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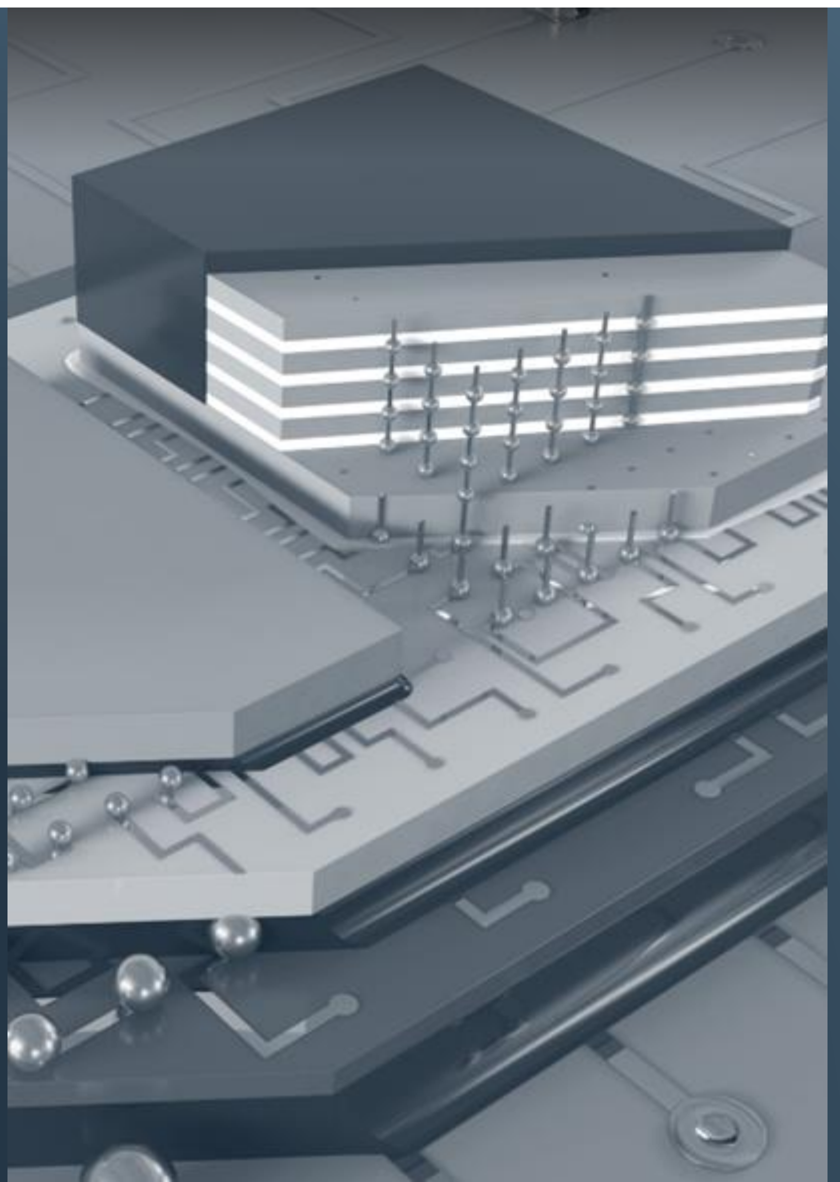

ADVANCED PACKAGING FOR GOVERNMENT NEEDS

Julian Warchall Ph.D., Senior Lead Engineer

Saverio Fazzari, Engineering Fellow

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APRIL 2023

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CONSULTING | ANALYTICS | DIGITAL SOLUTIONS | ENGINEERING | CYBER

A CHANGING LANDSCAPE REQUIRES MODERNIZATION

"The strategic landscape is rapidly changing. We are witnessing a fundamental shift in the character of war. […] China is increasing its military capability at an aggressive rate. We must ensure that we retain our competitive and technological edge against this pacing [challenge]."

VADM Ronald A. Boxall, USN
Joint Staff Director of Force Structure, Resources & Assessment

Source: U.S. Marine Corps

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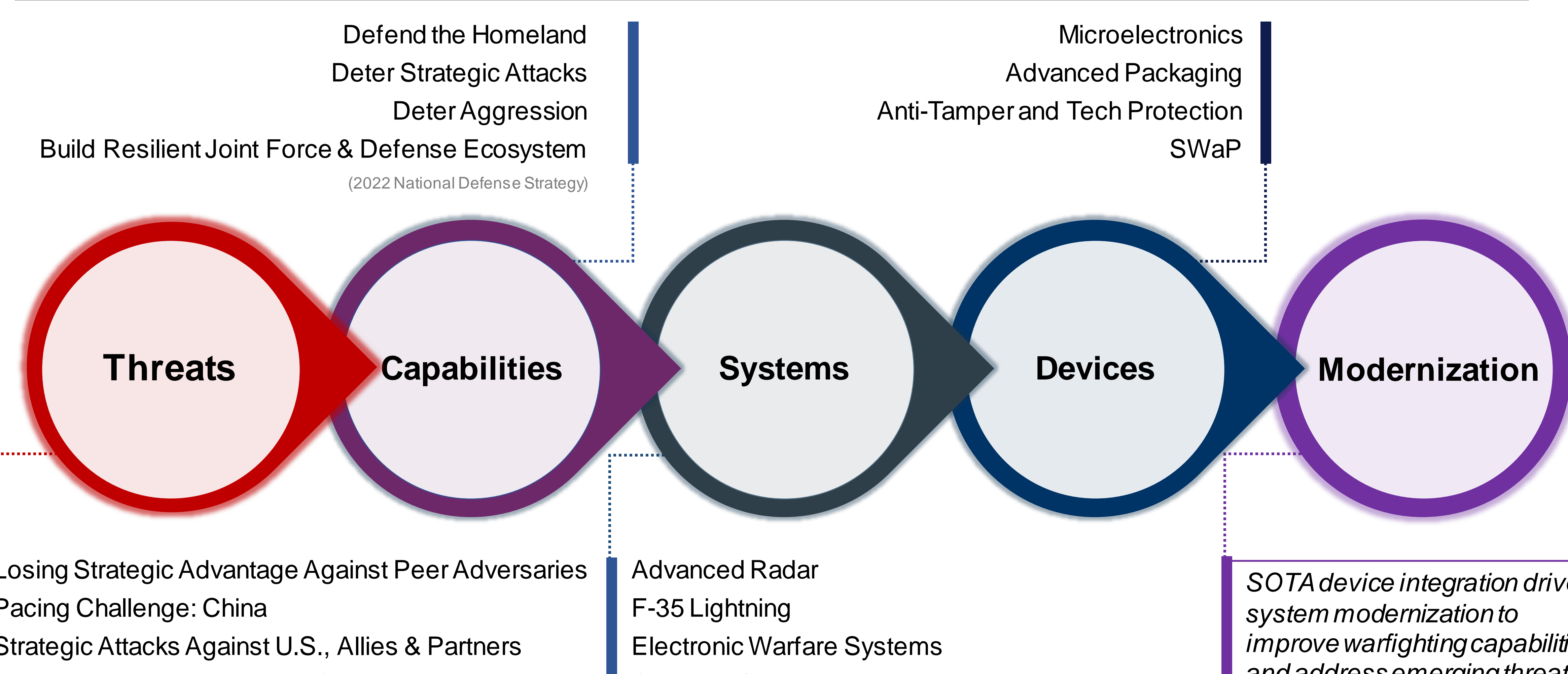
THREATS DRIVE WARFIGHTER NEEDS



