13th International Command and Control Research and Technology Symposium

C^2 for Complex Endeavours

C^2OLISEU – A Meta-Model For Research and Development of Complex Network Centric Operations

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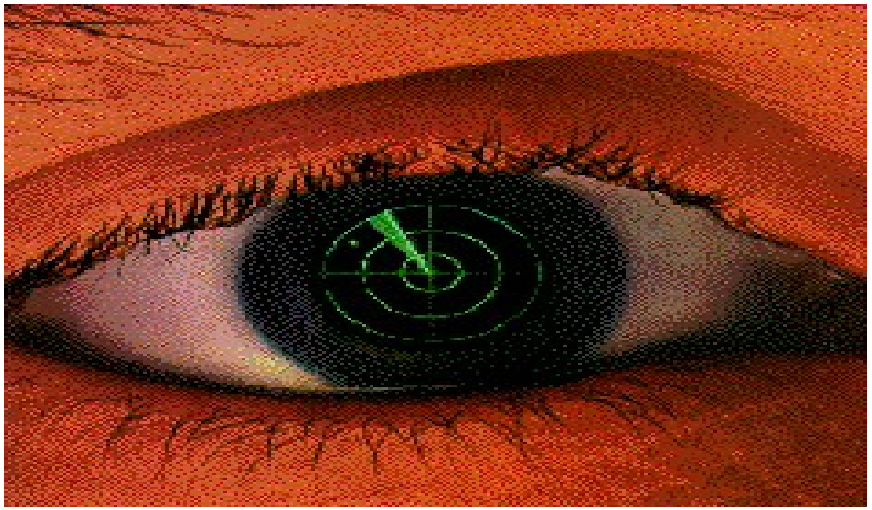
OBJECTIVE

To recognize the characteristics of C^2OLISEU Meta-Model and its relevance to Research, Development and Engineering of Complex, Net-Centric Systems.



SUMMARY

- Background
  - Architectural Frameworks
  - Cognition
  - Organization
- C^2OLISEU Framework
  - Overview
  - C^2OLISEU Agent
  - Metrics

ARCHITECTURAL FRAMEWORKS

- Have evolved since 1987 (Zachman)
- DoD Standard since 1997 (C4ISR AF)
- Wide acceptance by Industry (DoDAF)
- OV/SV provides good separation of concerns
- But...

ARCHITECTURAL FRAMEWORKS

- Executable Architectures still a Challenge
- Activity-Based Methodology *(Ring et al 2004)*
- Most of the work focused on Processes
- Cognition: part of the model, but not executable
- Organization: only to express property or control over nodes

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COGNITION

- Difficult to understand, even more difficult to represent in an executable model
- But the adaptive part of Complex Adaptive Systems means *(Ring et al 2004)*:
  - Context-sensitive behavior
  - Resilience
  - Robustness
  - Flexibility
  - Agility
  - Innovation
  - Learning

COGNITION

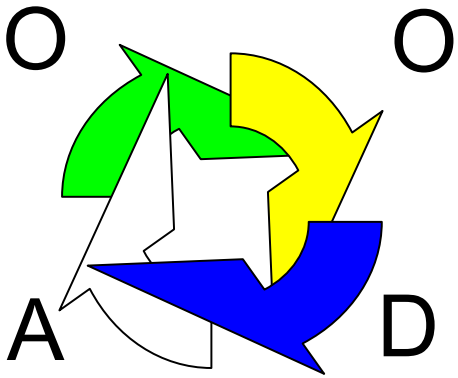
- The attributes in red are clearly of the cognitive domain
- The remaining (resilience, robustness and agility) can result of good networking and systems engineering
- For cognitive systems engineering of agile C^2, computational cognitive models are adequate *(Bonaceto and Burns 2004)*

COGNITION

- A cognitive agent architecture: Belief-Desire-Intention – BDI *(Rao and Georgeff 1995)*
  - *Beliefs* are what the agent knows
  - *Desires* are the agent's goals
  - *Intentions* are the commitments the agent does to reach its goals
- Well studied by academia, many applications in Defense *(Lucas and Goss 1999, Wallis et al 2002)*

COGNITION

- About BDI Agents and OODA Loops....



