



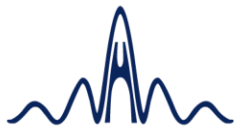
PROJECT PERFORMANCE  
INTERNATIONAL

# PROJECT PERFORMANCE INTERNATIONAL

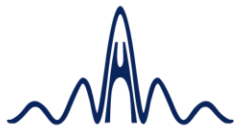


## *A world in which ...*

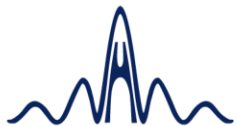
- *There is **systems engineering content in every engineering degree** worldwide and engineering academics, without exception, see systems engineering as **an integral part of the discipline of engineering**.*
- *CEOs expect and require systems engineering to be practiced at **every level of the enterprise**.*
- *The need for our services has disappeared because **every engineer graduates**, not only as a competent technologist, but with an understanding of how to go about successfully **applying** that technology expertise via **systems engineering**.*
- *There is systems engineering content in **every MBA**.*



*To improve the performance of our clients and the lives of their people by improving the practice of engineering, based on systems thinking, and using the principles and methods of systems engineering.*



*To grow agents of change in enterprises worldwide, at every level of the enterprise, by delivering demonstrably outstanding, evidence-based consulting and training services that win hearts and minds. To do so using a team of outstanding professionals who gain satisfaction from empowering others.*



## ROBERT J. HALLIGAN

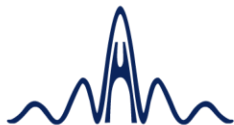
FIE Aust CPEng IntPE(Aus)



*rhalligan@ppi-int.com*

### CAREER HIGHLIGHTS

- **Founder & Managing Director** | Project Performance International
- **Content Contributor** | EIA/IS-632, EIA 632, IEEE 1220, ISO/IEC 15288 SE standards
- **Past INCOSE Head of Delegation** | ISO/IEC SC7 on Software and Systems Engineering
- **Past Member** | INCOSE Board of Directors
- **Past President** | Systems Engineering Society of Australia
- **Consultant/Trainer** | BAE Systems, Mitsubishi, Airbus, Thales, Raytheon, General Electric, Boeing, Lockheed, General Dynamics, OHB, Nokia, AREVA, BHP Billiton, Rio Tinto, Embraer, Halliburton, Dyson and many other leading enterprises on six continents



# KEY MEMBERS OF PPI'S CONSULTING AND TRAINING TEAM



**Paul Davies**



**Randall Iliff**



**John Fitch**



**Francois Retief**



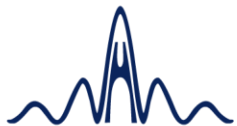
**George Sousa**



**Bijan Elahi**



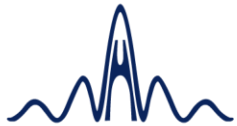
**Pat Byrne**





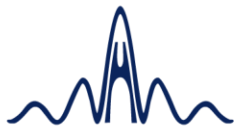
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More generally, PPI has trained 20,000 professionals worldwide in systems engineering, in 42 countries on six continents. CTI has trained another 3,500 professionals to take the SEP examination.



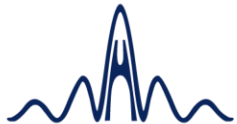
- **Architectural Design – AD5D (5-day)**
- **Engineering Successful Infrastructure Systems – ESIS5D (5-day)**
- **INCOSE SEP Exam Preparation - ISEP5D (5-day, delivered by CTI)**
- **Interface Engineering and Management – IEM2D (2-day)**
- **Medical Device Risk Management – MDRM2D (2-day)**
- **Project Risk and Opportunity Management – PROM3D (3-day)**
- **Requirements Engineering – RASW5D (5-day)**
- **Requirements, OCD & CONOPS in Capability Development – ROC5D (5-day)**
- **SE-ZERT® program – SEZERT12D (12 day, delivered by CTI)**
- **Systems Engineering Overview –SEO3D (3-day)**
- **Systems Engineering – SE5D (5-day) – our flagship course**
- **Systems Engineering Management – SEM5D (5-day)**

