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GLOBAL OPTICS

Finding a Voice for **Photonics**

Stewart Wills

International efforts to promote awareness—and funding—reflect different regional approaches and priorities.

For all of its vast economic importance—from the global Internet to the local supermarket scanner—photonics often stumbles in conveying its significance to policymakers and the public. Fragmented across sectors, companies and countries, the industry lacks a definable voice and community. The United Nations declaration of 2015 as the International Year of Light and Light-Based Technologies thus offers a great, and badly needed, "teachable moment" for raising public awareness of photonics' role in daily life worldwide.

But if the public will remember 2015 as the Year of Light, events of the past several years have already boosted photonics' profile in another arena: the fight for the government's ear. In Europe, efforts of the industry-led consortium Photonics21 to define a photonics community on the Continent, and to plug photonics into the economic consciousness of the European Union (EU), have borne fruit in a regional strategic roadmap and a new public-private partnership under the EU's Horizon 2020 funding framework. In the United States, meanwhile, both the recently formed National Photonics Initiative (NPI) and several steps by the Obama administration suggest that an assertive new voice for photonics is emerging in North America.

Here's a progress report on these efforts to put photonics on the global industrial-development map.

Europe and Photonics21

In the worldwide quest to "brand" photonics for government investment and industrial development, Europe took an early lead. One reason was the impact of a 1998 study by the U.S. National Research Council (NRC), *Harnessing Light*—which, ironically, seems to have carried more practical weight in Europe than it did in the United States. "Here was a document that, in one place, gave many

examples and many reasons why photonics should be funded," notes Chris Dainty, the 2011 president of The Optical Society (OSA) and currently on the faculty of the UCL Institute of Ophthalmology, London. "It had a significant impact."

Realizing that early vision, though, required shaping the fragmented European photonics industry into a community—and in that effort, Photonics21 has done much of the heavy lifting. Created in 2005, Photonics21 is one of some 40 European Technology Platforms (ETPs). These are industry-led advisory bodies recognized by the European Commission (EC) for setting technology research roadmaps and agendas. And, with more than 2,300 stakeholder representatives drawn from industry, academia and research institutions, Photonics21 has proved remarkably successful in creating a single voice for the Continent's highly diverse photonics sector (OPN, June 2011, pp. 12–13).

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That in itself represents quite an accomplishment, given the complex, many-layered nature of European science and science funding. In addition to private-sector spending, such funding ranges from the programs of individual national governments, the size and scope of which reflect varying national interests and levels of clout, all the way to the EU's massive "framework programs." These are multi-year, multi-billion-euro pots of R&D money whose targeting reflects not only scientific merit, but also Continent-wide priorities such as job creation, cross-border collaboration, and other social, environmental and political goals.

Each framework program lasts five to seven years; the seventh of them (FP7) ended in 2013. The eighth, dubbed Horizon 2020, has a budget of €78.6 billion, spread across the seven years from 2014 to 2020, with the specific aim of attracting additional private investment on top of that. Of that total budget, €13.6 billion is explicitly tied to "leadership in enabling and industrial technologies," such as photonics. It is the major, EU-level R&D funding of Horizon 2020 on which Photonics21 has focused, according to Dainty, himself a founding member of the consortium and former leader of one of its seven working groups.

A key motivation, he says, has been to boost strategic, longer-term research by industry. "In Europe, about 64 percent of R&D spending is actually done by industry, not government," according to Dainty, "and it typically tends to be largely on development—short term and close to market." Moreover, he adds, the perception in industry is that most EU-level funding goes to universities and to research institutes, such as the Fraunhofer Institutes in Germany. "What Photonics21 did was to empower and financially support its own industry members, engaging with universities and research organizations, to be a little more focused on longer-term, more strategic things."

