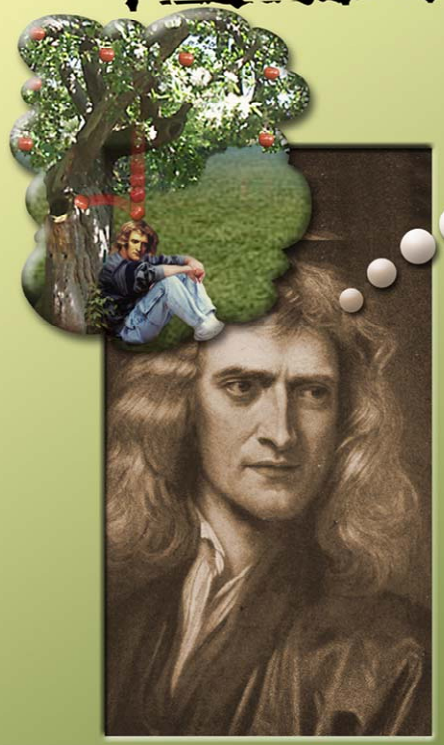
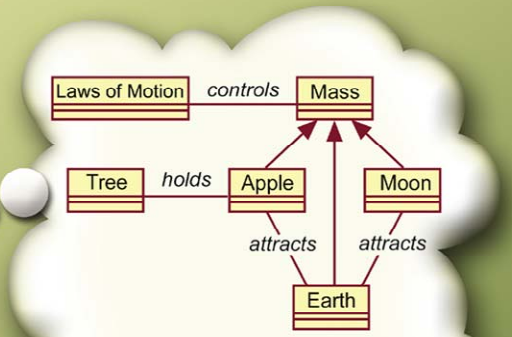
CONCEPTUAL MODELING PRACTICE



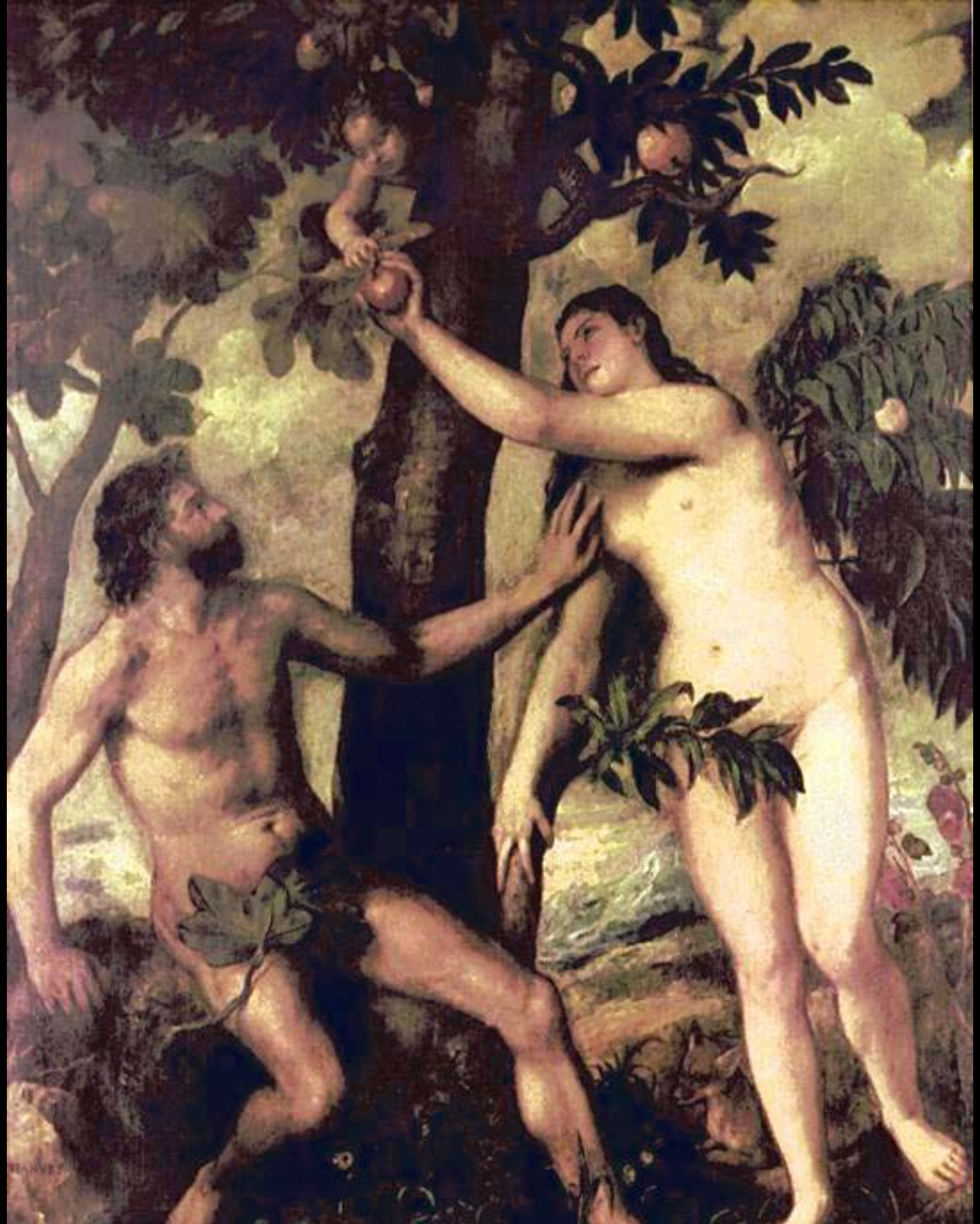


$$F = \frac{Gm_1m_2}{r^2} \qquad \vec{F} = m\vec{a}$$

$$\vec{v} = \int \vec{a}\,dt + c_1$$

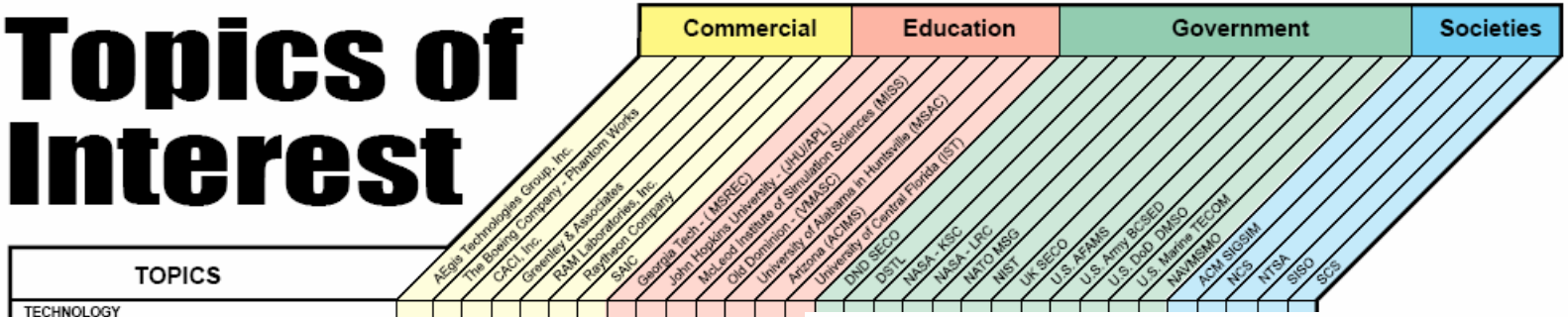
$$\vec{d} = \int \vec{v}\,dt + c_2$$

Wednesday, July 18, 2007
1:30 – 3:00
Sierra 5



SimSummit Topics

Topics of Interest



TOPICS
TECHNOLOGY
Research Agenda
Conceptual modelling
Composability
Interoperability
Data Management
Architecture Management
Standards
PROFESSIONAL DEVELOPMENT
Stakeholders
Community-of-Practice
WD Needs / Requirements
Body-of-knowledge Specification
Curricular Management
Professional Certification
Code of Ethics
INDUSTRIAL DEVELOPMENT
Identity, recognition
Scope
Fragmentation Versus Synergy
Labor Classification Codes
Industrial Classification Codes
M&S Asset (life-cycle) Management
Organizational Relations
Event Coordination
BUSINESS PRACTICE
Economics of M&S
M&S Market Description
M&S-based Enterprise
Business Case Specification
Acquisition/Procurement Application
M&S Investment (Techonology/Asset/Application) and ROI
Reuse of M&S assets
Cost of ... M&S asset development, uses, etc.
Value of ...
Economic Impact

TOPIC	QUESTION / ISSUE
TECHNOLOGY	What M&S powerful M&S technologies are available? What technology investment is desired?
Research Agenda	What is / ought-to-be the M&S technology research agenda?
Conceptual modelling	How can / do we abstract from our appreciation of the 'referent' to establish a conceptual model suitble for M&S development, qualification, integration, and use?
Composability	How can / do we cost-effectively compose persistent M&S assets into higher-order ensembles?
Interoperability	How can / do we cost-effectively guarantee interoperability of M&S assets reused in alternative contexts or integrated into higher-order ensembles?
Data Management	How can / do we cost-effectively acquire, qualify, use and re-use referent characterisetics / scenario / and behavior data and simulaitn asset operation data?
Architecture Management	What are the implications for M&S of architecture-managmeent concepts and practices (being) applied to: enterprise, objective systems, simulation assets, etc.?
Standards	How do standards affect M&S cost-utility? What standards are worth investment? How should standards definintion, promulgation, and compliance be administered?

Conceptual Modeling (SISO)

Terms of Reference (TOR) For the
SISO Study Group on:
"Simulation Conceptual Modeling"

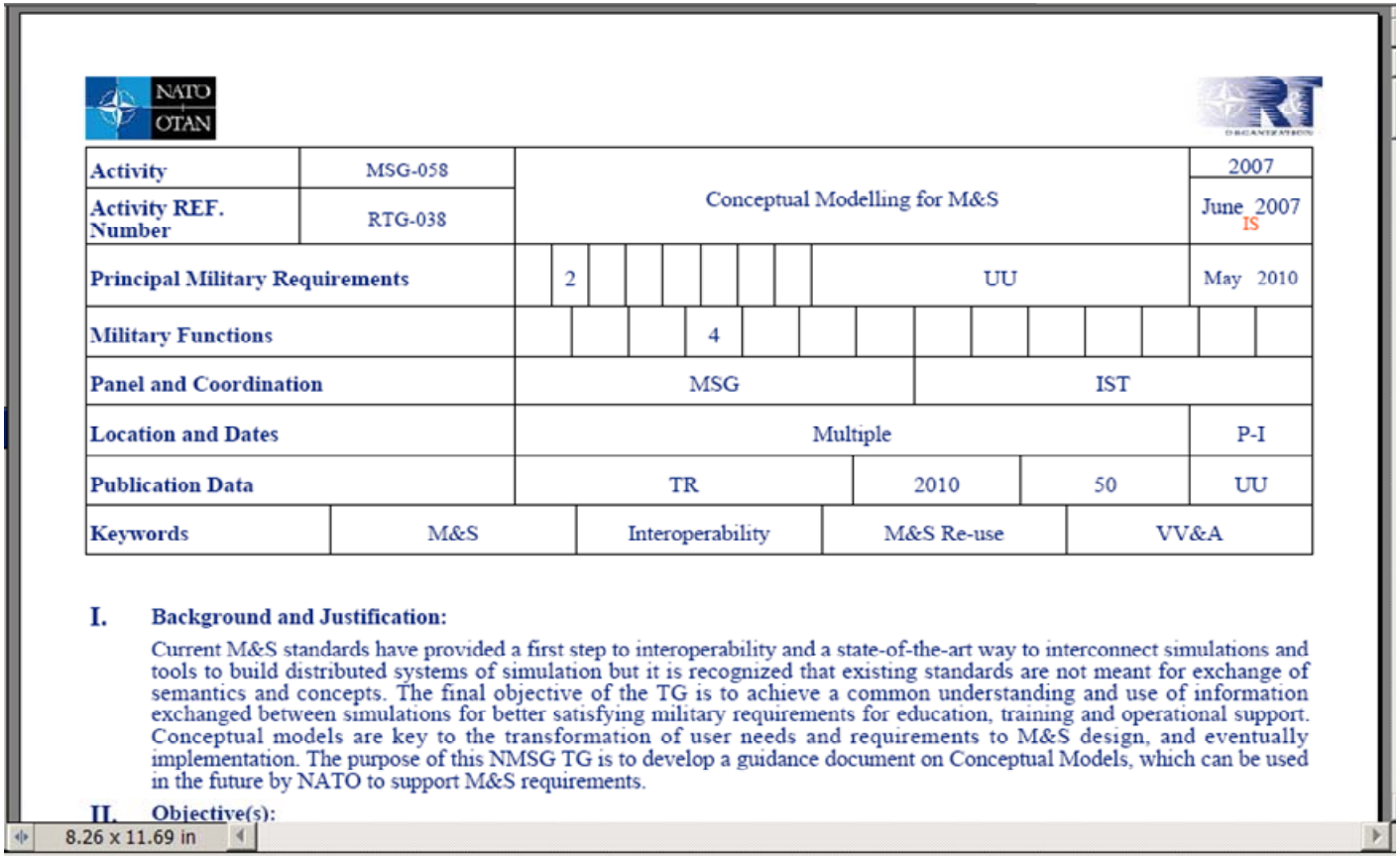
Standing:

Proposed to SISO EXCOM on 5 Dec 2002

Rationale:

The Simulation Conceptual Modeling Study Group is to be formed in order to conduct a preliminary investigation on the best practices of simulation conceptual modeling and to establish recommendations for pursuit of the topic within the scope of the SISO, if appropriate. A simulation conceptual model is an abstraction from either the existing or a notional physical world that serves as a frame of reference for further simulation development by documenting simulation-independent views of important entities and their key actions and interactions. A simulation conceptual model describes what the simulation will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the stakeholder's requirements. It bridges between these requirements, and simulation design.

Conceptual Modeling (NATO)



Activity	MSG-058	Conceptual Modelling for M&S	2007
Activity REF. Number	RTG-038		June 2007 IS
Principal Military Requirements	2	UU	May 2010
Military Functions	4		
Panel and Coordination	MSG	IST	
Location and Dates	Multiple		P-I
Publication Data	TR	2010	50 UU
Keywords	M&S	Interoperability	M&S Re-use VV&A

I. Background and Justification:

Current M&S standards have provided a first step to interoperability and a state-of-the-art way to interconnect simulations and tools to build distributed systems of simulation but it is recognized that existing standards are not meant for exchange of semantics and concepts. The final objective of the TG is to achieve a common understanding and use of information exchanged between simulations for better satisfying military requirements for education, training and operational support. Conceptual models are key to the transformation of user needs and requirements to M&S design, and eventually implementation. The purpose of this NMSG TG is to develop a guidance document on Conceptual Models, which can be used in the future by NATO to support M&S requirements.

II. Objective(s):

8.26 x 11.69 in

NATO MSG-058,
“Conceptual Modeling for M&S”
MEETING #1
Paris, France

April 16-17, 2007

TOR Objectives

- “Clarify the “Conceptual Model” concepts, discuss the terminology, and emphasize the utility to better formalize Conceptual Models, etc.”
- “Investigate methodologies, simulation and software engineering processes, initiatives and technologies,
- Draft a guidance document on conceptual modeling that can be used by different stakeholders,
- Foster the establishment of the guidance document as a SISO standard.”

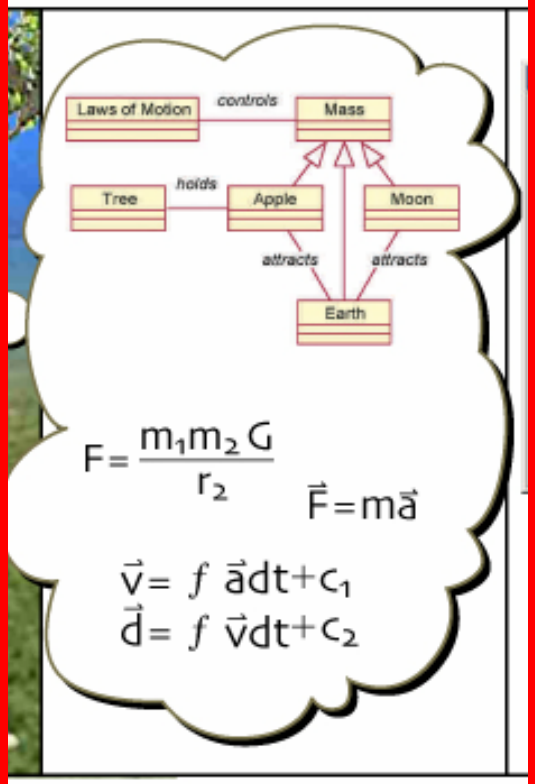
Distributed Collaborative Program

- *Dispersed membership with coordination meetings*
- Collaboration with NATO Group Activities:
  - MSG-054 Task Group on “An Overlay Standard for Verification , Validation , And Accreditation (VV&S) of Federations”.
  - MSG-052 Task Group on “ Establishment of a Knowledge Network for Federation Architecture and Design”
  - Prospective Task group via IST-075 / RTG-034 on “Semantic Operability” (nee IST Group ET-040 on “Ontology Fusion”.

