



Naval Integrated Fire Control–Counter Air Capability-Based System of Systems Engineering

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Jeffrey H. McConnell

jeffrey.mcconnell@navy.mil

Naval Surface Warfare Center, Dahlgren Division

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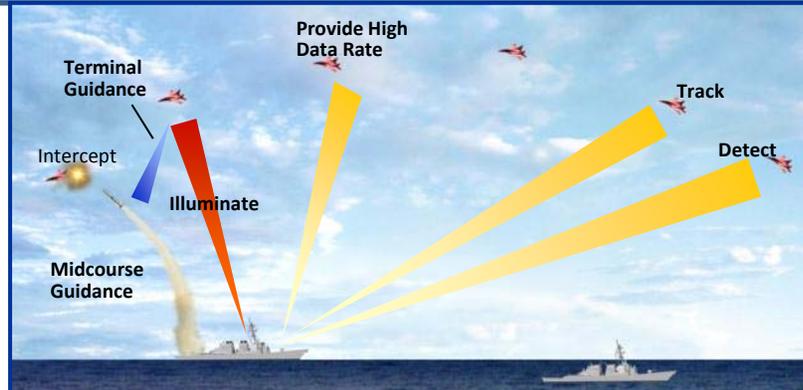
The NIFC-CA Program Challenge

- **Deploy a viable and robust Integrated Fire Control (IFC) System of Systems (SoS) by:**
 - **Distributing the AEGIS shipboard fire control loop, via a sensor network across diverse remote sensors, the AEGIS Baseline 9 (formerly Advanced Capability Build 12) combat system and Standard Missile (SM)-6 to achieve independent engagement consummation over-the-horizon (OTH), both over land and over water**

The NIFC-CA Engineering Challenge

Begin with current AEGIS anti-air warfare killchain

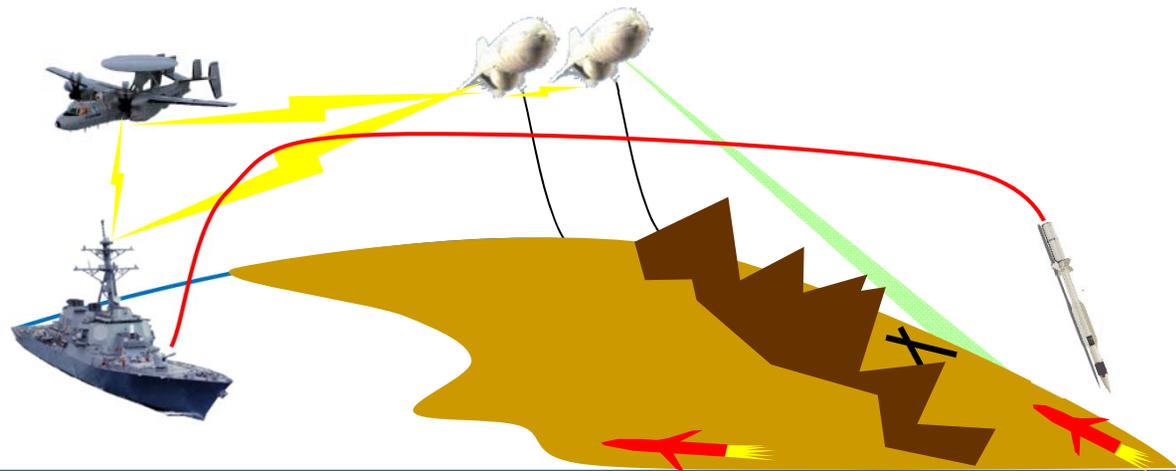
- fully organic
- tightly coupled
- horizon limited



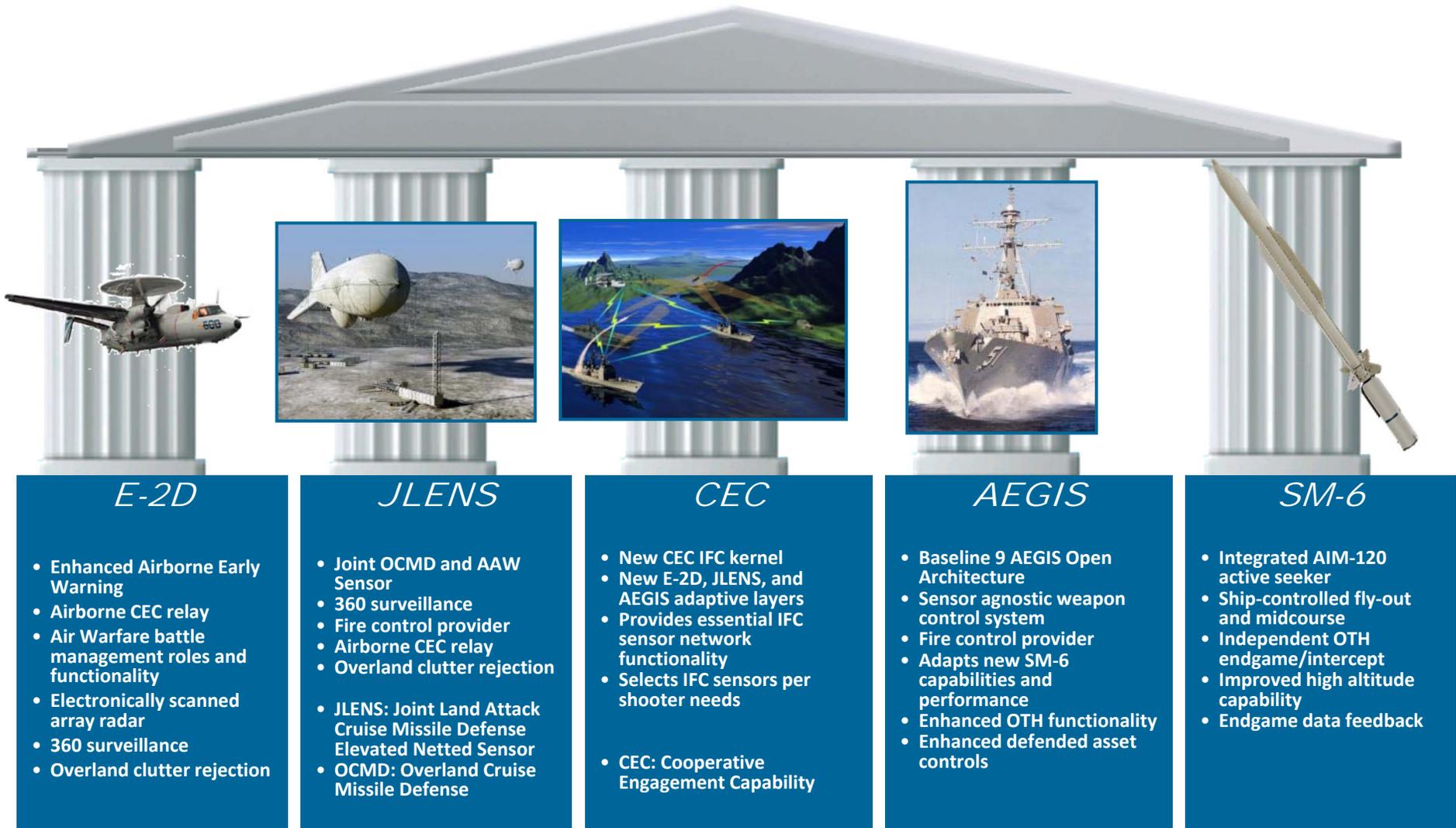
Add the NIFC-CA OTH mission killchain. Modify and distribute critical functionality across remote sensors, a sensor network, combat system, and active weapons.

