National Issues in Industrial Physics

Challenges and Opportunities

APS physics

The Report of a Workshop Sponsored by The American Physical Society and The Forum on Industrial and Applied Physics

October 2014

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and

The American Physical Society

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College Park, MD

Acknowledgements

This report contains the conclusions and recommendations of 38 experts who met for two days in October 2014 to identify issues pertaining to the health and well-being of industrial physics in the United States. The Workshop was convened by the Forum on Industrial and Applied Physics (FIAP), a unit of the American Physical Society, and by the American Physical Society (APS) itself. The meeting was part of a larger information gathering exercise by APS and FIAP to understand the services and products needed by the industrial physics community in the future.

While the importance of industrial physics to the technology portion of the U.S. economy has long been recognized, only recently have the decline of U.S. manufacturing and the globalization of scientific R&D led to recognition that U.S. leadership in industrial physics is being challenged. Because of the importance of industrial physics to the economy, it is imperative to understand the issues raised by that challenge. The issues identified by the Workshop attendees are real, and the possible actions to address those challenges have been formulated to be realistic and effective.

The Report was prepared by the Workshop Organizing Committee based on extensive notes of the conclusions and recommendations made by the Workshop participants. While the primary audience is APS and FIAP, the conclusions should be of interest to industrial physicists, the companies that employ and benefit from the work of industrial physicists, academic physics departments, and government agencies that support and make use of industry for technological progress and economic activity.

Workshop Organizing Committee

John Rumble (Co-Chair) .... R&R Data Services

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Christina Back .... General Atomics

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Copies of this report are available at **www.aps.org/units/fiap/meetings/upload/FIAP-2014.pdf**

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Executive Summary

Physics has been a prime mover of industrial development in the United States for over 100 years. Physicists in industry have made possible the technological advances of modern products that make our lives safer, better, and easier as well as improving the security and infrastructure of our Nation. In many ways, industrial physics is responsible for the creation of the modern age.

As we move deeper into the 21st Century, U.S. industrial leadership in using physics as a key driver for success is already significantly challenged and it is urgent to identify and address those challenges. Because industrial physics underpins economic growth in our technology driven economy, the American Physical Society (APS) recognized in its 2013-2017 Strategic Plan the need to serve better the industrial physics community. The APS Forum on Industrial and Applied Physics (FIAP) has similarly created a new FIAP Strategic Plan for the industrial and applied physics community for the next decade.

FIAP and APS jointly held a Workshop on National Issues in Industrial Physics: Challenges and Opportunities on October 6-7, 2014, at St. Michaels MD. The Workshop brought together senior and mid-level industrial physicists from diverse industries for a two-day meeting. The primary purpose of the Workshop was to identify and prioritize issues important to U.S. industrial physics. Workshop participants made the recommendations in four major areas of concern:

Preparing and Supporting the Industrial Physicist

- Encourage industrial internships for physics students
- Create a new culture of mentorship by industrial physicists
- Improve guidance on industrial physics careers
- Address the needs of early-, mid-, and late-career industrial physicists

Supporting Industrial Physics

- Improve Industry-Government cooperation on industrial physics R&D
- Improve Industry-Academia cooperation on industrial physics R&D
- Establish a FIAP Policy Advisory Committee

Promoting Industrial Physics

- Talk about success
- Prepare a report on the “Impact of U.S. Industrial Physics”
- Brand Industrial Physicists
- Provide leadership in building an Industrial Physics Community
- Hold meetings for industrial physicists
- Identify partnerships for clusters of industrial physics interests

The Way Forward

- Involve industrial physicists and their companies in APS programs and leadership
- Increase APS resources serving industrial physics
- Establish an APS Industrial Physics Advisory Board
- Expand FIAP’s programs serving individual industrial physicists

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1. Background

Industrial applications of physics have been a prime mover of the U.S. Industrial Age for well over a century. Technology advances in virtually every area have been made possible by industrial physicists applying the latest physics knowledge to develop technologies that improved the social good in electronics such as radio, television, computers, high speed telecommunication networks and GPS devices, and medical technology that have made our lives safer, better, and easier. Equally important have been the contributions of industrial physics to the security and infrastructure of our Nation, including jet aircraft, radar, space exploration, air traffic control system, and renewable energy.

We take for granted an unencumbered and continuous flow of physics from the efforts of individual physicists to those of large industrial companies based on physics. The world, however, continues to evolve: high quality physics research is done in more countries than ever; technology is globalized; physics information is widely available on the internet; and the world economy and our national financial situation have been severely challenged in the last decade. The very nature of industrial physics is also changing as many large central labs have been de-emphasized and the industrial physics community has become more geographically distributed, often in small, entrepreneurial companies.

