

# Enhancing Command and Control (C2) Assessment through Semantic Systems

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# Overview

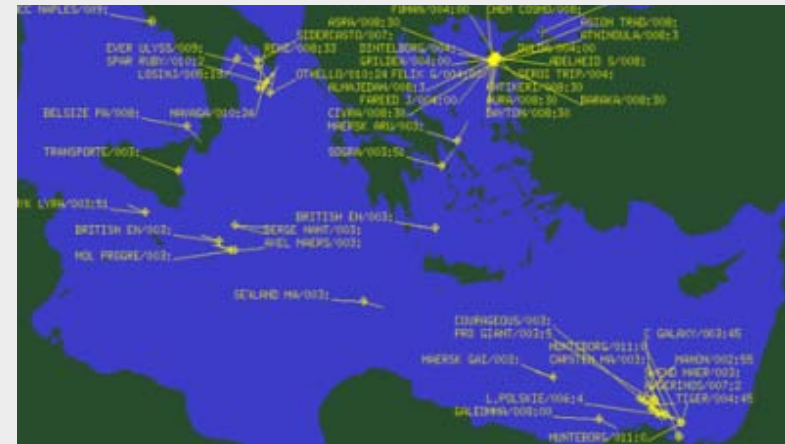
Enabling true assessment of operations through dynamic semantic modeling of the operational environment, the operational plan, and the relationships between the two.

## C2 – Current State

- Poor Cross-Domain Operational Planning, Execution, and Assessment
  - “...no matter how impressive the conduct of [..] operations might be at the tactical level, there is **no guarantee that linkages will exist to the strategic and operational levels** without a considerable intellectual effort to think through the potential effects of policy decisions and strategy, or the possible contributions that tactical actions might make to achieving operational or strategic effects.”
    - Dr. Williamson Murray, *Thoughts on Effects-Based Operations, Strategy, and the Conduct of War*

# C2 – Current State

- Problematic Integration, Coordination and Visualization of Operational Plans and Operational Environment Knowledge
  - COP/UDOPs do not fully meet requirements
  - Lack of data sharing between coalition, joint, service, and federated partners



## C2 – Current State

- Dislocated and Distributed C2
- Lack of Visualization supporting C2 Planning, Situational Awareness and Decision Making



# Unifying and Visualizing through Dynamic Modeling

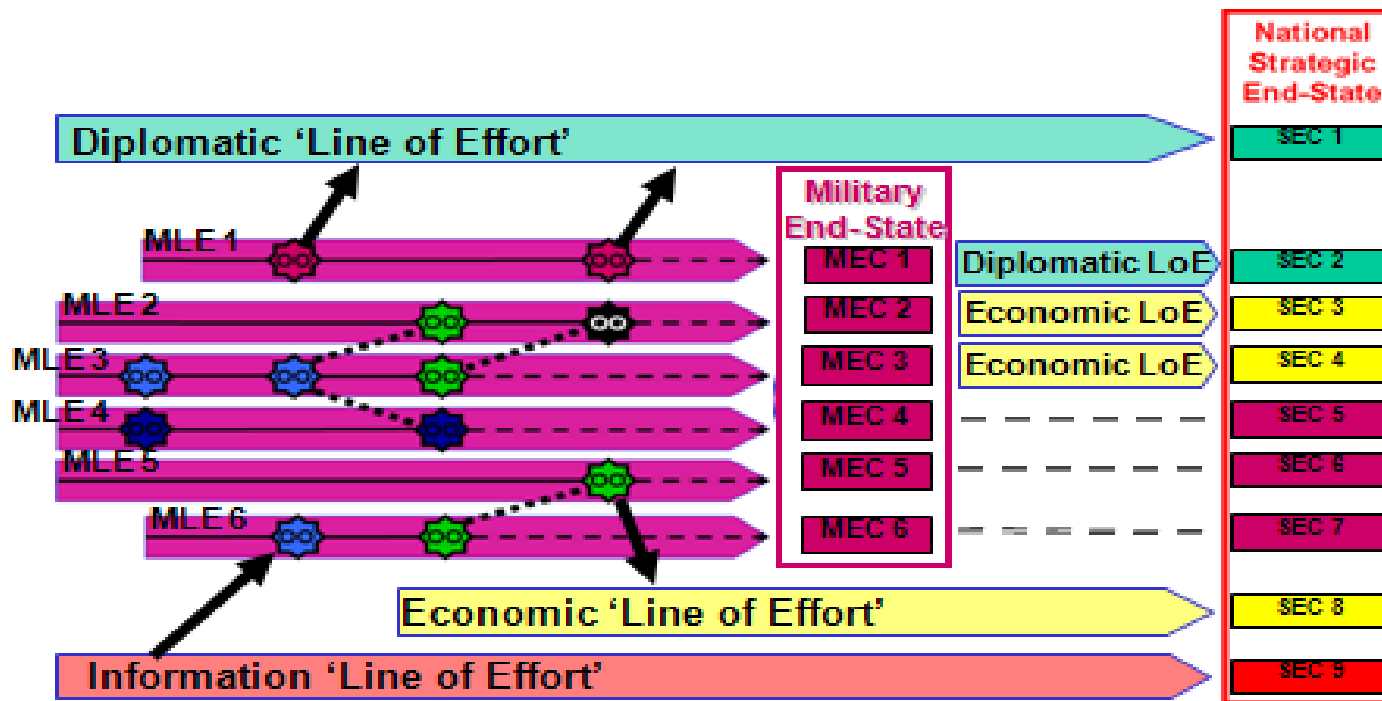
- ‘Unifying’ Cross-Domain Planning, Execution, and Assessment
  - Comprehensive, Conditions-Based Approach needed
  - Key Elements
    - A holistic understanding of the OE
    - A focus on the required outputs of change in the OE

