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U.S. Army Research, Development and Engineering Command

## The Warfighter Associate: Objective and Automated Metrics for Mission Command

# ARL

***TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.***

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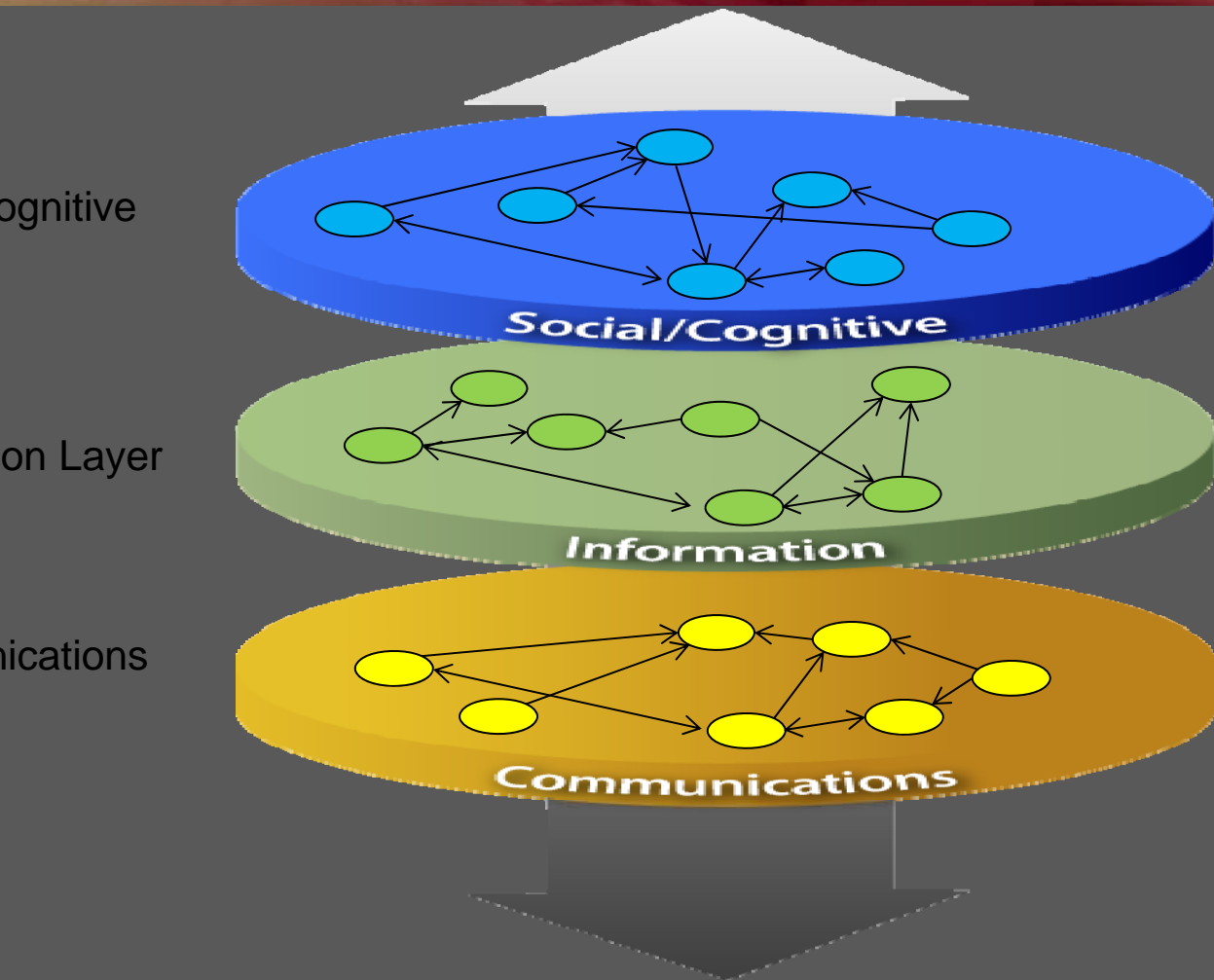
Stacey Sokoloff & Robert Hamm

Veloxiti Inc. (Alpharetta, GA)

International Command and Control Research and Technology Symposium (ICCRTS), 19-21 June  
Institute for Defense Analyses, Alexandria VA

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# Network Layers



Cognitive

Information Layer

Communications

**Data → Information → Knowledge → Decision Making → Action**

## Network Centric Operations

theoretical framework, the four tenets of **network-centric operations**  
(Alberts & Garstka, 2004):

- A robustly networked force improves information sharing and **collaboration**
- Such sharing and collaboration enhance the **quality of information** and **shared situational awareness**
- This enhancement, in turn, enables further **self-synchronization** and improves the sustainability and speed of command
- The combination dramatically increases **mission effectiveness**.

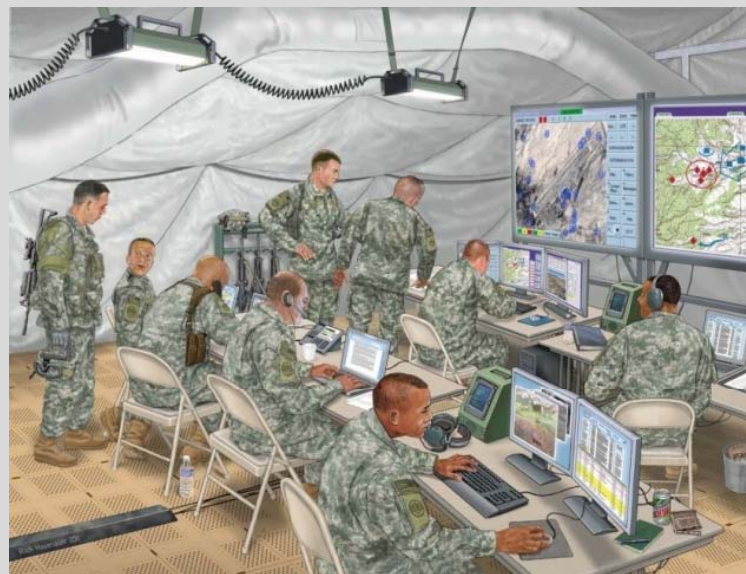
**stability** a necessity to advance theory.

**challenge:** Objective and *generalizable* measures of Mission Command effectiveness

## Motivation:

Help advance a scientific experimental infrastructure focusing on theory development, experimentation, hypothesis testing, data collection relevant to operations.<sup>1</sup>

Conduct more rigorous research on impact of networking on Mission Command and human cognition.



