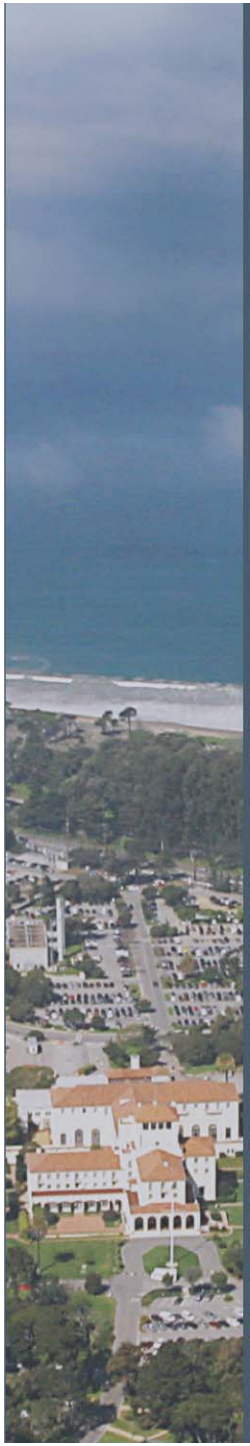

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Enabling Adaptive C2 via Semantic Communication and Smart Push: A Model-based Network Communication Approach

LtCol Carl Oros, USMC

Brief to

13th ICCRTS: *C2 for Complex Endeavors*

The Meydenbauer Center
Bellevue, WA
17 June 2008

The Literature:
Self-Synchronization and Shared Awareness

Desired Agile C2 Attributes

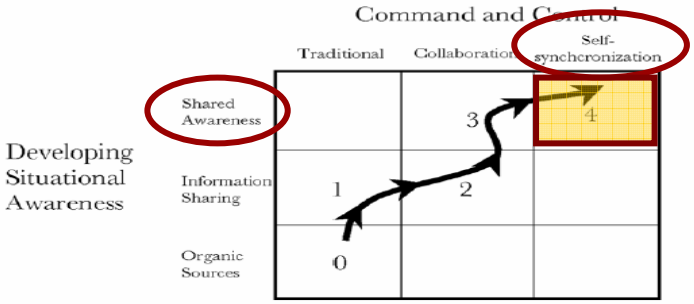


Figure 13. NCW Maturity Model[5]
From Power to the Edge

NCW is characterized by the ability of geographically dispersed forces (consisting of entities) to create a high level of ***shared battlespace awareness*** *that can be exploited via self- synchronization and other network-centric operations to achieve commanders' intent.* (Network Centric Warfare, 1999)

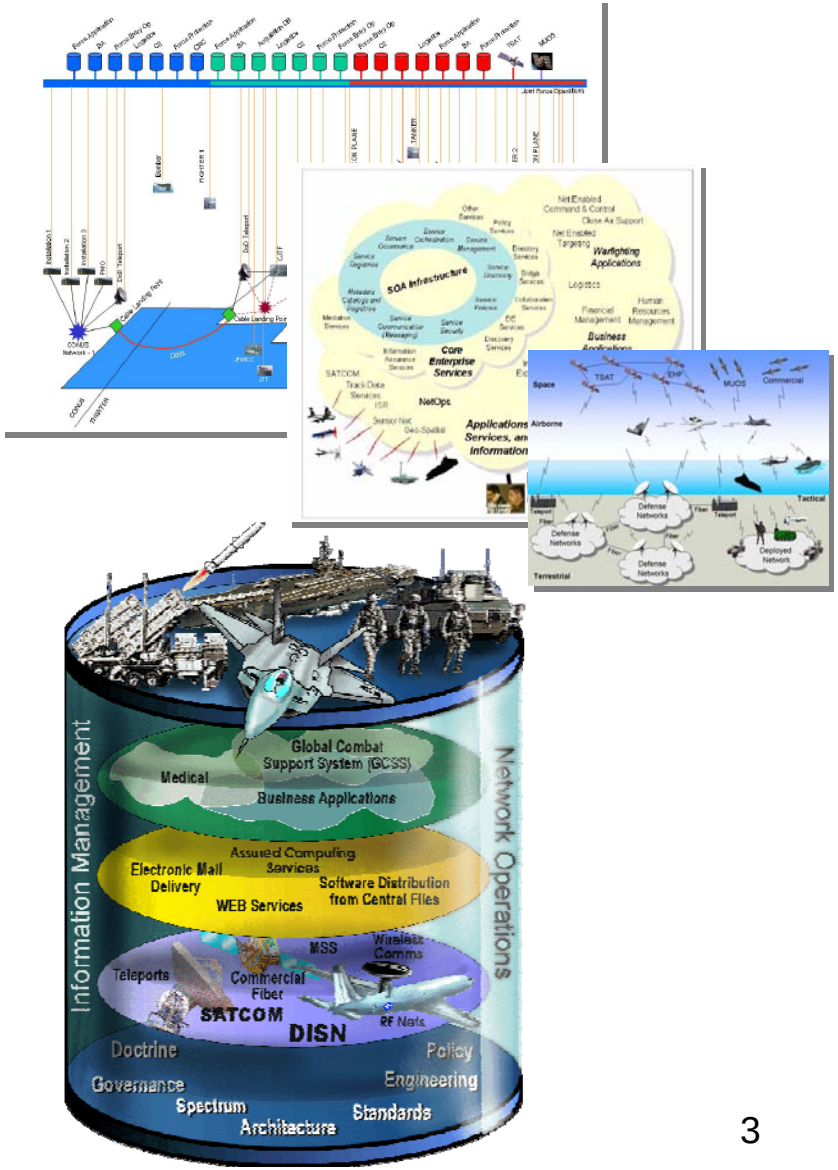
The ability to self-synchronize requires a ***rich shared understanding across the contributing elements****.* (Planning Complex Endeavors)

