Raytheon

Customer Success Is Our Mission

Raytheon Reference Architecture (RA)

Raytheon

Mission Architecture Program (RayMAP)

Topic 1: C2 Concepts, Theory, and Policy

Paper #40

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May 13, 2008

Enabling Timely and Affordable Customer Solutions

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Cleared for public release

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Complex Systems Demand Quality Architecture

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- Increasingly complex systems demand quality architecture up front
  - Solutions must be presented in the context of customer architectures
  - Architecture helps to better understand ***operational*** customer's needs; operational metrics must be rooted in architecture
    - Military utility, cost effectiveness, etc.
  - This presentation highlights Raytheon's approach to using a ***Reference Architecture*** for ***Command and Control*** systems

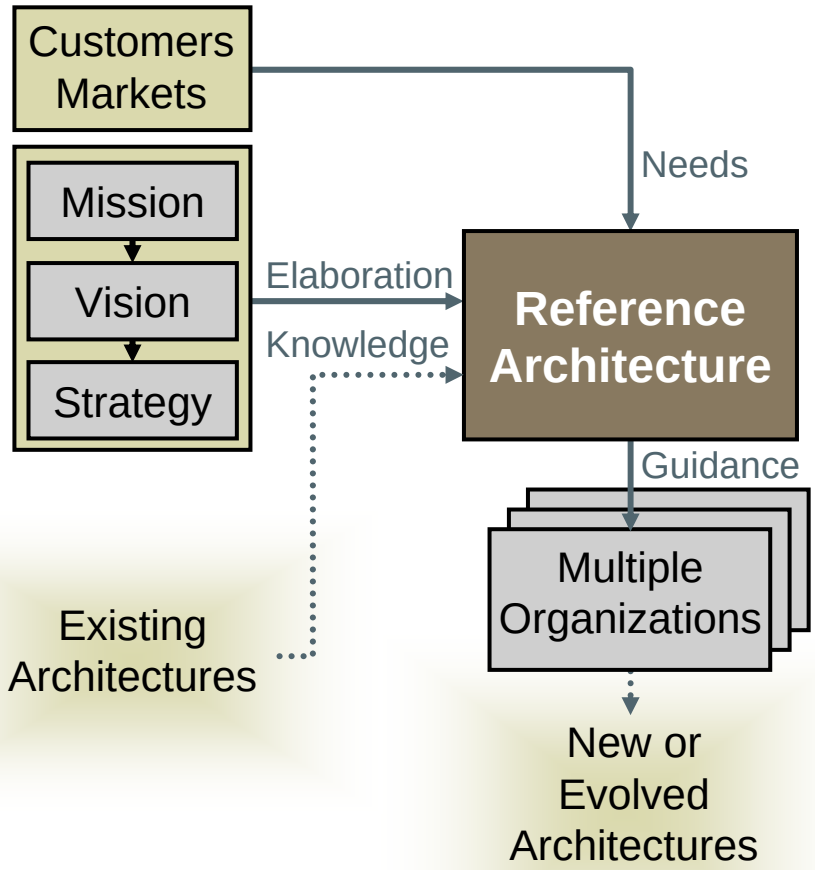
What is an Architecture?

- Architecture defines the fundamental ***structure*** and ***relationships*** of a complex entity, such as
  - How the entity is partitioned
  - Where interfaces occur
  - How these sub-entities interact with each other and the outside world
  - What universal rules the entity and its parts must comply with
    - Priorities
    - Operating modes
    - Standards
    - Safety, etc.

A disciplined and standardized methodology for understanding and managing complex systems

Raytheon Reference Architectures

- A ***reference architecture*** (RA) is a template
  - Providing reusable solutions
  - Promoting interoperable designs
  - Reducing potential duplication of effort
  - Reducing development time and risk
  - Facilitating compliance with policies
  - Incorporating lessons learned



Raytheon has developed several reference architectures for various customer domains

