# Command and Control Modeling in Soar

Randall W. Hill, Jr.

Jonathan Gratch

USC Information Sciences Institute

# Project Goals

- **Develop autonomous command forces**
  - Act autonomously for days at a time
    - Reduce load on human operators
  - Behave in human-like manner
    - Produce realistic training environment
  - Perform Command and Control (C2) functions
    - Reduce the number of human operators
    - Create realistic organizational interactions

# C2 Modeling Hypotheses

- **Continuous Planning**
  - Understand evolving situations
  - Achieve goals despite unplanned events
- **Collaborative Planning***
  - Understand behavior of other groups
  - Understand organizational constraints

* See Gratch's workshop talk on Rude Planner

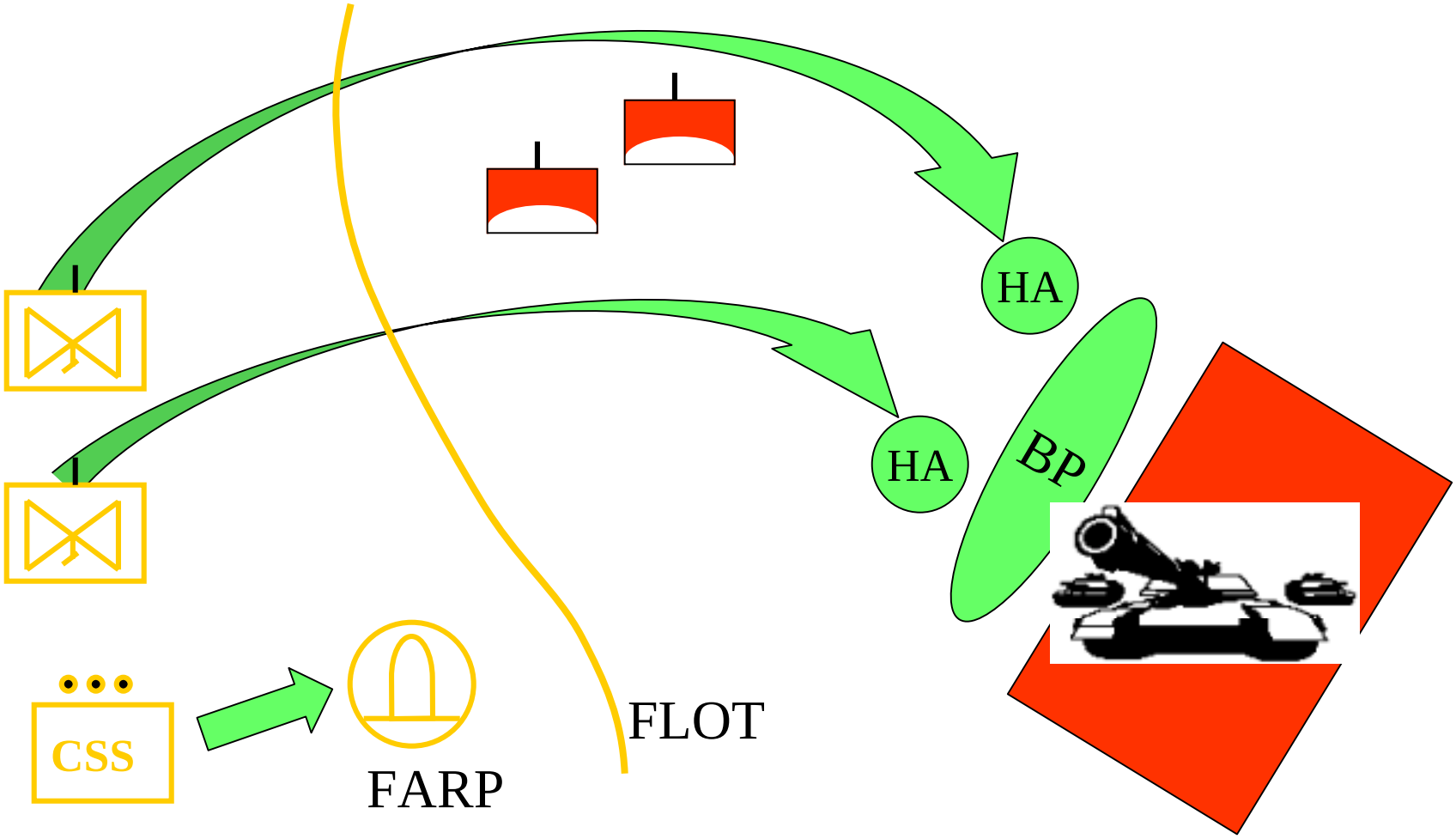
# C2 Modeling Hypotheses

- **Situation Awareness**
  - Identify information requirements
  - Focus intelligence collection efforts
  - Model intelligence constraints on planning
  - Fuse and assess sensor reports*

* See Zhang's workshop talk on clustering

# Mission Capabilities

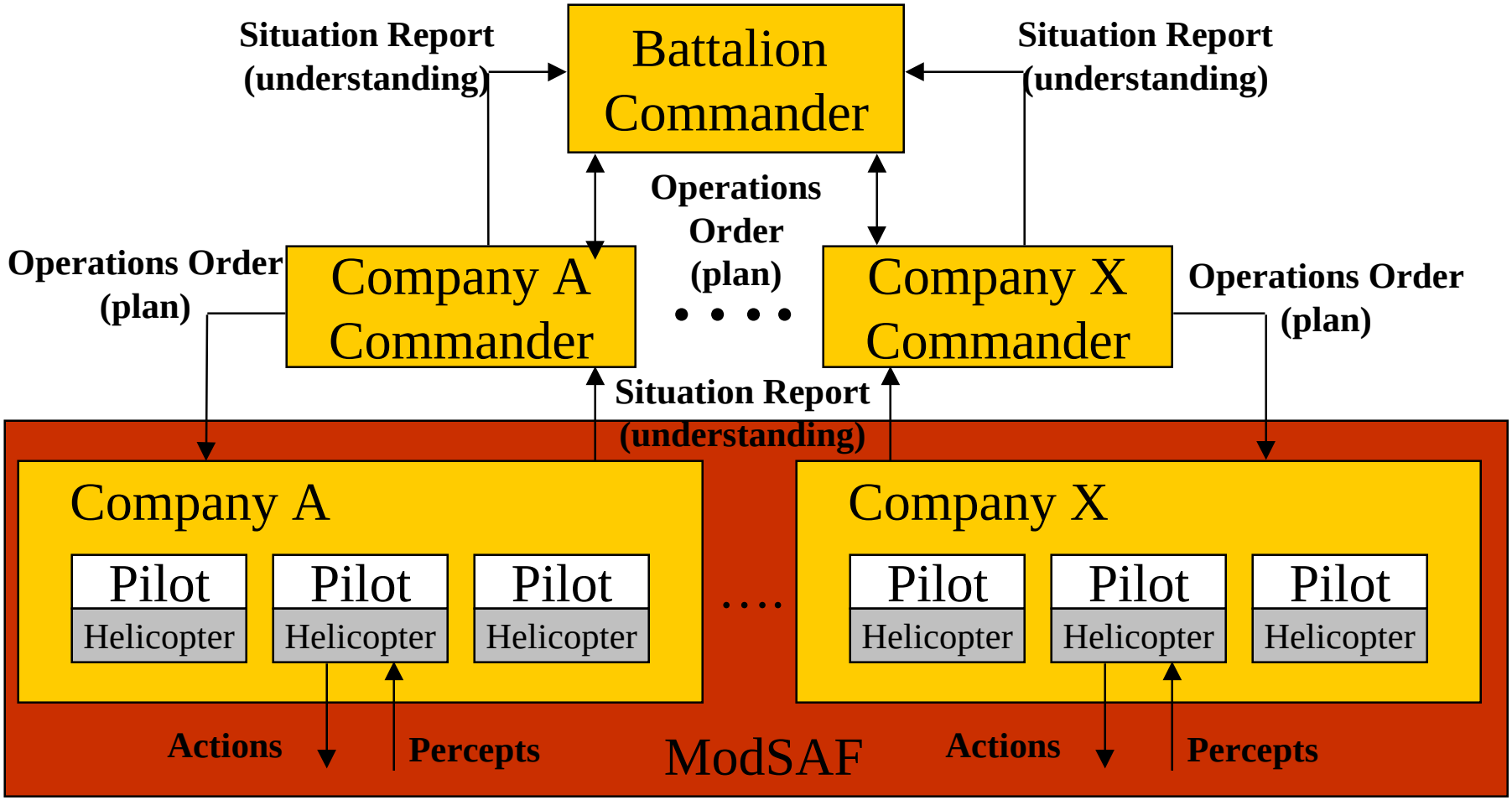
- **Army Aviation Deep Attack**
  - Battalion command agent
  - Company command agents
  - CSS command agent
  - AH64 Apache Rotary Wing Aircraft


