14TH ICCRTS

"C2 AND AGILITY"

Title: Planning For Manned And Unmanned Entities in Net-Centric Environment: Missions and Means Framework, Multi-Agent Simulation

SUGGESTED TOPICS: INFORMATION SHARING AND COLLABORATION PROCESSES AND BEHAVIORS; EXPERIMENTATION AND ANALYSIS; MODELING AND SIMULATION

Name Of Author(s): Kofi Nyamekye, Ph.D.
*** Maarten Sierhuis, Ph.D.**
*** Ron van Hoof, Computer Scientist**

Point of Contact: Kofi Nyamekye, Ph.D.

Name of Organization: INTEGRATED ACTIVITY-BASED SIMULATION RESEARCH, INC.

Address: P.O. BOX 421, Rolla, MO 65402

Telephone: 573-341-2141

E-mail address: kofinsoyameye@earthlink.net

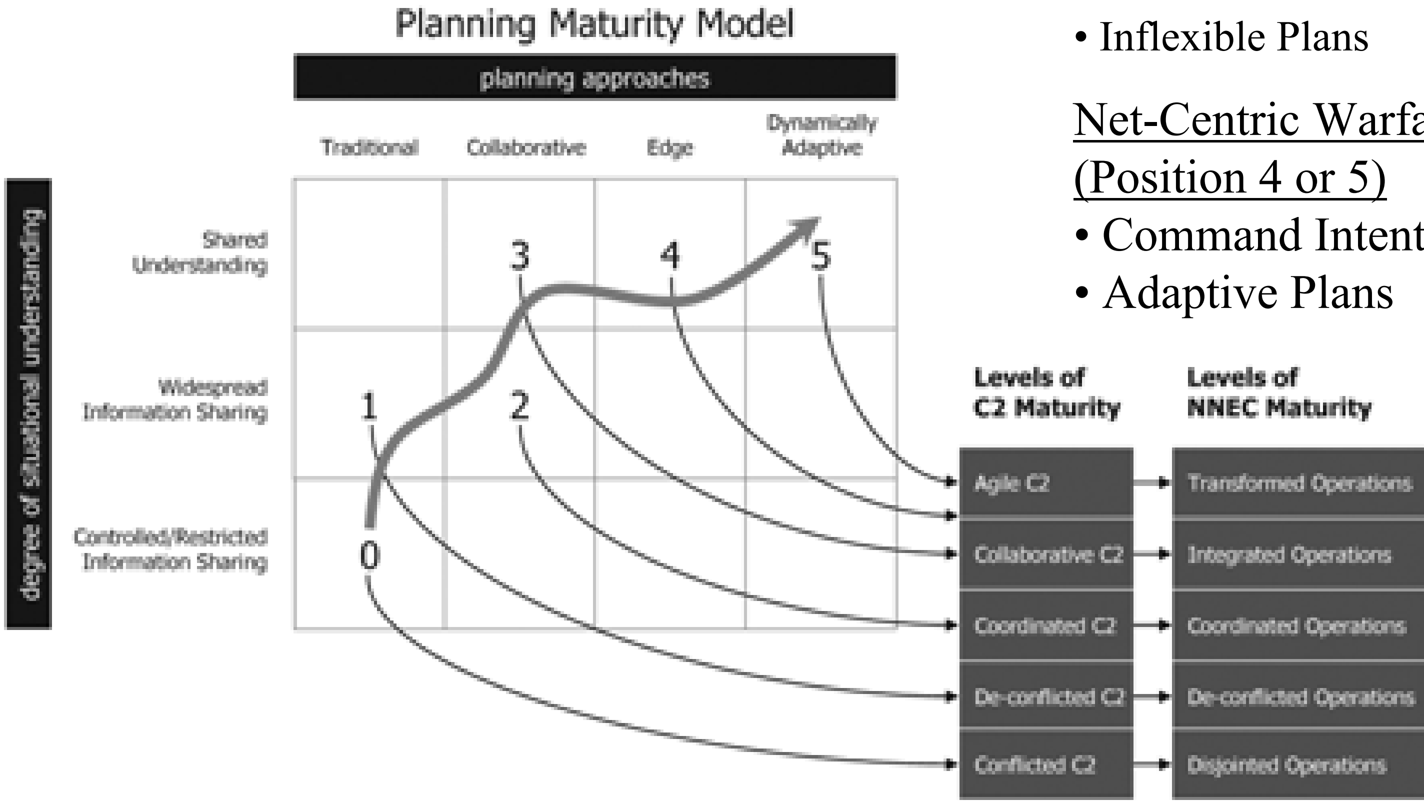
*** NASA Ames Research Center**

OVERVIEW

- Industrial Age Military Planning
- Deficiencies in Industrial Age Approach
- Net-Centric Warfare Approach
- Rittel's Work in Planning
  - Planning As An Example of Wicked Problems
  - Issue-Based Information Systems (IBIS)
  - Compendium as An Example of IBIS
- Axiomatic Design
  - AXIOMS 1 & 2, Corollaries
  - IBIS as An Extension of Corollary 4
- Multi-agent Simulation
  - NASA's Brahms
- Missions and Means Framework Model
- Generic High-Level Architecture Design for Collaborative Planning
- Conclusions
- Wrap-up and Questions

Traditional Planning (Position 0)
- Hierarchical (Cold War Model)
- Planning and Execution Separate
- Centralized
- Detailed Plans
- Inflexible Plans

