Air Force Research Laboratory

The AFOSR International Initiatives

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Air Force Office of Scientific Research (AFOSR)

Integrity ★ Service ★ Excellence

Overview

- Air Force Office of Scientific Research (AFOSR) Overview
- AFOSR/International Office (IO) Overview
- AFOSR International Initiatives
- Quick Review of Initiatives-Korea and Taiwan Initiatives and their Program Assessment
- Summary

AFRL Turning Science Into Capability

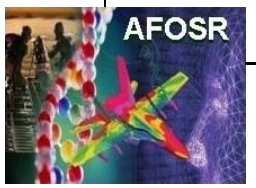
Basic Research (AFOSR)
~30% to TDs
~70% to Universities

Materials & Manufacturing (RX)

Space Vehicles (RV)

Information (RI)

Munitions (RW)



Air Force Office of Scientific Research (AFOSR)

- International Office (AFOSR/IO)
- Asian Office of Aerospace R&D (IOA – Tokyo)
- European Office of Aerospace R&D (IOE - London)
- Southern Office of Aerospace R&D (IOS - Santiago)
- North America (ION – Arlington, VA)

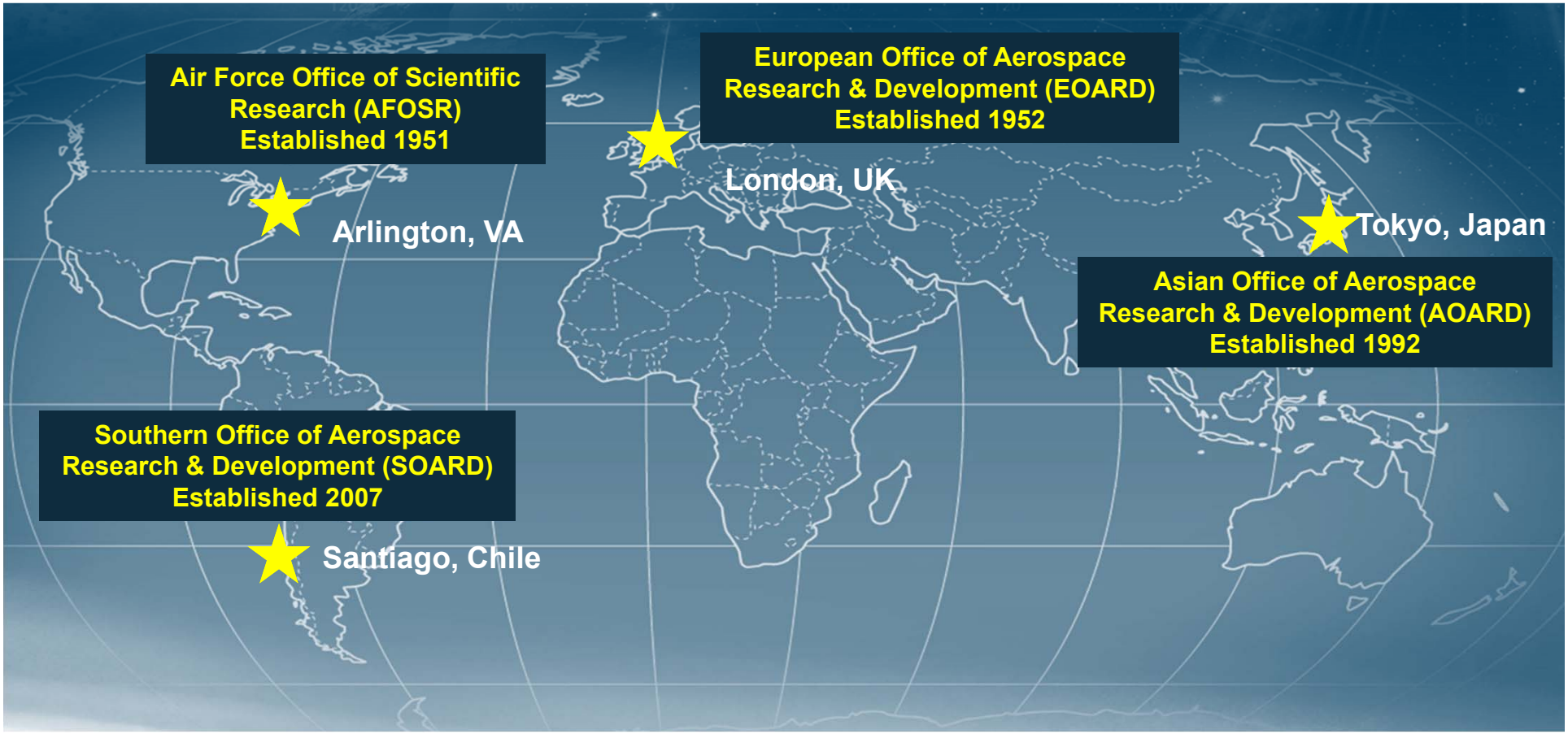
Sensors (RY)

Aerospace Systems (RQ)

