The State of Model Based Systems Engineering

INCOSE Chesapeake Chapter

16 February 2011

L. Mark Walker

INCOSE
International Council on Systems Engineering

City of Phoenix

Topics

- Overview of MBSE & The Four MBSE Essentials:
  - Object Oriented SE Method; SysML Language; Tools; Trained Staff
- INCOSE IW'11 Status: Mark Sampson & Sandy Friedenthal
- NDIA Final Draft Report on MBE
- INCOSE MBSE Initiative and Challenge Team Examples
  - SoS, DoDAF, UPDM: Ron Williamson, Ph.D./Raytheon
  - UPDM: Matthew Hause/Atego
  - Space Systems: Bjorn Cole /Jet Propulsion Lab
  - Telescope Modeling: Robert Karban/European Organization for Astronomy Research
- Summary & Conclusions

Majority of Charts are from the INCOSE IW'11 MBSE Presentations

INCOSE
International Council on Systems Engineering

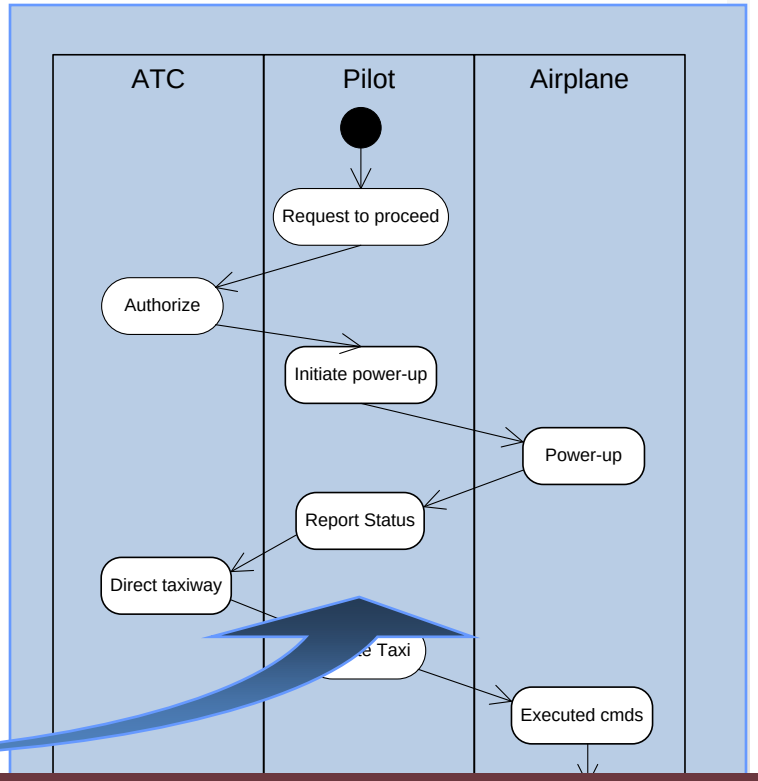
City of Phoenix

SE Practices for Describing Systems

Future

Past

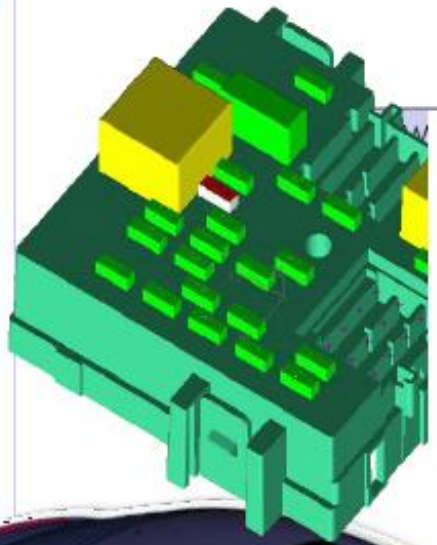
- **Missions/Conops**
- **Needs/requirements**
- **Interface**
- **System design & architecture**
- **Analysis & Trade-off**
- **Test plans**
- **Life Cycle Support**
- **Etc.**

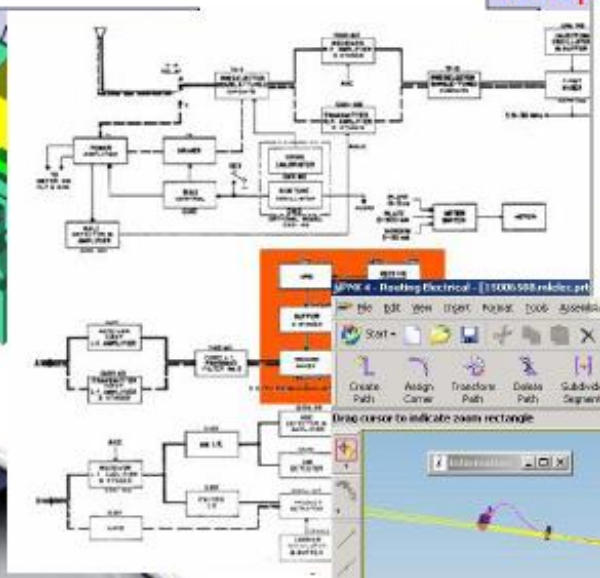


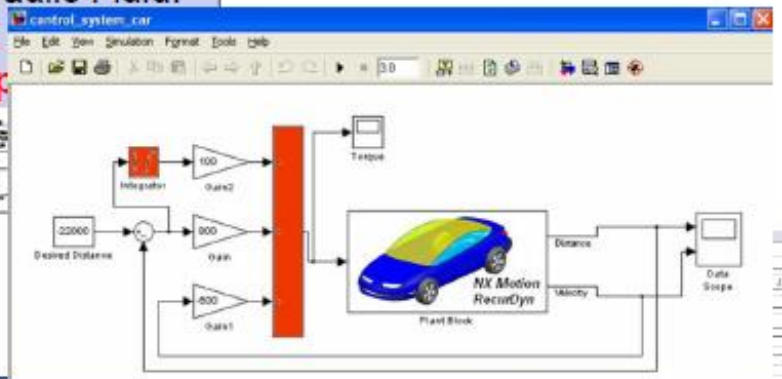
Moving from Document centric to Model centric

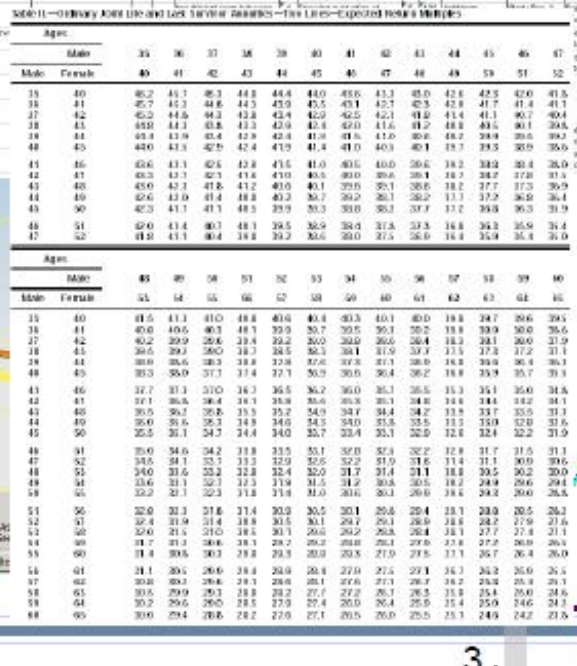
Integrated Systems Engineering Vision

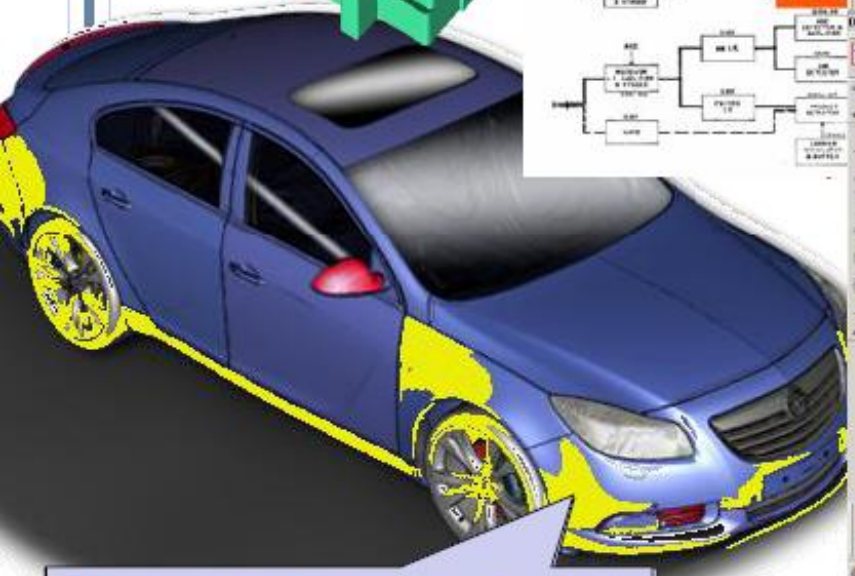
Hydraulic Fluid:
SAE
comp





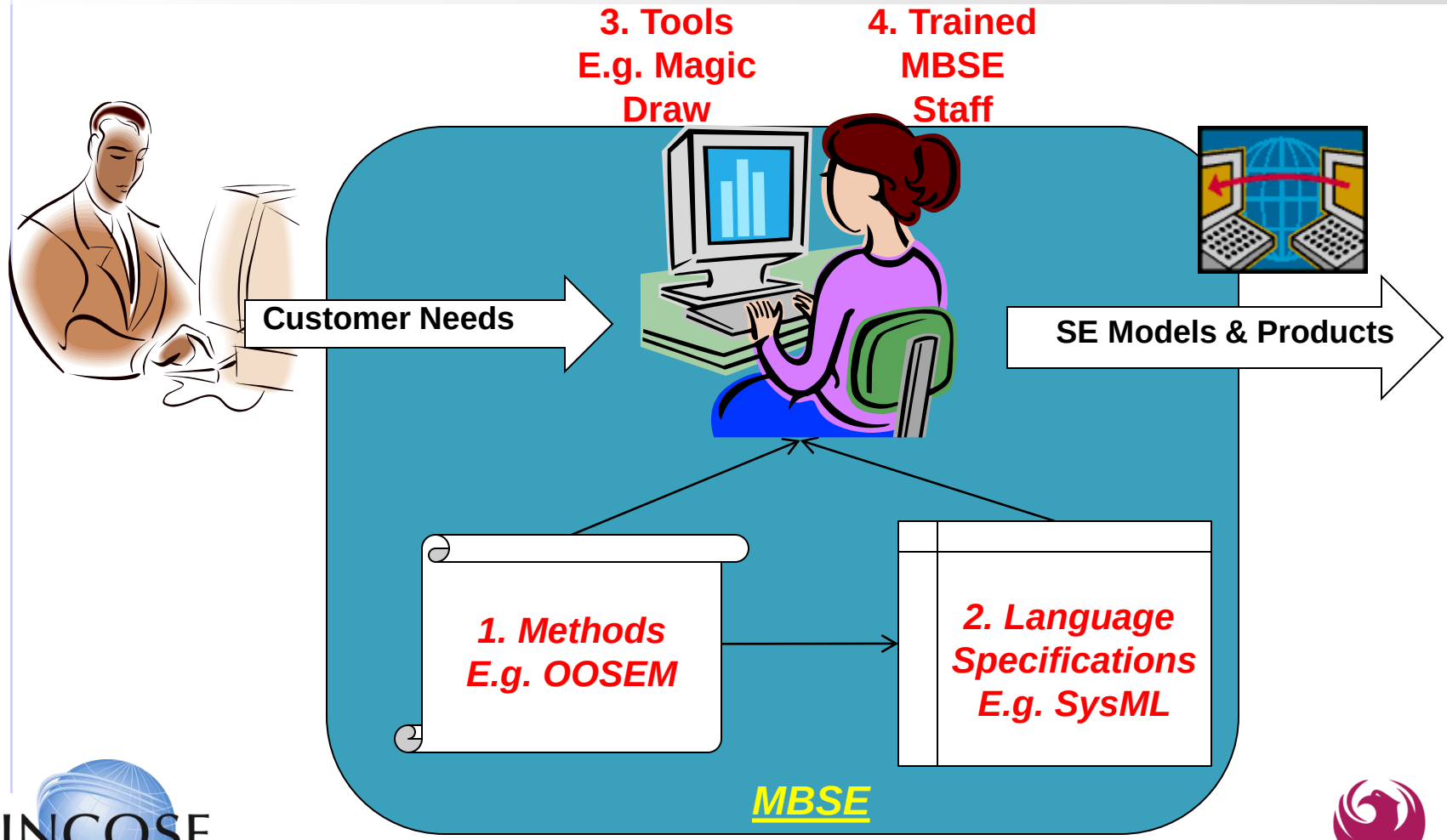


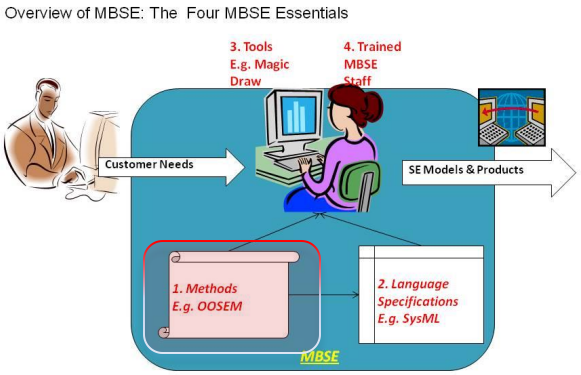




Minimum Turn Radius: 24 ft.
Dry Pavement Braking Distance
at 60 MPH : ~~110~~ ft. 90 ft

Overview of MBSE: The Four MBSE Essentials



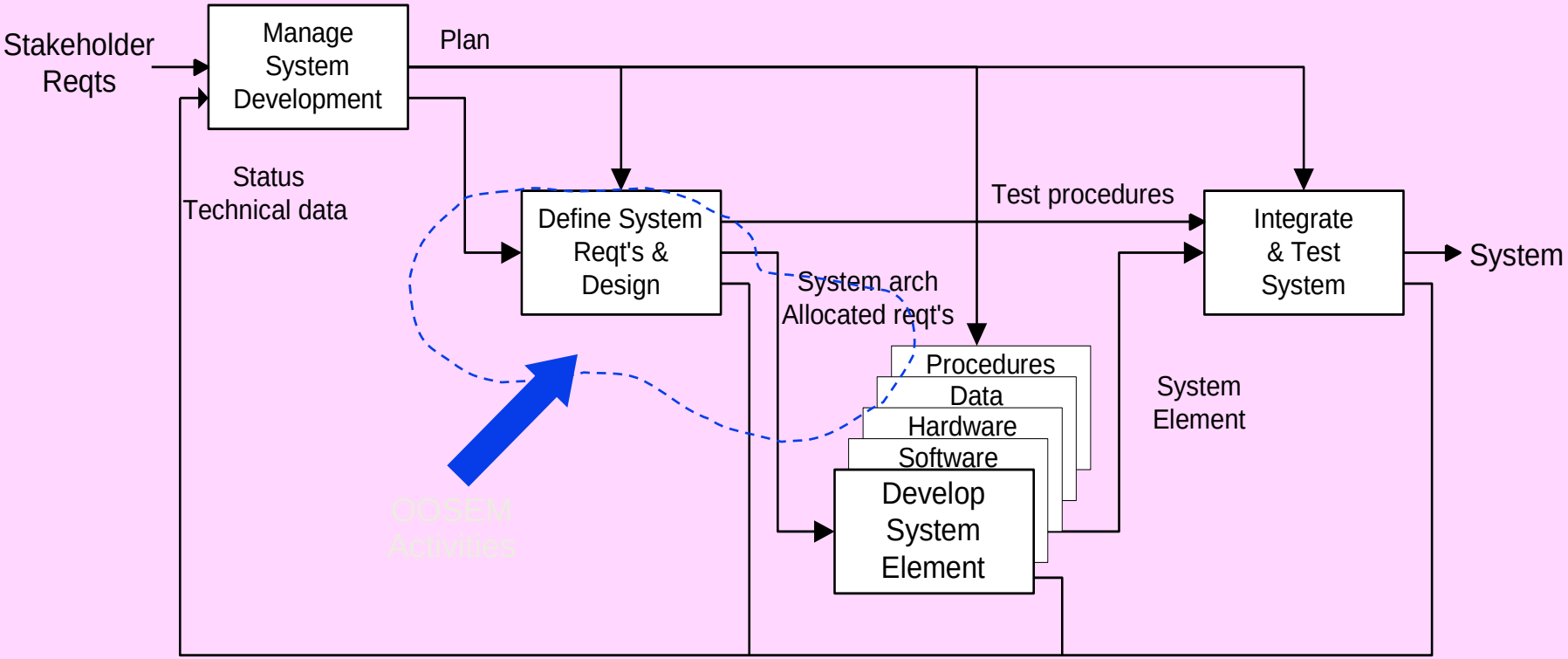


1- MBSE Methodologies

Jeff Estefan's Survey of MBSE Methodologies (2008)

- IBM Telelogic Harmony-SE
- INCOSE Object-Oriented Systems Engineering Method (OOSEM)
- IBM Rational Unified Process-Systems Engineering (RUP-SE) for Model-Driven System Design (MDSD)
- Vitech MBSE
- JPL State Analysis
- Object Process Methodology (OPM)

