# *A Game Loop Architecture for the Modeling and Simulation of Mission Threads*

Tom Tanner
thomas.l.tanner@saic.com
(540) 663-2739

# Outline

- Objective –
  - To assert the viability of the game loop architecture as a means of modeling mission threads
  - Elements of proof
    - Added value
    - Achievable
    - Avenue of relevance
      - Mechanism of exploitation/assimilation/socialization
      - Preferably a key role within a current strategy, initiative or movement
- Presentation
  - Alignment with the Systems 2020 Initiative
  - Mission Threads - Mission Thread Models
    - Brief (localized) description
    - Their role in the mission systems engineering process (the analyst's perspective)
  - The Game Loop Architecture
    - Mission centric vs. system centric approach
    - Components
    - Game loops
  - Demonstration
    - "Swarm Raid" mission thread from CGX program
    - Detailing the game loop
    - DEMO
  - Transition from wireframe to system design
  - Summary and Recommendations

# Applicability to the SE Division

## Executive Summary

***Findings***

- Significant opportunities exist to develop and deploy technologies to strengthen the Department's ability to conduct rapid capability fielding
  - However, non-technical challenges (e.g. cultural, budgetary, contracting, etc) must be simultaneously addressed
- ⇨ Greatest leverage in the "front end" of the life cycle
  - Concept Engineering: Rapidly elucidating the need, exploring solutions, developing CONOPs, and deriving requirements for materiel solutions
    - Virtual environments and rapid physical prototyping are linchpin technologies
- Opportunities exist to increase design, test, and production efficiencies
- ⇨ – Examples include physics-based M&S to reduce testing and model-based engineering and manufacturing approaches

***Recommendations***

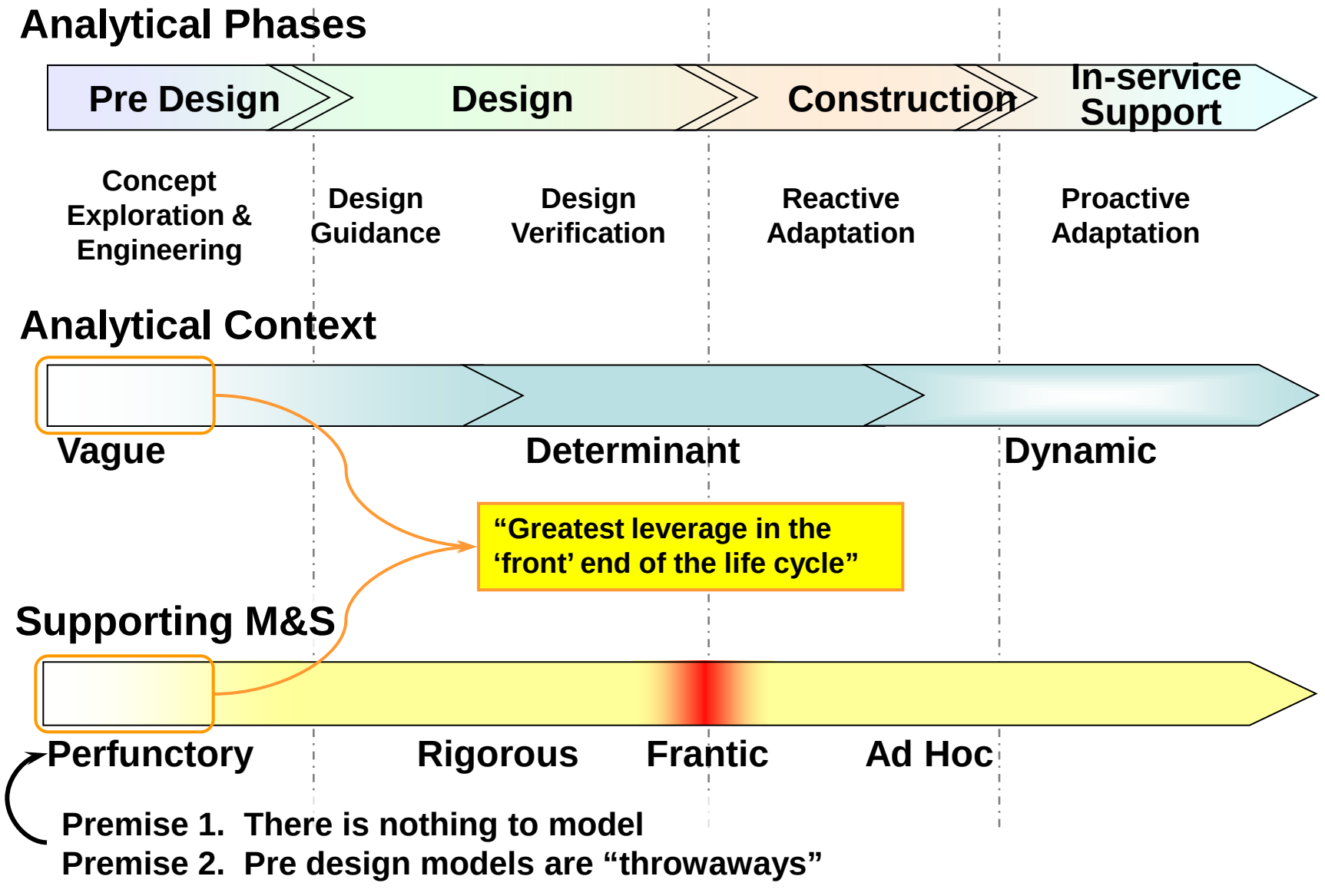
- ⇨ A concept engineering center should be implemented immediately that leverages the substantial existing capabilities across the Department
- A strategic R&D roadmap should be developed and implemented to mature and transition emerging tools and promising innovative ideas
- A set of potential pilots is recommended to demonstrate the application of today's toolset to relevant rapid capability challenges