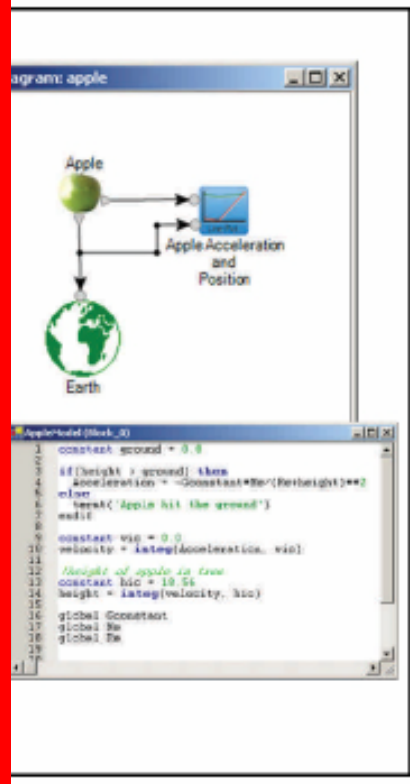
Coordination with SISO for publication dissemination of work product

Role of Conceptual Model

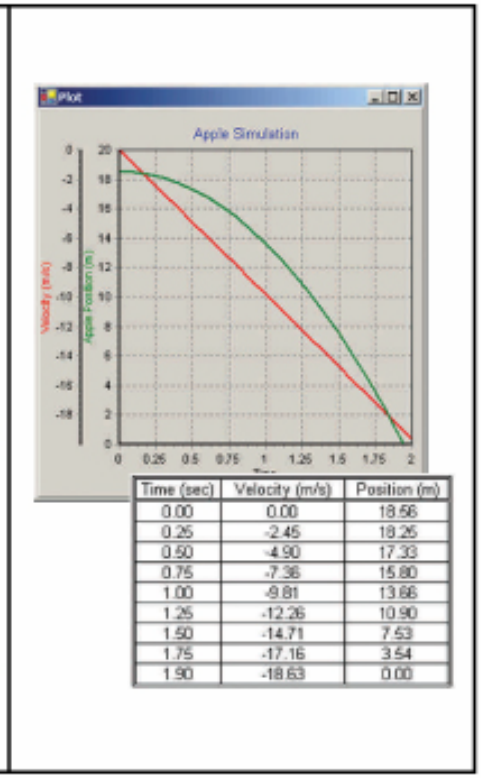
Real World



Conceptual Model



Simulation



Time (sec)	Velocity (m/s)	Position (m)
0.00	0.00	18.56
0.25	-2.45	18.25
0.50	-4.90	17.33
0.75	-7.36	15.80
1.00	-9.81	13.66
1.25	-12.26	10.90
1.50	-14.71	7.53
1.75	-17.16	3.54
1.90	-18.63	0.00

Analytical Results

STUDY GROUP MEMBER DISCISSION
- Perceived Need -

What needs are perceived to exist within the member's operational environment or within NATO that deserve to be addressed, and for which reasonable consequential results are within the scope and capacity of the Study Group to achieve?

STUDY GROUP MEMBER DISCISSION
- Perceived Need -

REFERENCES:

- **Minutes – "First Meeting on the MSA/ET-021 on Simulation Conceptual Modeling" – "Presentations and Discussions**
- **MSG 058 TOR: "Justification, Objectives", "Topics to be Covered:, "Military Objectives"**
- **"Conceptual Modeling- The Missing Link of Simulation Development"** **SISO Borah**
- **"Simulation Conceptual Modeling Standing Study Report: Spring '07 SIW SISO** **SIW Pace**

STUDY GROUP MEMBER DISCISSION
- Intentions and Expectations -

What intentions or expectations are desired to be achieved by the study group that will meet these needs? What are the criteria for success?

STUDY GROUP MEMBER DISCISSION
- Intentions and Expectations -

REFERENCES:

- **Definitions – "Body of Knowledge Definitions"** BOK lex
  "SISO CM References" SISO CM Bib
  "BOK References BOK Refs
- **Practice – "Conceptual Modeling- How do we do it?—A practical example"** SIW Process Rec
- **Process specification – "Unified Process Specification Language: Requirements for Modeling Process"** NISTIR 5910, **"HLA Federation Design / Development and Fed. Impl. Process Model"** HLA Process Spec
- **Best-practice Standard? - TBD**
- **Final Report – "SISO Final Report"** Ref 017-2006

STUDY GROUP MEMBER DISCISSION
- Technical Concepts and Issues -

What technical concepts are important to be understood by the members of the study group in order to operate successfully in a distributed collaborative environment and to produce desired work products?

STUDY GROUP MEMBER DISCISSION
- Technical Concepts and Issues -

1. User needs analysis
2. Technical references and Definitions (what is required of the level of abstraction)
3. Available (useful) programming languages/tools (UML?)
4. Supporting hardware/software needed for CM implementation
5. Standards used by nations and NATO or other international bodies. Is there a need for other standards?
6. Evaluation of nation's potential in CM
7. Impact study on existing technologies (HLA, CORBA, RMI)
8. Risk Analysis on main expected results

STUDY GROUP MEMBER DISCISSION
- Technical Concepts and Issues -

REFERENCES:

- **User needs analysis – Stakeholder roles and requirements analysis …. TBD**
- **Fundamental Concepts – Concepts are?... Ontology is?**
  - **“Conceptual Models in M&S Lifecycle”** Role of CM
  - **“Ontology Development 101”** Intro Ontology
- **Tools – “ A Survey on Ontological Tools”, IST-2000-29243**
- **Existing Technologies and Standards - TBD**
- **Evaluation of nation’s potential in CM - TBD**
- **Risk-Analysis Cost-benefit – Econ of M&S** Survey

Ballistic Missile Defense System (BMDS) Conceptual Model
- ‘Sample Problem’ -

Briefing Purpose and Exposition

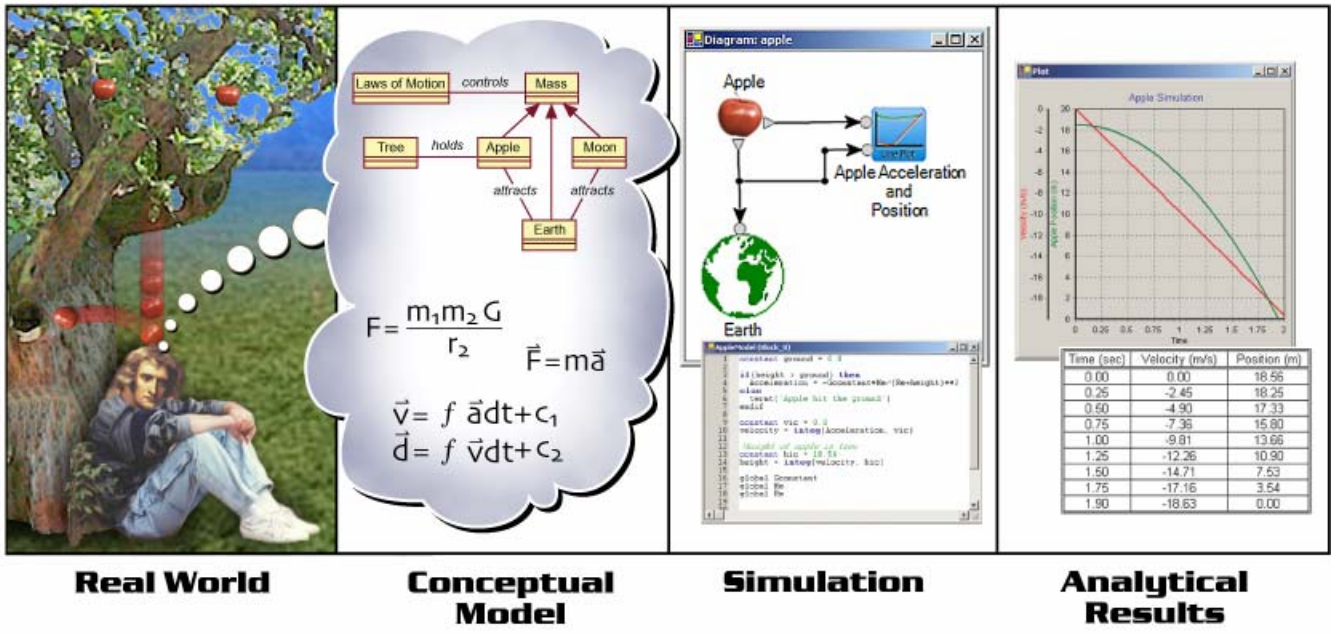
- **What is a "BMDS Conceptual Model"?**
- **What is the BMDS Conceptual Model Tasking?**
- **What Progress has been made?**
- **What Results are available?**
- **What Lessons have been learned?**

BMDS Conceptual Modeling Context – Definitions / Concepts

- Abstraction
- Referent
- Conceptual Model
- Simulation Conceptual Model
- Mission Space (or Real-World) Conceptual Model
- BMDS Conceptual Model
- Conceptual Model Specification
- … others

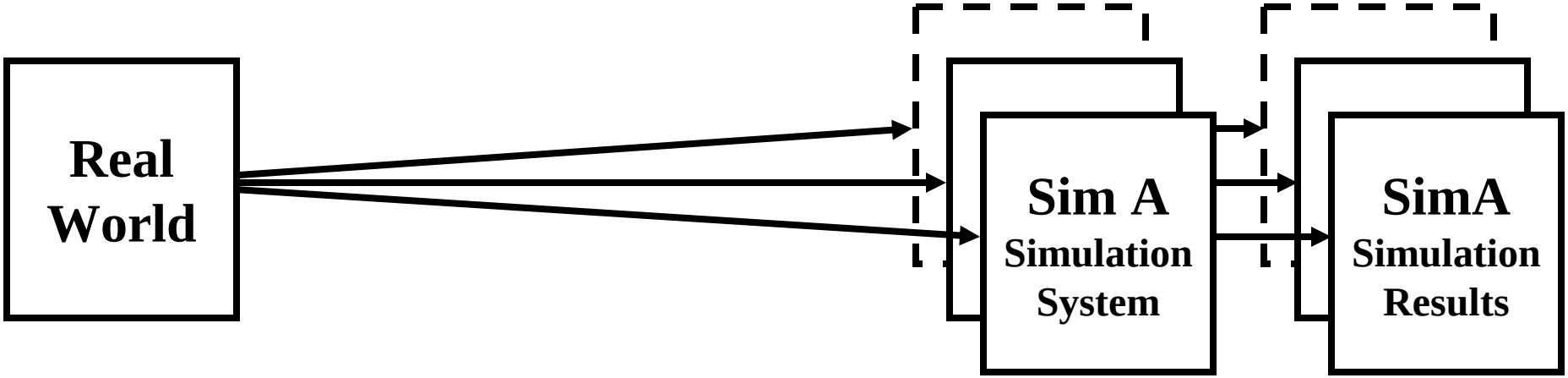
BMDS Conceptual Modeling Context - Circumstance

- **Canonical progression from real-world through conceptual model and simulation implementation to results**



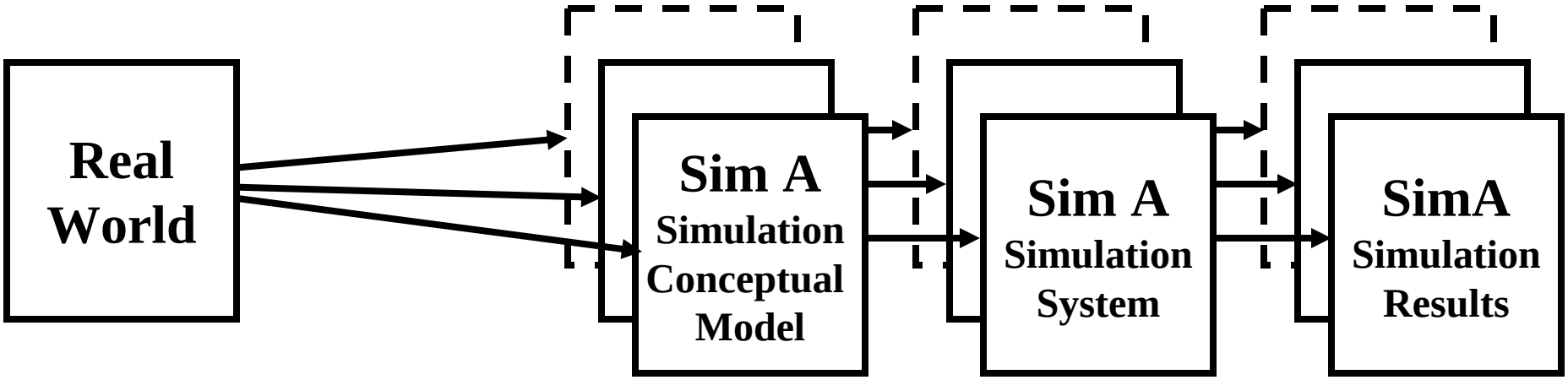
BMDS Conceptual Modeling Context - Circumstance

- **BMDS Simulation representations have been developed in parallel from concurrent, uncorrelated, 'best available' input as to real-world mission-space and entity abstractions**



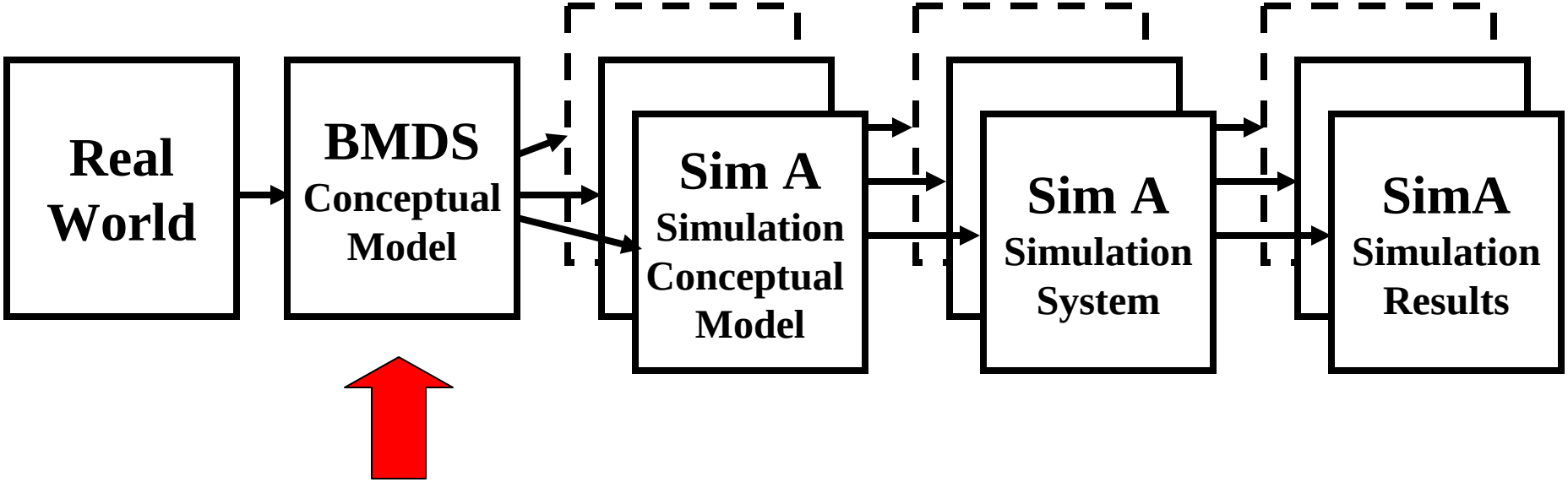
BMDS Conceptual Modeling Context - Circumstance

- **BMDS Simulation representations are now being developed in parallel through formal, controlled simulation conceptual model abstraction specifications**



BMDS Conceptual Modeling Context - Need

- **Formal BMDS conceptual model supports consistent development of simulations' representations**



BMDS Conceptual Modeling Context - Opportunity

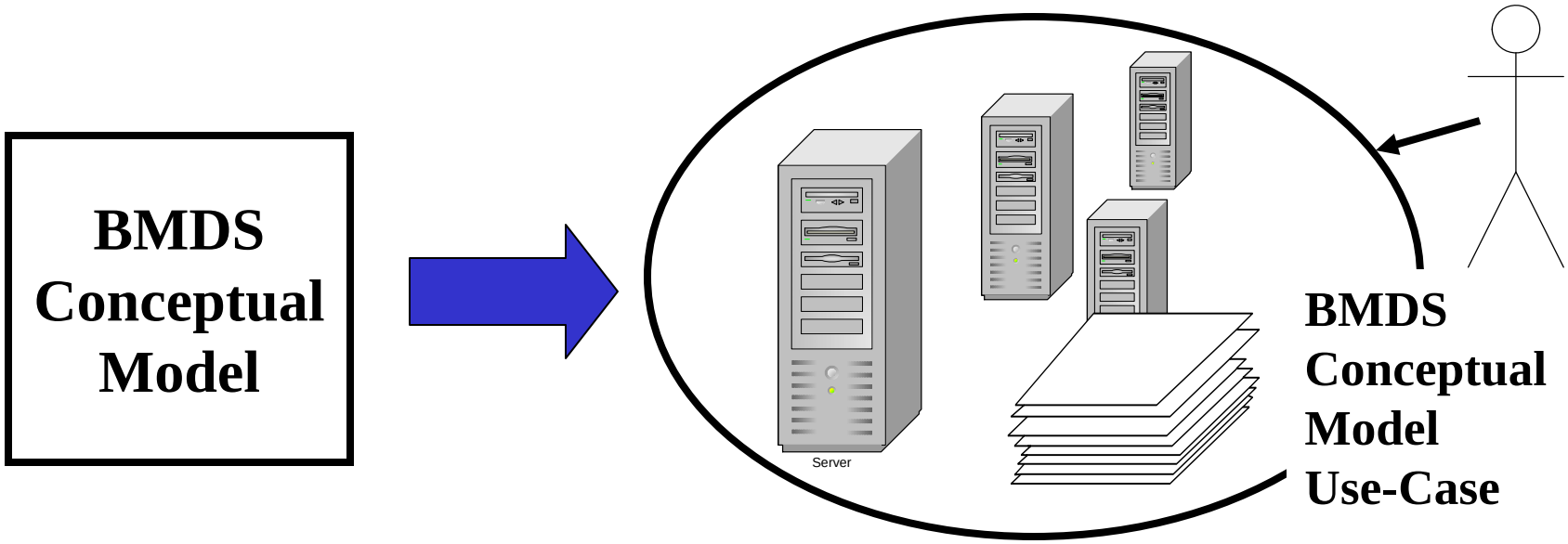
- **Formal BMDS conceptual model supports consistent development of simulations' representations**

... and in addition!

