Mission-driven Technology Transfer:
Perspectives from MIT Lincoln Laboratory

Lou Bellaire, Deputy Technology Ventures Officer
r.louis.bellaire@ll.mit.edu

12 January 2022

This material is based upon work supported by the United States Air Force under Air Force Contract No. FA8702-15-D-0001. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the United States Air Force.

Who We Are – A Little History

- **MIT Radiation Laboratory: October 1940 – December 1945**

Mission: ***Development of radar systems and technology***

Main projects: Surveillance radar
Fire control radar
Navigation systems

4000 employees
Designed half of all US WWII radars

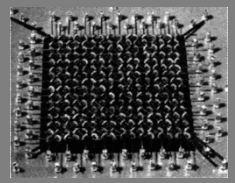
- **MIT Lincoln Laboratory in the 1950s**

Established 1951: ***Air defense and technology development***

Main projects: Semi-Automatic Ground Environment (SAGE)
- Spun-off Mitre in 1958 to operate SAGE

Major Innovations:

Real-Time Computing



Magnetic-core Memory

Light-pen CRT Interface

MIT Lincoln Laboratory Today

DoD Federally Funded Research and Development Center

Technology in Support of National Security

- Forward-looking national security architectures
- Long-term technology development
- Unique pathfinder prototypes
- Agile technology transfer

MIT LL
South Laboratory,
Lexington, MA

Mission: Technology in Support of National Security

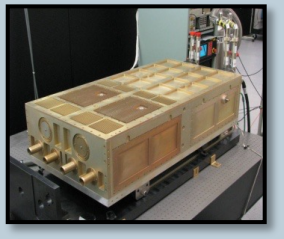
MIT Lincoln Laboratory Division Structure

Mission-specific technology focus

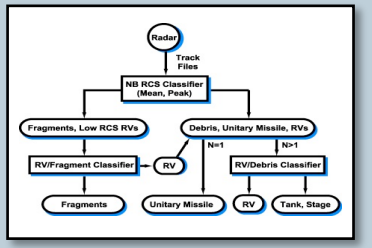
Broad-application technology focus

- Air, Missile and Maritime Defense Technology
- Homeland Protection
- Air Traffic Control
- Communication Systems
- Space Systems and Technology
- ISR Systems & Technology
- Tactical Systems
- Advanced Technology
- Cyber Security
- Engineering
- Biotechnology and Human Systems

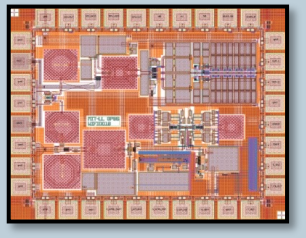
Enabling Technologies



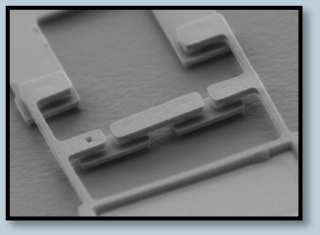
Cryogenic Yb:YAG Lasers



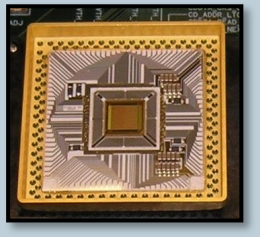
Decision Architectures



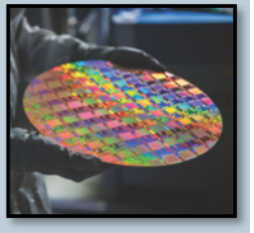
Miniature Low-Power Transceivers



Quantum Bits



Avalanche Photo Diode Arrays

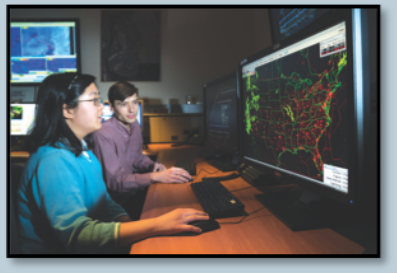


Advanced Focal Planes

Operational Prototypes

*MPAR (ATD)**

Haystack Ultra-Wideband



Aviation Weather Systems

Lunar Laser Comm Ground Station

Space Surveillance Telescope

*MPAR (ATD): Multifunction Phased Array Radar, Advanced Technology Demonstrator

Outline

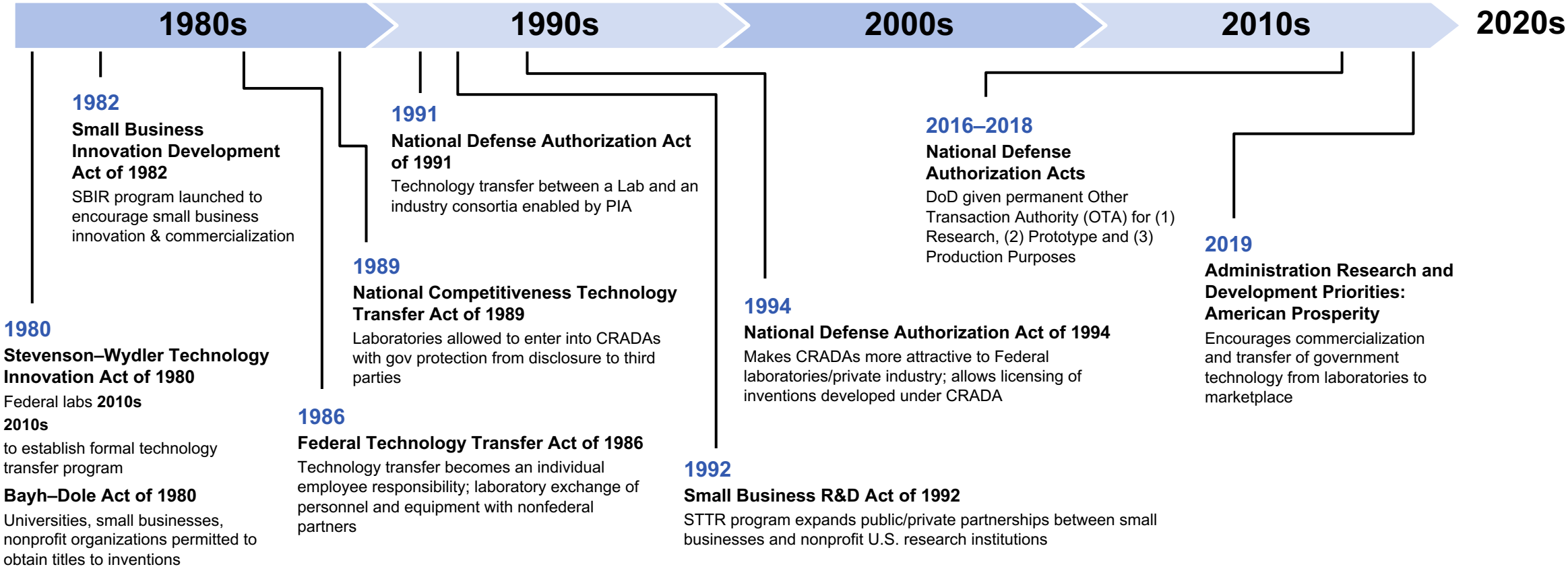
- Overview
- National Benefits of Technology Transfer
- Technology Transfer at MIT LL
- MIT LL Technology Ventures Office
- Summary

Why Transfer Technology?

- **Ensures the long-term competitive position of the United States**
  - **Unique and effective military capability**
  - **U.S. competitive economic advantage**
  - **Tools and capabilities that promote social well-being**
- **Recognizing these advantages:**
  - ***Congress* has established a system to facilitate the transfer of technology to the private sector and to state and local governments**
  - ***Presidential Administrations* have consistently implemented programs encouraging dual-use technologies be leveraged for civil applications**