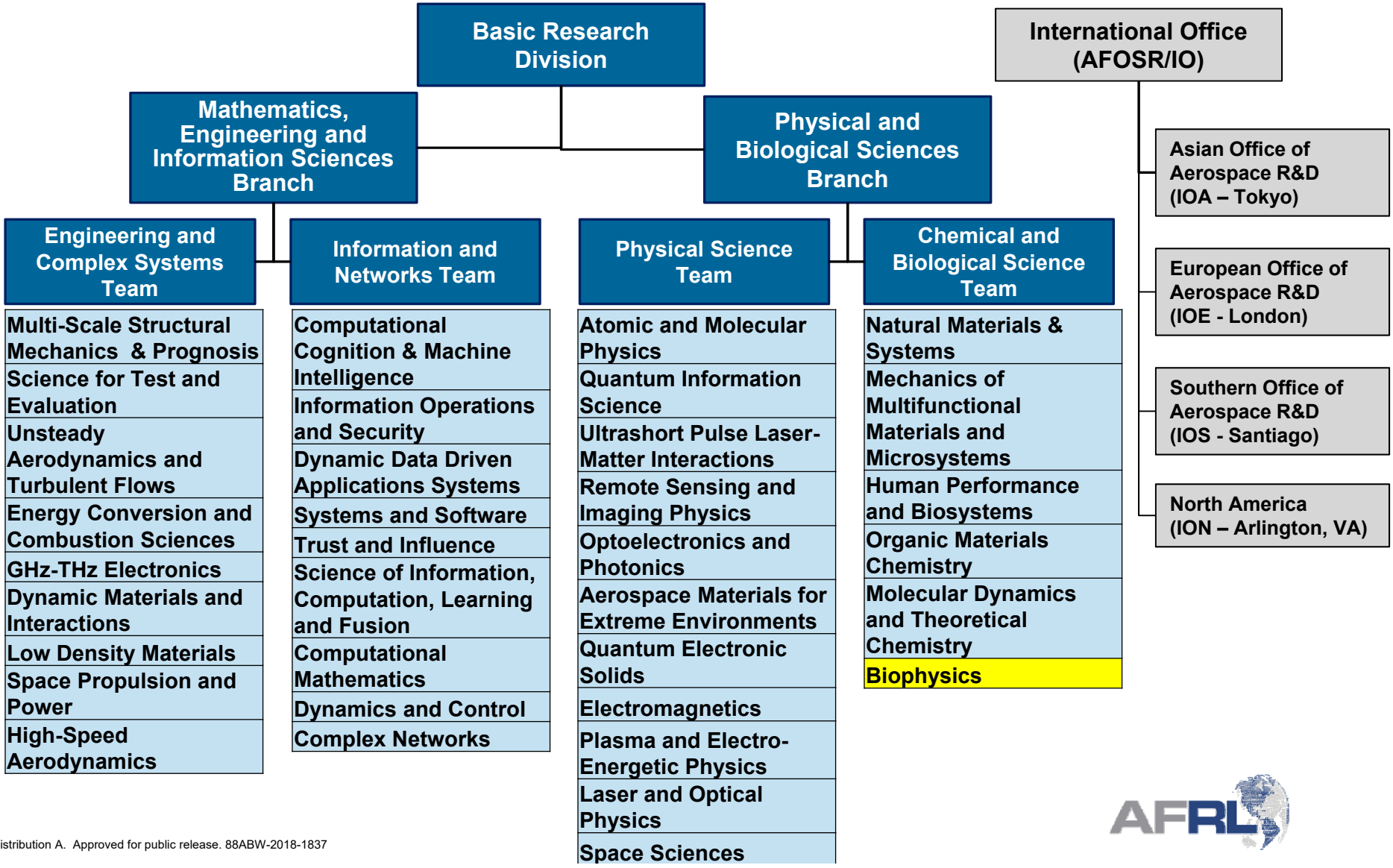
711th Human Performance Wing (711 HPW)

Directed Energy (RD)