- *Beliefs* can be related to *Observe* and *Orient* parts
- *Goals* can be related to the *Decide* part

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ORGANIZATION

- It's more than property over assets
- It is a set of constraints over its individuals' behavior *(Dignum and Dignum 2001)*
- To adequately model hidden organizations,it must be represented beyond formal Institutions
- Also, it must be able to model networked organizational structures

ORGANIZATION

- Many paradigms exist to represent organizations:

Paradigm	*Main Concepts*
AALAADIN (Ferber and Gutknecht 1998)	Roles, Groups and Agents
MOISE (Hannoun et al. 2000)	Roles, Groups, Missions, and Relationships
MOISE+ (Hübner 2003)	Roles, Groups, Missions, Relationships, Goals

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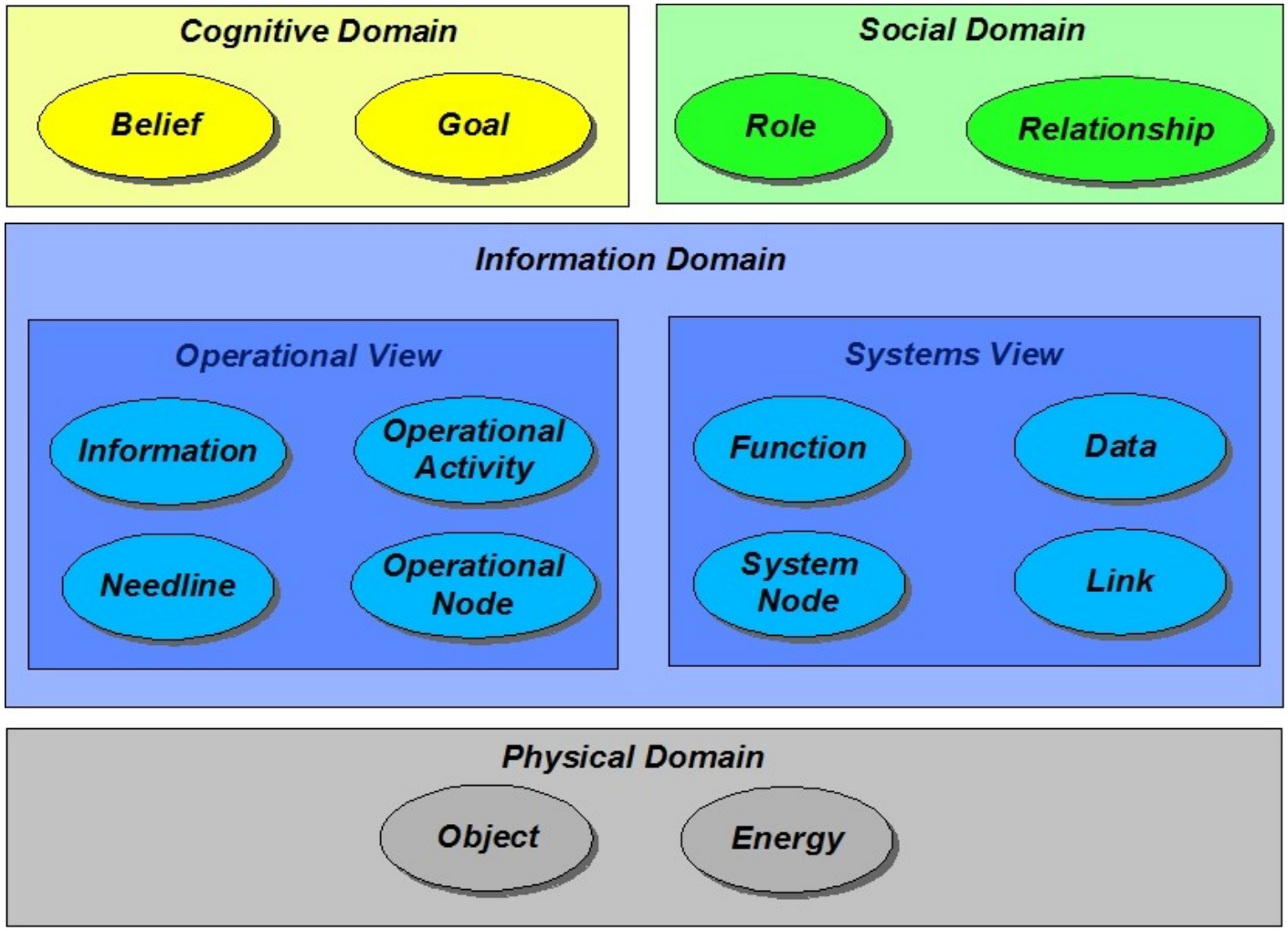
C^2OLISEU FRAMEWORK

- Main focus: Operations Analysis and Complex Systems Engineering
- Two core principles of ABM were kept:
  - Alignment of operational and system architecture objects and
  - Four core operational/system architecture entities objects
- Concepts layered in the 4 NCW key domains