Net-Centric Warfare (Position 4 or 5)
- Command Intent
- Adaptive Plans

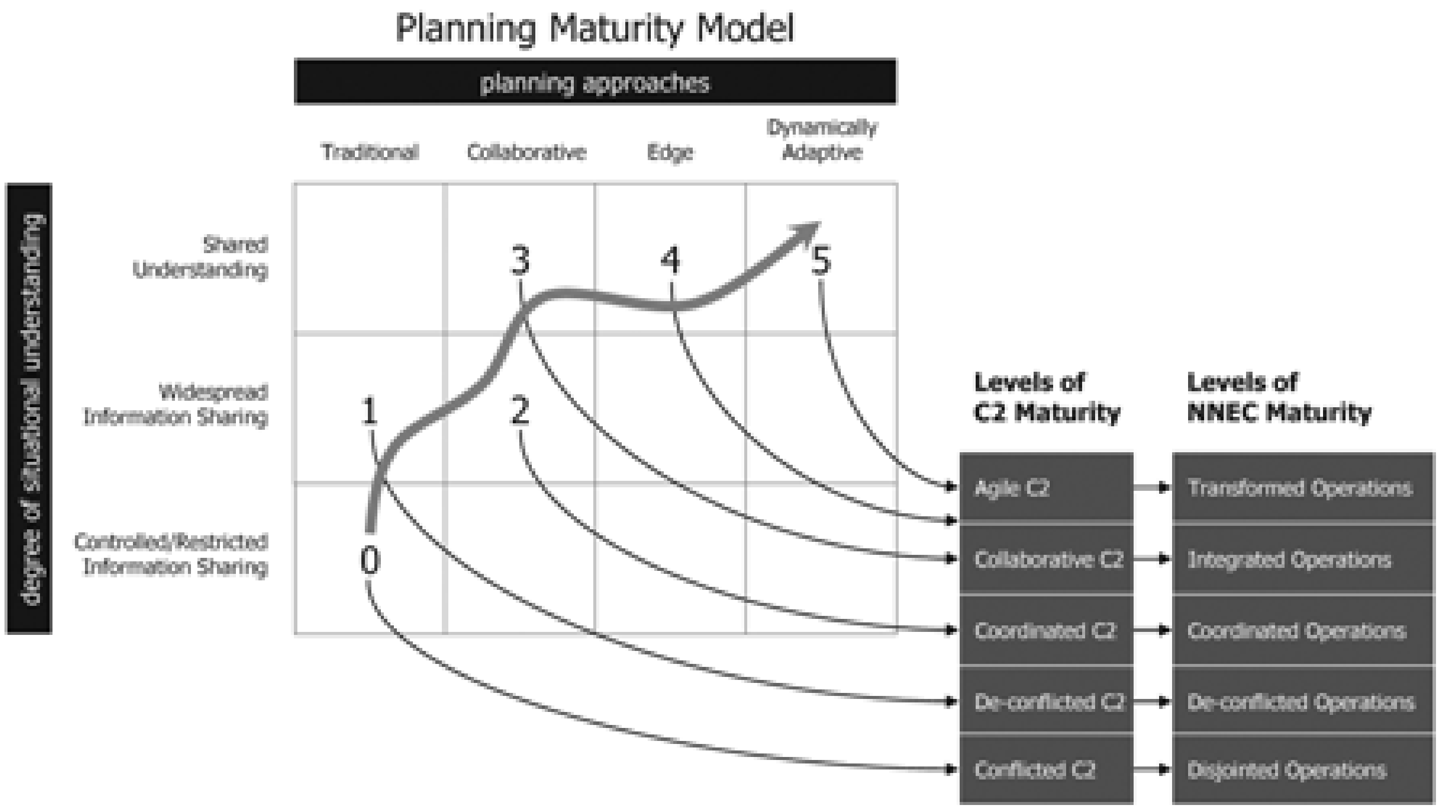


Focus For This Paper Is On Position 4 – "Distributed Collaborative Tactical Planning"

Net-Centric Capability and Command and Control Planning Maturity Models (NCCC2PMM) [Alberts et al. 2007].

Deficiencies In Traditional Planning Approach

- Hierarchical (Cold War Model) – Too Many Layers Needed for Planning
- Planning and Execution Conducted Separately
- Centralized Planning—Warfighters Never Involved in the Planning Loop
- Detailed Plans Needed for Execution – Too Much Time for Planning
- Inflexible Plans – Assumes That Adversary Is Always Hunkered Down in a Static Environment



Position 4 or 5 for Net-Centric Warfare Planning

RITTEL's GENERAL THEORY OF PLANNING: ISSUE-BASED INFORMATION SYSTEMS

- Wicked problem -- A problem that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize.
- Classical Scientific Concepts such as Operation Research not adequate to solve wicked problems
- Planning is an example of a wicked problem.
- Issue-Based Information Systems (IBIS), for solving wicked problems
- Compendium as a generic open source R & D system, as an example of IBIS

BRIEF OVERVIEW OF AXIOMATIC DESIGN– SUH FROM MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT)

TWO AXIOMS:

AXIOM 1: In a good design, the independence of functional requirements (FRs) is maintained.

AXIOM 2: The design that has the minimum information content is the optimal design.

On the battlefield, how much collateral damage, and how many casualties are "acceptable" in a theater operation, are examples of FRs [Alberts et al. 2003].

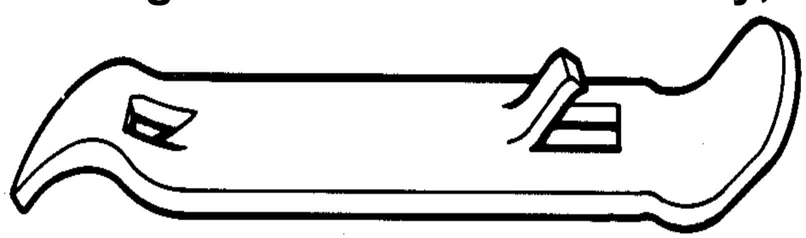
In addition to the functional requirements, a set of constraints may also exist. Constraints are factors that establish the boundary on acceptable design solutions. For example, some designers treat cost as a constraint. Constraints are very similar to functional requirements in character and attributes except that the independence of constraints is not required in a good design.

The figure below shows can and bottle opener. This device satisfies two objectives or functional requirements (FRs). The FRs are fulfilled by the following physical solutions or design parameters (DPs):

Goal 1 (FR1): Open cans; DP1: Can Opener

Goal 2 (FR2): Opens bottles; DP2: Bottle Opener

If the requirements are not to perform these two functions simultaneously, then this physically integrated device satisfies two independent goals or functional requirements (FRs). Otherwise ***coupling*** occurs if both goals must be concurrently met with the same device. We can use Corollary 1 to redesign the device to eliminate coupling, while fulfilling both FRs simultaneously, with both DPs.



Another Example: Iraq Yusufiyah Case, June 21, 2006 – Major Caldwell CNN Transcript
http://transcripts.cnn.com/TRANSCRIPTS/0606/21/sitroom.03.html

Goal 1 (FR1): Engage and defeat the enemy; DP1: 1 vehicle convoy of 3 soldiers
Goal 2 (FR2): Call the support group; DP2: 1 vehicle convoy of 3 soldiers

Among the corollaries and theorems derived from AXIOM 1 and AXIOM 2, the following four corollaries and a theorem, are essential for designing LNCVSDFSS, namely [Suh 1990; Suh 2001]:

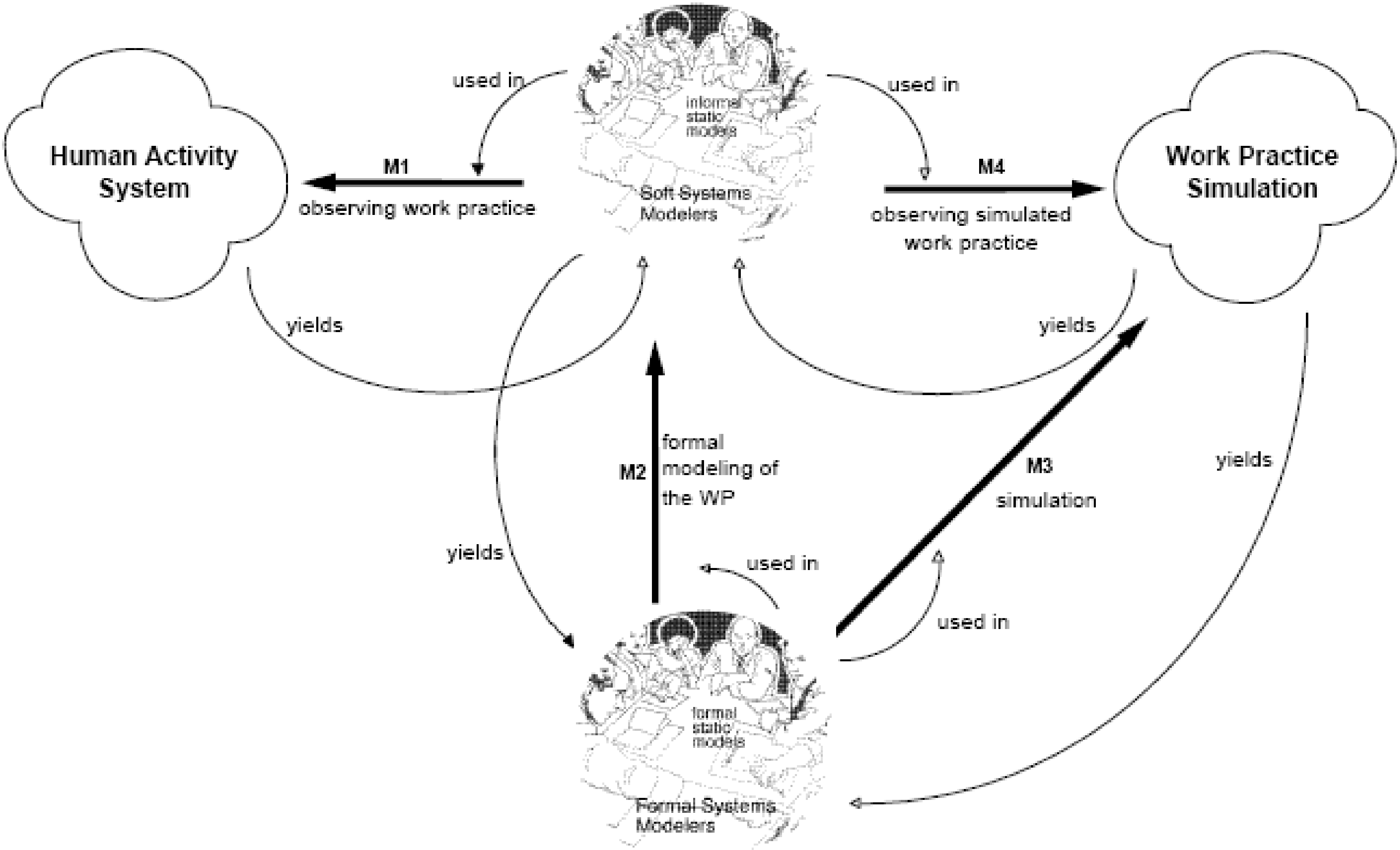
Corollary 1: Decoupling of Coupled Design: Decouple or separate parts or aspects of a solution if FRs are coupled or become interdependent in the proposed designs.

Corollary 2: Minimization of FRs: Minimize the number of functional requirements and constraints. Strive for maximum simplicity in overall design or the utmost simplicity in physical and functional characteristics.

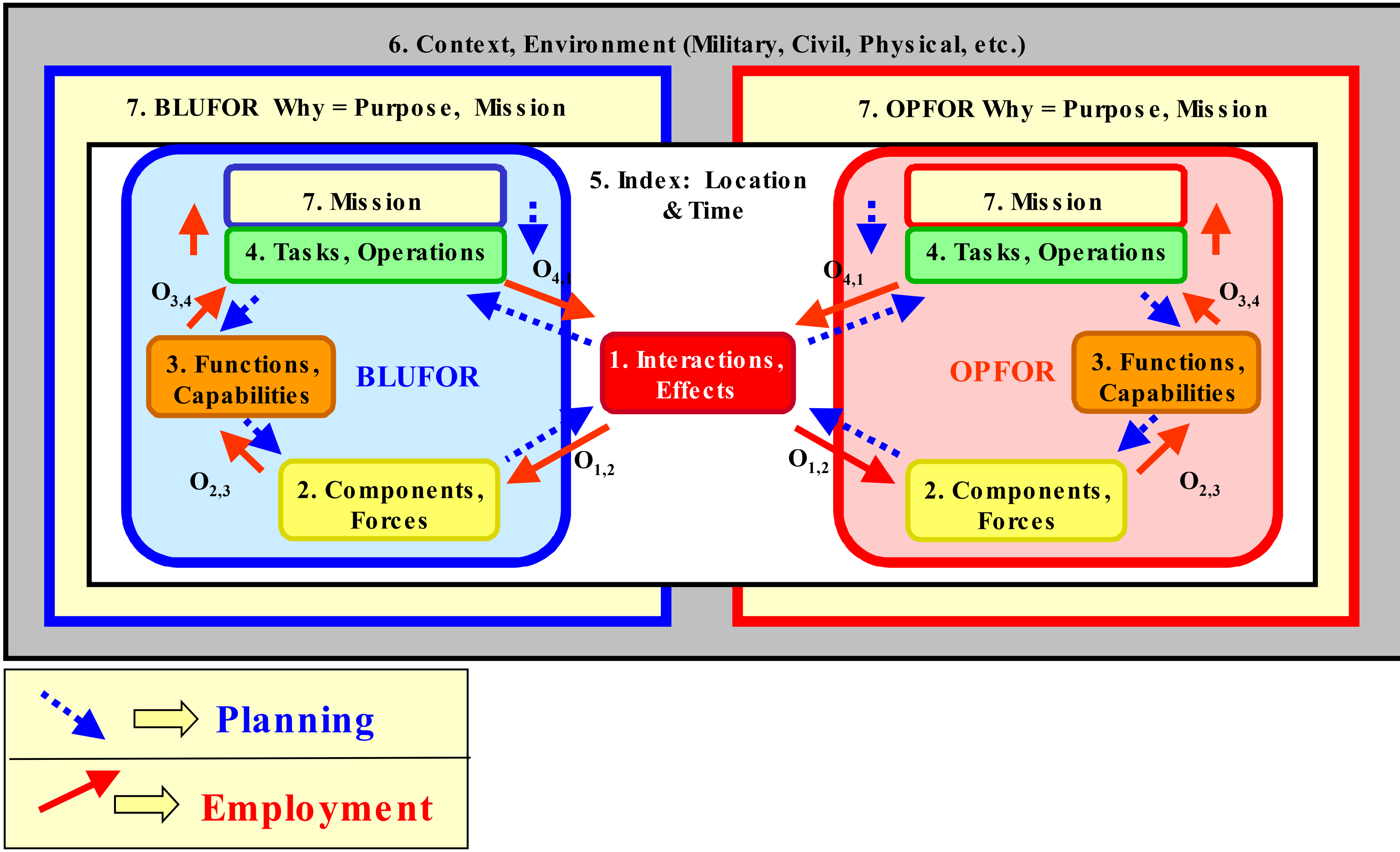
Corollary 3: Integration of Physical Parts: Integrate design features into a single physical process, device, or system when FRs can be independently satisfied in the proposed solution**.**

Corollary 4: Use of Standardization: Use standardized or interchangeable parts, architecture, process, device, or system if the use of these parts, architecture, process, device, scientific concept, or system is consistent with the FRs and constraints. This corollary establishes the governance model for designing any large-scale SoS. *Note: IBIS is an Extension of Corollary 4*

THEOREM M2 (Large System with Several Subunits) When a large (e.g., organization) consists of several subunits, each unit must satisfy independent subsets of FRs so as to eliminate the possibility of creating a resource-intensive system or a coupled design for the entire system.