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COMMERCIAL APPROACH HAS LOW SUSTAINMENT COST AND FASTER DEPLOYMENT

** Normalized to 2022 dollars

2007
Touchscreen, apps, camera
BOM $307 **

Blackberry

2010
+ Higher-res, gyroscope
BOM $251 **

Samsung
Blackberry

2015
+ Carplay, haptic I/F
BOM $261 **

Samsung
Google

2017
+ OLED, Face ID
BOM $442 **

Samsung
Google

2020
+ quad camera, XDR OLED
BOM $459 **

Samsung
Google

- Multi-decade platform
- Evolving adversaries and adversary capabilities
- Revisions utilize new HW and methodologies
- BOM doesn't always increase for new HW

2006
First flight

Russia
China

2012-2017
operational life

2023-2025

- HW system largely unchanged
  - DMS upcoming for multiple components
- Operational life issues remain (assumed)

Russia
Other ME suppliers
China
} *Adversaries Connecting*

- Multi-decade platform
- Evolving adversaries and adversary capabilities
- Revisions focus on socket replacements
- BOM increases for new HW

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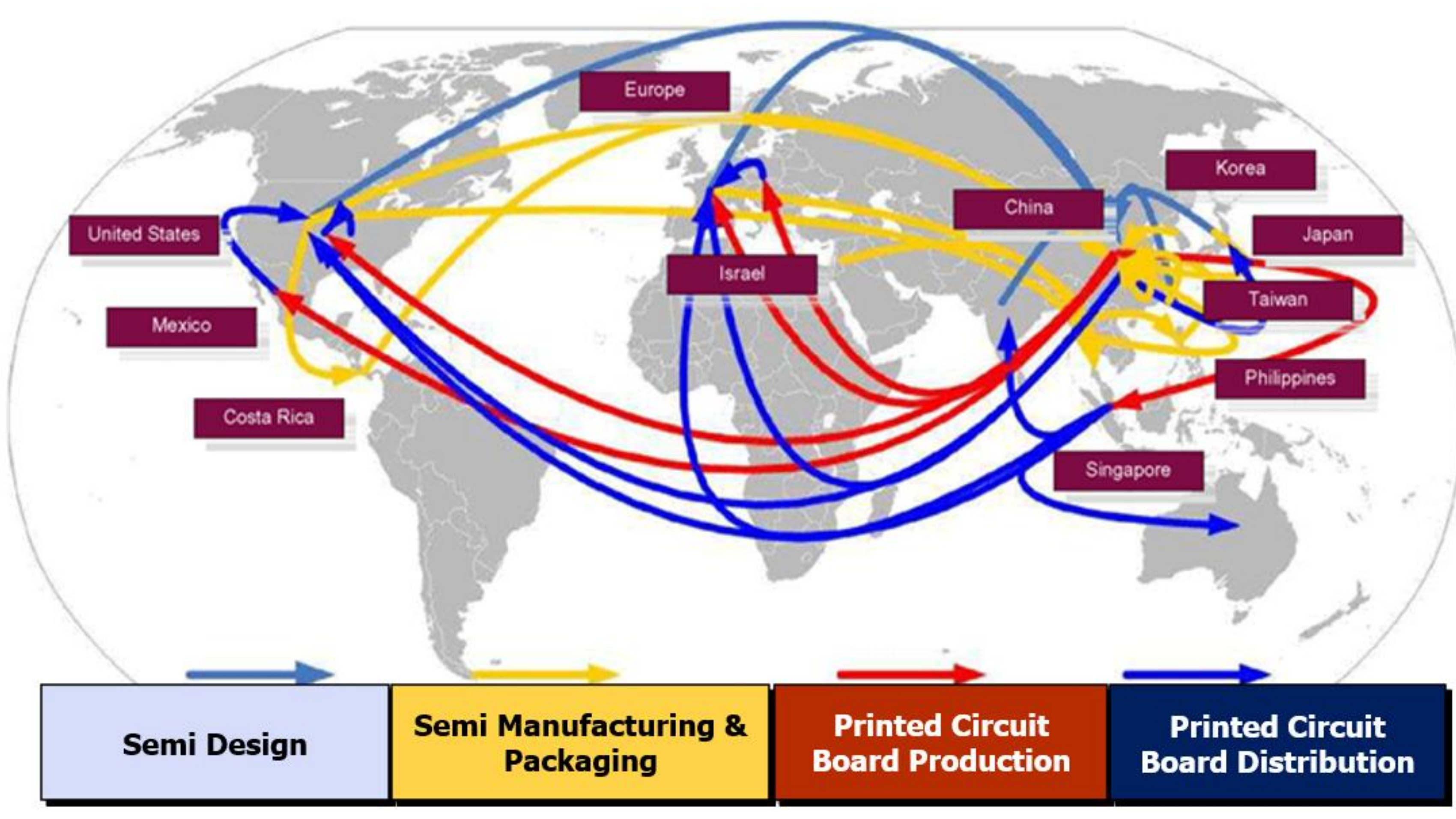
SEMICONDUCTOR SUPPLY CHAIN – COMPLEX, GLOBAL SUPPLY NETWORKS