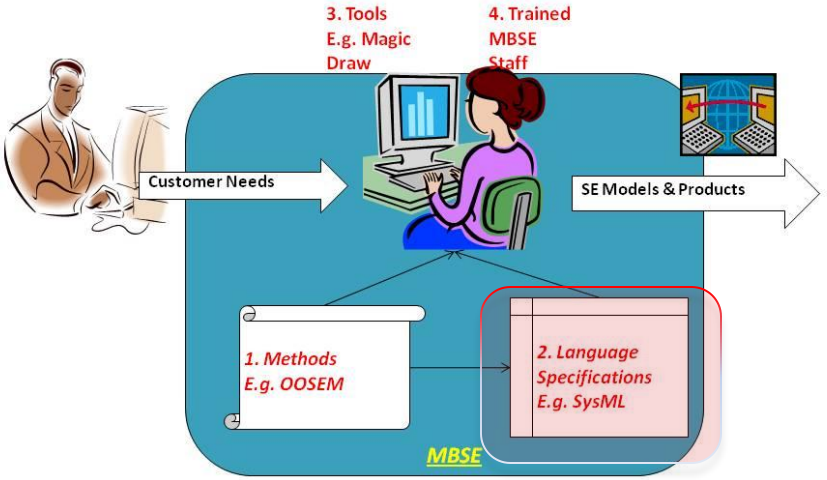
System Development Process



Integrated Product Development (IPD) is essential to improve communications

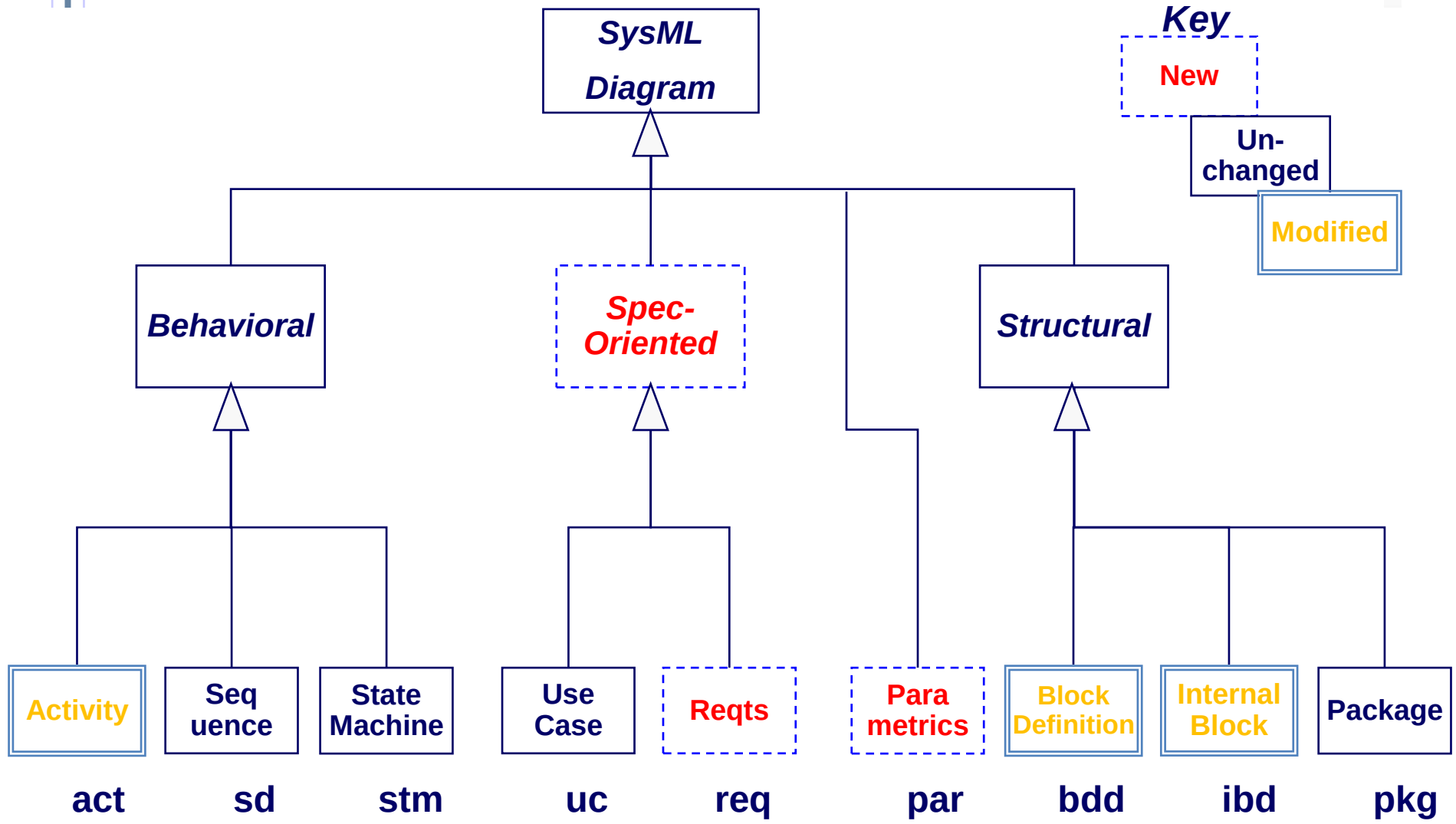
A Recursive V process that can be applied to multiple levels of the system hierarchy

Overview of MBSE: The Four MBSE Essentials



OMG's Systems Modeling Language (SysML)

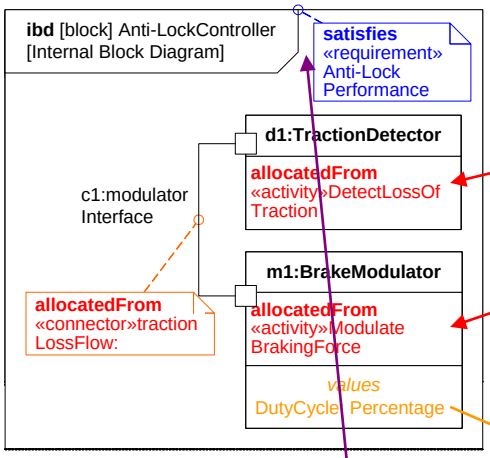
SysML Diagrams

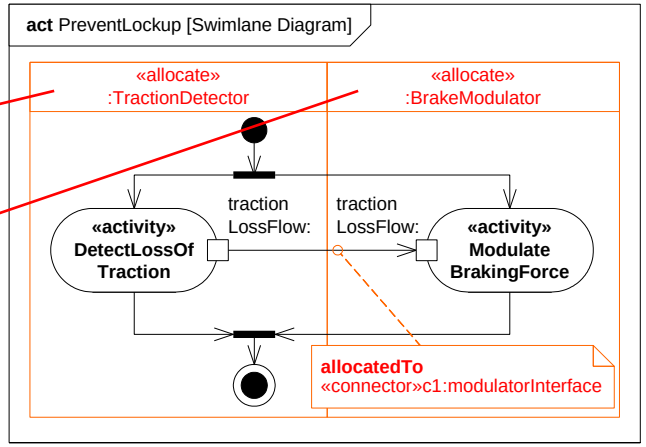


Cross Connecting Model Elements

Structure

Behavior

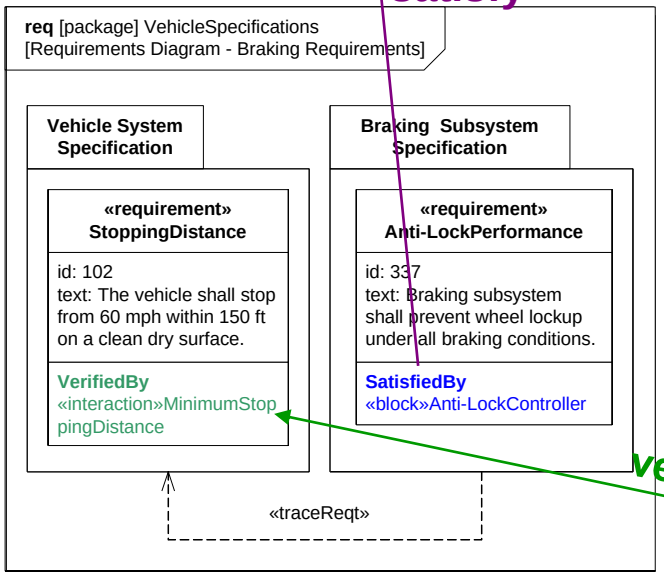


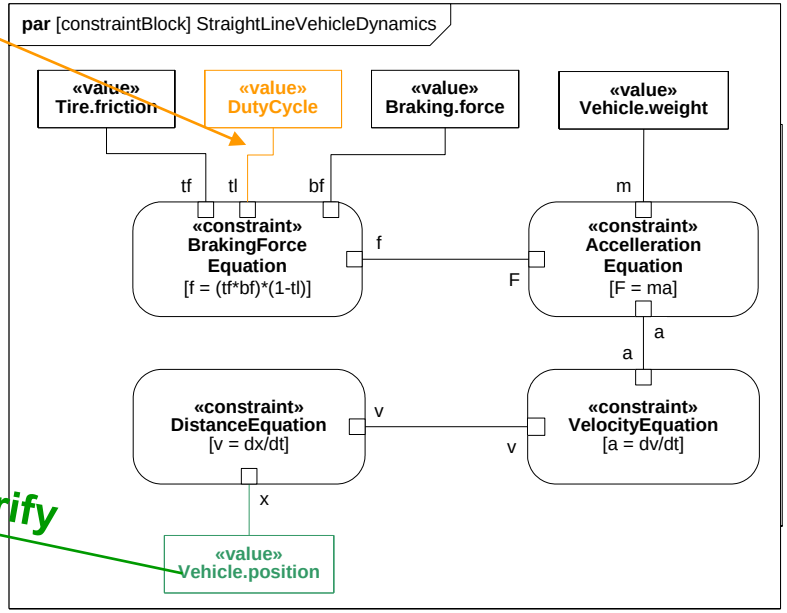


allocation

value binding

satisfy



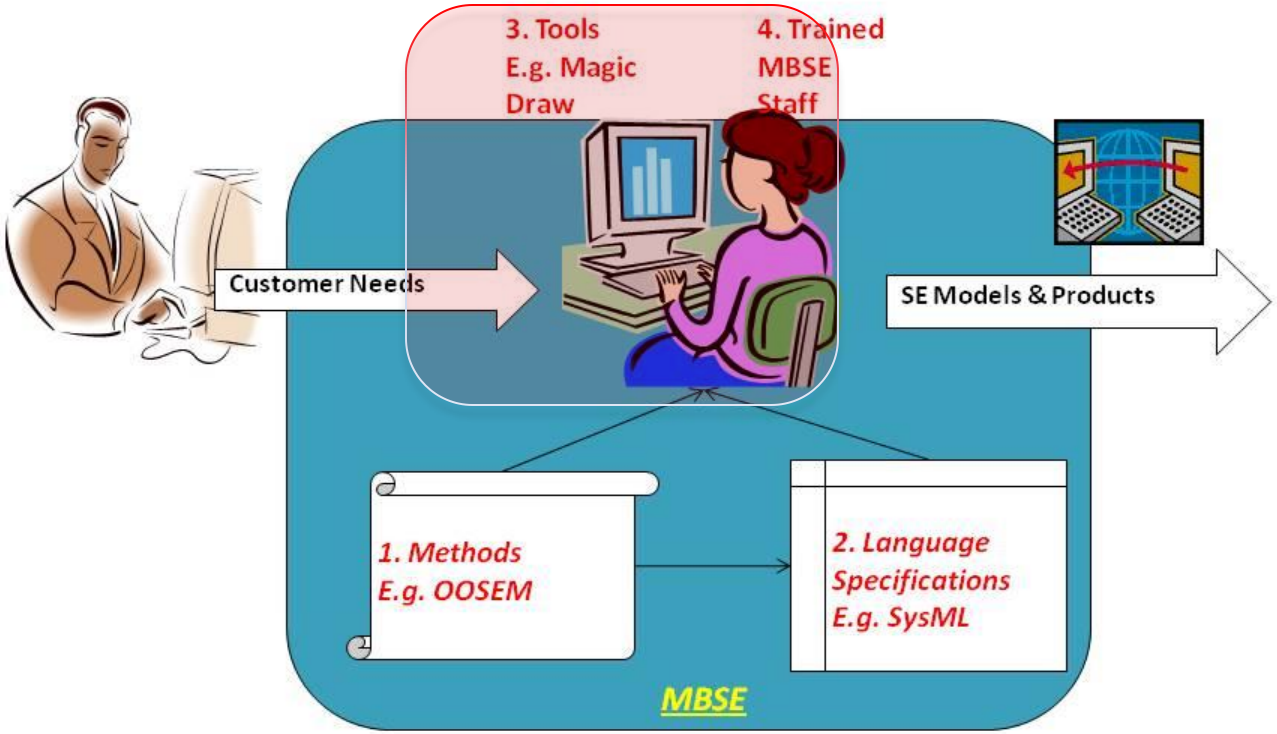


verify

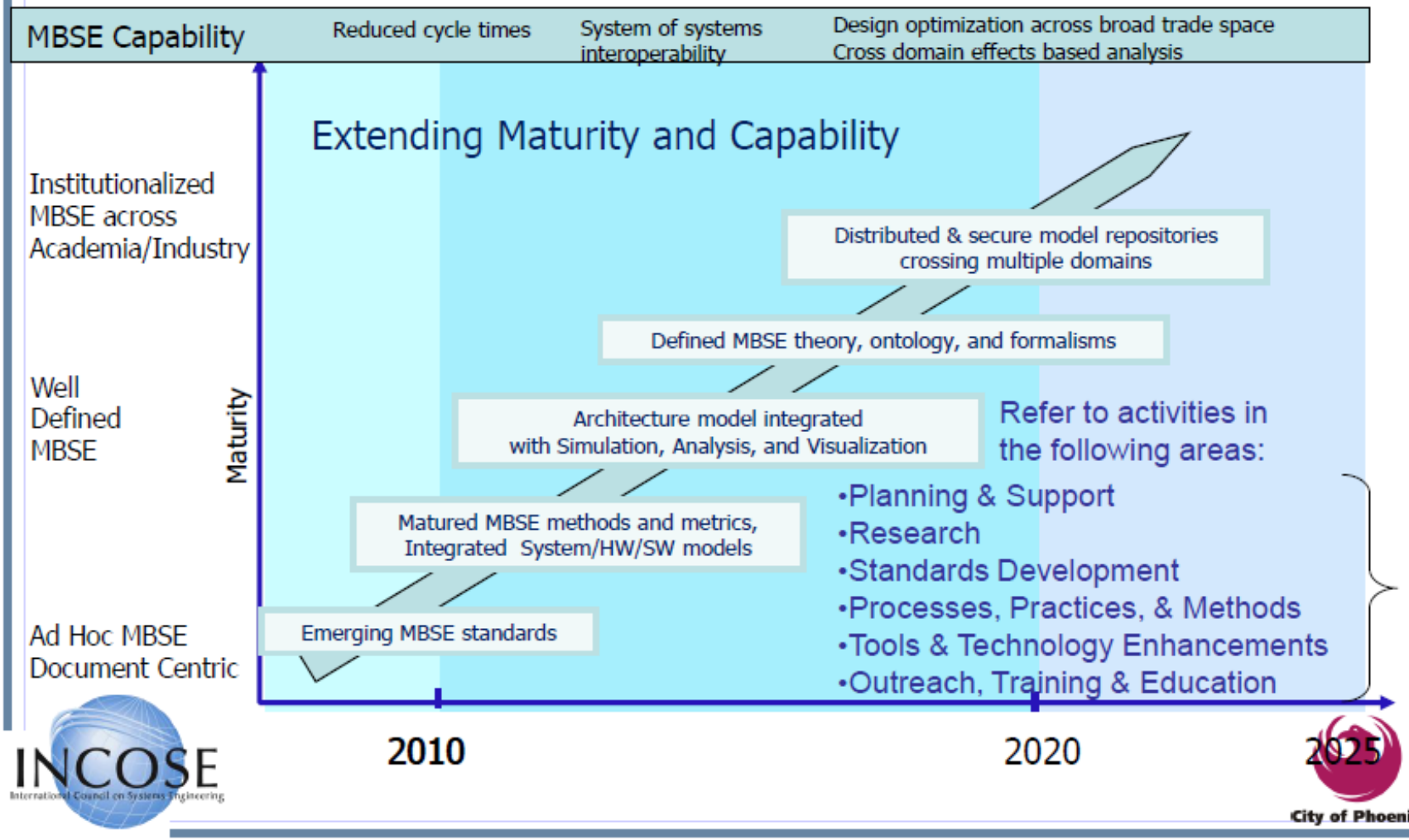
Requirements

Parametrics

Overview of MBSE: The Four MBSE Essentials



INCOSE MBSE Roadmap



INCOSE
International Council on Systems Engineering

City of Phoenix

MBSE Initiative Status

- Reorganized to Focus Initiative
  - Monthly telecons with expanded Leadership Team
- Monthly MBSE Webinars
  - Well attended and generally high quality
- Established MBSE Wiki
  - http://www.omgwiki.org/MBSE/doku.php
  - Hosted by the OMG
  - Populated by MBSE Activity and Challenge Teams
  - Provides open forum to foster industry collaboration
- MBSE Workshop at IW 2011

General Observations

- Continued broad interest in MBSE
  - Broad company participation and initiatives
  - DoD - NDIA MBE Report and Systems 2020
- INCOSE has opportunity to foster collaboration and maintain leadership role to advance the practice of MBSE
  - Webinars
  - Workshops
  - Wiki

MBSE Leadership Team

Management

- Chair Mark Sampson
- Co-Chair Sandy Friedenthal
- Webinars and Communications Ray Jorgensen
- MBSE Wiki Support David Lempia

Challenge Teams

- Modeling and Simulation Interoperability Russell Peak
- Space Systems Modeling Chris Delp
- Telescope Modeling Robert Karban
- GEOSS Modeling Larry McGovern

Activity Teams

- MBSE Usability Scott Workinger
- Methodology and Metrics Jeff Estefan
- Model Management Mark Sampson
- Modeling Standards Roger Burkhart
- Ontology Henson Graves
- System of Systems/Enterprise Modeling Ron Williamson

MBSE Presentations
Sunday, January 30 Agenda

08:00 – 12:00

- Introduction - Sandy Friedenthal / Mark Sampson (30 min)
- Methodology and metrics – Jeff Estefan (30 min)
- SoS/Enterprise Modeling – Ron Williamson (50 min)
- MBSE Usability - Scott Workinger / David Lempia (50 min)
- Challenge Team – Telescope Modeling - Robert Karban (50 min)