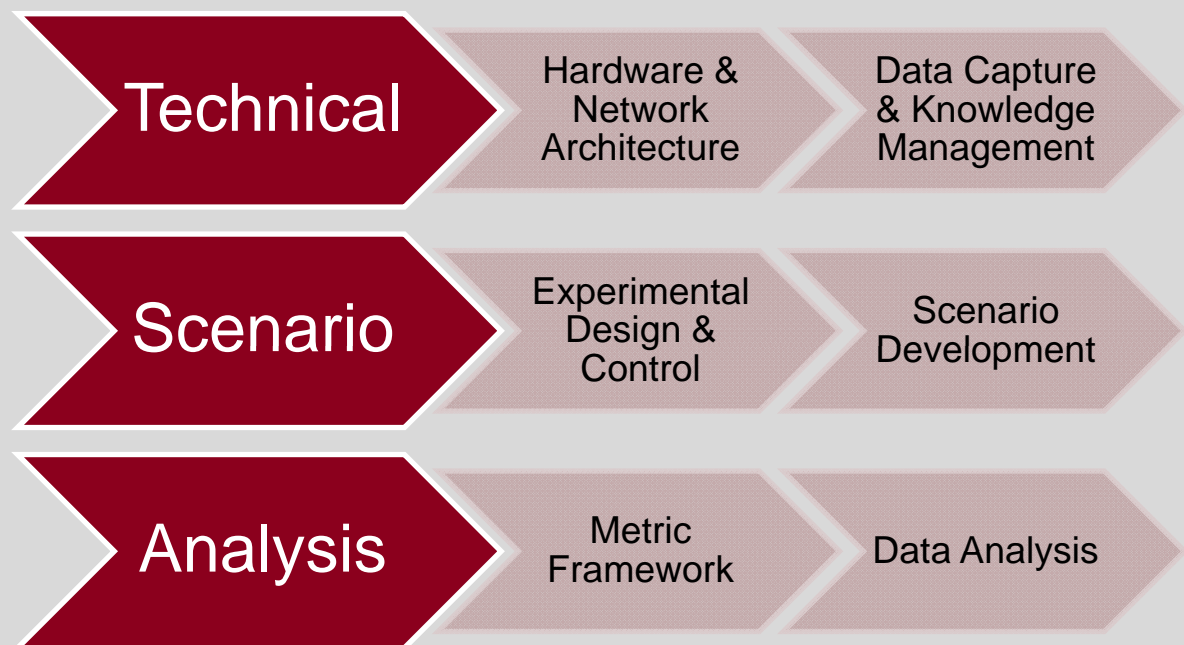
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<sup>1</sup> Draft-brief recommendation, Working Group #4 (Analysis of Human Decision Making in Networked Environment), MORS workshop “Joint Framework for Measuring Command and Control Effectiveness”. JHU-APL Laurel MD, 23-26 Jan 2012

**Challenge:**

Mission Command researchers need a means to automatically derive performance metrics of effective collaboration and decision-making during the conduct of network-enabled operations.

Convergent **three thrusts** of laboratory experimentation:



**Technology Purpose/Goal:**

***The WA is an intelligent decision support tool for Mission Command that considers user's intent, state of the world, and domain specific knowledge to recommend a course of action.***

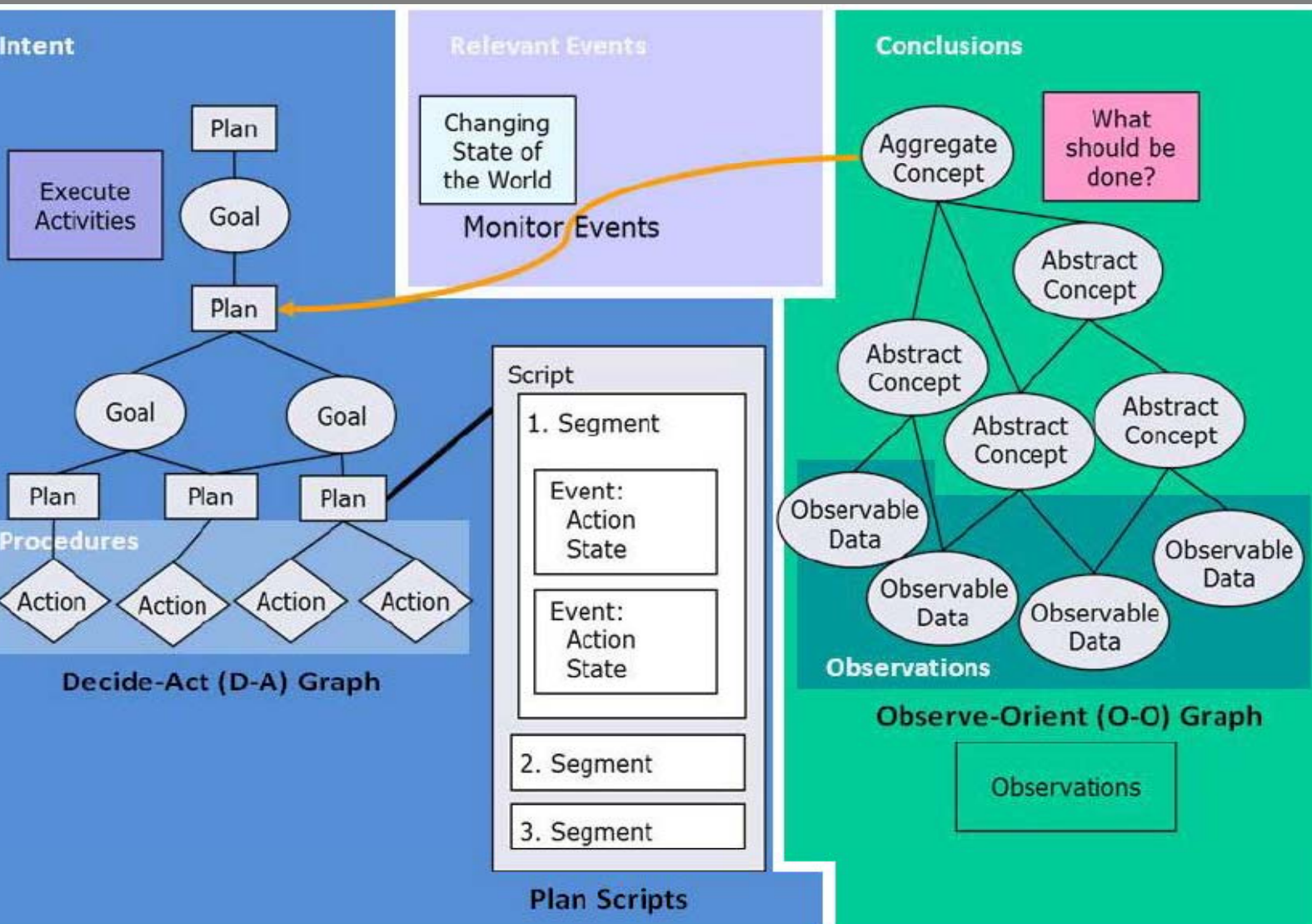
**Uses are to:**

- Improve performance in Mission Command;
- **Evaluate performance in Mission Command through real time network based measures of team cognition and team effectiveness**
- Apply as a training aid during debriefings in after-action reviews;
- Facilitate human system inter-operability

**Enabling Science:**

***Computational (graph-based) knowledge-based representation of Soldier specific information work flows coupled to battle-space monitoring.***