CTI is a wholly-owned  
subsidiary of PPI

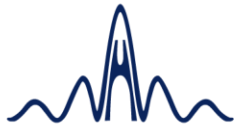


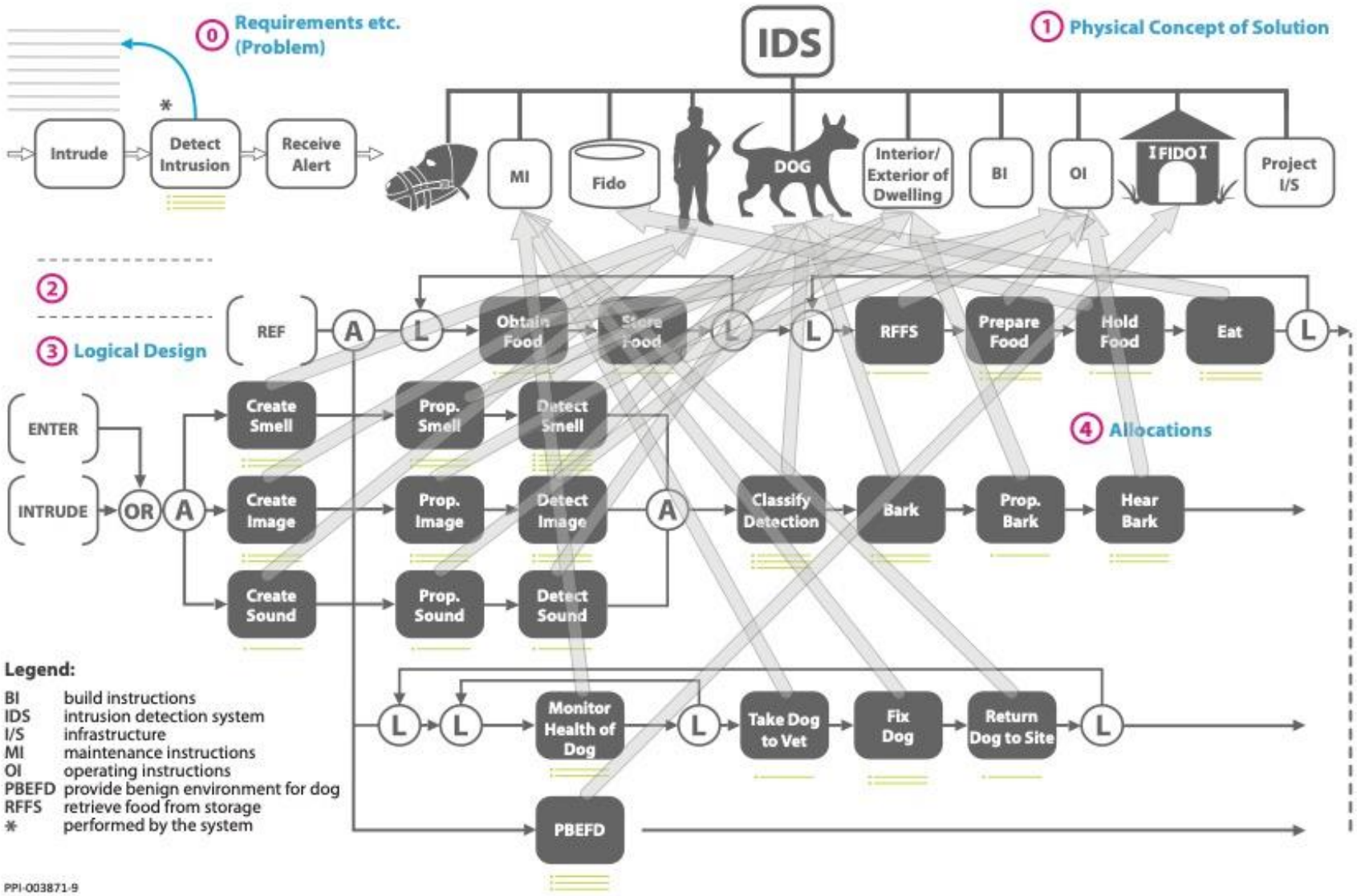


- **BAE Systems (Australia)**
- **Carl Zeiss (Germany)**
- **Genentech (USA)**
- **Harvard-Smithsonian Center for Astrophysics (USA)**
- **Hologic (USA)**
- **TÜBİTAK SAGE (Turkey)**
- **MISO (USA)**
- **NEC (Australia)**
- **New Zealand Defence Force (New Zealand)**
- **Singapore Institute of Technology (Singapore)**
- **Airservices Australia**
- **TDW (USA)**
- **Department of Defence (Australia)**



# SOME TALKING POINT DIAGRAMS





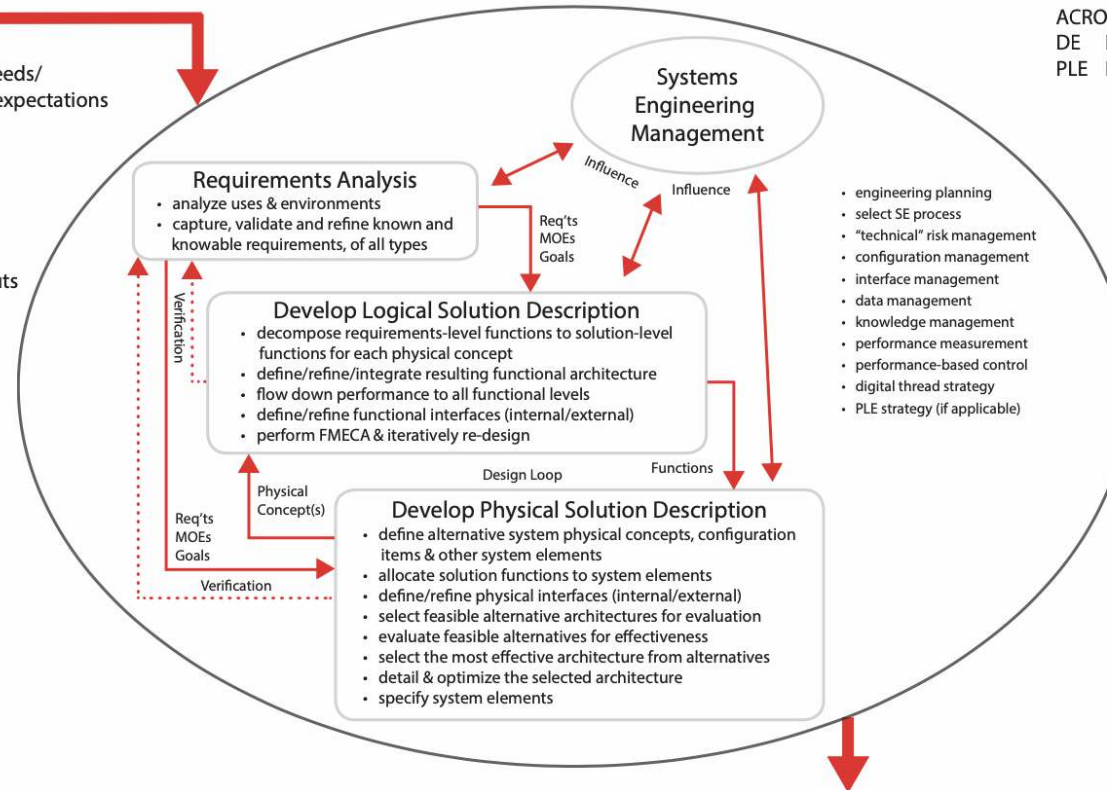
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# RELATIONSHIPS IN A SYSTEMS ENGINEERING APPROACH

## PROCESS INPUT

- problem domain info
  - user/customer/other stakeholder needs/ desires/wants/goals/requirements/expectations
  - uses/missions
  - measures of effectiveness
  - value information
  - environments
  - other constraints
- technology base
- concurrent engineering – related inputs



## ACRONYMS:

- DE Digital Engineering
- PLE Product Line Engineering

- engineering planning
- select SE process
- "technical" risk management
- configuration management
- interface management
- data management
- knowledge management
- performance measurement
- performance-based control
- digital thread strategy
- PLE strategy (if applicable)

## PROCESS OUTPUT

- **identification & specification of each system element, including build instructions**
- requirements traceability information
- system & system element verification requirements
- design traceability information (decision data base)
  - system functional & physical architecture and detail descriptions
  - design decision support data
  - design decision rationale data
- concurrent engineering-related outputs
- prototypes, where applicable

Note 1: The Systems Engineering Process is applied repeatedly to each design object, starting at, for example, the Capability, Mission or Use System, then to, for example, the Prime Mission or Use Product, Maintenance System, Production System, Operational Infrastructure, etc., then to subsystems of these systems.

