

# A Quantitative Model-Driven Comparison of Command Approaches in an Adversarial Process Model

12TH ICCRTS  
“Adapting C2 to the 21st Century”

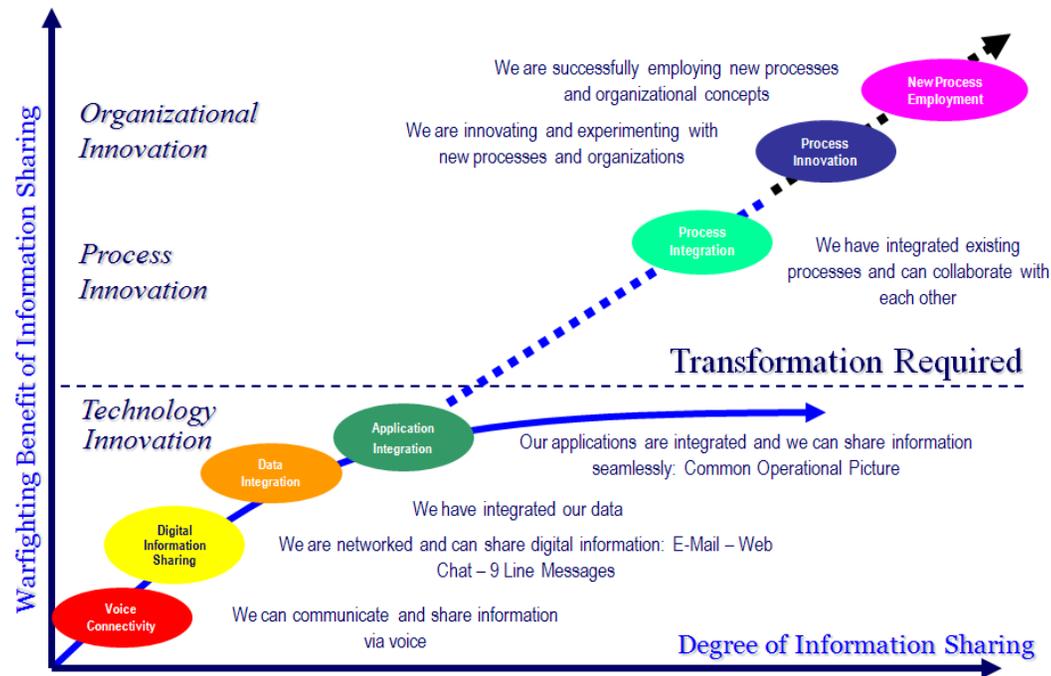
**Authors:** Robert Regal, Rebecca Reed, Matt Largent PhD  
**Organization:** Office of the Chief Engineer,  
Space and Naval Warfare Systems Center Charleston



# Objective

Systems Center  
Charleston

- Propose and demonstrate an analysis framework for Command and Control (C2) strategy evaluation
- Hypothesis: It is possible to integrate and evaluate C2 strategy approaches in a technology agnostic, adversarial process framework

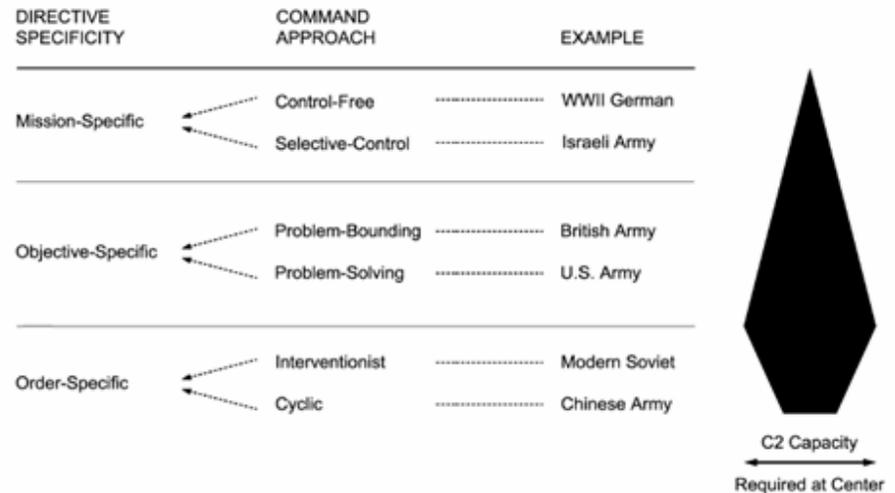


\*Based on a slide from Vice Admiral Art Cebrowski and Gartska

The vast majority of military assessments in the area of force transformation are focused on technology solutions to the problem of achieving agility and adaptability

- Compete Blue against Red for three C2 strategies
- Humanitarian Assistance, Counter Insurgency, Counter Proliferation (HA/CI/CP) multiple mission scenario
  - US conducting peacekeeping operations in friendly nation. Insurgent forces attempt to infiltrate weapons from a neighboring, neutral country via commercial shipping.