From KET to cPPP

In pursuing that strategic goal, a significant milestone for Photonics21 was the EC's decision, in 2009, to name photonics as a key enabling technology (KET) for the Continent. Photonics shares that designation in Europe with five other areas: nanotechnology, advanced materials, micro/nanoelectronics, industrial biotech and advanced manufacturing. That recognition, in

Horizon 2020 Budget, 2014–2020

Excellent science

European Research Council	€13.1
Future and Emerging Technologies	€2.7
Marie Curie actions	€6.2
Research infrastructures	€2.5
	€24.4 billion

Industrial leadership

Leadership in enabling and industrial technologies	€13.6
Access to risk finance	€2.8
Innovation in SMEs	€0.6
	€17.0 billion

Societal challenges

Health, demographic change and well-being	€7.5
Food security, sustainable agriculture, marine research, bioeconomy	€3.9
Secure, clean and efficient energy	€5.9
Smart, green and integrated transport	€6.3
Climate and resources	€3.1
Inclusive, innovative and secure societies	€3.0
	€29.7 billion

Excellence and participation/Science and society	**€1.3 billion**
European Institute of Innovation and Technology	**€2.7 billion**
Joint Research Centre (non-nuclear)	**€1.9 billion**
Euratom regulation (nuclear)	**€1.6 billion**
	Total Horizon 2020 €78.6 billion

€ billions; current prices
Source: Data from European Union

Charting the course

For Photonics21, a key step in its approach to Horizon 2020 was fashioning a consensus strategic roadmap covering the next seven years. As the global industry continues to evolve, such roadmapping activities at the national and regional level will become increasingly visible, and important.

In the United States. A new focus of photonics industry roadmapping in the United States is the Advanced Manufacturing Technology Consortia (AMTech) program of the National Institute of Standards and Technology. AMTech—started in fiscal 2013 to support roadmap development on "long-term, precompetitive and enabling technology" for U.S. manufacturing—has kicked off its photonics roadmap program with two half-million-dollar grants: one for a national technology roadmap for the photonics industry, and the other focusing more specifically on a roadmap for integrated photonics systems (OPN, July/August 2014, p. 13). Both projects have a time horizon of roughly a year and a half.

Other countries. Elsewhere in the world, roadmapping activities tend to fall to industry groups or consortia such as Japan's Optoelectronics Industry and Technology Development Association (OITDA), the Korea Association for Photonics Industry Development (KAPID), and Taiwan's Photonics Industry and Technology Development Association (PIDA). Obviously, these roadmaps reflect the strengths and national interests of the specific countries that these groups represent.

One vehicle for sharing information about national plans is the International Optoelectronics Association (IOA). The association, originally founded by OIDA, periodically brings together executives from OIDA, OITDA, KAPID, PIDA and five other national or regional optoelectronics/photonics trade groups, to share broad market data and thinking on national roadmaps. Christoph Harder, whose SwissPhotonics network is also a member of IOA, notes that the association is quite informal, and is "based on the personal initiative of the people involved."

Conspicuously absent from the list—and, in view of its growth, a very important omission—is China, which at present does not seem to have a single group or organization to speak for its photonics industry.

turn, increases photonics' leverage in competing for funding through the EU's framework programs, such as Horizon 2020.

"That's really big," says Dainty, "because it means that whatever the program—whether it's healthcare, or another area—if you're working in one of these KETs, you can apply for funding if you can apply your KET to that sector. It was a really big milestone, and it goes down to all member countries."

More recently, Photonics21 has focused on developing a comprehensive strategic plan and roadmap, published in April 2013, for the seven years covered by Horizon 2020. The roadmap explicitly identified its scope as providing "photonic solutions to the major socio-economic challenges of Europe," such as an aging population, food safety and energy efficiency. And it highlighted the need for strategies to bridge the "valley of death"—the gap between innovative research and actual product development.

The Photonics21 roadmap will underpin spending by a new photonics contractual public-private partnership (cPPP) under the aegis of Horizon 2020—another significant milestone. Under the terms of the partnership, which was announced last November and launched in early 2014, the EU will commit €700 million to photonics research over the seven years of Horizon 2020. The industrial partners in the cPPP are required to match that commitment four to one, with €2.8 billion over the same period. The cPPP involved the creation of a separate organization, the Photonics21 Association, that will include corporate members and will facilitate auditing of the required industrial contribution. That's a

departure from the consortium's previous structure, which focused on individual members.

