

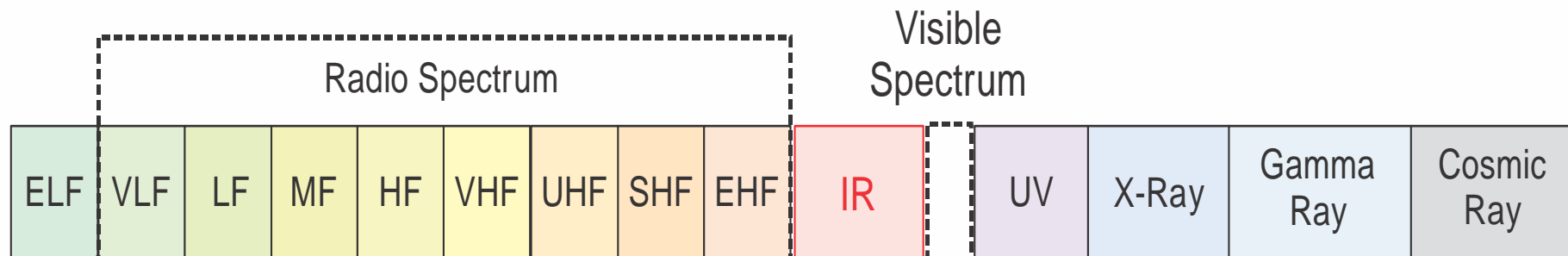
Future of Electromagnetic Spectrum Warfare



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EM spectrum more than just the radiofrequency spectrum



Legend

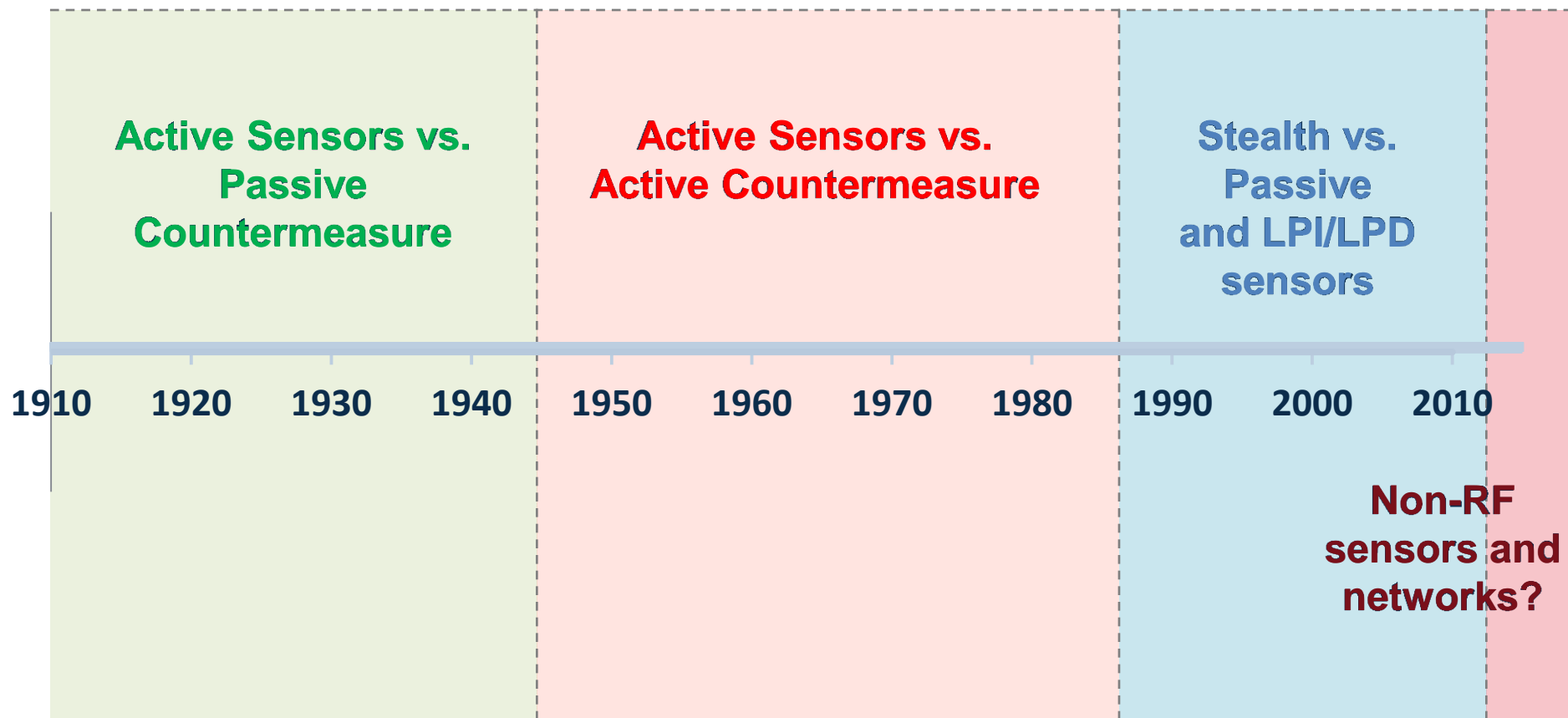
EHF extremely high frequency
ELF extremely low frequency
GHz gigahertz
HF high frequency
IR infrared

LF low frequency
MF medium frequency
MHz megahertz
SHF super-high frequency

UHF ultrahigh frequency
UV ultraviolet
VHF very high frequency
VLF very low frequency

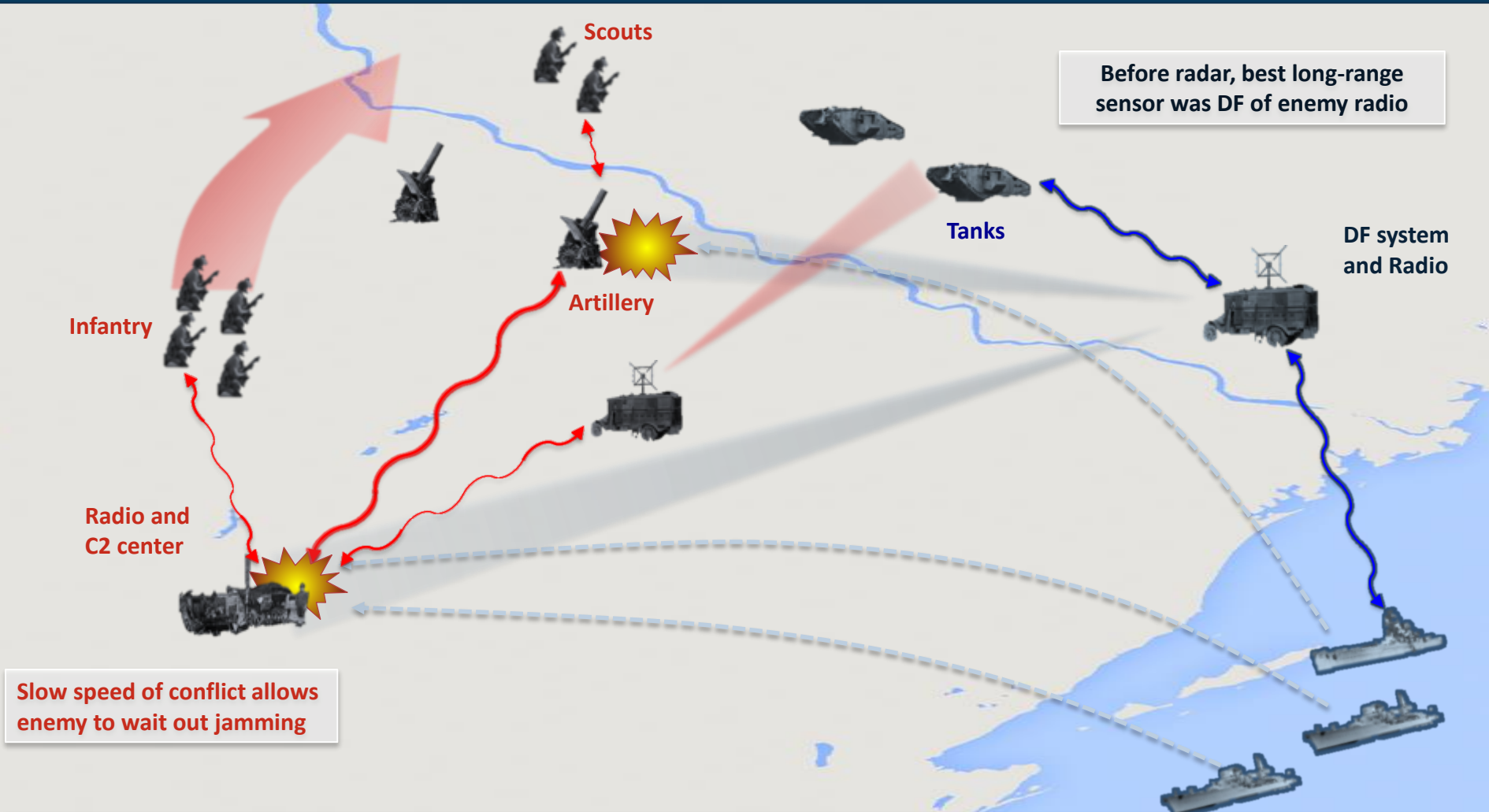
EMS warfare includes communications, sensing, and electronic warfare in RF, visible, IR, UV, and X-ray portions of the spectrum

Innovation proceeds through phases driven by predominant sensor tech



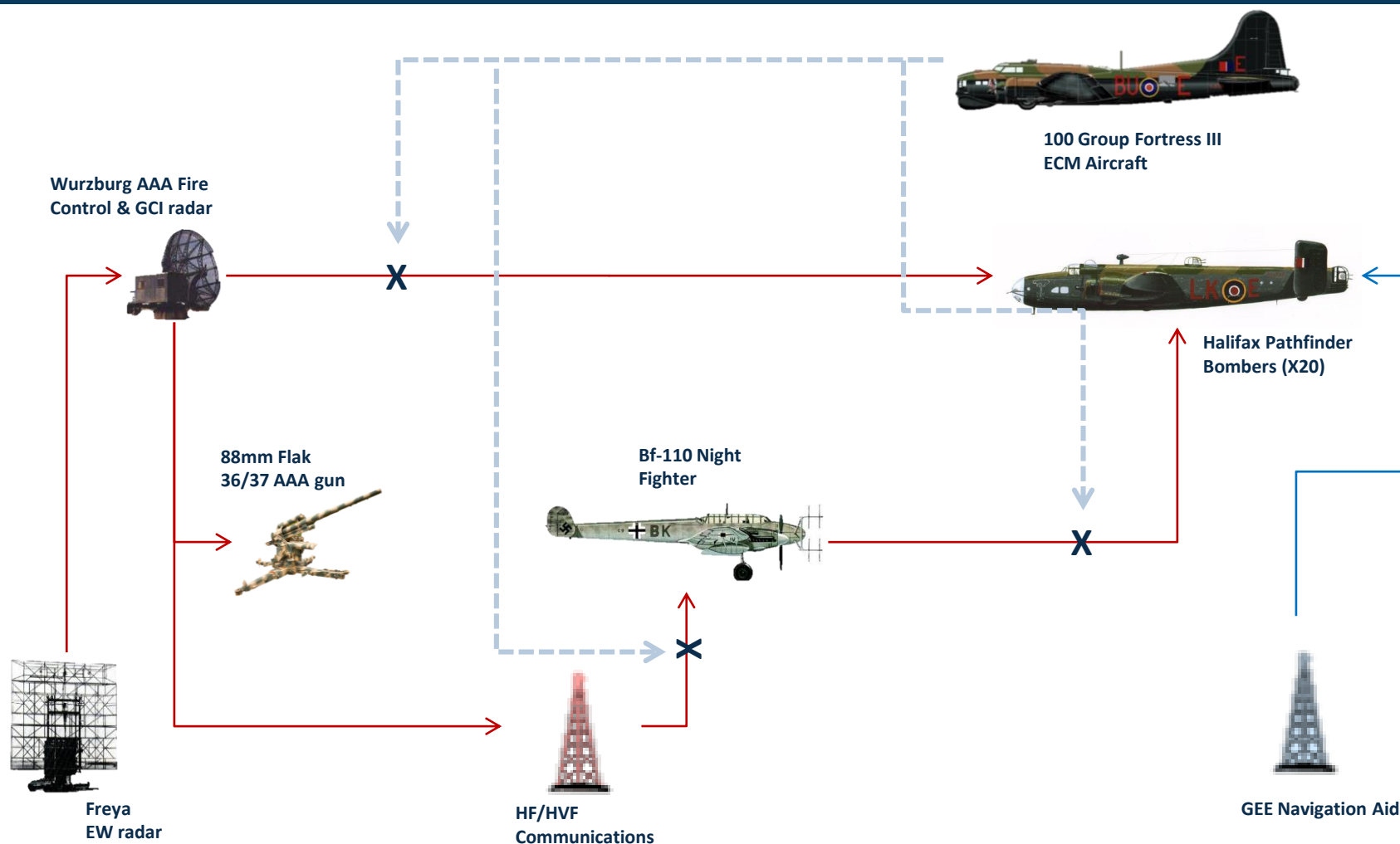
Move and countermove accelerates in each phase until a combination or new technology and operational concepts cause competition to jump to next phase