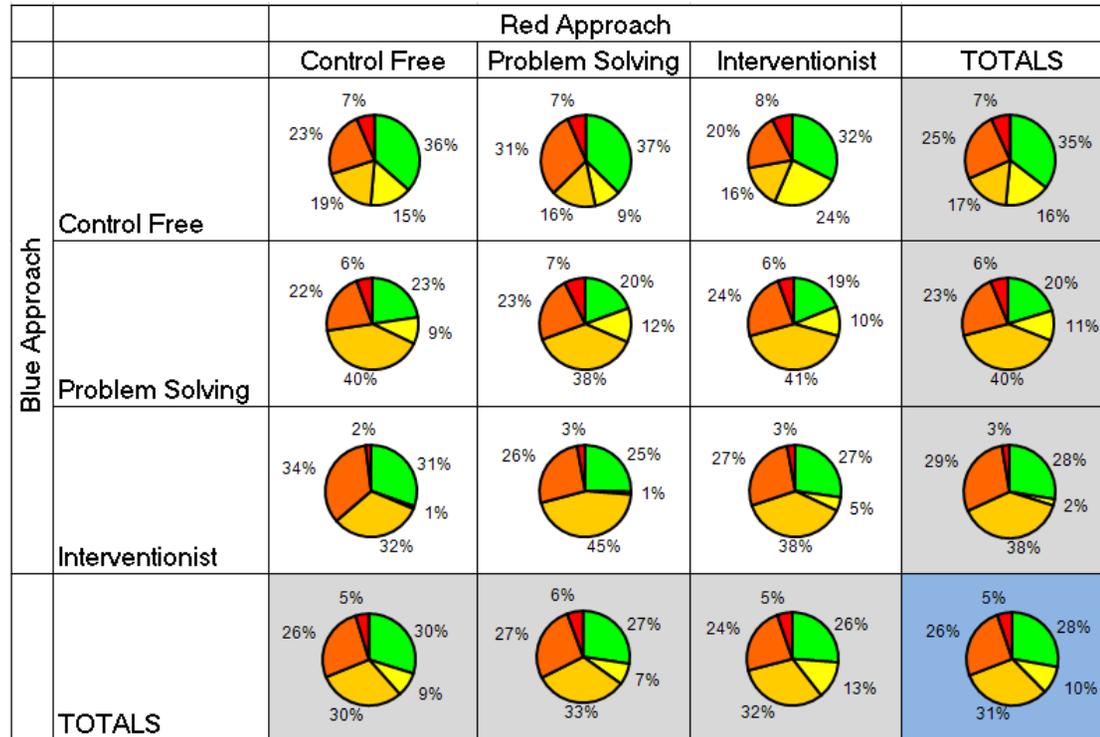
		RED STRATEGY		
		Control Free	Problem Solving	Inter-ventionist
BLUE STRATEGY	Control Free	?	?	?
	Problem Solving	?	?	?
	Inter-ventionist	?	?	?



# Outcome



- Blue Control Free strategy results in most positive outcomes in this scenario
  - Improved outcome is statistically significant when Red style is Interventionist
- # Successful Time Critical Strikes → 0 when Blue assumes Interventionist style
- Varying Blue strategy appears to have a greater impact on outcome than varying Red strategy in this scenario



\*Based on 100 simulations per strategy pair (total of 900 runs)

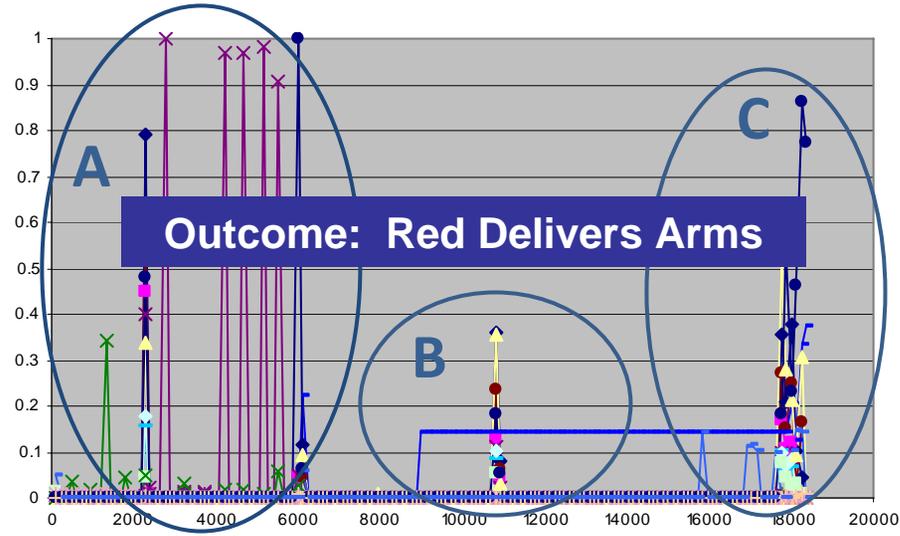
Test	K	Chi	Result
Ho: Equal Blue Means over Red CF	4.671969	5.991	accept Ho
Ho: Equal Blue Means over Red PS	2.008401	5.991	accept Ho
Ho: Equal Blue Means over Red IV	7.996643	5.991	reject Ho
Ho: Equal Red Means over Blue CF	0.426769	5.991	accept Ho
Ho: Equal Red Means over Blue PS	0.264483	5.991	accept Ho
Ho: Equal Red Means over Blue IV	0.228423	5.991	accept Ho

\*Kruskal-Wallis test statistics, calculated using MATLAB statistical toolbox

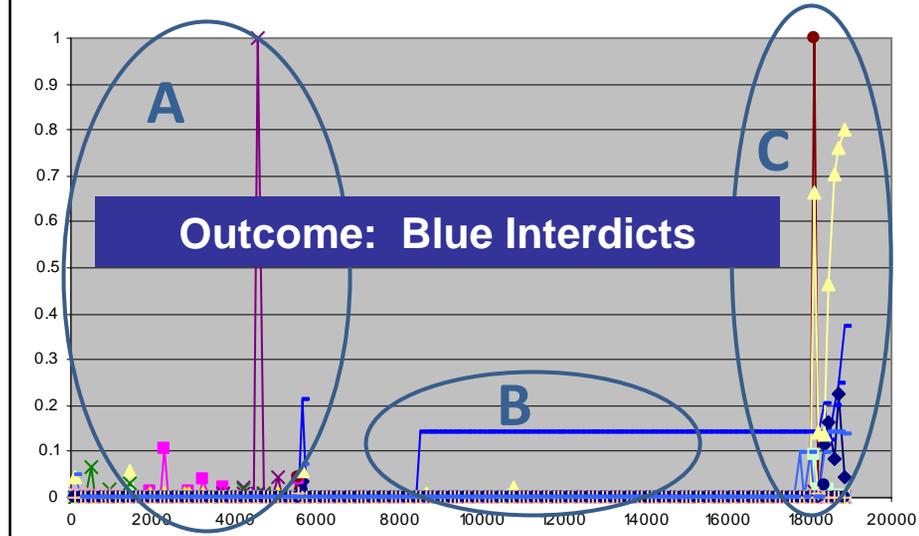
\*Null hypothesis assumes that C2 strategy does not affect mission outcome (equal outcome means). Rejecting this hypothesis implies that C2 strategy has a significant impact on mission outcome. See paper for details.

