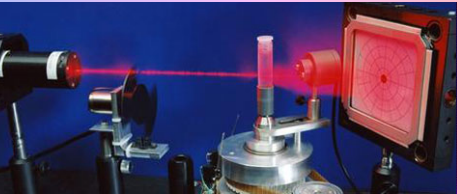


National Technology Roadmap for Photonics

NIST AMTech Review Meeting
September 10, 2014



NTRP
National Technology Roadmap for Photonics

NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

Purpose and Goals

Purpose of today's meeting

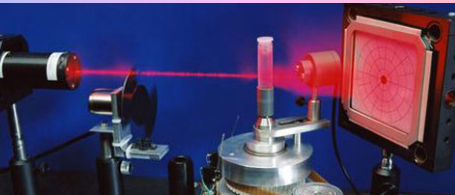
- Review progress on NTRP roadmapping activity
- Present some ideas for IMIs for photonics

Goals for morning

- Receive feedback on roadmapping, get ideas for improving it, make course corrections if necessary
- Hopefully, provide NIST with some best practices they can share with other AMTech awardees

Goals for afternoon

- Provide NIST (and the DoD) with useful information they can use to design IMIs for optics and photonics
- Receive feedback that we can use to build a consortium that will apply for an NNMI grant

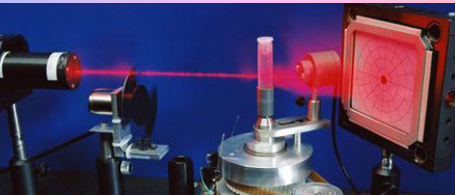


NTRP
National Technology Roadmap for Photonics

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U.S. Department of Commerce

Morning Agenda (NTRP)

8:30 – 8:45 – Introductions	All
8:45– 8:50 – Agenda and Goals for Meeting	Paul Ballentine, UR
8:50 – 9:10 – Overview of AMTech Program	Tom Lettieri, NIST
9:10 – 9:20 – NPI overview	Emily Flynn Pappas, Podesta Group
9:20 – 10:00– NTRP overview	Ballentine
Technical Working Group Presentations:	
10:00– 10:15 – Lasers	Jay Eastman, Optel and UR
10:15– 10:30 – Sensing and Imaging Systems	Robert Fiete, Exelis
10:30 – 10:45 – Coffee Break	
10:45 – 11:00 - Advanced Optics	Duncan Moore, UR
11:00– 11:15 – Displays	Mark Poliks, Binghamton University
11:15 – 11:30 - Biophotonic Devices	Jim Zavislan, UR
11:30 – 12:00 - Discussion of NTRP	All



NTRP
National Technology Roadmap for Photonics

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U.S. Department of Commerce

Afternoon Agenda (NNMI)

12:00 – 12:15 – Break and get lunches

12:15 – 1:00 – Manufacturing Consumer Optical Goods in the U.S.

Anurag Gupta, Google

1:00 – 2:00 – University Perspectives on an IMI for photonics (BU, CREOL, AZ, UNM)

2:00 – 2:30 – Designing an IMI for optics and photonics

Paul Ballentine

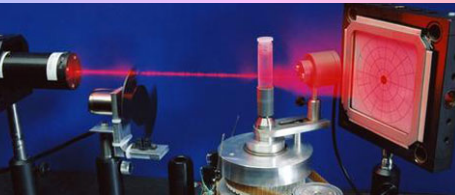
2:30 – 2:45 - Coffee Break

2:45 – 3:45 – Company perspectives (Exelis, LaserMax, RPO, IQE, GE, Inrad, Moondog Labs, EoS Photonics)

3:45 – 4:15 – Education and Workforce Development (AZ, UR, UNM, R-H, MCC, Open Photonics)

4:15 – 4:45 – Summary, Action Items, Next Steps

4:45 – 5:00 – NTRP TWG co-lead meeting



NTRP

National Technology Roadmap for Photonics

NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

NIST/AMTech NTRP Consortium Review Meeting

Thomas R. Lettieri
NIST/AMTech Project Manager

September 10, 2014



What is AMTech?

The Advanced Manufacturing Technology Consortia (AMTech) Program

Launched by NIST in FY 2013

- To incentivize the formation of, and provide resources to, industry-driven consortia
 - Supports both basic and applied research
 - Focuses on long-term, pre-competitive, and enabling technology development
- For the U.S. manufacturing industry



The goal of AMTech-supported consortia will be to strengthen the capacity of U.S. industry and the nation to compete in global markets

How Will AMTech Work?

- Once fully implemented, NIST envisions AMTech to offer funding in two broad areas: *planning awards* and *implementation awards*.
- The FY 2013 AMTech *planning awards* funded eligible applicants to create new, or strengthen existing, industry-led technology consortia.
- AMTech-supported consortia will:
 - Identify and prioritize long-term, pre-competitive industrial research needs;
 - Enable technology development;
 - Create the infrastructure necessary for more efficient transfer of technology;
 - Represent a broad range of involved firms across all stages of the value chain.
- There is no formal connection between AMTech and NNMI.

2013 Planning Grants

- To establish and strengthen new and existing industry-led consortia that are focused on developing advanced technologies to address major technical problems that inhibit the growth of advanced manufacturing in the U.S.
- To identify and prioritize research projects supporting long-term industrial research needs and a range of eligible activities including, but not limited to, creating new or updating existing industry-led, shared-vision technology roadmaps for the development of technologies underpinning next-generation and/or transformational innovations.
- To undertake other activities designed to establish and strengthen new and existing industry-led, multi-partner consortia that catalyze technology infrastructure and American excellence in advanced manufacturing.

2013 Competition Results

Nineteen Awards totaling \$9 million in NIST funding

Consortia Characteristics

Status: 11 New

8 Existing

Crosscutting Technologies (# of efforts):

- 1 - Additive Manufacturing
- 2 - Advanced Forming & Joining Technologies
- 7 - Advanced Manufacturing & Testing Equipment
- 2 - Advanced Materials Design, Synthesis & Processing
- 1 - Advancing Sensing, Measurement & Process Control
- 1 - Biomanufacturing & Bioinformatics
- 1 - Flexible Electronics Manufacturing
- 2 - Sustainable Manufacturing
- 2 - Visualization, Informatics & Digital Manufacturing Technologies

2013 Competition Results (cont'd)

Funded Projects

Electrochemical Pathway for Sustainable Manufacturing (EPSuM) Consortium	Ohio University
Consortium for Accelerated Innovation and Insertion of Advanced Composites (CAIIAC)	Georgia Tech Research Corporation
Pathway to Improved Metalcasting Manufacturing Technology & Processes - Taking Metalcasting Beyond 2020	American Foundry Society
Thermal Manufacturing Industries Advanced Technology Consortium (TMI ATC)	ASM International
MTConnect Roadmap Strategy to Promote Advanced Manufacturing in the United States	National Center for Defense Manufacturing and Machining
Advanced Simulation and Visualization for Steel Optimization Consortium	Purdue University
Technologies for Advanced Manufacturing of Pulp and Paper Products	Agenda 2020 Technology Alliance, Inc.
SMART Wind Consortium: Developing a Consensus Based Sustainable Manufacturing, Advanced Research and Technology Roadmap for Distributed Wind	Distributed Wind Energy Association
Facilitating Industry By Engineering, Roadmapping and Science (FIBERS) to Advance U.S. Manufacturing of Composites	University of Massachusetts Lowell
National Technology Roadmap for Photonics (NTRP)	University of Rochester
Semiconductor Supply Chain Road Mapping	SEMATECH, Inc.
Architecting an Institute for Flexible Electronics Manufacturing	AZ Board of Regents on behalf of Arizona State University
Development of a Comprehensive Advanced Joining and Forming Technology Roadmap	Edison Welding Institute
Cell Manufacturing Consortium	Georgia Research Alliance
Development of Roadmap and Consortium for Innovation in Sheet Metal Forming	Northwestern University
Strengthening the Domestic Power Electronics Ecosystem	Power Electronics Industry Collaborative
Partnership for Research and Innovation in Sustainable Manufacturing (PRISM): Product, Process and System Integration	University of Kentucky Research Foundation
Consortium for Additive Manufacturing Materials (CAMM)	The Pennsylvania State University
Photonic Systems Manufacturing Consortium (PSMC)	International Electronics Manufacturing Initiative, Inc.

[For details visit: www.nist.gov/amo/fundedawards.cfm](http://www.nist.gov/amo/fundedawards.cfm)

DWEA SMART Wind Consortium Pre-Kickoff



PRISM Sustainable Manufacturing Consortium (University of Kentucky)

Aerospace Industry

GE Aviation



Automotive Industry

Toyota Motor Manufacturing



Consumer Electronics Industry

Lexmark International



Automotive Manufacturing Technical Education Collaborative



2014 AMTech Competition

- AMTech anticipates awarding a total of \$5.6 million in (2-year-maximum) grants during the program's second competition. Awards will range between about \$250,000 and \$500,000, subject to the availability of funds.
- Pre-applications are required and were due on Sept. 5, 2014. Selected pre-applicants will be invited to submit a full application, which is due on Oct. 31, 2014.
- Selections will be announced during the first half of 2015.

National Technology Roadmap for Photonics (NTRP)

Project Objectives

- Develop manufacturing technology roadmaps in 5 areas of photonics (optics, lasers, imaging/sensing, displays, and bio-photonics).
- Identify opportunities for **pre-competitive collaboration** in a private-public partnership.

Lead Organization: University of Rochester

Funded Collaborators:

Rochester Institute of Technology

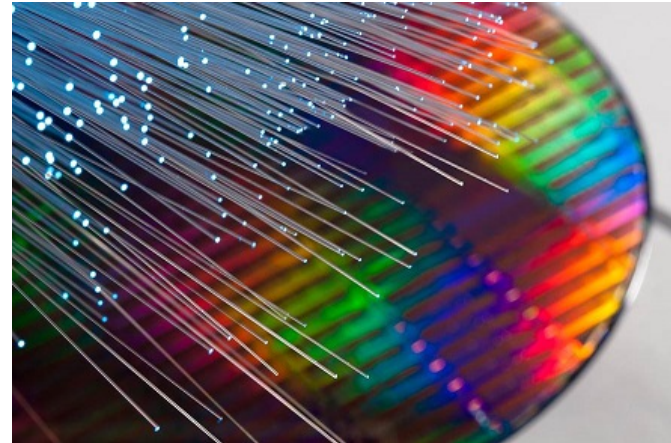
Rochester Regional Photonics Cluster

Project Event

- Technical Working Group kickoff meeting at OSA Headquarters (Washington, DC), Sept. 10, 2014

Project Deliverables

- A set of public roadmaps in the 5 photonics areas (May 2016)
- A set of recommendations for a national institute for photonics (May 2016)



NIST Funding: \$497,852

Project Period: June 2014 to May 2016

NIST POC: Thomas R. Lettieri

301-975-3496

thomas.lettieri@nist.gov

Project POC: Paul Ballentine

585-748-1408

paul.ballentine@rochester.edu



Photonic Systems Manufacturing Consortium (PSMC)

Project Objectives

- Define timelines and technology gaps/roadblocks for the U.S. photonic systems manufacturing industry
- Design a manufacturing platform for cost-effective, high-volume manufacturing of integrated photonics systems

Lead Organization: International Electronics Manufacturing Initiative

Funded Collaborator: Massachusetts Institute of Technology

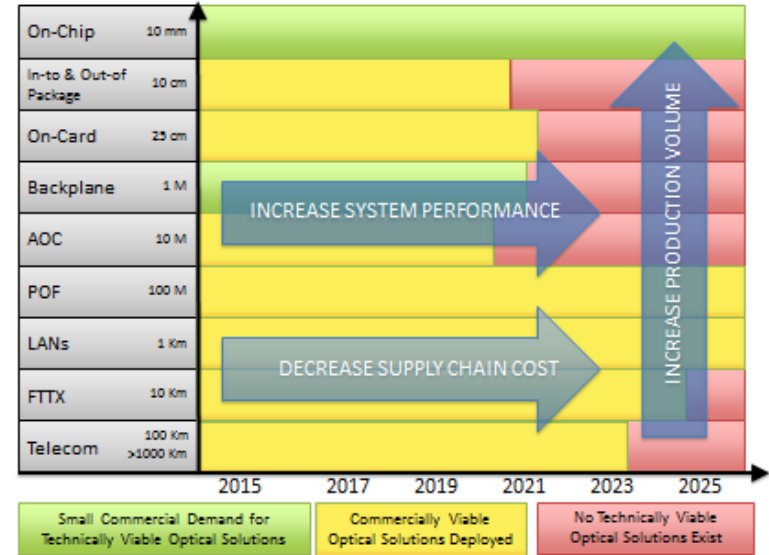
Project Event

- Workshop at MIT on November 6-7, 2014

Project Deliverables

- A roadmap for integrated photonics systems manufacturing
- Technology-based models of the cost and supply chain dynamics for the transition to high-volume, integrated photonic systems manufacturing in the U.S.

PHOTONIC SYSTEMS MANUFACTURING ROADMAP



NIST Funding: \$539,990

Project Period: June 2014 to May 2016

NIST POC: Thomas R. Lettieri

301-975-3496

thomas.lettieri@nist.gov

Project POC: Robert C. Pfahl

630-965-2462

bob.pfahl@inemi.org

PSMC Technology Working Groups (TWGs)

TWG	Chair	Scope
Hybrid Integration	Dick Otte otte@promex-ind.com	Cost, integration, assembly, test, functionality, tools
Packaging	Bill Bottoms bill_bottoms@3mts.com	Cost, materials, heat, footprint, port count, bandwidth
Connector & Substrate	John MacWilliams jmacwilliams@bishopinc.com	All separable interfaces within the system scope All circuit board and backplane components
Monolithic Integration	Lionel Kimerling lckim@mit.edu	Chips: silicon photonics, InP; Design for Manufacturing; Tradeoffs for cost, bandwidth density, power efficiency, and functional latency

[To join a TWG, contact the TWG leader](#)

[For further details, visit: www.photonicsmanufacturing.org](http://www.photonicsmanufacturing.org)

Miscellaneous

- **AMTech's goal** is for funded consortia to have broad National impact, so collaboration with NIST and other Federal agencies is encouraged.
- **NIST personnel** can, and are encouraged to, participate in any of the consortia and roadmapping activities (just coordinate first with the appropriate NIST/AMTech project manager).
- The **AMTech Website** will list dates for all consortia meetings, workshops, and other events, as well as due dates for roadmaps and other deliverables. It will link to all consortia Websites.
- AMTech has published **on-line consortia maps** to illustrate the National scope of participation.
- AMTech has a **LinkedIn account** that is available for consortia use. Recipients should use it to share information and seek input.