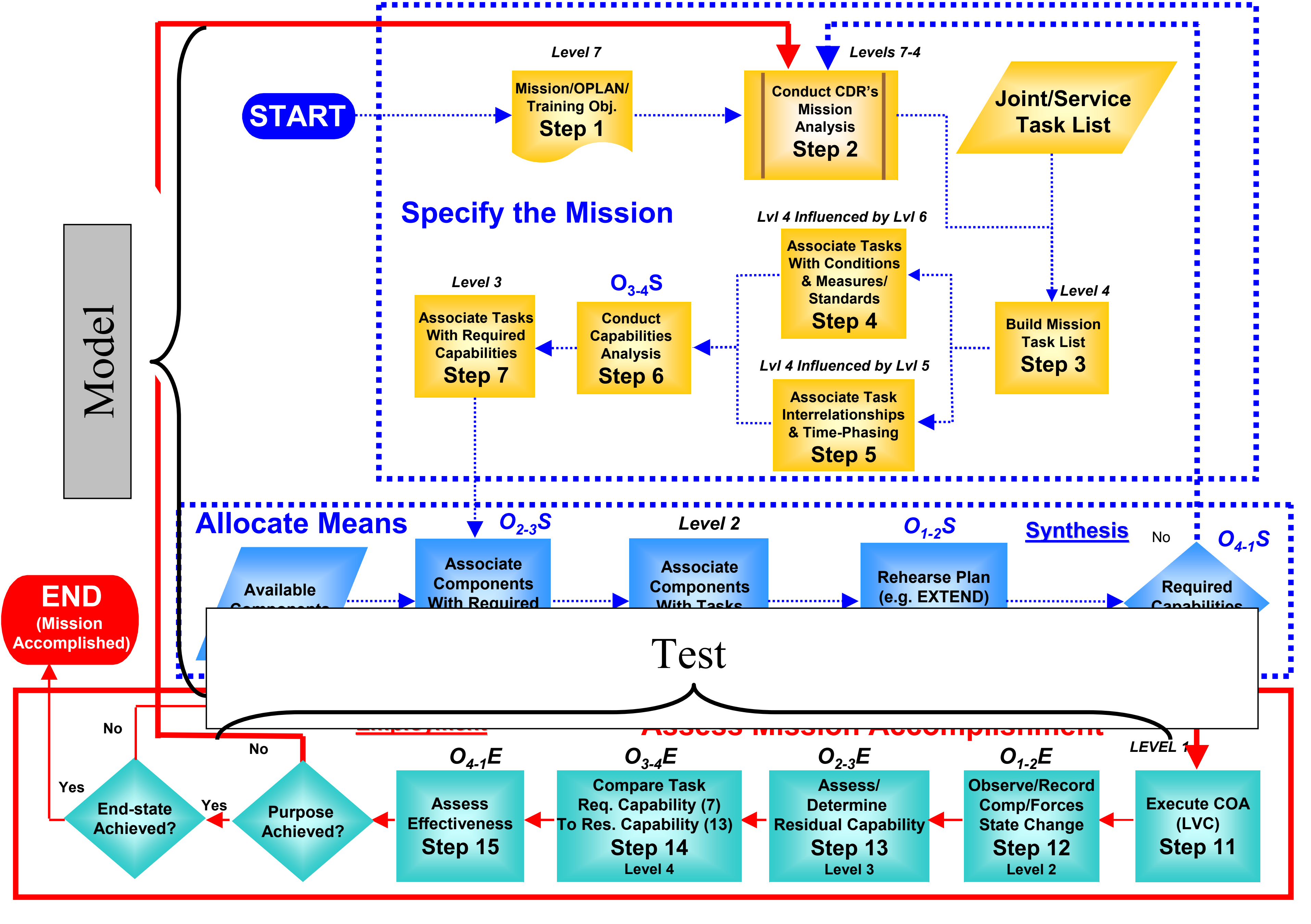


Brahms Multi-Agent Modeling and Simulation Architecture [Sierhuis 2001].

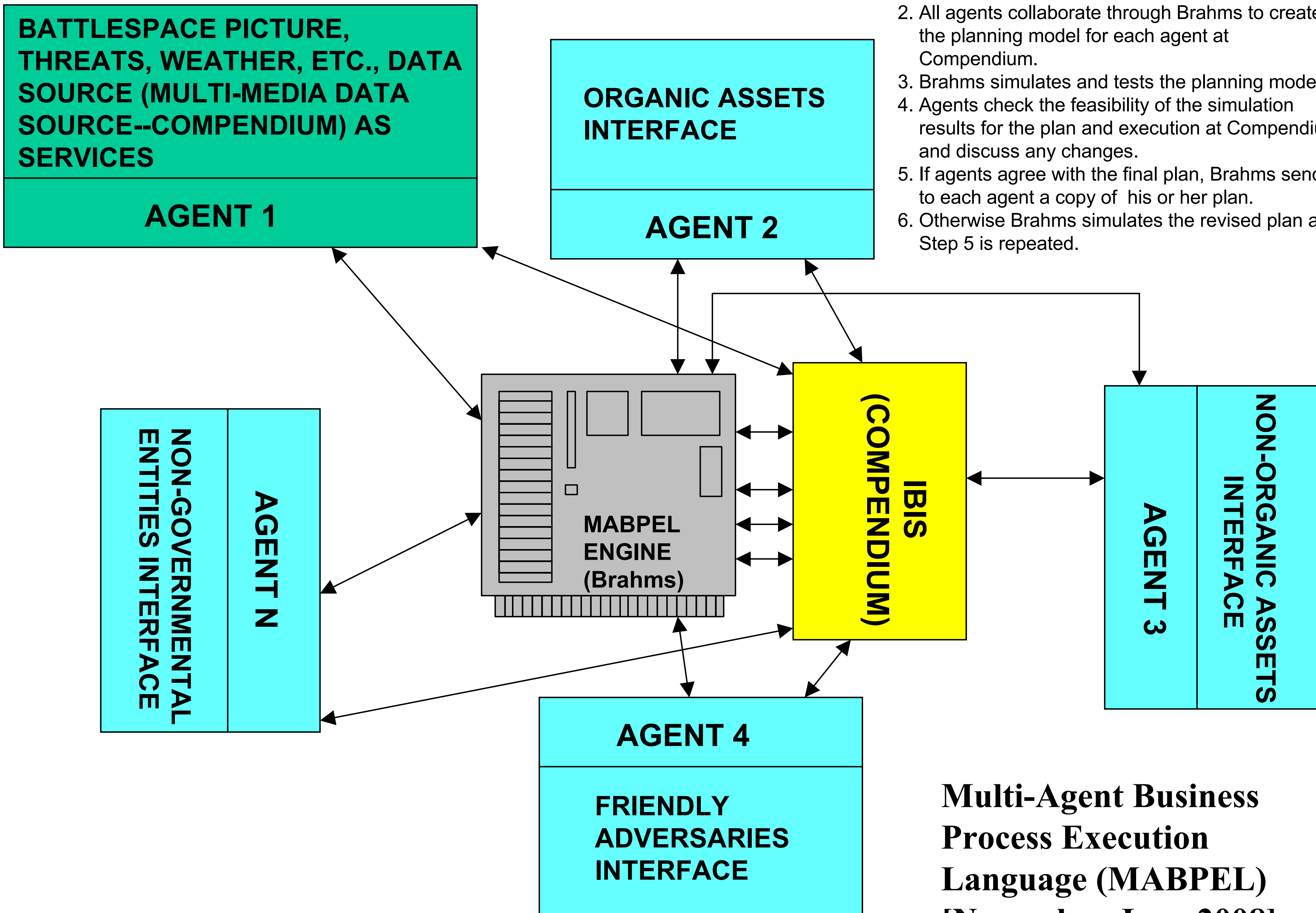


Missions and Means Framework [Dietz et al. May 9 2006].