# Resource Utilization

**Blue Interventionist**



**Blue Control Free**



**A**  
Interventionist  
planning requires  
more approvals,  
higher levels of  
the COC

- ◆ Cdr\_LCS
- ✖ COCOM
- ▲ CJTF\_Staff
- ✖ COCOM\_Staff
- JFMCC
- + JFMCC\_Staff
- + LCS
- + LCS\_CO
- + LCS\_TAO
- + LCS\_Watchstanders
- ▲ LCSCdr\_Staff
- ✖ Pres\_SECDEF
- ✖ Pres\_SECDEF\_Staff
- SCC
- + SCC\_Staff
- Sensor

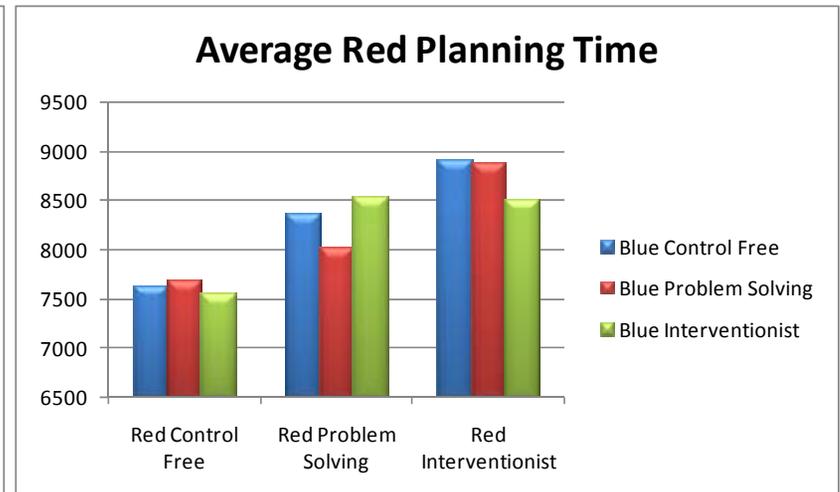
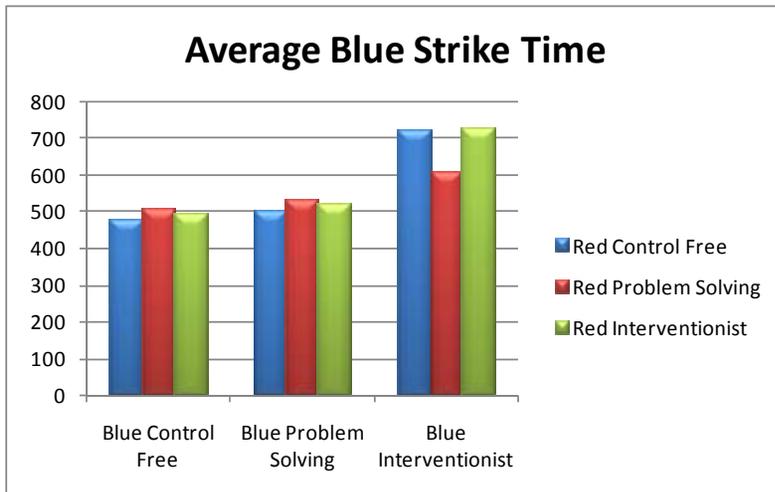
**B**  
Adversarial information can  
be analyzed and acted upon  
directly by LCS Cdr staff in a  
Control Free style

**C**  
When Red arms carrier is  
detected, Control free style  
requires less approvals, lower  
levels of the COC

\* Red Strategy = Control Free

# Other Results

- Significant differences found in mission phase times
  - When Blue is Interventionist, Blue Strike takes significantly more time due to the number of COC approvals required and resulting COC bottlenecks (results in very few successful Strikes)
  - When Red is Interventionist, Red Planning takes significantly more time due to limited staff at higher levels of Red COC and the number of approvals required



# Approach

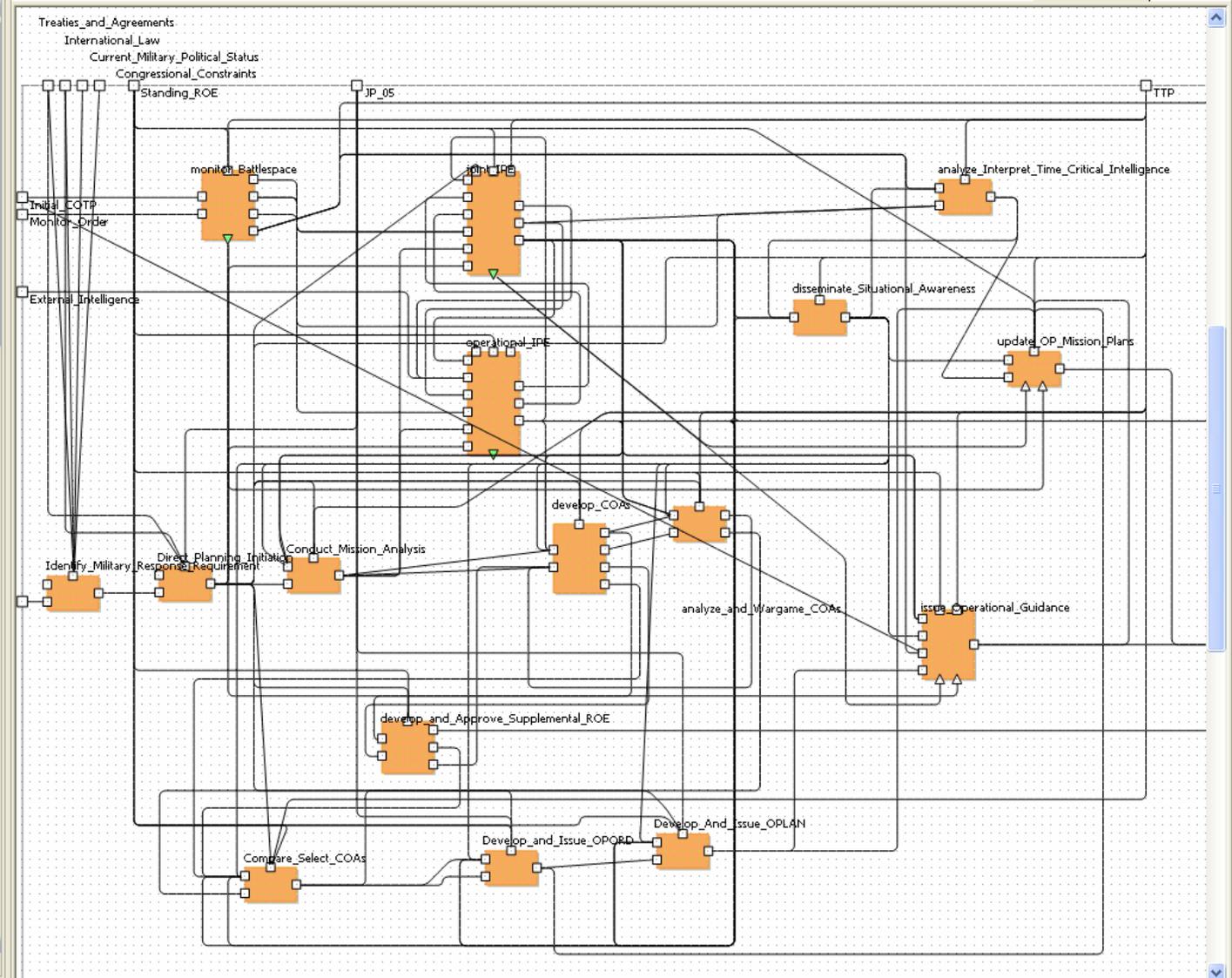
- Define and implement a baseline model of current US military (Blue) C2 process and organization
  - Integrate C2 process, organization, human performance & decision models
- Define and implement a baseline model of adversary's (Red) C2 process and organization
- Define and implement adversarial model (Blue versus Red)
- Process activities, COC organization and data gathered from:
  - Joint Doctrine/Publications, Military Experts, Navy Mission Essential Task List, 9/11 After Action Report, Historical Information
- Vary the baseline models to represent alternative command approaches
- Analyze metrics to determine if the command approaches have a significant impact on mission outcome in an example scenario, and determine relative efficiency and effectiveness



