JOG SYSTEM ENGINEERING
GRAND SYSTEMS DEVELOPMENT
TRAINING PROGRAM INTRODUCTORY PRESENTATION

THE MODEL, THE TEXTUAL AND GRAPHICAL RAS, AND THE SPECIFICATION – A LOGICAL AND EFFECTIVE PROGRESSION

Presented By
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Who Is Jeff Grady?

CURRENT POSITION

1993 – PRESENT

Owner, JOG System Engineering
System Engineering Assessment, Consulting, and Education Firm

PRIOR EXPERIENCE

1954 - 1964 U.S. Marine Corps

1964 - 1965 General Precision, Librascope Division

Customer Training Instructor, SUBROC and ASROC ASW Computing Systems

1965 - 1982 Teledyne Ryan Aeronautical

Field Engineer, AQM-34 Series Special Purpose Aircraft Systems
Project Engineer, System Engineer on Unmanned Aircraft Systems

1982 - 1984 General Dynamics Convair Division

System Engineer, Cruise Missile, Advanced Cruise Missile

1984 - 1993 General Dynamics Space Systems Division

Functional Engineering Manager Systems Development Department

FORMAL EDUCATION

SDSU BA Math, UCSD Systems Engineering Certificate,
USC MS Systems Management With Information Systems Certificate

INCOSE Founder, Fellow, ESEP, and First Elected Secretary

AUTHOR System Requirements Analysis (3), System Integration, System Validation and Verification, System Verification, System Engineering Planning and Enterprise Identity, System Engineering Deployment, System Synthesis, System Management

The Principal Presentation References

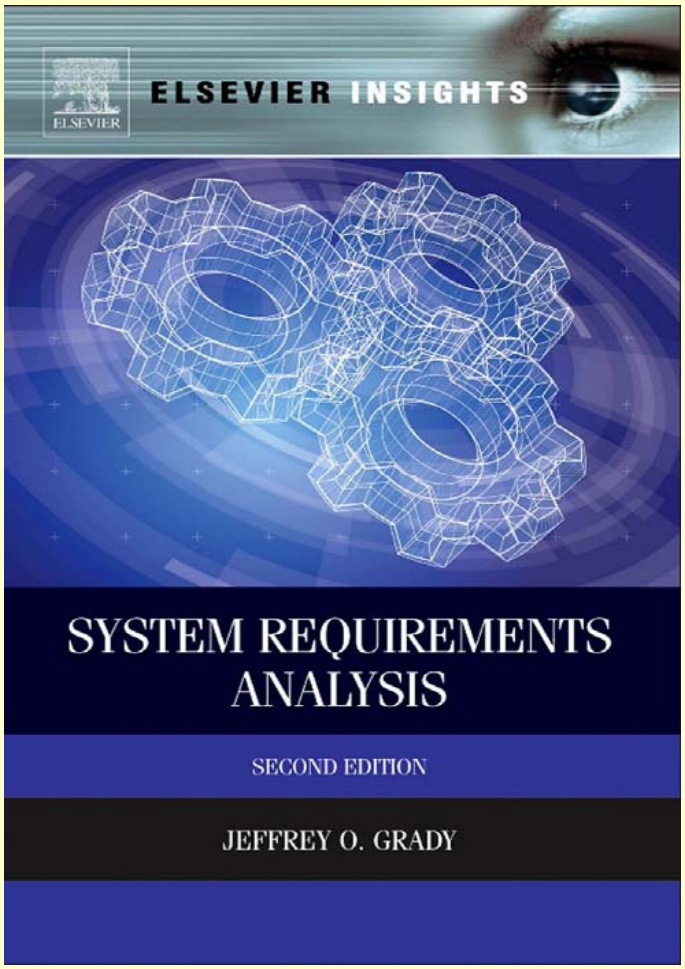
“System Requirements Analysis, 2nd Edition”, Jeffrey O. Grady, Elsevier Academic Press, 2014

"The Model, the Textual and Graphical RAS, and the Specification – A Logical and Effective Progression", Jeffrey O. Grady, paper not yet published, 2013

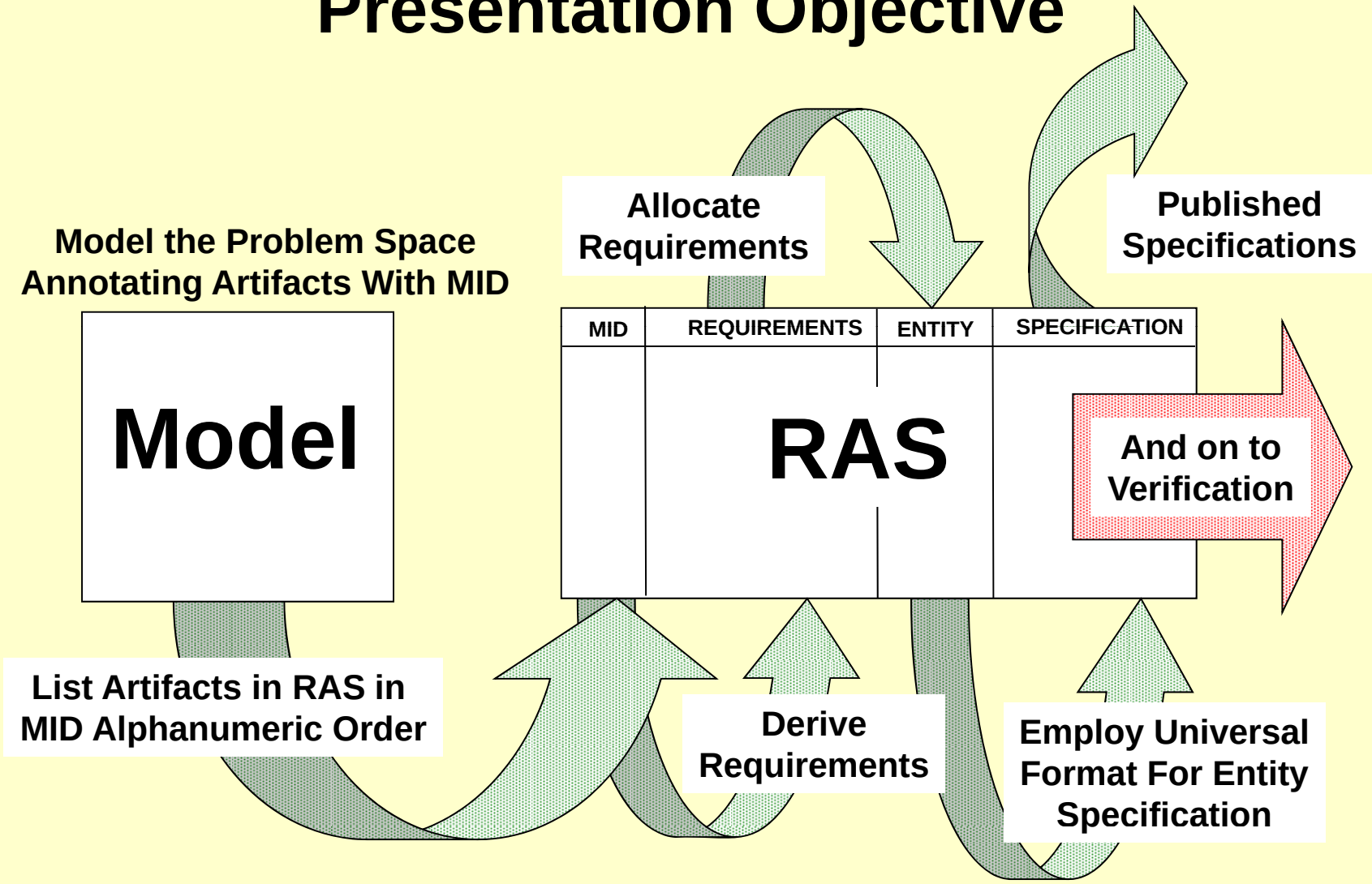
"Universal Architecture Description Framework (UADF)", Jeffrey O. Grady, Systems Engineering, The Journal of The International Council On Systems Engineering, Volume 12 Number 2, Summer 2009 (Best Paper 2009)

"Affordable Requirements Verification", Jeffrey O. Grady, INCOSE Insight, July 2013 (Volume 16, Issue 2)

New System Requirements Analysis Book in E-Book Format



Presentation Objective



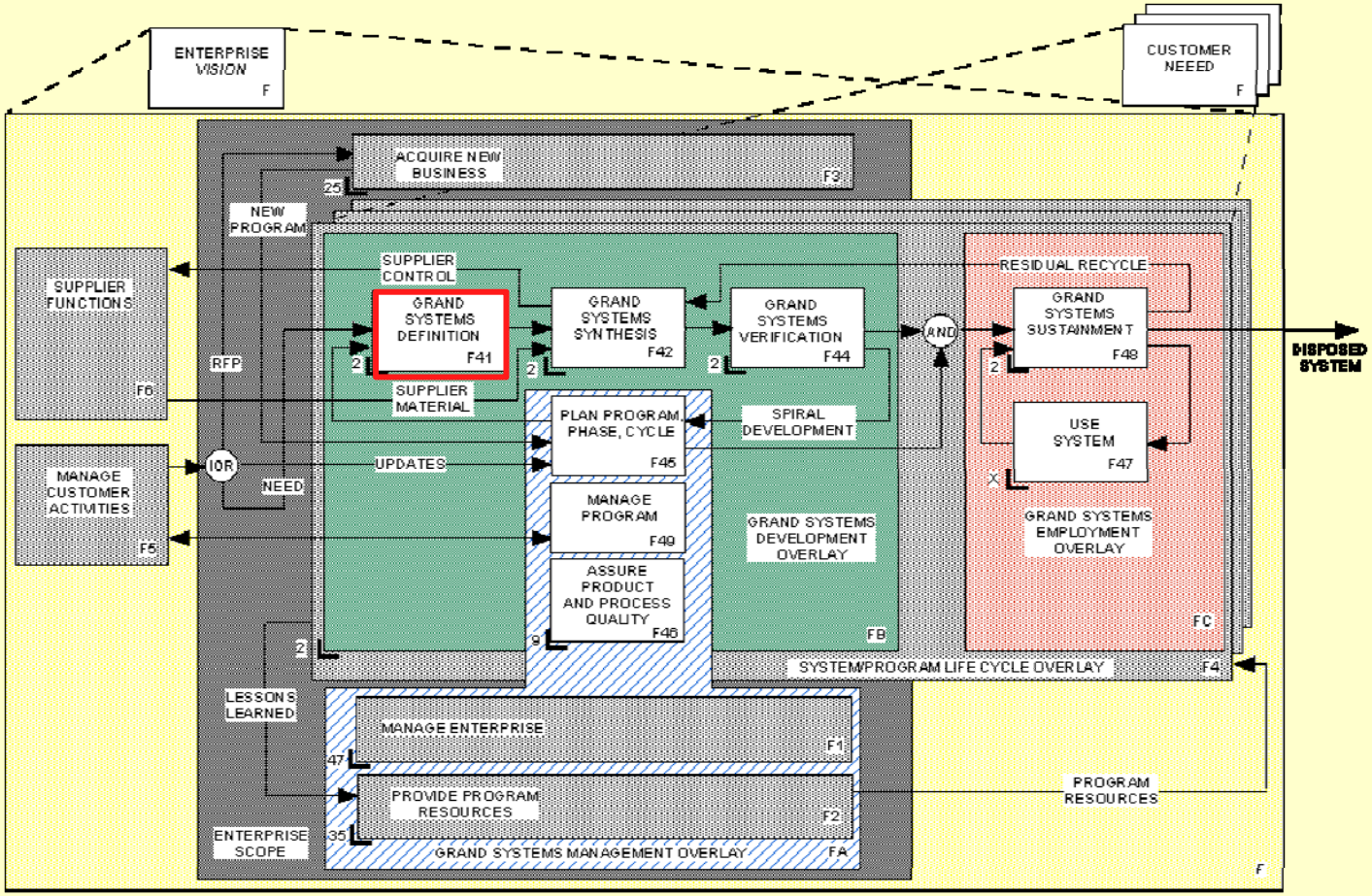
What Is a System?