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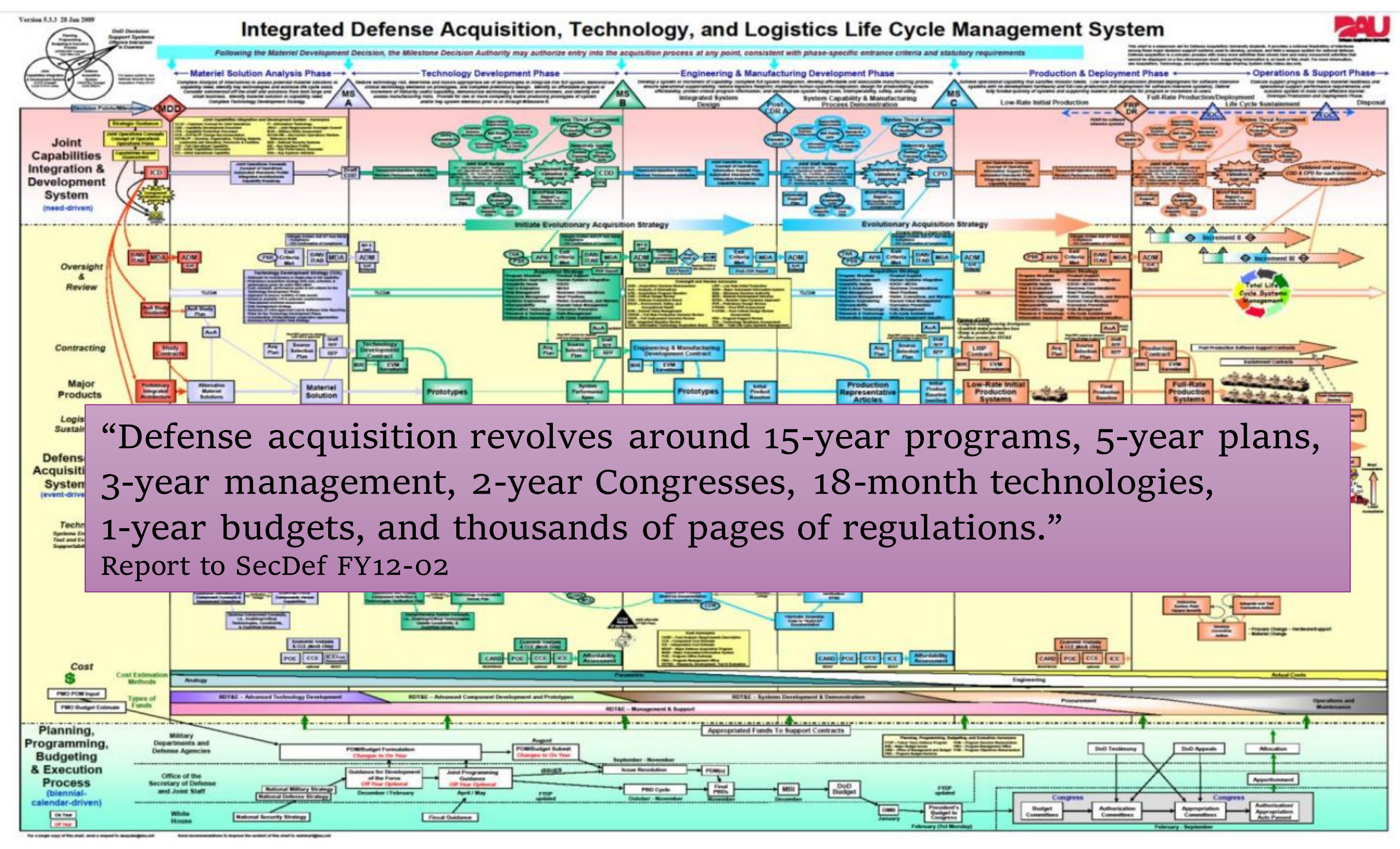
DOD ACQUISITION IS A MAN-MADE CHALLENGE



“Defense acquisition revolves around 15-year programs, 5-year plans, 3-year management, 2-year Congresses, 18-month technologies, 1-year budgets, and thousands of pages of regulations.”
Report to SecDef FY12-02

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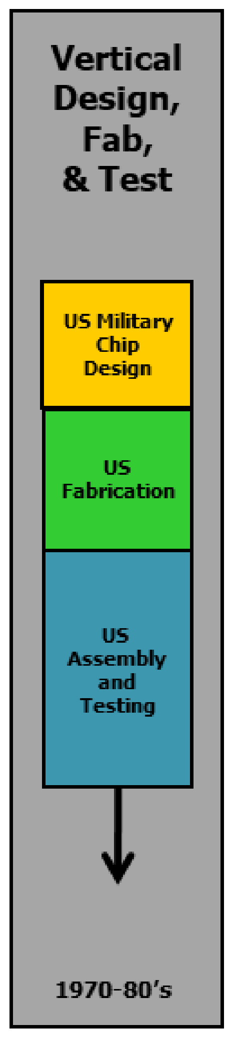
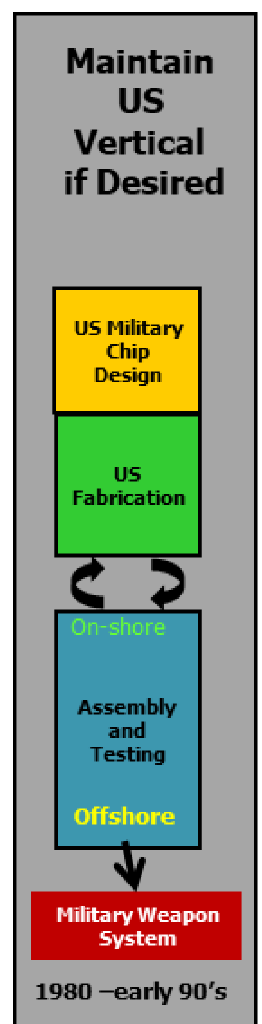
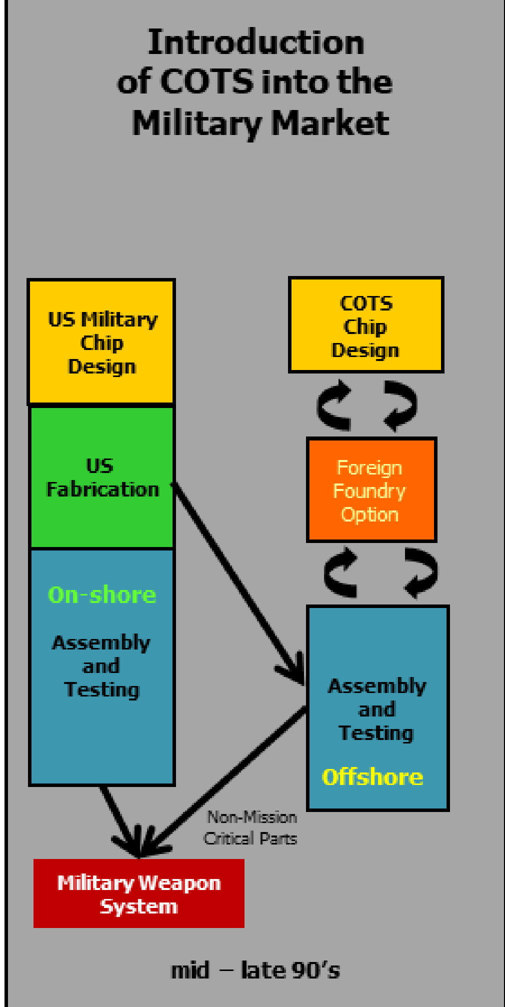
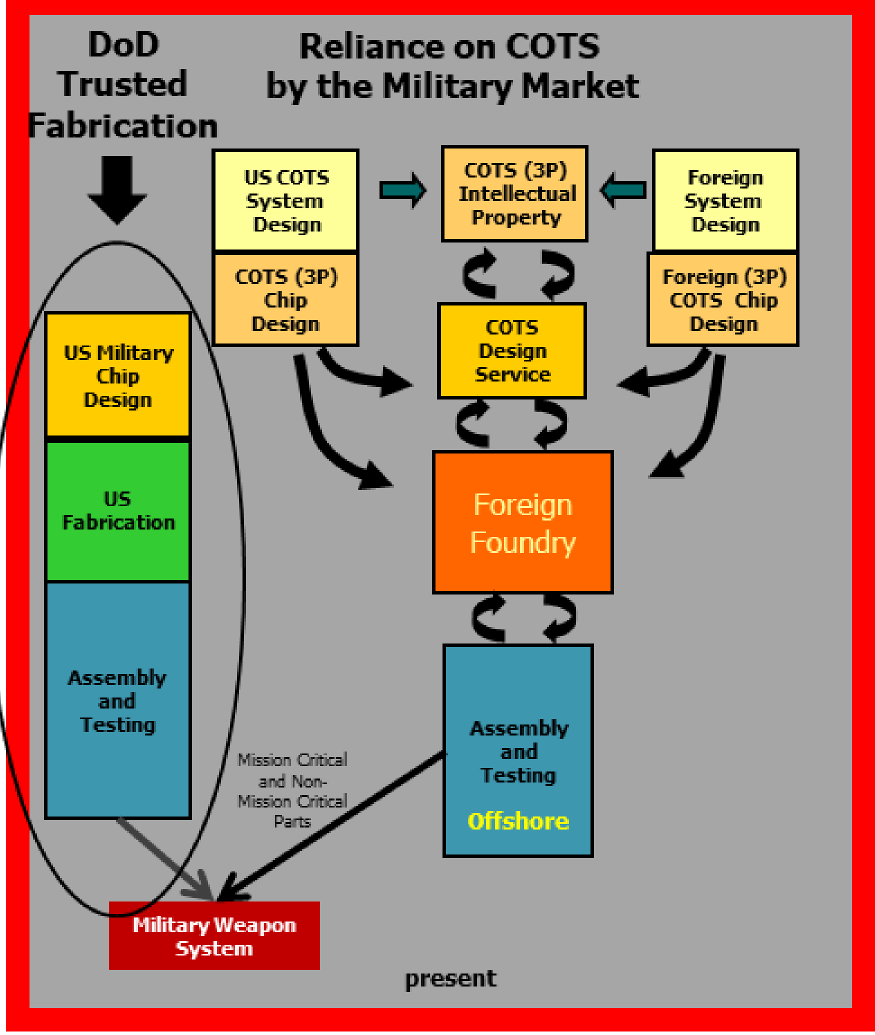
SUPPLY CHAIN EVOLUTION FOR MILITARY IC NEEDS