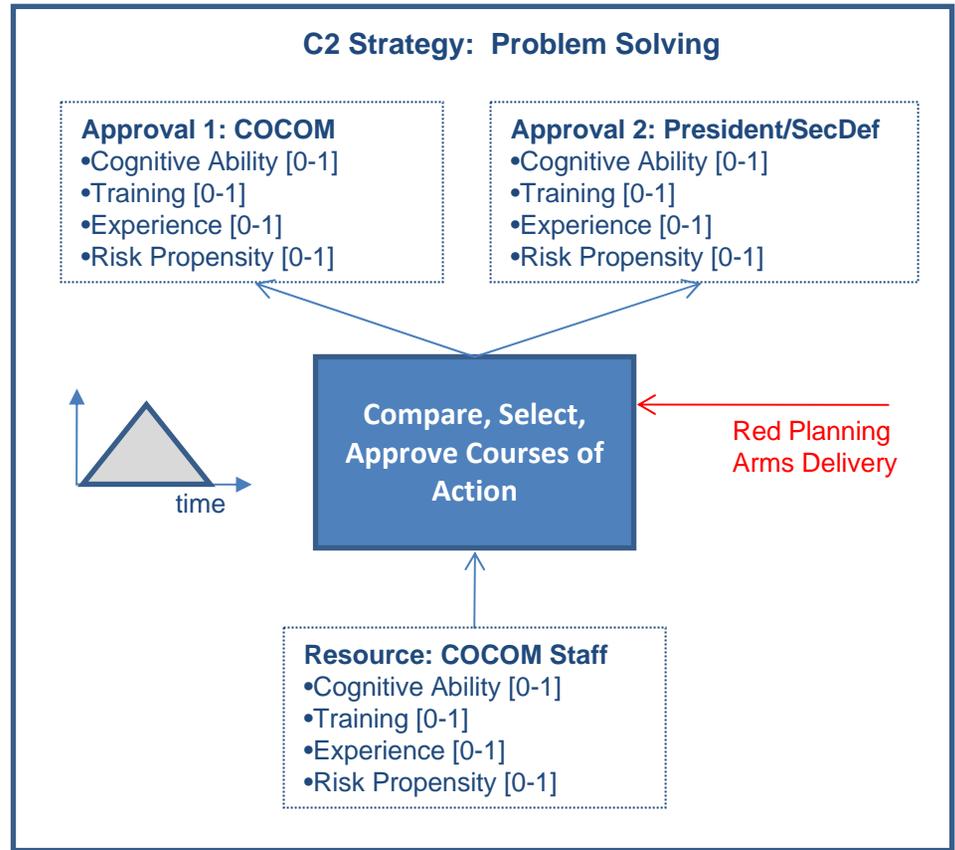


Project: Resource\_Singleton Resource\_Process Custom CoC\_Node SharedResource CoC\_Decision Chain\_of\_Command C2Main Blue\_C2Main US\_Planning

- Model
  - Blue
    - Background\_Traffic
    - Blue\_C2Main
    - Chain\_of\_Command
    - Resource\_Pool
    - Special\_Routing
    - US\_Interdiction
    - US\_Peacekeeping
    - US\_Planning
    - US\_Strike\_COA
  - C2
    - Adversarial\_Battlespace
    - Adversarial\_Replicator
    - BlueRedAnimation
    - BlueRedAnimation2
    - C2Main
    - CoC\_Decision
    - CoC\_Node
    - CurrentActivityPane
    - Generic\_Process
    - Geometry
    - Intel\_Hook
    - Output\_Process
    - Parallel\_Approval
    - Parallel\_Authority\_Singlet
    - Parallel\_Resource\_Singlet
    - Parallel\_Work
    - Probe
    - Resource\_Process
    - Resource\_Process\_Klein
  - hk
  - u
  - SmartPort.java
  - Klein\_HPM
    - Diagnose
    - Mental\_Simulation
    - Output\_Approval
    - Probe
    - RPDM
    - Select\_Action
    - Select\_Best\_Pattern\_Mat
    - Select\_Valid\_Pattern\_Mat
  - Messages
    - Approval
    - Contact
    - Input
    - Pattern
    - Resource\_Mgmt
    - Staff



