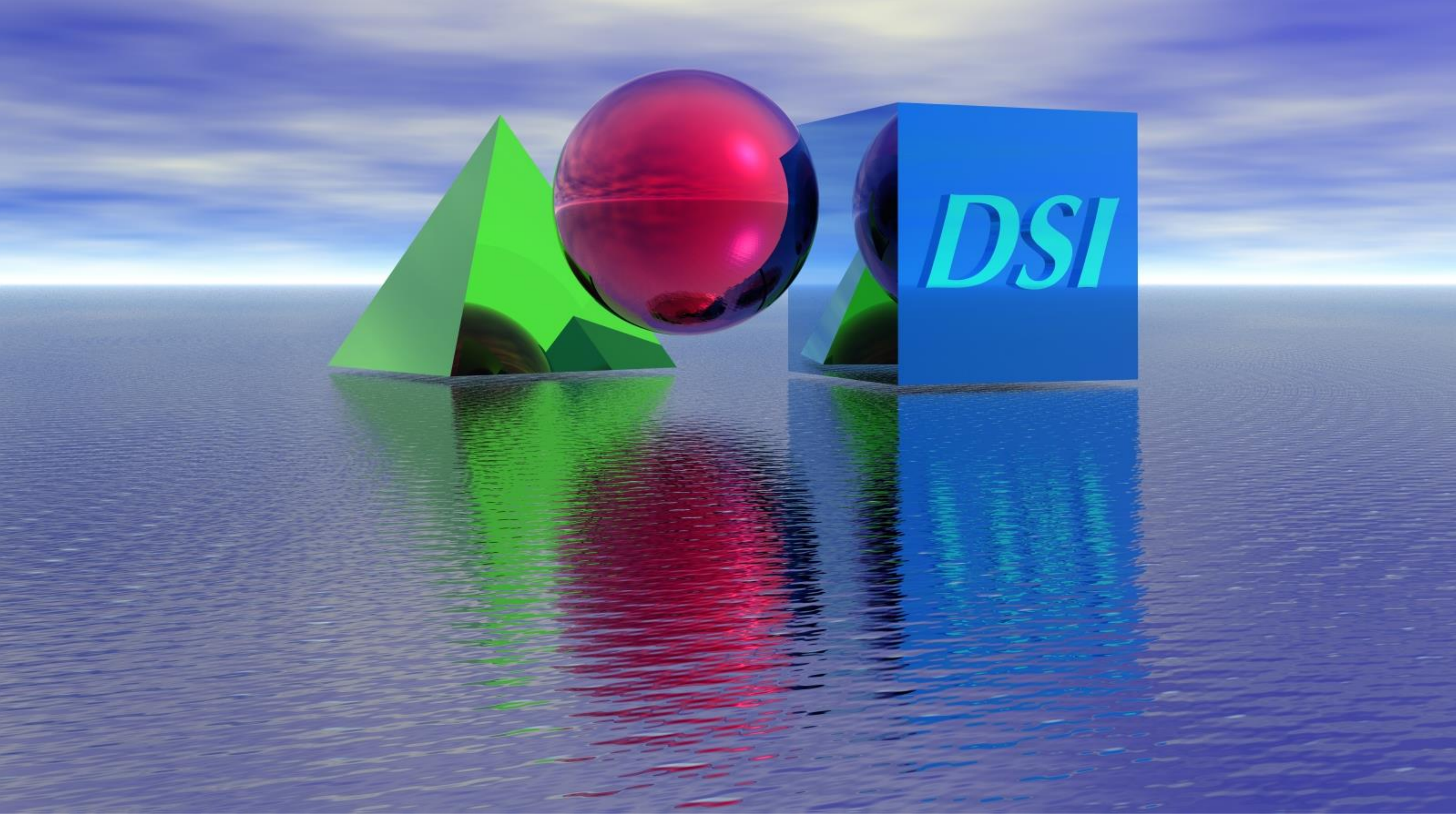
Basic *eXpress* Use and Modeling Techniques



Topic Contents

- Introduction to Basic Features and Concepts
  - Identifying the Need for an *eXpress* Modeling Effort
  - Planning for Use
  - Overview of Features and Basic Techniques
    - Lab #1 – The Flashlight Model
- Enhanced Modeling Techniques
  - Solving the Diagnostic Problem
    - Lab #2 – The Hydraulics Model
- Application Development
  - Addressing Real World Complex Solutions
    - Lab #3 – The BUS Model
- Advanced Technique Preview
  - Diagnostic Analyses
  - FMECA+