- **BMDS Conceptual Model supports communications across MDA enterprise, and development of BMDS**

BMDS Conceptual Modeling Context - Intention

- **Build technical data product …**
- **Capture, maintain intellectual property …**
- **Support MDA's simulation-based system development enterprise … over the entire life cycle of BMDS**



Technical Approach (OUTLINE)

- **Resources – What assets exist to support the execution of task activity?**
- **Notation – What conventions of notation, and documentary capture will we employ?**
- **Activity – What is the technical basis for the task activity?**
- **Products – What technical products will result from the effort?**

Technical Approach – Resources: GUIDANCE

- **Standards**
  - **OMG Standard "Unified Modeling Language (UML)" V 1.4,**
  - **IEEE 1471-2000 Standard for "Architecture Views and Viewpoints"**
- **Process**
  - **Rational Unified Process (RUP, contingent)**
  - **MDA Directive 5011, V4.0 1/6/03 DRAFT**
- **Practice**
  - **DMSO RPG**
  - **MDA TEM Conceptual Model Management Notes**
  - **Industry publications**

Technical Approach – Resources: DATA

- System Descriptions
  - BMDS Build 4 SDS
  - Element System Description Documents
- Simulation Conceptual Models
  - "MDSE Conceptual Model Version DRAFT Version 0.7", December 2002
  - "MDWAR Conceptual Model Version DRAFT Version 0.4 December 2002
  - EADTB…, CAPS…, EADSIM…, BEST…, ARROW

Technical Approach – Resources: TOOLS

- **Requirements Analysis**
  - **MS Word™, DOORS™ [rational's tool?] … ?**
- **Model Specification and Configuration Management**
  - **Rational Rose™**
- **Enterprise**
  - **E-mail reflectors, Web-based documentation pooling (BMDO IDC, TMDES FTP Site, DocuShare™), EndNote™**
- **Documentation**
  - **MS Word™**

Technical Approach – Notation: MOTIVATION

- **UML Notation is available, familiar, simple, suggestive, and powerful**
- **Notation is formally defined and *de facto* industry standard for software-intensive systems**
- **Notation directly supports simulation and software design / development.**
- **COTS database, generated / indicated through formal notation provides a single semantic artifact**

See UML Resource Center at http://www.rational.com/uml/index.jsp

Technical Approach – Notation: TACTICAL GUIDANCE

- **Alternative Views … of unary model**
  - **Object / Process**
  - **System / System-of-Systems**
  - **Capability / Architecture**

  } **Single Intellectual-property product**

- **Self-conscious management of: scope, detail, consistency, redundancy, etc.**

Technical Approach – Notation: CHARACTERISTICS

- **Notation provides a formal syntax and semantics for system specification … and development**
- **Notation denotes:**
  - **things (entities and classes of entities)**
  - **their attributes and operations**
  - **their relationships to one another**
  - **their behaviors together**
- **Notation is *neutral* as to:**
  - **what to represent**
  - **how to represent it**
  - **what the characteristics of any system being represented are**

See UML Quick Reference Guide and Poster

BMDS Conceptual Model
– CASE (UML) Views –

- Use Case Diagram(s)
- Class(ification) / Static Diagrams
- Behavior Diagrams
  - Statechart Diagrams
  - Activity Diagram
  - Interaction Diagram
  - Sequence Diagram
  - Collaboration Diagrams
- Implementation Diagrams
  - Component Diagram
  - Deployment Diagram

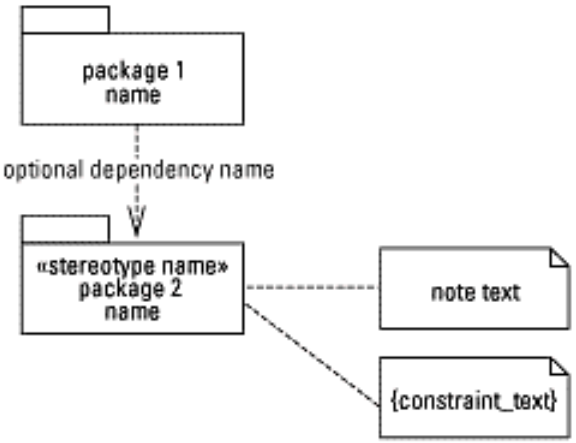
Technical Approach – Notation: VIEWS

- **The notation supports system module encapsulation and system use:**

GENERAL-PURPOSE CONCEPTS

Can be used on various diagram types

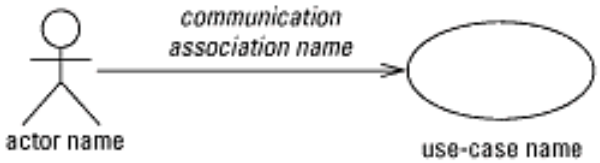
Package, dependency, note



USE-CASE DIAGRAM

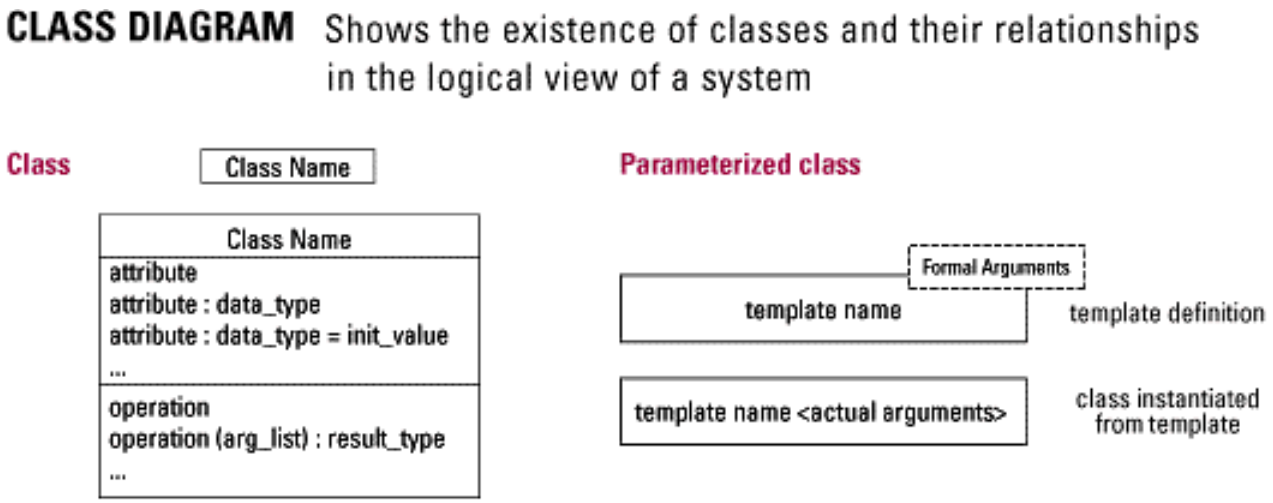
Shows the system's use cases and which actors interact with them

Actor, use case, and association



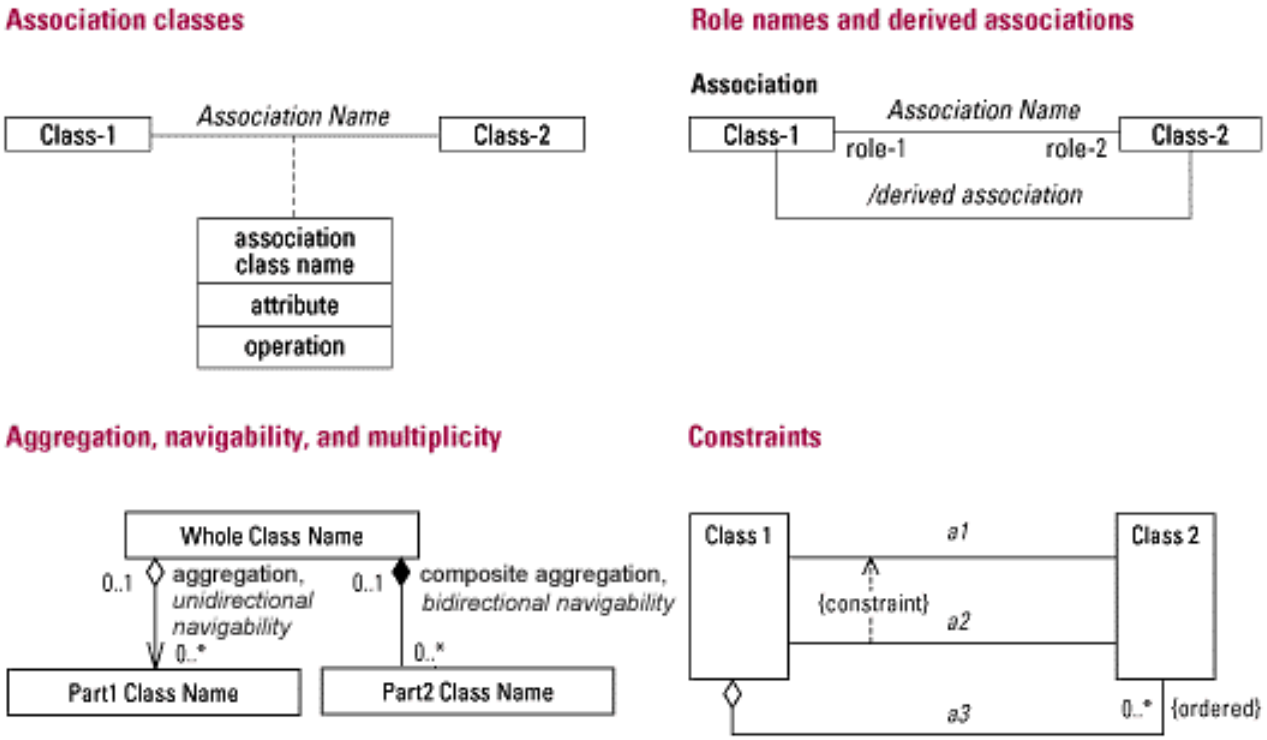
Technical Approach – Notation: VIEWS

- **The notation denotes classes (and instances) with their intrinsic attributes and operations:**



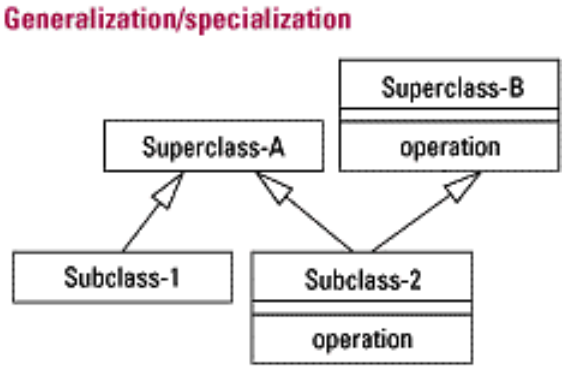
Technical Approach – Notation: VIEWS

- **Relationships among classes (or entities) can be specified. These include 'composition', generic 'association':**



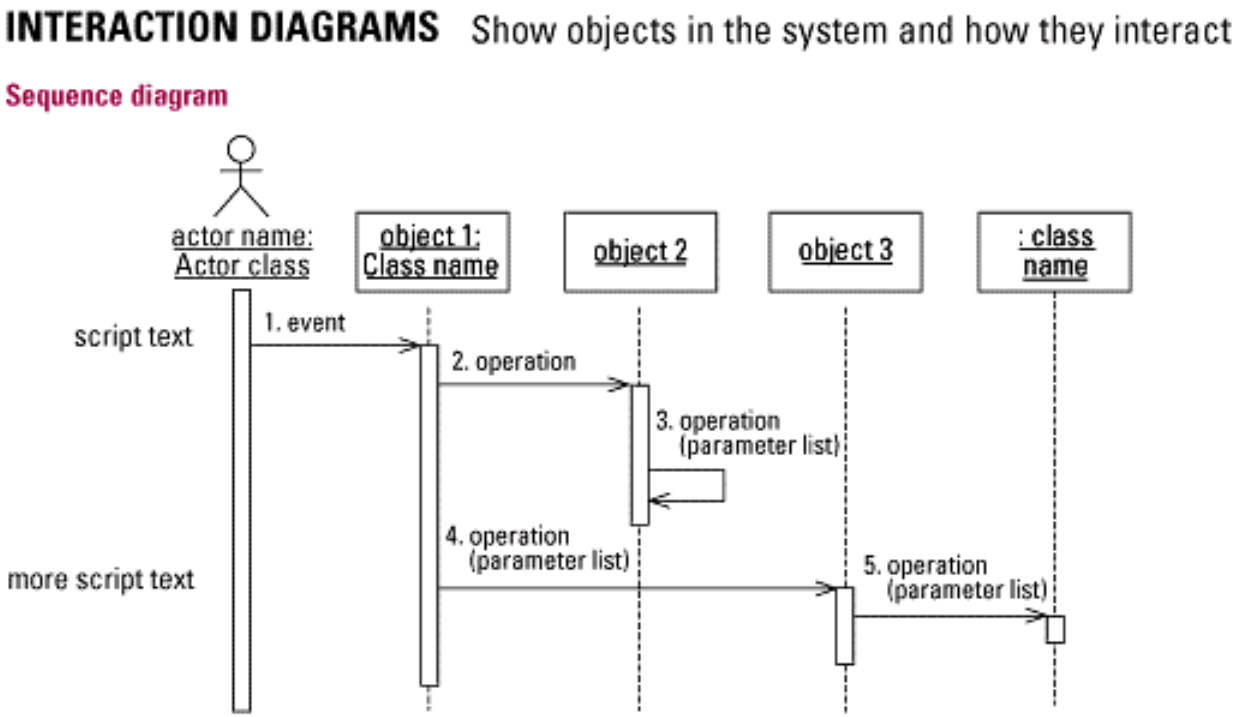
Technical Approach – Notation: VIEWS

- **… and ‘specialization’ whereby classes (and object entities) ‘inherit’ the attributes and operations of their parents:**



Technical Approach – Notation: VIEWS

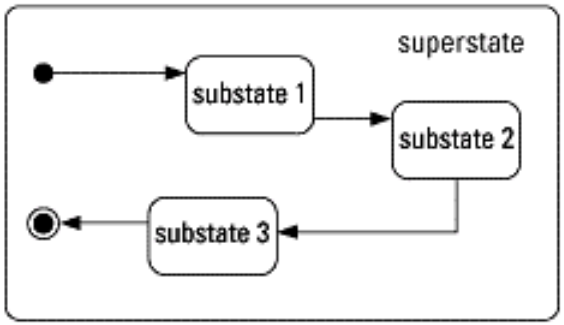
- **Sequential dynamic interaction among objects can be illustrated via ‘sequence diagrams’…:**



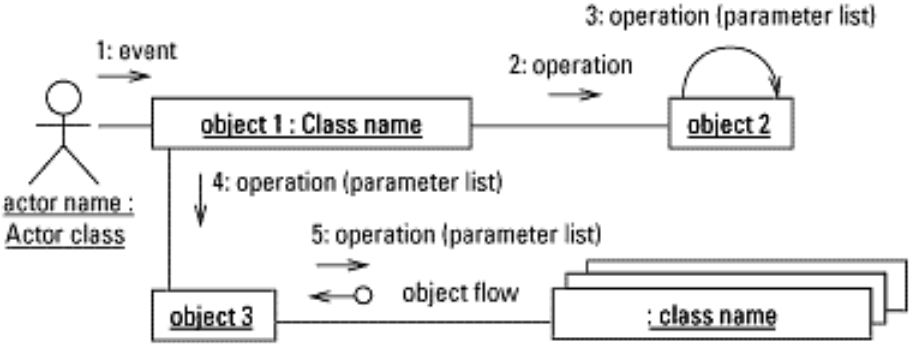
Technical Approach – Notation: VIEWS

- **… and other manifestations of dynamic behavior such as ‘state-transition’ and ‘collaboration’ or control-flow may be specified:**

Nesting



Collaboration diagram

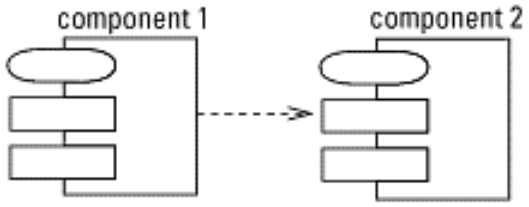


Technical Approach – Notation: VIEWS

- **Finally, deployment of systems to operational environments are denoted:**

COMPONENT DIAGRAM

Shows the dependencies between software components



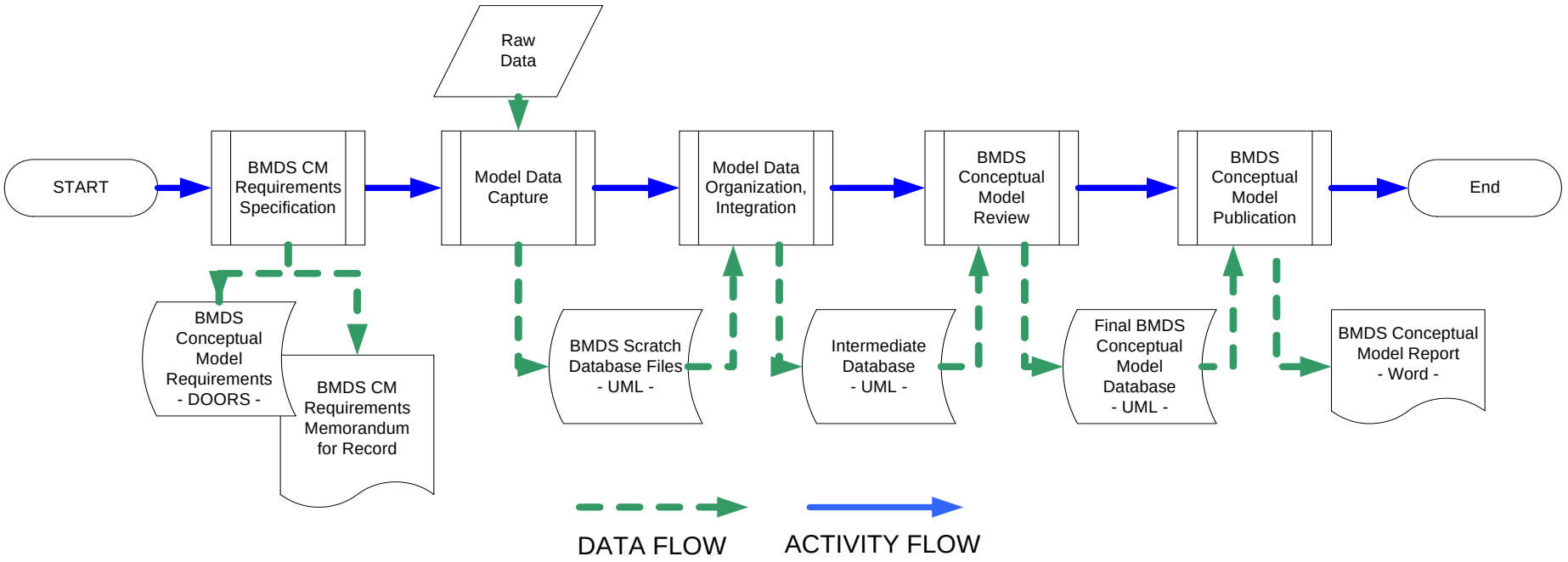
DEPLOYMENT DIAGRAM

Shows the configuration of runtime processing elements

Technical Approach – Activity: OPERATIONAL STRATEGIES

- **‘Parallel, iterative, layered’ development**
  - **Collect soil samples, Drill test hole, build foundation, complete structure**
- **Systematic configuration management**
  - **Case tool is record of original and persistent entry and provides developmental operational workspace**
- **Open source … collaboration**

Technical Approach – Activity: ACTIVITY (and DATA) FLOW

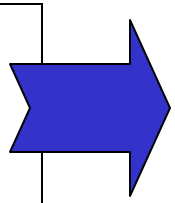


Technical Approach – Activity: PROCESS

- **Requirements Devolution and Specification**
- **Data Mining and Capture**
- **Model Data Organization / Integration**
- **Model Review and Evaluation**
- **Model Publication**

Requirements Devolution and Specification Activity

What is the Need?