Field a robust IFC SoS killchain

- distributed
- looser coupling
- no horizon limits
- expandable
- flexible

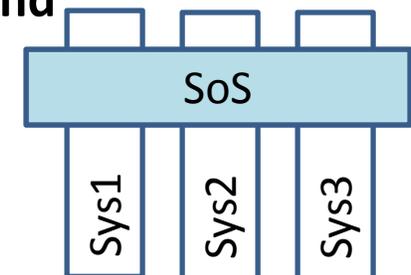
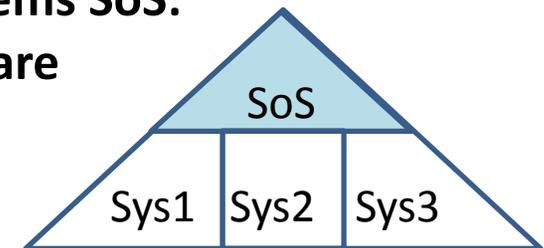


NIFC-CA From-the-Sea Killchain

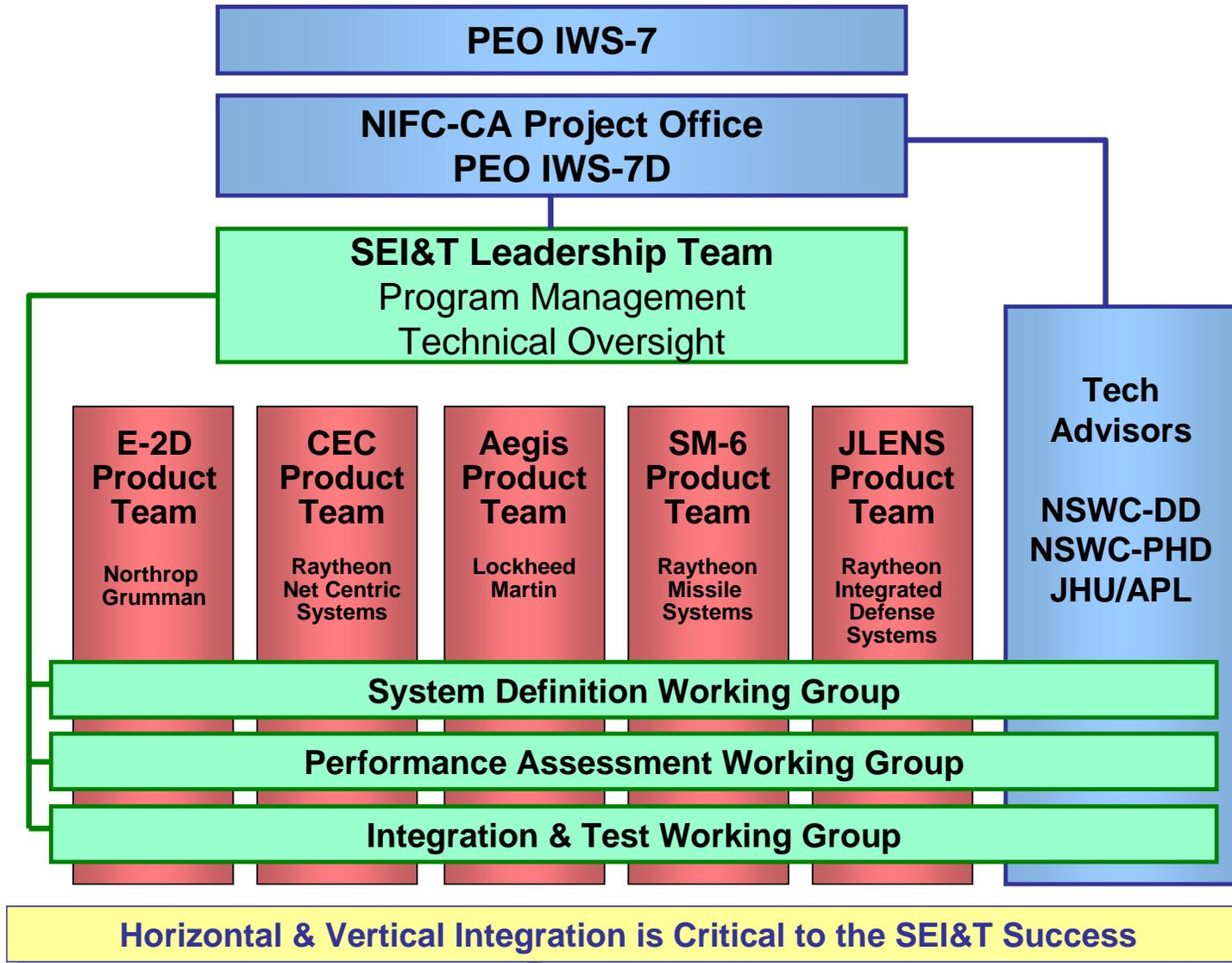


The NIFC-CA SoS Engineering Type

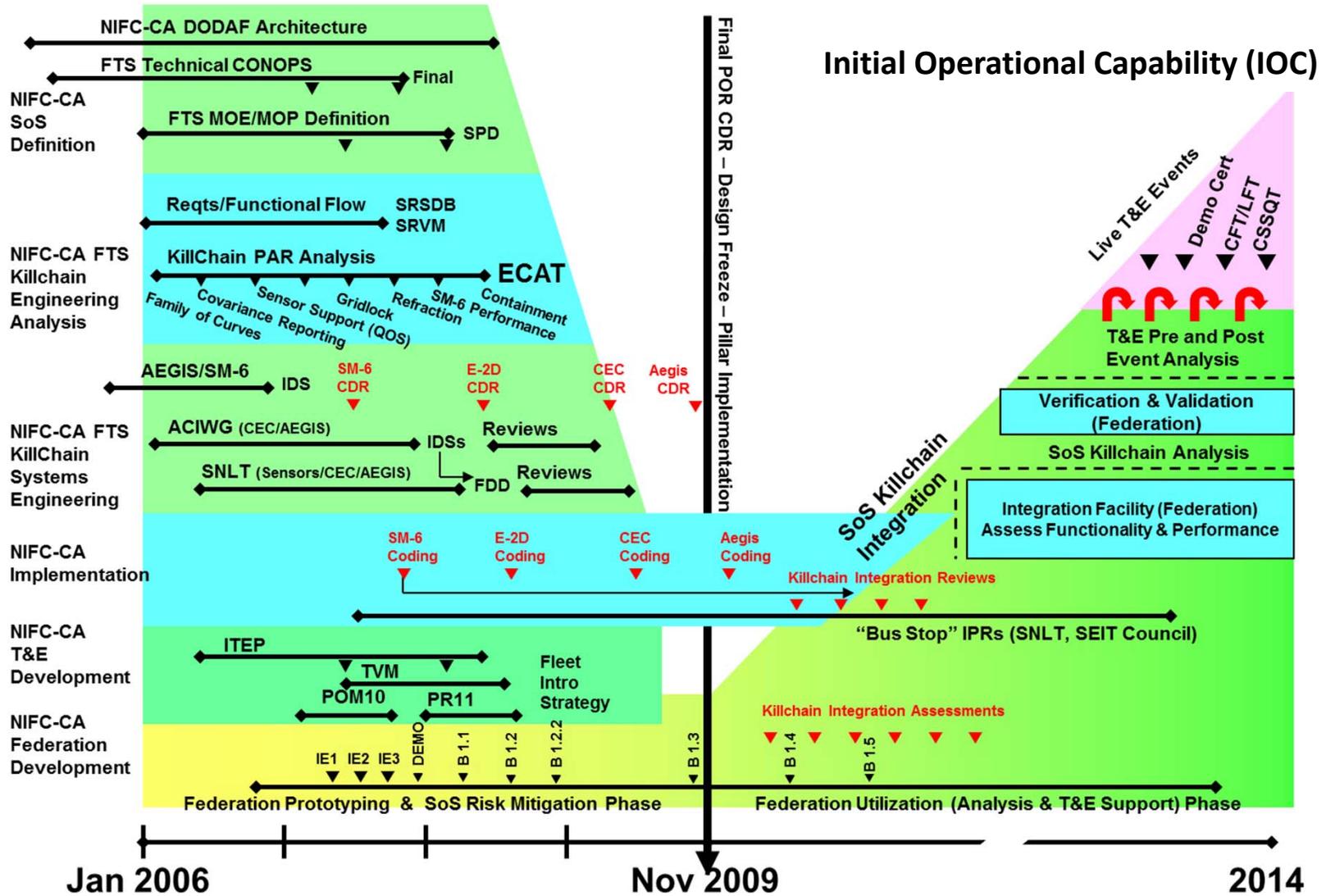
- **SoS:** an arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities. (*DoD Defense Acquisition Guidebook*)
- The Deputy Assistant Secretary of Defense for Systems Engineering (DASD(SE) *Systems Engineering Guide for Systems of Systems Version 1.0* lists two types of weapons systems SoS:
- **Directed:** The integrated SoS and component systems are managed and built to fulfill specific SoS requirements.
 - Component systems subordinated to SoS
 - Centrally managed; hierarchical approach
 - Usually authorized by DoD/service secretariat
 - Examples: Missile Defense Agency, Strategic Systems Program
- **Acknowledged:** The SoS has requirements, management, and resources, but the component systems are independent
 - Component systems not subordinated to the SoS
 - Collaborative approach between SoS and components
 - Example: NIFC-CA (Navy SoS systems engineering pilot project)