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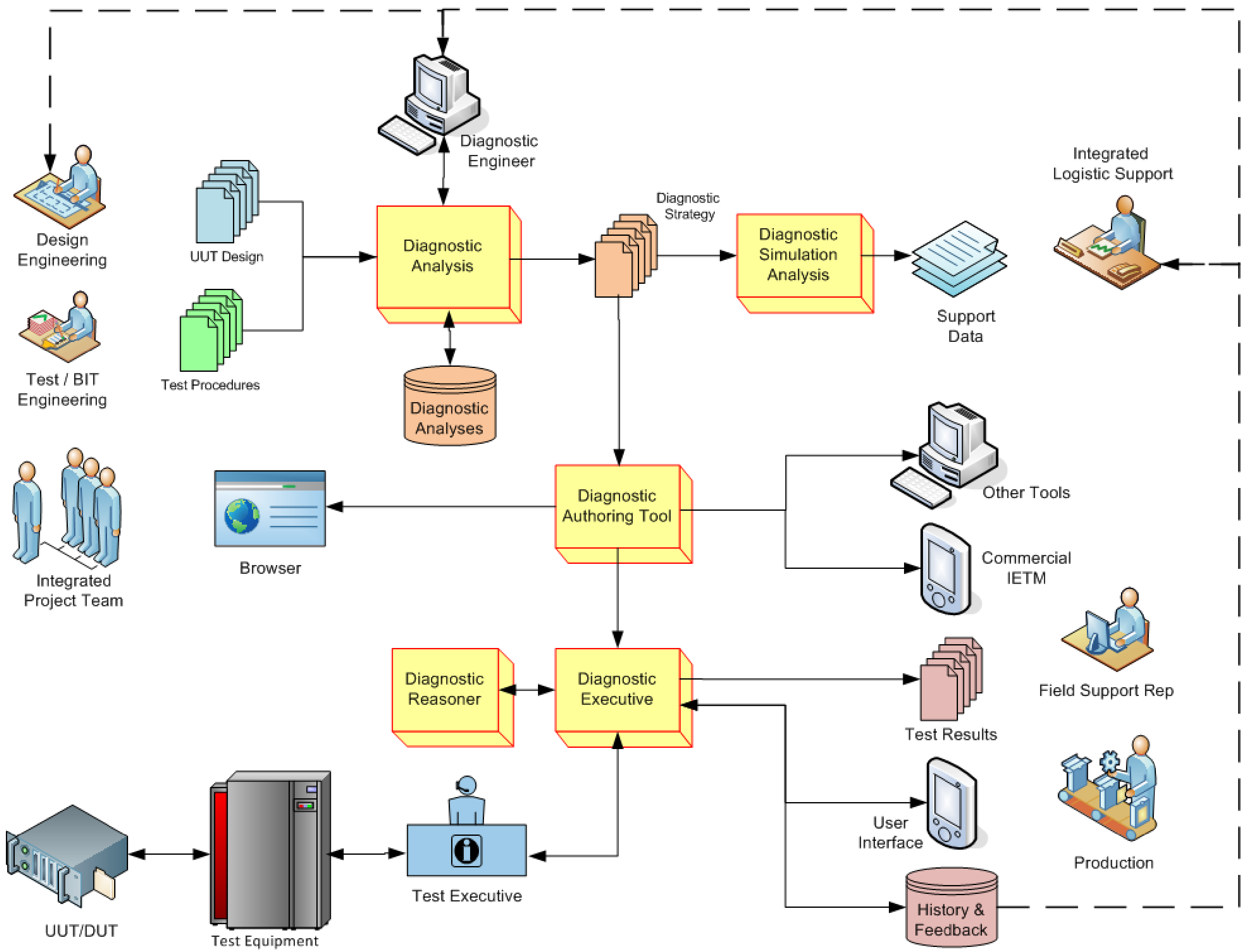
Integrated Diagnostic System



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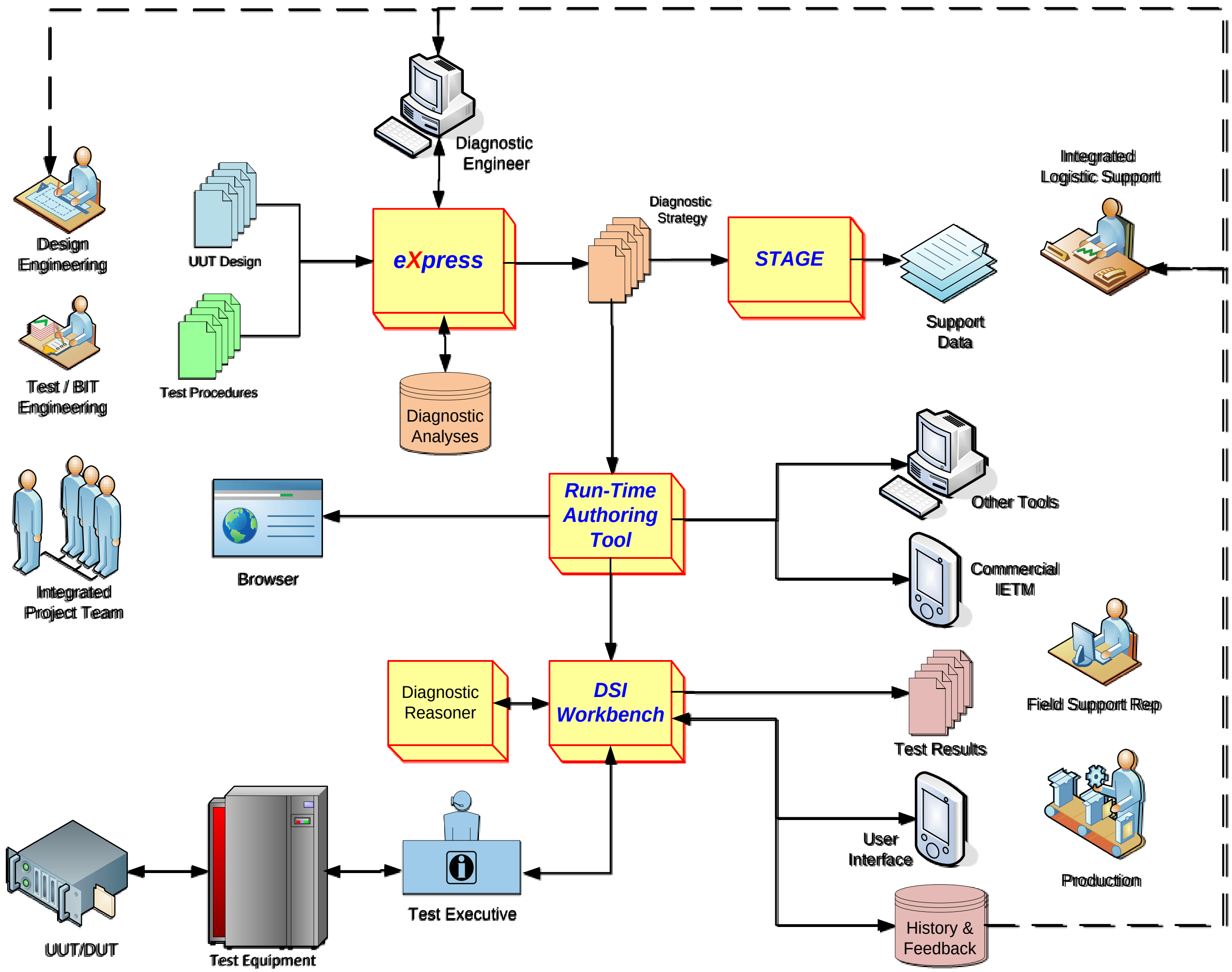
Integrated Diagnostic System



