Helicopter Information Awareness Module (I-AM)

An example of a Model-Based Communication Network (MCN) Architecture

Track 3 | Paper # 374
10th ICCRTS | 15 June 2005

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Intent of Paper…

- Illustrate a *thread,* or mission slice of a Network Centric construct via the lens of a tactical helicopter pilot [see operational vignette in paper or background slides]

- Propose a Model-based Communication Network (MCN) software architecture solution for distributed battlefield information awareness and C^2

  - (1) Provides the networked warrior a higher probability of mission success and survivability

  - (2) Elucidates an achievable goal that can evolve into a battlefield wide NCW componency

  - (3) Illustrates that adherence to interoperability standards alone is insufficient to transform today's warfighter into the network centric force of tomorrow

The Situation…

- The network is no longer confined to the garrison network operation centers (NOCs) or command post headquarters
- Information is now permeating our tactical combat systems (aircraft, vehicles, ships, ordnance) and personnel (rugged PDAs, etc.)
  - Most all tactical fighter aircraft today are "*Fly-by-Wire*"
  - Precision Guided Munitions
- Witnessing the co-evolution of molecules and information (Bits)
  - Realization that it is the software that enables our combat systems to achieve capabilities that far exceed the mere summation of their molecules

The Reality of Today's Battlefield:

- Community of systems (sensors, platforms) and actors (Joint & Coalition) equipped with primarily stove piped systems
- Coupled mainly by voice & a limited data networks
- Lack of distributed situational awareness
- Commonality of interoperability standards (COTS/GOTS) and middleware alone will not produce a Net-Centric Force
- **Where is the Architecture?**

A Typical Combat Operation Center Senior Watch Officer Mantra:

- *What Do I know?*
  - *What Do I Need to Know?*
    - *Who Needs to Know it?*
      - *Have I Told Them?*

Can we architect this concept into our tactical systems?

Implication:

- Bits have value
- Information should be ***Valuable***, ***Relevant***, and ***Timely***

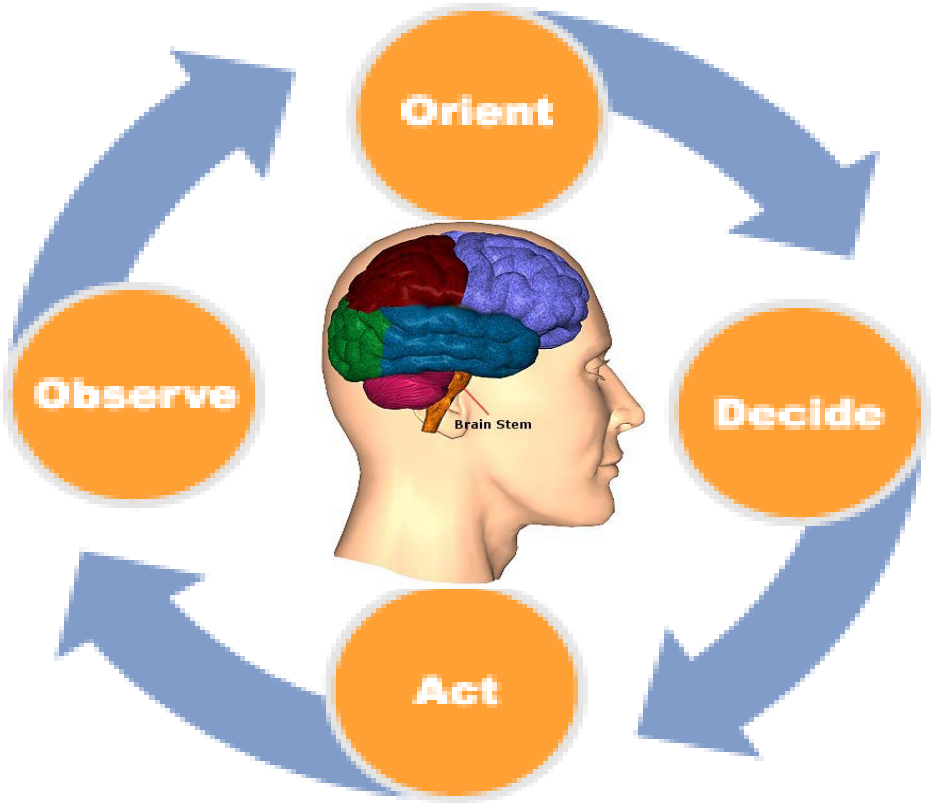
NCW Architecture Solution…

- Propose a **Model-based Communication Network (MCN) architecture** that addresses the innate need for shared battlespace awareness in near real time [see Dr. Rick Hayes-Roth ICCRTS paper # 375]
  - Not limited to aviation assets
  - Intent is to adopt an architecture framework that supports a software product line approach capable of addressing this fundamental warfighting need of all battlefield entities (Air, Ground, Sea, Space) and actors
- Shared awareness is facilitated by the tailored exchange of information that should be inherently:
  - Valuable
    - Relevant
      - Timely

