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Evolving Systems Engineering through Model Driven Functional Analysis

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General Dynamics Land Systems (GDLS)

GENERAL DYNAMICS

Agenda

- **Functional analysis gap assessment**
  - Who we are
  - What's the situation
  - What we did
  - What we found
- **Perspectives that might apply to your organization**
  - Perspectives on functional analysis
  - What are the impacts of Model Driven Engineering (MDE)
  - How are things evolving
  - Some common recommendations made to SSCI members

About the Consortium

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Systems and Software Engineering Practices

Realizing value from process improvement
- Value-driven process improvement
- Quantifiable business performance measures
- CMM®, CMMI® appraisals

Life cycle strategies for complex systems
- Disciplined Agility
- Systematic reuse / Product lines

Implementing integrated engineering
- Model-driven engineering
- Requirements analysis & automated testing
- Architecture and design
- Security
- Measurement & analysis
- Verification and validation/Mission assurance

Applied to Member Needs

As a Consortium
- Co-funded development
- Practitioner-led training
- Technology transfer

As a Teammate
- Subject matter experts
- Process consulting
- Technology consulting

As an Industry Association
- Voice of Industry
- Influence govt. agencies
- Best practices/guidelines
- Neutral ground/honest broker

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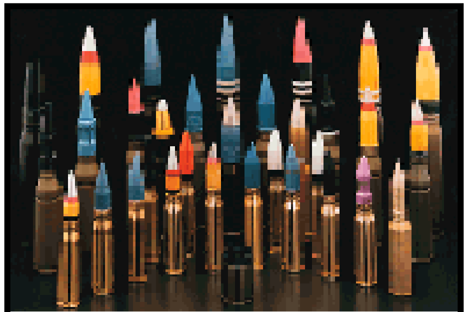
This Project: Problem Area Assessment

General Dynamics Overview

- **Corporate Overview**
  - 5th largest U.S. defense contractor and a leading manufacturer of business jets
  - 2008 Sales of $29.3 billion
  - Approximately 92,900 employees operating in: United States, Australia, Austria, Canada, Germany, Mexico, Spain, Switzerland and the United Kingdom
- **Business Units and Operating Groups**
  - Aerospace – 15,300 Employees
  - ***Combat Systems – 18,500 Employees***
  - Information Systems and Technology – 34,000 Employees
  - Marine Systems – 22,000 Employees

Combat Systems Group

- **General Dynamics Land Systems (GDLS) – Ground and Amphibious Combat Vehicles**
  - Headquartered in Sterling Heights, Michigan
  - Operating sites in Alabama, California, Florida, Maryland, Michigan, Ohio, Pennsylvania, Virginia, Washington, Australia and Canada
  - International Programs in Afghanistan, Australia, Canada, Egypt, Germany, Iraq, Israel, Kuwait, Morocco, New Zealand, Qatar, Saudi Arabia and the United Kingdom
- **European Land Systems – Armored Vehicles, Weapons and Ammunition**
  - Headquartered in Vienna, Austria with operating sites in Germany, Spain, Switzerland
- **Ordnance and Tactical Systems – Ammunition**
  - Headquartered in St. Petersburg, Florida with operating sites in Alabama, California, Florida, Illinois, Pennsylvania, Texas, Washington and Canada
- **Armament and Technical Products – Guns, Detection Systems and Composites**
  - Headquartered in Charlotte, North Carolina with operating sites in Arkansas, Maine, Mississippi, Nebraska, Virginia and Vermont



Medium Caliber Ammunition

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What's the Situation?

GDLS' processes and methods for functional analysis have the following objectives:

1. **Perform analysis in alignment with contract and industry standards**
2. **Reduce cycle time through continuous improvement**
3. **Maintain cycle time but increase value by greater through put, quality and consistency**
4. **Lead design by maturing interfaces, functional requirements and performance allocations into design cycle**

What We Did - Approach

- **GDLS requested that SSCI perform an assessment of their functional analysis practices**
  - SSCI worked with GDLS team to identify and scope the project – i.e. include anything related to functional analysis (e.g., processes, skills, technologies, organizational dynamics, etc.)
  - Conducted interviews/workshops with three lines of business that included domain experts, SMEs and a cross section of managers
  - Captured 110 individual items of feedback that SSCI reduced into about 20 general categories
  - Produced technical report summarizing the detailed findings
  - Conducted out-briefings to senior management on observations and recommendations