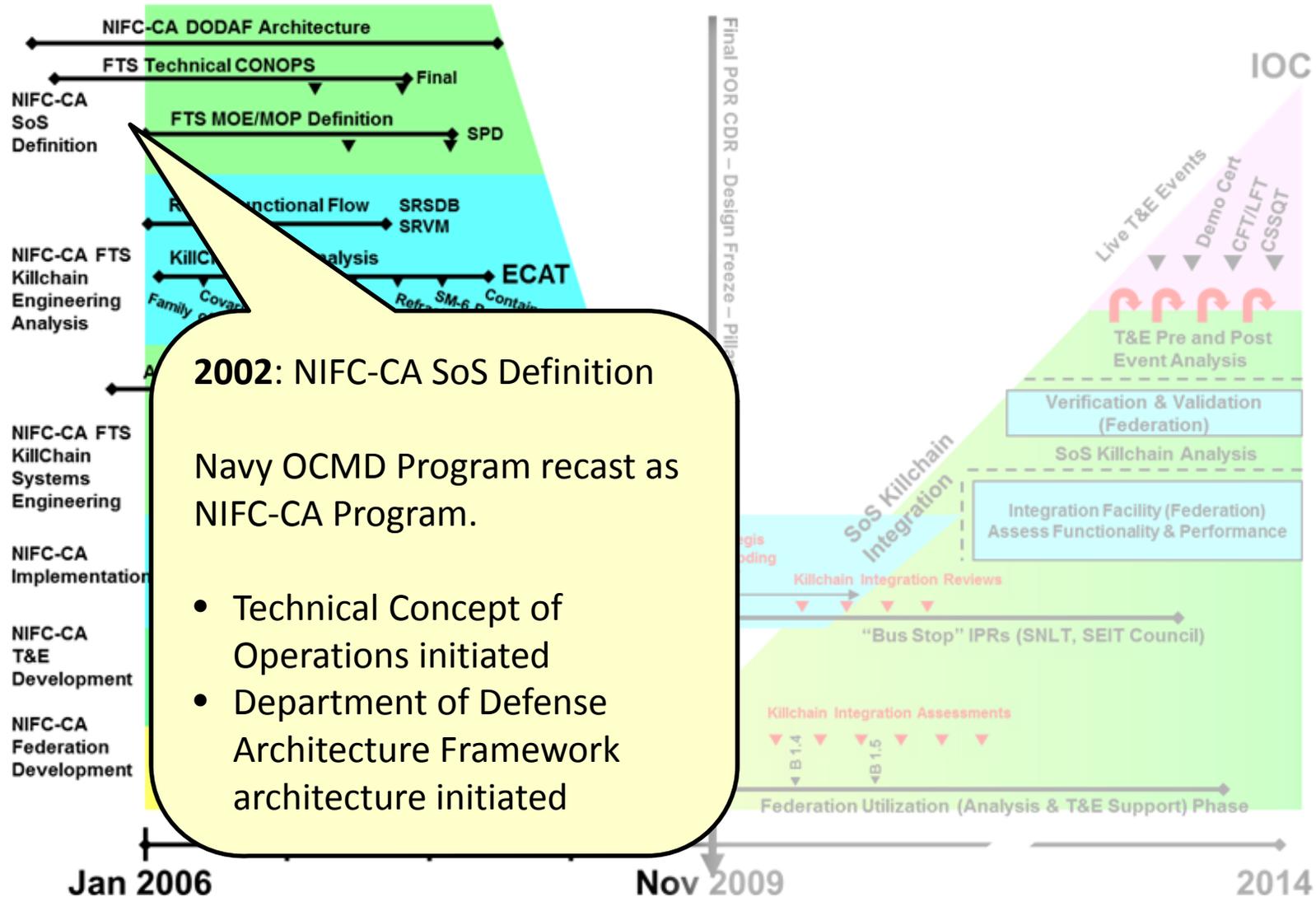
NIFC-CA SoS SE Team



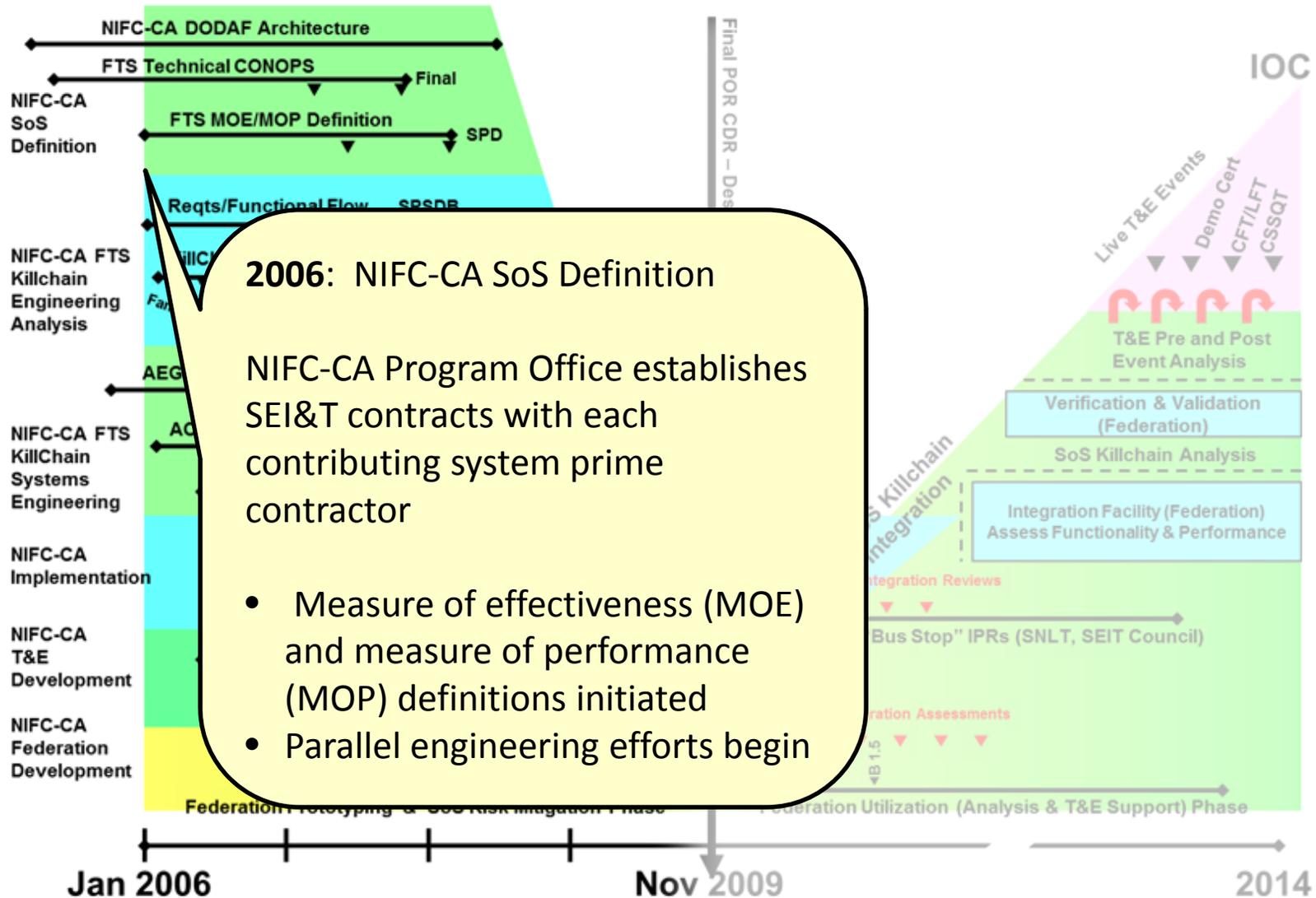
NIFC-CA Capability