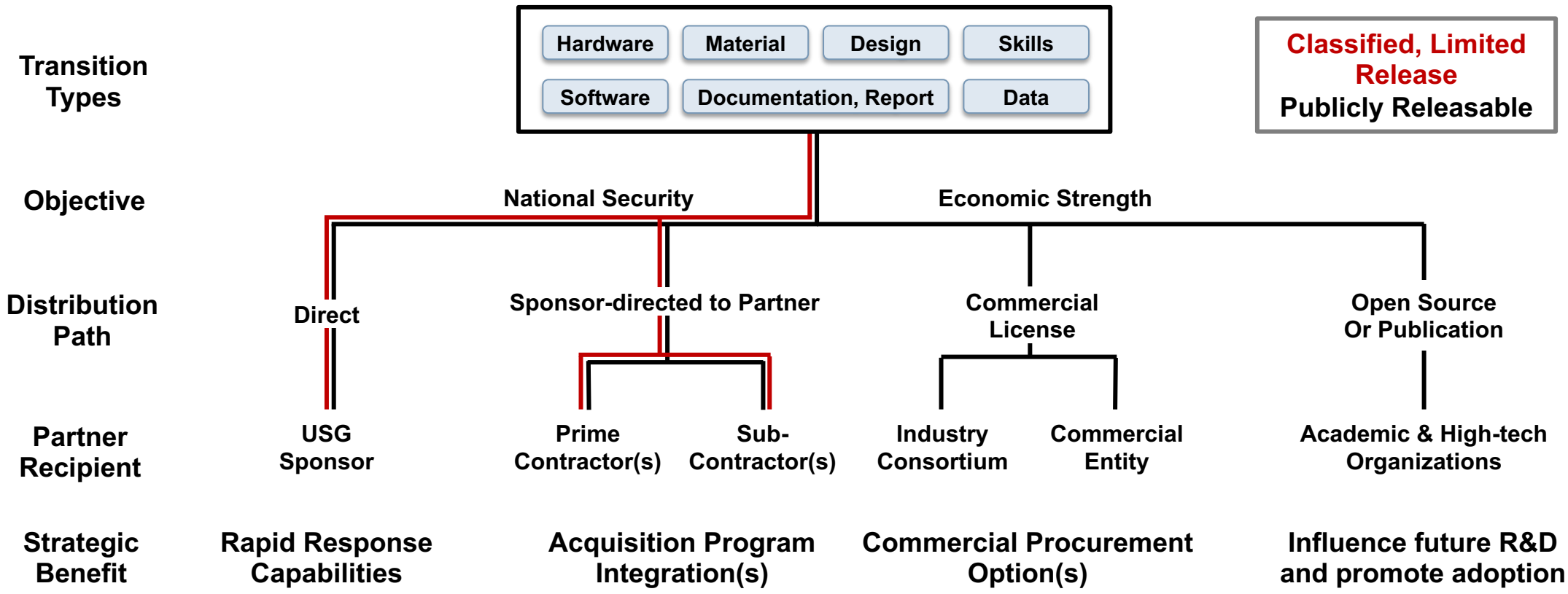
Fundamental to MIT LL's mission as a DoD FFRDC

Technology Transfer Legislative Authority



Since 1980, Congress has passed numerous pieces of legislation allowing FFRDCs to adapt their technology transfer strategies to maximize impact

Spectrum of Technology Transfer Benefits



Tech transfer delivers direct benefits to the sponsoring agency's mission while also advancing broader U.S. economic development objectives

Outline

- Overview
- National Benefits of Technology Transfer
- Technology Transfer at MIT LL
  - Transiting Exoplanet Survey Satellite (TESS)
  - Airborne Ladar for Disaster Response
- MIT LL Technology Ventures Office
- Summary

70 Years of Impact for the Nation

1950–1960s

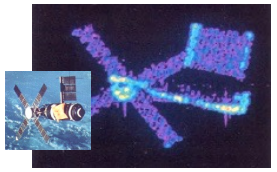
First Continental Air Defense System

Protected US from Soviet nuclear attack for 20 years

First Television Picture Transmission via Satellite

Used NASA'S Echo I Satellite

First RADAR-based Satellite Imaging



ALCOR radar located at Kwajalein

First Transmission of Packetized Speech

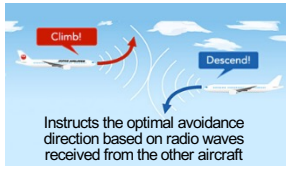
Forerunner of voice over internet protocol (VoIP)

1970–1980s

Air Defense of the National Capital Region

Rapid deployment post 9/11

Airborne Collision Avoidance System

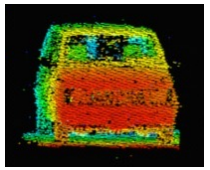


Installed on all planes with >19 passenger seats

First Prototypes for All Military Comm. Satellites

DSCS, MILSTAR, WGS, AEHF, MUOS

3-D Laser Imaging



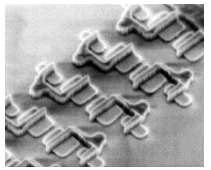
Permits airborne 3D imaging through trees

1990–2000s

First Laser Communications from Lunar Orbit

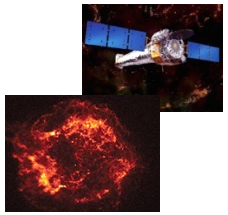
622 Mbps downlink for 30 days with zero bit errors

193nm Optical Lithography



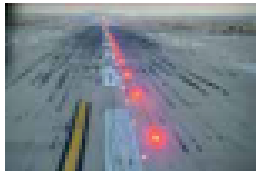
Leap ahead in integrated circuit technology

NASA Chandra X-Ray Observatory



Advanced CCD imaging spectrometer

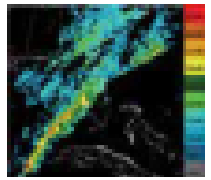
Runway Status Lights (RWSL)



Improvement of runway safety

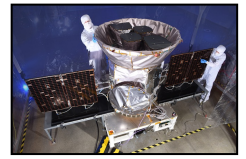
2010–Present

Offshore Precipitation Capability



Provides accurate and timely radar-like depictions of offshore and oceanic storms

Transiting Exoplanet Survey Satellite (TESS)



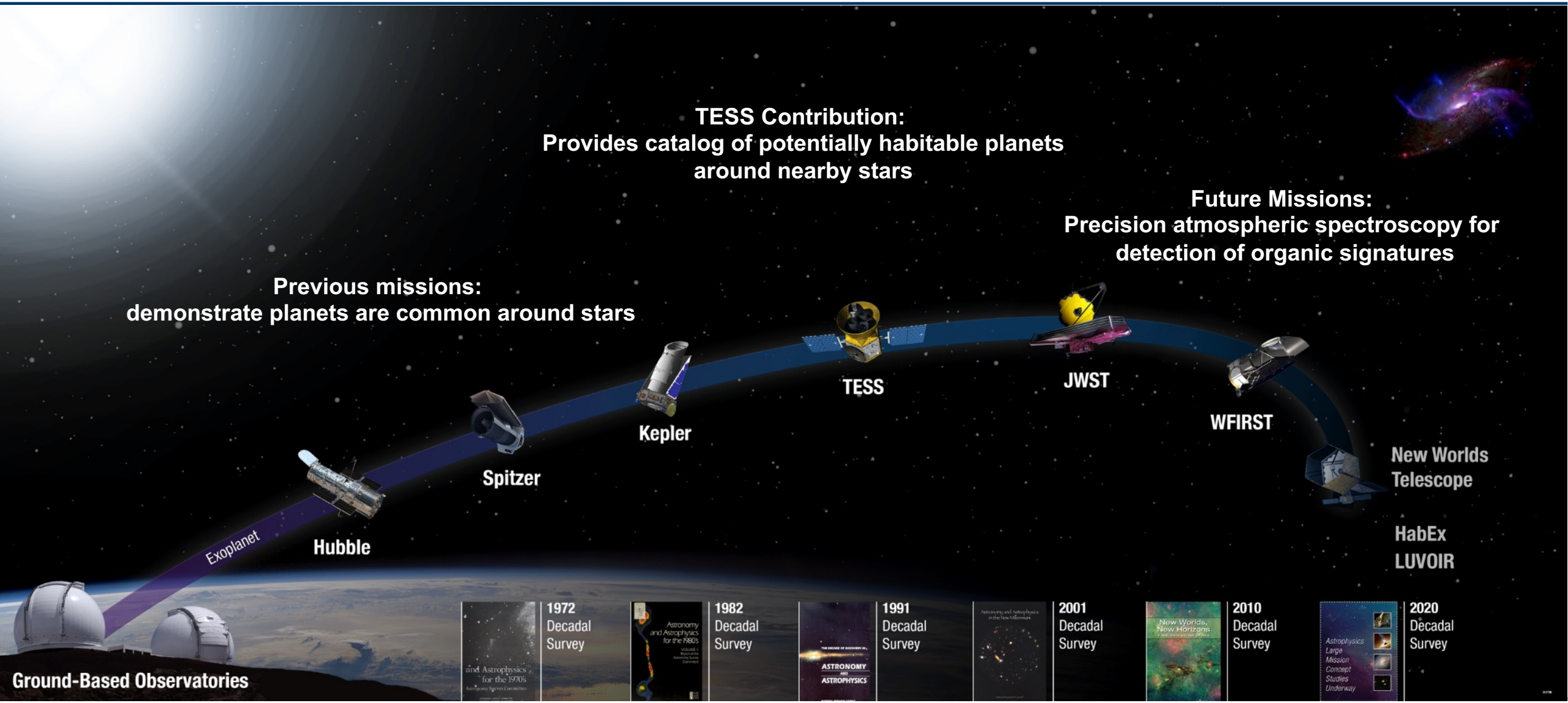
All-sky surveillance for the discovery of exoplanets

PACT(Private Automated Contact Tracing)

Augmenting contact tracing strategies to help slow COVID-19 pandemic

https://timeline.ll.mit.edu/timeline/

Contributions to Scientific Discovery: Does Life Exist on Planets Outside the Solar System?