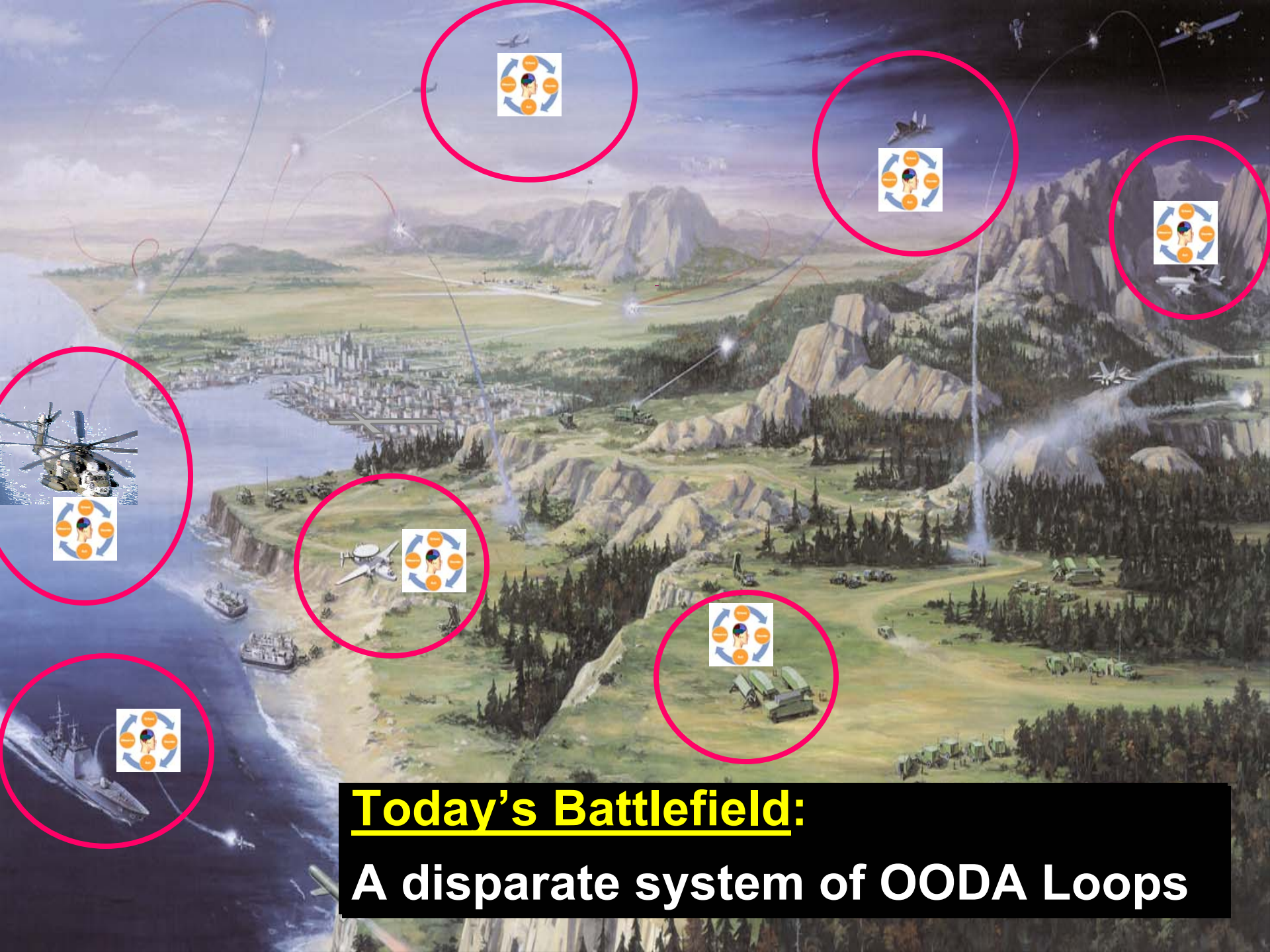
to any platform/sensor/actor that requires it

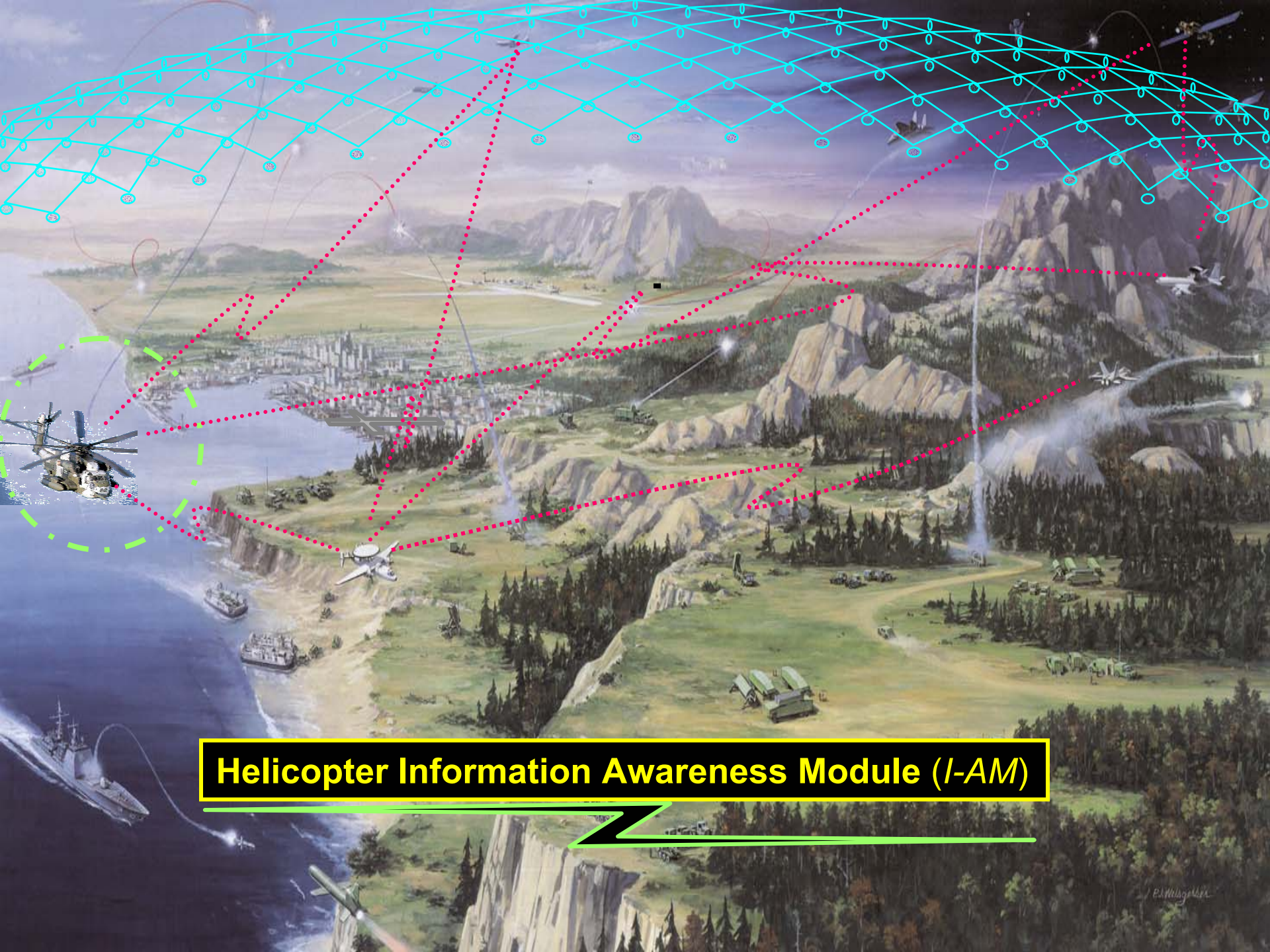
What is a Model-based Communication Network ?