Acquisition and Engineering



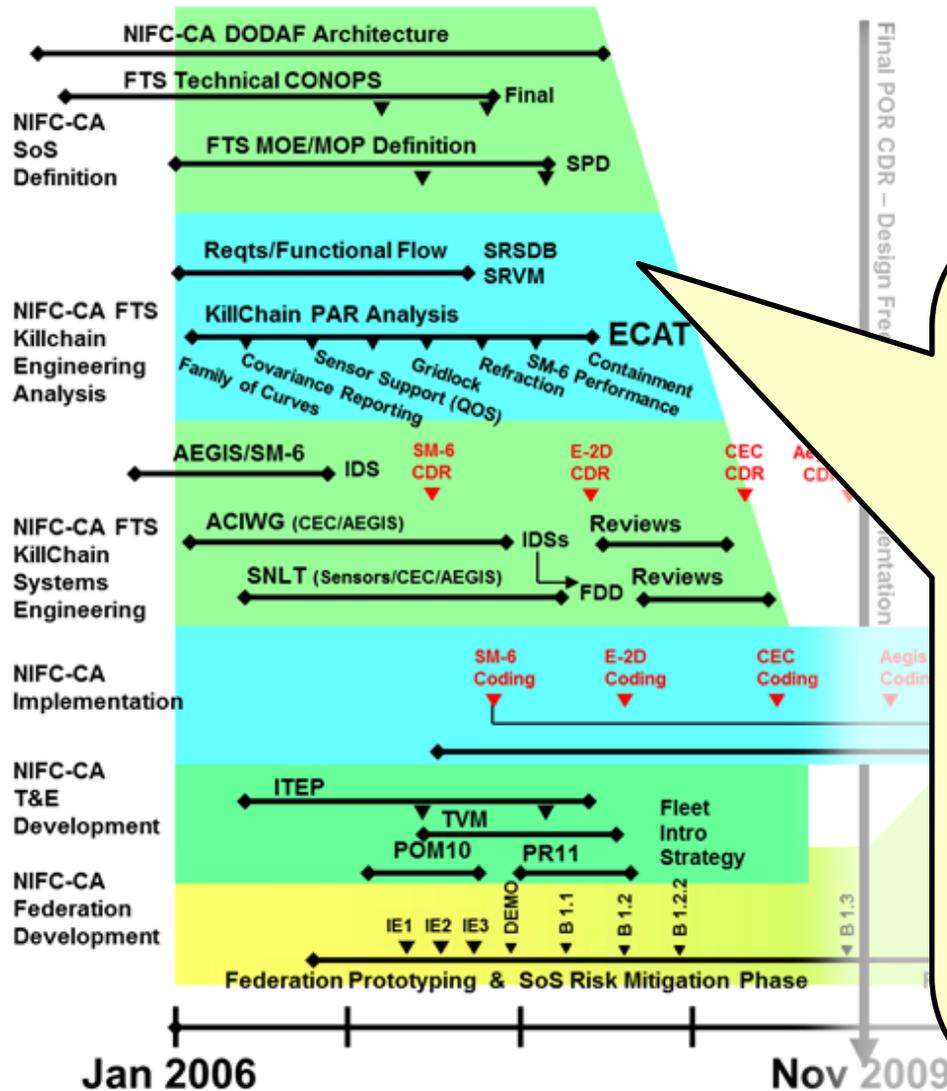
NIFC-CA Capability Acquisition and Engineering (cont'd)