C²OLISEU FRAMEWORK



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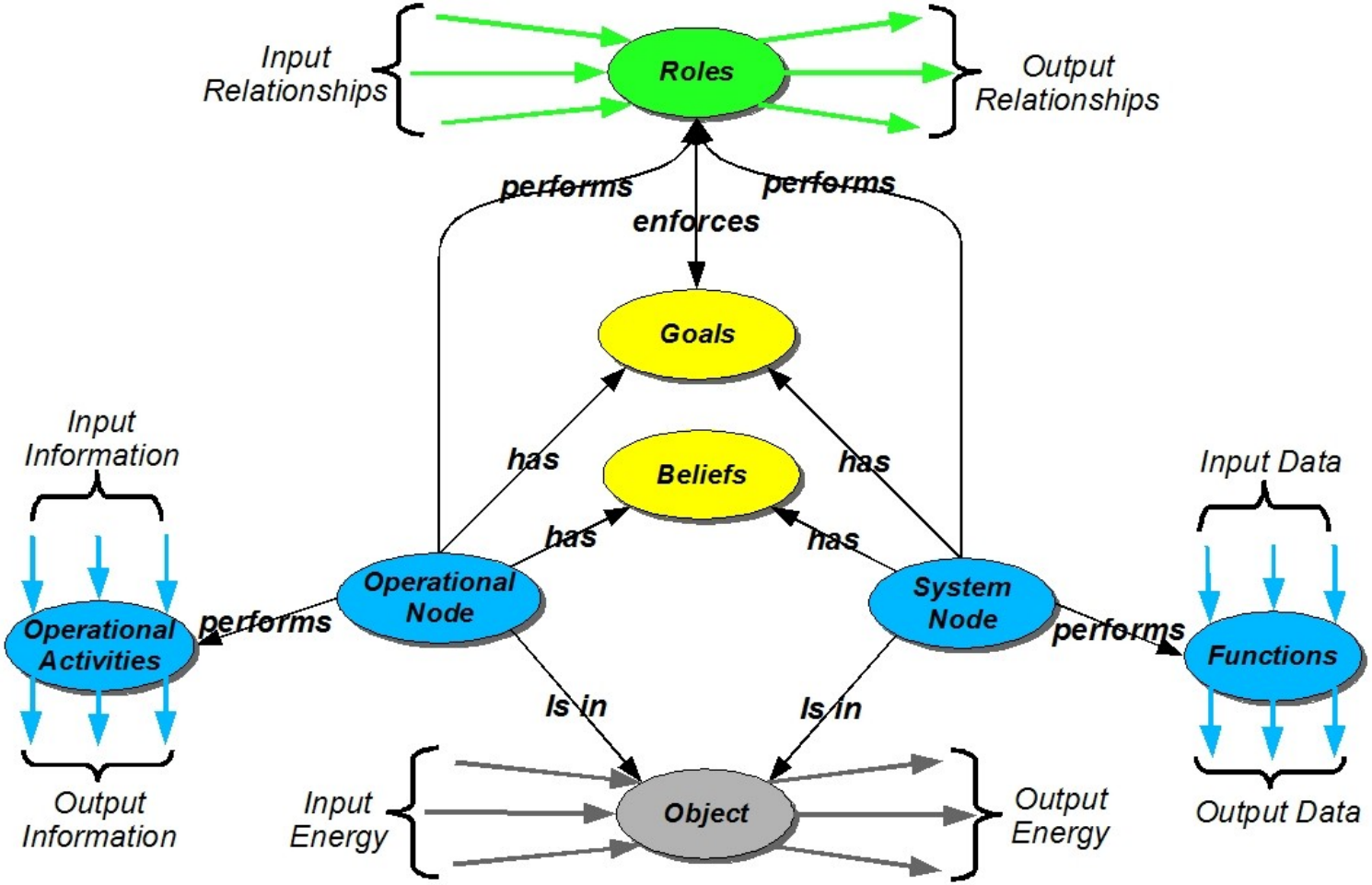