AFOSR Map



36 Programs in Basic Research Division AFOSR

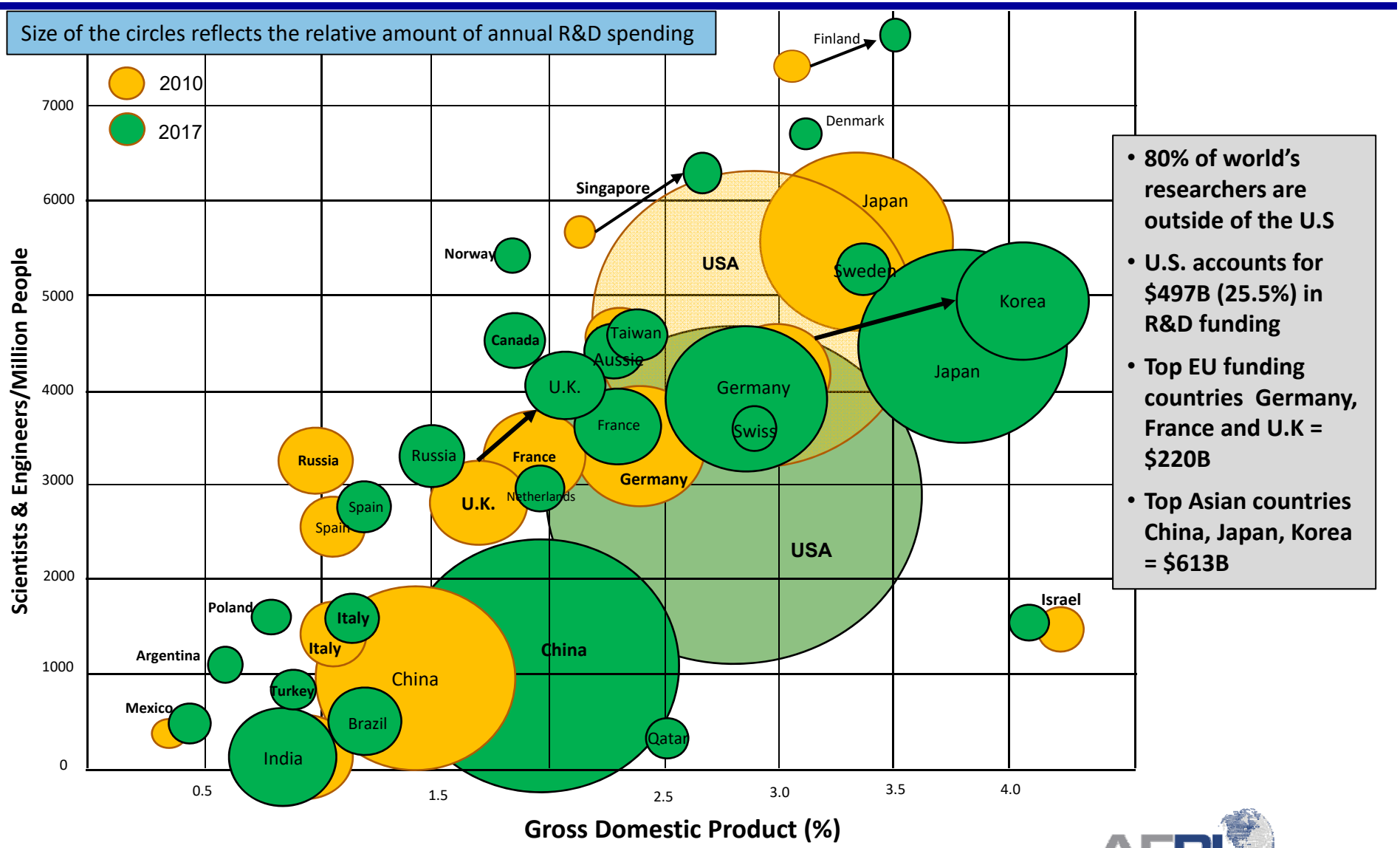


20 Programs
AFOSR International Office

International Office (AFOSR/IO)

Asian Office of Aerospace R&D (IOA – Tokyo) 9 IPOs	European Office of Aerospace R&D (IOE-London) 10 IPOs	Southern Office of Aerospace R&D (IOS–Santiago)2 IPOs	North America (ION – Arlington, VA)
Robotics & Autonomy	Aeronautical Sciences	Mathematics & Quantum Science	Science & Engineering
Sensors, EM & Device Physics	Directed Energy	Physical & Space Sciences	International Initiatives
Materials & Manufacturing Science	Space Science & Space Technology		Student Exchange Program
Lasers & Optics and Aero Sciences	Life Science & Human Performance		ESEP & Window-on-World
Quantum & Cyber Sciences	Materials & Physics		Window-on-Science
Lasers, Structural Materials &Autonomy	Autonomy, Cognitive & Human Factors		
Hypersonics, Space Sciences & Nanomagnetics	Optimization & mathematics		
Biophysics, Math & Behavioral Science	Advanced Aerospace Structures & Materials		
Big Data Analytics	Cyber & C4ISR		
	Autonomous Vehicles		

2017 vs 2010 Global R&D Data
(International R&D is Increasing: People & Funding)



- 80% of world's researchers are outside of the U.S
- U.S. accounts for $497B (25.5%) in R&D funding
- Top EU funding countries Germany, France and U.K = $220B
- Top Asian countries China, Japan, Korea = $613B

R&D Magazine Global R&D Funding Forecast

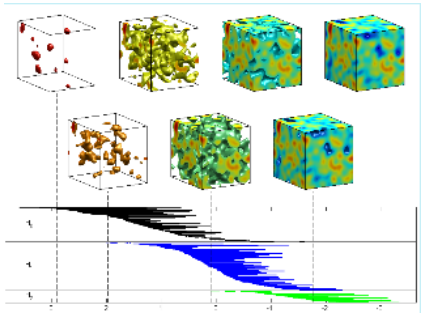
AFOSR International Office

Provide Awareness, Engagement, Relationships for Overseas Basic Research

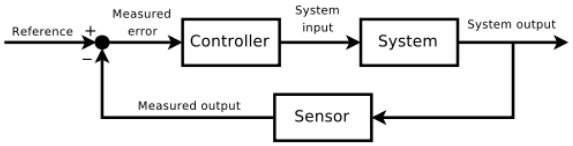
"Find" **Awareness** "Discover"

"Fund" **Engagement** "Acquire"

"Forward" **Relationships** "Transition"



Recent Work in Stochastic Algebraic Topology and Applications



Conference Support for Symposium on Estimation, Navigation, and Spacecraft Control

Initiative with Italy – Develop collaborative scientific exchanges with AFRL/U.S. institutions