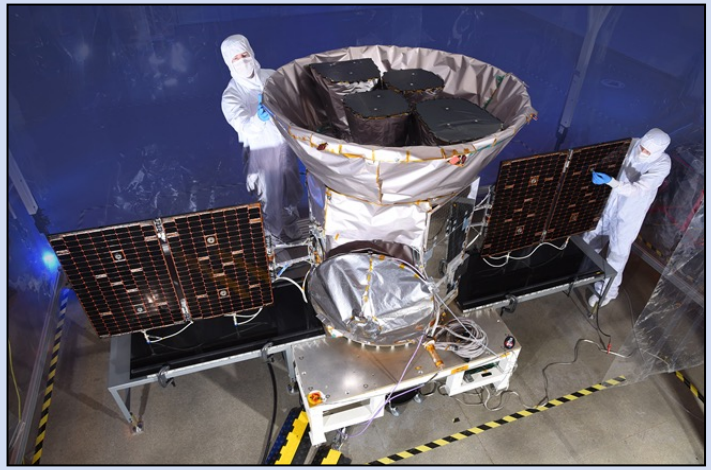
Various photos courtesy of NASA

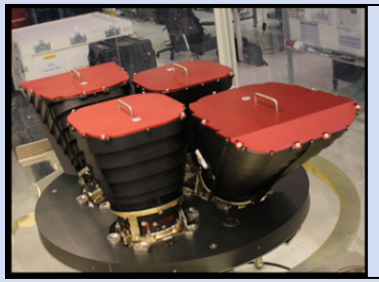
Transiting Exoplanet Survey Satellite (TESS)

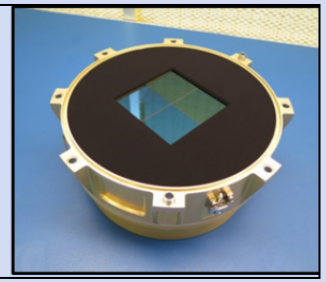
All-sky, two-year photometric exoplanet discovery mission

Sensor Payload

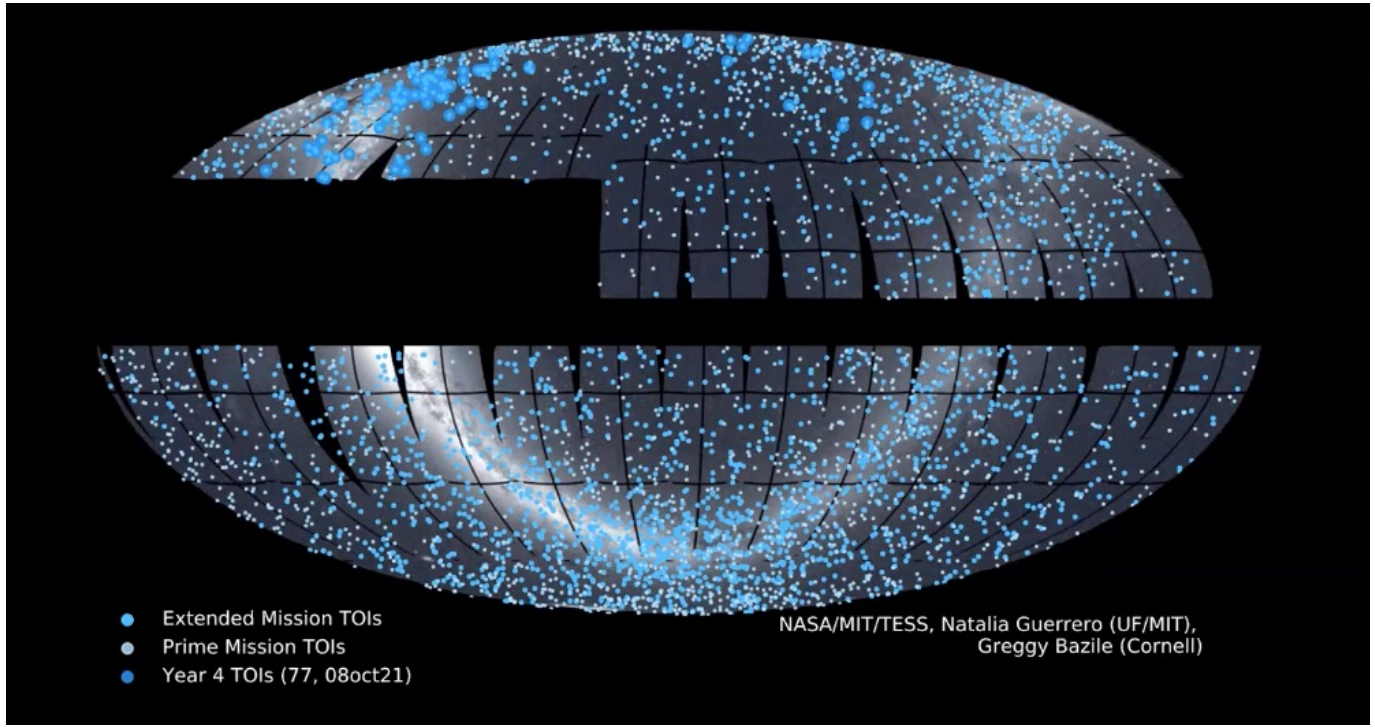
Launched 18 April 2018
Final Lunar Resonant Orbit: 30 May 2018







Exoplanets + Candidates (Fall 2021)



MKI NORTHROP GRUMMAN SPACEX MIT KAVLI INSTITUTE

Mission-driven T2- 12
RLB 12/23/21

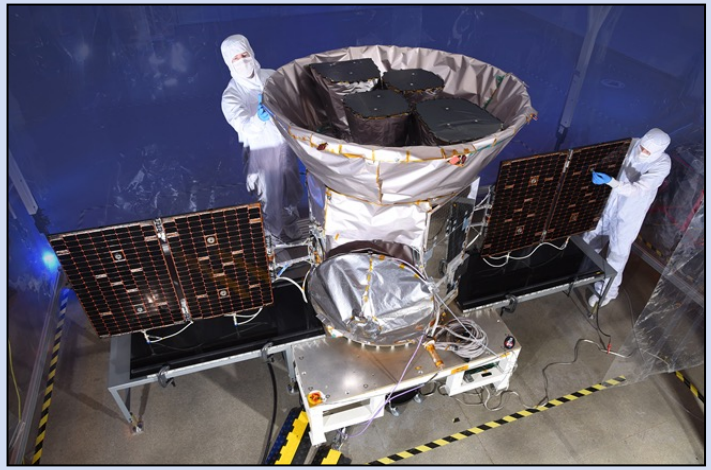
https://www.nasa.gov/tess-transiting-exoplanet-survey-satellite
https://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html

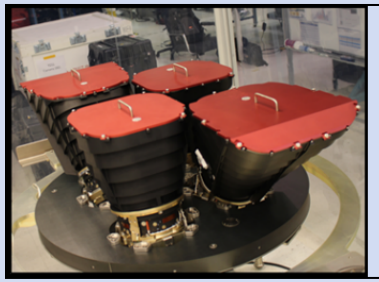
Transiting Exoplanet Survey Satellite (TESS)

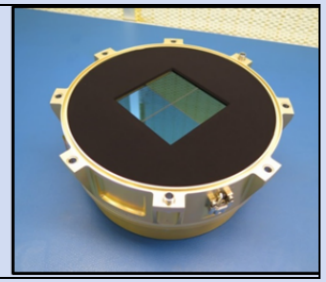
All-sky, two-year photometric exoplanet discovery mission