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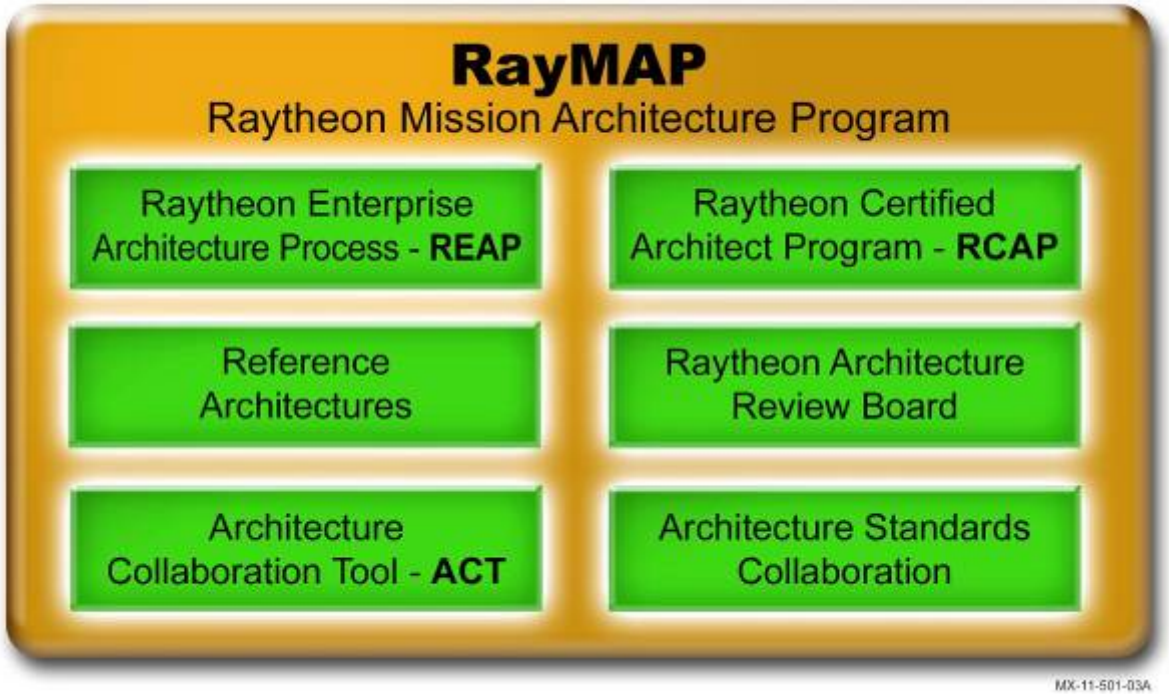
Raytheon Mission Architecture Program

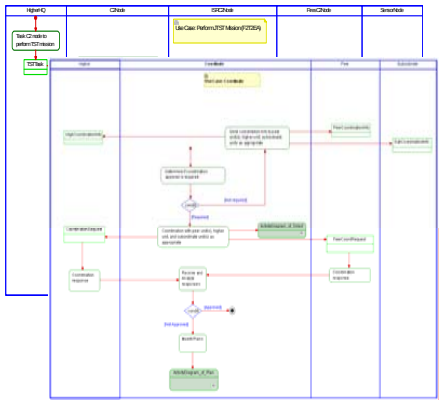


A Corporate initiative to leverage, align, mature and communicate architecture initiatives across Raytheon

Architecting = Meaningful solutions for Customers

Architecting = Meaningful solutions for Customers

Reference Architecture



- Reusable abstractions of patterns of structure found in real-world architectures
- Create implementation architectures
- Serve as a point of reference for a larger context

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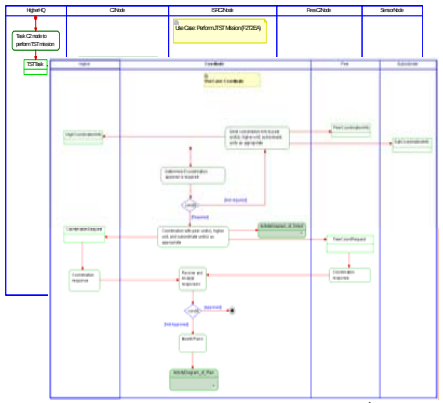
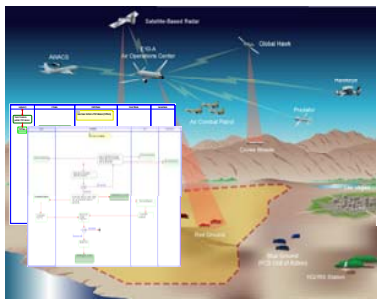
Architecting = Meaningful solutions for Customers

Reference Architecture



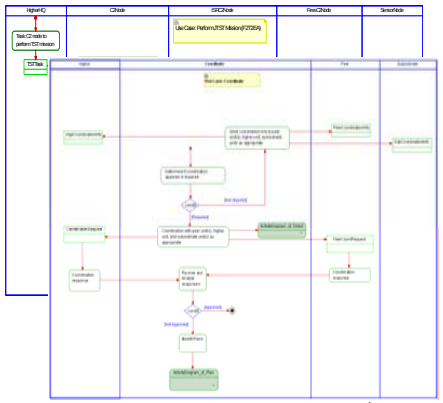
- Abstract definitions extended to describe a specific mission solution set
- System implementation specifics – weapons, comms, sensors and interfaces
- Used as a basis for system integration
- Capture lessons learned, best practices, and new patterns

