

Keeping an Unfair Advantage in a Globalized & Commoditized World via Open Systems Architecture

Douglas C. Schmidt
d.schmidt@vanderbilt.edu

Principal Researcher



Software Engineering Institute

Carnegie Mellon University



Professor of
Computer Science

Institute for
Software Integrated
Systems

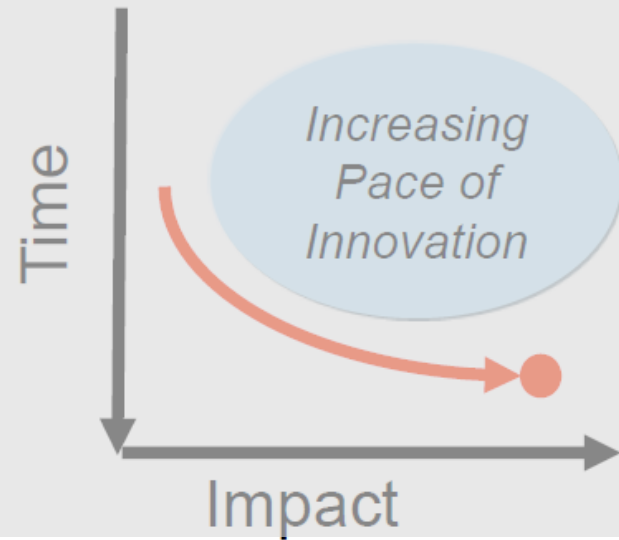
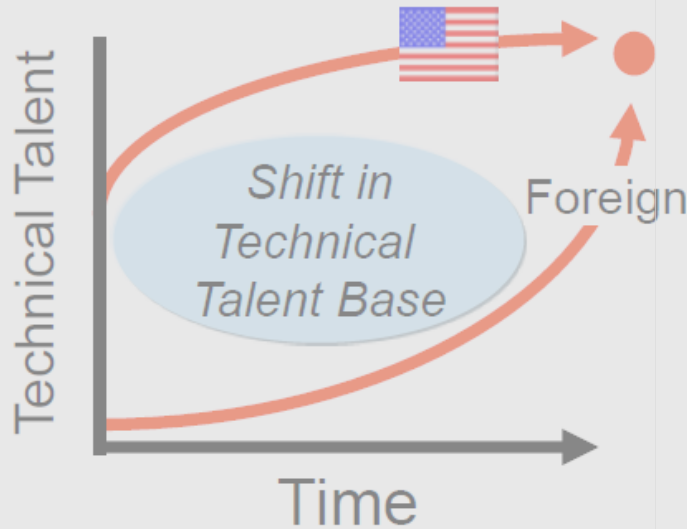
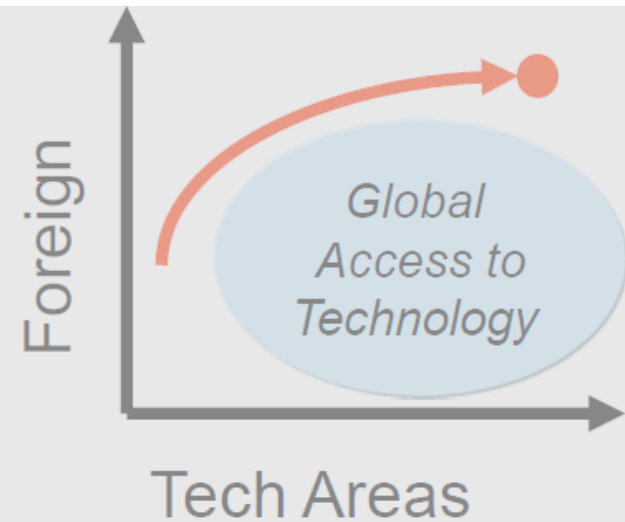
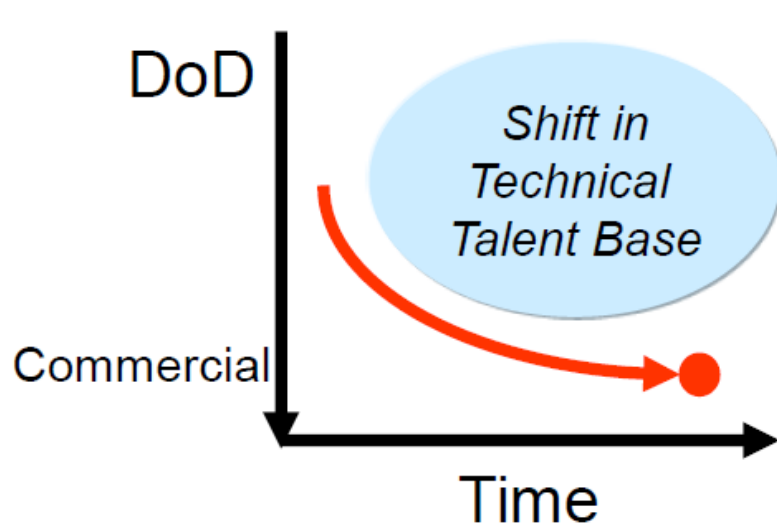
Vanderbilt University

Open Systems Architecture: Progress & Challenges
November 4th, 2014

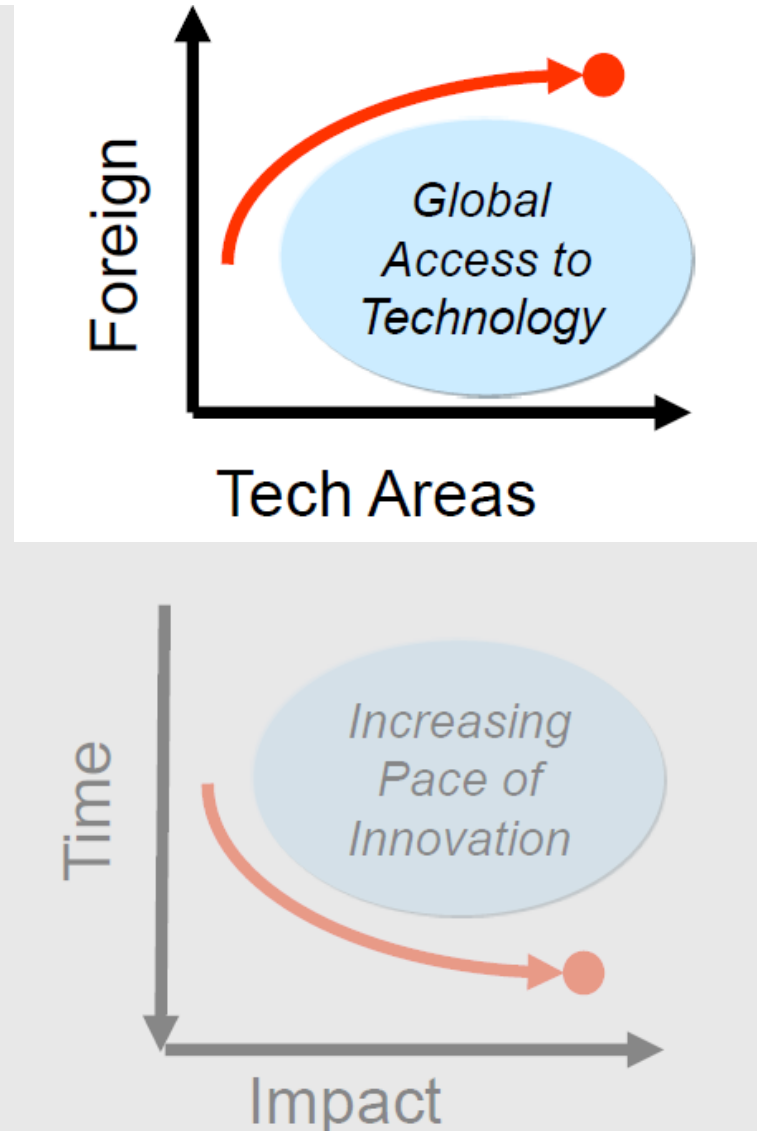
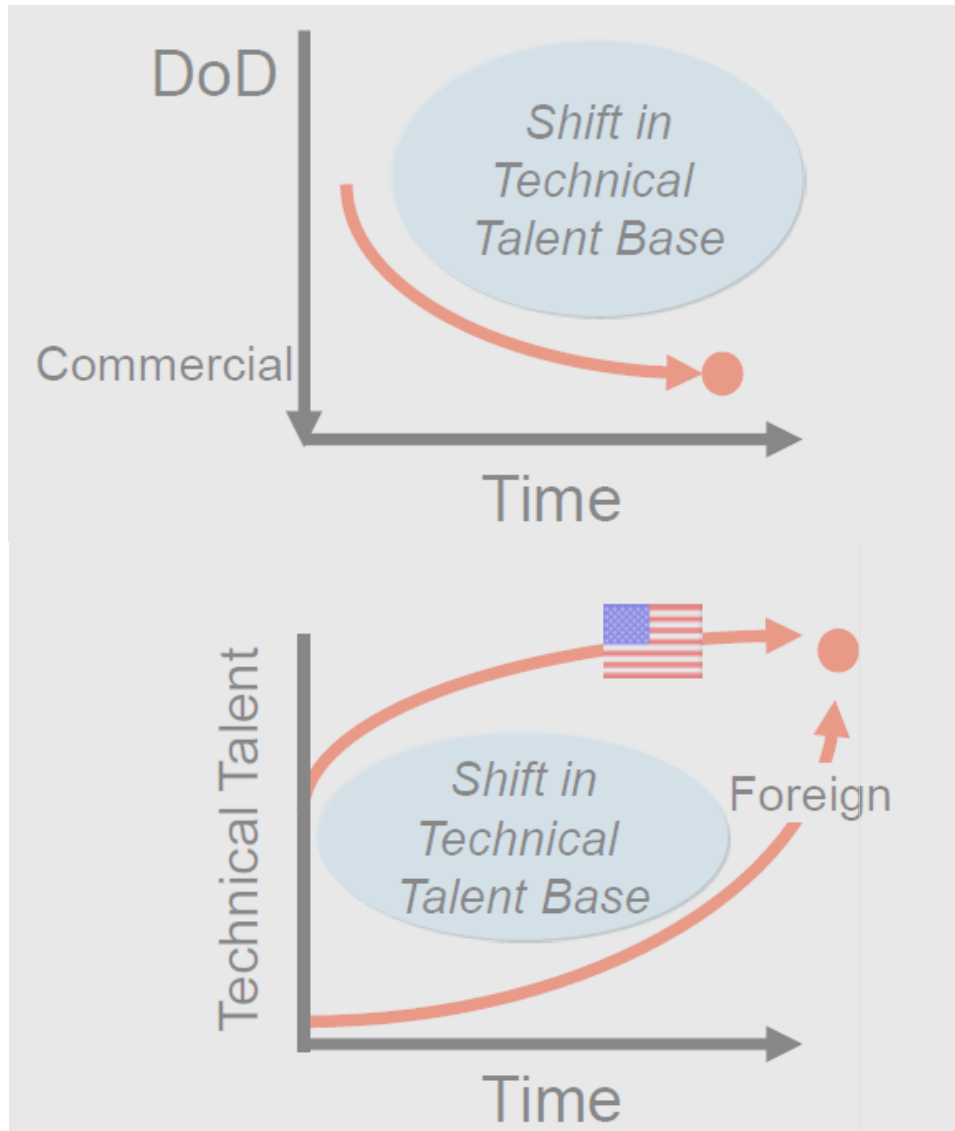
Implications of DoD Competing in a “Flat World”