**Rapid Capability Toolbox Study Final Report , March 2010**
**(Cited as Key Study in Systems 2010)**

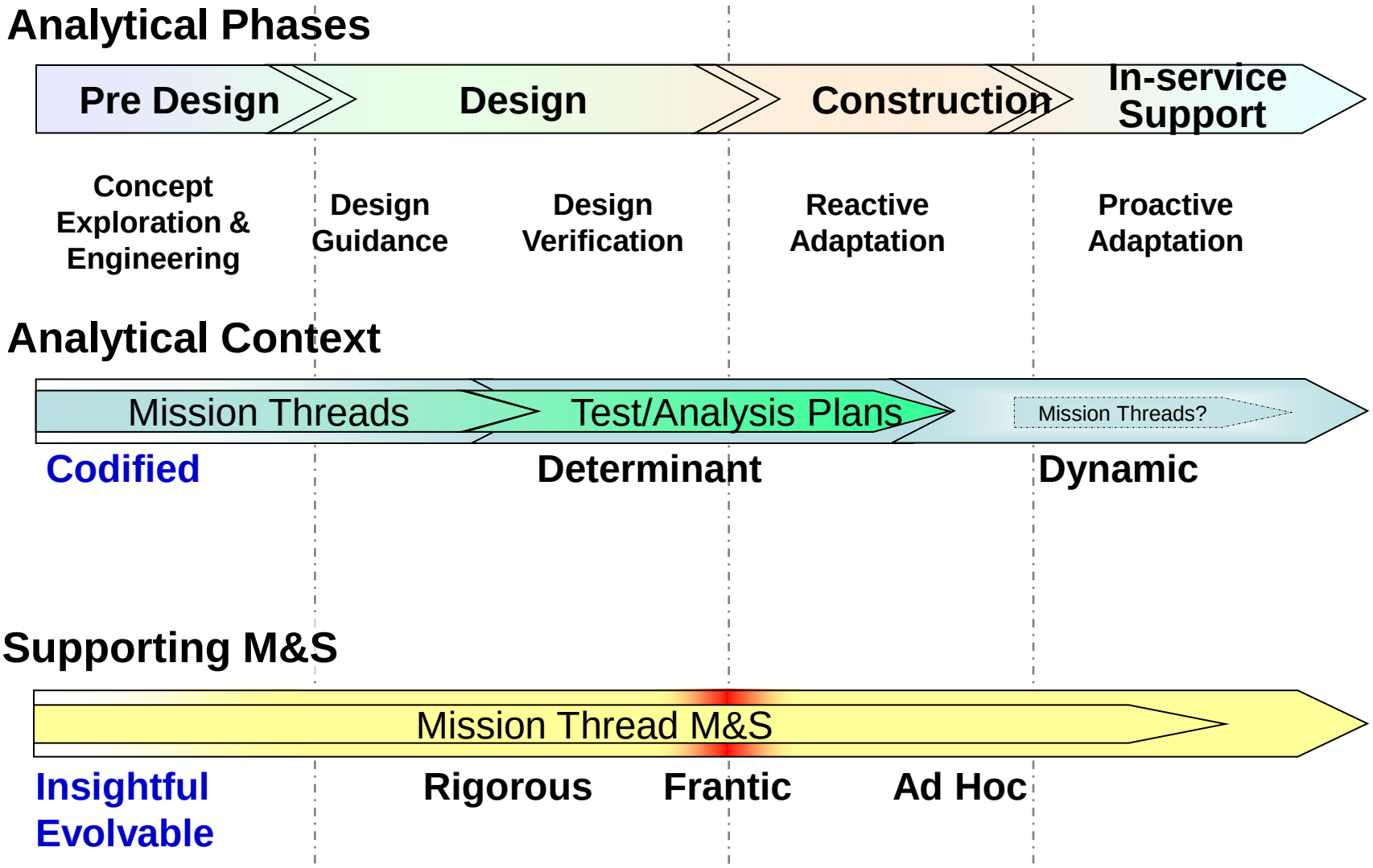
# Mission Threads (Quick Look)

- Analytical Context
  - The basis and the principle catalyst of analysis
- Scenario Based Context Provides:
  - A roadmap for mutually insightful discussions between operators and designers
  - The basis for assessing the mission system causation chain performances attributes ➡ capabilities ➡ effects ➡ objectives
- Mission Threads (as a type of scenario based context)
  - Qualitative, sequential representation of a mission scenario
  - A rapid means of framing the mission from end to end
  - Typically have prescribed branching decisions to ensure a productive trajectory
  - Ideal infusion point for “what ifs”
  - Well suited to requirements definition and design guidance
  - Useful as precursors of test and analysis plans
  - Current efforts to enhance quantitative attributes
  - **Agility and rapidity of development do not transfer to M&S**