- Collection of product entities intended to achieve a specific function
- Immersed in an environment
- Product and environmental entities inter-related through interfaces
- Product and interface entities clearly defined in a set of specifications where all of the content has been derived though application of a model to the problem space

Systems Development

- **Define the problem to be solved in a set of product and interface entity specifications**
- **Solve the problem through synthesis in a three-step process**
  - **Design**
  - **Procurement**
  - **Manufacturing**
- **Determine extent to which entities and the system comply with the content of the specifications through verification**
- **Manage the program well throughout its development period**

Enterprise Common Process View of System Life Cycle



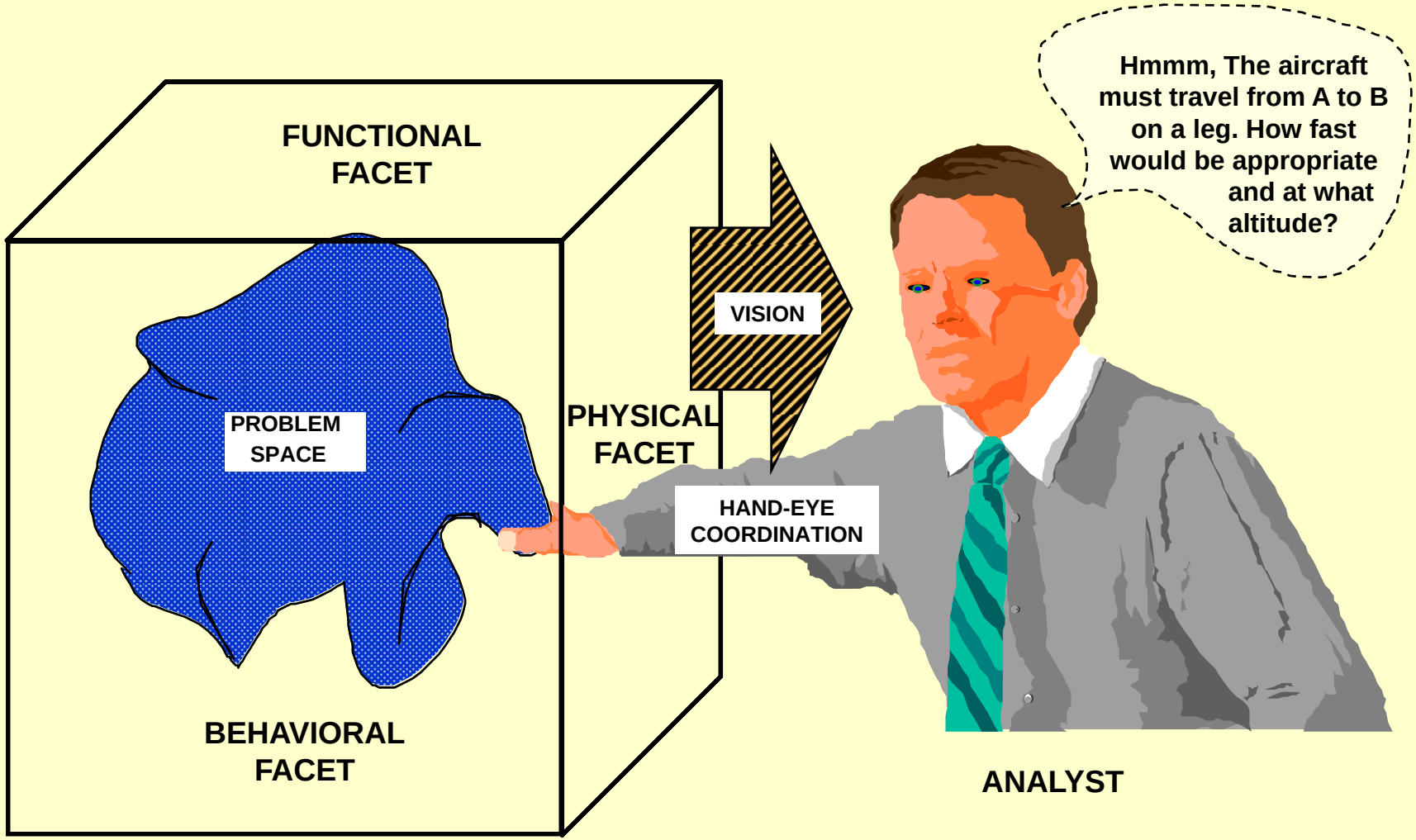
X: REFER TO PROGRAM SYSTEM DEFINITION DOCUMENT FOR EXPANSION

Major Problem on All Programs - Specification Content

- Each specification contains the essential characteristics its product or interface entity must possess in the form of requirements
- An enterprise should derive the content of all specifications on all programs using a single comprehensive universal architecture description framework (UADF) model
  - Functional
  - MSA-PSARE
  - UML-SysML
  - UPDM maybe
- Adopt the Model-RAS-Specification Sequence using your selected UADF and a template coordinated with it

Models Channel Requirements Into the Human Mind Through Vision –

A Picture is Worth 10^3 Words

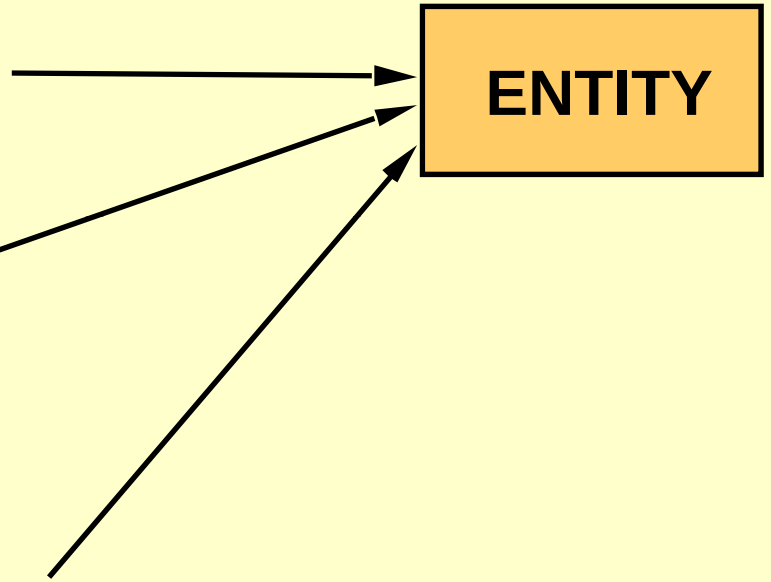


The First Objective of Modeling - Architecture

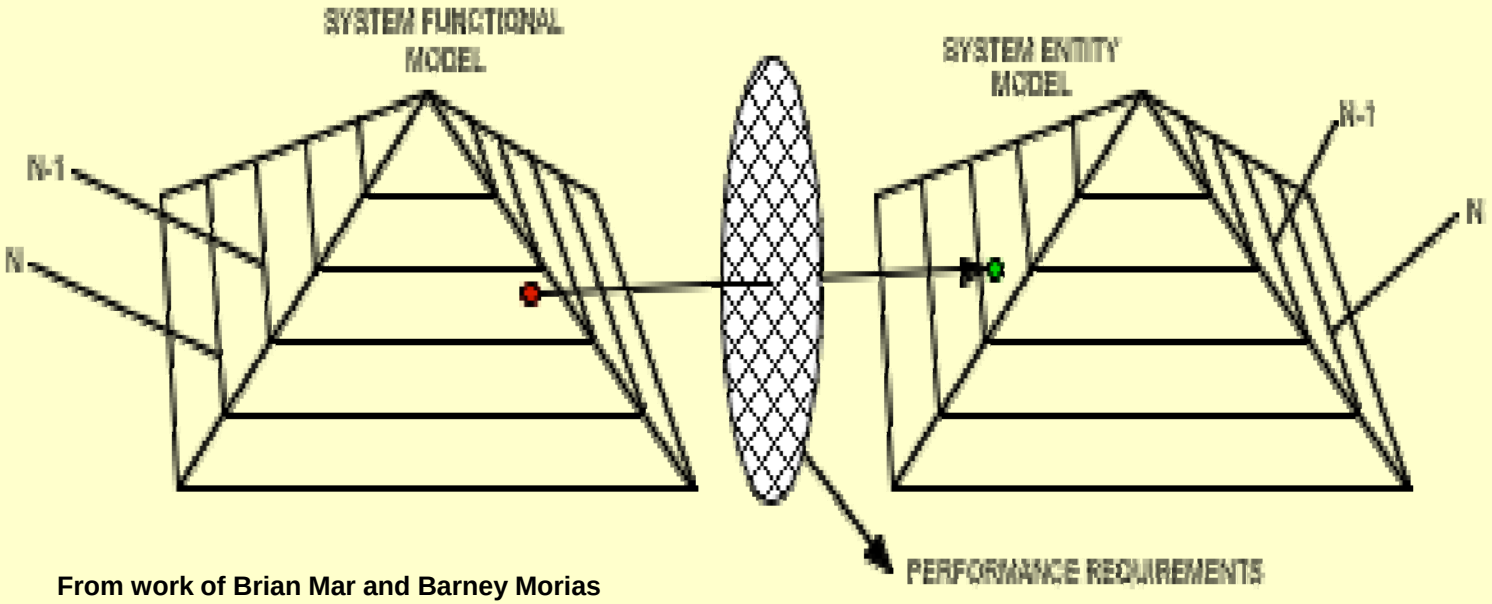
- What mission objective does the customer wish to achieve?
- What product entities shall the system consist of?
- How shall those product entities be inter-related through interfaces?
- What does the system environment consist of?
- How are the product entities related to the environment?
- What specialty engineering domains must be respected in the design?

The Second Objective of Modeling - Requirements

- Something wanted or necessary.
- Something essential to the existence or occurrence of an entity.
- A necessary characteristic or attribute of some thing (or entity).