What are the consequent required characteristics of the product?

Explicit deliberate requirements management for the BMDS Conceptual Model supports:

- **Conceptual Model Task Management**
- **Conceptual Model Development**
- **Conceptual Model Evaluation (Validation)**

Requirements Devolution and Specification Activity, Cont.

Need

Required characteristics

Basis for Simulation Conceptual Models

- **Detail NLT most detailed simulation within relevant scope**
- **Scope over Union of Simulation representation domains**
- **Neutral Notation**

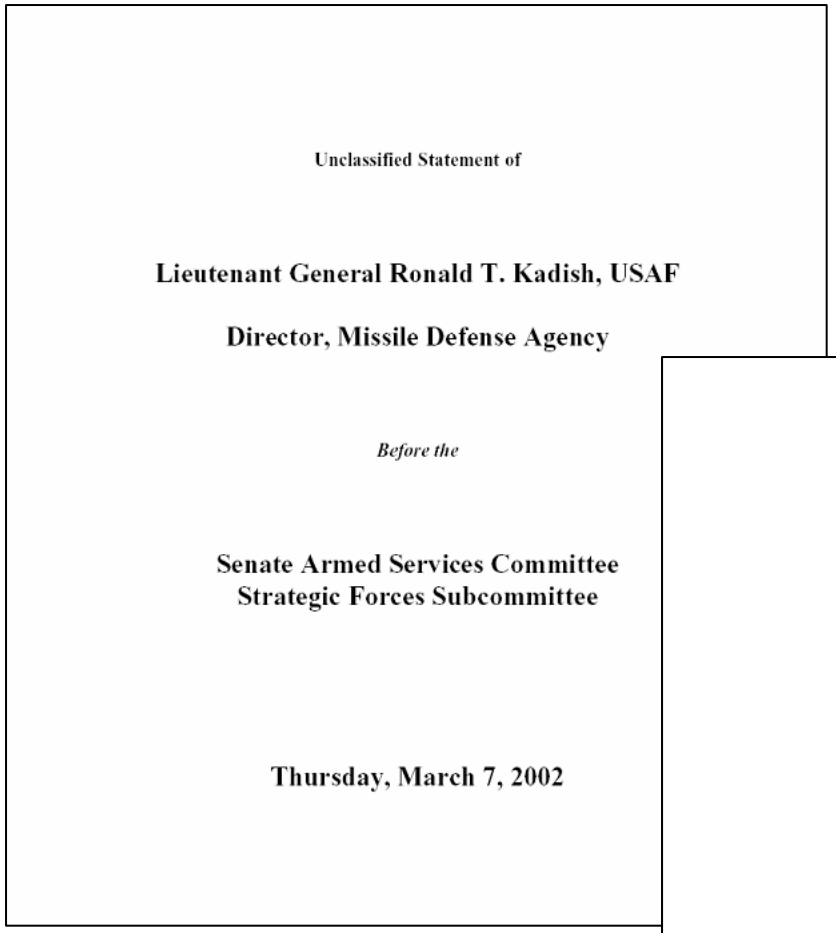
Basis for MDA M&S Collaboration

- **Neutral Notation**
- **Auditably traceable from authoritative data sources**

Data Mining and Capture Activity

- **Capture (with annotation) information from authoritative source to CASE Tool**
- **Check completeness, consistency of information ‘as stated’**
- **Supplement with ‘implied’ information (classes, associations, etc.) for completeness, consistency and logical convenience**

Authoritative Sources



Unclassified Statement of

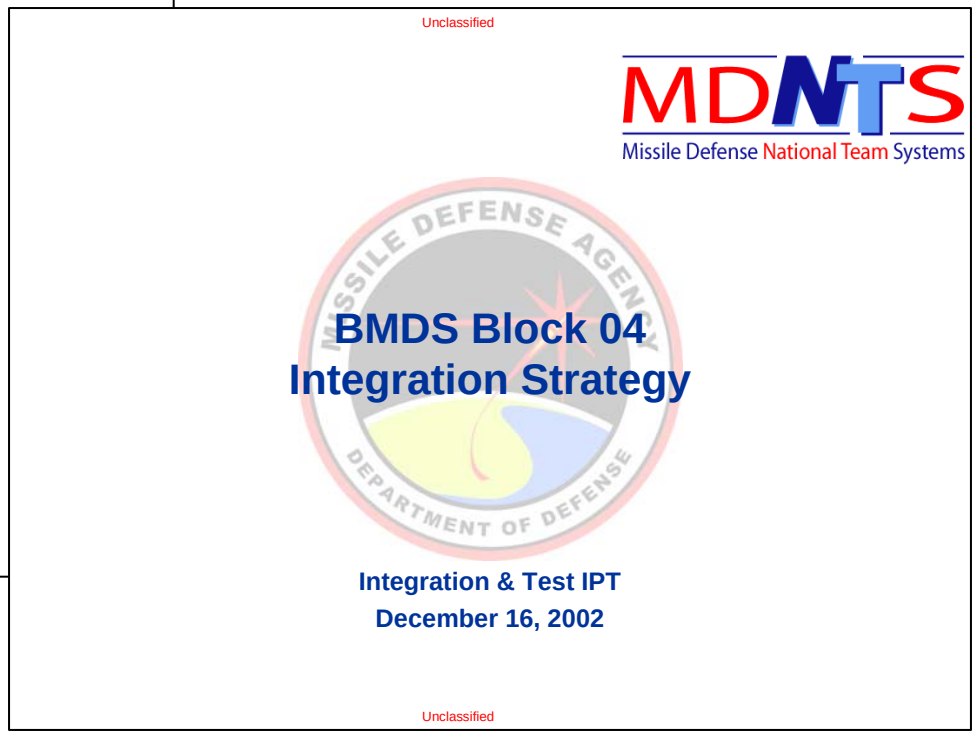
Lieutenant General Ronald T. Kadish, USAF

Director, Missile Defense Agency

Before the

Senate Armed Services Committee
Strategic Forces Subcommittee

Thursday, March 7, 2002



Unclassified

MDNTS
Missile Defense National Team Systems

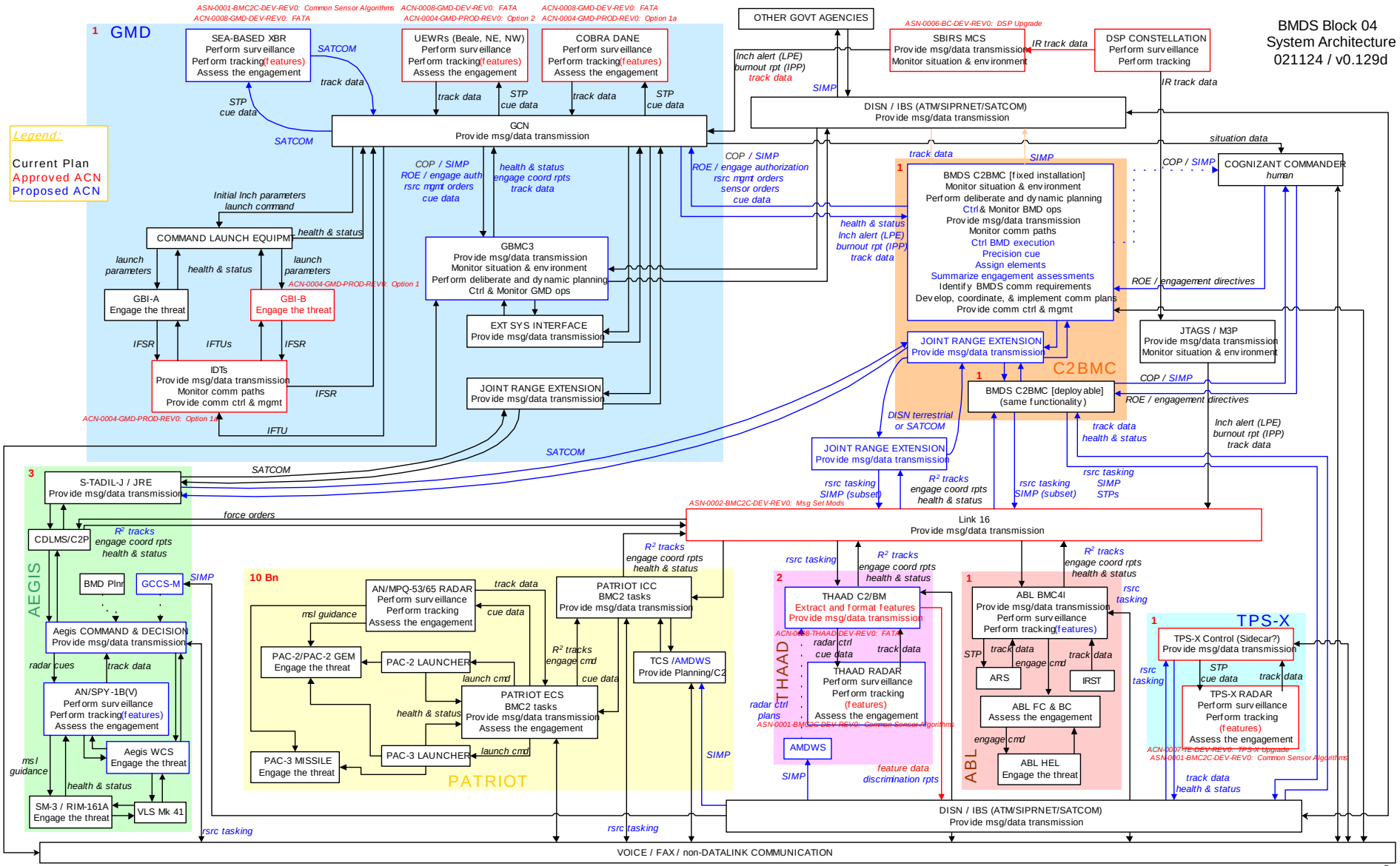
BMDS Block 04
Integration Strategy

Integration & Test IPT
December 16, 2002

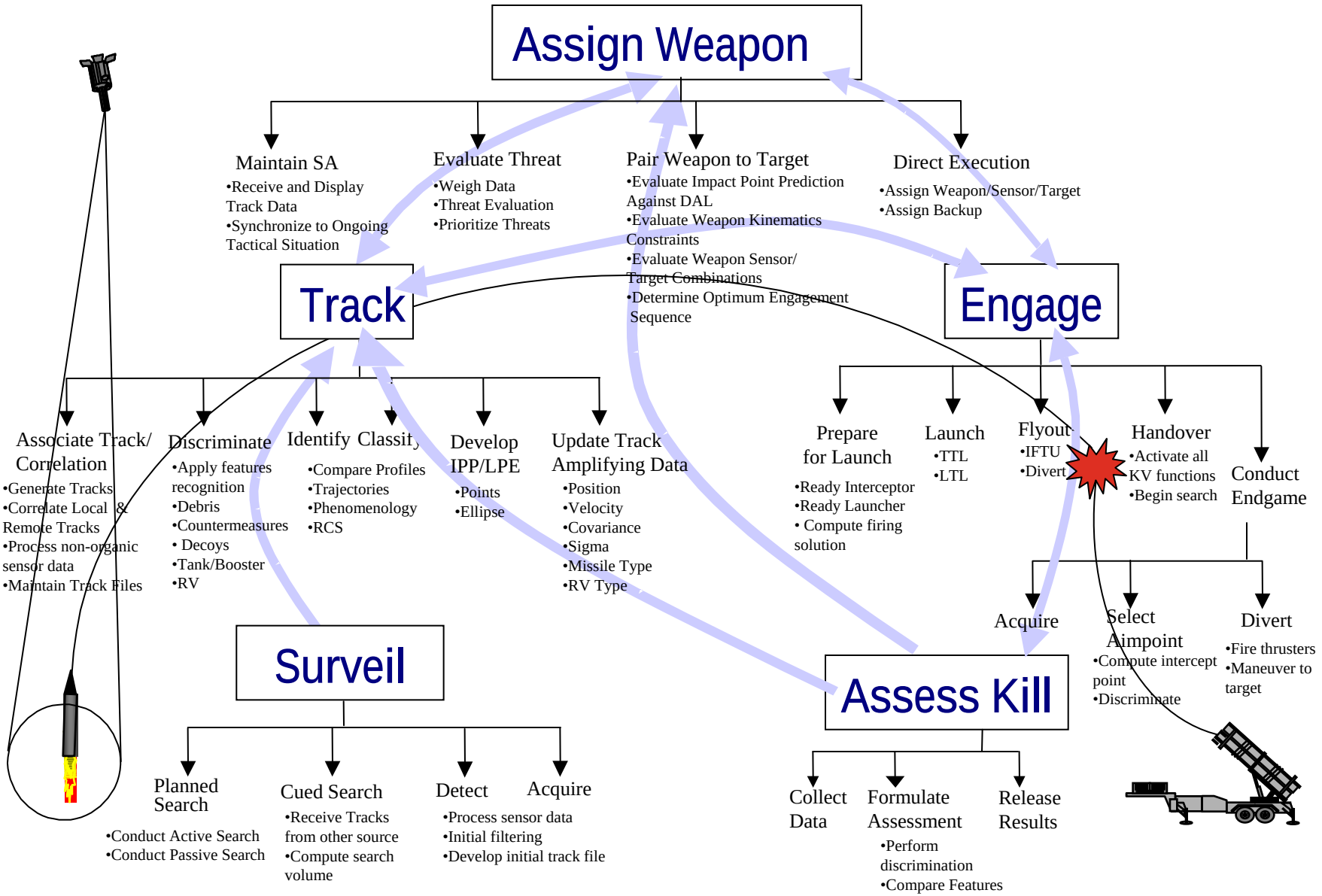
Unclassified

BMD Block 2004 SCS Architecture View

FOR OFFICIAL USE ONLY



IDEF0 Kill Chain Functions



Model Review and Evaluation Activity

- **Structured Walkthourgh(s)**
  - **For scope, detail, completeness, consistency, correctness, symmetry, auditability, etc.**
  - **By-model feature: classes, attributes, methods, affiliations, etc.**
  - **By BMDS system features: types (all the sensors?) components (all the parts of Aegis?), operational threads (full kill chain?), etc.**
- **Execute developmental QA and support formal IV&V**
- **Incidental feedback-upon-exposure … what your friends wouldn't tell you!**

BMDS Conceptual Model
- Evaluation Criteria -

- **Scope**
- **Detail**
- **Consistency**
- **Completeness**
- **Auditability**
- **Authoritativeness**
- **Correctness**

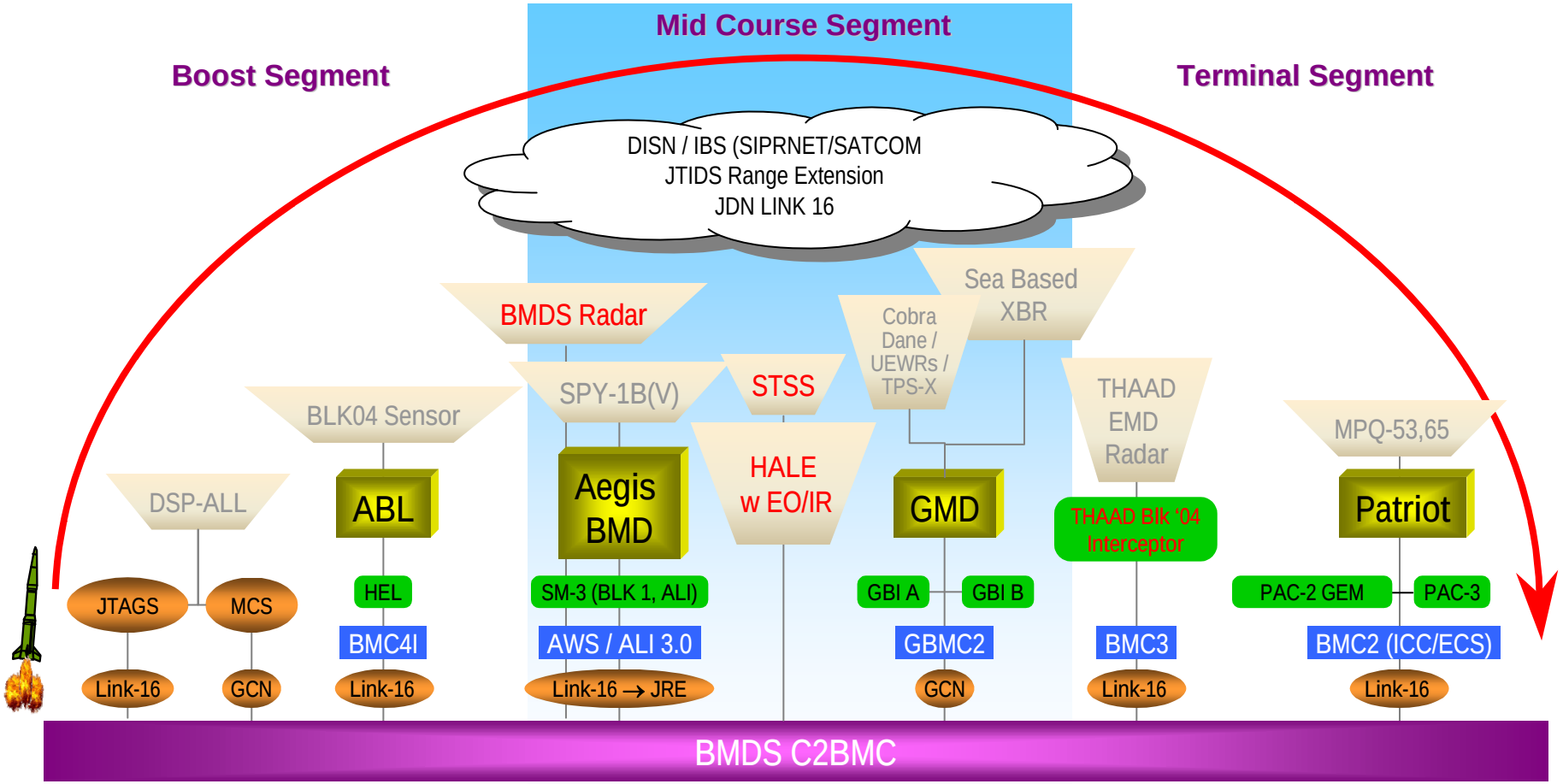
BMDS Conceptual Model
- Scope -

- **Scope – [of a conceptual model] the breadth of the domain of the referent (or alternatively the range of representation of the model) The span of that which is represented *at any given level of detail***
- **Scope is a matter of bounding the universe of discourse**
- **e.g. the scope of the BMDS conceptual model includes not only the BMDS itself (the system), but also its related threats, defended assets, and operational (natural and man-made) environments**
- **Scope is specific and evaluable … adequacy criterion is (obviously) contingent on intended use … therefore relevant to VV&A**