13:00 – 17:30

- Model Management - Mark Sampson (50 min)
- Ontology - Henson Graves (50 min)
- Challenge Team – Space Systems Modeling - Bjorn Cole (50 min)
- Challenge Team – M&S Interoperability - Russell Peak (50 min)
- Modeling Standards – Roger Burkhart (30 min)

DRAFT Final Report

Model Based Engineering (MBE) Subcommittee

Jeff Bergenthal (Subcommittee Lead)

NDIA Systems Engineering Division
M&S Committee

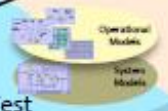
December, 2010

High-Level MBE Benefits

- Reduce time to acquisition of first article for systems and solutions
  - More complete evaluation of the trade space
  - Earlier risk identification and mitigation
  - Concurrent and collaborative engineering
  - Design reuse
  - Accelerated development
- Reduce the time to implement planned and foreseen changes in systems
  - Design reuse
  - Rapidly evaluate changing threats and explore trade space
- Enhance Reliability
  - Earlier and continuous requirements and system verification
  - Identify and resolve errors / issues earlier → fewer post-fielding issues
- Enhance Interoperability
  - Inclusion of the operating environment and external interfaces in system models
  - Early and continuous interface and interoperability verification

… and Each of These Benefits Enhance Affordability

MBE To-Be State



Material Solution Analysis
Technology Development
Engineering & Manufacturing Development
Production & Deployment
Operations & Support
Life Cycle Sustainment
A
B
C
Material Development Decision
Pre-Systems Acquisition
PDR
Integrated System Design
Post PDR Assessment
PDR
CDR
System Capability & Manufacturing Process Demonstration
Post CDR Assessment
LRIP
Full Rate Prod & Development
FRP Decision Review
Systems Acquisition
or
Program Management
Test
Systems
Hardware
Software
Configuration Management
Manufacturing
Logistics
Customer
Collaborative Foundation
Customers
Teammates
Suppliers

- Operational Needs
- Current Capabilities
- Budget/Schedule

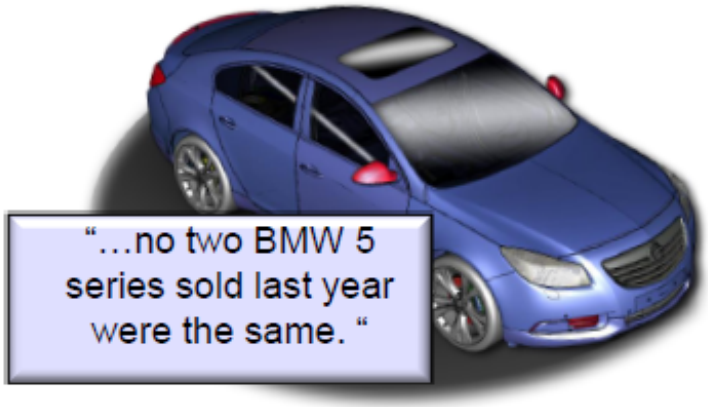
Collaborative Foundation:
- Standards
- Model Registry
- Trusted Environment with SIP
- Supporting Policy

MBE Enhances Affordability, Shortens Delivery and Reduces Risk Across the Acquisition Life Cycle

To restate the obvious…

- Complex systems are everywhere…
- They are becoming the norm, not the exception
- They require systems/cross-domain thinking to be successful
- Existing processes can't handle the complexity, magnitude, etc.
- Models are becoming the master, not drawings, not documents,…
- Model-based systems world is coming…

"You're not going to lay out a billion-gate integrated circuit by hand in your life-time" *1972 Dr. Charles Rose at TI (Inventor of HDL's)*



"…no two BMW 5 series sold last year were the same. "

~5000 sensors, ECU's, etc. communicating over 9000 connections via 1,000,000+ types of messages, performing 2000+ functions in triple-redundant, physically separated fashion with each tail number a different configuration

Recent Updates

- Activity area expanded to include metrics, now officially called "Methodology and Metrics Activity Team"
- MBSE Wiki stood up as publically-accessible portal for collecting MBSE Activity and Challenge Teams information and work products
  - Methodology and Metrics Wiki page includes brief description of methodologies surveyed in 2008 report *plus* those identified as gaps since report
    - Weilkiens Systems Modeling Process (SYSMOD)
    - Fernandez Process Pipelines in OO Architectures (PPOOA)
  - Also includes section on Metrics w/special interest in *tool metrics* as well as *process metrics*
    - Michelle Sprecht of IBM contributed to tool metrics content
- Jeff Estefan to transfer Activity Lead role to John Watson of LMCO

Presentation for Today

- Chris Davies – Ford Motor Company
- A Senior Technical Leader within the Ford Global Electrical and Electronic Systems Engineering organization, (EESE). He has over 20 years of real-time controls and embedded software experience across multiple automotive domains. He received his bachelor's degree from the University of Sussex, UK in Control Systems, a Masters degree in Advanced Automotive Systems Engineering at the University of Loughborough, UK and an Engineering Management Masters from Wayne State University, USA.

INCOSE (MBSE)
Model Based System Engineering
(SoS) System of Systems Activity Introduction

Ron Williamson, Ph.D.
Raytheon
ron.williamson@incose.org

Jan 30-31, 2011
INCOSE IW11 MBSE Workshop
MBSE Wiki page: http://www.omgwiki.org/mbse
MBSE SoS/Enterprise Modeling Wiki page:
http://www.omgwiki.org/MBSE/doku.php?id=mbse:enterprise

INCOSE
International Council on Systems Engineering

City of Phoenix

Introduction SoS Engineering Key Concepts

	Traditional Systems Engineering	System-of-Systems Engineering
Purpose	Development of single system to meet stakeholder requirements and defined performance	Evolving new system-of-systems capability by leveraging synergies of legacy systems
System Architecture	System architecture established early in lifecycle and remains relatively stable	Dynamic reconfiguration of architecture as needs change; use of service oriented architecture approach as enabler
System Interoperability	Defines and implements specific interface requirements to integrate components in system	Component systems can operate independently of SoS in a useful manner Protocols and standards essential to enable interoperable systems
System "ilities"	Reliability, Maintainability, Availability are typical ilities	Added "ilities" such as Flexibility, Adaptability, Composeability
Acquisition and Management	Centralized acquisition and management of the system	Component systems separately acquired and continue to be managed as independent systems
Anticipation of Needs	Concept phase activity to determine system needs	Intense concept phase analysis followed by continuous anticipation, aided by ongoing experimentation

Saunders, T. *et al,* "United States Air Force Scientific Advisory Board Report on System-of-Systems Engineering for Air Force Capability Development," SAB-TR-05-04, July 2005

- **SoS Engineering Key Concepts**
  - **Legacy Systems**
  - **Dynamic Reconfiguration of Architecture**
  - **Service Oriented Architecture Enabler**
  - **Protocols and Standards to Enable Interoperable Systems**
  - **Added "ilities" or Quality Attributes**
  - **Federated Acquisition**
  - **Independent Systems**
  - **Concept of Operations Critical**
  - **Ongoing Experimentation**
  - **Converging Spirals**

SoS Modeling Implications →

INCOSE International Council on Systems Engineering

City of Phoenix

Introduction …SoS MBSE Implications

Legacy Systems	→	Models for behavior, interfaces, requirements, performance, e.g. SysML, Modelica, MARTE
Dynamic Reconfiguration of Architecture	→	Dynamic Reconfigurable models of architecture, e.g. UPDM with UML/SysML model version management
Service Oriented Architecture Enabler	→	SOA modeling language, e.g. SoaML, SOA Patterns
Protocols and Standards to Enable Interoperable Systems	→	Models for protocols, standards, interoperability, e.g. UPDM, DoDAF 2 MetaModel
Added "ilities" or Quality Attributes	→	Specialty Engineering models, e.g assurance
Federated Acquisition	→	Models for acquisition project synergy, e.g. UPDM, MODAF, DoDAF 2 MetaModel
Independent Systems	→	Models for independence in system functionality, e.g. Agent Based, federated models
Concept of Operations Critical	→	Models for CONOPs including Mission, Objectives, Courses of Action, etc. e.g. UPDM Operational Viewpoint, BPMN Business Processes
Ongoing Experimentation	→	Analysis of Alternatives models for all viewpoints and model versioning

Matthew Hause
UPDM Co-Chair
Atego Chief Consulting Engineer

UPDM Group

Adaptive	Northrop Grumman
Artisan Software	L3 Comms
ASMG	MOD
BAE Systems	NoMagic
DoD	Raytheon
DND	Rolls Royce
Generic	Sparx Systems
General Dynamics	VisumPoint
IBM	Selex SI
Lockheed Martin Co	Thales
Mega	Unisys
Mitre	

INCOSE
International Council on Systems Engineering

City of Phoenix

What is UPDM? - Summary

- UPDM 1.0 is a standardized way of expressing DoDAF 1.5 and MODAF 1.2 artefacts using UML and SysML
  - UPDM is ***NOT*** a new Architectural Framework
  - UPDM is not a methodology or a process
- UPDM 1.0 was developed by members of the OMG with help from industry and government domain experts.
- UPDM 1.0 has been implemented by multiple tool vendors.
  - Tools supporting UPDM 1.0 are available now.
- UPDM 2.0 supports DoDAF 2.0, MODAF 1.2, NAF 3.x, and DNDAF 1.7

INCOSE
International Council on Systems Engineering

City of Phoenix

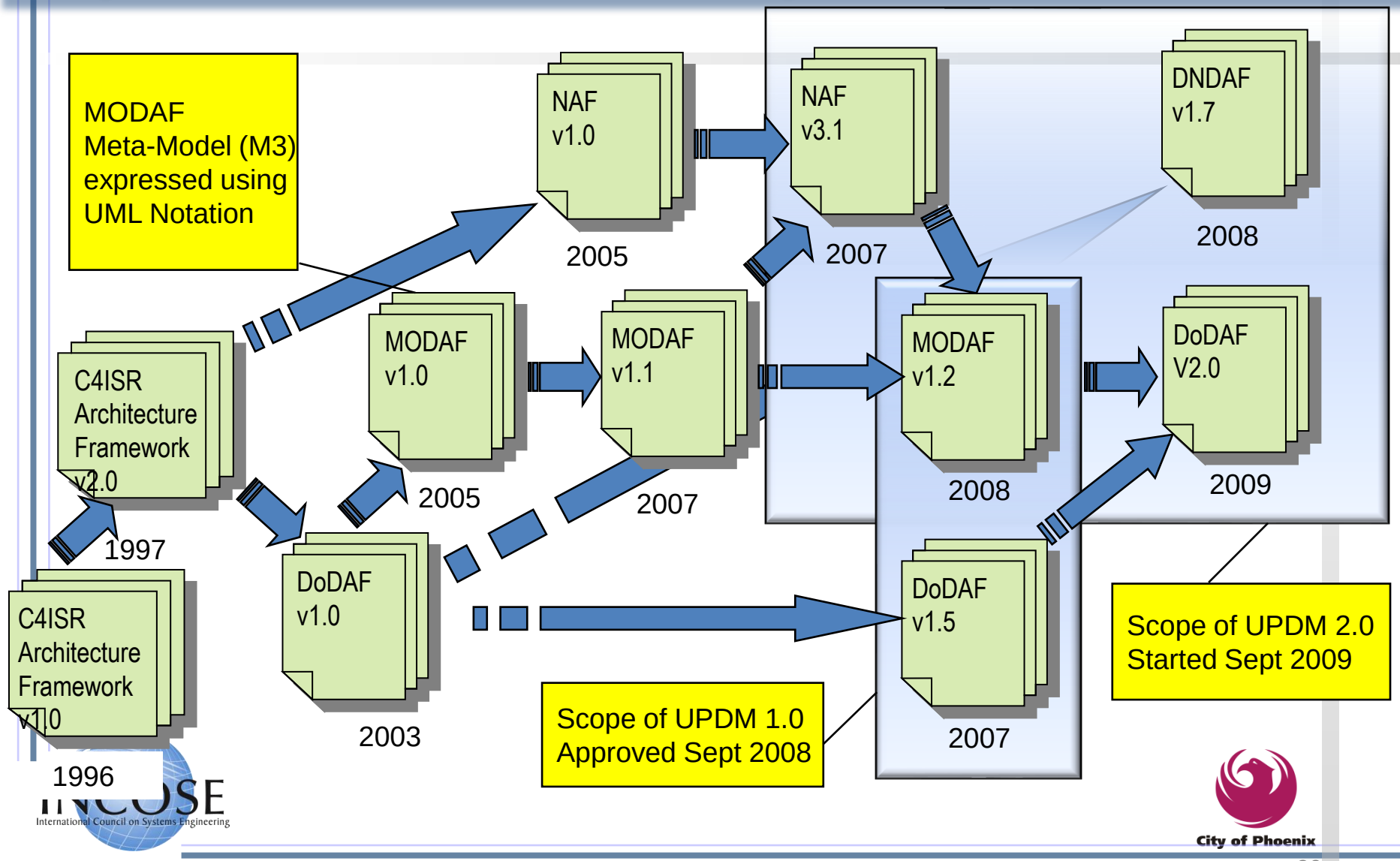
Why? The need for UPDM.

- Motivation
  - US DoD and UK MOD interested in leveraging commercial standards for their Military Architecture Framework
  - Military Architecture Framework Tool Interoperability
    - Key Goal for DoD, MOD, Enterprise and System Architects and Engineers
  - Formal MetaModel basis for the Military Architecture Framework
    - Critical to Interoperability Objectives
    - Critical to Understanding Profile Requirements
- Proliferation of Military Architectural frameworks
  - DoDAF, MODAF, DNDAF, NAF, AGATE, ADOAF, MDAF, etc.
  - Defence organizations, contractors and tool vendors are hoping to find a way out of the alphabet soup.

INCOSE
International Council on Systems Engineering

City of Phoenix

Why and When: Historical Development of AF's.



Who and Where: UPDM Team Members

- US DoD Liaison - DoD/DISA, OSD CIO, Mitre, Silver Bullet
- UK MOD Liaison - UK MOD, ModelFutures
- Canada DND Liaison – DND and ASMG Ltd
- NATO – Generic AB on behalf of SwAF and on contract by FMV
- Tool Vendors – Adaptive, Atego (Co-Chair), EmbeddedPlus, IBM (Co-Chair), Mega, NoMagic (Co-Chair), Sparx Systems, Visumpoint
- Aerospace – BAE Systems, General Dynamics, L3 Communications, Lockheed Martin, Northrop Grumman, Raytheon, Rolls-Royce, Selex SI, Thales, Unisys
- Advisors – Decisive Analytics
- Distributed multi national team (US, UK, France, Sweden, Lithuania, Australia, Canada, Thailand, Italy)

INCOSE
International Council on Systems Engineering

City of Phoenix

How: UPDM Level 1 Compliance SysML Extensions

- Enables UPDM to leverage SysML features
  - SysML blocks to represent structural elements such as operational nodes, artifacts (systems), capability configurations, which enable the use of flow ports, item flows, and value properties with units and distributions
  - SysML activities to support continuous flow modeling, activity hierarchies, and support for enhanced functional flow block diagrams
  - SysML parametrics to enable the integration of engineering analysis with the architecture models (e.g., performance parameters in an SV-7 can be captured in parametric equations)
  - SysML allocations to support various types of mappings such as an SV-5 that maps system functions to operational activities
- Other SysML Features
  - SysML requirements enable text based requirements to be captured and traced to other model elements using the satisfy, derive, verify and refine relationships
  - SysML view and viewpoint enable provide for multiple perspectives of the model, and to manage, control, and organize information.
  - Callout notation

When: UPDM 2.0 Roadmap

- Signed and Released DoDAF 2.0 in June 2009
- Preparation of RFP for UPDM 2.0 (Next Slide)
- Issue UPDM 2.0 RFP Sept 2009
- ….

INCOSE
International Council on Systems Engineering

City of Phoenix

When: UPDM 2.0 Roadmap

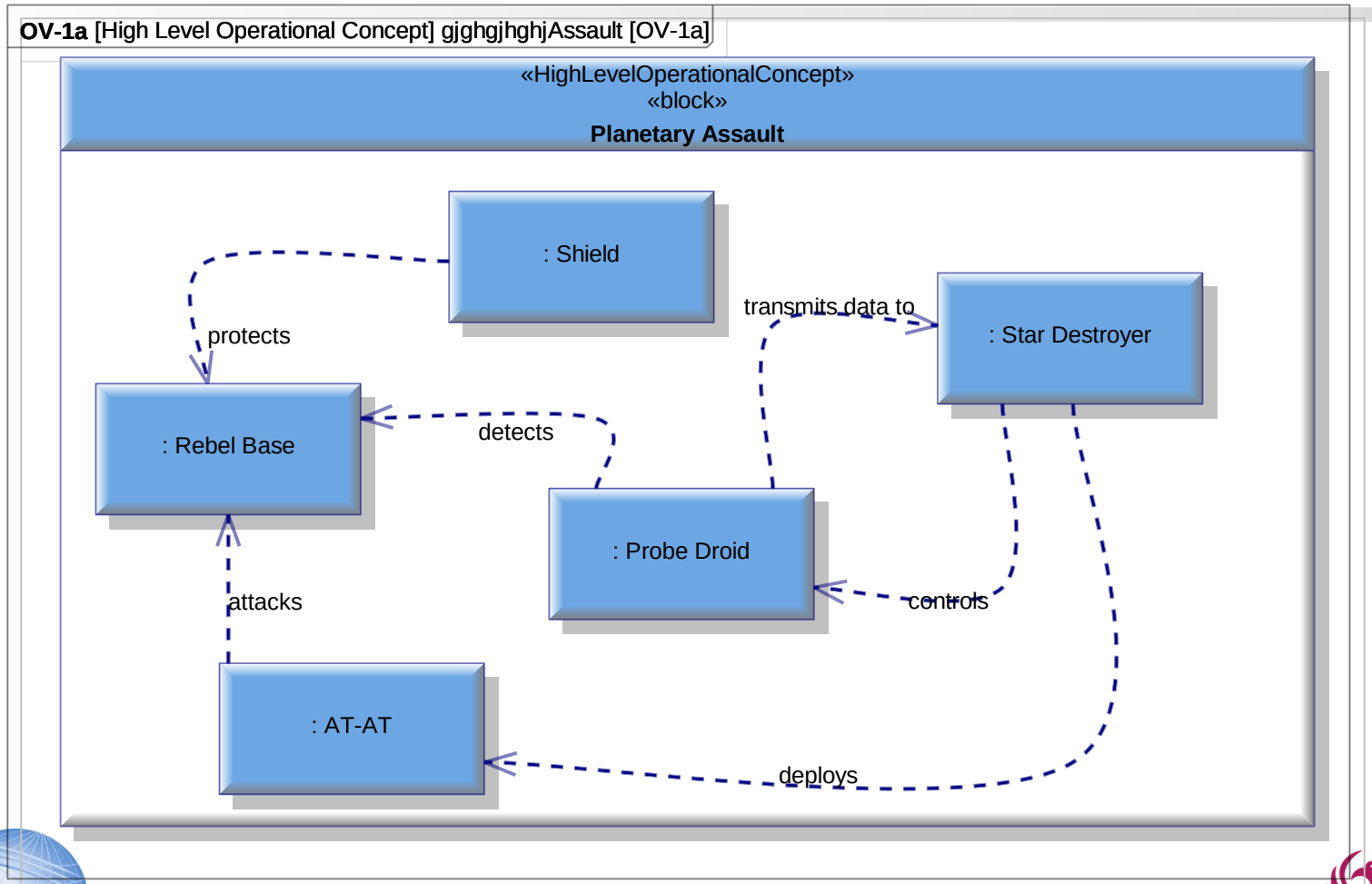
- RFP for UPDM 2.0
  - Inclusion of DoDAF 2.0
  - Continuing support for MODAF 1.2
  - Support for NAF 3
  - Support for DNDAF including the Information and Security views
  - Human Factors Views based on MODAF and DNDAF
  - Business Motivational Modeling/SBVR profile integration
  - Business process Modeling Notation
    - UPDM v2 optionally could use BPMN to model operational views
  - Others?

