Complex Systems:
T&E to Meet the Pace of Need

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Purpose

- Discuss the complex T&E environment and why it is imperative that we continue to enhance our testing acumen to meet the "speed of need"…and outpace our adversaries

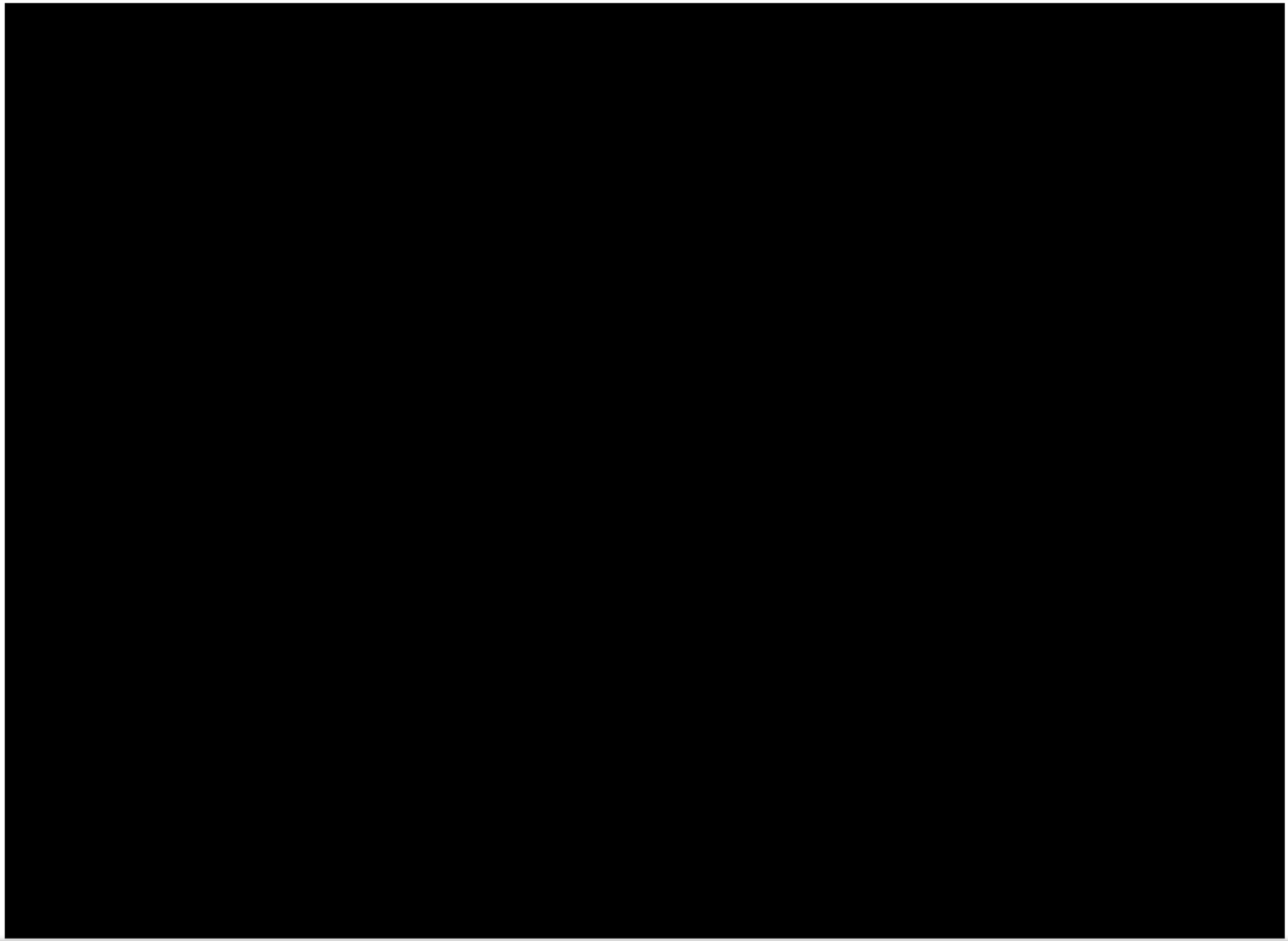
Overview

- The Pace of Need….Speed = Life
  - Speeding up the Arc of Acquisition
- Intro to the Complex Systems Environment
  - 5th-Generation, Systems-of-Systems test design
- Closing Thoughts & Discussion

Mission

Test and Evaluate New Capabilities in Operationally Realistic Environments to Inform Warfighters and Influence National Resource Decisions

Will it Work?
(Developmental Test)



Will it Work…In Combat?
(Operational Test)

The "Pace of Need" 2020+

- **Acquisition/test must grow & adapt commensurate with:**
  - **Technology**
  - **Declining Resources**
  - **The Threat**
  - **DoD's 3rd Offset Strategy Weapons Portfolio**


Deep Learning systems
Assisted Human Operations
Network-Enabled, Cyber-Hardened Weapons
Human-Machine Collaboration
Human-Machine Combat Teaming
Hypersonics & Directed Energy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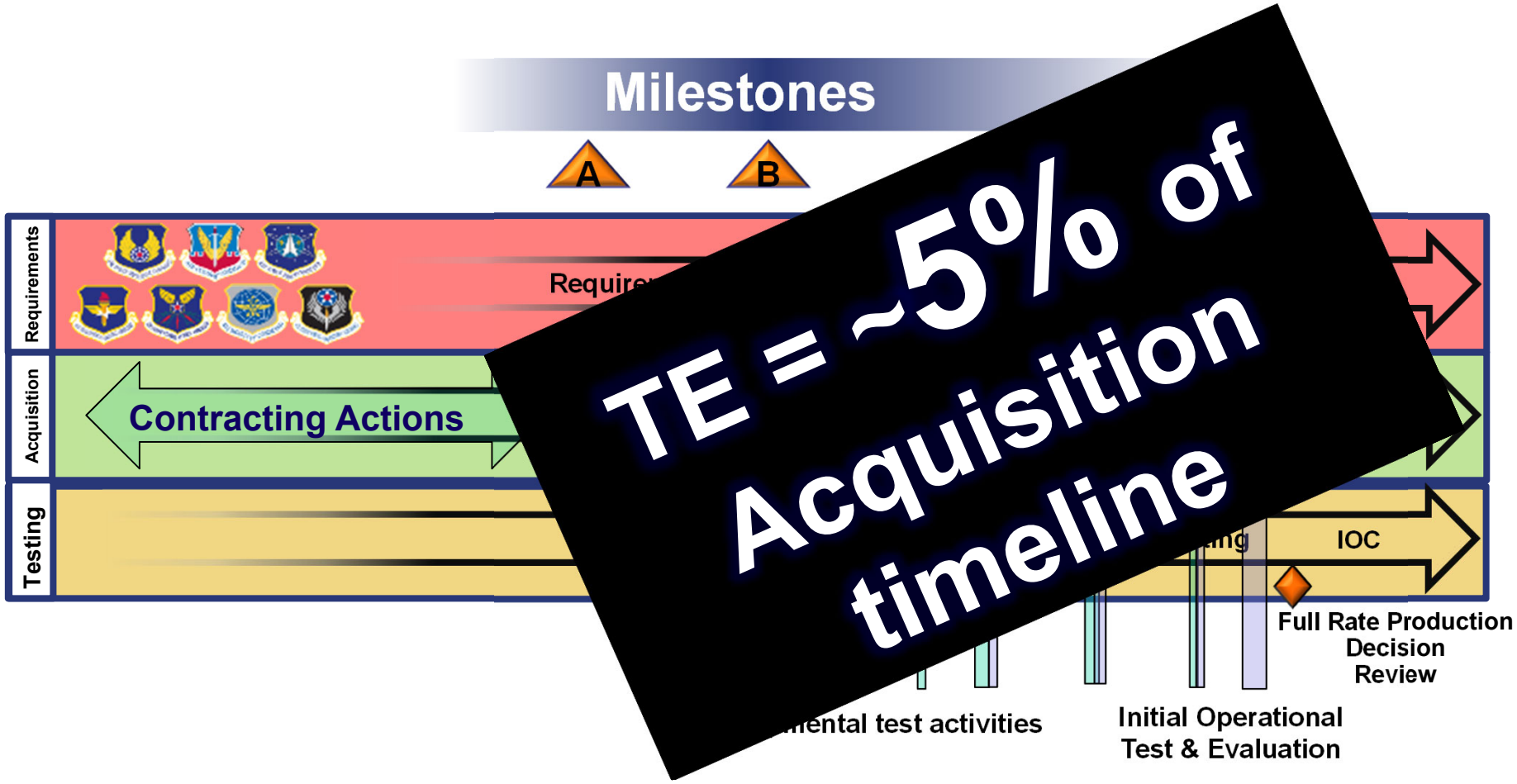
Five Points of Leverage
…to answer speed & complexity