Sensor Payload

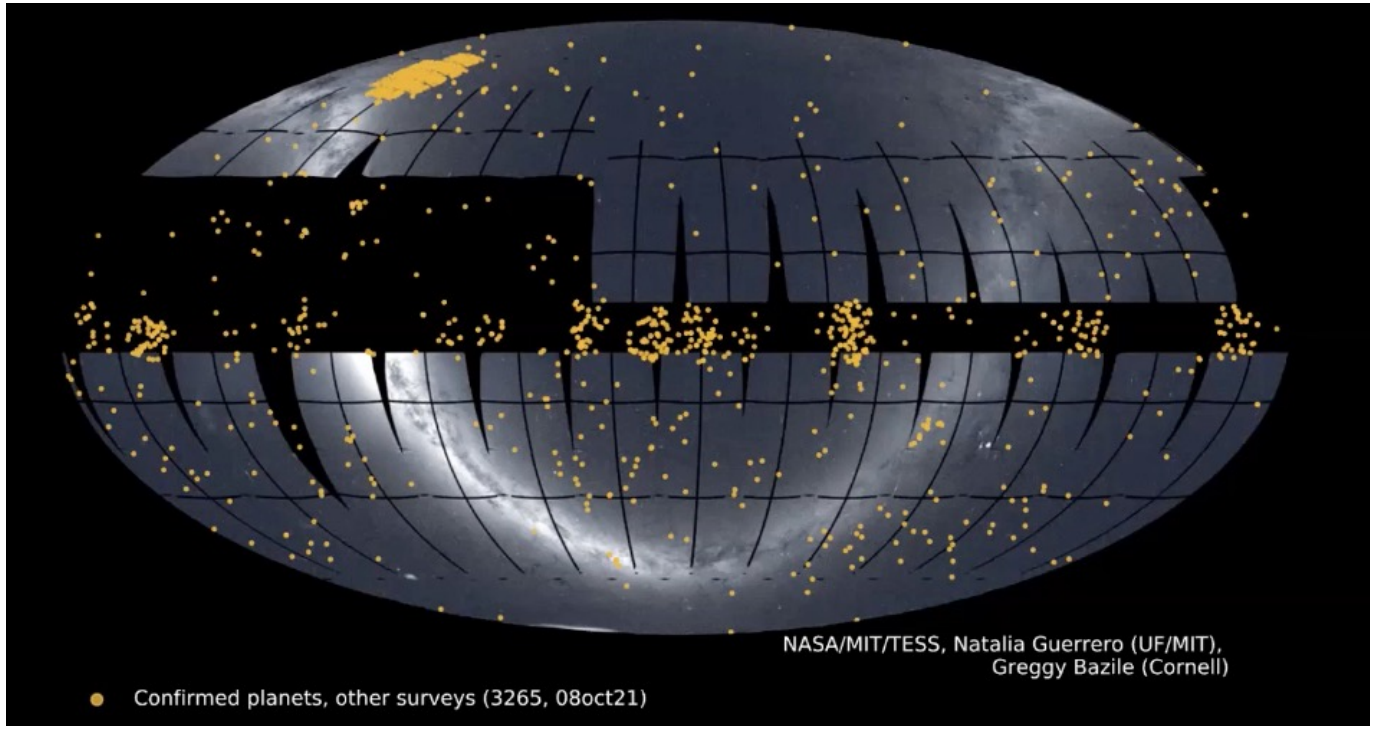
Launched 18 April 2018
Final Lunar Resonant Orbit: 30 May 2018







Coverage Prior to TESS

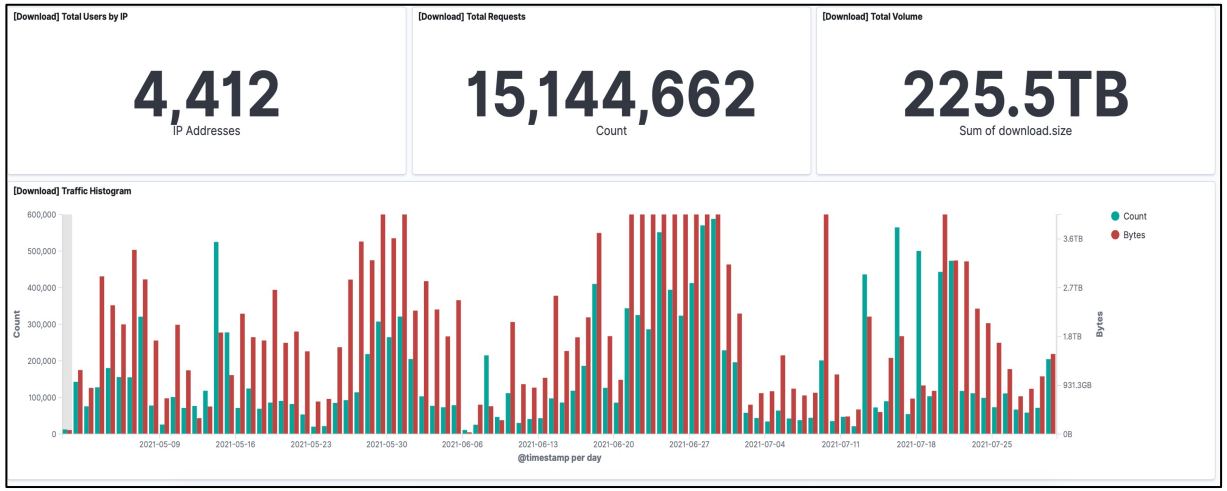


MIT KAVLI INSTITUTE

https://www.nasa.gov/tess-transiting-exoplanet-survey-satellite
https://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html

Prompt release of data multiplies TESS' science impact

TESS Download requests, May-July 2022



- 1.5 million MIT light curves requested from >1200 unique IP addresses
- Serving nearly 1 Pb TESS data per year
- Comparison to *Hubble Space Telescope* in Summer 2021:
  - 1.5x more TESS files requested
  - 2x more unique users (by IP address)

Outline

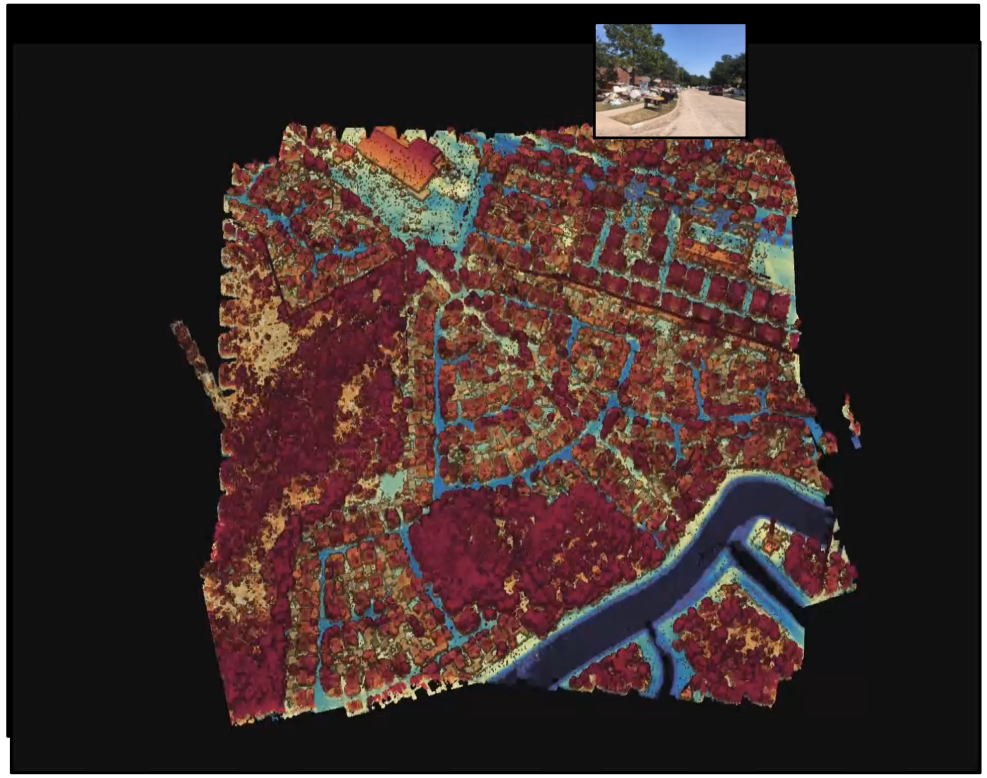
- Overview
- National Benefits of Technology Transfer
- Technology Transfer at MIT LL
  - Laying the groundwork for success
  - ⇨ Airborne Ladar for Disaster Response
- MIT LL Technology Ventures Office
- Summary

Airborne Ladar for Disaster Response

MIT LL Airborne Optical Systems Testbed

3D GM-APD laser radar on Twin Otter aircraft

Post-Harvey Debris Quantification



MIT Lincoln Laboratory rapidly deployed an advanced ladar system and analytics to support FEMA and the National Guard with Texas Hurricane Harvey recovery

