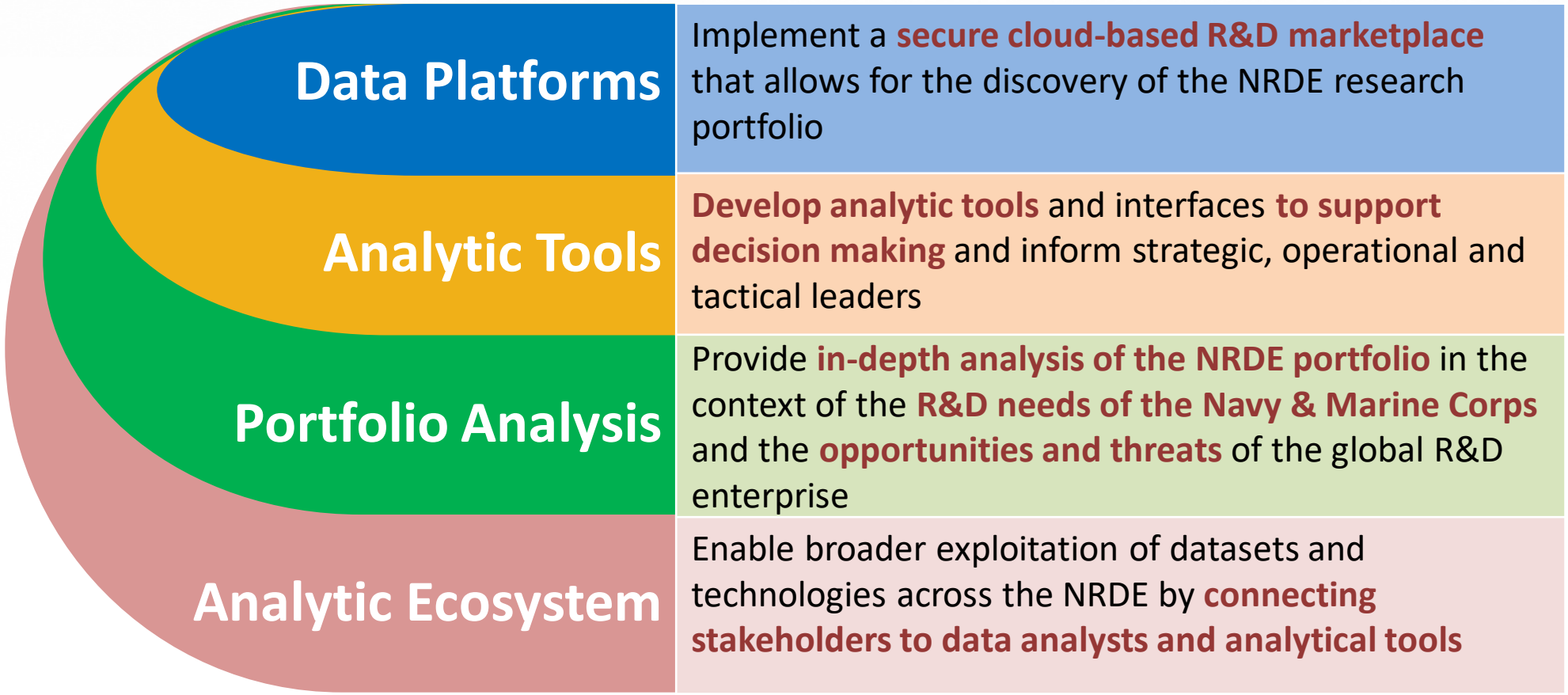
ONR Analytics Overview
October 2 2020

Dr. Ryan Zelnio
Chief Analytics Officer, ONR

D&A Mission to support Data-Driven Decision Making

D&A Division Mission Statement:

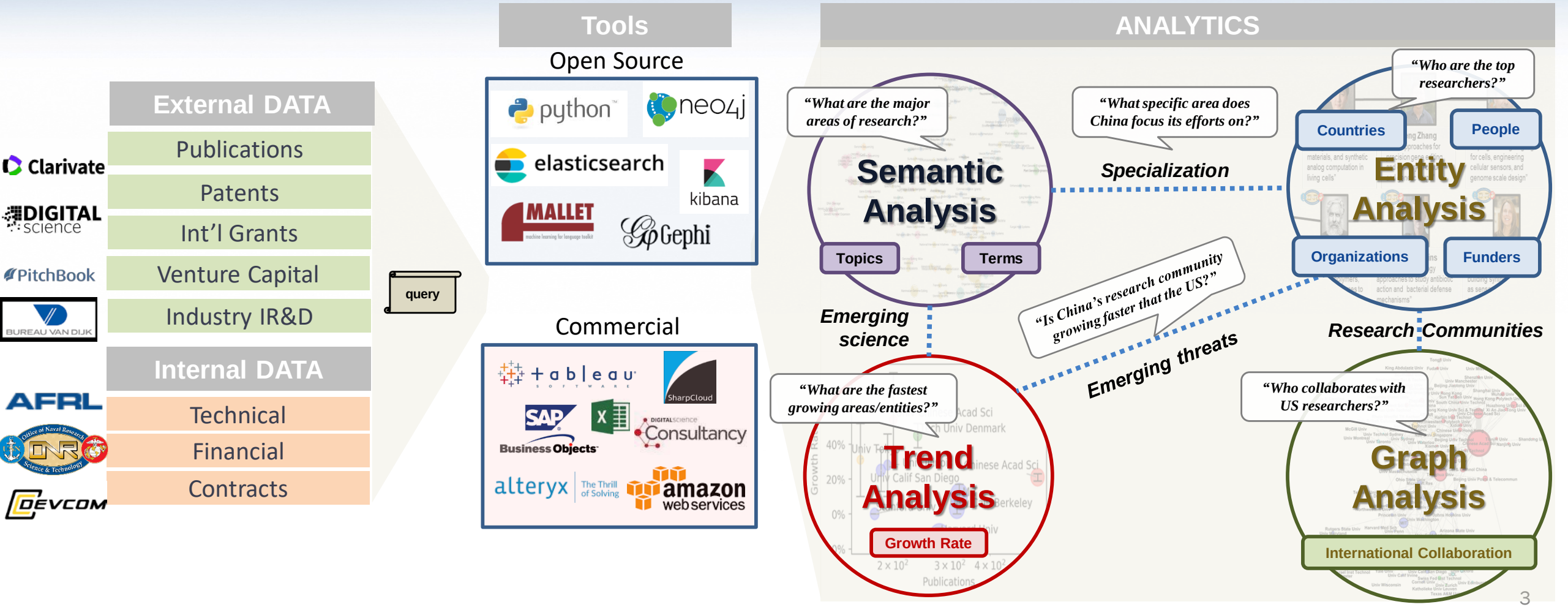
Support strategic, operational and tactical R&D decision making across the Navy with in-depth analysis of the Naval Research & Development Enterprise (NRDE) portfolio to enhance mission effectiveness for U.S. Naval Forces.