WW I: radio & radar vs. passive countermeasures



*Jamming possible but not used because friendly comms would also be affected;
slow pace made exploitation of comms and radar more beneficial*

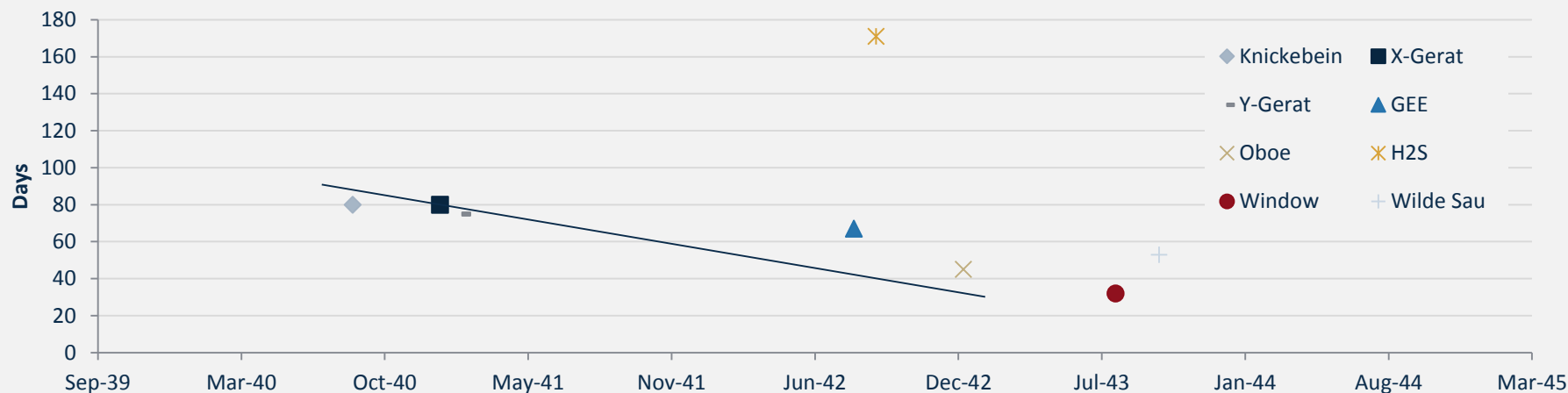
WW II: Radio & radar vs. active countermeasures (jamming)



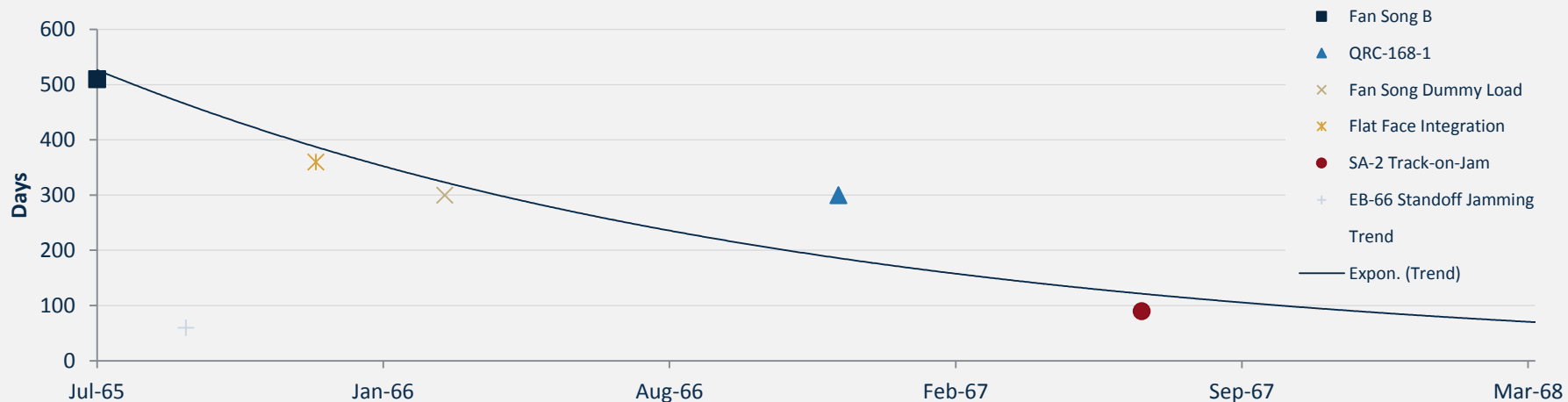
Smaller, more powerful radars & jammers and speed of conflict increased the benefit of jamming of sensors / communications in addition to exploitation

Technical advancements accelerated in active/active phase

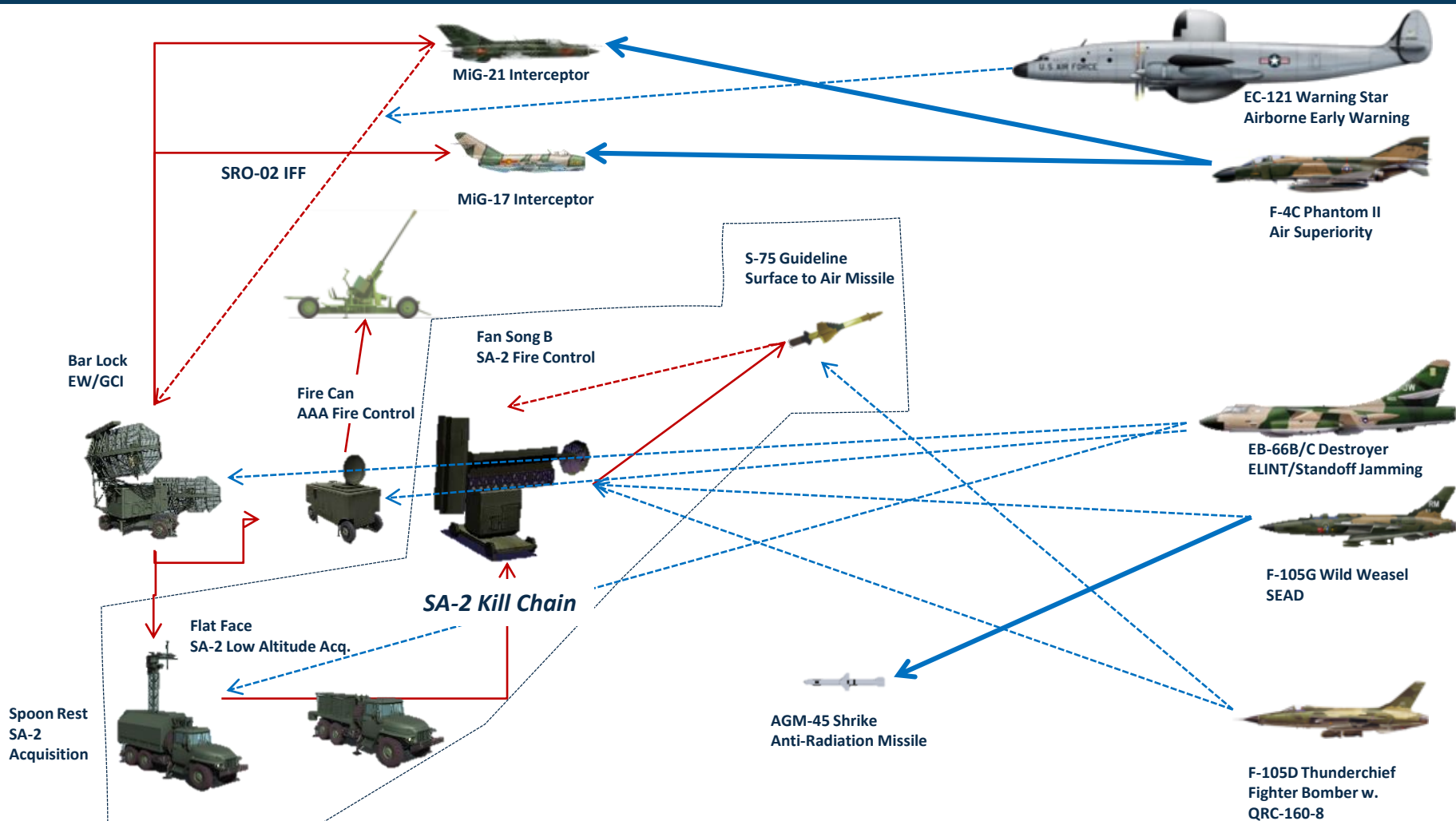
Lifetime of technical advancements during World War II



Lifetime of technical advancements during Vietnam War



1970s: jamming became unsustainable vs. improving defenses



*Half of strike packages devoted to suppression of air defenses;
“virtual attrition” demanded new approach to protecting strike forces*

U.S. shifts to stealth after Vietnam



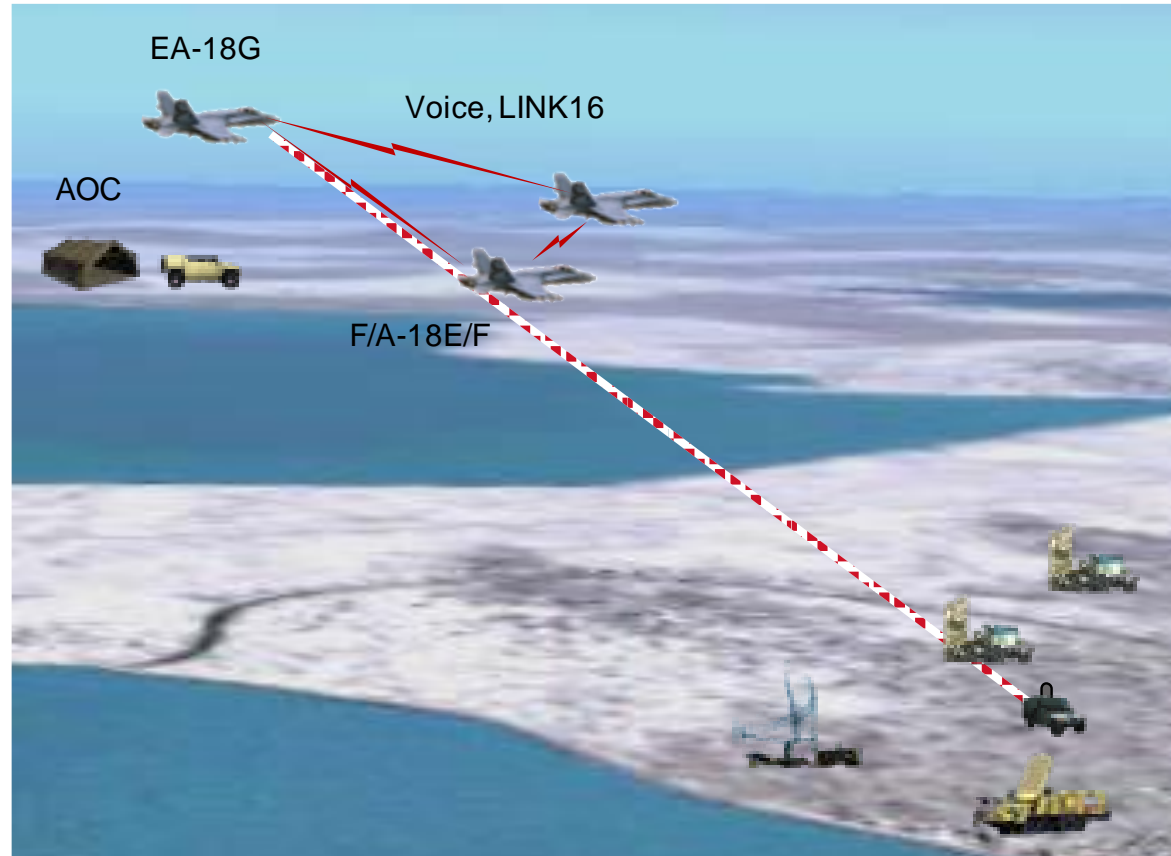
DARPA Have Blue demo led to F-117 and showed ability to reduce RF signature in some frequencies and aspects