Mission Architecture

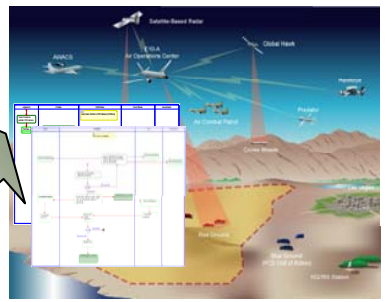


Architecting = Meaningful solutions for Customers

Reference Architecture



Mission Architecture



Customer needs
And CONOPS

DoD photo

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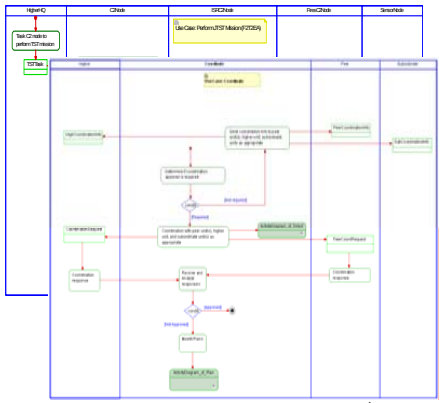
Architecting = Meaningful solutions for Customers

Reference Architecture

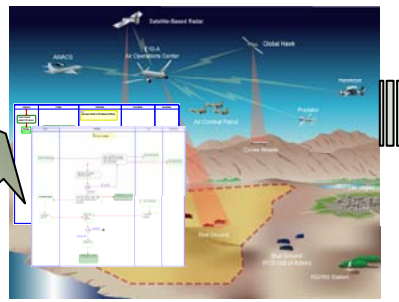


- Validate executability of mission architecture
- Enable mission analysis and architecture trades
- Demonstrate CONOPS and architectural maturity
- Analyze architectural alternatives