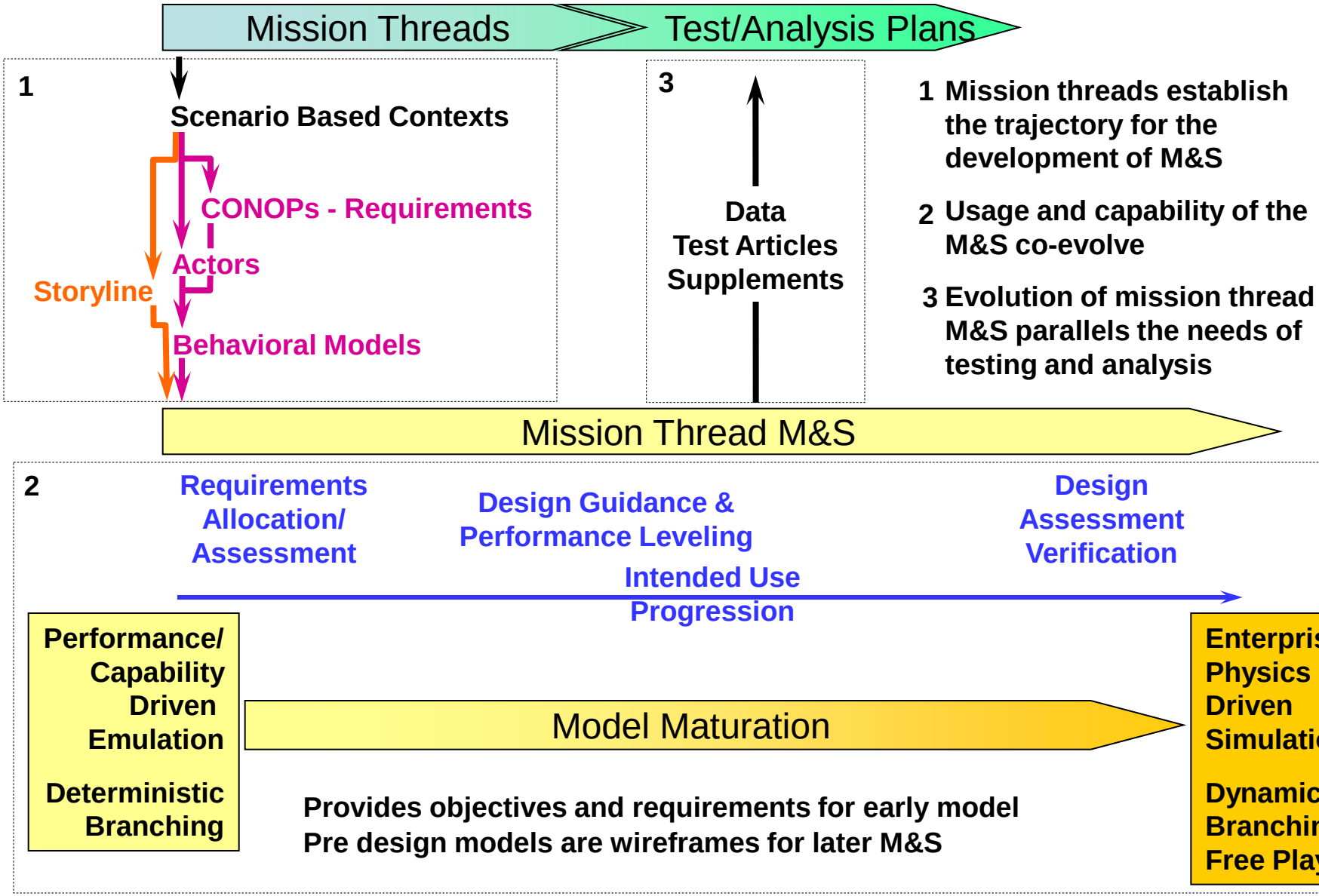
# Analytic Life Cycle



# Mission Threads in the Analytic Life Cycle



# Dynamics of Mission Thread Modeling



# Mission Thread Modeling

- Payoffs
  - Requirements bridge between analytical needs and M&S capabilities
  - Scoping mechanism for self contained, piecewise analysis of a complex mission space
  - Continuity of analysis, design and test cases
  - Provides a basis for confidence based on an understanding what the M&S is doing
- Making it Work
  - Experience suggests incremental development starting with a wire frame of essential features using place holders if needed
  - Simulation must be modular, agile, expandable and readily evolvable
  - Host structure must support large scale composability of an eclectic assortment of component models
  - Must be functional at the front end of a project