NEMO: Exploring the Depths of Research across ONR's Portfolio

Objective: Develop in-depth analysis of the DoD S&T ecosystem across to support portfolio management

Vision:

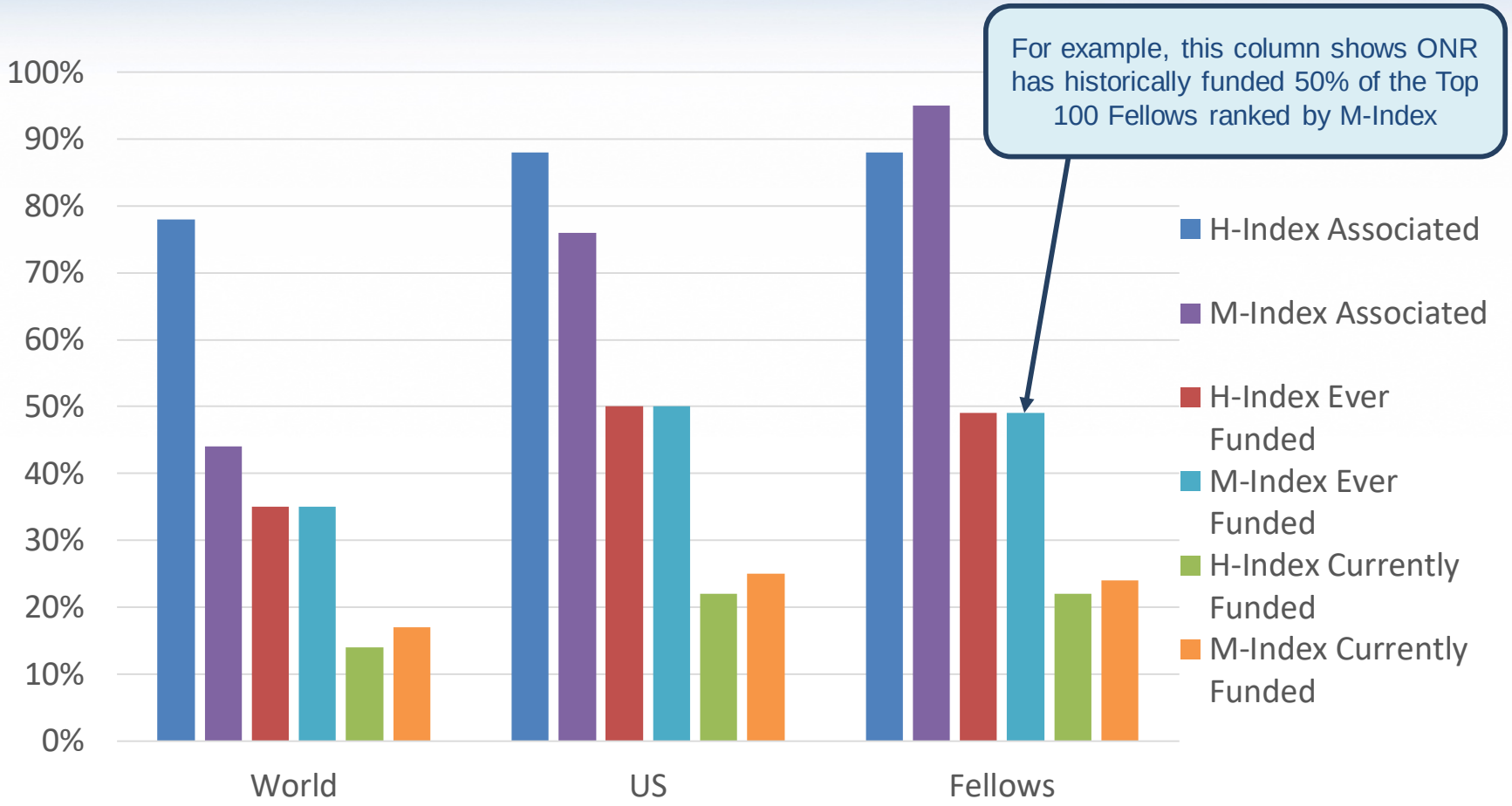


Linking Analytics to Decisions

- ***Tech Watch***
  - Supporting ONR Program Officers with identifying threats and opportunities to their portfolios
- ***ONR Red Cell Assessments (ORCA) to help shape the portfolio (6 weeks)***
  - Compare threat topics of interest with S&T portfolio investments to consider opportunities for rebalancing the portfolio.
- ***Horizon Scan to avoid tech surprise (annual)***
  - Detect early signs of potentially important developments through a systematic examination of potential threats and opportunities, with emphasis on new technology and its effects on an issue of consideration
- ***Misc. Portfolio Analytics Examples***
  - ***Task Force Ocean Support*** – Evaluate the impact of ONR's portfolio on Ocean Science over the past 30 years to support shaping investments
  - ***Gender Diversity in ONR's Portfolio*** – Baselining STEM workforce to support policy interventions
  - ***ONR's access to Top 100 Material Scientists*** – Evaluate if ONR is challenging the best and brightest scientists with Naval problems.

ONR and Top 100 Material Scientists Overlap

Reference Point Matters when Defining "Top 100"



KEY TAKE-AWAYS

- **H-Index and M-Index have only 12% researcher overlap**