NIFC-CA Capability Acquisition and Engineering (cont'd)



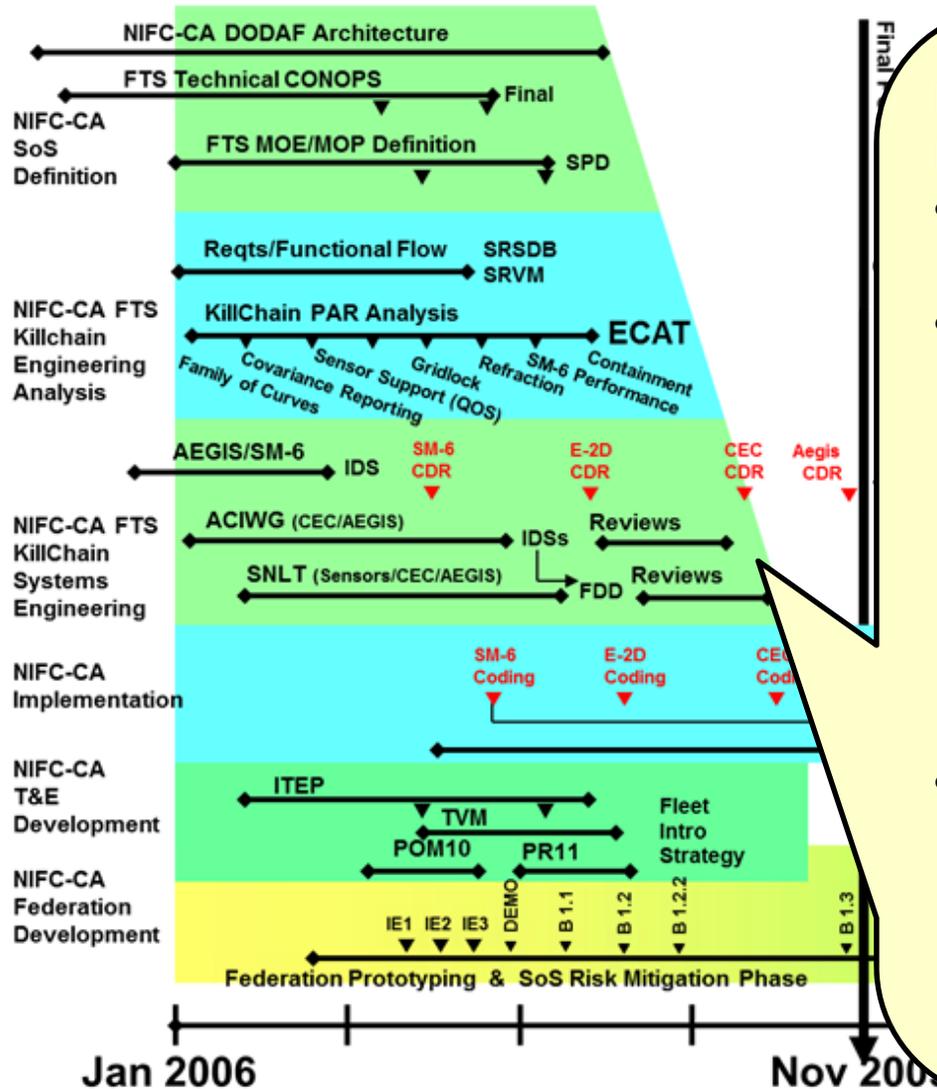
NIFC-CA Capability Acquisition and Engineering (cont'd)



NIFC-CA Killchain Engineering Analysis

- Captured SoS capability needs and requirements
- Captured contributing system performance and functions
- Analyzed and balanced critical performance parameters and functions across the killchain, such as sensors, gridlock, latency budget, missile seeker containment, etc.

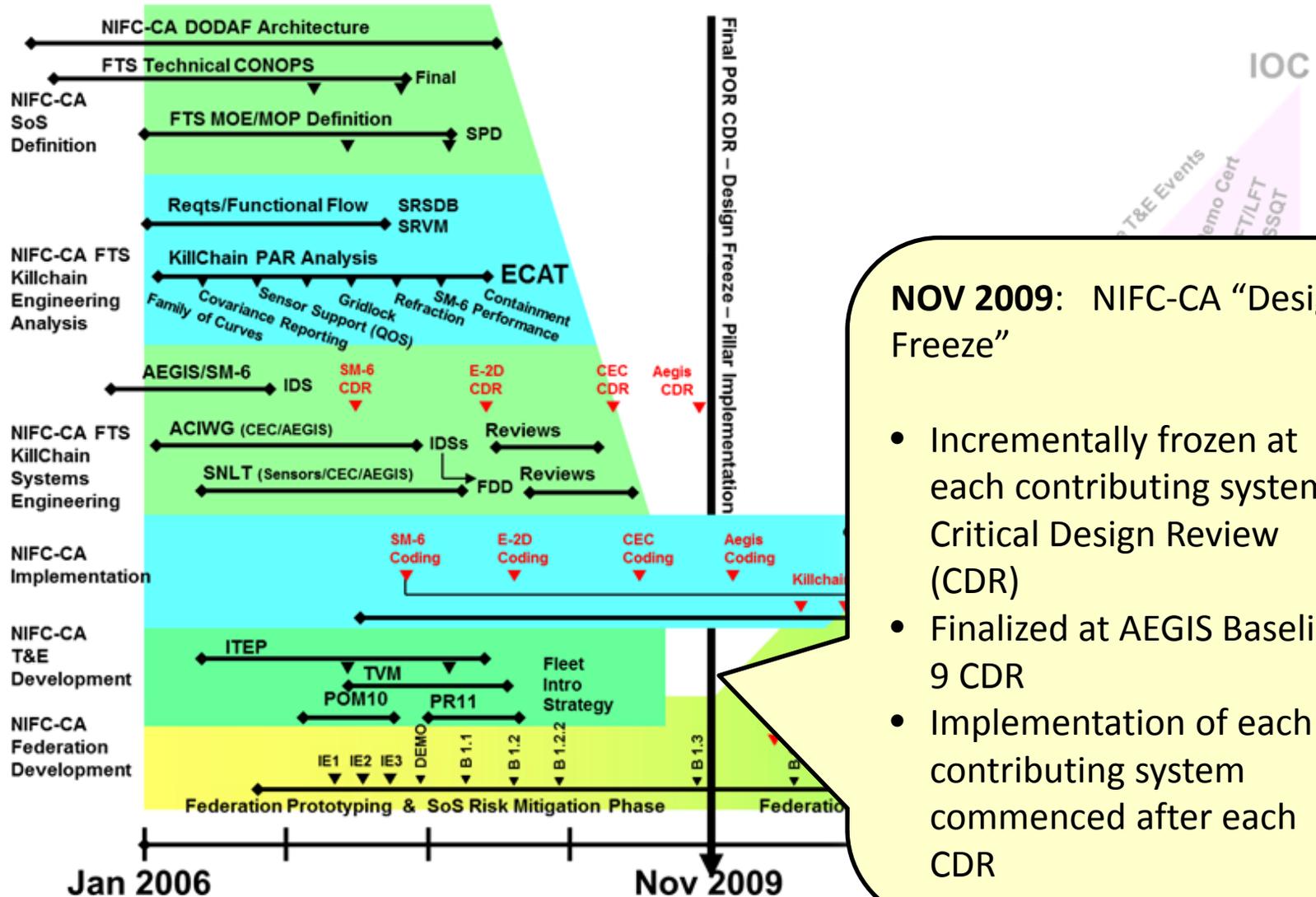
NIFC-CA Capability Acquisition and Engineering (cont'd)