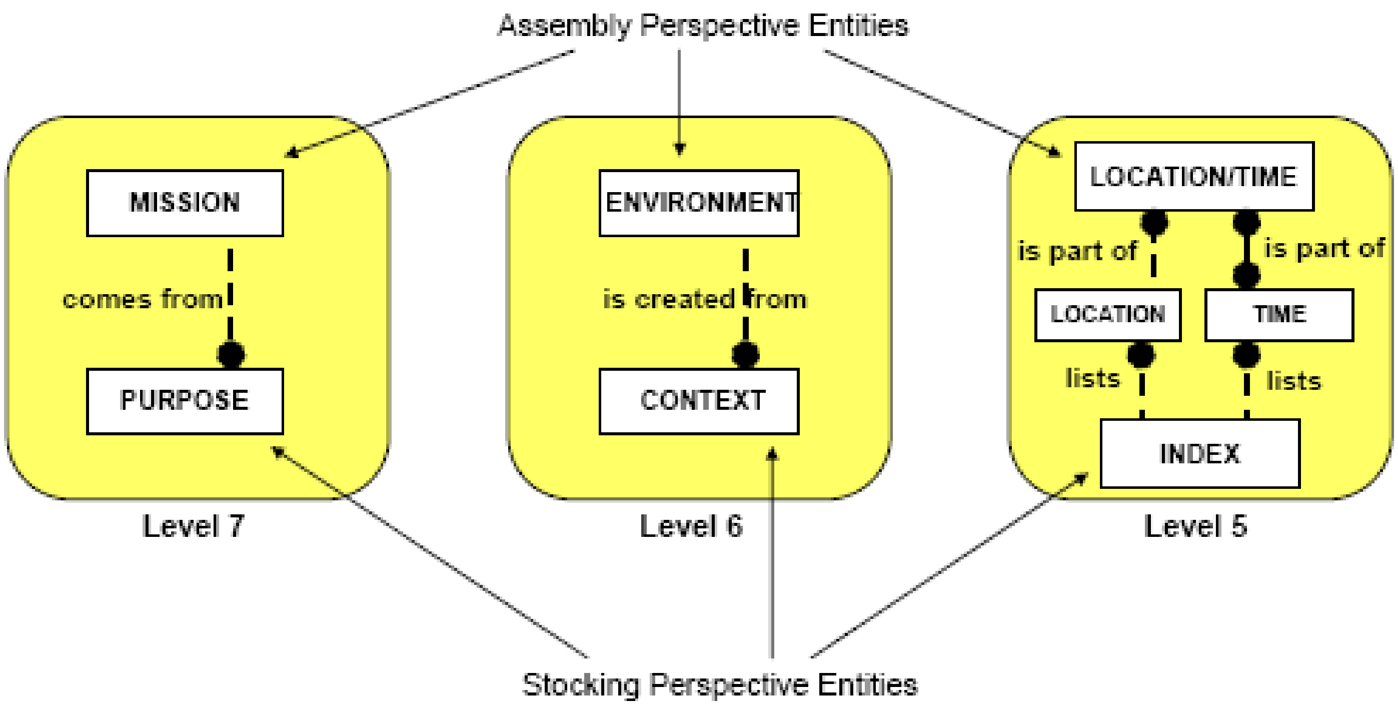
MMF Formal Process Diagram [Dietz et al. May 9 2006].



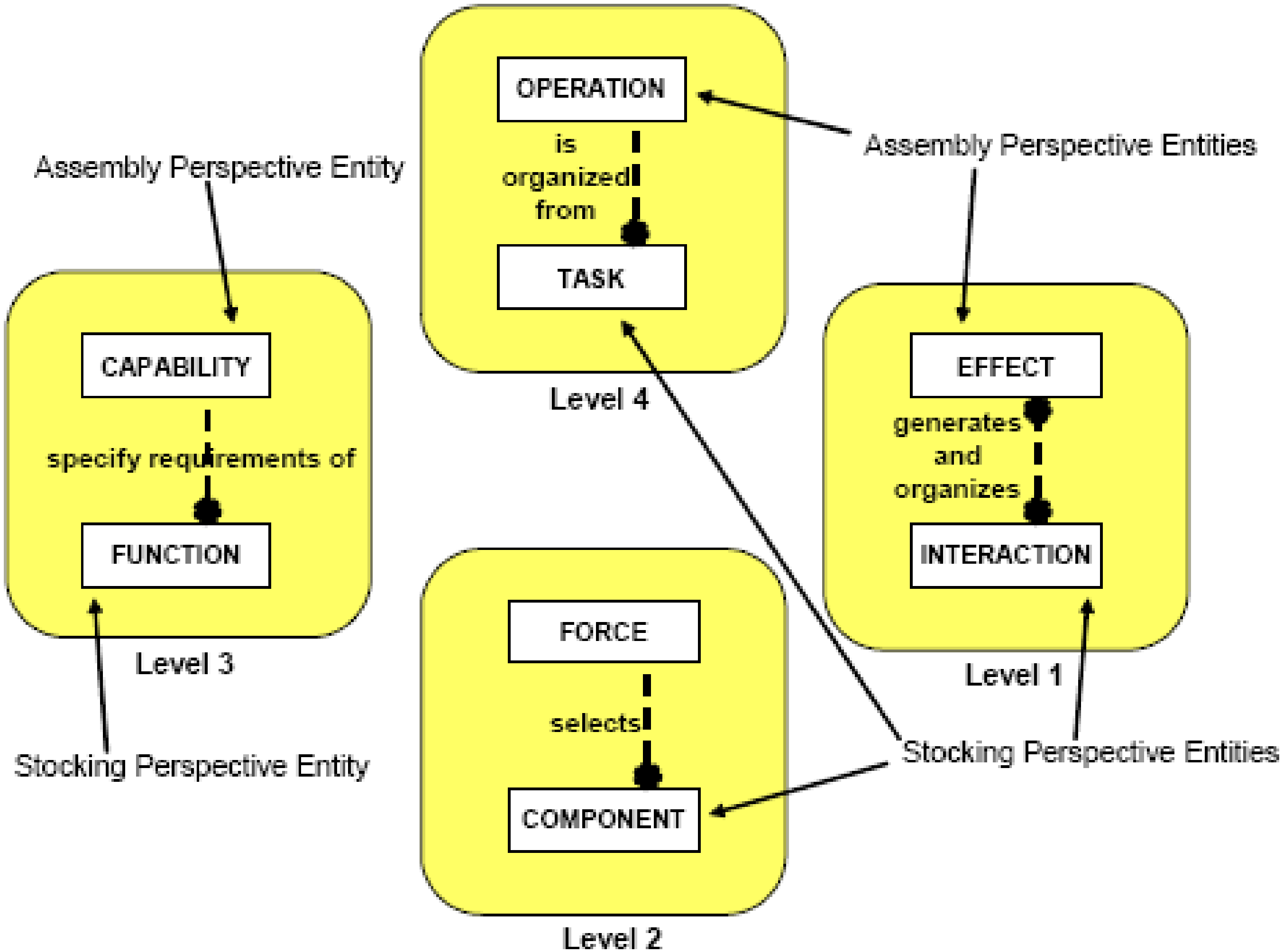
1. Agent 1 sends the battlespace picture to Brahms which shares it with all agents, and creates a copy of the picture in Compendium.
2. All agents collaborate through Brahms to create the planning model for each agent at Compendium.
3. Brahms simulates and tests the planning model.
4. Agents check the feasibility of the simulation results for the plan and execution at Compendium and discuss any changes.
5. If agents agree with the final plan, Brahms sends to each agent a copy of his or her plan.
6. Otherwise Brahms simulates the revised plan and Step 5 is repeated.