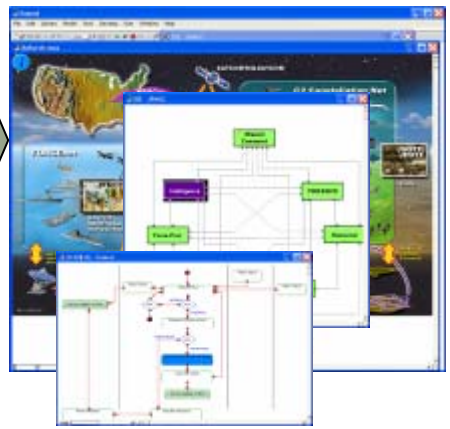
Customer needs
And CONOPS

DoD photo

Mission Architecture

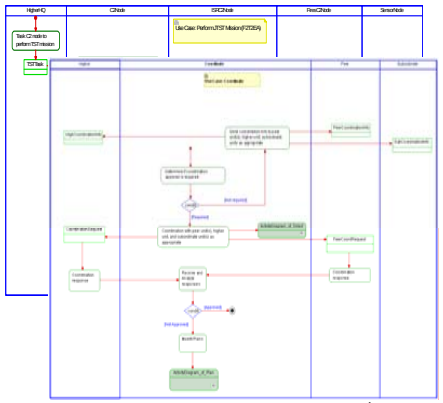


Dynamic Architecture Simulation



Architecting = Meaningful solutions for Customers

Reference Architecture



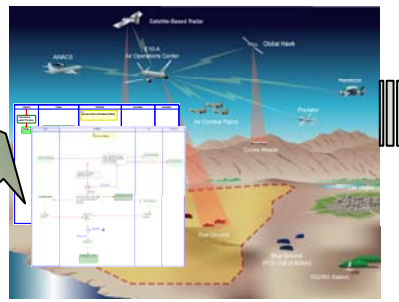
Mission Architecture

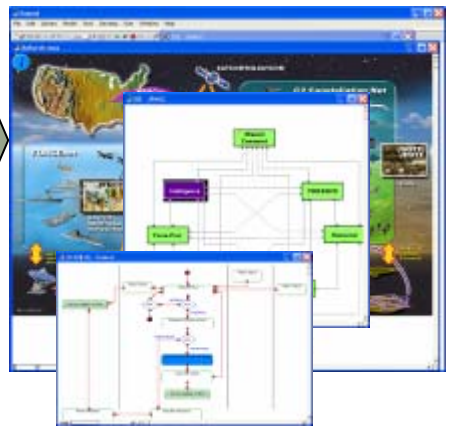
Dynamic Architecture Simulation

Customer needs

And CONOPS

DoD photo





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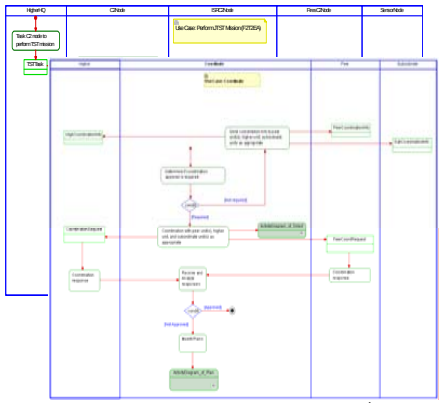
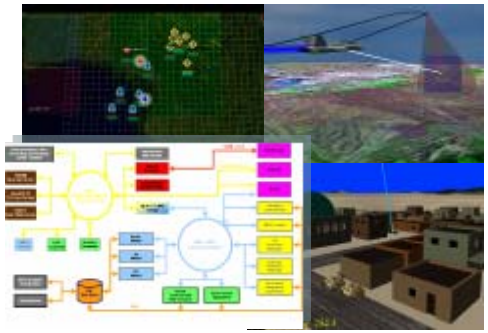
Reference Architecture



- Prototype software and systems
- Man-in-the-loop testing
- Engineering-level development of fine-detail capabilities
- Benchmark executable model against integrated performance
- Experiments suggest new approaches to mission solution

Simulations and Testbeds



Customer needs
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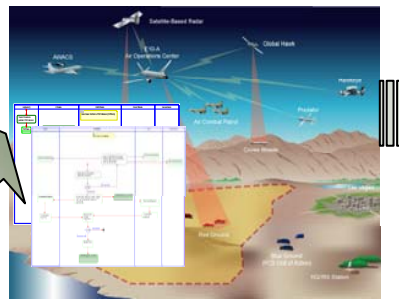
Mission Architecture



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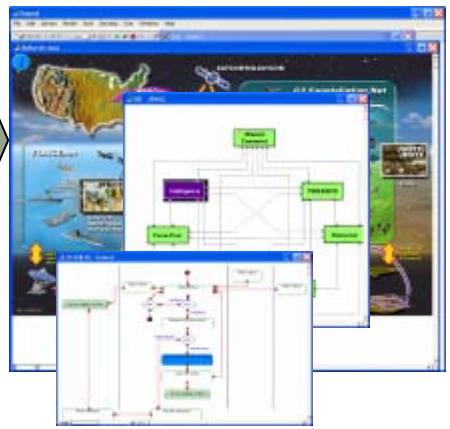

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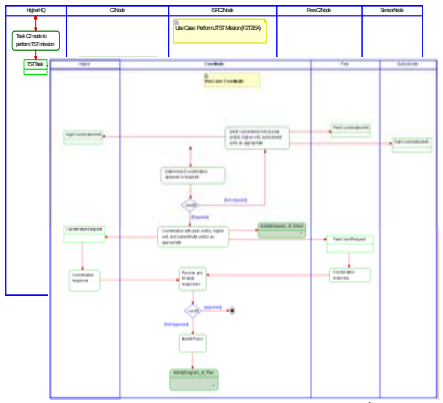
Reference Architecture



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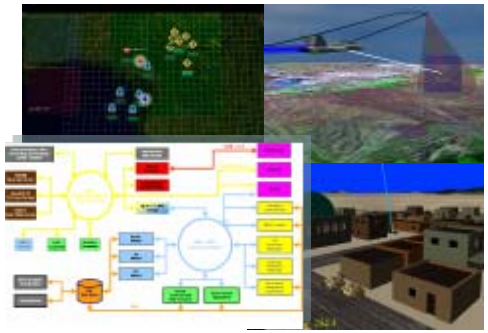

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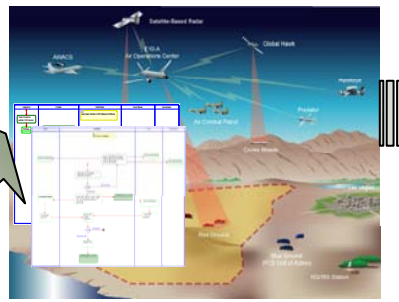