<b>Independent Variables</b>	<ul style="list-style-type: none"> <li>- Resource Allocation</li> <li>- Personnel Performance</li> <li>- Collaboration/Delegation Strategy</li> </ul>
<b>Control Variables</b>	<ul style="list-style-type: none"> <li>- Scenario</li> <li>- Warfighting Process</li> <li>- Nominal Process Execution Time</li> </ul>
<b>Random Effects</b>	<ul style="list-style-type: none"> <li>- Activity Times</li> <li>- Adversarial Information</li> <li>- Custom Activity Probabilities</li> </ul>
<b>Response Variables</b>	<ul style="list-style-type: none"> <li>- Scenario Outcome</li> <li>- Action Distance</li> <li>- Resource Utilization</li> </ul>



### OPSIT: Terrorist Leadership Target

**Timeframe: Today**

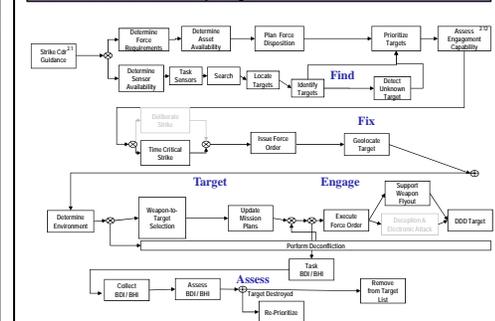
**Situation: Peace Keeping Terrorist Leadership Target (TLT)**  
 Terrorist Leadership Target (TLT) detected at port facility of neighboring neutral nation. Indications they may infiltrate Peace Keeping Zone via merchant vessel.

**Task:** Confirm current location of TLT; eliminate them if they enter Peace Keeping Zone

**Targeting Data:** TLT small boat and occupants identified by HUMINT Assets. Vulnerability window ~20 minutes.

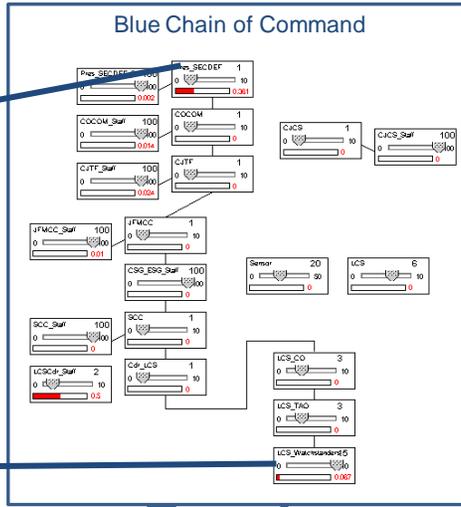
**Assumptions:**  
 NTM and ISR Aircraft are available for tasking and cueing, as well as BDA.  
 UAV and ISR aircraft available for targeting support.

### Command Approach – Problem Solving OPSIT – Terrorist Leadership Target

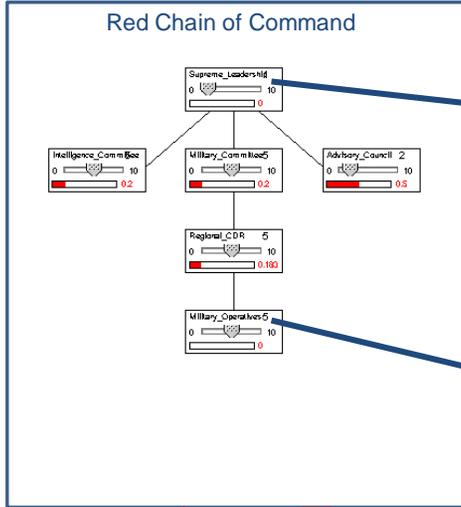


# Component Interactions

Cognitive Ability  
Experience  
Training  
Risk Propens  
...



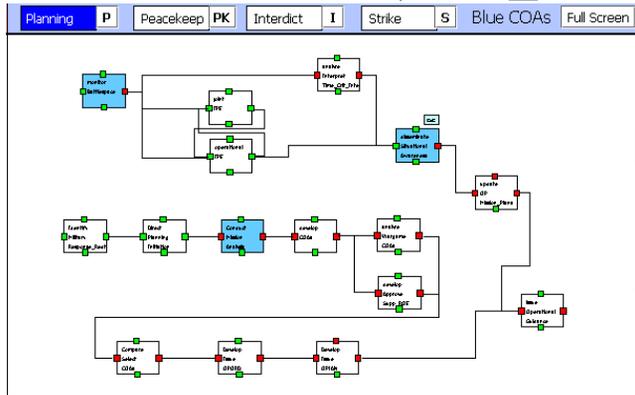
Cognitive Ability  
Experience  
Training  
Risk Propens  
...



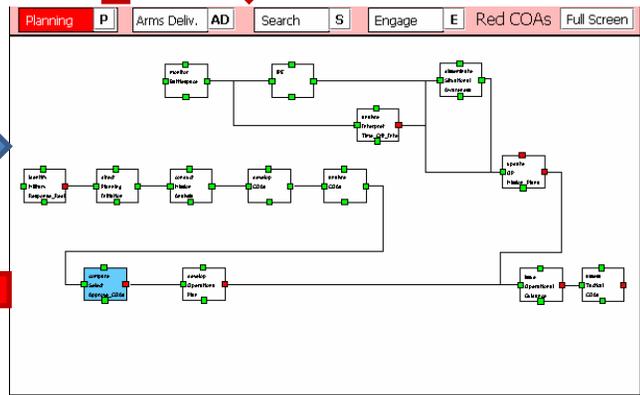
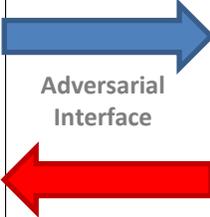
Cognitive Ability  
Experience  
Training  
Risk Propens  
...



Cognitive Ability  
Experience  
Training  
Risk Propens  
...