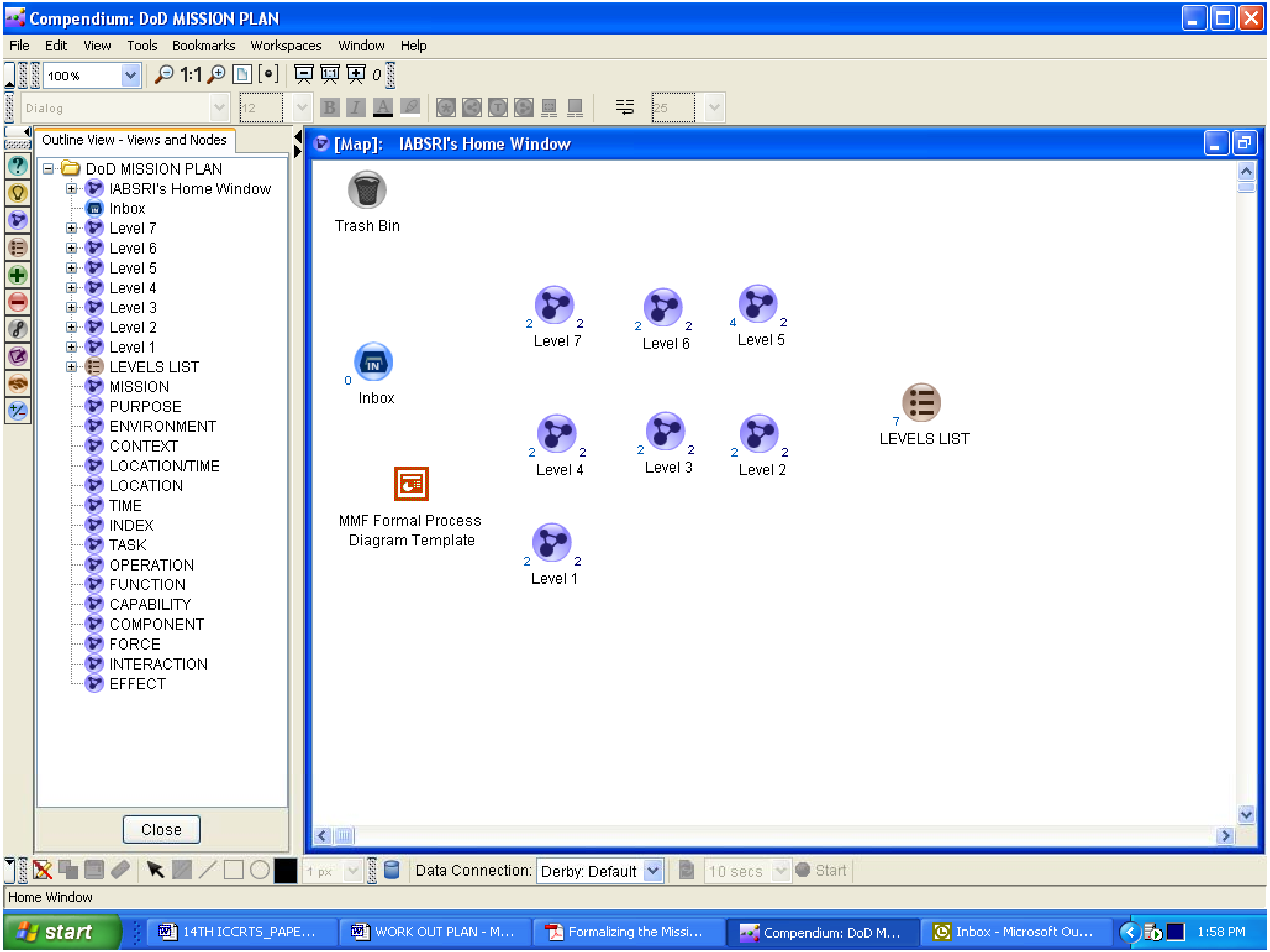
Multi-Agent Business Process Execution Language (MABPEL) [Nyamekye June 2008].



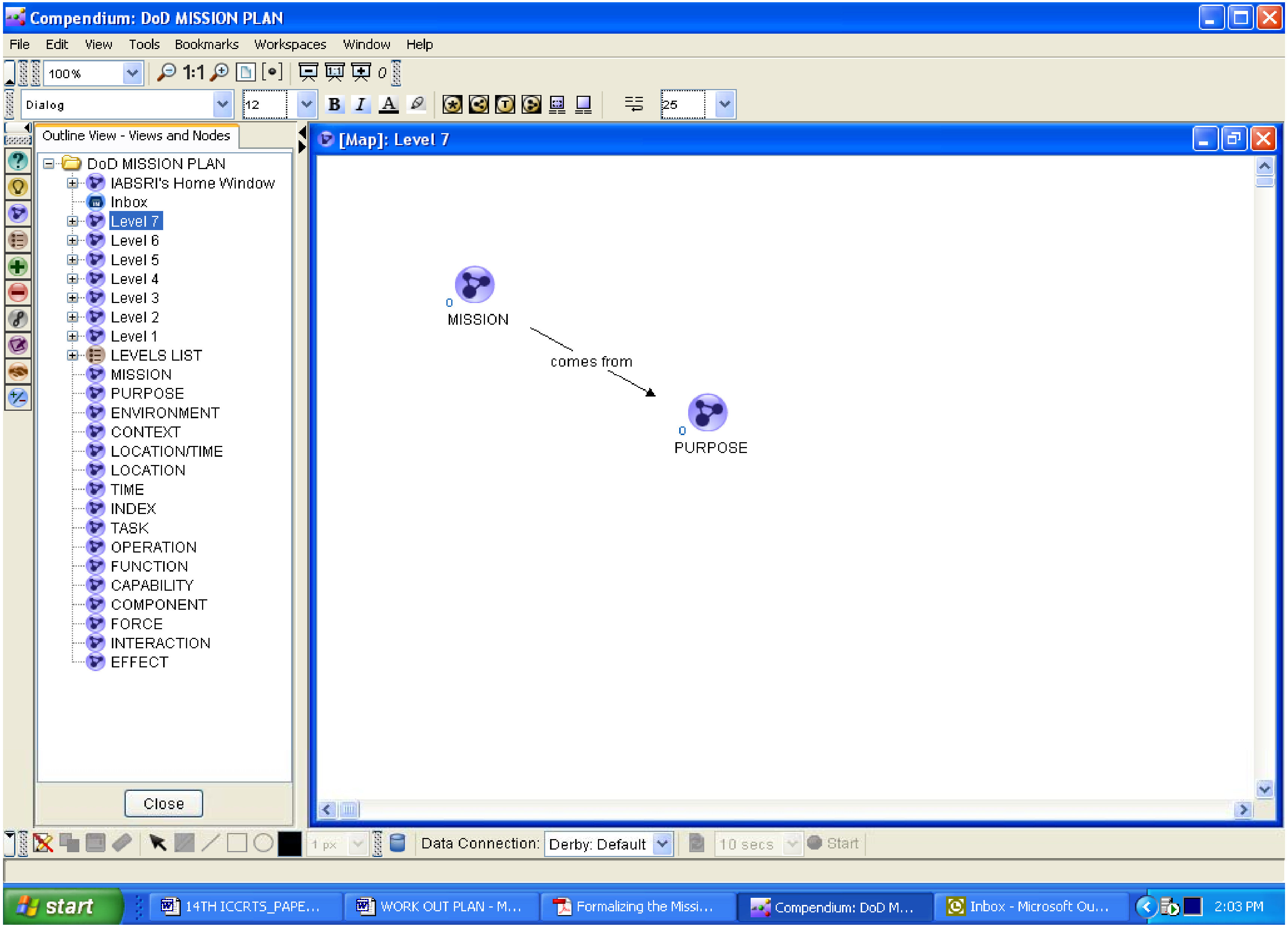
Relationships Between Entities at Each Level for Levels 5-7 [Watkins et al.].