**For further information, visit the
AMTech Website at www.nist.gov/amo**



Emily Pappas

Vice President, Podesta Group

September 10, 2014

What is the NPI?

The logo for the National Photonics Initiative (NPI), consisting of the letters 'NPI' in white on a dark blue square background.

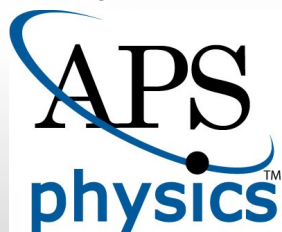
- A collaborative alliance seeking to unite industry, academia and government to identify and advance areas of photonics critical to maintaining US competitiveness and national security:
 - Advanced Manufacturing
 - Health and Medicine
 - Defense and National Security
 - Communications and Information Technology
 - Energy
- Launched in May 2013

Who is the NPI?

- NPI Founding Sponsors:



- NPI Sponsors:



Critical Timeframe

NPI

- Historically the US has been the world leader in deploying photonics research to power cutting-edge technologies, driving global awareness and investment.
- Global competition has put US leadership in photonics at risk.
- The US has lost a substantial share of the global market to overseas competitors as well as thousands of jobs.
- US investment in photonics-driven fields will create jobs in the US and help grow international economies.
- 2012 National Research Council report, “Optics and Photonics: Essential Technologies for our Nation.”

NPI Goals

The logo for the National Photonics Initiative (NPI), consisting of the letters "NPI" in white, bold, sans-serif font inside a dark grey square.

- Raise awareness about photonics and the impact of photonics on our everyday lives.
- Increase collaboration and coordination among US industry, government and academia to advance photonics-driven fields.
- Drive US funding and investment in areas of photonics critical to maintaining competitiveness and national security.

NPI Audience

The logo consists of the letters 'NPI' in a bold, white, sans-serif font, centered within a dark gray square.

- General public
- Policymakers
- Industry and academia
- Media

Timeline

NPI

Months 1-8

- Define a vision for the NPI
- Engage stakeholders from within the photonics industry
- Initiate outreach to the media and secure media placements
- Raise the profile of the initiative and photonics

Months 9 to present

- Bring the NPI message to Washington
- Secure favorable policies and funding opportunities for photonics



Building the NPI Brand

PHOTONICS: A PRIORITY FOR THE UNITED STATES

A HISTORY LESSON

A 1998 National Research Council report, "Harvesting Light," presented... and photonics on important industries. In response, several economies... funding several programs targeting photonics supply chains; and, the F... program, has directed \$1.6 billion (over \$2 billion in USD) to photonics

The United States, however, did not develop a cohesive strategy. His... in deploying photonics research to power cutting-edge technology... position, which is causing a substantial loss of global market share

THE NATIONAL PHOTONICS INITIATIVE

In 2012, the National Research Council released a sequel to "H... to identify and advance areas of photonics critical to maintaini... more than 100 experts from industry, academia and government... funding and investment in five key photonics-driven fields: e... telecommunications, advanced manufacturing, and nationa... New opportunities in these fields — including solar powe... nuclear threat identification, cancer detection and new of... potential for even greater societal impact in the next few... and improve the lives of our people, and position the U

DEFENSE & NATIONAL SECURITY

Optics and photonics greatly enhance the... its troops. Current and future communicat... throughout the defense and security infra... environmental stability, size, weight, pow... more high-bandwidth, secure, reliable c... sensitive data and knowledge to strate...

Lasers also play a key role in defense... illuminators, rangefinders and intellig... weapons provide the potential of ult... nearly an unlimited magazine. The... incoming rockets, artillery shells a

ENERGY

The renewable energy sector r... on foreign oil, stronger nation... Over the next 20 years, indu... demand, creating a global r... the US to regain its leader... technologies and high-eff

NATIONAL PHOTONICS INITIATIVE

LIGHTING THE PATH TO A COMPETITIVE, SECURE FUTURE

A WHITE PAPER BY THE NATIONAL PHOTONICS INITIATIVE
MAY 23, 2013

NATIONAL PHOTONICS INITIATIVE

LIGHT
Innovating the Future

Light Our Future

The National Photonics Initiative (NPI) is a collaborative alliance among industry, academia and government seeking to raise awareness of photonics - the application of light - and drive US funding and investment in five key photonics-driven fields critical to US competitiveness and national security: advanced manufacturing, communications and information technology, defense and national security, energy, and health and medicine.

[NPI white paper, "Lighting the Path to a Competitive, Secure Future"](#)

- About NPI
- What is photonics?
- News & Resources
- Contact
- Sponsors

- Recommendations & Reports
- Advanced Manufacturing
- Communications & IT
- Defense & National Security
- Energy
- Health & Medicine

National Photonics Initiative Lights a Path to Economic Growth, Competitiveness, Security

Today marks the launch of the [National Photonics Initiative \(NPI\)](#), a collaborative alliance among industry, academia and government seeking to raise awareness of photonics – the applications of light.

The launch coincides with the release of an NPI [white paper](#), "Lighting the Path to a Competitive, Secure Future," detailing recommendations for US funding and investment in five key photonics-driven fields critical to US competitiveness and national security: advanced manufacturing, communications and information technology, defense and national security, energy, and health and medicine.

"LIGHTING THE PATH TO A COMPETITIVE, SECURE FUTURE," A WHITE PAPER BY THE NPI

CLICK TO READ

From your phone to your TV to your computer, photonics is all around you. Specifically, photonics detects, generates and harnesses light to form the backbone of the internet, guide energy exploration and keep our troops safe on the battlefield with night vision, GPS, and physiological feedback. Simply put, photonics is addressing and

Launching the NPI

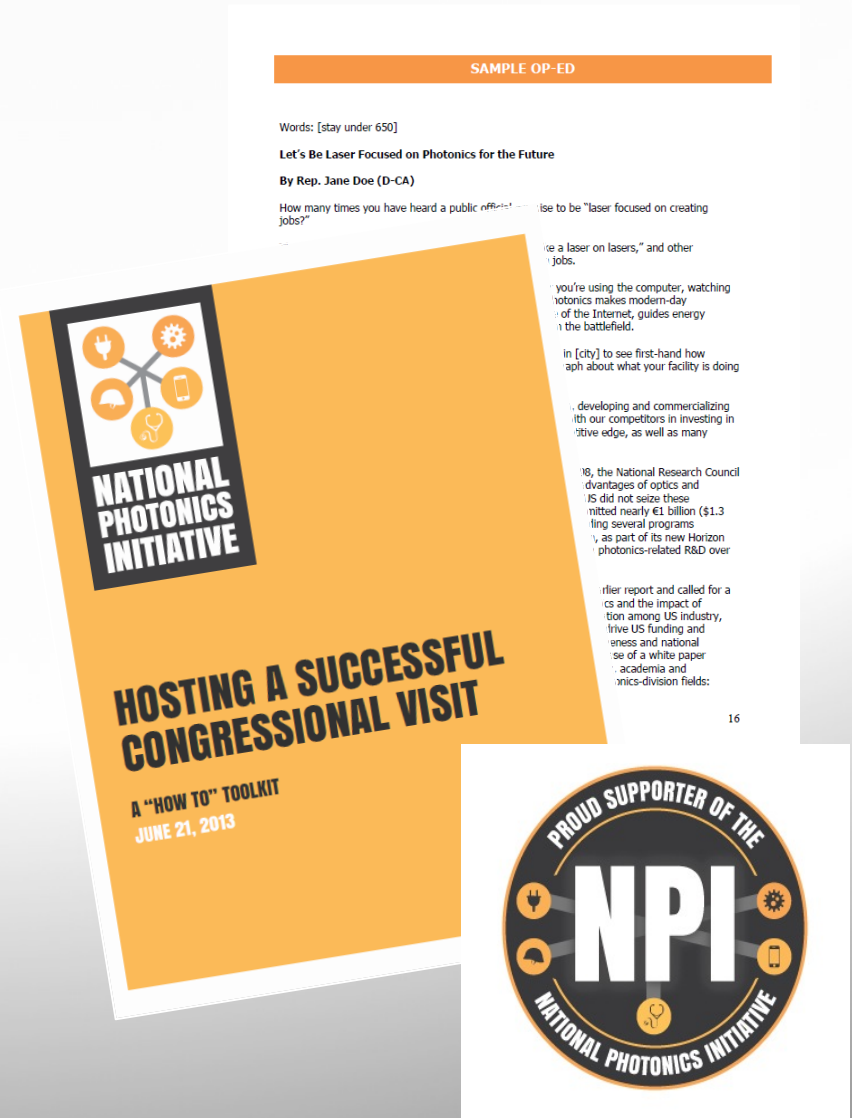
The logo consists of the letters "NPI" in a bold, white, sans-serif font, centered within a dark gray square.

- Launched the NPI website – www.lightourfuture.org
- Distributed a press release that appears on 370 media websites
- 18 unique articles about the NPI launch published in key trade publications
- Reached more than 50,000 people as a result of tweets
- Over 70 took part in the launch day webinar to discuss the release of the NPI white paper
- e-blast sent to nearly 200 select staff on Capitol Hill

Engaging the Industry



- Created Congressional Toolkit for NPI supporters
- Designed web sticker for NPI supporter organizations and individuals to display on webpages and printed materials
- Disseminated NPI social media messages for stakeholders to push out via Twitter and Facebook
- Held webinars to train and educate NPI supporters on opportunities to advocate



Educating Elected Officials

Rep. Ron Barber

Rep. Ron Barber Timeline Recent

Rep. Ron Barber August 15

Rep. Barber Visits UA's College of Optical Sciences (4 photos)

Rep. Ron Barber visited the University of Arizona's College of Optical Sciences on August 14. He met with students, faculty and business leaders to talk about jobs in the optics industry. The college does a great job preparing young people to enter optics and grow our economy in Arizona. The Congressman also toured the Steward Observatory Mirror Lab. — at The University of Arizona.

Unlike · Comment · Share

You and 66 others like this.

View 4 more comments

ONLINE (N) www.azstarnet.com

Arizona Daily Star

University of Arizona joins push for better understanding of photonics

By Tom Beal
August 14, 2013

The "average person, or average congressman" doesn't know much about photonics, according to a coalition of industry and academic groups pushing a National Photonics Initiative.

Part of the problem could easily be the name, said Thomas Koch, dean of the University of Arizona College of Optical Sciences, who hosted a push for greater recognition at the college Wednesday, inviting Rep. Ron Barber, D-Ariz., to hear pleas for greater federal involvement in promoting the industry and funding research.

People recognize the term "optics" as dealing with lenses and generation and detection of that light, puts the science of optics

"We use the terms interchangeably most of the time in the field

Koch called photonics the "ubiquitous and invisible" industry. In a smartphone, which would not exist without it, he said.

"We are not recognized as an industry," said Jack W. Schuman, president of the Arizona Optics Industry Association.

Optics and photonics are critical to a number of industries but

It's a big industry, said Koch, accounting for \$3 trillion and 10 per

The U.S. share of the optics industry is eroding, he said, as Europe



Search for people, places and things

John L. Mica Photos

Photos Albums

Touring the College of Optics and Photonics (CREOL) at UCF
August 7 · 🌐

Share

23 others like this.

Write a comment...

J. Solleau Great to have Congressman Mica visit CREOL (a jewel of the 7th District) and become an optics fan, or, as I might say, a Congressman Mica.

Reply · August 8 at 3:20pm

Mike Whiteside Thank you for taking time out of your busy schedule to meet with us!

Reply · August 8 at 12:50pm

more comments

Orlando Sentinel

Let's be laser-focused on photonics for the future

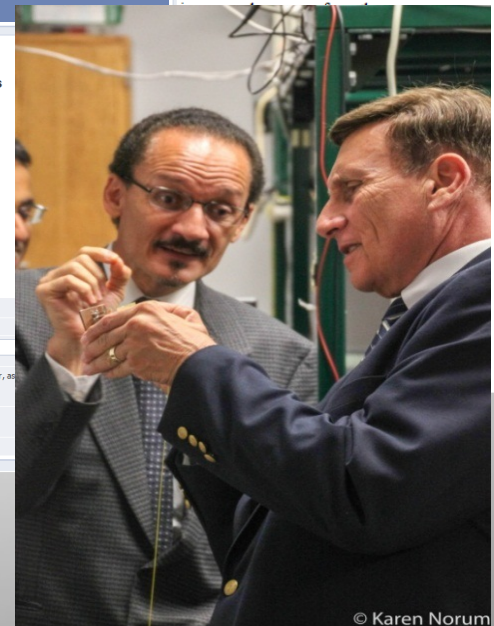
By John Mica Guest columnist

August 20, 2013

How many times you have heard a public official promise to be "laser-focused on creating jobs?"

The next time you hear that ask him or her to "focus like a laser on lasers," and other American jobs.

Whether you're using the computer, in your smartphone, photonics makes up the backbone of the Internet.