New approaches to both command and control are necessitated amongst other things by (1) a need to accommodate the realities of complex operations such as coalition and civil-military operations and ***(2) a desire to increase awareness and leverage shared awareness across a large, distributed enterprise consisting of many different kinds of participants.*** (Planning Complex Endeavors)

The Future

The GIG will support and enable highly responsive, agile, adaptable, and information-centric operations characterized by:

- An increased ability to share information
- Greatly expanded sources and forms of information and related expertise to support rapid, collaborative decision-making
- Highly flexible, dynamic, and interoperable communications, computing, and information infrastructures that are responsive to rapidly changing operational needs
- Assurance and trust that the right information to accomplish assigned tasks is available when and where needed, that the information is correct, and that the infrastructure is available and protected



Source: DoD GIG Architecture Vision 1.0 Jun 07, p. 2.

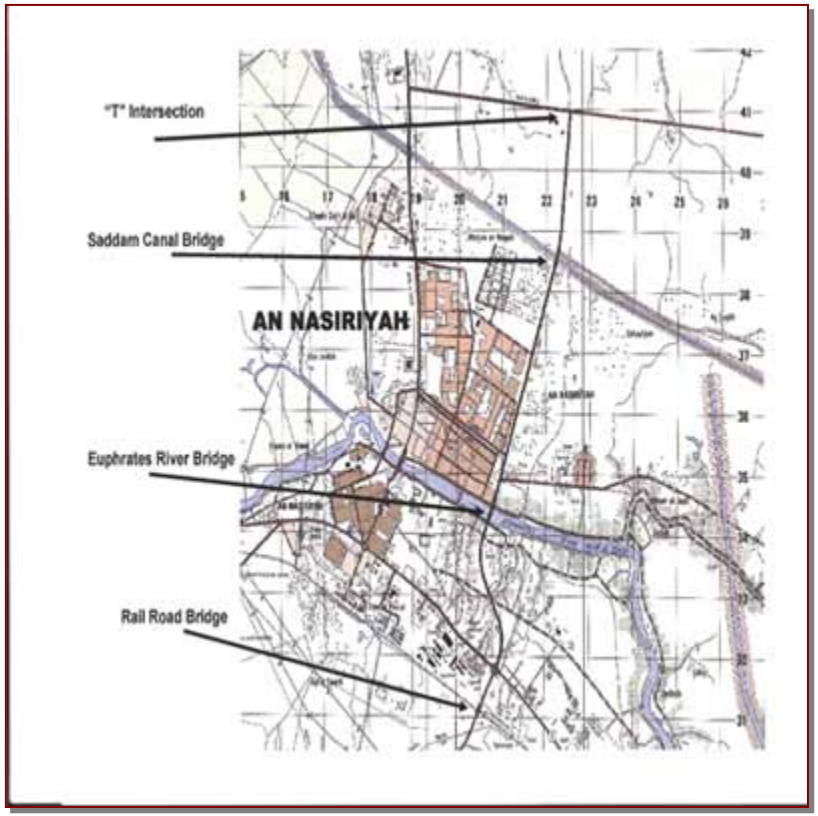
The Reality:
The Battle for An Nasiriyah 2003*

