Model-Based Systems Engineering: A Practical Approach

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Agenda

- Why invoke Model-Based Systems Engineering?
- What is Model-Based Systems Engineering?
- What we did on the Surrogate SATCOM IRaD
- What should you do?

The Perception?

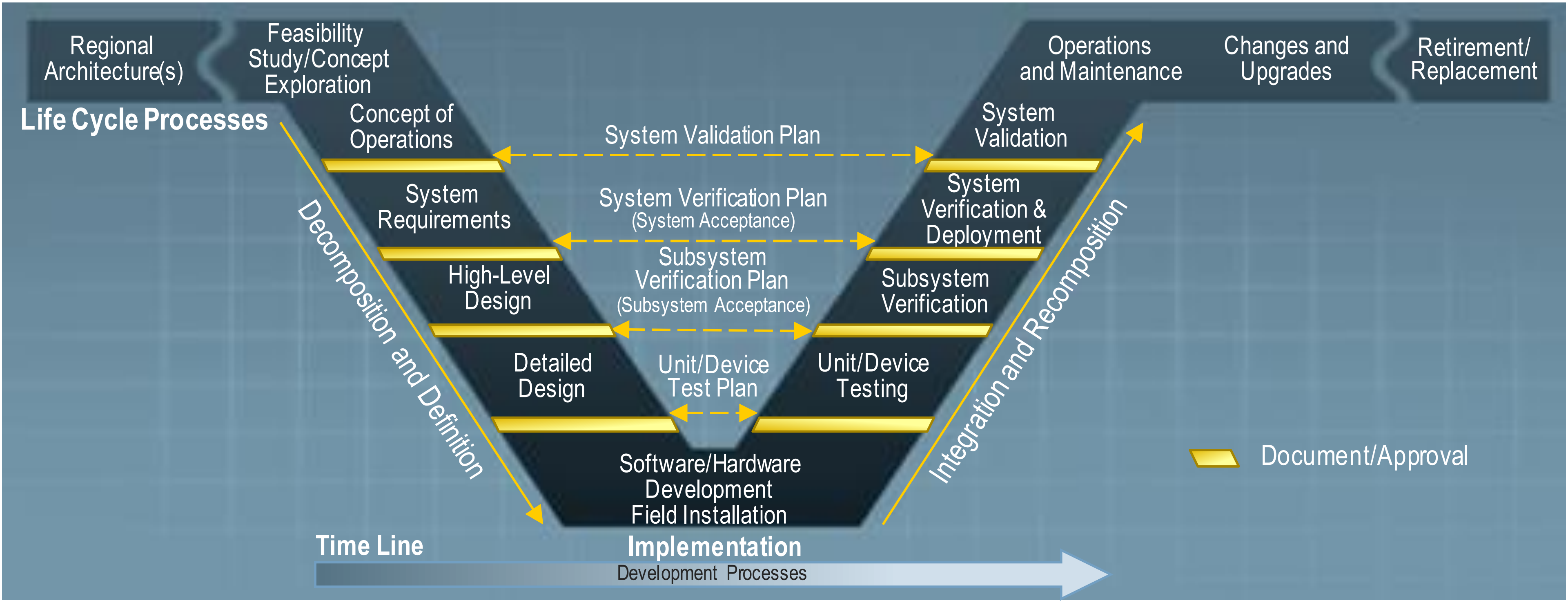
"Process is not the enemy – bad process is."

- *Toward Agile Systems Engineering Processes*, Turner, CrossTalk April 2007)

Practicality Needn't Be Cumbersome

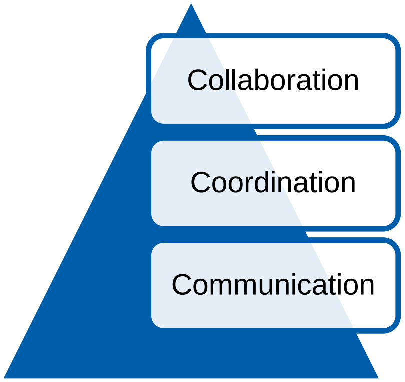
Why

- Systems Engineering V Model



Why (cont.)