- For verified ONR investment (i.e. "Ever Funded" or "Currently Funded"), **ONR invests nearly equally in both M-Index and H-Index Top 100**
- **ONR has a preference towards US-based researchers**
- H-index is an indicator of lifetime achievement, while M-index may be an indicator for rising stars

- **Associated = Co-author on publication acknowledging ONR funding**
- **Ever Funded = Program Officer feedback on historic funding**
- **Currently Funded = Validated through ONR awards data (2017-present) and Program Officer feedback**

Tech Watch Scoping

- **What's the topic?**

- Keywords or phrases that you'd use to search
- Canonical or exemplary papers
- Known individuals
- Specific grants made in the past
- Existing program description
  - ex. Public webpage, BAA text, etc.

- Boundaries / Scope Limiters
  - Good for discussion, often better handled via analysis rather than query/scope limitations

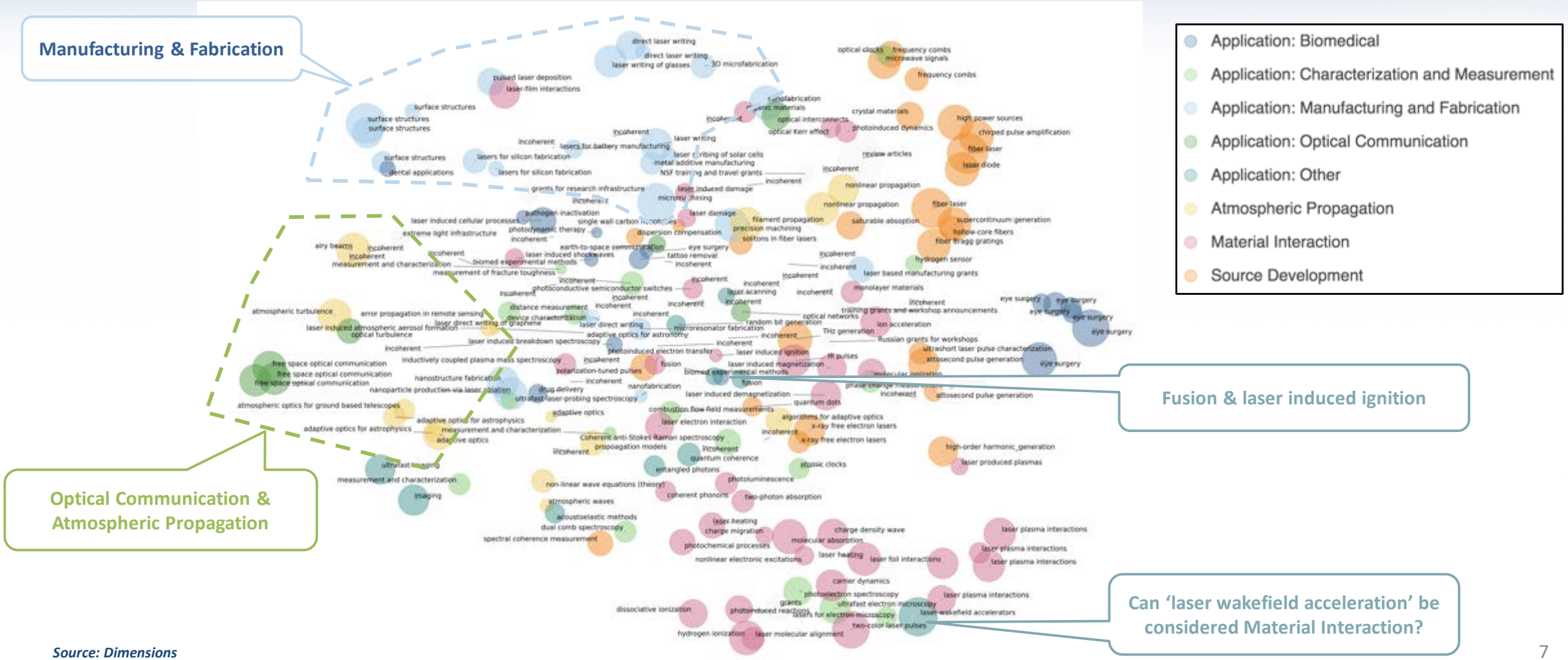
- **Why now?**

- Considering a new research program in this area
- Developing a new MURI topic
- Participating in a DOD/USG working group
- Assessment of transition to a higher TRL
  - ex. 6.3 -> 6.4
  - What footprints are we leaving?
- Focus coordination with ONR-Global
- Explore the domestic / international industrial base
- …

Tech Watch: Ultrashort Pulse Lasers

Topic Modeling Map

Unsupervised machine learning identifies topics by statistically discovering co-occurring groups of technical terms. Human-readable labels are added to these topics and aggregated into related groups for analytic purposes.