B-2 bomber built on Have Blue and F-117 to provide all-aspect stealth across wider frequency range

Stealthy aircraft and systems were designed to hide from adversary sensors, rather than needing to jam them

Shift to stealth ended w/ Cold War



Today's force uses a mix of stealthy and non-stealthy forces; but:

- *RF systems of non-stealthy forces known by adversaries & difficult to change*
- *Adversaries can exploit "home field" to find stealthy platforms*
- *U.S. forces not exploiting visible and infrared portions of spectrum*

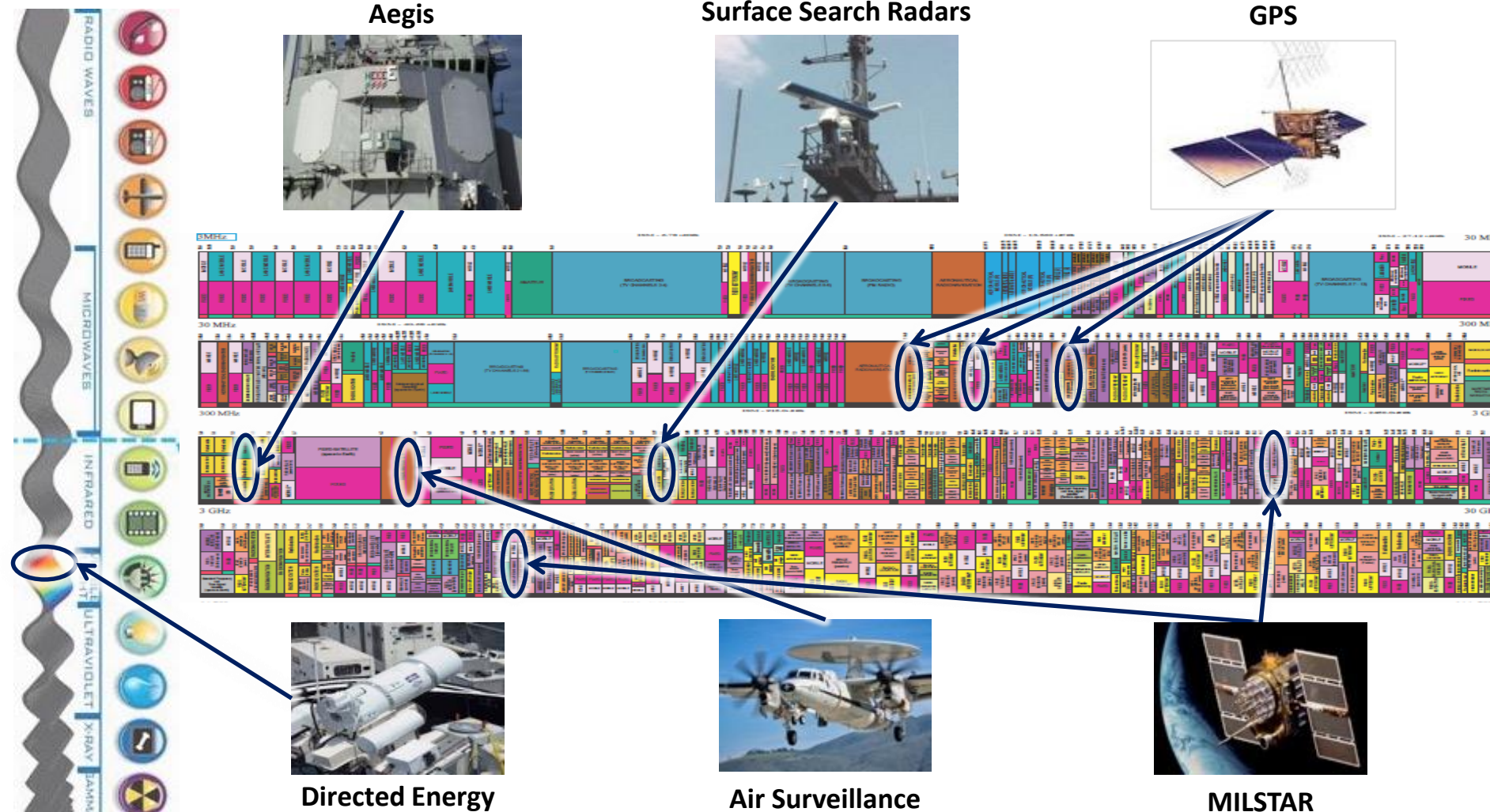


Challenges of today's electronic warfare approach

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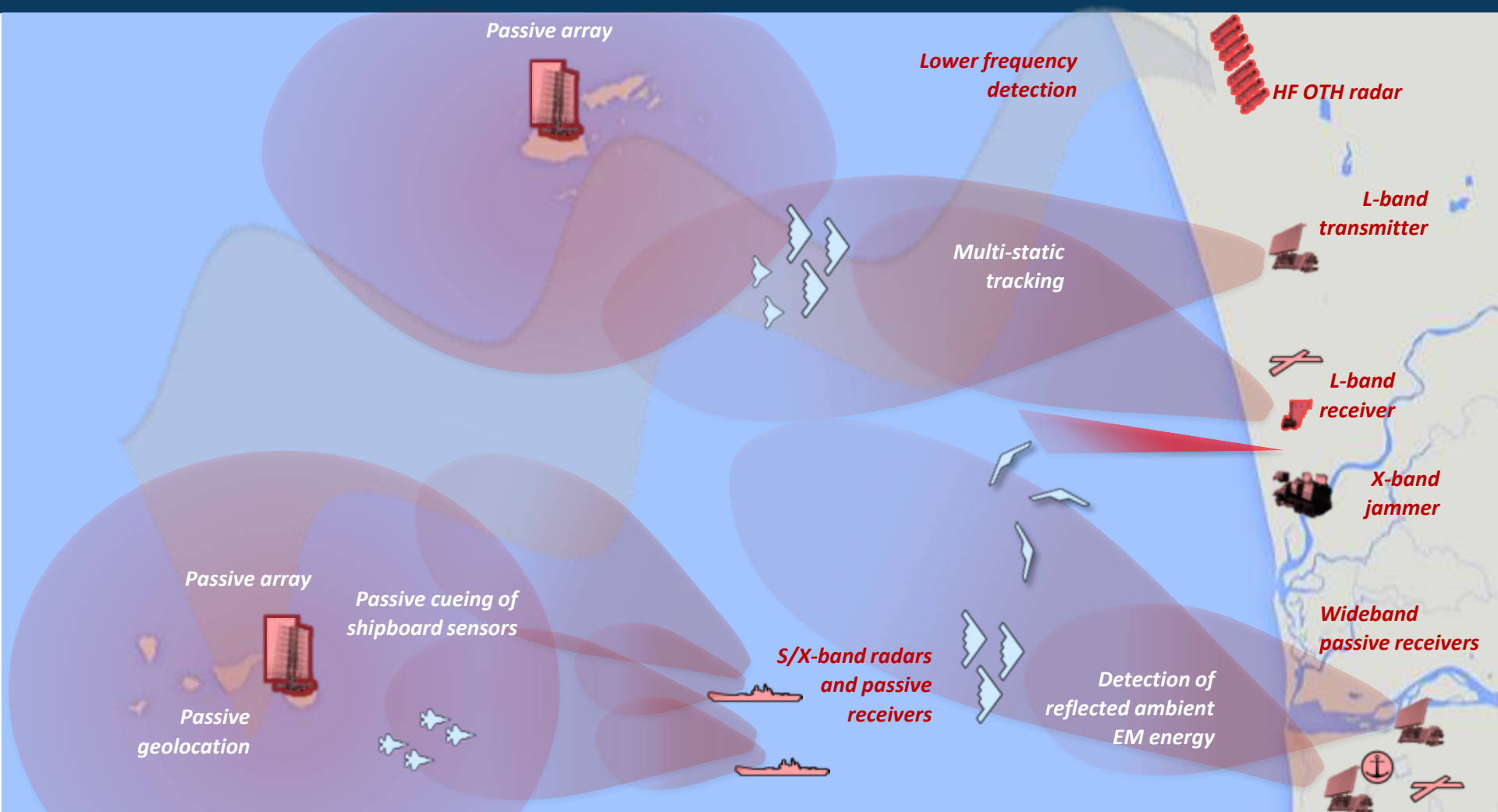
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U.S. systems are well known to enemy and lack agility



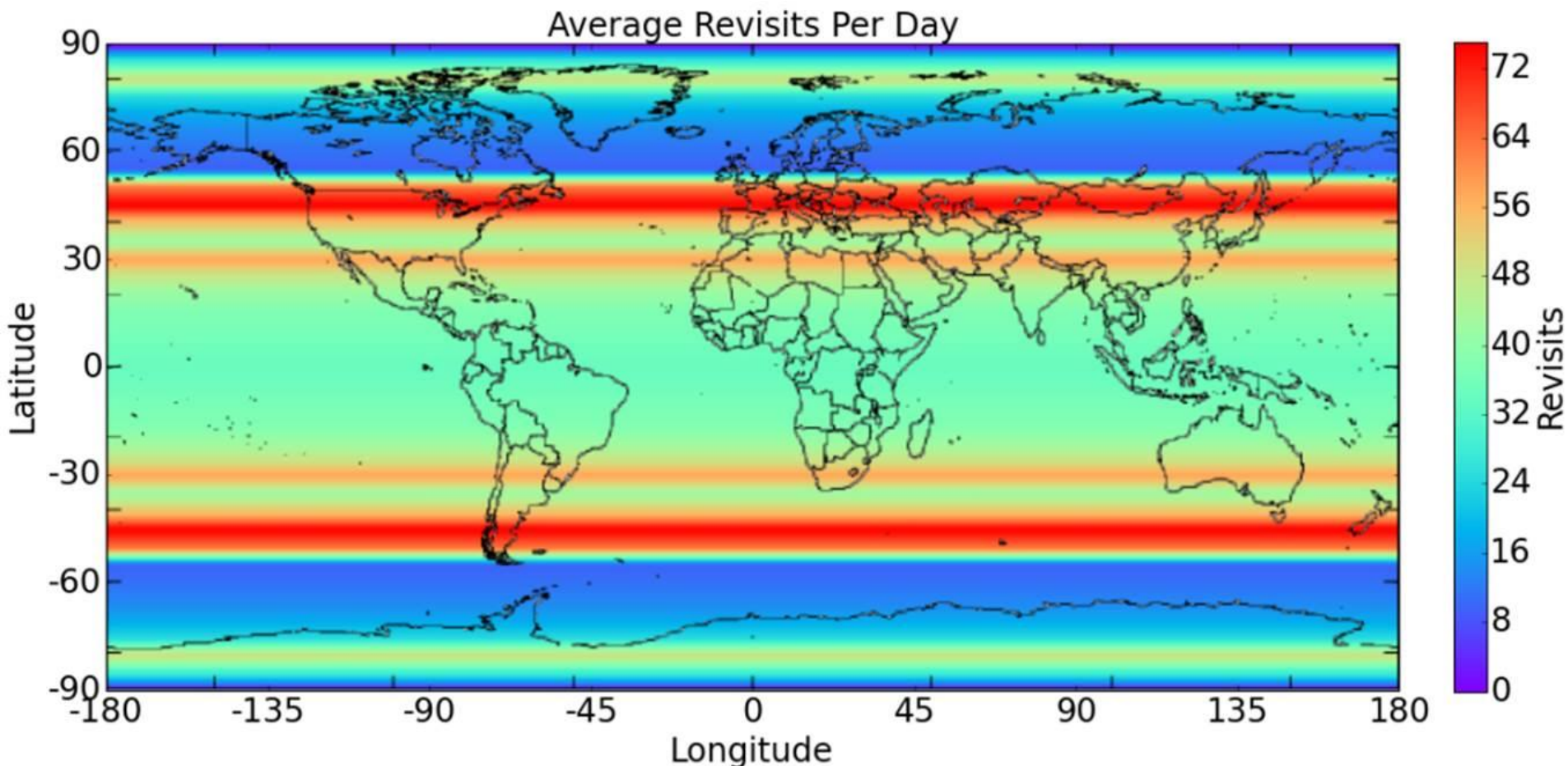
Adversary EW targets U.S. EM sensors while their weapons avoid U.S. EW capabilities; hard-wired U.S. systems cannot change characteristics easily

Adversaries exploit “home field” to field long-range sensor networks



Enemy can emplace effective long-range passive and low-frequency sensors and better understand EM environment; could enable them to detect U.S. forces first

Visible & IR sensors proliferating



***Blacksky EO/IR satellite constellation expanding to 60 satellites by 2025;
Other commercial providers and military systems expanding***