NPI Next Steps

- Bring together experts to explore, identify and pursue other areas where private sector and federal government interests align.
 - Biophotonics
 - High powered lasers
 - Sensors
 - Education

NPI Next Steps

The logo consists of the letters 'NPI' in a bold, white, sans-serif font, centered within a dark gray square.

- Continue to press for legislation highlighting importance of optics and photonics and advancing NPI objectives.
- Continue to build support in the House and Senate and expand congressional champions.
- Engage the White House, federal agencies and the Congress in new photonics areas.

Contact

NPI

Emily Pappas

Podesta Group

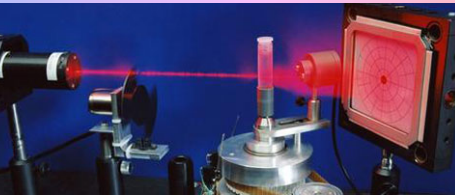
epappas@podestagroup.com

AMTech NTRP Grant

- \$500K over 18 Months (6/1/2014 – 12/1/2015)
- Prime: University of Rochester CEIS
- Subcontracts: Rochester Institute of Technology and Rochester Regional Photonics Cluster

Three parts:

- Develop a National Technology Roadmap for Photonics
 - First generation roadmaps
 - Put in place a robust, sustainable process for future generations
- Put together a consortium that could evolve into an IMI
- Develop a strategy for expanding photonics manufacturing in NY State



NTRP
National Technology Roadmap for Photonics

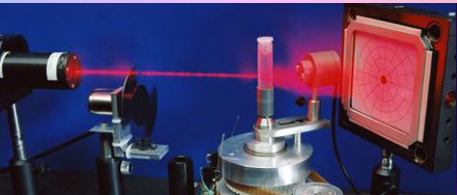
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NTRP Leadership

Executive Steering Committee Members	
Steve Anderson	SPIE
John Bruning	Corning (retired)
Stephen Fantone	Optikos
Tom Hausken	OSA
Thomas Koch	University of Arizon
Duncan Moore	University of Rochester
MartinRichardson	University of Central Florida
PeterBocko	Corning (retired)

Technology Working Group Leaders				
Optics	Lasers	Imaging and Sensing	Displays	Biophotonics
Tom Battley	Martin Richardson	Bob Fiete	Mark Poliks	Jim Zavislan
Megan Shaw	John Marciante	Michael Richardson	Bob Boudreau	Bruce Tromberg
Duncan Moore	Jay Eastman			

Staff	
Paul Ballentine (PI)	University of Rochester
Michael Richardson	Rochester Institute of Technology
Tom Battley	Rochester Regional Photonics Cluster
Jay Eastman	Optel



Value of Shared Roadmaps

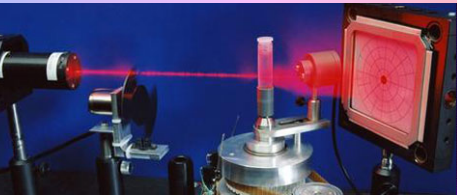
Industry

- Help strengthen supply chain
 - Gives SMEs visibility of market needs they otherwise may not have and an opportunity to form partnerships
- Help companies develop internal roadmaps
 - Reduce R&D costs, time to market, and risk
- Communicate investment needs to government
- **The roadmapping process can be as valuable as the roadmaps themselves**

Government

- Increase competitiveness of domestic manufacturers
- Stimulate economic growth and manufacturing jobs
- Identify opportunities for public private partnership investments
- Identify basic (university) research needs

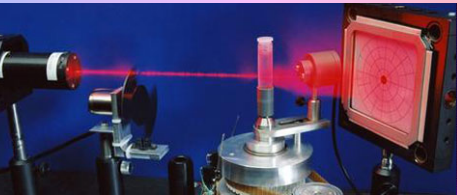
Technology roadmaps do not stifle disruptive innovation



NTRP

National Technology Roadmap for Photonics

Roadmapping Process (from iNEMI)



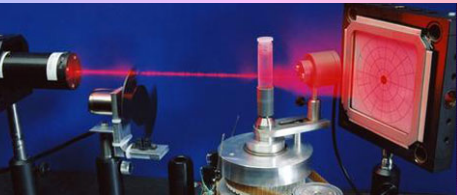
NTRP

National Technology Roadmap for Photonics

Market Roadmaps

Market Roadmaps

- Forecast market trends
- Forecast system performance requirements
 - Provide detailed lists of component performance requirements to meet system requirements
- Cost is taken into consideration
- Driven by large OEMs with inputs from suppliers and universities



NTRP

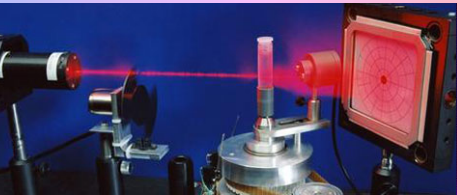
National Technology Roadmap for Photonics

Manufacturing Roadmaps



Mfg. Roadmaps

- Forecast manufacturing technology availability for each requirement
 - Machines, materials, and methods
- Driven by suppliers with inputs from OEMs and universities
- Conversely, forecast development of innovative new manufacturing technologies that could change market roadmaps (e.g. 3D printing of optical components could enable new designs)

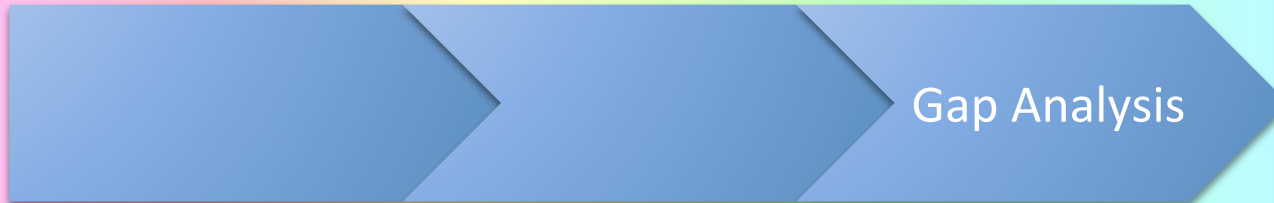


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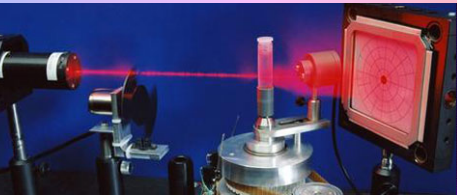
National Technology Roadmap for Photonics

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Gap Analysis

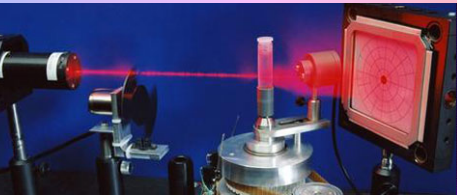


- Identify gaps between what is needed and what is available
- Identify opportunities for pre-competitive collaboration (i.e. could be done in an IMI)



Proposed Market Roadmaps (not covered in AMTech Grant)

- Market roadmaps can be broken down into major economic sectors
 - Defense and Aerospace
 - Advanced Manufacturing
 - Computing and Communications
 - Healthcare
 - Energy and the Environment
 - Food and Agriculture
 - Transportation
 - Commercial
 - Consumer
 - Scientific
- The first 5 follow the NRC report and the work of the NPI.
- We do not have resources to develop market roadmaps during the AMTech grant period, so we will use existing data and interviews with OEMs.
- Sustaining process should have market roadmap teams.



Photonics Technology Roadmaps

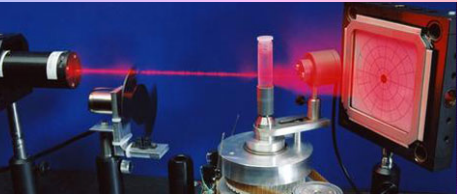
AMTech Roadmaps

- Advanced Optics
- Lasers
- Imaging and Sensing Systems
- Display Modules
- Biophotonic Devices
- Photonic Integrated Circuits
 - (being done by iNEMI)

Other Potential Photonics Roadmaps

- Solid State Lighting
- Photovoltaics
- Fiber Optics

This grant



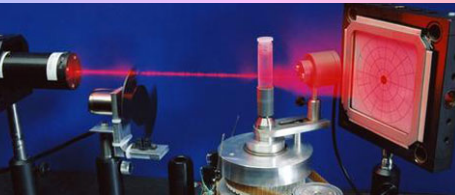
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Crosscutting Roadmaps

Roadmaps that apply to most if not all markets and technologies

- Workforce Training (NPI taskforce)
 - Involves community colleges to train workers for midlevel skill positions
 - BS, MS, and Ph.D education and research programs to protect U.S. lead in photonics innovation
- Design
- Packaging
- Metrology
- Materials



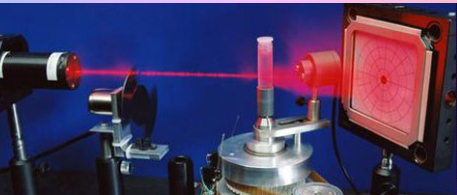
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Photonics Roadmapping Matrix

	Industrial	IT	Healthcare	Defense	Energy and the Environment	Consumer and Portable	Commercial	Food and Agriculture	Scientific and Measurement		
Optics											
Lasers/Sources											
Imaging and Sensing Systems											
Display Modules											
Biophotonic Devices (?)											
Photonic Integrated Circuits											
Solid State Lighting											
Photovoltaics											
Fiber Optics											
Crosscutting Technologies/Needs											
Design											
Packaging and Integration											
Workforce Training											
Metrology											

The vision for the NTRP is to have a complete set of chapters encompassing all markets, technologies, and crosscutting functions.

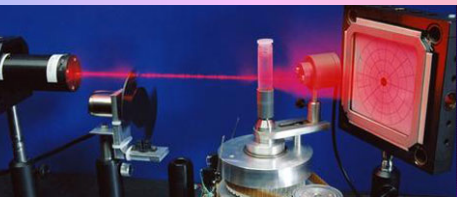


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Example Market Roadmap

Defense and Aerospace Roadmap												
	Metric	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Optics												
First class of optical components												
Parameter 1	e.g. size	value	value	value	value	value	value	value	value	value	value	value
Parameter 2	performance	value	value	value	value	value	value	value	value	value	value	value
Parameter 3	cost/unit	value	value	value	value	value	value	value	value	value	value	value
...	etc.	value	value	value	value	value	value	value	value	value	value	value
Second class of optical components												
Parameter 1		value	value	value	value	value	value	value	value	value	value	value
Parameter 2		value	value	value	value	value	value	value	value	value	value	value
Parameter 3		value	value	value	value	value	value	value	value	value	value	value
... (could be many)		value	value	value	value	value	value	value	value	value	value	value
Lasers												
Parameter 1		value	value	value	value	value	value	value	value	value	value	value
Parameter 2		value	value	value	value	value	value	value	value	value	value	value
Parameter 3		value	value	value	value	value	value	value	value	value	value	value
...		value	value	value	value	value	value	value	value	value	value	value
etc.												
Crosscutting technologies												
Workforce Training		value	value	value	value	value	value	value	value	value	value	value
Design		value	value	value	value	value	value	value	value	value	value	value
Materials		value	value	value	value	value	value	value	value	value	value	value
Packaging		value	value	value	value	value	value	value	value	value	value	value



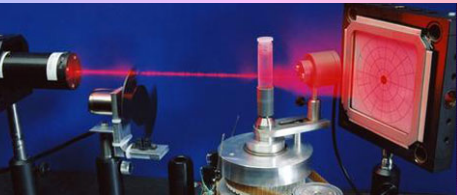
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Gap Analysis

Defense and Aerospace Roadmap												
	Metric	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Optics												
First class of optical components												
Parameter 1	e.g. size	value	value	value	value	value	value	value	value	value	value	value
Parameter 2	performance	value	value	value	value	value	value	value	value	value	value	value
Parameter 3	cost/unit	value	value	value	value	value	value	value	value	value	value	value
...	etc.	value	value	value	value	value	value	value	value	value	value	value
Second class of optical components												
Parameter 1		value	value	value	value	value	value	value	value	value	value	value
Parameter 2		value	value	value	value	value	value	value	value	value	value	value
Parameter 3		value	value	value	value	value	value	value	value	value	value	value
... (could be many)		value	value	value	value	value	value	value	value	value	value	value
Lasers												
Parameter 1		value	value	value	value	value	value	value	value	value	value	value
Parameter 2		value	value	value	value	value	value	value	value	value	value	value
Parameter 3		value	value	value	value	value	value	value	value	value	value	value
...		value	value	value	value	value	value	value	value	value	value	value
etc.												
Crosscutting technologies												
Workforce Training		value	value	value	value	value	value	value	value	value	value	value
Design		value	value	value	value	value	value	value	value	value	value	value
Materials		value	value	value	value	value	value	value	value	value	value	value
Packaging		value	value	value	value	value	value	value	value	value	value	value

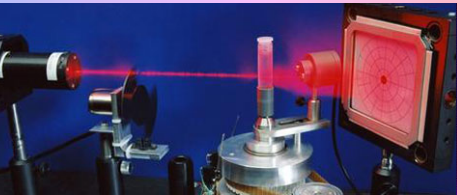
solution exists (MRL 8-10)
 solution under development (MRL 4-7)
 no known solution (MRL 1-3)



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TWG Presentations



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AMTech Roadmap of the Laser Industry

Martin Richardson

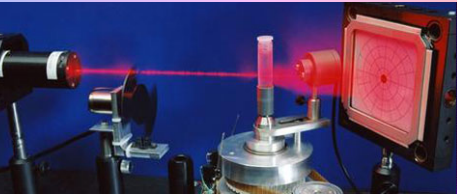
*Director, Townes Laser Institute,
Trustee Chair and Pegasus Professor
Northrop Grumman Professor of X-Ray Photonics
Professor of Optics, Physics and ECE
College of Optics & Photonics,
University of Central Florida,
Orlando, Florida, USA*

Tel: 407 823 6819 Fax: 407 823 6880 Email: mcr@creol.ucf.edu

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E-mail: marciante@optics.rochester.edu*



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AMTech Roadmap of the Laser Industry

Presenter

Jay M. Eastman, Ph.D.