Note 2: Also, where applicable, validate data products (not shown diagrammatically).

Note 3: The process also performs the integration of the system elements to build the system for the first time (system integration).

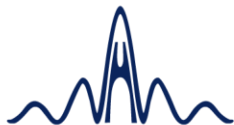
Note 4: The process also includes the conduct of verification of the produced system against the requirements for that system, thereby verifying both the system, and the design of the system.

Note 5: The process also includes the conduct of validation of the produced system against the need.

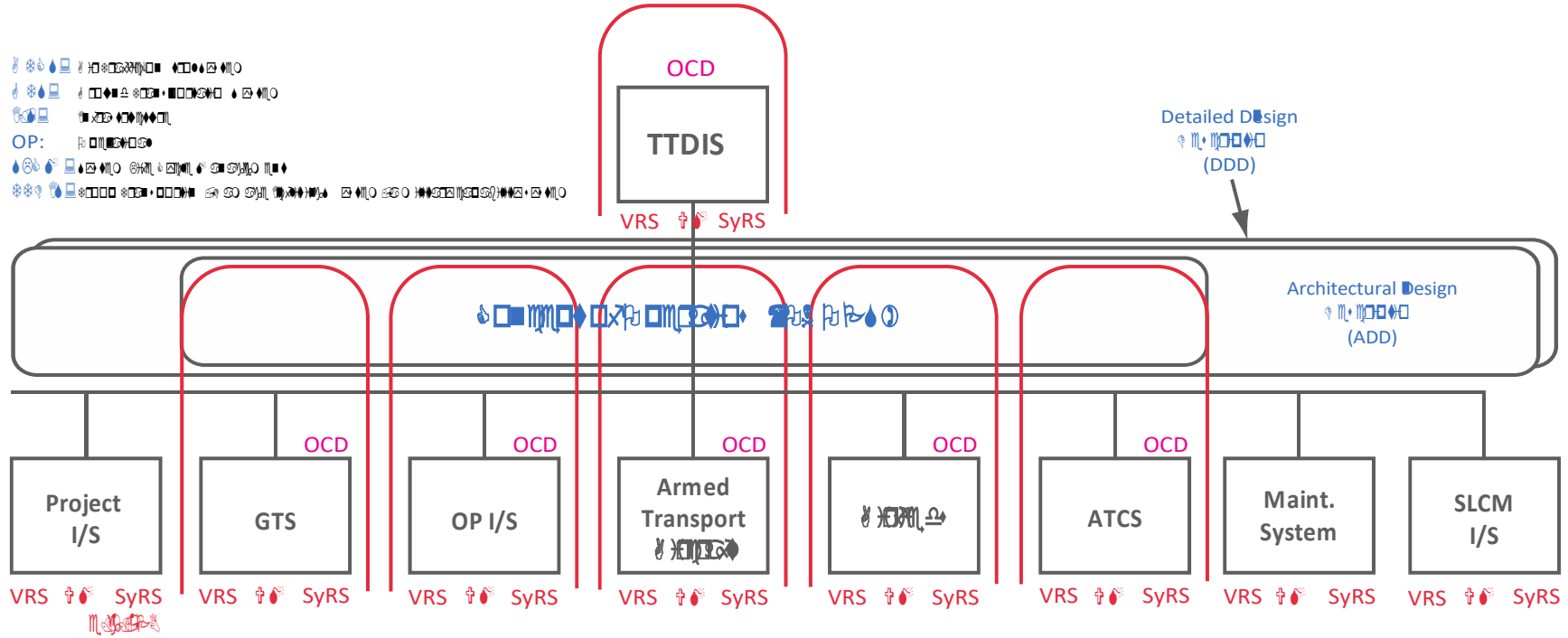
## A systems engineering approach ...