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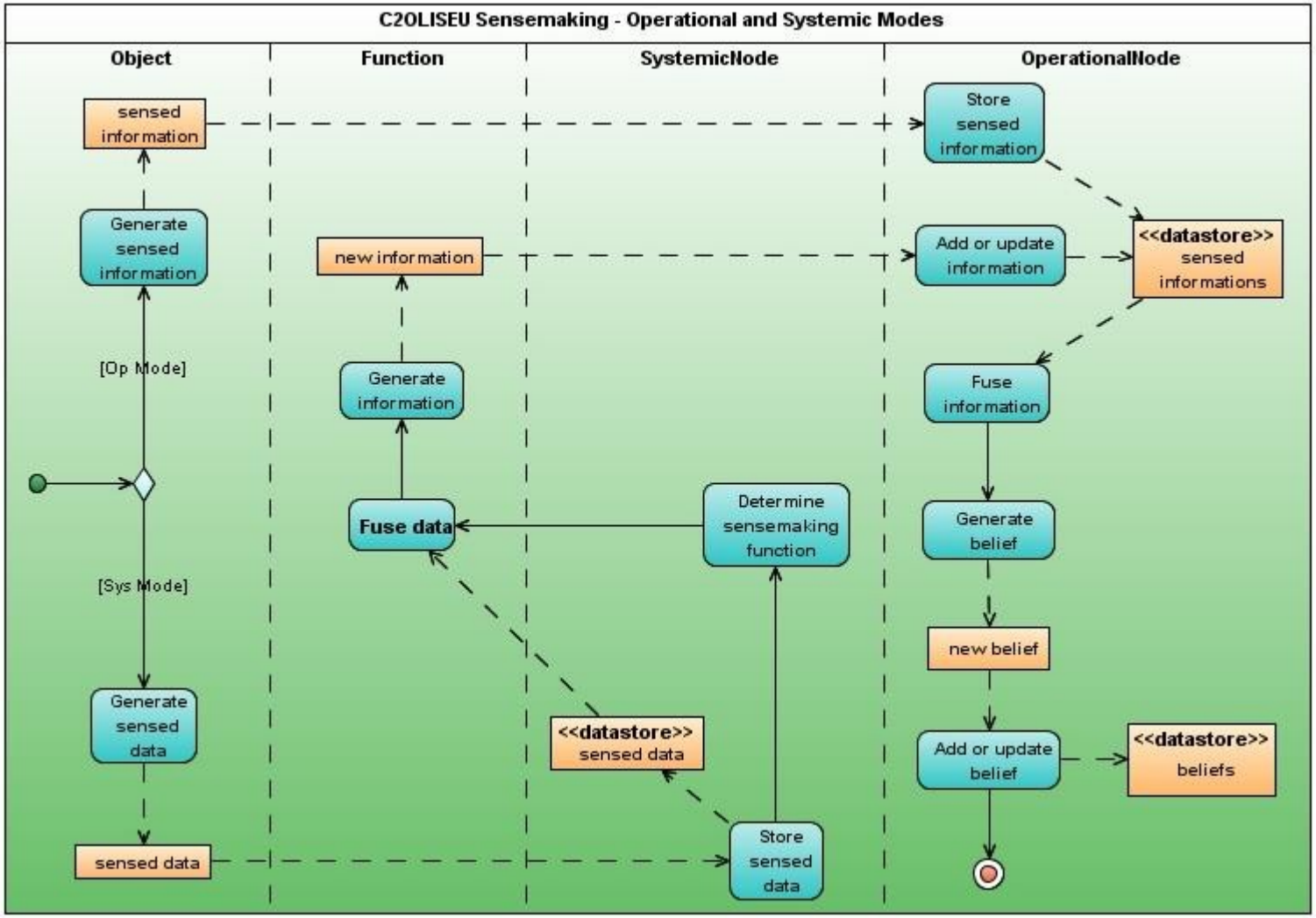