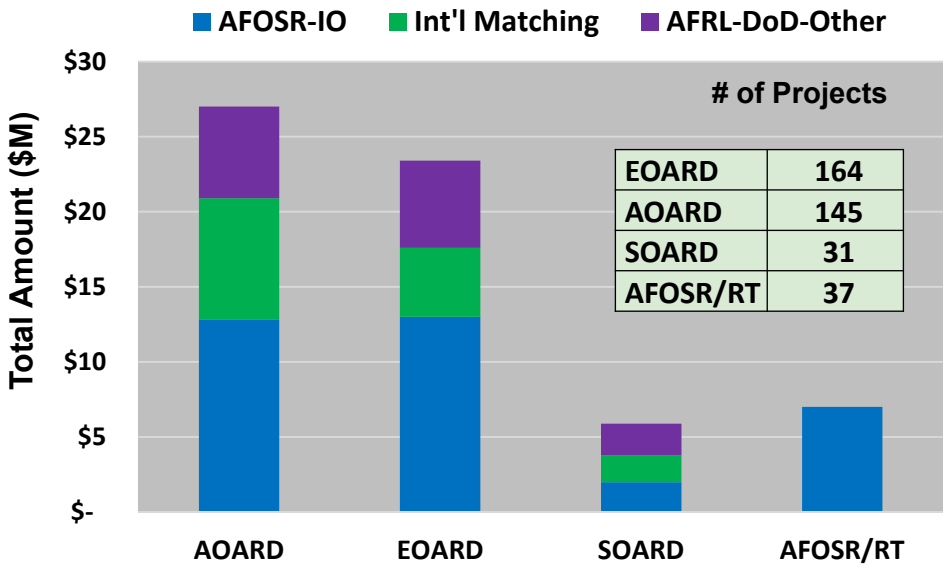
- **Promote awareness of state-of-the-art and newly emerging S&T across the global spectrum**
- **Develop regional engagement strategies to capture unique opportunities**
- **Foster relationships and shape research from a global perspective**
- **Identify priority areas and mechanisms for research exchange**
- **Conduct outreach on behalf of AFRL and the USAF's greater research enterprise**

International Funding Mechanisms

Research Grants	*Typically single-investigator, modest funding, and generally shorter duration than domestic grants*
International Initiatives Research Grants	*Structured as a team consisting of the US/foreign research partners where AFOSR funds the US half and foreign country funds the foreign half, and generally three years of duration*
Conference Support	*Promotes collaborations and research dissemination to enable advances in areas of high AF interest, often stimulates interest in working with AFOSR*
Windows on Science	*Provides travel support for foreign investigators to present research to AF/DoD audiences, typically leading to new or continued collaborations and grant proposals*
Windows on the World	*Provides travel support for AF scientists and engineers to work in a foreign lab (typically a university) for a couple weeks to 6 months*

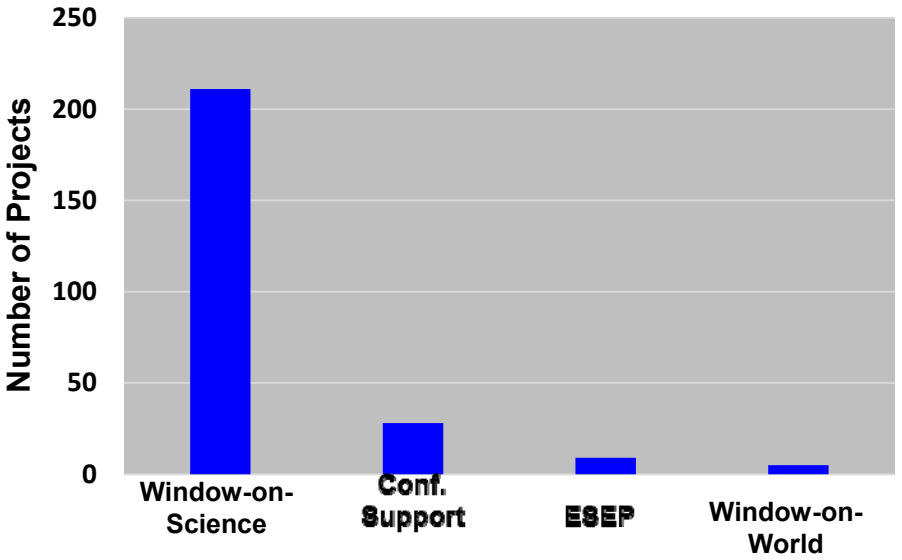
AFOSR International Office (IO) Research Funding and other Programs in FY2017