*"The command group had **little situational awareness (SA)** outside of the three city blocks it occupied.."*

*"The simultaneous engagements, urban terrain, and distances separating individual companies were **wreaking havoc on the Com. network.** "*

"Information that would normally come to the command group and be passed to the battalion commander and operations officer suffered delay and distortion through second-, third-, and fourth-party relays. Attempts by the command group to raise the battalion commander on radio only added to the congestion and were quickly abandoned. "

Task Force Tarawa



•Rohr, Karl.C., "*Fighting Through the Fog of War", Marine Corps Gazette, 2006, available:* http://www.mca-marines.org/Gazette/2006/06rohr.html

The Reality:
The Battle for An Nasiriyah, 23 March 2003*

- *"fires could only be in his zone against targets visually identified as enemy"*
- *"a firefight of this nature will have difficulty tracking other friendly forces operating nearby but out of sight."*
- *"Some aircraft did not have the ability to communicate with the FSCC"*
- *"With communications disrupted, the air officer was not able to coordinate the flow of aircraft."*
- *"(FACs) had to build the pilots' SA and do weaponeering as the aircraft checked in"*

•Rohr, Karl.C., "*Fighting Through the Fog of War", Marine Corps Gazette, 2006, available:* http://www.mca-marines.org/Gazette/2006/06rohr.html

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Challenges: The Evolving Environment

- Traditional force structures (Battalions, Companies) are being forced to disperse and operate on vast frontages & in urban settings
  - A traditional battalion frontage is 1 -2 Km
  - Today, certain units are operating in over 3600 sq. mile area, controlling over 20 battle positions, and monitoring over 70 coalition positions
- The nature of the threat has
  - Increased the need for precision targeting
  - Forced the dispersion of forces, both in urban and in rural environs
  - Placed a high demand on the *infostructure* for focused information and actionable intelligence

Challenges: System Bandwidth

- Physical bandwidth and available spectrum are limited resources
  - FCS BW demand 10 x > Army capability
    - 43M lines of code (exceeds JSF program as #1)*

    Source: Congressional Budget Office Study, "The Army's Bandwidth Bottleneck", 2003.
  - A typical USMC MEF is doctrinally provisioned 2 Mbps for a corps sized force
    - BW demand will increase as computer systems migrate to lower tactical echelons (Battalion and below)

Challenges: Cognitive Bandwidth

- Human bandwidth is fixed
  - *InfoGlut* (Denning): Computer generated information capabilities vastly exceed human info processing ability
  - Increases in System BW capability (broadband) exacerbates the problem: more data is transmitted to the user
    - A UAV has the potential to generate terabytes of data/hour.
    - 14,000 UAV hrs/month typical = petabytes (10^{15}) monthly/exabytes (10^{18}) yearly for these systems alone.
      - AKA: ***Digital Landfills*** (Gen Tom Hobbins, USAF)
  - Service Oriented Architectures (SOA) & Data tagging will "unearth" more searchable data and further compound the problem

The Resultant Dilemma: InfoGlut

- Potential to overload the operator with *bits*, as we have with *molecules*

The Recommended Solution

- Shannon is not enough
  - Shared awareness cannot be attained through physical bandwidth alone (i.e. “pipes”)
  - Bandwidth for mobile entities will always be in high demand
  - User bandwidth is fixed
- Substantially reduce bit flow by only transmitting significant bits
- How?
  - Equip entities/actors with a shared, stateful model (the “kernel”)
  - Transmit the “deltas” of these models when user defined conditions warrant it