# Architecture



# Knowledge Engineering

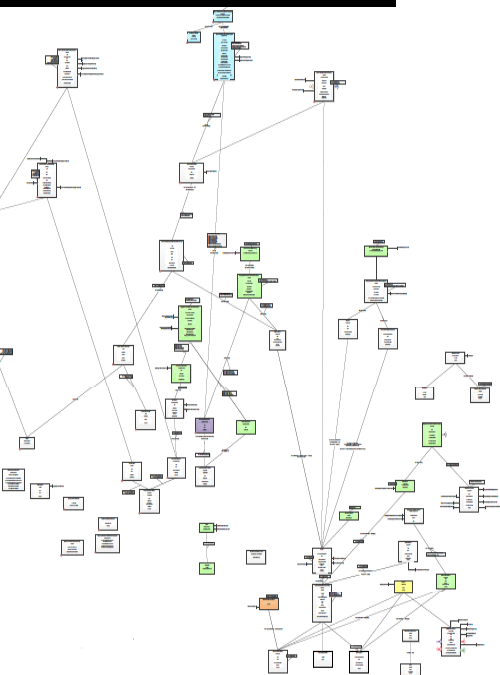


## Fighter Associate able to respond to:

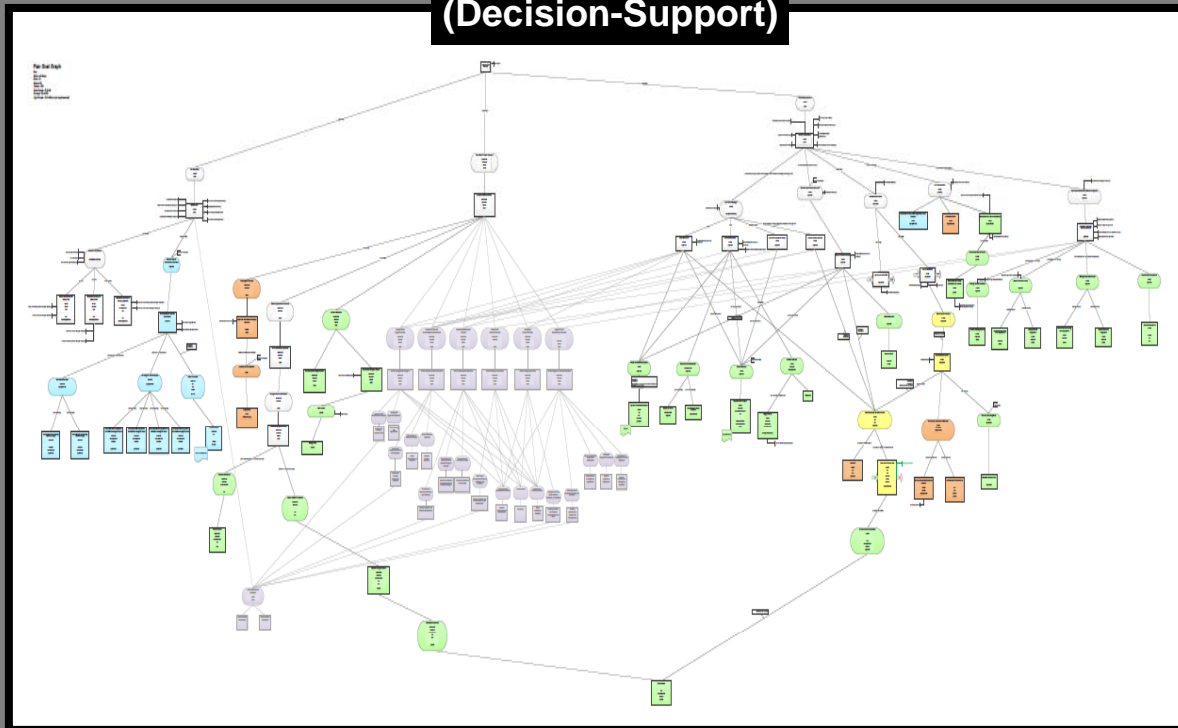
- Normal doctrinal operations
- Threats in Contact (TIC)
- Personnel recovery/downed aircraft
- CASEVAC and casualty evacuation (CASEVAC)
- Missions of improvised explosive device (IED) attacks
- Hostile fires
- Threats
- Weapons fire

- Airspace deconfliction
- High value targets
- Intelligence Surveillance Reconnaissance (ISR) asset management
- Unit boundary coordination
- Joint and coalition coordination
- Minefields
- Civilian demonstrations