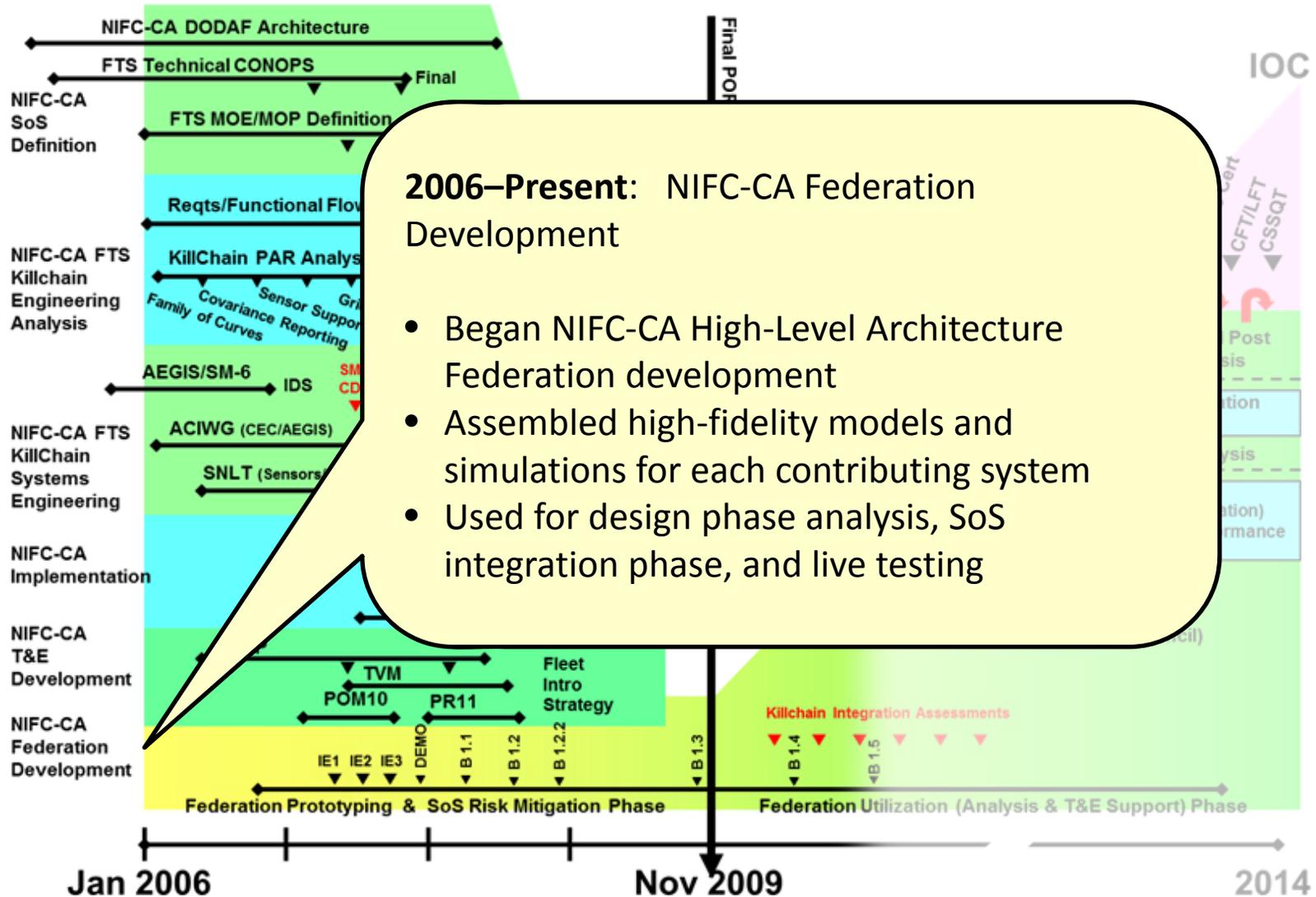
NIFC-CA Killchain Systems Engineering

- Executed by several government and industry teams
- Evaluated and reallocated functions across contributing systems
- Developed new functions as needed
- Documented results in NIFC-CA Functional Description Document
- Developed new IFC information exchange requirements (IERs) between systems. Documented in contributing systems engineering documents