The larger European context

Dainty notes that the cPPP has "more or less doubled" the EU's historical funding commitment to photonics. But even that enhanced support represents only a tiny share of science funding in Europe—relative both to the near-€80 billion Horizon 2020 budget and to the funding efforts of a number of the larger EU member states.

"It's just a fraction of the overall funding in Europe," says Christoph Harder, the president of Switzerland's national photonics network SwissPhotonics and a member of the advisory board of the Optoelectronics Industry Development Association (OIDA), a division of OSA. For example, notes Harder, the average €100 million yearly EU contribution under the photonics cPPP about equals the amount that the German government alone pumps into photonics research each year. But, he adds, for countries with smaller programs, such as Greece and Spain, the cPPP contribution could represent a significant boost.

More important than the actual funding amount, Harder suggests, has been Photonics21's impact in creating a transnational identity and network for photonics in Europe. "Projects need to have participants from different countries," he says. "The European integration really gives a lot to that—people get together, and it makes for better work on the national level as well." Harder adds that there is a tough selection process based on quality—"only one in six is funded," he says, "further improving the impact."

The ability of Photonics21 to provide that integrated voice, says Chris Dainty, has underpinned its strong track record with the EU. "It's been successful because it has, through the community, set priorities that can be demonstrated as the consensus of the hundreds, or even thousands, of people who took part," he observes. "That actually is a great achievement."

A group of five nonprofit organizations united to launch the NPI as an independent effort.

A "fast track" for photonics in the United States

Just as the 1998 U.S. NRC report *Harnessing Light* shaped European thinking, its successor—*Optics and Photonics: Essential Technologies for Our Nation*, which appeared in August 2012—has similarly galvanized the U.S. photonics field and has ratcheted up awareness of photonics in government circles.

The *Essential Technologies* report highlighted the enormous, largely hidden sway of photonics on the U.S. economy, and framed five "grand challenges" to bridge current technological gaps. One immediate outcome of that call to action came in April 2013, when the National Science and Technology Council, an arm of the White House Office of Science and Technology Policy, chartered a Fast-Track Action Committee on Optics and Photonics (FTAC-OP) to help set priorities for federal research in the field.

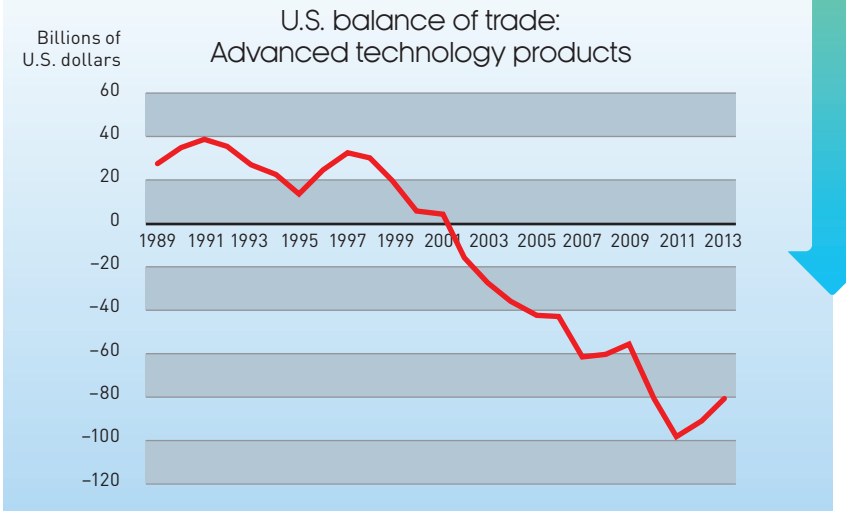
FTAC-OP released its final report and recommendations in April of this year. The recommendations highlighted four basic research opportunities—biophotonics for biology and disease research, faint-light and single-photon research, imaging through complex media, and ultra-low-power nano-optoelectronics. FTAC-OP also identified three "capability opportunities" needed to provide photonics advances. These included investment in accessible fabrication facilities for researchers, in technologies such as compact light sources and detectors at "exotic" wavelengths, and in domestic sources for critical materials.