BMDS Block 06 Integration

MDNTS
Missile Defense National Team Systems

Block 06
Added Capability

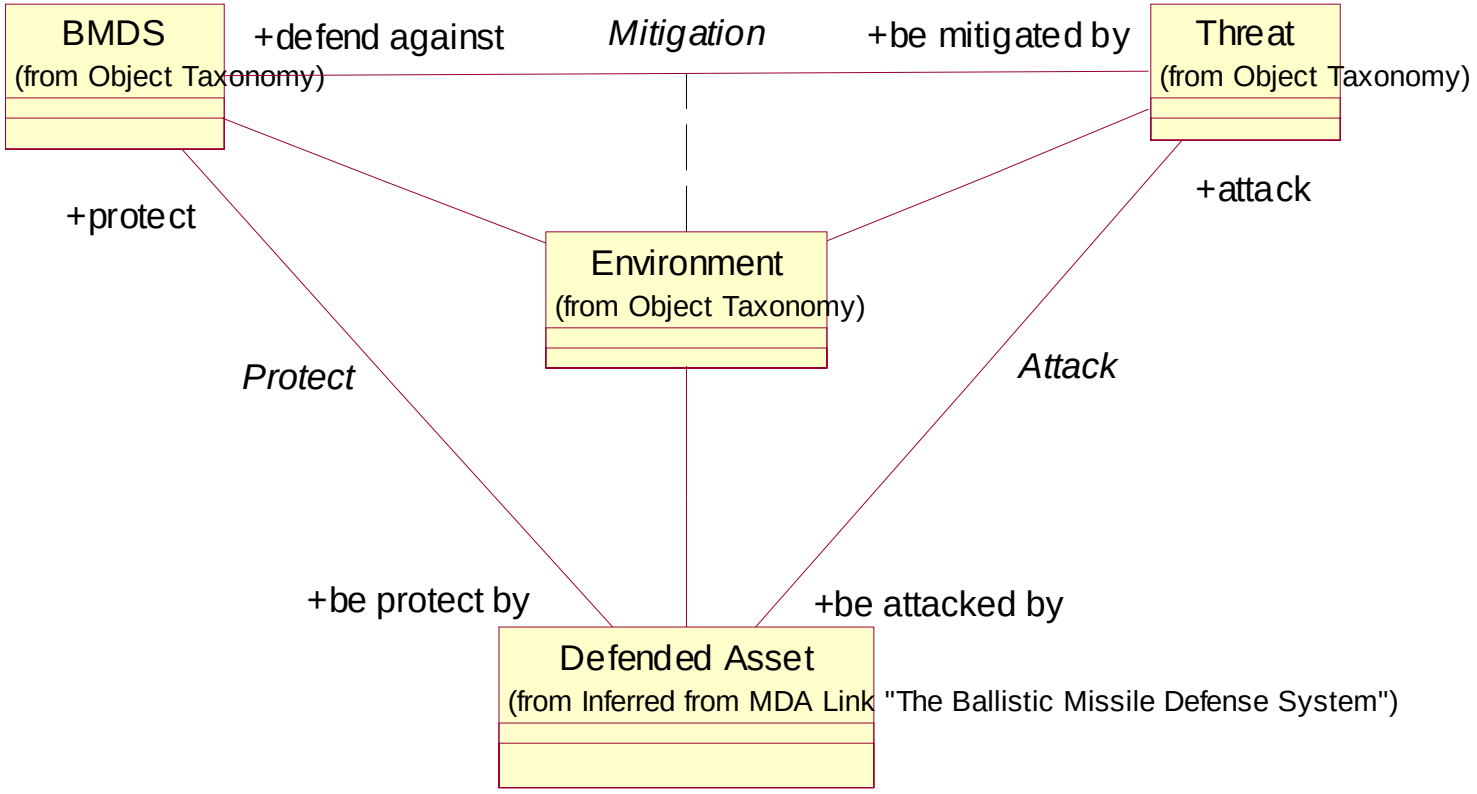


BMDS Conceptual Model
- Scope -

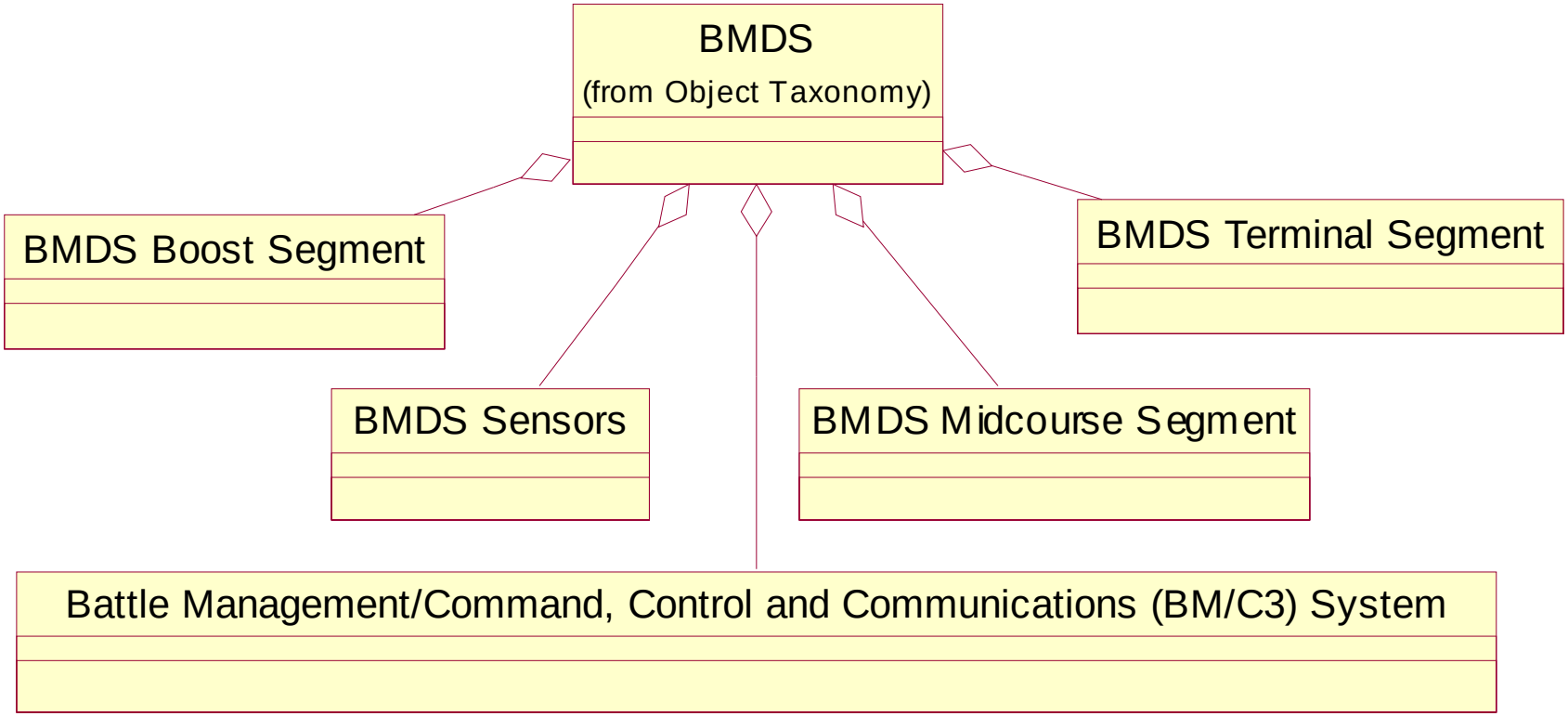
Example illustrations of conceptual model scope include:

- **BMDS in Operational Context**
- **Operational Segments**
- **Segment / Element Composites**
- **Other Scoping Dimensions**

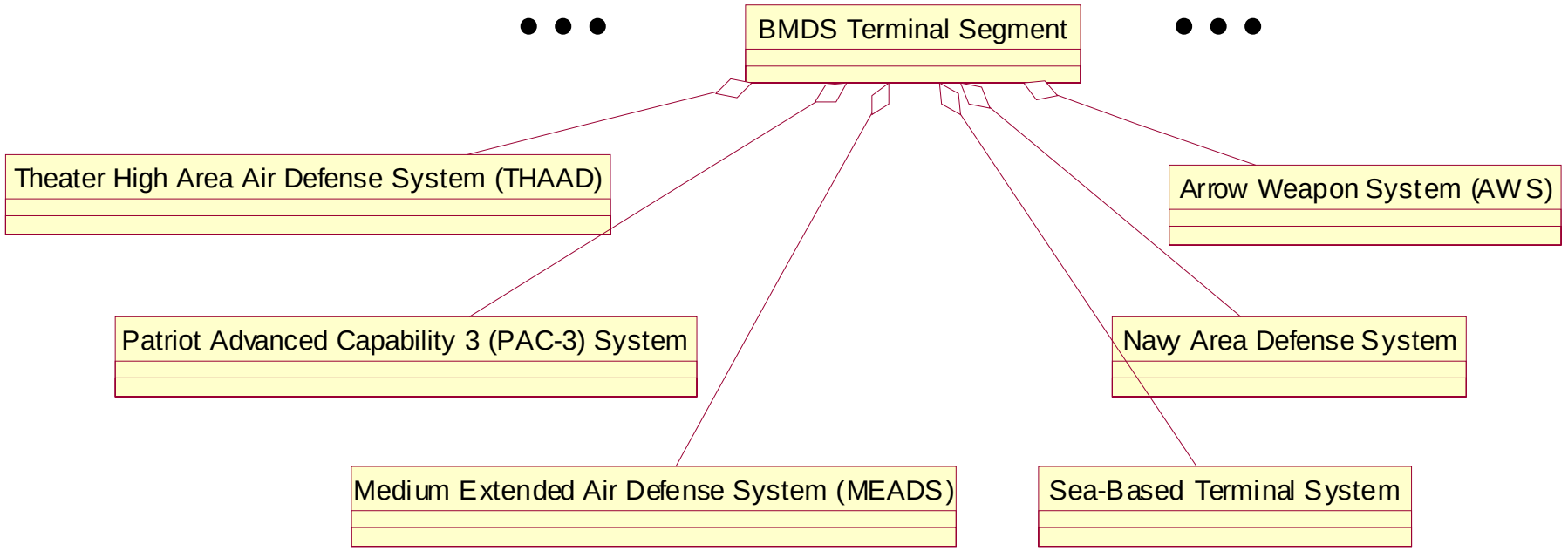
BMDS Conceptual Model - Scope
BMDS in Operational Context-



BMDS Conceptual Model - Scope Operational Segments



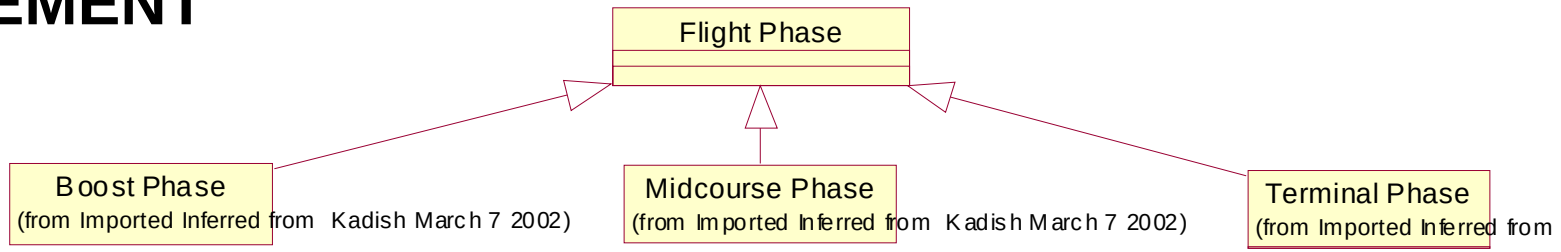
BMDS Conceptual Model - Scope Segment / Element Composites