**The Game Loop Architecture**

# Two Approaches to Mission System Modeling

## System Centric
**Model the system and wrap the war around it**




Logical appeal in that it leverages the representation of the system of interest

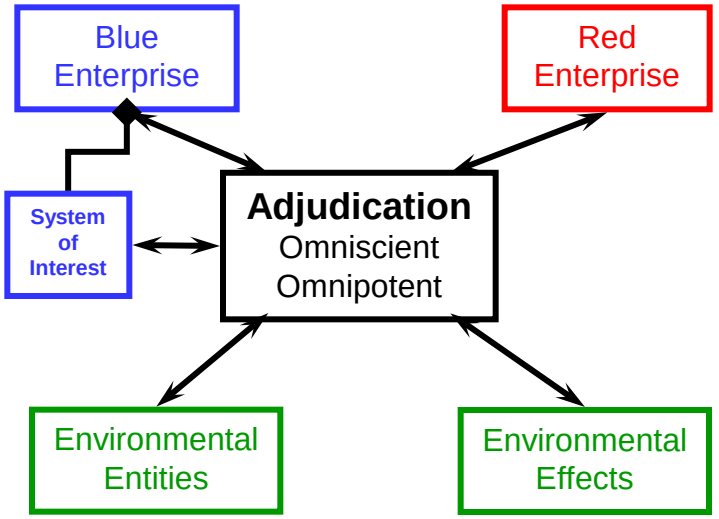
Ideally suited to design assessment

Simulation lags design – limiting usefulness for design guidance

Invites bias in free play scenarios

Decentralized (inconsistent?) adjudication

## Mission Centric
**Model the war and put the system in it**




**Simulation can run prior to system design (using place holder if required)**

**Consistent with the charter of the suggested "Concept Engineering Center"**

**Mitigates ripple effect induced by changes to the representation of the system of interest**

**Localizes branching decisions to adjudication**

**Context for Game Loops**

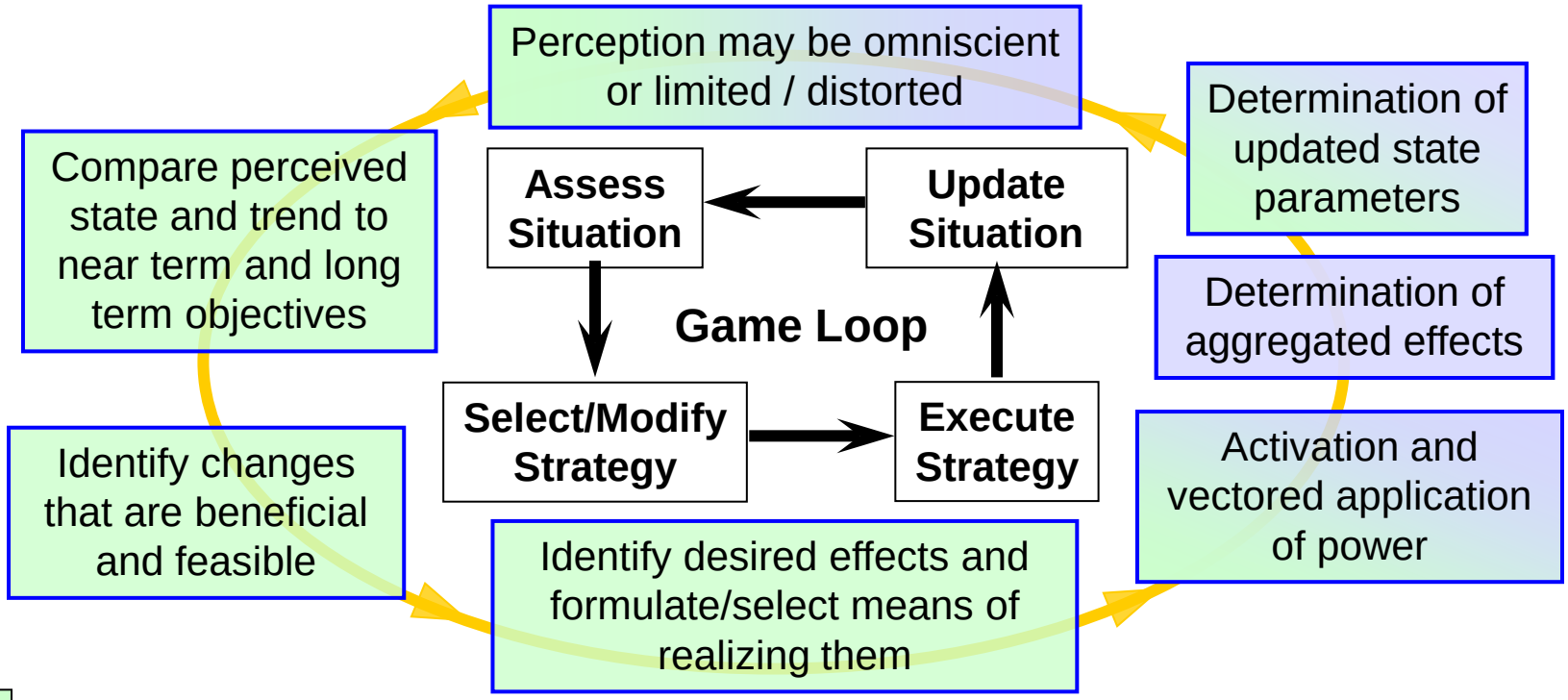
# Game Loop Architecture

- Players
  - Mutually incompatible objectives
  - Capabilities that can influence the end point of the “game”
  - Represented by quasi autonomous objects
- Rule Set and Adjudication Mechanism
  - Rule Set can be combination of convention and “physics” based
  - Centralized adjudication component
    - Fields adjudication requests from players
    - Promulgates results to effected players
- Venue
  - Common Operational Environment
  - Optional “game board”
- Game Driver
  - Consistent with quasi autonomous objects
  - Centralized – Event Queue enforces temporal causality) (event drive with time driven and agent based tendencies)
  - Decentralized – Individual Game Loop

Legend
**Problem Domain**
**Core Architecture**

# Basic Game Loop Model

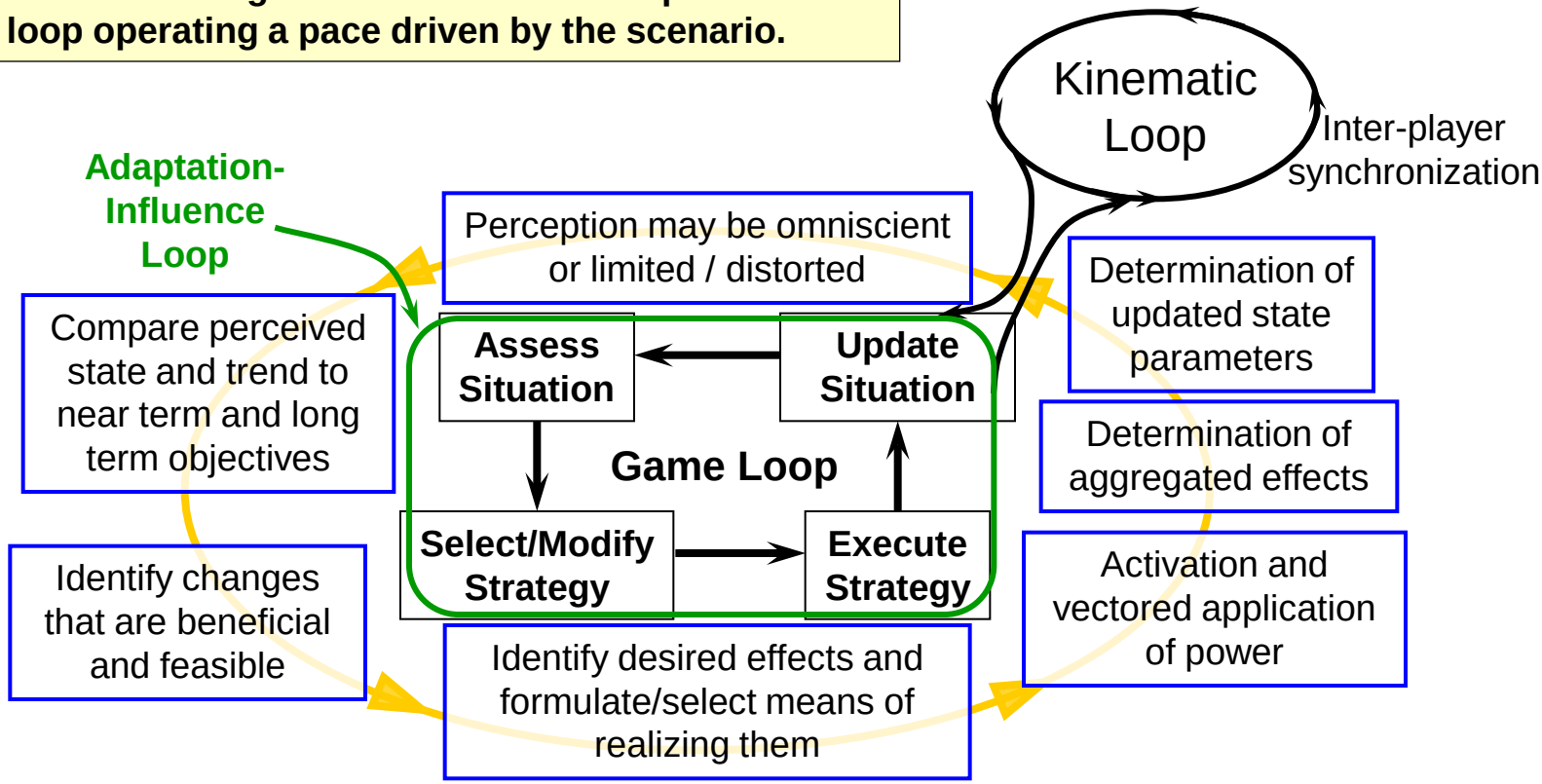
**The basic game loop model can be applied any game**
- **Sport, Card, Board, Wargame, Combat …**
- **One loop per player (players of similar type can share the loop implementation)**
- **Situations are based on a shared Common Operation Environment (COE)**
- **Can be implemented as an OODA loop**