What We Found

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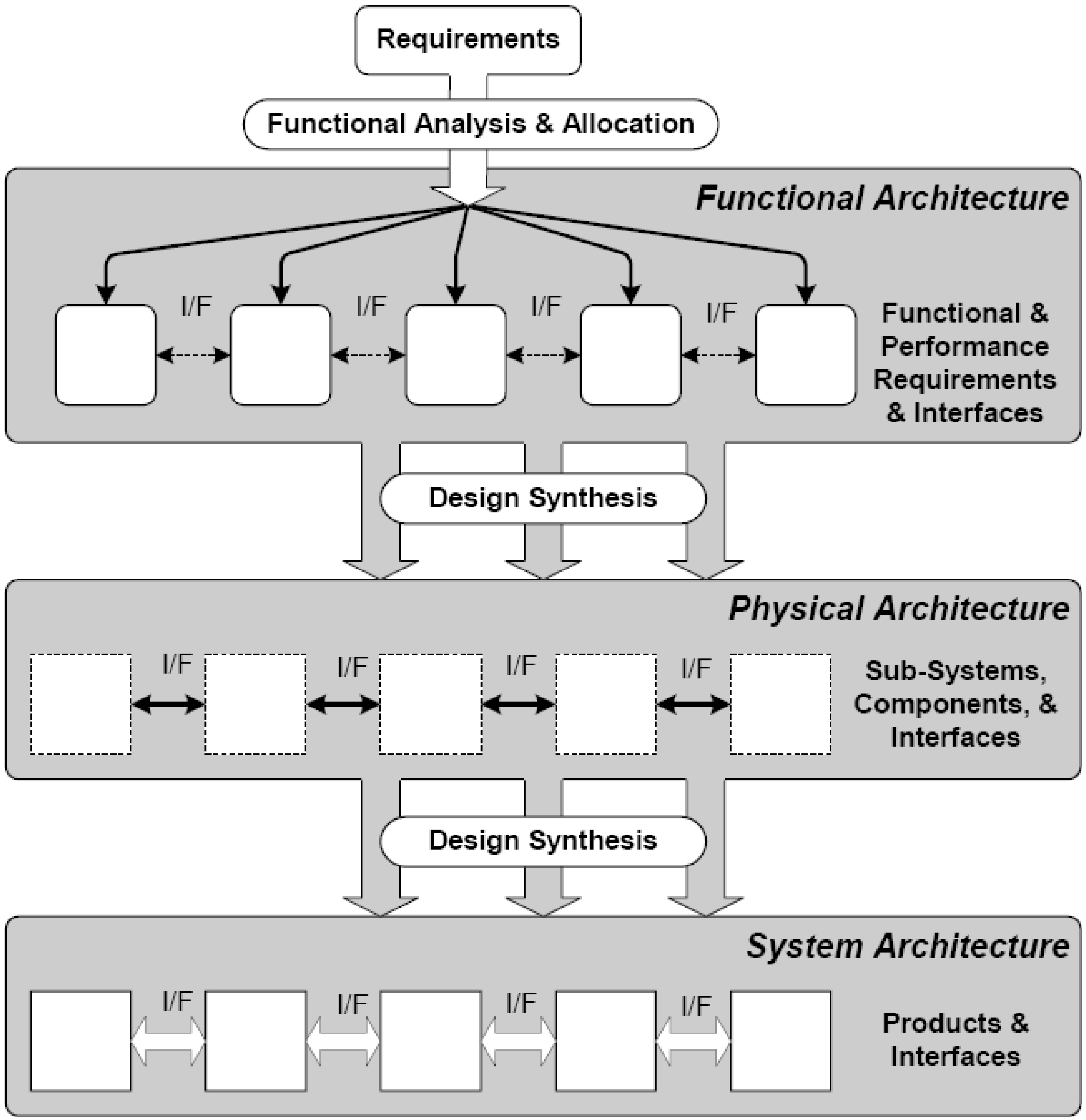
- **Key Findings and Insights:**
  - Good processes, practices, and training have been developed and are in use by GDLS programs, but could be more tightly integrated
  - Modeling and simulation is being used to provide means for assessing performance and design alternatives to support system concept selection
  - Practices are evolving to leverage model-driven engineering
- **SSCI Recommendations**
  - Short-term and long-term recommendations addressing:
    - ***Integrated engineering***
    - ***Technology adoption***
    - ***Customer discussions on technology and process evolution***
    - Organization and responsibilities
    - Leveraging methods and domain knowledge expertise