## Observe-Orient Graph (Battlespace Monitoring)



## Decide-Act Graph (Decision-Support)





# MEDEVAC Example (Sub-section of Decide-Act Graph)



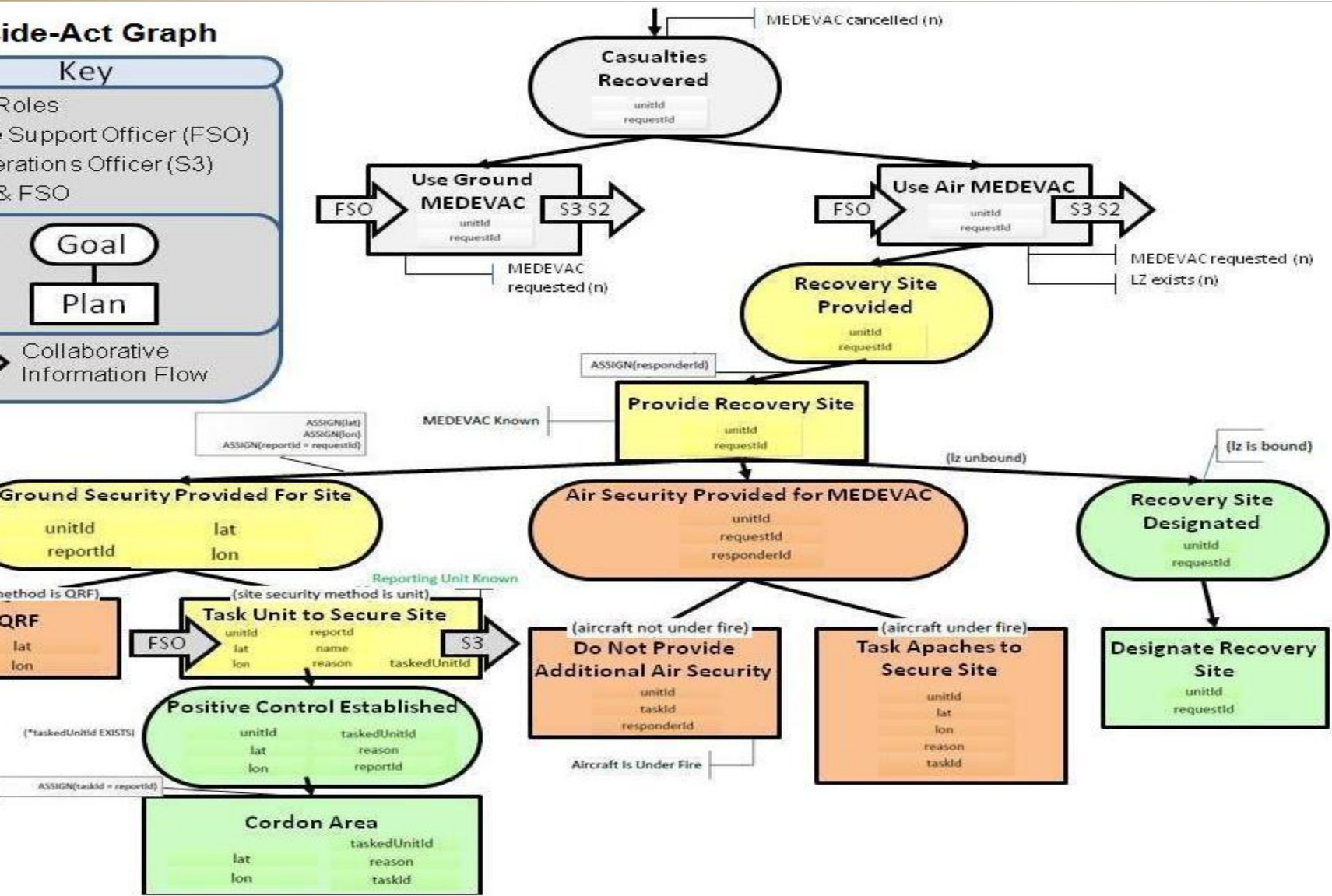
## Decide-Act Graph

**Key**

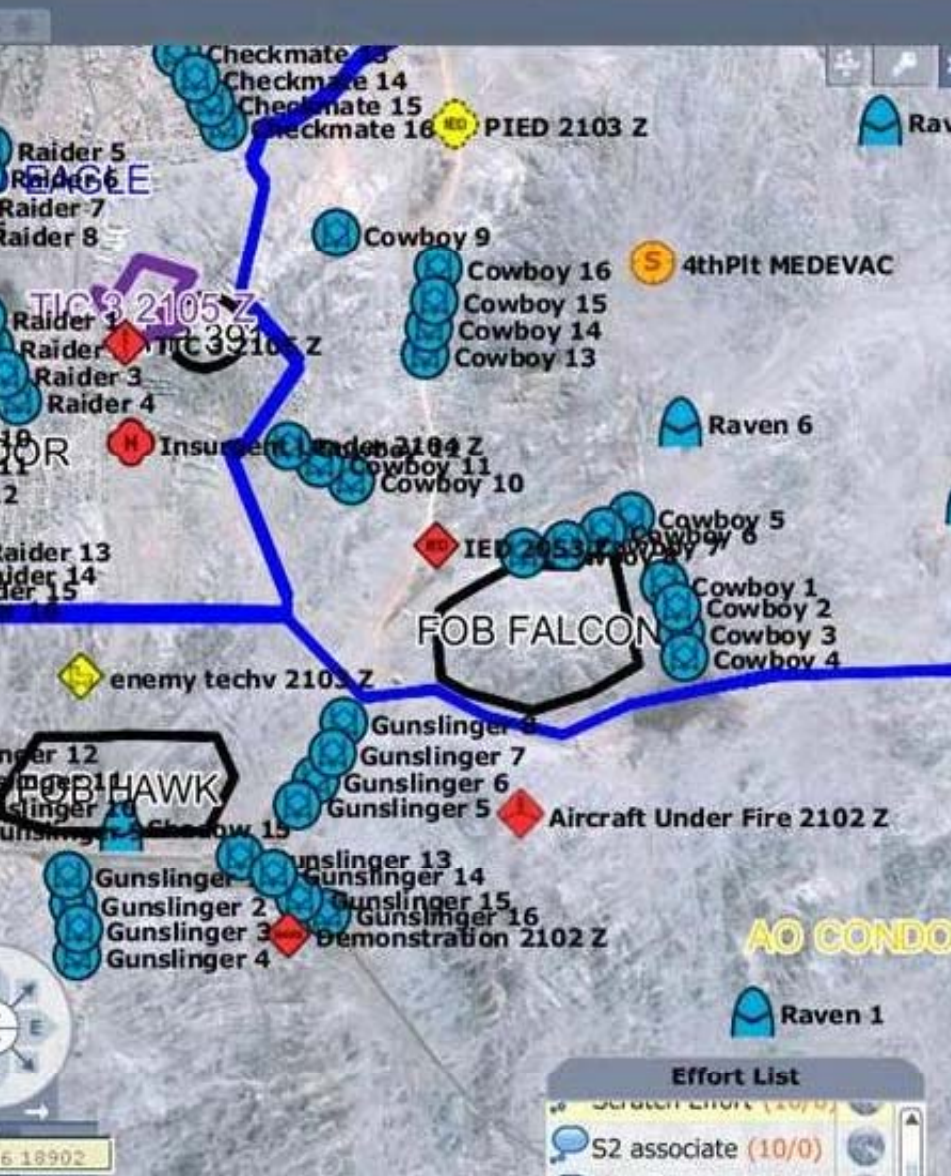
Roles  
 Support Officer (FSO)  
 Operations Officer (S3)  
 & FSO

Goal  
 Plan

Collaborative Information Flow



Tailored Decision Support  
(Intelligence Officer S2 Recommendations)



### S2 Current Situation

- 2105 Z: 1stPlt reports **TIC 3** at WL355343 (AO EAGLE)
- 2104 Z: Insurgent leader at WL357310 (AO EAGLE)
- Potential IED attack indicated by: (Weak Evidence)
- 2103 Z: 1stPlt reports dead animal at WL467414
- 2103 Z: 1stPlt reports hotspot at WL467414
- 3 Personnel missing, last seen VIC WL538378
- Down aircraft at WL527383
- Air MEDEVAC needed for 4thPlt VIC WL535368
- 2102 Z: 4thPlt reports **Demonstration** at WL409148 (AO HAWK)
- 2102 Z: aircraft under fire VIC WL488188 (AO HAWK)

### S2 Recommendations

- Query DCGS TIC 3 2105 Z
- Assets in range of TIC 3: E-8C JSTARS, Pred 1, Pred 2, Shadow 15, Shadow 16, APACHE 05, APACHE 06, Tusk 11, and Tusk 12
- Pred 1 (DIV asset) is the best asset for tactical cross cue for TIC 3
- Query DCGS Insurgent Leader 2104 Z
- Assets in range of Insurgent Leader: E-8C JSTARS, Pred 1, Pred 2, Shadow 15, Shadow 16, APACHE 05, APACHE 06, Tusk 11, and Tusk 12
- Pred 1 (DIV asset) is the best asset for tactical cross cue for Insurgent Leader
- Query DCGS Downed Aircraft 2103 Z
- Assets in range of Downed Aircraft: E-8C JSTARS, Pred 1, Pred 2, Shadow 15, Shadow 16, APACHE 05, APACHE 06, Tusk 11, and Tusk 12
- Shadow 16 (TF 2-159 asset) is the best asset for tactical cross cue for Downed Aircraft
- Query DCGS Demonstration 2102 Z
- Assets in range of Demonstration: E-8C JSTARS, Pred 1, Pred 2, Shadow 15, Shadow 16, APACHE 05, Tusk 11, and Tusk 12
- Shadow 15 (TF 4-99 asset) is the best asset for tactical cross cue for Demonstration

### S2 Active PIRs

#### CCIR List

- TIC 3 (TIC) - 2105 Z - WL355343
- Insurgent Leader (Insurgent Leader) - 2104 Z - WL357310
- Zhakan Clan (possible match): 2103 Z - WL339233 (AO HAWK)
- Downed Aircraft (Downed Aircraft) - 2103 Z - WL527383
- Demonstration (Demonstration) - 2102 Z - WL409148
- IED (IED) - 2053 Z - WL460276

## Data Analysis Toolset



### Log Analyzer

- Query Database
- Metric: Task Completion Timing

### Knowledge Graph

- Summation of Activation of Knowledge Graphs “Heat Map”
- Metric: Summarized Activity

### Activation Chart

- Timeline of Activation (single node)
- Metric: Cognitive Workload

# Data Analysis Toolset:



## Log Analyzer (Task Completion Timing)

Run Monday 7 - Data Analysis Tool (version 0.7)