Progressive Modeling

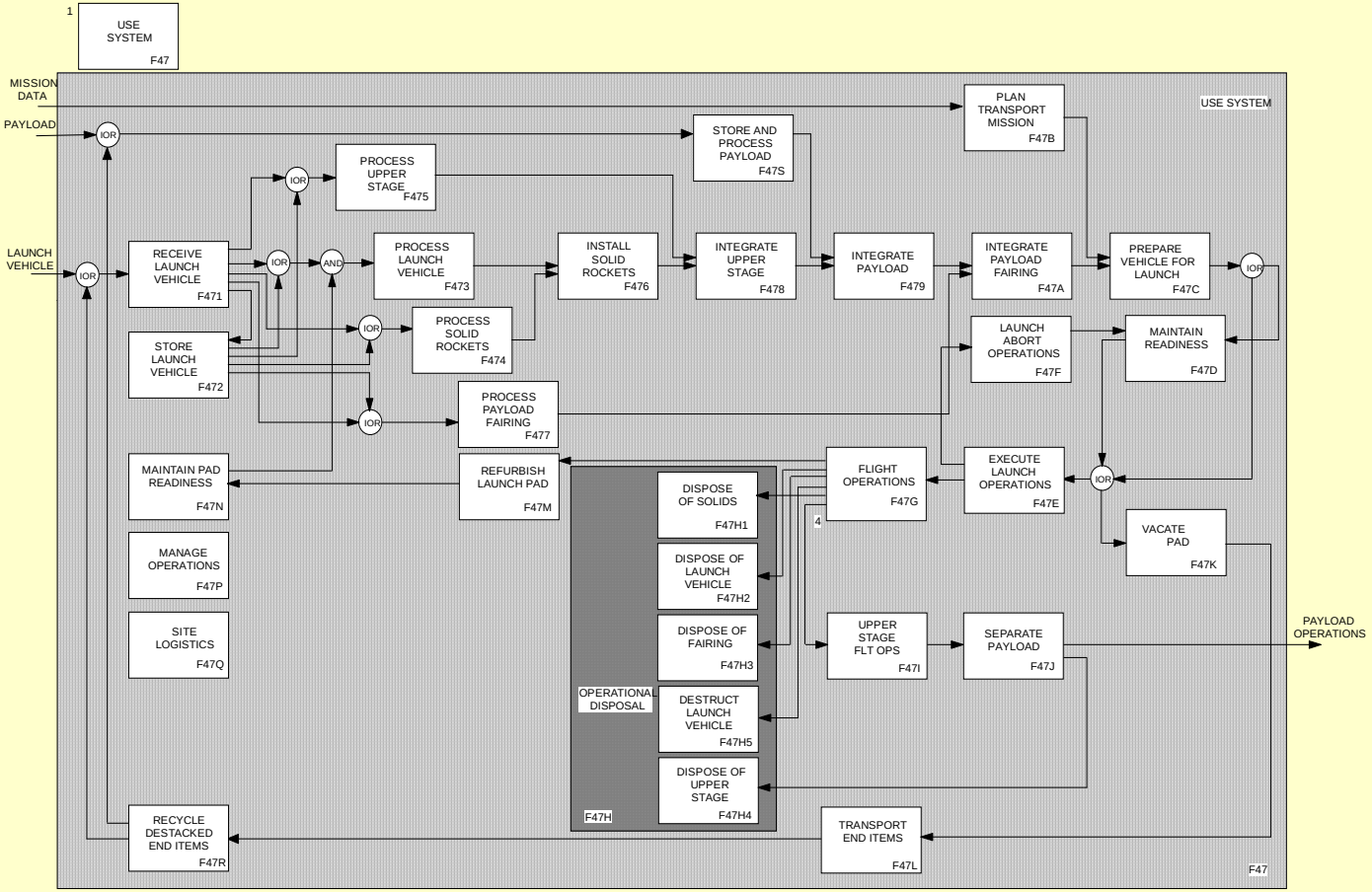


From work of Brian Mar and Barney Morias

Three UADF Are Available

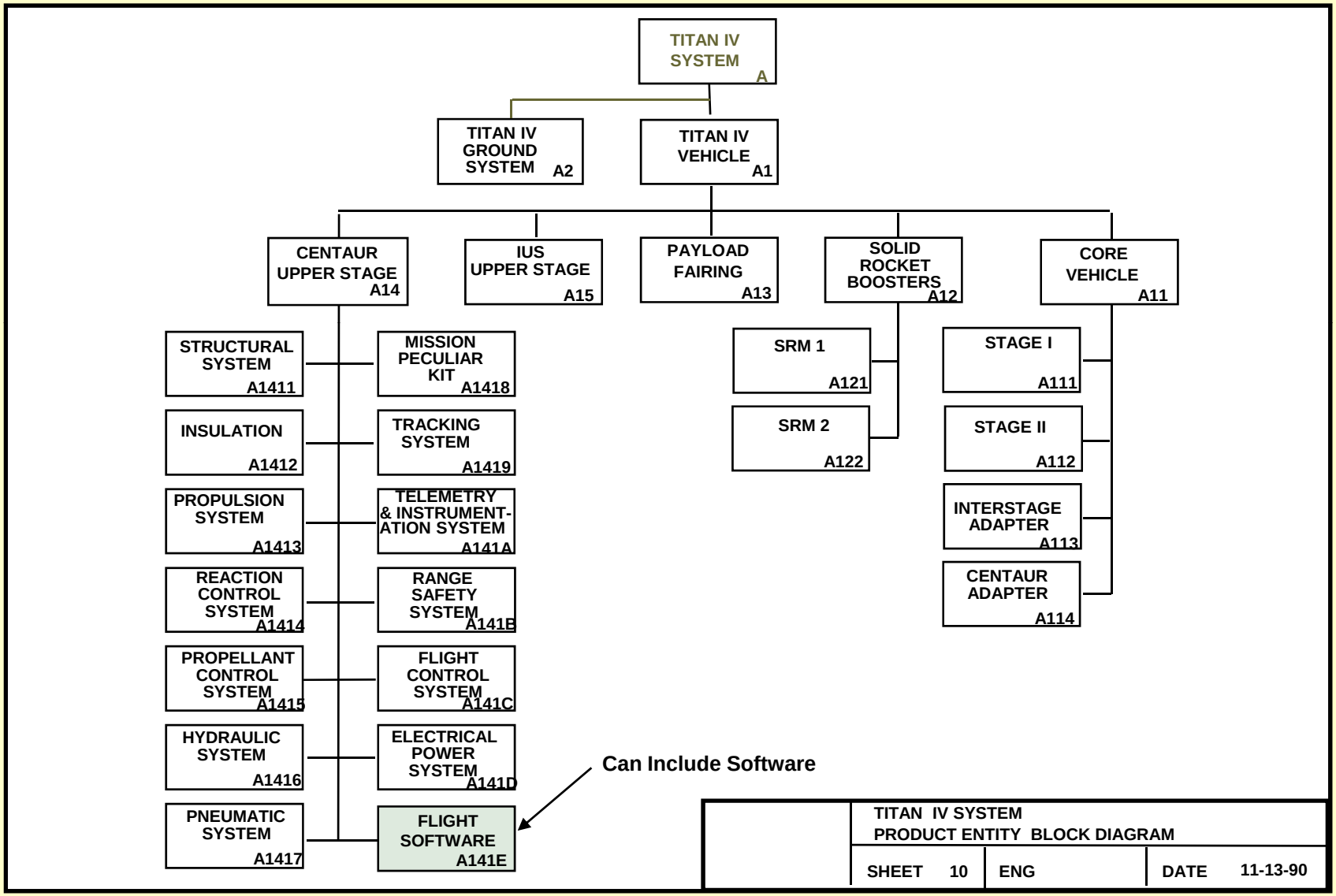
- A UADF is a comprehensive modeling approach in that it matters not how you will implement the solution in HW, SW, or people doing things
- One model is equally effective in HW and SW
- Pick one
  - Functional
  - MSA-PSARE
  - UML-SysML
  - UPDM maybe

Functional UADF Functional Flow Diagramming

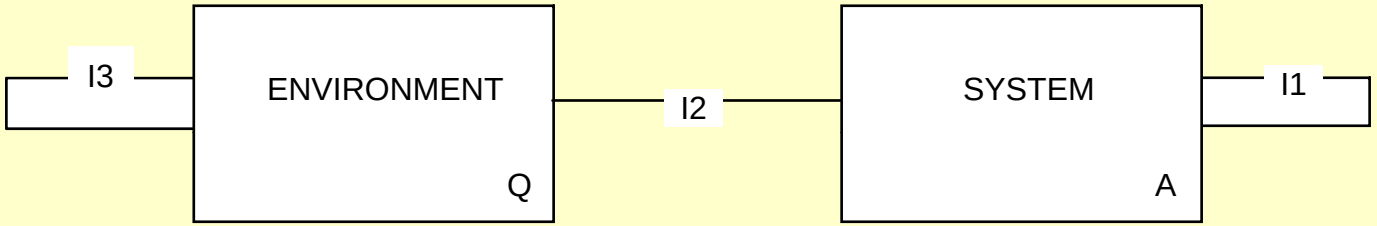


But this technique will work with any UADF.

Functional UADF Product Entity Diagram



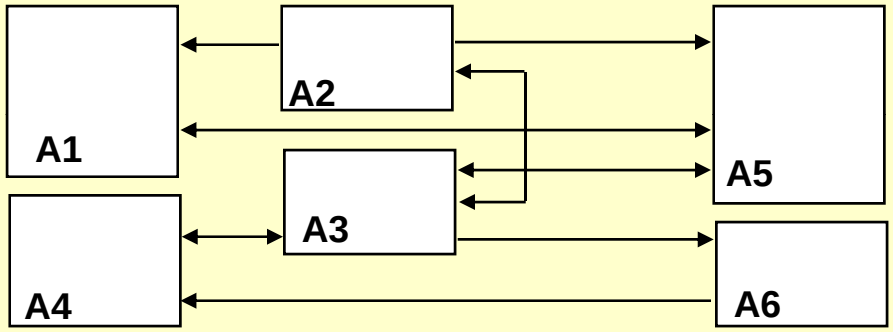
Functional UADF
Top-Level View of System Interface



Internal Interface
I1 Innerface
External Interface
I2 Crossface
I3 Outerface

Functional UADF
Two Interface Reporting Models

Schematic block diagramming



Lines define interfaces

Blocks are objects selected only from the product entity structure

N-square diagramming

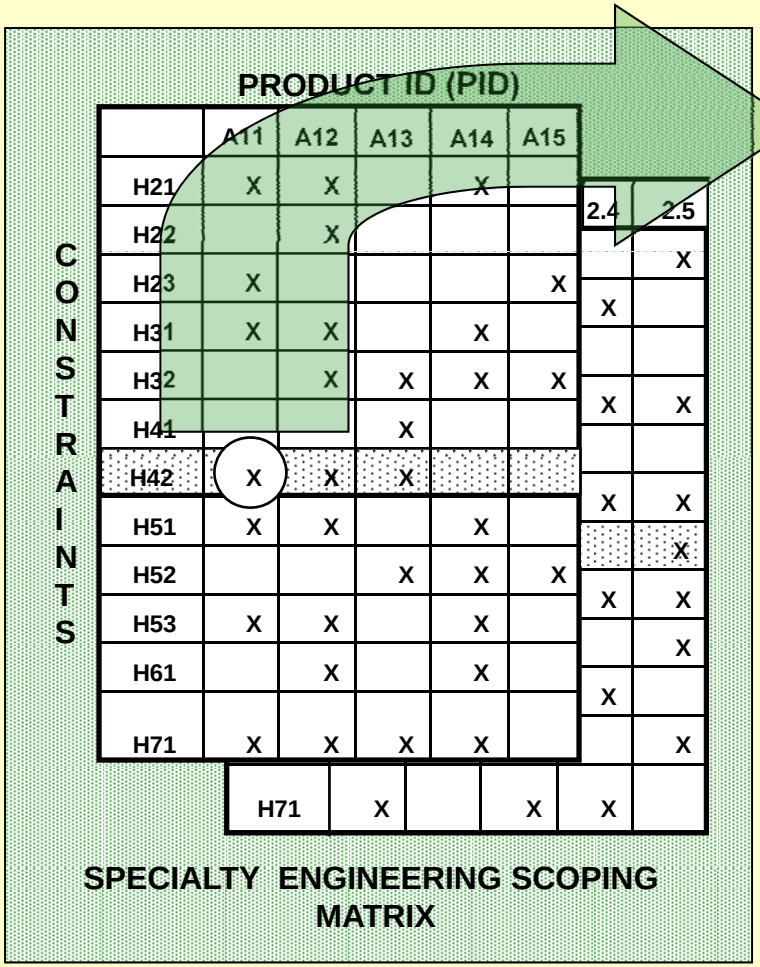
A1				X	
X	A2	X		X	
	X	A3	X	X	X
		X	A4		
X		X		A5	
			X		A6