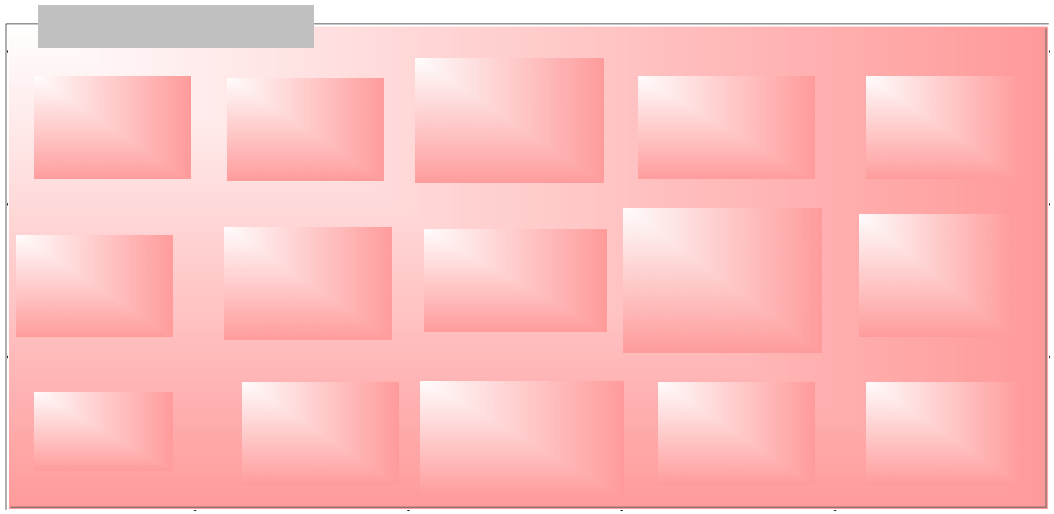
MCN-VIRT: Doing More with *Less*

- Communicate significant bits
  - Maintain a shared understanding of the dynamic situation
    - Agree upon *semantics*
    - Distribute a stateful, meaningful model
    - Filter bits by *value* & *push* them to the operator
- Implication
  - Decrease required BW (transmit “deltas” of the model
  - Increase available cognitive BW (reduce glut)

An Operationalized World Model

Model: A collection of our plans, assumptions, beliefs, and intent

i.e. …



- Today this model is instantiated in our:
  - **Plans**: OPLANs, CONPLANs, OPORDs, FRAGOs, mission orders, Air Tasking Order (ATO), terrain models, maps
  - **Select Systems**: Theater Battle Management Corps System (TBMCS), Global C2 System (GCCS), C2PC/FBCB2, limited mission systems
- Carried into battle by humans on maps, knee-board cards, Microsoft Office products, Face-2-Face briefs and in memory

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Today: Distributing the Battlefield Model

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Today: Distributing the Battlefield Model