As we move deeper into the 21st century, U.S. industrial leadership in using physics as a key driver for success is already significantly challenged and it is urgent to identify and address those challenges. The issues include the availability of physicists to perform industrial physics at the highest levels, the availability of new physics to overcome technological challenges, and the support of the industrial physics community by the government, the legal system, the financial sectors, and perhaps most importantly the academic physics community as a key player in improving society as well as an important driver for new economic activity, wealth, and socio-economic well-being.

The APS 2013 strategic plan identifies the Industrial physics community as a major target for new services

Based on the fact that industrial physics underpins technology advancement and economic growth in our technology driven economy, the American Physical Society (APS) recognized the need to better serve the industrial physics community in its 2013-2017 Strategic Plan. The APS Forum on Industrial and Applied Physics (FIAP), which was started in 1995 to serve the industrial physics community, has similarly created a new FIAP Strategic Plan that emphasizes identifying and addressing needs of the industrial physics community in the next decade.

FIAP and APS jointly held a Workshop on National Issues in Industrial Physics: 21st Century Leadership of U.S. Physics in Industry on October 6-7, 2014, at St. Michaels, MD. The Workshop brought together senior and mid-level industrial physicists from a diversity of industries for a two day meeting. The primary purpose of the Workshop was to identify and prioritize issues important to U.S. industrial physics. A copy of the Workshop agenda and list of participants starts on Page 22.

2. The Industrial Physics Landscape of the 21st Century

It is clear that the pace of technological progress in the coming decades will likely outpace what occurred during the second half of the 20th century. Rapid advances will continue in computers and electronics, while fundamental developments in transportation, materials, bio-medicine and nanotechnology will drive future economic development. Physics will continue to generate and provide the foundation for these technological advances, with industrial physicists playing a critical role in translating fundamental physical discoveries into viable commodities and technologies, with continuous pressure to reduce the time and expense required to bring products and services to market. Industrial physicists are especially suited to support different types of technology development as industrial interests evolve. Often the barriers to success occur at the most fundamental physical level. ***The ability to translate basic physics knowledge into application-oriented solutions remains the forte of industrial physicists.***

Global competition for leadership in industrial physics continues to grow and the United States has to increase cooperation among industry, academia, and government to meet that

The success of industrial physics depends critically on the free flow of ideas, access to the best worldwide physics talent and the entire world's scientific literature, and increased cooperation among industry, academia, and government on a national and international scale. These elements have been critical to the success for U.S. industrial physics, but are so embedded in physics culture that their existence is assumed. Given the dynamic emergence of the global economy, especially with respect to technology, it is essential to re-examine and re-state the assumptions of these interfaces and to determine what evolutionary changes are necessary to ensure continued U.S. preeminence in industrial physics.

Industrial physics must be recognized as a key U.S. scientific community and economic driving force whose needs are understood and addressed by groups such as the American Physical Society, U.S. National Laboratories, federal funding agencies, and industry itself. Such recognition requires answers to the following questions.

- Where does the community stand today?
- What are the challenges that confront continued excellence of U.S. industrial physics?
- What actions are needed and by whom to overcome these challenges?

These are the issues the FIAP/APS Workshop on National Issues for Industrial Physics discussed, and the means to address those issues follow. The identification and discussion of specific issues was developed under four broad categories:

- Preparing and Supporting the Industrial Physicist
- Supporting Industrial Physics
- Promoting Industrial Physics
- The Way Forward

Each of these categories is discussed in more detail below, with a brief summary of the present day status, challenges that the workshop identified, and a list of possible actions to address the challenges.

3. Preparing and Supporting the Industrial Physicist

STATUS

The practice of industrial physics begins with a supply of outstanding physicists, well trained in many fields of physics and other sciences and technology, and capable and willing to work in an industrial environment. While in many cases graduate degrees are required, many industrial opportunities exist for those with only an undergraduate physics degree. The transition from academic physics to industrial physics may require changes in priorities and focus, but most physicists embarking on an industrial career realize their education has not ended with the award of a degree, but instead will continue throughout their career.

Industrial physicists quickly learn many of the basics of industry: accountability, dealing with constraints, identification and focus on the customer, active listening, business practices (e.g. business case development, return on investment, deadlines, and sunk costs), rapid problem solving, working in teams, multi-disciplinary projects, communication skills, and the importance of profit. The Workshop participants identified a number of salient points about the present day status of preparing and supporting industrial physicists for the 21st century.

First, from a number of perspectives, U.S. graduate education in physics continues to be the world's best. U.S. physics departments take graduate education seriously. The past four decades has seen growth in outstanding physics programs at additional universities across the United States, and U.S. physics departments have maintained outstanding research facilities and publication records. Foreign students continue to seek U.S. graduate physics degrees, and many of them desire to and succeed in staying on for both academic and industrial careers. While the influx of foreign graduate students slowed around 2001, it appears to have returned to previous numbers[1]. Students educated in the U.S. continue to generate important literature and many of them populate academic ranks to strengthen education programs.