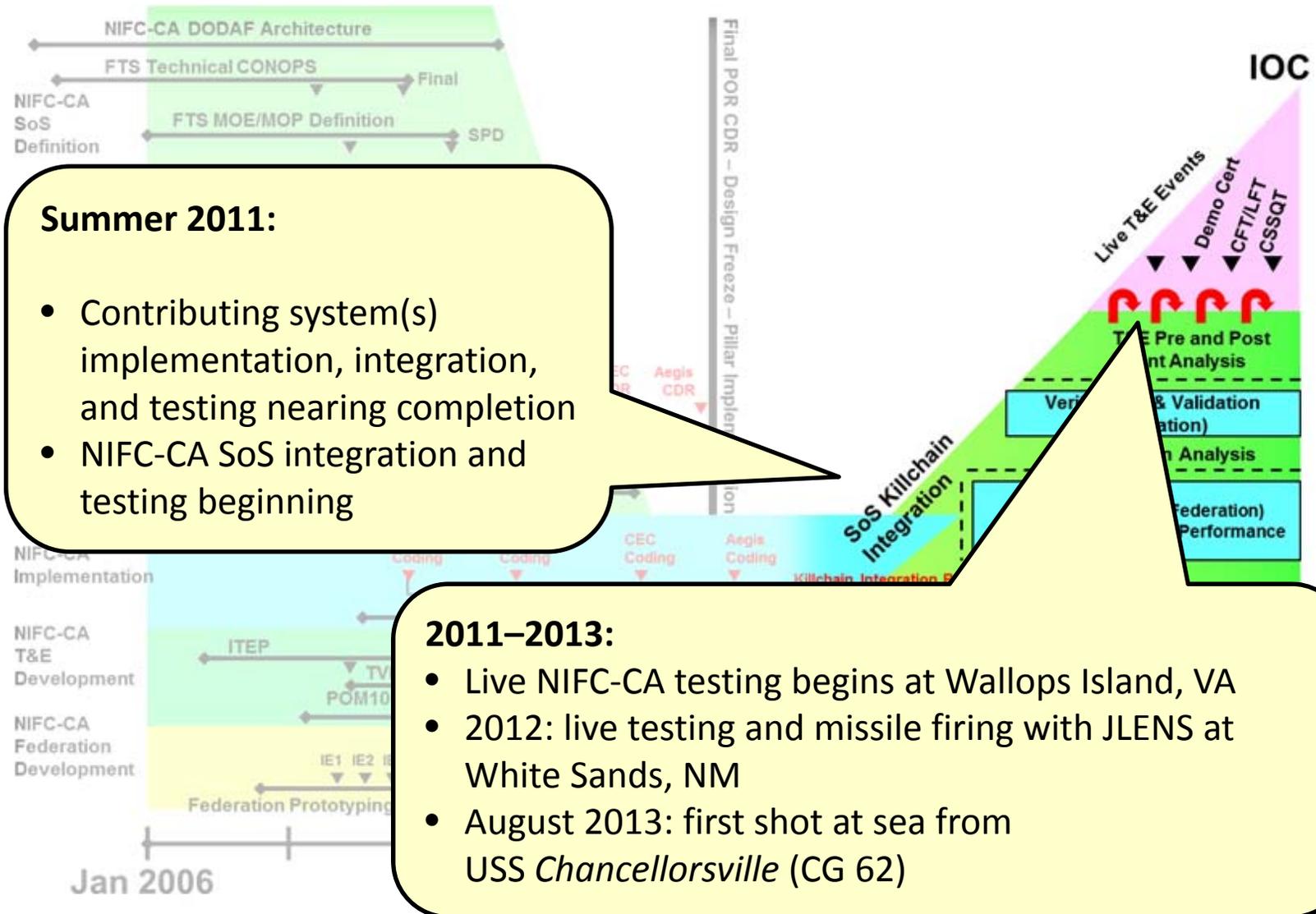
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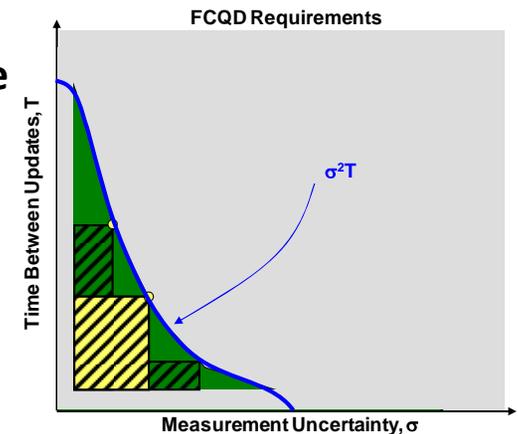
SoS Systems Engineering Accomplishments

- With multiple NIFC-CA SoS systems engineering accomplishments, primary is the design and implementation of an expandable architecture that distributes and/or decouples primary detect/control and control/engage interfaces and functions.

	DETECT/CONTROL	CONTROL/ENGAGE
LEGACY	<p>Entire D-C-E sequence executed with shipboard organic SPY radar.</p> <ul style="list-style-type: none"> • SPY and SM-2 missile performance explicitly matched and coupled 	<p>Initial and midcourse SM-2 guidance commands transmitted by organic SPY uplink dwells</p> <ul style="list-style-type: none"> • SM-2 endgame semi-active target illumination provided by shipboard illuminators
NIFC-CA	<p>A variety of remote surface and airborne radars provide tracking and fire control for OTH targets.</p> <ul style="list-style-type: none"> • Sensor-agnostic AEGIS weapon control system (WCS) • CEC remote sensor management • CEC best sensor selection 	<p>Initial and midcourse SM-6 guidance commands transmitted by organic SPY uplink dwells</p> <ul style="list-style-type: none"> • After target acquisition, SM-6 active seeker performs independent OTH endgame intercept

Key AEGIS IFC Implementation

- **AEGIS Baseline 9 is the program of record for NIFC-CA implementation**
- **Integrates and deploys new SM-6**
- **Implements new NIFC-CA killchain IERs**
 - Can act as a NIFC-CA remote sensor fire control provider
- **Sensor-agnostic WCS**
 - WCS does not know which remote sensor(s) are providing fire control data
 - Computes required quality of service (QOS) for threat
 - Sensor update rate
 - Covariance-based target containment
 - Asks CEC to find remote sensors to provide QOS for a specific engagement time window
- **WCS Reduced State Estimator Filter**
 - Uses covariance-based track information
 - Receives one-to-several remote sensor streams via CEC
 - Fuses these streams post-filter for composite engagement