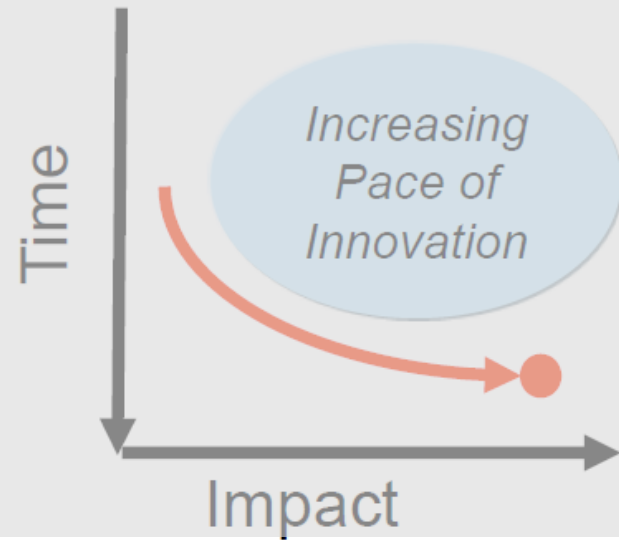
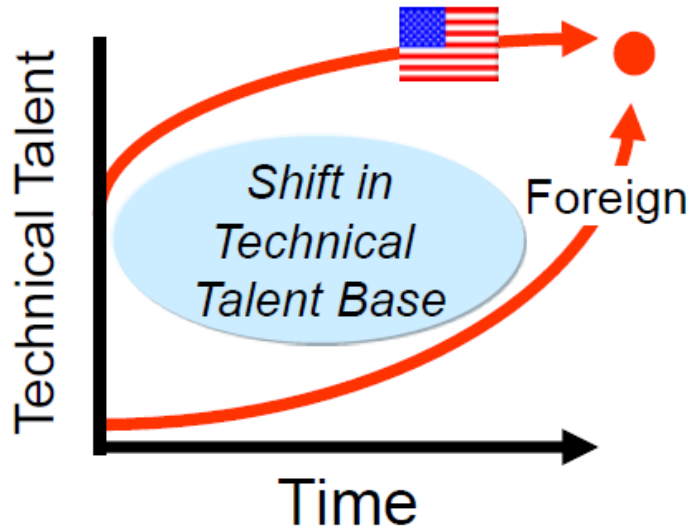
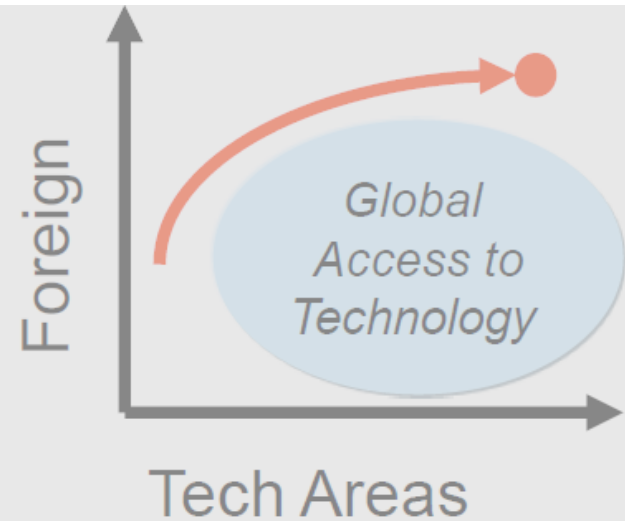
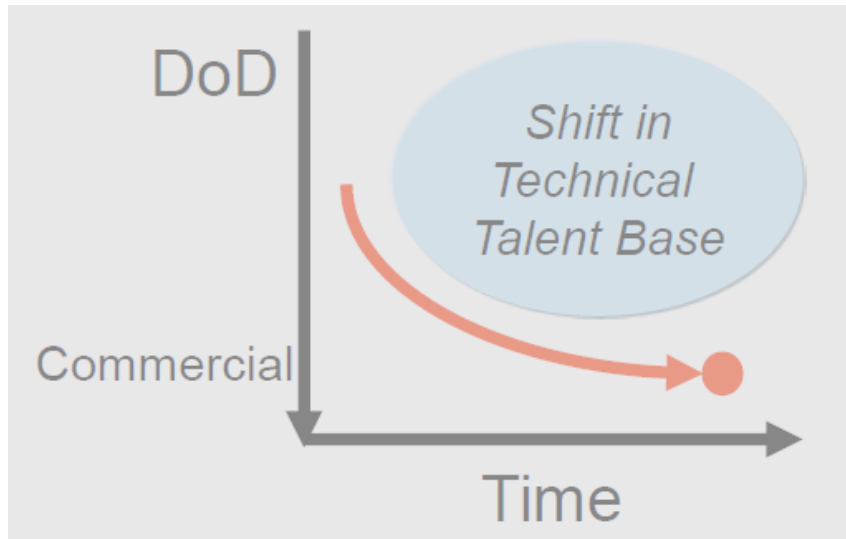
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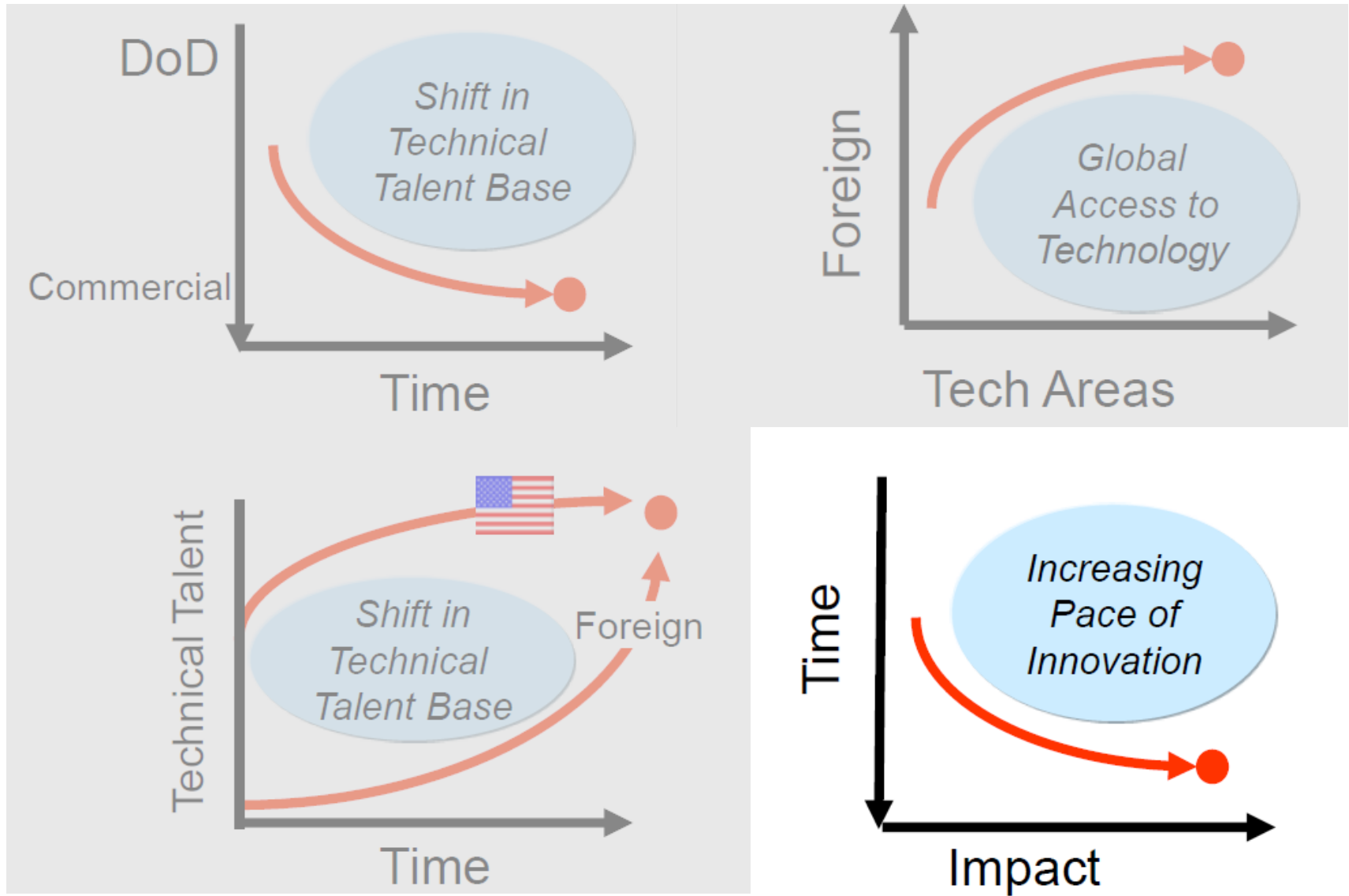
Implications of DoD Competing in a “Flat World”



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Implications of DoD Competing in a “Flat World”



Leveling the playing field gives competitors an equal opportunity

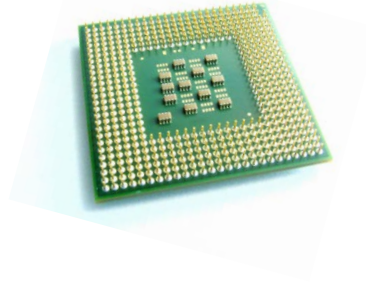
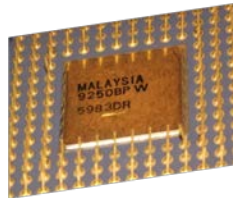
Commoditization of Information Technology



Commoditization of Hardware

- Processor & network performance has increased by many orders of magnitude

*Single-core 10
Megahertz to
3+ Gigahertz
multi-cores*

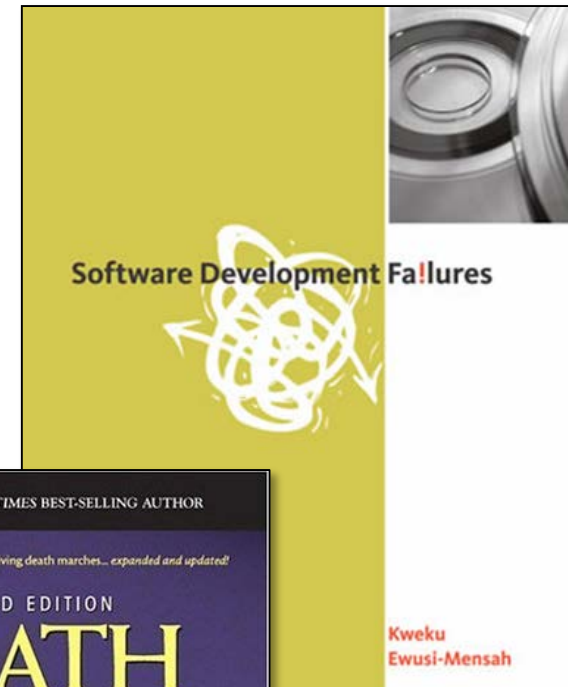
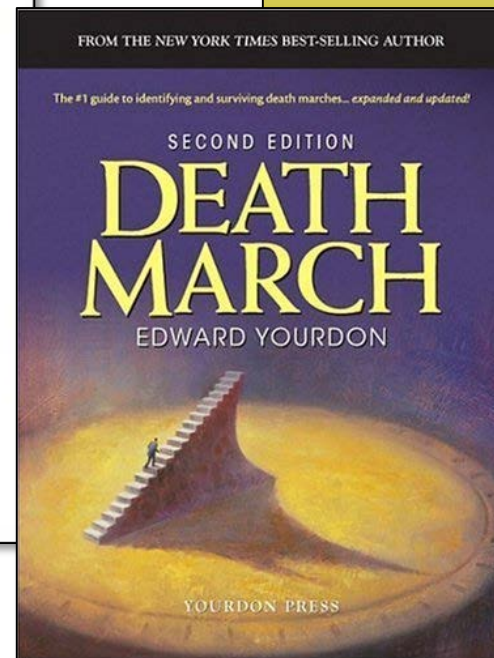
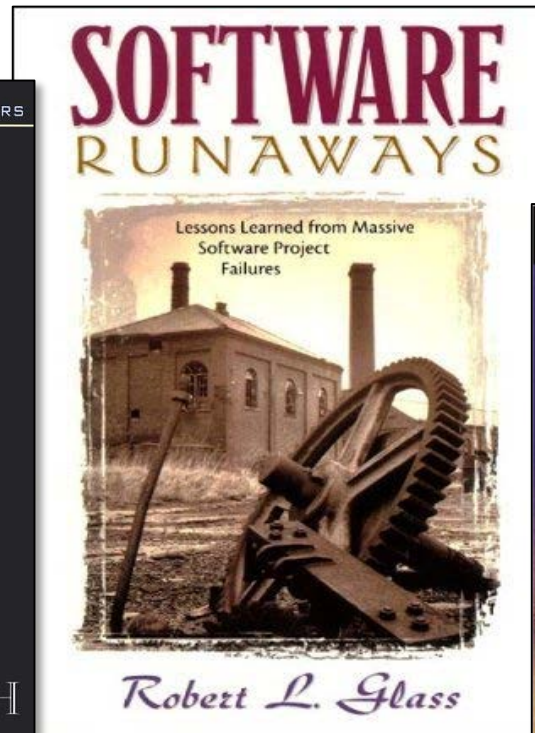
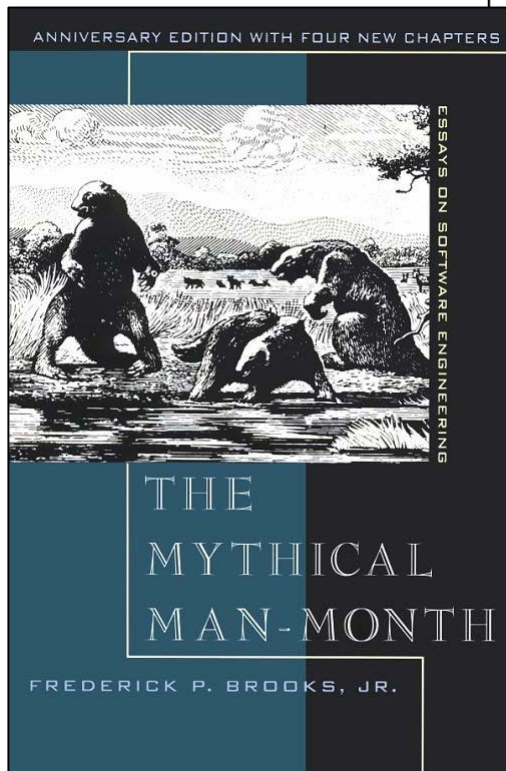