# The Modified Game Loop

**In simulations of mission systems the speed of the reaction, adaptation process has tactical significance.**

**The game loop can be implemented as a kinematic loop synchronized with the "game clock" and an adaptation influence loop operating a pace driven by the scenario.**



# Demonstration
# Swarm Raid Mission Thread from CGX

This scenario pits CGX against 15 small, agile, missile capable surface craft in 3 groups of 5

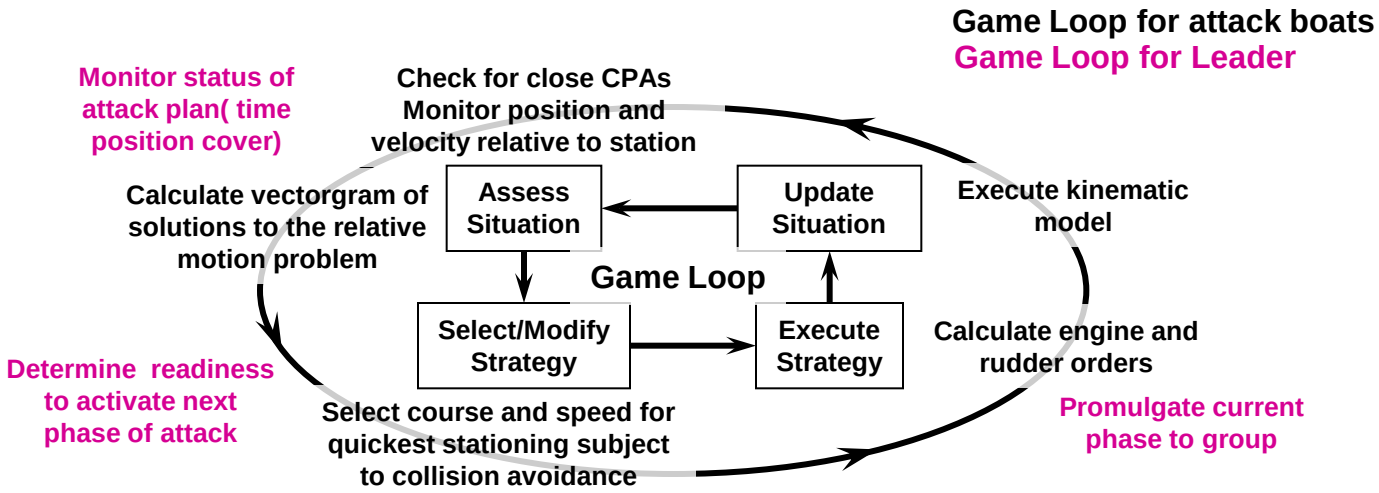
There is a vibrant fishing industry and a shipping lane off shore that will provide cover for the attack. This demonstration is tuned to finding exploitable indicators of a pending attack.

The same scenario can be used to explore and assess all options in the detect to engagement sequence.

Each entity (CGX, small boat, merchant, fishing boat, helo, UAV ) executes its own game loop.

The attack profile consists of 6 phases for each of the groups. Each group has a designated leader that will decided when to proceed to the next phase based on achieving the objectives of the current phase and meeting the prerequisites of the next