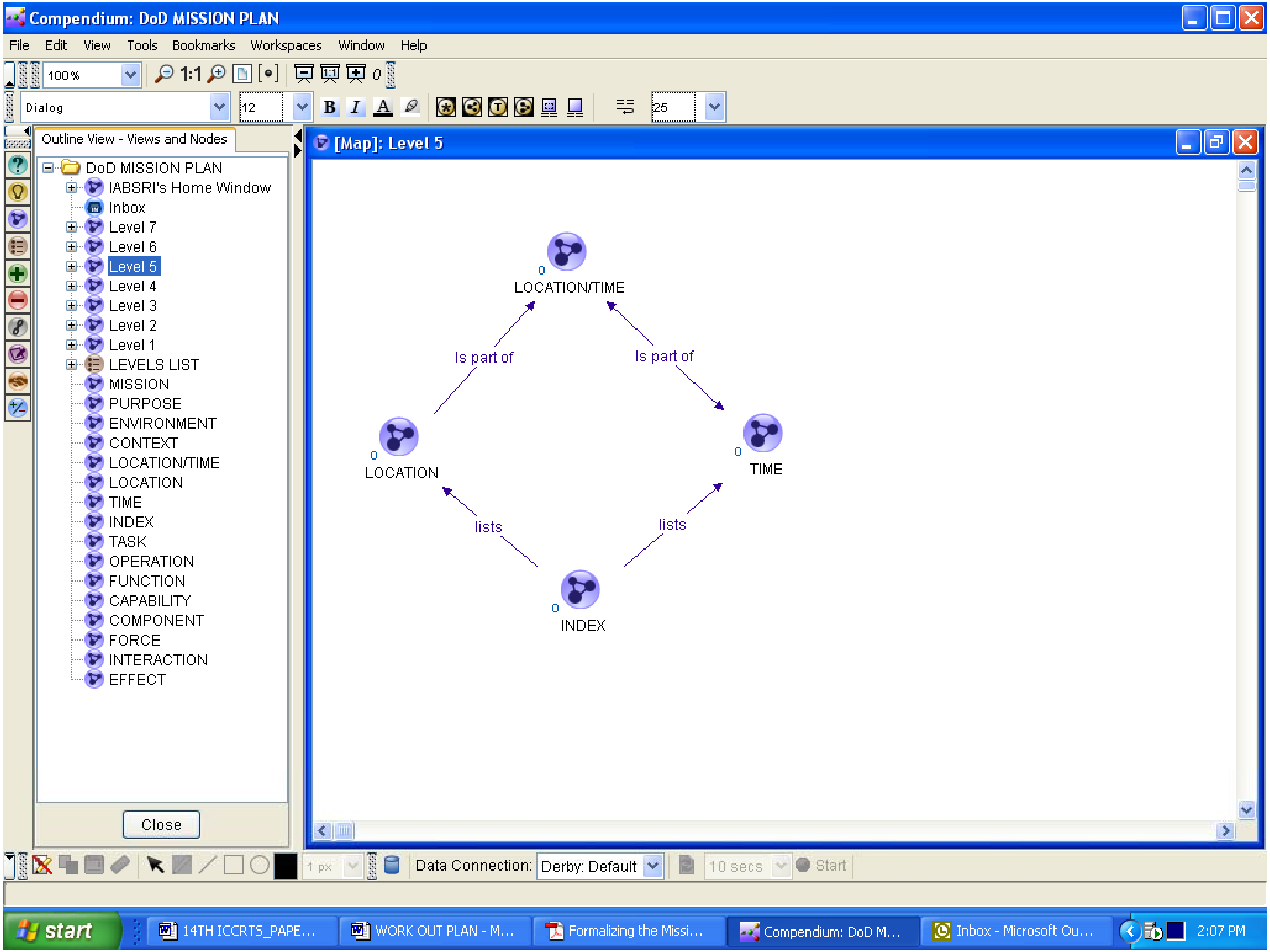
Relationships Between Entities at Each Level for Levels 1-4 [Watkins et al.].



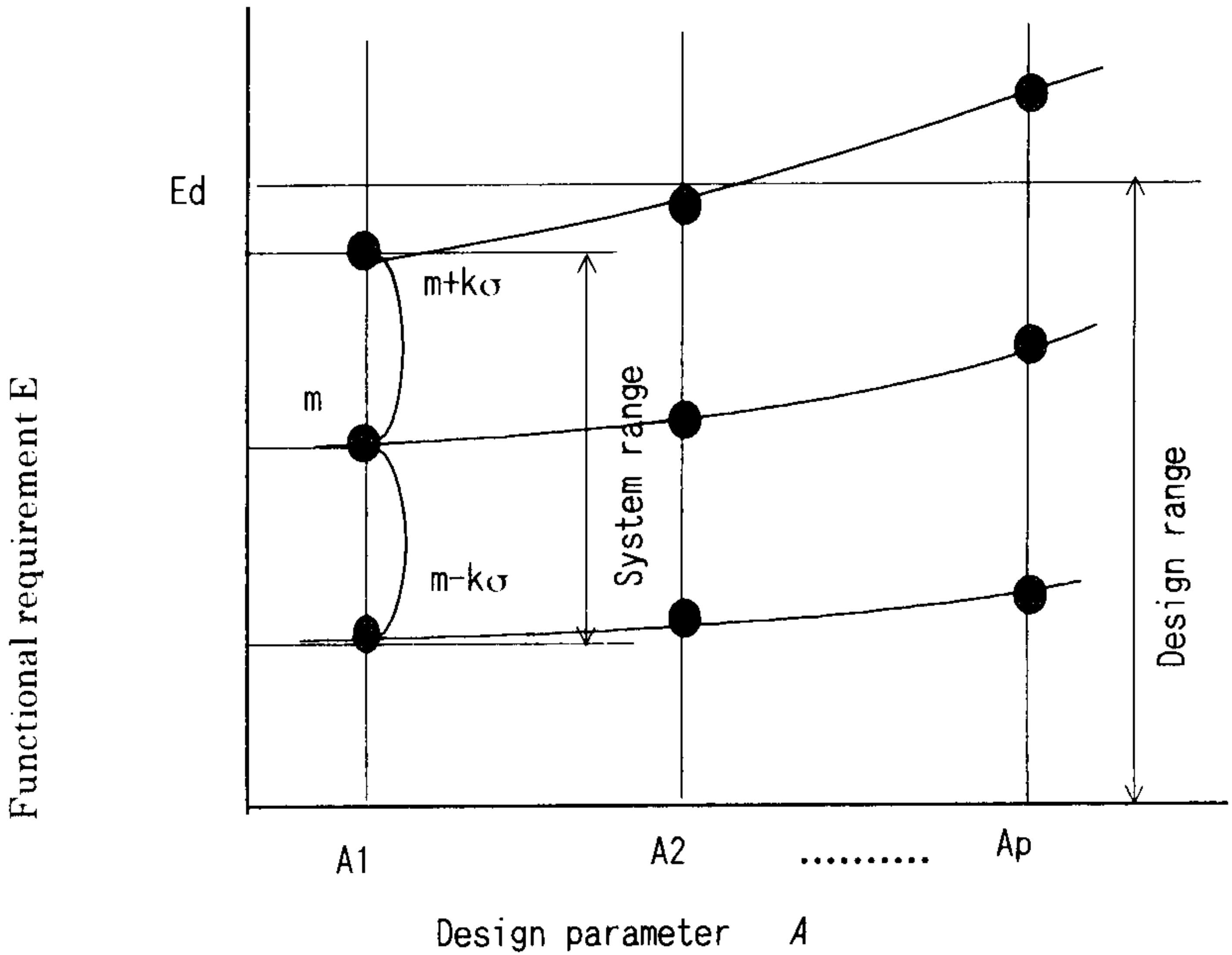
Nodes Representing Levels 1 To 7.