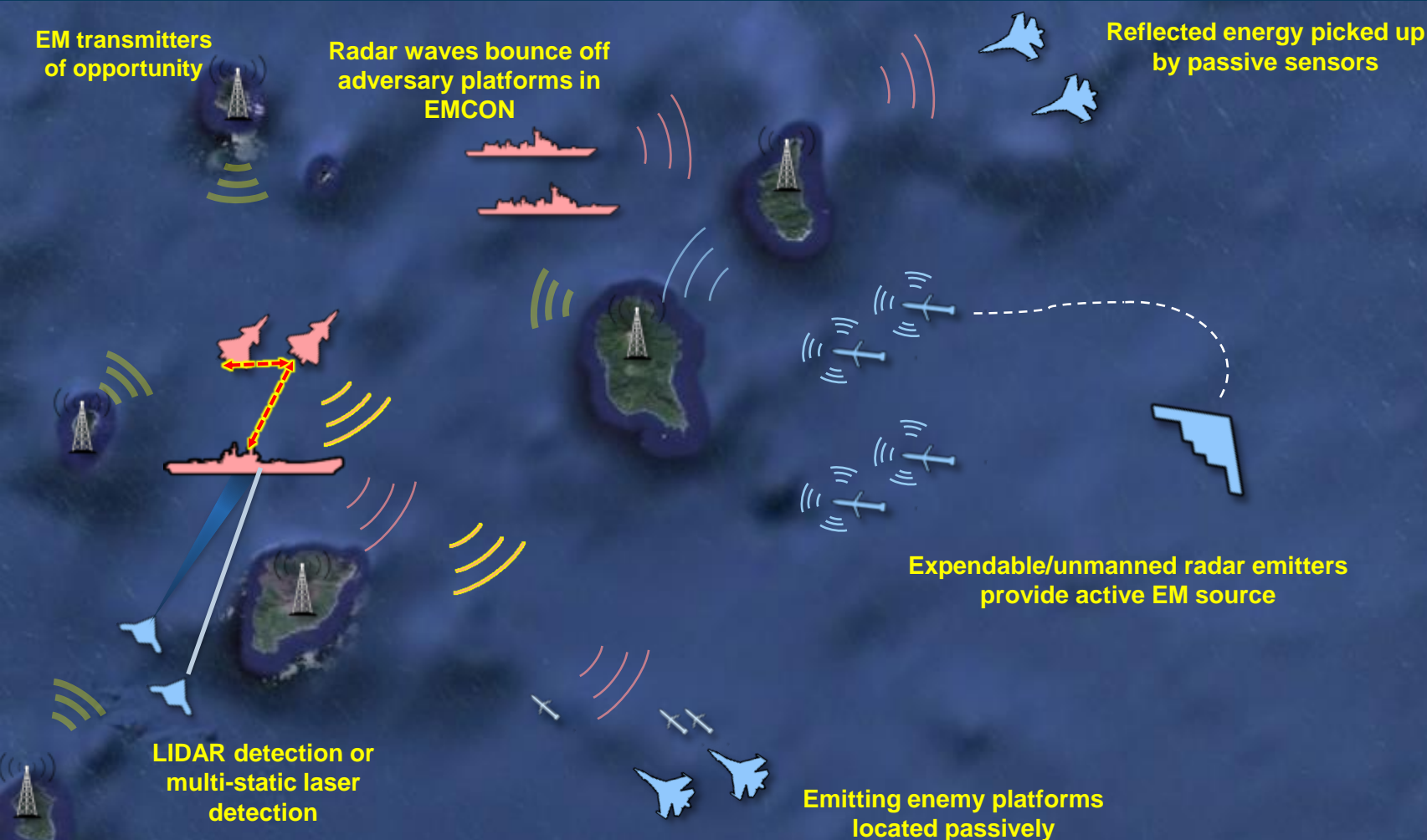


New operating concepts for EM spectrum warfare

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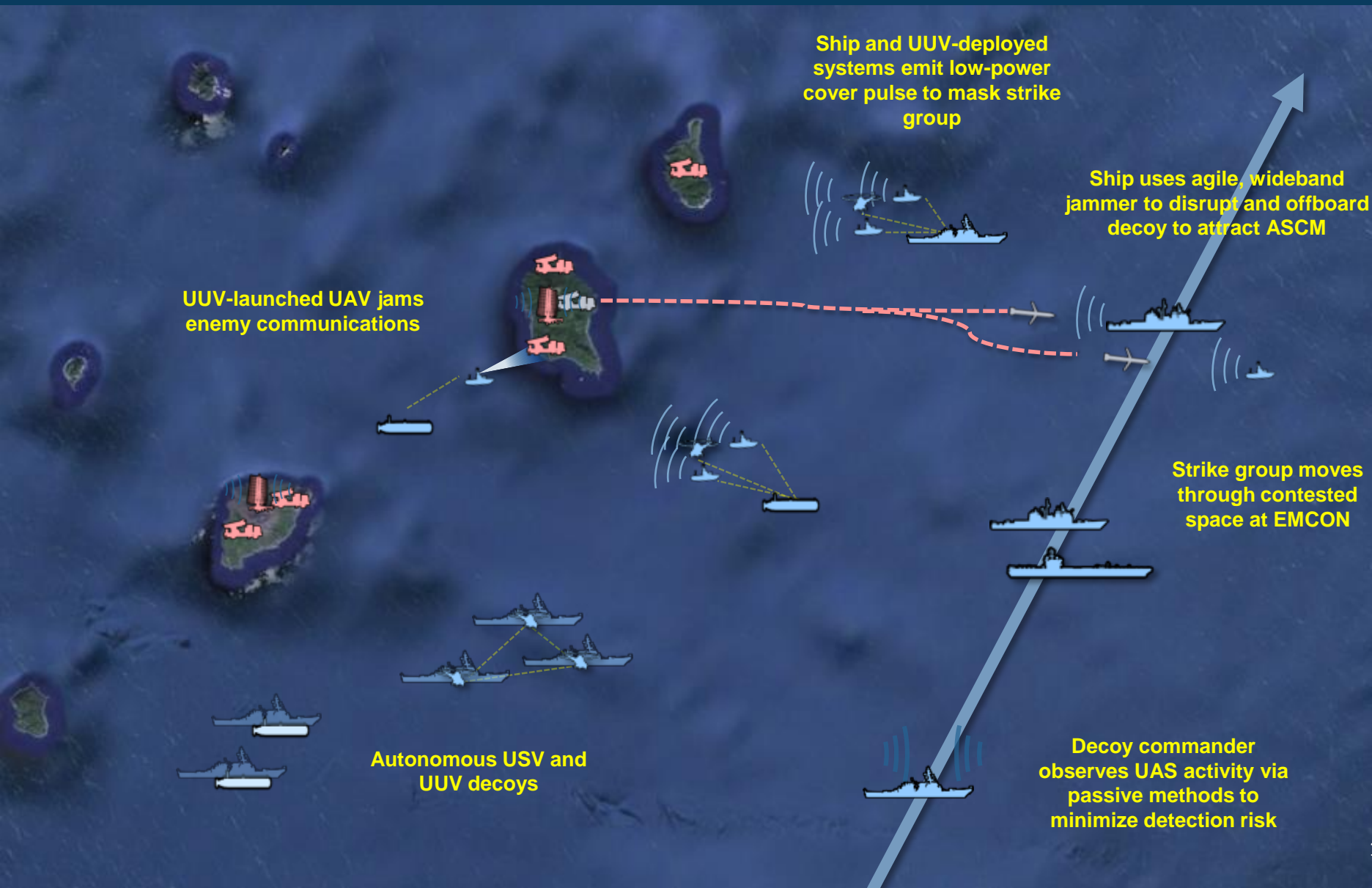
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New approaches needed to find enemy without being counterdetected

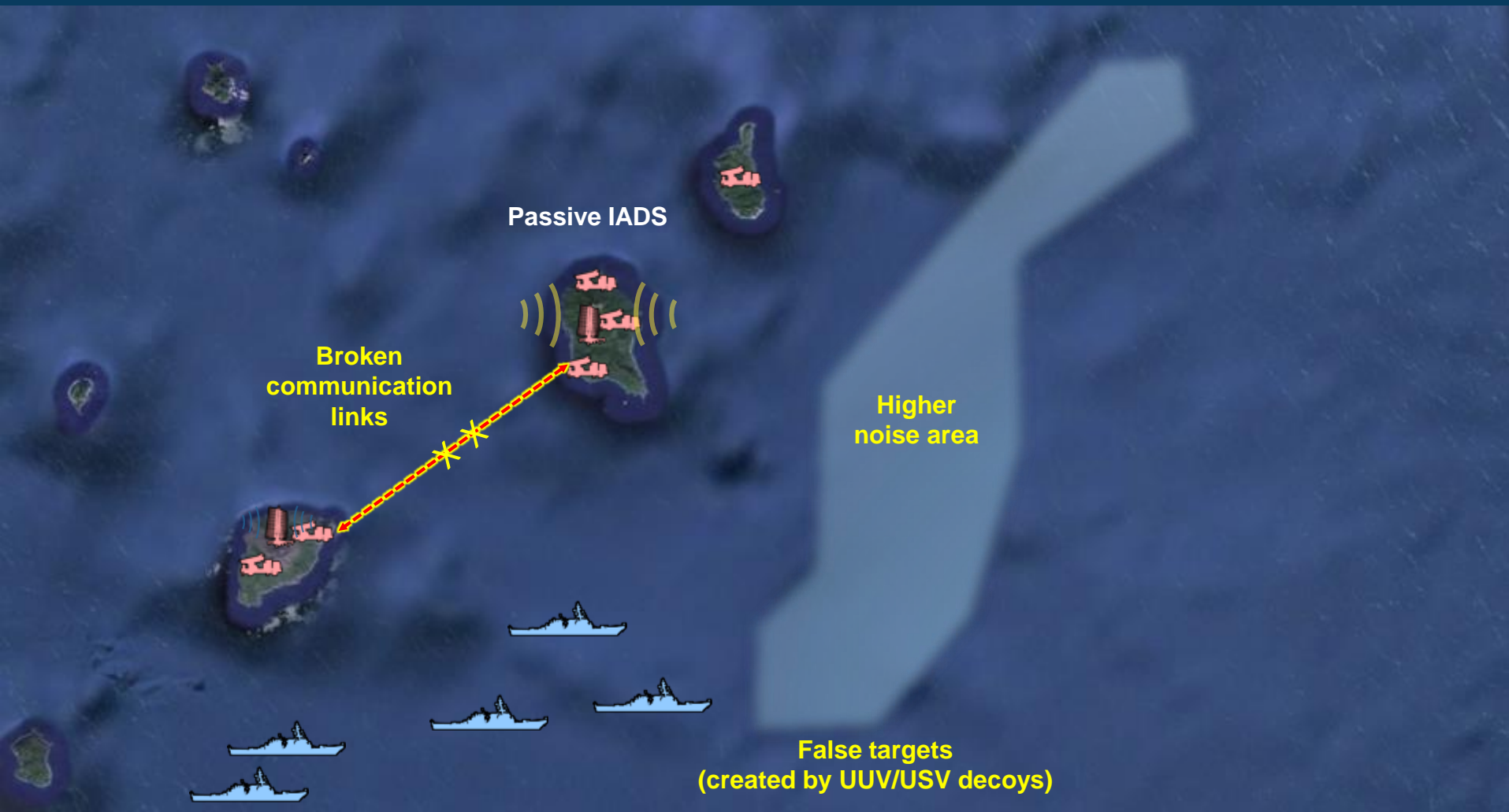


Shifting to passive and LPI/LPD sensors to find targets at increasing ranges while reducing counterdetection risk to friendly forces