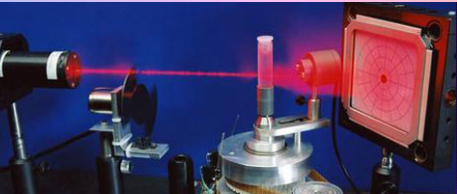
*Chief Executive Officer,
Optel, Inc.*

*70 Van Voorhis Road
Pittsford, New York*

Tel: (585) 230-4589

Email: jme@optel-inc.com

*Adjunct faculty member
The Institute of Optics
University of Rochester*



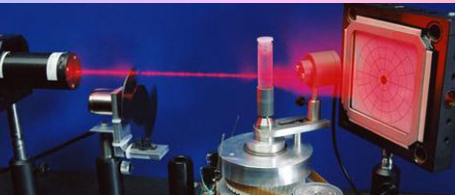
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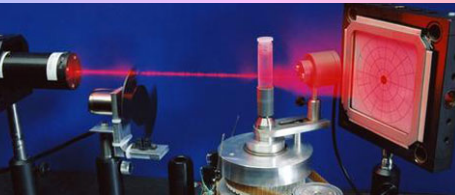
Scope

- 1) Restricted to US laser industry.
- 2) Scope and size of foreign laser industry assessed only to compare its overall competitive position.
- 3) Key current and future application areas will be identified, however, their scope and size will not be the subject of this study.
- 4) Judicious assessment of trends in primary areas will be studied to determine their possible impact on future laser markets.
- 5) The study will not include the diode, or diode laser markets. The majority of this market is in the lighting and display industry, considered to be outside the scope of this study. The size and scope of the pump-diode industry for high power lasers will be assessed separately.



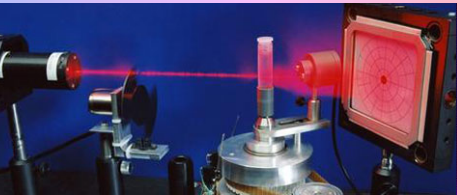
Purpose

- 1) Assess the current and future size and scope of the US laser industry.
- 2) Identify past, current, and future trends in the laser market
- 3) Identify strengths and weaknesses in the US laser market relative to foreign competition.
- 4) Examine technologies on the horizon that could be transformative to the US laser industry.
- 5) Make recommendations with respect to government, academia and industrial investment in technologies that will strengthen the US laser market.



Participants

- Involvement of many representatives of laser companies will be recruited in three categories:
 - (a) major corporations;
 - (b) small and medium enterprises (so-called SME's); and
 - (c) start-up companies, (entrepreneurial enterprises – “EE's”)
- SME's are defined as small businesses (< 500 employees).
- EE's are defined as < 10 employees and a gross market of < \$1M/yr.
- Participants will be listed the study report in accordance to their wishes.

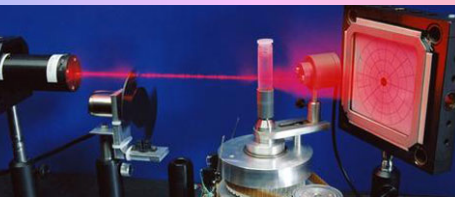


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Approach

- 1) The Co-Chairs of the study (M. Richardson and J. Marciante) will construct a carefully worded and comprehensive electronic survey.
- 2) All corporate participants will be asked to complete this electronic survey with respect to their own company.
- 3) All responses to this poll will be collated without revealing the identity of the respondents. We will only know whether a particular participant has responded - only one response will be permitted.
- 4) The responses to this poll will be synthesized by the investigators.
- 5) Participants in the study will have access to the study results.



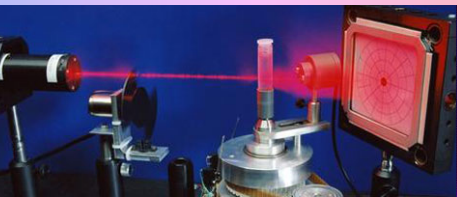
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Additional components

The Co-Chairs will seek the opinions of well-known experts from the laser industry, government and academic institutions, both domestic and foreign, in order to formulate an accurate view of current and future trends, potential roadblocks to further progress and the like.

The Co-Chairs will provide their own synthesized assessment of the data from the survey, together with the input from well-known experts, in a sectionalized report covering all the principal components of the US laser industry (within the scope of the study as described).



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Imaging and Sensing Systems Roadmap

September 10, 2014

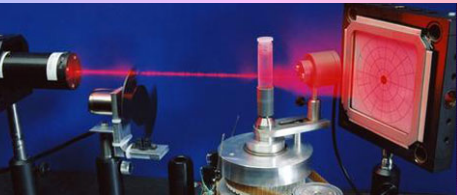
Co-leaders

Bob Fiete – Director R&D, Exelis Geospatial Systems

Mike Richardson – Distinguished Researcher, RIT

Team Members (to date)

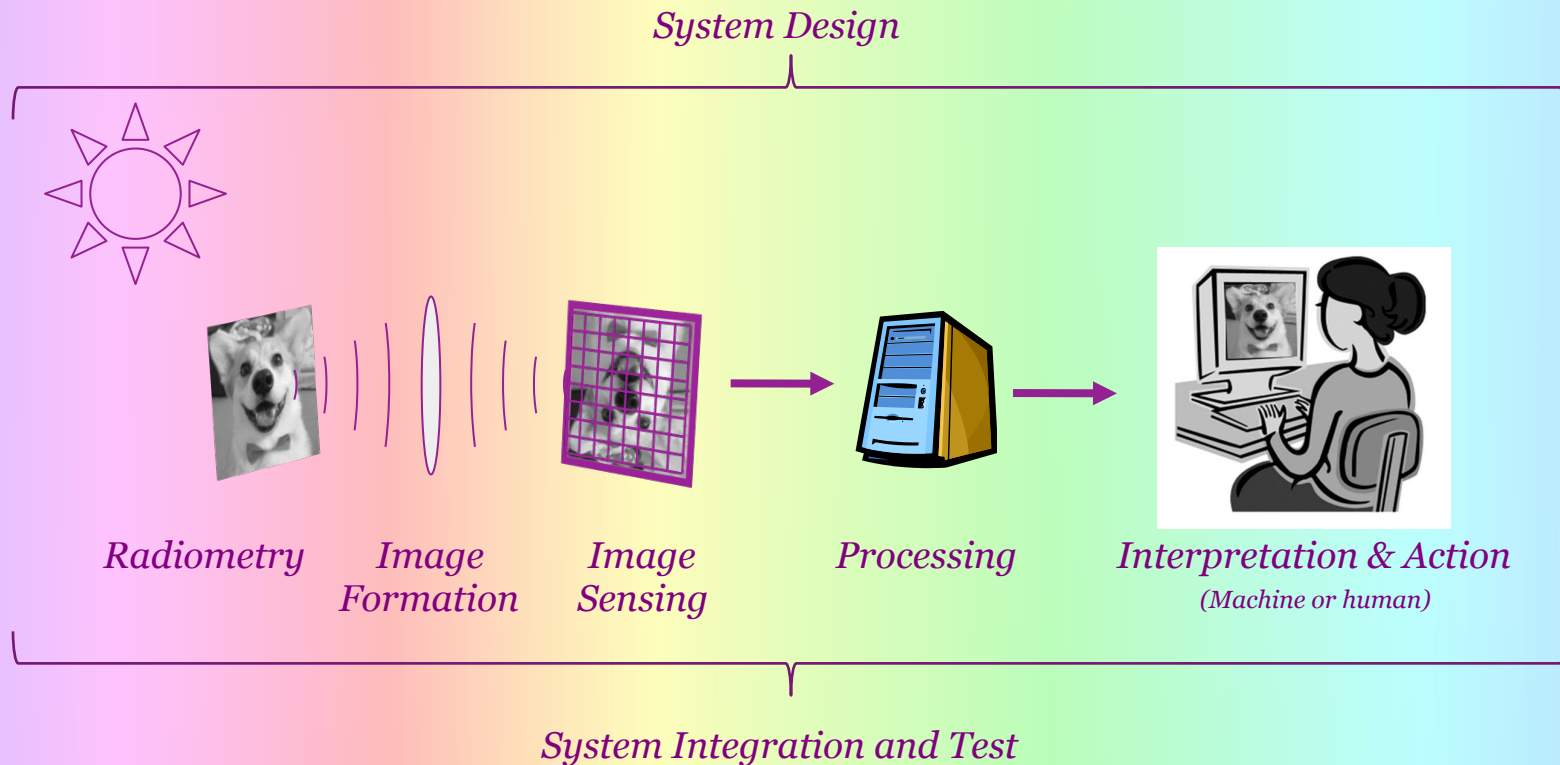
Rob Parada – Senior Imaging Technology Consultant



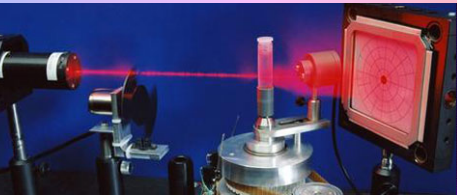
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Elements of an Imaging System

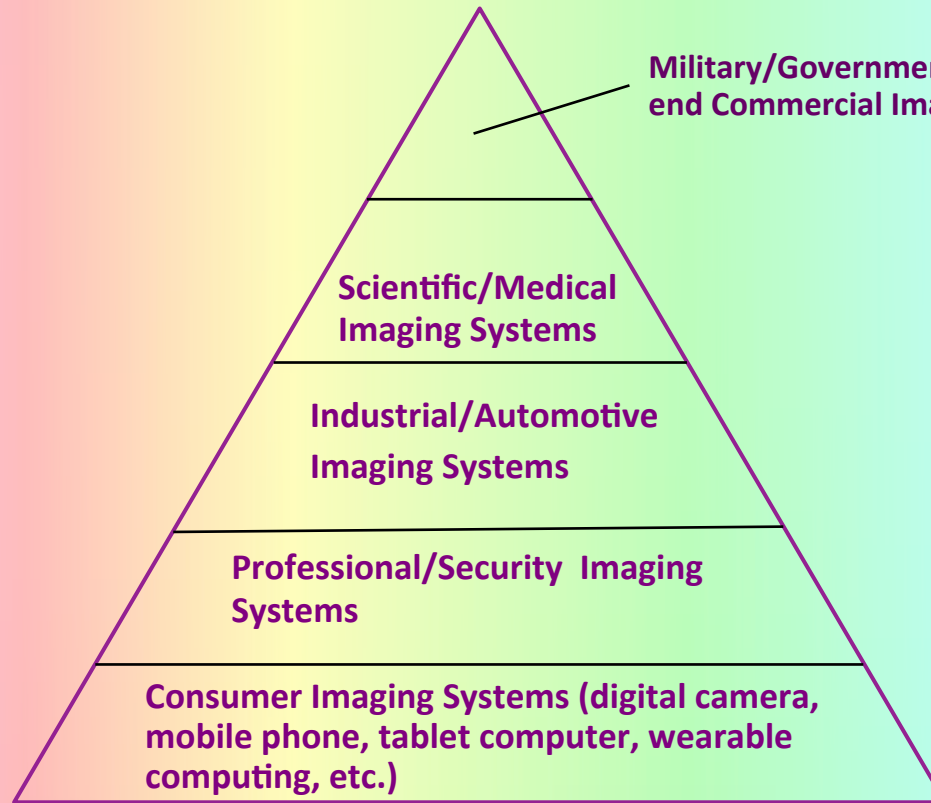


Which elements are most critical for manufacturing growth?

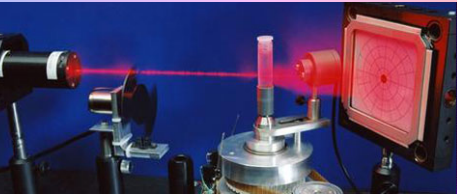


Imaging System Market Segments

Complex, Custom, Limited
Production, High Unit Cost



General Purpose, High
Production, Low Unit Cost



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Imaging System Future Trends

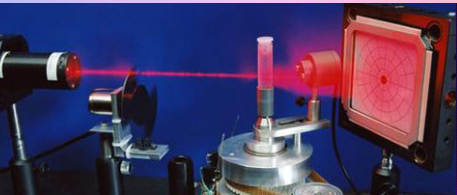
Component Technology

- Optics
- Sensors
- Radiometric sources
- Analytic processors
- Low SWAP-C

Integration “with the world” Technology

- Every image instantly “stored in the cloud”
- Convergence: selected images end up in a video game
- 24/7 Image capture
- Cameras located “everywhere” (buildings, borders, streets, vehicles, people)
- 3D Imaging System
- Wearable Imaging Devices
- “Grain-of-salt” Camera System
- VR Integrated Camera System

Imaging System Technology



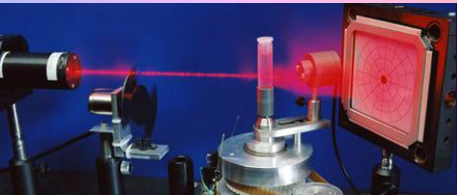
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Key Drivers: Company Competitiveness

- Internal Factors – elements a company can directly control
 - Cost structure (salaries, benefits, overhead costs, efficiency, etc.)
 - Organizational structure and communication between departments (marketing, sales, customer service, R&D, manufacturing, etc.)
 - Investment and innovation (R&D investment and prioritization of the right talent to execute)
 - Investment and market knowledge (marketing investment, the talent to execute, and an in-depth knowledge of the market)
- External Factors
 - Access to talent
 - Access to capital investment
 - Access to markets
 - Business climate (taxes, regulation, etc.)