INCOSE
International Council on Systems Engineering

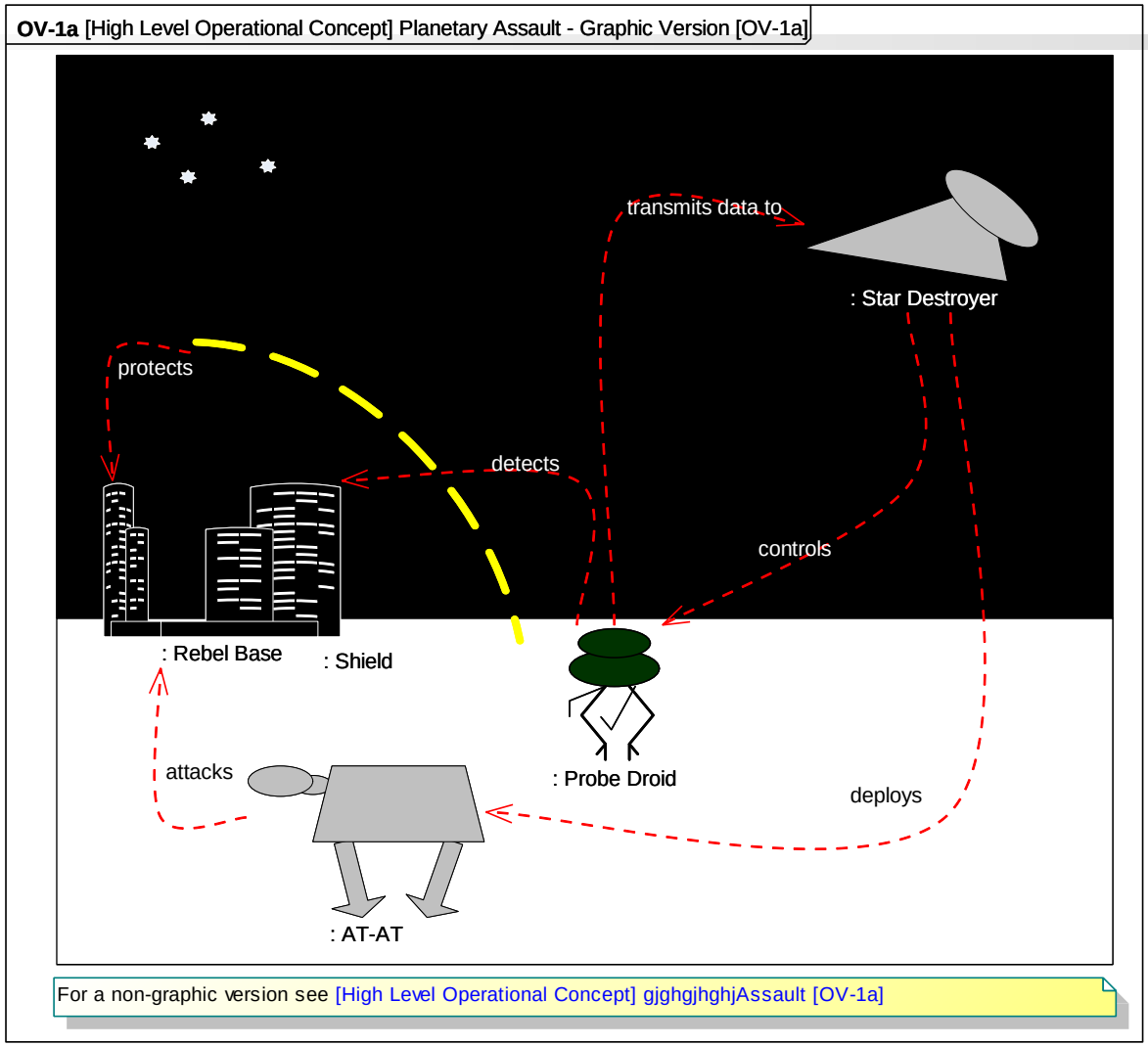
City of Phoenix

UPDM - Profile Example

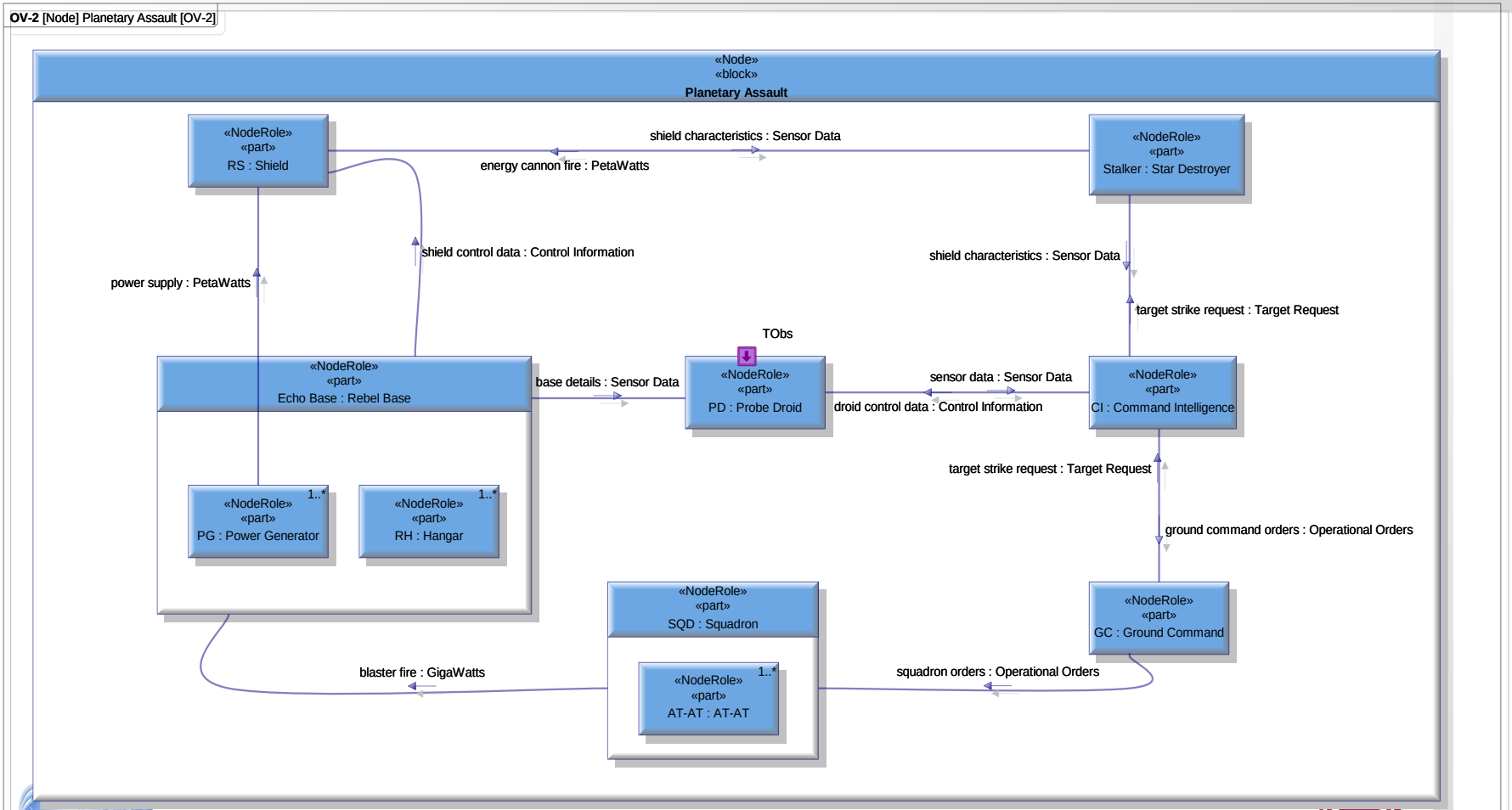
OV-1a: Operational Context Graphic



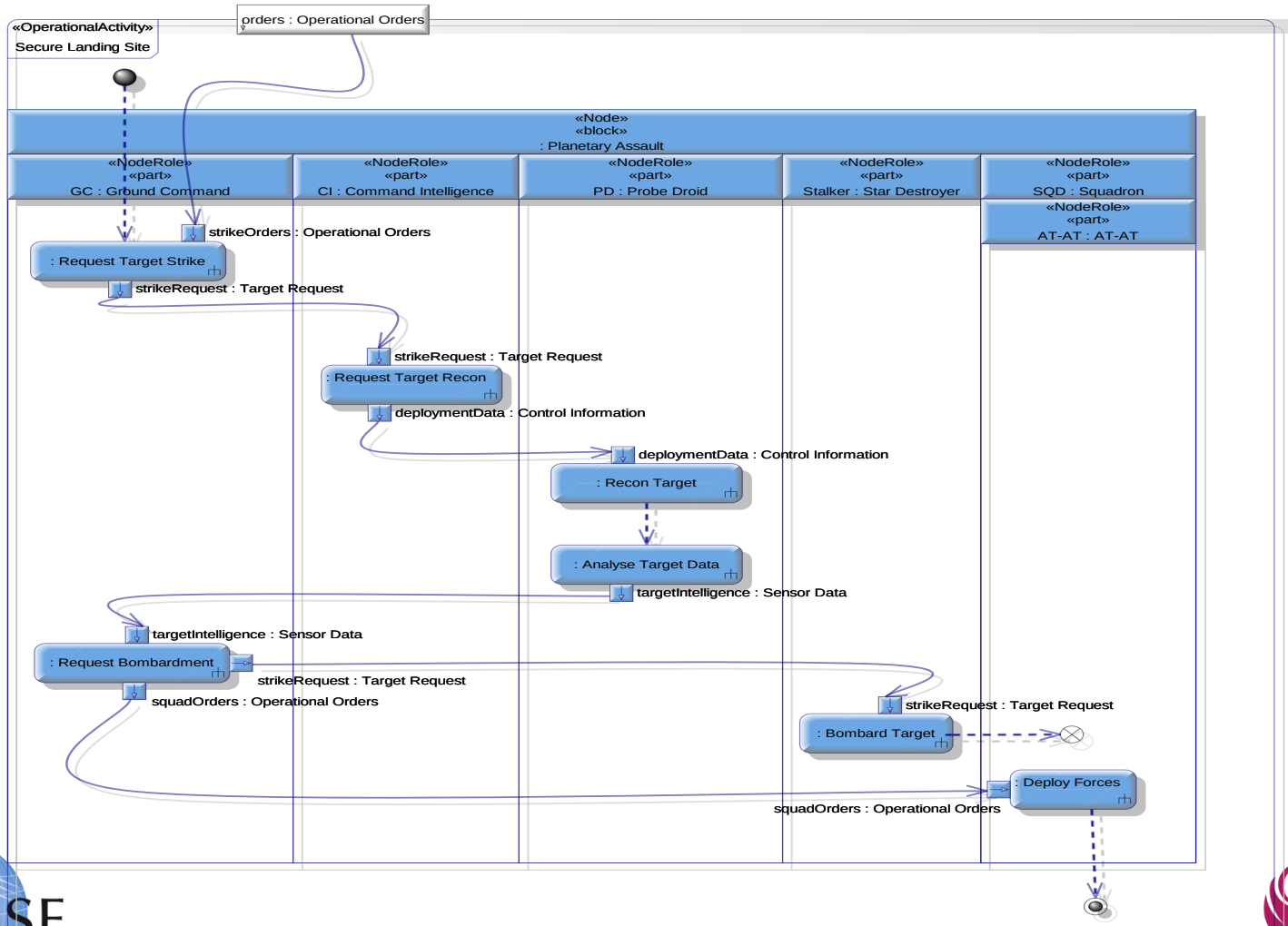
OV-1: Operational Context Graphic



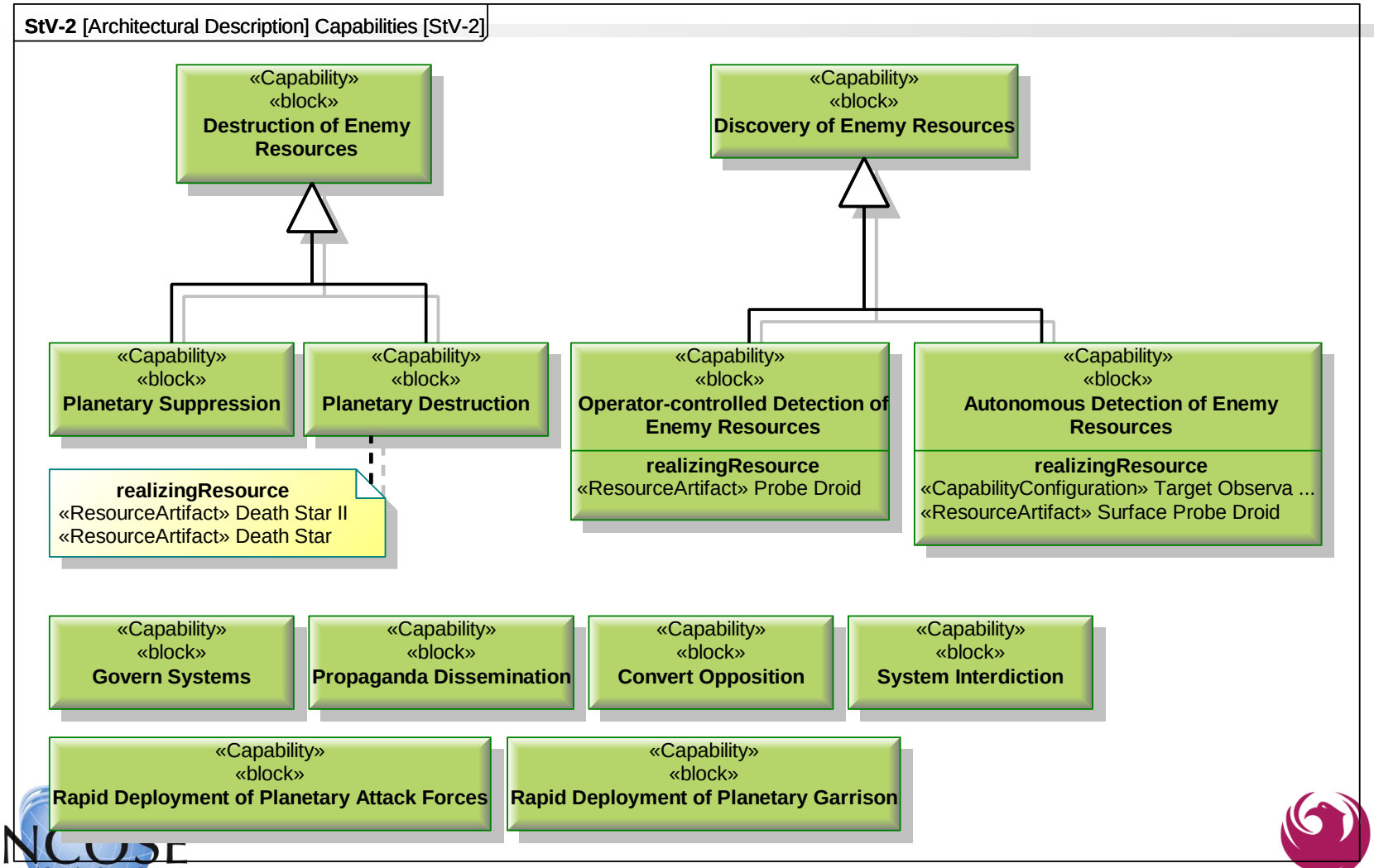
OV-2 Operational Nodes



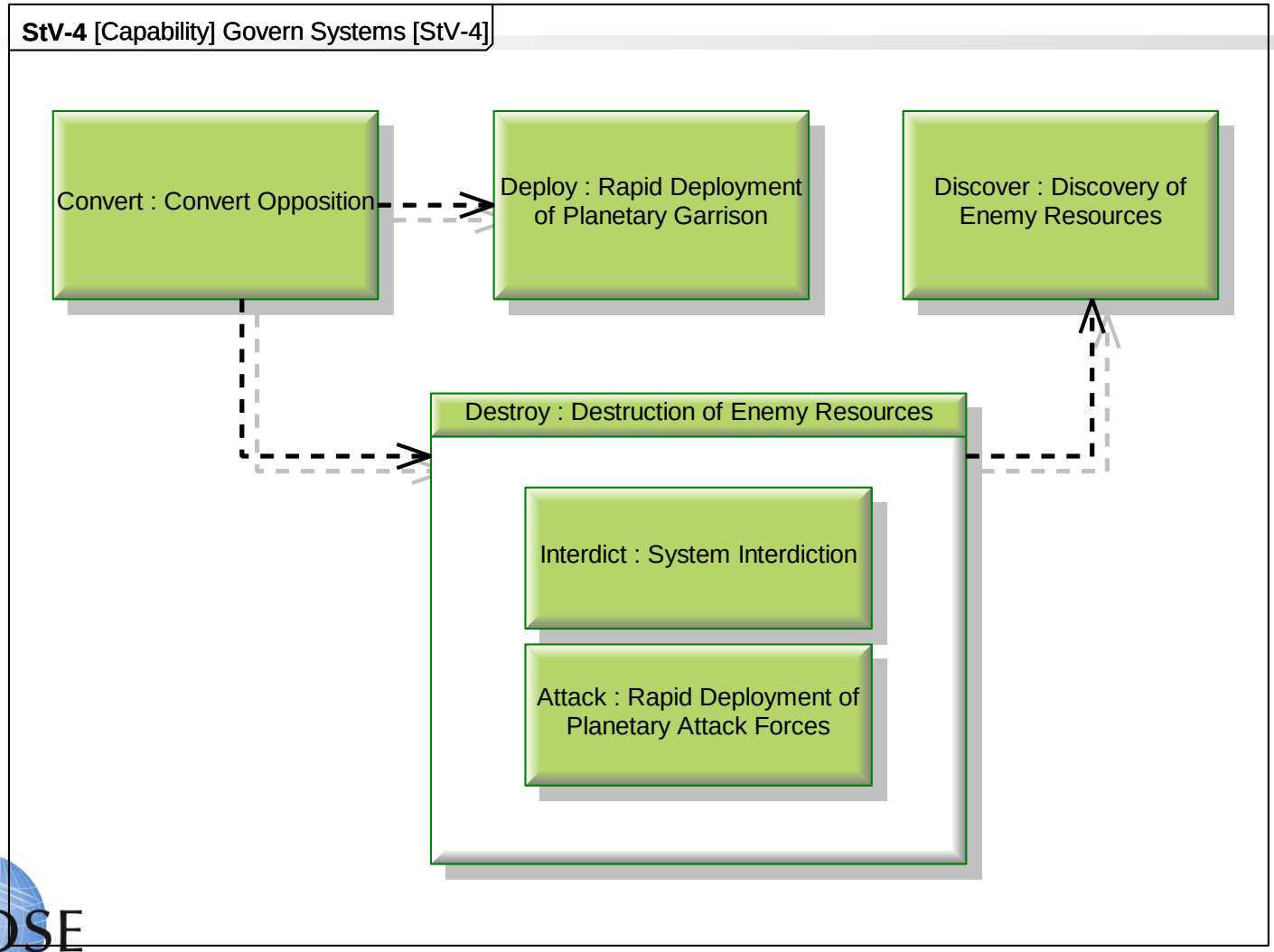
OV-5 Activity Diagram



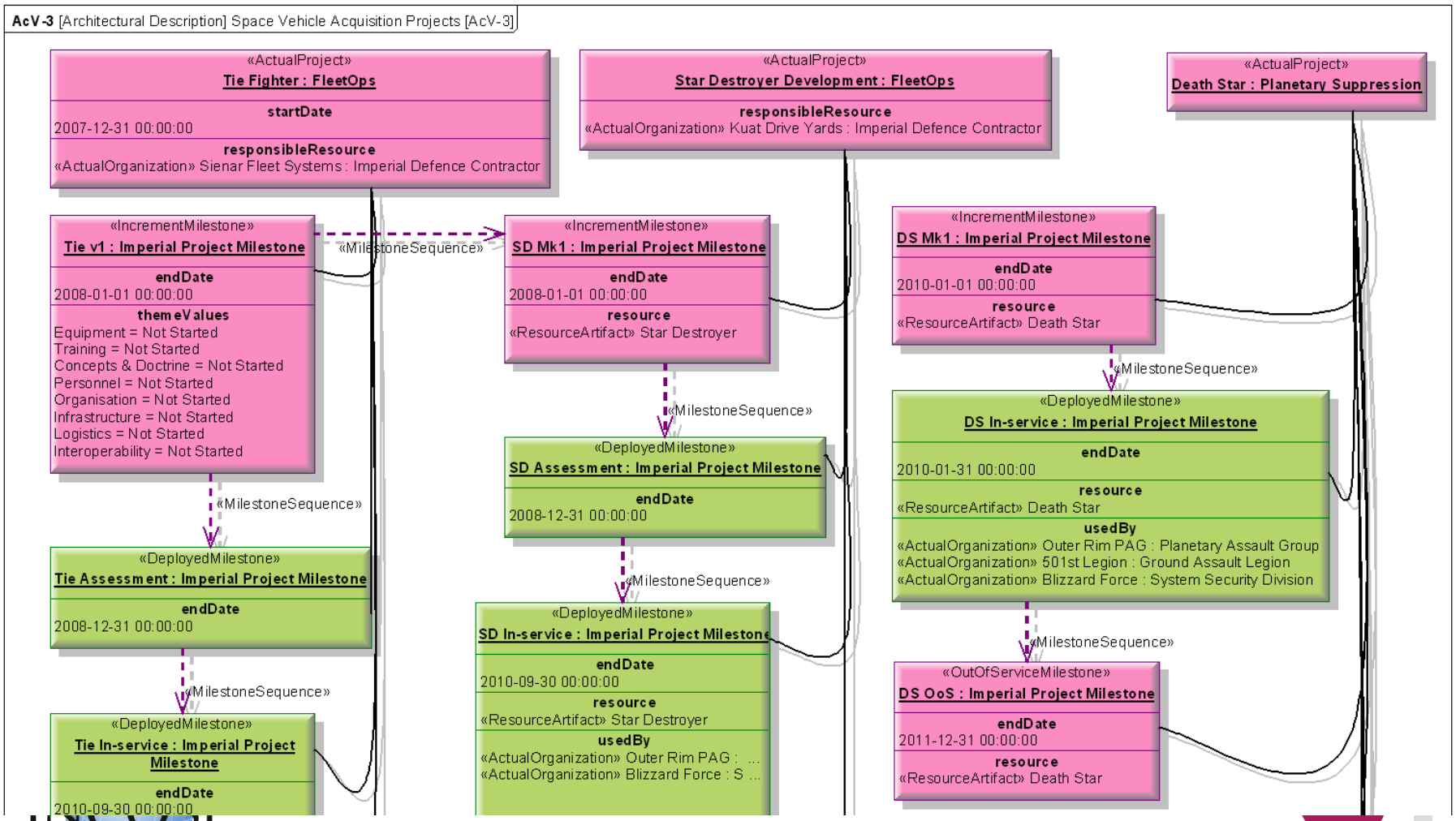
StV-2: Capability Taxonomy



StV-4: Capability Dependencies



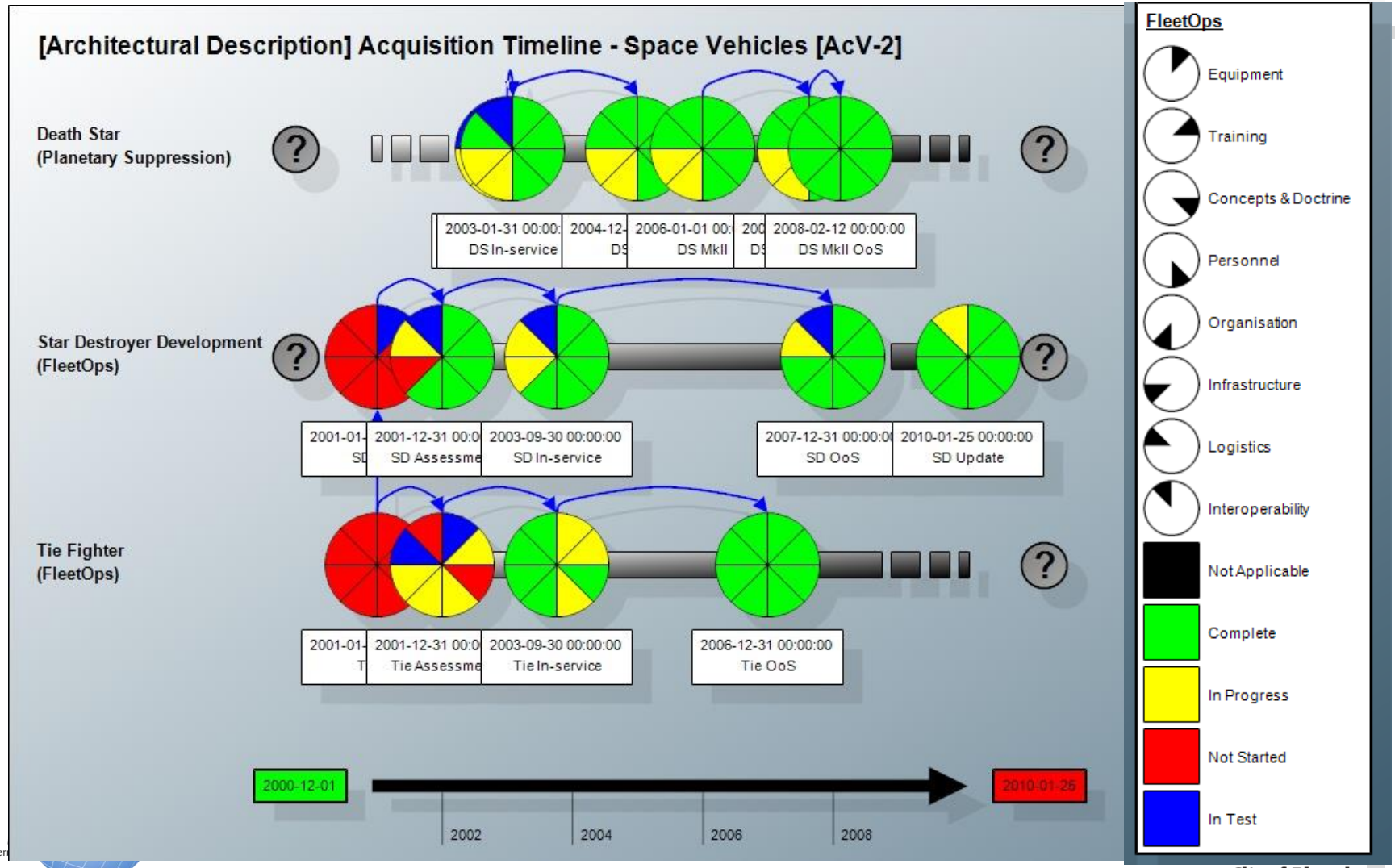
AcV-2 Project Views - Milestones



StV-3: Table/Gantt Chart

	Year 1						Year 2						Year 3					
	J	M	M	J	S	N	J	M	M	J	S	N	J	M	M	J	S	N
Discovery of enemy resources																		
Operator-controlled detection of enemy resources	Probe Droid																	
Autonomous detection of enemy resources								Surface Probe Droid										