Open Config Save Config Export CSV Manage Select Associates Real Time Help

ports Charts Configuration

Associate	Start Time	Update / Sto...	Duration	Name	Attributes	Type	Lifecycle State
FSO	08-06-2012 14:44:38 Slider: 0:04.20	08-06-2012 ...	2 minutes, 3...	Actions On C...	<ul style="list-style-type: none"> <li>• PatternName: Actions On Contact</li> <li>• unitId: 1-74 HBCT</li> <li>• reportId: EA1326933000-1</li> </ul>	Plan	Active
FSO	08-06-2012 14:41:33 Slider: 0:01.15	08-06-2012 ...	2 minutes, 2...	Actions On D...	<ul style="list-style-type: none"> <li>• PatternName: Actions On Demonstration</li> <li>• unitId: 1-74 HBCT</li> <li>• reportId: EA1326932216-1</li> </ul>	Plan	Active
FSO	08-06-2012 14:43:03 Slider: 0:02.45	08-06-2012 ...	2 minutes, 1...	Actions On IED	<ul style="list-style-type: none"> <li>• PatternName: Actions On IED</li> <li>• unitId: 1-74 HBCT</li> <li>• reportId: EA1326932287-1</li> </ul>	Plan	Active
FSO	08-06-2012 14:42:08 Slider: 0:01.50	---	ongoing	Actions On In...	<ul style="list-style-type: none"> <li>• PatternName: Actions On Insurgent Leader</li> <li>• unitId: 1-74 HBCT</li> <li>• reportId: EA1326932324-1</li> </ul>	Plan	Active
FSO	08-06-2012 14:47:56 Slider: 0:07.38	---	ongoing	Actions On P...	<ul style="list-style-type: none"> <li>• PatternName: Actions On Potential IED</li> <li>• reportId: EA1331770917-1</li> <li>• unitId: 1-74 HBCT</li> </ul>	Plan	Active
FSO	08-06-2012 14:41:33 Slider: 0:01.15	---	ongoing	Aware Of Are...	<ul style="list-style-type: none"> <li>• PatternName: Aware Of Area Of Interest</li> <li>• unitId: 1-74 HBCT</li> </ul>	Goal	Active
FSO	08-06-2012 14:40:19 Slider: 0:00.01	---	ongoing	Complete Mi...	<ul style="list-style-type: none"> <li>• PatternName: Complete Mission Phase</li> <li>• missionId: EURYALE</li> <li>• phaseId: p1</li> <li>• bdId: 1-74 HBCT</li> <li>• bnId: TF290</li> </ul>	Plan	Active

Refresh Print Table

Show:

- Associate
- Start Time
- Update / Stop Time
- Duration
- Name
- Attributes
- Type
- Lifecycle State

Include:

- Plans
- Goals
- Concepts

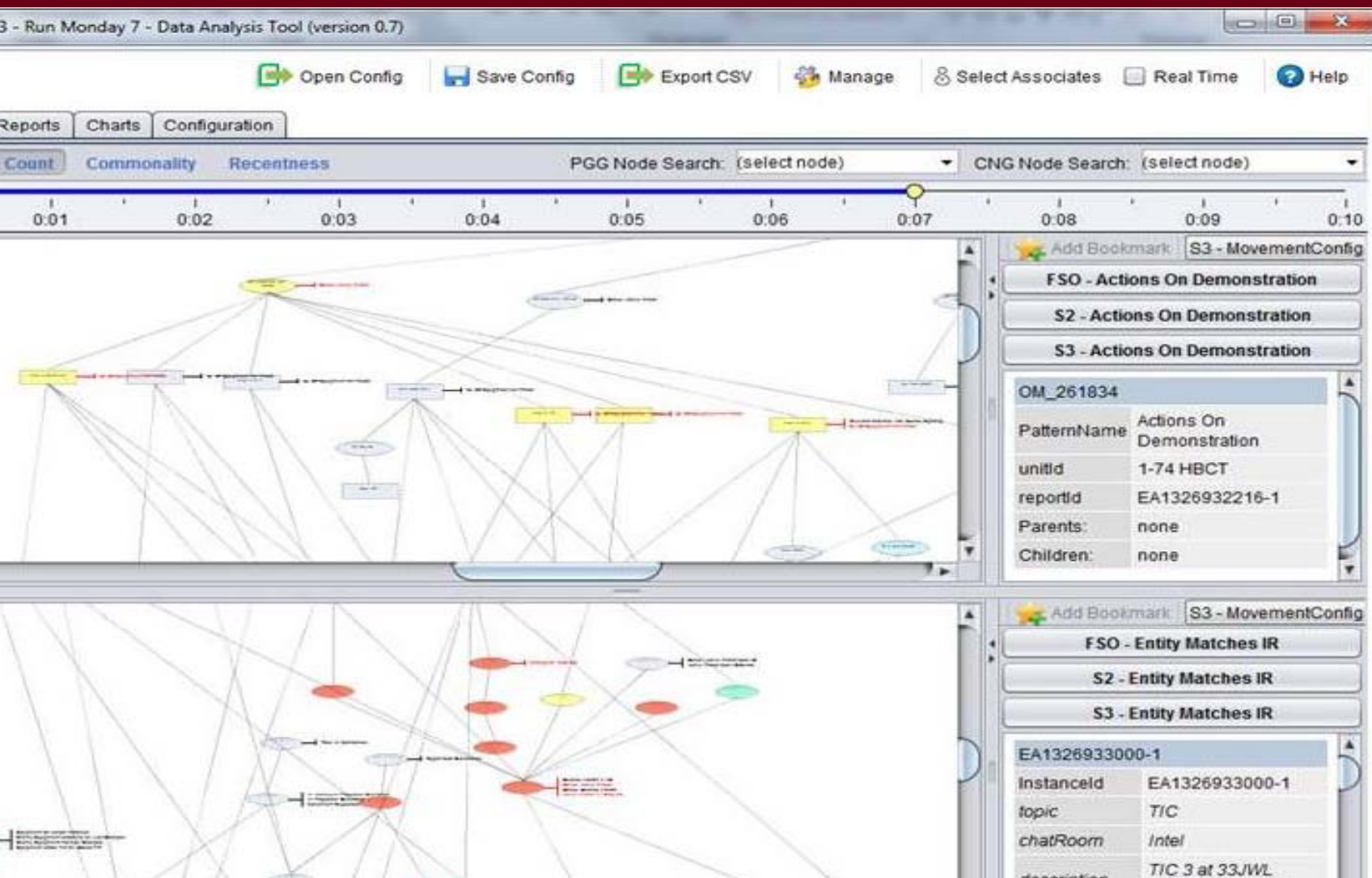
Filter rows:

Apply Filter

# Data Analysis Toolset:



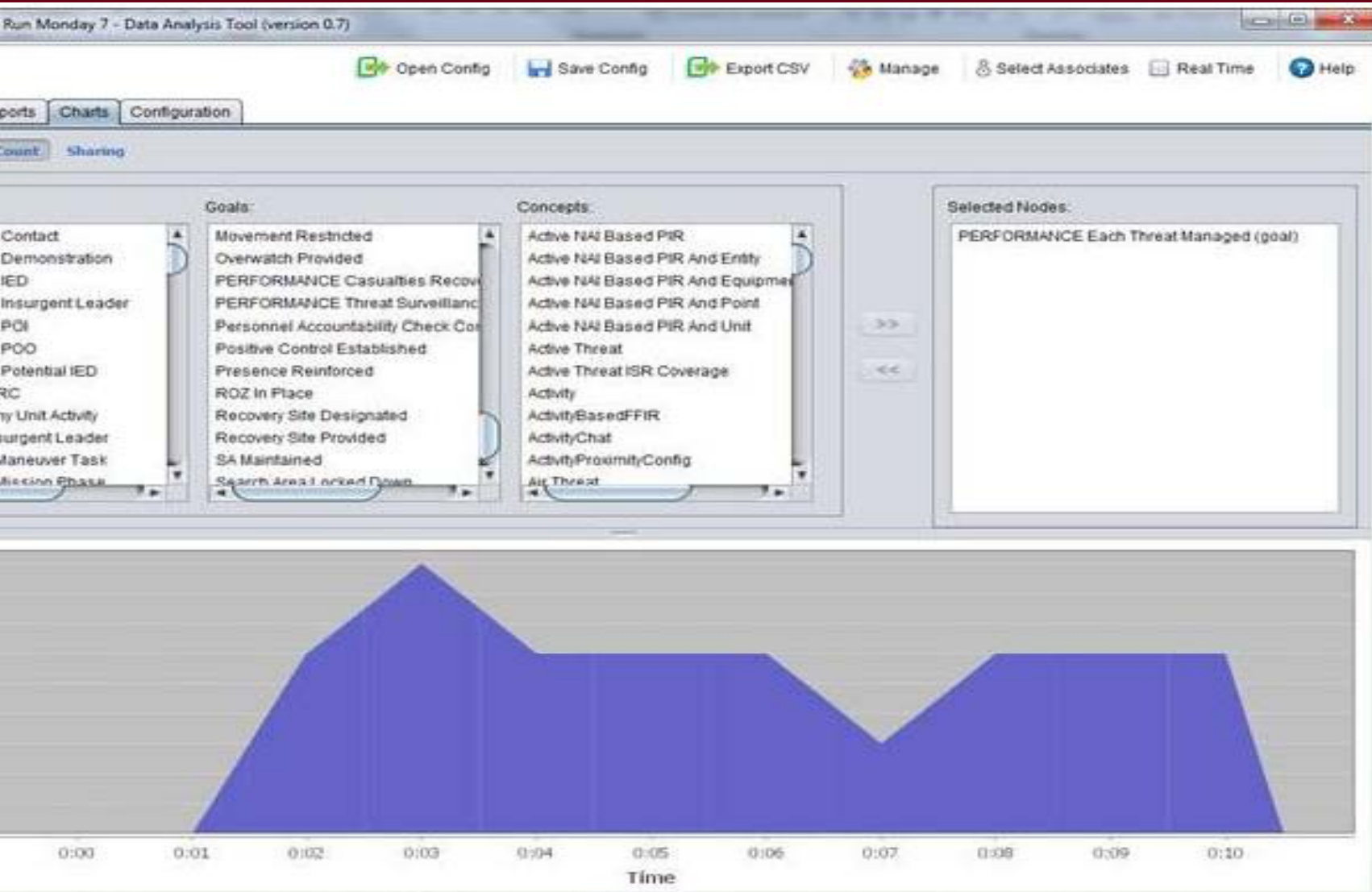
## Knowledge Graph Heat-map Summary of Activated Workflows



# Data Analysis Toolset:



## Timeline of Node Activation (Cognitive Workload)



# Laboratory Experiment



## Soldier-participants

- Maneuver Officer (S3)
- Intelligence Officer (S2)
- Fire Support Officer (FSO)

## Data Collection

- Warfighter Associate Data
- Communications (voice, chatroom)
- Human-Computer Interaction

## Chatrooms

## Common Operational Picture

Maneuver	Intelligence	Fires
<p>This paper describes a unique and promising intelligent agent technology for a Mission Command System (MCS) that updates the user MCS interface(s) and provides recommendations for courses of action (COAs), updates the current common "battle map")</p> <p>for situational grid 0213 2093                      Okay                      Roger                      Move predator over to 33JWL</p>	<p>This paper describes a unique and promising intelligent agent technology for a Mission Command System (MCS) that updates the user MCS interface(s) and provides recommendations for courses of action (COAs), updates the current common "battle map")</p> <p>Two interrelated knowledge graphs are</p>	<p>This paper describes a unique and promising intelligent agent technology for a Mission Command System (MCS) that updates the user MCS interface(s) and provides recommendations for courses of action (COAs), updates the current common operational picture (i.e. "battle intent and monitors the state of the operational environment</p>
HICON/JSOC	Gorgas Net	Sustainm
<p>This paper describes a unique and promising intelligent agent technology for a Mission Command System (MCS) that continuously monitors the operational environment to: Support cognition by increasing situation understanding, collaboration, force</p>	<p>This paper describes a unique and promising intelligent agent technology for a Mission Command System (MCS) that updates the user MCS interface(s) and provides recommendations for courses of action (COAs), updates the current common operational picture (i.e. "battle intent and monitors the state of the operational environment</p>	<p>This paper describes a unique and promising intelligent agent technology for a Mission Command System (MCS) that updates the user MCS interface(s) and provides recommendations for courses of action (COAs), updates the current common operational picture (i.e. "battle intent and monitors the state of the operational environment</p>



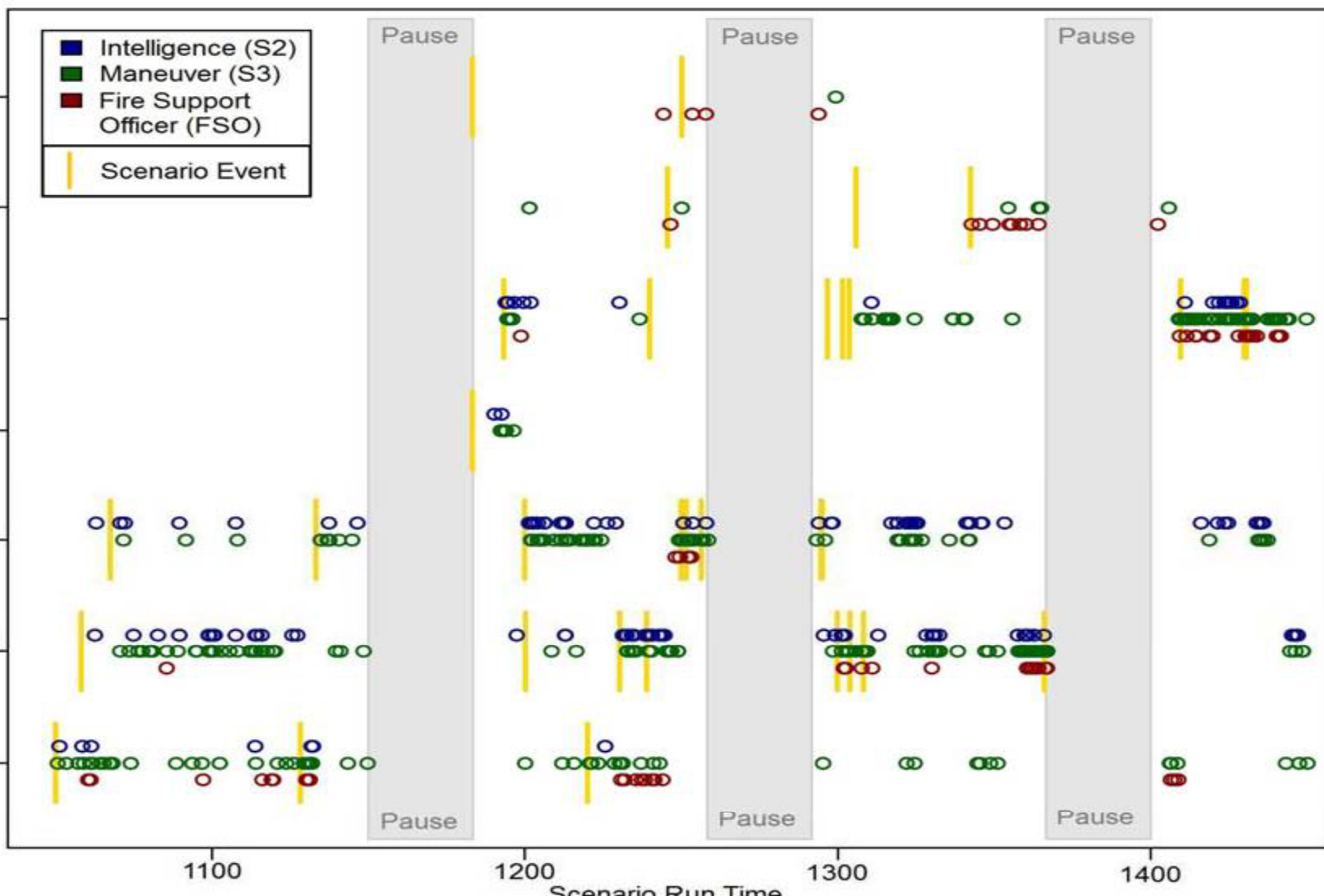
(Screen #1)