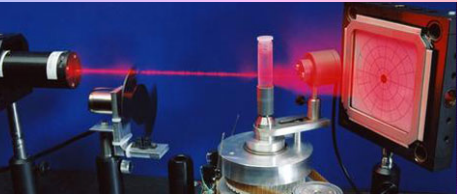


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Survey and Interviews

- Survey developed to focus on required roadmap inputs
 - General (contact information, company overview and demographics)
 - Technology plan
 - Manufacturing capability and human resources
 - Business (products, competition, regulatory concerns, big picture drivers)
- Discussions and interviews conducted to date
 - Exelis Geospatial Systems – August 12, 2014
 - Carestream Health – August 28, 2014
 - ON Semiconductor (formerly Truesense Imaging) – September 3, 2014
 - *Kodak declined, citing they are no longer an imaging company*
 - *Ball Aerospace is reviewing opportunity with senior management*

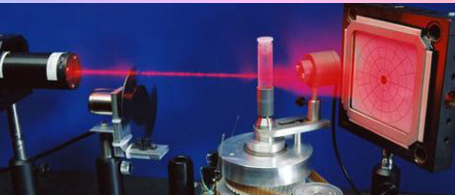


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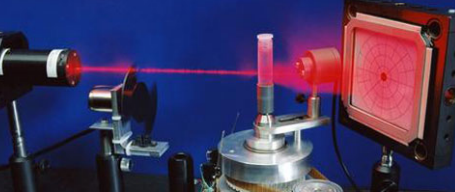
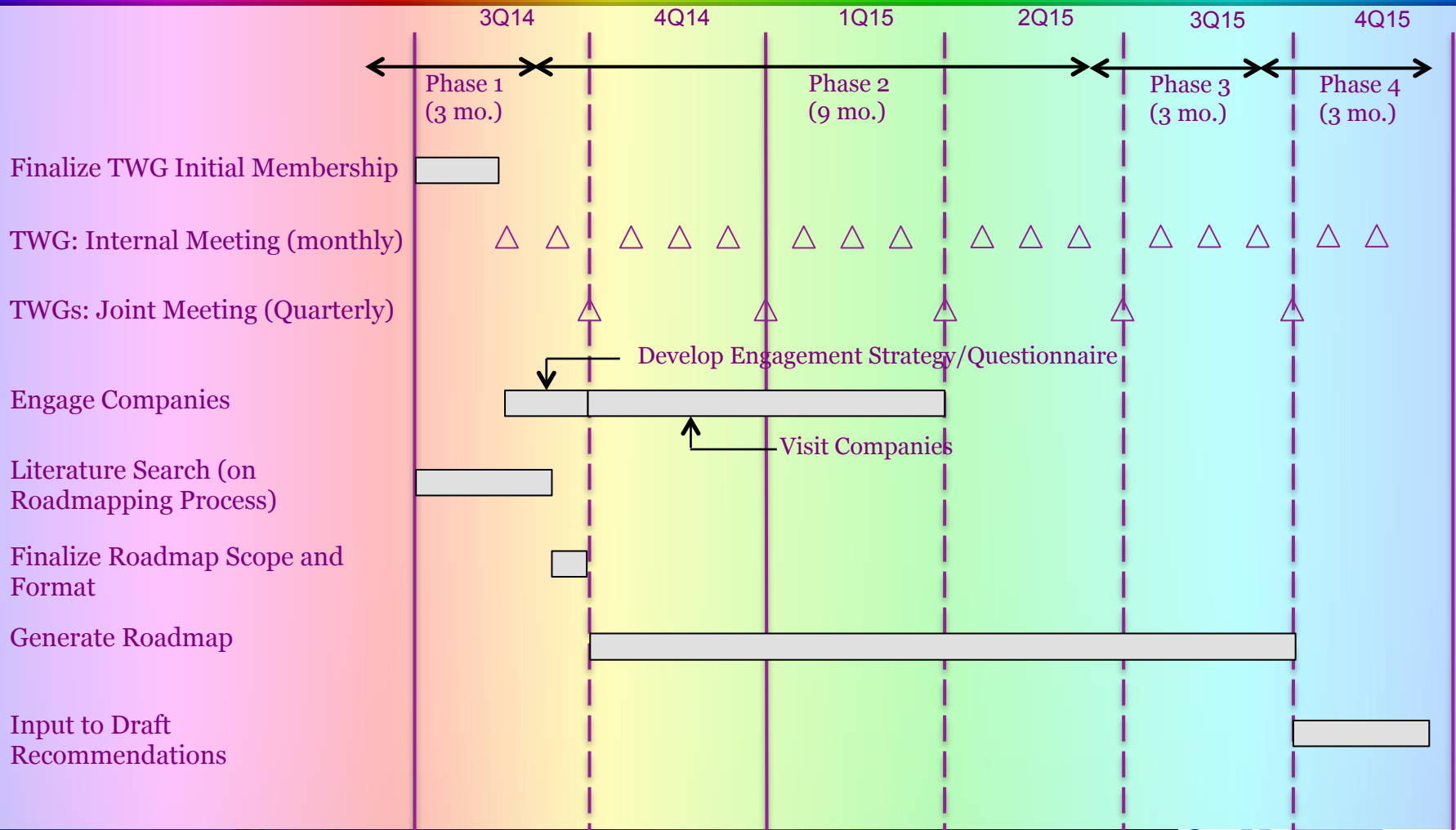
Challenges Foreseen

- TWG's are comprised of volunteers
 - Membership and necessary time from members will be challenging
- Details of manufacturing and technology investment strategies are typically proprietary
 - Access to “game changing” technologies within companies may be difficult
 - May be difficult to identify the manufacturing needs for future technologies
 - May be difficult to get broad spectrum of companies in consortium
- “Imaging Systems” comprise a broad spectrum of technologies
 - Need to find focus areas that best impact manufacturing growth



Timeline

Imaging Systems Technology Working Groups



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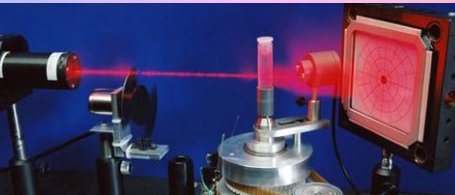
Advanced Optics

Co-leaders

Tom Battley, Executive Director, New York Photonics, tbattley@newyorkphotonics.org;
585-329-4029

Megan Shay, Managing Partner, Meaning/Design/Structure, LLC, mdshay65@gmail.com;
607-280-6100

Duncan Moore, Rudolf and Hilda Kingslake Professor in Optical Engineering Science
Professor of Optics, Professor of Biomedical Engineering
Professor of Business Administration in the William E. Simon Graduate School of Business
Administration
moore@optics.rochester.edu, (585) 275-5248

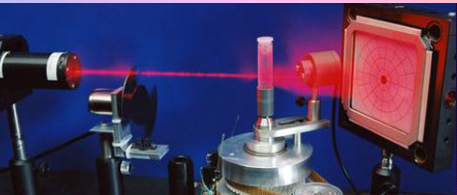


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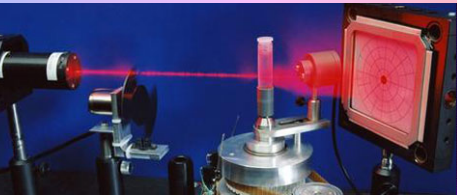
Process

- First steps taken – draft of market sectors in development
 - Connecting constituents to market
 - Identify Market Sectors
 - Draft List -- complete
 - Vet with industry organizations like SPIE and OSA – in process
 - Circulate to memberships for input via survey – in process
 - » Use this step to build awareness of the road mapping and collect ideas for team members
 - » Complete team development simultaneously
 - Identify technology leaders in market sectors
 - » Garner support for roadmap with leadership and identify point persons for spec matrices
 - Support Market Sectors with subsectors that allow our constituents to identify themselves in the supply chain – In process
 - Example:
 - » Level 1 – Transportation
 - » Level 2 -- Automotive (Others are Aerospace, Freight, Shipping)
 - » Level 3 – Vision, Guidance, Sensors
 - » Company recognizes: “I coat mirrors for heads up displays in automobiles”
 - Identify industry reports for market sectors and sub sectors – in process
 - Provide abridged info in lieu of formal Market Working Groups if necessary
 - Provide convenient access to resources for constituents who participate



Initial thoughts on scope

- OSA: hot topic areas such as photonics for brain mapping, molecular imaging, high-power lasers, nanophotonics, optofluidics, nonlinear optics, quantum optics



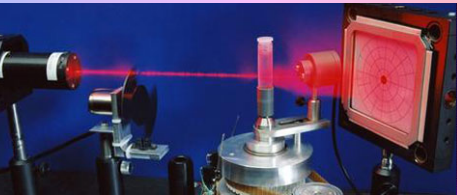
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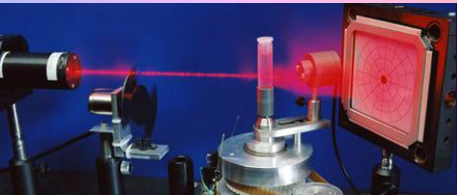
Potential challenges or special circumstances for this TWG

- No USA road mapping infrastructure for Optics
 - Can piggyback off of iNEMI work
 - Some relevance in existing road mapping
 - Lack of existing networks at the right level
 - Support from Industry Associations in Market Sectors will be helpful
 - Government entities with interests in Market Sectors have influence
 - Senior leadership in Academia can leverage connections
 - Largest companies in the Optics industry can leverage connections
- Deep position of optics in supply chain makes it challenging for optics companies to be helpful in identifying the key people in product design who shape the market needs
 - This is the reason that this project is so critical to the Optics industry
 - Lack of big picture vision
 - Reward will be tremendous



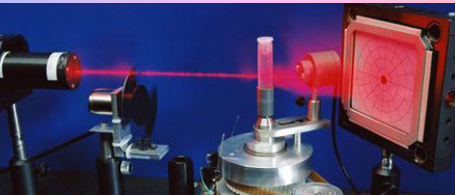
Display Technology

- Team Leaders: Robert Boudreau (Corning, Inc.) & Mark Poliks (Binghamton Univ./CAMM)
- Identified other team members:
 - Mike Ciesinski (Flex Tech Alliance) & John Kymissis (Columbia) will help to define a larger team.
 - Plan to reach out to: Universal Display Corp (NJ), Kent Display, E Ink, Applied Materials and 3M.
 - May request input from or participation by LG Display, Samsung and Sharp.
- Focus is impact to US economy: US based suppliers, technology & innovation
- First steps taken: need to define scope by holding telephone and online meetings with extended team.
- Sources of market input: Corning, Inc., Flex Tech Alliance and others
- Initial thoughts on scope:
 - OLED, materials & tools, emerging flexible displays, alternative manufacturing approaches including additive processing and roll-to-roll.
- Potential challenges or special circumstances for this TWG
 - Many US firms develop materials and tooling for the display industry, but most display manufacturing is based in Asia.



Biophotonics

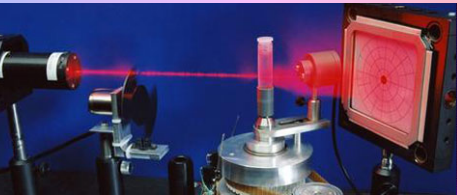
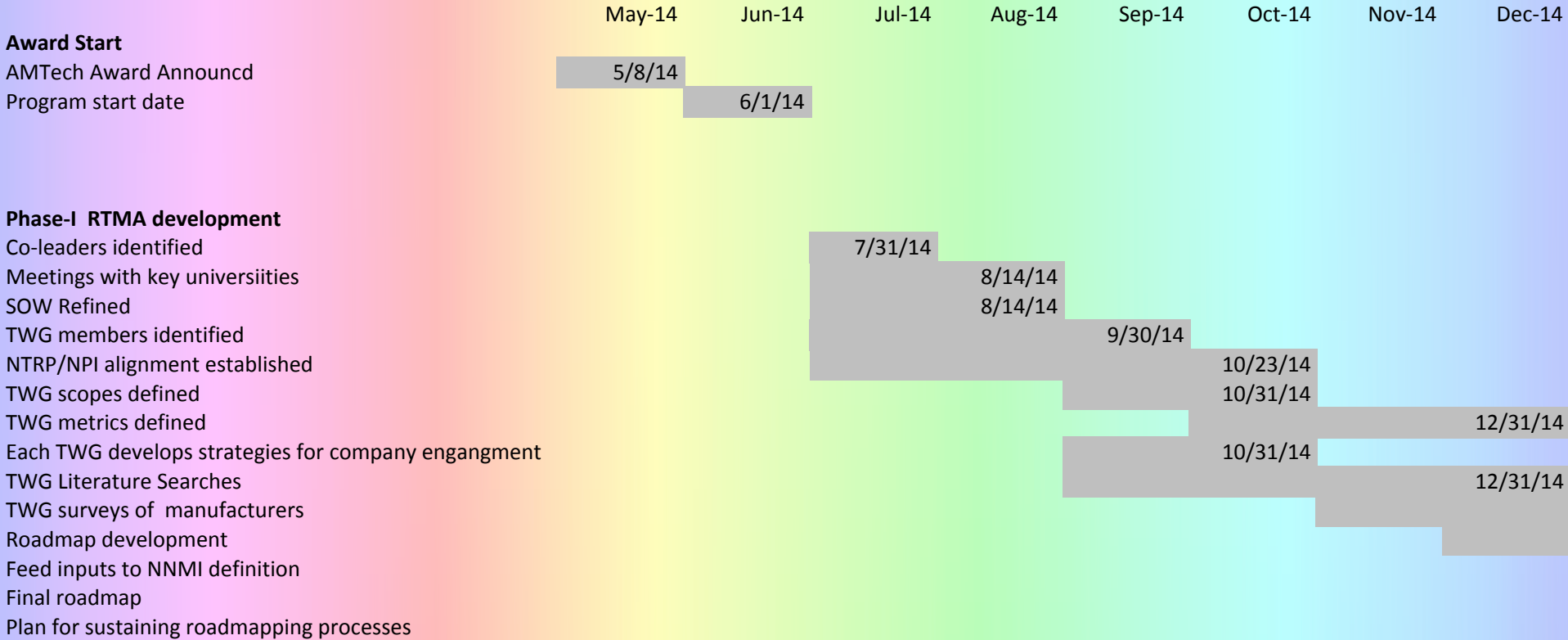
- Co-Chairs: Jim Zavislan, Univ. of Rochester and Bruce Tromberg, Univ. Cal. Irvine
- Members: Rongguang Liang, University of Arizona, Selim Ünlü and Alice White, Boston University
- Steps taken: Initial market segments, time horizons and technologies identified
- Sources of market input: National Photonics Initiative, NIH Roadmap, Frost and Sullivan Reports, Thought leader and company interviews during Photonics West 2015
- Initial thoughts on scope: Focus on technology gaps of performance and cost
- Potential challenges or special circumstances:
 - Principally a diverse application area: from research to clinical medicine, diagnostics to therapeutics
 - Many technologies are not yet standard of care
 - Opportunity: Biophotonics will contribute to improved outcomes, higher efficiency and lower cost.