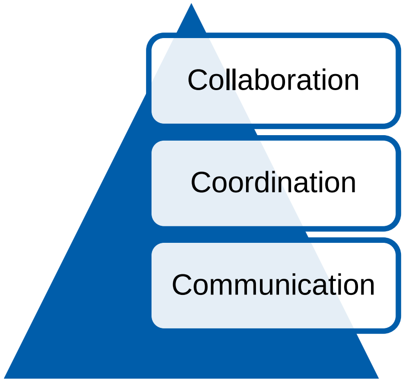
- Communication
  - Common understanding
    - What the system is supposed to do
    - What the system parts are called
      - Normalized terminology
    - How the system is configured
      - Define subsystems and components
      - Identify interfaces
      - Logical and Physical
- Coordination
  - Multiple engineering efforts
    - Who's developing which parts of the system
  - Accommodate changes



Effective Development is the Goal

Why (cont.)

- Collaboration
  - Develop models
    - Requirements: CONOPS, COIs, Missions, etc.
    - Architecture: OV1, Block Diagrams, Data Flows, Drawings, etc.
    - Operation: Mock-ups, Test and Demo plans, etc.
  - From different points of view
    - Business Development
    - Hardware
    - Software
    - Cybersecurity
    - Test
    - Deployment
    - Sustainments, Logistics, Operations and Maintenance



We see things differently

What

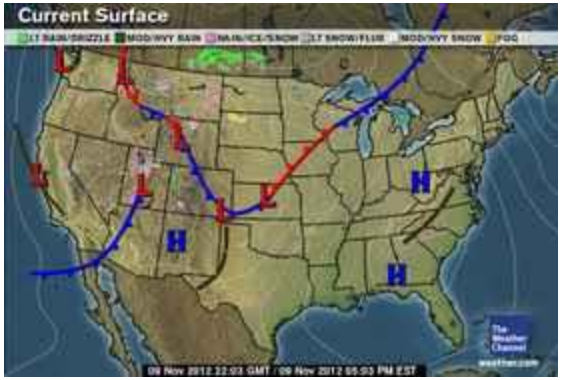
- **Model-based systems engineering** (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases

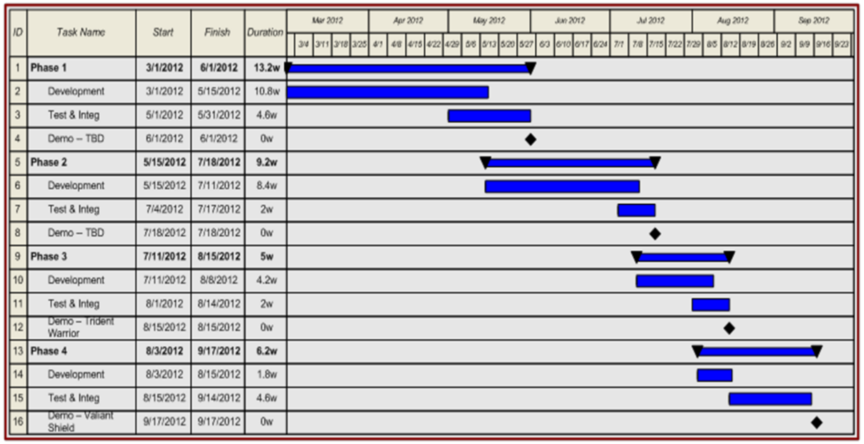
- A **model** is an approximation, representation, or idealization of selected aspects of the structure, behavior, operation, or other characteristics of a real-world process, concept, or system, i.e. an **abstraction**

- A model usually offers different **views** in order to serve different purposes
  - A **view** is a representation of a system from the perspective of related concerns or issues