Boyd's OODA Loop (Decision Cycle) for a 1v1 Fighter Engagement



Has a Brain-Based World Model at it's Core

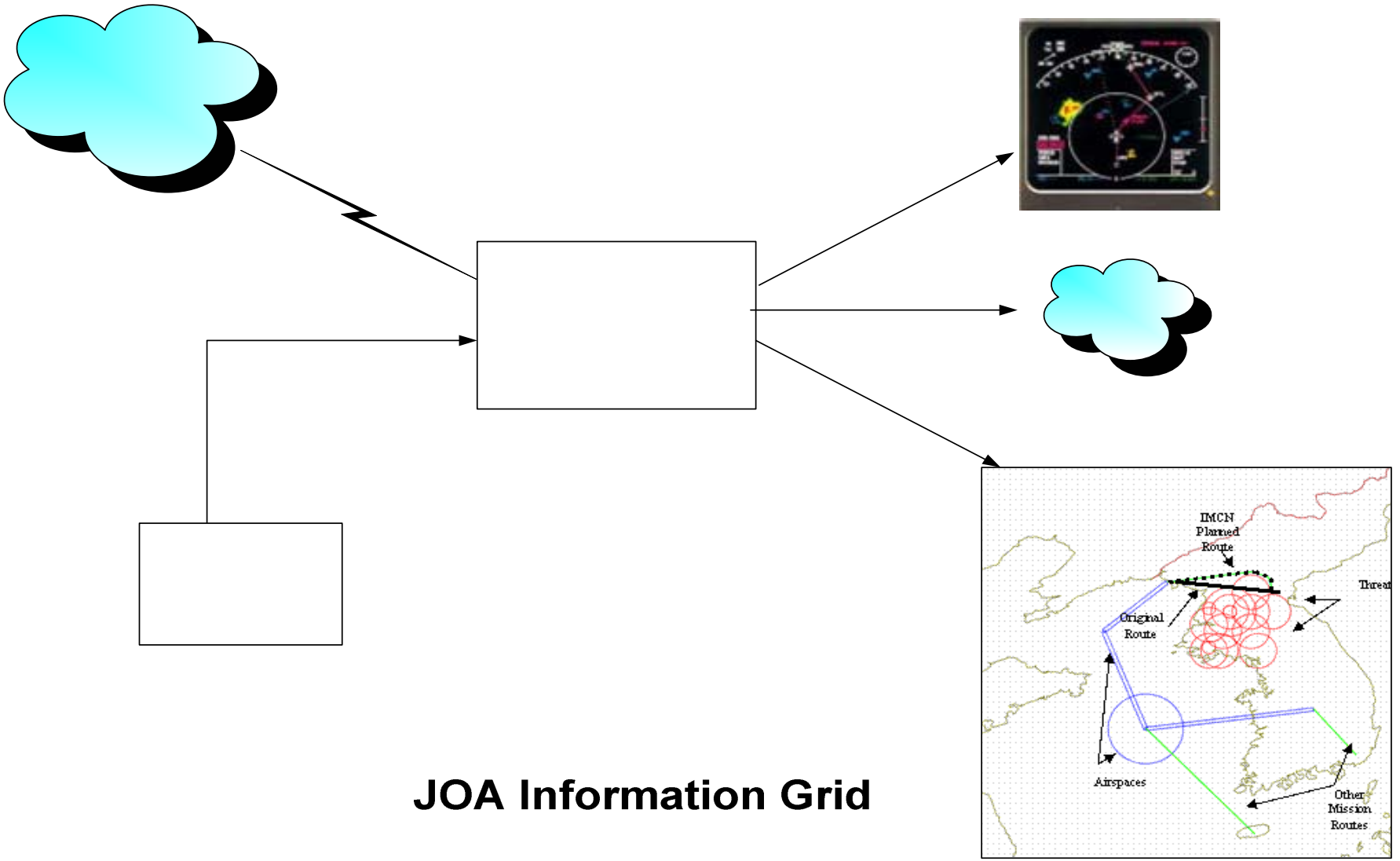

Today's Battlefield:
A disparate system of OODA Loops


Helicopter Information Awareness Module (*I-AM*)