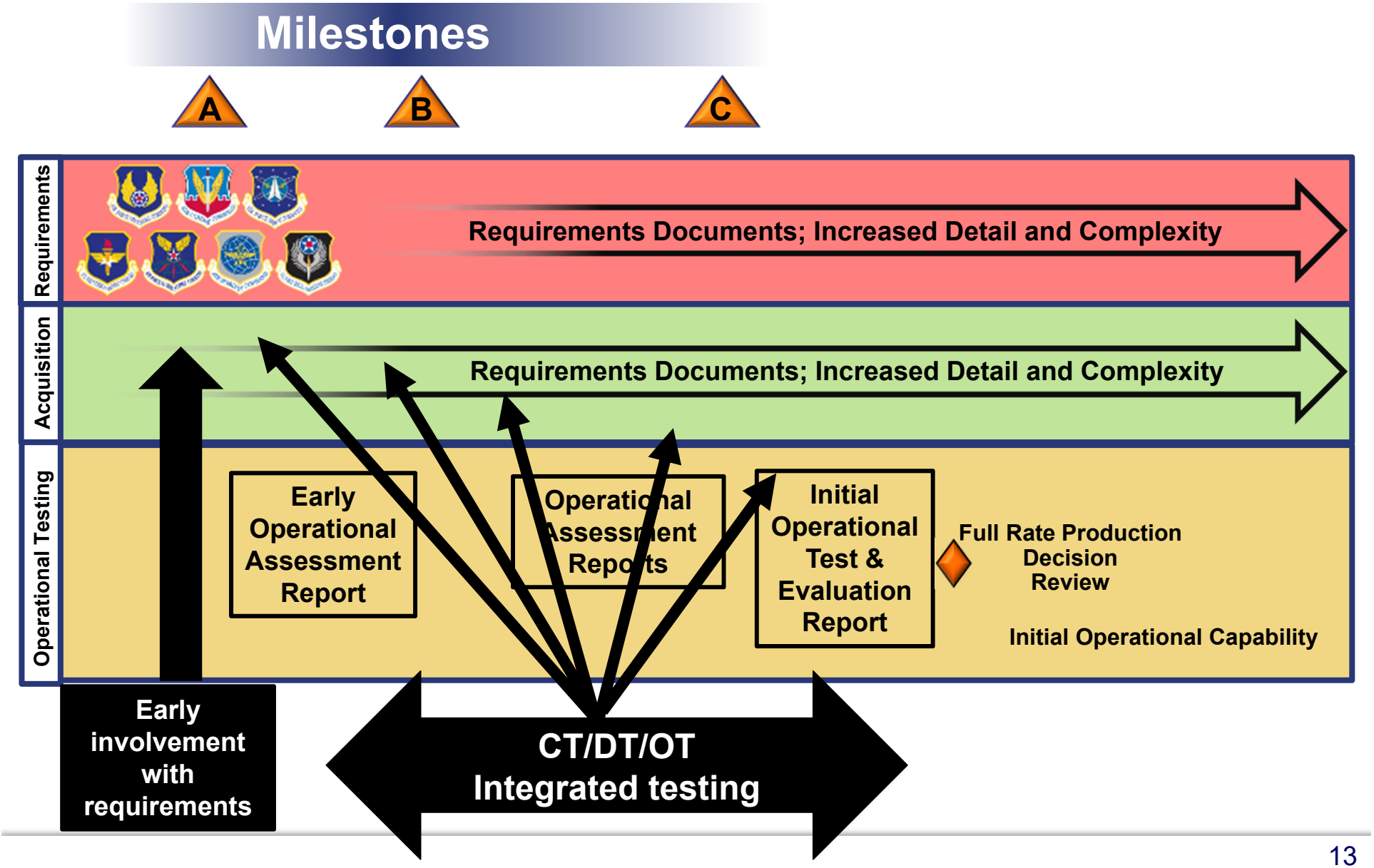
1. T&E Early & Integrated & Continuous
   VV&A…"Moving left; Moving Right"
2. 5th Gen Design of Experiment (DoE)
3. Modeling & Simulation
4. T&E Connective Tissue
5. T&E Automation

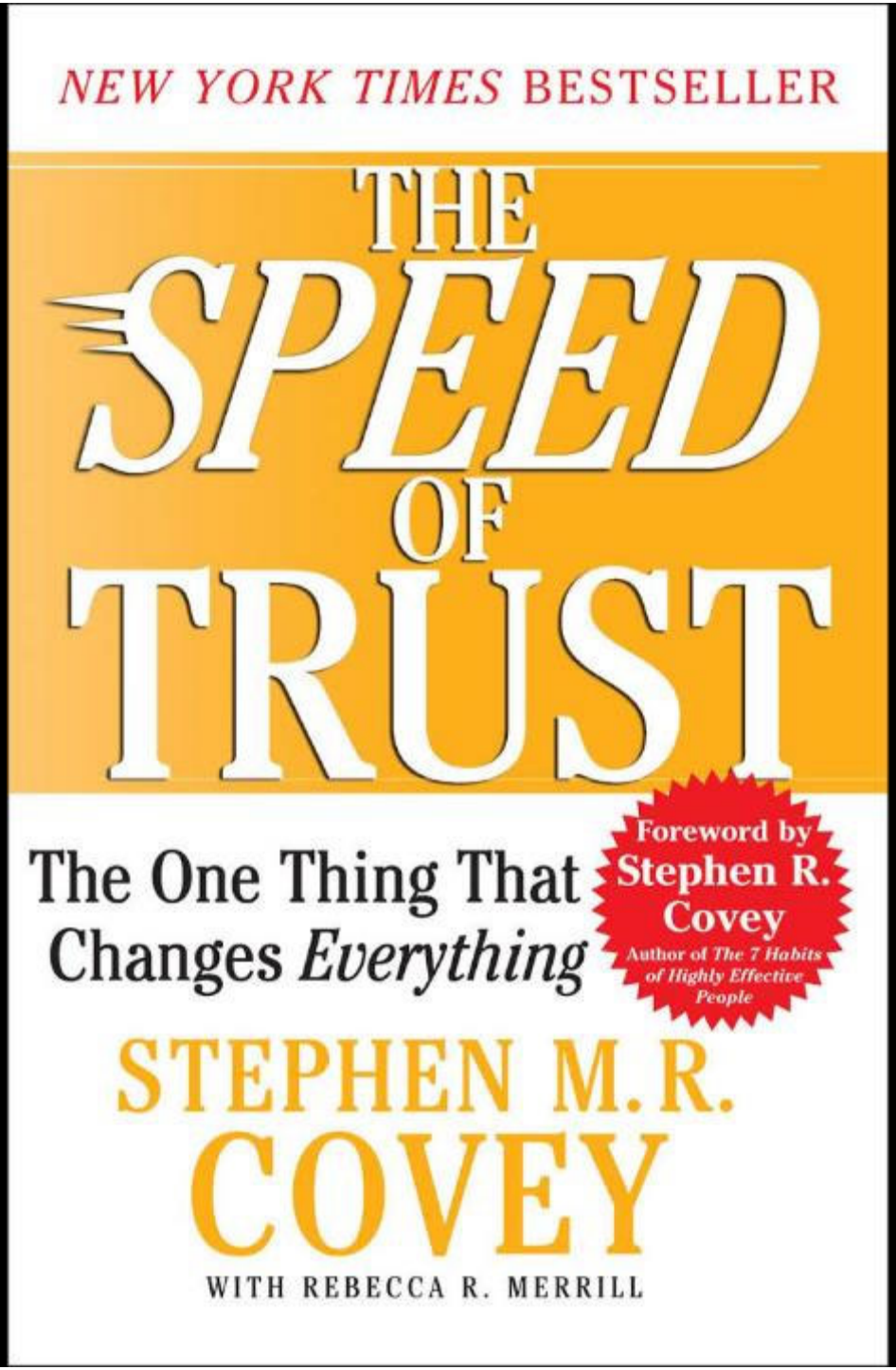
#1. Earlier & Integrated T&E Involvement

“Speeding things up”:



#1. Earlier & Integrated T&E Involvement

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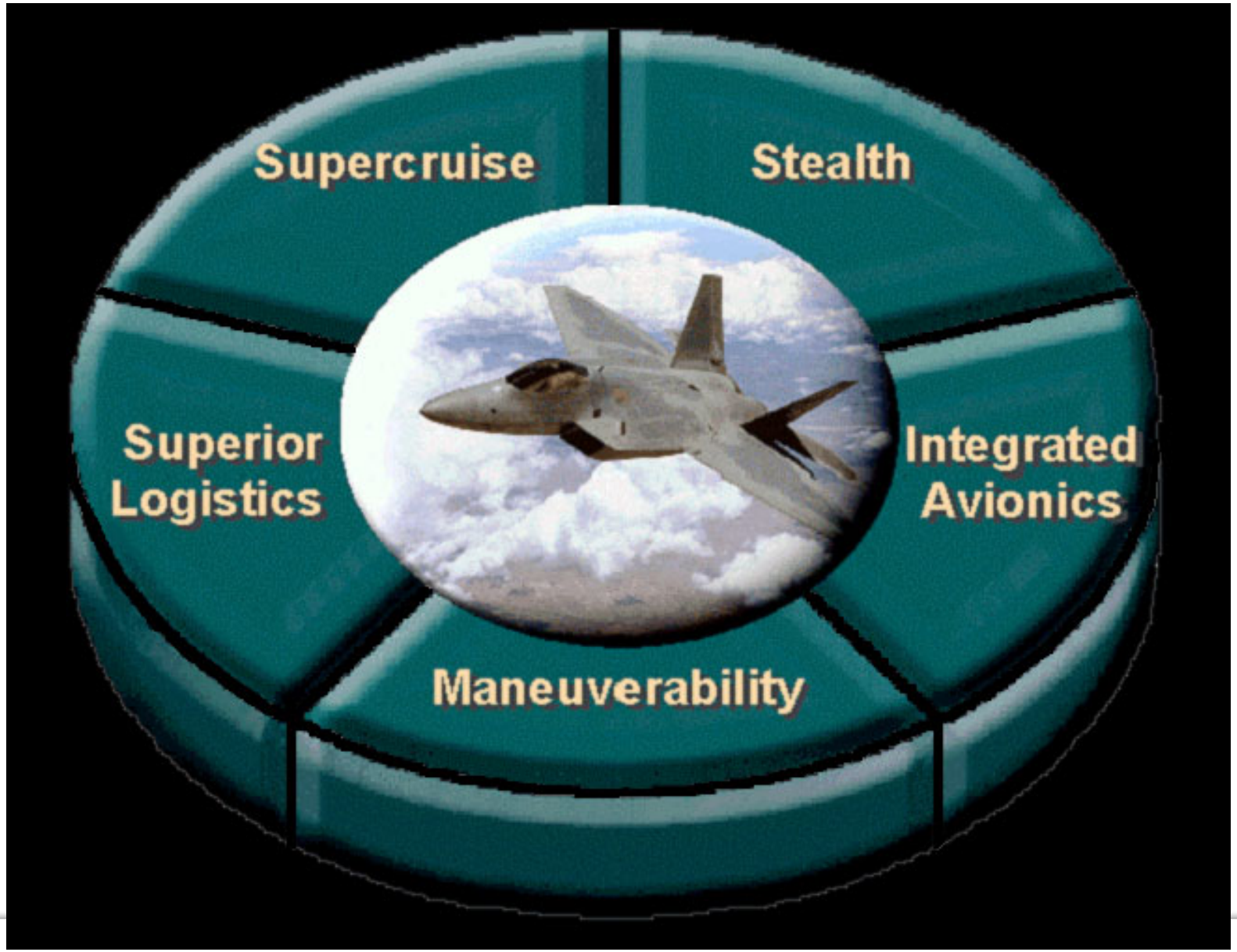
THE SPEED OF TRUST
The One Thing That Changes Everything
Foreword by Stephen R. Covey
Author of The 7 Habits of Highly Effective People
STEPHEN M.R. COVEY
WITH REBECCA R. MERRILL

5th Generation Fighters

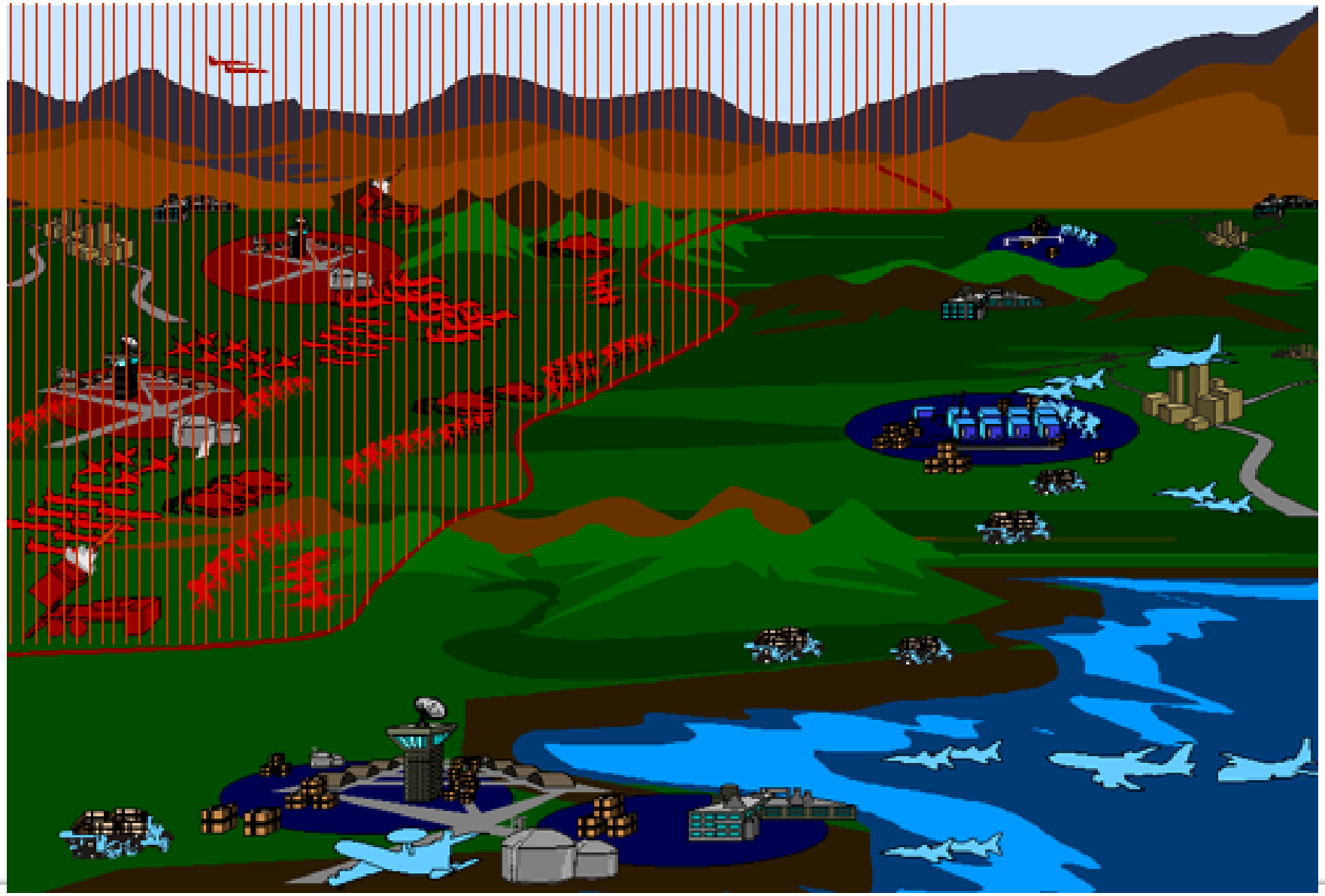
T&E for Complex Systems

#2. 5th Gen DoE
What is a 5th Gen Aircraft?