Destruction of enemy resources																		
Planetary suppression				Star Destroyer														
Planetary destruction									Death Star									

AcV-2 Project Views - Milestones



SoV-1: Service Taxonomy

SOV-1 [Architectural Description] Service Taxonomy [SOV-1]

«ServiceInterface»
Root Service

«ServiceInterface»
Intelligence Service

«ServiceInterface»
Communication Service

«ServiceInterface»
Target Observation

providedFunction
«ServiceFunction» Observe Target ()
«ServiceFunction» Initialise (in searchParams : Search Parameters)
«ServiceFunction» Transmit Data ()
«ServiceFunction» Perform Preliminary Analysis ()

«ServiceAttribute» Range : Kilometers

«ServiceInterface»
Intelligence Fusion

«ServiceInterface»
SIGINT

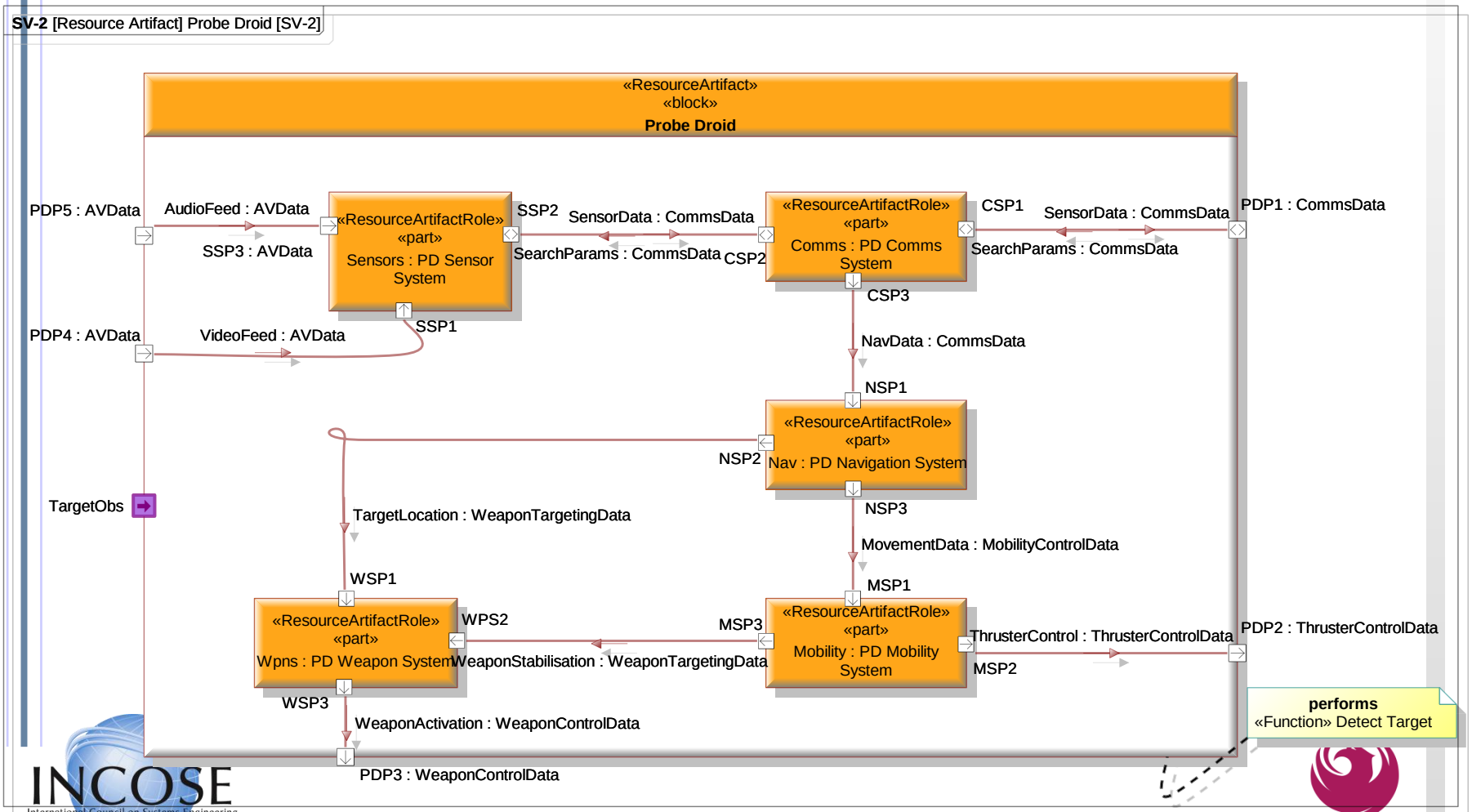
«ServiceInterface»
Email Service

«ServiceInterface»
Military Messaging Service

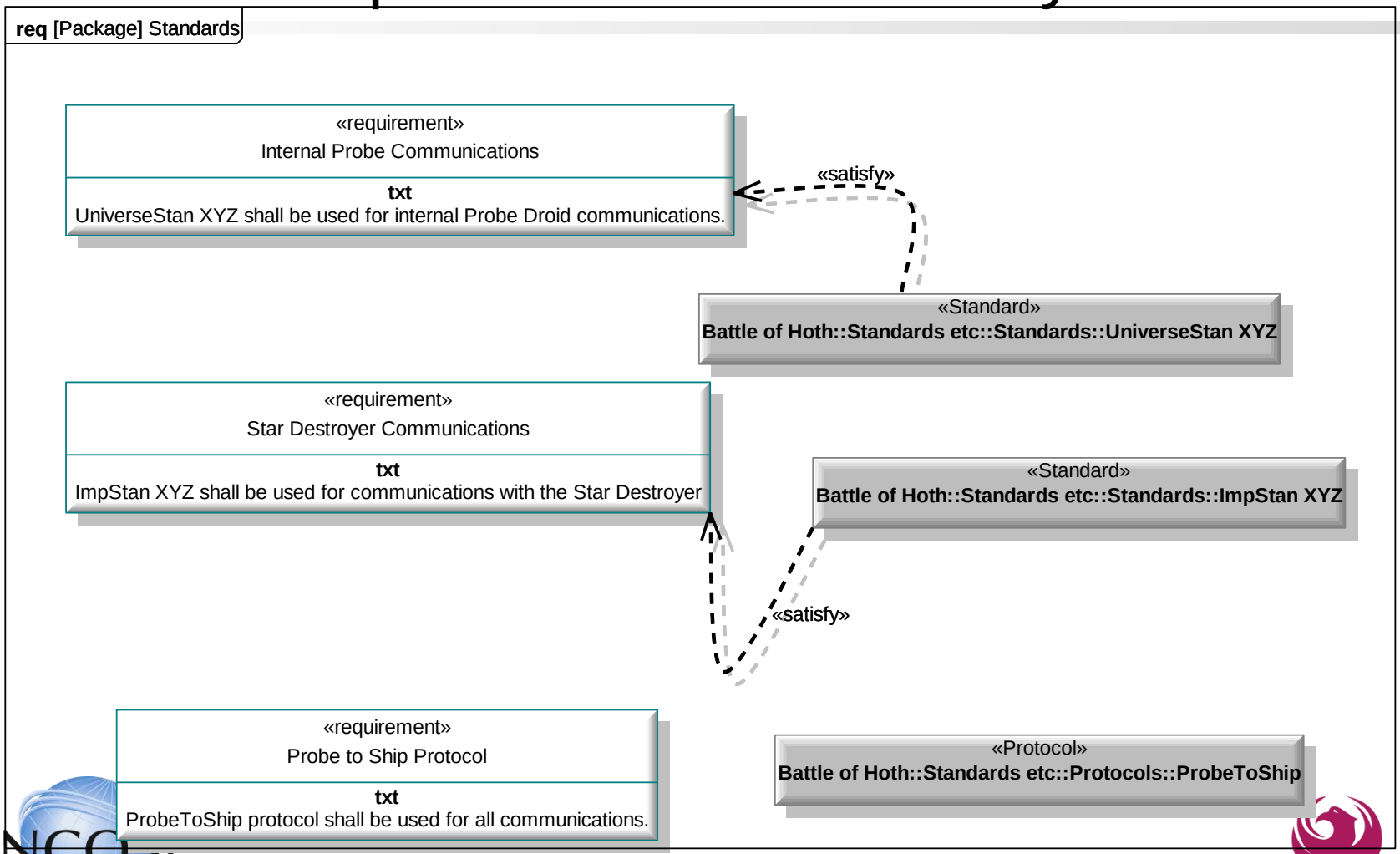
INCOSE
International Council on Systems Engineering