These specific areas, FTAC-OP stressed, mesh both with the grand challenges outlined in *Essential Technologies* and with broader U.S. federal priorities. The U.S. National Science Foundation (NSF) seems to agree. On 16 July, it issued a "Dear Colleague" letter encouraging "innovative research proposals" in optics and photonics in several key areas. And it cited the FTAC-OP report as a key input in that decision.

The National Photonics Initiative

Among the inputs to the fast-track process were an early informational event organized by, and subsequent testimony from, the newly formed NPI—the creation of which was another immediate outcome of the *Essential Technologies* report.

The seeds of the NPI lay in the NRC study's recommendation that the federal government "develop an integrated initiative in photonics," akin to the existing federal National Nanotechnology Initiative,



Source: U.S. Census Bureau

that would bring together industry, government and academia to foster a coherent photonics R&D agenda. "The whole theme here was to help organize the broader photonics community in the U.S.," notes Thomas Baer of Stanford University, the 2009 president of OSA and the chair of the NPI steering committee, as well as a coauthor of the *Essential Technologies* report.

Taking a cue from the report—but also mindful of the length of U.S. budgetary cycles and the long lead time to get government-led efforts off the ground—a group of five nonprofit organizations (OSA, SPIE, the IEEE Photonics Society, the Laser Institute of America and the APS's Division of Laser Science) united to launch the NPI as an independent effort.

"We wanted to start getting momentum behind the idea, before taking the time and effort to try to get something governmentally sustainable," says Matthew Weed of Open Photonics, Inc., who has worked on developing the NPI as a member of OSA's Public Policy Committee and a member of the NPI steering committee. Weed says that the example of Europe's Photonics21 "was one of the things that spurred us to take this really seriously right now," adding that the community in the United States has arguably been less successful in communicating the value of photonics to broad economic growth and competitiveness.

But tempting as it might be to view the NPI as "Photonics21 for the U.S.," both Baer and Weed stress that the two organizations are very different. A close collaborative relationship between industry and government in establishing an R&D investment agenda is an easier sell in Europe, which has a long tradition of such ties—exemplified in efforts such as the German Fraunhofer program's government-industry-academic complex—than it would be in the United States, where government-industry ties are viewed with more suspicion. "In the EU," Weed says, "there's a bit less fear of picking winners and losers" than in the United States.

Instead, the NPI operates as what Weed calls "a sort of professional society clearinghouse," building consensus among a wide array of stakeholders and providing a communication channel to government and the public for the interests of the broadly dispersed U.S. photonics community. And that, says Thomas Baer, is an advantageous structure.

"What's happened with the NPI," Baer says, "is it's really been a hybrid" between industry and academia, through the professional societies. "And that's been a real strength, because those societies represent both of those communities very effectively. It's facilitated a real increase in the communication bandwidth between those sectors." Baer also credits the collaborative efforts of the volunteers and staff from the five societies involved, which he says has been "a key element of success" in delivering a unified message to the government.

Another distinctive element of the NPI, adds Baer, is its significant outreach effort to commercial firms that, while not photonics companies in themselves, use photonics as a key technology in their commercial efforts. "These are the likes of Intel, Google, Facebook, Halliburton, Lockheed-Martin—not typically people we see wandering the halls at CLEO," the annual Conference on Lasers and Electro-Optics. The NPI, he says, provides a vehicle for a dialogue on how photonics can solve problems of crucial interest to those companies. "That's probably been the most rewarding part of this," in Baer's view.

The advanced-manufacturing challenge

The NPI's bottom-up communication channel with government comes at an opportune moment, in light of competitive challenges for U.S. manufacturing generally and for photonics in particular.