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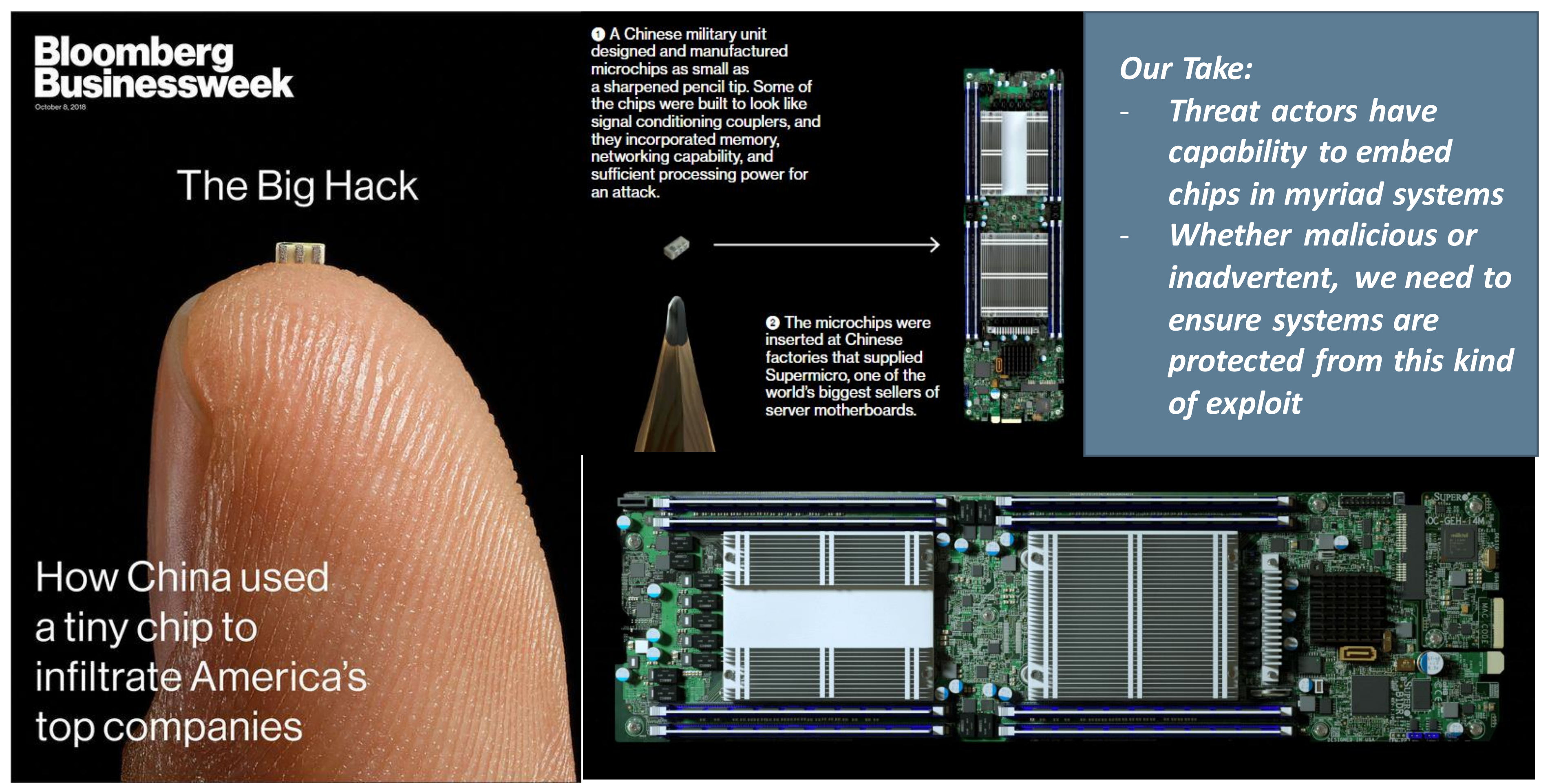
HARDWARE SUPPLY CHAIN: THREATS HAVE EVOLVED AND BROADENED IN SCOPE