Recent data[2] show that about 70% of U.S. physics graduate students enter non-academic careers such as those in industry, government, NGOs, and business start-ups, mostly but not always in physics-related fields. While their physics training is on par with the minority who go into academic careers, a number of specific challenges have been identified as discussed below. It is important to recognize that the flow of physicists into non-academic careers takes place at many different times after final graduation. Many PhDs take one or more postdoctoral positions before leaving academia, often entering a new field of physics that broadens their knowledge and increases their attractiveness to industry. Faculty members also choose to leave academia at various points in their careers.

70% of graduate physicists go into non-academic careers and need skills and knowledge beyond physics to succeed

CHALLENGES

The Workshop participants concluded that despite the many strengths of the present U.S. graduate physics system, graduate physicists who go into non-academic careers could significantly benefit from better services directed towards their career paths. Every industrial physicist has anecdotes of specific knowledge s/he could have used in an industrial career, but a number of more universal

1 www.aps.org/publications/apsnews/200501/graduate-students.cfm

2 http://scitation.aip.org/content/aip/magazine/physicstoday/article/66/8/10.1063/PT.3.2083

issues have been identified as discussed below. While the cultural disconnect between the physics academic system and future non-academic careers is a fundamental underlying problem, all of the broader issues were viewed as remediable. The major current graduate education issues identified were as follows.

Career guidance is too narrow

In spite of the fact that the large majority of physics graduate students end up in non-academic careers, very little coaching is available to them to take advantage of the broad career landscape; and the coaching that is available is perceived as inadequate. There is a noticeable lack of mentors for students interested in non-academic careers as few physics graduate departments have connections with industrial physicists for their students. While some universities have close ties to national laboratories if they are nearby, that remains the exception rather than the rule. The lack of exposure to non-academic careers is demonstrated by the small number of industrial internships, few on-campus speakers from industrial physics, and few opportunities to network with industrial physicists in whatever area the school is located.

Deficits in technical training

In many cases, physics thesis research today is so specialized that graduates in experimental physics do not receive the broader, hands-on experience that was common before advanced commercial equipment, electronics, and computers supplanted building scientific apparatus and recording data. The complexity of today's consumer products (automobiles, radios, television, sound equipment) has already reduced the tinkering and exploring that budding physicists did in the past. This combined with the increased specialization of modern physics apparatus has led to a significantly reduced hands-on experience that is often needed in industrial physics research.

The same issues arise with respect to software skills. Data capture, management, and analysis packages have become so sophisticated that many students have not experienced software writing in any depth. While the same software packages are found in most industrial labs, frequently proprietary or state-of-the-art research requires software skills that have to now be learned on the job.

Deficits in work skills

Many of these issues reflect a deficit in general work skills that are fundamental requirements for industrial, national lab, and other non-academic careers. These skills are often overlooked, however, in the intense drive to complete one's thesis project. Teamwork skills are critical; industrial physics almost always takes place in a team environment, usually involving close work with experts who are not physicists. Again graduate thesis work is directly tailored to be an individual accomplishment, and yet young physicists must immediately go through an adjustment to the industrial team environment upon starting a job in industry.

Communication skills can be incorporated into all types of academic programs

Communication skills are equally important and their development is frequently ignored in academic settings. The ability to describe one's work succinctly and accurately to knowledgeable, or more importantly, non-knowledgeable, people takes time to develop. While giving talks at regional and physics meetings provides training in making presentations, the emphasis is on demonstrating success, not on describing problems that have arisen, or the meaning of results unexpectedly found. This is even truer for written communications that are not scientific papers. Communication in industry requires concise and precise writing, especially for management. The style of writing used in scientific papers does not favor brevity or conciseness. The ability to market ideas is critical. Whether selling an idea to a manager, to peers, or to an external customer, the ability to market effectively is often a key to success. One aspect of communication often overlooked is listening, especially to understand what a customer or peer has to say. We are taught to promote our own ideas, but not taught to listen to and understand the ideas of others. This includes learning to listen to experts in other disciplines.

Cross-disciplinary science is not a fad; the real life products and services provided by modern industry rarely result from the straightforward application of physics. Chemistry, materials science, engineering, biology, and medicine are so intricately interwoven into products that collaboration is required. Industrial physicists must routinely learn about and understand many sub-disciplines, yet a multi-disciplinary thesis across departments is still far from the norm in academia. Efforts such as NSF initiatives and other interdisciplinary centers are successful to some degree, but the typical physics graduate still has worked in physics by herself/himself.

The progression from research result to successful technology development involves many steps as captured in the technology readiness levels originally proposed by NASA[3]. Introducing this system to physics graduate students would help them prepare for the different expectations in an industrial environment.