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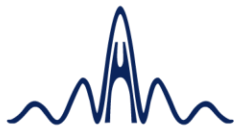
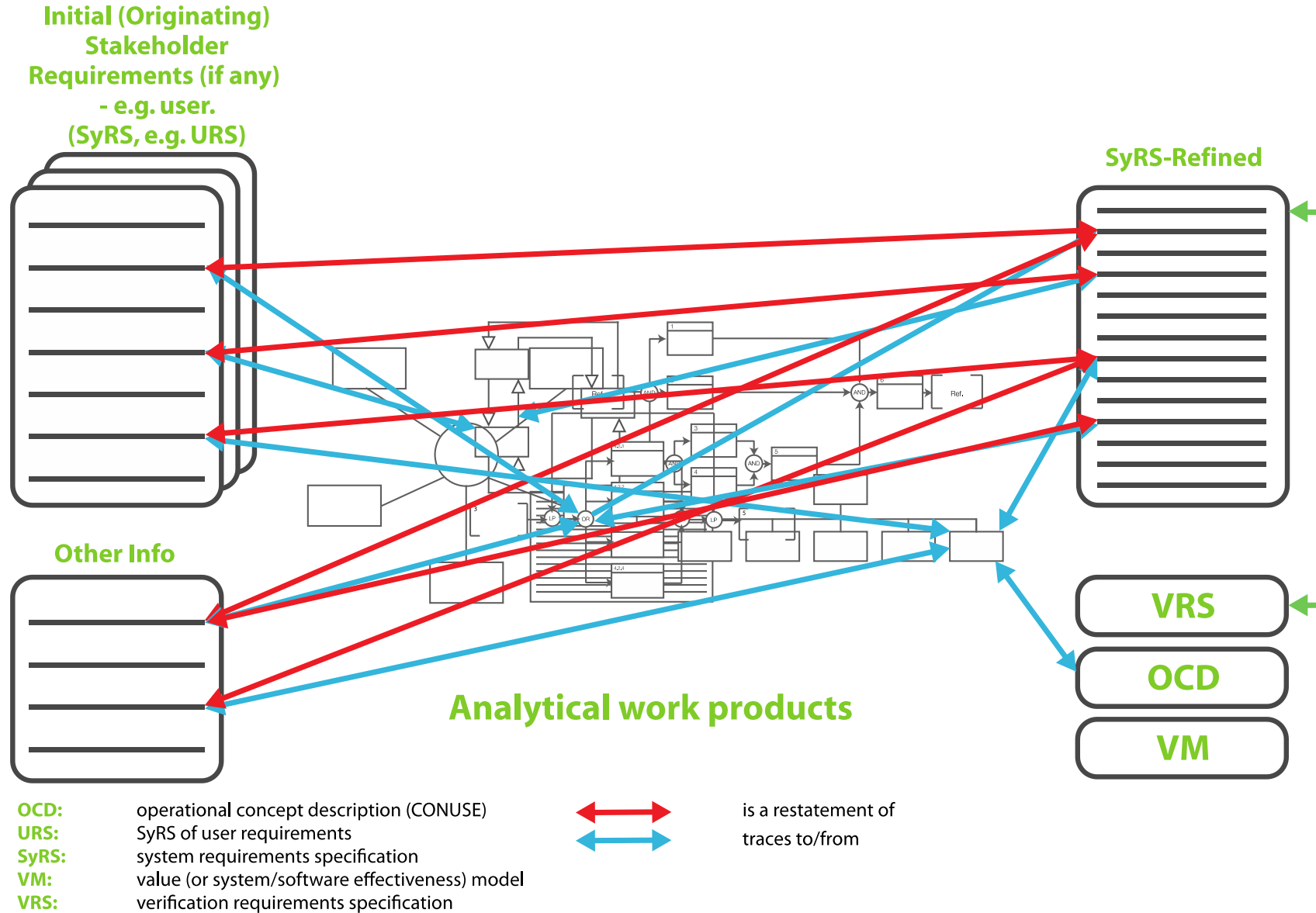
# A FOCUS ON VALUE DELIVERY, LIFE-CYCLE BASIS



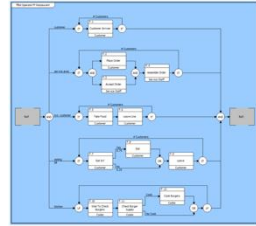
- ADD:** [Text in Sinhala]
- CONOPS:** [Text in Sinhala]
- DDD:** [Text in Sinhala]
- OCD:** [Text in Sinhala]
- PB:** [Text in Sinhala]
- SyRS:** [Text in Sinhala]
- VRS:** [Text in Sinhala]



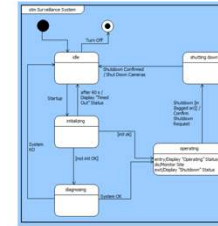
# ENSURE ADEQUATE PROBLEM DEFINITION



## Functional Logic (General):



## State-Based Logic:



## Mathematical Logic:

$$\sum_{i=1}^n i = \frac{n(n+1)}{2}$$

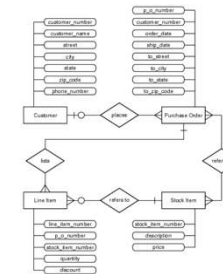
$$\sum_{i=1}^n i^2 = \frac{n(n+1)(2n+1)}{6}$$

$$\sum_{i=1}^n i^3 = \frac{n^2(n+1)^2}{4}$$

## Relationship Logic:

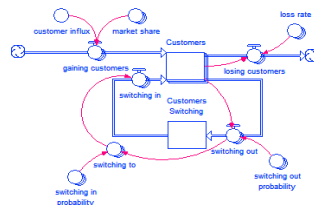
### Symbols:

- entity type
- attribute
- relationship between entities
- one-to-one association
- one-to-many association
- many-to-many association
- partly optional association
- fully optional association

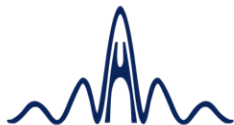
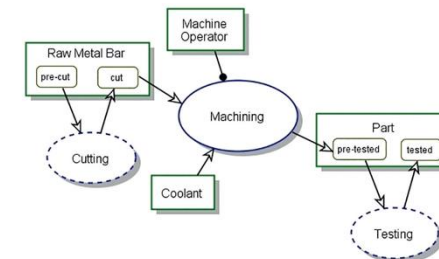


## System Dynamics:

(incorporation functional logic)



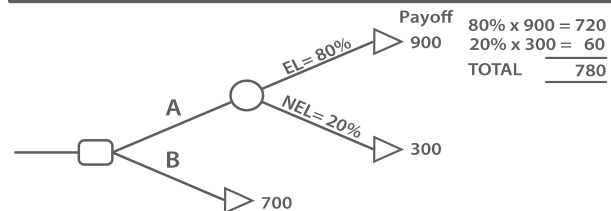
## Object Process Methodology:



## Value (System Effectiveness) Model

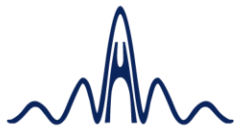
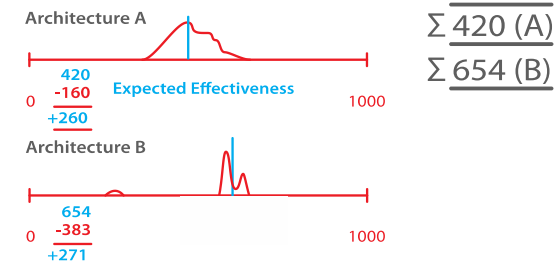
## Architecture A Evaluation