Our Take:

- ***Threat actors have capability to embed chips in myriad systems***
- ***Whether malicious or inadvertent, we need to ensure systems are protected from this kind of exploit***

https://www.bloomberg.com/news/features/2018-10-04/the-big-hack-how-china-used-a-tiny-chip-to-infiltrate-america-s-top-companies

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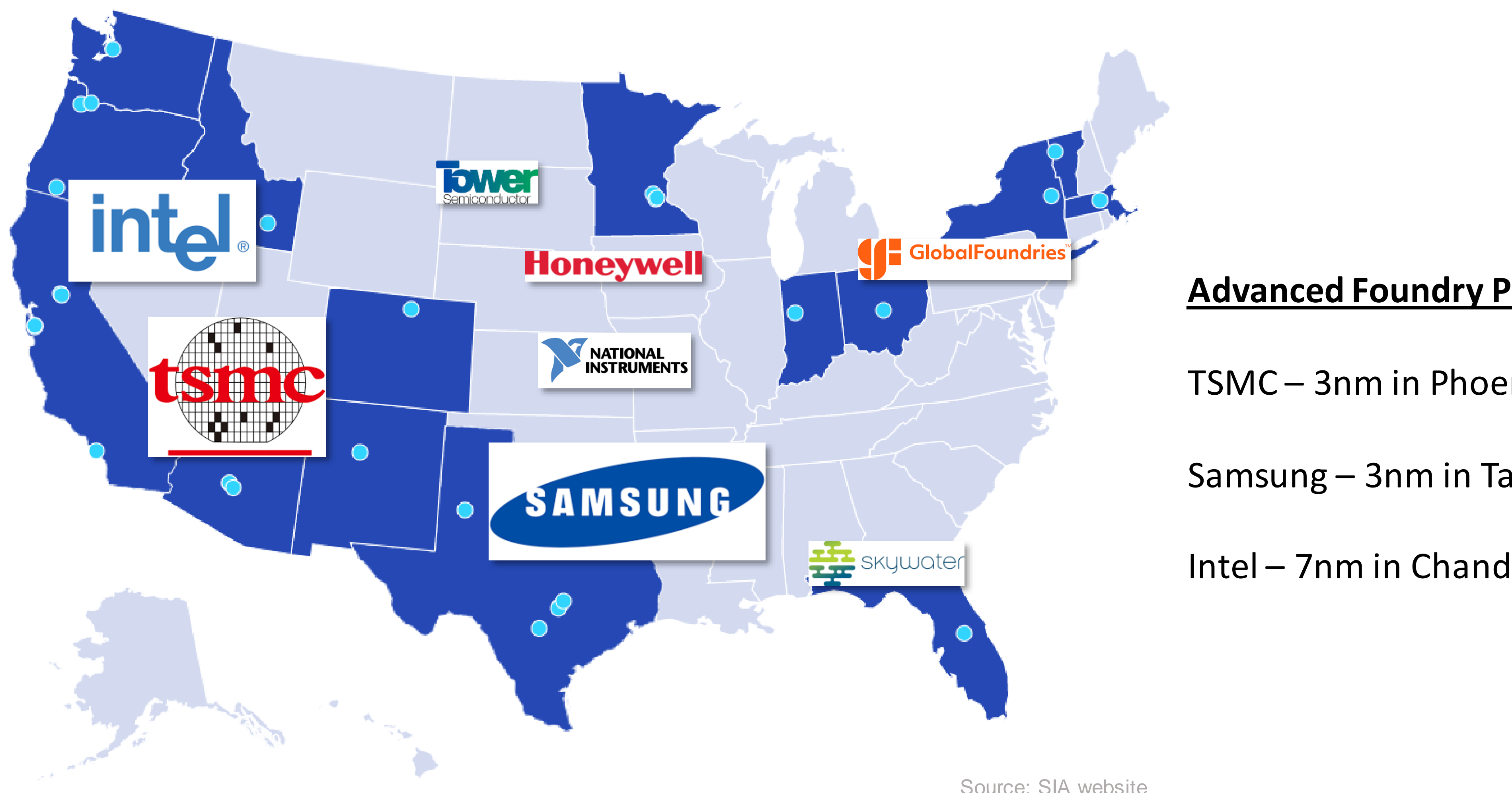
ON-SHORING: FOUNDRIES IN THE U.S., BUT IS IT ENOUGH?



Source: SIA website

Advanced Foundry Plans:

TSMC – 3nm in Phoenix, AZ

Samsung – 3nm in Taylor, TX

Intel – 7nm in Chandler, AZ

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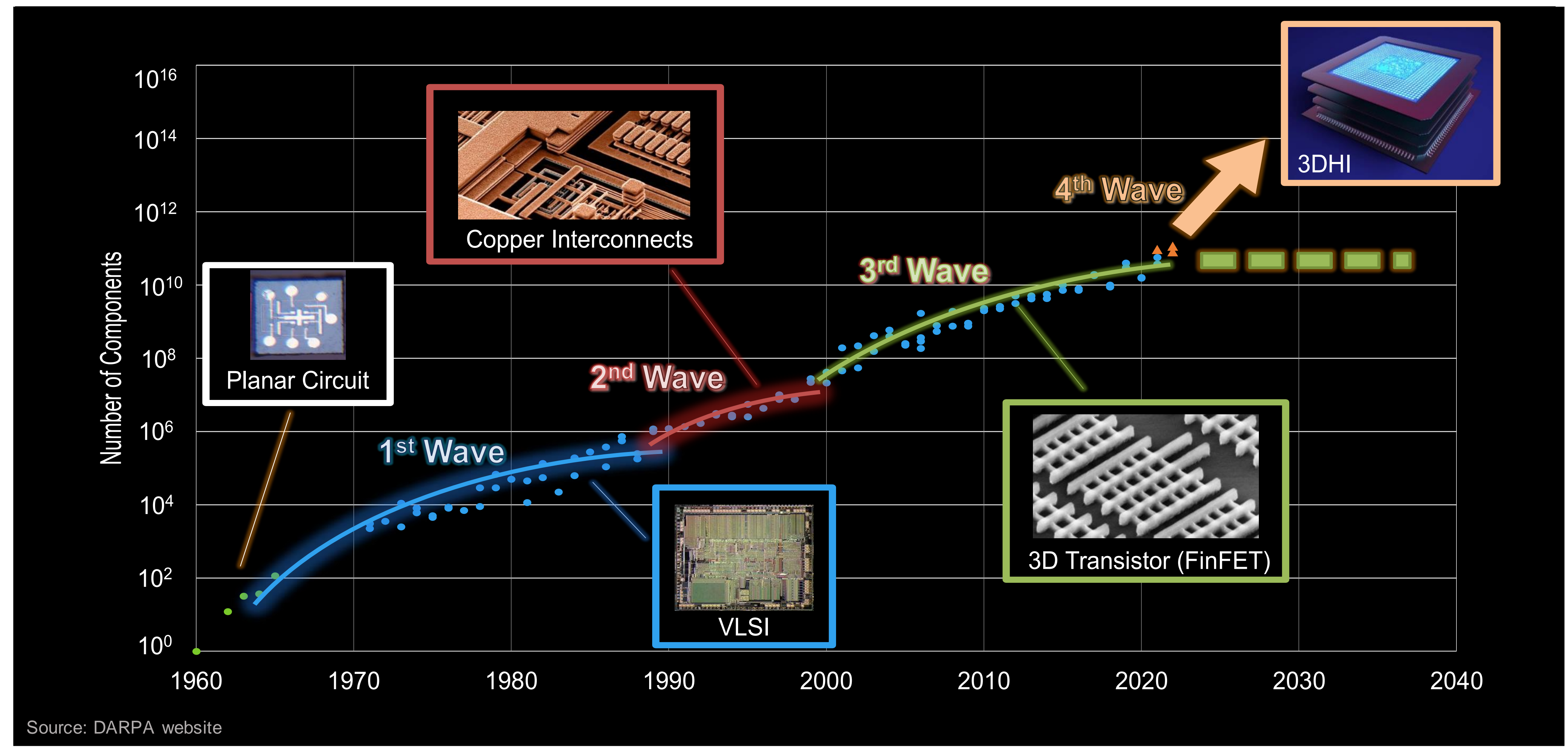
DARPA ERI 2.0: FOUR WAVES IN MICROELECTRONICS INNOVATIONS