# Unifying and Visualizing through Dynamic Modeling - CAPE

- Comprehensive Adaptive Planning and Execution (CAPE)
  - Captures unifying logic of operational plans across all domains
  - Employs the **Line of Effort** (LOE) concept,
    - Key construct element
    - Primary construct for logic-based visualizations

# Unifying and Visualizing through Dynamic Modeling – CAPE (Continued)

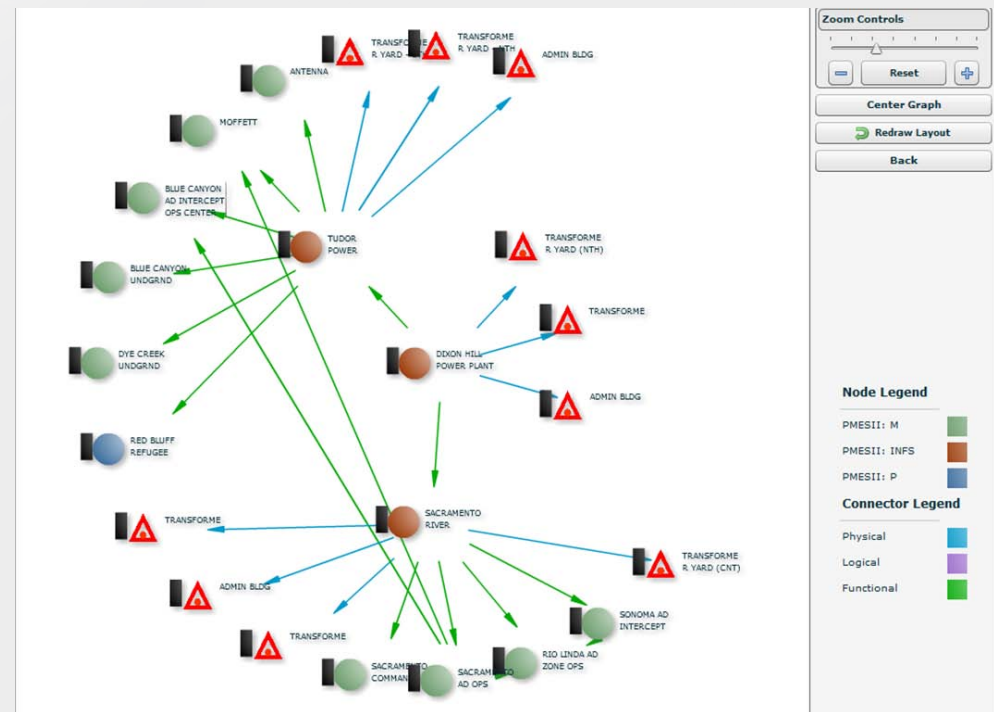
## CAPE Construct *Integrating Military Objectives w. Strategic LOEs*



