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

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Open Systems Architecture: Progress & Challenges
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Implications of DoD Competing in a “Flat World”
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- Shift in Technical Talent Base
- Global Access to Technology
- Shift in Technical Talent Base
- Increasing Pace of Innovation
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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
• 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)

\[\text{Avionics Mission Computing Functions}\]

- 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.

Innovations packaged as COTS technologies.

x86 chipsets

TCP/IP switches
Why Software Doesn’t Improve as Consistently

CPS software is not as standardized or reusable as hardware

Standard/COTS/GOTS Hardware & Networks
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Proprietary & Stovepiped Application/Infrastructure Software

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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
"New GAO report highlights $6.9 billion in over-budget IT projects at the Department of Defense" – ZDNet, 9/30/2010
CPS Software is Growing in Size & Importance

Software & testing delays push costs above the Congressional ceiling

Multi-year delays associated with software & system stability

Source: Lockheed Martin Aeronautics

% of Specification Requirements Involving Software Control

- 0% - 100%
- 20% - 80%
- 40% - 60%
- 80% - 100%

Program (Year):
- F-4 (1960)
- A-7 (1964)
- F-111 (1970)
- F-15 (1975)
- F-16 (1982)
- B-2 (1990)
- F-22 (2000)
- F-35 (2006)
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% of Specification Requirements Involving Software Control

Source: FY11 Air Force SAB study on “Sustaining Aging Aircraft”
CPS Software is Growing in Size & Importance

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

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

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

In the misconception, the IT industry is portrayed as a well-populated oasis, suggesting a thriving and abundant environment for CPS programs. In reality, the IT industry is depicted as a desert, indicating a need for significant R&D investment to transform it into a hospitable environment for CPS development. This visual contrast highlights the need for substantial investment in research and development to make the IT industry more conducive to CPS projects. The names of various companies and organizations, such as Google, Apple, Microsoft, Cisco, IBM, HP, Xerox PARC, Oracle, Facebook, DoD Service Labs, DARPA, SEI, NIST, DOE, NASA, NSF, and FAA, are used to illustrate the scale and scope of the investment required.
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Gap between (1) IT needs for CPS & (2) IT that can be afforded given
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- Google
- Apple
- Microsoft
- HP
- Cisco
- IBM
- Xerox PARC
- Oracle
- Facebook
- DoD Service Labs
- SEI
- DARPA
- NASA
- NIST
- DOE
- NSF
- FAA

Gap between (1) IT *needs* for CPS & (2) IT that can be *afforded* given
- Current technology maturity
Gap between (1) IT *needs* for CPS & (2) IT that can be *afforded* given:

- Current technology maturity
- Limited software R&D investment
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Gap between (1) IT *needs* for CPS & (2) IT that can be *afforded* given
- Current technology maturity
- Limited software R&D investment
- Atrophy of government expertise
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Industry R&D *Alone* is Insufficient
• Targeted for specific products
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- Focus is on selling products
  – dependability is lower priority
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- FAA
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- CMU
- Stanford
- USC ISI
- MIT

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- 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

- Requirements Formulation & Sponsorship
- Programs & Agencies
- Domain Expertise & Systems Integration
- DoD & COTS Industry
- Academia & R&D Labs
- S&T Innovations & Risk Reduction

EXPLORE  CREATE  APPLY  AMPLIFY  SUSTAIN
Elements of a Collaborative R&D Strategy

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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
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)