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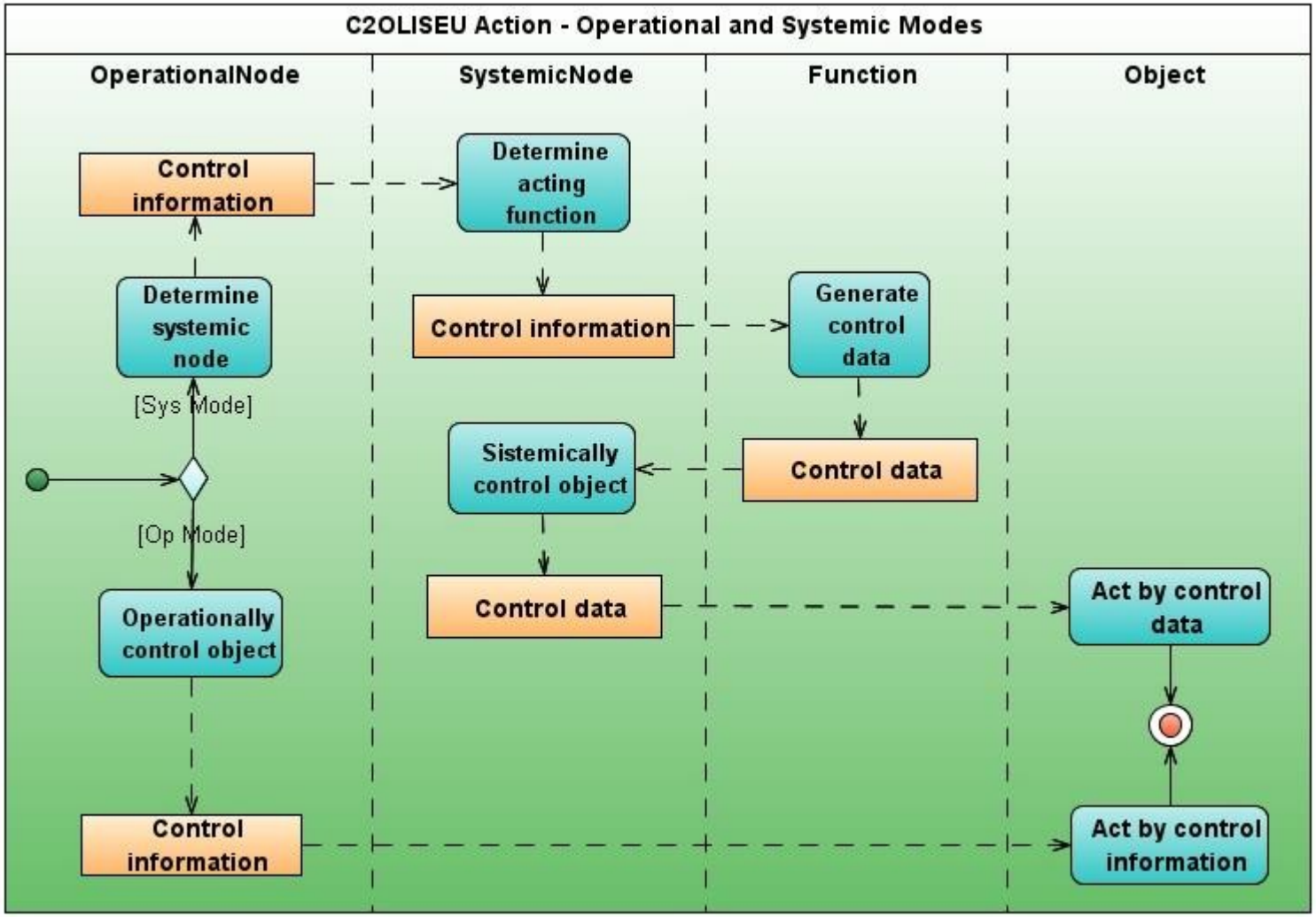

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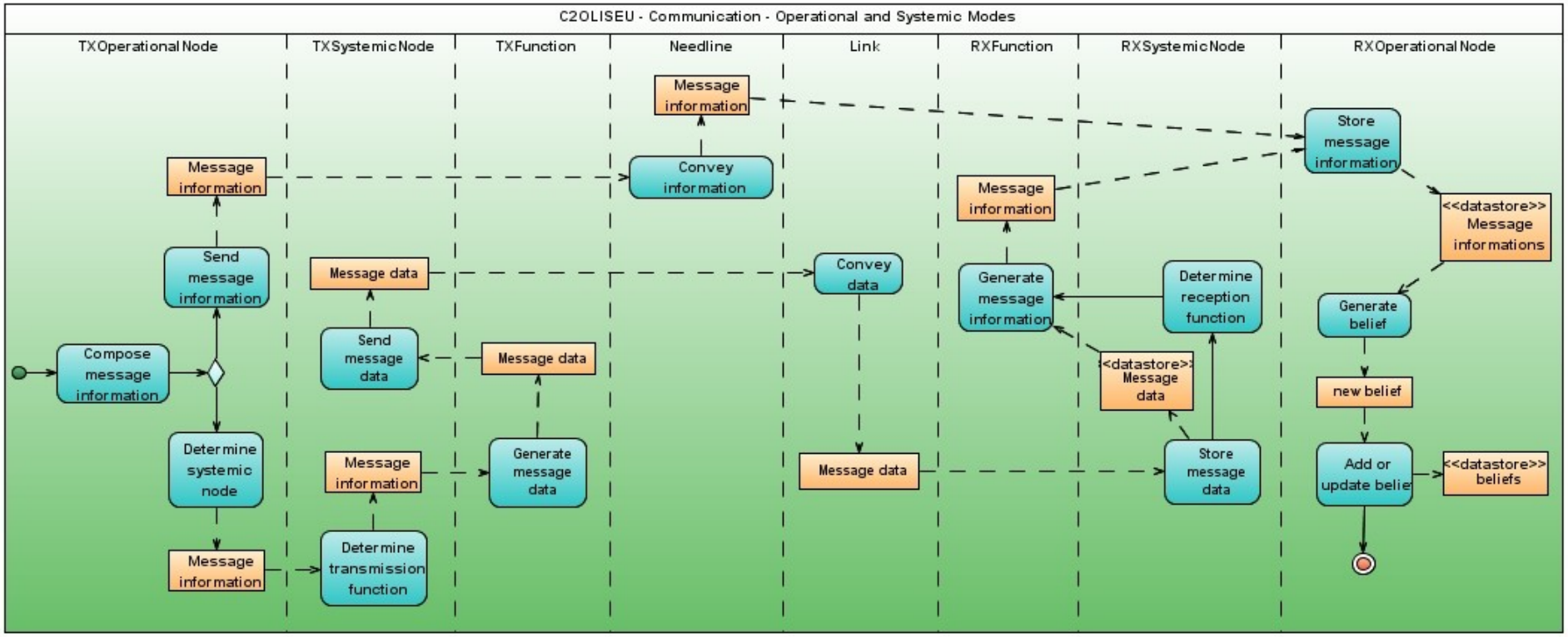