(Screen #2)

# Communication Timeline Results



Timeline of Mission Command Staff Communications Across Experimental Scenario Threads and Events

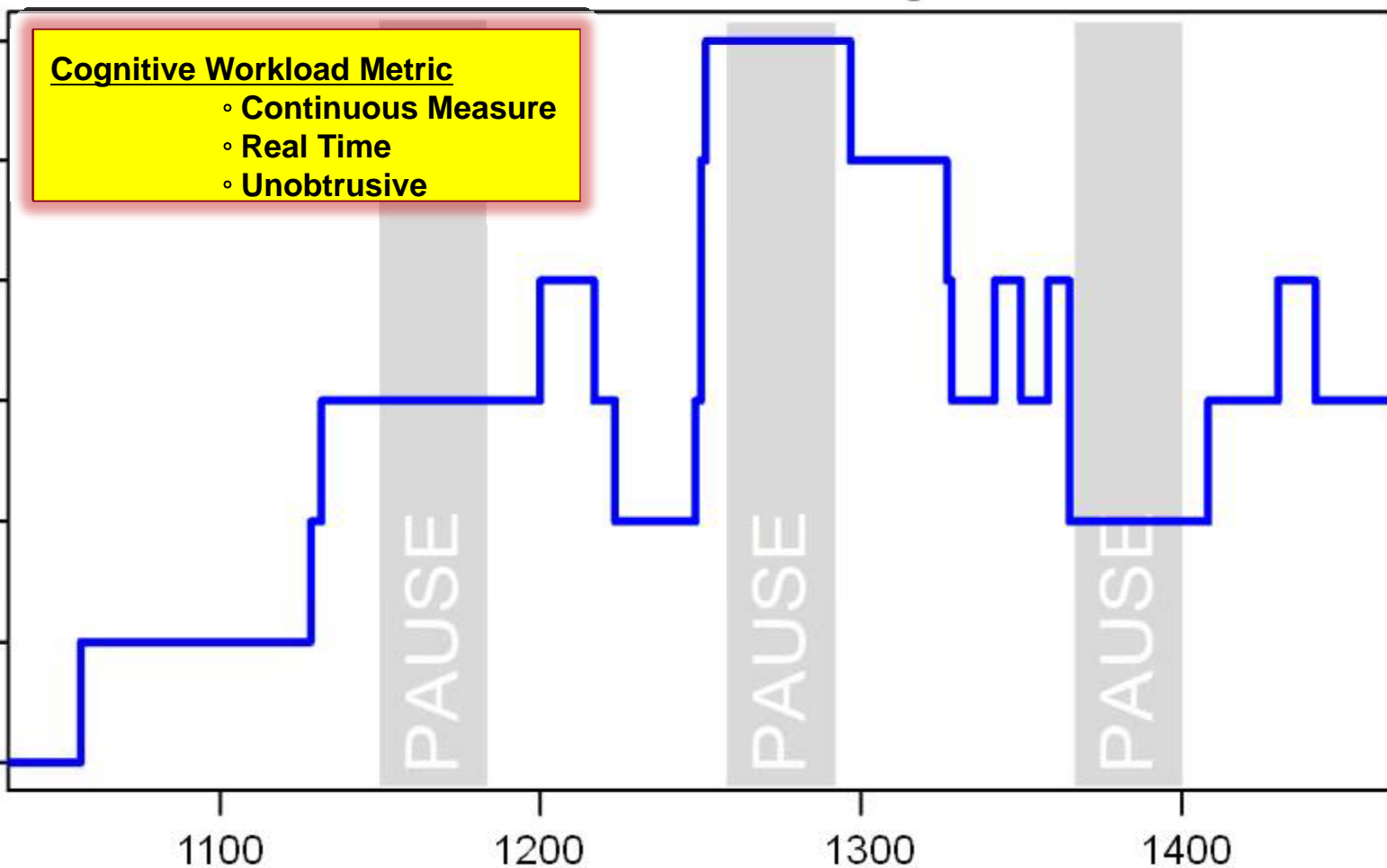




## Cognitive Workload Metric



Timeline of Activation of the Goal Node <Each Threat Managed>  
Across the Experimental Scenario

