent on waveguide synthesis and which was developing its own graphical system based on O'Connell's work.[44] Financial records show that Stanford paid more than $5,000 to law firm Flehr Hohbach for an analysis of the Korg patent.[45] A preliminary working memo from the firm indicated that many of Korg's claims appeared to be covered by prior art and would not withstand a legal challenge.[46] A legal challenge, however, would be expensive. Moreover, it could be bad press. Ultimately, Yamaha—a major Korg partner—stepped in to resolve the conflict and Korg signed as a Sondius licensee.[47]

As the Stanford team worked to develop the Sondius trademark by building example sounds through SynthBuilder, Yamaha also had a large engineering staff—around a hundred people—dedicated to developing the technology. In 1994, they released their first commercial product based on DWT: the Yamaha VL1 synthesizer. The instrument received significant press attention in outlets ranging from *Business Week* to *Wired* to trade magazines like *Keyboard* and *Electronic Musician*. Smith received interviews from the *Wall Street Journal*, the *Washington Post*, *Billboard*, and NPR's "All Things Considered."[48]

The VL1 is a beautiful instrument, with gold hardware and a burr-Walnut veneer panel "similar to a Jag's dashboard," according to one reviewer.[49] Its sounds were phenomenal, too—particularly for string and woodwind instruments. The same reviewer noted, "NOTHING in the synth world produces rock guitars like a VL1."[50] Such praise was particularly nice for Smith, a talented guitarist.

Whereas the DX7's introduction, however, marked a period of rapid sales, the VL1 was not a commercial success. First, it was expensive, with a list price of $5,000 amid a more common $2,500 price point for professional synthesizers. Second, the VL1 could produce only two notes at a time, owing to the significant computational requirements and complexity of DWT. Thus, it could be used for "leads" and solos, but it was not useful as an all-around keyboard to mimic pianos, organs, and other instruments that play several notes at once. As such, it was a specialty instrument.

Perhaps the most significant challenge to the VL1, however, was that DWT required a new type of interface to realize its potential. Thus, although the VL1 looked like a traditional keyboard, it required the simultaneous use of various foot and mouth controllers, too. Yamaha bundled the instrument with a breath controller that looks like a microphone attached to a headset and that uses the performer's breath to control a selected synthesis parameter. As one music guide summarized the situation, "[The VL1 is] undoubtedly expressive beyond any normal synth's wildest dreams but, like a 'real instrument,' it takes time to master."[51] For the vast majority of keyboard players who had already mastered the piano-type key system, the need to learn additional interfaces stymied adoption. Put slightly differently, the VL1 moved away from one of the longest-established standards in the music-making world—black-and-white piano-style keys—and it ran into severe resistance as a result. As noted, CCRMA participants had long encountered the benefits and costs of technical standards. (Recall the move from specialized to widely available computers, for example.) In the commercial realm, Yamaha and CCRMA found that moving away from a standard—even when such moves offered musical benefits—could dramatically quell adoption.

Though the VL1's lack of commercial success may have been a bad omen, the Stanford team continued to develop DWT. By the end of 1996, the team had completed SynthBuilder and several demonstration sounds. To their dismay, however, the years of effort—and the large financial investment—yielded only two additional licensees.

Rather than watch the development team disband, OTL licensing associate Koepnick took the unusual step in late 1996 of leaving Stanford to start a company that would continue DWT commercialization efforts. He and the other cofounders—essentially, the CCRMA development team—named the company Staccato Systems. Staccato received licenses to the Sondius technologies in exchange for an equity stake by Stanford.

Stanford, indeed, had high hopes for the company. A January 1998 article in the *Stanford Magazine* described the frantic efforts at the university to identify a successor to the highly lucrative Cohen–Boyer rDNA patents, which expired in 1997. As the article notes:

As they sift through the Cohen/Boyer wannabes, [OTL Director Kathy] Ku and her OTL colleagues have settled on an unlikely group of Stanford grads as the heir apparent with the most potential. Until recently, Staccato Systems, Inc., ran its "worldwide headquarters" from a two-car garage in Mountain View, complete with a washer-dryer and cement floor carpeted by dust bunnies. A complicated array of desktop computers and electronic synthesizers was jammed into the center of the room and along the walls. If you looked carefully, you could see the garage door behind a pile of sound-absorbing sponge.

… Staccato is a classic Silicon Valley paradigm—a group of musicians, engineers, computer nerds and a director who left his full-time job at OTL to run them in this ordered chaos.[52]

Staccato presented a tricky situation, however, for both Stanford and Yamaha: Yamaha's collaborator in the OTL, Koepnick, was suddenly leading a potential competitor. Kathy Ku (the OTL director), Jon Sandelin, and Mary Watanabe (Koepnick's replacement on the Sondius docket) were nervous, therefore, as they traveled to Japan in January 1997 to meet with Yamaha.