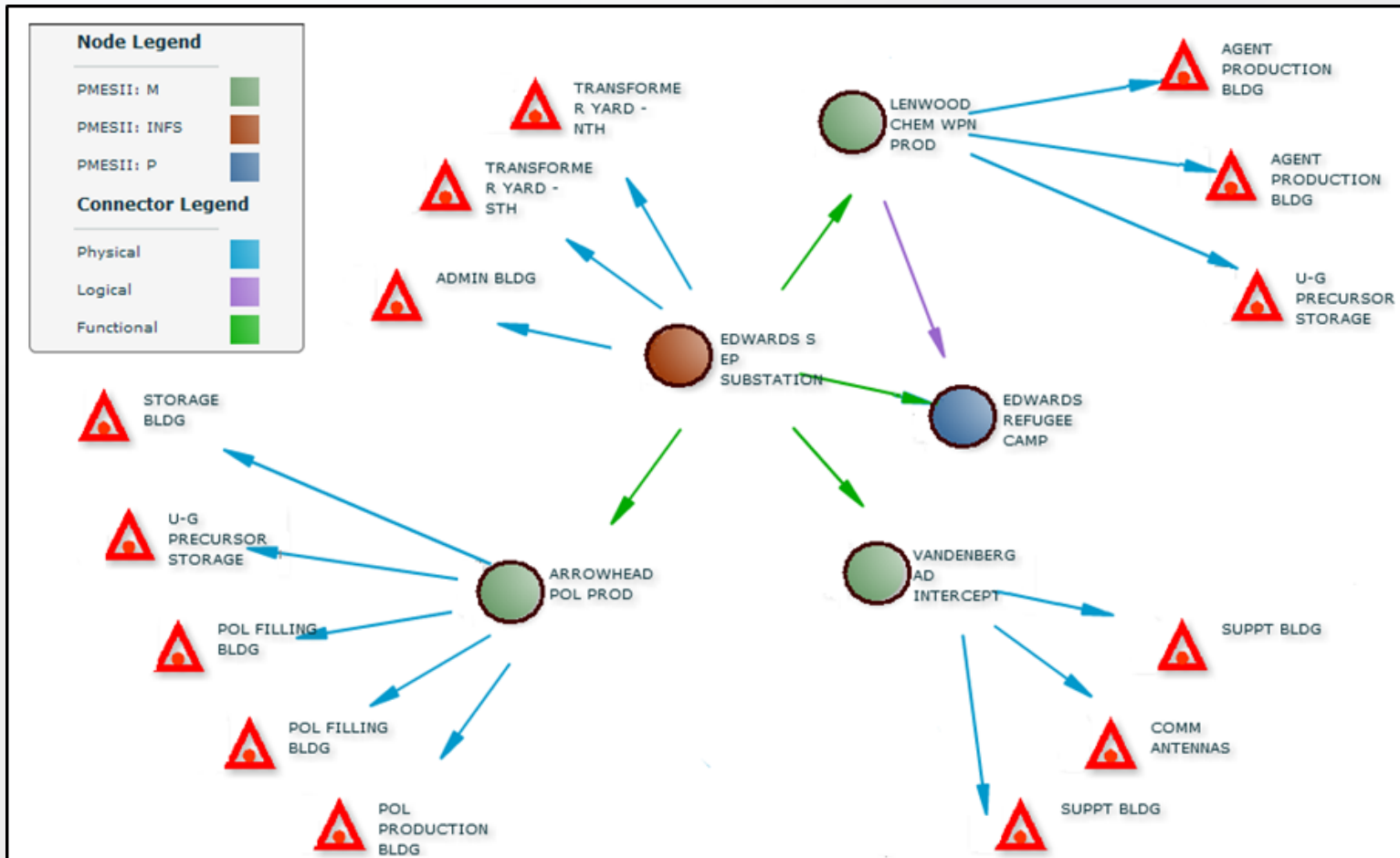


# Integrating Operational Knowledge through Dynamic Modeling

- Automated creation of dynamic, user-defined Operational Environment Models (OEMs)
- OEMs provide more than a snapshot in time of friendly, neutral and enemy systems