*1,200 bits/sec to
10+ Gigabits/sec*

Hardware == Better, Faster, Cheaper

Commoditization of Software

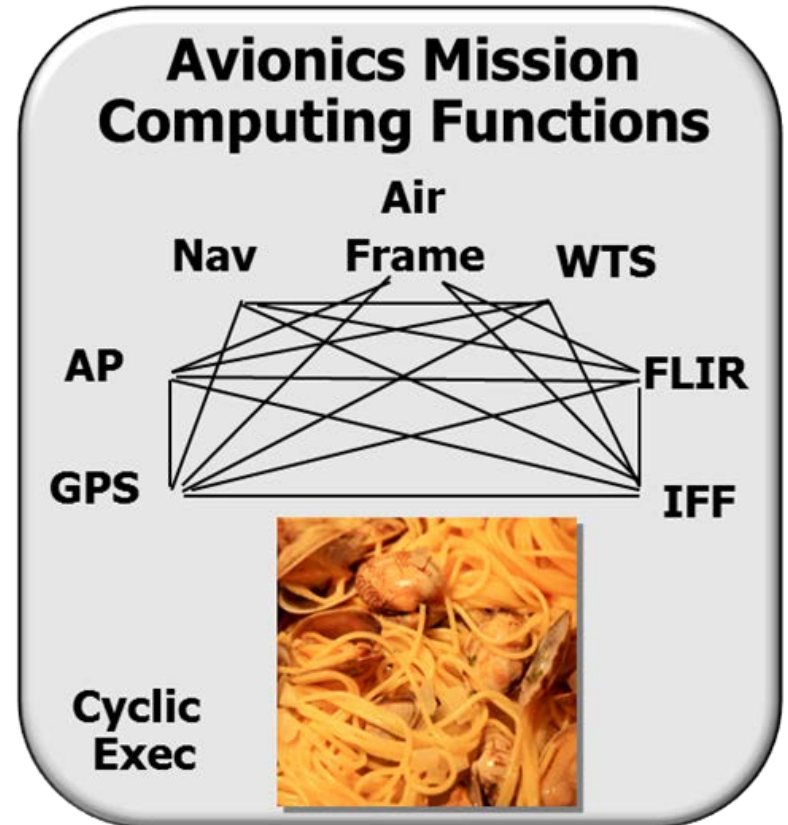
- Software quality & productivity hasn't improved as rapidly or predictably as hardware



Software == Buggier, Slower, Costlier

Commoditization of Software

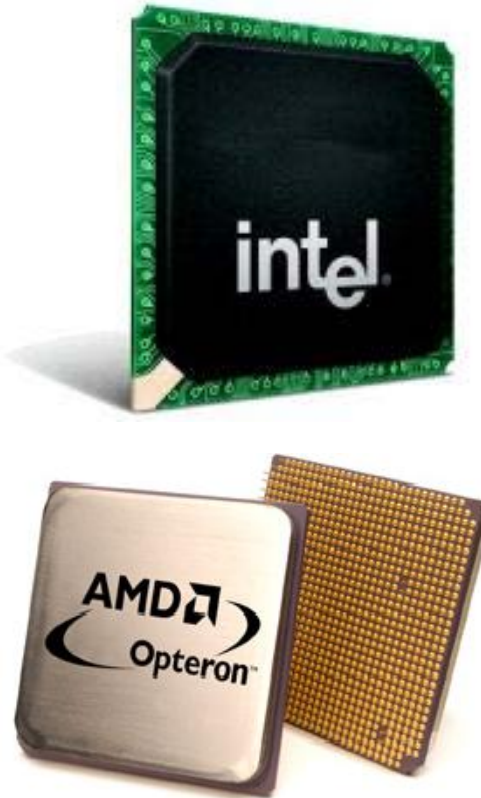
- This is particularly problematic for mission-critical, software-reliant *cyber-physical systems* (CPS)



In CPS the “right answer” delivered too late becomes the “wrong answer”

Why Hardware Improves Consistently

Hardware advances stem from maturation of *standardized* & *reusable* interfaces, protocols, & modeling tools



x86 chipsets



TCP/IP switches

Innovations packaged as COTS technologies

Why Software Doesn't Improve as Consistently

CPS software is not as standardized or reusable as hardware



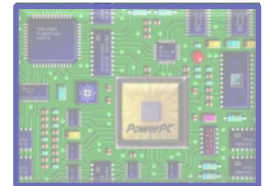
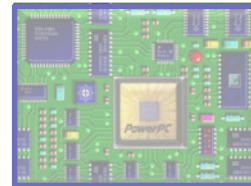
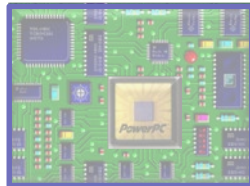
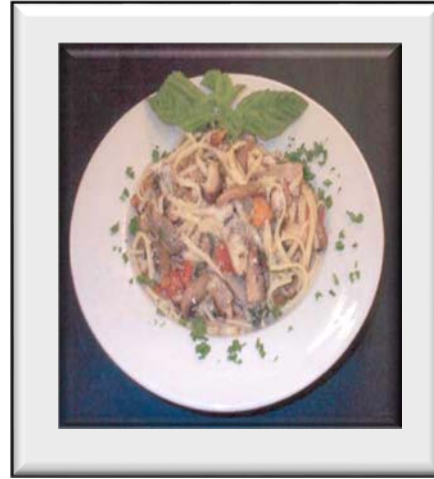
Standard/COTS/GOTS Hardware & Networks

Why Software Doesn't Improve as Consistently

CPS software is not as standardized or reusable as hardware



Proprietary & Stovepiped Application/Infrastructure Software



Standard/COTS/GOTS Hardware & Networks

Why Software Doesn't Improve as Consistently

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Proprietary & Stovepiped Application/Infrastructure Software



Software developers often manually rediscover & reinvent “point solutions” that are expensive to develop, integrate, validate, & sustain



Cyber-Physical System (CPS) Technology Challenges



CPS Software Challenges

“New GAO report highlights \$6.9 billion in over-budget IT projects at the Department of Defense” – ZDNet, 9/30/2010

F/A-22



**SBIRS
High**



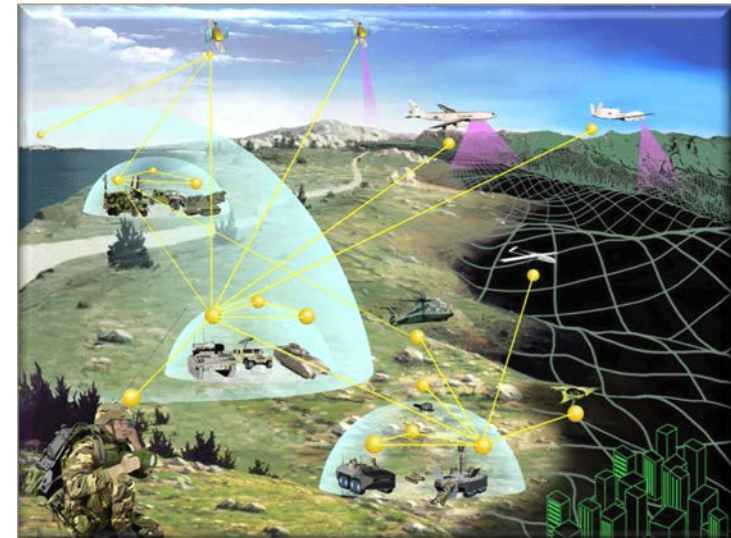
**Joint Tactical Radio
Systems (JTRS)**



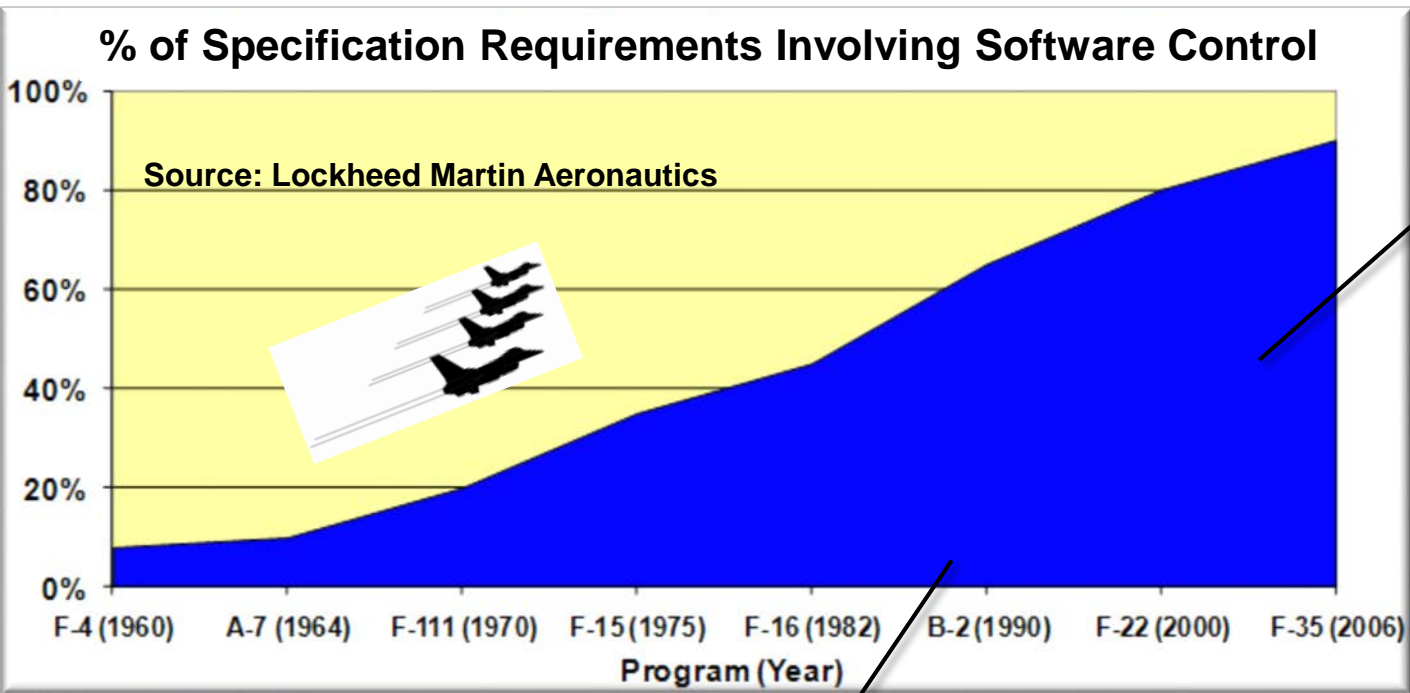
**DDG
1000**



**Future
Combat
System
(FCS)**



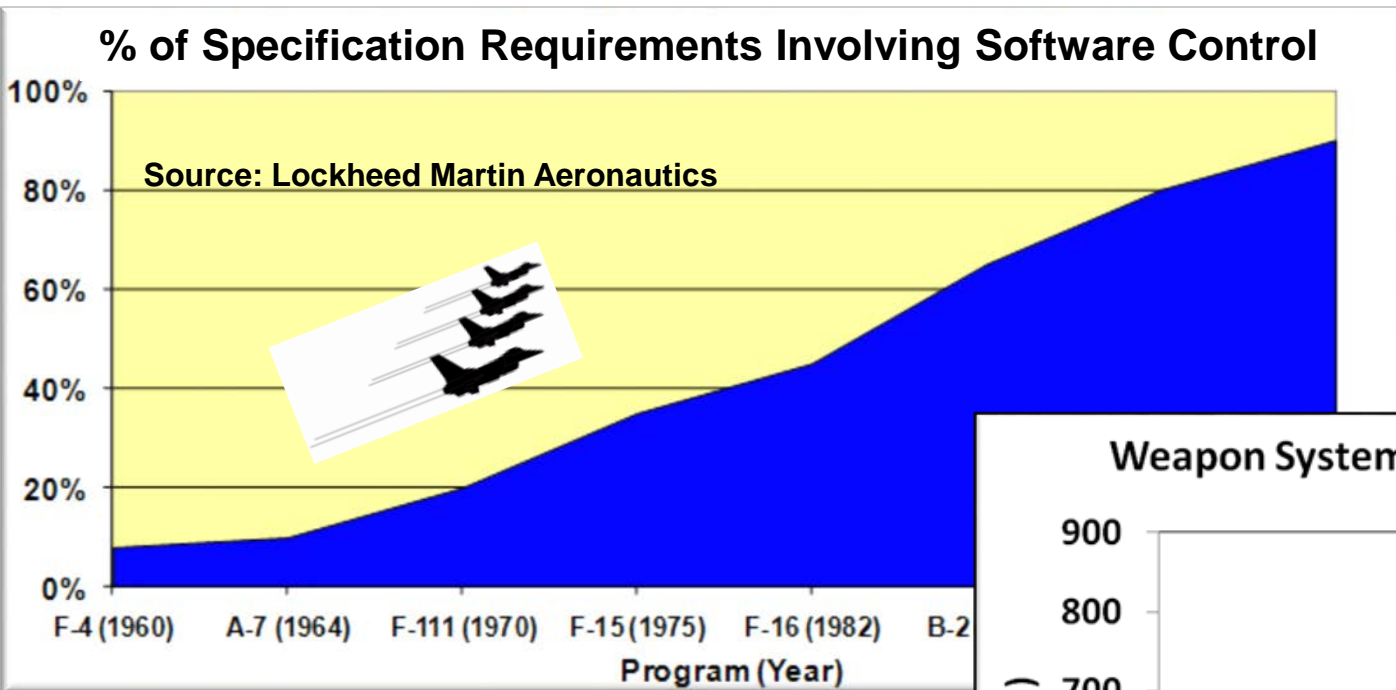
CPS Software is Growing in Size & Importance