A final work skill needed almost immediately in an industrial career can be loosely described as project management. This includes everything from postulating brief but accurate problem statements, budgeting, people management, time management, and decision oriented progress reports. Again thesis work does not usually involve any training for these skills.

POSSIBLE ACTIONS

There are no quick fixes for the challenges listed above, nor does the response require some type of revolutionary approach to the preparation and support of industrial physicists, especially those just leaving academia. Rather, there is a strong need for a discussion of these issues and most importantly for groups such as the American Physical Society to both encourage and facilitate such interactions.

This list of possible actions is not exhaustive, but the Workshop participants reached agreement that these would be an excellent start to improve the flow of well-trained physicists into industry.

Encourage internships in industrial physics for physics students

Internships and mentoring are very effective ways to teach students about industrial physics careers

One of the most useful introductions to a career of industrial physics is through an internship, either at the undergraduate or graduate level. People who have been an intern almost universally enjoyed the experience for an understanding of what industry is like as well as the professional relationships that are almost always formed. Internships can be difficult to fit into an undergraduate or graduate program, but that problem can easily be overcome by careful scheduling or adjustment of class loads. The benefits clearly outweigh the perceived difficulties.

Internships are foreign to most physics departments, and work must be done to facilitate their inclusion in those departments. Among the actions that would help are the following.

- Establish an internship clearinghouse: Identify companies willing to accept interns, including funding possibilities

[3] www.nasa.gov/content/technology-readiness-level/#.VJLQ1ivF-So and http://esto.nasa.gov/files/trl_definitions.pdf

- Provide guidance to departments for supporting internships: Identify implications for the student and the department; describe how to integrate an internship into a full academic or thesis schedule

- Learn from engineering departments: Many routinely offer internships to their students and have experience on their management as well as possible problems and how to overcome them

- Encourage internships to be physics-oriented, even if the overall project is more engineering oriented: Provide guidance to industry to keep the focus on physics

- Request departments publicize internship connections: Such information should be widely available to prospective and existing students

- Work with graduate funding agencies to cover appropriate costs: Identify ways funding can be adjusted if an internship delays completion of a degree

Create a new culture of mentorship by industrial physicists

Almost every physicist has had a mentor at some point in her/his career, whether it be informal such as a friendly professor, more formal such as a thesis advisor, or deliberately formal such as an assigned mentor on the job. Before reaching industry, however, the likelihood of a physicist having a mentor with significant industrial experience is quite small. Internships can fill that void to some extent, except the potential mentor is usually one's "boss" which can get in the way of an effective mentoring relationship.

It is possible to create effective mentoring relationships for graduate students even while they are working on their degree. The key is to create a formal opportunity that starts the mentoring. University departments can do this, for example, by soliciting potential mentors from local industry or former graduates who are now in industry. Departments can encourage their students to take advantage of such a program, especially as a graduation date approaches. A number of actions were identified by the Workshop participants that would foster mentoring by industrial physicists.

- Set up department or APS clearinghouses of potential mentors: Soliciting mentors through ties with local industry and former graduates, and issue a call for industrial physicists interested in mentoring

- Provide guidance to potential industrial mentors: What is involved; what is the time commit ment; what if the relationship does not work

- Use APS's Local Links in places where it has started: This new program holds regular meet ings to bring together students, industry physicists, and academics in a geographically defined region

- Work with departments to define the relationship of mentors and thesis advisors: A mentor should concentrate on advising students about their careers, not helping to complete their thesis

- Emphasize importance of receiving mentoring: Students should be encouraged to have a mentor, especially if they are heading towards an industrial physics career

- Request departments publicize mentoring connections: Mentoring should be viewed as a selling point for departments helping them to attract the best potential candidates.

Improve guidance on industrial physics careers

All too often, once graduate students get immersed in their thesis, the project becomes all-consuming until they have the sudden realization that in fact they will finish and will then have to move on to the next step in their career. Yet good career planning takes time and should be started at the beginning of their studies, not the end. That is not to say that one must know one's career path in detail; that is not usually possible. What is possible is creating awareness in students of potential career paths by exposing them to the possibilities early on. The APS Strategic Plan highlighted this issue, and significant progress has been made through expanded APS career services. Those resources and activities should be expanded and advertised more broadly.

Career guidance should be designed to make students aware of possibilities, not to decide for them

It is the responsibility of physics departments and physics societies to help make this happen. Possible actions include the following.