What – Model Examples

- Video games
- Weather maps
- Schedules
- Simulators
- Test Configurations

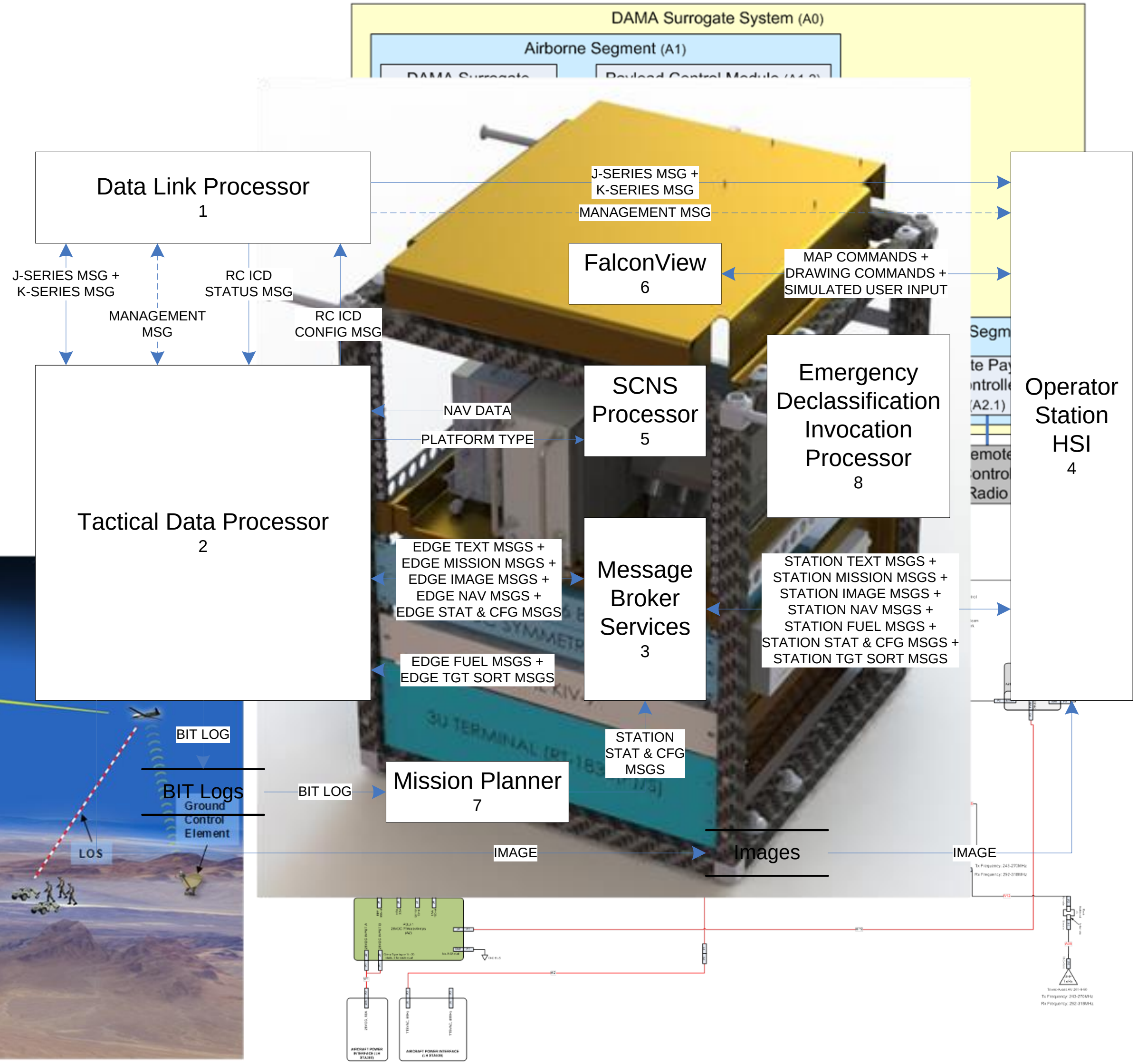


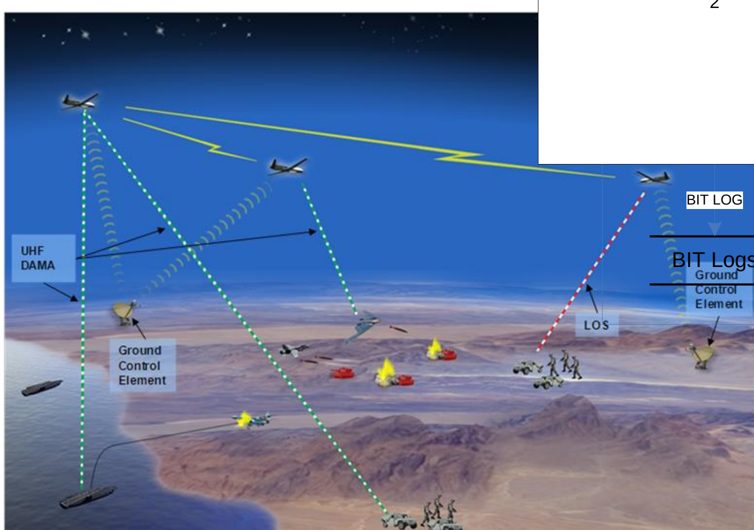


ID	Task Name	Start	Finish	Duration
1	**Phase 1**	**3/1/2012**	**6/1/2012**	**13.2w**
2	Development	3/1/2012	5/15/2012	10.8w
3	Test & Integ	5/1/2012	5/31/2012	4.6w
4	Demo – TBD	6/1/2012	6/1/2012	0w
5	**Phase 2**	**5/15/2012**	**7/18/2012**	**9.2w**
6	Development	5/15/2012	7/11/2012	8.4w
7	Test & Integ	7/4/2012	7/17/2012	2w
8	Demo – TBD	7/18/2012	7/18/2012	0w
9	**Phase 3**	**7/11/2012**	**8/15/2012**	**5w**
10	Development	7/11/2012	8/8/2012	4.2w
11	Test & Integ	8/1/2012	8/14/2012	2w
12	Demo – Trident Warrior	8/15/2012	8/15/2012	0w
13	**Phase 4**	**8/3/2012**	**9/17/2012**	**6.2w**
14	Development	8/3/2012	8/15/2012	1.8w
15	Test & Integ	8/15/2012	9/14/2012	4.6w
16	Demo – Valiant Shield	9/17/2012	9/17/2012	0w

What – View Examples

- Hardware
- Software
- System
  - Logical
  - Physical
  - Operational





How

- Operational
  - CONOPS, Missions
  - COIs, MOEs, MOPs
  - OV1
  - Requirements
  - Test and Demo Plans
- Functional
  - Decomposition
  - Data Flow Diagrams
  - Use Cases
- Logical
  - Context Diagrams
  - Architecture Block Diagram
  - Interconnect Diagrams
  - Architecture Flow Diagrams
- Physical
  - Product Entity Diagram
  - Drawings
  - Equipment Configuration Diagrams
  - Checklists

Capture the Thinking

How – Operational

- CONOPS, Missions
- COIs, MOEs, MOPs
- OV1
- Requirements
- Test and Demo Plans

ID	COI	MOE	MOP
1	Need to increase crop yield for amount of time and material used		