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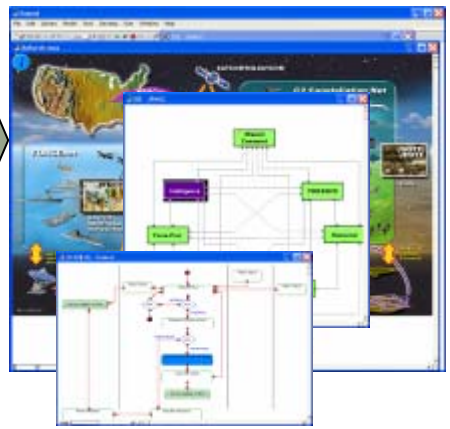

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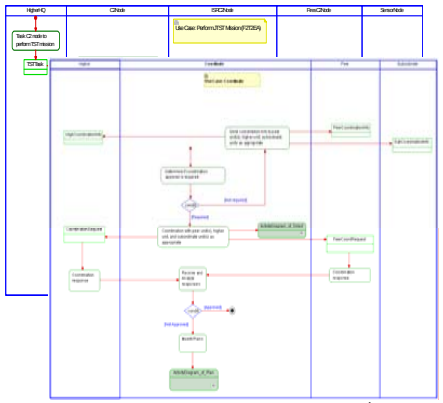

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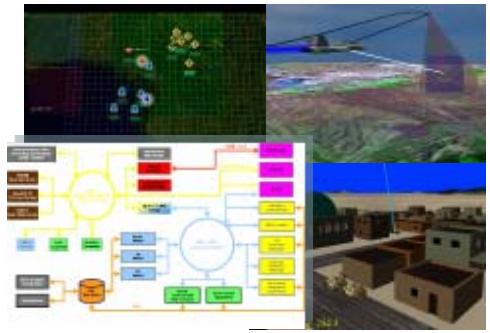

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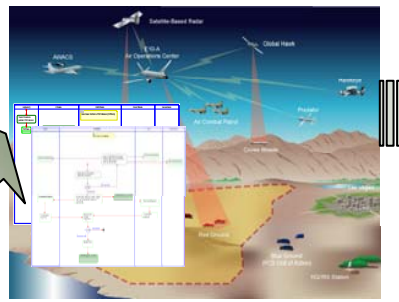

Dynamic Architecture Simulation

Define the problem
Architect an operational solution
Design a solution system
Develop tools for mission analysis
Build a solution

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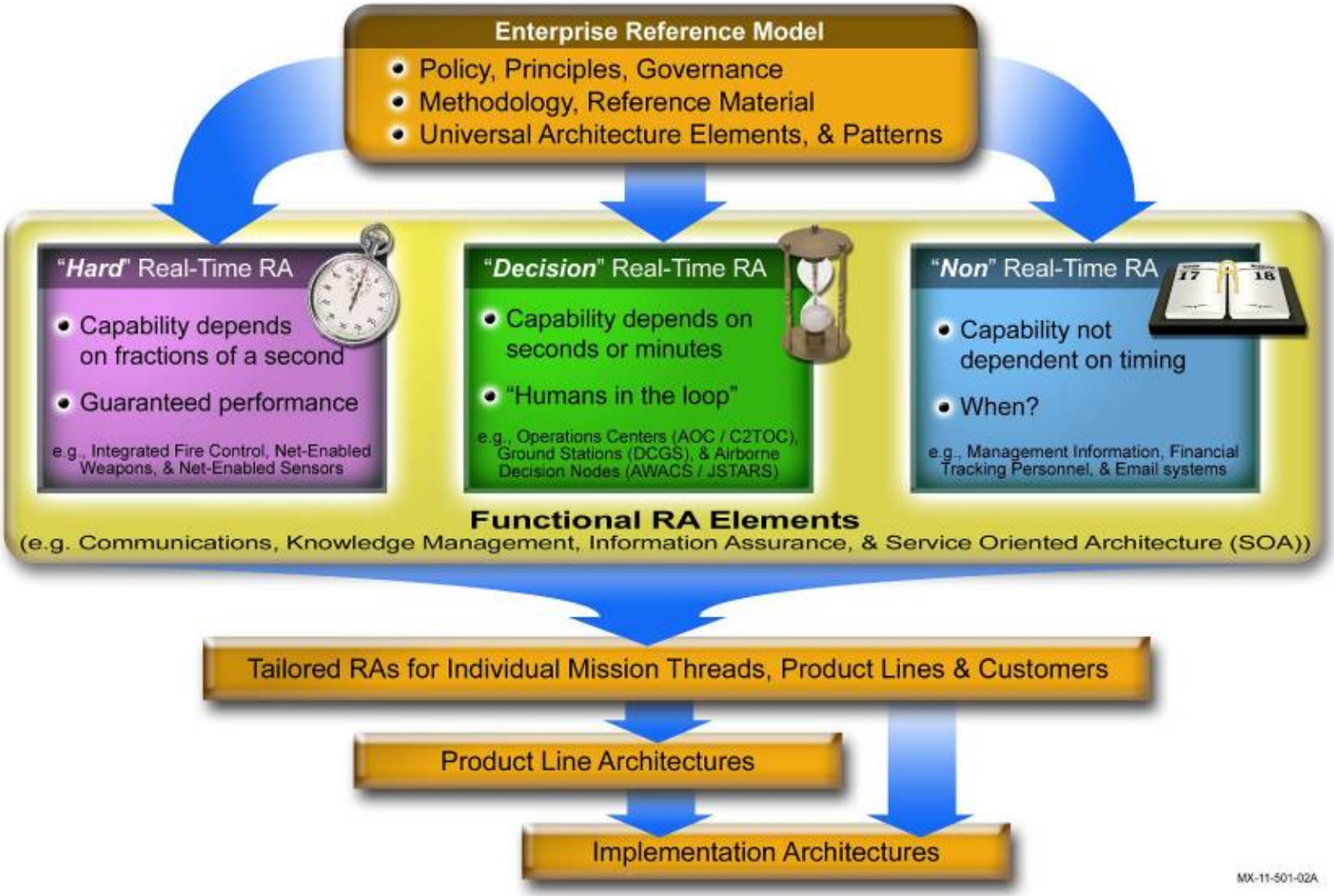
Raytheon family of Reference Architectures