Research Funding



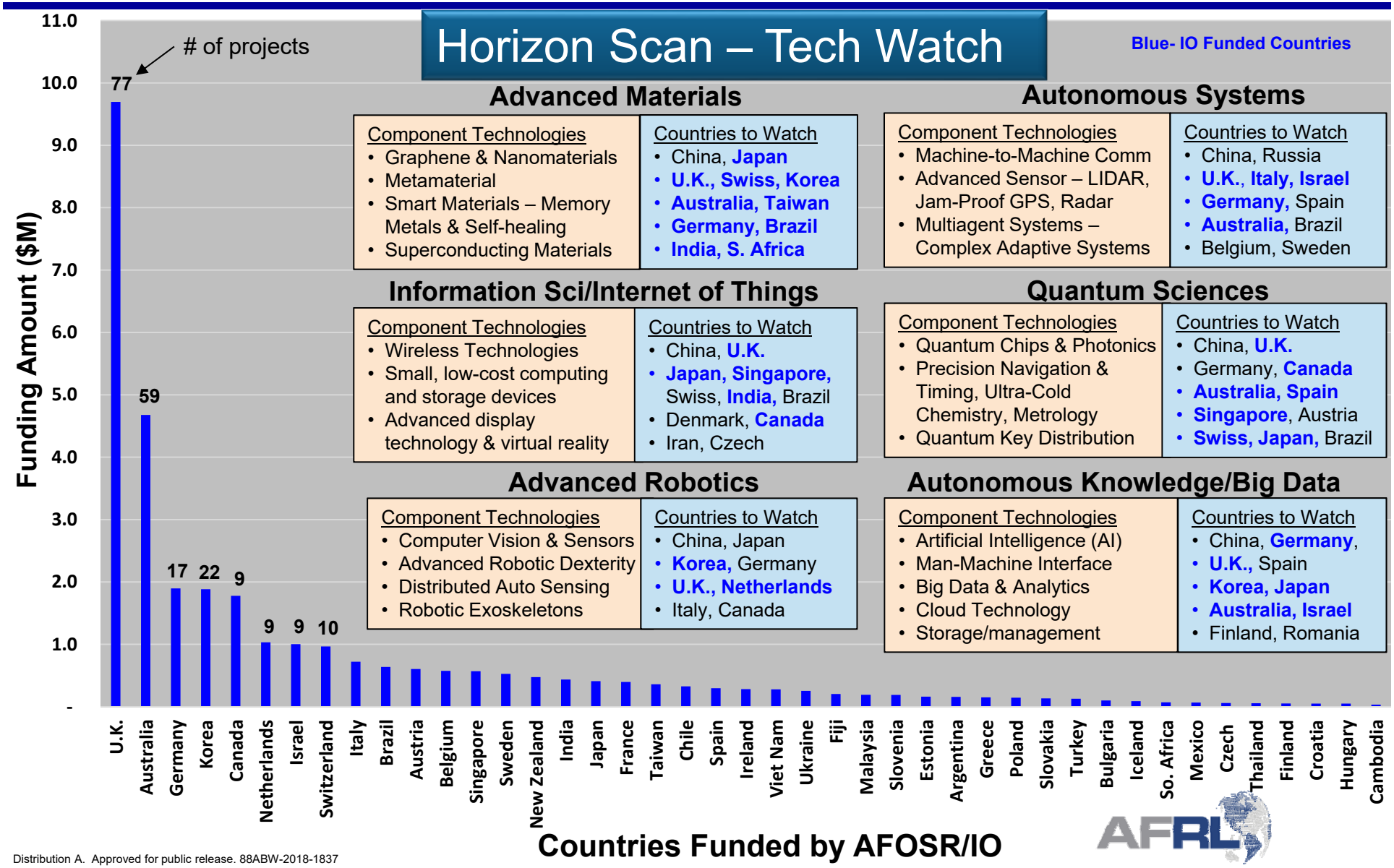
# of Projects	
EOARD	164
AOARD	145
SOARD	31
AFOSR/RT	37

Other Programs



FY17 Int'l Basic Research Funding

Countries = 43; Projects = 356



Advanced Materials

Component Technologies	Countries to Watch
• Graphene & Nanomaterials • Metamaterial • Smart Materials – Memory Metals & Self-healing • Superconducting Materials	• China, **Japan** • **U.K., Swiss, Korea** • **Australia, Taiwan** • **Germany, Brazil** • **India, S. Africa**

Autonomous Systems

Component Technologies	Countries to Watch
• Machine-to-Machine Comm • Advanced Sensor – LIDAR, Jam-Proof GPS, Radar • Multiagent Systems – Complex Adaptive Systems	• China, Russia • **U.K., Italy, Israel** • **Germany,** Spain • **Australia,** Brazil • Belgium, Sweden

Information Sci/Internet of Things

Component Technologies	Countries to Watch
• Wireless Technologies • Small, low-cost computing and storage devices • Advanced display technology & virtual reality	• China, **U.K.** • **Japan, Singapore,** Swiss, **India,** Brazil • Denmark, **Canada** • Iran, Czech

Quantum Sciences

Component Technologies	Countries to Watch
• Quantum Chips & Photonics • Precision Navigation & Timing, Ultra-Cold Chemistry, Metrology • Quantum Key Distribution	• China, **U.K.** • Germany, **Canada** • **Australia, Spain** • **Singapore**, Austria • **Swiss, Japan,** Brazil

Advanced Robotics

Component Technologies	Countries to Watch
• Computer Vision & Sensors • Advanced Robotic Dexterity • Distributed Auto Sensing • Robotic Exoskeletons	• China, Japan • **Korea,** Germany • **U.K., Netherlands** • Italy, Canada

Autonomous Knowledge/Big Data

Component Technologies	Countries to Watch
• Artificial Intelligence (AI) • Man-Machine Interface • Big Data & Analytics • Cloud Technology • Storage/management	• China, **Germany**, • **U.K.,** Spain • **Korea, Japan** • **Australia, Israel** • Finland, Romania

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What and Why International Initiatives?

What:

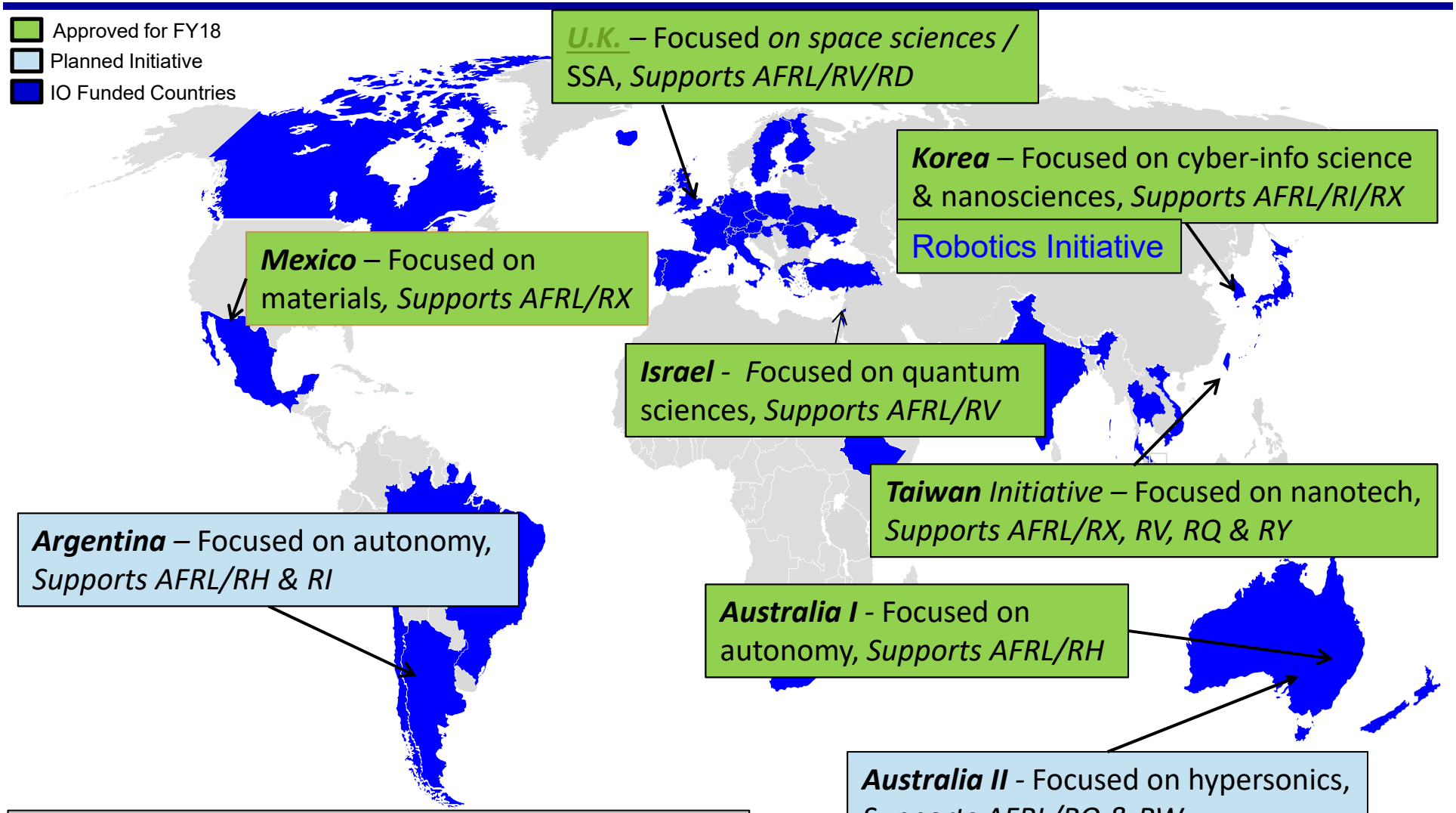
- Structured and Self-organized International Programs
- Team proposals Consisting of a US partner and a foreign partner
- Cost shared by both nation's funding agencies
  - ~ US funds half; Foreign partner funds half
- Host-Nation's funding call best reaches its top scientists
- Competitive Joint Selection: About 10% to 30% acceptance

Why Unique:

- Leverages large global R&D investment
- Special synergy opportunities
- Scientific experts of each nation
  - ~ more than individual accomplishments
  - ~ Leverages partner's expertise
- Strong return on investment for both participating countries

AFOSR Global Initiatives

(Matching Funding from Host Countries)



$3 million in matching funds from international partners

USAF-Asian Collaborative Research

US National Nanoscience Initiative – 2001

AFOSR-Korea NBIT

2003 - 2007	2007 - 2010	2010 - 2013	2013 - 2016
1-year seed grants	Phase I: 10 grants	Phase II: 9 grants	Phase III: 8 grants
17 exploratory grants (AFOSR visits MOST, Korea)	University Collaborations	University/AFRL/DOD Collaborations	University/AF/DOD Collaborations

USAF-Taiwan Initiative:

2003 - 2010	2011 - 2014	2014 - 2017
Initiative Program: Seed grants (single/multi-year)	*Joint Program:* Phase I: 16 grants	*Joint Program:* Phase II: 7 grants
	Collaborative research (Funded AFRL & US Universities)	

Workshops / Reviews (30 since 2002), locations alternate between countries

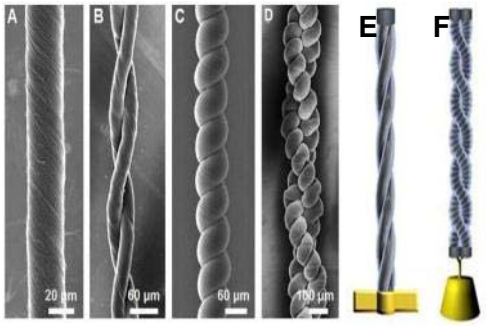
Korean Nanotech Program
NBIT Phase III: 2013-2016

1. **Layer-by-Layer Growth of 2D Quantum Superlattices**
   Jiwoong Park / Cornell Univ — *Hee Cheul Choi / POSTECH*
2. **Environmentally Powered Yarn Arrays that Sense, Actuate, Harvest, and Store Energy**
   Ray Baughman / Univ of Texas Dallas — *Seon Jeong Kim / Hanyang Univ*
3. **Bioinspired Engineering Synthesis Technology (BEST) for Active Photonic Devices**
   Luke Lee / Univ of CA Berkeley — *Taewook Kang/ Sogang Univ*
4. **Bio-inspired Nano-capillary Self-powered Fluid Transport in Nanocomposite**
   Jimmy Xu / Brown Univ — *Ki Tae Nam / Seoul National Univ*
5. **Nano Electronics on Atomically Controlled van der Waals Quantum Heterostructures**
   Philip Kim / Harvard Univ — *Gyu-Chul Yi / Seoul National Univ*
6. **Flexible 2D RF Nanoelectronics based on Layered Semiconductor Transistor**
   Costas Grigoropoulos / Univ of CA Berkeley — *Sunkook Kim / Kyung Hee Univ*, *Woong Choi Kookmin Univ*
7. **Plasmonic Optoelectronic Interactions**
   Chad Mirkin / Northwestern University — *Jae-Won Jang / Pukyong Nat'l Univ*
8. **Nanotube-on-Graphene Heterostructures for Smart Nano/Bio-Interface**
   SungWoo Nam / Univ of IL Urbana-Champaign — *Won Il Park / Hanyang Univ*