Source: Dimensions

ultrashort pulse lasers

Who is Funding Grants?

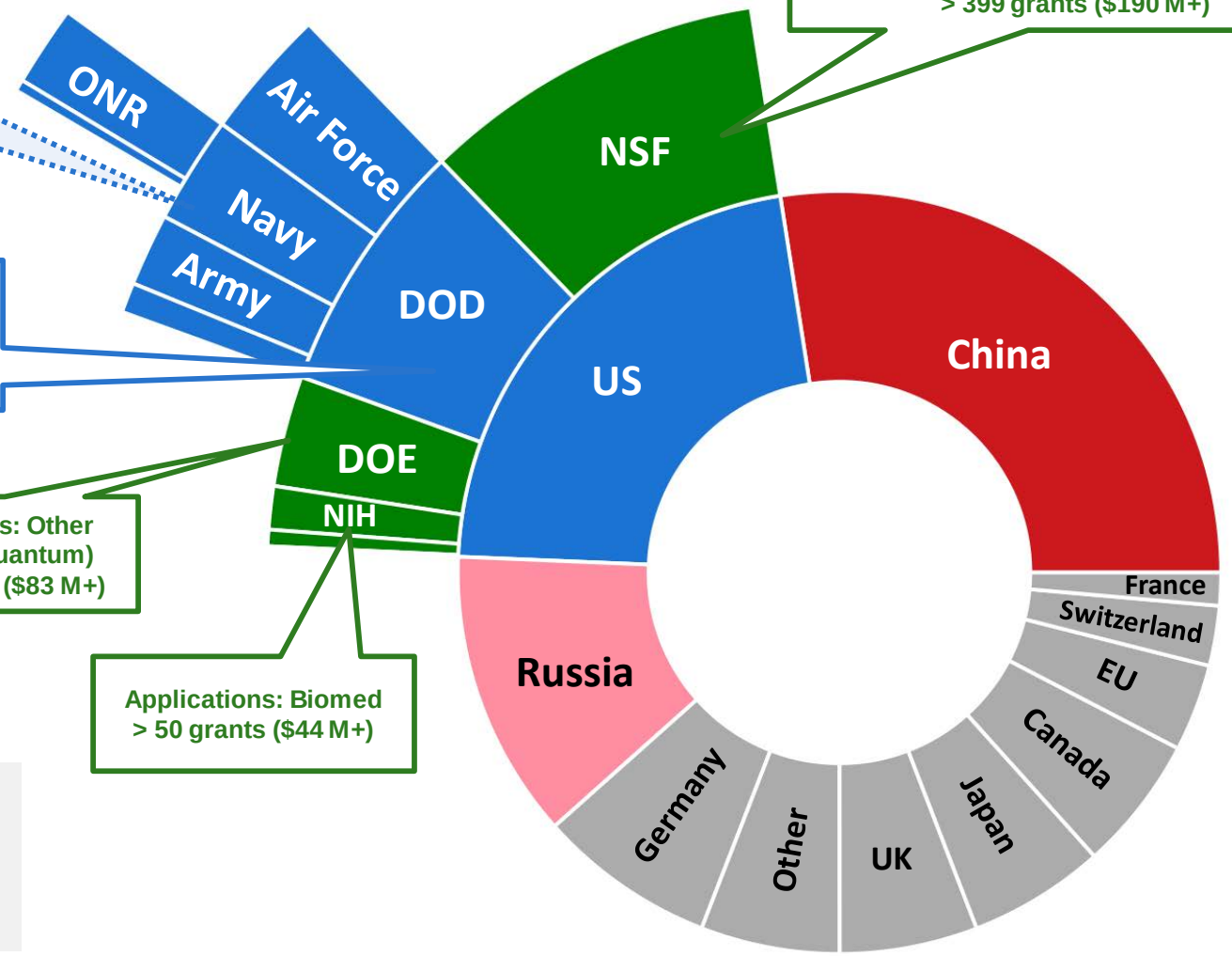
~1/3 of Navy funded awards are SBIR

Material Interaction, Atmospheric Prop Adjacent Grants (workshops, training, etc) > 399 grants ($190 M+)

Material Interaction, Optical Communication & Atmospheric Prop. > 269 grants ($168 M +)

Applications: Other (fusion & quantum) > 127 grants ($83 M+)

Applications: Biomed > 50 grants ($44 M+)



Source: Dimensions for Funders, Digital Science (Grants, Start Year 2014 – 2018)
Pie slice proportional to the number of grants
Data sourced from country & funder specific public data repositories; timeliness & completeness varies by source
DOD data is from dodgrantawards.dtic.mil & sbir.gov;
ONR = N00014, ONR-Global = N62909

US Government Program Managers

Name	# of Awards (127 total awards)
Kramer Akli	27
Eric Colby	14
Thomas Settersten	11
Lane Wilson	5
Eliane Lessner	5
Lek (L.K.) Len	4
Curtis Bolton	4
Ahmet Refik Kortan	4
Missing	16
Other 27 PMs with < 3 awards	30