Yamaha had plans of its own. A number of musical instrument manufacturers had agreed to the General MIDI standard in 1991, which specified

Figure 7.1
Staccato Systems cofounders (pictured from left to right) Scott Van Duyne, Nick Porcaro, and Pat Scandalis in 1997 in the Mountain View garage that first housed the start-up. Courtesy of the Stanford News Service. Photo by Linda Cicero.

certain standard instruments or sounds that a compliant device would produce. The general idea was that if a standard MIDI file specified a part to be played by sound number 41 on an instrument, a user could be assured that sound 41 would correspond to a violin—and that the device contained a violin sound in the first place. Different manufacturers, however, then extended the General MIDI standard in different ways—still adhering to the core sound bank but offering additional standard sounds as an attempted competitive advantage. Yamaha, for example, introduced the XG standard in 1994, which raised the number of sounds from 128 to 600 and included a number of additional control parameters. Of course, such manufacturer-specific efforts failed to yield additional benefits from standardization, precisely because they were not shared across manufacturers.

In the January meeting with Stanford, Yamaha proposed that the two groups combine forces under a new trademark, "Sondius XG," which combined Stanford's Sondius program with Yamaha's XG program. The new trademark, to many observers, marked a new era in university technology licensing. As the then president of the Association of University Technology Managers, Marvin Guthrie, commented in 1998, "I can't think of a technology where a university has become so closely associated with the product as Stanford appears to be with this. … They had a special technology and they saw a way to build a relationship."[53] Traditionally, universities licensed intellectual property to companies, and the university association was not obvious in the final product, except to industry insiders who understood the technology and the intellectual property landscape. With Sondius, however, Stanford attempted to leverage the Stanford name itself to "brand" products. In turn, Sondius XG publicly branded the alliance between Stanford and Yamaha. In light of the earlier criticism that had been leveled for Stanford's close relationship with Yamaha (recall the critiques from Media Vision and ARP, along with the *San Francisco Chronicle* article), the overt shift to cobranding music technologies is itself evidence of the dramatic shift in perceptions around university–industry engagement: activities that had raised suspicion and concern just a decade earlier were now unabashedly publicized.

Stanford and Yamaha announced the partnership at a joint press conference in July 1997. In turn, Staccato Systems became the first Sondius-XG licensee[54] and Yamaha offered to invest $1 million in Staccato in order to align the interests of Stanford, Yamaha, and Staccato. Staccato raised another $3.2 million from Allegis Capital and Chase Capital Partners.

The Staccato team continued development efforts begun at CCRMA, redirecting this work toward the computer games market, where they met with considerable success. In 2001, Staccato Systems sold to Analog Devices for $30 million.

The Sondius XG trademark, however, never had much traction. Only Korg signed as a licensee, under pressure from Yamaha and in the shadow of the patent dispute with Stanford. Part of this lackluster performance may be attributed to a lack of marketing: neither CCRMA nor the OTL put any money into marketing the Sondius trademark. In fact, although the Sondius plan includes a number of royalty comparisons and projections, it is striking for the lack of attention to marketing: nowhere does the forty-seven-page plan address how consumers will come to learn about and value Sondius. The only reference to marketing at all is a note accompanying one phase of the plan to "begin promoting the trademark informally through use and develop a plan for promoting the mark formally." The idea seems to have been that products would display the trademark, and as these products were successful, the trademark would increase in value. This approach, however, introduced a "chicken–egg" challenge: with no immediate brand value to end users, companies had less motivation to license the trademark; but, without companies licensing the trademark and using it on successful products, end users did not understand its value. As Koepnick later reflected:

> Sondius was very ambitious. … What we didn't realize is that creating value as a brand is an incredibly long process and it's very intensive. That was when the dot-com things came out. Everybody's investing in these small companies. The brands are going to win. … Brand is very powerful. Sony's brand is very powerful, but it took hundreds of years to get to this point. That was where we just didn't have the resources.[55]

The difficulty and expense of developing a brand caught the Sondius team by surprise—in part, because it was composed of technical experts with a strong musical orientation but little experience in purposefully generating a substantial new market.

To many observers of the Sondius XG trademark program, however, the program was never intended to gain traction. As Smith described the situation, Yamaha had agreed to exclusivity but for North American companies because that agreement kept Creative Technology, a Singapore-based company, from accessing the technology. (Yamaha had lost to Creative Technology in the PC soundcards market, as discussed at the end of chapter 5.) In 1996, however, Creative Technology established a distribution agreement with US-based Seer Systems, which already had a Sondius license. Suddenly, Creative Technology effectively had a license, too, through Seer Systems. As Smith recalled:

> [The Creative–Seer Systems relationship] caused some real upheavals. That caused the Sondius XG program. It triggered the pooling of IP. They basically shifted, a big turn at sea, they shifted the model from exclusive patent licensing to "Let's build up our own trademark, the XG trademark, and let's put all of our patents into this XG trademark. And if you want to use these patents, you've got to use our trademark."[56]

Thus, Sondius XG was as much a competitive reaction as it was a proactive development program.