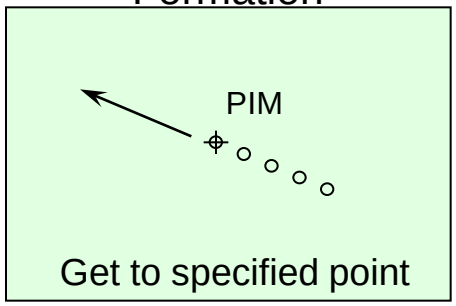
**Attack Boat Game Loop**



# Swarm Raid Mission Phases

## Transit

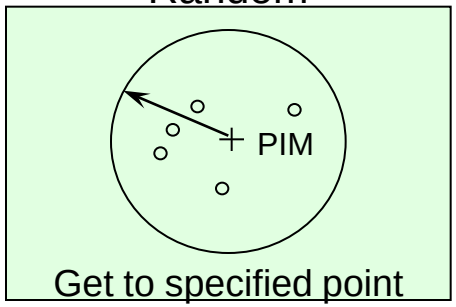
Formation




Initial condition - None

Terminal condition - Posit

Random

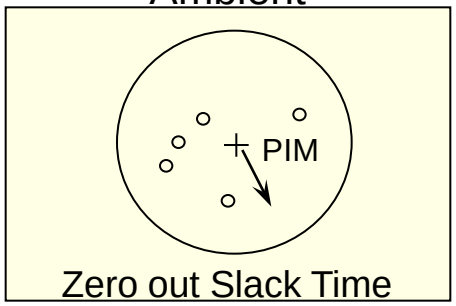



Initial condition - None

Terminal condition - Posit

## Loiter

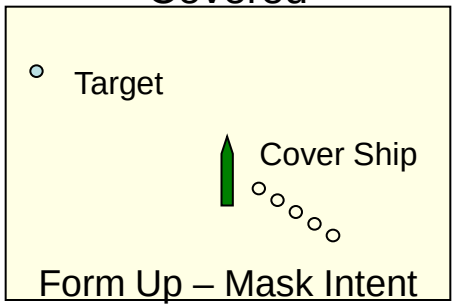
Ambient




Initial condition - None

Terminal condition - Time or posit

Covered

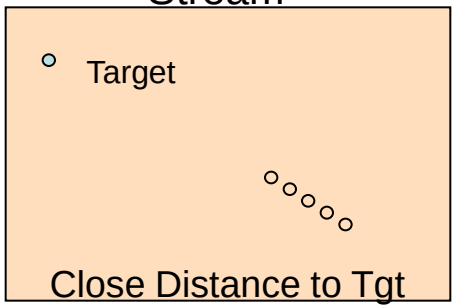



Initial condition – Target & cover assigned

Terminal condition - Time or posit

## Dash

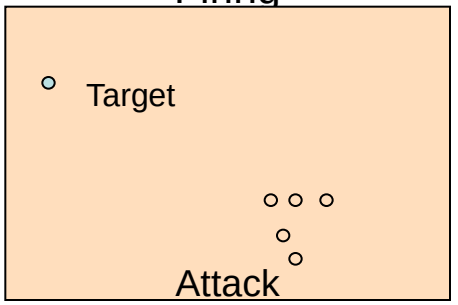
Stream




Initial condition – Time & posit

Terminal condition - Time & posit

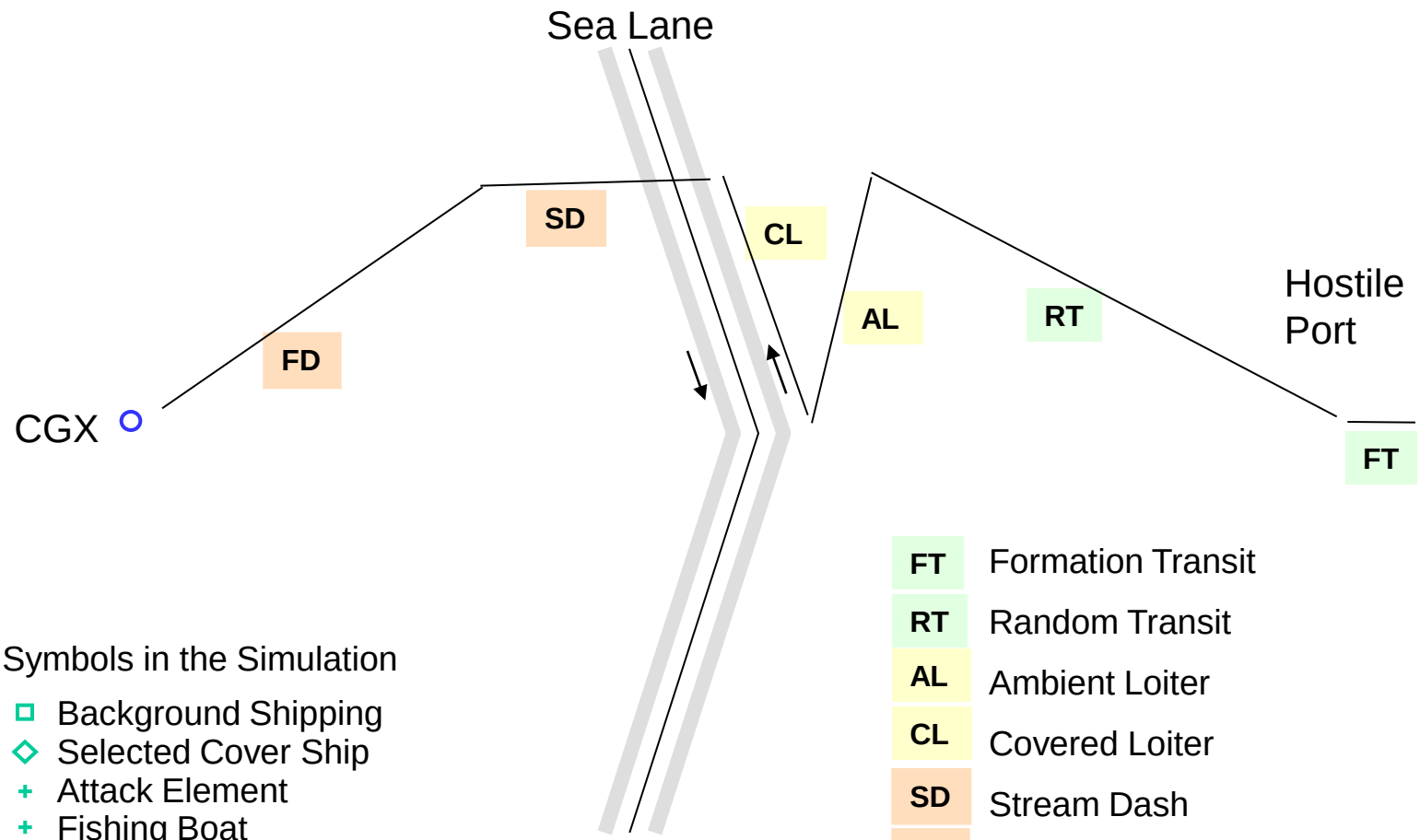
Firing




Initial condition – At launch range (time opt.)