Marked intersections define interfaces

Diagonal blocks are objects only from product entity structure

Apparent ambiguity reflects directionality

Functional UADF
Specialty Engineering Scoping Matrix



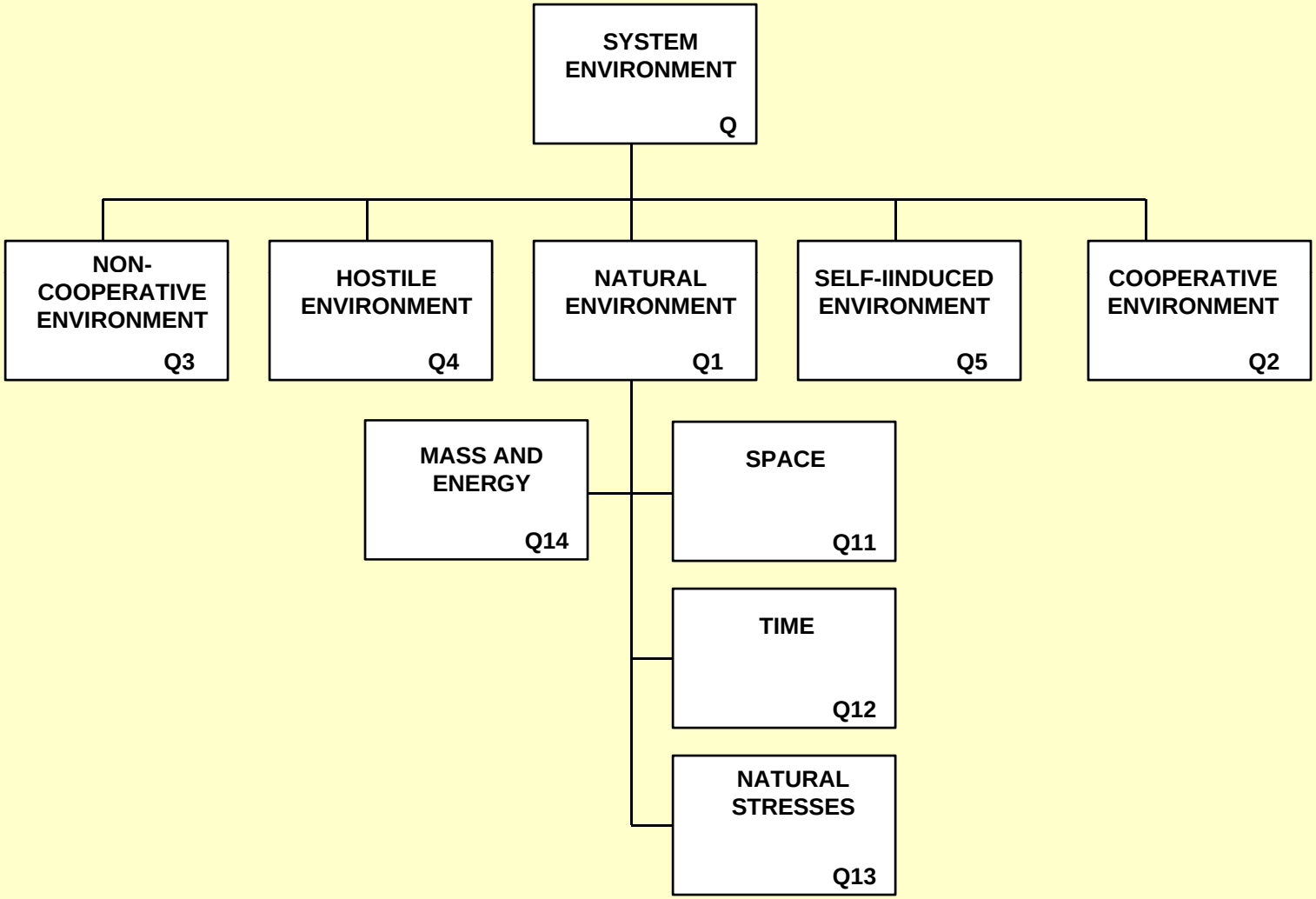
	A11	A12	A13	A14	A15	2.4	2.5
H21	X	X		X			X
H22		X				X	
H23	X				X		
H31	X	X		X			
H32		X	X	X	X	X	X
H41			X				
H42	X	X	X			X	X
H51	X	X		X			X
H52			X	X	X	X	X
H53	X	X		X			X
H61		X		X		X	
H71	X	X	X	X			X
H71	X		X	X			

Specialty Engineering Requirements Analysis

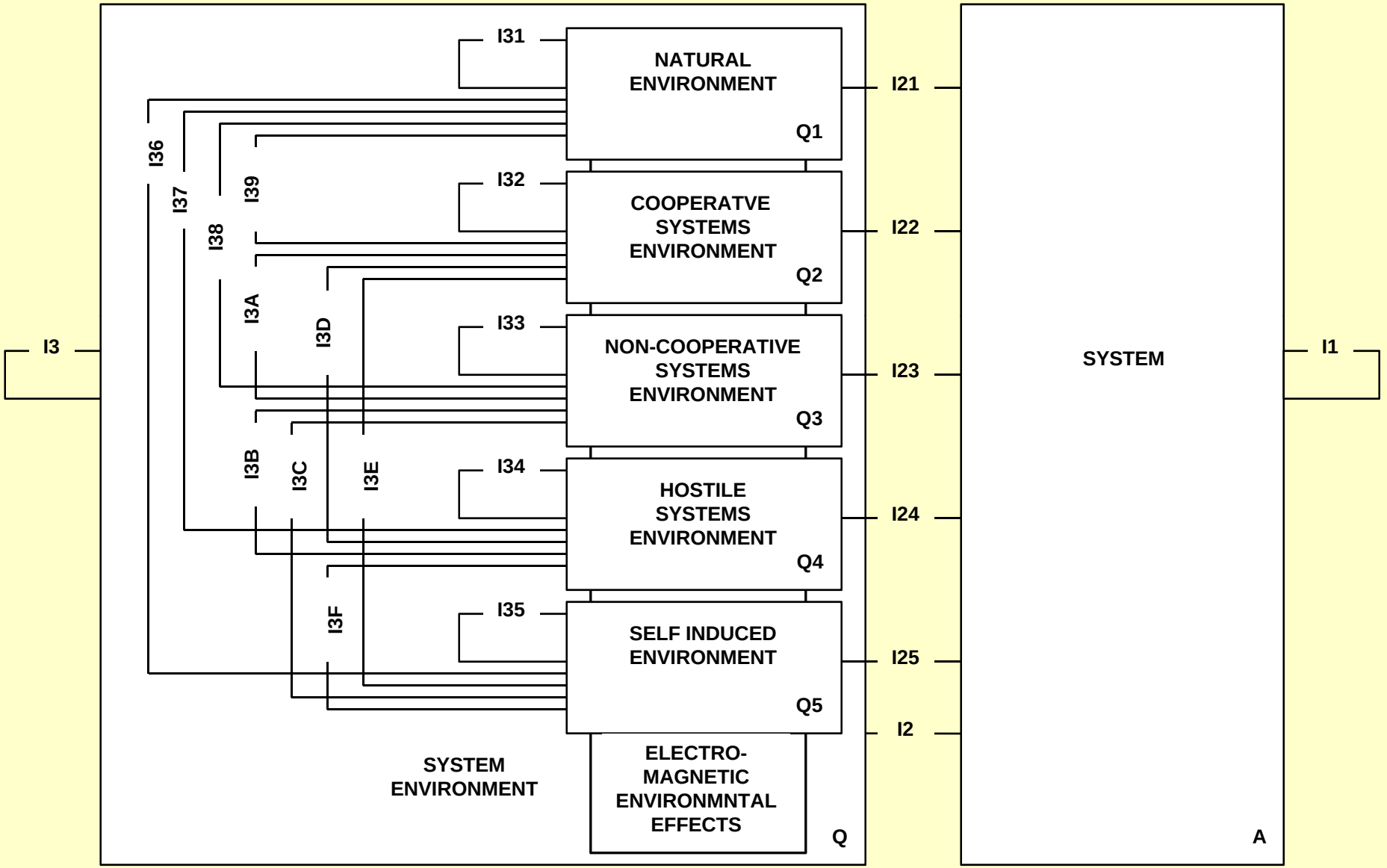
CONSTRAINT	PID	PARA
H42	A11	FROM TEMPLATE
H42	A12	
H42	A13	
H42	A21	

REQUIREMENTS ANALYSIS SHEET
(IN A COMPUTER DATABASE)