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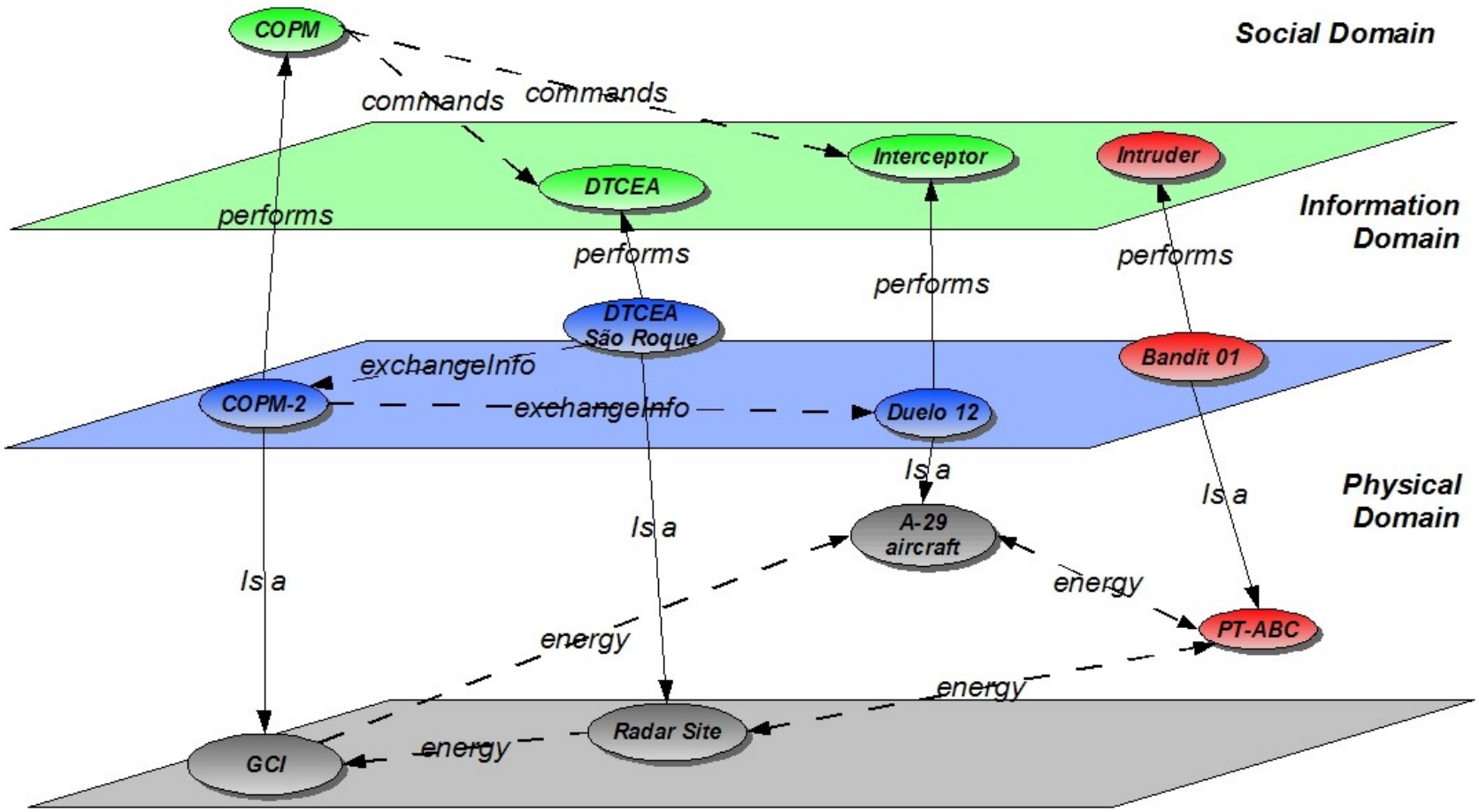

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METRICS

- 4 Graphs are present in C^2OLISEU Models:
  - 1 for the Social Domain, with the organizational structure
  - 2 for the Information Domain: 1 for OV, 1 for SV
  - 1 for the Physical Domain