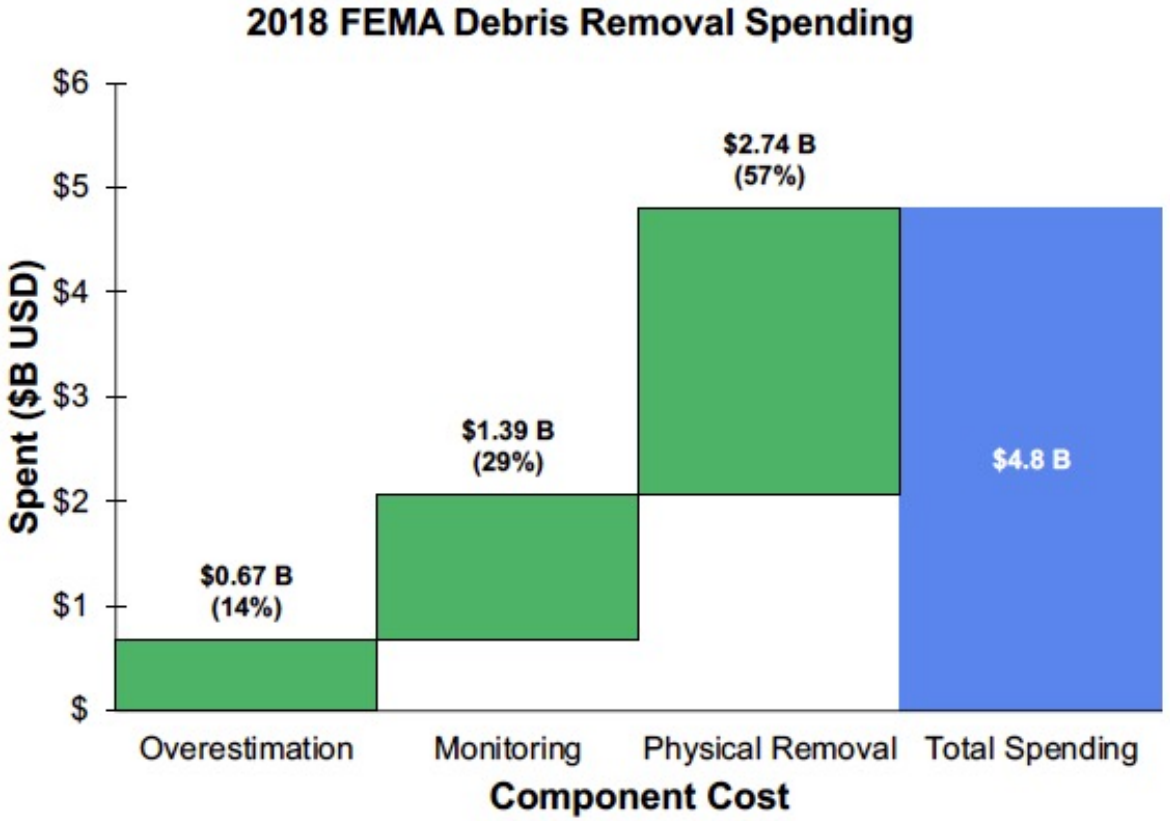
GM-APD = *Geiger Mode Avalanche Photodiode*

Economics of Debris Removal

- **Fraud is a major concern in debris removal**
  - **Contractors and monitors over-report quantities of actual debris removed**

Truck reported 95% Full

Truck reported 50% Full



FEMA = Federal Emergency Management Agency

FY21 Technology Transfer Highlights

Direct to USG Sponsor

NASA: Laser Communications Relay Demonstration (LCRD)

Essential data enabling >1.0 Gbps on space missions[2]

Allows NASA to collect more science data and to explore further

Direct to Partner(s) at Sponsors' Direction*

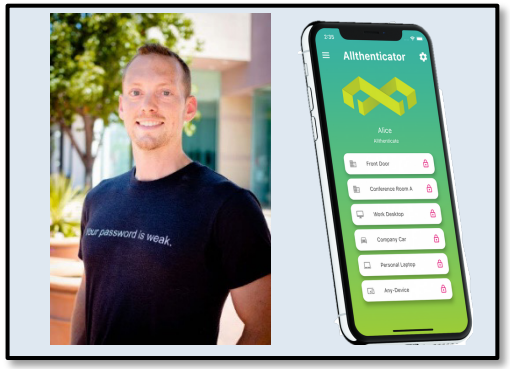
SkyWater: RadHard Electronics

Semiconductor electronics[3] hardened to withstand harsh environments

Builds industry base for critical DoD microelectronic components

Direct to Commercialization

Allthenticate[4]: VC-funded secure authentication spinout

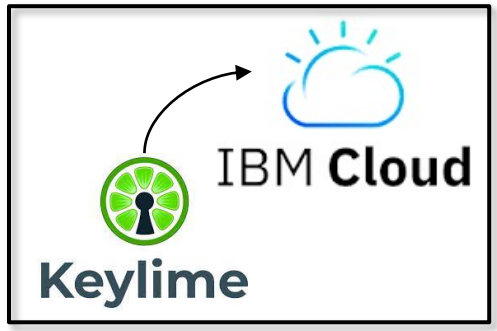


Integrated authentication, asset management, physical access control

Extends cyber-security services to commercial users

Open Source or Publication

Keylime: Linux Operating System Integration[5]



Enabling Trust in the Cloud, Edge, IoT

Enables world-wide adoption and extension of the security framework

[1] **FY21 United Launch Alliance Atlas V rocket**
[2] https://www.nasa.gov/press-release

[3] **FDSOI CMOS = Fully Depleted Silicon on Insulator Complementary Metal–Oxide–Semiconductors**

[4] Pacific Coast Business Times **Aug 2020**

[5] IBM's integration of Keylime

**** Industry, non-profit, or other non-sponsor entity***

Notable Lincoln Laboratory Spin-Offs

Outline

- Overview
- National Benefits of Technology Transfer
- Technology Transfer at MIT LL
- MIT LL Technology Ventures Office
  - Laying the groundwork for success
  - Perspectives on dual-use technology
- Summary

Technology Ventures Office (established 2018)

- **Mission:**
  - **To facilitate the rapid transfer of advanced technology into and out of MIT Lincoln Laboratory for the benefit of national security in the broadest sense**

Sponsor-directed Transition

Facilitate sponsor-directed technology transfer to partners through early engagement and transfer-process management.

Commercial Engagement

Engage with small-to-medium sized companies, especially non-traditionals, to support our R&D and create transition pipeline.

Intellectual Property

Develop a strategy for IP management appropriate for a Federal Lab and make it easy for the staff to participate

Non-traditional Missions

Leverage non-government support to expand societal impact of LL technologies

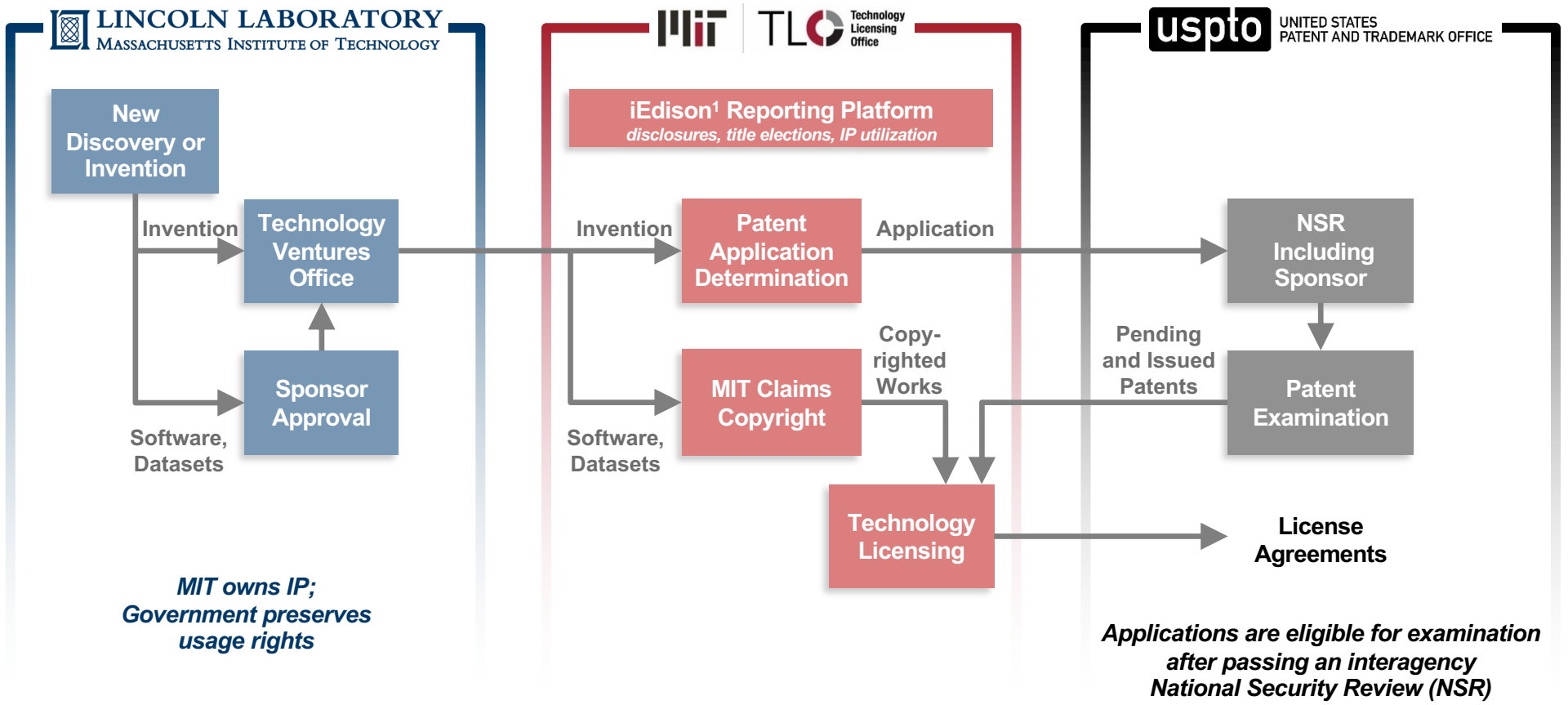
Bernadette Johnson, Chief (2018)