1.1		Crop yields compared to historical yields under similar conditions	
1.1.1			Annual crop yield
			Cost of soil amendments

Objective 3.2	Demonstrate exchange of data from ground sensor to central control station via the sensor network.
Entry Criteria	Scenario dry run completed. Transmission load simulator calibrated. Test readiness reviewed and approved.
Exit Criteria	Data transmitted from sensor, data received at central control station for post-processing and verified by test engineer
Test Scenarios	**General**: Sensor data transmission, single channel **Scenario 1**: 25 kHz Tx in sensor network **Scenario 2**: 5 kHz Tx in sensor network
Test Output Data	Sensor data logged by central control station. System configuration files.
Data Analysis	**Message latency**: Determine average elapsed time between transmission of sensor data from the source sensor and receipt of the sensor data at the central control station. **Message quality**: Sensor data transmitted matches data received.

SYS Tag	Requirem…	Name	Req ID	Criticality	Verification Method
SYS8	The RSMS shall monitor ch… including the soil pH, eleme… for an operator-designated s… material and organic matter… grown.	3.1.2 Operational Requirements	SYS.OP.010	KPP	Test
SYS9	The RSMS shall deliver soil… and salinity levelers based o… system settings designated b…	3.1.2 Operational Requirements	SYS.OP.020	KPP	Test
SYS10	The RSMS shall monitor the… the soil with emphasis on w… maintain optimum levels for… structure and crop type.	3.1.2 Operational Requirements	SYS.OP.030	KPP	Test
SYS11	The RSMS shall deliver or w…	3.1.2 Operational Requirements	SYS.OP.040	KPP	Test