Layer Name	*Node Definition (n_i)*	*Edge Definition($e_{i,j}$)*
Social Domain	Role	Relationship
Information Domain	Operational Node Systemic Node	Needline Link
Physical Domain	Object	Energy

METRICS

- An attractive generic network attribute: ***Centrality***
  - Degree $$C_D(n_k) = \sum_{i=1}^{n} a(n_i, n_k)$$
  - Betweenness $$C_B(n_k) = \sum_{i}^{n} \sum_{j}^{n} b_{ij}(n_k) \qquad b_{ij}(n_k) = \frac{g_{ij}(p_k)}{g_{ij}}$$
  - Closeness $$C_C(n_k) = \frac{1}{\sum_{i=1}^{n} d(n_i, n_k)}$$

METRICS

- These metrics differs noticeably, except for the extreme cases (fully connected and star networks)
- Degree-based: *communications activity*
- Betweeness-based: *control of communications*
- Closeness-based: *independence of relay, efficiency*
- The meaning of these properties for each NCW key domain layer means great opportunity for research in a multi-domain framework like C^2OLISEU

COMPLEXITY FRAMEWORK KEY REQUIREMENTS

(Couture and Charpentier 2007)

- Be as generic as possible, it should allow to address a wide spectrum of complex problems in different fields or domains (YES);
- Ease the understanding of underlying notions of complexity theory (TBD);
- Provide guidance on how to address complex problems (TBD);
- Facilitate the reutilization of any proven solution (YES);
  - Reflect and make use of the commonalities that can be found in the scientific literature dedicated to Complexity Theory (YES, Partially).

CONCLUSIONS

- C^2OLISEU Framework is about NCW and its key domains
- Each key domain is represented using well known paradigms for organizations, cognition, information systems and physical laws
- The domains are inter-related, by an agent architecture and its basic processes
- Evidence points it to be suited for the study of complex systems

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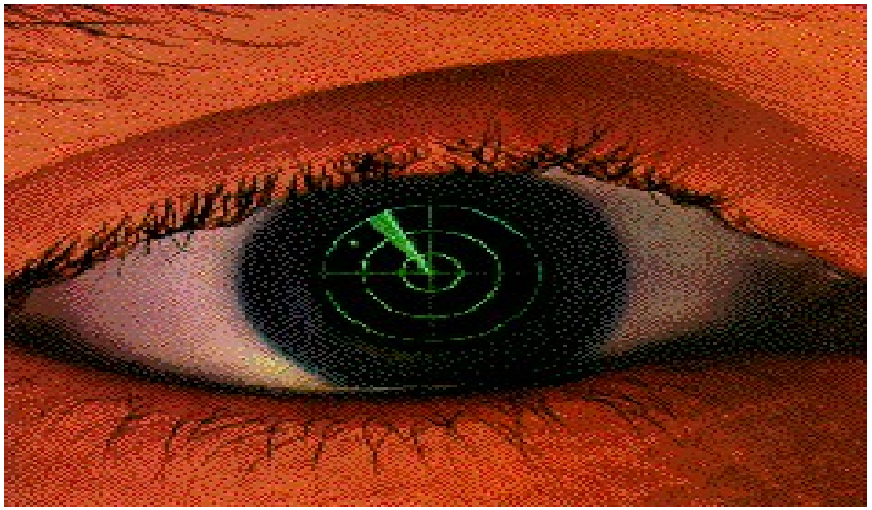