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C2 Reference Architecture

Cabinet War Room
Copyright © 2006 Kaihsu Tai

Homeland Security National Operations Center
DHS photo

1940s

21st Century

Different Century, Same Problem, More Complex

C2 RA developed for DoD and non-DoD applications

Plan – Direct – Coordinate – Control – Understand Environment

Raytheon C2 RA Functions and Nodes

C2 Function
Planning
Operations Management
Situational Awareness Management
Intel Management
Logistics Management
Sensor Management
Effector Management
Platform Management
Infrastructure Management
Communications Management
Resource Management

C2 Node
Maneuver
Logistics
ISR
Sensor
Effector
Platform
Infrastructure
Communication

Raytheon C2 RA Quality Attributes

Quality Attribute	How Achieved	Tactics Used
Interoperability	(1) All C2 functions will utilize common net-centric enterprise services (NCES) e.g., discovery service, messaging service, information service, etc. (2) A common data model based on JC3IEDM will be used by services to exchange data	Common infrastructure services and common data model used
Security	Authorization, auditing, and authentication services will be invoked on each transaction to ensure trusted access to the node data and services	Authentication; authorization; auditing
Maintainability	Use layered service oriented architecture to support modularity which facilitates ease of maintenance. In addition, SOA enables new capabilities to be added with minimal impacted to the architecture	SOA
Scalability	C2 services and their support are designed to be network enabled and distributed services. This allows the services to be load balanced across the network	SOA and distributed architecture