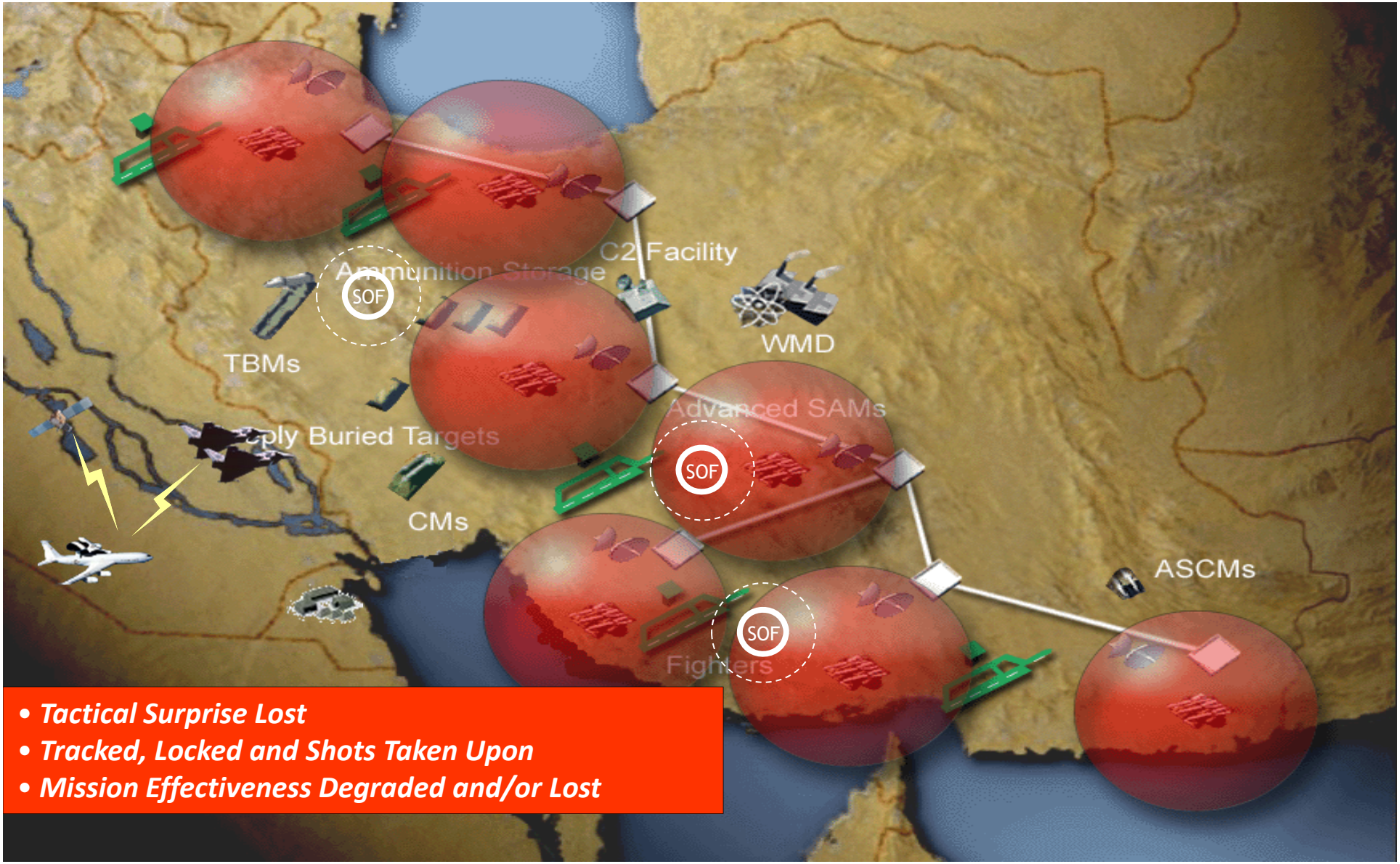


5th Gen Stealth….

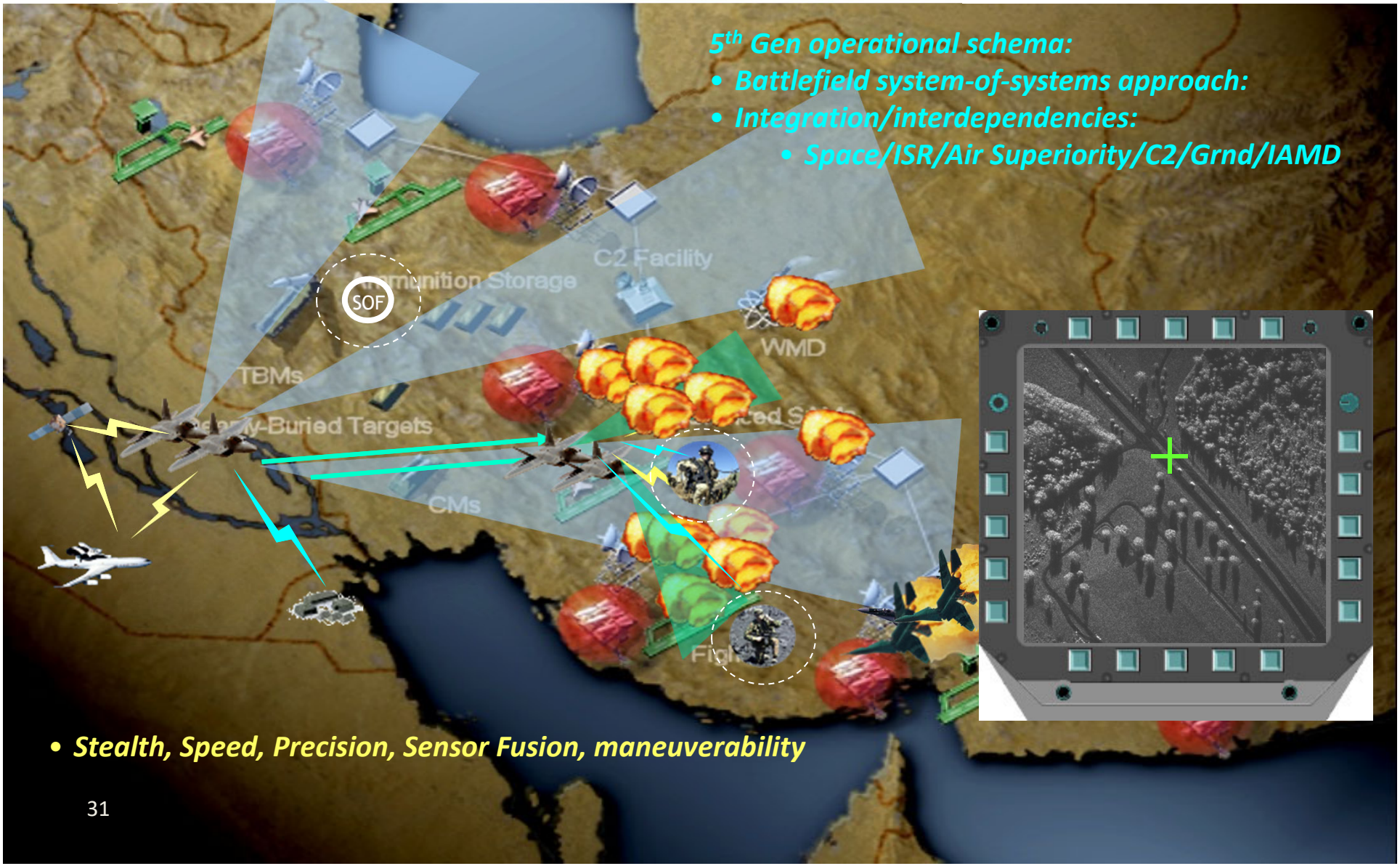
This is our Situation…"A2/AD"



Legacy Aircraft in Anti-Access Environment …High Mission Risk



Assymetric Advantage of 5th Gen



#2. 5th Gen DoE S-o-S Testing Challenges

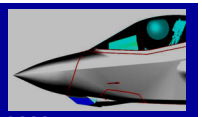
- **Where do you draw the test boundaries on a SoS weapons system?**
  - **Fifth-generation platforms are redefining classical boundaries as systems evolve from cooperative…to integrated…to *interdependent***
- **How do you appropriately measure "Suitability", "Effectiveness" and "Mission Capability" in a System-of-System weapons platform?**
  - **If the autonomic Logistics Information System is compromised can the F-35 be Suitable and Mission Capable in the operational environment?**

#2. 5th Gen DoE
F-35 as a System-of-Systems

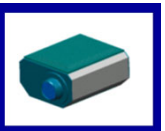
Cockpit
Projection Display Technology for Enlarged Screen Area and Availability

EW
More Capability at 1/2 the Cost - Digital Modules, Production Processes, Apertures

EOTS
Low Profile Window Optimized for Visibility & Configuration Integration



DAS
Demonstrated Significant Contributions to Situation Awareness



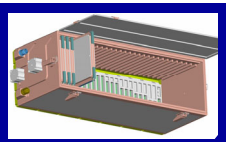
Radar
Half the Weight, Half the Cost Goal Being Realized

CNI
Critical H/W Elements and S/W Reuse Demonstrated

ICP
COTS Technology Refresh Demonstrated

Weapons
Finalized Carriage Concepts Support All Weapons

Common Components
Economy of Scale Savings



Open Architecture / Software
Standard Interfaces, Loose Coupling, Object Oriented Design, Commercial Tools for Simpler Integration

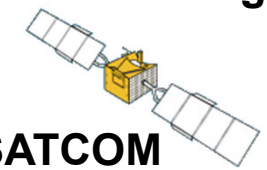
Mission Support
Finalized Carriage Concepts Support All Weapons

#2. 5th Gen DoE "A System-of-Systems-of-Systems"

- Link 4/ACLS, ICLS
- Link 16
- UHF/VHF Voice/Data
- SATCOM 2 Way Voice/Data
- LAN/WAN/Internet

Link -16
Aviation & Air Defense Assets

Beyond Line of Sight



F-35 IOT&E:
We are pathfinders for the art & science of 3rd Offset Strategy weapons systems testing

PHM
Datalink

Joint Tactical Radio System (JTRS)
Functionality
Variable Message Format
VMF

Autonomic Logistics Information System "ALIS"

Global Supply Chain Mngmt

94 Information Exchange Requirements to Ensure Interoperability Across US and Coalition Forces

#2. 5th Gen DoE
Constructing a Complex Air Vehicle (F-35) Test

What is to be tested?
- Mission Capability
- Effectiveness and Suitability
- Requirements Satisfied