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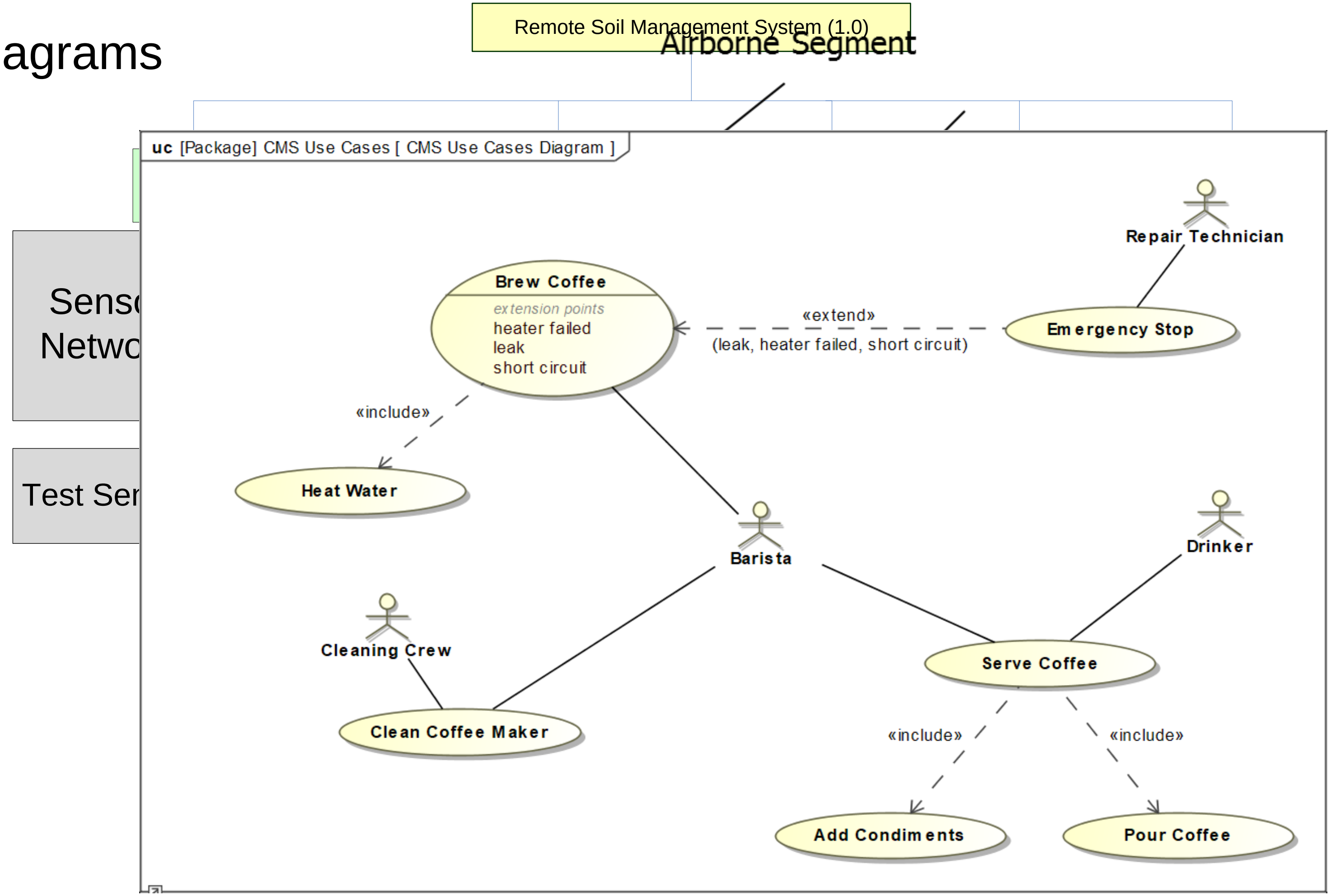
How – Functional