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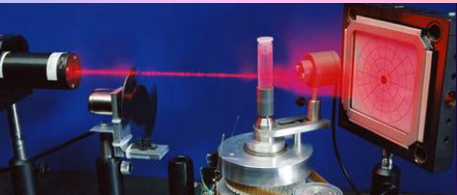
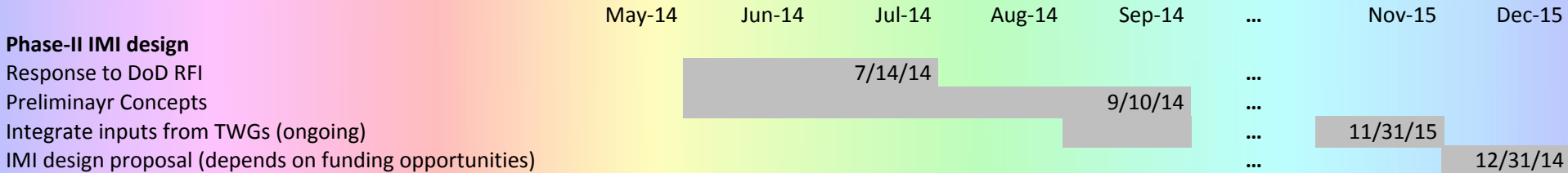
Program Schedule (phase I)



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Program Schedule (phase II)

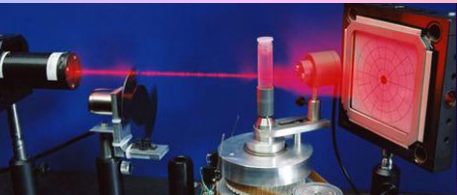


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Meeting Schedules

- The TWG (co)leaders will have autonomy to set their own schedules
- It is recommended that the teams meet via teleconference and web meeting at least once per month – we've set up AT&T telecon and web meeting svc.
- In-between meetings, leaders and members will do research and analysis, work on roadmaps, and prepare documents for next meeting.
- It is expected that all team members actively participate in calls and intervening work
 - A possible exception could be members from national labs, who may only be able to contribute at a high level
- Face to face meetings of each team and joint meetings will be held during national meetings: OSA/FiO, Photonics West, DSS, SPIE

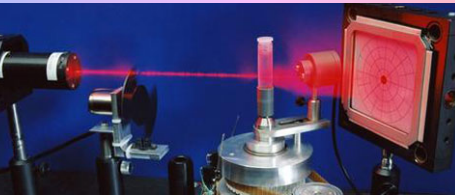


Teamwork.com Web Site

The screenshot shows the Teamwork.com dashboard for Paul Ballentine. The browser address bar displays <https://ntrp.teamwork.com/dashboard>. The dashboard header includes navigation tabs for DASHBOARD, EVERYTHING, PROJECTS, CALENDAR, STATUSES, and PEOPLE. A search bar and user profile are visible in the top right. The main content area is titled "Dashboard" and shows a list of items assigned to everyone. The items are grouped by project: PRISM and NTRP. The PRISM project includes a message and two files. The NTRP project includes a message and two files. The footer contains links for Help, Feedback & Support, and Refer TeamworkPM, along with the text "Powered by Teamwork.com".

Item Type	Item Name	Created by	Created at	Created on
Project	PRISM	Paul B.	8 minutes ago	Today
Message	Teamwork for NTRP	Paul B.	at 17:04	02 Sep
File	NIST National Technology Roadmap for Photonics Summary 20140725.pdf (V1 - 42KB)	Paul B.	at 16:50	02 Sep
File	NTRP TWG Co-Chair Meeting 20140828.pptx (V1 - 620KB)	Paul B.	at 16:50	02 Sep
Project	NTRP	Paul B.	at 16:45	02 Sep

<https://ntrp.teamwork.com/index.cfm>



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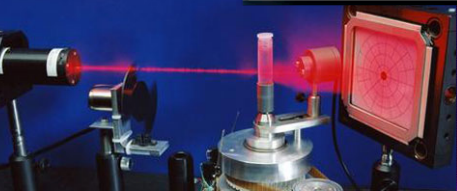
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Calendar

September 2014

MON	TUE	WED	THU	FRI	SAT	SUN
1	2	3	4	5	6	7
8 • 09:00 NIST review prep call	9 • 09:00 NIST review prep call • 19:15 Dinner with UR, AZ, CREOL, j	10 NIST review	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30 • 13:00 All TWG telecon	1	2	3	4	5

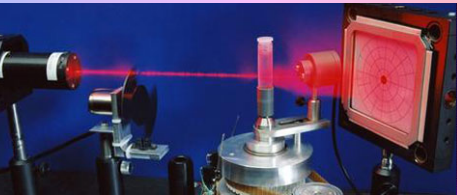


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Discussion Period (some starters)

- Participation by non-US companies
- Should these roadmaps be public or confidential?
 - Confidential to U.S. companies?
 - Confidential to members of a consortium
 - Available for a fee?
- What to do about the cross-cutting roadmaps?
- What to do about the market roadmaps?



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Afternoon Agenda (NNMI)

12:00 – 12:15 – Break and get lunches

12:15 – 1:00 – Google presentation on optics manufacturing

Anurag Gupta, Google

1:00 – 1:30 – University Perspectives (UR, BU, CREOL, AZ, UNM)

1:30 – 2:30 – Designing an IMI for optics and photonics

Paul Ballentine

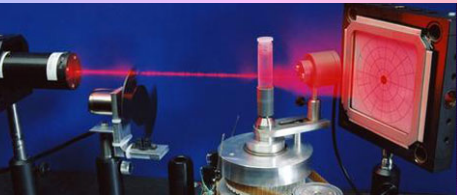
2:30 – 2:45 - Coffee Break

2:45 – 3:45 – Open Discussion of IMI with company perspectives (Exelis, LaserMax, RPO, IQE, GE, Inrad, Moondog Labs, EoS Photonics)

3:45 – 4:15 – Education and Workforce Development (AZ, UR, UNM, R-H, MCC, Open Photonics)

4:15 – 4:45 – Summary, Action Items, Next Steps

4:45 – 5:00 – NTRP TWG co-lead meeting

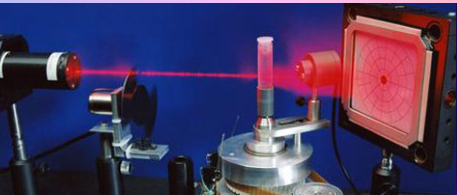


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Our Photonics IMI Timeline

- **October 2012:** submitted response to NIST RFI recommending establishment of POMATech (Photonics and Optics Manufacturing Technology)
- **December 2012:** held first town hall meeting – over 100 participated
- **January 2013:** attended NNMI Design mtg. in Huntsville
- **January 2013 – March 2014 :** refined model and built awareness nationally
- **May 2014:** received AMTech grant, allowing us to accelerate effort
- **July 2014:** submitted response to DoD RFI calling for establishment of PRISM (Photonics Research, Innovation, Systems, and Manufacturing)
- **July and August 2014:** Visited major optics and photonics universities and gained some consensus on what is in the best national interest.

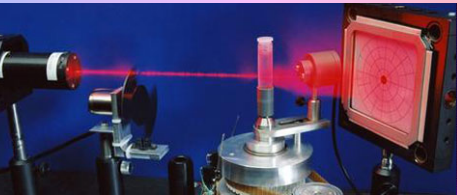


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Key Must-Haves for a Photonics IMI

- Works on technologies that will have broad economic impact
- Works on translational technologies (TRL 4 – TRL 7)
- Strong Participation by SMEs
- Supports Education and Workforce Training
- Led by industry
- Sustainable without NNMI funding after 5-7 years

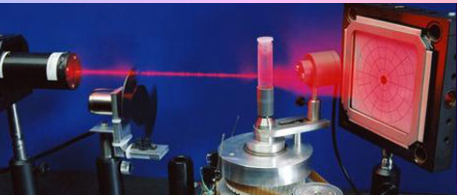


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University Perspectives



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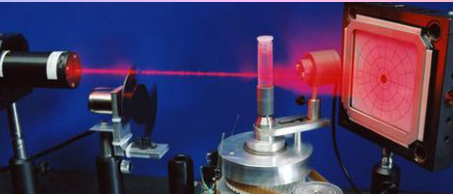
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Design of a National Institute for for Photonics Manufacturing

Leveraging the Nation's Resources and
Planning for the Future

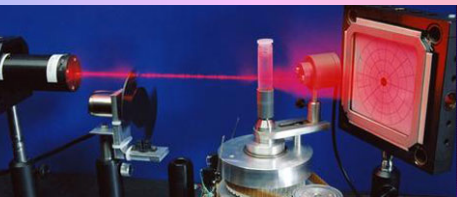


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Learning from the Fraunhofer Institutes for Photonics



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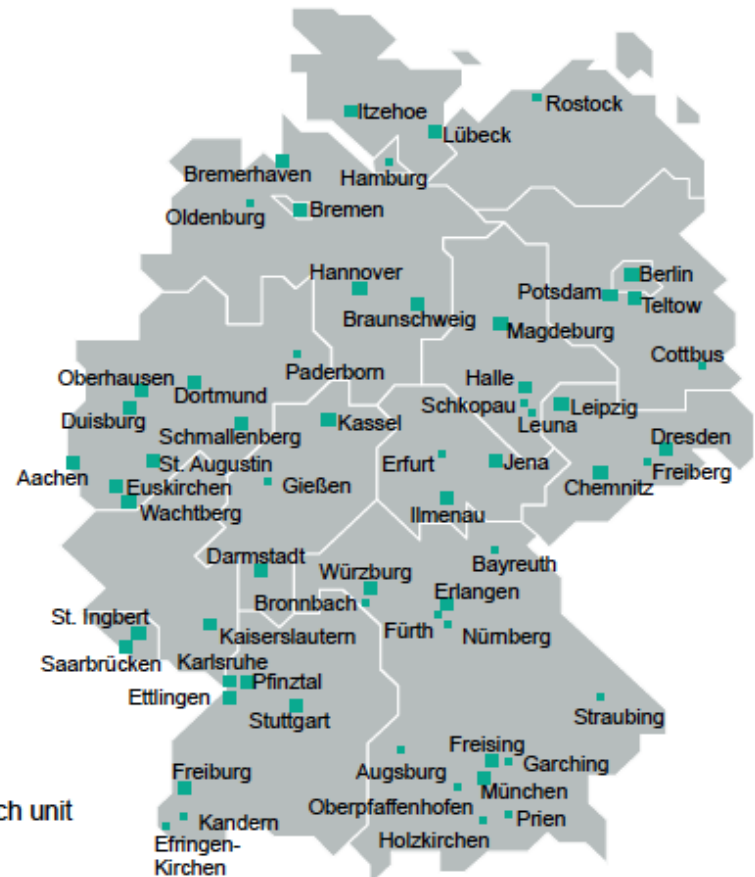
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Fraunhofer-Gesellschaft

Locations in Germany

Data 2013

- 67 institutes and independent research units
- 7 Fraunhofer Groups
- Worldwide locations



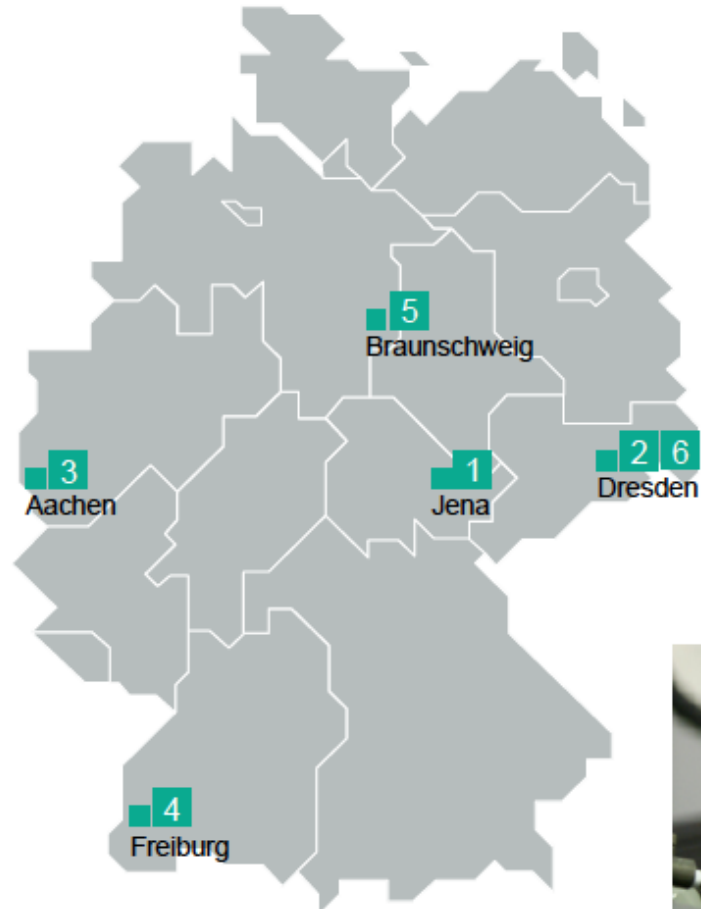
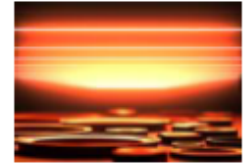
Pooling expertise Fraunhofer Groups