MOEs	Worst	Best	Pri	Pts	Weight %	UF	Value of MOE	RVC	AVC (RVC x wt)	
Cost, \$ks per unit	200	50	1	100	25		<del>55k</del> 57	<del>10</del>	<del>250</del>	
Reliability, %	95	100	1	100	25		<del>95.5%</del> 97.5	<del>1</del> 5	<del>25</del> 125	+100
Interoperability	0	17	7	14	4		0	0	0	0
Size(A/B/C)	C	A	8	3	1		<del>C</del> B	<del>0</del> 5	<del>0</del> 5	+5
Schedule (Months)	12	6	3	40	10		<del>7</del> 8	<del>10</del> 9	<del>100</del> 90	-10
Visible Optical Range, m	1000	5000	5	30	7		<del>1200</del> 2500	<del>2</del> 5	<del>14</del> 35	+21
Duration of Transmission, hr	48	96	6	27	6		50	0.5	3	
Readiness, %	90	100	4	39	10		<del>91</del> 95	<del>1</del> 5	<del>40</del> 50	+40
OS & D Cost, \$k pu/10 years	300	10	2	50	12		<del>300k</del> 106	<del>1.5</del> 8	<del>18</del> 96	+78
				<u>403</u>	<u>100</u>					



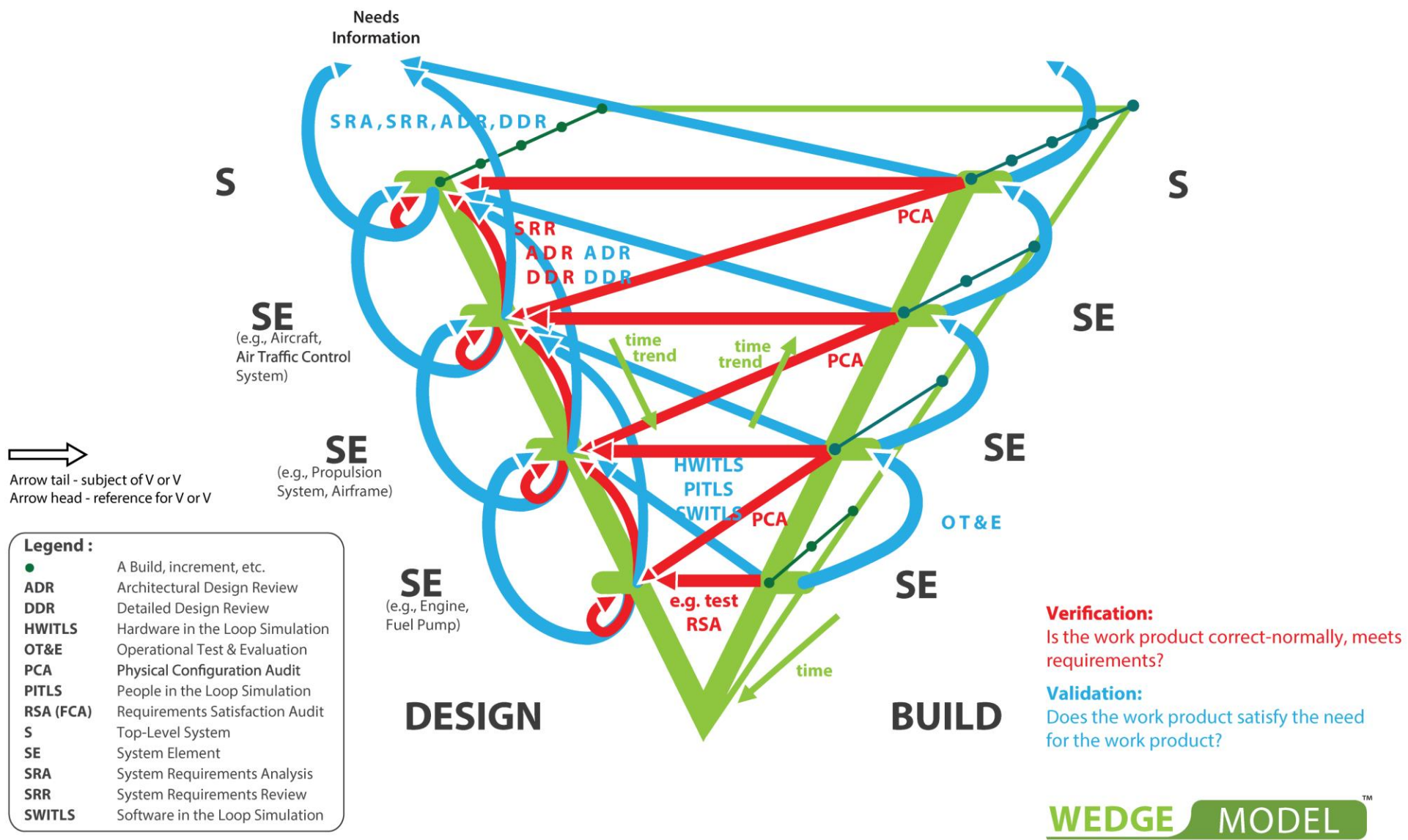
Payoff is the optimized outcome for A & B respectively, without consideration for A of the risk added by needing to obtain an Export License (EL).