- Decomposition
- Data Flow Diagrams
- Use Cases



How – Logical

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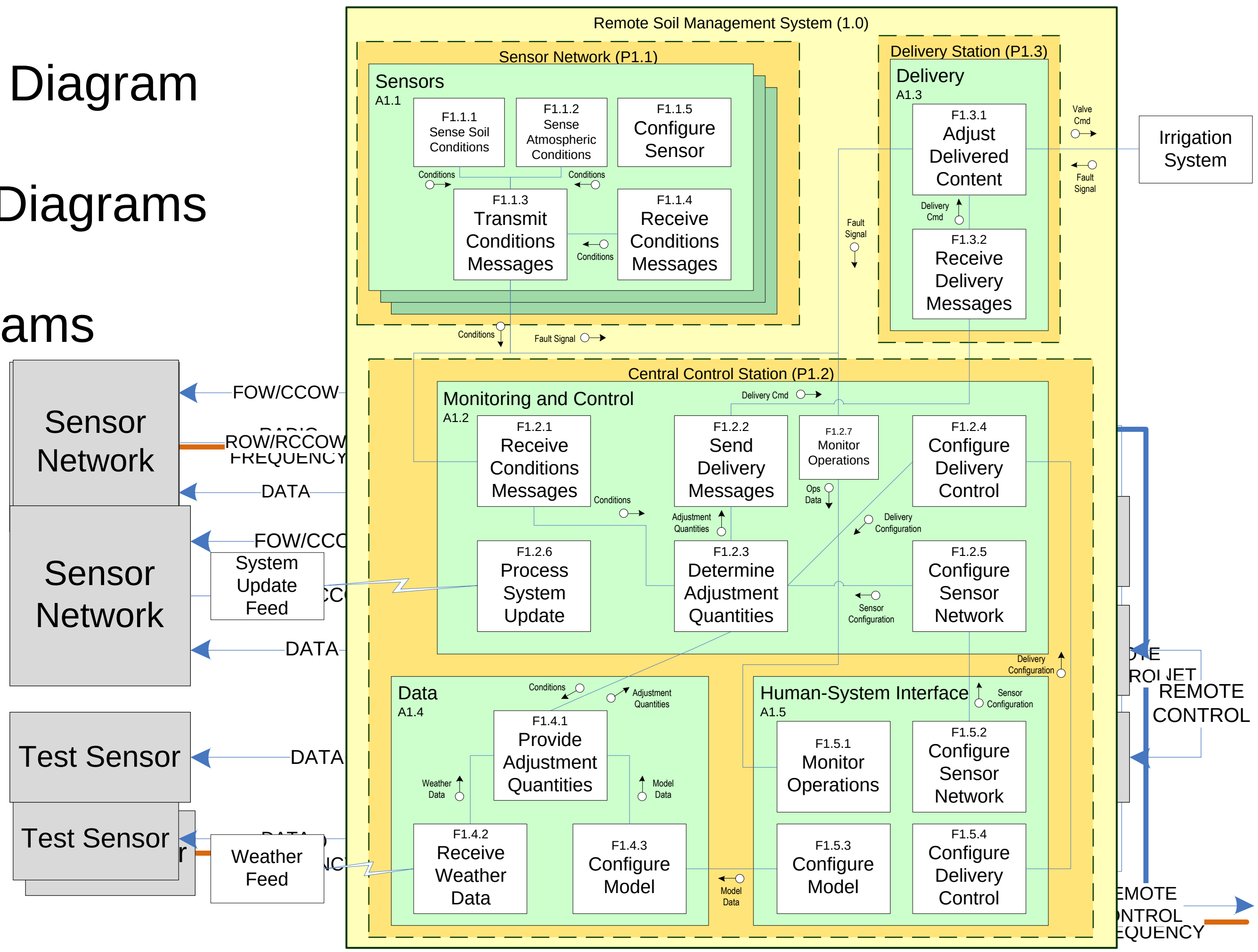