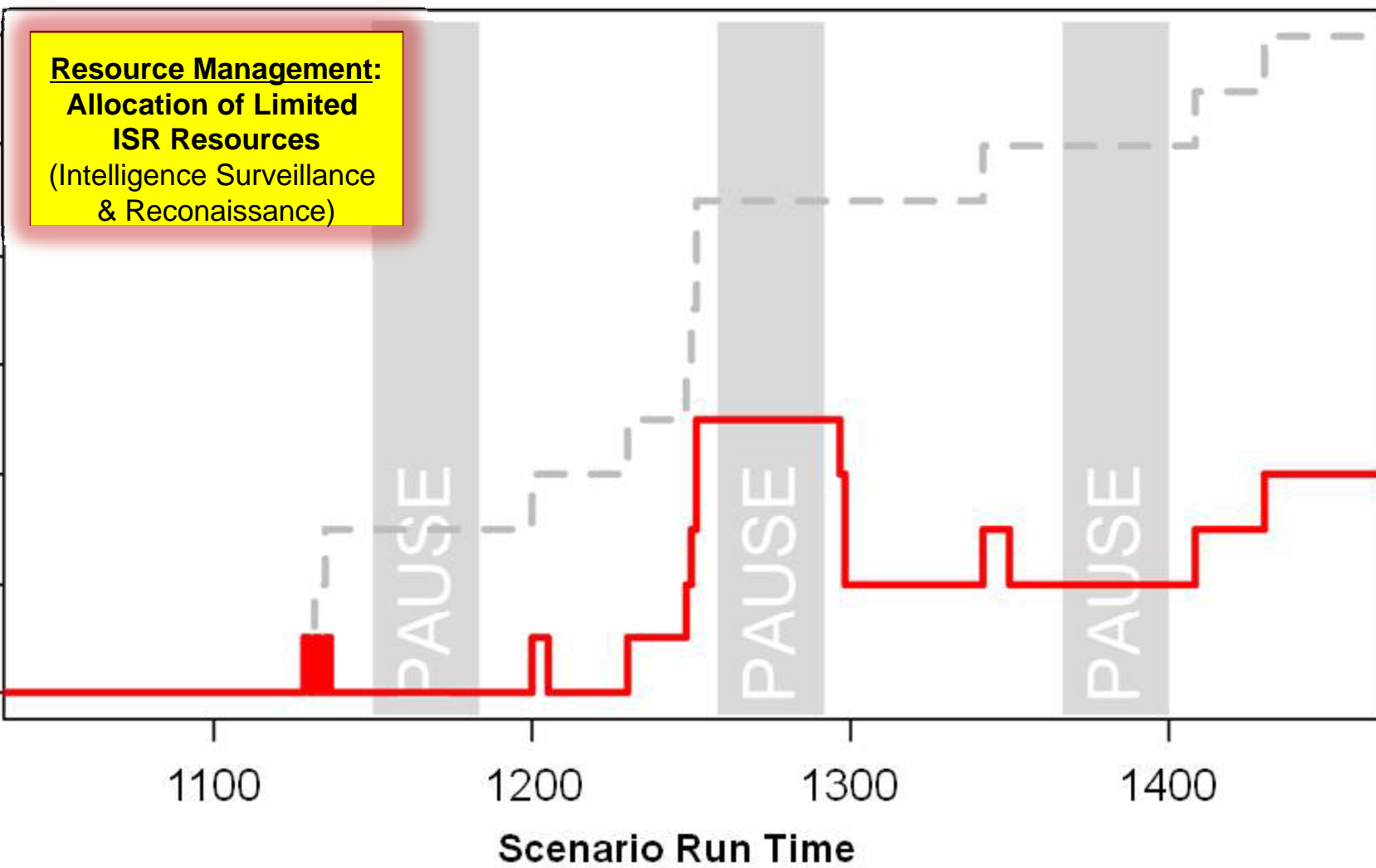


## Resource Management of ISR Assets



### Timeline of Activation of the Goal Node <Threat Surveillance Adequate> Across the Experimental Scenario

**Resource Management:  
Allocation of Limited  
ISR Resources**  
(Intelligence Surveillance  
& Reconnaissance)



## Conclusions

### etrics:

Objective, unobtrusive, and real-time metrics of Mission Command performance based on knowledge-based systems approach.

- Cognitive Workload measure
- Resource management

Data-to-decisions initiative

Knowledge is inherently modifiable (knowledge engineering)

Can be used for field studies

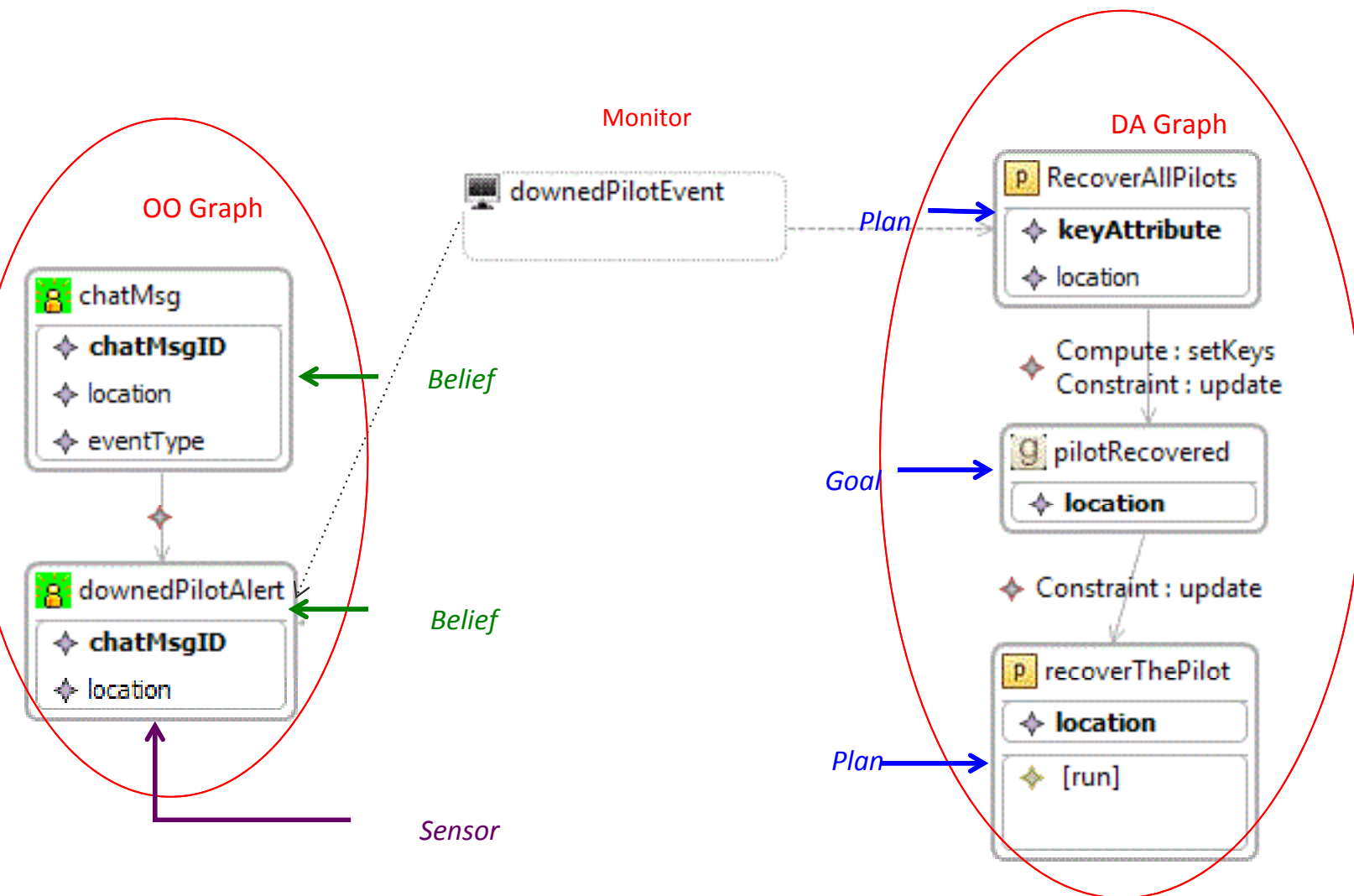
### ecision-Support:

Training technology (decision-aiding & after-action review)

Support users in suboptimal conditions (fatigue, inexperience, degraded networks...)

Support joint and coalition operations

# Backup A Graphical View of Knowledge



# Decision Support by Traversing Knowledge Graphs



ghter Associate (WA)  
 s are goal and event

gent knowledge tailored  
 OODA-loop decision-  
 g cycle

## Observe-Orient Graph

sensors input data

Observe-Orient nodes  
 combine data

Monitors fire triggers

## Decide-Act Graph

triggers activate Act-Decide  
 processing...

... to determine which actions