Understand:
- System Under Test
- Operations
- Battlespace Conditions

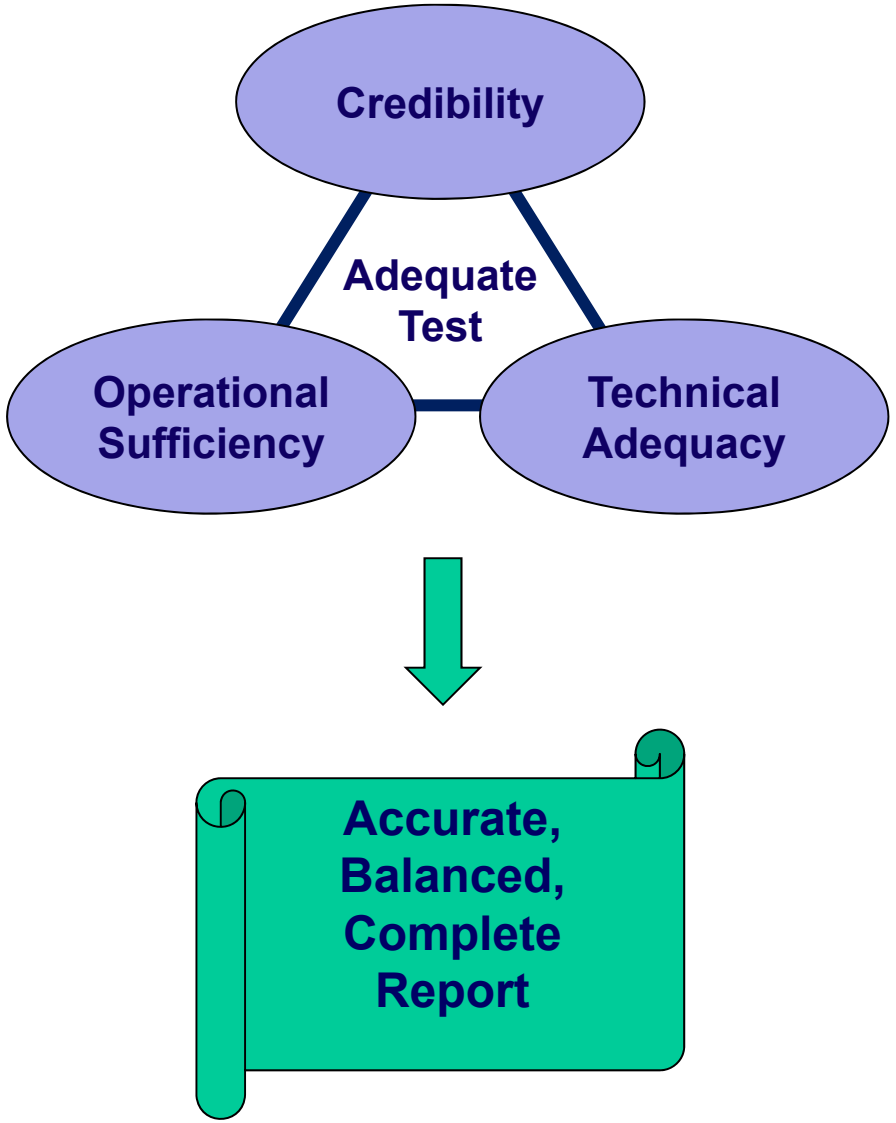
Test Design
- Characterize, ID Problems, Thresholds
- Scientific Test & Analysis Techniques
- Measures

Resources
- OAR, M&S, Instrumentation, Assets, INFO!

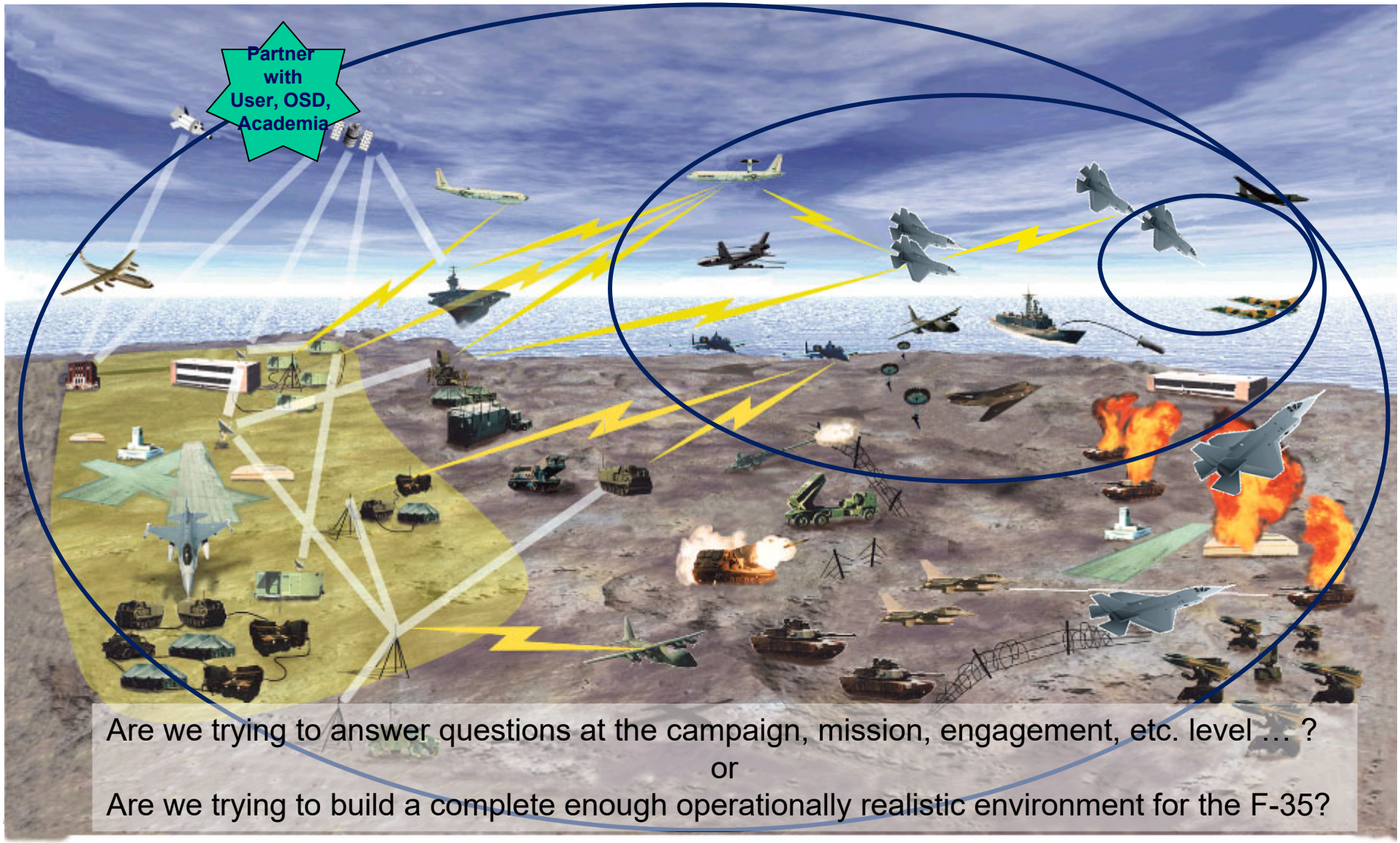
Execute
- Operational realistic

Analyze/Evaluate

Report



#2. 5th Gen DoE F-35 Battlespace



Are we trying to answer questions at the campaign, mission, engagement, etc. level … ?

or

Are we trying to build a complete enough operationally realistic environment for the F-35?

#2. 5th Gen DoE F-35 Mission Areas

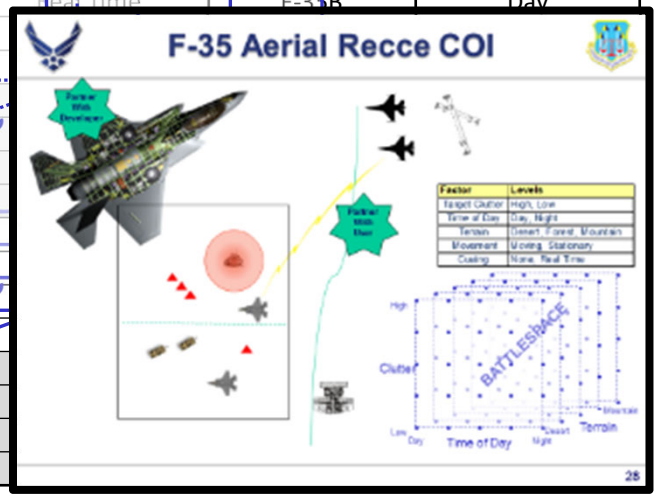
- Mission Areas, or "COIs", i.e. what things are the key operational things we expect the F-35 to do??
  - Air to Surface Attack
    - Pre-planned - Air Interdiction, Strategic Attack, OCA – Surface Attack
    - Un-Planned - Strike Coordination and Reconnaissance, Armed Reconnaissance
  - Close Air Support
    - Close Air Support (CAS) Forward Air Controller (Airborne)
  - Air Warfare
    - Offensive Counter Air (OCA); Defensive Counter Air (DCA)
    - Cruise Missile Defense (CMD)
  - Electronic Attack
    - Suppression of Enemy Air Defenses (SEAD)
    - Destruction of Enemy Air Defenses (DEAD)
  - Combat Search and Rescue
    - Combat Search and Rescue (CSAR)
    - Tactical Recovery of Aircraft and Personnel (TRAP) Assault Support Escort (ASE)
  - Aerial Reconnaissance
  - Suitability: Deployability, Fwd Basing; Sortie Generation; Training; Logistics Support