Blue  
Process



Red  
Process

# Conclusions

- We believe this research has proven the hypothesis that it is possible to integrate and evaluate command approaches in a technology agnostic, adversarial process framework
- An analytical framework that extracts C2 from C4ISR provides a valuable tool for identifying optimal command and control strategies
- In a complex scenario, local effects of varying command strategy may be dampened when considering only overall mission outcome
  - The optimal command strategy will vary based on the scenario, and will most likely vary within a given scenario

# Way Ahead

- Using this initial research as a foundation, we plan to test the following hypothesis:
  - The optimal organizational model is strongly dependent on the mission being executed
- We expect to show that:
  - Static organizations are sub-optimal across a subset of missions
  - Only guarantee for optimal mission organizational structure occurs when the organization emerges out of the process requirements

# Future Work

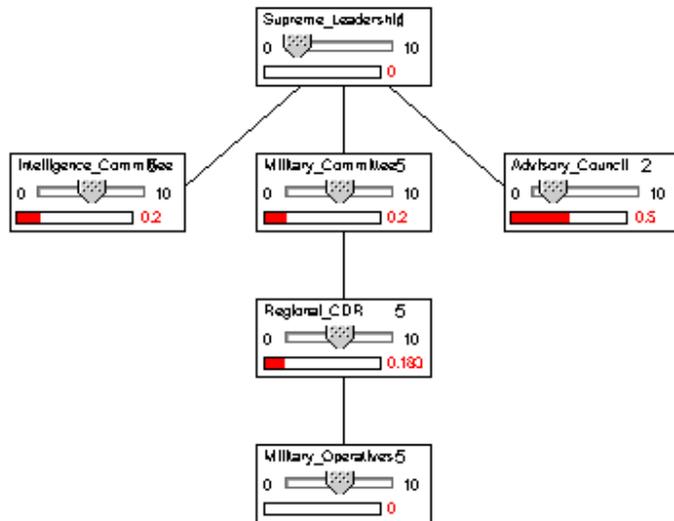
- Explore sensitivity of results to modifications in scenario
- Model new scenarios and multiple, concurrent scenarios
  - Evaluate optimal organizational structure across a portfolio of missions
- Explicitly model mission plan and policy (ex. ROE)
  - Will provide a more accurate representation of command strategy
  - Will make available a greater number of metrics for analysis (quality of mission)
- Develop hybridized or unique command approaches that are most effective for specific mission portfolios
- Reverse engineer human performance attributes as requirements
  - If Blue assumes a control free command strategy in this scenario, what levels of training, experience, etc are required to achieve the desired mission outcome?
- Continue to explore more robust methods for analyzing ordinal data