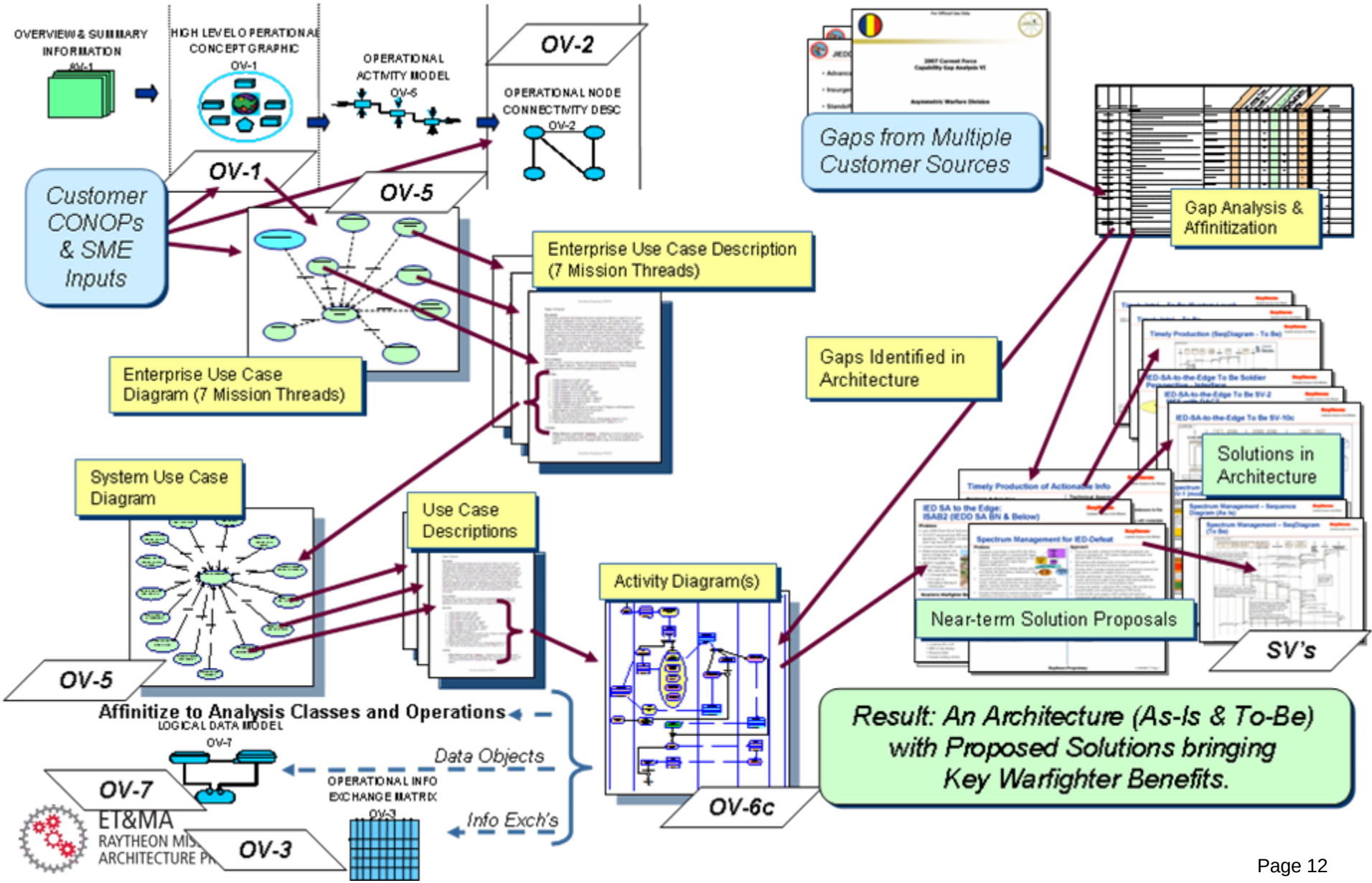
Application of Raytheon's C2 RA

- C2 RA developed in 2006
- C2 RA applied in 2007
- One specific application worth noting: C2 for IED defeat
  - Raytheon one-company enterprise initiative
- Focused on brigade and regiment echelons and below
- Products developed
  - "As is" IEDD C2 architecture
  - IEDD C2 capability gaps
  - IED C2 solutions
  - Suggested RA improvements

Talon robot ready to detonate an IED

(U.S. Army photo)

RA Tailoring Process (for IED Defeat C2)



Challenges of Modeling C2

- Simulating C2 allows analysts to study
  - Efficient patterns of information exchange
  - Optimize the delegation of decision-making authority
  - Characterize time allocated to decision-makers
- DoDAF encourages simulation to V&V architectures
- But, DoDAF does not mandate a particular simulation methodology
- Modeling C2 not likely accurate enough to predict real-world performance to a high degree
  - Dynamic nature of human involvement
  - Possibility of human error in judgment
  - Non-linear nature or C2 systems
  - Modeling people's behavior inherently introduces variability

Comparative studies help optimize the system

Lessons Learned in Using RAs

- What worked in tailoring the C2 RA
  - Having architects on the team with working knowledge of the RAs
  - Using RA alignment to surface issues
  - Focusing on solution scalability, distribution, commonality, etc.
  - Having RA examples were useful in stimulating ideas
- What did not work
  - More user-friendly method of importing data files
  - Need to train more architects on use of RAs
  - Some terminology inconsistencies
- Areas for improvement
  - Make artifacts and models easier to find and access
  - More definition required for architecture change management
  - Include guidelines on how to use reference architectures

Reference Architecture Lessons Learned

- Helped bound IED defeat C2 domain
- Helped guide the team in developing C2
- Significant reduction in startup time
- Use case-driven approach to help bound problem space
- Have a diverse set of skills involved in architecture development
- Using the C2 RA helped identify capability gaps early
- C2 RA helped in planning of demonstrations

…and many, many more

Raytheon RA and RayMAP –
Enabling Timely and Affordable Customer Solutions

Raytheon

- Complexity in today's C2 systems demands architected solutions
- Raytheon has developed a family of RA
- Initial focus
  - Command and Control
  - C2 RA already being put to use
- Already realizing benefits
  - Reduced startup times
  - Reuse
- Drives commonality and interoperability