Avoid being targeted using EMCON, decoys and low power jamming



Counter-ISR makes large salvos necessary for a successful attack



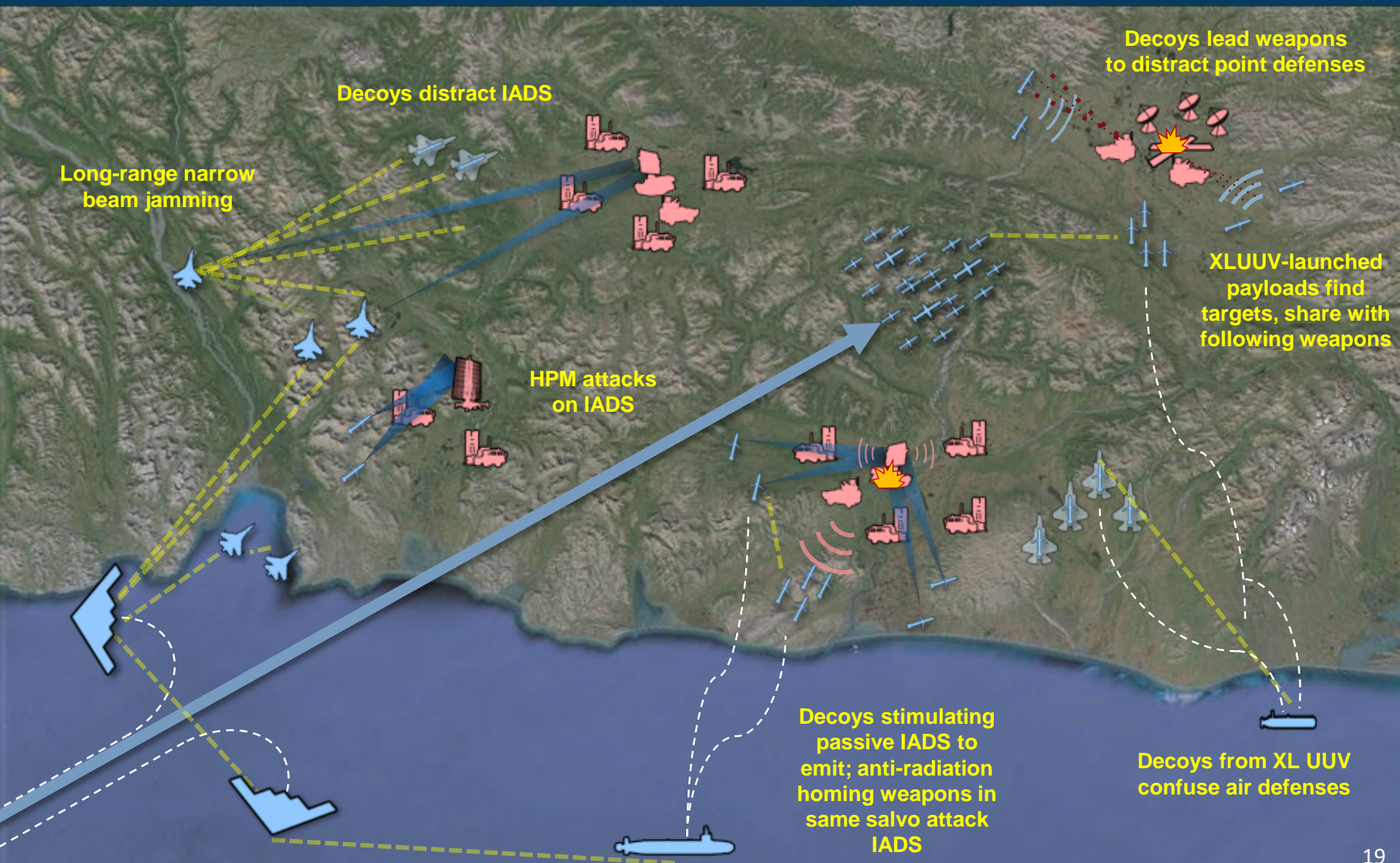
U.S. forces will not be able to completely hide; will need instead to create large number of possible targets using decoys and by obscuring real forces

Hiding now must incorporate includes visible & IR spectra



*Obscurants, decoys, and camouflage improving;
only need to be good enough to make real system and decoy look alike*

EM spectrum operations are essential to successful power projection



A light gray world map is centered on the page, showing the outlines of continents. The map is set against a background of a fine, light gray grid.

New EMS technologies

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Priorities for EMS warfare tech

- **Networked**
- **Agile and maneuverable**
- **Multifunction**
- **Smaller and less expensive**
- **Cognitive**

Networking essential to future EM spectrum operational concepts

Passive coherent location and lower frequency detection requires multiple geographically dispersed receivers

Multi-static detection using expendable illuminators networked to UCAV receivers

Passive geolocation of IADS using multiple networked UAV receivers

Passive sensors find radar; stand-in jammers confuse it; both pass info to weapons

Anti-radiation IADS

Passive EM array

S-band radar

X-band IADS

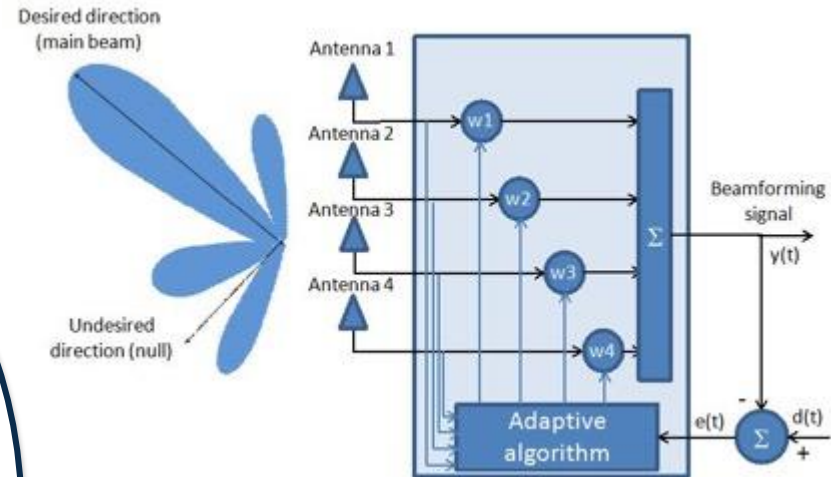
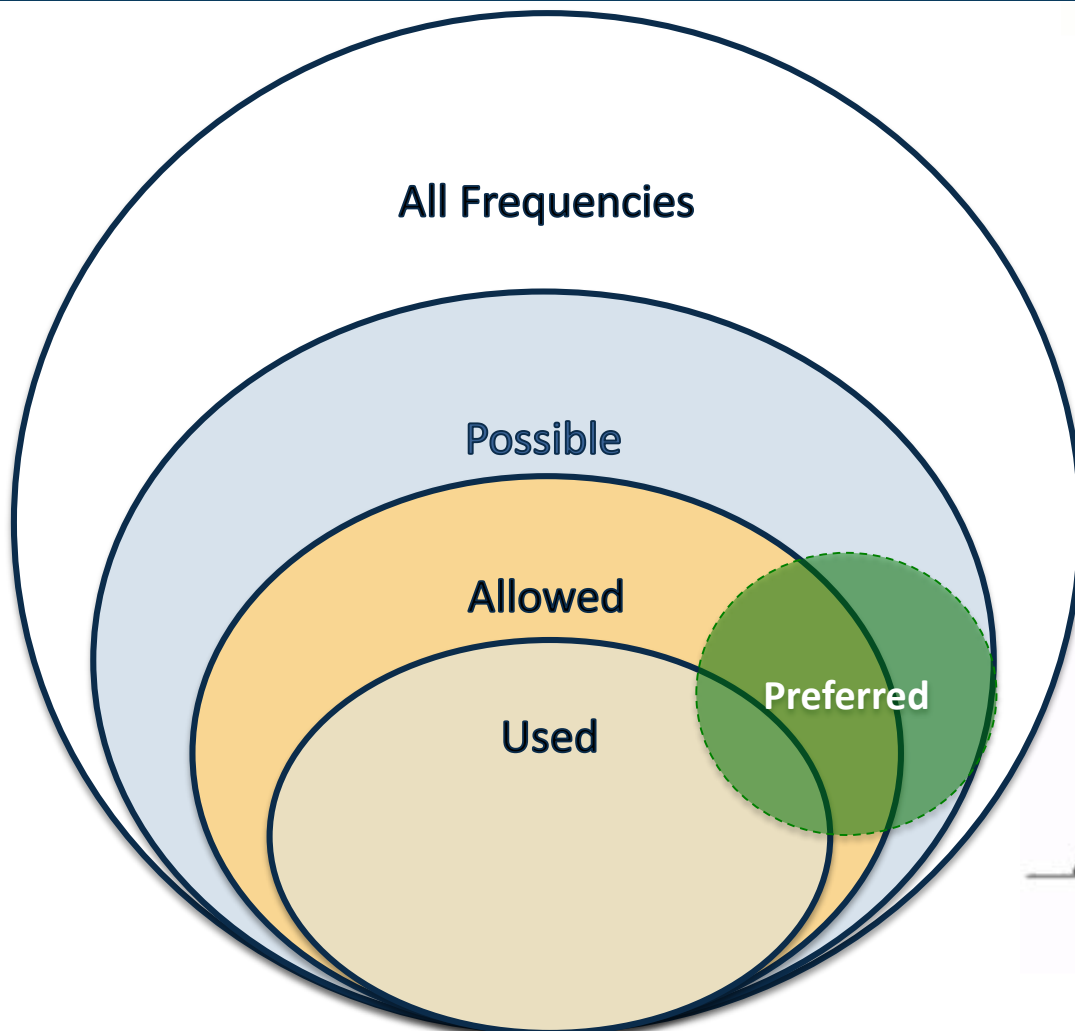
Collaborative weapons

Decoys

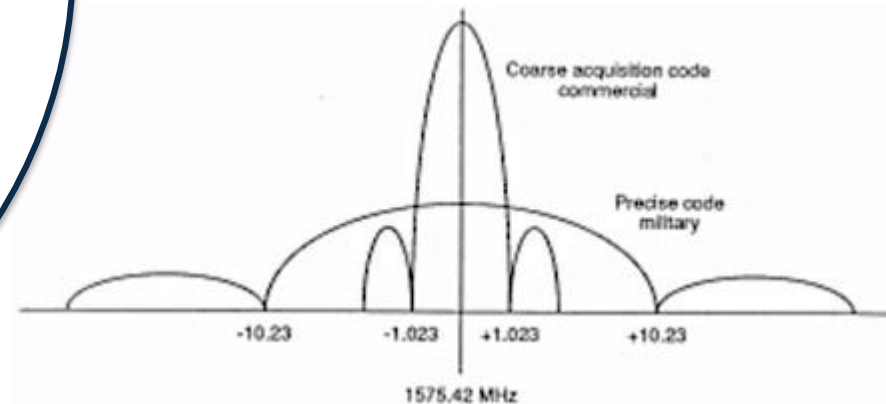
LPI/LPD links

Passive and multi-static sensing, decoys, collaborative weapons, and LPI/LPD jamming require platforms and payloads to be connected

Agility needed to evade countermeasures & detection



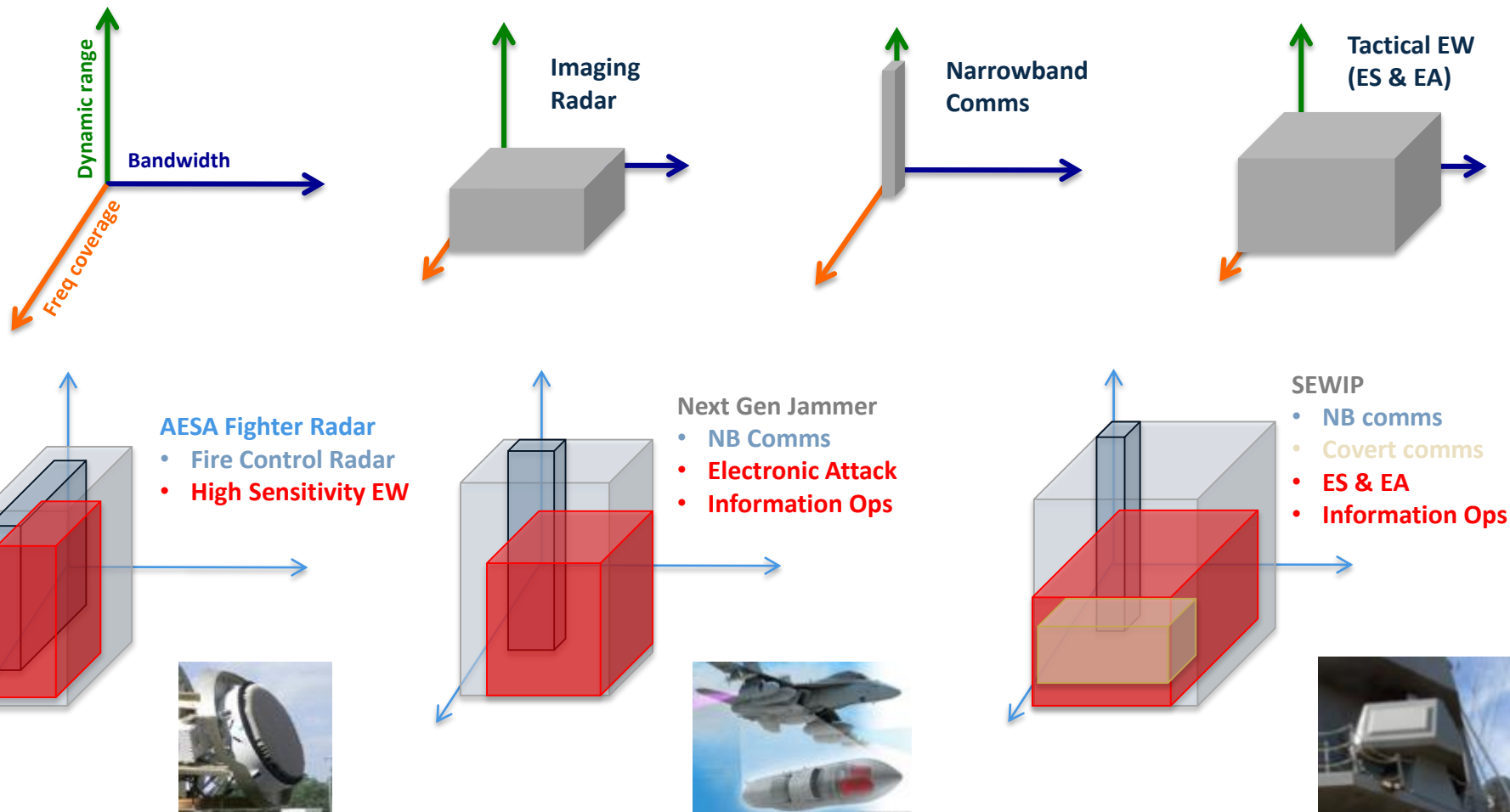
Beamforming and steering



Signal spreading

Maneuver in frequency, power, time, beam direction, & beam shape to protect friendly EMS operations while denying those of enemy; including visible and IR