Terminal condition - None

# Swarm Raid Scenario Setup




Symbols in the Simulation

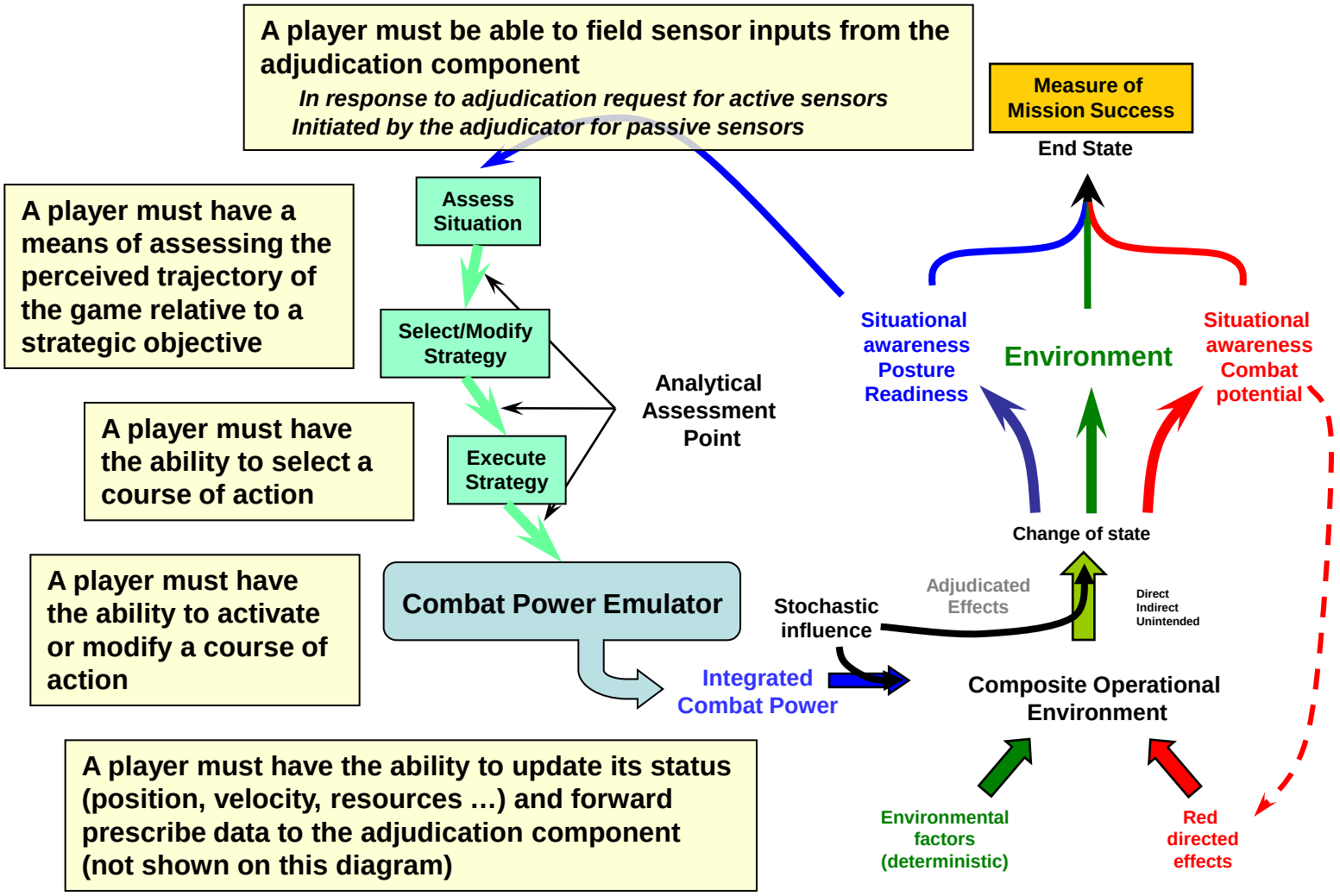
- Background Shipping
- Selected Cover Ship
- Attack Element
- Fishing Boat
- CGX

| | |
|---|---|
| FT | Formation Transit |
| RT | Random Transit |
| AL | Ambient Loiter |
| CL | Covered Loiter |
| SD | Stream Dash |
| FD | Firing Dash |

# Hosting the System of Interest

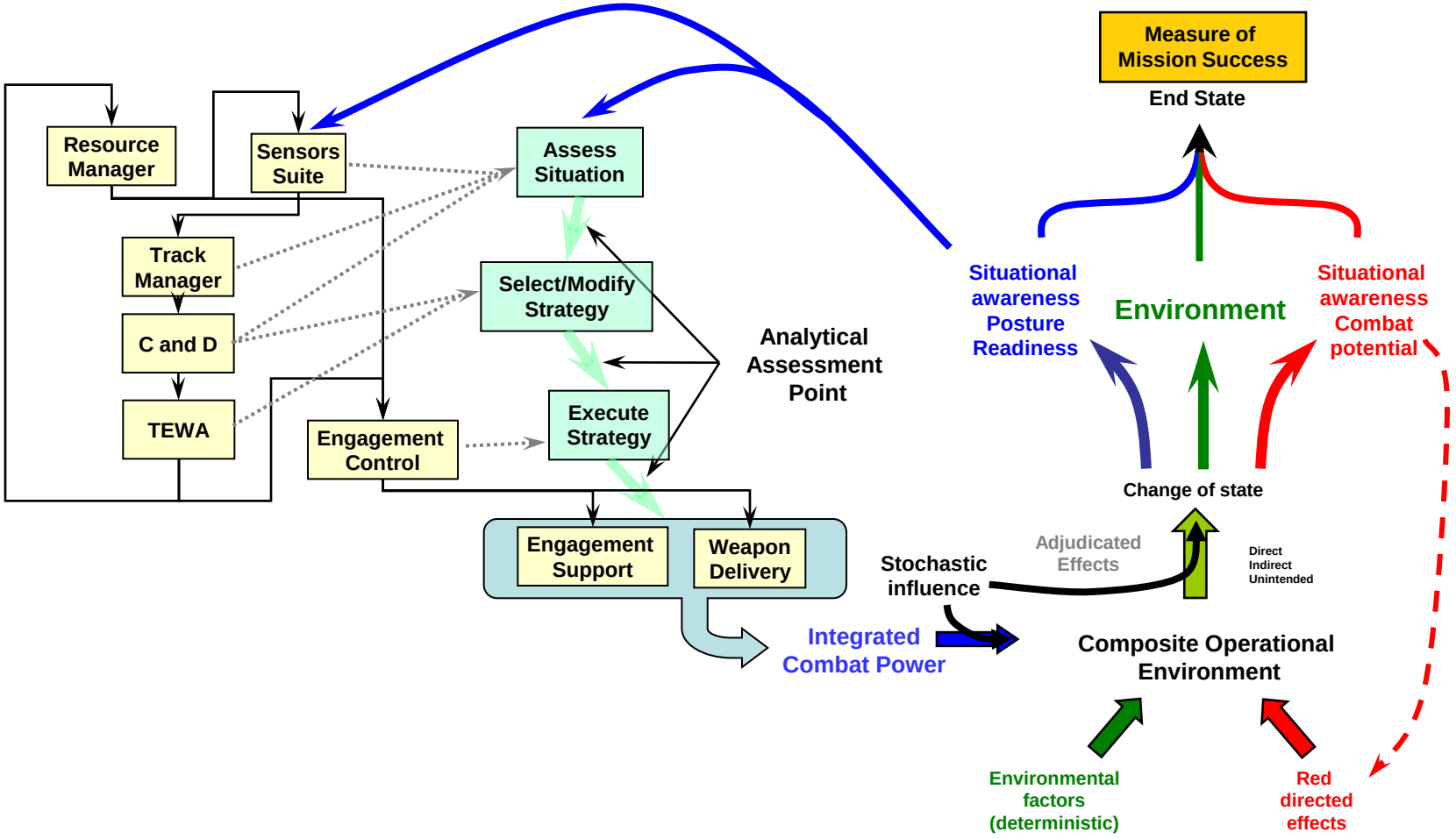
(Closing the Game Loop – integration with the host)