Functional UADF Environmental Classes



Functional UADF
Generic External Interface MID



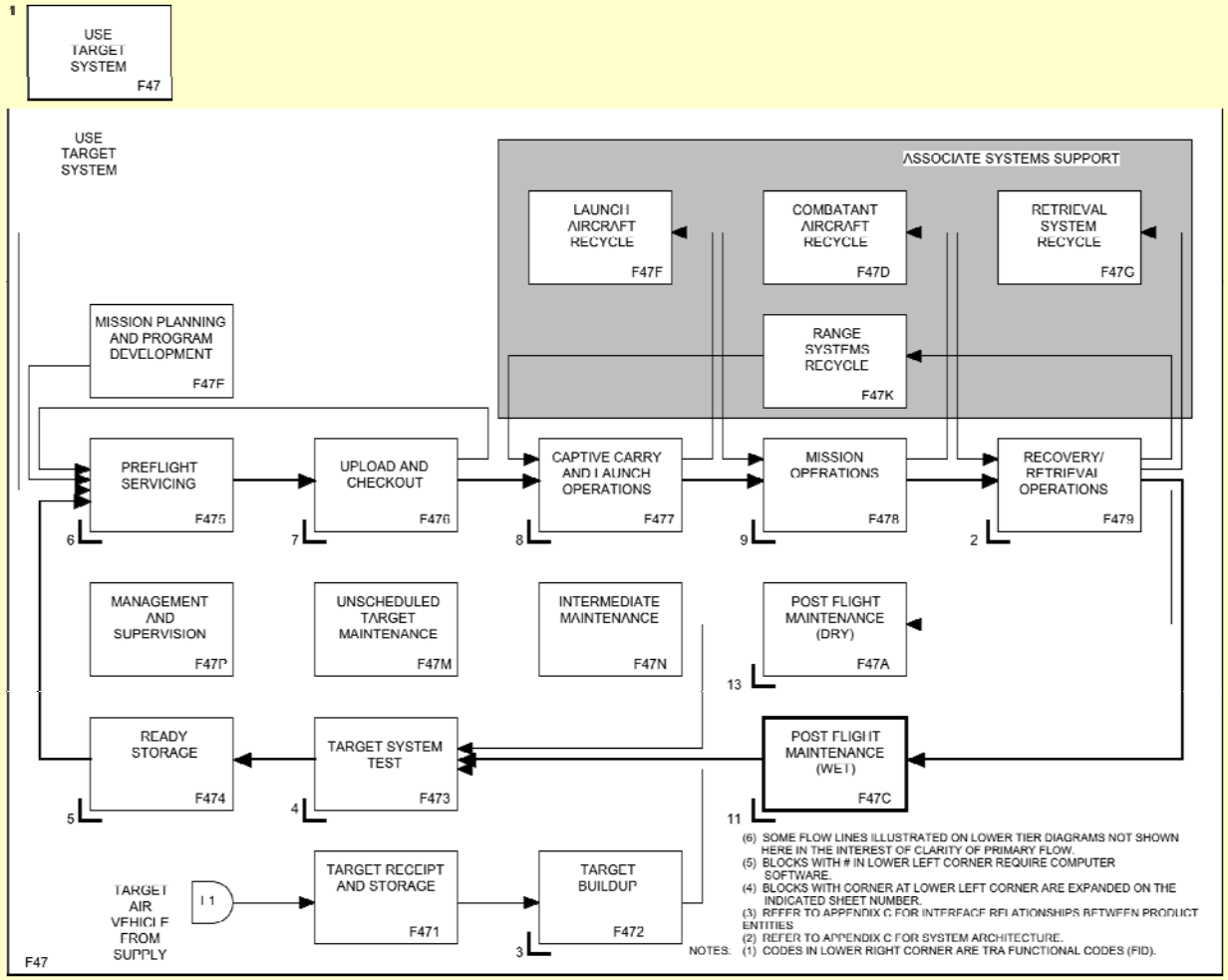
VERSION 14.0

122A-21

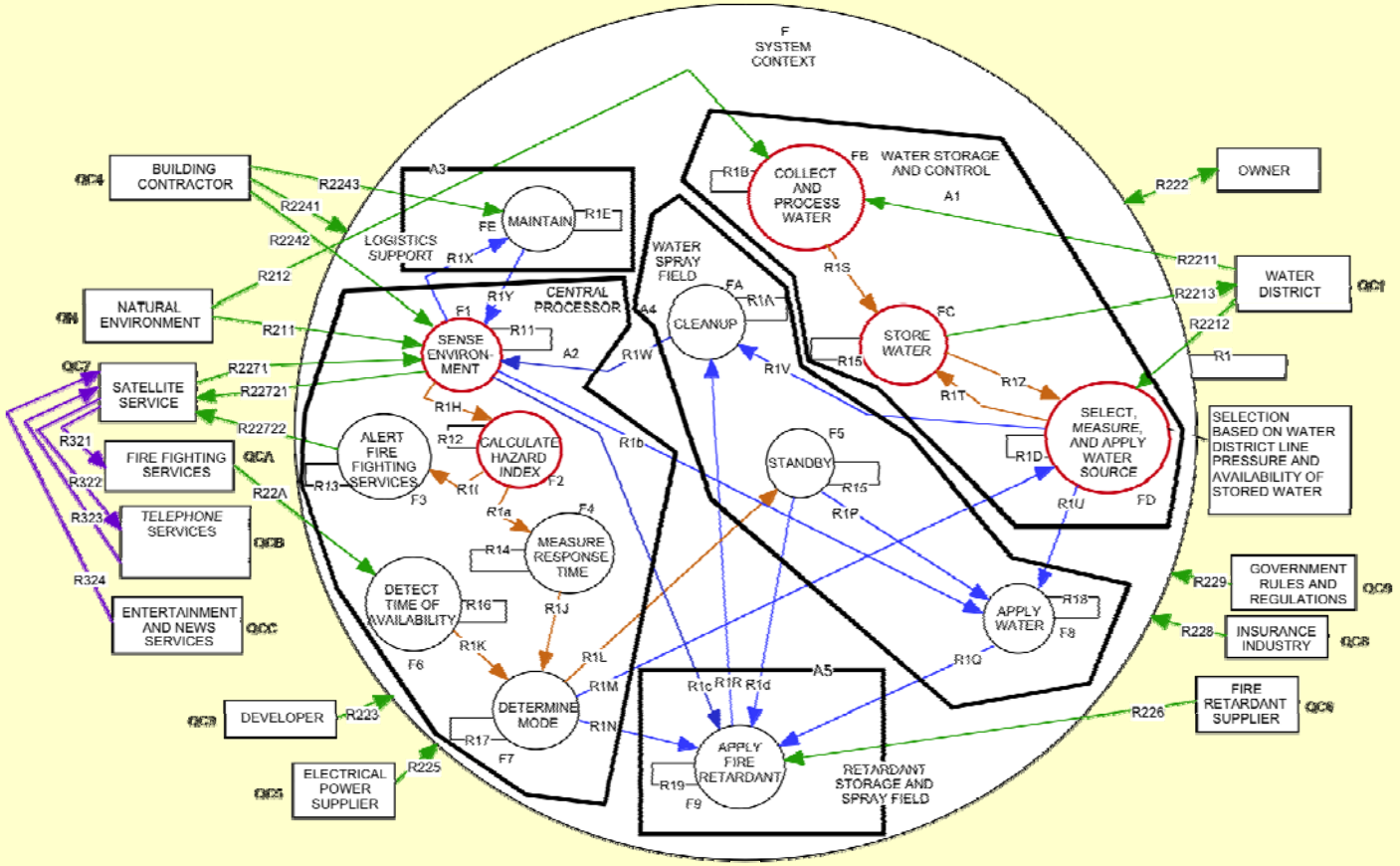
Functional UADF
Three Tier Environmental Modeling

- System level using integrated union of tailored standards
- End item level using three dimensional service use profile
  - Product entities
  - Environmental stresses
  - Process steps
- Component level using end item zoning and mapping components to zones
- Possible need for an environmental sub system

Functional UADF Process Flow Diagram
Needed as Part of the End Item Environmental Model

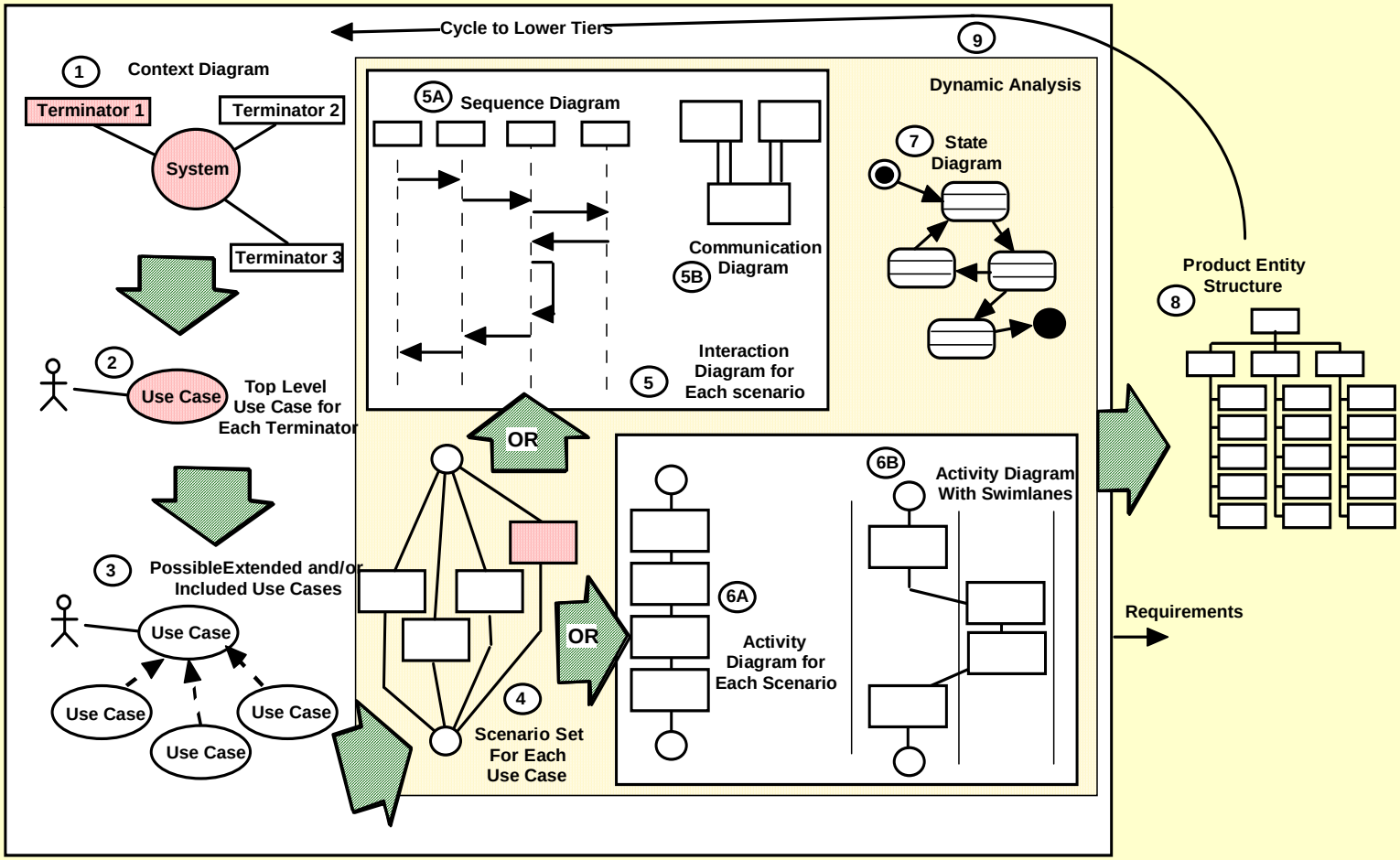


Systems Development Using the MSA-PSARE UADF

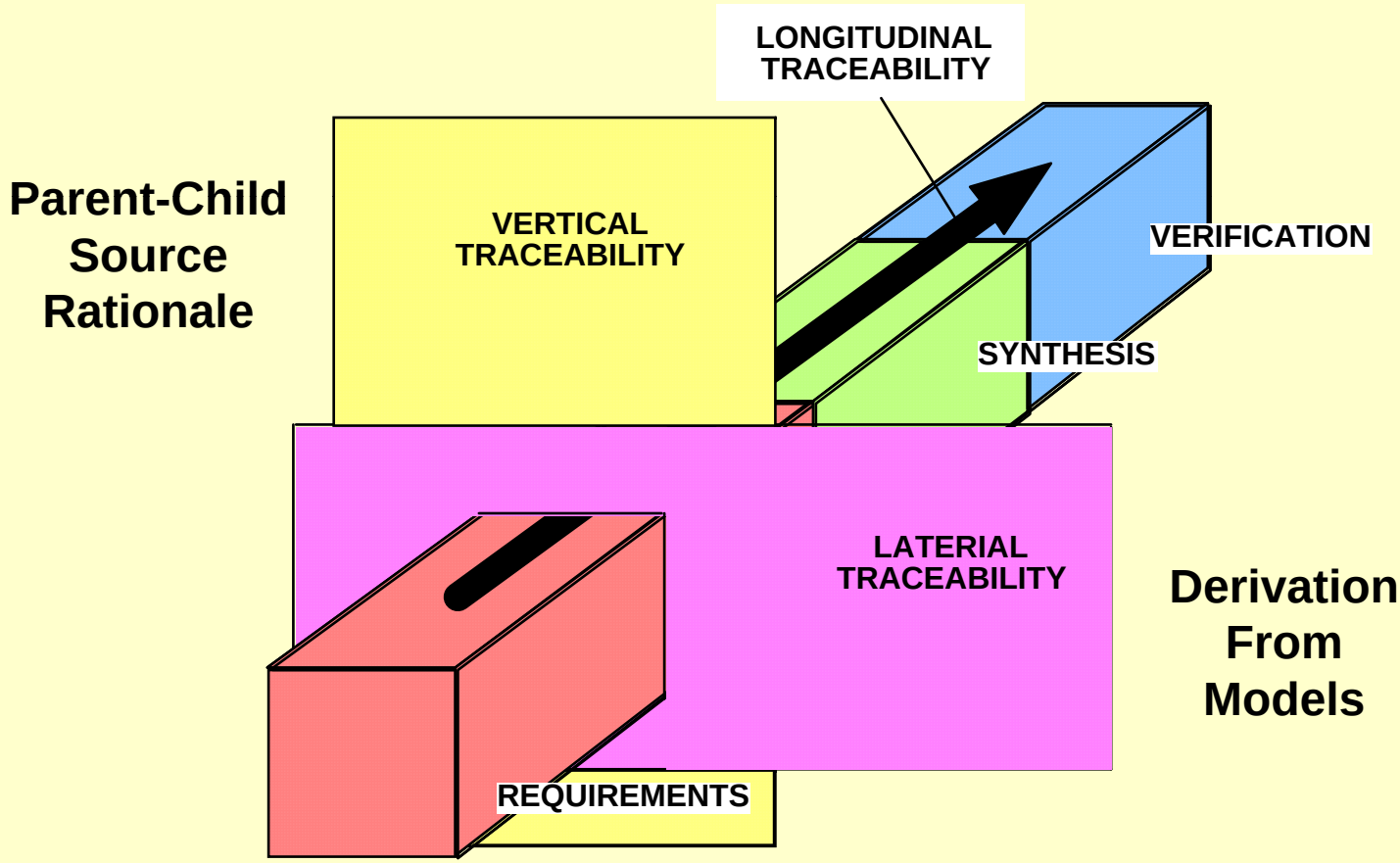


Assign Product Entity MID (A) to Super Bubbles
Assign Interface MID (I) to Functional Relations (R)