Current Helicopter System Status …*the as is*:

- No data link
- No moving map
- No Common Operational Picture
- Limited GPS navigation system
- Limited/no computer integration of onboard avionics/sensors with internal flight and external C2 systems
- GPS waypoints can be downloaded from Portable Flight Planning System (PFPS) Software
- Voice communication and IFF provide the only means of dynamic information exchange with tactical peers and JOA battlefield entities
- Not capable of receiving or sharing external sensor threat information

Helicopter I-AM Priority Requirements

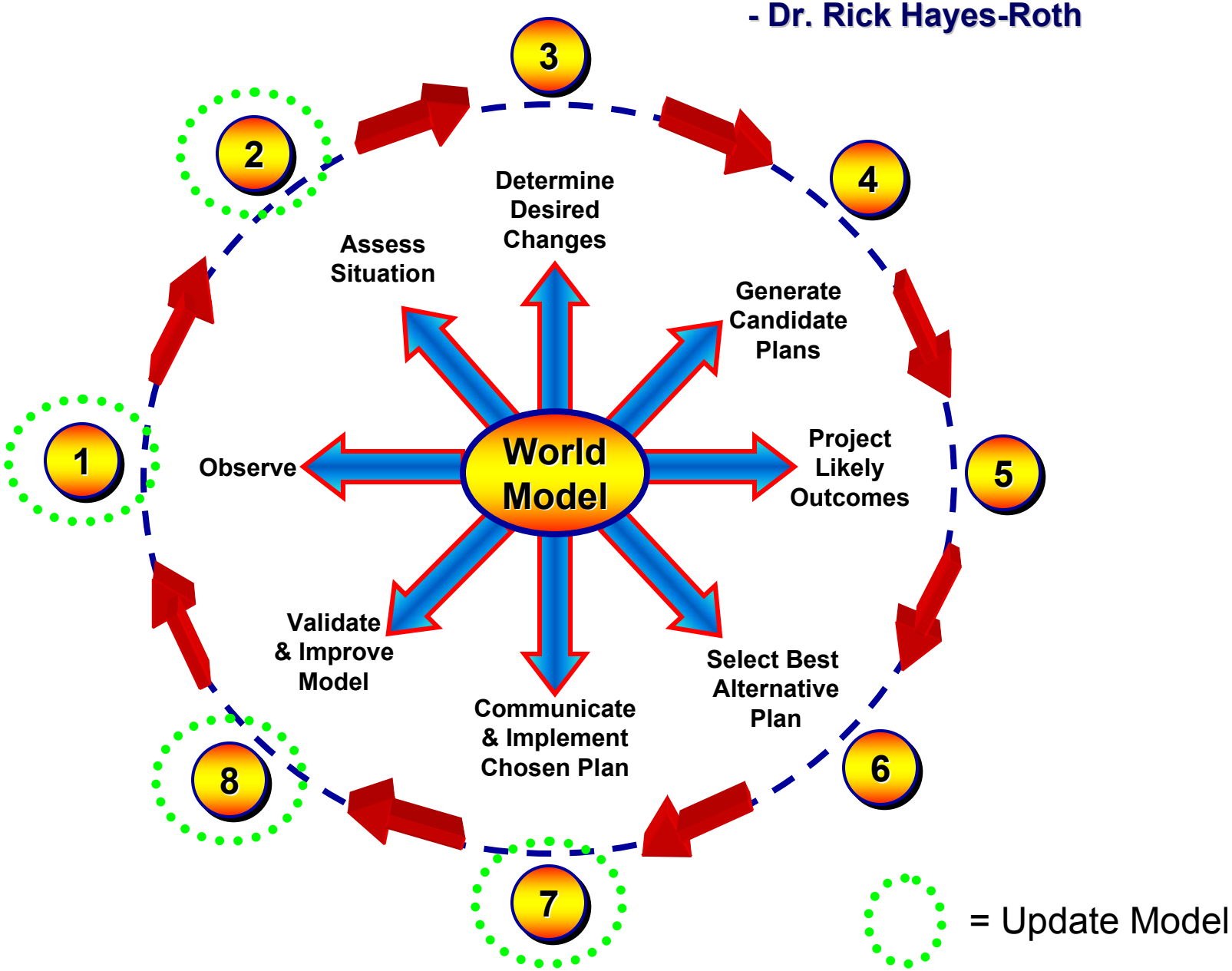


JOA Information Grid

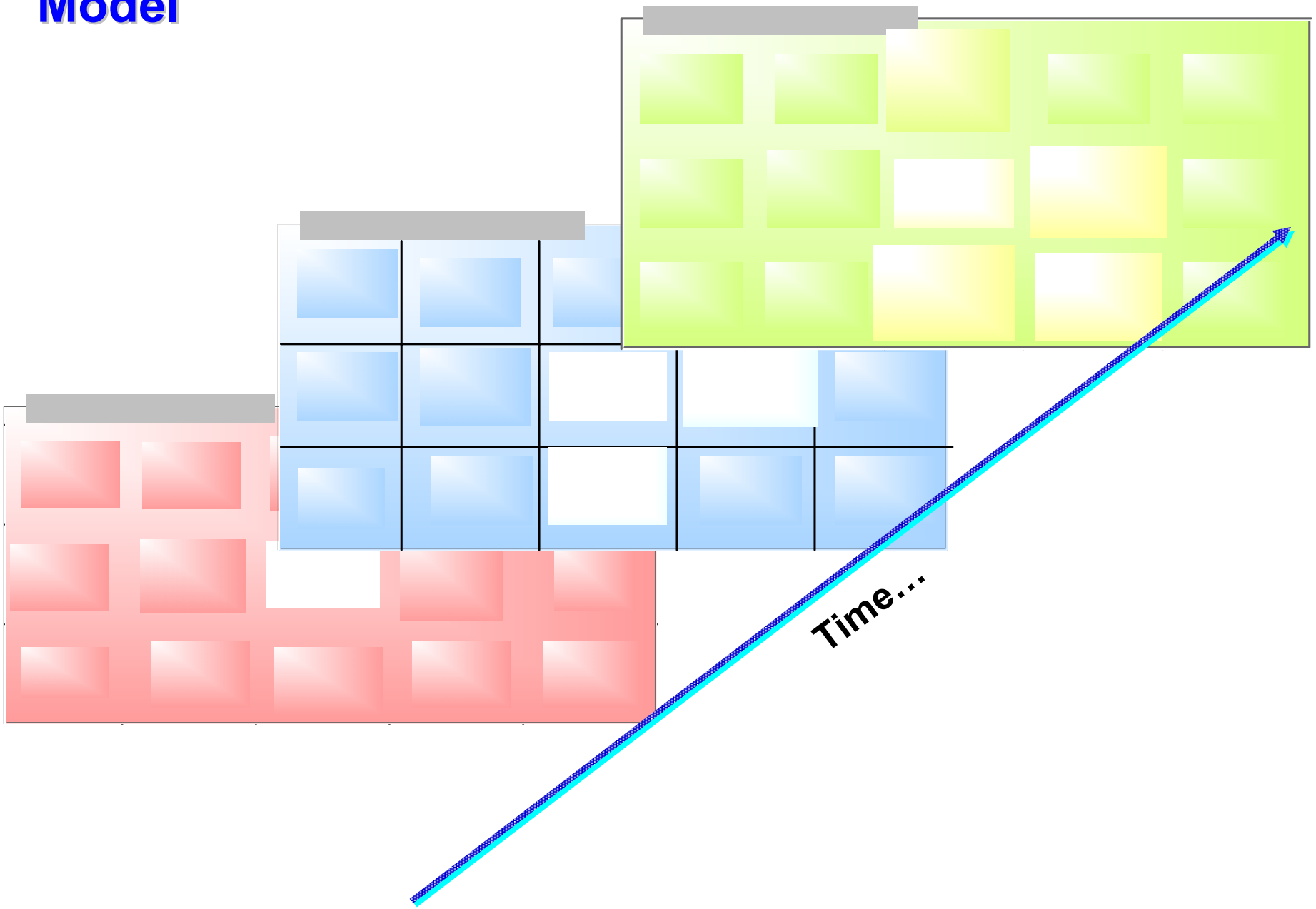
A Software Architecture Alternative:

The World Model & Eight Key Functions of Efficient Thought

- Dr. Rick Hayes-Roth



The Helo *I-AM* Joint Operations Area (JOA) World Model



Core Functional Requirement Enablers

- Concurrent candidate plan generation & updating
- Continuous threat & hazard avoidance predictions calculated/correlated in real time from external & internal information
- Ability to dynamically filter in real time the views, processes, simulations, and predictions of the world model to address the current, relevant mission “slice”, or micro-model

The Eight Steps Manifested in the I-AM Architecture

1.Observe:

- I-AM observes the environment by monitoring data received

Internally:

-Indigenous onboard sensors (GPS, RADAR Warning, IR Warning, avionics components (temp, barometric/RADAR altimeters, airspeed, attitude)

Externally:

- Satellite, Command & control aircraft, intra flight communications, ground based stations

2. Assess:

- Compares information with the forecast plan model

3. Determine Desired Changes:

- I-AM determines the degree of changes to make to the model

The Eight Steps Manifested in the I-AM Architecture

4. Generate Candidate Plans:

- Candidate COAs are generated and presented to the pilot for acceptance
  - i.e. alternate routes to circumvent threats

5. Project Likely Outcomes:

- Ramifications of selecting a COA are modeled and analyzed

6. Select best Alternative Plan:

- Pilot/Mission Cdr must choose to ignore the proposed COA or select best fit for circumstances