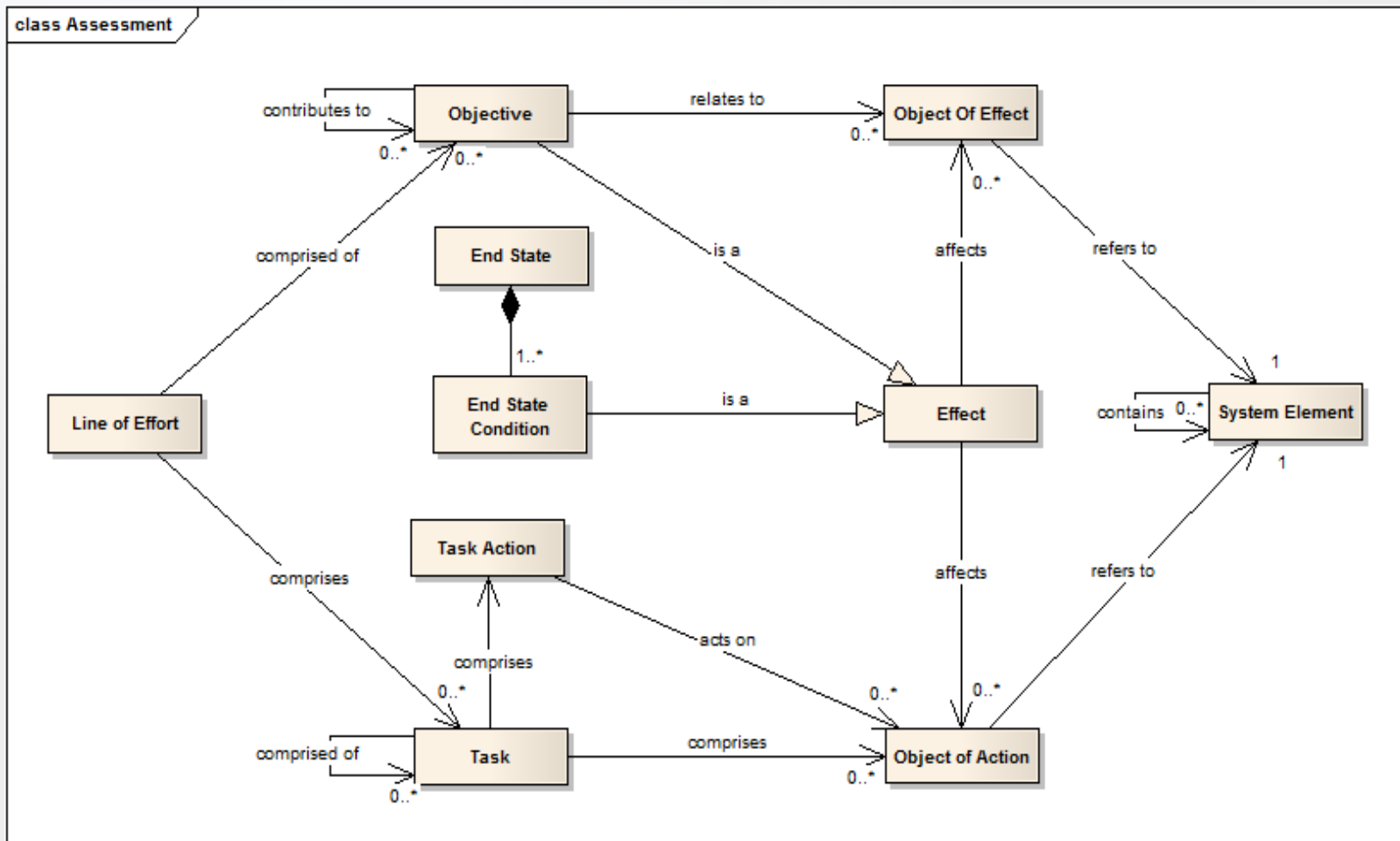
# Integrating Operational Knowledge through Dynamic Modeling