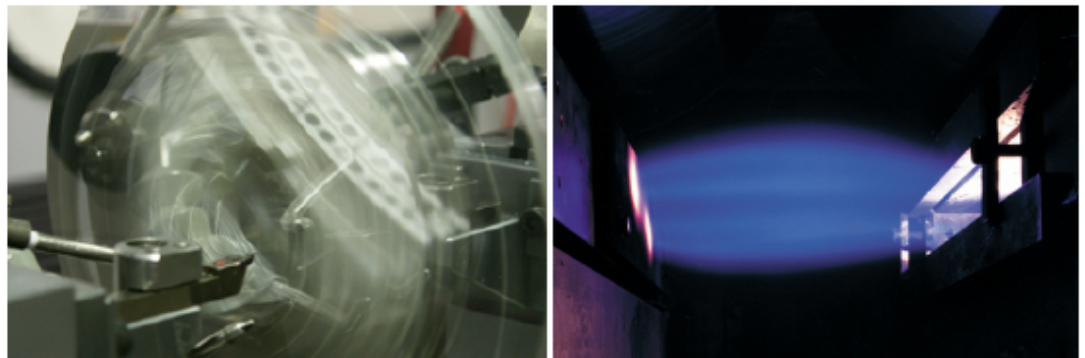
- Institutes working in related subject areas cooperate in Fraunhofer Groups
 - foster a joint presence on the R&D market
 - help to define the Fraunhofer-Gesellschaft's business policy

- ICT
- Life Sciences
- Light & Surfaces
- Microelectronics
- Production
- Materials and Components – MATERIALS
- Defense and Security VVS

Fraunhofer Group for Light & Surfaces



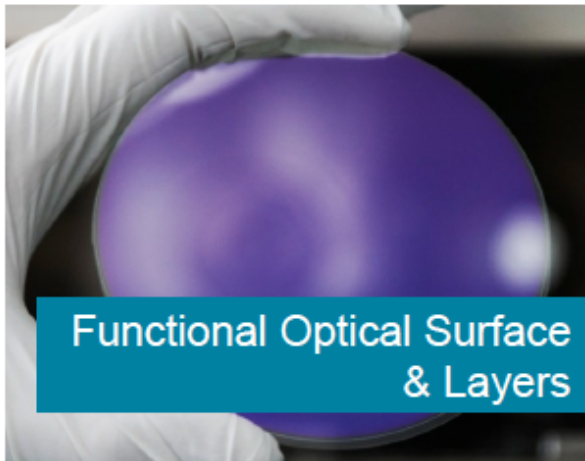
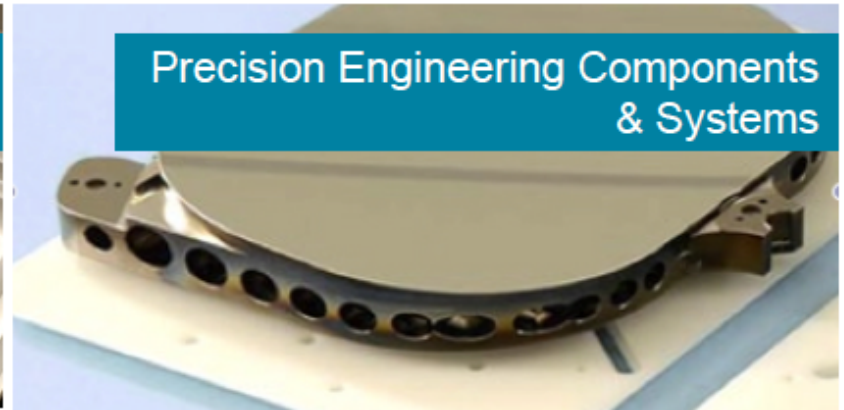
- 1 Applied Optics and Precision Engineering **IOF**
- 2 Electron Beam and Plasma Technology **FEP**
- 3 Laser Technology **ILT**
- 4 Physical Measurement Techniques **IPM**
- 5 Surface Engineering and Thin Films **IST**
- 6 Material and Beam Technology **IWS**



Fraunhofer IOF Business Fields

Current Major Project Areas:

1. Freeform optics
2. Fiber lasers
3. Micro and nano modification of surfaces
4. Human interface with automation systems



Some Differences Between Germany and U.S.

Germany

- 400 miles wide, 137K sq miles
- 80 million people
- GDP \$3.7 trillion
- Military budget \$44B
- Industry/Govt. collaboration common

US

- 3000 miles wide, 3.8M sq miles
- 314 million people
- GDP \$17 trillion
- DoD budget \$600B
- Less Industry/Govt. collaboration

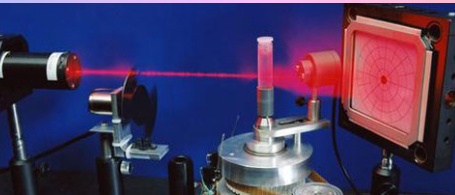
Exact same model is not optimum for the U.S.

Fraunhofer Institutes

- Founded in 1949
- 67 Institutes
- ~20% of budget comes from foundation

NNMI

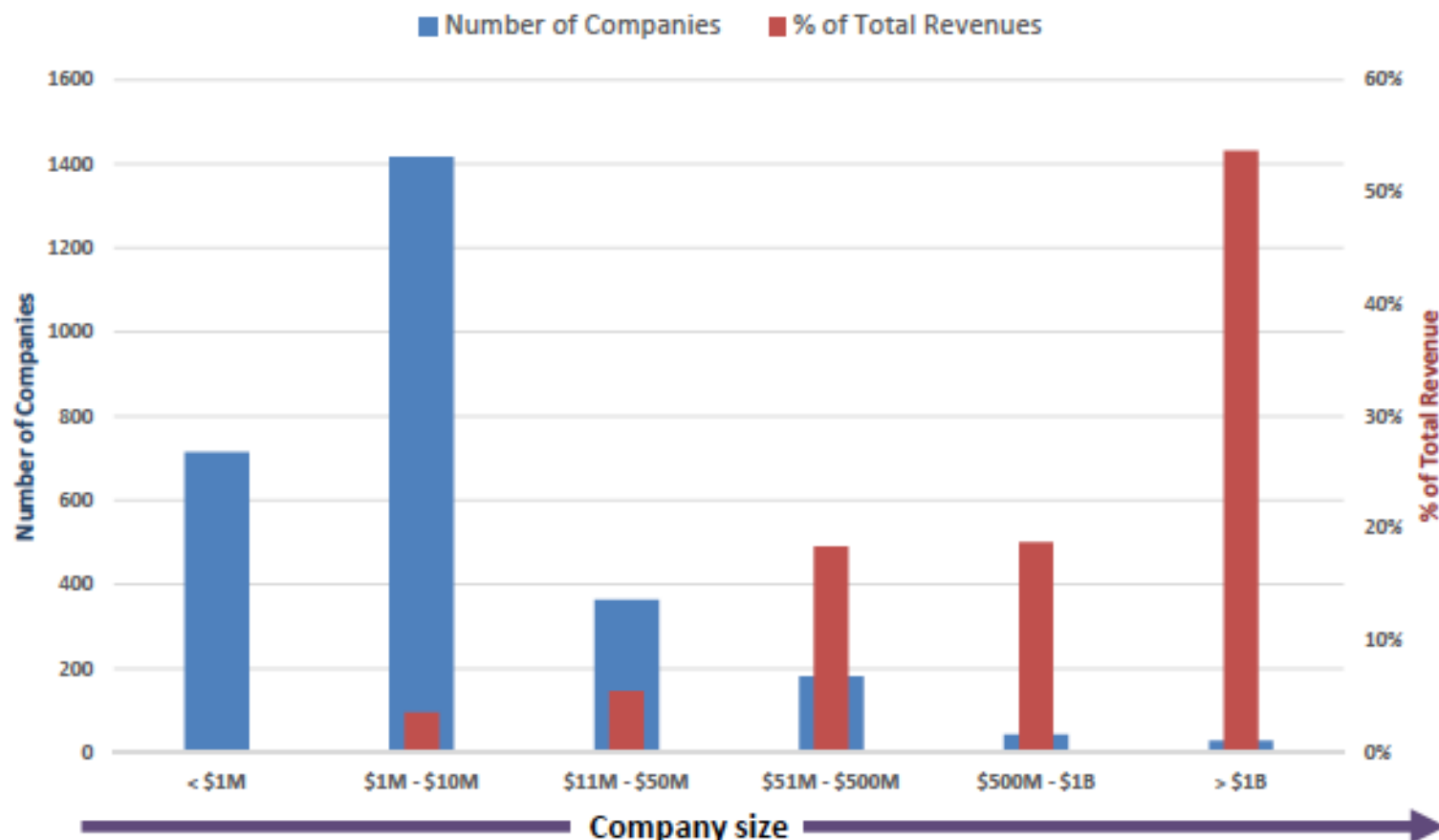
- Founded in 2012
- 45 after 10 years
- Are to be self sustaining in 5-7 years



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National Technology Roadmap for Photonics

Companies Grouped by Size (\$) for Core Photonics Suppliers, WW



- ✓ **69 firms with photonics revenues > \$500 M account for >72% of total sales**
- ✓ **2132 firms with photonics revenues < \$10 M account for only ~3.7% of total sales**
- ✓ **<10% of photonics firms employ ~77% of the workforce**

Potential Photonics IMI Technologies

- Lasers
- Advanced optics
- Imaging and Sensing
- Biophotonics
- Photonic Integrated Circuits
- Displays
- LEDs
- PV
- Metrology

Lasers, Sensors, and Imaging (LSI) IMI

- Lasers
- Advanced optics
- Imaging and Sensing
- Biophotonics
- Photonic Integrated Circuits
- Displays
- LEDs
- PV
- Metrology

LSI Scope

- Advanced Optics
- Detectors
- Imaging and Sensing Systems
- QCL Lasers
- E/O IR
- Biophotonics
- Fiber lasers
- DoD influenced
- ITAR compatible

Photonic Integrated Devices (PID) IMI

- Lasers
 - Advanced optics
 - Imaging and Sensing
 - Biophotonics
 - Photonic Integrated Circuits
 - Displays
 - LEDs
 - PV
 - Metrology
- (PID) Scope
- Photonic Integrated Circuits
 - Biophotonic ICs
 - Imaging Arrays
 - PIC Foundry
 - Primarily commercial
 - NIST influenced

Advanced Photonic Manufacturing (APM) IMI

- Lasers
- Advanced optics
- Imaging and Sensing
- Biophotonics
- Photonic Integrated Circuits
- Displays
- LEDs
- PV

APM Scope

- High Power Lasers (e.g. fiber lasers)
- Lithography and Metrology
- Machine vision
- Both manufacturing of industrial lasers and applications of lasers in manufacturing
- NIST and DOD influenced

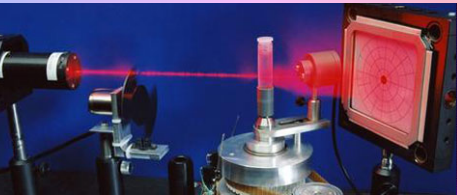
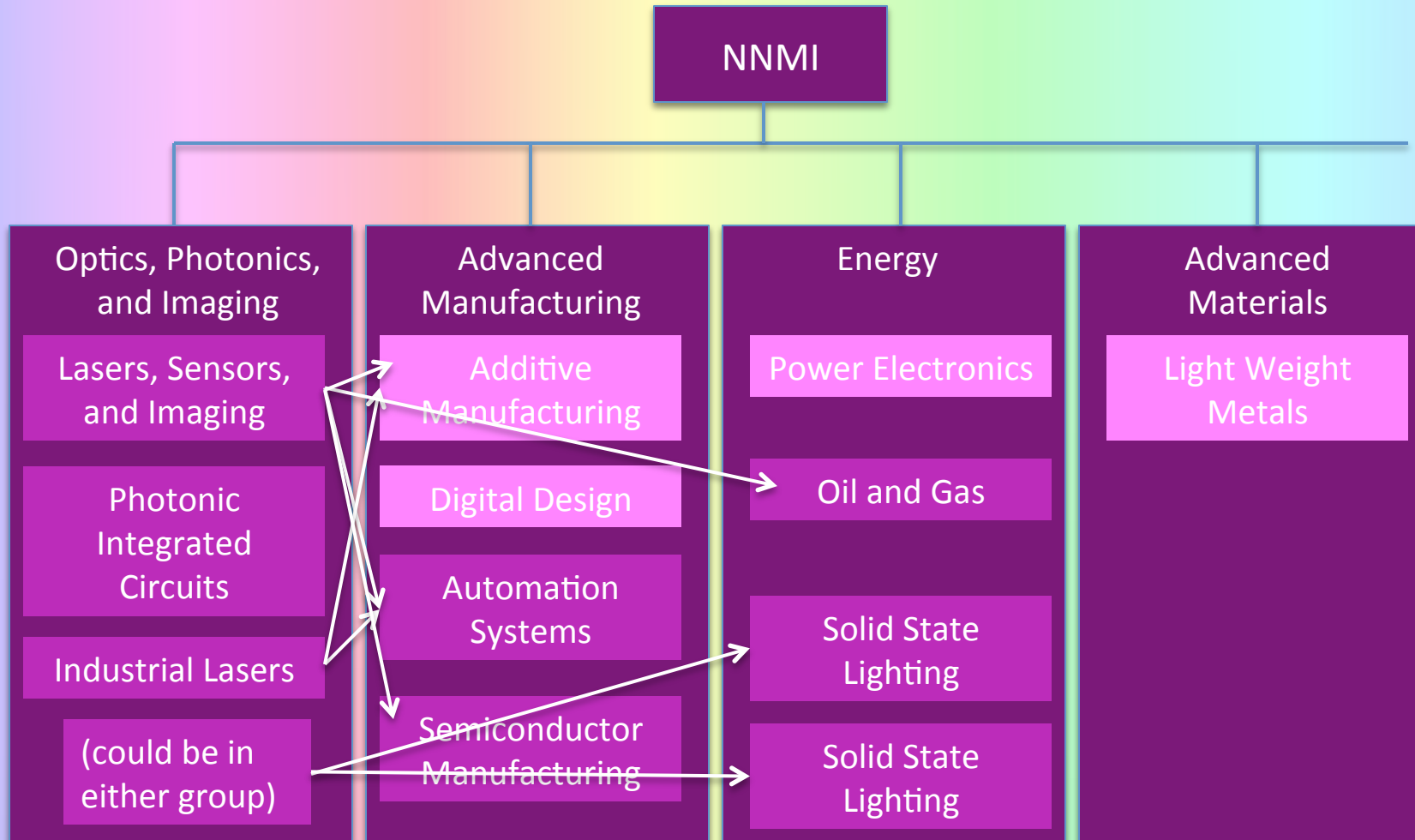
PV and Solid State Lighting (PVSSL) IMI