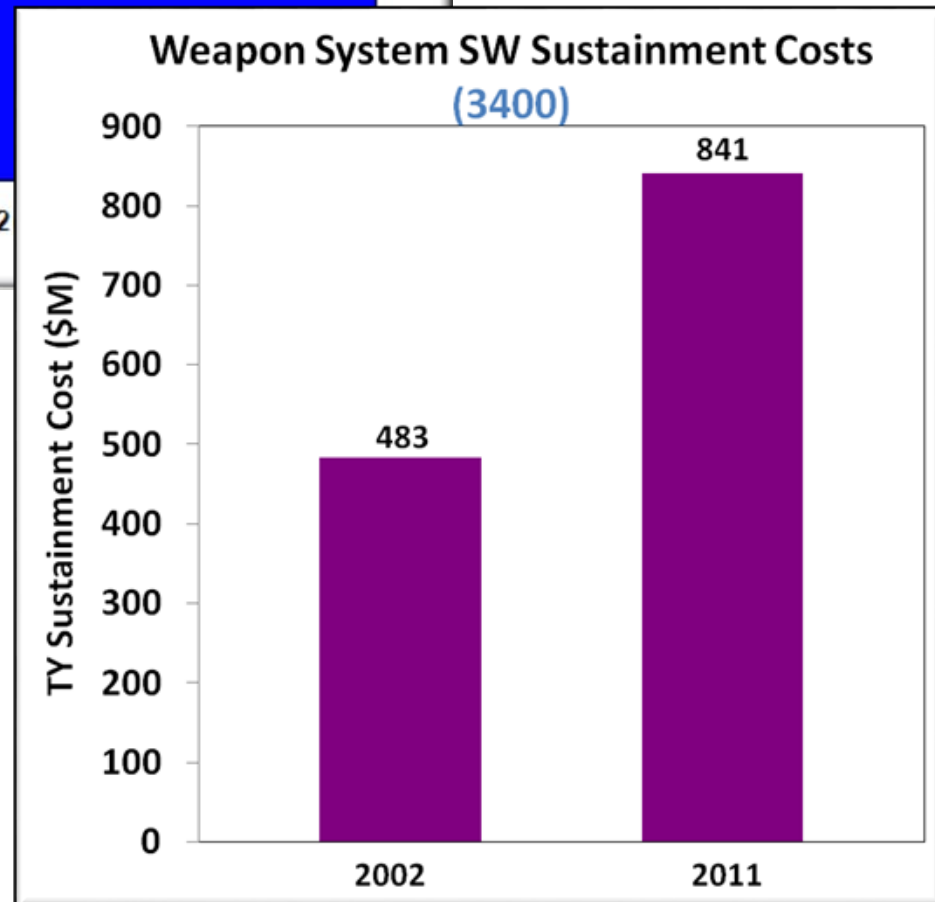
*Multi-year delays
associated with
software & system
stability*

*Software & testing delays
push costs above the
Congressional ceiling*

CPS Software is Growing in Size & Importance

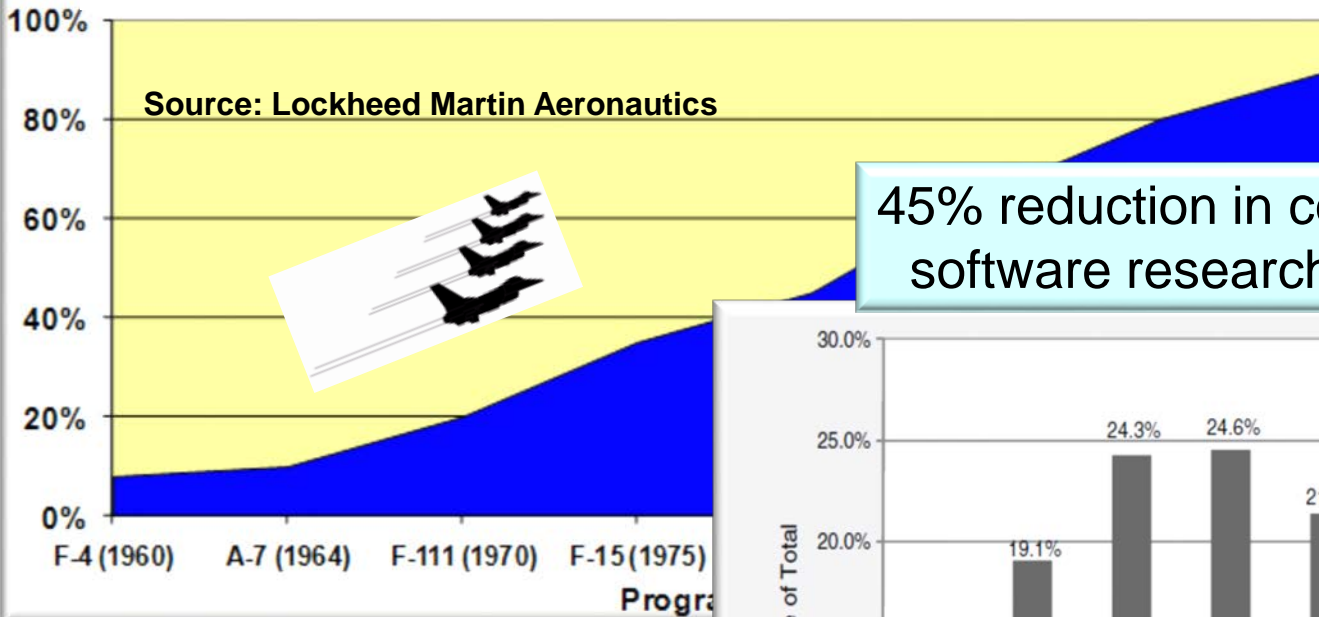


Source: FY11 Air Force
SAB study on “Sustaining
Aging Aircraft”



CPS Software is Growing in Size & Importance

% of Specification Requirements Involving Software Control



45% reduction in constant dollars for software research (SDP & HCSS)

CPS increasingly depend on software, but it's hard to motivate investments in software research

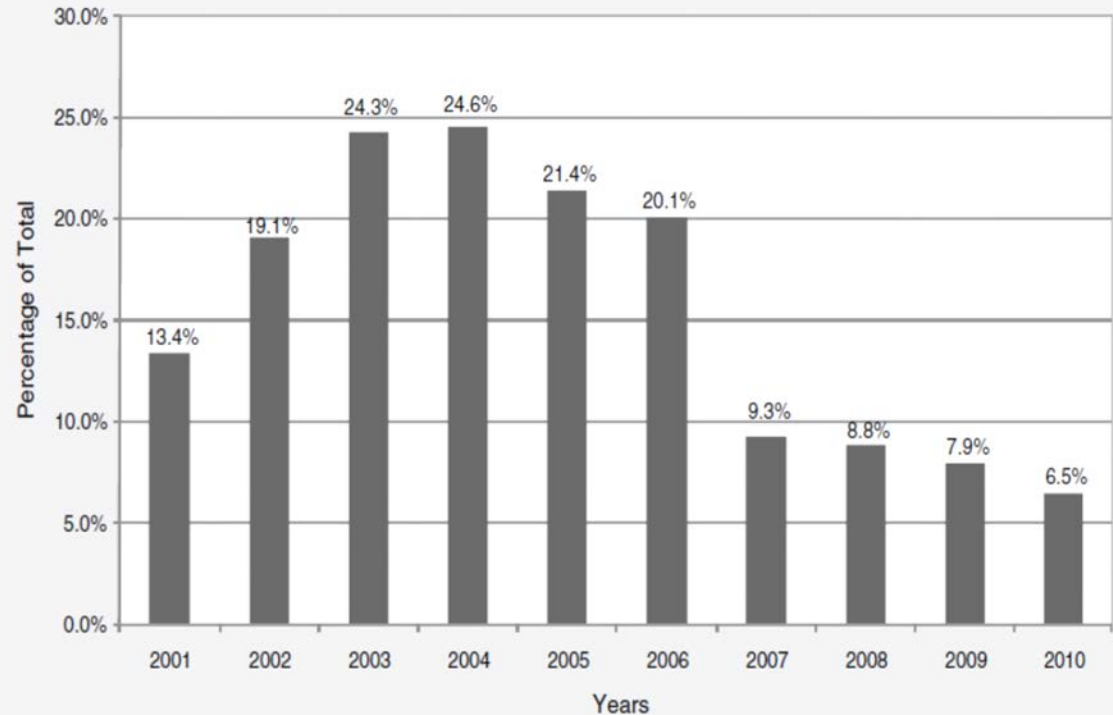


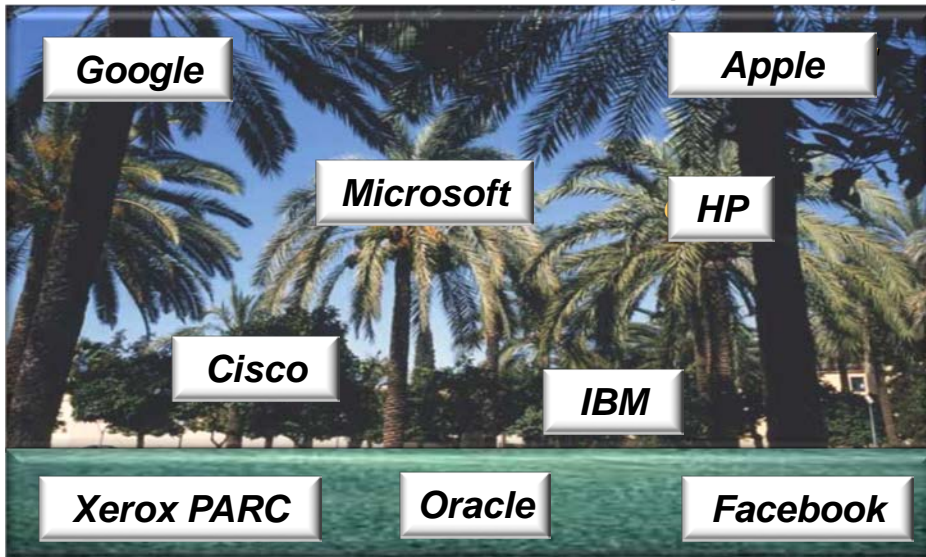
Figure 1.5.3 Percentage of total NITRD investment in either SDP or HCSS.