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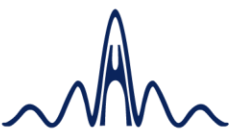


# THE WEDGE MODEL™ AS A FRAMEWORK FOR VERIFICATION AND VALIDATION



→  
Arrow tail - subject of V or V  
Arrow head - reference for V or V

PPI-006003-12  
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## DOING SYSTEMS ENGINEERING (SE)

- Requirements Analysis
- Architectural & detail design – physical
- Architectural & detail design – logical
- Trade-off Studies (EE&D)
- Specification of System Elements
- Specialty Engineering
- System Integration
- Verification & Validation

## SYSTEMS ENGINEERING MANAGEMENT (SEM)

- Requirements Management
- Design Management
- Interface Management
- Tailoring the technical processes
- Management of technical processes
- Leading the engineering team
- SE Planning
- SE Assessment & Control (Performance Management)
- SE Decision Management
- SE Schedule Management
- SE/Product Cost Management
- Configuration Management
- SE Data Management
- SE Knowledge Management
- SE Opportunity and Risk Management
- Engineering Specialty Integration
- SE Stakeholder Management
- Release and Deployment Management
- Digital thread strategy
- PLE strategy (if applicable)

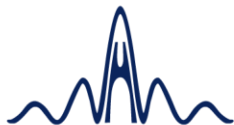
## REST OF PROJECT MANAGEMENT (PM)

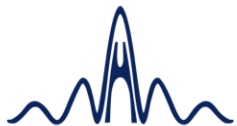
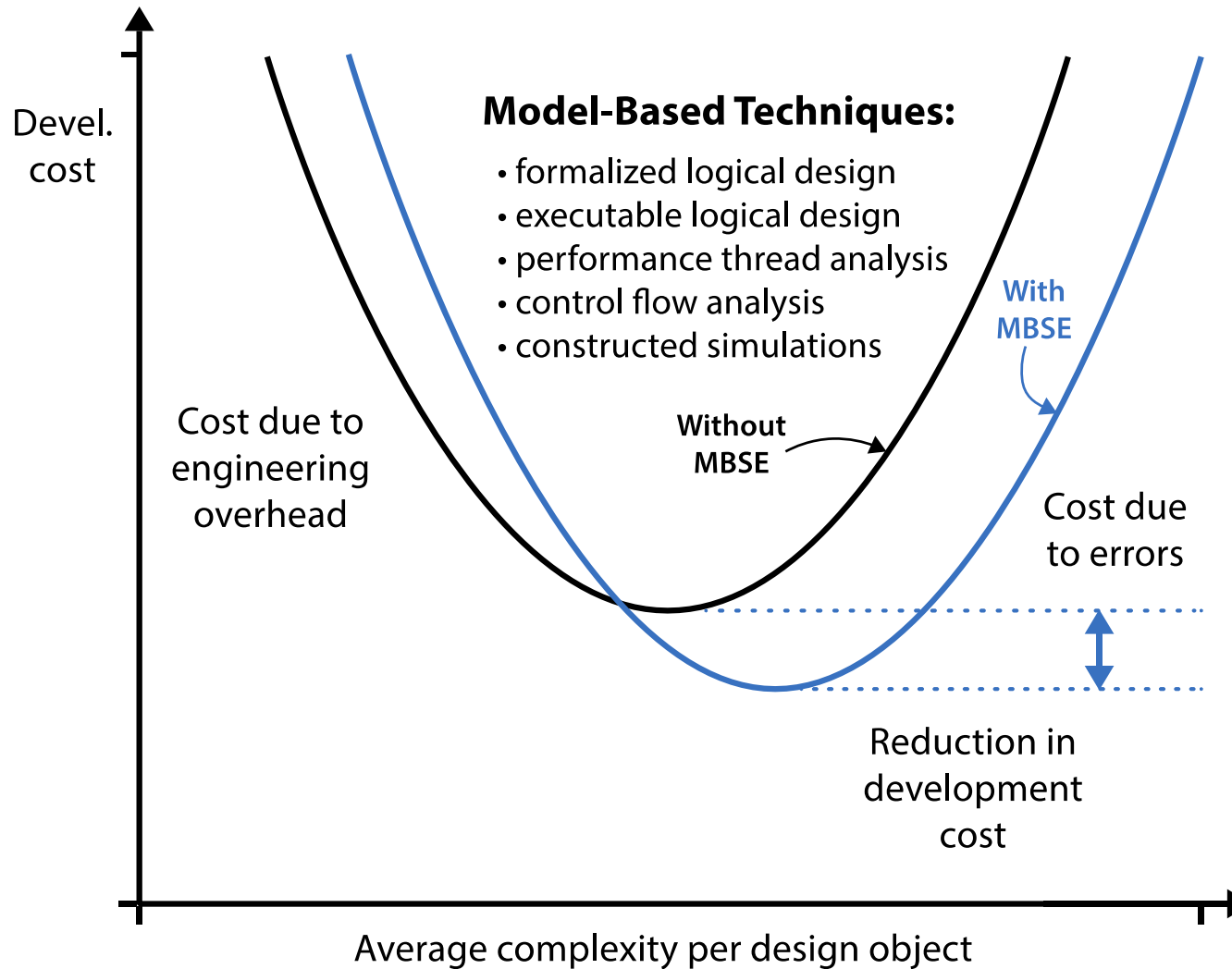
- Managing the scope of the project for which the management is not delegated.
- Managing the managers/management

### Legend:

EE&D Effectiveness Evaluation & Decision  
PLE Product Line Engineering

**Note:** The manager of the project may delegate the management of the systems engineering, and potentially other elements of project scope, e.g., production, commissioning, contract.