System Development Using the UML-SysML UADF



No Matter the UADF Selected – Employ Three-Dimensional Requirements Traceability



Suggested Specification Section 3 Template

TIMID ADVANCE

3.	REQUIREMENTS	3.4	Specialty Engineering Requirements
3.1	Modeling	3.5	Environmental Requirements
3.2	Performance Requirements	3.5.1	Natural Environment
3.3	Interface Requirements	3.5.2	Cooperative Environment
3.3.1	Internal Interfaces (I1)	3.5.3	Non-Cooperative Environment
3.3.2	External Interfaces (I2)	3.5.4	Hostile Environment
3.3.3	Outside Interfaces (I3)	3.5.5	Self-Induced Environment

AGGRESSIVE ADVANCE

3.	REQUIREMENTS	3.3.2.1	Natural Environment
3.1	Modeling	3.3.2.2	Cooperative Systems Environment
3.2	Performance Requirements	3.3.2.3	Non-Cooperative Environment
3.3	Interface Requirements	3.3.2.4	Hostile Environment
3.3.1	Internal Interfaces	3.3.2.5	Self-Induced Environment
3.3.2	External Interfaces	3.4	Specialty Engineering Requirements

Unique Modeling Artifact Identification To Support Lateral Traceability

MID	MEANING	PARA	DEPT	PREFERRED MODEL
A	Product Entity	3.1	331	Product Entity Block Diagram
F	Functionality	3.1	331	Functional Flow Diagramming
H	Specialty Engineering Domain	3.4	331	Specialty Engineering Scoping Matrix
H1	Engineering Domain	3.4.1	3XX	-
H11	Aerodynamics	3.4.1.1	321	Modeling and Simulation
H12	Thermodynamics	3.4.1.2	322	Thermodynamic Analysis
H13	Structural Integrity	3.4.1.3	323	Modeling and Simulation
H14	Structural Statics	3.4.1.4	323	Modeling and Simulation
H15	Structural Dynamics	3.4.1.5	323	Modeling and Simulation
H2	Logistics Domain	3.4.2	341	Functional Flow Diagramming
I	Physical Interface	3.3	331	N-Square Diagram
I1	Internal Interface	3.3.1	331	N-Square Diagram
I2	External Interface	3.3.2	331	N-Square Diagram
I3	Outside Interface	3.2.3	331	N-Square Diagram
J	Functional Interface	NA	331	N-Square Diagram
P	Process	-	-	Process Flow Diagram
Q	Environment	3.5	331	Three Tier Model
Q1	Natural Environment	3.5.1	331	Standards
Q11	Space	3.5.1.1	331	Mission Analysis and Packaging
Q12	Time	3.5.1.2	331	Time Lines
Q13	Natural Stresses	3.5.1.3	331	Standards
Q2	Cooperative Environment	3.3.2	331	N-Square Diagram
Q3	Non-Cooperative Environment	3.3.3	331	Threat Analysis
Q4	Hostile Environment	3.3.4	331	Threat Analysis
Q5	Self-Induced Environment	3.3.5	331	No Specific Model
R	Requirement	3	3XX	-

RAS-Complete In Table Form

MODEL ENTITY		REQUIREMENT ENTITY		PRODUCT ENTITY		DOCUMENT ENTITY	
MID	MODEL ENTITY NAME	RID	REQUIREMENT	PID	ITEM NAME	PARA	TITLE
F47	Use System			A	Product System		
F471	Deployment Ship Operations			A	Product System		
F4711	Store Array Operationally	RXR67	Storage Volume < 10 ISO Vans	A1	Sensor Subsystem		
H	Specialty Engineering Disciplines			A	Product System		
H11	Reliability	REW34	Failure Rate < 10 x 10-6	A1	Sensor Subsystem	3.1.5	Reliability
H11	Reliability	RG31R	Failure Rate < 3 x 10-6	A11	Cable	3.1.5	Reliability
H11	Reliability	RFYH4	Failure Rate < 5 x 10-6	A12	Sensor Element	3.1.5	Reliability
H11	Reliability	RG8R4	Failure Rate < 2 x 10-6	A13	Pressure Vessel	3.1.5	Reliability
H12	Maintainability	R6GHU	Mean Time to Repair < 0.2 Hours	A1	Sensor Subsystem	3.1.6	Maintainability
H12	Maintainability	RU9R4	Mean Time to Repair < 0.4 Hours	A11	Cable	3.1.6	Maintainability
H12	Maintainability	RJ897	Mean Time to Repair < 0.2 Hours	A12	Sensor Element	3.1.6	Maintainability
H12	Maintainability	R9D7H	Mean Time to Repair < 0.1 Hours	A13	Pressure Vessel	3.1.6	Maintainability
I	System Interface			A	Product System		
I1	Internal Interface			A	Product System		
I11	Sensor Subsystem Innerface			A1			
I181	Aggregate Signal Feed Source Impedance	RE37H	Aggregate Signal Feed Source Impedance= 52 ohms $\pm$ 2 ohms	A1	Sensor Subsystem		
I181	Aggregate Signal Feed Load Impedance	RE37I	Aggregate Signal Feed Load Impedance= 52 ohms $\pm$ 2 ohms	A4	Analysis and Reporting Subsystem		
I2	System External Interface			A	Product System		
Q	System Environment			A	Product System		
QH	Hostile Environment			A	Product System		
QI	Self-Induced Environmental Stresses			A	Product System		
QN	Natural Environment			A	Product System		
QN1	Temperature	R6D74	-40 degrees F< Temperature < +140 degrees F	A	Product System		
QX	Non-Cooperative Environmental Stresses			A	Product System		

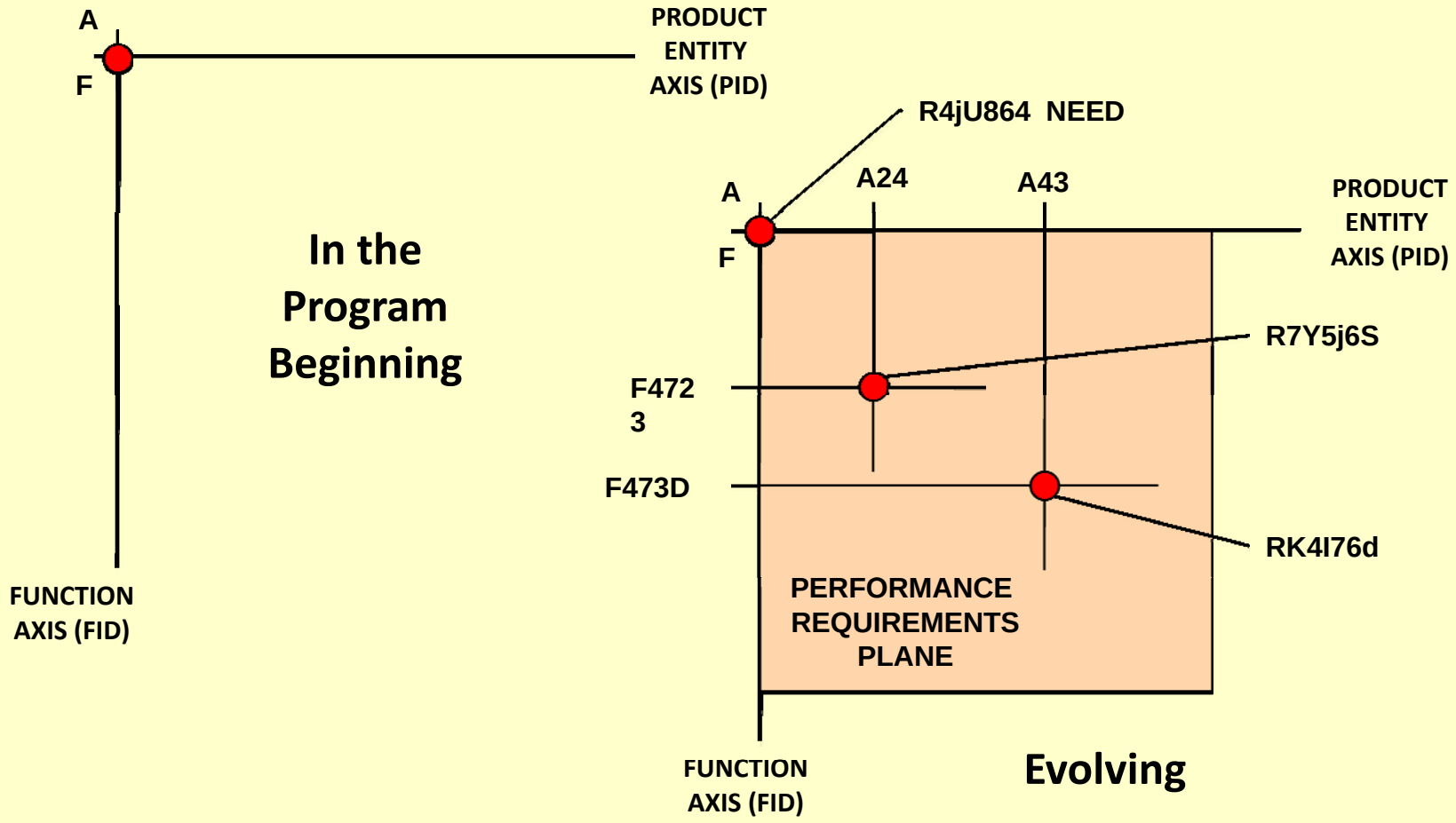
The Requirements Analysis Sheet (RAS)

- **Tabular RAS in a computer database from which specifications may be printed is needed on every program**
- **Graphical RAS will be used in this presentation to explain the content and loading the tabular RAS from models**
- **In this presentation the functional UADF modeling artifacts are used in building the graphical RAS but the idea is compatible with the other two UADF as well**

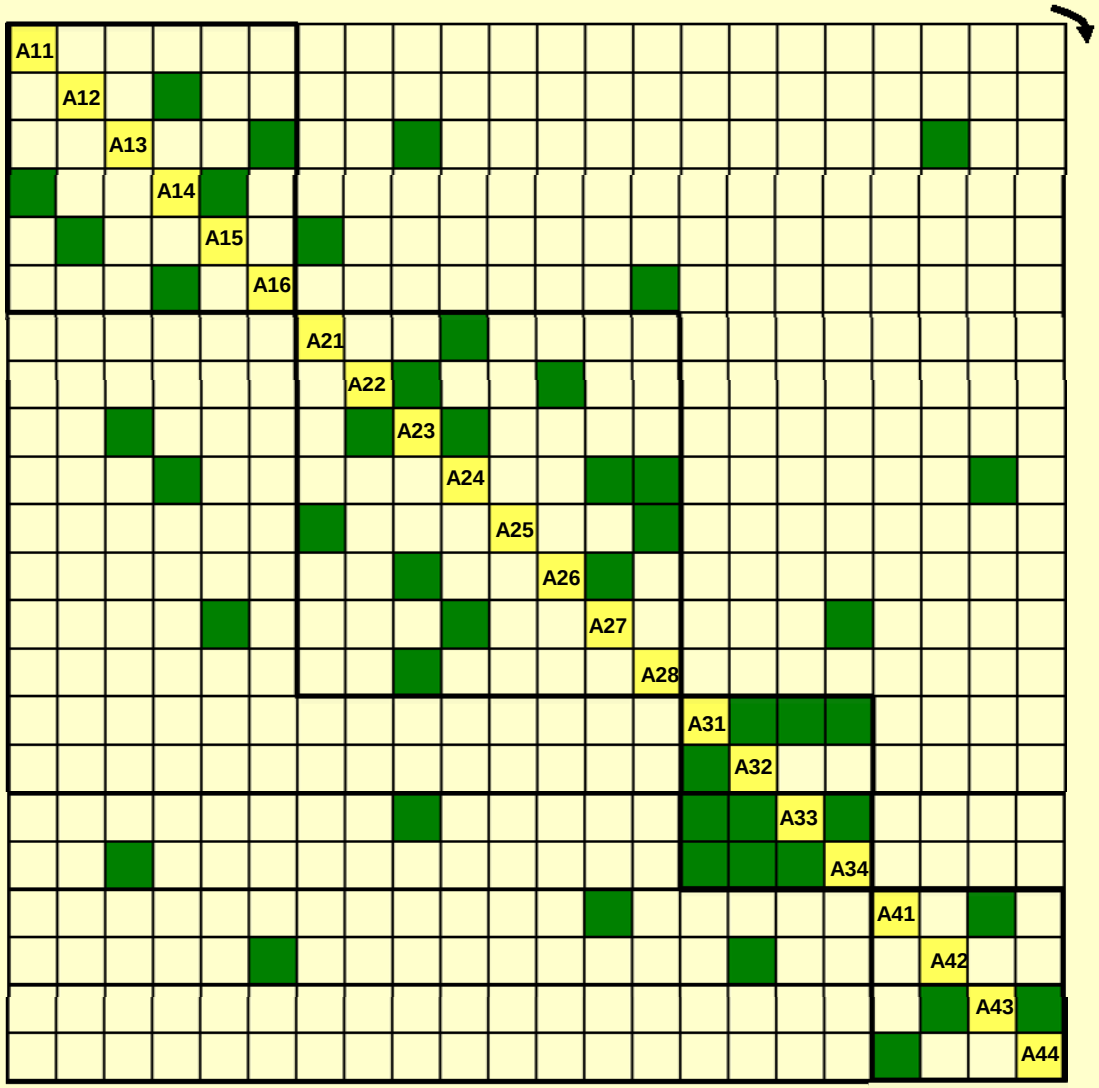
Capture the Model and Configuration Manage It