**BACKUP**

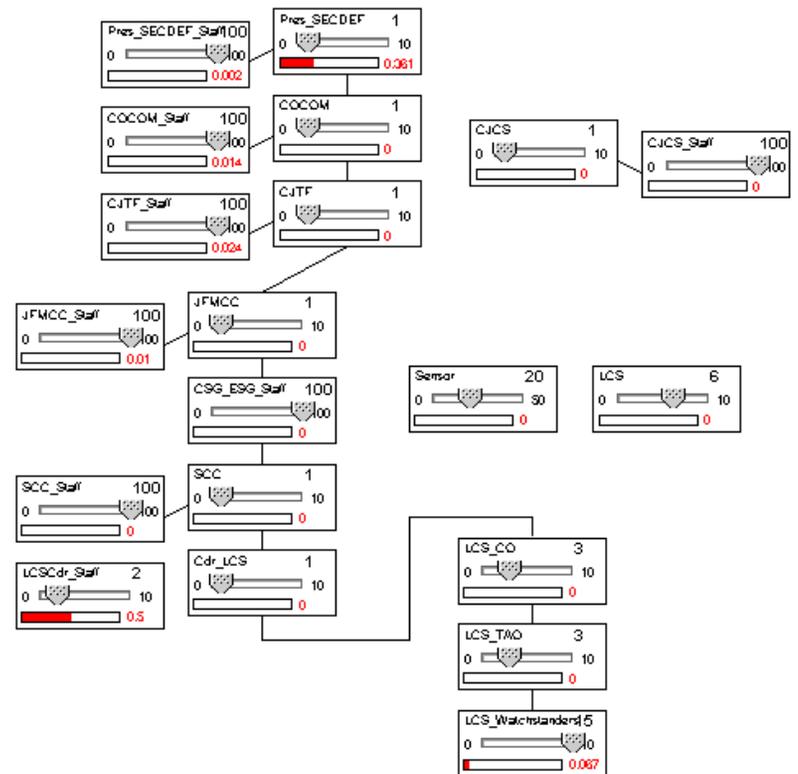
# Model Variables

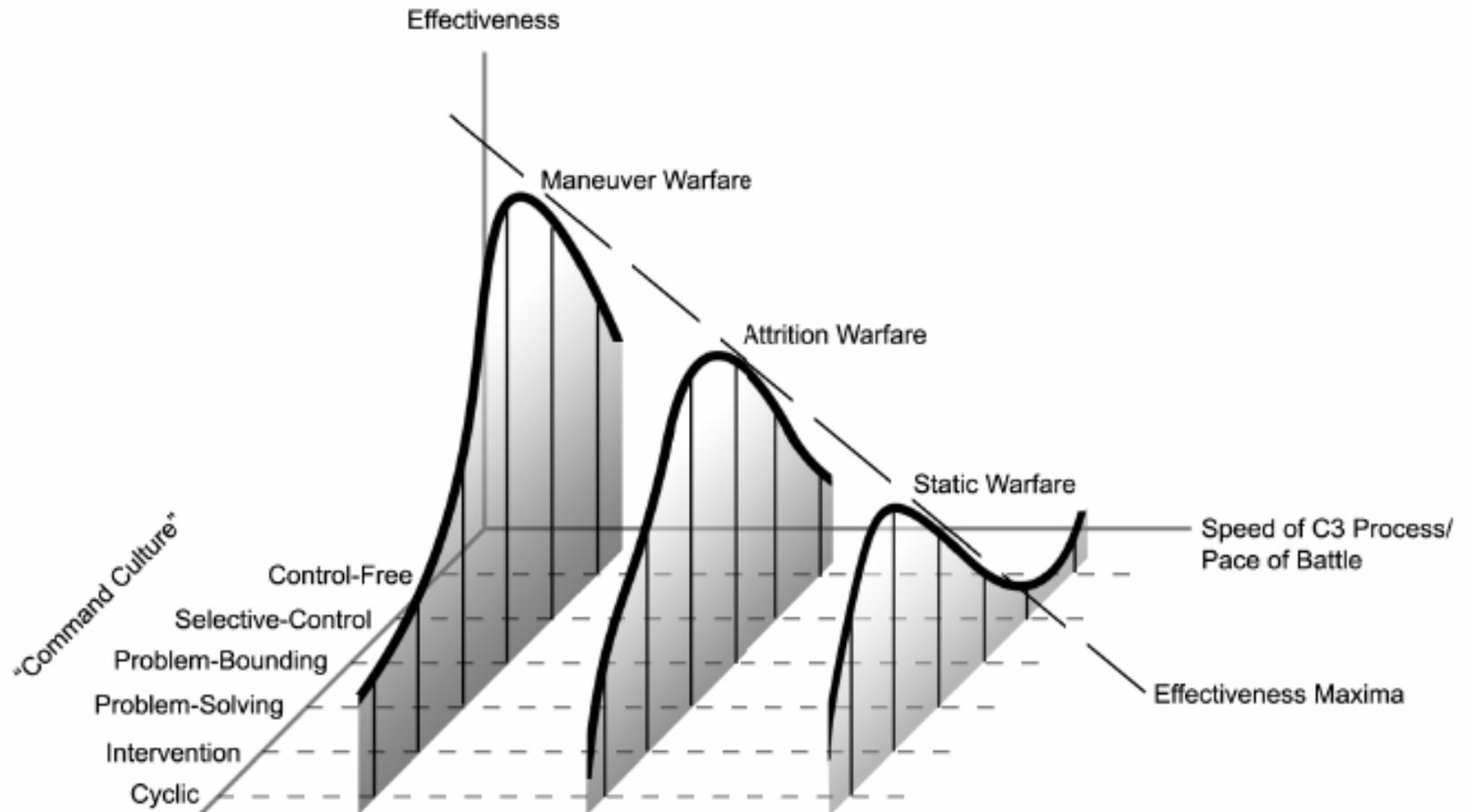
- Independent Variables
  - Resource Allocation: Node performing activity (e.g. CJTF)
  - Personnel Performance: Cognitive Ability, Training, Experience, Risk Propensity
  - Collaboration/Delegation Strategy: Node with approval authority (e.g. COCOM)
- Control Variables
  - Scenario: Operational Situation (i.e. Environment, Assets, etc)
  - Warfighting Process: Sequence of operational activities
  - Nominal Process Execution Time: Activity time distribution
- Random Effects
  - Activity Times: Random draw from activity time distribution
  - Adversarial Information: Information received about adversary (planning, location, etc)
  - Custom Activity Probabilities: e.g. Probability of Detection on Blue Search Activity
- Response Variables
  - Scenario Outcome: Blue Interdicts, Blue Strikes, Red Aborts, Red Delivers Arms, Red Engages
  - Action Distance: Data, Analysis, Decision and Overall Latencies
  - Resource Utilization: Proportion of time resource is actively supporting mission

## Red Chain of Command

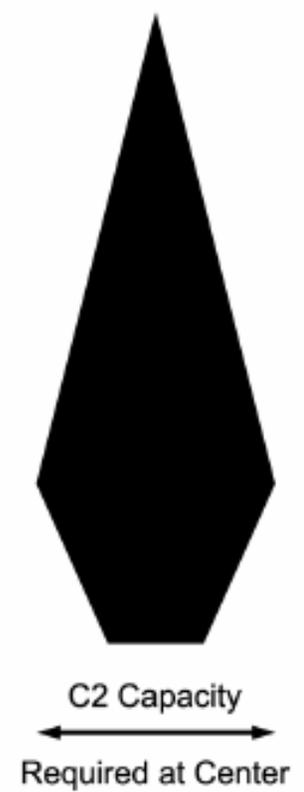


## Blue Chain of Command





DIRECTIVE SPECIFICITY		COMMAND APPROACH	EXAMPLE
Mission-Specific	↙	Control-Free	----- WWII German
	↘	Selective-Control	----- Israeli Army
Objective-Specific	↙	Problem-Bounding	----- British Army
	↘	Problem-Solving	----- U.S. Army
Order-Specific	↙	Interventionist	----- Modern Soviet
	↘	Cyclic	----- Chinese Army



Command Approach	<u>INPUTS</u>		<u>PROCESSING</u>	<u>OUTPUTS</u>		<u>SUBORDINATE ATTRIBUTES</u>	
	Detail of Update	Frequency of Update	Quantity Required	Level of Detail	Frequency	Professional Competence	Creativity/ Initiative
Control-Free	Low	Low	Low	Low	Low	Very High	Very High
Selective-Control	Low	Very High	Moderate/Low	Low	Moderate/Low	High	High
Problem-Bounding	Moderate	Moderate	Moderate	Moderate	Moderate	High/Moderate	High/Moderate
Problem-Solving	Moderate	Moderate	High/Moderate	High/Moderate	High/Moderate	Moderate	Moderate
Interventionist	High	Very High	Very High	Moderate	High	Moderate/Low	Moderate/Low
Cyclic	High	Very Low	High/Moderate	Very High	Very Low	Low	Very Low

# OPSIT: Terrorist Leadership Target

## Timeframe: Today

## Situation: Peace Keeping

Terrorist Leadership Target (TLT) detected at port facility of neighboring neutral nation. Indications they may infiltrate Peace Keeping Zone via merchant vessel.