# Integrating Operational Knowledge through Dynamic Modeling

- Logical abstractions of CAPE used to develop complete operational planning, execution, and assessment ontology
  - Allows an Operational Plan Model (OPM) to be built and maintained on the fly.
  - Defines semantic relationships between OE system nodes and CAPE plan elements

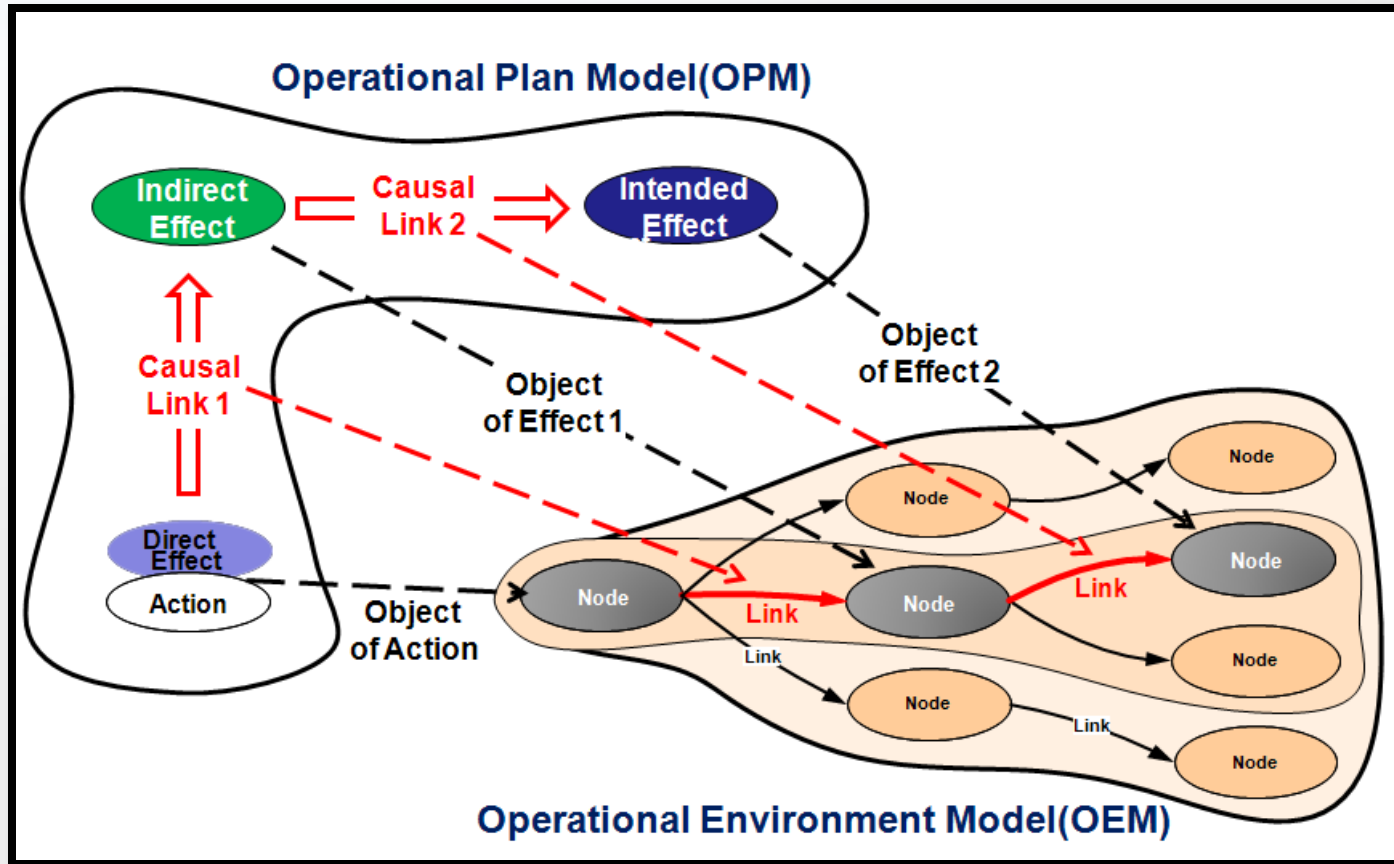
# Integrating Operational Knowledge through Dynamic Modeling