Lou Bellaire, Deputy (2019)

Jennifer Falciglia, Program Manager (2019)

Teresa Fazio, Ventures Officer (2020)

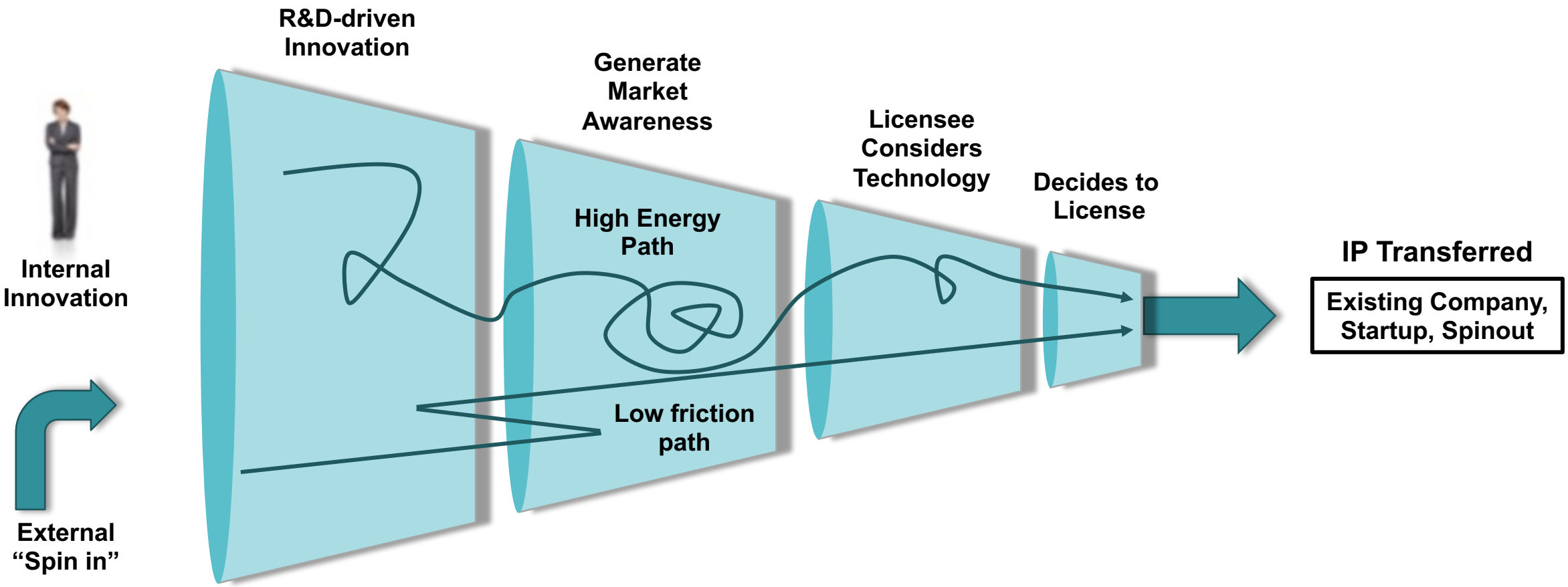
Intellectual Property Management Process



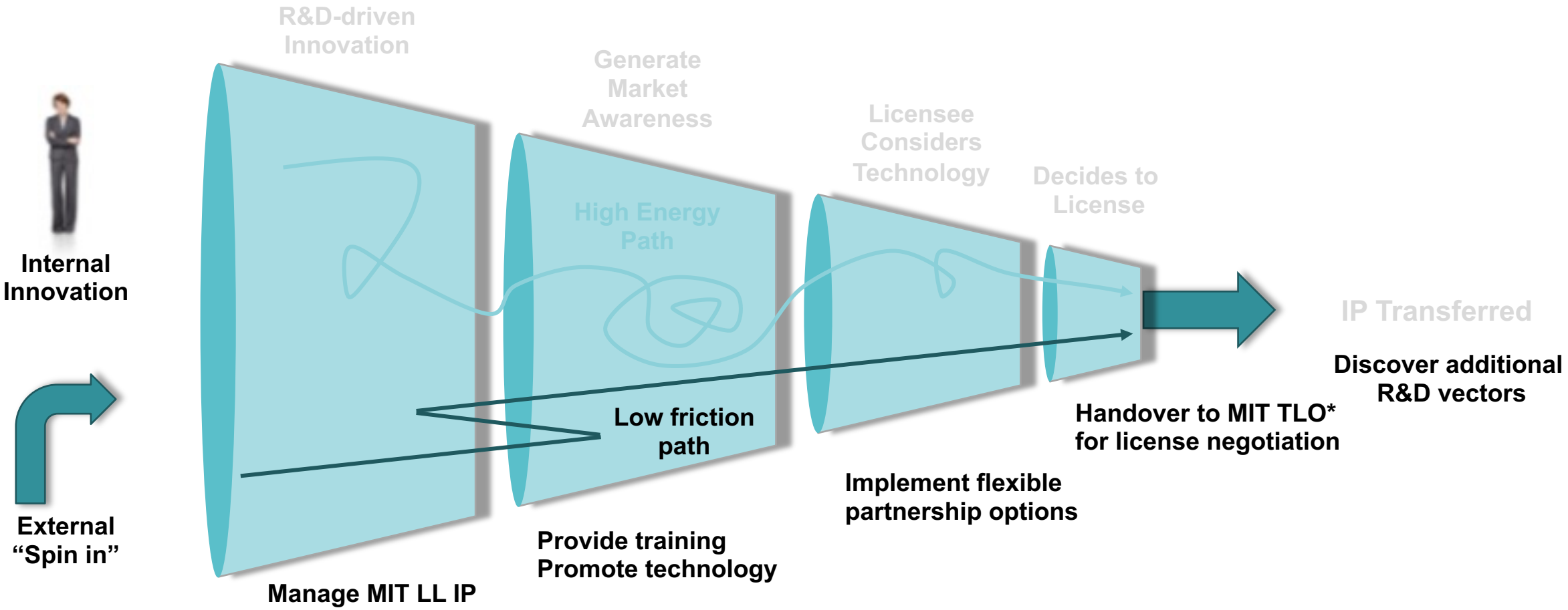
U.S. Government investment is protected while simultaneously enabling further economic returns and societal benefits through licensing activities

[1] iEdison = interagency Edison: online platform for reporting Intellectual Property utilization of research and development by participating federal agencies, including DoD

Pipeline to Facilitate Technology Transfer



Pipeline to Facilitate Technology Transfer



Commercialization capacity is enhanced through a series of engagement activities

**MIT TLO = Technology Licensing Office*

Preparing Great Innovations

Generate Market Awareness

I-Corps Training: "Scientific Method meets Entrepreneurship"

MIT I-Corps MIT Innovation Corps

NSF

Since 2018, over 100 Lincoln staff members have enrolled in I-Corps in multiple technical areas

Peer Recognition:

Opportunities to showcase technology, performance results and receive feedback

Awards, Competitions

SXSW PITCH AWARDS CEREMONY

R&D 100

Conferences/Publications

nature International weekly journal of science

IEEE

Accelerator Programs:

Programs that prepare technologies for transition into commercial practice

US Government

DEPARTMENT OF HOMELAND SECURITY

DHS CAP[1]