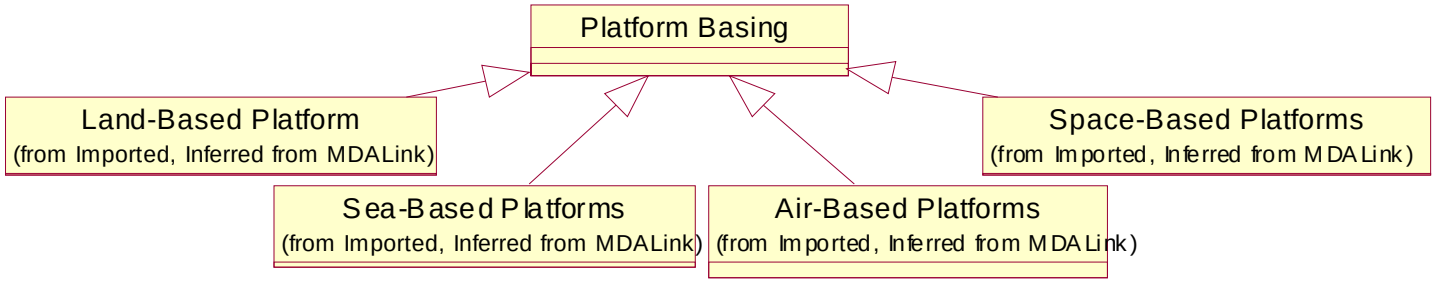
Other Scoping Dimensions

PROGRAMMATIC

ENGAGEMENT REGIME



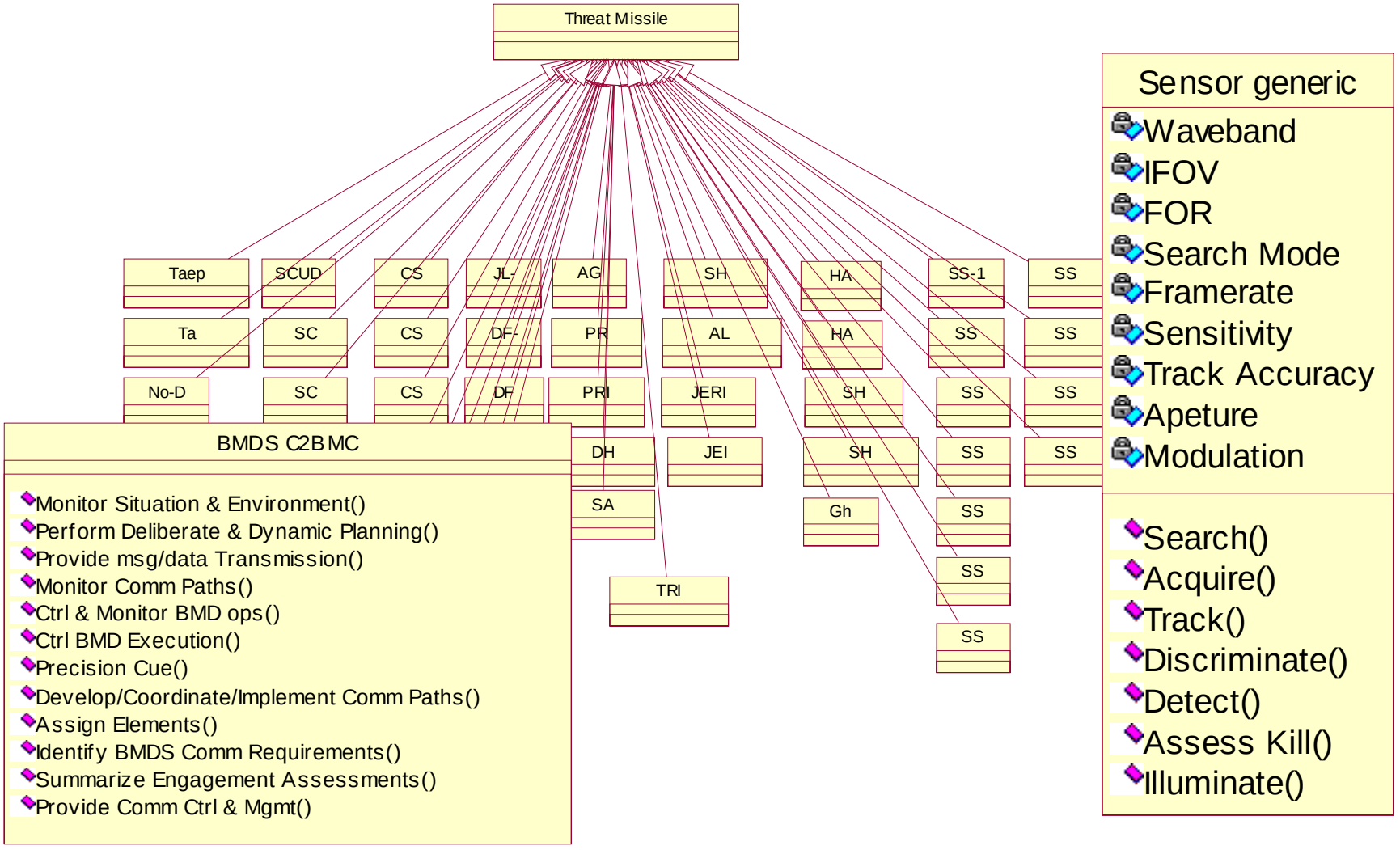
BASING OPTIONS



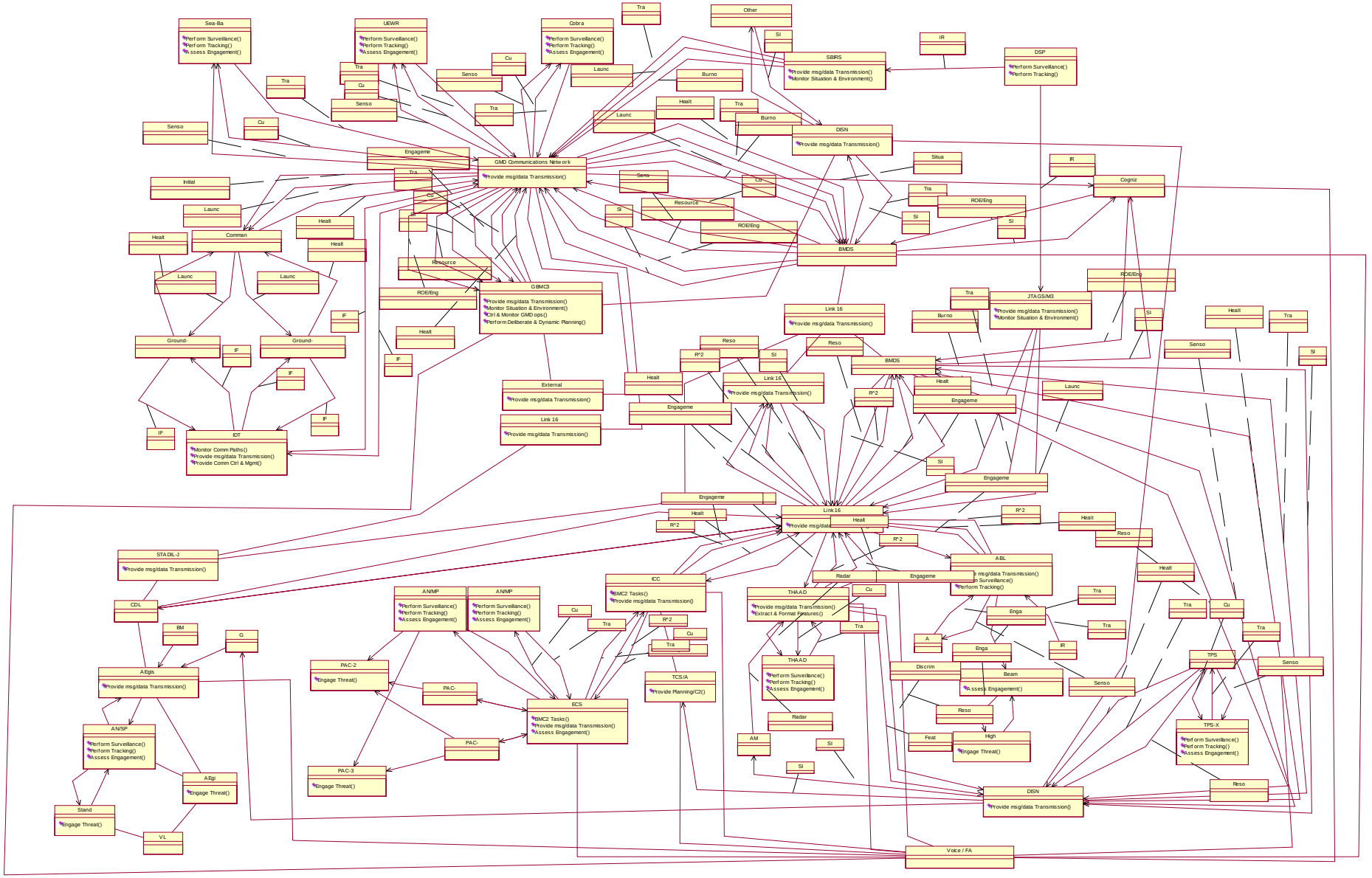
BMDS Conceptual Model
- Detail -

- **Detail – [of a conceptual model] the fineness or precision with which the model is expressed The degree of modularity of that which is represented *at any given scope***
- **Detail is commensurate with the cardinality of partition of any of the dimensions of the manifold in which the model lies – related to explicitness, precision, complexity and to Shannon information metrics**
- **e.g. how many (class types, classes, objects, attributes, operations, operational steps, relationships, views, etc.) the model comprises**
- **Detail is specific and evaluable … adequacy criterion is (obviously) contingent on intended use … therefore relevant to VV&A**

BMDS Conceptual Model - Detail



More Detail ? (GMD Comms)



BMDS Conceptual Model
- Consistency -

- **Similarity of representation of comparable entities, e.g.:**
  - **Patriot and THAAD systems composition**
  - **Sensor operations– detect, acquire, track, discriminate, etc.**
  - **Views provided for alternative elements**
  - **Use of denotative terminology – ‘sensor’, ‘track algorithm’, ‘interceptor’, ‘launcher’**
- **Freedom from logical contradiction**

BMDS Conceptual Model
- Completeness -

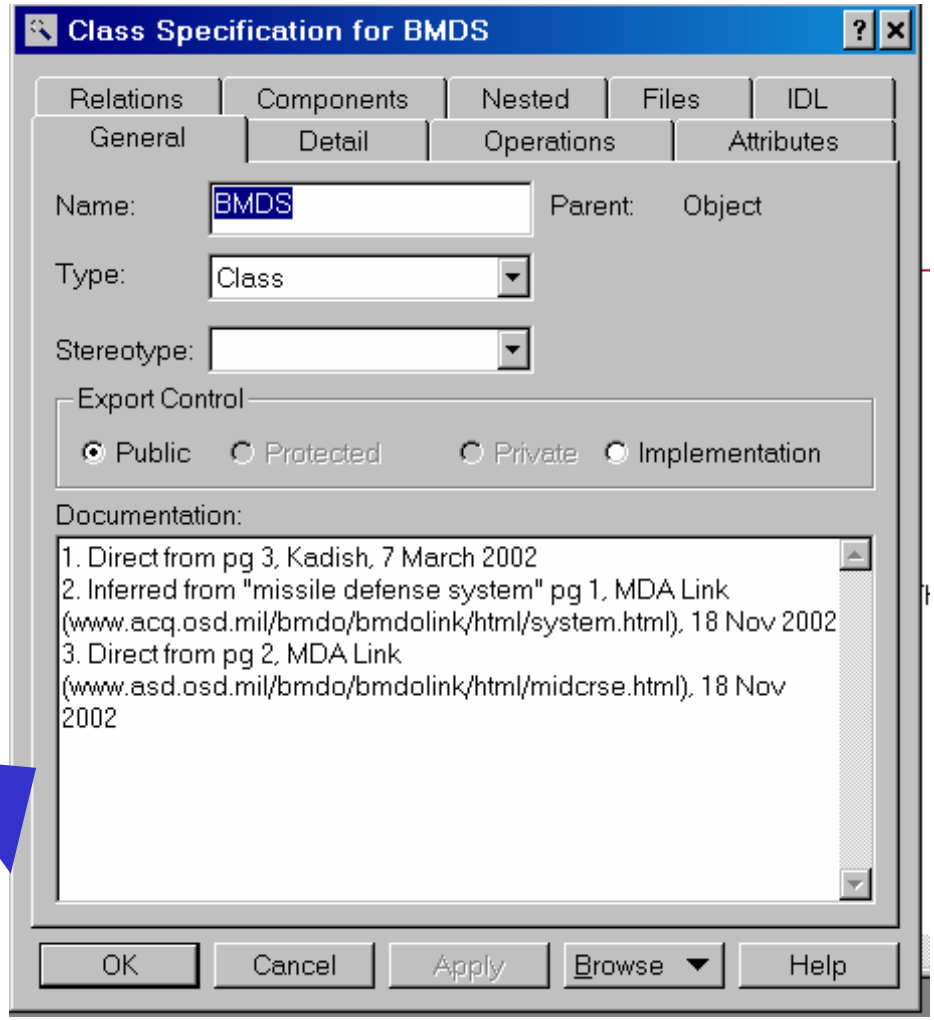
- **Exhaustion of:**
  - **Referent Scope (at given detail)**
  - **Referent Detail (for given scope)**
  - **Representational Schema Views**

.AND.

- **Sufficiency in scope and detail for intended use**

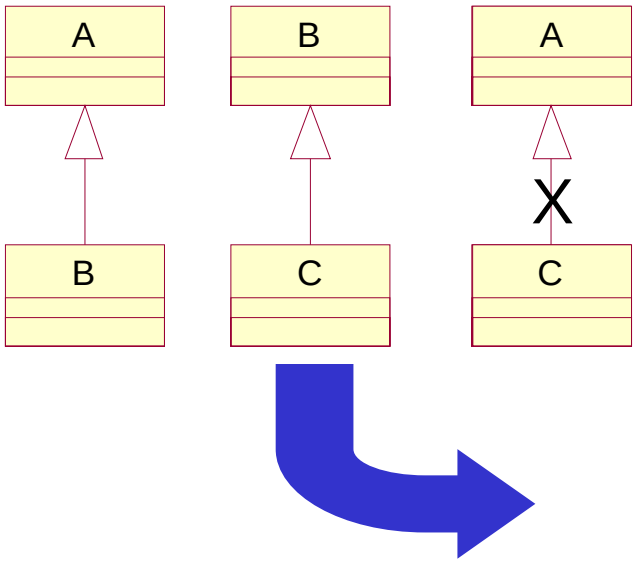
BMDS Conceptual Model
- Auditability / Authoritativeness -

- **Traceable from recognized source based on explicit model annotation**
- **Recognized Source is authoritative based on policy, practice, or declaration**

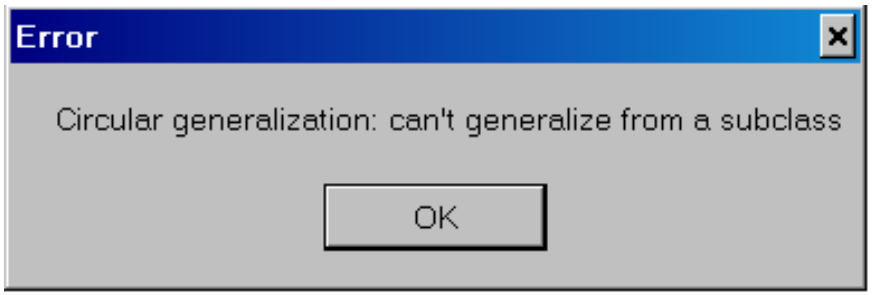


BMDS Conceptual Model
- Correctness -

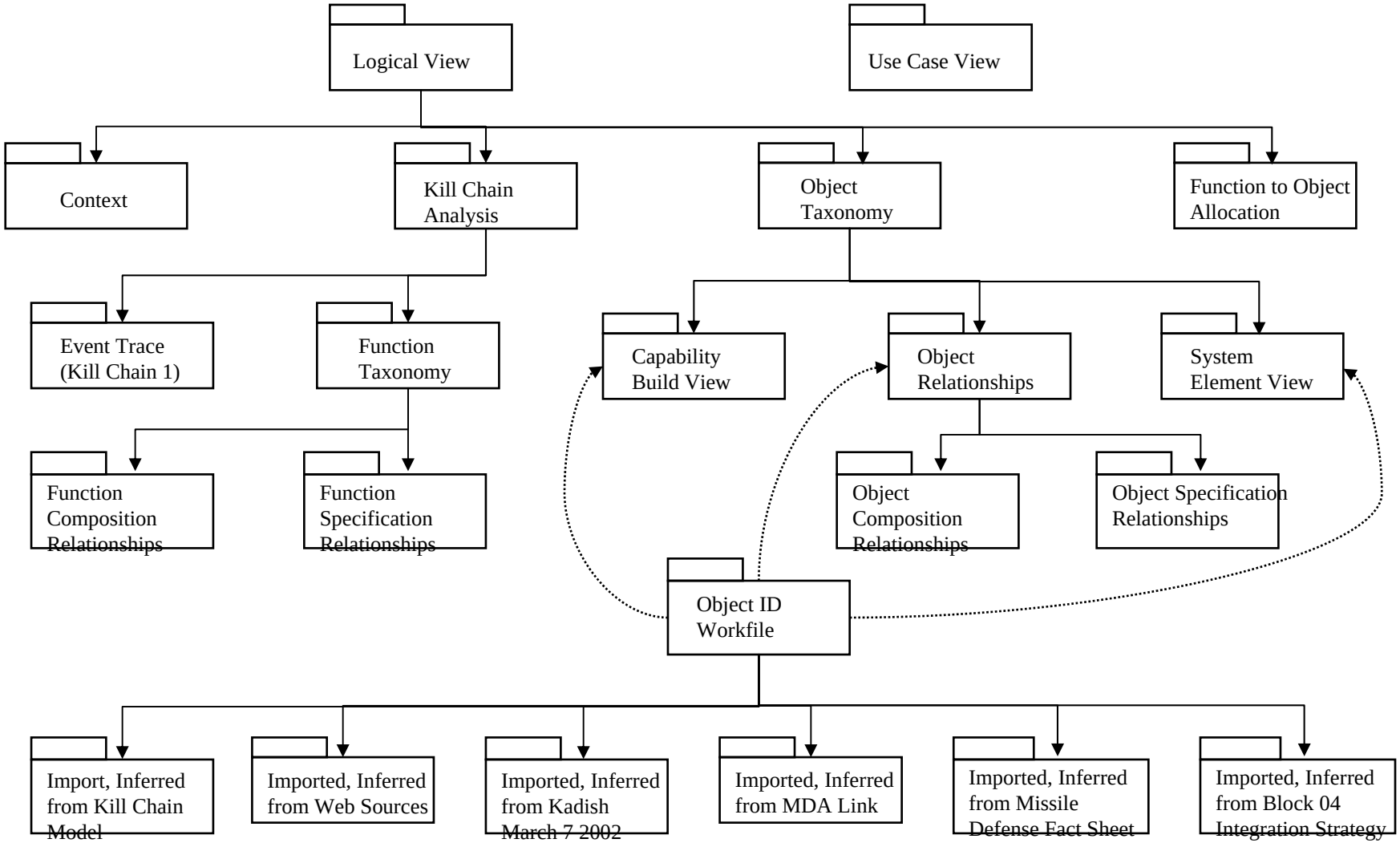
- **Conformance to authoritative documentation**
- **Freedom from logical inconsistencies, e.g.:**



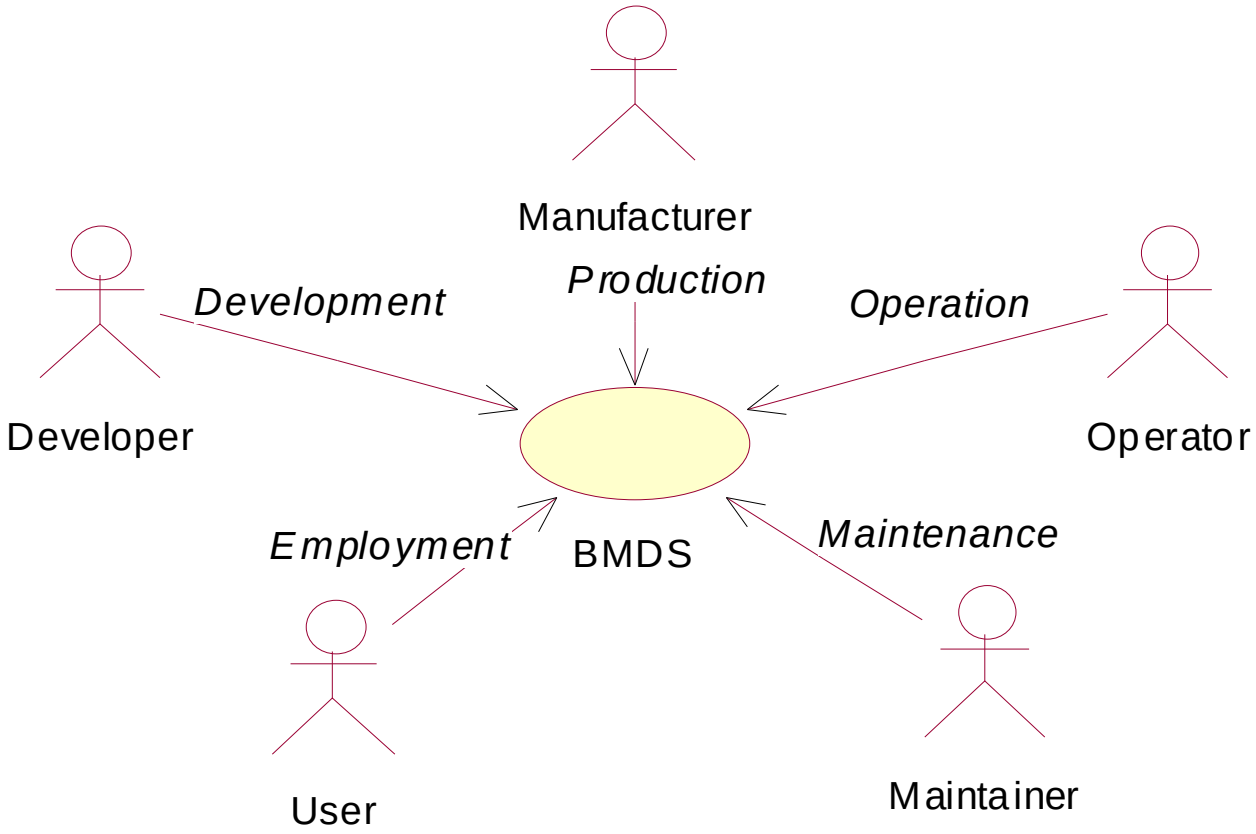
Circularity-of-inclusion inhibition results from theory-of-types and Transitivity-of-specialization enforcement… error trapped by CASE Tool