# MAPPING TO THE INCOSE SE COMPETENCY FRAMEWORK

ISECF Competency Areas	AD5D	ISEP	ROC5D	SE-ZERT	RASW5D	SE5D	SEM5D	IEM2D
<b>ISECF Core Systems Engineering Principles</b>								
Systems Thinking	L	L	X	L	L	X	L	
Lifecycles		X	X	X	L	X	X	
Capability Engineering	X	L	X	L	L	X	L	
Critical Thinking	L	L	L	X	L	X	X	
Systems Modelling & Anal.	X		X	L	X	X		
<b>ISECF Technical</b>								
Requirements Definition			X	L	X	X	L	
System Architecting	X		X	L		X	L	L
Design for...	X	L	L	X		X	L	
Integration		L	L	L		X	X	L
Interfaces	X	L	L	L	X	X	L	X
Verification		L		L		X	L	
Validation		L		L	X	X	L	
Transition*		L	L	L			L	
Operations & Support*		L	X	L	L	X	L	
<b>ISECF Professional</b>								
Communications				X			X	

## Legend for PPI/CTI training courses:

**AD5D:** Architectural Design 5-Day

**ISEP:** INCOSE SEP Exam Prep Training 4-5 Day (by CTI)

**ROC5D:** Requirements, OCD and CONOPS in Military Capability Development 5-Day

**SE-ZERT:** German SE Certification counterpart of INCOSE SEP 10-Day (by CTI)

**RASW5D:** Requirements Analysis and Specification Writing 5-Day

**SE5D:** Systems Engineering 5-Day

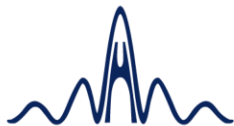
**SEM5D:** Systems Engineering Management 5-Day

**IEM2D:** Interface Engineering and Management 2-Day

L – low but useful fulfillment of competency area

X – substantial fulfillment of competency area

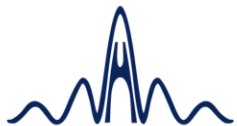
Only some of the mapping is shown. The full mapping is available upon request.



## PPI Data Item Descriptions:

- **Project Plan (PP)**
- **Task Specification (TS)**
- **Statement of Work (SOW)**
- **Systems Engineering Plan (SEP)**
- **Operational Concept Description (OCD)**
- **System Requirements Specification (SyRS)**
- **Software Requirements Specification (SRS)**
- **Verification Requirements Specification (VRS)**
- **Interface Requirements Specifications (IRS)**
- **Interface Design Description (IDD)**
- **System/Subsystem Design Description (SSDD)**
- **Concept of Operations (CONOPS) – Operational Solution Description (OSD)**

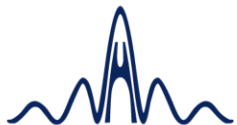
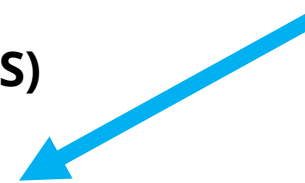
All of our clients gain immediate access to a host of high quality templates and data item descriptions to streamline their work.



## PPI Example Documents:

- **Concept of Employment (CONEMP)**
- **Concept of Use (CONUSE - OCD)**
- **Capability System Requirements Specification (CapSyRS)**
- **Capability System Value Model**
- **Operational Solution Description (OSD)**
- **Concept of Use (CONUSE - OCD) for a technology item**
- **Systems Requirements Specification (SyRS) for a technology item**
- **Interface Requirements Specification (IRS)**
- **System Effectiveness Model for a technology item**
- **Statement of Work (SOW)**
- **Verification Requirements Specification (VRS) for a technology item**

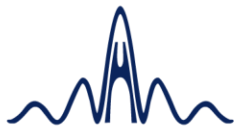
You can access for free a coordinated, high quality set of example engineering documents



## PPI Application Guides to Systems Engineering Standards:

- **EIA-632: 2003**
- **IEEE 1220**
- **ECSS-E-ST-10C**
- **ISO/IEC 15288:2008**
- **ISO/IEC/IEEE 15288:2015**
- **ISO/IEC/IEEE 29148:2018**
- **ISO/IEC/IEEE 15288:202X (when released)**

Be aware of the many pitfalls in the use of systems engineering standards. These guides to the standards, authored by PPI, can help enormously. We have content in many of the standards.



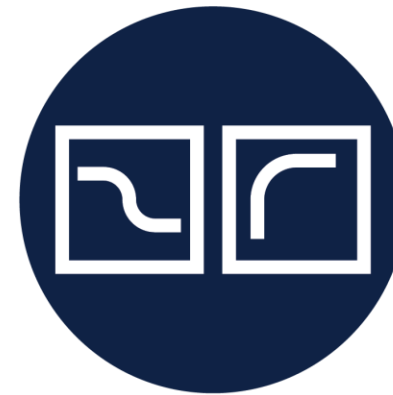
## PPI Practice Guides:



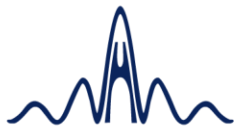
**Requirements  
Capture and  
Validation Guide**



**Requirements  
Specification  
Development  
Guide**



**Military  
Capability  
Development Guide**





**The Systems Engineering Goldmine (SEG) is a dedicated website developed and maintained by PPI that provides clients with free access to:**

## **Documents:**

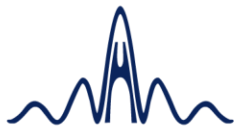
- An archive of over 4GB of downloadable project performance documents, mainly on systems engineering
- The archive includes handbooks, guides, standards, papers and other resources, all curated, with flexible search facilities (but not of internal content)
- There are links to documents that cannot be included for reason of copyright.

## **Definitions:**

- A searchable database of project performance-related definitions, mainly systems engineering, presently 7,900+ terms.

## **Systems Engineering Tools Database:**

- Jointly developed and operated with INCOSE under a MOU and available via the SEG.





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Most access requests are approved. Log in details will be provided by email. We apologise for being unable to respond to access requests that are declined.

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## Welcome to Project Performance International's "Systems Engineering Goldmine"

**Systems Engineering Goldmine is a resource containing a wealth of reference information relevant primarily to the engineering of systems.**

This free resource is intended for use by clients, alumni and friends of Project Performance International (PPI) as well as clients, alumni and friends of subsidiary company Certification Training International (CTI). Other members of the engineering community may navigate around the site, but with limited search and no download capabilities.

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### SE Goldmine Features

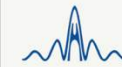
Project Performance International (PPI) welcomes you to the Systems Engineering Goldmine (SEG). The Goldmine is a searchable database of systems engineering-related documents, definitions and acronyms, and software tools. The specific searches available are:

#### Documents Search

You can flexibly search the names and identifiers over over 4.5GB of mainly systems engineering-related documents - for example handbooks, guides, papers and standards. SEG account holders can download these documents. The search capability also includes records of key systems engineering documents such as some standards and handbooks that cannot be provided for download, for reasons of IP status. Most documents are in English, but "search by language" is also provided.