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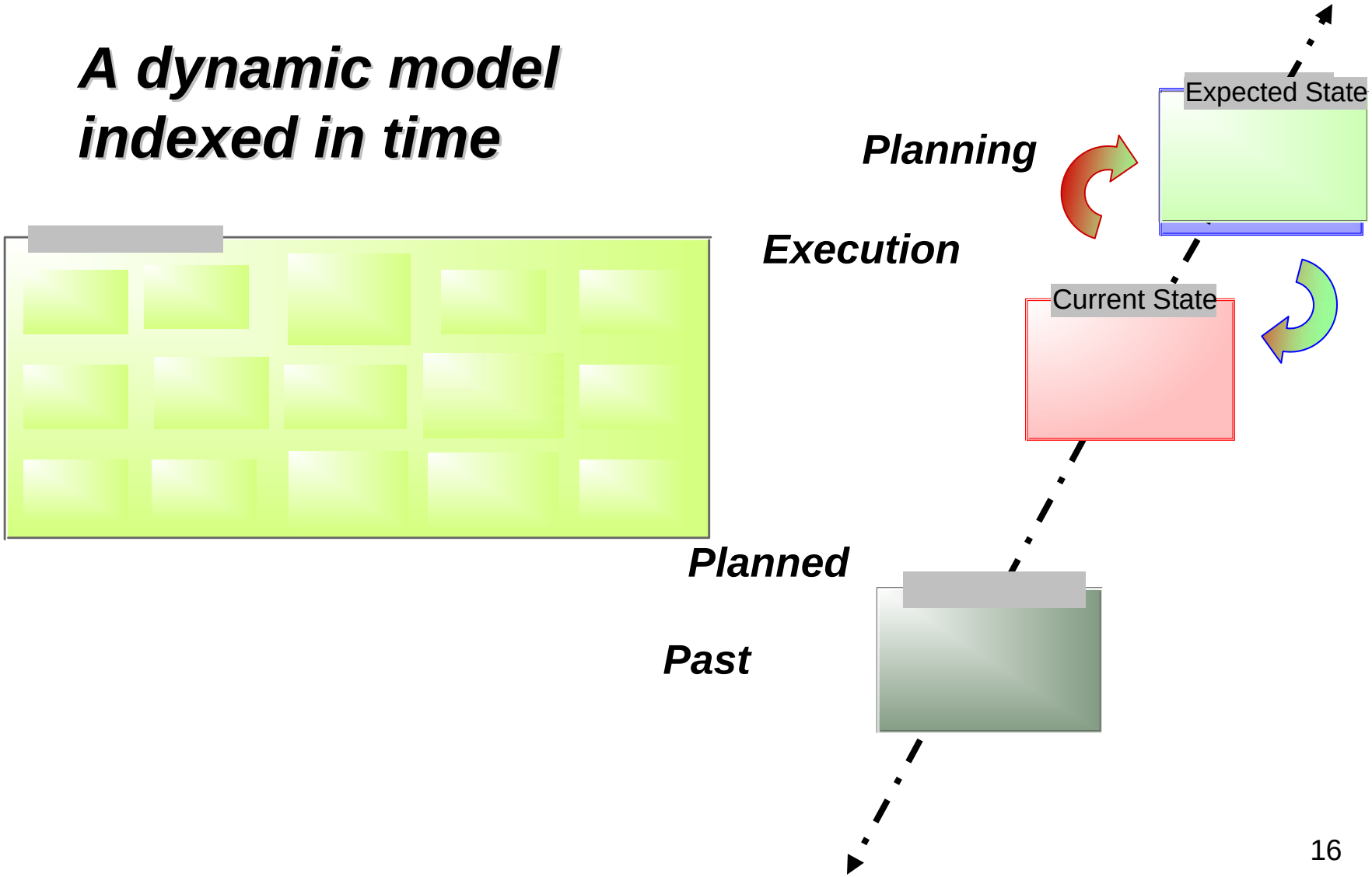
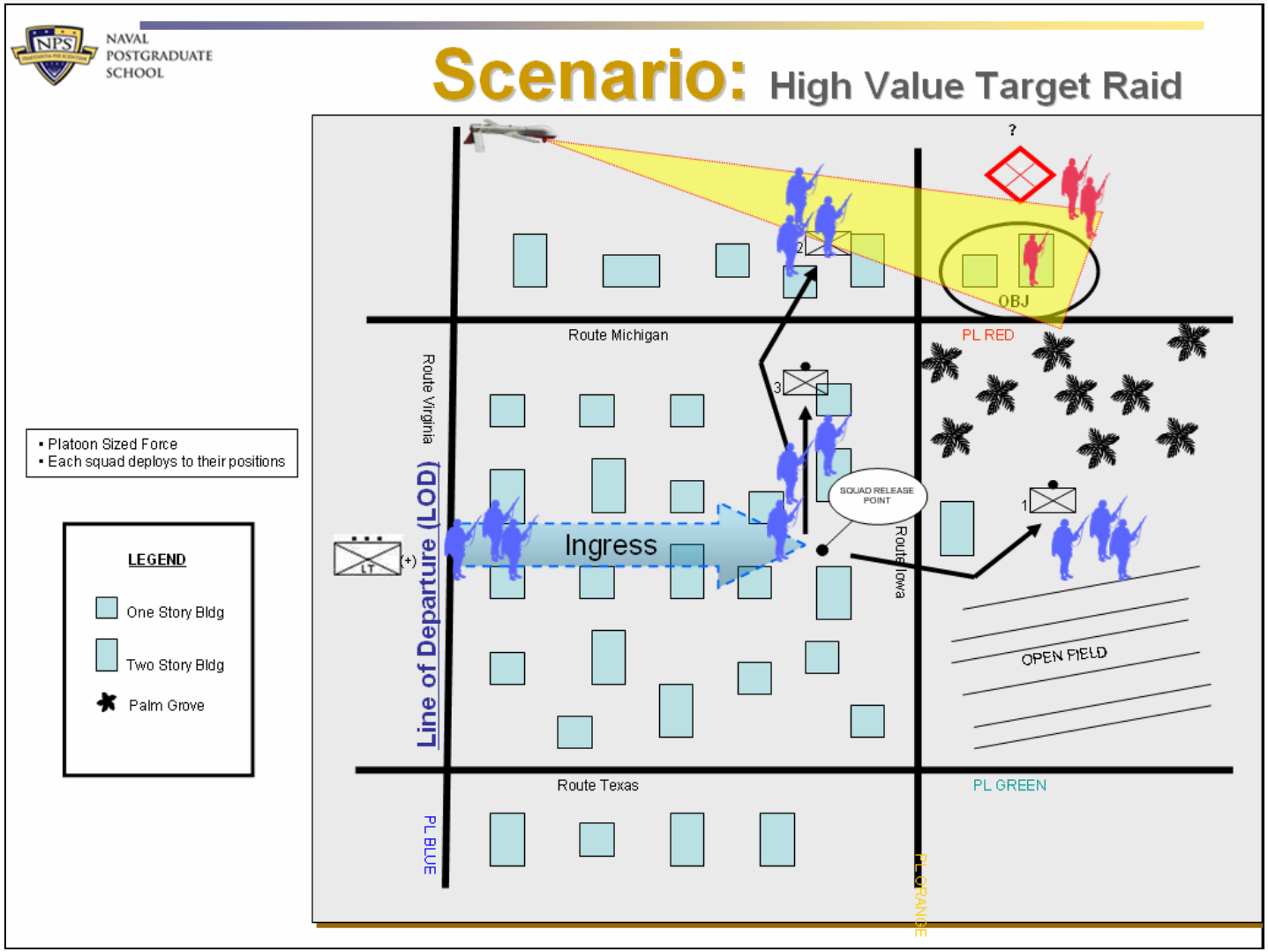
Today: Distributing the Battlefield Model