Encapsulation / Configuration Management

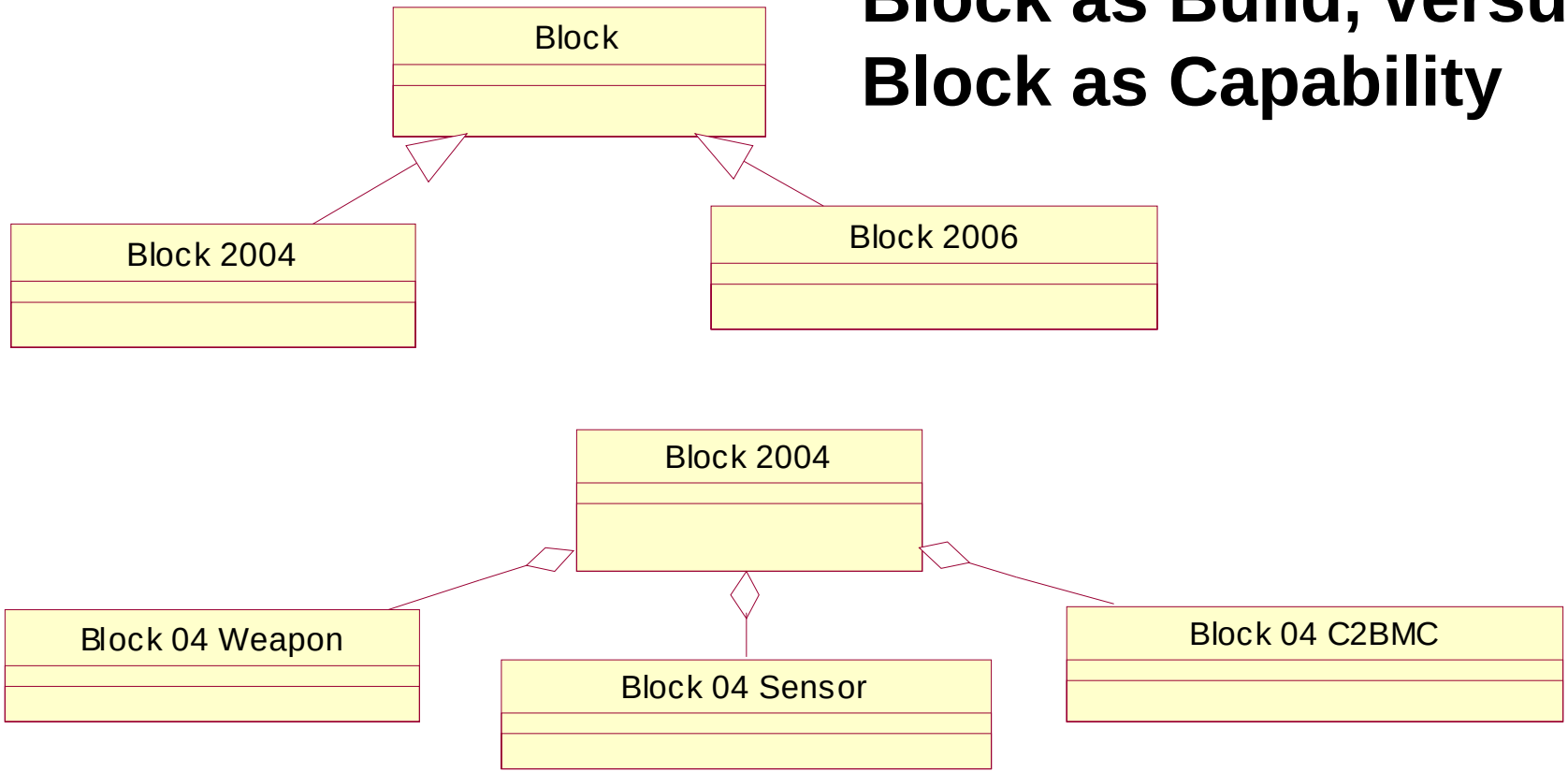


Use Case Diagram(s)