City of Phoenix

SV-2: System Detail



SysML Example: Requirements Traceability



International Adoption of UPDM

- United States
  - DoD statements of support issued
  - Vendor presentations given to DoD, Industry, conferences
  - UPDM being used on both bids and projects
- Great Britain
  - MOD statements of support issued
  - Vendor presentations given to MOD, Industry, conferences
  - UPDM being used on both bids and projects
- France
  - DGA favoring NATO NAF over AGATE; investigating UPDM
  - Vendor presentations given to DGA, Industry, conferences

Working Through System Models

Space Systems Challenge Team

INCOSE MBSE Initiative

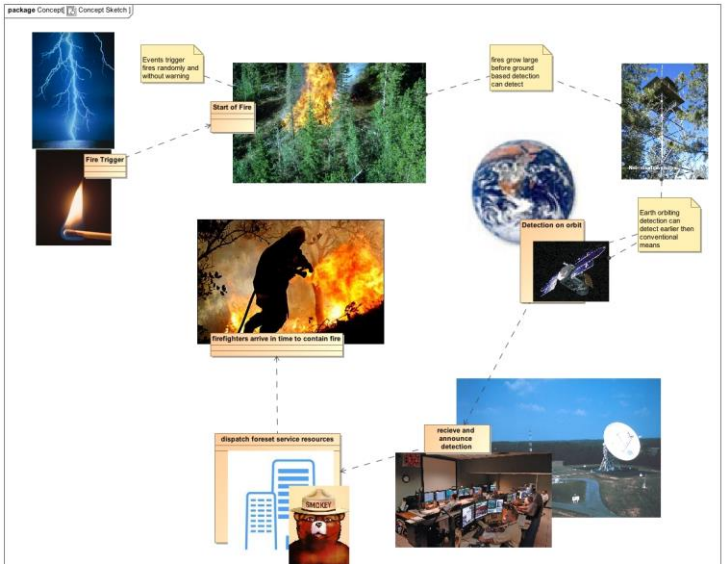
Presented by

Bjorn Cole (for Chris Delp)
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California, U.S.A.
Bjorn.Cole@jpl.nasa.gov

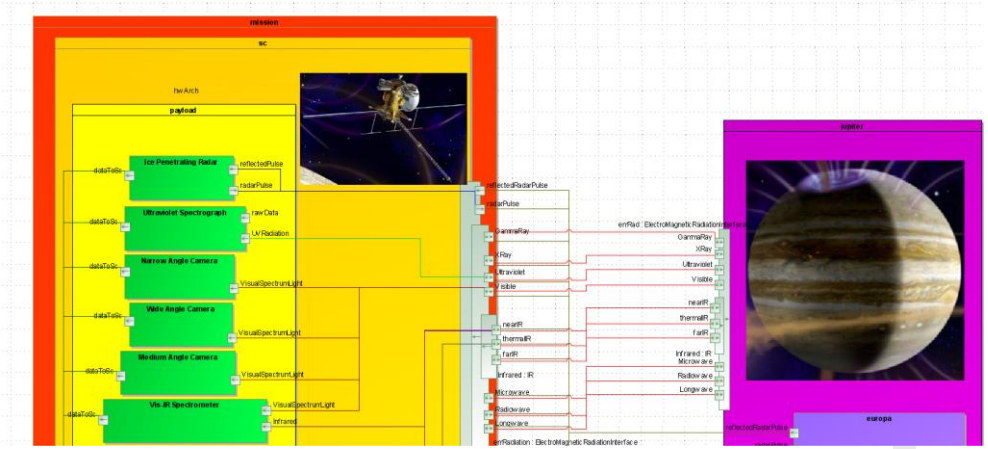
INCOSE
International Council on Systems Engineering

City of Phoenix

Success in past years!



FireSat – International and Academic Collaboration w/ publically available concept [5]



Pilot on publically available Outer Planets Flagship Mission concept with integrated Parametrics execution [3]

INCOSE
International Council on Systems Engineering

City of Phoenix

Results of MOS Revitalization Experience with Document Generation

- Made the design clearer to reviewers
- Saved time on iteration as model was revised in preparation for reviews
- Board was able to sync to team's semantics and use them to provide critiques
- Saved a great deal of effort hunting down trivial inconsistencies and guided work toward meaningful issues

INCOSE
International Council on Systems Engineering

City of Phoenix

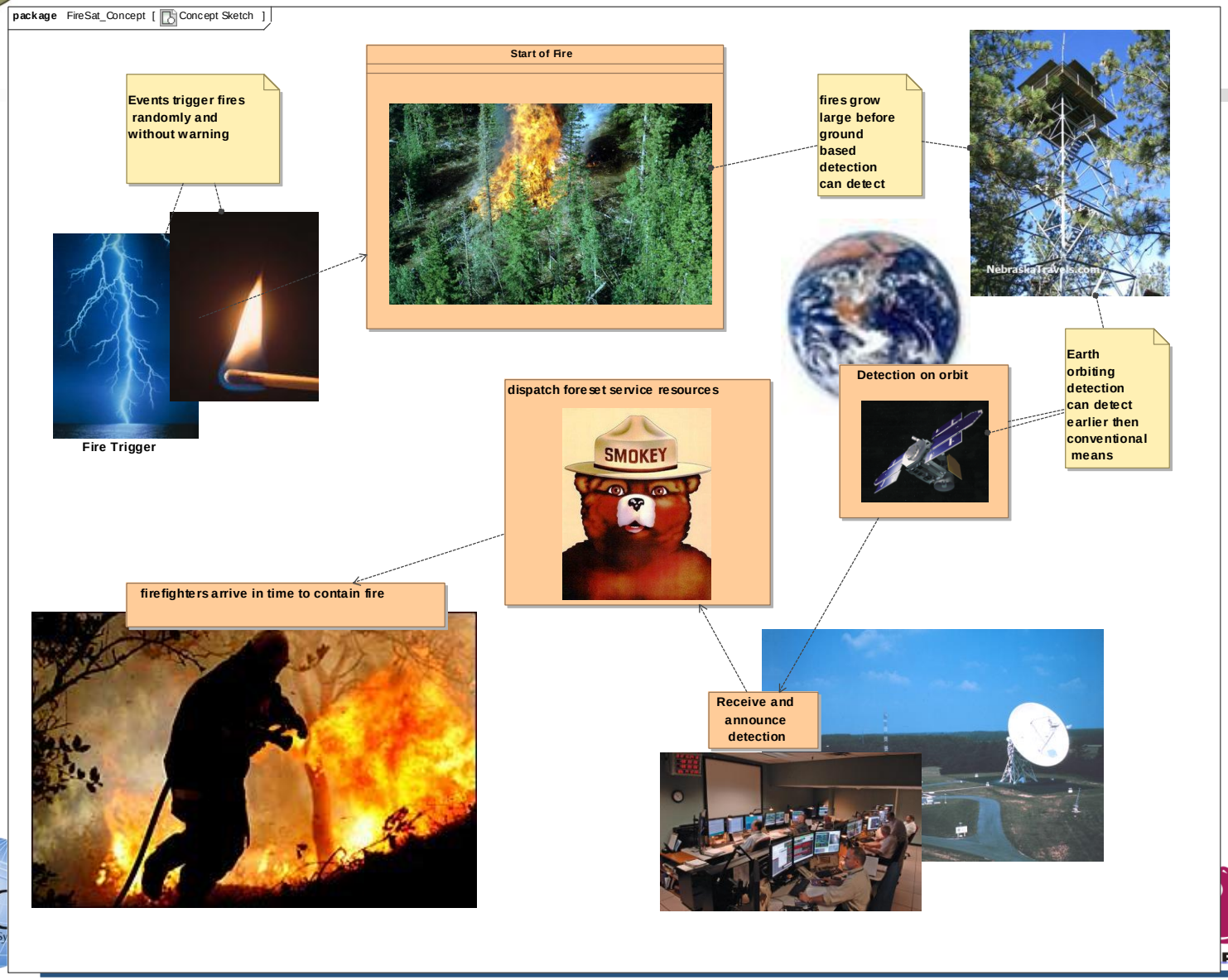
SysML with STK [6,7]

- Next segment of work is a collaboration between AGI and InterCAX to experiment with connecting SysML to an orbital analysis tool
- This is the combination of model-based specification and high-fidelity analysis

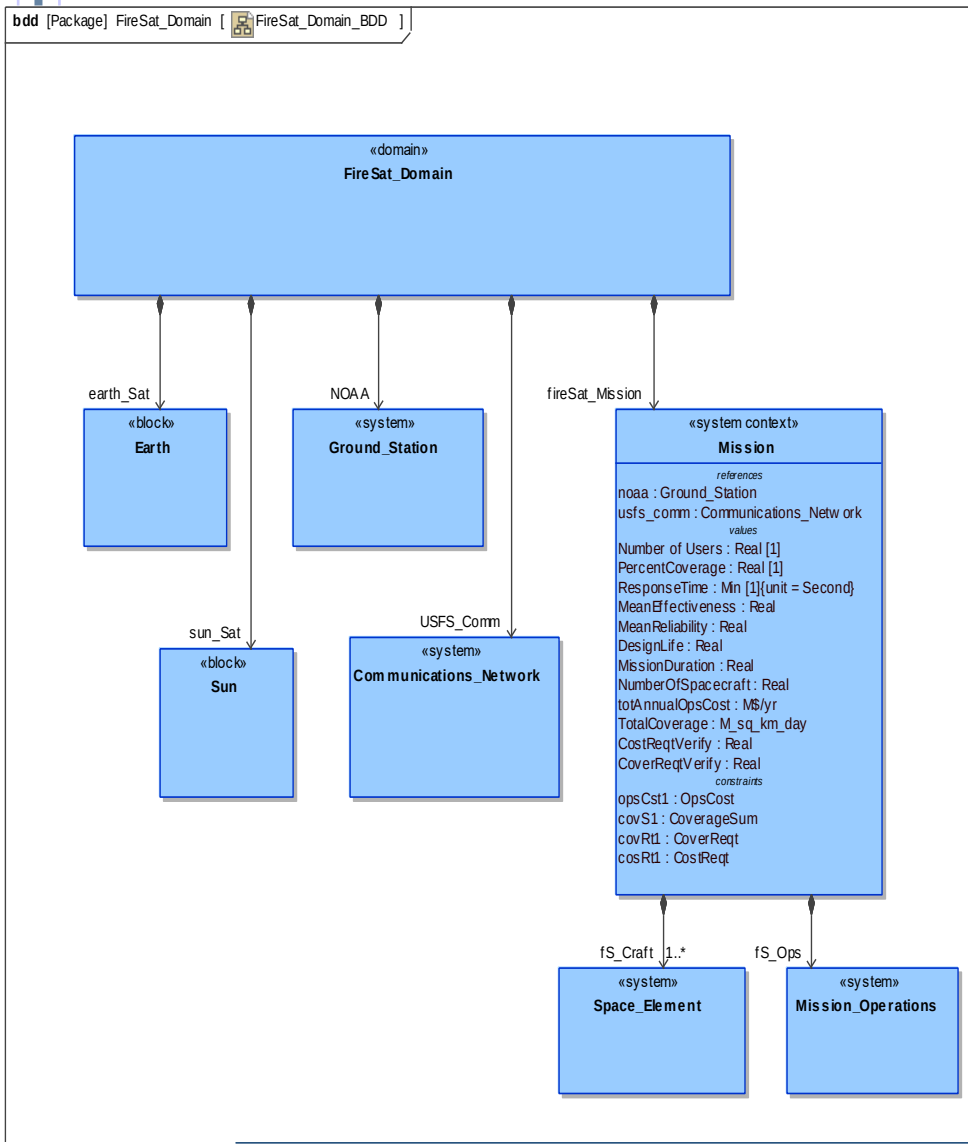
INCOSE
International Council on Systems Engineering