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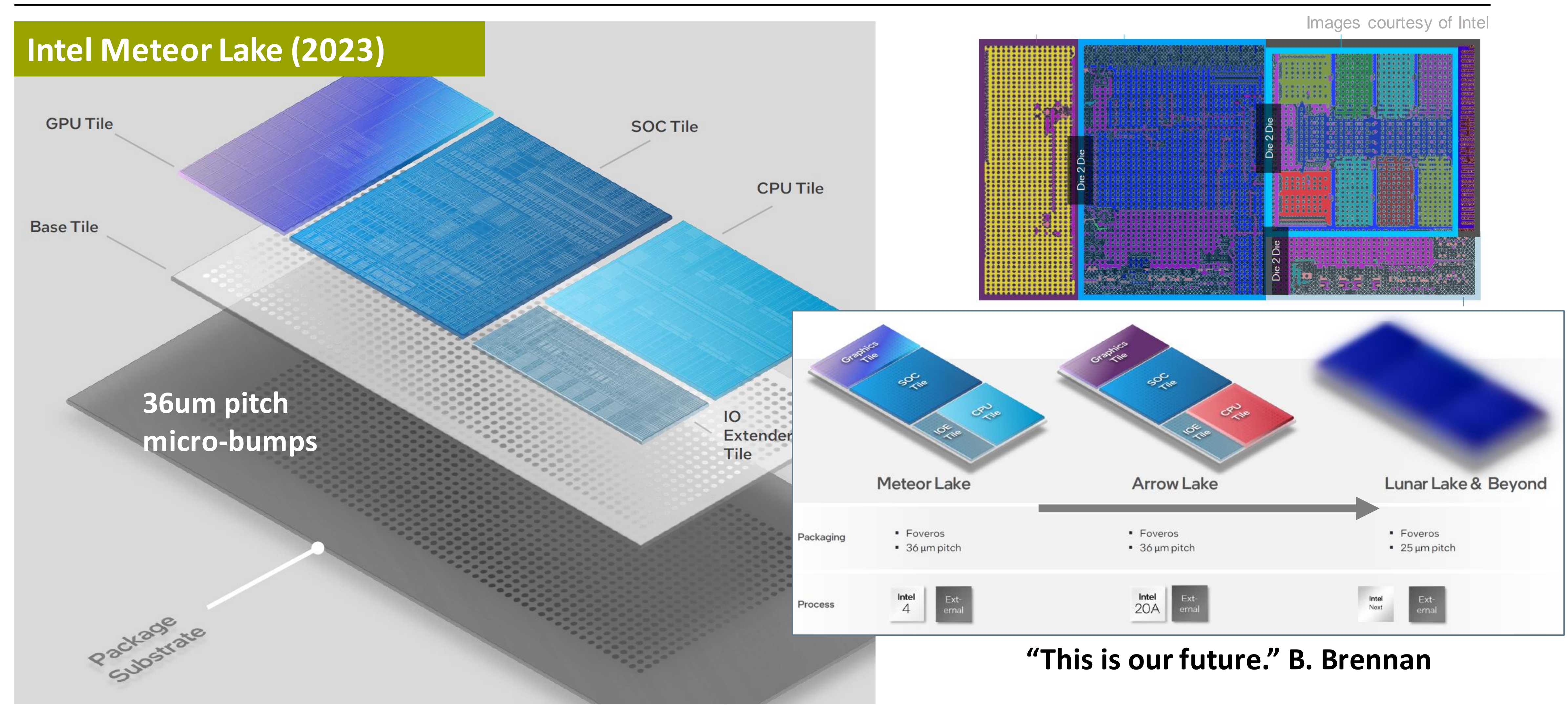
THE FOURTH WAVE IS UNDERWAY

Intel Meteor Lake (2023)

Images courtesy of Intel



"This is our future." B. Brennan

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OVERSEAS COMPETITION RIDING THE WAVE

China forms its own chiplet standard amid isolation

Technology News | March 27, 2023

By Peter Clarke

INTERCONNECT & CABLES | CHINA | IOT | ANALOG

The China Chiplet Industry Alliance has released the ‘Chiplet Interconnection Interface Standard’ known as ACC1.0, according to the *Financial Association Press.*

https://www.eenewseurope.com/en/china-forms-its-own-chiplet-standard-amid-isolation/

> “This could allow China’s trailing-edge manufacturing capability to continue to contribute to relatively advanced ASICs.”