- Improve the career tool box: Expand use of techniques such as social media, web-based, You Tube, LinkedIn, and blogs, as well as traditional printed materials

- Continue to expand career programs at national, regional, and local physics meetings: Bring in industrial physicists to talk and allow plenty of Q&A; Consider holding APS career events at national industrial conferences such as Mobile World Conference and InfoComm

- Provide mentors with career information: Mentors are ideal ways to expand a student's view of careers

- Encourage physics departments to advertise and participate in career fairs: Use APS and local resources to encourage employers to participate; also partner with engineering departments that already do career fairs and expand them to include physics-oriented companies

- Enhance the "FIAP Industrial Speakers List": Publicize it as a resource for physics departments and graduate student associations

Address the needs of early-, mid- and late-career industrial physicists

Career paths into industrial physics are not always linear from graduate (or undergraduate) school directly into industry. Many PhDs take one or two postdoctoral fellowships. Young, mid-career, and even late-career professors often want or need a new challenge and find industry attractive.

The need to nurture these physicists must be recognized. In this case, an organization such as the American Physical Society, rather than a department, is most aptly placed to provide help. Programs such as the following are important.

- Mentoring: Provide mentoring possibilities to mid- and late-career physicists looking to change careers

- Career guidance: Develop career information for this cohort, including advice on updating re sumes and training for interviews

- Industrial physics jobs listings: Expand and promote existing job boards
- Mid- and late-career networking: Encourage APS Local Links and industry days at national and regional meetings
- Access to scientific knowledge: Develop new information resources to help mid-career physicists moving into new areas and needing to get up to speed quickly on topics unfamiliar to them
- Reciprocal society memberships: Enable multi-society membership-sharing to reduce costs

Many mid- and late-career physicists seek career changes, yet few resources are available to help them pursue change

4. Supporting Industrial Physics

STATUS

The progression of new physics from the research bench, whether in academia, industry, national labs, or other institutions, continues unabated. Recent advances in solid state, optical, and materials physics, as well as those in nanotechnology are providing technology industries with new ideas and interesting opportunities for new devices, products, and capabilities. U.S. technology industries have recognized the increasing importance of physics generated in foreign countries, and foreign-based research labs have been established by those companies around the world.

One very prominent and positive change over the last two or three decades is the growth of partnerships among industry, national labs, and academia, which has arisen for a number of reasons. First, new user facilities at government labs or government-sponsored (federal and states) at universities have become available in this time frame, providing specialized measurement and characterization capability to small and large companies At the same time, new federal programs, such as SBIR/STTR, DARPA, NIST Centers of Excellence, and ARPA-E, have been aimed at industrial physics companies to address specialized needs in support of government programs and technology goals.

With passage of the Bayh-Dole Patent Act (Pub. L. 96-517, December 12, 1980), universities, national laboratories, and businesses were able to patent inventions resulting from government funding. This Act brought in a new attitude about commercializing research results and opened the door to closer partnerships among academia, national labs, and industry that has fueled new technology in many areas. This new entrepreneurial spirit in the country has fostered many startups and small companies, which has mitigated the fact that some large company labs have been reduced and/or replaced in part by acquisition of innovations developed by small companies.

The United States technology industry has long faced growing competition, first in the 1960s to 1980s from developed countries (especially Germany, Japan, and France) recovering from World War II and next starting in the 1990s from emerging economies, both large (China and India) and small (Korea and Singapore). Yet it is clear that industrial physics has provided major support to the U.S. industry that has enabled continued excellence, world-wide leadership, and strong contributions to our economy.

CHALLENGES

While the flow of physics ideas continues strong, a number of non-technology challenges have been identified. Individually the challenges may seem small, but collectively these challenges impede success, especially in face of growing foreign competition.

- **National lab user facilities**

Industry is considered a major customer, but the timescale for approvals often does not fit with the fast pace of industry requirements, which include both problem solving (on very short time scales) and design and performance validation (on time scales to meet possible competition or preserving leaps of innovation)

- **Federal competitive contracting**

This process can be very costly and slow, especially for small businesses. Over the last decade, many new companies have declined to compete for federal contracts because of these challenges.

SBIR/STTR programs

The programs are helpful, but often are overly bureaucratic. Companies that have successfully used SBIR funding to achieve success have found that several related awards are needed to succeed. In addition, a number of agencies have only reluctantly made SBIR funding available, providing the minimum overall amount required.

Entrepreneurship opportunities for physicists have never been better

Intellectual property rights

IPR continue to impede collaborations between industry and universities, Universities often do not recognize that one individual patent rarely leads to commercial success; instead usually a portfolio of patents are required. This misconception leads to difficult negotiations that industry might walk away from rather than spend too much to reach an agreement.

Industrial physics policy issues

Few mechanisms exist to bring forward industrial physics policy issues of importance to the government, university organizations, and professional societies. Academic physics has well identified advocates, but the industrial physics community often gets lumped together with manufacturing, which overlooks the particular needs of industrial physics.