- Systems Architecture Report (SAR) Recommended
- For the Functional UADF the following appendices are suggested
  - A Functional Flow Diagram
  - B Environment (Natural, Cooperative, Non-cooperative, Hostile, Self-Induced)
  - C Product Entity Block Diagram
  - D Interface Diagram (Schematic Block or N-Square Diagram)
  - E Specialty Engineering Scoping Matrix
  - F Process Diagram
  - G RAS or reference to its location

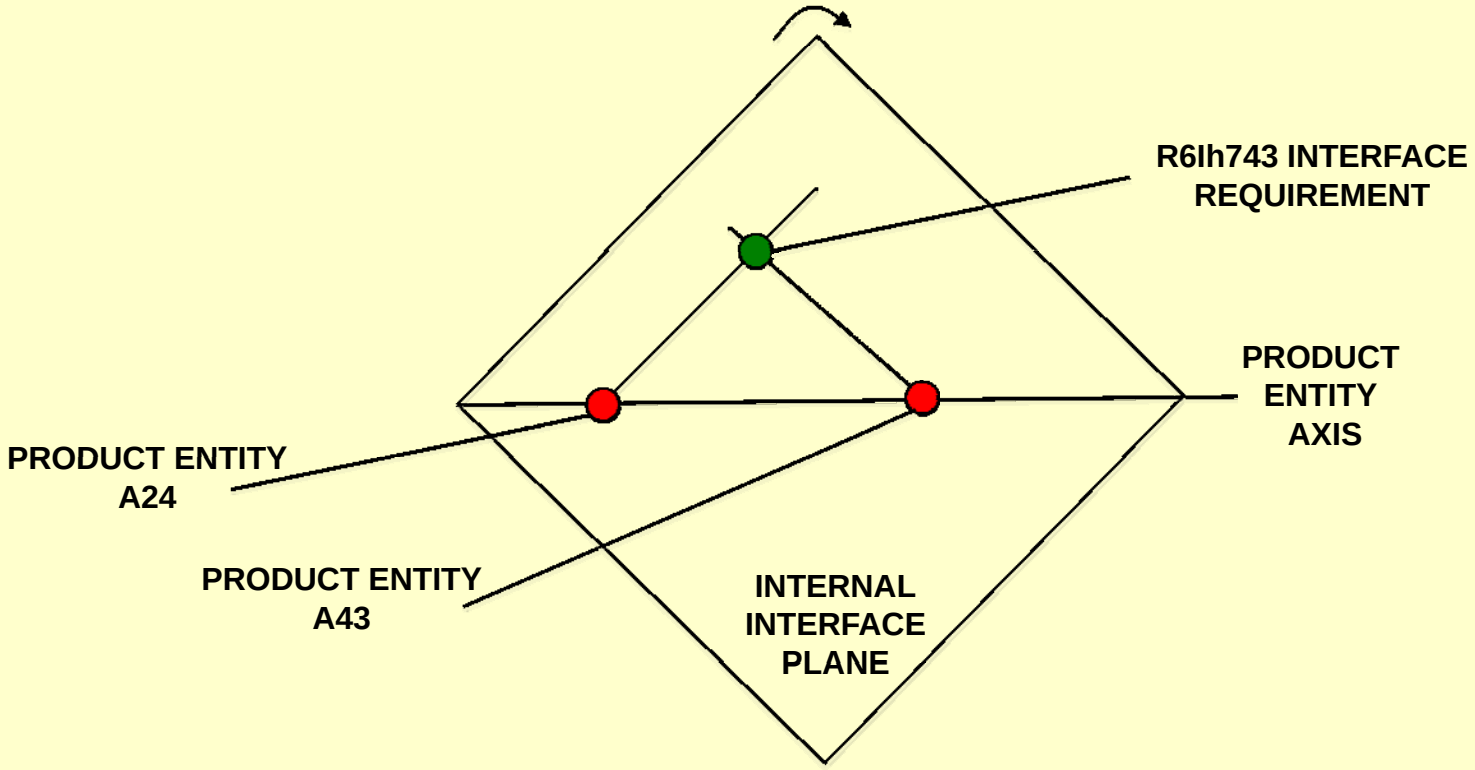
Graphical RAS – Performance Requirements Plane



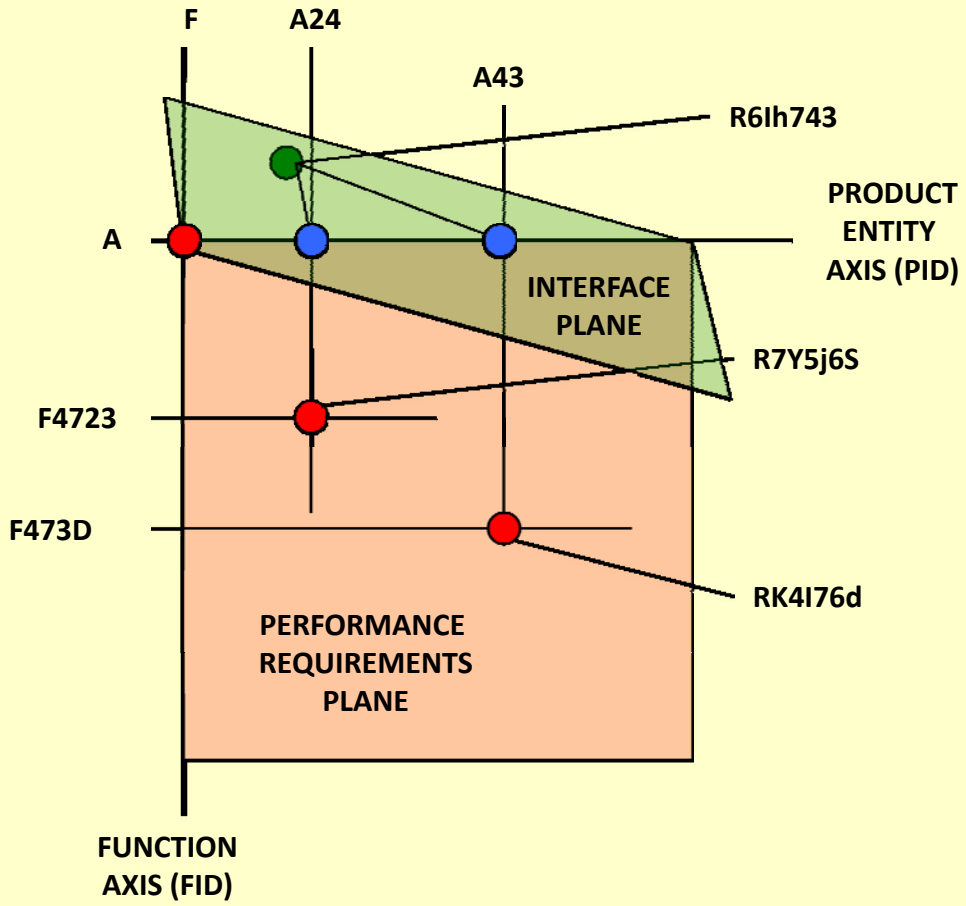
Graphical RAS – Internal Interface Plane



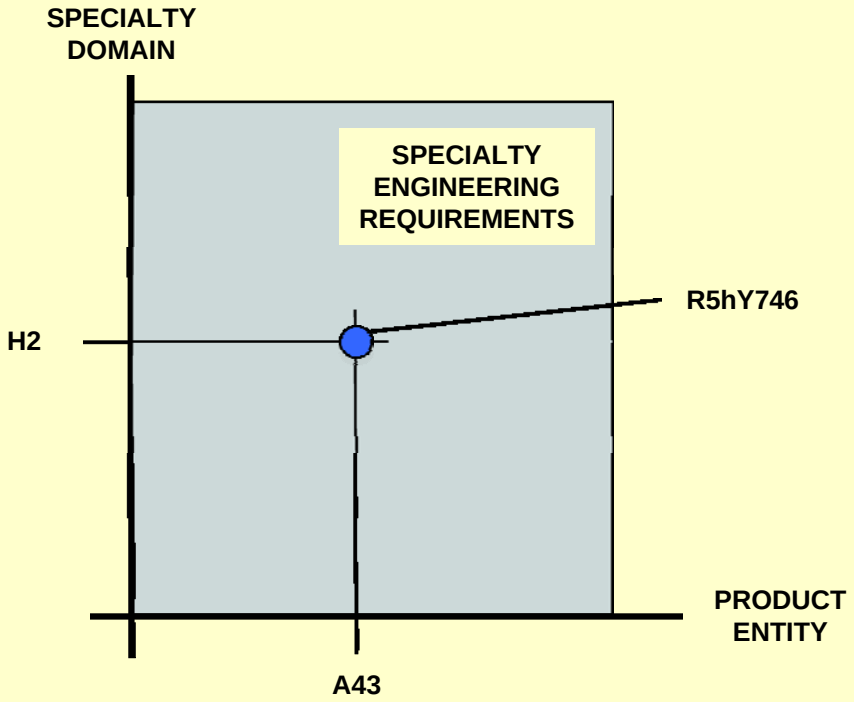
Graphical RAS – Rotate Internal Interface Plane