From NRC Report *Critical Code: Software Producibility for Defense* (2010), sponsored by Office of Secretary of Defense
www.nap.edu/openbook.php?record_id=12979&page=R1

CPS Software Misconceptions versus Reality

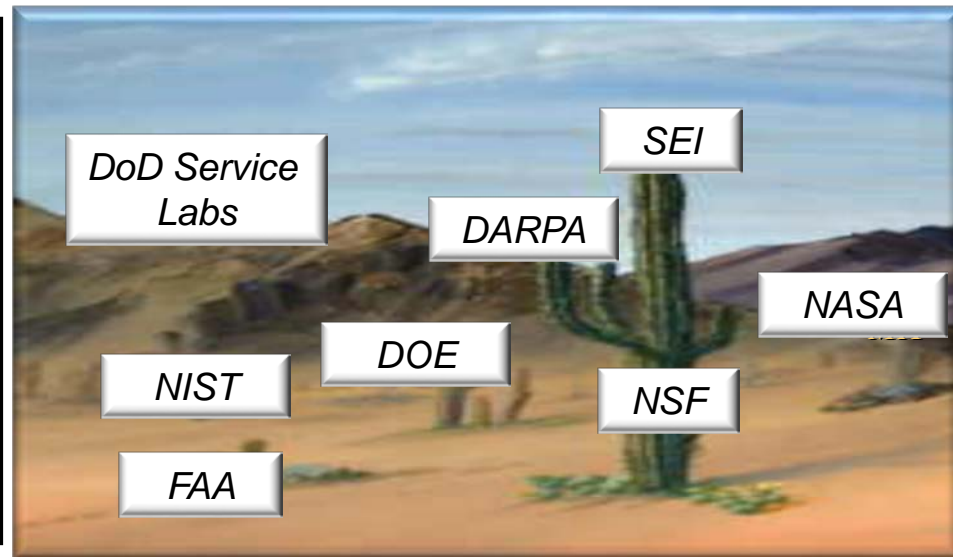
Misconception

IT industry is a well-populated oasis for mission-critical CPS programs



Reality

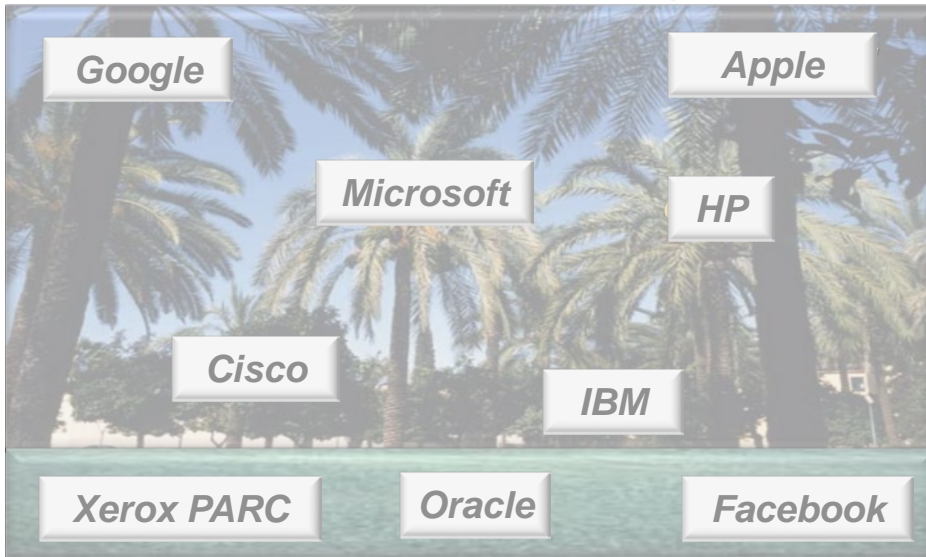
R&D investment needed to transform IT desert into arable land for CPS



CPS Software Misconceptions versus Reality

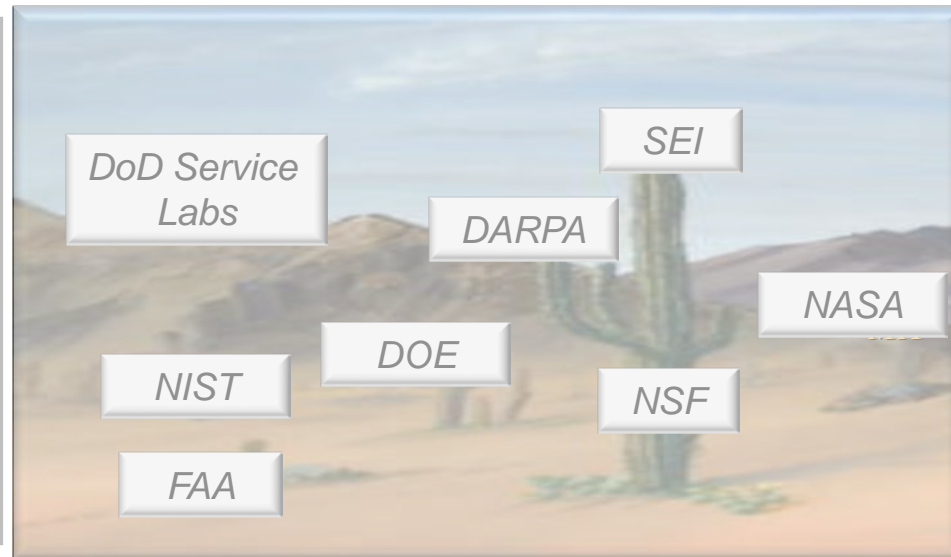
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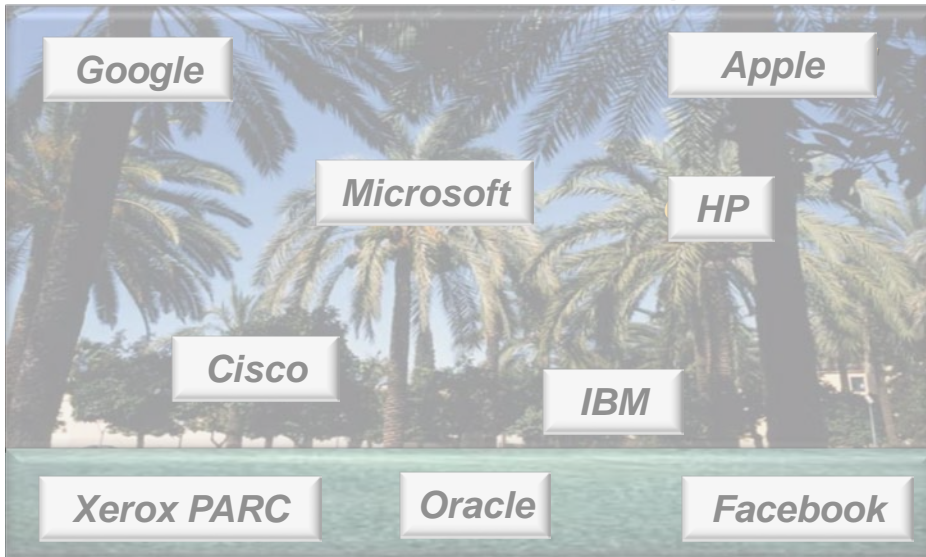
Gap between (1) IT *needs* for CPS
& (2) IT that can be *afforded* given



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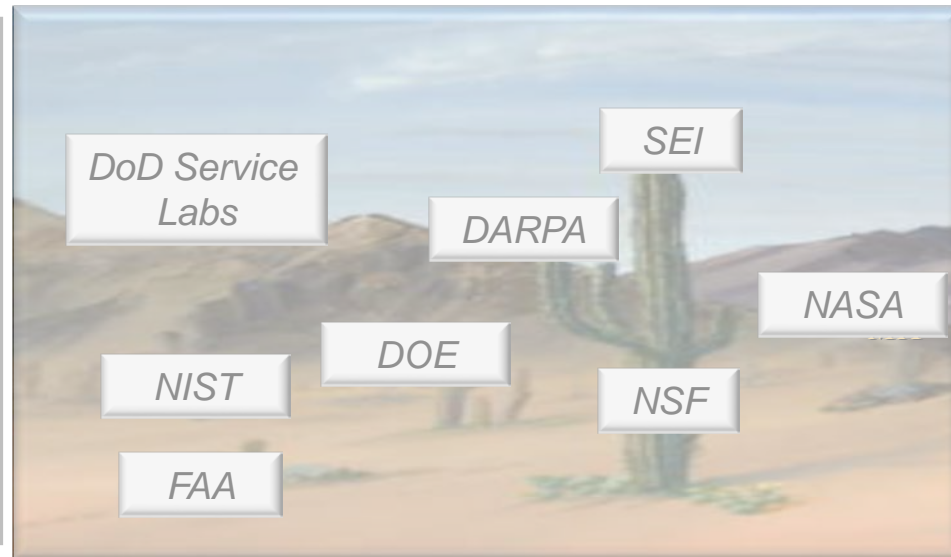
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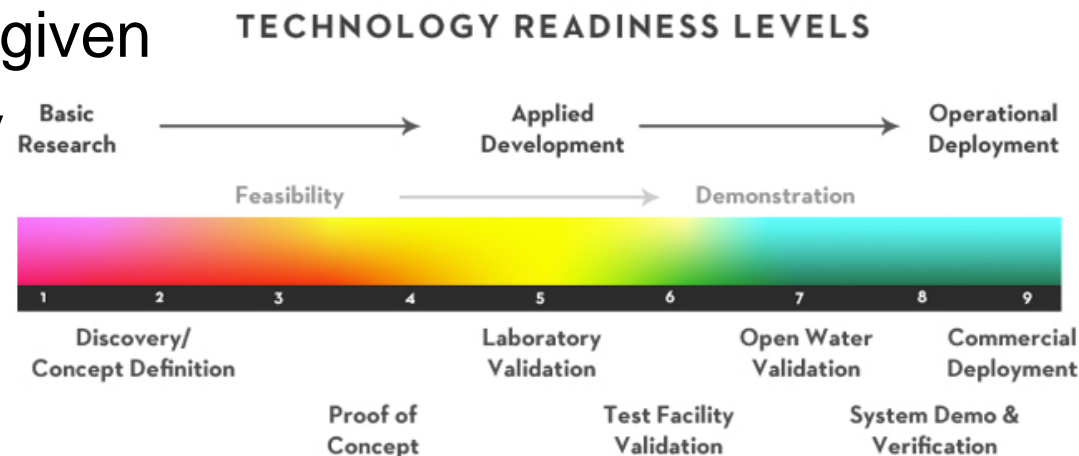
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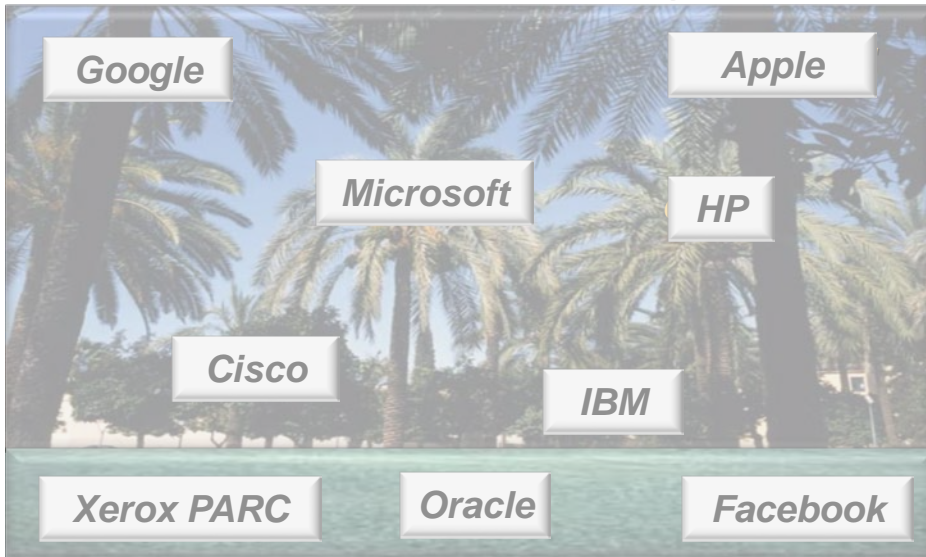
- Current technology maturity