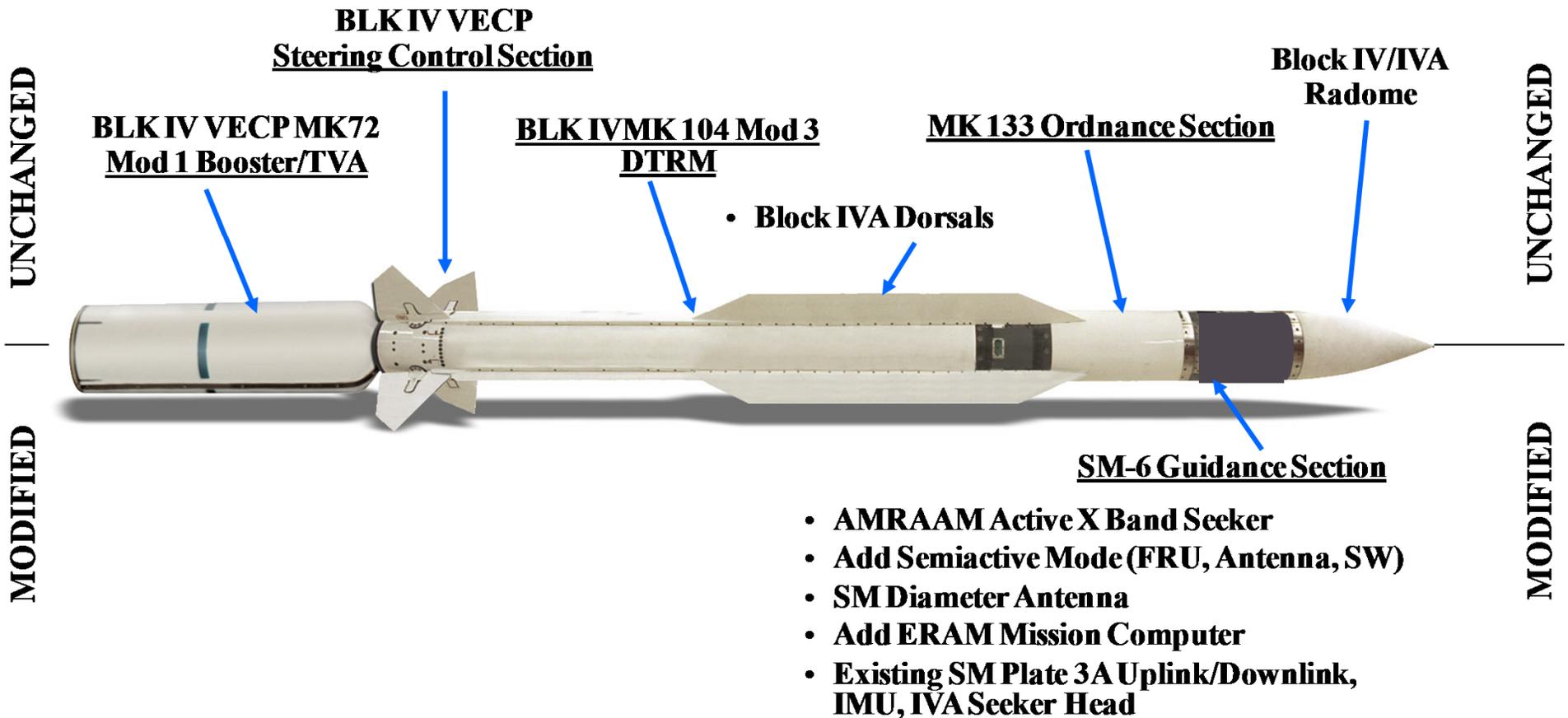




Key CEC IFC Implementation

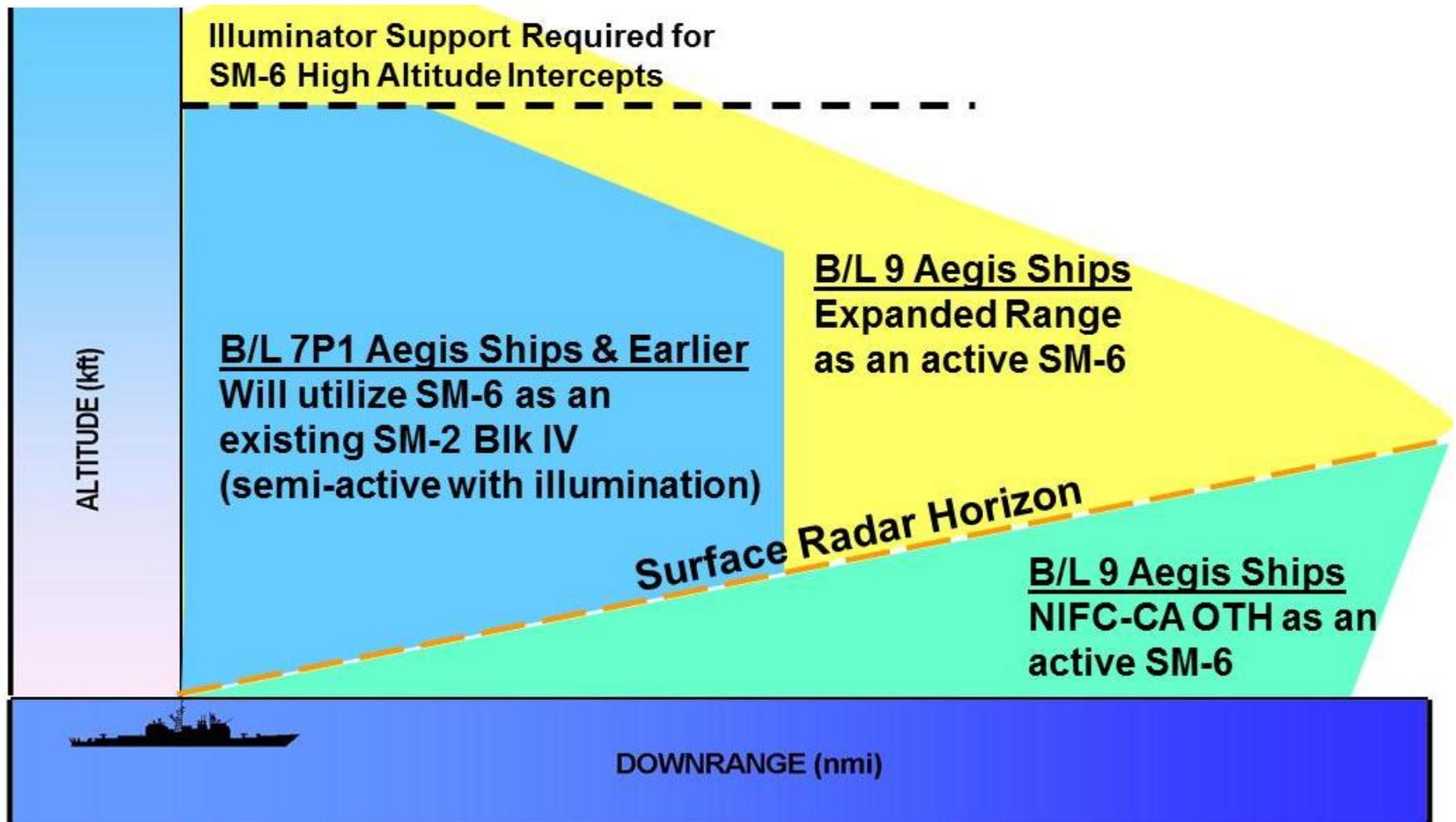
- **Builds upon deployed CEC sensor network capability and functionality including sensor/platform gridlock, remote sensor registration, and network management**
- **Implements new NIFC-CA killchain IERs**
- **Implements IFC best sensor selection function**
 - **Receives QOS request and specific engagement time window from AEGIS shooter**
 - **Asks candidate sensors if they can commit to support these parameters**
 - **Establishes contracts with a primary sensor and secondary and tertiary sensors (if available)**
- **Provides sensor data streams to shooter for duration of engagement**

Key SM-6 IFC Implementation



Active seeker technology uncouples the OTH endgame

NIFC-CA Battlespace Improvements





Summary

- **The “acknowledged” type of SoS acquisition can be effectively executed but is very challenging**
 - **Strong *programmatic* leadership and collaboration is required**
 - **Strong *engineering* leadership and collaboration is required**
 - **Clear delineation of responsibility, accountability, and authority required at all levels and all phases of development and fielding**
- **DASD(SE) anticipates most future SoS acquisitions will be the acknowledged type**
- **The NIFC-CA SoS systems engineering process will field major warfighter capability at initial operational capability and subsequent spirals**
 - **Open sensor and weapon interfaces are enabling a diversity of sensor providers and future active weapon developments**
 - **The NIFC-CA-enabled force will greatly multiply in-theater surface combatant capabilities**