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eXpress Basic Course Objectives

- Planning and Scoping an *eXpress* Model
- Creating *eXpress* Models that contain
  - Basic and Hierarchical Objects
  - Ports, Nets and Functions
  - Attributes
  - Failure Modes and Object States
  - Tests and Test Sets
- Performing Basic Design Verification

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Identifying the Purpose of a Model

- Presentation Only
- Documentation of Design Details
- Design Verification and/or Design Influence
- Test Development and/or Verification
- Diagnostic Development and/or Assessment
- Testability or Maintainability Analysis
- FMECA Generation or System Reliability Studies
- Many other potential purposes…

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Identifying the Uses of a Model

- **Is the model intended to be integrated into a *higher-level system model*?**
- **Will a *lower-level model* be integrated into this model?**
- **If the model is part of a hierarchical system, are the various models in the system being developed by a few relatively local analysts or by *numerous analysts* spread among different companies or divisions?**
- **Will the model be used for *multiple instances* of a part in a hierarchical design?**
- **Is the model likely to be *reused* in other designs?**
- **Will the model be incorporated into an overall *Diagnostic Engineering process*?**
- **Is the model to be used to *corroborate other analyses*?**

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Impact the Modeling Process

- Coordination of *labeling* in the model and assembly *I/O interface*
- Use of *templates* to ensure consistent attribute definitions across multiple designs
- Use of *generalized part names*, rather than schematic-specific identifiers
- *Import* of data (into *eXpress*) from another tool
- *Export* of data (from eXpress) to another tool
- Use of labels that can be easily mapped to the names in an external tool

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How to Approach the Audience

Engineers	Models that resemble engineering drawings / schematics
Managers	Models that correspond to departmental management diagrams
Contractors	Models that demonstrate how design meets contract needs
Customers	Models that resemble the appearance of the end product
Maintainers	Models that can be easily mapped to both the end product and representations in technical manuals

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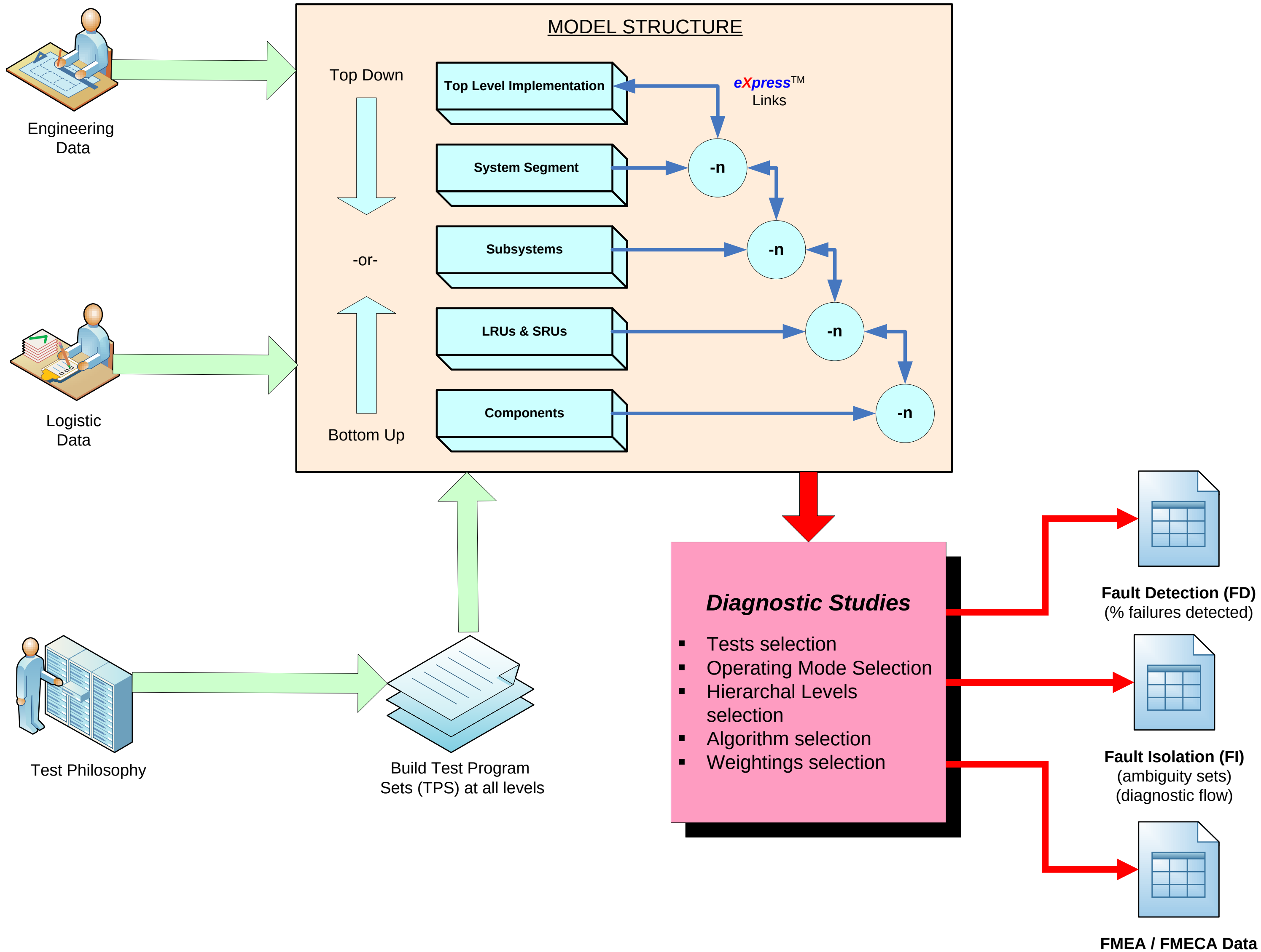
eXpress Data Needs



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Types of Engineering / Logistic Data