NSIN

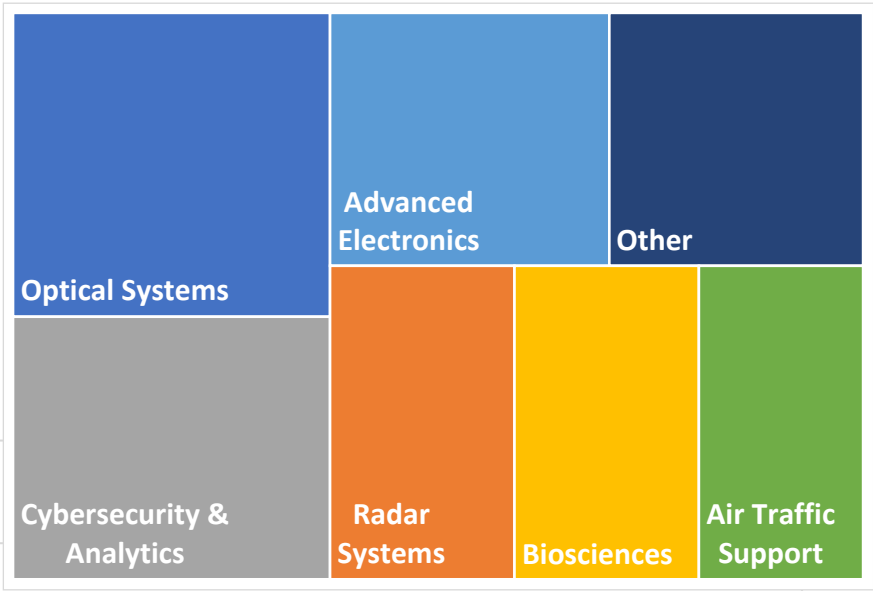
Non-Profits

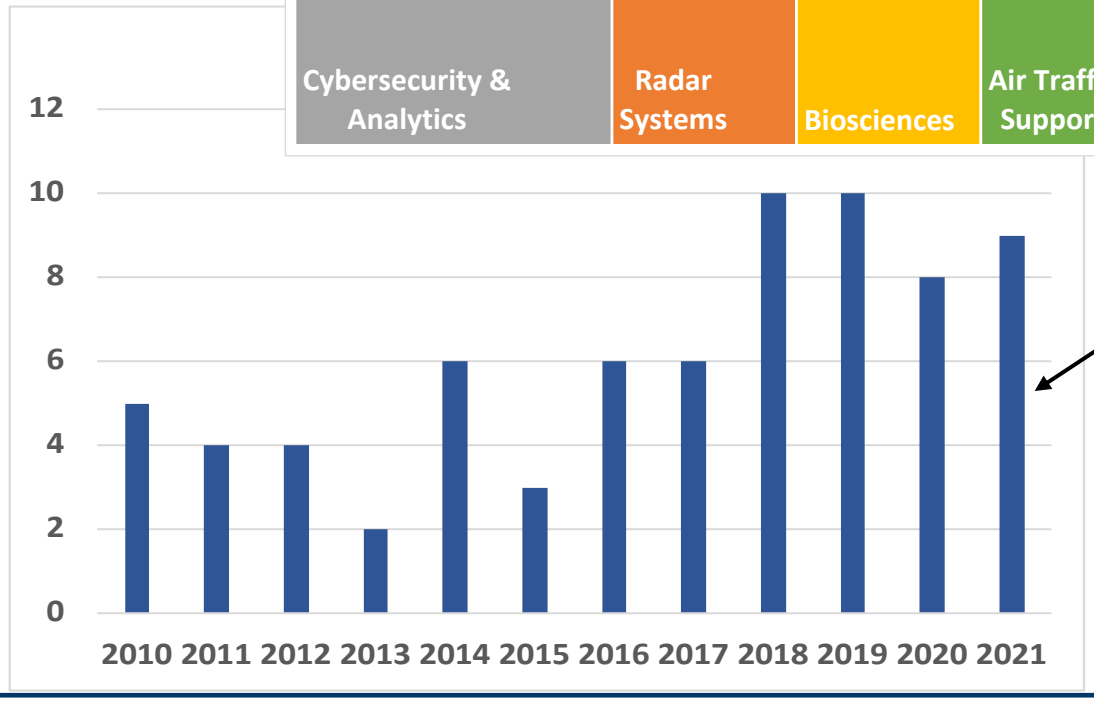
CLOUD NATIVE SANDBOX

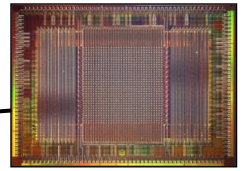
APACHE INCUBATOR

Lincoln Laboratory R&D 100 Awards

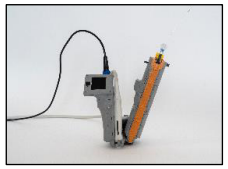
75 awards since 2010 across broad range of technical categories

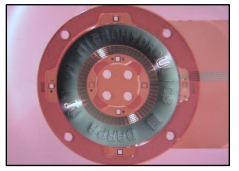





Field-programmable Imaging Array

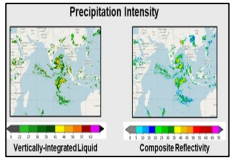

Free-space Quantum Network


Guided Ultrasound Intervention Device

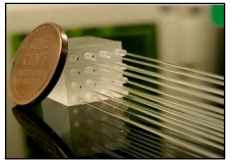

Microhydraulic Motors

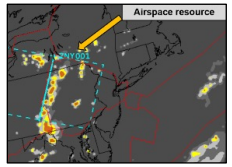

MURMUR


Spectrally Efficient Digital Logic



Global Synthetic Weather Radar


Monolithic Fiber Array Launcher



Traffic Flow Impact Tool

Commercial Partnerships

Licensee Considers Technology

Seed New Innovation

Entrepreneurial Fellowships

Collaborative R&D

3DEO

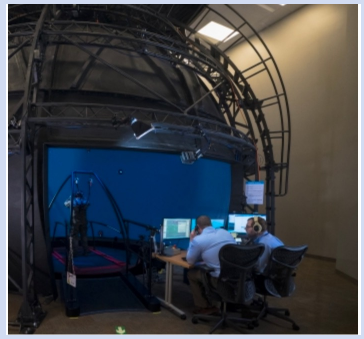
POLYVERSE

FLUKE

tsi

Test and Evaluation

Microelectronics Laboratory



STRIVE Center

Agreement Type	Description
License Option	An option provides a fixed period of time to evaluate the technology and its market potential prior to licensing
Cooperative Research and Development Agreement (CRADA)	Collaborative R&D with a commercial entity resulting in technology transfer with industry; funded by non-federal funds
SBIR/STTR	Joint efforts with a small business addressing a specific USG agency topic and solicitation
Test Agreement	Allows private sector organizations to test their technology in MIT LL's facilities on a reimbursable, non-interfering basis.

FY2021 Transfer Metrics

R&D-driven Innovation → Decides to License

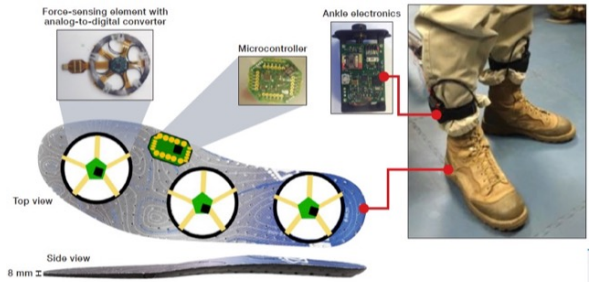
FISCAL YEAR
2021

TECHNOLOGY TRANSFER BY THE NUMBERS

103 Articles in technical journals	65 Papers in published proceedings	54 Patents issued
19 Lincoln Laboratory–hosted conferences	104 Technology disclosures filed	9 R&D 100 Awards

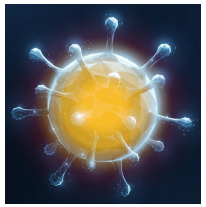
Licenses

ELVEE



Mobility and Biomechanics Insert for Load Evaluation

smiths detection



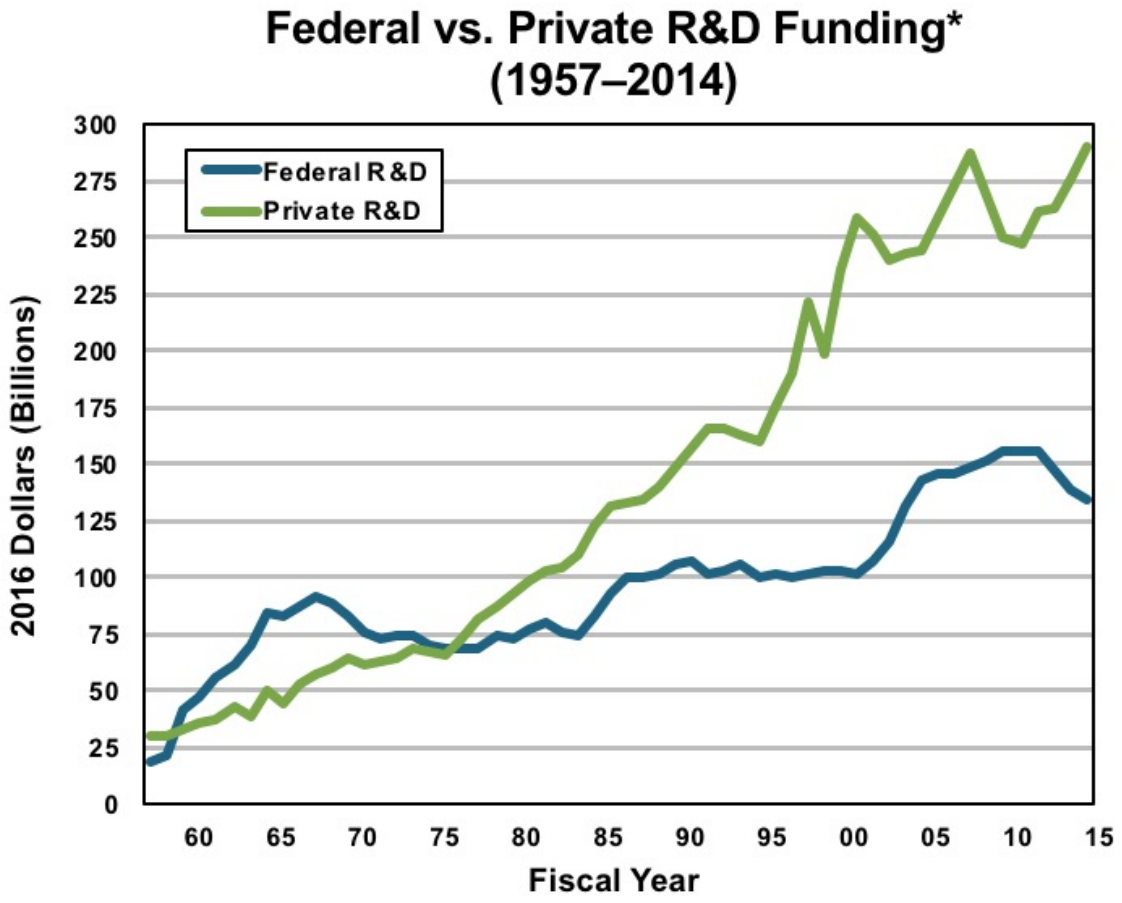
SARS-COV-2 Airborne Detection System

Outline

- Overview
- National Benefits of Technology Transfer
- Technology Transfer at MIT LL
- MIT LL Technology Ventures Office
  - Laying the groundwork for success
  - ⇨ Perspectives on dual-use technology
- Summary

Why has the DoD Embraced Engaging with the Commercial Sector?