Reduction in the supply of foreign industrial physicists

For the last century, U.S. industrial physics has been populated by both U.S. born and foreign born physicists. Since 2001, industry has had considerable difficulty in bringing in sufficient numbers of foreign born industrial physicists because of visa restrictions and security concerns. It is time to reconsider these restrictions. Many U.S. universities invest tremendous amounts of money in preparing highly skilled PhD physicists who would be welcomed by U.S. industry if these barriers could be reduced.

POSSIBLE ACTIONS

Most of these actions require a longer term effort, and in some cases, the initial action is to organize the involved organizations in a conversation regarding challenges and possible solutions. There was wide agreement at the Workshop that the voice of industrial physics is neither well-articulated nor well heard, a situation must be changed.

Improve industry-government cooperation on industrial physics R&D

Over the past three decades, the federal government has steadily increased its investments in the technology sector using a number of different mechanisms. Many of these efforts have had significant positive impact, but improvements are possible in a number of areas.

1. Create better industrial physics advisory groups for government agencies: While in a number of situations, prominent industrial people are involved in various advisory groups to the government, including DOE and their national labs, NSF, NIH, NIST, and other federal labs and agencies, more effective and diverse representation is needed. Agencies especially need a greater understanding of industry timescales and ROIs

2. Foster entrepreneurship in industrial physics through more agile investment programs: Reduce the bureaucracy; accept risk; establish smaller, quicker programs; encourage agencies to accept failure as part of doing business; recognize that industrial physics investments do not have to lead directly related to manufacturing; establish an industrial physics advisory group to provide input and guidance

3. Restructure the handling of intellectual property rights: Publicize best practices from industry collaborations with national labs and academia; request that the Office of Science and Technology Policy (OSTP) review IPR issues

4. Address issues concerning foreign born industrial physicists: Provide “industrial physics” viewpoint to government policy and funding agencies on issues

- Self-defeating visa restrictions
- Easier procedures for foreign born, U.S. trained graduates to stay in the United States
- Unnecessary security clearance requirements for students
- Clarification of when firewalls are needed for non-U.S. citizen researchers

Improve industry-academia cooperation on industrial physics R&D

Universities are not businesses, and there is a need to reduce expectations that industrial cooperation should only benefit universities. Universities must better understand that companies must protect their intellectual property, even in a joint investment situation. Three specific actions were recommended by the Workshop.

1. Define roles more clearly: There is a pressing need for a better widespread understanding of the individual roles that industry and universities should have in a research partnership. This understanding should transcend individual agreements and be accepted by groups such as the Association of American Universities (http://www.aau.edu/about/default.aspx?id=58) and physics-oriented professional societies including the American Physical Society.

2. Build on best practices: A number of university-industry partnerships have tried innovative approaches to IPR to solve problems quickly, again on industrial timescales, without legions of lawyers or legislative action. A compilation and description of best practices would be important input into a broader and more agile approach as described above.

3. Encourage sabbaticals in industry for university professors: These interactions would build relationships beneficial to many constituencies. Academic departments might need to use different metrics to evaluate the results of these sabbaticals if the output does not include publications.

Establish a FIAP policy advisory committee

In spite of its importance to U.S. industry and the economy, the voice of industrial physics is rarely heard in policy discussions

While occasional workshops such as the one recently sponsored by FIAP and APS help identify pressing issues, the importance of industrial physics to the health of our economy suggests that a more permanent longer-term approach is needed to identify and advocate for issues impacting industrial physics. As the APS group designed to represent industrial and applied physics, FIAP is ideally positioned to identify issues on an ongoing basis through a permanent Policy Advisory Committee. The membership of FIAP covers the broad spectrum of industrial physicists in terms of disciplines and levels of responsibility and would be a source of active participants.

This advice, however, must reach persons and organizations capable of taking the requested actions, so care must be given to ensure that a FIAP Policy Advisory Committee is effectively linked to APS policy teams – Panel on Policy Affairs (POPA) and Physics Policy Committee (PPC) as well as external groups such as federal advisory bodies. Advice must also be provided in a timely fashion.

5. Promoting Industrial Physics

STATUS

Though it is well recognized that industrial physics has made major contributions to U.S. technological success, the industrial physics community, as such, is rarely recognized as a coherent entity. Yet it needs to be nurtured as an entity. The previous two sections have discussed how to help ensure the flow of high quality physicists, which number about 50% of all physics students, undergraduate and graduate, into the industrial physics community as well as how to support the practice of industrial physics. In this section we are concerned with the community as a whole and what can be done to promote industrial physics as a vibrant and strong contributor to our future.

The role of physics in U.S. technology is well understood by industry and U.S. national labs, but that understanding does not extend to the public, Congress, or even academic physics departments. Yet as we look for solutions to major societal problems such as environment degradation, the health and well-being of people both nationally and globally, continued poverty, and energy generation and conservation, it is clear that physics will have a major role to play, especially in industry.