Perspective on Functional Analysis

- **First notable methods for functional analysis is often attributed to Lawrence D. Miles who was a design engineer for General Electric (1940s)**
  - Charles Bytheway extended Mile's functional analysis concepts and introduced the methodology called Function Analysis Systems Technique (FAST)
  - Key perspective came at functional analysis from a value perspective
  - Key focus is on alternative designs to achieve only the required functions at the lowest cost while meeting the fundamental requirements of the customer
- **As system complexity increases and where product lines are necessary, a broader view is needed**
  - Functional analysis provides inputs to architecting which are important for product lines

Conceptual Outputs of Systems Engineering Process*

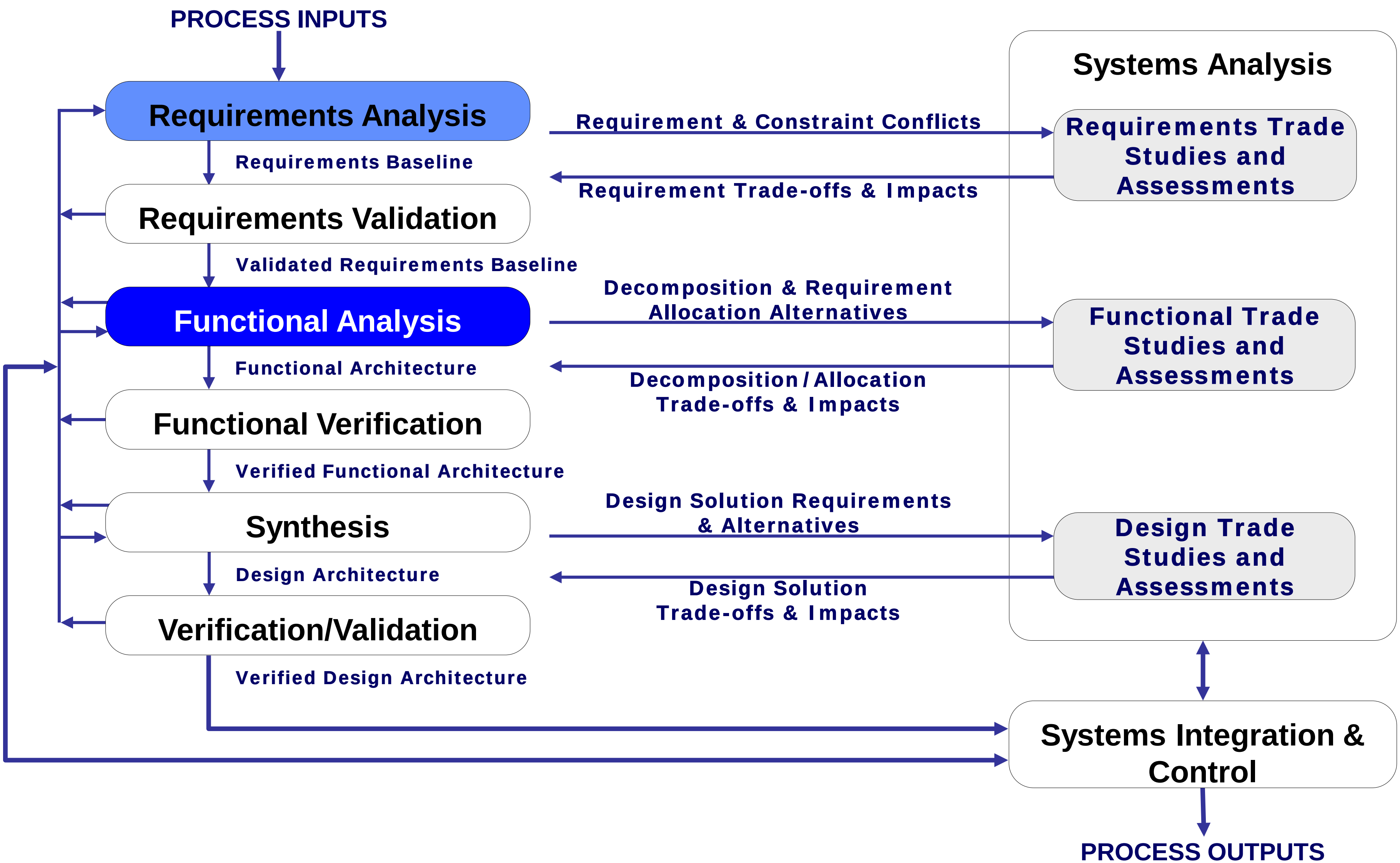


- **Fundamental information from functional analysis is:**
  - Derived requirements
  - Performance requirements
  - Interfaces
- **Documentation of alternatives and decisions**