**Placeholders are useful for "closing the game loop" providing a complete but rudimentary set of capabilities player must play have to participate in the game**



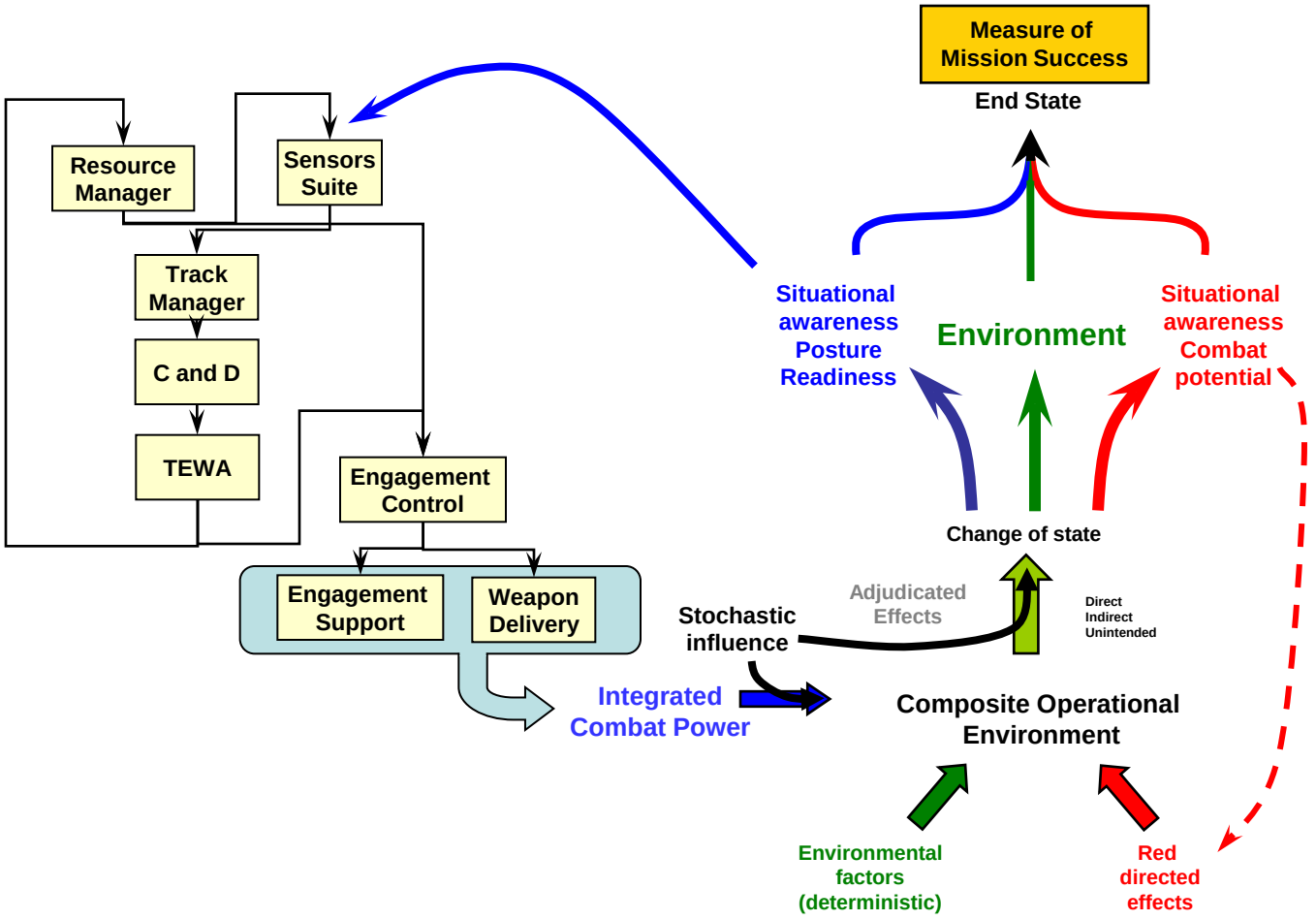
# Hosting the System of Interest
## (Interim Hosting)

**Placeholders can be modified incrementally to incorporate prototypes or equivalent representations of proposed system elements**



# Hosting the System of Interest
## (Functional Hosting)

**When the system is sufficiently mature and complete to satisfies the basic game loop requirements the original wireframe can be retired and the system refined incrementally**



# Summary and Recommendations

- Summary
  - Mission threads are effective and affordable analysis drivers in support of mission system engineering
  - Their utility as simulation drivers is an appealing but elusive goal
  - Mission threads and mission modeling are inline with the “Systems 2020” initiative
  - The game loop architecture is well suited to the needs and the objectives of mission thread modeling and simulation
- Opinion
  - The entrepreneurial culture of NDIA is a potential boon to the “*Concept Engineering Center*” recommend by the “*Rapid Capability Toolbox Study*”
  - Mission threads and mission thread modeling are critical enablers of the objectives identified for the *Concept Engineering Center*
- Recommendation
  - To assemble a nucleolus of expertise pursuant to concept engineering under the auspices of the SE division of NDIA
  - To scrutinize and socialize the techniques of game loop driven simulations under the auspices of the M&S committee