A Stateful World Model Example

A dynamic model indexed in time



Mission Thread HVT Scenario



Discovering Conditions of Interest

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Conditions of Interest

1-1. Notify me if my target location is no longer valid.

1-1.a. The distance we are concerned with is a variable. For this instance, we say +/- 100m

1-2-1. Tell me if there are any of friendly organic forces injured to the extent that it impacts mission accomplishment.

1-2-1.a. Variable here is the definition of what hinders the mission. Examples include mobility, life threatening injuries, and combat effectiveness issues.

1-2-2. Same as 1-1. Variable here is the distance of the squad from it's expected location; We are concerned with +/- 50m.

1-2-3. Tell me if any organic blue force weapons become inoperable.

1-2-3a. By inoperable, we mean incapable of sending a round downrange. Does not take into account multiple weapon systems (203 grenade launcher)

Target location known	*Actual Target location not as planned / expected*
All organic blue forces are mission capable	*Organic blue force casualties exceeds Go-No-Go threshold*
Squads' locations are accurate	*Squads' locations are not as planned / expected*
Weapons are mission capable	*# non-mission capable Weapon systems exceeds Go-No-Go threshold*
Still within my communication's threshold	*Approaching my communication device's threshold*

Formalizing Valuable Information: Conditions of Interest

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Example Information Requirements and Conditions of Interest (COIs)

In_1.0 **//Target Location has changed//**

1 **Current target location not as planned**

[Mission]: Msn_#, Msn_Type-HVT,[Phase]:= Ingress, [Target]:Tgt_ID, [Location]: Location_ID, Coordinates ≠ Coordinates Planned

2 **Current target location not as expected**

[Mission]: Msn_#, Msn_Type-HVT,[Phase]:= Ingress, [Target]:Tgt_ID, [Location]: Location_ID, Coordinates ≠ Coordinates Expected

In_2.0 **//Health & status of organic, mission assigned, friendly forces//**

1 **Blue organic force member is seriously injured**

[Mission]: Msn_#, Msn_Type-HVT,[Phase]:= Ingress, [Rifleman]: Rifleman_ID **and/or** [Squad]: Sqd_Ldr **and /or** [Fire_Team]: FireTeam_Ldr, Health_N_Status = Serious Injury