Source: Condensed Guidelines for Successful Acquisition and Management of Software-Intensive Systems Handbook

GDLS Process Extends IEEE 1220 System Engineering Process

- **Represents the interfaces to Functional Analysis**



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More of What We Found

- **GDLS is moving towards a broader view of functional analysis through the integration of:**
  - System concept selection supported by computational-based decision analysis for ranking alternatives
  - Modeling & simulation supporting performance, dynamic, structural, thermal, functional and combat analyses
  - System-level functional analysis that traces the potentially significant impact on lower-level decisions down through subsystems
  - Capture operational threads that cut across subsystems
- **Integrating functional analysis throughout system engineering and subsystems can be challenging**

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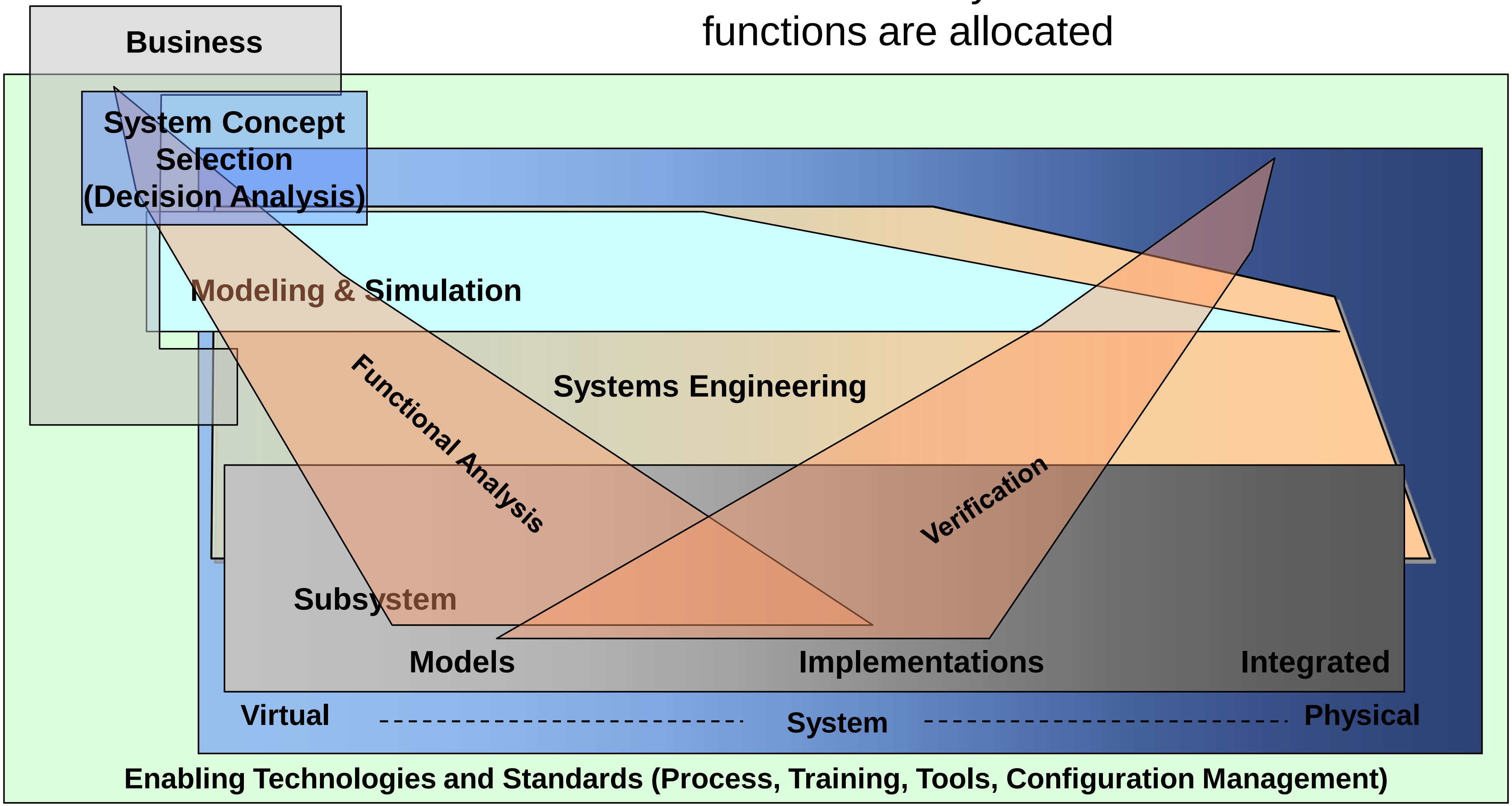
Integrated Engineering