HA
HA
BP
CSS
FARP
FLOT

# Soar-CFOR Planning Architecture

- **Support for continuous planning**
  - Integrates planning, execution and repair
  - Requires enhanced situation awareness
- **Support for collaborative planning**
  - Reasons about plans of multiple groups
  - Plan sharing among entities
  - Explicit plan management activities

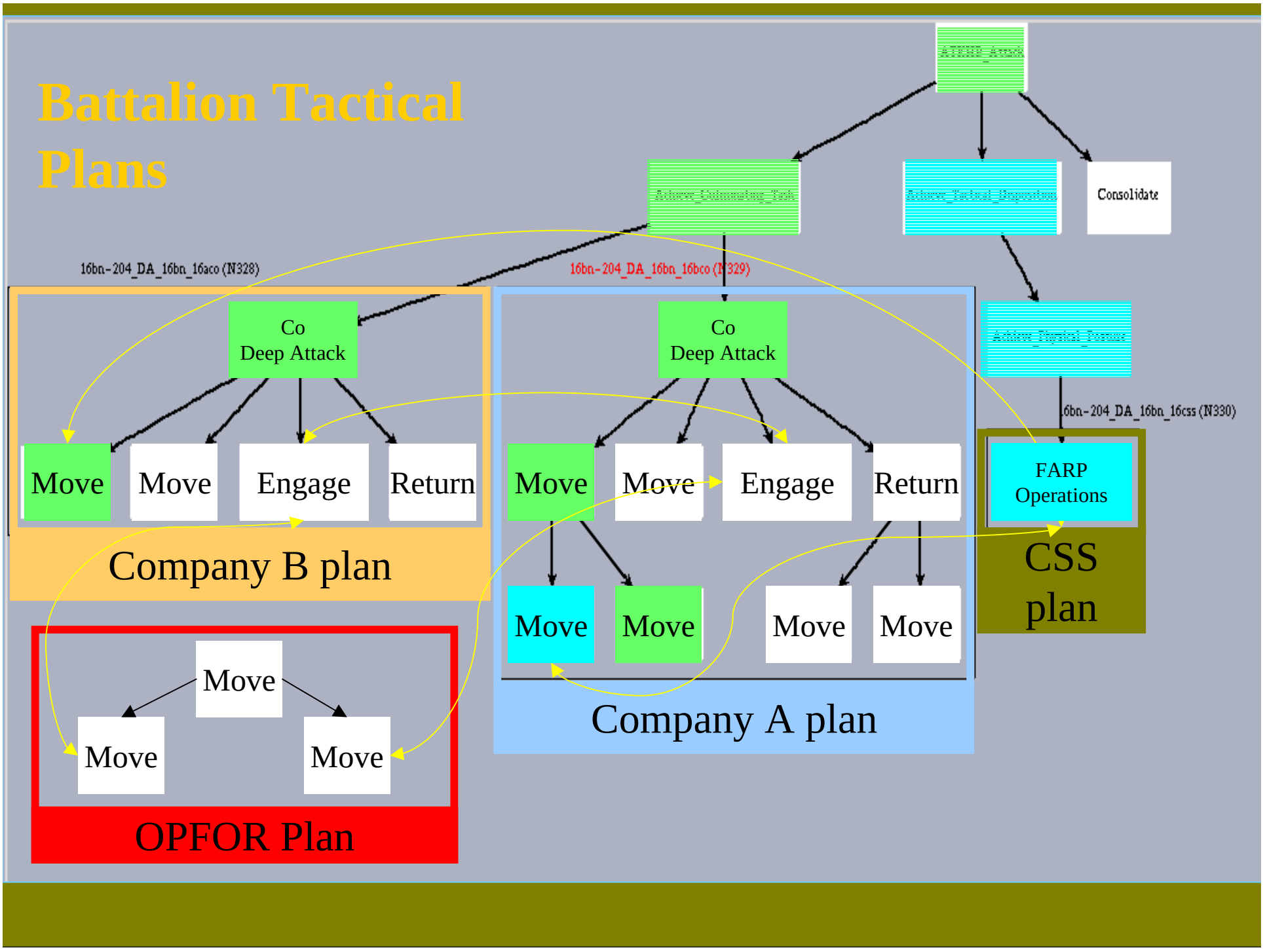
# C2 Architecture



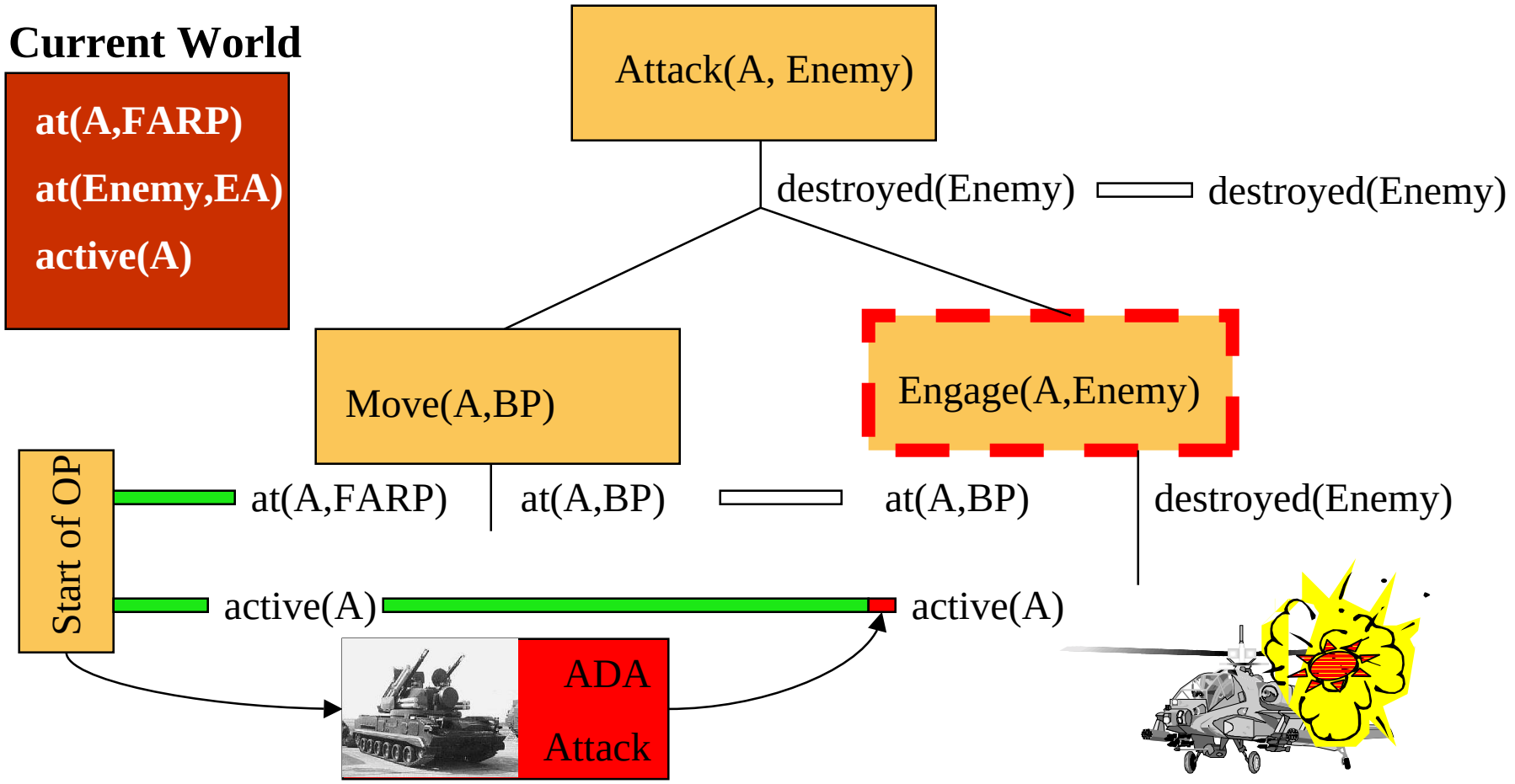
# Continuous Planning

- **Plan generation**
  - Sketch basic structure via decomposition
  - Fill in details with causal-link planning
- **Plan execution**
  - Explicitly initiate and terminate tasks
  - Initiate tasks whose preconditions unify with the current world
  - Terminate tasks whose effects unify with the current world
- **Plan Repair**
  - Recognize situation interrupt
  - Repair plan by adding, retracting tasks

# Battalion Tactical Plans



# Situation Interrupts Happen!



# Reacting to Situation Interrupt

- **Situations evolve unexpectedly**