- Lasers
- Advanced optics
- Imaging and Sensing
- Biophotonics
- Photonic Integrated Circuits
- Displays
- Solid State Lighting
- PV

PVSSL Scope

- PV
- Solid State Lighting
- DOE and NIST influenced

Photonics IMIs Support Other IMIs

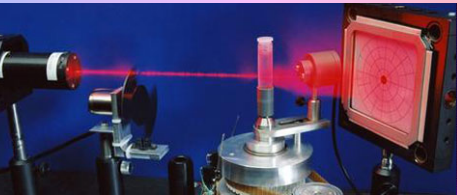


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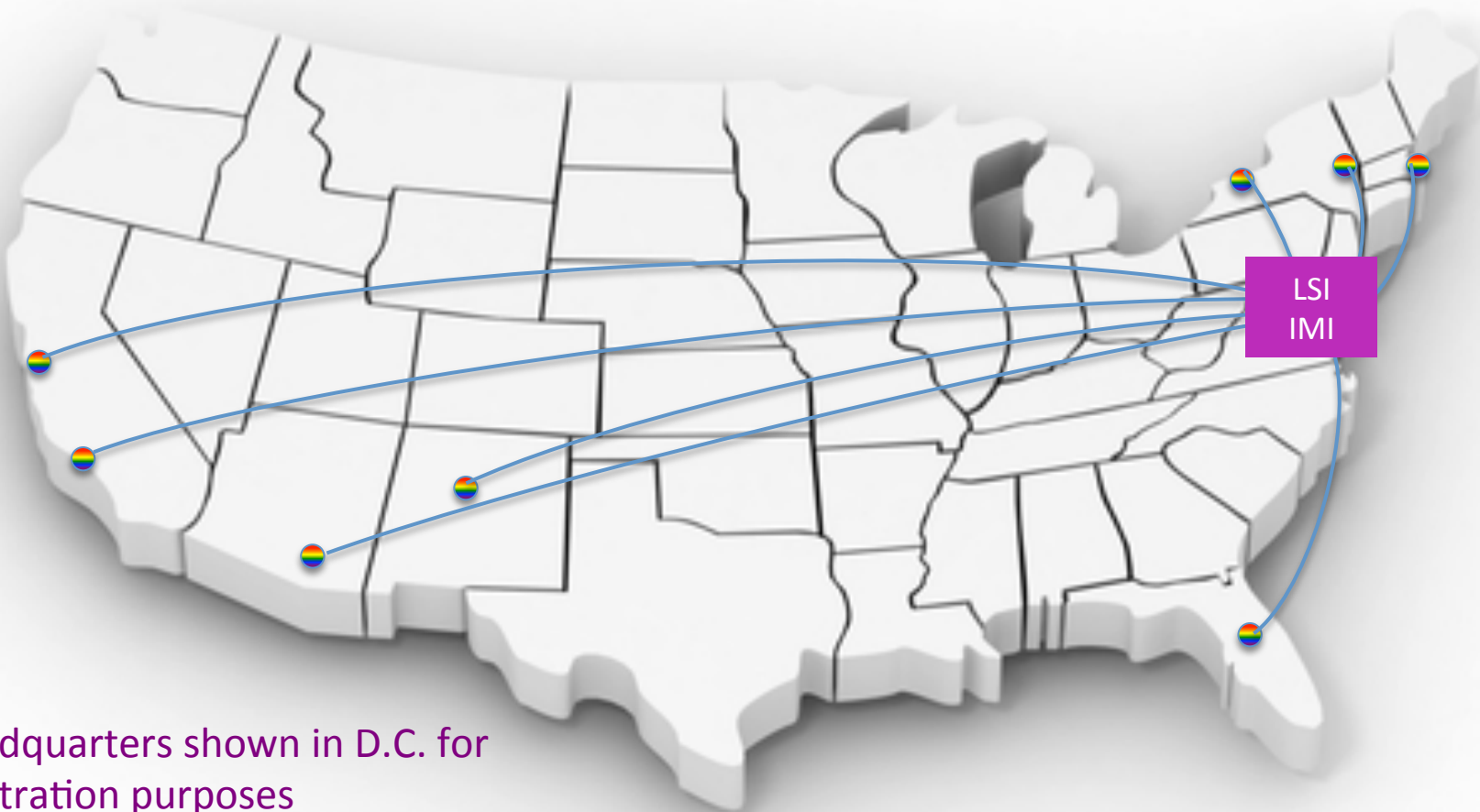
National Technology Roadmap for Photonics

One Approach to Setting up Photonics IMIs

- Set up one first – we suggest Lasers, Sensing, and Imaging
- Make that the base for the eventual OPI group
- Have the LSI IMI be composed of Centers of Excellence (COEs) around the major photonics hubs in the U.S.
 - Albany – photonic integrated circuits
 - Albuquerque – IR materials and systems
 - Boston – biophotonics and photonic integrated circuits
 - Orlando – Lasers and Optics
 - Rochester – Optics, Imaging, and Lasers
 - Tucson – Optics, biophotonics, imaging
- If more photonics IMIs are set up, the COEs could evolve into them.
- Close collaboration within the group ensures continuity of strategy and operation



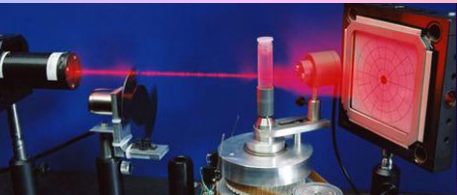
NNMI OPI Group



Headquarters shown in D.C. for illustration purposes

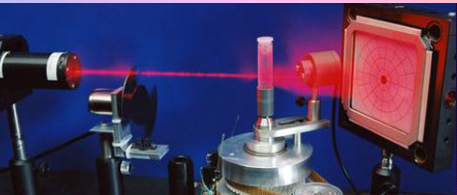
Value of a Distributed COE Model

- The US has vast photonics resources with several large clusters. These should be leveraged in an NNMI
- Regional centers will make participation by SMEs much easier.
- Regional centers will make workforce training at the 2-year school level more valuable
- Regional centers will enhance industry/university collaboration and increase efficiency and economic impact
- State and regional governments are making large investments in photonics-related economic development. This should be leveraged at the national level.
- The current plan is to have “only” 45 IMIs within 10 years. Germany has 67 Fraunhofer Institutes for an economy 1/5 the size of the US, so having each IMI include multiple COEs may be appropriate for the US.



Possible Starting Focus Areas of a LSI IMI

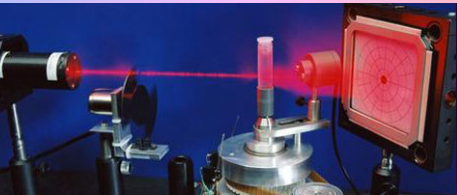
- Freeform optics manufacturing
- E/O IR
- Photonic materials
- QCLs
- Biophotonic devices
- Hyperspectral Sensing and Imaging



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**Open Discussion of a National
Institute for Optics and Photonics
Manufacturing Technology
Development**



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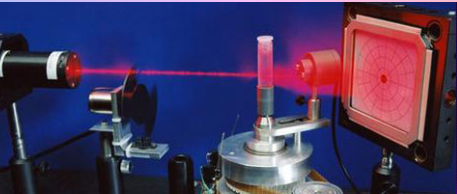
Companies Represented

Companies

- LaserMax
- GE Global Research
- Rochester Precision Optics
- Inrad
- IQE
- Exelis
- IoS
- Moondog Labs
- Former Sr. Executives
 - Corning
 - Kodak

Types of Companies

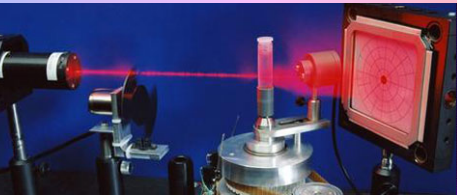
- Small, Medium, and Large Companies
- Serving Diverse Markets
 - Defense
 - Consumer
 - Commercial
 - Biomedical
- Built around different photonics technologies
 - Lasers
 - Optics
 - Materials
 - Imaging
 - Displays



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National Technology Roadmap for Photonics

Education and Workforce Development for the U.S. Photonics Industry



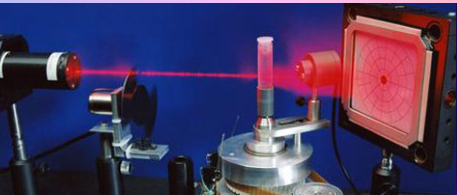
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Objective

Ensure there are the right number of photonics workers, at the right skill level, in the right technologies, in the right regions, at the right time to support growth of the U.S. photonics industry



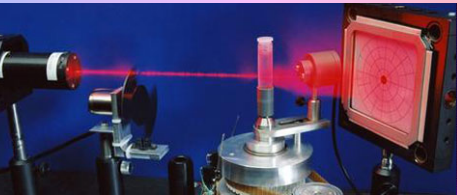
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National Resources

- All of the 2-year, 4-year, and graduate programs
- OSA, SPIE programs
- OP-TEC (a NSF Advanced Technological Education Program in Waco, TX)
- Others?
- Recent activities
 - NPI Taskforce of Education and Workforce Development
 - AMTech NTRP program
 - Eventual optics and photonics IMIs

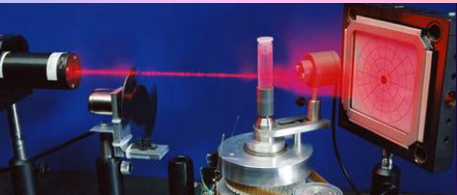


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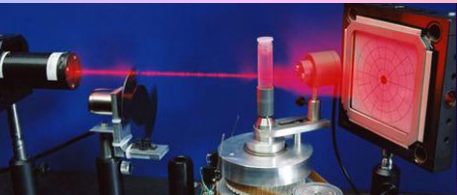
Challenges

- We need better data on the job market (now and future!)
 - What skills are required?
 - What levels?
 - How many people?
 - Where?
 - When?
- How can the colleges and universities optimize their optics and photonics curricula to meet the needs of the market?



Challenges

- It is very difficult to get high school graduates interested in careers in optics and photonics
 - Not just any students – the best and brightest
 - Not recognized like EE or MechE at the HS level (or by parents!)



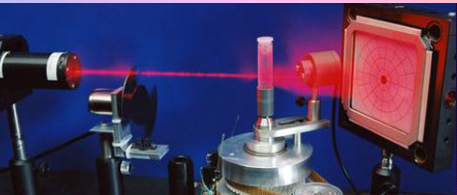
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NPI Taskforce on Education and Workforce Development

- Leader – Matthew Weed, Open Photonics
- Three part strategy
 - Careers marketing
 - Skills roadmapping
 - Industry-partnered training



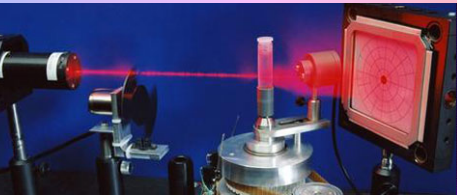
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Discussion Questions

- How can the NTRP grant help support the NPI Taskforce on Education and Workforce Development?
 - Careers Marketing
 - Skills roadmapping
 - Industry-partnered training
- How would a photonics-centric IMI support the nation's photonics workforce need?
- How would an IMI best collaborate with existing efforts (OP-TEC, the NPI, etc)?



Discussion Questions: *Industry Influence*

1. How could an O&P employers coalition best communicate a skills roadmap to academic institutions?
2. How could such a coalition aid in the execution of such a roadmap that demands an adaptive curriculum?
3. How could such a coalition accredit training programs in post-secondary landscape?

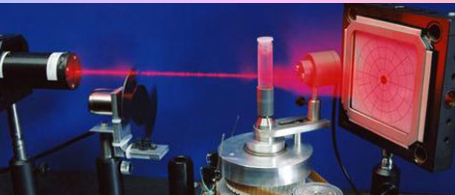


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Discussion Questions: *Government/Agency Influence*

1. What can governments and agencies do to off-set the cost of adding and up keeping technology in classrooms?
2. What such groups do to communicate O&P as a field of key strategic and economic importance to the broader citizenry?



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