#2. 5th Gen DoE
Managing Complexity F-35 Test Design

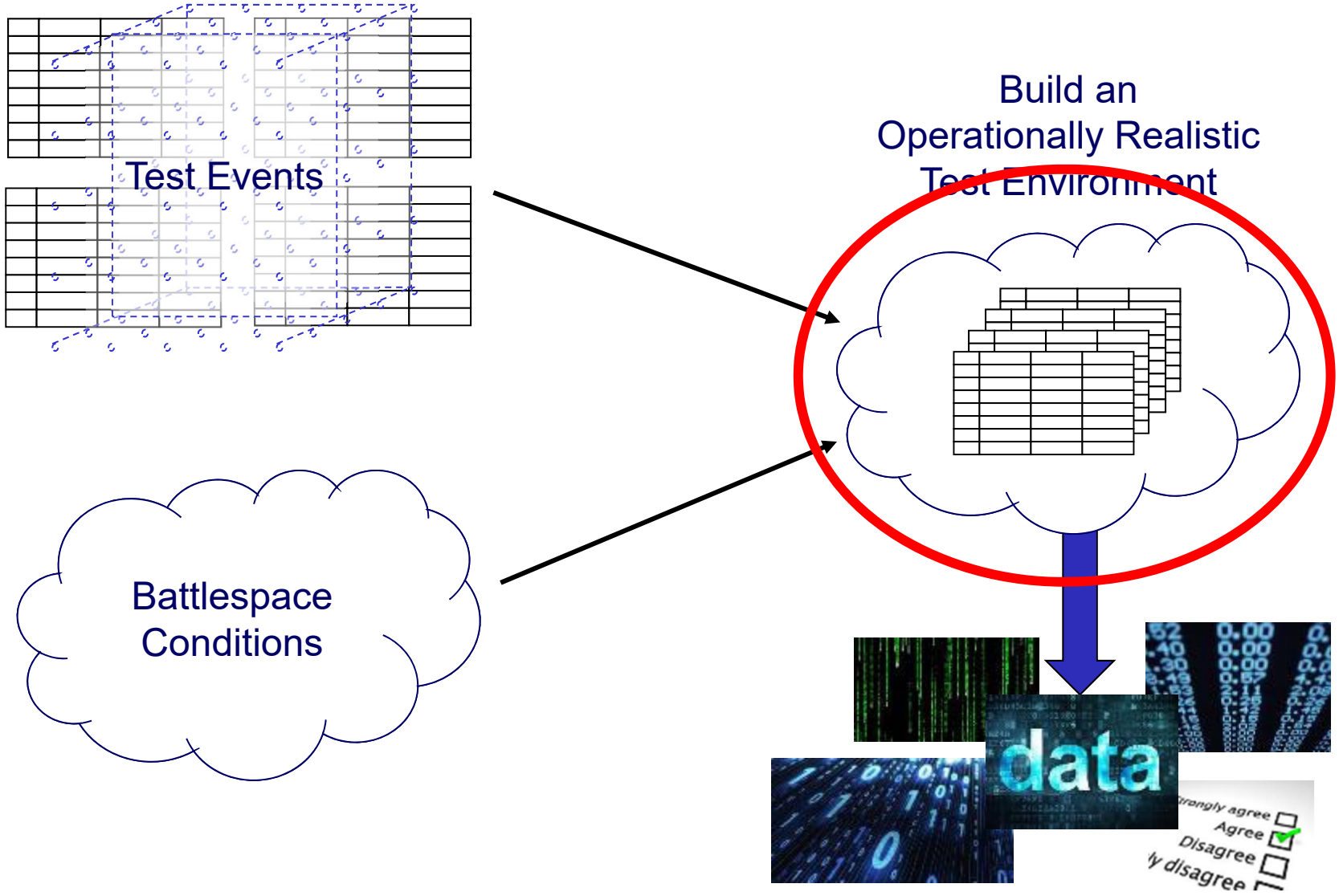
Test Trial	Design Point	Target Clutter	Priority Target Movement	Cueing	F-35 Variant	Time of Day
1	1	High	Stationary	None	F-35A	Night
	2	Low	Stationary	Real Time	F-35A	Night
	3	Low	Moving	None	F-3	Night
	4	High	Stationary	Real Time		Night
2	5	High	Moving	None		Day
	6	High	Stationary	Real Time		Day
	7	Low	Stationary	Real Time		Day
	8	Low	Stationary	None	F-35A	Day
3	9	High	Stationary	Real Time	F-35B	Night
	10	Low	Stationary	None	F-35B	Night
	11	High	Stationary	None	F-35B	Night
	12	Low	Moving	Real Time	F-35B	Night
4	13	Low	Stationary	Real Time	F-35C	Day
	14	Low	Stationary	None	F-35C	Day
	15	High	Moving	Real Time	F-35C	Day
	16	High	Stationary	None	F-35C	Day
5	17	Low	Moving	Real Time	F-35B	Day
	18	High	Stationary	Real Time	F-35B	Day
	19	Low	Stationary			
	20	High	Stationary			
6	21	Low	Stationary			
	22	Low	Stationary			
	23	High	Moving			
	24	High	Stationary			
7	25	High	Stationary			
	26	Low	Moving			
	27	Low	Stationary			
	28	High	Stationary			
8	29	Low	Stationary			
	30	High	Moving			
	31	High	Stationary			
	32	Low	Stationary			