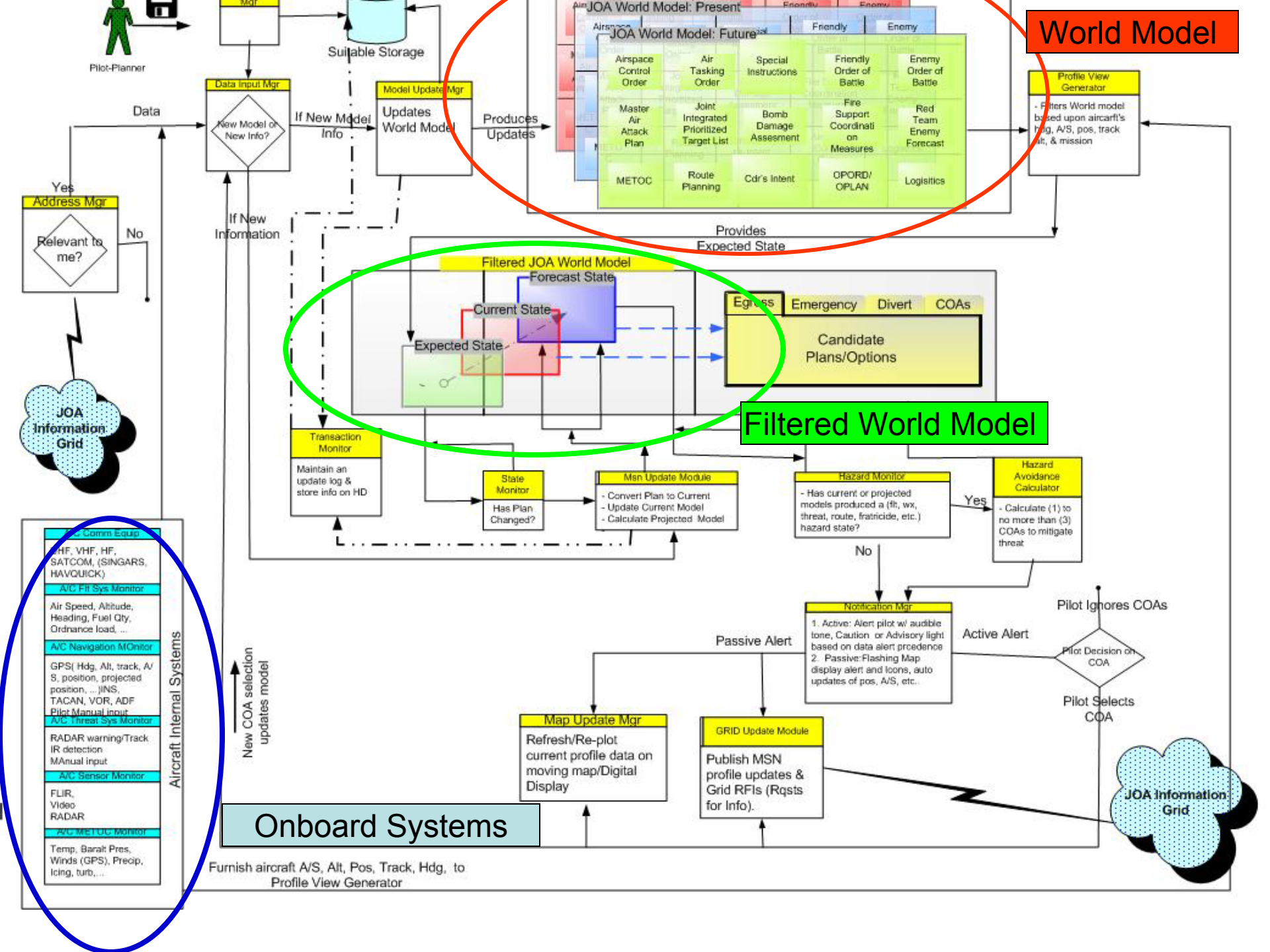
7. Communicate and Implement Chosen Plan:

- Plan intention is transmitted to the JIG upon pilot acceptance

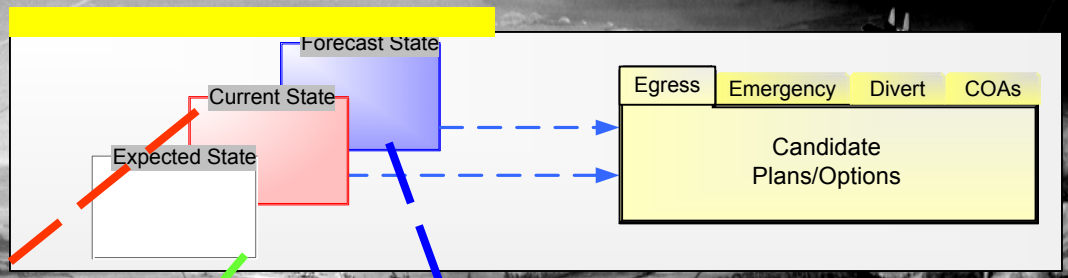
8. Validate & Improve the Model:

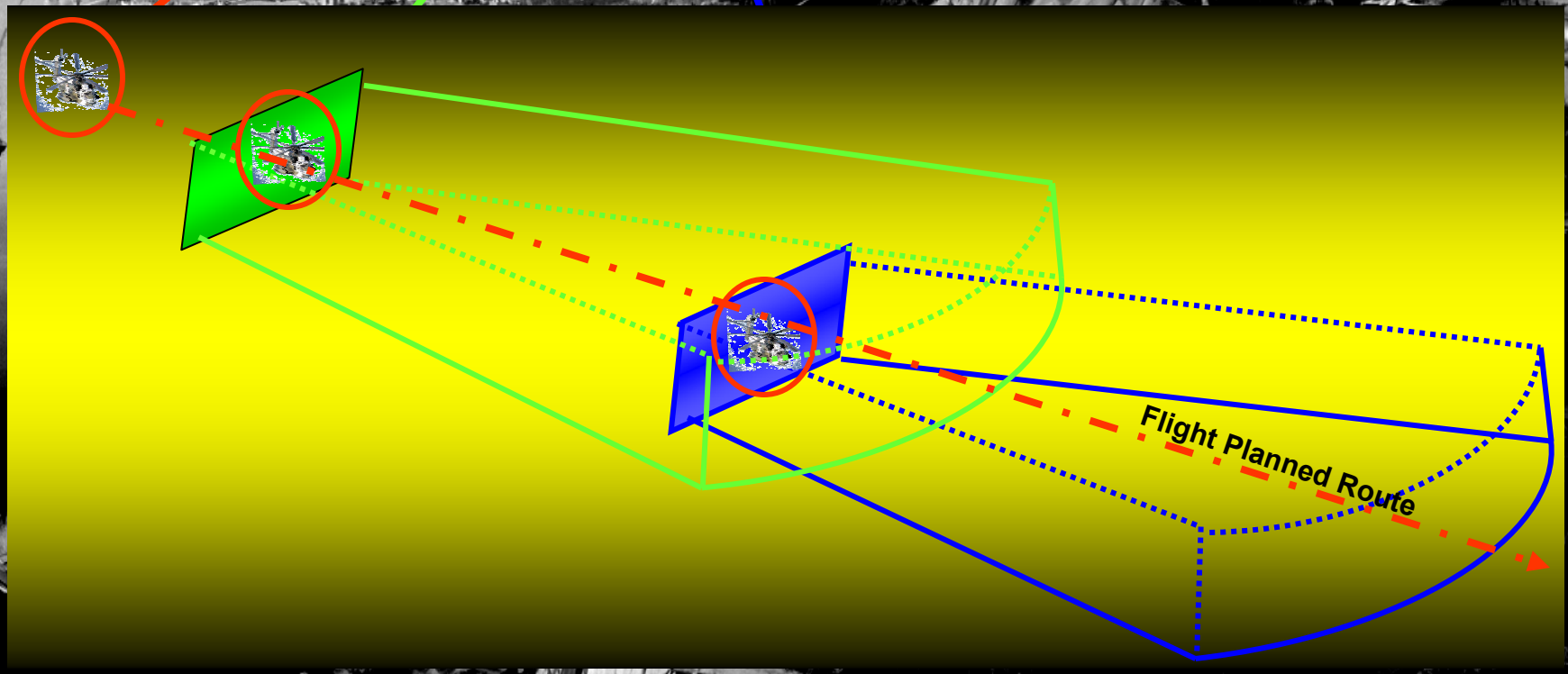
- Model is updated with the new plan and the cycle begins anew

What's Under the Hood?


World Model
JOA World Model: Present
JOA World Model: Future
Airspace Control Order
Air Tasking Order
Special Instructions
Friendly Order of Battle
Enemy Order of Battle
Master Air Attack Plan
Joint Integrated Prioritized Target List
Bomb Damage Assesment
Fire Support Coordination Measures
Red Team Enemy Forecast
METOC
Route Planning
Cdr's Intent
OPORD/ OPLAN
Logistics
Pilot-Planner
Suitable Storage
Data
Data Input Mgr
New Model or New Info?
If New Model Info
Model Update Mgr
Updates World Model
Produces Updates
Profile View Generator
- Filters World model based upon aircarft's Hdg, A/S, pos, track Alt, & mission
Yes
Address Mgr
Relevant to me?
No
If New Information
Provides Expected State
Filtered JOA World Model
Forecast State
Current State
Expected State
Egress
Emergency
Divert
COAs
Candidate Plans/Options
Filtered World Model
JOA Information Grid
Transaction Monitor
Maintain an update log & store info on HD
State Monitor
Has Plan Changed?
Msn Update Module
- Convert Plan to Current
- Update Current Model
- Calculate Projected Model
Hazard Monitor
- Has current or projected models produced a (flt, wx, threat, route, fratricide, etc.) hazard state?
Yes
Hazard Avoidance Calculator
- Calculate (1) to no more than (3) COAs to mitigate threat
No
Notification Mgr
1. Active: Alert pilot w/ audible tone, Caution or Advisory light based on data alert precedence
2. Passive: Flashing Map display alert and Icons, auto updates of pos, A/S, etc.
Passive Alert
Active Alert
Pilot Ignores COAs
Pilot Decision on COA
Pilot Selects COA
Map Update Mgr
Refresh/Re-plot current profile data on moving map/Digital Display
GRID Update Module
Publish MSN profile updates & Grid RFIs (Rqsts for Info).
JOA Information Grid
New COA selection updates model
Aircraft Internal Systems
A/C Comm Equip
UHF, VHF, HF, SATCOM, (SINGARS, HAVQUICK)
A/C Flt Sys Monitor
Air Speed, Altitude, Heading, Fuel Qty, Ordnance load, ...
A/C Navigation MOnitor
GPS(Hdg, Alt, track, A/S, position, projected position, ...)INS, TACAN, VOR, ADF
Pilot Manual input
A/C Threat Sys Monitor
RADAR warning/Track
IR detection
MAnual input
A/C Sensor Monitor
FLIR,
Video
RADAR
A/C METOC Monitor
Temp, Baralt Pres, Winds (GPS), Precip, Icing, turb,...
Onboard Systems
Furnish aircraft A/S, Alt, Pos, Track, Hdg, to Profile View Generator

The Helicopter's Filtered World Model





Take away…

- NCW means changing the way systems behave to support the personalized requirements of the warfighter
- Bits have contextual, perishable value
- We cannot get there without a common, shared, software architecture model
- Though this slice can be generalized to other operators, it will simply not emerge from a generic approach to Enterprise Architecture (EA) or a standardization of communication “pipes”

Background Slides

The Operational Vignette Behind the I-AM Architecture:

The Joint Force Air Component Commander's (JFACC) Air Tasking Order (ATO) for the following day's air operations was released at 1800z. On board the amphibious assault ship Tarawa, pilots of Marine Heavy Helicopter Squadron (HMH) 465 (Reinforced) continued their mission planning for the following day's assault. HMH-465 was a composite squadron and was designated as the Aviation Combat Element (ACE) for the 15th Marine Expeditionary Unit (MEU). The squadron was comprised of a mix of CH-53X, AH-1Y, UH-1Z, MV-22, and Joint Strike Fighter (JSF) aircraft. Utilizing Information Awareness Module (I-AM) mission planning client terminals in the Ready Room, pilots were able to access a mission planning application that dynamically fused and interacted with the Joint Operation Area Information Grid (JIG). Upon entering the ATO assigned mission ID, their "slice" of the battle space was filtered and made available for planning. Routing options were displayed based upon the constraints & framework of the Air Tasking Order (ATO), the Air Space Control Order (ACO) & Special Instructions (SPINs). Threat observations, assessments, and expectations fed from the Enemy Air/Ground Order of Battle information were fused with the Commander's Intent (strategic through tactical), the Friendly Air/Ground/Sea Orders of Battle and Meteorological (METOC) information that generated optimum mission paths for aircrew selection. The pilots then entered the detailed mission specifics (number of aircraft, specific take off/landing times, fuel & ordnance loads, LZs, targets, objectives, etc.) and system calculated go-no-go criteria, optimum airspeeds, ordnance, fuels loads, divert options, and printable knee board mission "smart packs." The mission commander approved the plan, and it was simultaneously uploaded into the JIG and down linked (or manually disk loaded) into each of the squadron's aircraft in preparation for the following day's mission.

The aircrew manned up their aircraft at 0600. As the on board flight computers came on line, each aircraft's I-AM logged into the JIG. Immediately, updates from the last 24 hours of battle were received and the preplanned mission was dynamically updated & transformed into a current model for execution. As the aircraft lifted off and proceeded feet dry, on board sensors (GPS, Radar Warning Receivers), Navigational Instruments (airspeed, barometric altimeter, fuel flow/quantity, etc.), and the IFF command & control module (Identification Friend or Foe C2) began to publish the current state of each aircraft as they pressed on along their mission ingress routes. Intra-flight and inter-JIG communication was minimized by adhering to the rule of publishing information by exception. That is, there was no requirement for mission status updates as long as the flight proceeded within the plan tolerance "known" by all need to know JIG C2 entities. Occasional aircraft "heartbeats" published the aircraft state to the JIG in order to facilitate C2 and avert fratricide. These status heart beats were programmed to occur on a seemingly random, yet algorithmically controlled basis to counter enemy tracking & spoofing.

As the flight approached phase line red, the aircrew completed their penetration checklists. Door gunners test fired their weapons, and the aircraft assumed a terrain flight (TERF) profile at 50 feet to avoid enemy radar detection. Satellite ELINT sensors orbiting high over the joint operating area detected new enemy early warning & target tracking radars associated with a surface to air missile launcher in close proximity to the route's Initial Point (IP). Once detected, the information was published to the JIG where it was then routed to all entities that were either determined to be in critical need or were valid subscribers of this particular subset of information. Immediately, the cockpit information display alerted the pilots of critical new information that directly impacted the planned mission. The aircrew's attention was immediately drawn to the digital map display where the new threat was accurately plotted complete with threat rings. The copilot immediately selected the hazard avoidance overlay button and three optimum routes to the LZ were displayed over the existing profile.

Since L-Hour was firm, the Air Mission Commander selected the option that ensured the mission would meet its time on target (TOT) in addition to maximizing the fuel available for the AH-1Y escorts. Instantaneously, the JIG & all aircraft in the flight were updated with the new plan information. As the flight maneuvered along their new route, the Joint Strike Fighters escorts quickly neutralized the pop up threat. The rest of the mission proved to be uneventful….

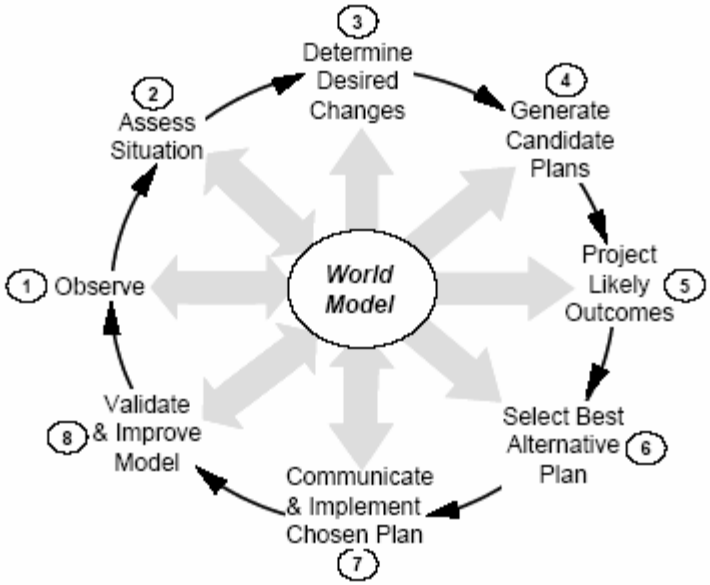


Figure 2. Efficient thought employs eight key functions supported by a world model.

The eight steps are numbered in a typical sequence, though in most complex organizations all eight steps operate in parallel. The intelligent being (1) observes what's happening in the environment, (2) assesses the situation for significant threats and opportunities, (3) determines what changes would be desirable, (4) generates candidate plans for making those changes, (5) projects the likely outcomes of those plans, (6) selects the best plan, and (7) communicates that plans to key parties and implements it. Throughout, the intelligent being (8) validates and improves its model. The model supports all eight activities, although only steps 1, 2, 7 and 8 directly update and modify the model.