The United States remains an unmistakable leader in the funding and practice of science. Total research spending by the

U.S. government—through a wide variety of agencies including the Defense and Energy departments, NSF, the National Institutes of Health, and smaller efforts by units such as the National Institute of Standards and Technology—equals or exceeds aggregate spending by European national governments and the EU. Historically, the United States has also been the world leader in photonics innovation.

But in recent years, globalization of manufacturing and increased competition from Europe and Asia have eroded some of that edge, and made it difficult for U.S. innovation to translate into industry dollars. According to the U.S. Census Bureau, the balance of trade in advanced technology products slumped from a surplus of US$32.3 billion in 1997 to a deficit of US$81.3 billion in 2013.

In its initial whitepaper, *Lighting the Path to a Competitive, Secure Future*, the NPI noted the potential of photonics technologies, particularly in areas such as ultrashort-pulse lasers and 3-D printing, to re-establish U.S. leadership in high-value-added manufacturing. The subsequent report of the NPI's task force on next-generation data centers—one of several task forces pulled together by the initiative to drive forward discussion on specific, critical areas—recommended the promotion of photonics-driven advanced manufacturing through the Obama administration's evolving National Network for Manufacturing Innovation (NNMI) program. And there are signs that the argument has found a receptive audience.

"Valley of death," U.S. edition

The NNMI is the Obama administration's answer to the "valley of death" problem that has also preoccupied the photonics industry in Europe (and, for that matter, most of the world). The valley is simply the gap in investment between the development of new technologies in universities and government, and their mainstream production by the private sector. To pursue this "missing middle," the Obama administration has proposed creating up to 45 Institutes for Manufacturing Innovation (IMIs)—public-private partnerships, partly funded by the government, that would allow industry and academia to work together on bridging the gap.

Getting photonics on the IMI agenda suggests that the more integrated messaging around photonics as an enabling technology is starting to bear fruit.

For photonics, the big news on this front came late this spring, when the Department of Defense (DoD) issued a request for information (RFI) to create two new IMIs in areas of specific interest to national security. The RFI identified six technology areas under consideration, only two of which will be selected for the IMIs. And one of the six was photonics.

Thomas Baer says that the NPI's advisory efforts and government outreach were among the inputs to the DoD decision, and believes that they helped persuade DoD to include photonics on the short list. The NPI also actively coordinated and encouraged member responses to the RFI, which closed for input on 14 July.

As this issue went to press, DoD had not yet determined whether photonics would be one of the two technologies selected for the new IMIs. (That decision will come sometime before 1 October, so that the two new institutes can fall within the fiscal 2014 budget.) But irrespective of the outcome of this NNMI round—and there will be others—getting photonics on the IMI agenda suggests that the more integrated messaging around photonics as an enabling technology is starting to bear fruit. "That," Matthew Weed concludes, "is pretty exciting." OPN

Stewart Wills (swills@osa.org) is OPN's editor and content director.

To learn more ...

- *Harnessing Light: Optical Science and Engineering for the 21st Century* (U.S. National Research Council, Washington, D.C., 1998).
- *Optics and Photonics: Essential Technologies for Our Nation* (U.S. National Research Council, Washington, D.C., 2013).
- *Towards 2020—Photonics Driving Economic Growth in Europe: Multiannual Strategic Roadmap 2014–2020* (European Technology Platform Photonics21, Brussels, April 2013).
- *Lighting the Path to a Competitive, Secure Future* (National Photonics Initiative, Washington, D.C., May 2013).
- Fast-Track Action Committee on Optics and Photonics, *Building a Brighter Future with Optics and Photonics* (National Science and Technology Council, Washington, D.C., April 2014).
- Advanced Manufacturing Technology Consortia (AMTech) Program, www.nist.gov/amo/
- Optoelectronics Industry Development Association, www.osa.org/en-us/oida/
- International Optoelectronics Association, www.internationaloptoelectronicsassociation.org/