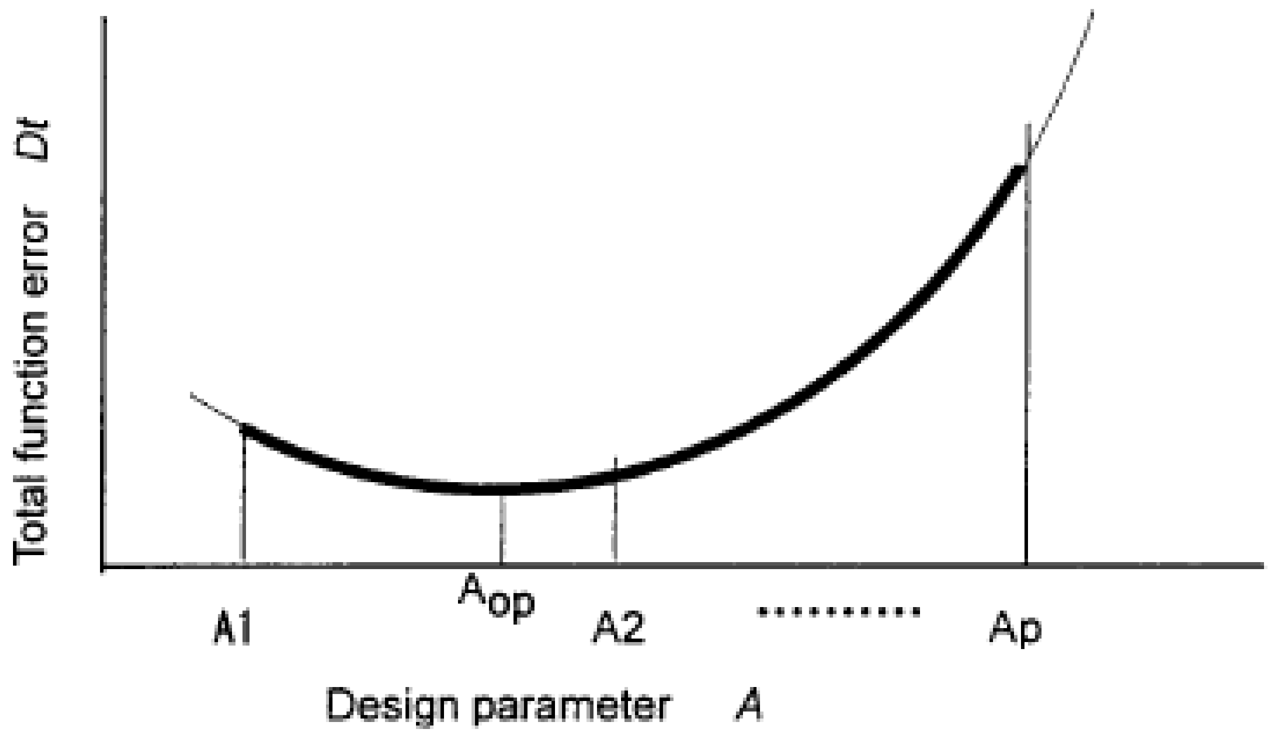
One-To-Many Relationship Between MISSION node and the PURPOSE Node.



The Relationships Among The Four Nodes Associated With Level 5 Node.



System Range of Design Parameter A for Functional Requirement E [Nakazawa 2001].



Total Information Content (Function Error Curve) [Nakazawa 2001].

NO	DESIGN PARAMETERS (DPs)				EXPERIMENTAL OR SIMULATION RESULTS FOR FUNCTIONAL REQUIREMENTS (FRs)		
	A	B	C	D	E	F	G
1	A1	B1	C1	D1	E1	F1	G1
2	A1	B2	C2	D2	E2	F2	G2
3	A1	B3	C3	D3	E3	F3	G3
4	A2	B1	C1	D1	E1	F1	G1
5	A2	B2	C2	D2	E2	F2	G2
6	A2	B3	C3	D3	E3	F3	G3
7	A3	B1	C1	D1	E1	F1	G1
8	A3	B2	C2	D2	E2	F2	G2
9	A3	B3	C3	D3	E3	F3	G3

Table 1. Orthogonal Table For Experimental Design for Evaluating the Collaborative Planning [Nakazawa 2001]. The functional requirements (FRs) correspond to measures-of-merit (MOM).

CONCLUSIONS

Using the Issue-Based Information Systems (IBIS) concepts with Compendium as an example of a generic IBIS for solving wicked problems typical in collaborative tactical planning, NASA Brahms multi-agent oriented modeling and simulation language as a generic language, and Missions and Means Framework Model, the paper discusses the design of a generic high-level approach for distributed collaborated tactical planning--Position 4 in integrated Planning Maturity Models. The paper then borrows from Design Navigation Method, a design scientific method that uses minimum information content theory (AXIOM 2 of Axiomatic Design) to discuss evaluating the test plans. The concepts from the paper can be adapted to designing any ad hoc distributed collaborative tactical planning system that involves many stakeholders with different agendas, for example in humanitarian assistance efforts during natural disasters such as Katrina and Tsunami. Such mission planning involves only specifying the Unity of Command (for example from United Nations) to each participating organization. Each participating organization then develops and tests the plan to fulfill the Unity of Purpose. No hierarchical Command and Control structure occurs in such mission planning scenarios. We can use it for planning for any Edge-Based organization [Sviokla November 11 2008]. More importantly, we can use the concepts to dynamically create adaptive distributed collaborative tactical planning systems for building ad hoc value ecosystems such as the supply chains for the construction industry, or even intelligent adaptive collaborative tactical planning for distributed energy infrastructure, which adapts itself on-demand to changing energy requirements of the customers, thereby achieving an overall energy efficiency of the ecosystem.