Multifunction arrays more efficient & enable one array on small platforms



*Each platform and payload must participate in EMS warfare network;
multifunction arrays reduce the number of separate systems needed*

Smaller, cheaper systems needed to proliferate EMS capabilities



New concepts being pursued:

- Use more expendable jammer, decoy, sensor payloads
- Incorporate almost every manned or unmanned platform
- Employ multiple RF and EO/IR arrays per platform

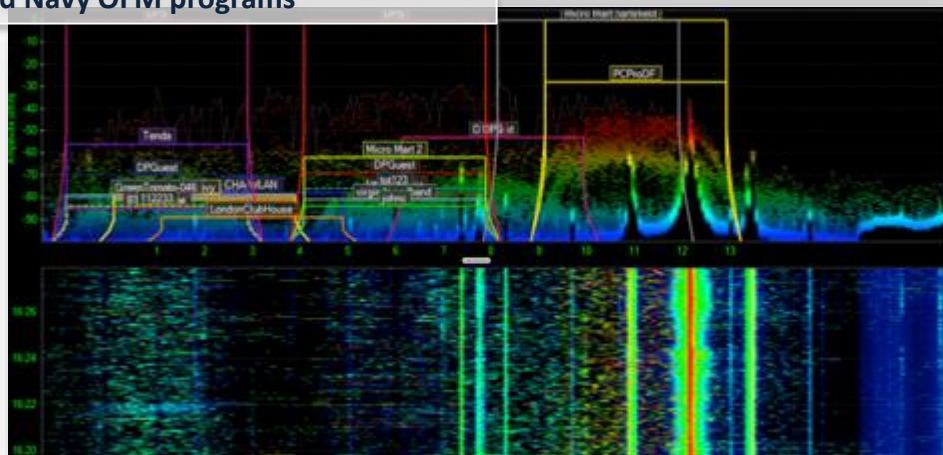
EMS emitter/receivers need to become commoditized to enable every platform and payload to participate in network

Shift from automated systems to cognitive or intelligent controls

Examples include ONR REAM and NEMESIS and DARPA ARC and BLADE programs



Examples include DARPA RadioMap and Navy OFM programs



EMS Warfare Operating Cycle

Assess threats, opportunities and previously attempted EM effects

Review & adjust EM requirements based on commander's intent and current environment

Develop COAs using modeling and simulation

Allocate EM operations by function

Schedule tasks to EM systems

Tasks to EM systems

Generate EM effects

Spectrum Monitoring

Today's systems react to recognized situations w/ pre-planned responses; future systems must assess environment to develop & refine COAs that best exploit it



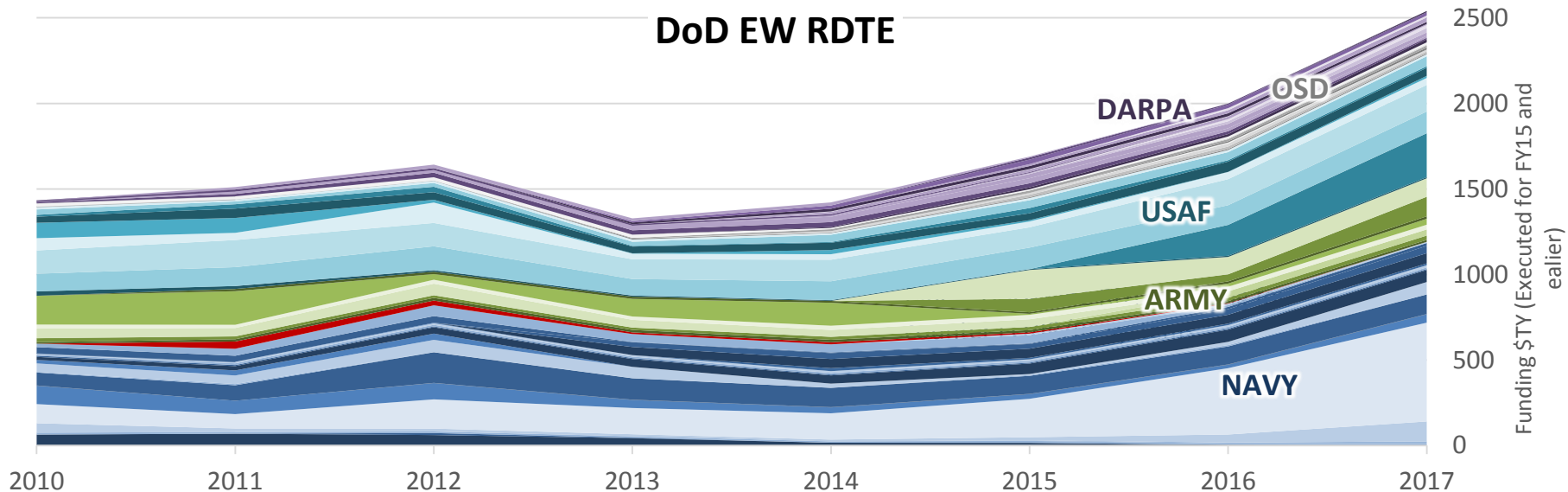
Challenges to change

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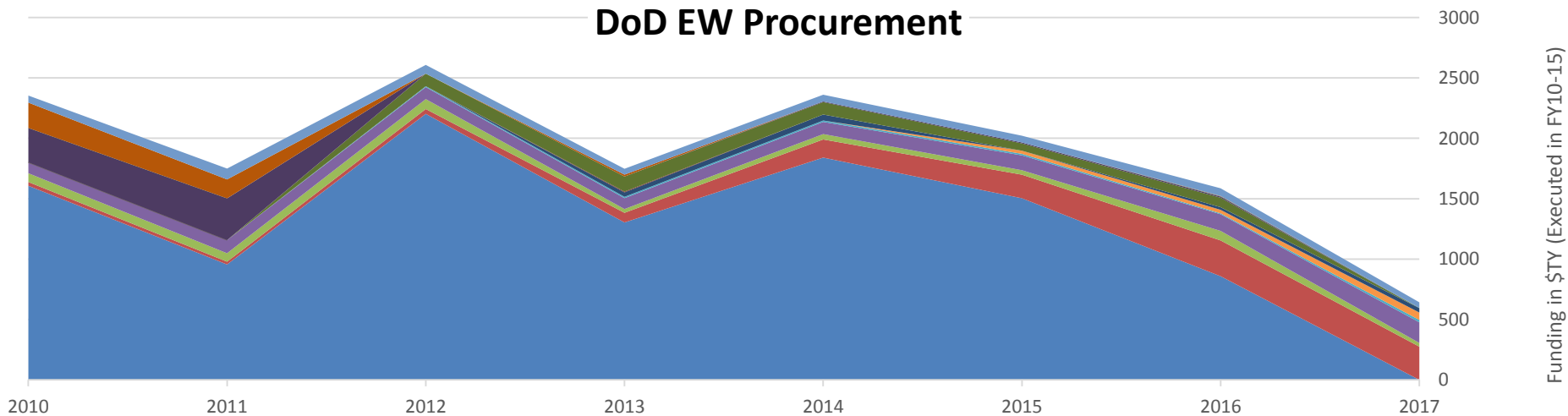
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New tech maturing, not being fielded