CPS Software Misconceptions versus Reality

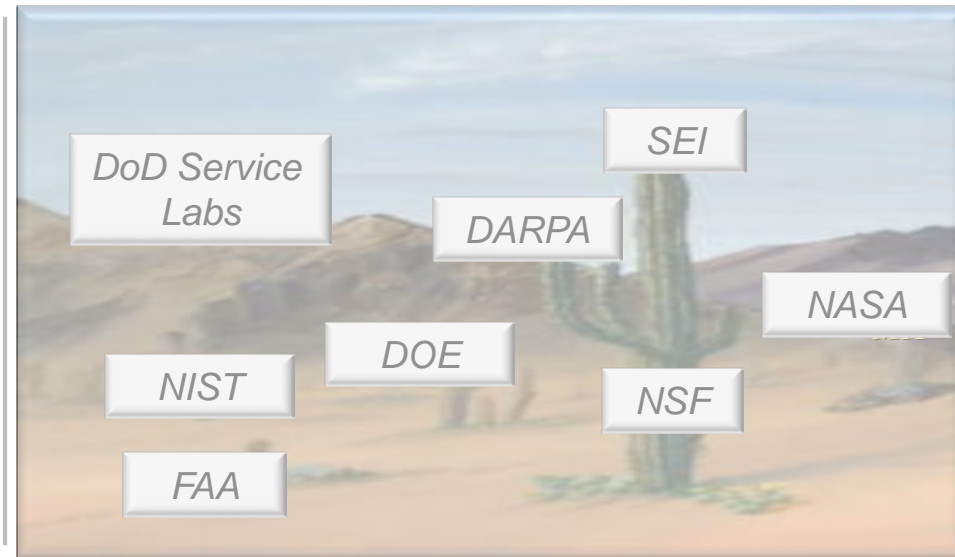
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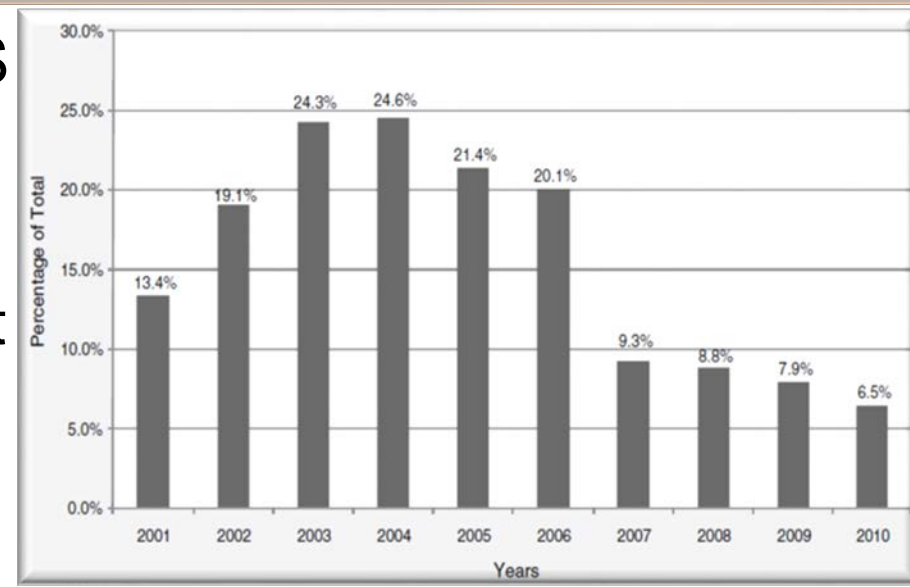
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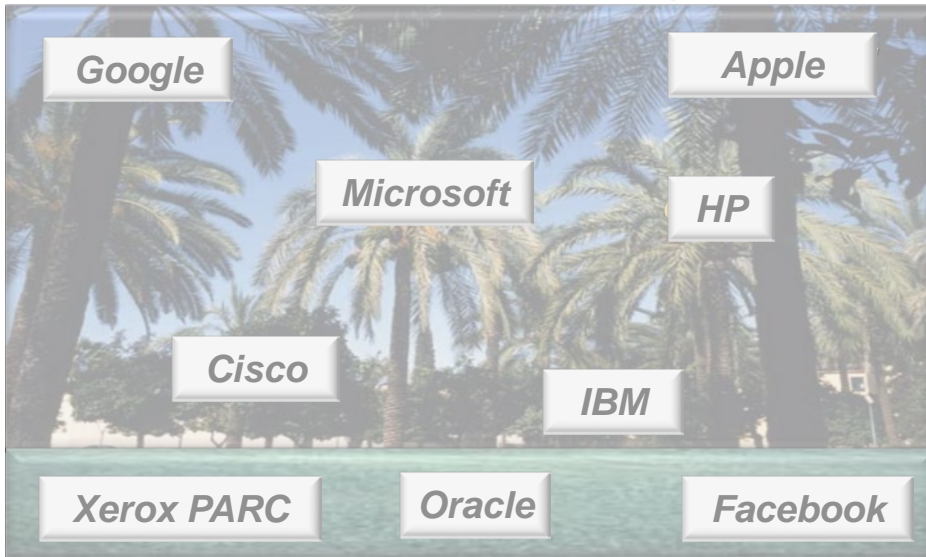
- Current technology maturity
- Limited software R&D investment



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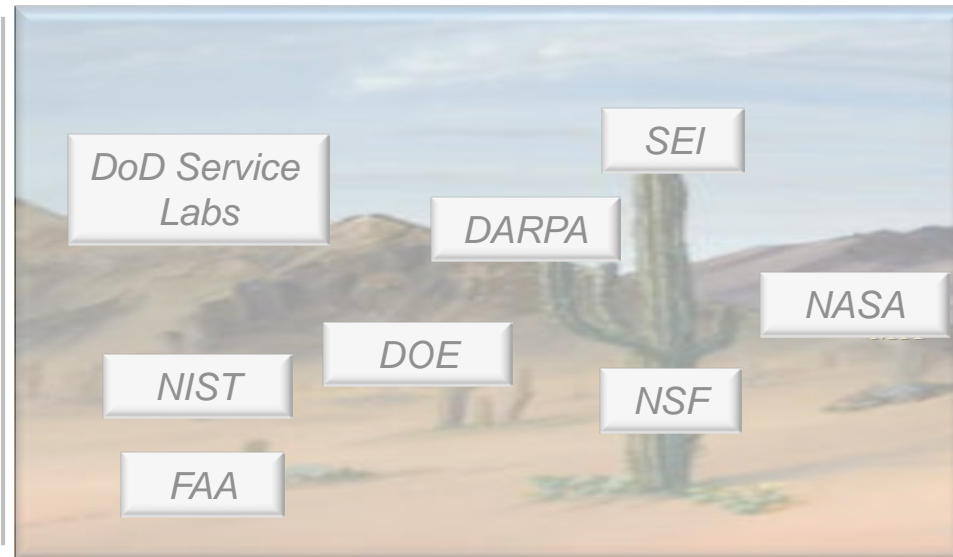
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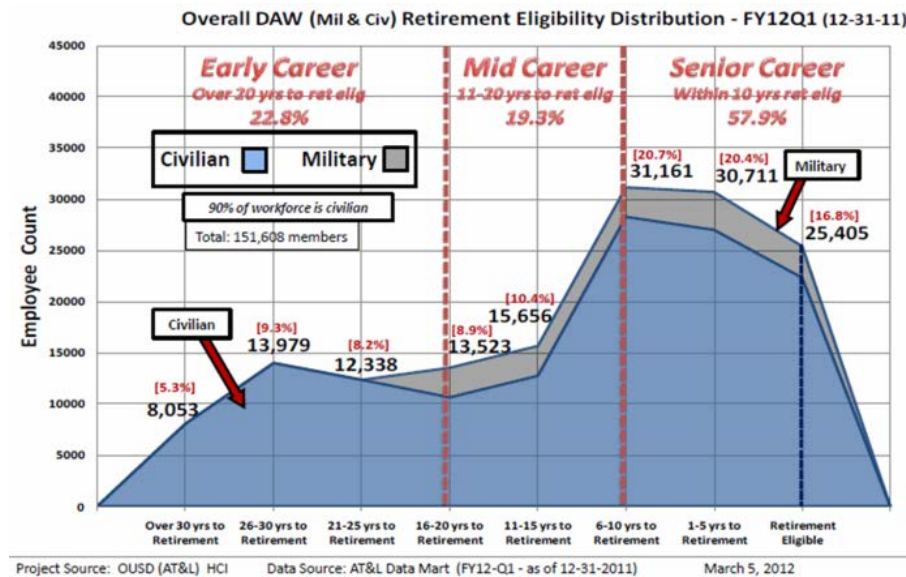
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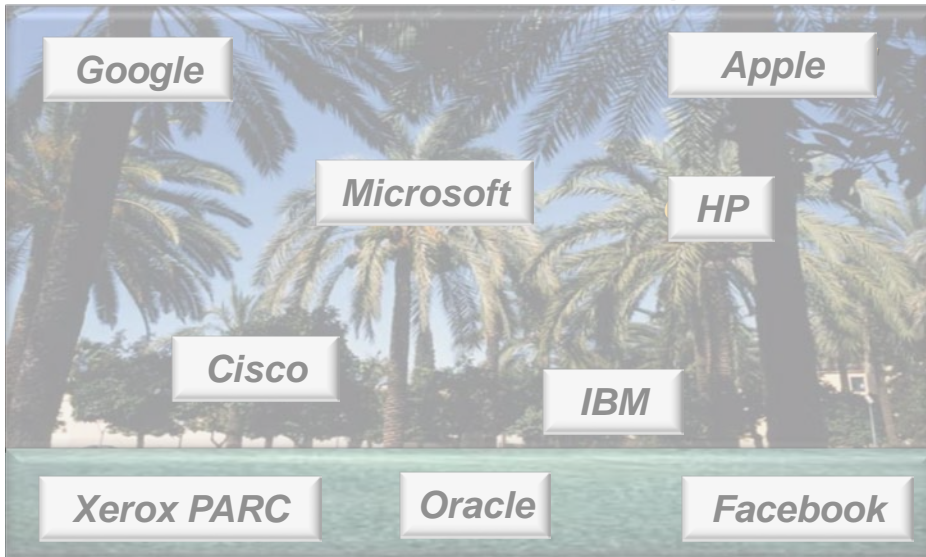
- Current technology maturity
- Limited software R&D investment
- Atrophy of government expertise



CPS Software Misconceptions versus Reality

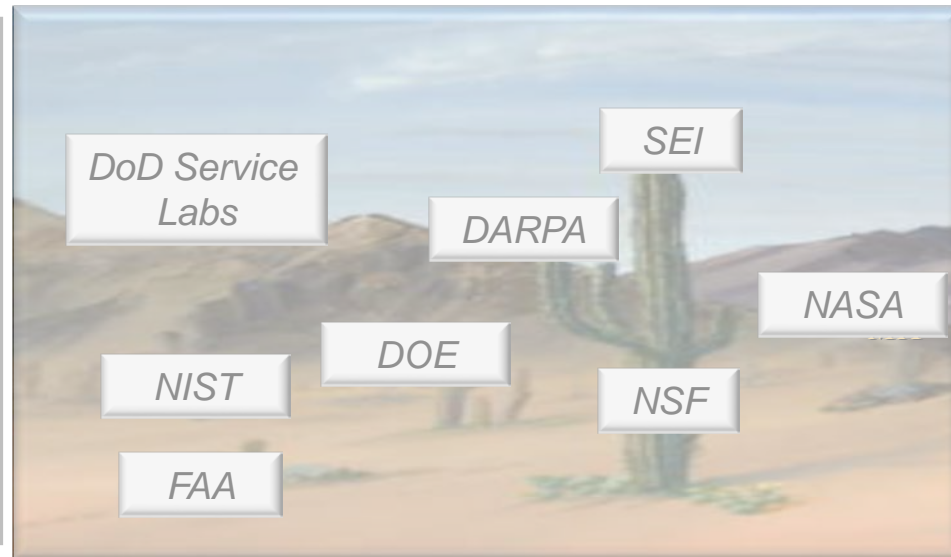
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Industry R&D *Alone* is Insufficient