### Training Quicklinks

- [Systems Engineering](#)
- [Architectural Design](#)
- [Requirements, OCD & CONOPS](#)
- [Requirements Analysis](#)
- [Specification Writing](#)
- [Interface Engineering & Management](#)
- [INCOSE SEP Exam Preparation](#)
- [Project Risk & Opportunity Management](#)
- [Medical Device Risk Management](#)
- [Software Engineering](#)



### Provided by Project Performance International

Project Performance International (PPI) is an expert provider of training and consulting in systems engineering, software engineering, project management, and in related disciplines. PPI works routinely on six continents, supporting from the smallest enterprises to some of the world's largest and best known technology-oriented companies.

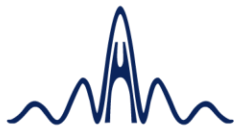
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## Search for documents (Table View)

You can flexibly search the names and identifiers over over 4.5GB of mainly systems engineering-related documents - for example handbooks, guides, papers and standards. SEG account holders can download these documents. The scope of the search also includes records of key systems engineering documents such as some standards and handbooks that cannot be provided for download for reasons of IP status.

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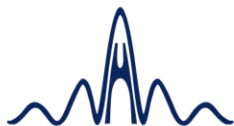
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Document identifier	Type	Title	Date	Author(s)	Size	
	technical white paper	Evaluating ARCADIA/Capella vs. OOSEM/SysML for System Architecture Development	2019-08		44.64 MB	
		Architecture Evaluation and Quality Attribute Specification for Software, Systems and SoS Architectures	2011-03	Mike Gagliardi, Bill Wood	1.81 MB	
		La ville de demain pensée avec l'Architecture des Systèmes	2011		3.63 MB	
	conference presentation	The Integrated Defence Architecture- The Models and The Value	2010-11-12		1.5 MB	
		Architecture Frameworks	2010-10		471.69 KB	
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	presentation	Applying Enterprise Architecture to Model Based Systems Engineering	2010-05-11		3.97 MB	





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This search looks for the selected term (definition or acronym) in the definitions databases for Systems Engineering, Acquisition, Project Management, and Software Engineering.

Defined Term

Acronym

Engineering glossaries

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- 1 Architecture**  
Acronym:

The structure of components, their interrelationships, and the principle guidelines governing their design and evolution over time.

**Source:** [DSMC Definitions](#)

---

A high level design that provides decisions made about: the problem(s) that the product will solve, component descriptions, relationships between components, and dynamic operation description.

**Source:** [EIA/IS-731.1 Document2 - Systems Engineering Capability Model](#)

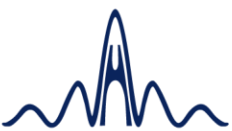
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The structure of components in a program/system, their interrelationships, and the principles and guidelines governing their design and evolution over time.

**Source:** [Modelling\\_SimGlossary-1](#)

---

The fundamental organization of a system embodied in its components, their relationships to each other, and to the environment,





## Systems Engineering Tools Database

Welcome from the International Council on Systems Engineering (INCOSE) and Project Performance International (PPI) to the Systems Engineering Tools Database (SETDB). We hope that the SETDB helps you to find appropriate software tools and cloud services that support your engineering activities. In order to access the SETDB, you need to be an INCOSE member logged in to the INCOSE website, or a PPI alumna, alumna or guest logged in to PPI's Systems Engineering Goldmine website, from which you can navigate to a SETDB landing page without further login. This home page is mainly for the benefit of members of the engineering community who are not already members of INCOSE or account holders with PPI, to gain exposure to the SETDB. You can explore example content of the SETDB from this page (see Explore below). This page also provides access for Tool Vendors to register and list their tools, and login access for SETDB administration.

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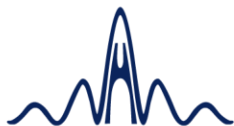
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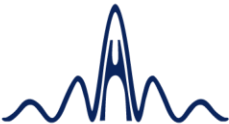
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Product Name ▲▼	Vendor ▲▼	Version	Tool Categories	Created ▲▼	Modified ▲▼	
Business Architecture Solution	Capstera		Modeling & Simulation - MBSE (excluding CAD, Math & Value Modeling) Requirements Engineering	2021-03-23	2021-11-09	
3D Models	MVRsimulation Inc.	7.0	Visualization - Other	2022-03-12	2022-03-12	
3D Terrain	MVRsimulation Inc.	7.0	Modeling & Simulation - MBSE (excluding CAD, Math & Value Modeling) Visualization - Other	2022-03-12	2022-03-12	
@RISK	Palisade	8	Mathematical Analysis & Modeling Risk Management Decision Support - Other and more	2022-03-11	2022-03-11	
ABACUS	avolution	6.0	Modeling & Simulation - MBSE (excluding CAD, Math & Value Modeling) Engineering Management - Other Engineering Planning and more	2021-03-03	2021-07-12	
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Accompa	Accompa Inc.		Requirements Engineering	2021-05-11	2021-07-18	
Accunote	Pluron, Inc. (DBA Acunote)		Domain Specific - Software Engineering Management - Other Engineering Planning and more	2021-03-03	2021-11-09	
Acoustic Testing	Siemens Digital Industries Software	2021	Modeling & Simulation - MBSE (excluding CAD, Math & Value Modeling) Verification & Validation - Other	2022-03-08	2022-03-08	
Active Risk Manager	Sword GRC	2020	Risk Management	2022-03-11	2022-03-11	

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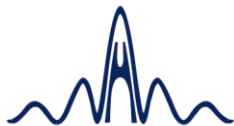
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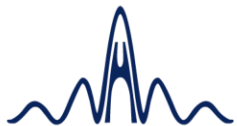
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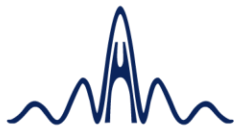
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