CHALLENGES

The challenges can be classified as three general types:

- Lack of knowledge about industrial physics
- Lack of cohesiveness among industrial physicists
- Lack of community leadership

Defining the message

Clearly there is a need to communicate "What Industrial Physics Is" on a much broader scale than is being done now. The challenge here is to construct a message about what industrial physics does and why it is important. That message needs to include a clear description of the role that industrial physicists play in transforming new fundamental physics knowledge into technology products, services, and processes. This should include the many contributions of industrial physicists to addressing societal problems such as pollution, climate change, and alternative energy.

Building an industrial physics community

Professional societies are major contributors to the scientific community within the United States, yet there is no society today focused on industrial physics. As a consequence, the industrial physics community is not organized and has no strong proponent voice. Very few national meetings are tailored specifically to industrial physics as a whole, and thus industrial physicists rarely gather together except under the umbrella of application-oriented meetings and organizations.

Industrial physics as a community needs more cohesion to face the challenges of the. 21st century

Creating a community requires creating a common identity, but that can be done. Industrial physicists generally still consider themselves to be physicists, even though they might often work in an engineering or other non-physics environment. The key challenge to overcome is this lack of unity.

Lack of Leadership

Building a community requires leadership that is dedicated and able to effect the required changes. The APS Forum on Industrial and Applied Physics has taken some steps towards exerting the necessary leadership, but it so far has lacked the resources to move ahead rapidly.

POSSIBLE ACTIONS

The overall message is concise and cogent: Industrial physics transforms discovery into products and innovates improvements to existing products; it harnesses physics for society and social good. The challenge is to construct the message so it is heard and understood. A variety of approaches are necessary.

Talk about success

Virtually every technology today owes its success to physics knowledge that has been developed over the last century. The successes are compelling and range from the GPS (and atomic and molecular physics) to integrated circuits and modern computing (solid state and materials physics) to energy generation and conservation (nuclear, solid state, and materials physics).

Many of these stories have been told individually before, but rarely have these successes been tied together under the broader entity of industrial physics. It is time to do that. Specific target audiences include the general public, government agencies, Congress, Office of Science and Technology Policy (OSTP), science writers, students, and faculty members. While traditional print media continues to be important, the new media (web, YouTube, TED/Khan talks) must also be used.

In spite of the emergence of new media, traditional magazines still have a role to play in establishing a community of interest. Since the demise of Industrial Physicist magazine that was published by the American Institute of Physics, no magazine has been targeted to this audience. The closest, perhaps, is the MIT Technology Review, which could serve as a model for a new magazine aimed at industrial physics.

Prepare report on impact of U.S. industrial physics

A report on the impact of industrial physics on U.S. technology excellence and the U.S. economy is an important mechanism to promote industrial physics here. Similar to several European reports[4,5,6] on the importance of physics in general, this report would focus exclusively on industrial physics. Such a report should point out the key contributions made by industrial physics in helping to solve societal problems, including climate change, clean water, energy, health, and food supply. The report can be done by a number of different groups, but it is now time for it to happen. The resources required to produce need to be found.

Brand industrial physicists

Many industrial physicists have outstanding accomplishments that are rarely known, yet in their own right are “Rock Stars” that deserve to be more highly honored and recognized. While the American Physical Society offers some prestigious awards for work in industry, they often are overlooked in

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4 http://c.ymcdn.com/sites/www.eps.org/resource/resmgr/policy/EPS_economyReport2013.pdf

5 http://static.sif.it/SIF/resources/public/files/report_2014/SIF-Final-Report.pdf

6 http://www.iop.org/publications/iop/2012/file_58713.pdf

comparison with the more numerous awards for academic physicists. Greater publicity needs to be given to the existing awards, and additional awards should be considered. Many industrial physicists are problem solvers of the highest intellect, and greater prominence to those successes would help create a more visible brand for industrial physics. Those accomplishments can form the basis for good story telling by industrial physicists (à la Feynman) in videos.

Provide leadership in building an industrial physics community

Community building has to start somewhere, and most effectively happens when the need meets the opportunity. The best place to start is to bring industrial physicists together for a reason, such as a meeting on common interests or through partnerships. The American Physical Society, already with significant member from industry is well placed to move ahead on this community building.

Hold meetings for industrial physicists

As mentioned previously, there are no general meetings held for industrial physics. While the APS March Meeting traditionally has some sessions focused on topics of interest to industrial physics, these are usually limited to one or two days and are overwhelmed in numbers by more academic sessions. While it is useful to have opportunities for industrial physicists and academic physicists to meet and exchange ideas, it is equally important to have meetings with industrial physics as the primary focus. Some societies offer very specialized meetings on specific topics, but rarely is there a gathering aimed directly at industrial physics that cover a broad range of topics. The synergism and catalytic nature of such a meeting would propel it to importance almost immediately.