Name	# of Awards (50 total awards)
Randy King	5
Paul Sammak	4
Edmund Talley	4
Ward Smith	3
Thomas Greenwell	3
Paula Flicker	2
Jerome Wujek	2
Francesca Bosetti	2
Alena Horska	2
Other 23 PMs with 1 awards	23

Name	# of Awards (399 total awards)
Vyacheslav Lukin	33
John Gillaspy	33
Colby Foss	28
Dominique Dagenais	19
Peter Kurczynski	16
Lin He	14
Victor Roytburd	12
Khershed Cooper	12
Robert Opila	11
Germano Iannacchione	10
Other 90 PMs with < 10 awards	211

Source: Dimensions for Funders, Digital Science (Grants, Start Year 2014 – 2018)
Names as reported in public sources:
- *nsf.gov/awardsearch*
- *projectreporter.nih.gov*
- *pampublic.science.energy.gov*

ORCA

BLUF: ONR conducts a quarterly, classified, internal forum called the ONR Red Cell Assessment (ORCA) to compare threat topics of interest with S&T portfolio investments to consider opportunities for rebalancing the portfolio.

FORMAT: Chaired by Portfolio Director with review of (1) open source technology landscape analysis by the D&A team, (2) global opportunity assessment by ONR-G, (3) Red Assessment by IC partner, (4) NRE investment review by ONR, NRL and PMR-51, and (5) comments from other (invited) DoD stakeholders.

Completed Topics	Future Topics Under Consideration
Swarming, FY18-Q3	Navigation Warfare
Hypersonics, FY18-Q4	Information Operations (PSYOPS)
Quantum, FY19-Q1	Environmental DNA for Warfighting Advantage
Long Range Kill Chain, FY19-Q1	Novel Energetic Materials
Brain-Inspired Computing, FY19-Q2	**Logistics for Distributed Maritime Operations**
Synthetic Biology, FY19-Q3	Stealth & Camouflage for People & Platforms
AI for Maritime Decision Aids FY20-Q2	Non-Lethal Directed Energy Weapons
	- as of September 2020

Hypersonics ORCA

Key Findings:

- There are significant difficulties in transitioning programs from 6.1 to 6.2 to 6.3 to POR
- US workforce and infrastructure are aging and insufficient
- China is aggressively investing in basic science with growth of publications growing exponentially while the US remains steadily flat over the past 10 years. This is giving China a younger workforce with newer facilities.
- China is publishing heavily in controls, an area where US is not currently investing in either ONR's or AFOSR's portfolio.

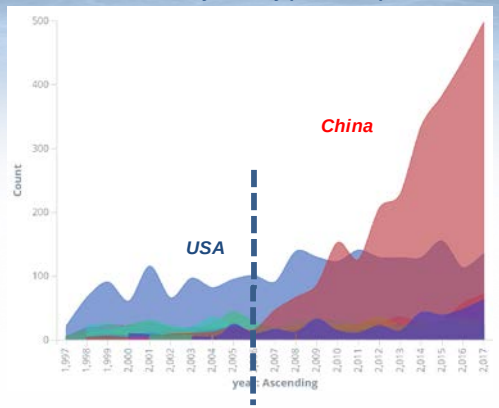
Actions:

- ONR to identify Naval unique needs and long-range S&T plan for hypersonics– led to INP
- DoD to invest in controls – Congressional language pending
- Need to invest in newer workforce and infrastructure – UARC Congressional language pending

Participants:

- ONR, ONRG, NRL, PMR-51, N94, PMA-201, OSD, DARPA, AFOSR, NASIC

Trend by country (1997-2017)



China is only country focusing on control systems for hypersonic vehicles

2006: China announces hypersonics effort in 15-year S&T Plan

Primary Research Portfolio Focus*	Countries	Papers	Cites	Clicks**	Cites/ Paper	Clicks/ Paper
Controls	China	2,803	16,730	7,529	6.0	2.7
Aerothermodynamics	USA	1,393	13,556	2,106	9.7	1.5
Aerothermodynamics	Russia	365	1,338	361	3.7	1.0
Aerothermodynamics	India	345	1,300	482	3.8	1.4
Materials	Germany	287	2,301	381	8.0	1.3
Materials	Italy	269	2,748	539	10.2	2.0
Materials	U.K.	222	2,929	548	13.2	2.5
Propulsion	Australia	221	1,509	404	6.8	1.8
Propulsion	Japan	210	1,178	288	5.6	1.4
Materials	France	195	1,712	297	8.8	1.5

On average, USA papers tend to be cited more than China

However, China papers tend to be accessed/read more than USA papers

Conversely, no one seems to be paying attention to Russia, despite producing the 3rd largest amount of papers

Papers from U.K. have the highest citation efficiency and a very high usage rate

** Focus does not necessarily mean that country produces the most work in that area, but rather it has more research in their portfolio relative to other areas (and the rest of world)*
*** Every time a Web of Science user clicks on an article to read it, it is recorded and remembered. This is the sum of all of the clicks in the last 6 months of all of the papers published by a country.*

Quantum ORCA

Key Findings:

- Quantum computing, sensing and communication are three distinct research communities
- Quantum computing has a strong commercial presence and Chinese research institutions are working closely with the international community
- Quantum sensing is led by US w/ Chinese research institutions more isolated from global community.
  - ONR is a significant contributor to this area
- Quantum communication is led by Chinese