Raytheon is interested in feedback on our approach to standardizing C2 capabilities through our RA

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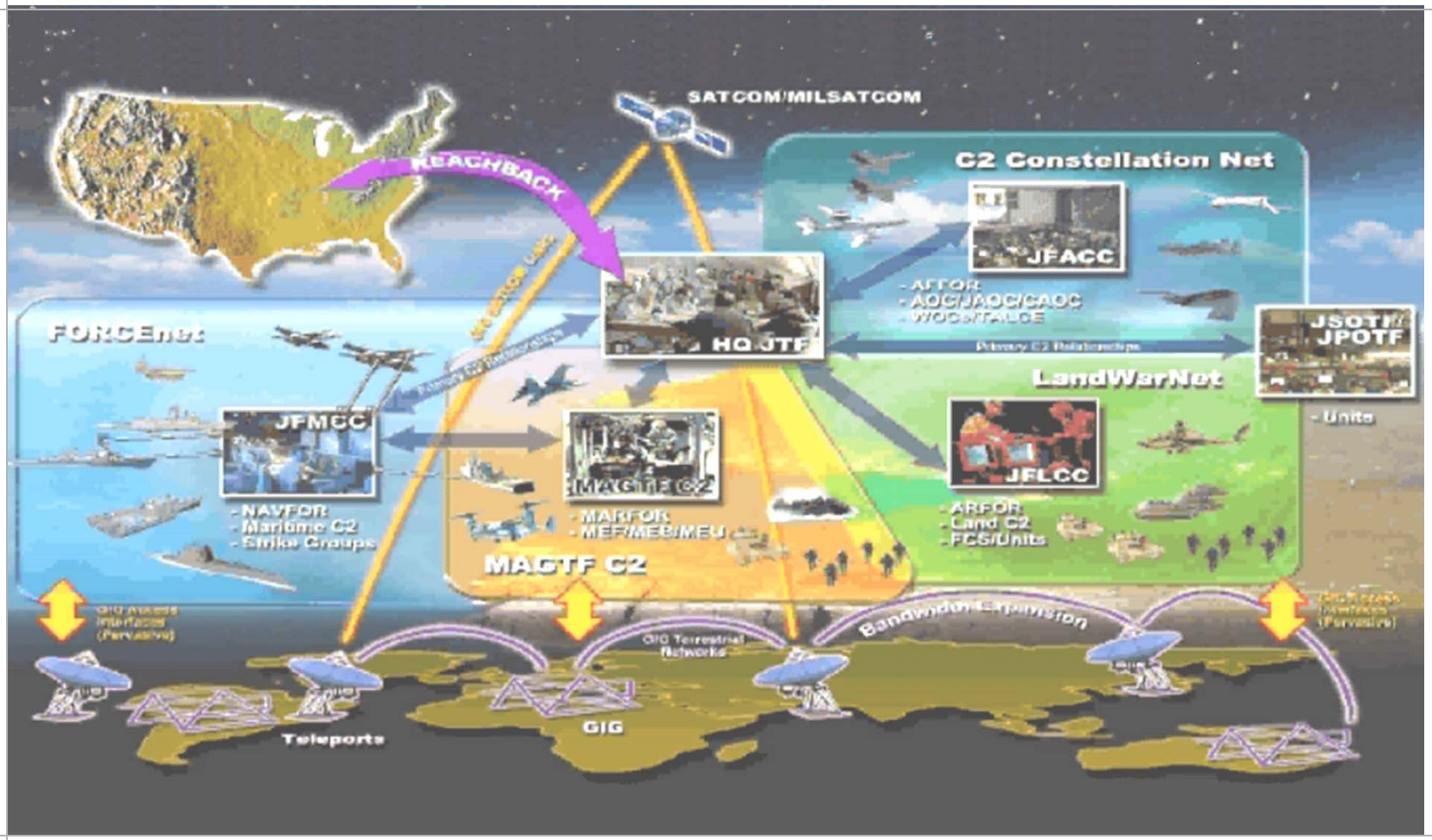
Questions?


SATCOM/MILSATCOM
REACHBACK
C2 Constellation Net
JFACC
- AFFOR
- AOC/JAOC/CAOC
- WOC/TACE
HQ JTF
JSOTF/
JPOTF
- Units
LandWarNet
JFMCC
- NAVFOR
- Maritime C2
- Strike Groups
MAGTF C2
- MARFOR
- MEF/MEB/MEU
JFLCC
- ARFOR
- Land C2
- FCS/Units
Bandwidth Expansion
GIG Terrestrial Networks
Teleports
GIG