- Theory and Modes of Operation
- Bill of Materials
- Block Diagrams
- Schematics
- Reliability and Cost Data
- FMECA Reports
- Testing and BIT Approach Utilized
- Structures Drawings
- Preliminary Testability Analysis Report (PTAR)
- Detailed Testability Analysis Report (DTAR)
- Replacement and Maintenance Data
- Net-Lists
- Failure Mechanisms
- Access Times
- Documented Naming Conventions

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Testability Primer

- Standard Definition
  - A design characteristic which allow the status (operable, inoperable, degraded) of an item to be determined and the isolation of faults within the item to be performed in a timely manner
- Testability Features
  - Characteristic of a design
  - Enables determination of item status
  - Facilitates testing / diagnostics

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Integrated Systems Diagnostics Results

- Testability Metrics
  - Improved Fault Detection Confidence (FD%)
  - Improved Fault Isolation to Optimum Repair Level (FI%)
  - Improved Safety Through Critical Fault Analysis (FMECA)
- Maintainability
  - Reduced False Alarms / False Removals (FA%)
  - Optimized Prognostics and Remediation
  - Lower Mean Time to Isolate (MTTI)
- Integrated Logistics System (ILS) Improvements
  - Reduced Logistics Needs
  - Improved Operational Availability (Ao)
  - Reduced Life Cycle Cost

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Common Metric Requirements

- FD/FI Calculation
  - Model to the LRU
  - Include Reliability
- FMECA Generation
  - Model to the Failure Mode
  - Include Reliability
  - Include Failure Effects
- Mean Time to Repair
  - Model to the LRU
  - Include Reliability
  - Include Test and Replacement Times

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Design Influences

- Maintenance Requirements
  - Initial requirements need to be defined early to be able to influence design
- Design Needs to Fit Support Environment / Maintenance Goals
  - Turnaround Time / Mean Time to Repair / Availability
  - Cost of Ownership / Life Cycle Cost
  - Supply Chain Concept / Level of Repair
  - Balance between Embedded Diagnostics / Support Equipment
  - Balance between Automated Diagnostics / Technical Documentation & Training
  - Resource Availability / Specialization (Personnel, Equipment, Facilities)
- Design Development and Optimization
  - Maintenance planning and requirements development is an iterative process and must be part of the overall design strategy

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Implied Inputs and Outputs

- **When creating a model, *not all inputs and outputs must be modeled*. The inputs and outputs that are modeled depend largely on the following factors:**
  - **Does the I/O constitute a necessary test point or stimulus?**
  - **Does the I/O provide interface to a higher level model?**
  - **Does the I/O document unused portions of an interface?**
  - **Does the I/O expose normally forgotten causal relationships?**
    - **(e.g., man-in-the-loop, assumptions about how a battery is charged or a tank is filled, etc.)**

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eXpress User Interface

Starting *eXpress*

- **How to do it…**
  - **Using the Start Menu**
  - **Opening from a Design**
- ***eXpress* Licensing**
  - **Early Windows version**
    - **Placed anywhere**
  - **Windows Vista and later**
    - **Normal Installation in** *…\Program Files\DSI International\eXpress*
    - **Other *eXpress* files in** *…\Program Data\DSI International\eXpress*
  - **Networked**
- **Class Introductory Example**
  - *…\eXpress\Designs\Examples\ABS System (Flat Model)\Braking System Revised.exd*

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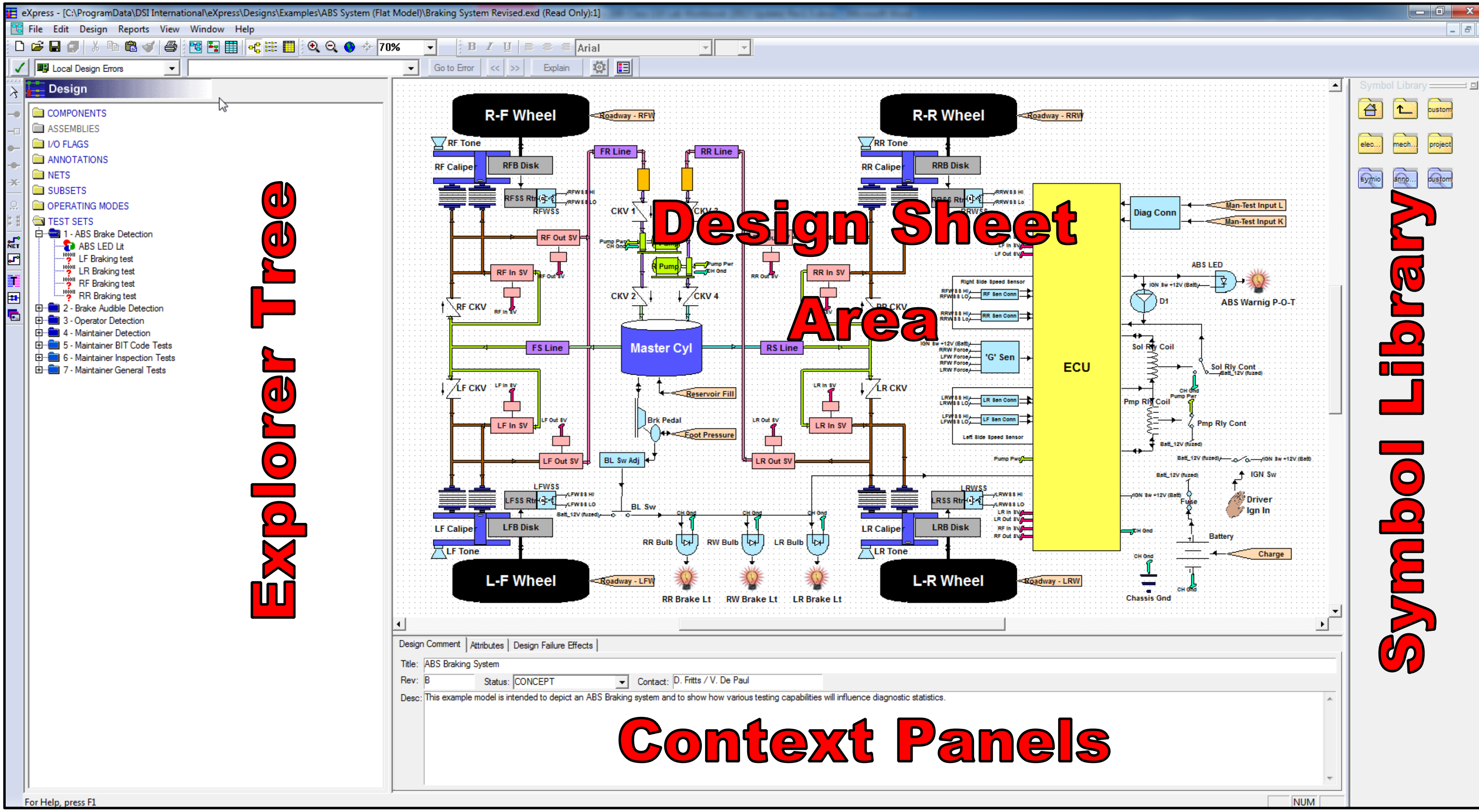
eXpress User Interface Layout