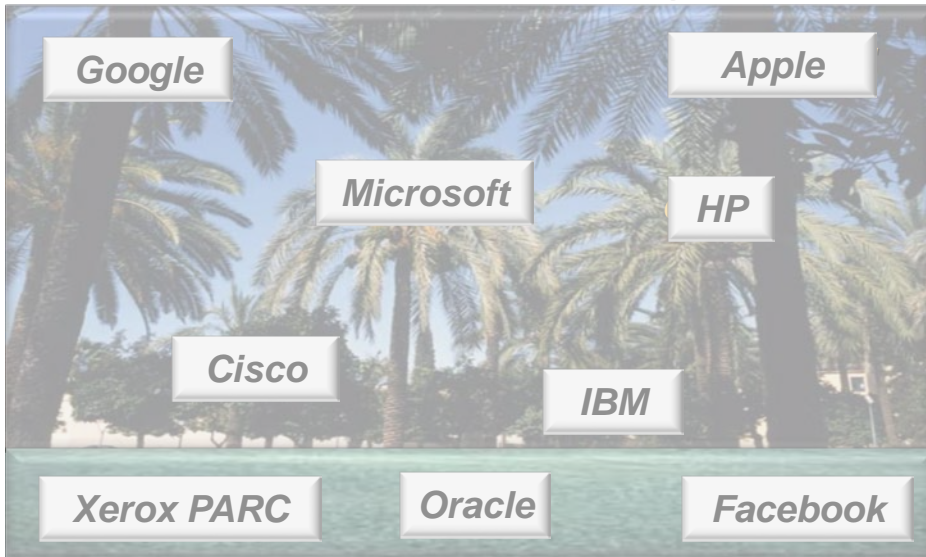
- Targeted for specific products



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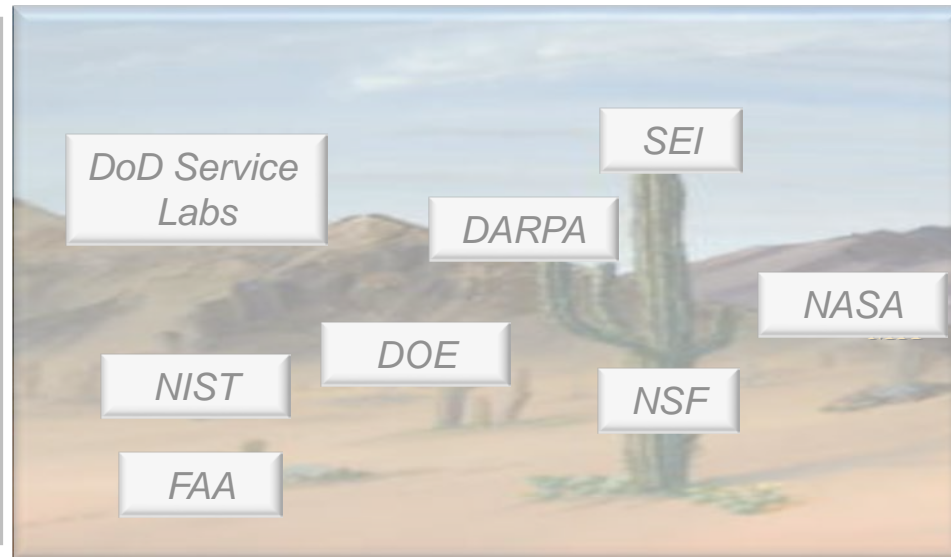
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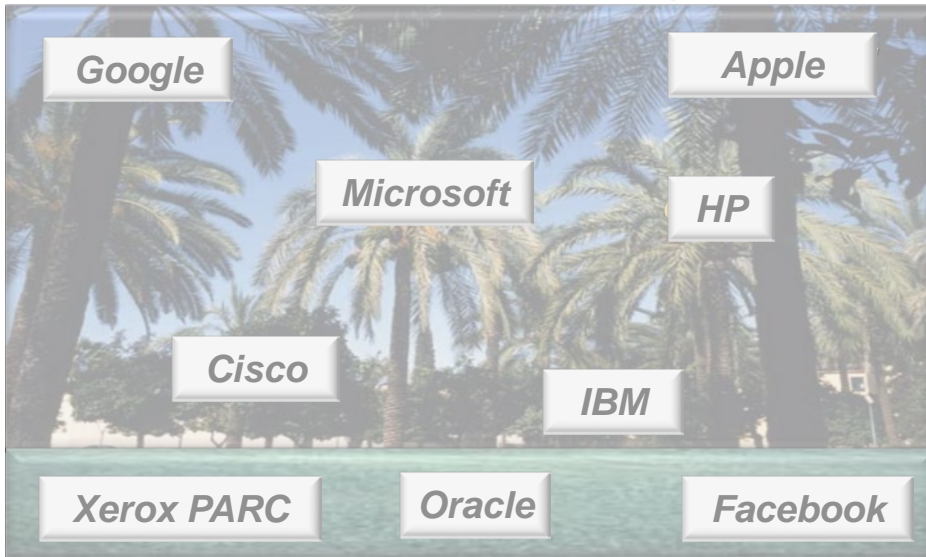
- Targeted for specific products
- Focus is on selling products
 - dependability is lower priority



CPS Software Misconceptions versus Reality

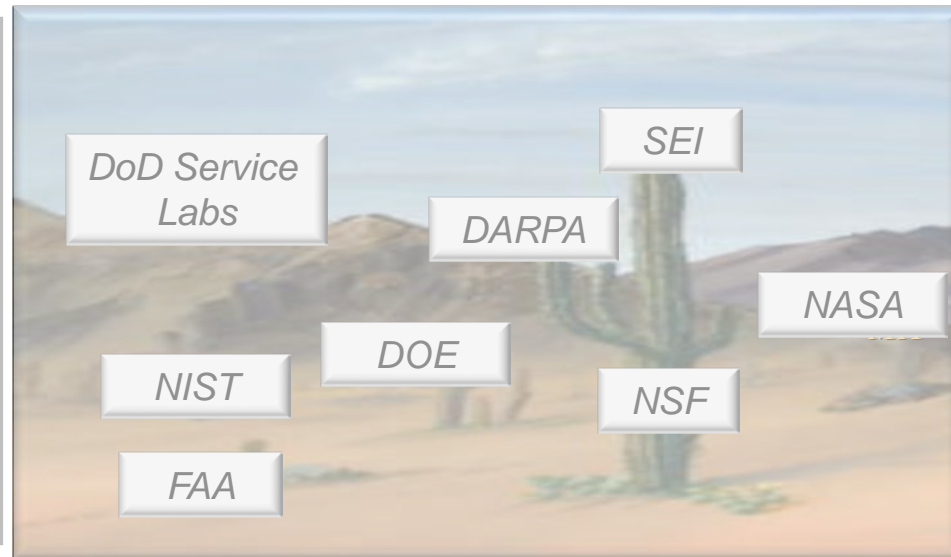
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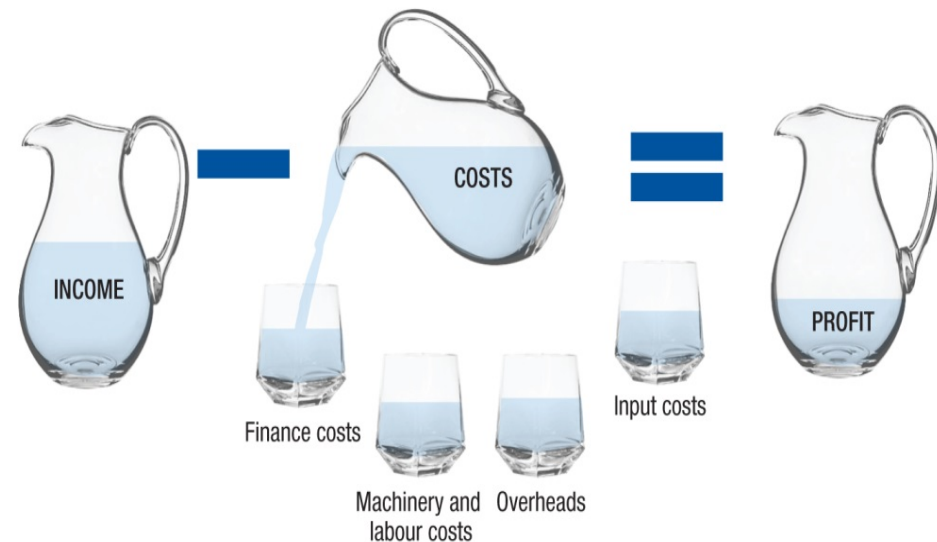
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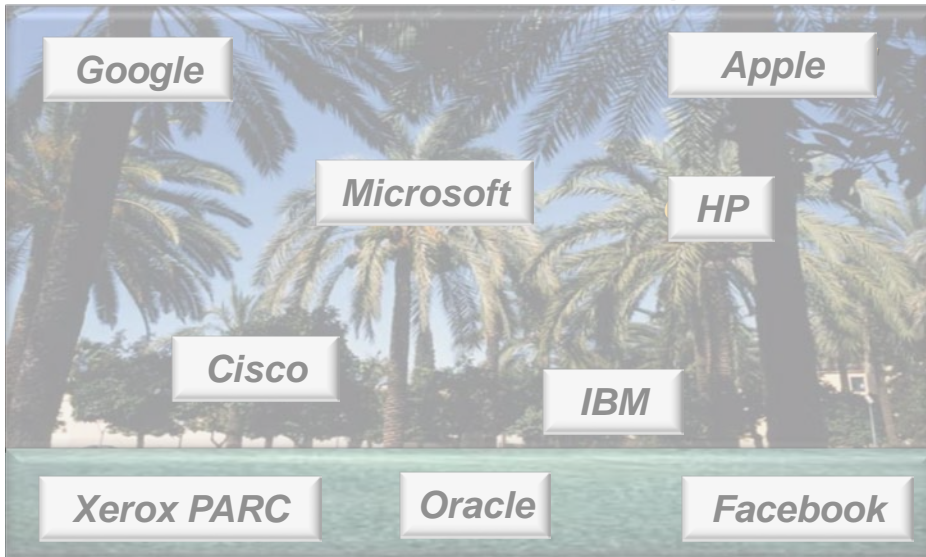
- Targeted for specific products
- Focus is on selling products
- LSIs haven't viewed software as profit driver historically



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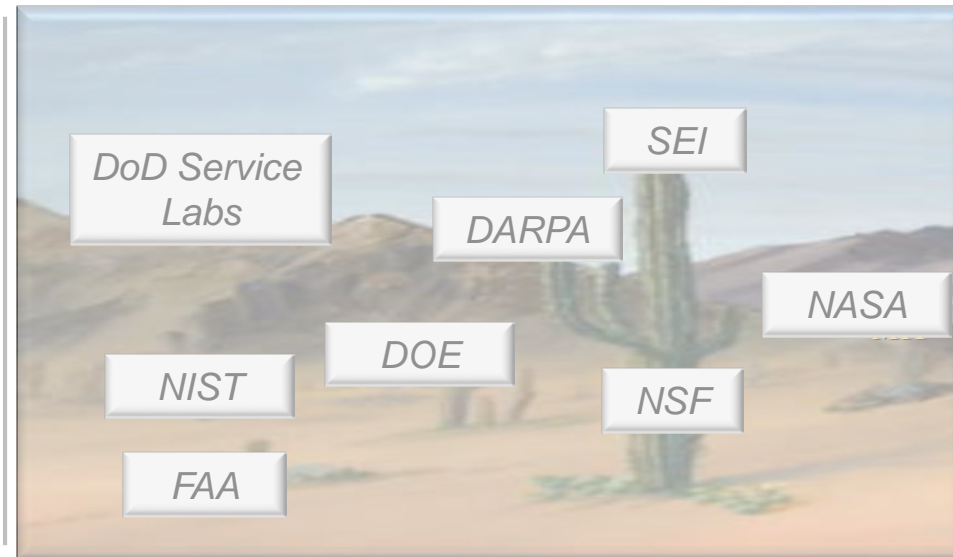
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Industry R&D *Alone* is Insufficient

- Targeted for specific products
- Focus is on selling products
- LSIs haven't viewed software as profit driver historically
- Global resourcing for R&D is limited in the mil/aero domain

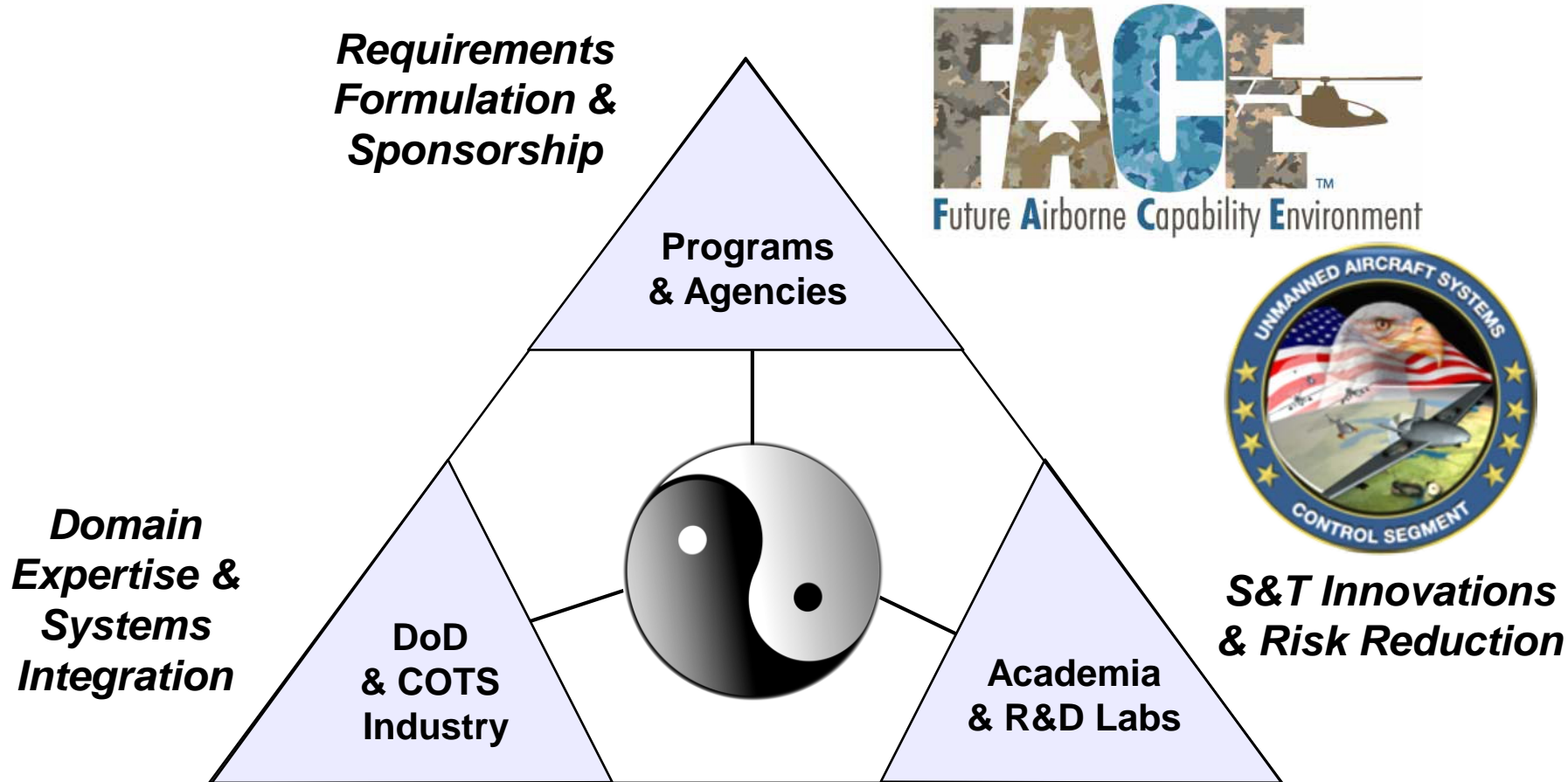


A Path Forward



Elements of a Collaborative R&D Strategy

Advance the practice of mission-critical CPS via intentionally coordinated research & OSA-based technology transition