  - Goals change, actions fail, intelligence incorrect
- **Determine whether plan affected**
  - Invalidate assumptions?
  - Violate dependency constraints?
- **Repair plan as needed**
  - Retract tasks invalidated by change
  - Add new tasks
  - Re-compute dependencies

# Collaborative Planning

- **Represent plans of others**
  - Extend plan network to include others' plans
- **Detect interactions among plans**
  - Same as with "normal" plan monitoring
- **Apply planning modulators:**
  - Organizational roles
  - What others need to know
  - Phase of the planning
  - Stance of the planner wrt phase and role

# Situation Awareness

- **Current situation: consolidated picture**
  - Use summary from higher headquarters
  - Fuse sensor reports
  - Apply clustering and classification algorithms (Zhang)
  - Make inferences about behavior and intentions
- **Future situation: knowledge goals**
  - What will I need to know for this plan to work?
  - Establish Priority Intelligence Requirements (PIR)
    - What commander needs to know about opposing force
    - Drives the placement of sensors and observation posts
  - Constrains the pace of plan execution

# Automating PIR

- **Identify PIR in my own plans**
  - Find preconditions, assumptions, and triggering conditions that are dependent on OPFOR behavior
- **Extract PIR from higher echelon orders**
  - Specialize as appropriate for my areas of operation
- **Derive tasks for satisfying PIR**
  - Sensor placement

- **Ensure consistency of augmented plans**

# Summary

- **Nuggets**
  - Continuous planning paradigm appears to work well for C2 behavior in the joint synthetic battlespaces domain
    - Handles situation interrupts in test cases
  - Enabled collaboration with a few extensions to planner
  - After playing w/ planners, Gratch appreciates Soar a lot more
- **Coal**
  - Planning in Soar still EXPENSIVE  c.f. workshop
  - More evaluation needed!
    - Scalability, robustness, efficiency, ...