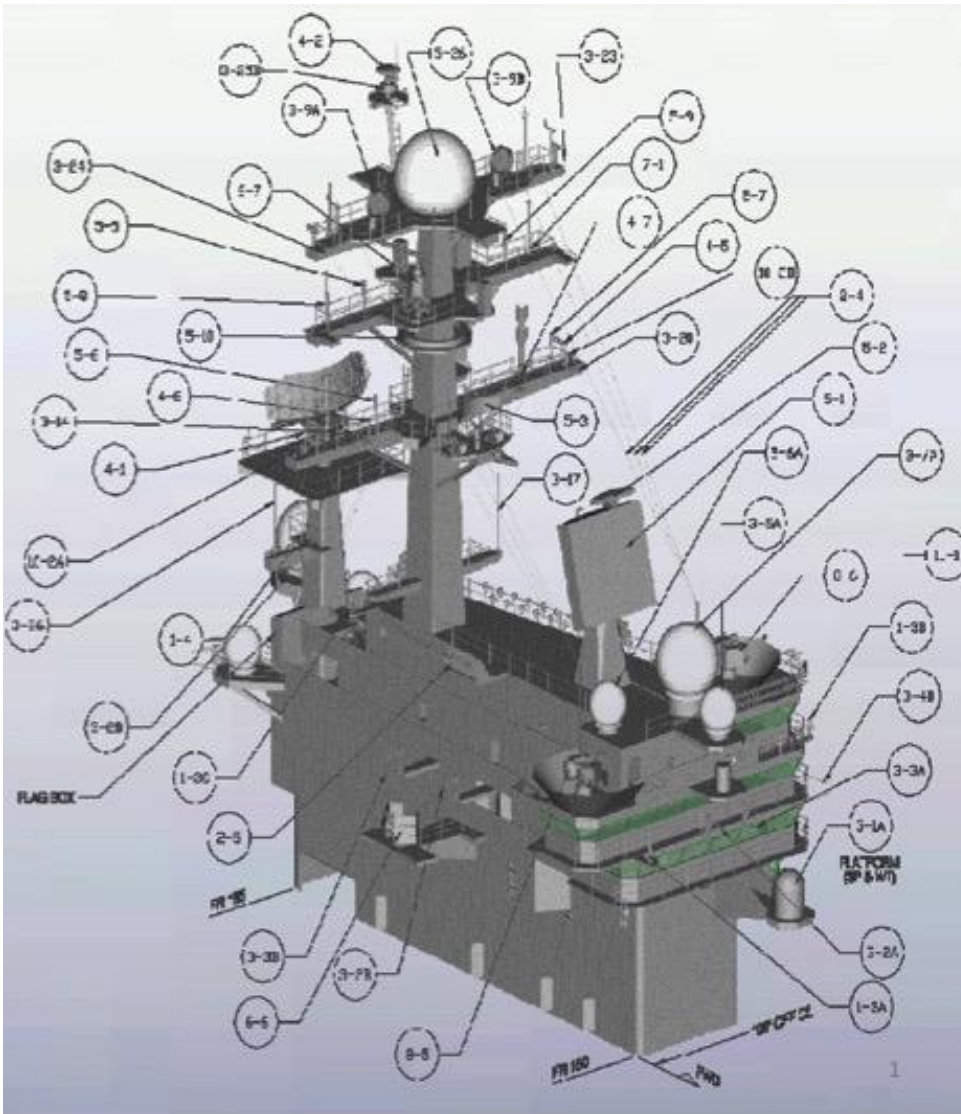
DoD EW RDTE



DoD EW Procurement



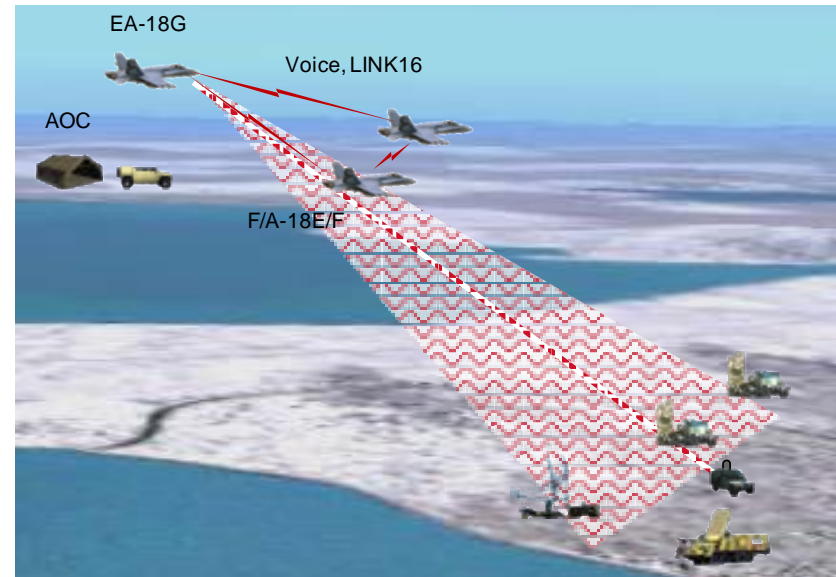
Acquisition structure stove-piped



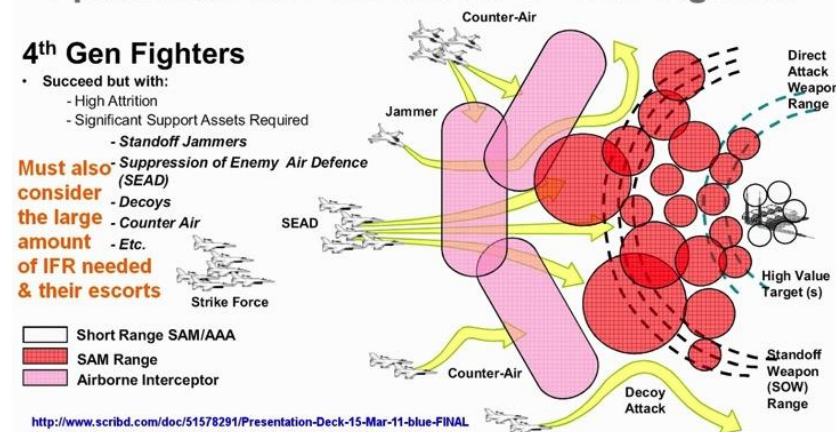
- **Numerous acquisition agents**
 - PMs for each different mission (radio, EW, RWR, radar, SIGINT)
 - PEOs organized by platform, not mission or system
- **No incentives for cooperation**
 - Multifunction EM systems cross multiple PMs and PEOs
 - Increases programmatic risk
- **Lack of requirements “pull”**
 - Operating concepts outdated
 - Limited options to work around requirements process
- **New USD(R&E) and USD(A&S)**
 - Could help improve pull of new technologies into acquisition

Today's CONOPs limit innovation

- **Concepts don't leverage new tech**
 - Networked emitters/receivers
 - Adaptive EMS systems
 - Agile EO/IR/RF operations
 - Multifunction arrays & controllers
- **Use system v. system approach**
 - Pre-planned techniques
 - Library of threats and responses
- **Prevent changes to requirements**
- **EW strategy could change this**
 - New directions in concepts



Canadian JSF Program Operational Impact Tech Brief 17 March 2011 Operations and Tactics for 4th Gen Fighters



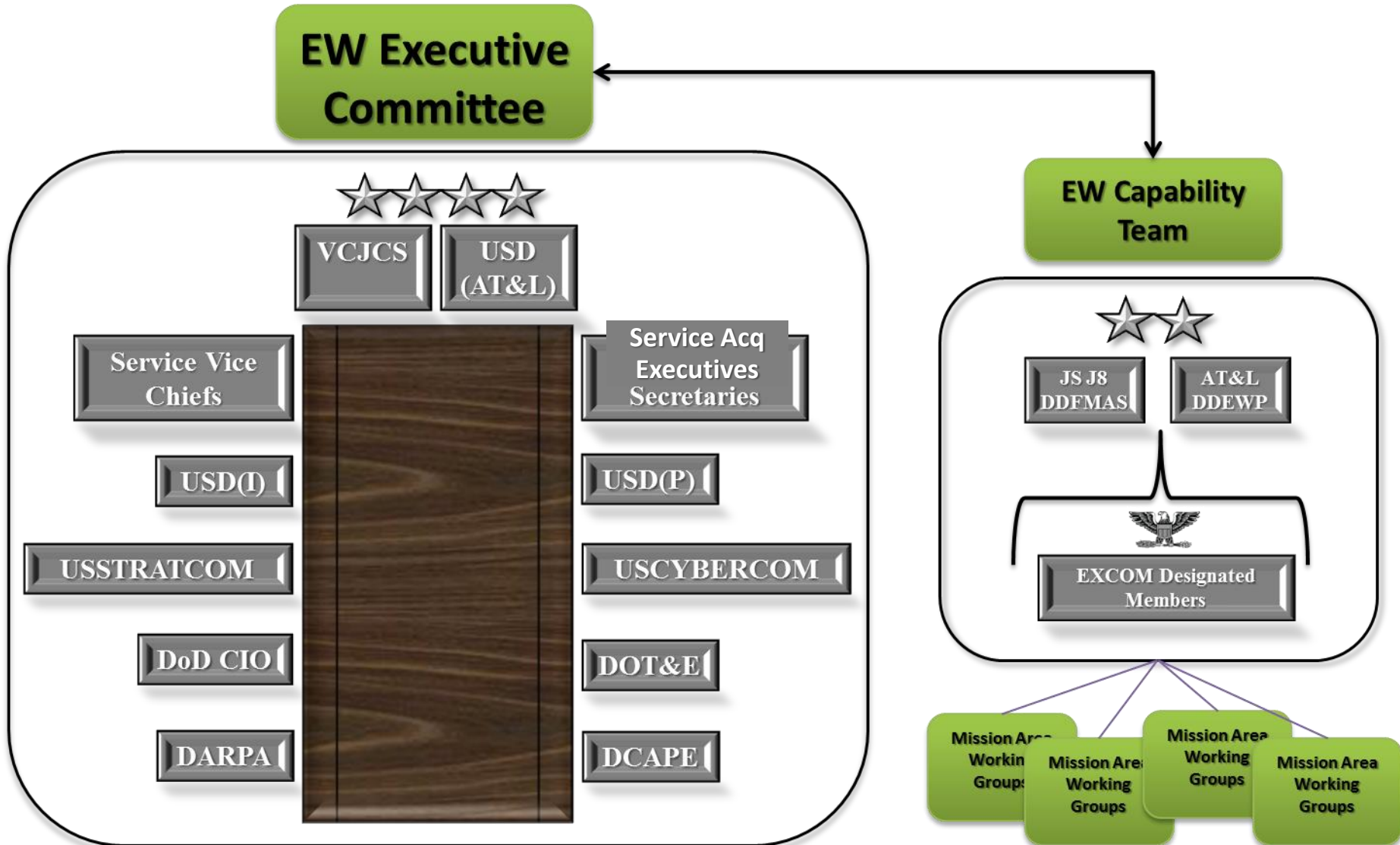


Recent improvements

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EW EXCOMM driving change



New strategy starts shift

- **Organize to maintain EMS superiority**
 - Make EMS a domain
 - Improve EW workforce
- **Train and educate in EW competencies**
 - Maneuver-mindset regarding ops in EMS
 - Expand warfighter knowledge and competency
- **Equip force w/agile, adaptive, integrated EW**
 - Field EA, incl. directed energy, for EMS superiority
 - Field capabilities to detect, locate & replicate signals
 - Maintain strike and counter-A2/AD capabilities
 - Field EW battle management capabilities
 - Field interoperable. Asymmetric EW capabilities
 - Develop M&S to aid decision making
- **Build and maintain partnerships**
 - Academic, international, and industrial base

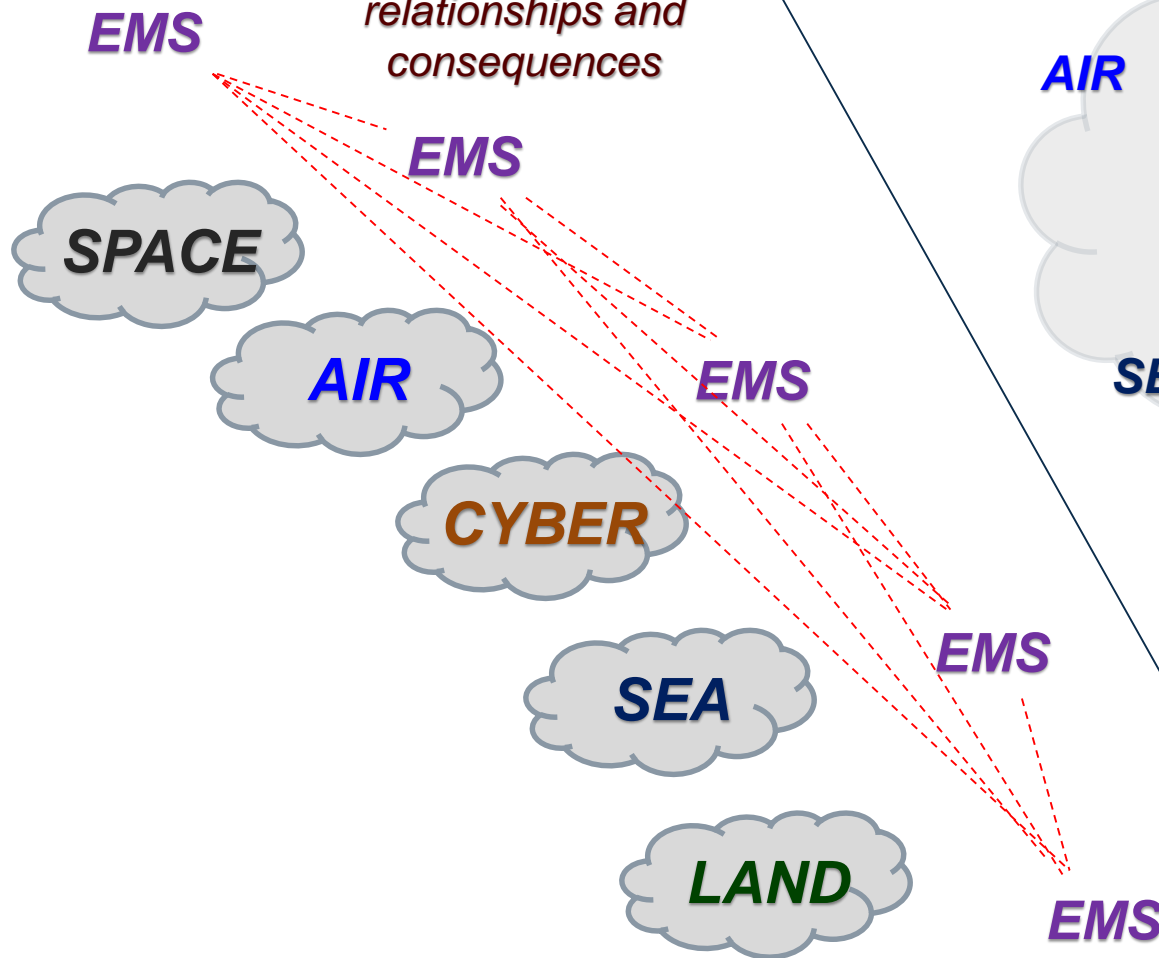


Increasing investment in EW; but more importantly, adopting new approaches to EMS Warfare and equipping force to use them