# Integrating Operational Knowledge through Dynamic Modeling

- Two logical bridges between OEM and OPM
  - Object of Action/Object of Effect
    - Objects within the OPM are entities within the OEM
    - Enables interactions between models
  - Causal Link (CL)
    - Deduced during operational design and planning
    - Operational Plan CLs instantiated within the OPM
      - Relate to some form of physical, functional, or logical link
    - CLs exist between entities in the OE

# Integrating Operational Knowledge through Dynamic Modeling



Inter-connections between OPMs and OEMs

# Generating and Integrating Semantic Models

- Semantic Model: a data modeling technique to define the meaning of data within the context of its interrelationships with other data
  - Formalizes knowledge in a machine readable format
  - Can be reasoned over to support explanation & prediction
  - Semantic models may be constructed using various techniques
    - Ontology constructs are the primary implementation
    - Maintained using the Web Ontology Language (OWL)
    - For this effort, the term semantic model and ontology are synonymous

# Generating and Integrating Semantic Models

- Semantic Modeling of Cross-Domain Plans and the Operational Environment
  - Formalization of strategy, plans, execution, and assessment within an operational environment
  - Semantic models can change dynamically to accommodate growth of domain or new knowledge
  - OEMs include taxonomies ranging from facilities, equipment, and organizations to an OEs “soft” factors (political, cultural, and social)