2 **# of organic blue forces injured exceeds mission Go-No-Go criteria**

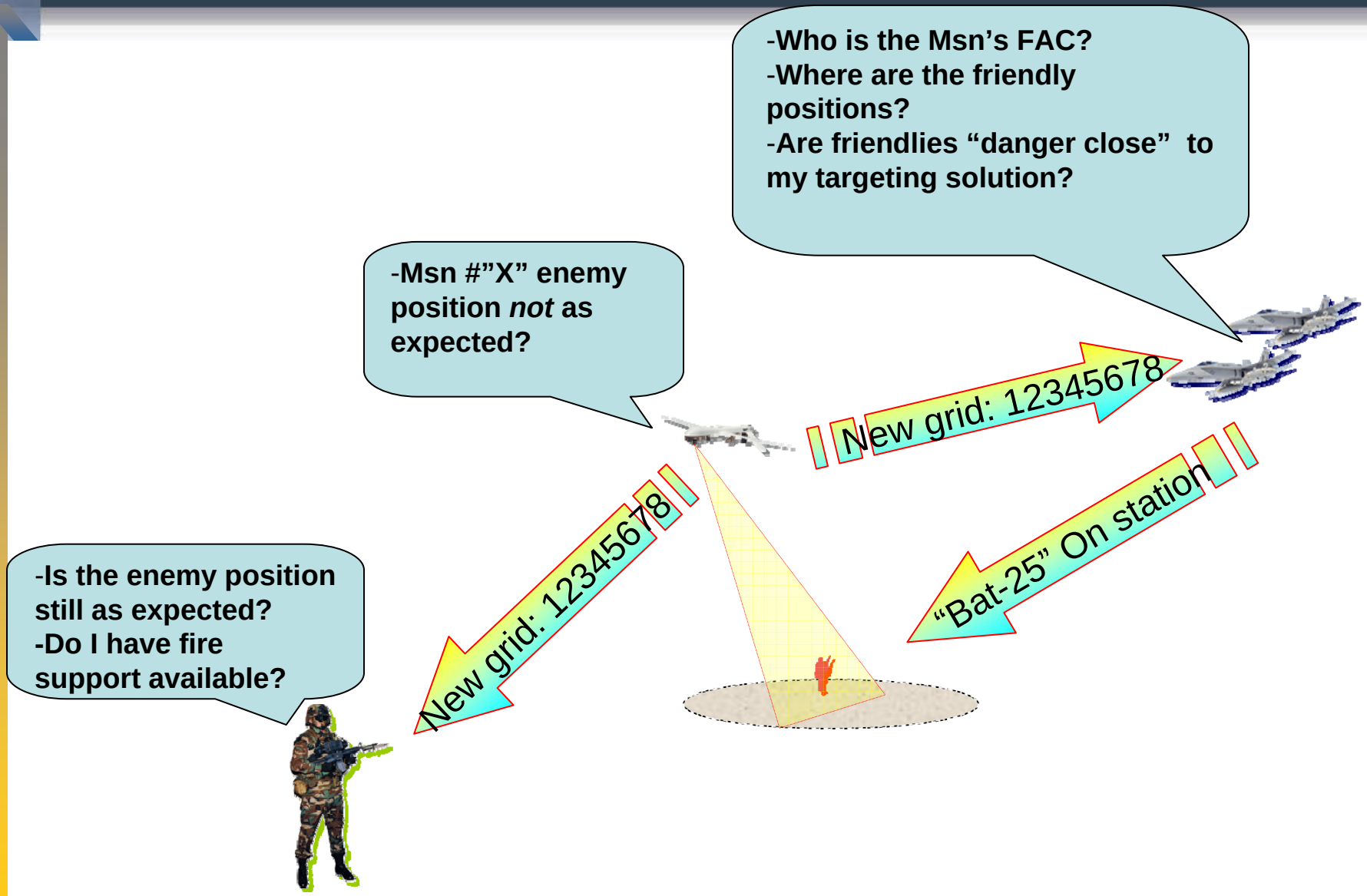
[Mission]: Msn_#, Msn_Type-HVT,[Phase]:= Ingress, [Rifleman]: Rifleman_ID **and/or** [Squad]: Sqd_Ldr **and /or** [Fire_Team]: FireTeam_Ldr, Health_N_Status **SUM Qty** Serious Injury ≥ **Go_No_Go_Criteria {abort}**

In_3.0 **//Location of msn essential organic blue force maneuver elements, in this case a 12 man squad.//**

1 **Current position of Squad(n) is not as planned**

[Mission]: Msn_#, Msn_Type-HVT,[Phase]:= Ingress, [Squad]:Squad_ID, [Location]: Location_ID, Coordinates ≠ Coordinates Planned

User Defined Conditions of Interest and *Smart Push*



Take Away

MCN-VIRT:

- Reduces InfoGlut by conserving Physical and Human bandwidth
- All actors/entities share a dynamic, semantic model at its core
- Communicates significant bits
  - Pushes valuable bits to the operators when user defined conditions of interest (COIs) emerge
- Promotes C2 agility/self-synchronization by distributing a shared, stateful, operational model

Questions?

Backup

Back up

VIRT/MCN Defined

- *A Model-based Communication Network (MCN) is a state-full distributed system of collaborating nodes that maintains an optimal shared understanding of the situation.*
  - *The situation at each node is composed of models of all entities relevant to its mission*
  - *Understands the state of its collaborating nodes*
    - *Including missions, assumptions, and beliefs*

- VIRT: Services that deliver *valued information at the right time to* MCNs
  - VIRT services filter information so high value bits are prioritized and low value bits are depreciated

Semantic Object Model

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USMC-VIRT Semantic Object Model v.1

Concepts of…

Mission
- ‡MSN_# 1-1
- MSN_Type 1-1
- MSN_Precedence 1-1
- MSN_Category 1-1
- Objective 1-N
- Phase 1-N
- Location 1-1
- Platoon 1-1
- Time 1-1
- Target 0-1