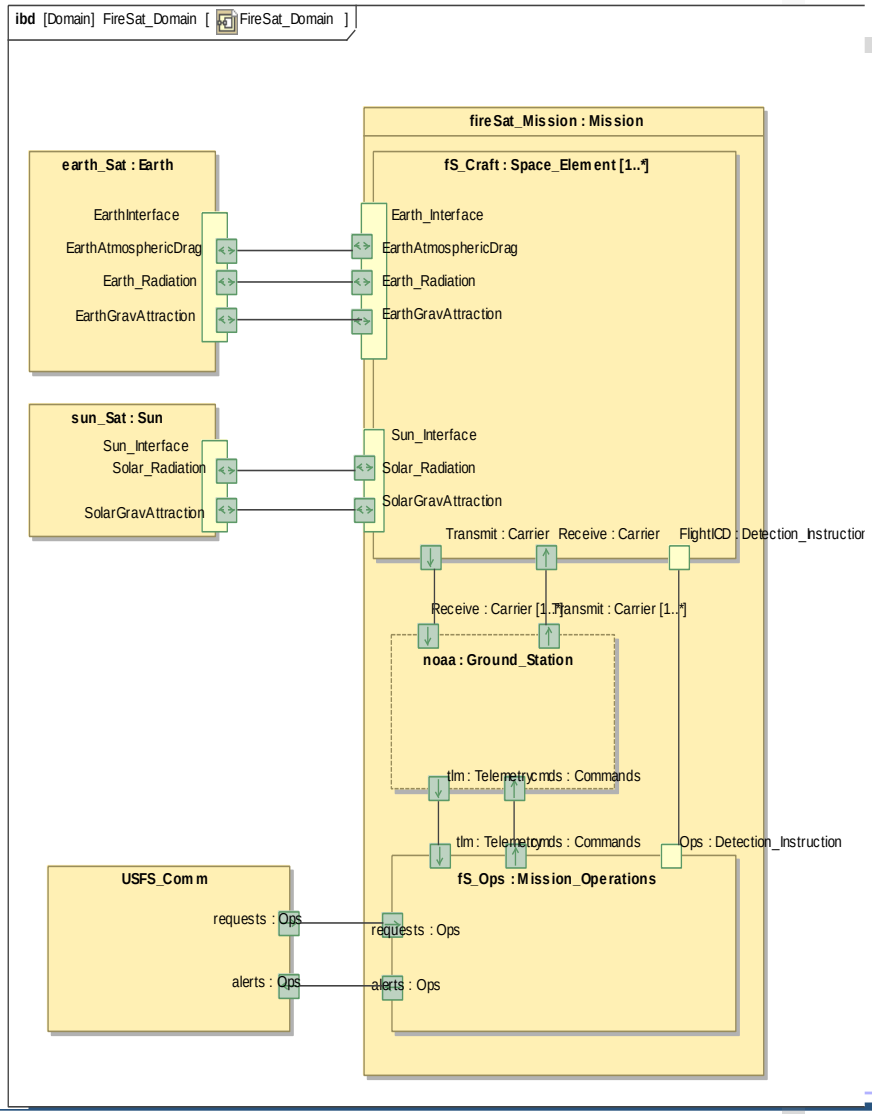
City of Phoenix

Concept Model

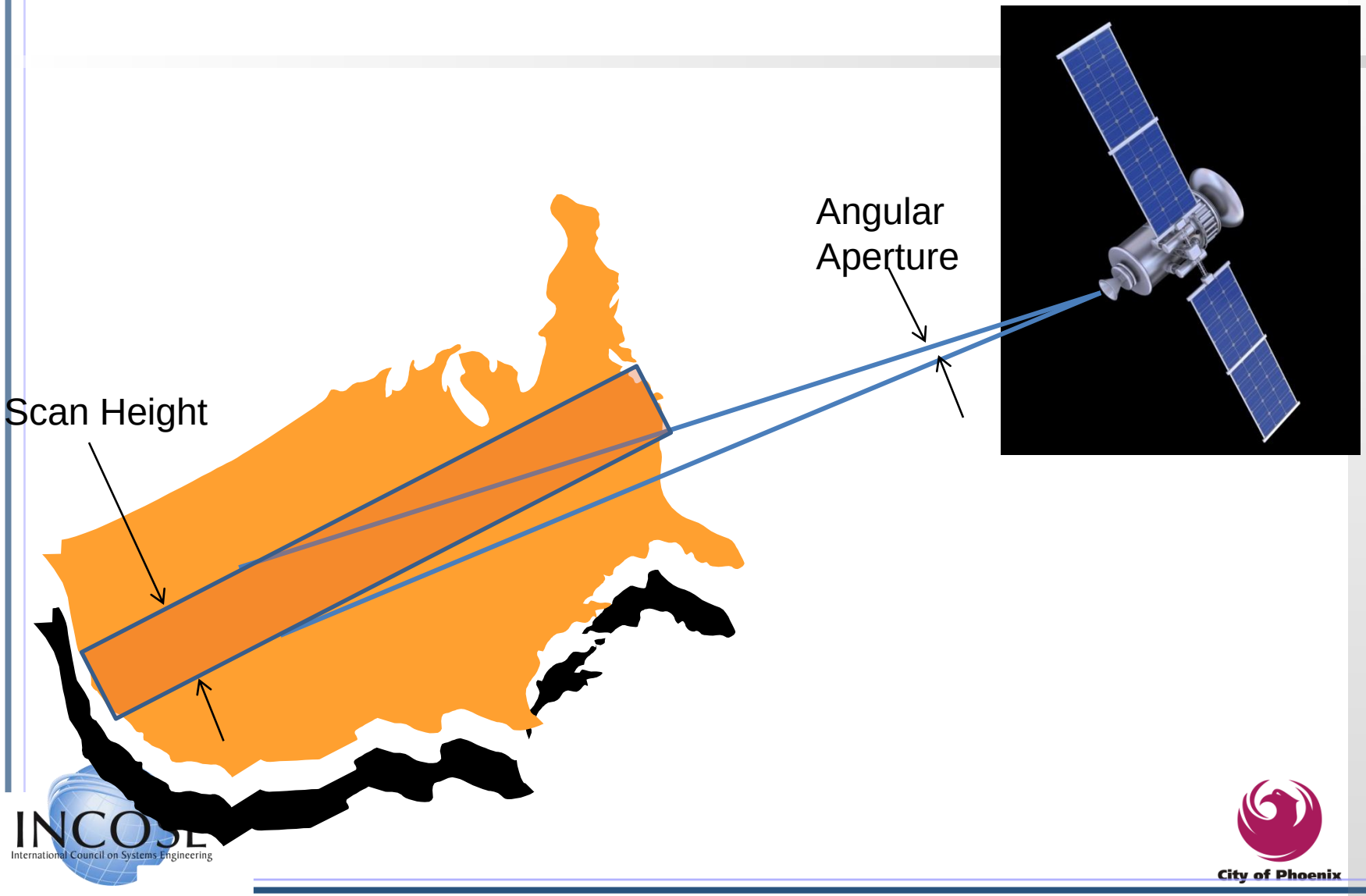


FireSat Structural Model

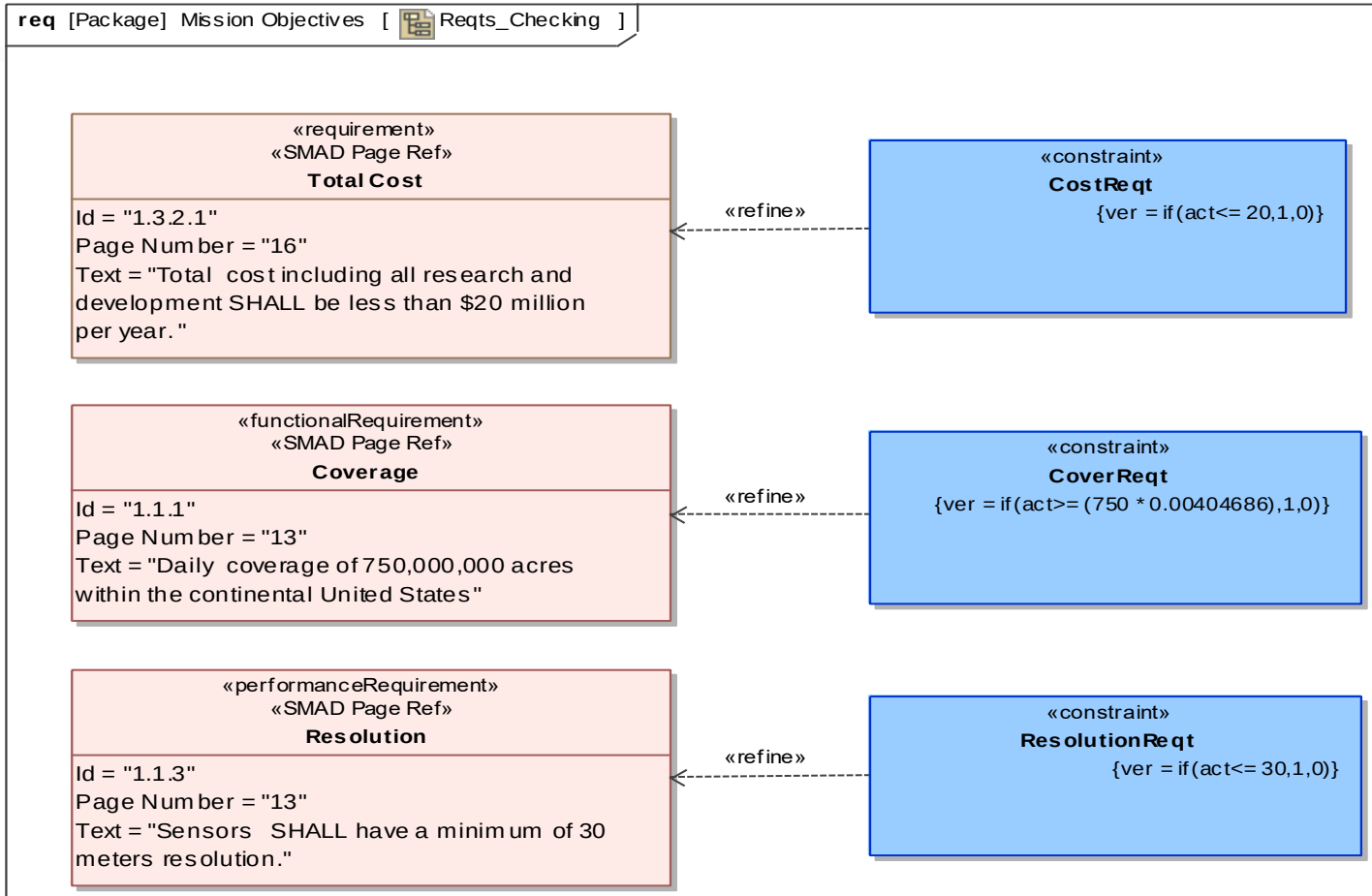




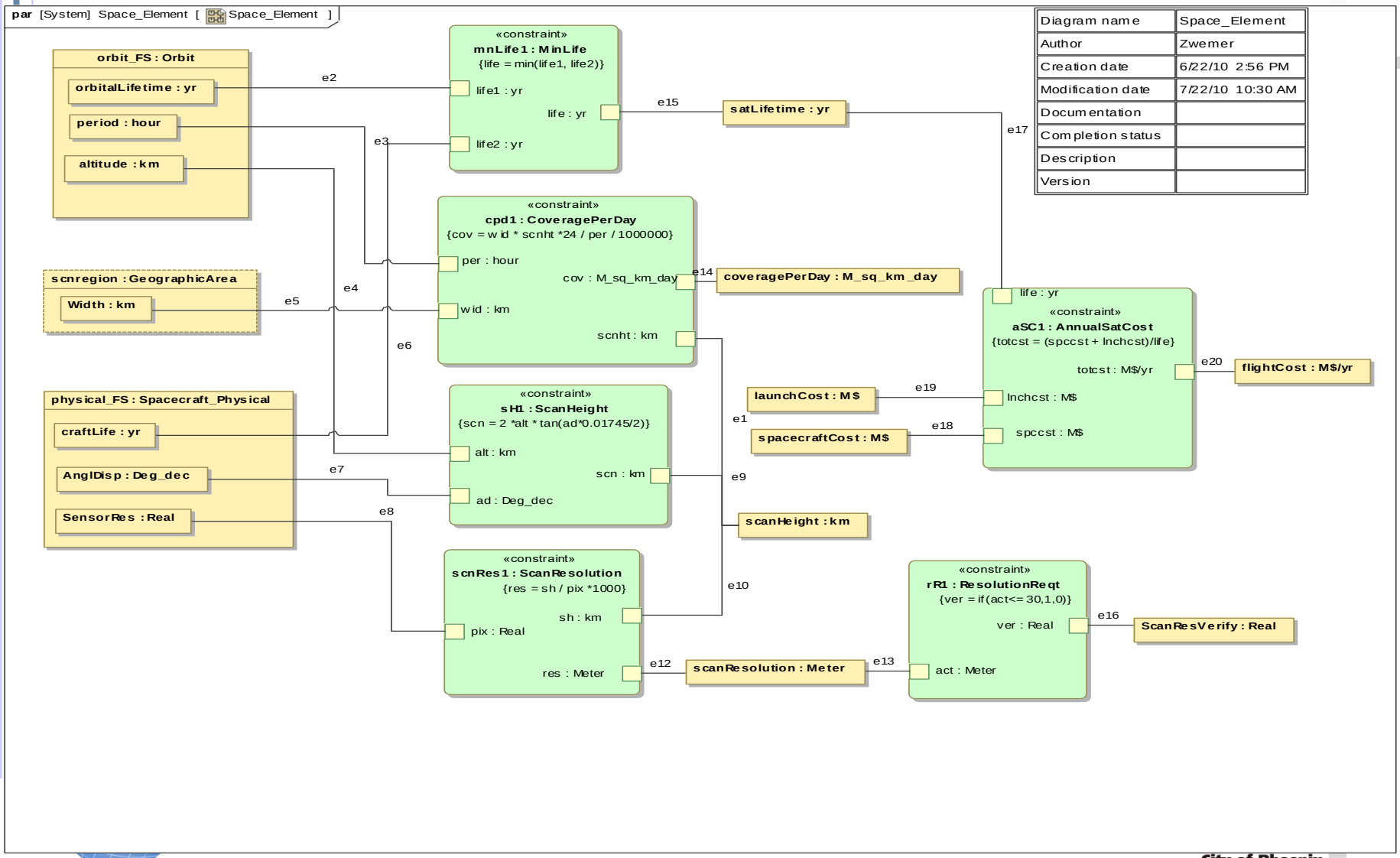
Scanned Area



Requirements Verification

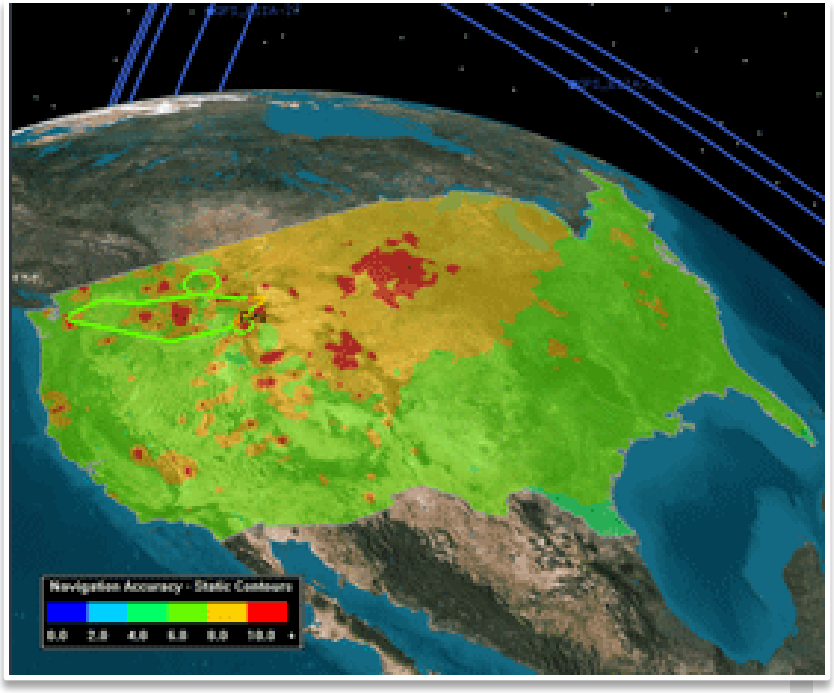


Space Element Parametrics



Satellite Toolkit in 60 seconds

- General-purpose modeling and analysis
- Integrated visualization
- Many modules for air, sea, and space applications
  - Coverage analysis
  - Communications analysis
  - Orbital propagation
  - Mission design



SysML in Telescope Modeling

Robert Karban

Credit to members of the ESO, OMG, INCOSE, and the MBSE initiative to use some of their material

INCOSE
International Council on Systems Engineering

City of Phoenix

What is ESO?

Non-profit Intergovernmental European Organisation for Astronomical Research in the Southern Hemisphere

http://www.eso.org

Headquarters in Munich, Germany

3 Observatories in Chile

Mission statement

Build and operate world class ground based astronomical facilities

INCOSE
International Council on Systems Engineering

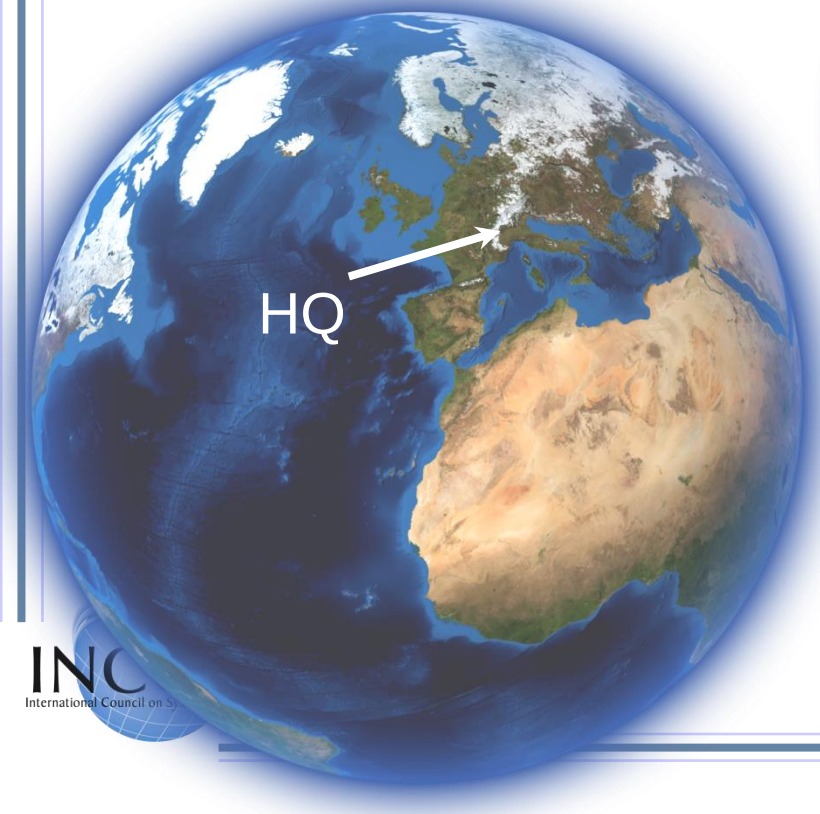
City of Phoenix

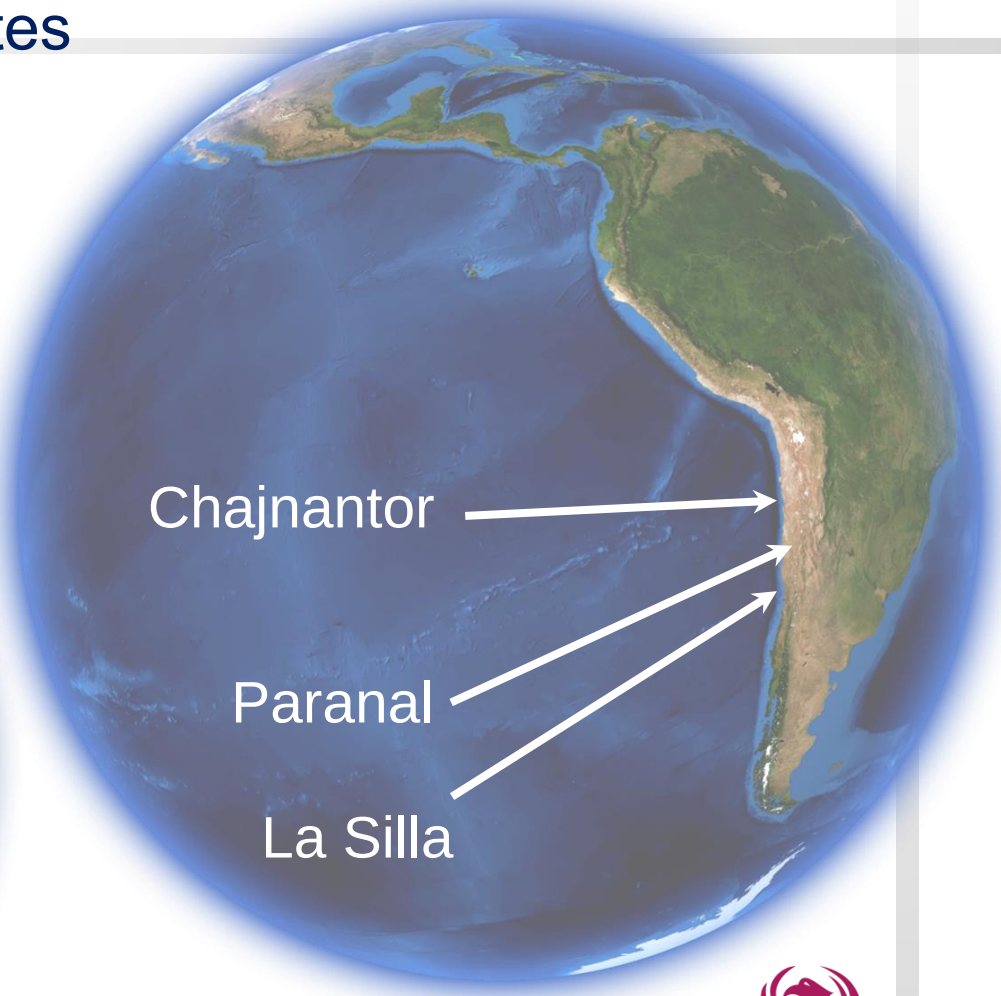
About SE^2

- Collaboration between European Southern Observatory (ESO) and German Chapter of INCOSE (GfSE) since 2007
- Access to high-tech project, the Active Phasing Experiment (APE).
- The team members are:
  - Robert Karban (ESO)
  - Tim Weilkiens (oose GmbH)
  - Rudolf Hauber (HOOD Group)
  - Rainer Diekmann
  - Michele Zamparelli (ESO)
  - Andreas Hein (TU Munich)
- Former members: Andreas Peukert (TU Munich)