AFRL

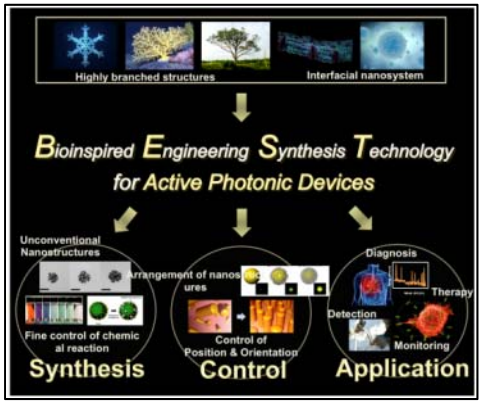
Topic Area: Nanostructures, Materials, Convergence

US-Korea NBIT Phase III



Environmentally Powered Yarn Arrays that Sense, Actuate, Harvest, and Store Energy (Baughman, Kim)

- Demonstrate 1st all-solid-state, torsional & tensile artificial yarn muscles that are electrochemically driven
- R&D 100 Gold award for Market Disruptor Products (2015)

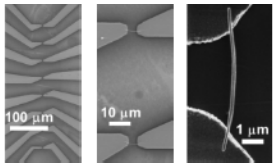


Bioinspired Engineering Synthesis Technology (BEST) for Active Photonic Devices(Lee, Kang)

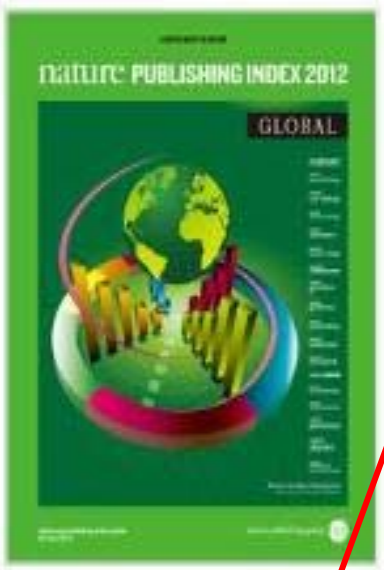
- Novel, easy, room-temperature (RT) synthesis and spontaneous assembly methods of unconventional plasmonic nanoantennae, which also allow (1) simple integration to photonic devices and (2) standardized optical sensing protocols, compared to the conventional synthesis methods.

Plasmonic Optoelectronic Interactions (Mirkin, Jang)

- How do the interactions between plasmons & organic and inorganic semiconductors influence the generation of photocurrents?
- Novel synthetic and assembly approach to create large quantities of hybrid semiconductor-metal nanowire structures and position them on electrodes for study



USAF-Taiwan Spotlight

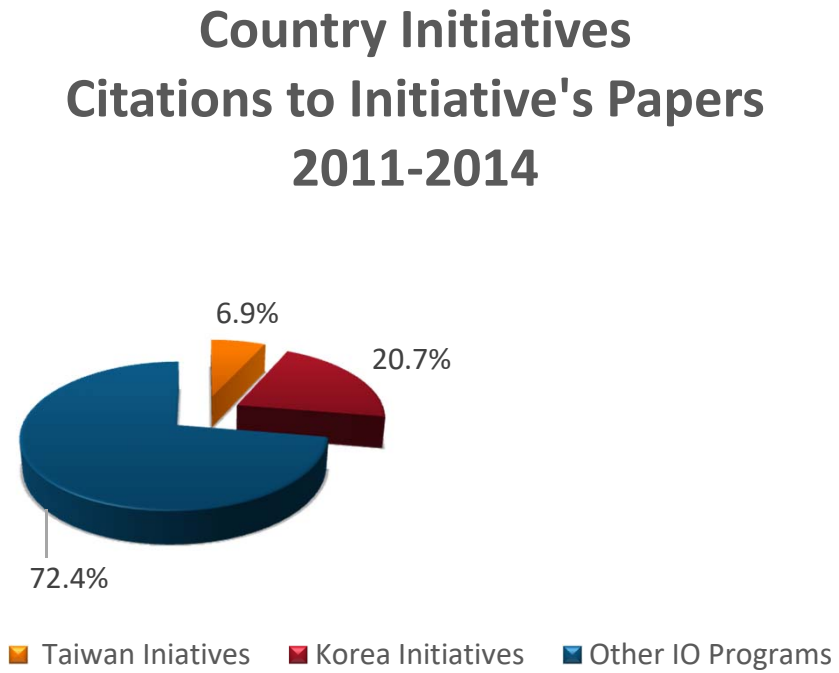


Taiwan's particular strengths lie in genetics, chemical biology and materials sciences. This year, for instance, its scientists published notable papers concerning genome-wide association studies, protein structures, graphene and transition metals in a range of Nature journals. In a culmination of these areas, researchers at the National Chiao Tung University in Hsinchu published a paper in *Nature Nanotechnology* concerning a protein-based transistor they had built using gold nanoparticles. But, as with South Korea, much of Taiwan's scientific effort is devoted to technological applications rather than fundamental research (it is one of the world's major computer chip manufacturers). This means it spends more than US$5 billion a year — more than 20% of its research outlay — on royalties for access to basic technologies.