- **"Modern" perspective on functional analysis**

"Architect" needs to factor many alternatives into how functions are allocated



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GENERAL DYNAMICS

Impacts of MDE Adoption

- **Driver: use UML-based notation to improve communication with software engineers**
- **Barrier: what UML-based notations for functional analysis are usable by system engineers and understandable by customers**
  - System Modeling Language (SysML) derived from UML for system engineers
  - UML and SysML are designed as a general-purpose language
  - Challenge becomes determining what modeling artifacts to use - how and when
- **Benefits of automation through tailored and integrated tooling**
- **Technology adoption readiness is a common issue with SSCI members**

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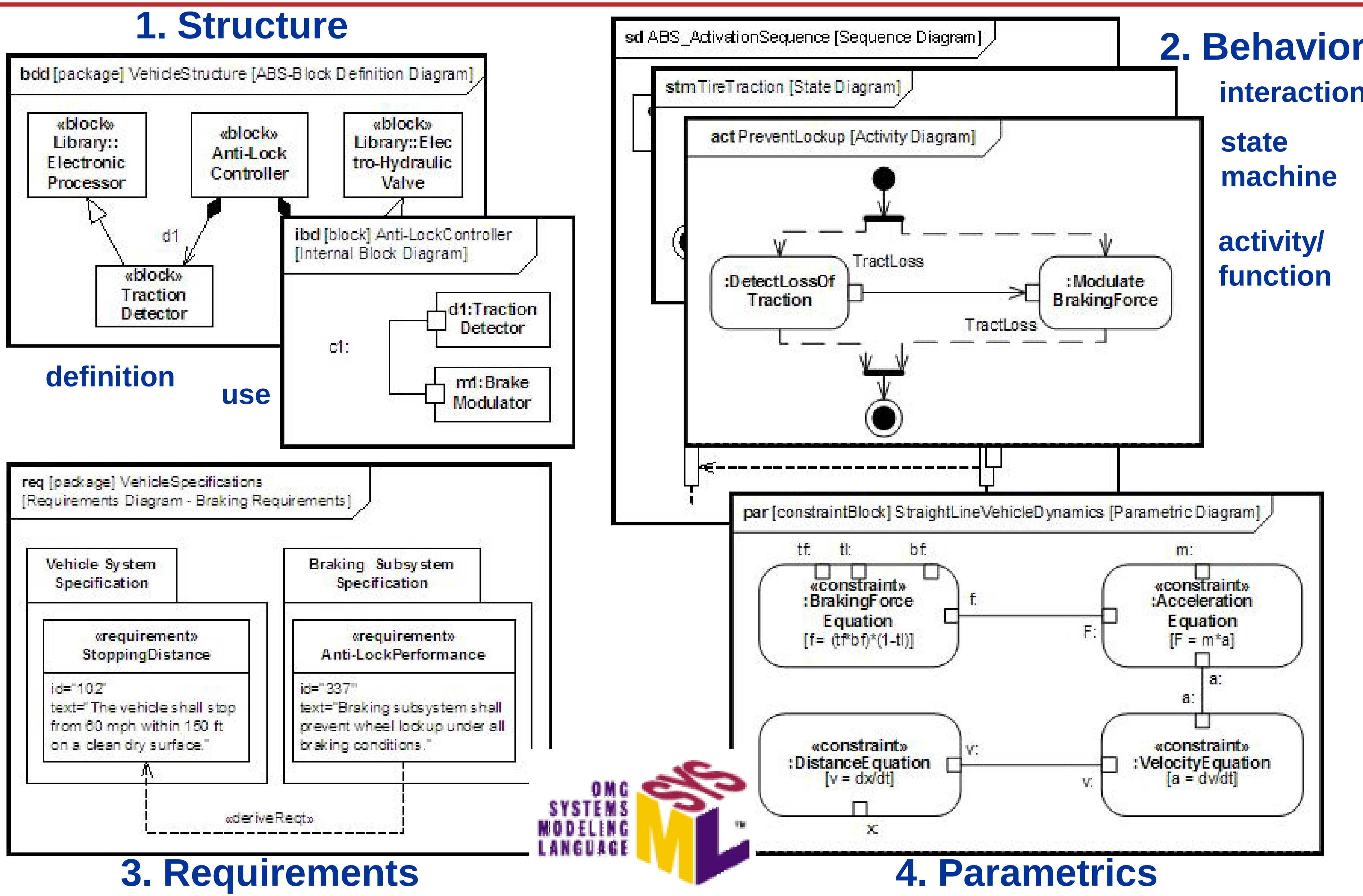
The Four Pillars of SysML



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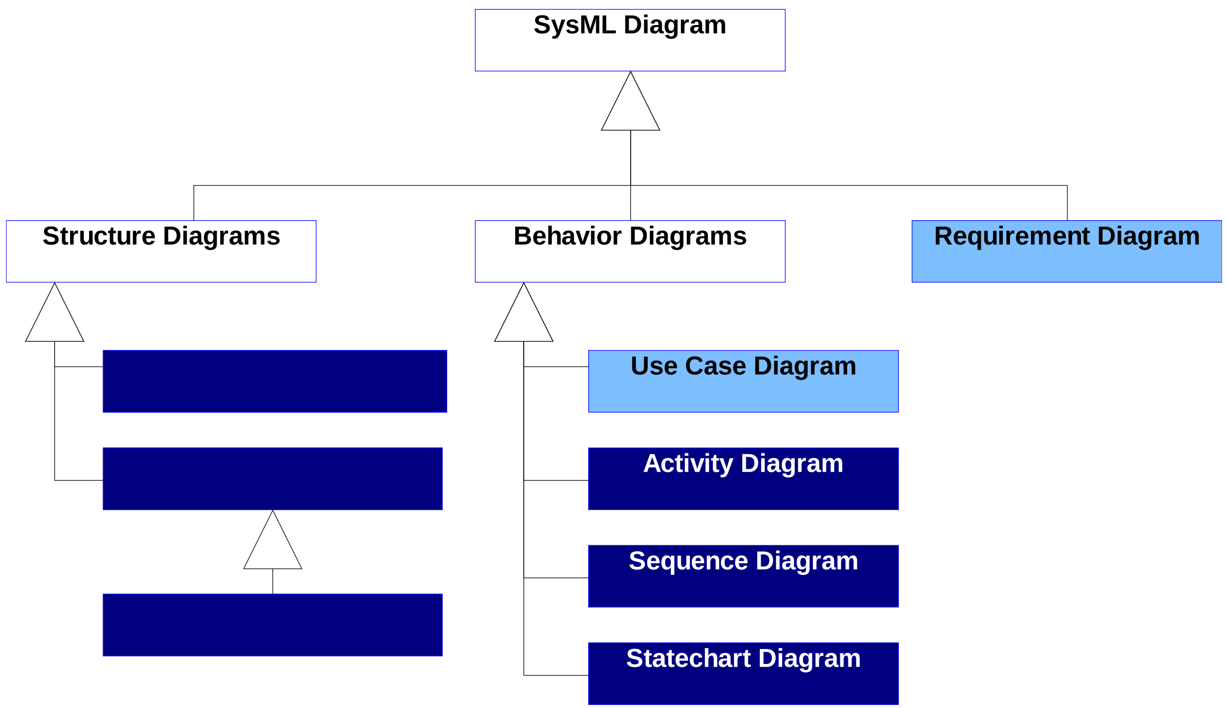
Version 1.0