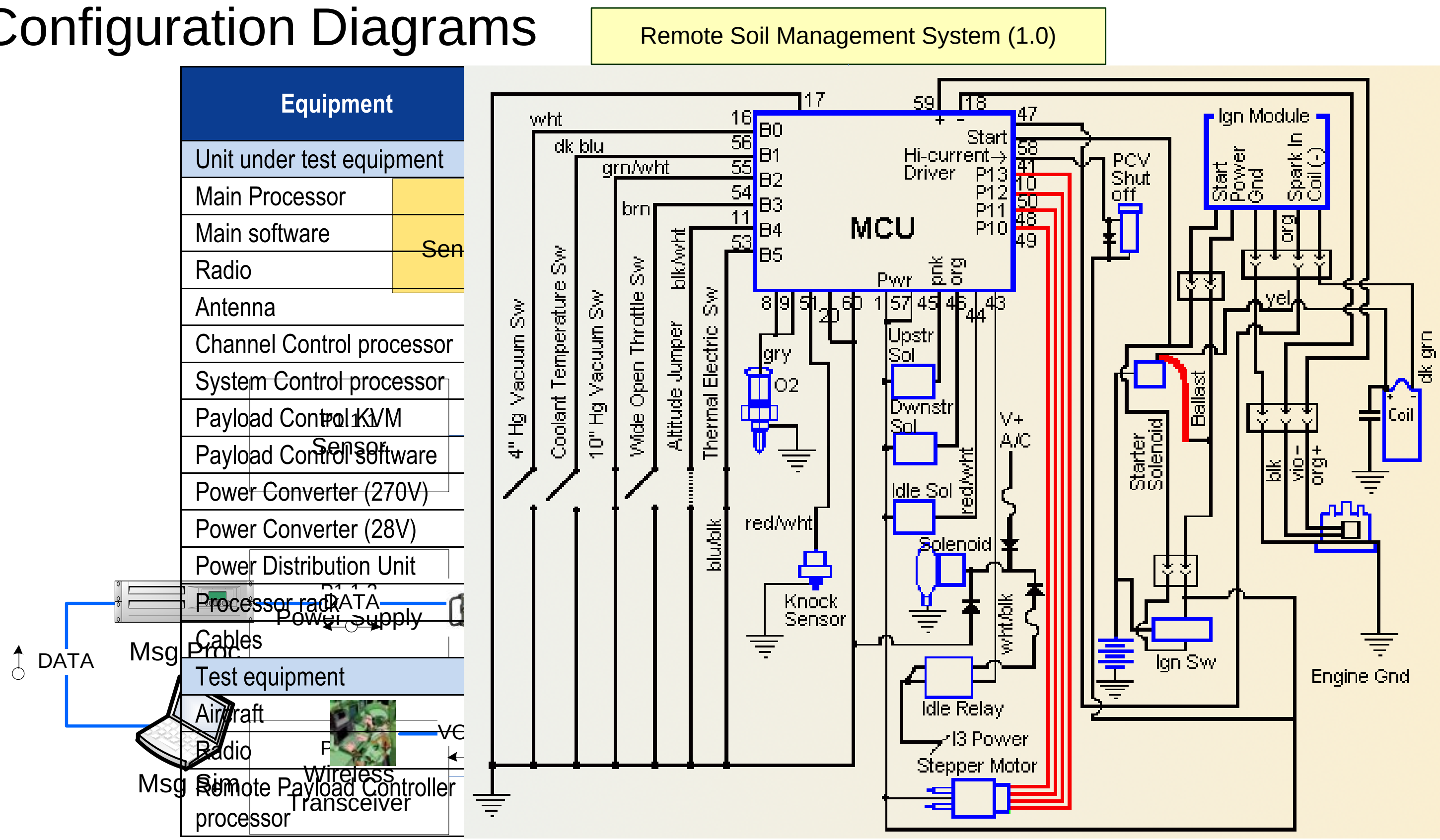
- Context Diagrams
- Architecture Block Diagram
- Architecture Flow Diagrams
- Interconnect Diagrams