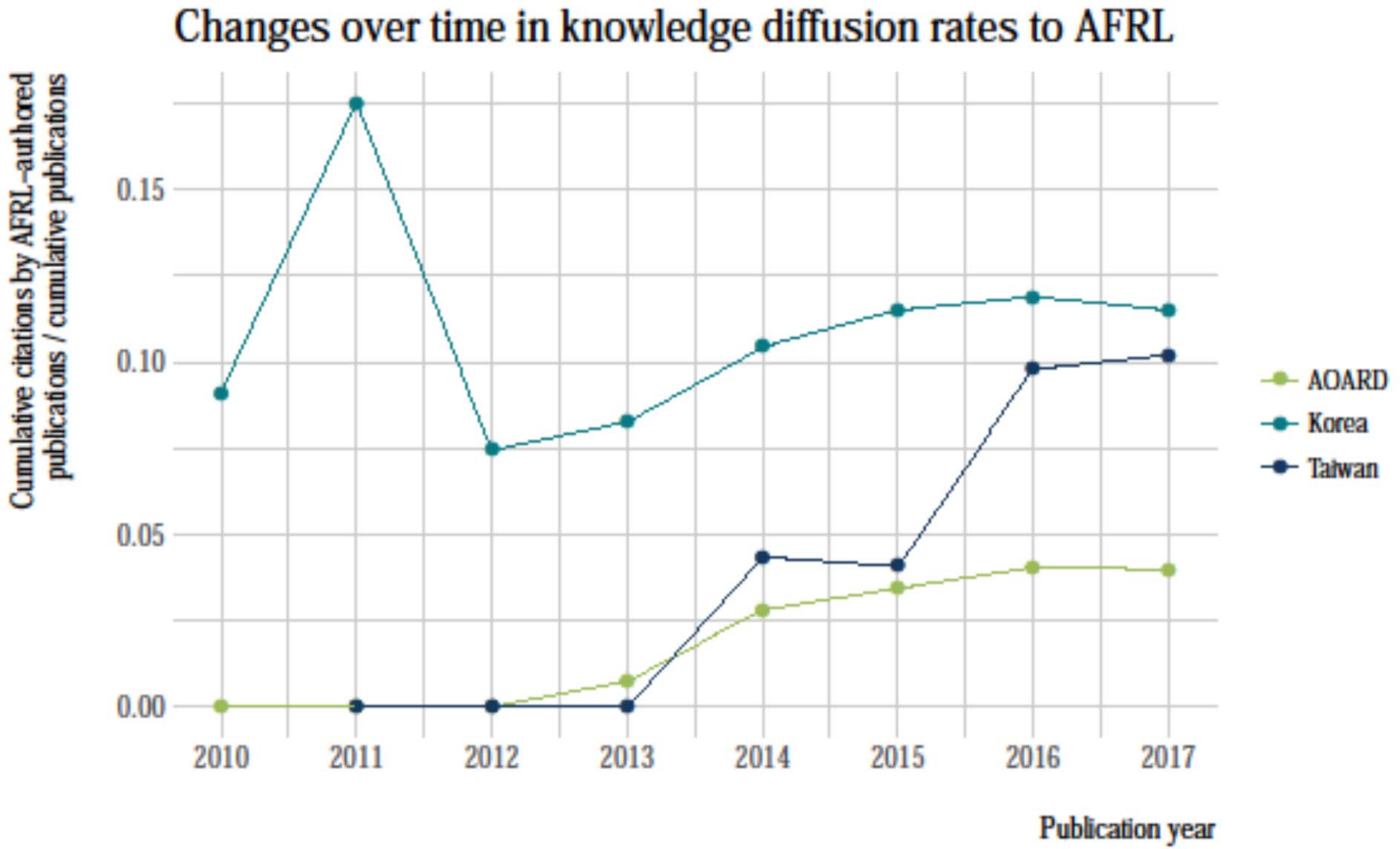
Highlighted work a result of research funded by the USAF Taiwan Initiative!

Quantitative Program Metrics 2015 Study

- **2x - 3x Impact of our Typical Programs**



AFRL Publications citing AFOSR/IOA



Qualitative Program Metrics

- Collaborative Methods: workshops, reviews, site visits, grants, professor/student exchanges
- International organizational interaction with Korea NRF and Taiwan MOST

2004 workshop led by Maj Gen Nielsen, AFRL/CC (circled)

2013 workshop had 5 participants from Taiwan who have attended all 10 workshops!

Continued partnerships outside NBIT

The 2015 workshop in Seoul was joint between both the Korea and Taiwan Programs!

Summary

AFOSR International "Initiative" Programs Key Points

- **Team proposals** from Joint US-Foreign Collaboration
- Leverage **large national investments** … pay only for the synergy.
- **Cost shared** funding between countries
- **Self organized** and selective: Scientist propose best synergy combinations
- **Foreign funding agency "Call"** ensures awareness/access of best talent
- Building mutual awareness, relationships, synergy with annual **program reviews**

Assessments

- Over 300 publications with 9000 citations
- For AFOSR International, 2x-3x more effective than our typical program
- Praised by Secretary of the USAF in our Technology Strategy Documents
- AFRL pubs directly cite papers from "Initiative" 2x more than other international programs