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Benefits of Object-Oriented Modeling

- Functional Dependency Modeling
  - Using directionality of Ports
- Linking by Using Nets
  - Establishing relationships between objects
- Encapsulation of Data
  - Capturing Attributes and Properties
  - Can be used for transferring or linking data

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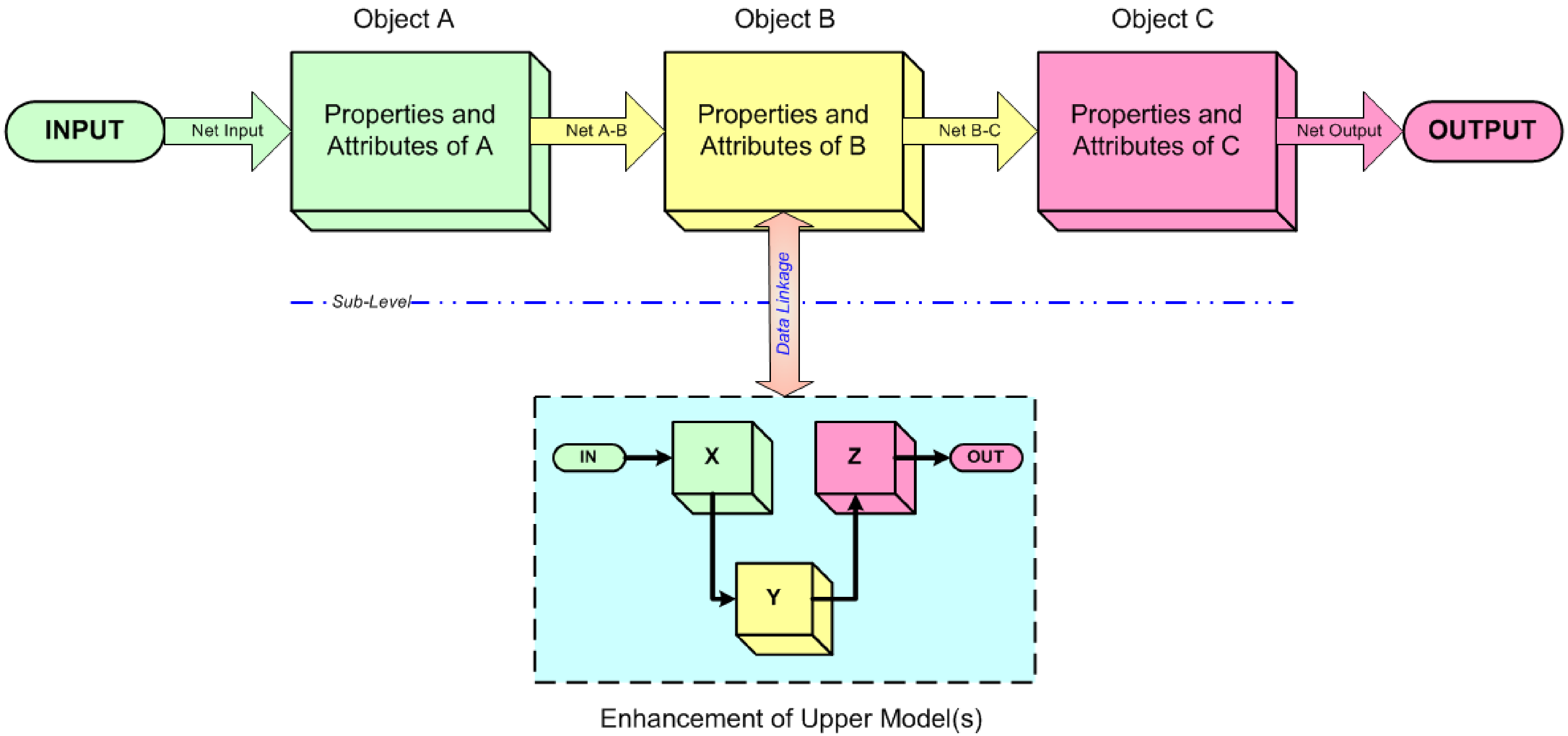
Object-Oriented Modeling Paradigm



All information about a design element is encapsulated in the objects. The objects then form the building blocks of a larger structure (system, components, subcomponents, etc.).

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User Interface Architecture

- **Explorer Tree**
  - **Provides a view of nearly all the information in the model through a Windows Explorer-like interface. Changes based on the context.**
- **Design Sheet Area**
  - **Area for drawing. Interactive and is like typical drawing program responding to mouse and keyboard commands.**
- **Context Panels**
  - **Context Panels provide detailed properties of the entities being highlighted in either the Explorer Tree or Design Sheet. for a given entity, multiple panels can be selected through tabs at the top of the context panel area.**
- **Symbol Library**
  - **provides iconic display of symbols and symbol directories. Navigation accomplished by clicking on the symbols or directories.**
- **Online Help**
  - **Extensive *Online Help* available similar to most MS Windows applications. Can be invoked and accessed using several methods.**

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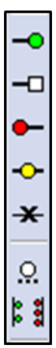
Main Menu and Toolbars