Identify partnerships for clusters of industrial physics interests

The workshop participants pointed out groups such as SEMATECH bring together industrial physicists that are already “birds of a feather.” Other such partnerships are possible and would build communities of interest for subsets of industrial physicists.

6. The Way Forward

As discussed above the industrial physics community does not exist as a true professional community at the present time. The Workshop participants concluded that given the importance of industrial physics to the technology-based industry in particular, and the U.S. economy in general, there are many advantages to trying to create a stronger community now. While many groups can participate in this effort, the American Physical Society is in a premier position to act as catalyst, leader and innovator in making this happen. Many individual steps are needed, as detailed below, and everything cannot be done at once. A start can and should be made, as the technological basis of our economy continues to grow.

Involve industrial physicists and their companies in APS programs and leadership

APS is ideally positioned to provide more services directed specifically to industrial physicists and the companies for which they work. Specific activities should include:

- More services to early career physicists to help them prepare for and choose careers in indus trial physics
- More services to mid-career industrial physicists to help them expand their careers
- Meetings focused on and directly relevant to industrial physics, perhaps clusters of topical meetings
- More effective publicity on APS outreach and educational programs for industrial physicists
- Recruit members from industry for leadership and committee positions

Increase APS resources serving industrial physics

- New activities that expand present, academic-oriented activities
- Continuation of the position in APS Headquarters of Industrial Physics Fellow
- New APS committees focused on industrial physics issues

Establish an APS industrial physics advisory board

- Oversight of the proposed impact study
- Guidance to APS on government/academic/industrial relationships and partnerships
- Policy advice and development
- Industrial Physics Foundation

Expand FIAP's programs serving individual industrial physicists

- Aggressive membership recruitment (only 30% of APS "company" members are in FIAP!)
- Membership criteria review
- Meetings relevant to industry
- Additional career services
- Increased recognition for FIAP fellowships for industrial physicists

7. Summary

As new physics continues to move from laboratory results and computer simulations into industrial products, the importance of industrial physics and the people who practice it remains high. This community has been instrumental in creating the technological success of U.S. industry and improving our way of life. The 21st century brings new challenges that can be met with collective action. The actions the Workshop identified are major steps forward in meeting those challenges.

APS physics™

The American Physical Society is in a premier position to act as catalyst, leader and innovator in making things happen for industrial physics

National Issues in Industrial Physics

Challenges and Opportunities

October 2014

Agenda

Monday, October 6

Welcome .... Steven Lambert, *Chair*

Malcolm Beasley, *President, American Physical Society*

Kate Kirby, *Executive Director, American Physical Society*

Workshop Overview .... John Rumble FIAP Chair

Opening Session: Setting the Stage
How does the industrial physics community approach its future?

Opportunities in industrial physics created by emerging knowledge .... Jim Bray, *General Electric*

Innovation and entrepreneurship in industrial physics .... Duncan Moore, *University of Rochester*

Dynamics in industry driving new innovation modes:

The national lab perspective .... Sam Aronson, *Brookhaven*

Physics research in the future .... Alice White, *Boston University*

Session 2: Generating Ideas

Breakout Groups 1 .... Identify issues of importance to industrial physics community

Discussion .... *Steven Lambert*

Tuesday, October 7

Session 3: Ideas to Consensus

Need for US leadership in physics .... Malcolm Beasley, *Stanford University*

Breakout Groups 2 .... *Consider top issues, amplify, and prioritize*

Discussion and Consensus Seeking .... *Steven Lambert*

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Participants

Name	Affiliation
Jim Adams	Corvus Integration
Sam Aronson	Brookhaven National Lab, APS President Elect
Malcolm Beasley	Stanford University, APS President
Jim Bray	General Electric
Brian Clark	Schlumberger
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Jeff Hunt	Boeing
Barbara Jones	IBM
Matt Kim	Quanterra
Kate Kirby	American Physical Society, Executive Officer
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Marissa LaMadrid-Herrmannsfeldt	Microsoft
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Mike Lubell	American Physical Society, DC office
Alex Malozemoff	American Superconductor Corp
Joseph Mantese	United Technologes
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Duncan Moore	Univ of Rochester
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Charles Santori	HP
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James T. Taylor	American Physical Society
Tom Theis	IBM
Matthew Thompson	TriAlpha Energy
Peter Weichman	BAE Systems
Aaron Weiss	Google ATAP Lab
Alice White	Boston U, formerly Alcatel-Lucent/Bell Labs
Larry Woolf	General Atomics

National Issues in Industrial Physics

Challenges and Opportunities

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The Report of a Workshop Sponsored by
American Physical Society and
The Forum on Industrial and Applied Physics
October 2014