Target
- ‡TGT_ID 1-1
- Tgt_Name 0-1
- Tgt_State 0-1
- Tgt_Priority 0-1
- Tgt_Location 0-1
- Tgt_Category 0-1
- Tgt_Type 0-1
- Location 1-1
- Mission 1-1

Location
- ‡Location_ID 1-1
- Coordinates 1-1
  - Lat_Long 1-1
  - 10_Digit_Grid 1-1
  - Coord_Units 1-1
  - Coord_Type 1-1
- Start_Location 0-1
  - Planned_Loc 0-1
  - Actual_Loc 0-1
  - Expected_Loc 0-1
- End_Loc 0-1
  - Planned_Loc 0-1
  - Expected_Loc 0-1
  - Actual_Loc 0-1
- Mission 0-N
- Platoon 0-N
- Rifleman 0-N
- Fire_Team 0-N
- Squad 0-N
- Enemy 0-N
- Target 0-N

Objective
- *Obj_Type 0-1
- Obj_Name 0-1
- Mission 1-N

Phase
- *Phase_Name 1-N
- *Mission 1-1
- Start_Time 0-1
  - Planned_Time 0-1
  - Expected_Time 0-1
  - Actual_Time 0-1
- End_Time 0-1
  - Planned_Time 0-1
  - Expected_Time 0-1
  - Actual_Time 0-1
- Start_Location 0-1
  - Planned_Loc 0-1
  - Actual_Loc 0-1
  - Expected_Loc 0-1
- End_Loc 0-1
  - Planned_Loc 0-1
  - Expected_Loc 0-1
  - Actual_Loc 0-1
- Space_Transited 0-1
  - Planned_Time 0-1
  - Planned_Loc 0-1
  - Expected_Time 0-1
  - Expected_Loc 0-1
  - Actual_Time 0-1
  - Actual_Loc 0-1

Time
- Time_Zone 1-1
- MSN_Time 0-1
  - Current_Time 0-1
  - Elapsed_Time 0-1
  - Start_Time 1-1
    - Planned_St_Time 0-1
    - Expected_St_Time 0-1
    - Actual_St_Time 0-1
  - End_Time 0-1
    - Planned_End_Time 0-1
    - Expected_End_Time 0-1
    - Actual_End_Time 0-1
- Mission 1-1

Table of Equip
- ‡TE_# 1-1
- TE_ID 1-1
- Unit 0-1
  - Unit_Category 0-1
  - Unit_Type 0-1
  - Unit_Name 0-1
  - Unit Designator 0-1
  - Unit_Cmbt Readiness 0-1
- Qty_Small Arms 0-1
- Qty_Large Caliber 0-1
- Qty_Arty 0-1
- Qty_NVGs 0-1
- Qty_Aircraft 0-1

Enemy
- ‡Enemy_ID 1-1
- Unit 1-N
  - Unit_Category 0-1
  - Unit_Type 0-1
  - Unit_Name 0-1
  - Unit Designator 0-1
  - Unit_Cmbt Readiness 0
- Unit_Size 0-1
  - Unit_TO Strength 0-1
  - Unit_TO Actual 0-1
- Activity 1-1
  - In Place 0-1
  - Transiting 0-1
  - Withdrawing 0-1
  - Defending 0-1
  - Retreating 0-1
  - Reinforcing 0-1
  - Attacking 0-1
- Location 1-1
- Unit_Equip 1-1
  - Table_of_Equip# 0-1
  - Qty_AAA 0-1
  - Qty_MANPADs 0-1
  - Qty_Small_Arms 0-1
  - Qty_Hvy_Wpns 0-1
  - Comm_Gear_Code 0-1

Platoon
- ‡Platoon_ID 1-1
- Platoon_Ldr 1-1
- Plt_Sgt 0-1
- Health_N_Status 0-1
- Squad 3-3
- Location 1-1
- Mission 1-1
- Fire_Team 0-1

Squad
- ‡Squad_ID 1-1
- Sqd_Ldr_Pri 1-1
- Squad_Ldr_Alt_1 0-1
- CommGear_T/E# 0-1
- Weapon_T/E# 0-1
- Fire_Team 4-4
- Platoon 1-1
- Location 1-1

Fire_Team
- ‡FireTeam_ID 1-1
- FireTeam_Ldr 1-1
- Squad 1-1
- Platoon 1-1
- Rifleman 3-3
- Location 1-1

Rifleman
- ‡Rifleman_ID 1-1
- CommGear_Type 1-1
- Weapon_Type 1-1
- Fire_Team 1-1
- Location 1-1