ESO's sites

- Paranal (2600 m)
- La Silla (2400 m)
- Chajnantor (5000 m)

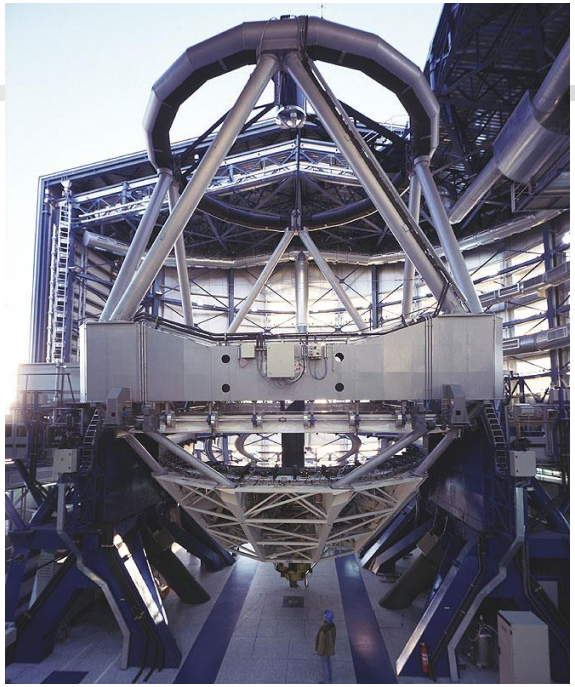




ESO major projects

Very Large Telescope (VLT)

Started 1988, in operation since 1999

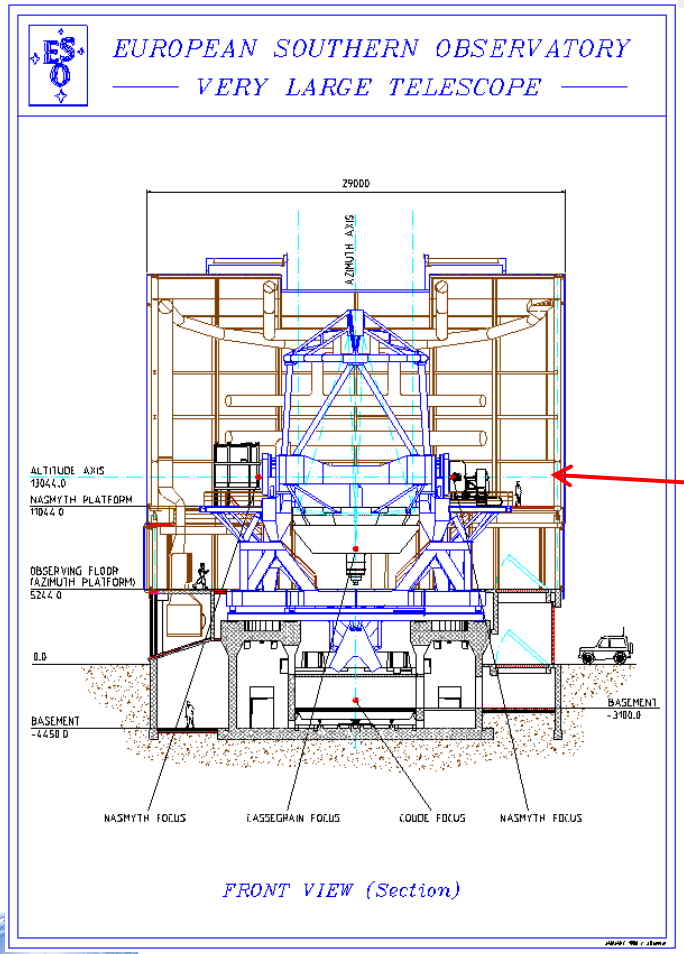


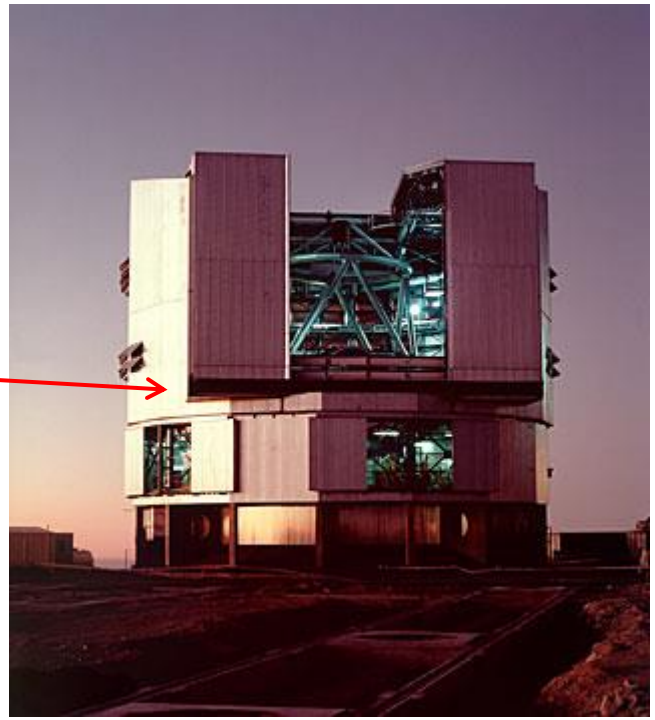
Atacama Large Millimeter Array (ALMA)

Europe-US-Japan

Started 1998, installation starting now

Images on this slide were produced by ESO



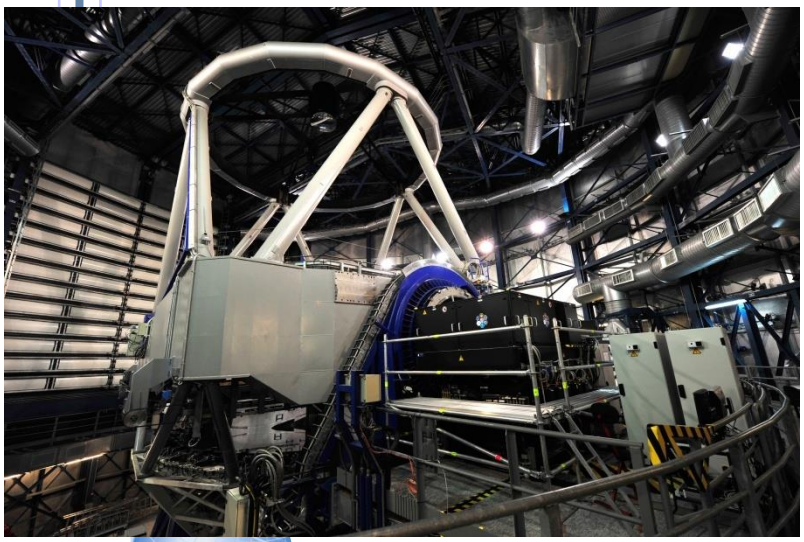


APE was installed at telescope in Atacama desert, Chile.

Images on this slide were produced by ESO

What is the challenge project about?

- System case study
  - APE technology demonstrator for future Extremely Large Telescope (ELT)
  - High-Tech interdisciplinary opto-mechatronical system in operation at Paranal observatory
- Goals
  - Create modeling guidelines and conventions for all system aspects, hierarchy levels, and views
  - Create fully fledged SysML model
  - **Documented at http://mbse.gfse.de**

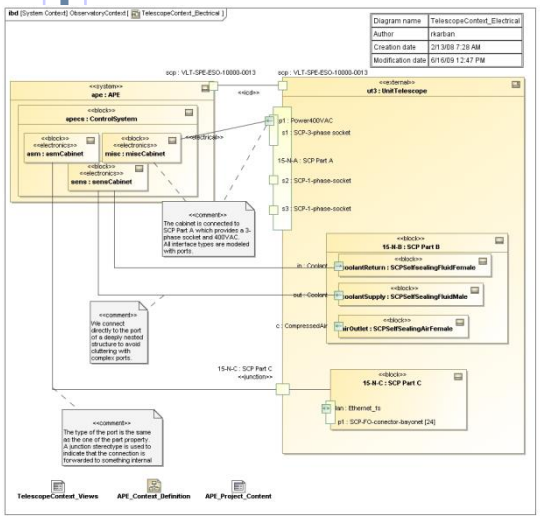


INCOSE
International Council on Systems Engineering

What have we achieved?

- APE model, guidelines and best practices:
  - Model Organization
  - Style, Layout Naming Conventions
  - System Views
  - Requirements and Use Case Modeling
  - Structure, Interface, and Behavior Modeling
  - Non-functional Aspects Ontologies, Part Catalogs
  - Variant Modeling
  - Integration with other Disciplines
  - Cross-cutting the model and Traceability
  - Domain Specific Model Extensions
- Model, Model library and SE Profile
- Plug-in for modeling tool
- Input for tool vendor and SysML RTF

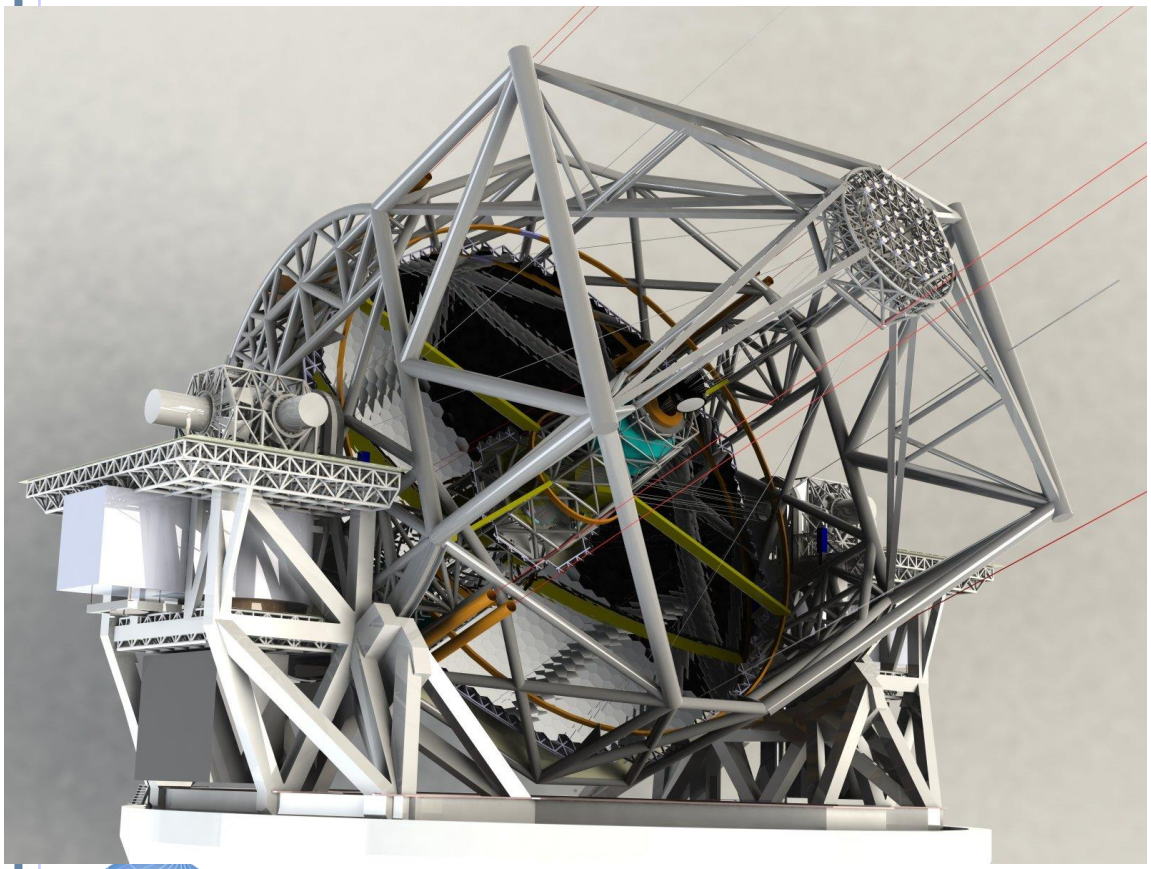
Cookbook for MBSE with SysML



What is next?

- Update and elaborate guidelines and best practices
- Create a product – **MBSE SysML Cookbook**
  - Recipes, applied guidelines, and best practices
  - Integrated navigable SysML reference model
  - Automatically generated booklet
- Elaborate APE reference model
- More applications of variant modelling and parametric modelling
- Enhance integration of modelling with MBSE process
- Create examples and guidelines for open issues

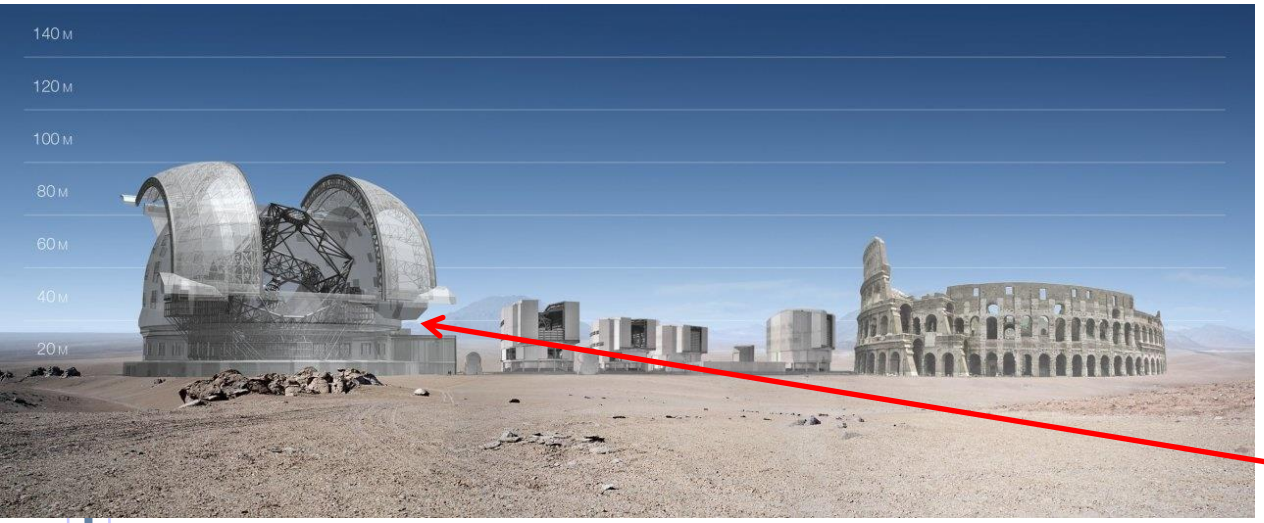
What we want to have: The E-ELT

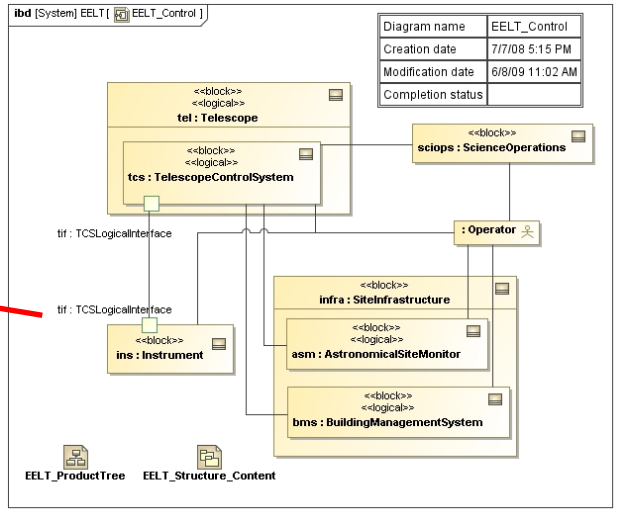


- With its 42 m diameter mirror, the E-ELT will be the largest optical/near-infrared telescope in the world: “the biggest eye on the sky”.
- E-ELT will gather 15 times more light than any other telescope today.
- Exciting science: extra solar planets and discs, galaxy formation, dark energy/dark matter, and frontiers of physics.
- If approved construction could start in 2012 with beginning of operations 2020-2022

Images on this slide were produced by ESO

Early adopters of MBSE





- 10000 tons of steel and glass
- 20000 actuators, 1000 mirrors
- 50000 I/O points, 700Gflops/s, 17Gbyte/s
- Many distributed control loops, excessive control strategy
- Applying SysML/MBSE for the Telescope Control System

INCOSE
International Council on Systems Engineering

Images on this slide were produced by ESO

Why a model for the E-ELT TCS?

- Define infrastructure (e.g. network)
- Define interfaces to sub-systems
- Provide a cost estimate, power consumption
- Define common standards based on catalogs and design conventions
- Define requirements for subsystems (e.g. data rates, data volume, latency)
- Consistent information model of TCS properties to manage its size
- Provide a design which satisfies telescope functions (e.g. wave front control strategies)

INCOSE
International Council on Systems Engineering

City of Phoenix

Summary

- MBSE:
  - Strong Drivers supporting future Systems Engineering and System Development (DoD, INCOSE, OMG, Industry Leaders, ….)
  - Benefits: Agility, Team environment, Models versus Documents, reduced costs, improved team communications, training, …
  - Evolving- Initiated about 2000, rapidly becoming applied to prototypes and systems/contracts
- INCOSE: Many WGs, etc.
  - MBSE Initiative is one of INCOSE top 5 priorities
  - MBSE Initiative & its Challenge Teams; OOSEM WG, Architecture WG, Tools, Standards Committee, ….
- OMG
  - Major Specifications/Standards for MBSE
  - SysML, UPDM, UML, SoaML, ….
  - DoD a strong advocate for the standards

INCOSE
International Council on Systems Engineering

City of Phoenix

Summary (Cont.)

- Tool significantly improving with implementations of UML V2.0, SysML, UPDM…
  - Many tools available
- Implementing MBSE in an organization should include a transition plan that addresses
  - detailed guidance consistent with organizational process and tools
  - MBSE Method, SysML standard, tools and training in all of these
  - Incremental piloting of approach
  - Tailoring depth and breadth to needs of project

INCOSE
International Council on Systems Engineering

City of Phoenix