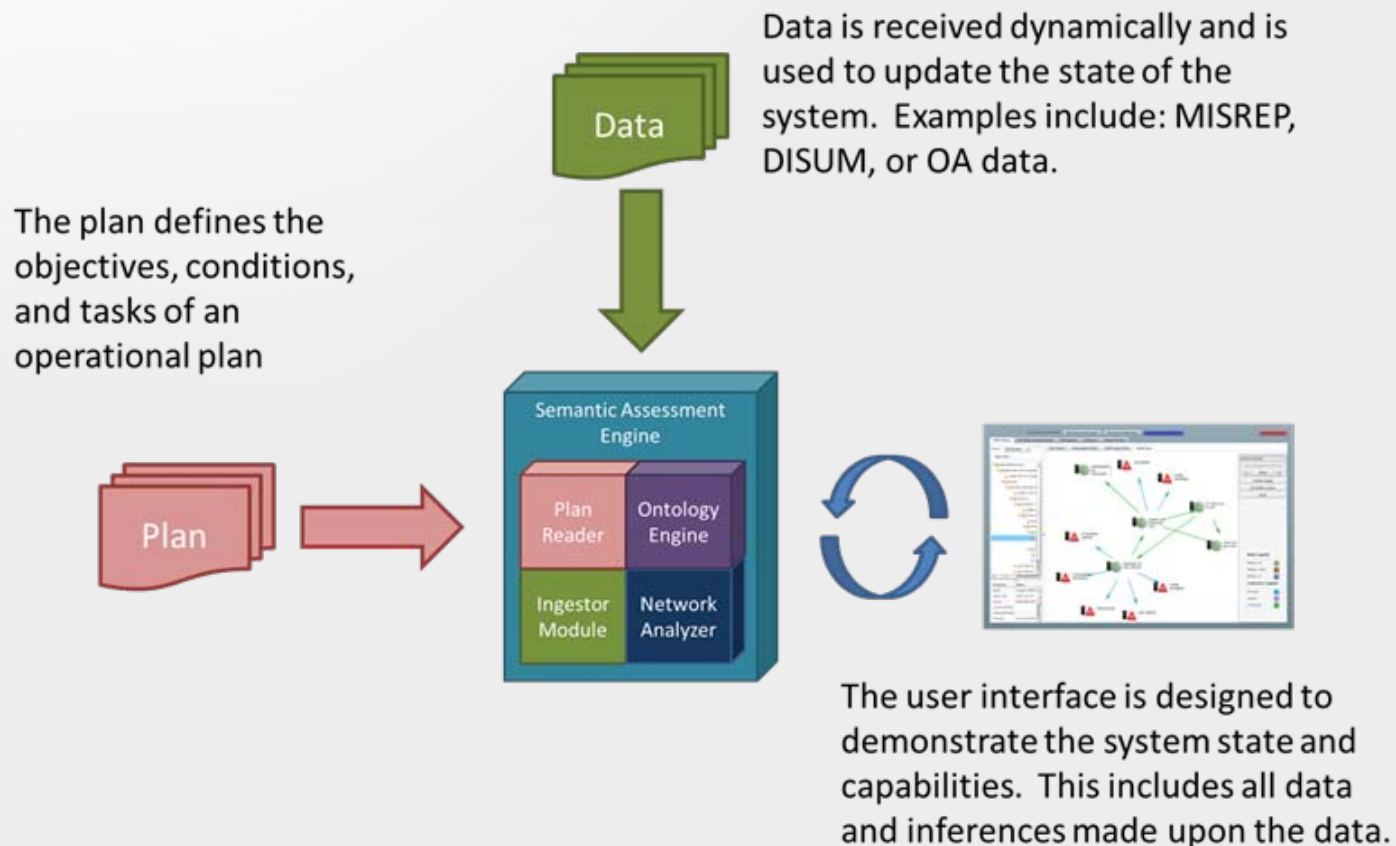


# Generating and Integrating Semantic Models

- **Stereotypical OEM**
  - Modeled after widely used databases and artifacts (e.g. MIDB)
  - Classified by type then semantically defined using patterns
  - Enables users to reason about and make inferences towards the state of specific objects and related objects
- **Instantiated OEM**
  - Provides adversary and/or campaign specificity to the stereotypical OEM
  - Populated as instances of the stereotypical constructs
  - Related to OPM to complete a comprehensive semantic model

# CAPE Realization

- Semantic Assessment Engine (SAE)



# CAPE Realization

- CAPE Visualization

The screenshot displays the CAPE (Cyber Air Power Enterprise) visualization software interface, which is used for mission planning and target management. The interface is divided into several main sections:

- Top Panel:** Contains navigation tabs for OPR Viewer, OE Entity/Target Viewer, ATO Report, Evidence, and Target History. It also features a search bar for BE Number and a dropdown menu for BE Number Search.
- Left Panel:** A table listing various target sites and their attributes. The table columns include Target Name, BE Number, CATCODE, OSuffix, PRESID, System, Set, Physical Status, and Functional Status.
 