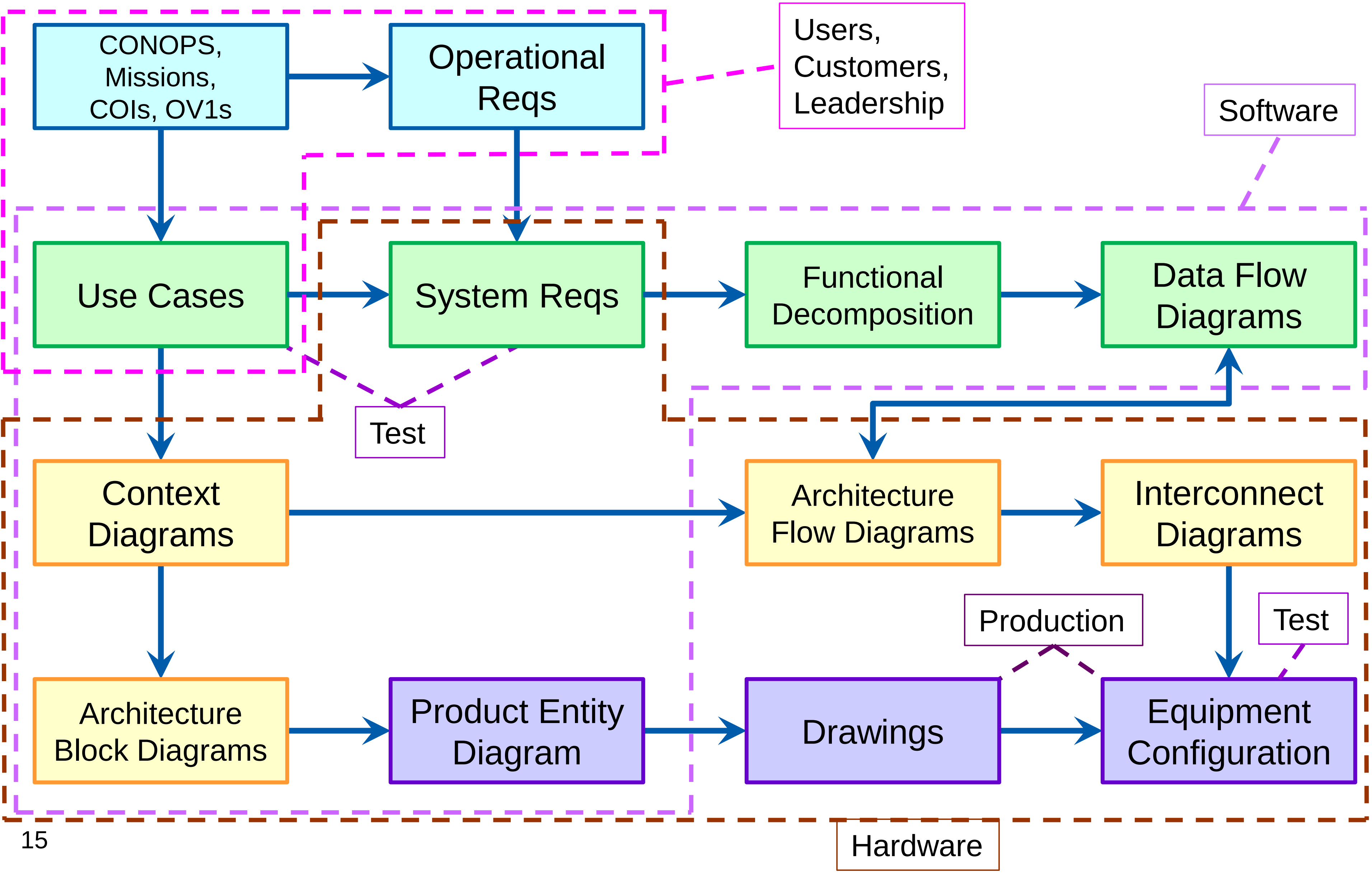


How – Physical

- Product Entity Diagram
- Drawings
- Equipment Configuration Diagrams
- Checklists



Tie It All Together



Questions

Actions for Success

- Document and review the system development plan
  - SEMP or SEIT Plan (what, who, when)
- Document and review system operational concepts
  - CONOPS
  - Missions
  - OV1s
  - COIs, MOEs, MOPs
- Identify, document, and review operational requirements
- Describe, document, and review the system functionally
  - Functional Decomposition
  - Data Flow Diagrams
  - Use Cases
- Identify, document, and review system requirements

Actions for Success (cont.)

- Describe, document, and review the system at the logical level
  - Context Diagrams
  - Architecture Block Diagrams
  - Interconnect Diagrams
  - Architecture Flow Diagrams
- Describe, document, and review the system physically
  - Product Entity Diagrams
  - Drawings
  - Equipment Configuration Diagrams
- Document and review system test and demo plans and procedures
- Create and use checklists

Know Your Audience

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