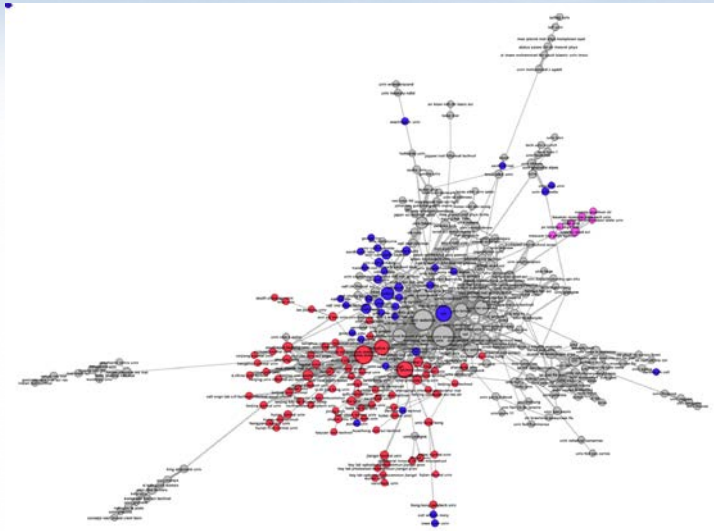
Actions:

- NRL to develop quantum computing strategy
- ONR to develop strategy for basic research – Hired new PO in Sep

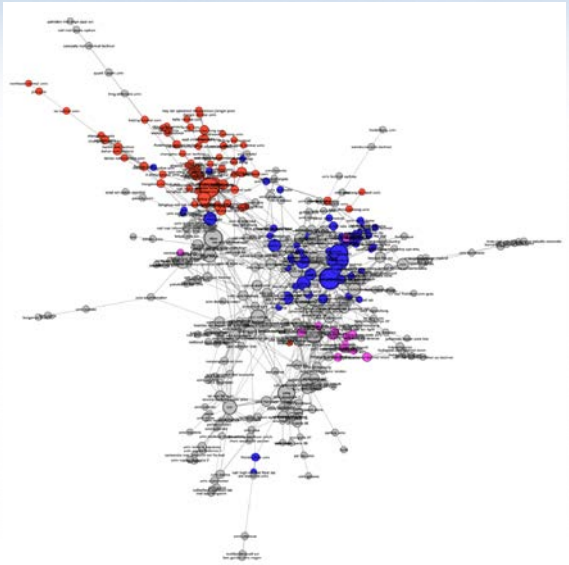
Participants:

- ONR, ONRG, NRL, PMR-51, N94, ONI, LPS, CIA

Quantum Computing

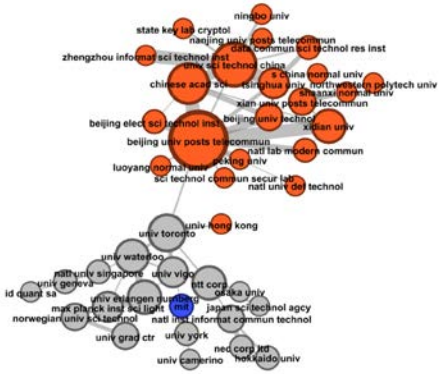


Quantum Sensing



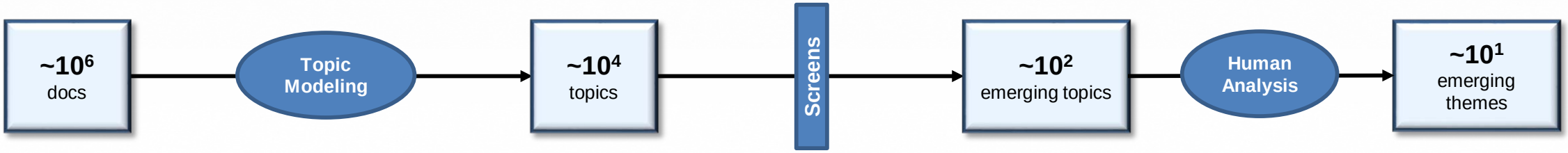
Institution co-authorship networks
Blue=USA, Red=China, Pink=Russia

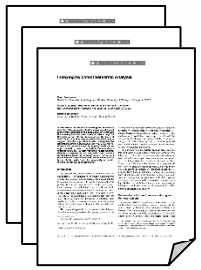
Quantum Communications



Horizon Scanning Methodology

Identifying top emerging technology areas in the scientific literature using bibliometric scanning

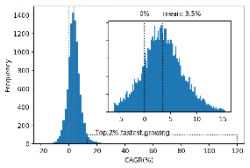




Scientific Publications, Patents & Grant Awards
- 2014-2018
- titles, abstracts

Probabilistic Model using NLP/ML
- Curated vocabulary
- Latent Dirichlet Allocation (LDA)
- ~3-day computation

Topic Map
- Visualization of topic model using MDS UMAP



Screens
- Growth Rate (CAGR) via Nonlinear Regression
- Location Quotient (LQ)