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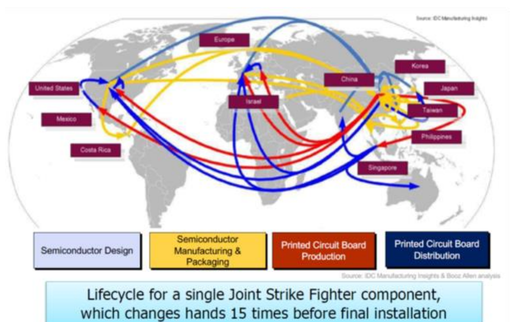
CHALLENGES FOR THE GOVERNMENT IN THE ADVANCED PACKAGING (AP) LANDSCAPE

Complex International Supply Chain



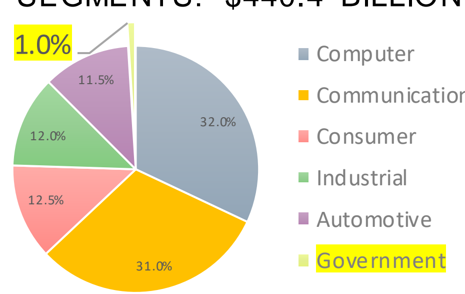
- SOTA microelectronics devices travel around the globe many times over
- >90% of packaging activities are done offshore
- Global semiconductor manufacturing is at 100% capacity

Heterogeneous Integration Challenges

- New/emerging commercial trends, chiplets and HI, provide a unique opportunity for USG and DoD to gain SOTA packaging solutions
- USG and Industry collaboration is critical to address challenges

Consumer-Driven Market

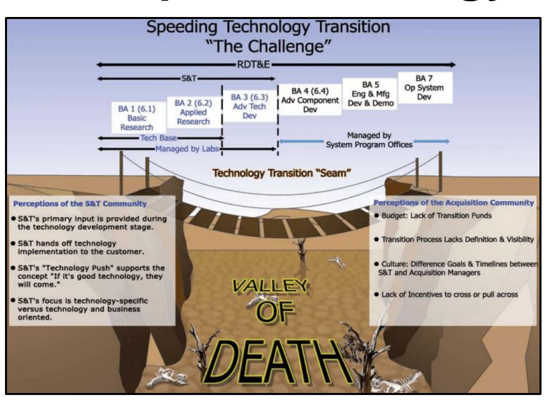
SEMICONDUCTOR MARKET SEGMENTS: $440.4 BILLION



Source: SIA 2021

- DoD is <1% of total microelectronics revenue
- Market and innovation is driven by high-performance commercial market
- High-mix, low-volume DoD needs don't align with commercial strategy

Rapid Technology Change and Adoption



- While front-end nodes advance every 2-years, AP technologies advance much more rapidly
- Lifecycle of DoD systems leads to need for consistent modernization
- "Valley of Death"

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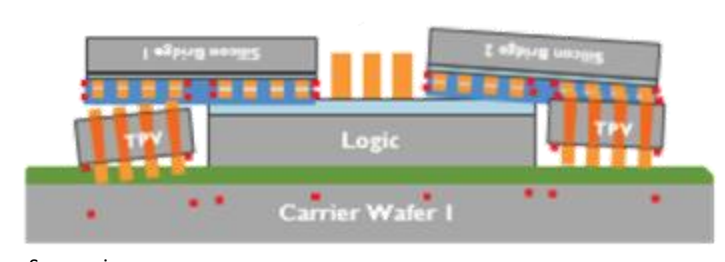
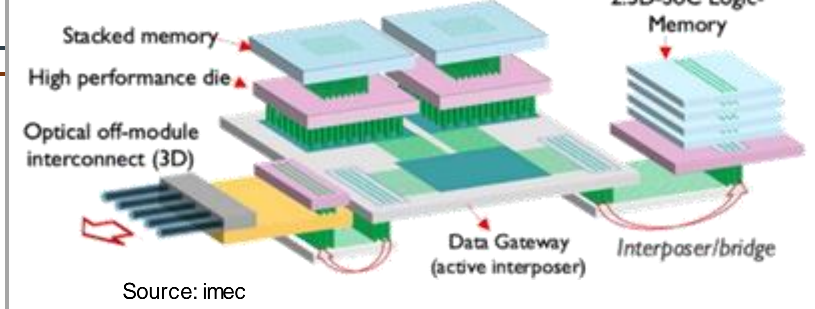
ADDRESSING CHALLENGES: DOD AND INDUSTRY COLLABORATION



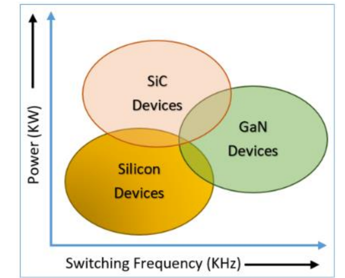
Source: imec

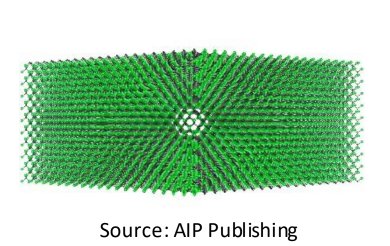
WLP combined with 2.5D/3D lowers latency and can reduce power consumption
Warpage, Die Shift, Die Tilt, Reliability

DoD and Industry collaboration will enable solutions for SOTA packaging challenges while granting the DoD access to SOTA packaging through programs like SHIP



Source: imec





Source: AIP Publishing

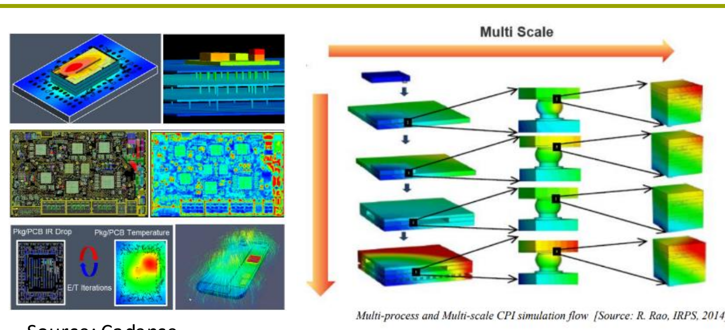
Integrating material sets for HI to support high power and mixed signals
Thermal Management, CTE Mismatch

Bump size & pitch

Standard C4 bump	Fine pitch C4	Micro C4 bump	Cu pillar bump	Flat Cu pillar	Bump-less
100 µm, 150 -200 µm pitch	50 µm, 100 µm pitch	20 - 30 µm, 30 - 60 µm pitch	15 - 20 µm, 20 – 40 µm pitch	10 µm, 20 µm pitch	5 µm, 10 µm pitch

S. Ramalingam, CMC conf. 2016

Bump scaling leads to higher interconnect density for increased performance
Yield, Reliability, Domestic Capability, Capital Investment



Source: Cadence

Design & verification for HI requires multi scale and multi physic tools
Cost, Design Time

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ADDRESSING A CONSUMER-DRIVEN MARKET: THE NAVY SHIP PROGRAM

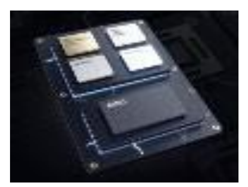
State-of-the-Art Heterogeneous Integrated Packaging (SHIP) Program