- **Main Menu**

- **Standard Toolbar**

- **Formatting Toolbar**

- **Design Editing Toolbar**



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Model 1 – The Flashlight

Objectives of the “Flashlight Model”

- The *Flashlight Model* consists of:
  - **Two batteries, placed in series**
  - **A user-operated switch**
  - **A light bulb**
  - **A visible output of Light**

For the purposes of this *Flashlight* example, there will be a single output:

- Light output from the bulb

And, we will be assuming the following:

- The batteries are pre-charged and are non-rechargeable
- The switching "ON" and "OFF" of the flashlight is part of the test instructions, and not considered a source of input

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Steps in Model 1 Lab

- Creating the Model
  - Refer to “Model 1” in the *Lab Exercise Workbook*
  - Objects
  - Ports
  - Nets
  - Functions
- Topological Modeling
  - I/O Flags
  - Signal Flow
  - Functionality
  - Attributes
  - Repair Items

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Functional Propagation

- Active Propagation
  - When one or more signals enter a part and a new signal leaves the part. The model keeps track of the dependency, but the visibility is lost to the user from that point on.
- Passive Propagation
  - When signals enter a part, and are passed through to an output, such that visibility to each input signal remains.
  - The rule for *passive propagation* is that there must be one and only one input port as a dependency to an output function for it to be considered passive.
  - It may have more than one dependency however, by also depending on control ports.
  - Dependencies to bidirectional ports are considered to be standard inputs (green ports).

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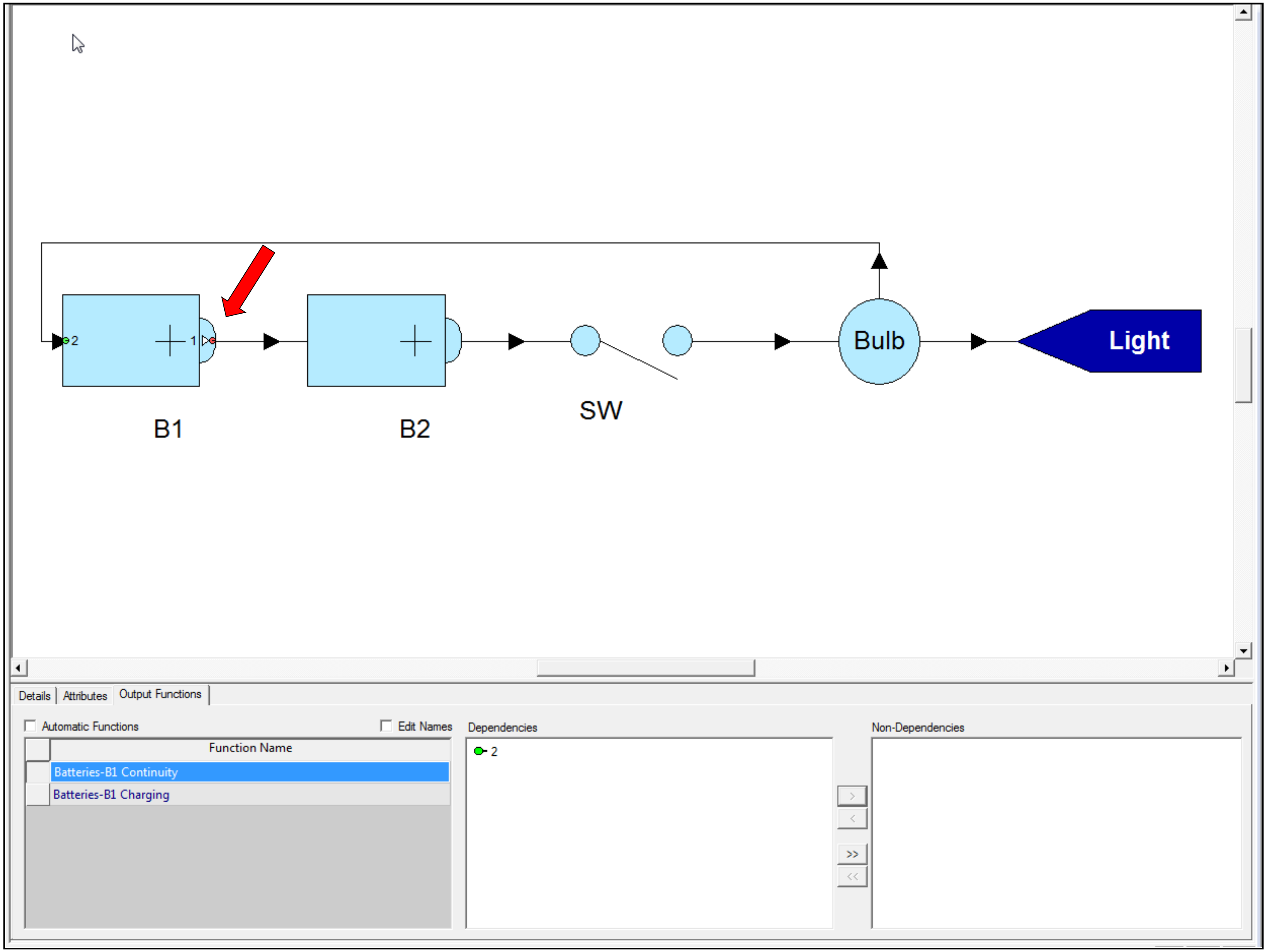
Passive Propagation