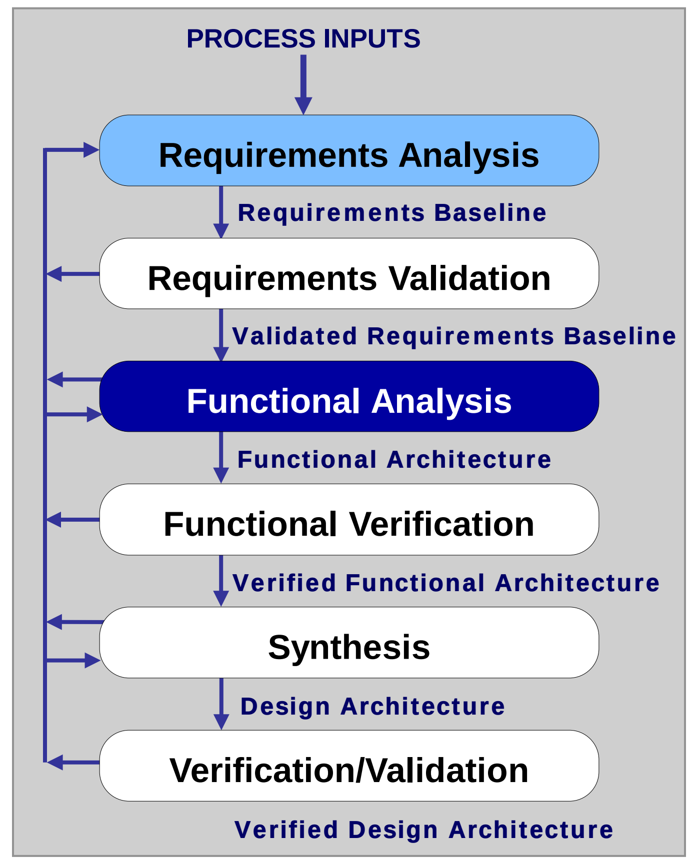
GENERAL DYNAMICS

SysML Diagrams Represent System Engineering Views

- **SSCI members are interested in how SysML supports key system engineering processes for requirement, functional analysis, and more**



IEEE 1220 SE Process



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GDLS MDE-Related Improvements

- **Use of storyboards addressing need for better CONOPS that are easy to understand and relevant to stakeholders – tailored activity diagrams**
- **Generation of sequence diagram with automation to move derived requirements to be linked during process of elaborating sequence diagram**
  - — Efficiency and completeness step to ensure derived requirements moved to sequence diagram, where traceability links are added
- **Allows for automated movement of requirements to DOORS®**
- **Validation through execution**
- **Allows for automated generation of measurement data for status/measurement of the analysis activities**

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Technology Adoption Recommendation

- **Don’t “jump” into projects without determining how to use MDE tools**
  - — One SSCI Member said: “after training we know how the tool works, but we don’t know how to produce work with the tools”
- **Use pilot projects first to understand the “real” value of artifacts produced by tools**
- **Don’t over estimate value of results in comparison to effort needed to put tools and processes in place**
- **Align proposals with new types of deliverables**
  - — It takes more time to produce models for an SRR or SFR than it does using a document-centric approach
  - — Documents can be incomplete (“good enough”) for reviews, but inconsistent or incomplete models cannot
- **Prepare for tool evolution (version upgrades)**