Target Name	BE Number	CATCODE	OSuffix	PRESID	System	Set	Physical Status	Functional Status
AGUA DELUCE SA-3 SITE	0992-08002	87250	DD001	M	IADS	SAN	Inferred Physically Damaged	Assessed Limited Operations
ALPINE LAKE POWER PLANT	0992-02552	42200	DD001	INFS	Electrical PWR	Power Plnt	Ready	Operational
ANTENNA FARM CATALINA	0992-03275	41100	DD001	M	Rest C2	Other Support Fac	Ready	Operational
ANTENNA FARM R	0992-03294	41100	DD001	M	IADS	Other Support Fac	Ready	Operational
ARROWHEAD POL PRDG	0992-00097	21130	DD001	M	POL	SUPPLY	Ready	Operational
BLUE CANYON AD INTERCEPT OPS CENTER	0992-03808	82400	DD001	M	IADS	CMD Posts	Ready	Operational
BLUE CANYON UNDERGRD CHD POST	0992-02839	89310	DD001	M	NAT C2	CMD Posts	Inferred Physically Damaged	Assessed Limited Operations
CARBENAS TRANSFORMER STATION	0992-02588	42610	DD001	INFS	Electrical PWR	XFER Stat	Inferred Physically Damaged	Assessed Limited Operations
COARSEGRD UNDERGRD CHD POST	0992-03862	89310	DD001	M	NAT C2	CMD Posts	Inferred Physically Damaged	Assessed Run-Operational
COCONDOBE SA-3 SITE	0992-08003	87250	DD001	M	IADS	SAN	Ready	Operational
DEVON HILL POWER PLANT	0992-02538	42200	DD001	INFS	Electrical PWR	Power Plnt	Ready	Operational
DYF CREEK UNDERGRD CHD POST	0992-03861	89310	DD001	M	NAT C2	CMD Posts	Ready	Operational
EDWARDS 5 IP SUBSTATION	0992-02593	42600	DD001	INFS	EP Supply	EP	Ready	Operational
EL TORO SA-3 SITE	0992-08001	87250	DD001	M	IADS	SAN	Ready	Operational
LAKE TAMCIE WRM REPAIR/FABRICATION	0992-00072	63800	DD001	M	WRM	Weapons	Ready	Operational
LEWISWOOD CHER WRM PRDG	0992-00099	64100	DD001	M	WRM	Weapons	Ready	Operational
MURPHY 4000 TOWER	0992-03128	82370	DD001	M	IADS	ADOC	Ready	Operational
MOFFETT TRANSFORMER STATION	0992-02592	42610	DD001	INFS	Electrical PWR	XFER Stat	Ready	Operational
POL FAC - KERTBERY	0992-01939	21000	DD001	M	POL	Supply	Ready	Operational
RICE CHER WRM PRDG	0992-00100	64100	DD001	M	WRM	Weapons	Ready	Operational
R10 LINDA AD ZONE OPS CTR	0992-03806	82022	DD001	M	IADS	CHD Post	Ready	Operational
- Center Panel:** A detailed mission plan diagram showing a sequence of operations. It includes a timeline with tasks such as "Gain and maintain Air and Cyber superiority to ensure freedom of action" and "Disrupt CN political leadership direction to pipelines and control services". The diagram uses various symbols and arrows to represent different mission elements and their relationships.
- Right Panel:** A table listing mission details, including Mission #, Callign, RAIDER03, Aircraft Count, Aircraft, Payload, EGBU27, Unit, 35FS, TO, 0604032, TOT, 0605052, LNO, 0606102. It also includes a table for Weapons, listing BE Number, DMPI ID, DMPI Description, and DMPI Coordinate.
- Bottom Panel:** A network diagram showing the relationships between various nodes and connectors. The nodes represent different systems and their physical status, while the connectors represent the interactions between them. A legend at the bottom provides information about the node and connector types.

# Dynamic Tactical Assessment

- “Over a decade of lessons learned from conflicts since DESERT STORM emphasize that the traditional concepts, practices, organizations, and tool sets constituting traditional “battle damage assessment” (BDA) do not meet warfighters’ needs for assessment...”
  - AFDD 3-60 (formerly 2-1.9)
- “How do we view the enemy as a system vice counting all the specifics that are out there? ...I think that's the direction that we want to head to in the future.”
  - OIF Lessons Learned: Army Brig. Gen. Robert W. Cone, director, Joint Center for Lessons Learned, U.S. Joint Forces Command, 10/2/03



# Dynamic Tactical Assessment

- Plan and OE Element Relationships
  - Any structured plan seeking to affect change can be represented by OPM and OEM interactions
  - Models dynamically updated as information becomes available
- Data Gathering and Correlation
  - Automated correlation/processing of information
  - Allows users to concentrate on higher-level cognitive tasks

# Dynamic Tactical Assessment

- Evidence Evaluation
  - SAE extracts data from incoming messages and makes that data available to the core engine and users
  - Results are available against individual or a group of targets
  
- Information Visualization
  - Semantic relationships maintained in the OPM and OEM make options for visualizing data almost limitless
  - Analysts can search models for effects or allow the SAE to assist in reporting effect indications

# Conclusion

- Enables the realization of 'living' plans - through the constant interaction of the 'living' OPM of the ever changing plan with streaming and changing outputs from the 'living' OEM
- Analysis engine to reason across the models provides clear potential to assist C2 planning, execution, and assessment in any domain.