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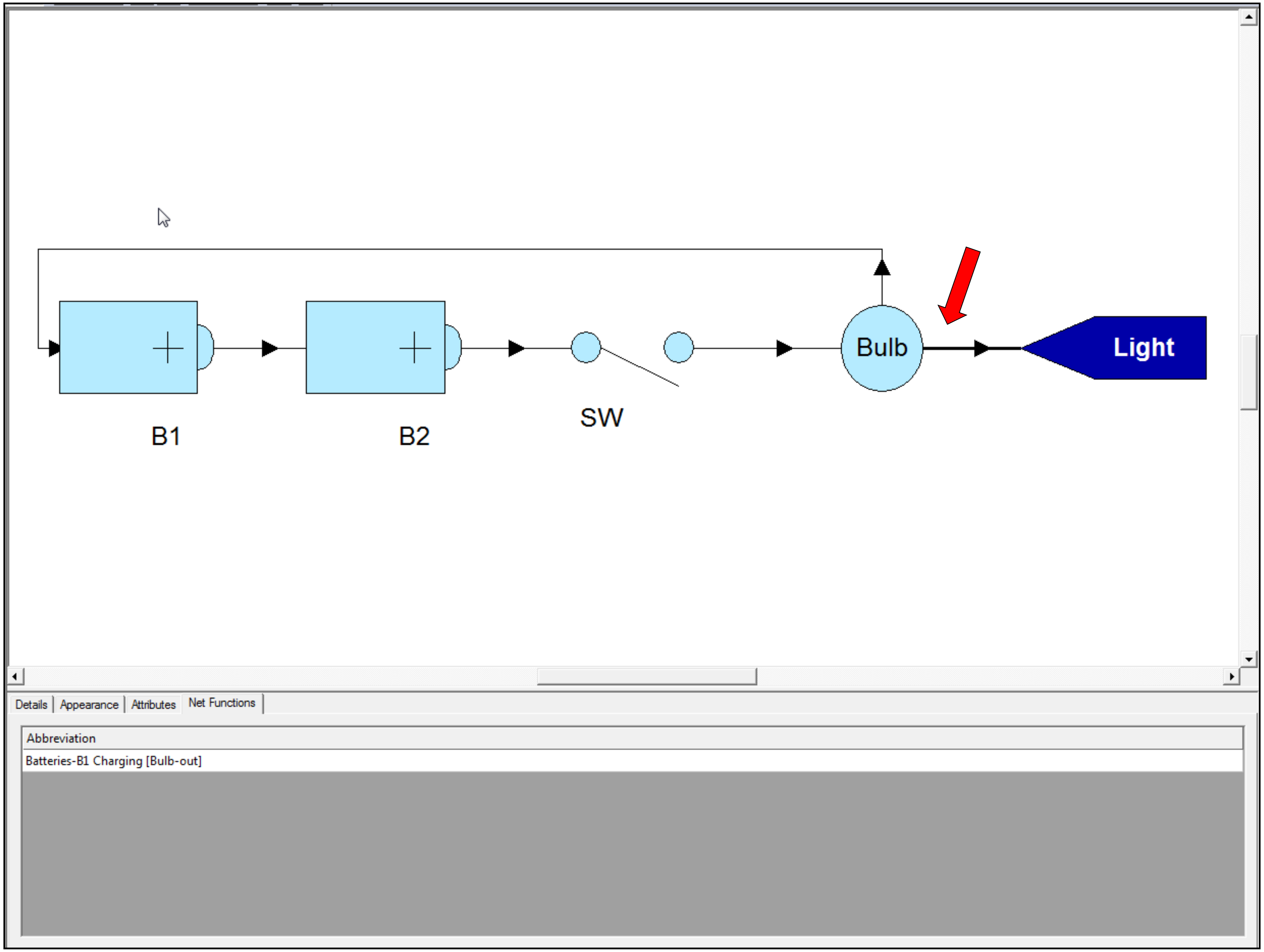
Active Propagation



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Steps in Model 1 Lab (cont.)

- **Diagnostic Modeling**
  - Topological model becomes Diagnostic Model when Tests are added
- **Evaluating and Updating**
  - Error Checker
  - Basic Design Reports
    - *Basic Design Statistics Report*
      - Sub-Reports
    - *Feedback Reports*
- **Grid View**
- **Auto-Connect**

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Resolving the Effect of Feedback

- **Is the feedback loop an accurate representation of the design?**
  - **If not, fix the modeling error**
- **Is the feedback the result of events that take place at different times being represented as if they were simultaneous?**
  - **If so, introduce object states to represent the functions that are active at a particular time**
- **Is the feedback likely to result in an inability to meet diagnostic goals?**
  - **If not, then consider leaving the feedback intact.**
- **Must the feedback remain intact during diagnostics?**
  - **If not, determine if there is or can be a mechanism for breaking the feedback loop during diagnostics. Introduce objects/object states to represent this mechanism.**
- **Can signatures be used to identify specific malfunctions while the feedback is intact?**
  - **If so, introduce signature tests that can be used to isolate certain faults within the feedback loop.**

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Skills Learned

Attributes

- ☑ Define Attributes
- ☑ Assign Values

Functions

- ☑ Dependencies, Modifying
- ☑ Output Functions, Adding
- ☑ Output Functions, Modifying Dependencies
- ☑ Output Functions List, Generating
- ☑ Output Functions by Object Listing, Generating

Nets

- ☑ Nets, Changing Color
- ☑ Nets, Changing Routing Style
- ☑ Nets, Changing Types
- ☑ Nets, Labeling

Objects

- ☑ Objects, Changing Color
- ☑ Objects, Changing Text Font Size
- ☑ Objects, Changing Text Position

Ports

- ☑ Ports, Adding (to multiple objects)
- ☑ Ports, Labeling (Automatically, from Nets)

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Model 2 – Hydraulics

Objectives of the "Hydraulic Model"

- The hydraulic model consists of:
  - Two Tanks
  - Three Valves
  - Two Pumps (redundant)
  - Two Antennas
  - System and Diagnostic Controllers
  - Level Sensors, 3 Flow Sensors and 2 Current Sensors
- The hydraulic model will be developed in 3 passes:
  - Pass 1 - Modeling the Operational Hardware
  - Pass 2 - Modeling the Control Hardware
  - Pass 3 - Modeling the Diagnostic Hardware

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Hydraulic Model Guidelines

- *Note*: All of the skills that were learned when modeling the flashlight will also be applicable to this model
- It is often useful to create a model in multiple passes
  - The flashlight model was created in 3 passes (structural, topological and diagnostic)
  - This approach was intended to resemble different levels of information
- The approach used in developing the hydraulic model is practical for different reasons, including:
  - Complex designs can be developed more quickly in layers
  - Design errors can be separately resolved during each pass
  - Design details need only be obtained for one portion of the design at a time
  - Modeling may commence earlier in the development cycle (since, during product development, the operational details of a design are often available much earlier that the control and diagnostic details of the design)