Talk with Customer About Technology, Process, and Deliverable Changes

- **Typical SRR and SFR (PDR/CDR) are based on traditional document-centric and waterfall lifecycle**
- **Model-based approaches result in artifacts that can contribute to multiple reviews, and can contribute downstream (e.g., V&V)**
- **Internal and external stakeholders need to understand that model-driven upfront work is superior to document-centric analysis**
- **Successful SSCI member example:**
  - — Organization adopting new modeling practices brought customer in for multi-days review of new approach and deliverables
  - — Customer recognized increased details in model-based artifacts that typically don't exist with document-based processes
  - — Customer understood how details would be beneficial over entire development lifecycle
  - — Customer was pleased and wanted to know why other projects were not using modeling approach

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Points to Remember

- **Integrated engineering is challenging, but needed as impacts of functional analysis decisions can cut across subsystems**
  - — MDE can provide many efficiencies and help link functional analysis information so that impacts can be identified faster and more easily
- **Technology adoption**
  - — Evolving from document-centric to model-centric approach requires coordination with stakeholders
    - – Models can take longer to develop, especially the first time
    - – Models identify issues early and provide other downstream value
  - — Technology readiness can impact MDE adoption:
    - – Know what/how models map to current processes
    - – Understand tool value derived from operating on models
    - – Understand how tool chains can support the entire life cycle
    - – Use pilot projects to prepare for adoption
- **Consider discussing technology and process evolution changes with customers/stakeholders**

For More Information

- **Questions on MDE**
  - — Contact Mark R. Blackburn, Ph.D.
  - — 561.637.3452; blackburn@systemsandsoftware.org

- **General questions, products, services**
  - — Main Consortium number 703.742.8877
  - — Home page www.systemsandsoftware.org

Terms and Acronyms

AADL	Architecture Analysis & Design Language
AP233	Application Protocol 233
BPML	Business Process Modeling Language
CAD	Computer-Aided Design
CASE	Computer-Aided Software Engineering
CATIA	Computer Aided Three-dimensional Interactive Application
CDR	Critical Design Review
CMM ®	Capability Maturity Model
CMMI ®	Capability Maturity Model Integration
CONOPS	Concept of Operations
CWM	Common Warehouse Metamodel
DBMS	Database Management System
DoDAF	Depart of Defense Architectural Framework
DSL	Domain Specific Languages
GDLS	General Dynamics Land Systems
IBM	International Business Machines
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
INCOSE	International Council on Systems Engineering
IPR	Integration Problem Report
ISO	International Organization for Standardization
IT	Information Technology
Linux	An operating system created by Linus Torvalds
MAP	Modeling Adoption Practices
MARTE	Modeling and Analysis of Real Time Embedded systems
MATRIXx	Product family for model-based control system design produced by National Instruments
MBT	Model Based Testing
MDA®	Model Driven Architecture®
MDD™	Model Driven Development
MDE	Model Driven Engineering
MDSD	Model Driven Software Development
MDSE	Model Driven Software Engineering
MIC	Model Integrated Computing
MMM	Modeling Maturity Model
MoDAF	United Kingdom Ministry of Defence Architectural Framework
MOF	Meta Object Facility
NASA	National Aeronautics and Space Administration
OCL	Object Constraint Language
OMG	Object Management Group
OO	Object oriented
PDR	Preliminary Design Review
PIM	Platform Independent Model
Pro/E	Pro/ENGINEER
PSM	Platform Specific Model
RFP	Request for Proposal
ROI	Return On Investment
RTW	Mathworks Real Time Workshop
SSCI	Systems and Software Consortium
Simulink/ Stateflow	Product family for model-based control system produced by The Mathworks
SCR	Software Cost Reduction
SDD	Software Design Document
SE	System Engineering
SFR	System Functional Review
SME	Subject Matter Expert
SQL	Structured Query Language
SRR	System Requirement Review
SRS	Software Requirement Specification
SysML	System Modeling Language
SystemC	IEEE Standard 1666
UML	Unified Modeling Language
XMI	XML Metadata Interchange
XML	eXtensible Markup Language
xUML	Executable UML
Unix	An operating system with trademark held by Open Group
VHDL	Verilog Hardware Description Language
VGS	T-VEC Vector Generation System
VxWorks	Operating system owned by WindRiver

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