The problem, of course, was that few companies had a desire to advertise a Yamaha trademark on their own products. As Pat Scandalis saw it:

> When you added the XG, it polarized the other vendors because we couldn't really go to Roland and say, "Hey would you like to license this technology? It's really cool. You can make way cool products." They wouldn't have anything to do with it if it had XG [since XG was a Yamaha trademark].[57]

Similarly, Joe Bryan, a Korg engineer, argued:

> There's a barrier to widespread adoption of physical modeling (PM) synths. Anyone who wants to develop one has to pay Yamaha/Stanford for the Sondius license and co-brand their work with it. If you haven't read the Sondius agreement, it's pretty interesting. Suffice to say no one's rushing out to develop PM synths anymore.[58]

The close branding association between Yamaha and Sondius XG effectively killed the adoption of Sondius XG by other companies.

Progress in complementary technologies also threatened the DWT program. Specifically, a major advantage of DWT lies in its very low memory requirements. As the price of computer memory fell through the 1980s, it eroded DWT's advantage. As Scandalis recalled, "Originally, people were thinking that physical modeling was going to solve the memory problem. But in the end, memory wasn't a problem." Continued improvement in wavetable synthesis, an alternative technology, also presented challenges. Scandalis remembered, "It was becoming apparent that wavetable was really better for a lot of things and that physical modeling was really good for just a few things."[59] Moreover, the technical implementation was difficult—even for the CCRMA engineers who were among the most skilled in the world. As Watanabe, the licensing associate, characterized the situation: "The technology was much more difficult from a technical standpoint than we originally thought. … Much more difficult for people to assimilate into their programs."[60] Indeed, it was one thing for highly skilled CCRMA personnel to use and develop DWT in their own research and compositions; it was another thing for them to develop it in a way that enabled *others* to easily do so.

Ultimately, the experiment of placing developers within CCRMA in order to increase intellectual property revenue met with mixed success: on one hand, their work facilitated the emergence of Staccato Systems and, thus, its subsequent sale; in this way, the university may have incubated the technology during a critical early period. On the other hand, the program fell far short of expectations. Moreover, there is some evidence that university development efforts were actually *harmful* to the technology's diffusion. Again, Stanford's primary goal in the development project was to increase the value of the patent portfolio, which would allow the university to earn more money from the licenses. Presumably, therefore, further development drove higher licensing fees. The Sondius licensing fee was $50,000 up front, with a $25,000 annual "maintenance fee" and a negotiated percentage of royalties on product sales. To Smith, "They priced it out of reach of small companies. It's extremely expensive. … There have been lots of people over the years who want to do something, but are locked out."[61] Ironically, Stanford's own development efforts may have prevented others from engaging in development as a result of the high licensing fees. In turn, these actions may have limited the diffusion of the technology.

Stanford's technology development efforts also raised new questions about sharing, as with the dilemma over sounds and Schottstaedt's CLM program. Smith, too, recalled questions about sharing research results in academic seminars: "What if someone from the outside attends? You could argue that's disclosure and lose the patent."[62] Whereas traditional university environments may value and reward such disclosure, commercial interests inject new concerns into sharing conversations—critically, spilling over into long-standing academic traditions such as seminars. In other words, emergent tensions were not limited to the commercial activities themselves, but instead implicated existing academic activities.

In turn, the sale of Staccato Systems to Analog Devices effectively shut down most avenues of information sharing; Analog Devices did not openly share information about further developments in the tools. Moreover, the academics were left with little incentive to continue research with their current version of the tool since intellectual property rights to any discoveries would be tied to Analog Devices, which now owned the tool; academic researchers would be pursuing projects legally bound to a commercial entity with which they had no formal ties. As Smith noted in 2004, "This was not good for the lab. When Staccato went, so did the intellectual property, so did the software tools. We would have to start all over without the tools. It's never going to happen."[63] Smith went on to describe several potential and valuable extensions of the technology that could not be executed because of these restrictions. (Interestingly, however, Smith, Scandalis, and Porcaro released an iPhone/iPad electric guitar based on DWT—the MoForte Guitar—in 2014, after the key patents had expired.)

Ultimately, these observations highlight how the importation of commercial development activities into an academic lab served not merely to extend or accelerate technology development, as the instigators hoped, but also affected intellectual production at CCRMA by reorienting the activities of faculty and students and by altering open sharing practices. In turn, the Sondius experiment may serve as a counterexample around the coevolution of academic disciplines, technological discoveries, and commercial activities: When CCRMA emphasized the academic aims—but, critically, with openness to commercial potential as an *outgrowth* of these aims—they realized success. Conversely, when CCRMA consciously emphasized commercial aims, these activities threatened to displace academic activities. In other words, Sondius illustrates that interdisciplinarity, open innovation, and commercialization are not only intertwined, but also that the particular shape of these relationships—game-changing novelty, as with CCRMA's emergence and renewal, or unrealized expectations and commercially tied tensions, as with Sondius—depend on the prioritization and balance between these activities.

Sondius yielded another important lesson, too, in that it was tied to a particularistic model of commercialization: the licensing of patents. As CCRMA would emphasize in the 2000s, however, there were other ways to spur commercialization and to realize financial benefits while maintaining an emphasis on artistic and academic aims.