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Steps in Model 2 Lab

- Refer to "Model 2" in the Lab Exercise Workbook
- Creating, Evaluating, and Updating
  - Pass 1 - Modeling the Operational Hardware
    - Objects and Ports
    - Nets
      - Fixing Design Errors
    - Functions and States
      - Fixing Design Errors
    - Tests

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eXpress Testing vs. Diagnostics

- **Testing**
  - Tests Identify Nominal and Non-Nominal Behavior
    - Sensors, BIT, and Fault Codes
    - Manual Tests and Inspections
    - Rules based upon empirical or “case-based” knowledge
  - Test Definition in *eXpress*
    - Tests are used to represent diagnostic conclusions
    - Several types of tests can be implemented
- **Diagnostics**
  - A process that correlates the results of multiple tests to determine overall system status and generate hypotheses (fault groups) for maintenance / remediation
  - Diagnostic Development
    - The method for designing a troubleshooting / maintenance strategy
  - Testability
    - Provides the metrics to evaluate testing / diagnostic effectiveness

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Steps in Model 2 Lab (cont.)

- Pass 2 - Modeling the Control Hardware
  - Objects and Ports
  - Nets
    - Fixing Design Errors
- Pass 3 - Modeling the Diagnostic Hardware
  - Objects and Ports
  - Nets
    - Fixing Design Errors
  - Functions
  - Annotations

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Skills Learned

Functions

- ☑ Dependencies, Modifying
- ☑ Output Functions, Adding
- ☑ Output Functions, Modifying Dependencies
- ☑ Output Functions List, Generating
- ☑ Output Functions by Object Listing, Generating

Nets

- ☑ Nets, Changing Color
- ☑ Nets, Changing Routing Style
- ☑ Nets, Changing Types
- ☑ Nets, Labeling

Objects

- ☑ Objects, Changing Color
- ☑ Objects, Changing Text Font Size
- ☑ Objects, Changing Text Position

Ports

- ☑ Ports, Adding (to multiple objects)
- ☑ Ports, Labeling (Automatically, from Nets)

States

- ☑ States, Adding
- ☑ States, Adding Control Dependencies
- ☑ States, Selecting Active Functions

Test

- ☑ Tests, Creating
- ☑ Tests, Selecting States
- ☑ Test Sets, Creating

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Model 3 – BUS

Objectives of the "BUS Model"

- Model 3 represents a typical Bus application
  - It draws concepts from the previous 2 models and expands them for use in this application
- There are 3 stages of model development
  - Planning
  - Scoping
  - Creating

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Benefits of Hierarchical Modeling

- **Top-Down Modeling**
  - Enables requirements allocation case studies
  - Facilitates communication with customer / engineers
- **Bottom-Up Modeling**
  - Provides rollup of design and attribute data
  - Establishes maintenance levels for diagnostics
- **“Meet-in-the-Middle” Modeling**
  - Ensures a rigorous approach to system integration
  - Allows low-level assessments to be evaluated in context

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Steps in Model 3 Lab

- Refer to “Model 3” in the *Lab Exercise Workbook*
- Creating
  - Top Level 1553 BUS Model
  - Lower Level Engine Model
- Modeling Structure and Topology
  - Modeling the Engine
    - Checking Engine Model
  - Modeling the 1553 BUS
    - Creating Hierarchical Links
    - Developing the BUS Architecture
    - Setup Dependency on BUS Devices
    - Checking for Errors

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Diagnostic Engineering

- Definition
  - The engineering discipline through which the diagnostic capability of a system or device is developed assessed and optimized. Diagnostic Engineering is comprised of three inter-related processes:
- Diagnostic Development (test strategy generation)
  - Diagnostics developed simultaneously with design
  - Updated based on iterative assessments
- Diagnostic Assessment (evaluates both diagnostics and design)
  - Evaluates Diagnostics Together with Design
  - Provides Feedback to Both Diagnostics and Design
  - Used to Determine Requirement Allocations
  - Assessments Become More Frequent As Design and Diagnostics Mature
- Design Development
  - Diagnosability Assessed in Earliest Development Phases
  - Updated based on Iterative Assessments

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Steps in Model 3 Lab (cont.)

- Modeling the Operational Concept
  - Establish Master-Slave Communications
  - Create Tests
    - User-Initiated Test
    - In-Flight Test
  - Create Setup for FMECA Production
    - Failure Modes
    - Object Failure Effects
    - Design Failure Effects
    - Subsets

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Review: Engineering Data Required

- Functional Objects
  - Block diagrams, schematics, partitioning info (LRUs / WRAs), and design pictorials (optional)
  - Mechanical and fluid functions
  - Theory of operation (operating modes, states)
- Ports and I/O Flags
  - Functional dependencies, I/O naming conventions, sensor or monitoring functions (Gages, LEDs, etc.)
- Nets
  - Interconnectivity (ICDs, schematics, lists, etc.)
- Failure Information
  - Reliability analyses
- Test Information
  - BIT designs, FMECAs, etc.

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Skills Learned

Designing Techniques for the 1553 BUS

- ☑ Assign States to Handle Master-Slave Communication
- ☑ Model the 1553 BUS
- ☑ Create a Combined 1553 Coupler Object
- ☑ Create a Simplified 1553 Coupler Object

Failure Modes

- ☑ Add Failure Modes
- ☑ Set Affected Functions on Failure Modes

Failure Effects

- ☑ Add Object Failure Effects
- ☑ Add Design Failure Effects
- ☑ Set Failure Effect Severity

Objects

- ☑ Convert between Object Types
- ☑ Create Assemblies (Hierarchical Objects)
- ☑ Descend into Hierarchy
- ☑ Reduce Hierarchical Interface
- ☑ View Functions on an Assembly

Subsets

- ☑ Create Subsets
- ☑ Define Subsets

Tests

- ☑ Reduce Test Stimuli

Composite Model Development Process

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Back-Up Slides

Understanding Diagnostics

Changing the Paradigm

Creating a System Engineering Coordinating Resource