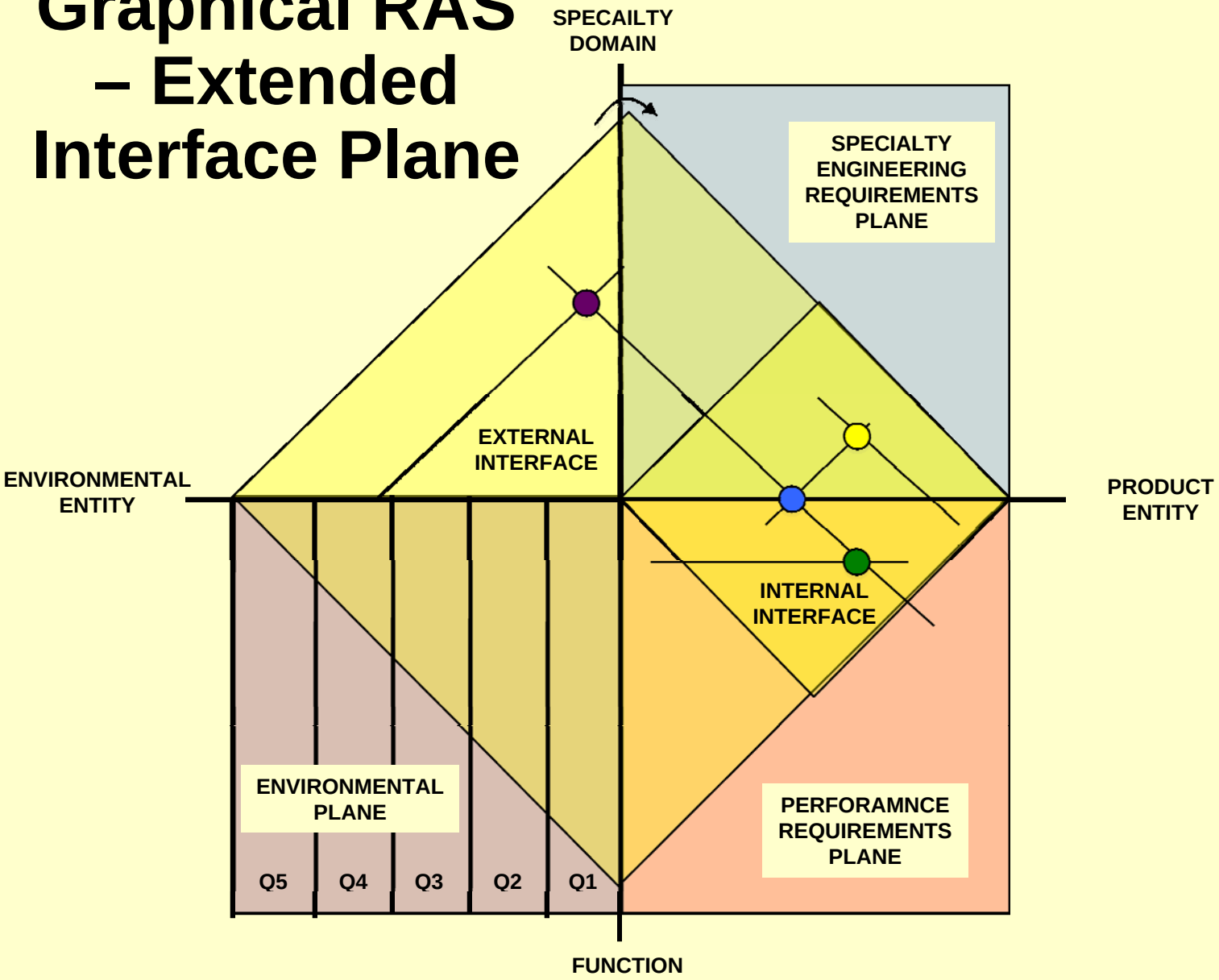
Graphical RAS – Functional Plane Coordinated With Interface Plane



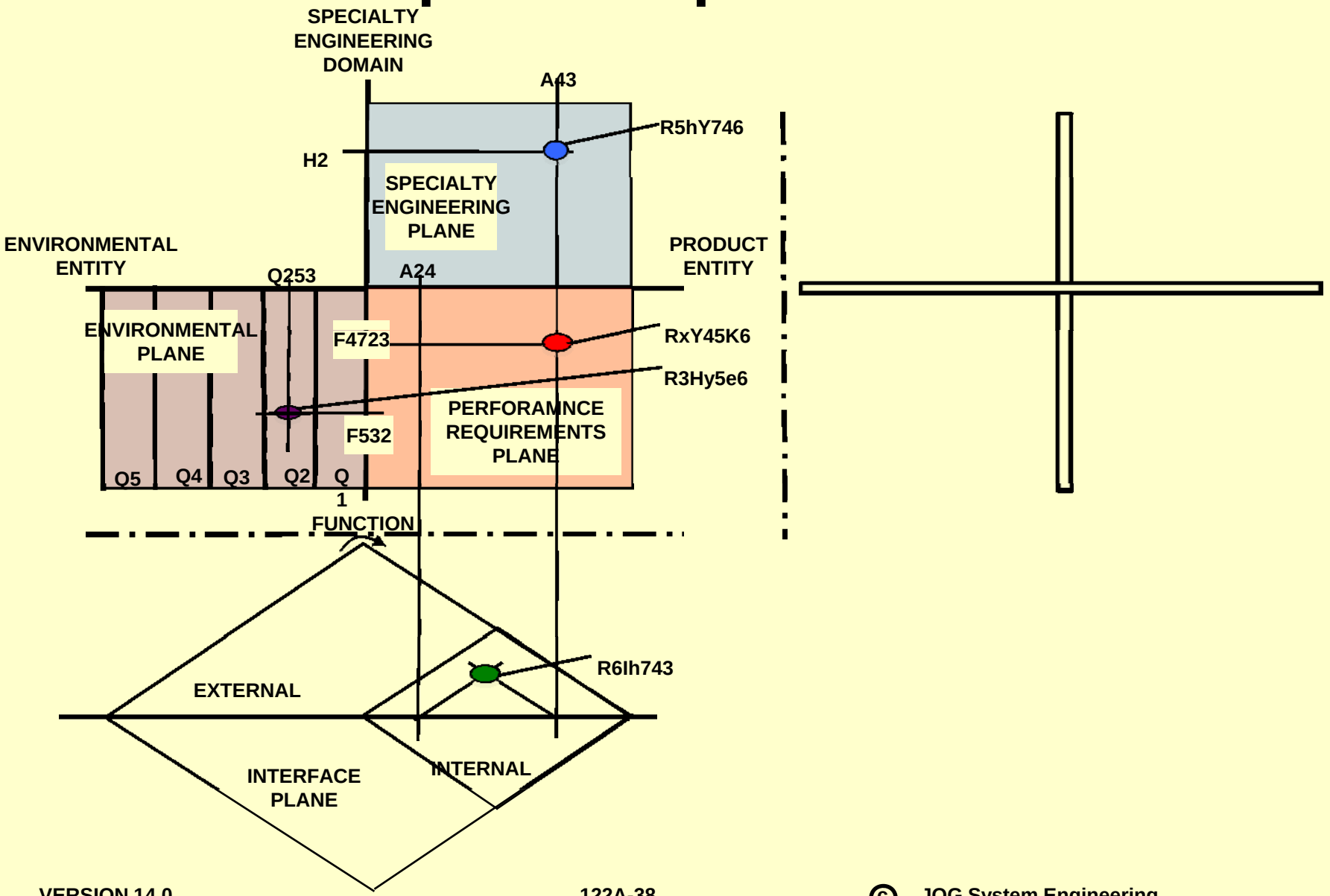
Graphical RAS – Specialty Engineering Plane



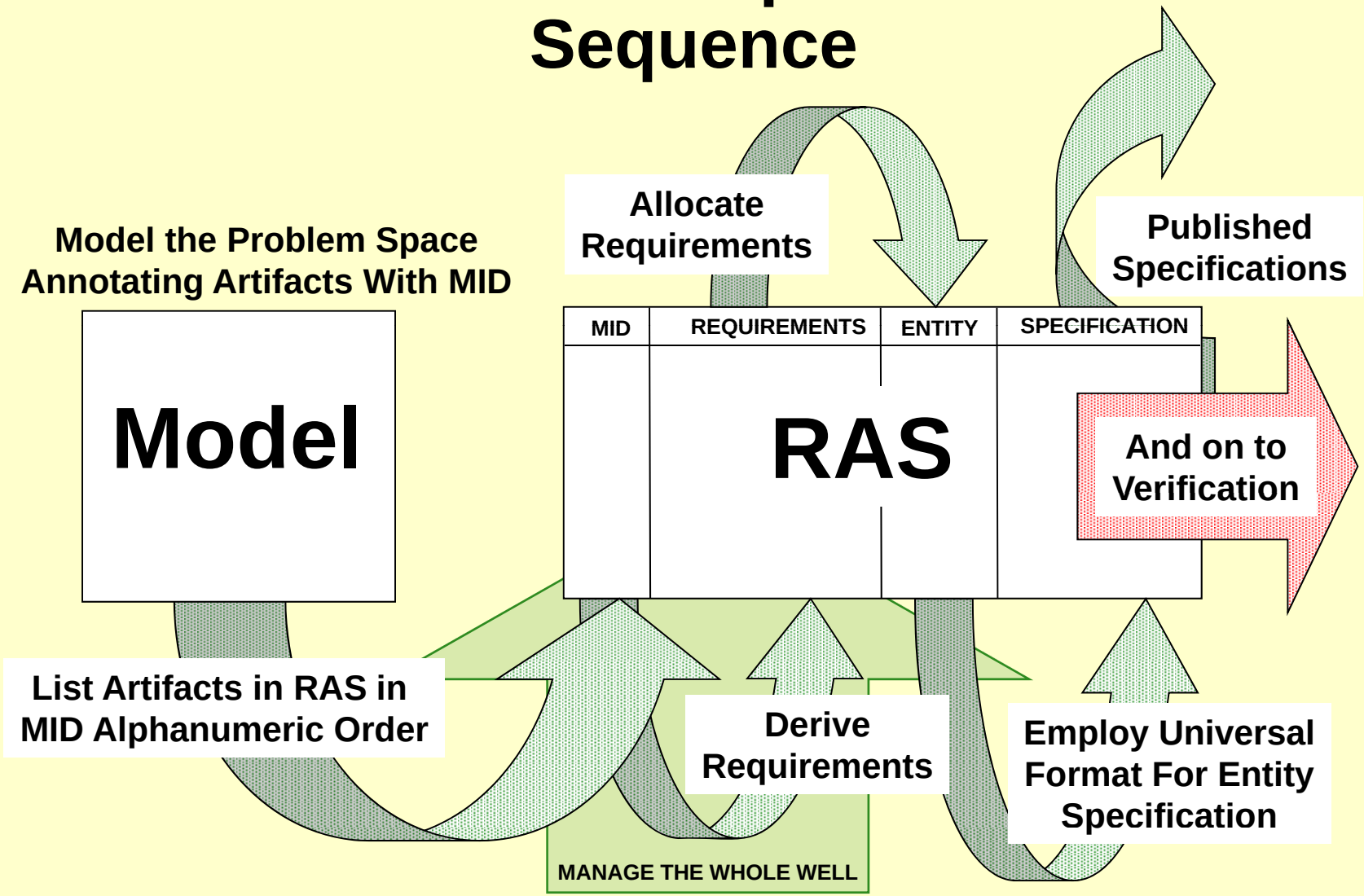
Graphical RAS – Extended Interface Plane



Complete Graphical RAS



Model - RAS - Specification Sequence



Prescription For the Enterprise That Has Not Yet Reached Perfection

1. Adopt a UADF and insist that all persons doing architecture development and requirements analysis work use it.
2. Adopt a way of uniquely identifying all modeling artifacts from which requirements may be derived.
3. Adopt a means by which personnel may capture modeling and specification content such that they may be configuration managed. There are not any computer tools known to the author that could capture all of the modeling and documentation features covered in the paper but one could build a simple text-oriented database linked to hand drawn or computer application graphics modeling artifacts.
4. Adopt a means for personnel to accomplish modeling work and retention of masters in the formal system baseline documentation.
5. Adopt a set of specification templates coordinated with modeling.
6. Establish a policy such as Table 1 of the supporting text suggests that clearly assigns responsibility for all specification content to personnel from specific functional departments on all programs.
7. Prepare a written document telling how this work is to be done on programs.
8. Train all personnel who have a role in this work in the appropriate parts of it assigned to their functional department.
9. Establish a quality assurance means that will assure that the work is accomplished in accordance with the prepared instructions and contractual requirements on programs.