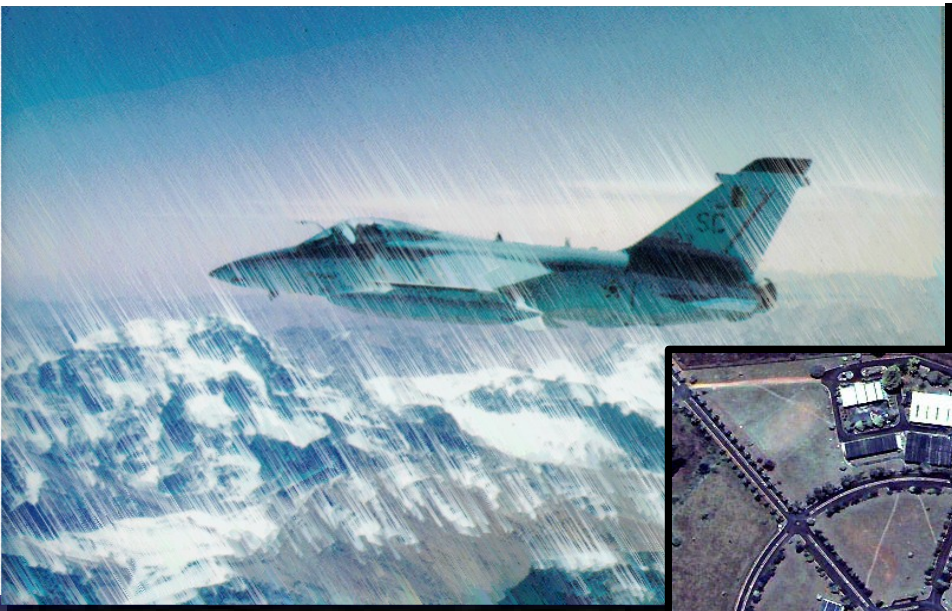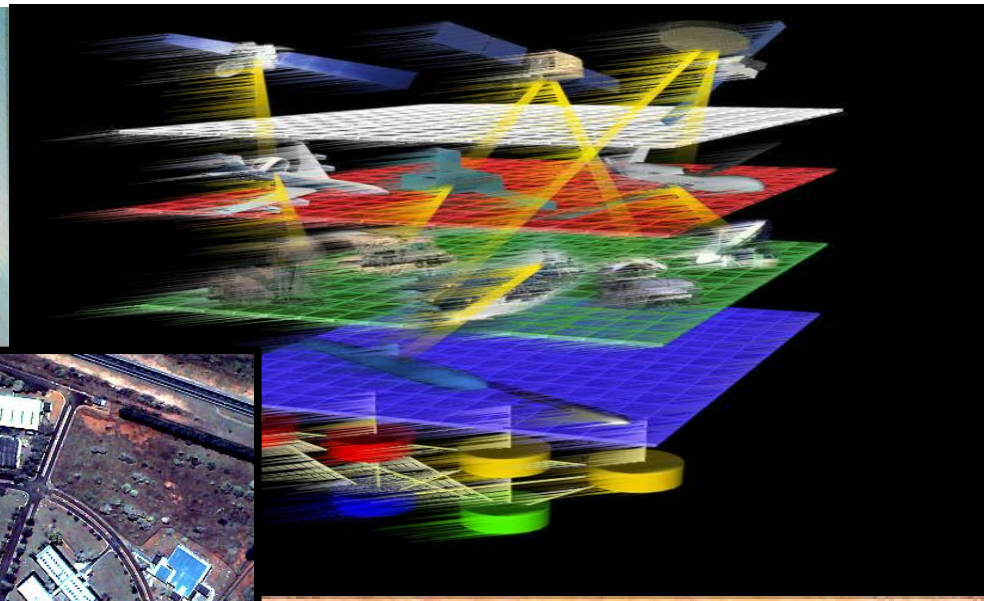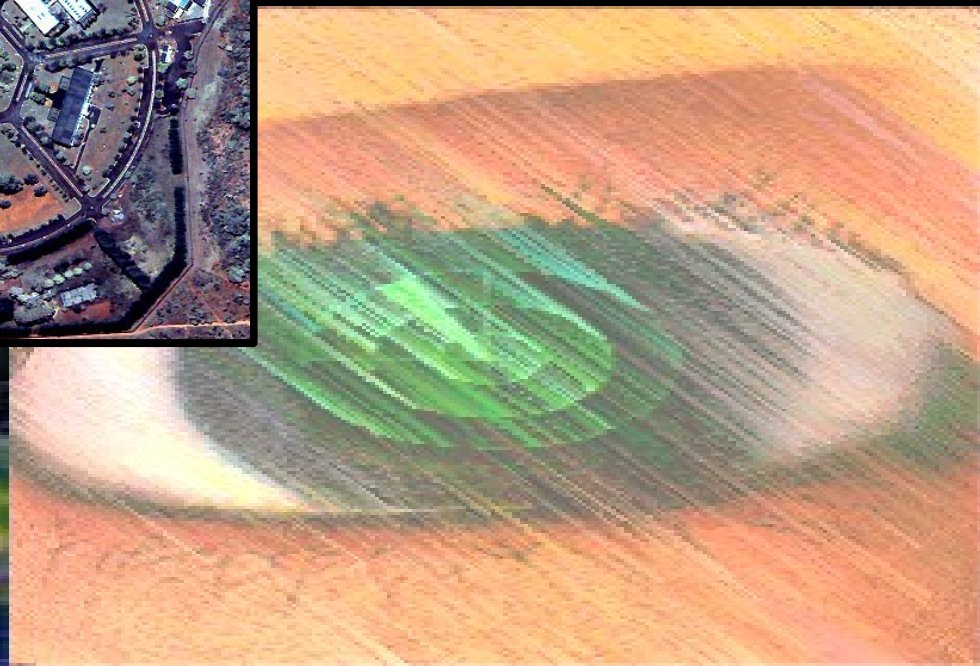
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