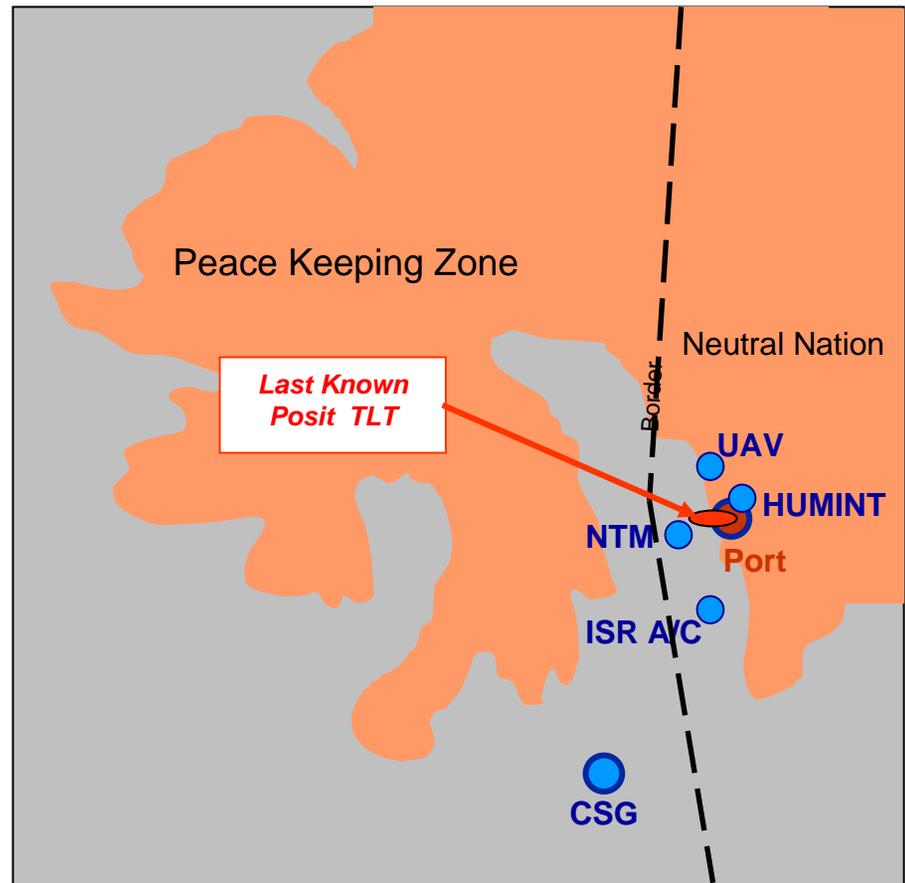
**Task:** Confirm current location of TLT; eliminate them if they enter Peace Keeping Zone

**Targeting Data:** TLT small boat and occupants identified by HUMINT Assets. Vulnerability window ~20 minutes.

### Assumptions:

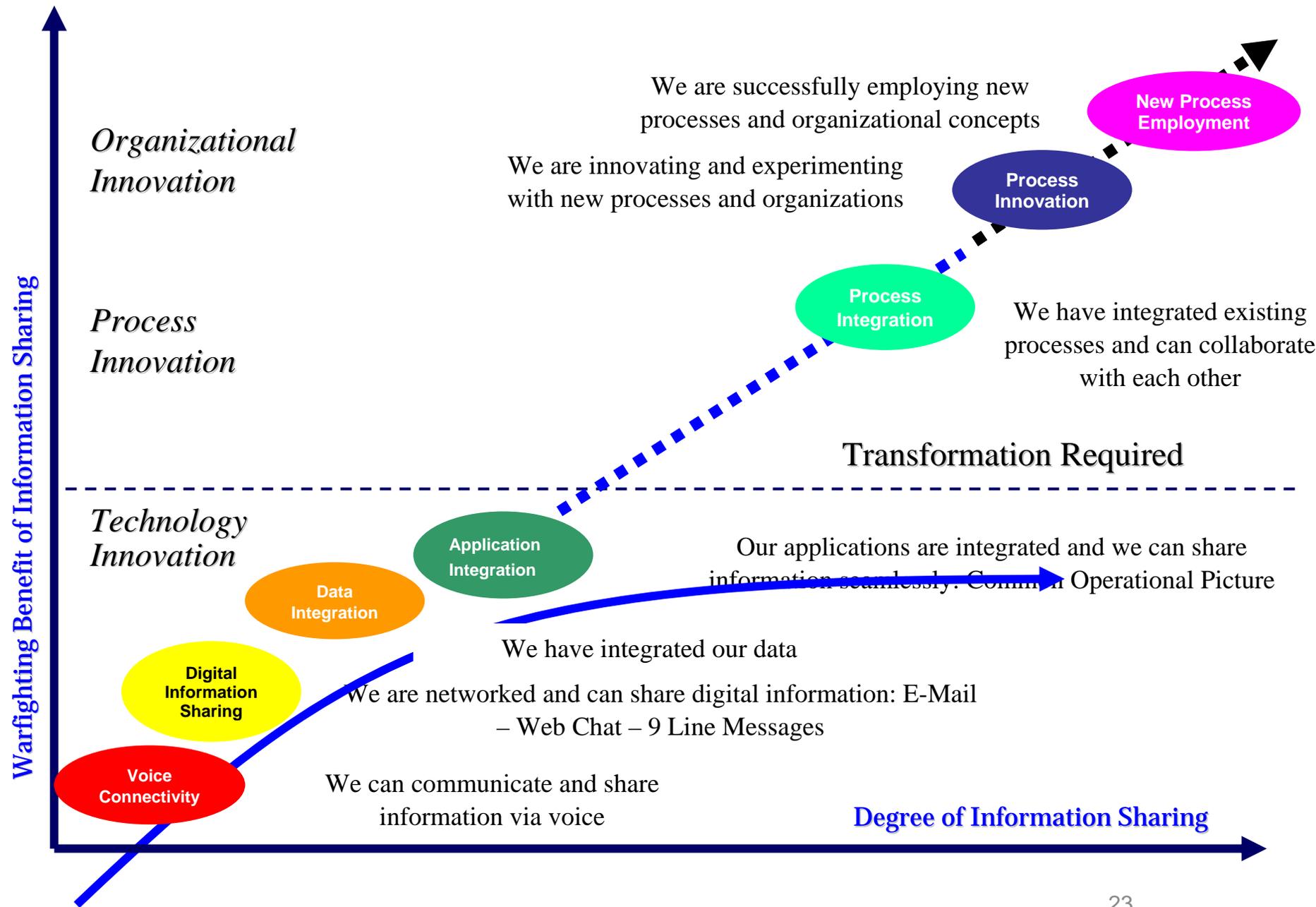
NTM and ISR Aircraft are available for tasking and cueing, as well as BDA.

UAV and ISR aircraft available for targeting support.



# Assumptions

- Scenario specific
  - Initial results are based on a single operational scenario to **illustrate potential** of modeling and simulation solution strategy
  - Results and conclusion's validity are highly specific to selected scenario
- Social and Political impacts are not considered or modeled
- Technology agnostic
- Limited option space



Information Sharing ↑

*Organizational  
Innovation*

*Process  
Innovation*

We are successfully employing new processes  
and organizational concepts

We are innovating and experimenting with  
new processes and organizations

Process  
Integration

Process  
Innovation

New Process  
Employment

We have integrated existing  
processes and can collaborate with  
each other