Statistical Summary

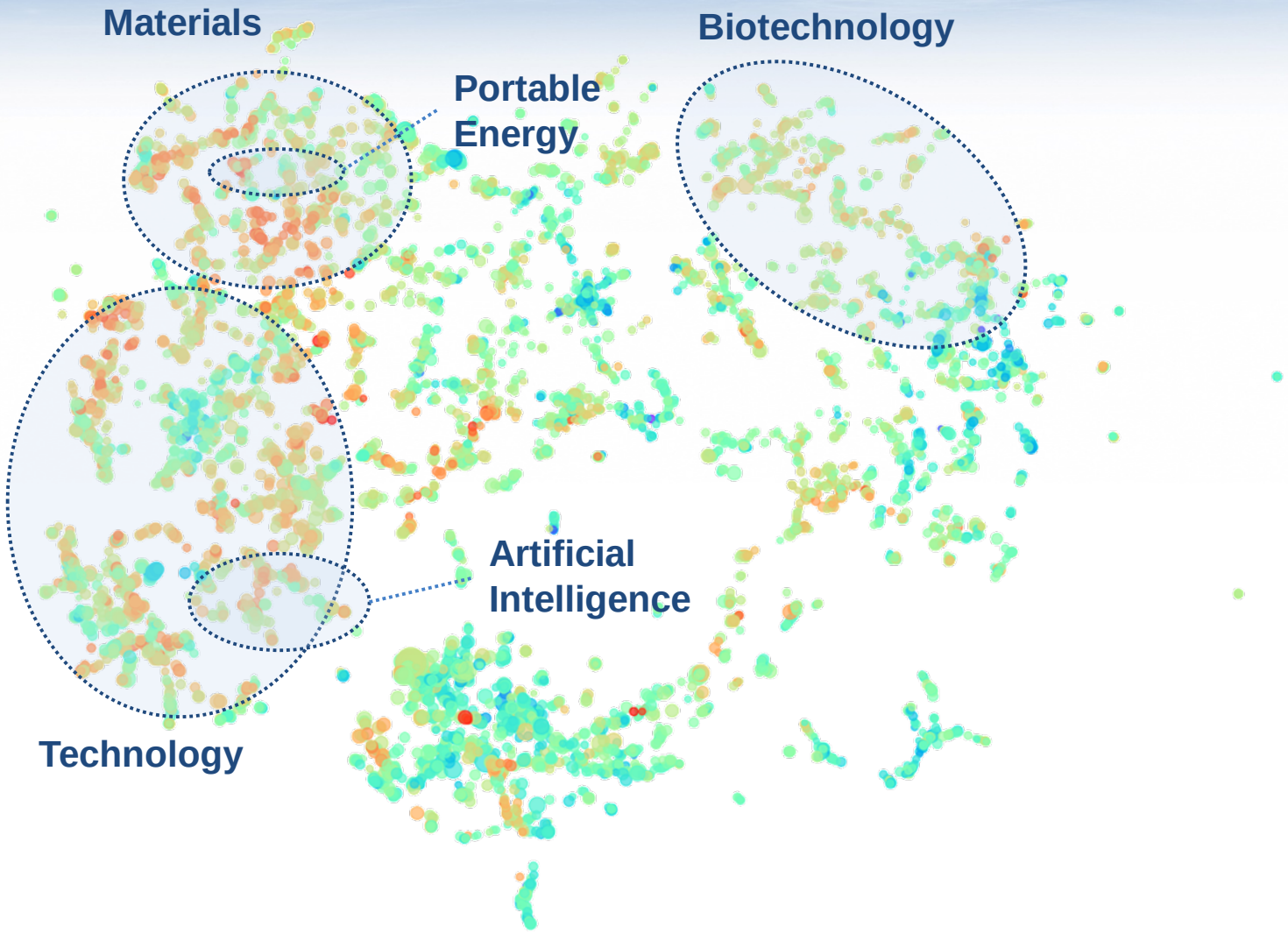
Human-in-Loop Interpretation
- Topic labeling
- Interviews with SME's
- Aggregation of similar areas
- Elimination of junk topics

Analysis, Reporting, etc
- Further subdivides tech areas into specific technology innovations

DoD Relevant Areas by Growth Rate

“Hot spots” in topic map reflect DoD focus

- Not concentrated in a specific area, but distributed across multiple disciplines
- Clustered in interrelated, sometimes overlapping areas
- Not all disciplines are interesting (Navy-relevant etc.)
- Long-range synergies can be inferred



Broad DoD-Relevant Emerging Topic Categories

Technology

- Internet of Things
- Cloud Computing
- Mobile Computing
- Wearable Devices
- Smart Assistant
- Virtual/Augmented Reality
- Social Media
- MIMO Antenna
- Blockchain
- Flexible Sensors
- Smart Infrastructure
- Smart Sensors
- Cybersecurity

Materials

- 2D Materials
- Molybdenum Sulfide Monolayers
- Metal-Organic Frameworks
- Photothermal Therapy
- Graphene Nanoplatelets
- Nitrogen Doped Carbon
- Graphene
- Topological Insulators
- Phase Change Material
- Hydrogel
- Steel Microstructure
- Microplastics

Portable Energy

- Perovskite Solar Cells
- Supercapacitors
- Lithium-based Batteries
- Battery Electrodes
- Wireless Power Transfer
- Photocatalysts
- Oxygen Reduction
- Hydrogen Evolution
- Photocatalytic Water Splitting
- Electrochemical Electrodes
- Titanium Dioxide Photocatalysts

Artificial Intelligence

- Deep Learning
- Neural Networks
- Extreme Learning Machines
- Support Vector Machines
- Reinforcement Learning
- Decision Trees
- Image Classification
- Hyperspectral Image Classification
- Image Recognition
- Image Segmentation
- Drones
- Unmanned Aerial Vehicles
- Autonomous Vehicles