Partner With Academia

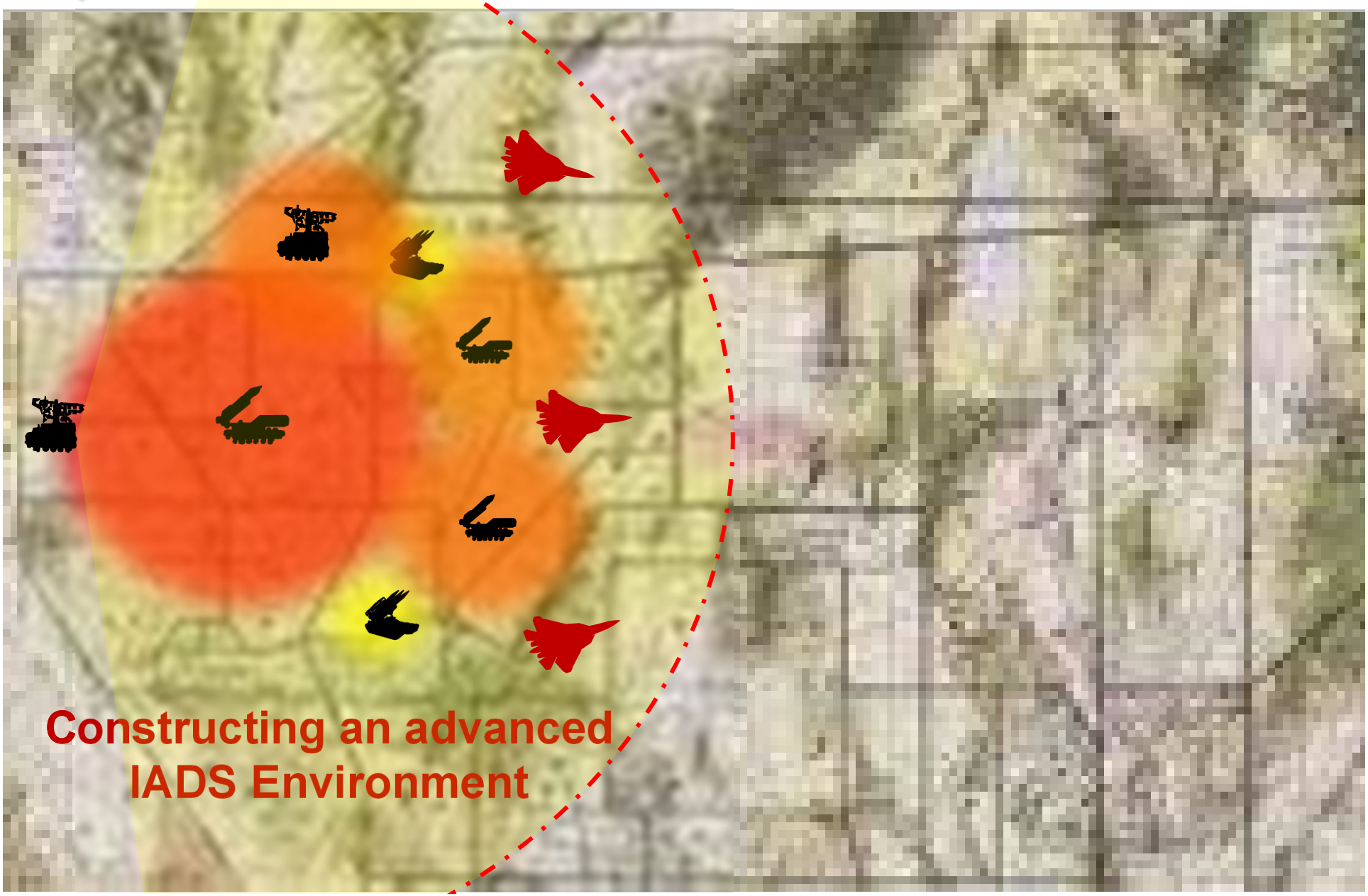
Partner With OSD



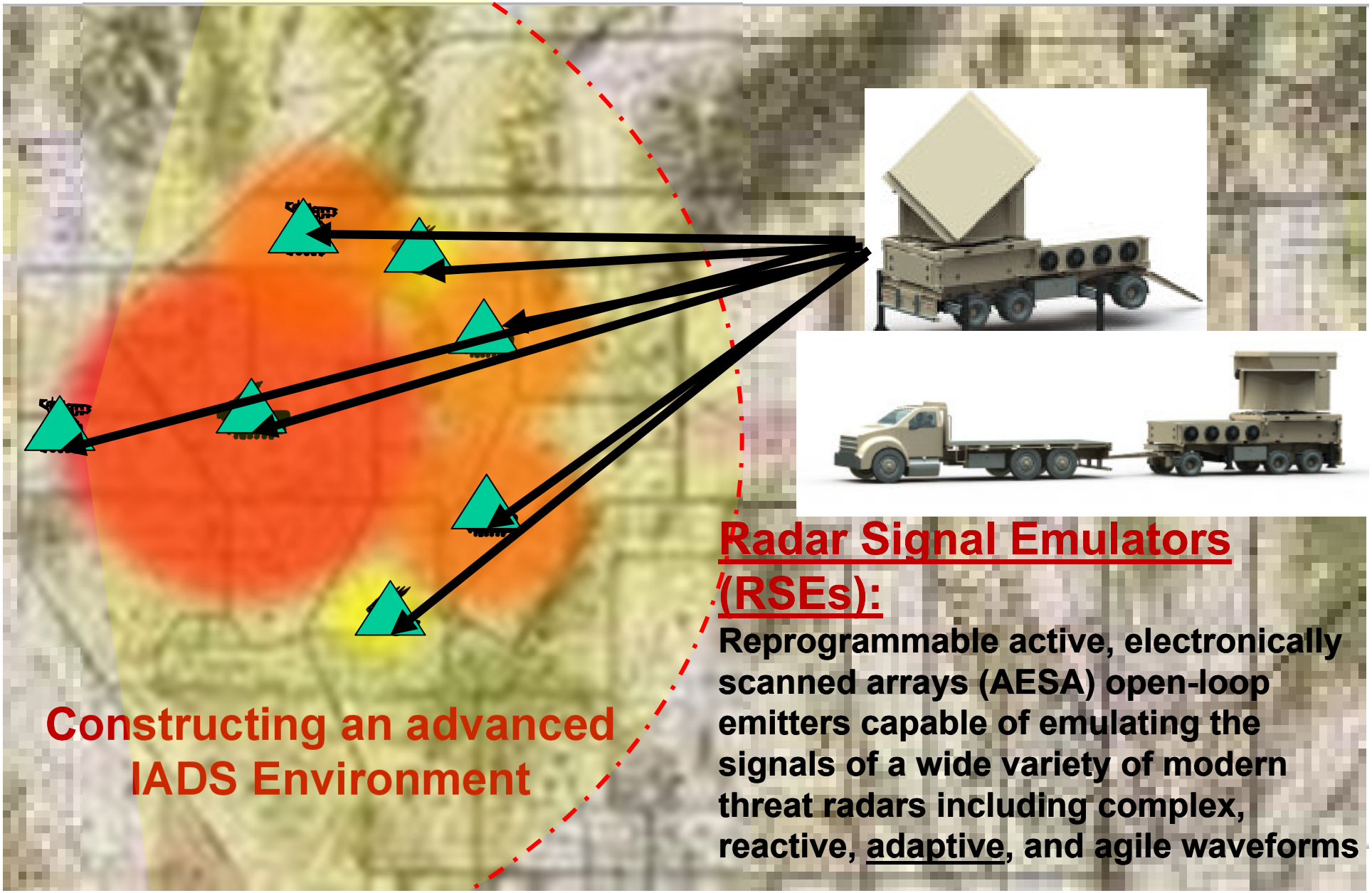
#2. 5th Gen DoE Realistic Test Environment



#2. 5th Gen DoE
Operationally Realistic Test Environment



Constructing a Synthetic Realistic Threat

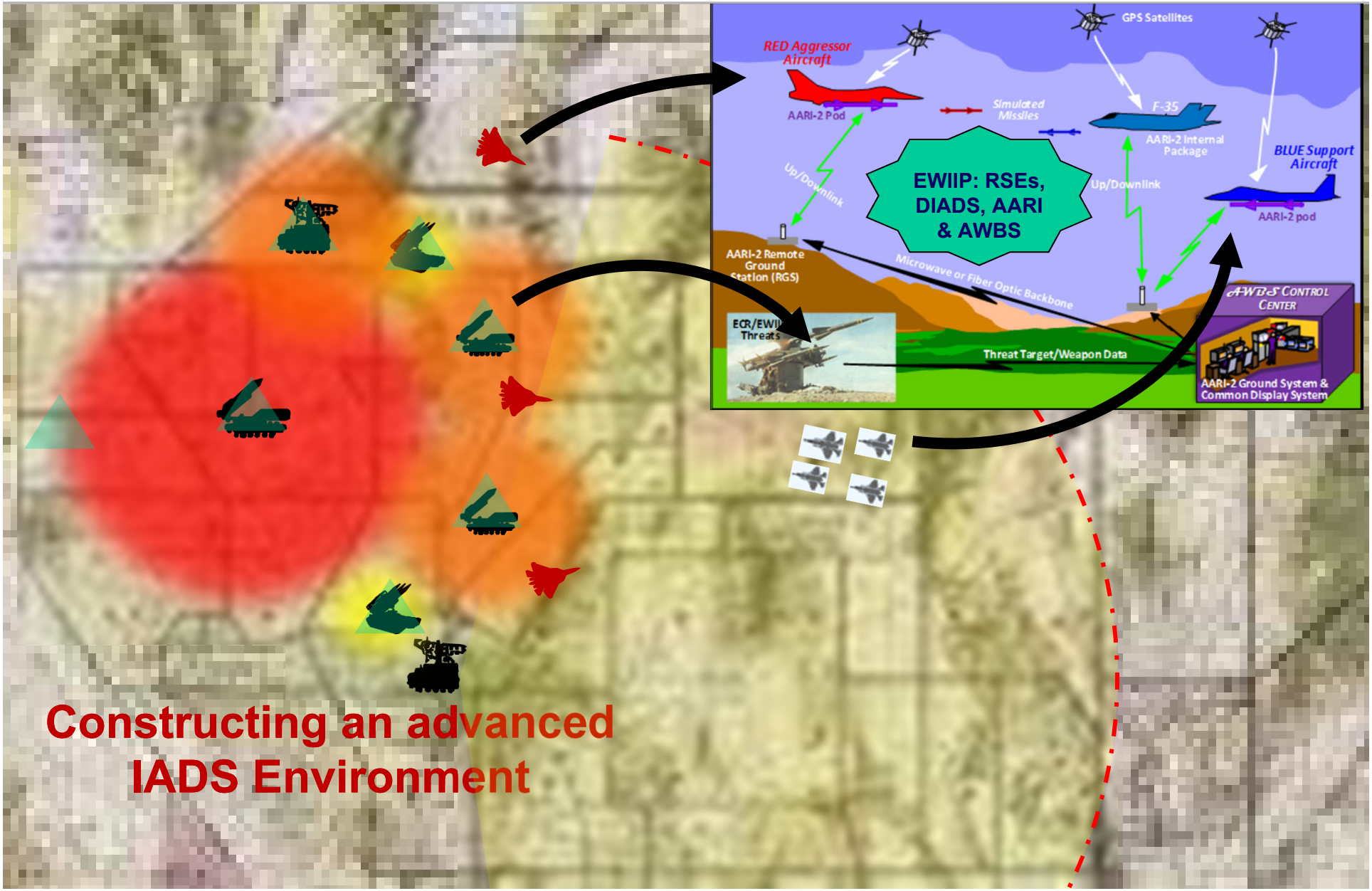


Constructing an advanced IADS Environment

Radar Signal Emulators (RSEs):