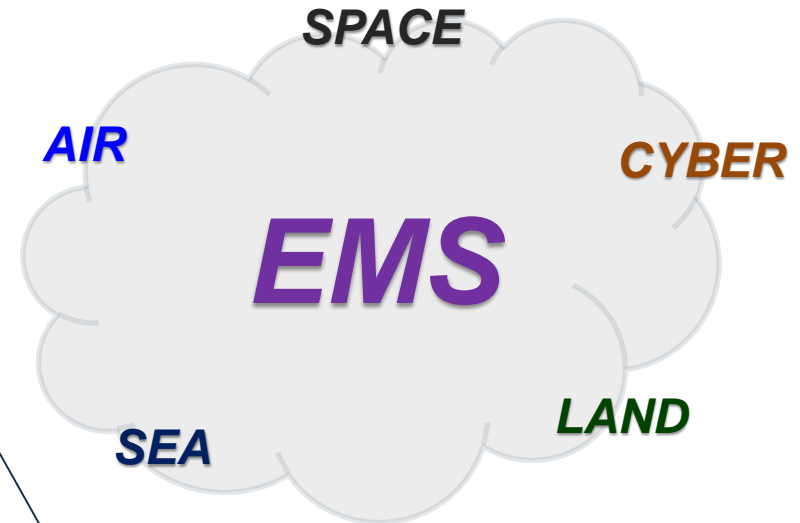
EW Strategy treats EMS as domain

TODAY

*Unacknowledged
interdependencies,
relationships and
consequences*

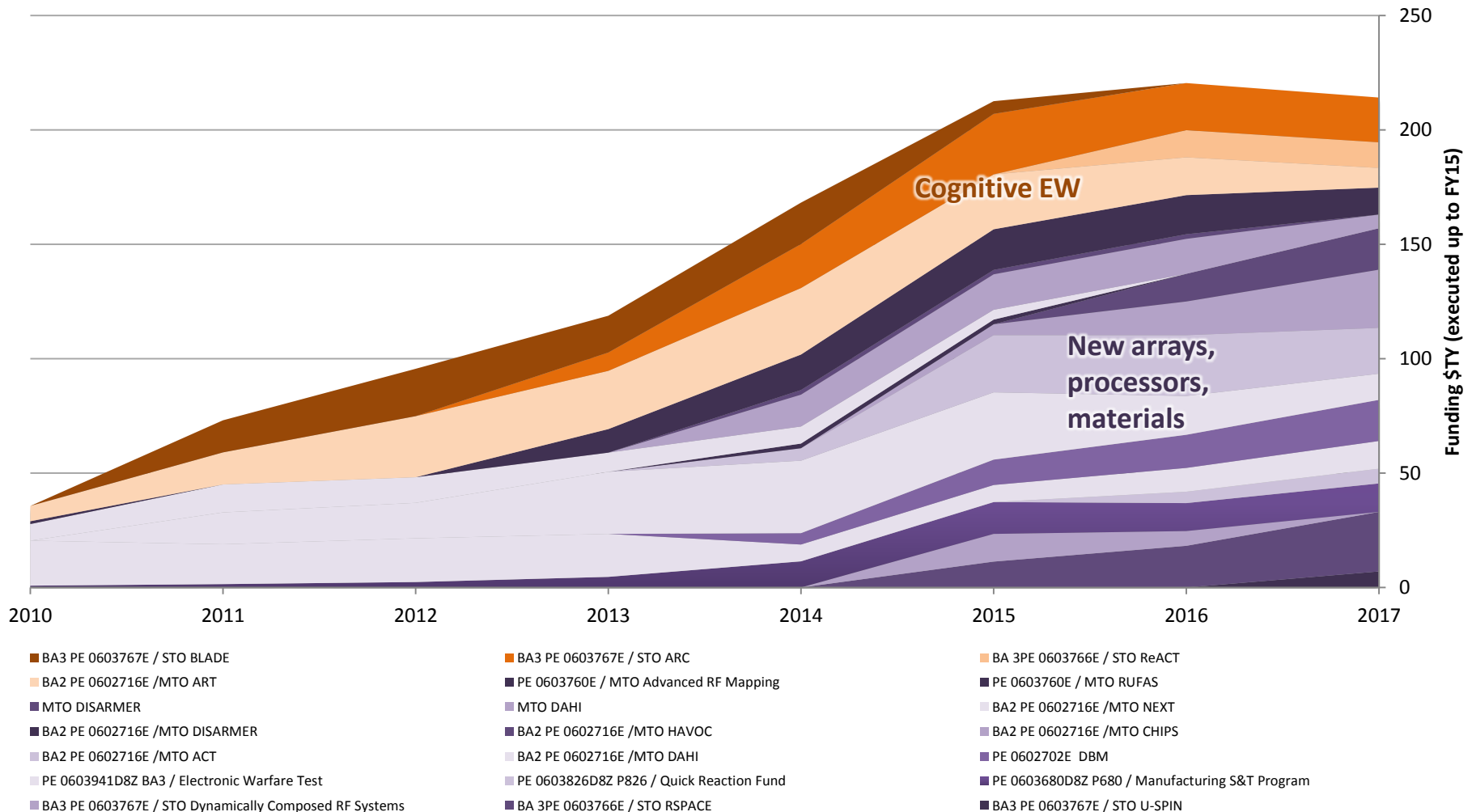


FUTURE



*Leveraging friendly
interdependencies;
Exploiting those of enemy*

DARPA prioritizing needed tech



DARPA developing the exact capabilities needed for the current and next phase of EMS warfare

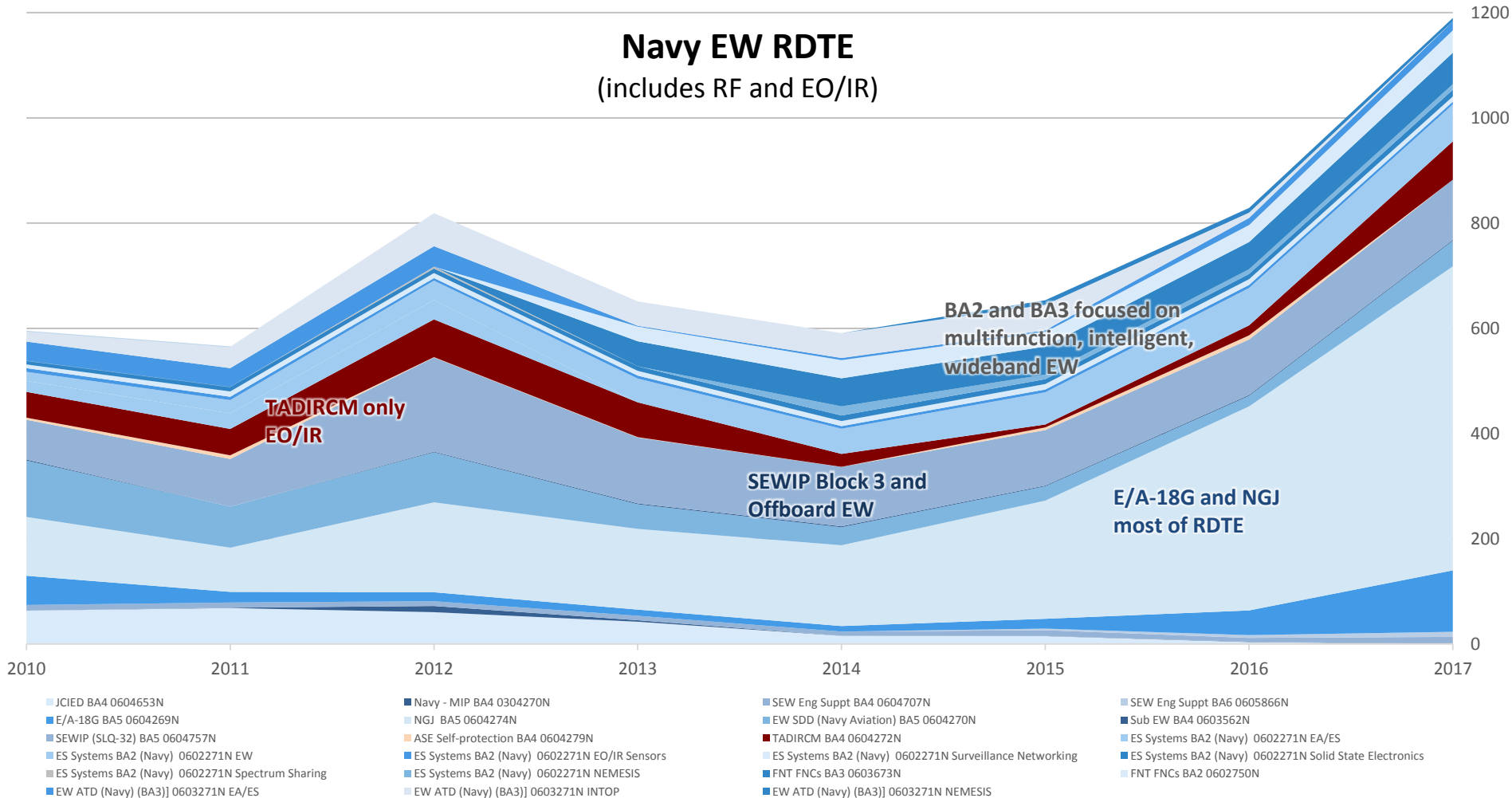


Questions?

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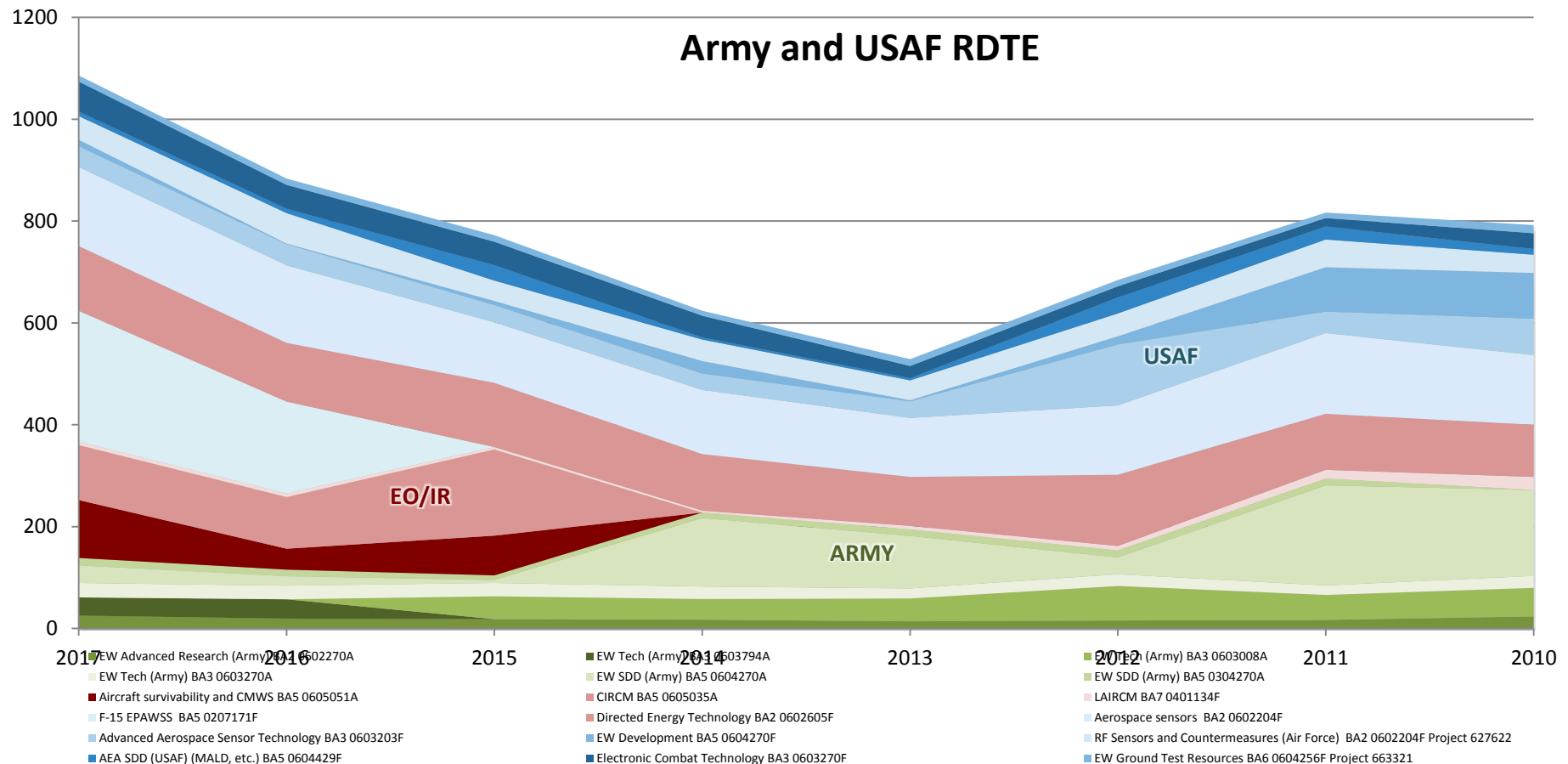
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Navy RDTE overwhelming in RF



Navy focused on confusing or defeating overhead and land-based radars and passive ELINT/SIGINT sensors; at risk of EO/IR search technologies

Army & USAF balance EO vs. RF



Army and Air Force better positioned for shift to passive and EO/IR sensing, but investments mostly counter IR-guided missiles, rather than EO/IR sensors