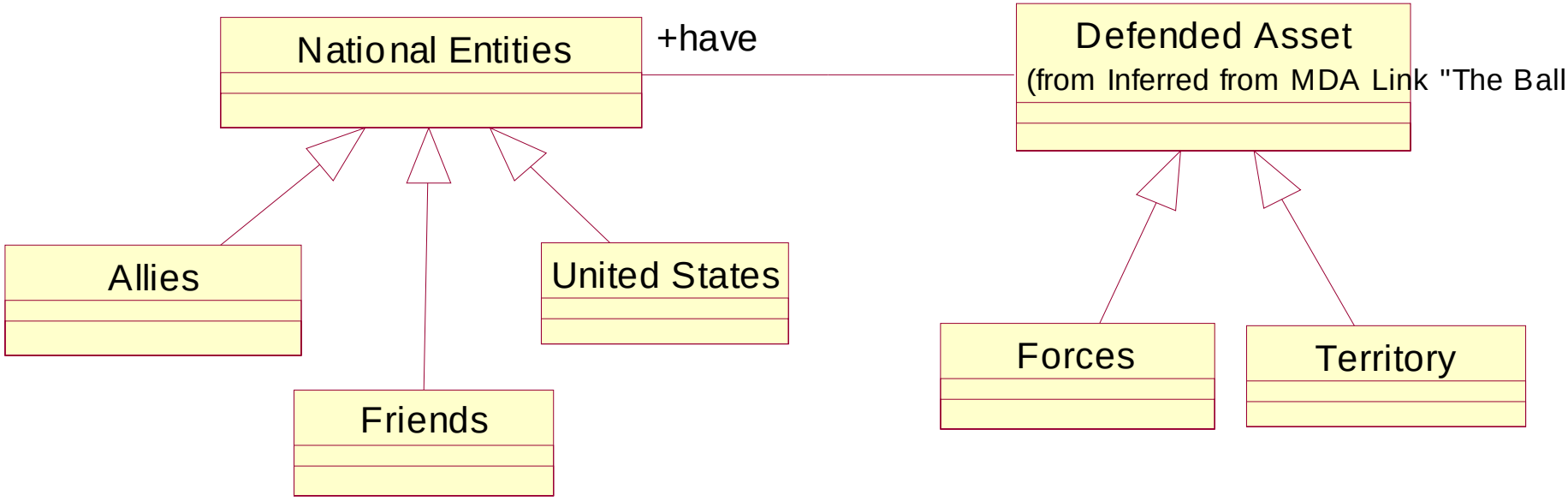


System-of-Systems Perspective
- Block -

Block as Build, versus
Block as Capability

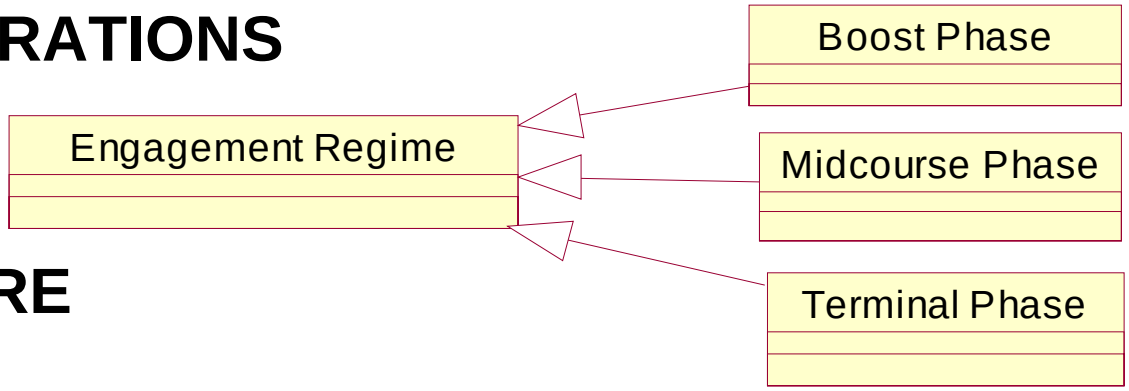


Context
- Defended Assets -

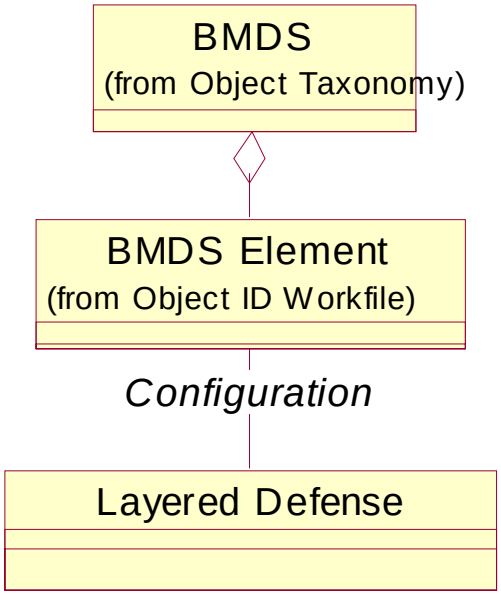


BMDS Conceptual Model
- Terminology Overloading -

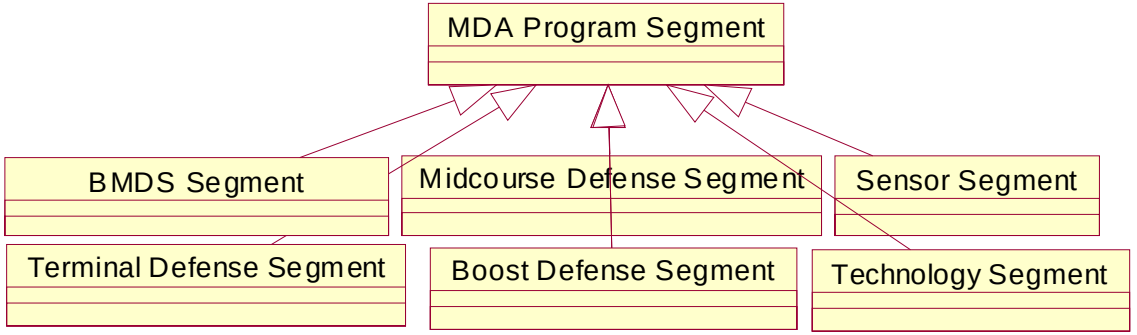
OPERATIONS



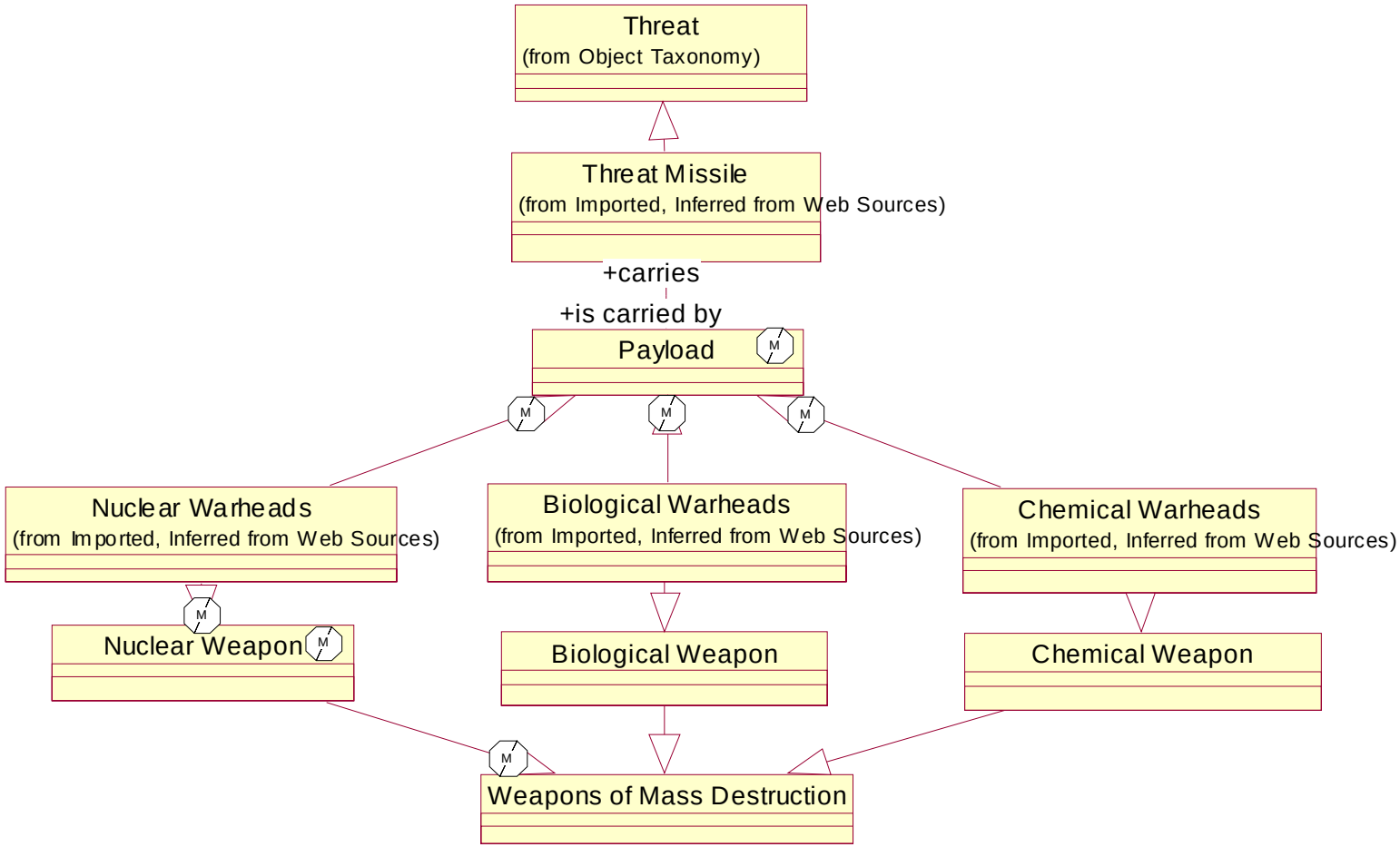
ARCHITECTURE



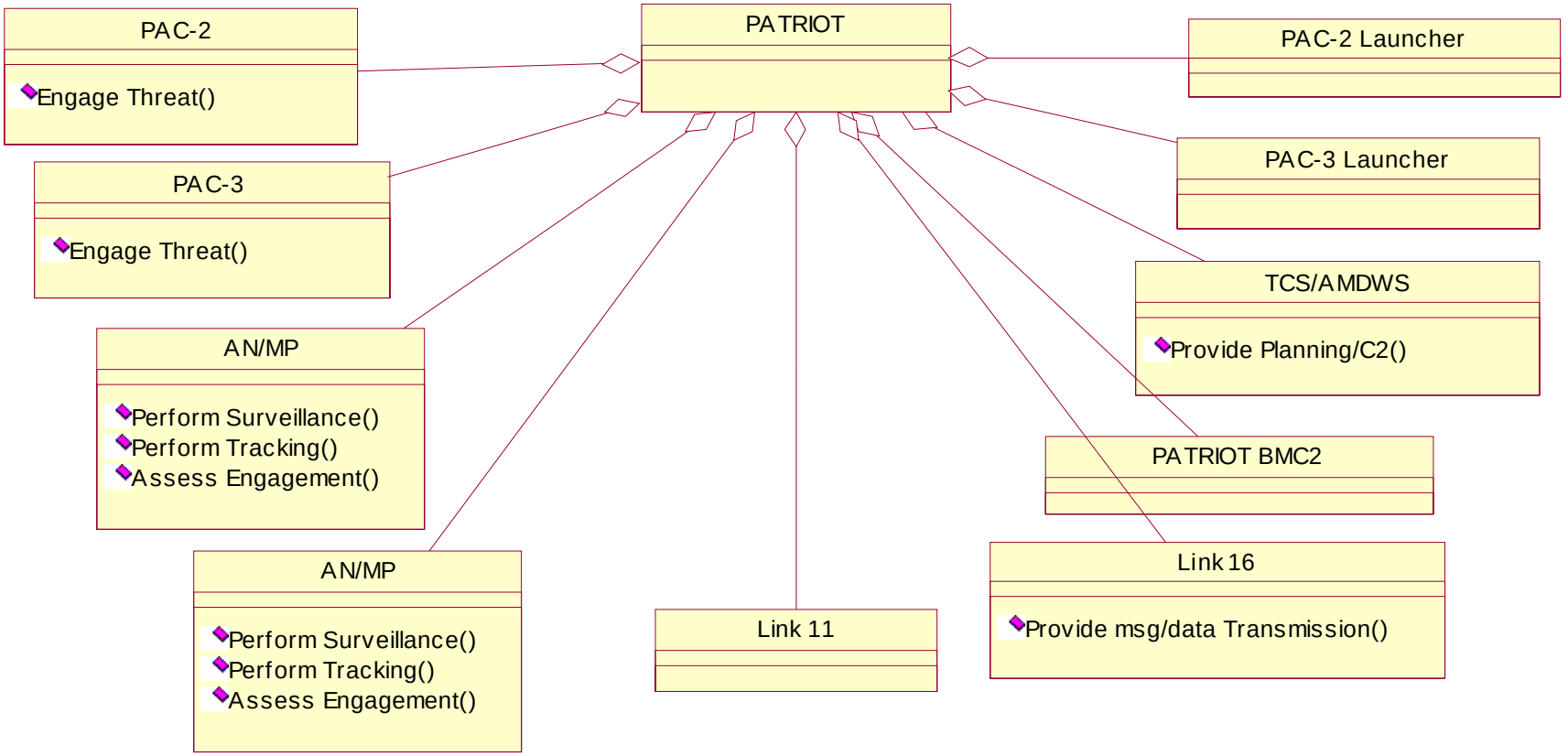
PROGRAMMATICS



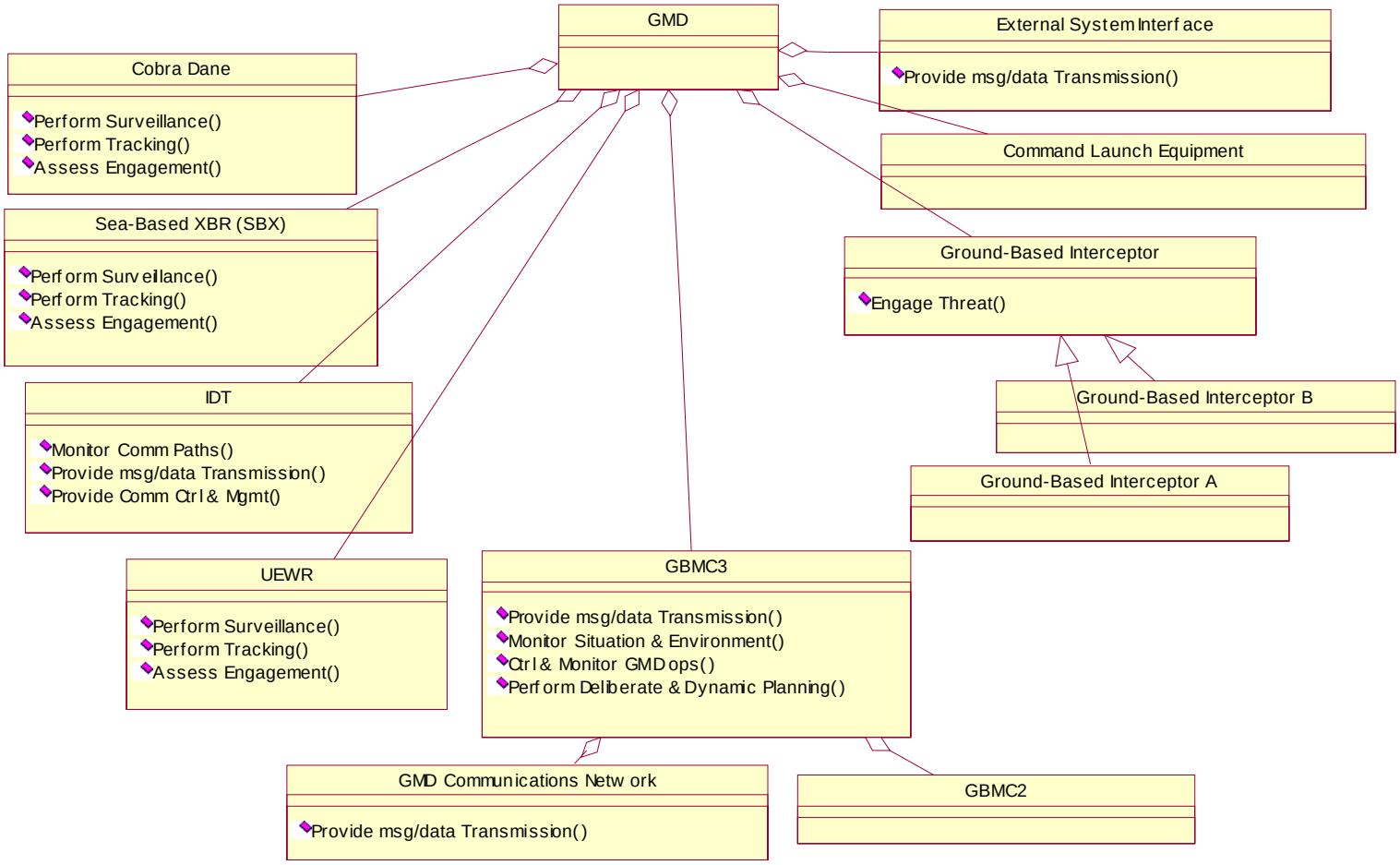
Multiple Inheritance
- Threat Taxonomy -



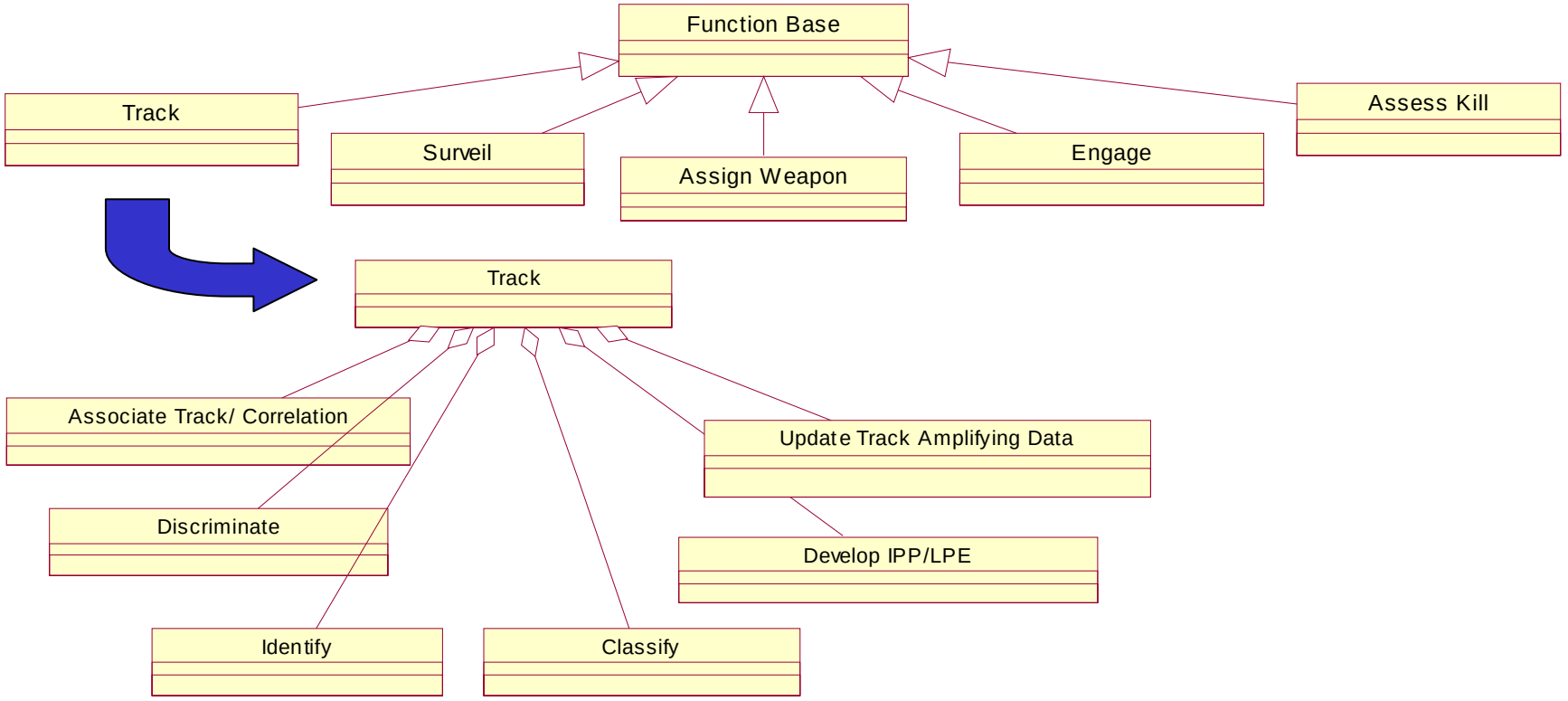
Element Perspective
- Patriot Composition -



Element Perspective
- GMD Composition -

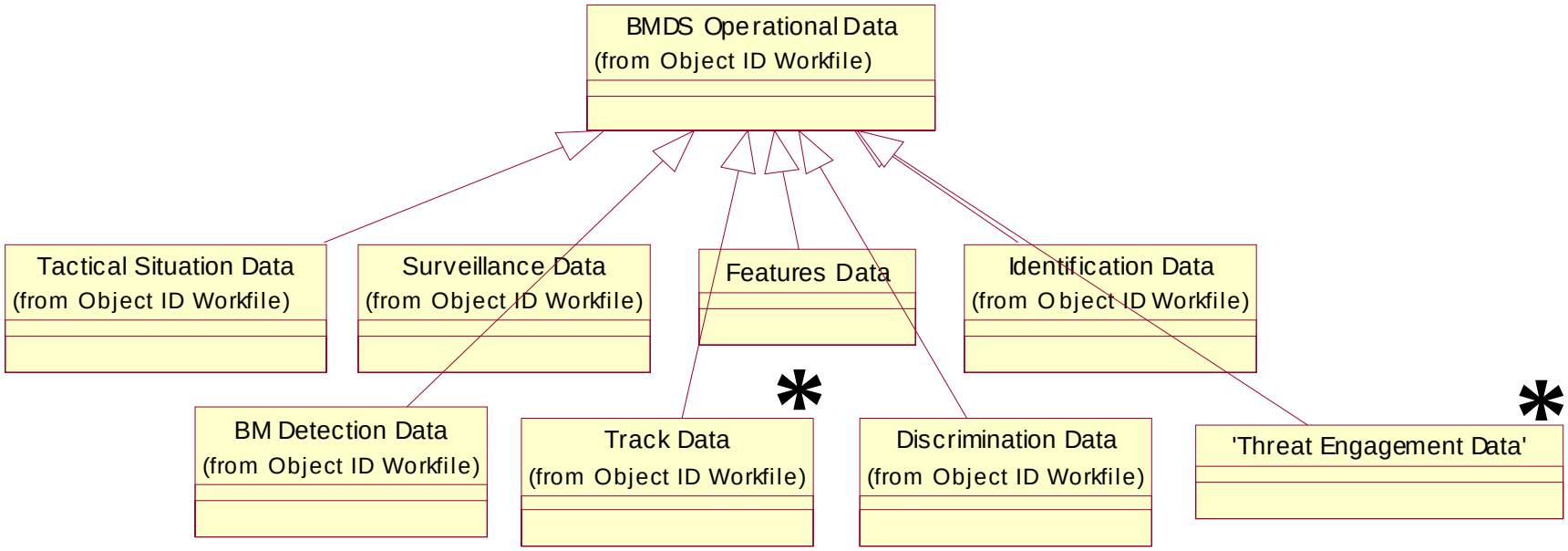


‘Classification’ of BMDS Functions / Processes

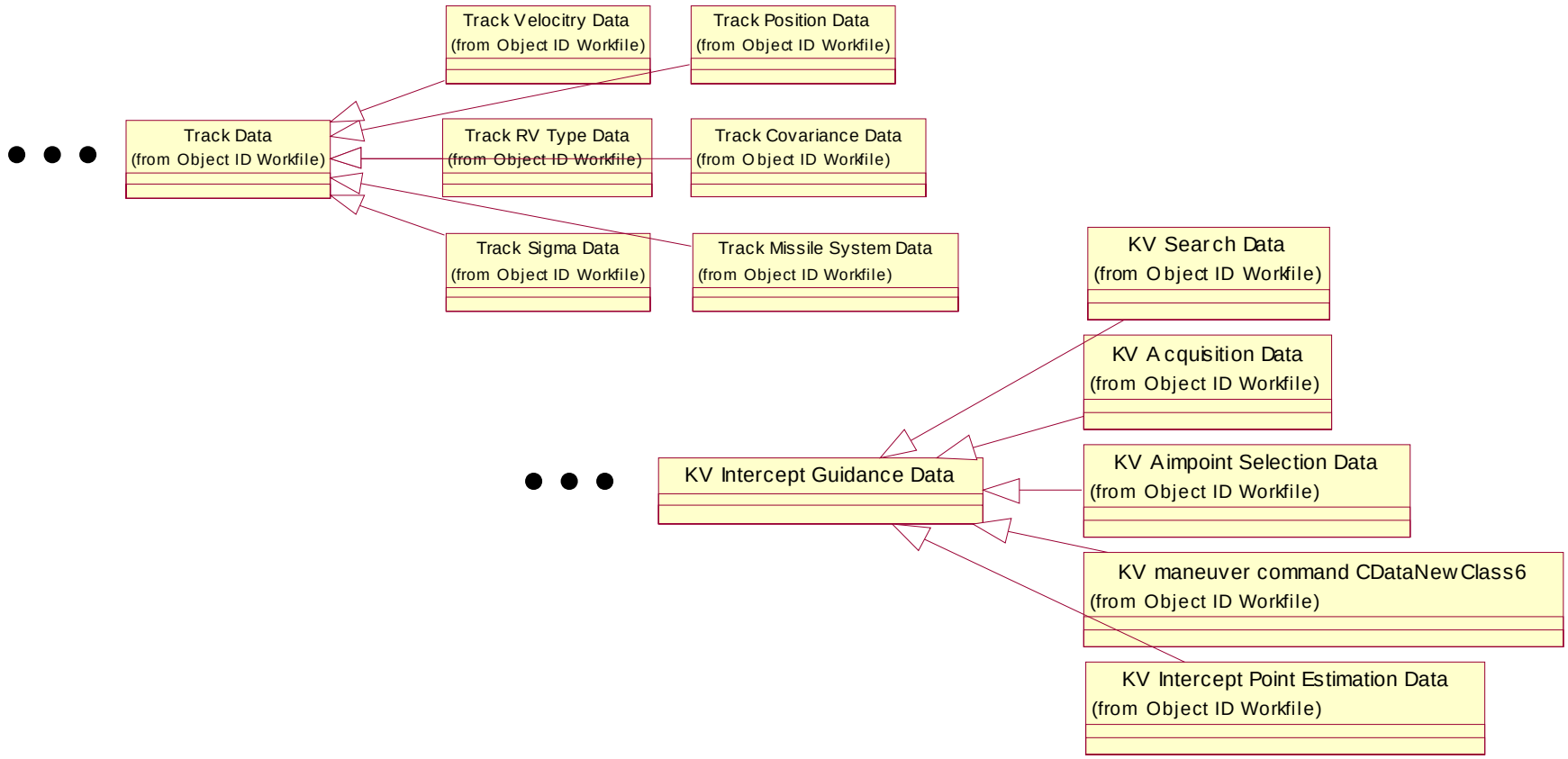


… pending identification and allocation of entity class ‘operations’ and object ‘methods’

‘Classification’ of BMDS Operational Data



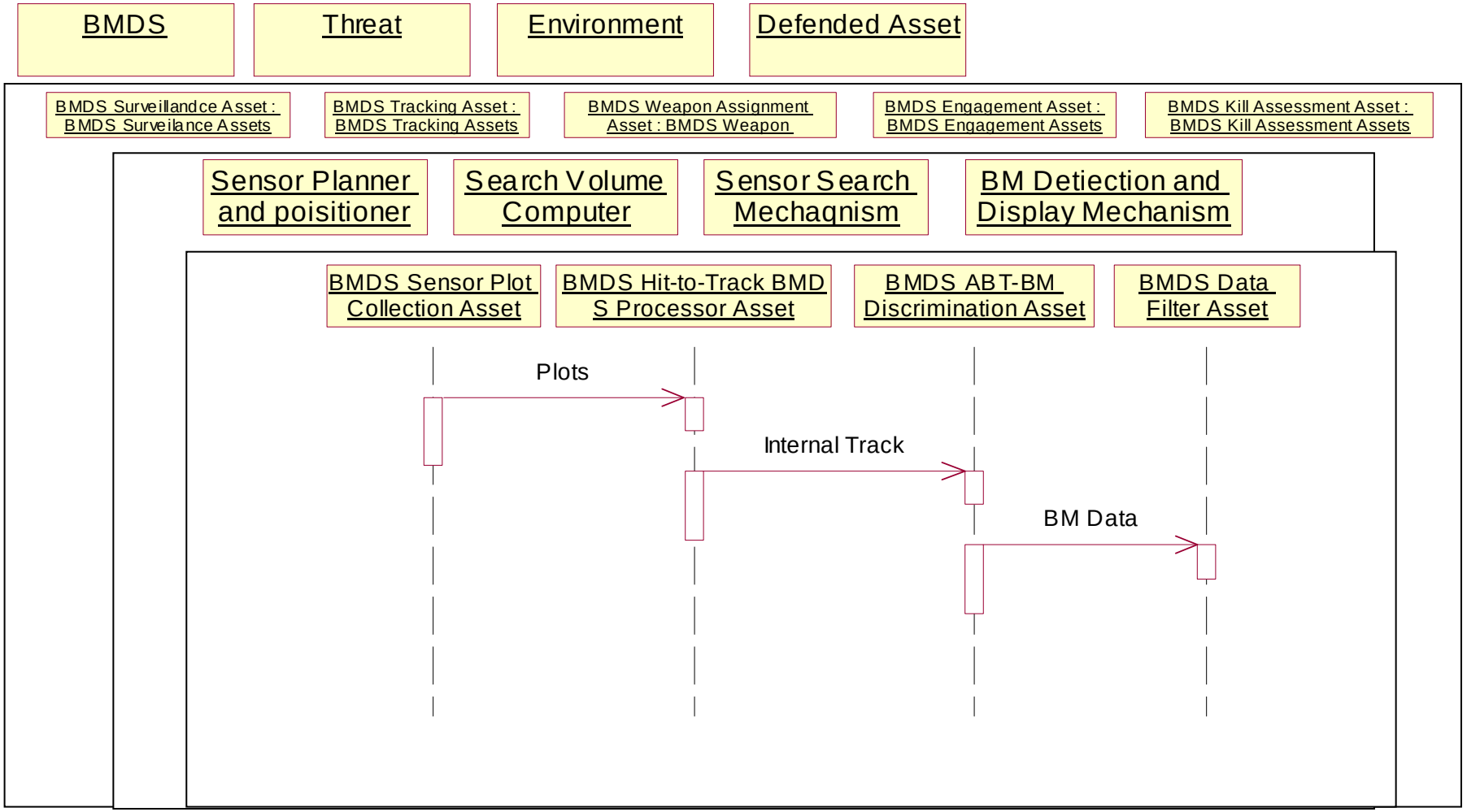
‘Classification’ of BMDS Operational Data



BMDS Conceptual Model Behavior Diagrams

- Statechart Diagrams
- Activity Diagram
- Interaction Diagram
- Sequence Diagram
- Collaboration Diagrams

Scenario Perspective
Sequence Diagrams for ‘Kill Chain’



Implementation Diagrams

- **Component Diagram**
- **Deployment Diagram**

…to be differed till need is manifest

Lessons-Learned

- Observations / Issues / Opportunities -

- **Collaboration among modeling community is effective and efficient**
- **Practice is converging … thought there are a variety of discretionary choices wrt practice, documentation, etc.**
- **Authoritative data management requires attention**

DISCUSSION

- **What will it take to establish ‘best-practice’ in conceptual modeling for the M&S community-of-practice**
- **What role should SCS play in establishing such best-practice**
- **What will *you* do?**
- **ACTION?**