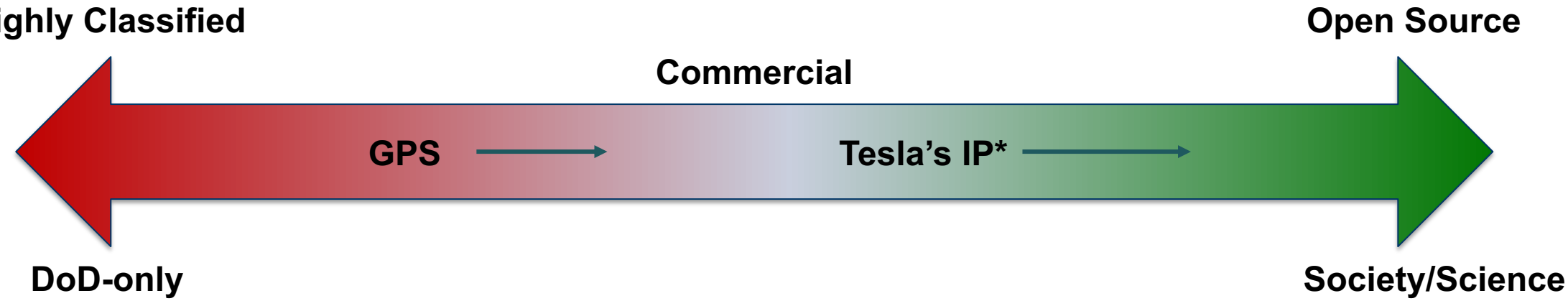
- **Commercial R&D investments are outpacing Federal R&D by > 3:1**
- **Relative Defense Industrial Base spending on R&D diminishing; as is number of companies**
- **Nontraditional companies do not always want or know how to do business with the government**
  - > $50B R&D derives from companies with fewer than 500 people**
- **US Military often does not have rapid access to best available technology**
  - Adversaries do



* Sources: The NSF Business R&D and Innovation Survey (BRDIS), The NSF Survey of Industry R&D (SIRD), and AAAS.org : Historical Trends in Federal R&D

** Sources:
The NSF Business R&D and Innovation Survey (BRDIS) and The NSF Survey of Industry R&D (SIRD)

Deciding What to Transfer



It is (relatively) easy to decide what NOT to transfer:

- Dep't of Commerce – Export Administration Regulations (EAR)
- Dep't of State – International Traffic in Arms Regulations (ITAR)
- Treasury Dep't – Office of Foreign Assets Control (OFAC)
- Uniform Trade Secrets Act
- Economic Espionage Act of 1996
- Committee on Foreign Investment in the United States (CFIUS)
  Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA)
- USPTO's Invention Secrecy Act

But how do we quantify "societal benefit"? How do we weigh the risks vs rewards?

*All Our Patent Are Belong To You, Elon Musk, CEO June 12, 2014

Two Questions to Consider

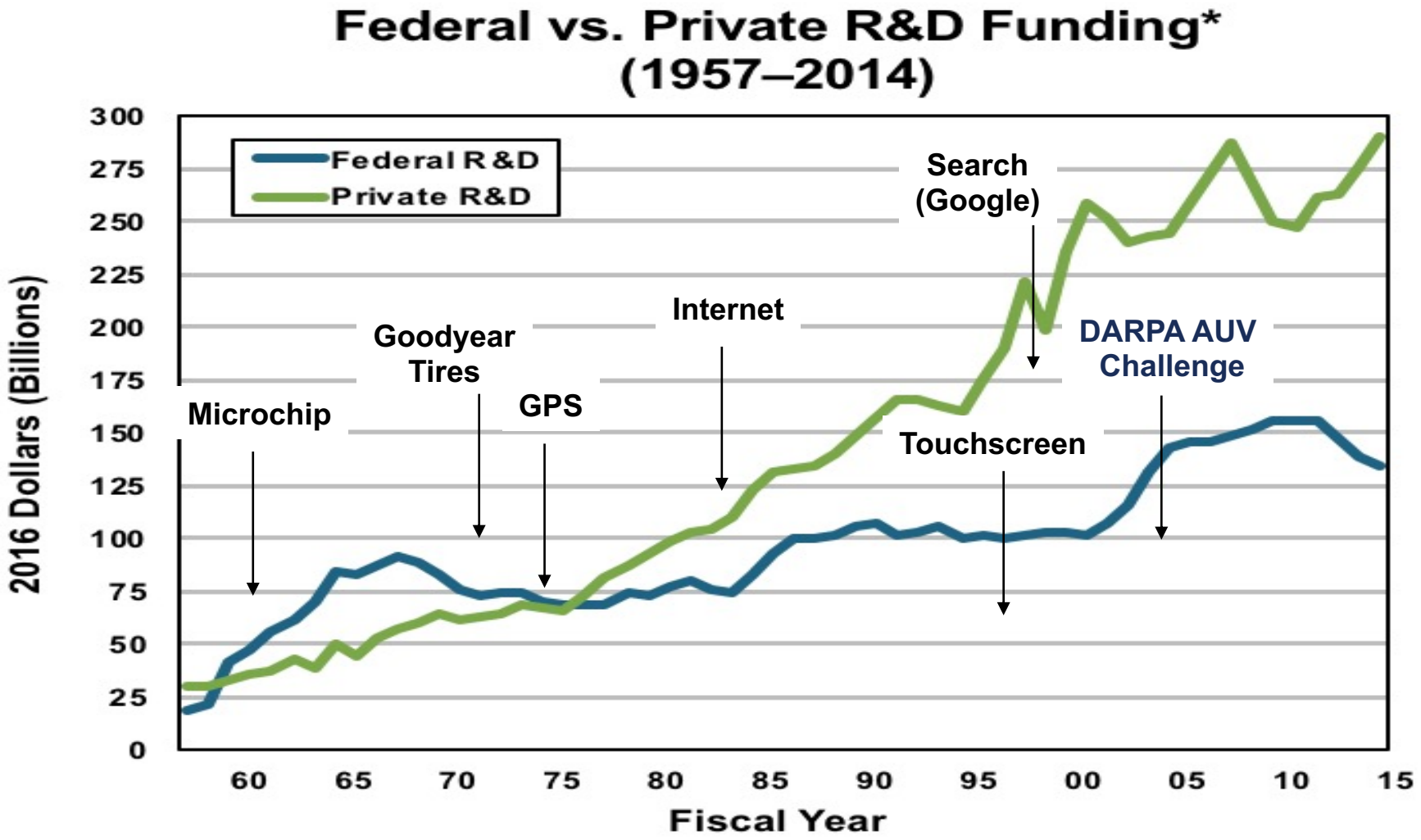
How is tech transfer in the best interest of the Nation?

Example Technologies*:	Compact Radar Systems	Non-Contact Ultrasound	Cyber Vulnerability Assessment	Mass-producible Biofuels
Safeguards nation/military	✓	✓	✓	?
Contributes to US economic prosperity	✓	✓	?	✓
Improves social well being	?	✓	?	✓
Enhances reputation and/or revenue	✓	✓	✓	✓

How is tech transfer in the best interest of MIT?

*** Both real and aspirational**

One Perspective: Economic Prosperity Often Derives from Government Investments



Parting Thought

"The accelerating pace of technology innovation and intense competition in the global marketplace demand new solutions," said Under Secretary of Commerce for Standards and Technology and NIST Director Walter G. Copan. "Removing roadblocks, enabling entrepreneurs, attracting private investment and getting inventions from the laboratory into the marketplace faster are essential to unleash American innovation and to strengthen U.S. economic competitiveness and national security."

Learn more about MIT Lincoln Laboratory