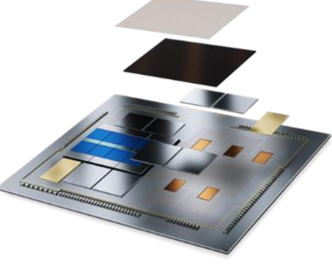
Motivation

- Earlier access to assured SOTA microelectronics
- US-based, economically-viable SHIP capability for DoD system performance enhancement and assurance/security applications
- Provide sustainable, quantifiably-assured SOTA advanced packaging access to the DoD and the DIB

Objectives

- Develop a model for access to SOTA parts
  - Self-sustained business model for DoD access to customized SOTA parts using standard commercial flow
  - Prototypes validate the model, are not the end goal
- Advance DoD capabilities
  - Improved performance, SWaP-C
  - Availability of SOTA parts
  - Domestic manufacturing
  - Increased functional density
  - Pathway to modernization

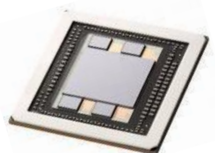




SHIP Digital

Design, Assembly, Test, & Security Knowledge Transfer

SHIP RF



Delivering value to the USG and DIB

SHIP leverages top commercial tech while allowing DoD customization

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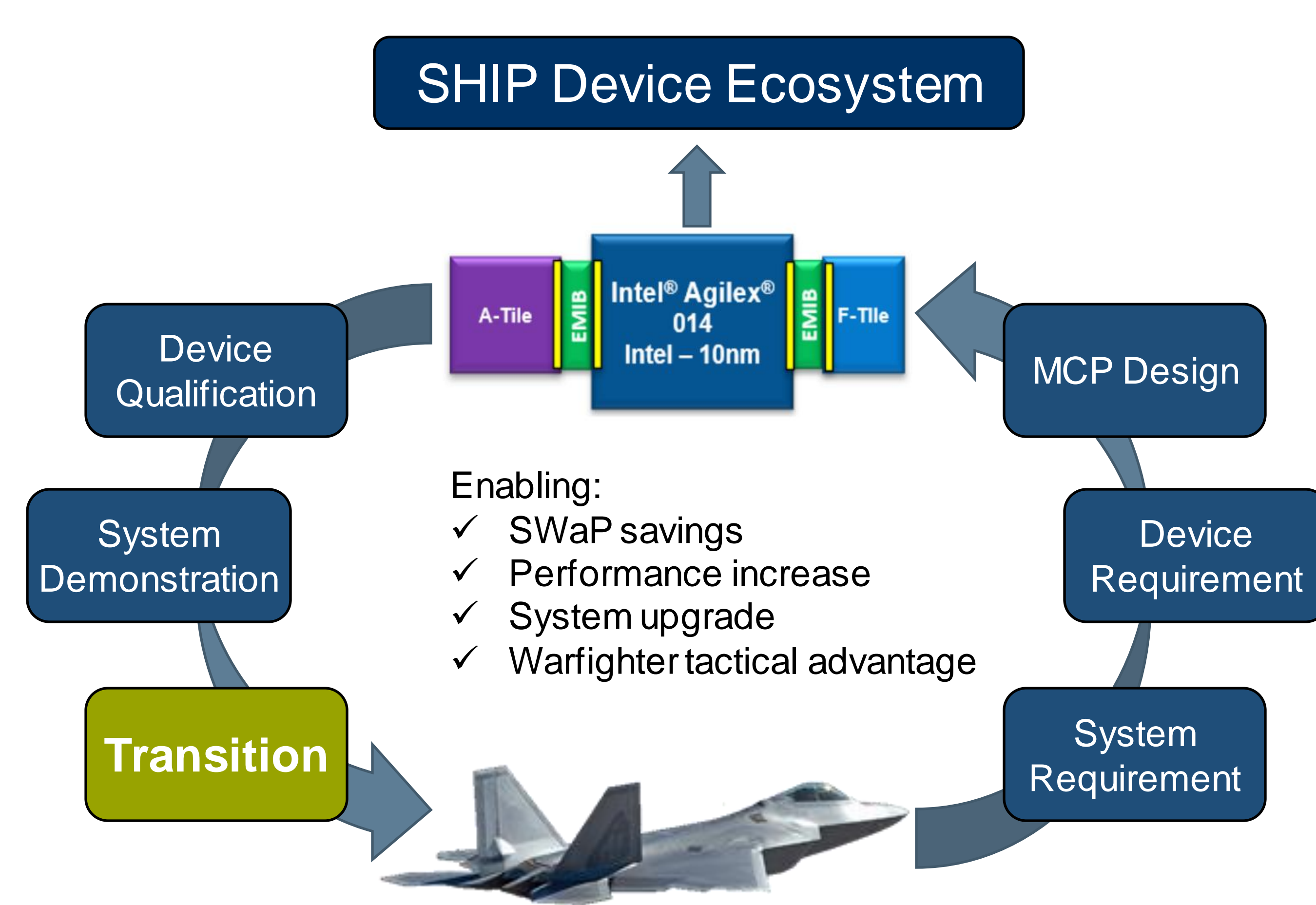
ADDRESSING RAPID TECHNOLOGY CHANGE: SHIP TRANSITION

- **DIB, Services, and Program Office collaboration is critical for SHIP device transition**
- DIB is in the position to translate DoD warfighting capabilities down to MCP functionality and performance requirements
- SHIP is a prototyping program; transition falls on the Acquisition community
- Navy is engaged in transition strategy extended past typical prototyping efforts
- Transition is a critical metric of success; must be clearly demonstrated to sustain future programs



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DOD MODERNIZATION IMPACT

System Capability Modernization

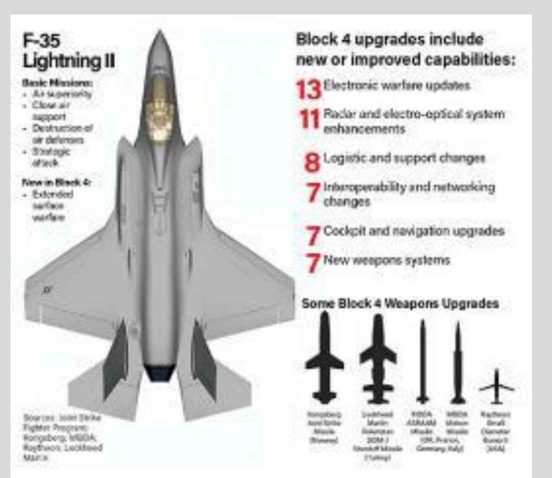
- Increased Functional Density and Performance
- Facilitated through SWaP-C improvements
- Enables increased functional density of systems; capabilities and performance continually augmented and fit into the same from factor

Current
Block 4

F35A 2006 1st Flight

Continuous enhancements and improvements will be made to increase capabilities that **make the F-35 more lethal and survivable**.

Increasing the number of separate subsystems into ever more tightly integrated packages → Increased function, performance, capabilities



53 improvements to counter both air- and ground-based threats

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THANK YOU!

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