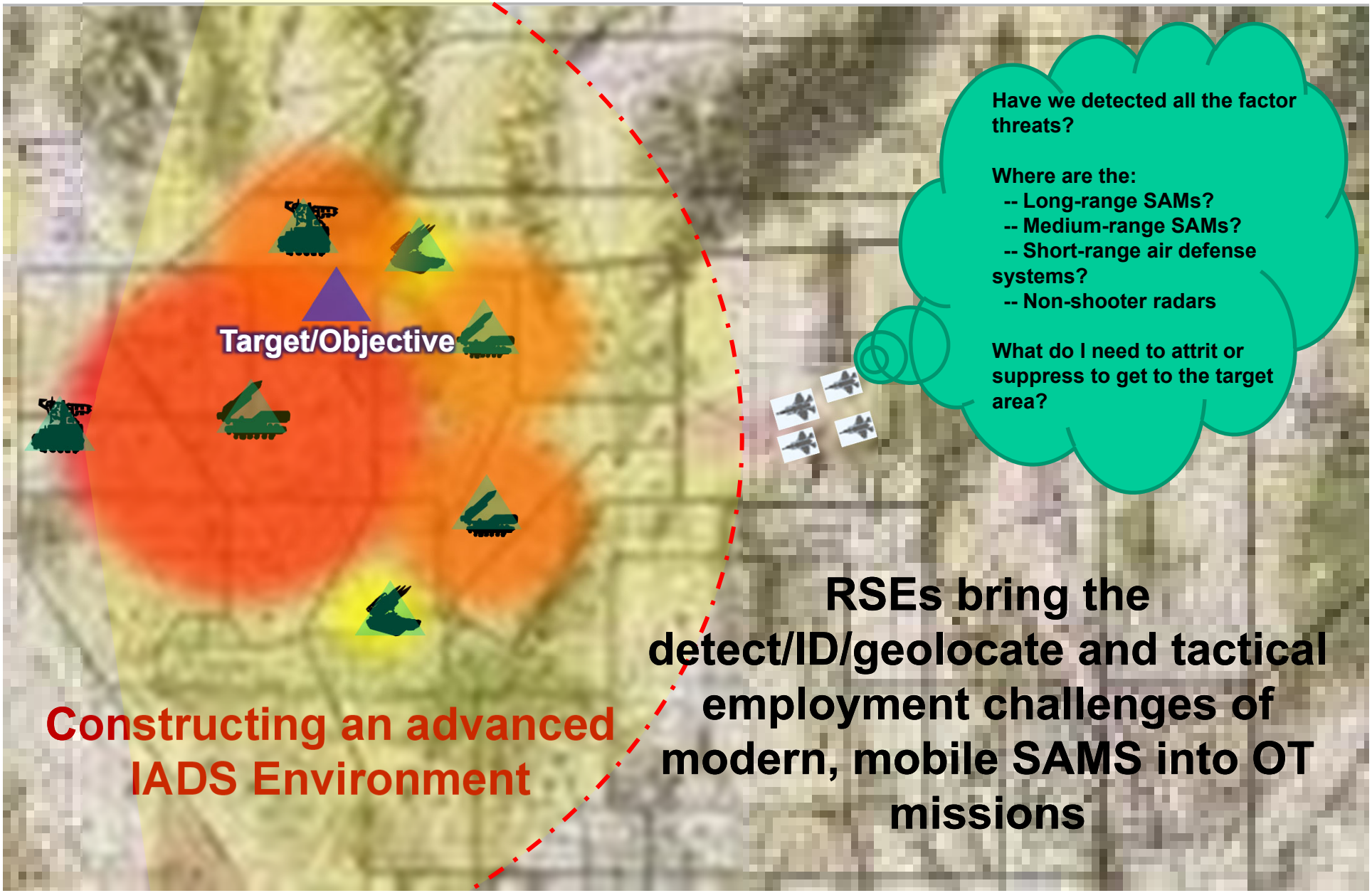
Reprogrammable active, electronically scanned arrays (AESA) open-loop emitters capable of emulating the signals of a wide variety of modern threat radars including complex, reactive, adaptive, and agile waveforms

#2. 5th Gen DoE
Operationally Realistic Test Environment



Constructing an advanced IADS Environment

#2. 5th Gen DoE
Operationally Realistic Test Environment



#3. Modeling & Simulation

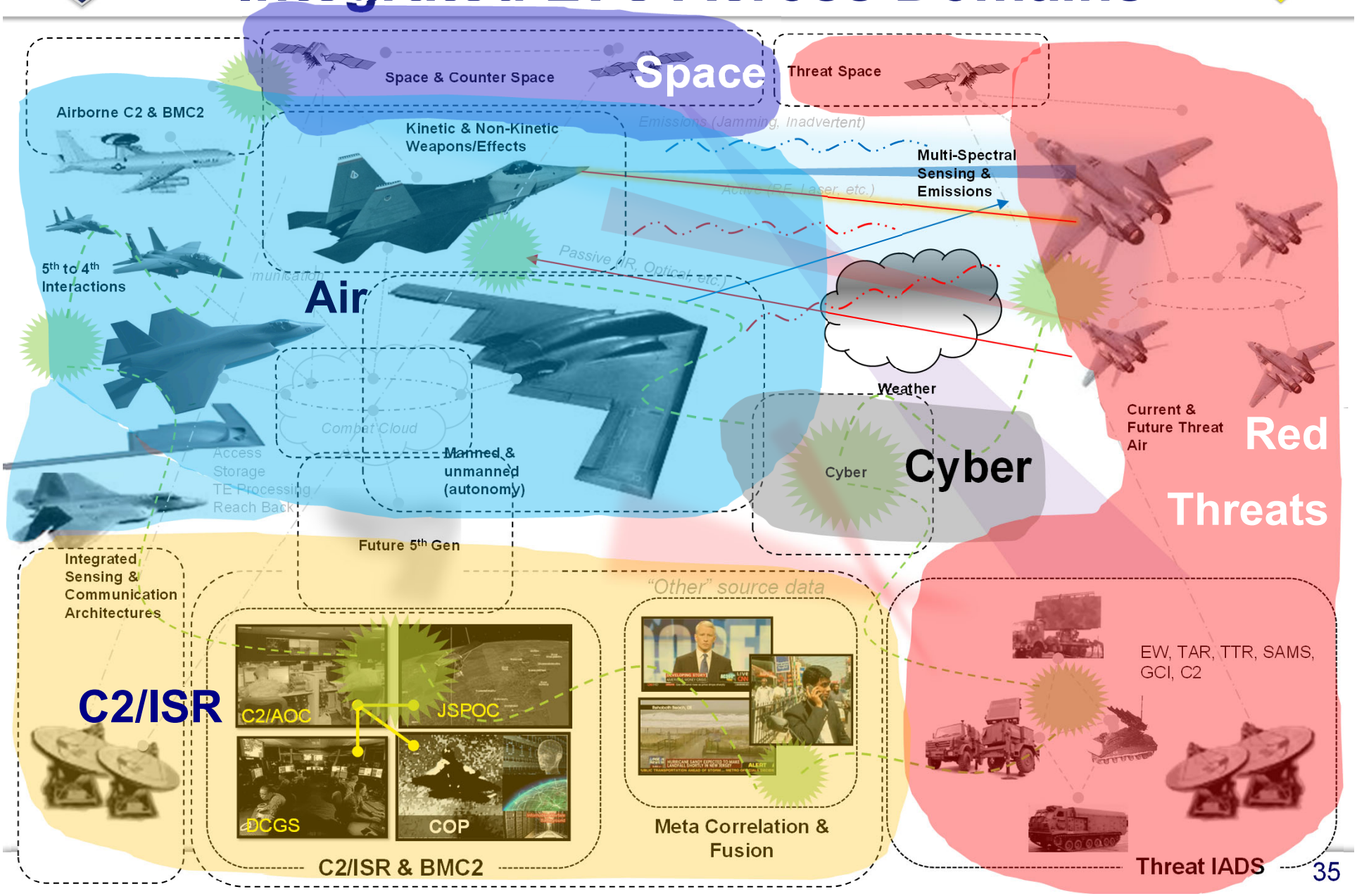
- M&S must be a foundational element of 5th/Next-gen/3rd Offset weapons systems testing

- We have hit the limits of being able to construct an adequate threat-representative live-fly environment

#3. Modeling & Simulation

- There are tough challenges posed by 5th gen M&S:
  - Creating the virtual battlespace and how the stealthy air vehicle dynamically interacts within it
  - Accurately modeling advanced threats
  - Inserting blue forces into the virtual battlespace

#3. Modeling & Simulation Integrated LVC Across Domains



#4. Connecting Test Resources

- **Connected, integrated test ranges & facilities**
  - **Cyber range-NTTR-China Lake-Aegis-space-HWIL (you get the picture…)**

#4. T&E Automation

"Pace of Need" mandates we employ state-of-the-art tools & resources:

- **Create and leverage an automated analytical test tool chest…**

- **3rd Offset mindset in T&E:**
  - ***Deep-Learning Systems***
  - ***Human-Machine Collaboration***
  - ***Cybersecurity Automation***

Questions & Comments