Biotechnology

- MicroRNA
- Long Noncoding RNA
- CRISPR/Cas9
- Exosome
- Gene Expression
- Noncoding RNA
- Cell Free DNA
- Gene Expression
- Microbiome
- Gut Microbiome
- Microbial Community
- Bacterial Community

Other Topics (less DoD Relevance)

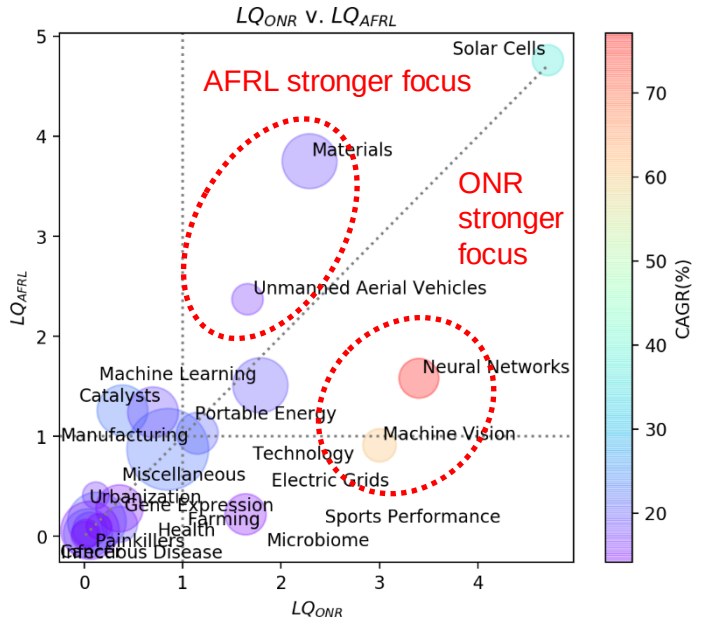
- Electric Grids
- Infectious Disease
- Urbanization
- Health
- Sports Performance
- Painkillers
- Farming

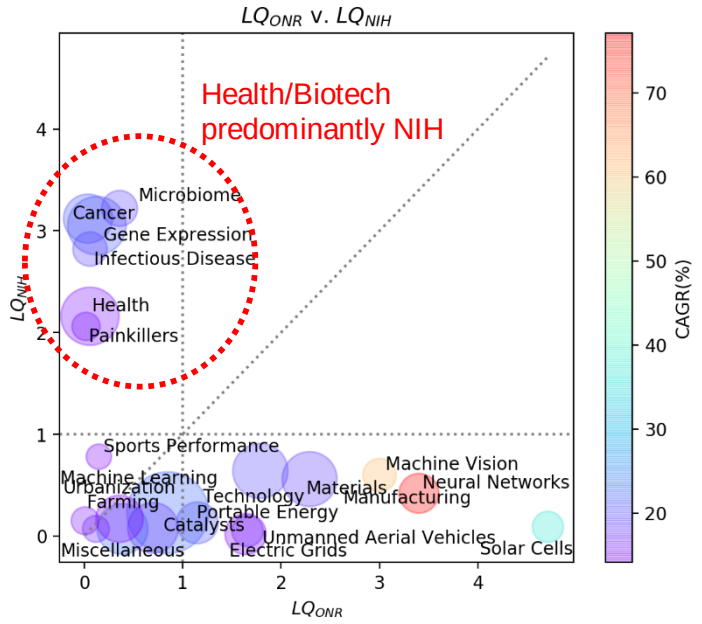
** (strong patent focus)*

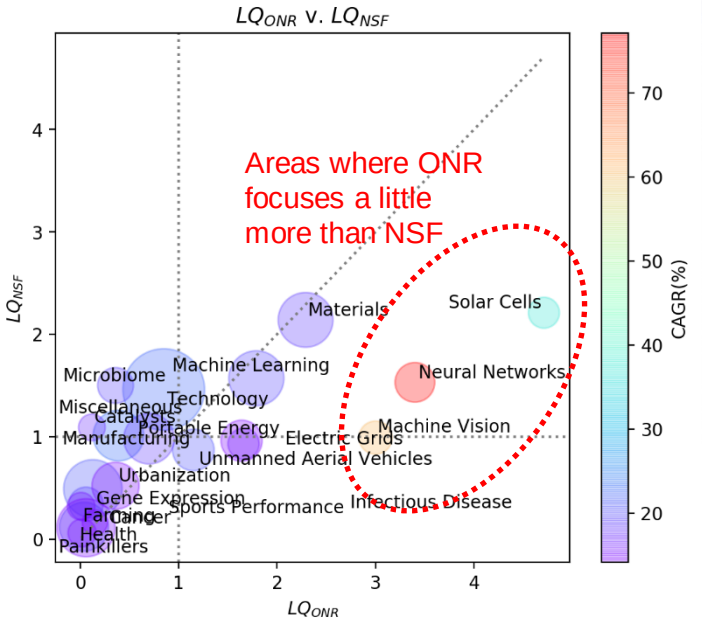
Comparison of ONR and Peers

How does ONR's research portfolio overlap with other US Funding agencies?

LQ vs. LQ: Correlated Research in diagonal (I,III) uncorrelated research areas in off-diagonal (II,IV)







ONR and AFRL are well correlated

ONR and NIH are poorly correlated

ONR and NSF are more closely correlated than ONR and NIH

ONR consistently more preferentially represented in the top emerging areas (Neural Networks, Machine Vision, Perovskite Solar Cells)

Location Quotient:
>1 *= Stronger focus than everyone else*
0 *= Same focus as everyone else*
<1 *= Weaker focus than everyone else*