EXPLORE

CREATE

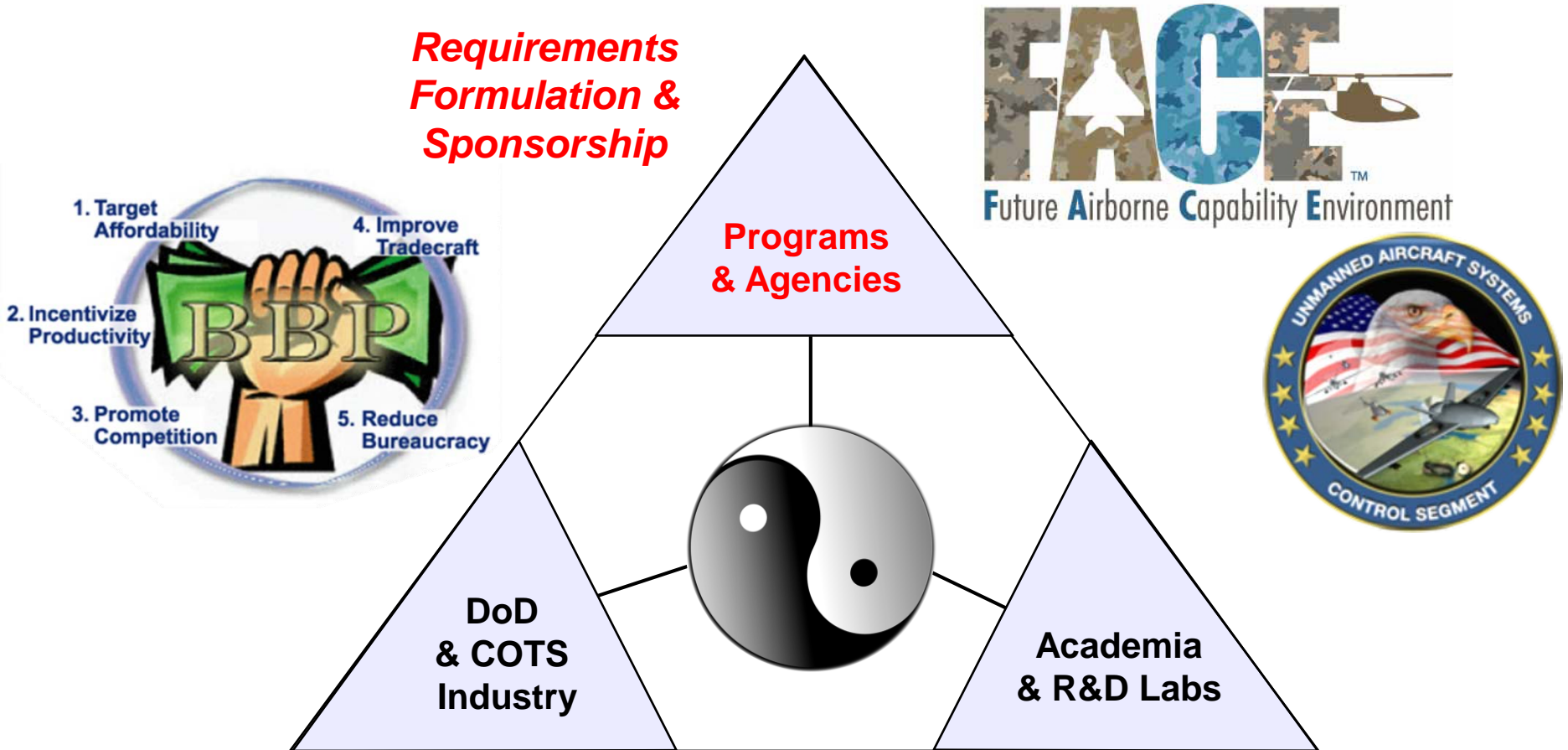
APPLY

AMPLIFY

SUSTAIN

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EXPLORE

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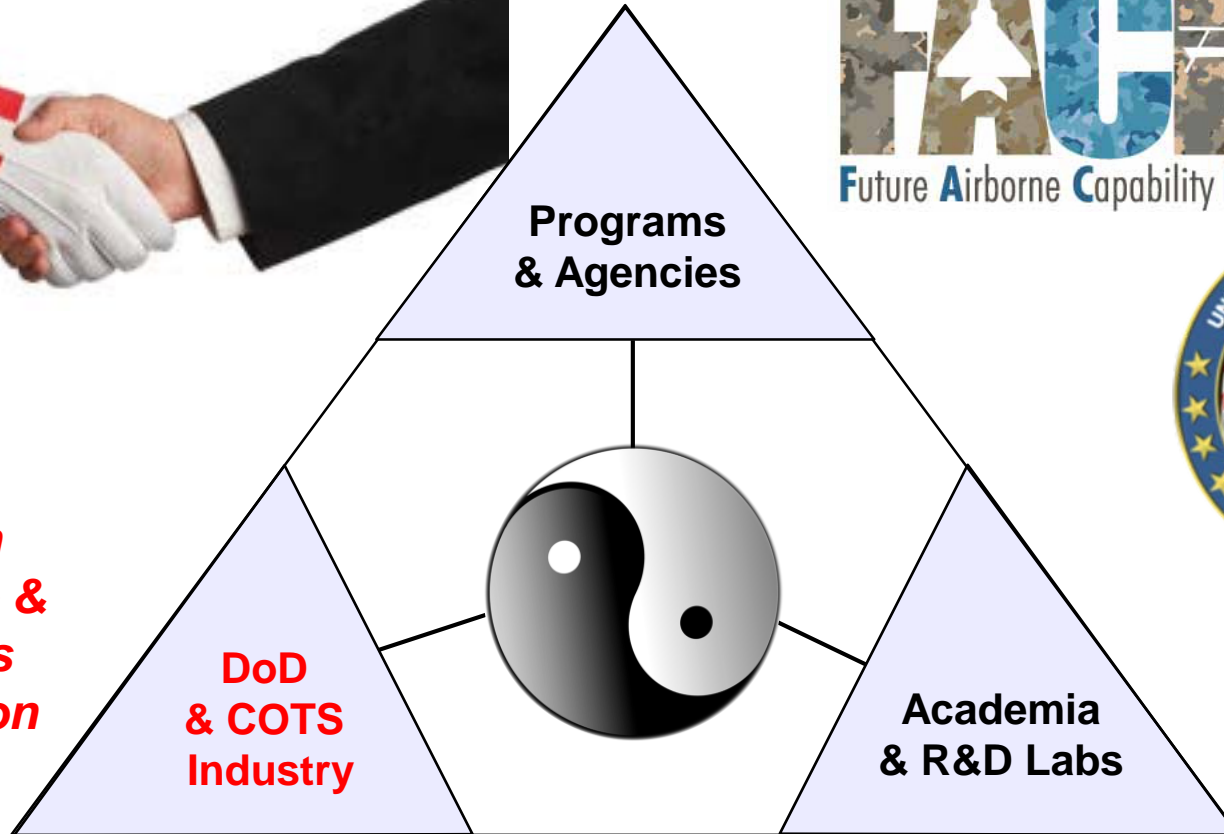
SUSTAIN

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Advance the practice of mission-critical CPS via intentionally coordinated research & OSA-based technology transition



**Domain
Expertise &
Systems
Integration**



EXPLORE

CREATE

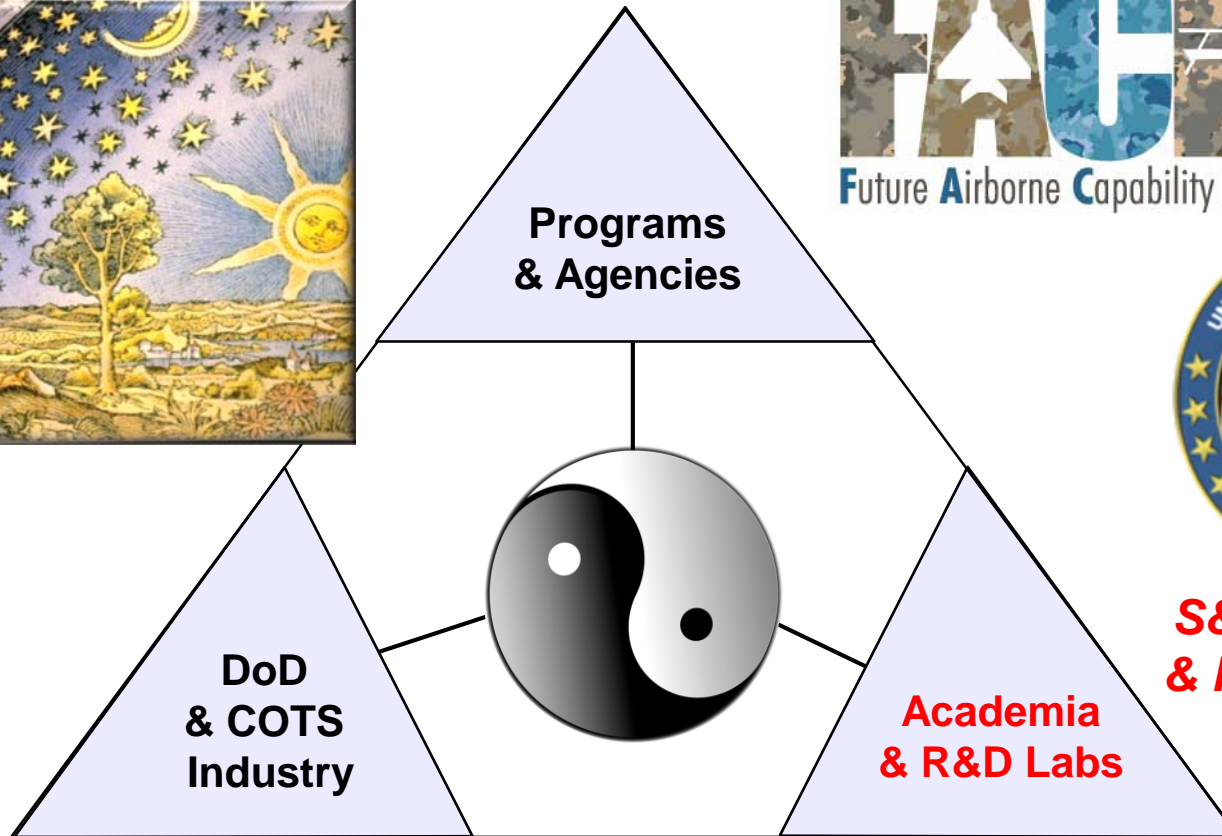
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**S&T Innovations
& Risk Reduction**

EXPLORE

CREATE

APPLY

AMPLIFY

SUSTAIN

Keeping an Unfair Advantage in a COTS World

Premium value & competitive advantage flows to programs, companies, & individuals that

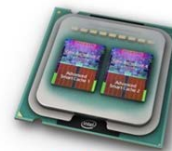
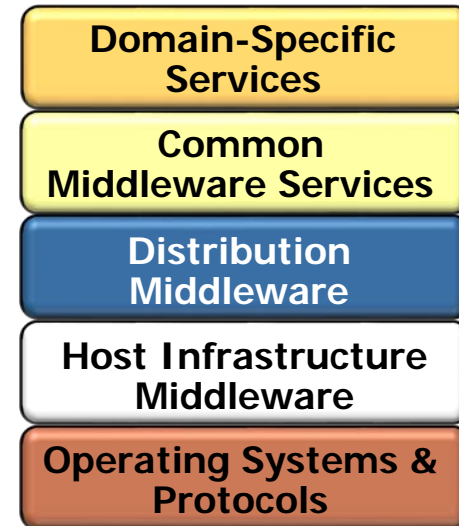
- Invest wisely in R&D



Keeping an Unfair Advantage in a COTS World

Premium value & competitive advantage flows to programs, companies, & individuals that

- Invest wisely in R&D
 - e.g., leveraging advances in COTS hardware & software



*Multi-core
Chips*



*Symmetric
Multiprocessors*



Blade Clusters



Public/Private Clouds

Keeping an Unfair Advantage in a COTS World

Premium value & competitive advantage flows to programs, companies, & individuals that

- Invest wisely in R&D
- Master principles, patterns, & protocols needed to integrate COTS hardware & software in complex systems that *can't* be bought off-the-shelf (yet)

