Systems Engineering Management

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a.k.a.: creating order from chaos

Definitions

- ## What is Systems Engineering?

  - the ensemble of coordinated analyses, simulations, and processes which lead to a technical product which best meets the needs of an identified customer.

- ## What does it mean to manage systems engineering?

  - Systems engineering management requires the allocation of resources in a manner that ensures success.

  - Resources include funds, schedule, personnel, tools, and environment.

  - Proper allocation requires that the manager continuously predicts the future needs of the program and technical hurdles and allocates the currently available resources such that these needs are met and these hurdles are cleared at the appropriate time.

The Restaurant Analogy

- INGREDIENTS - available technologies, funds, schedule, personnel, etc.

- APPLIANCES - tools (e.g., software) for synthesizing, modeling, and analyzing a design.

- KITCHEN - environment in which tools and communications are exercised (e.g., design room).

- CHEF & ASSISTANTS - the systems engineering team.

- RECIPE - the sequence of activities, tests, and refinements used to ensure the successful completion of the product

- MEAL - the product that arrives on time, on budget, and meets requirements (tastes good)

All are required to produce a good yet cost-effective meal/product

Key Elements of Systems Management

- ## Resources (margins)
  - Resources provide the fuel. Holding margin ensures that fuel is available when you need it. Spend it sparingly and wisely. Very painful to get more later

- ## Scheduling
  - Scheduling coordinates the various activities of the team to ensure that the team receives information and hardware when it is needed. Scheduling identifies when and on what to spend resources (including allocating personnel) to ensure success when it is needed.

- ## Prototyping
  - Analysis and simulation only answer some questions. Others require actual testing in hardware. Prototyping can be a resource-effective element of the design process.

Key Elements (cont.)

- Communications
  - Keep the team on the same page. Time spent by team members designing under old assumptions is a waste of resources.
  - Good communication with your customer(s) is essential in maintaining advocacy and access to resources.
  - Assures that expectations do not drift

- Interfaces
  - In larger projects, interfaces between groups/subsystems must be well-defined.
  - Two types of interfaces: physical and functional.
  - Interface violations will happen. Need to be arbitrated at next highest level.
  - Keep your interfaces to the outside world simple, clear, defined, and consistent.

Systems Engineering Management
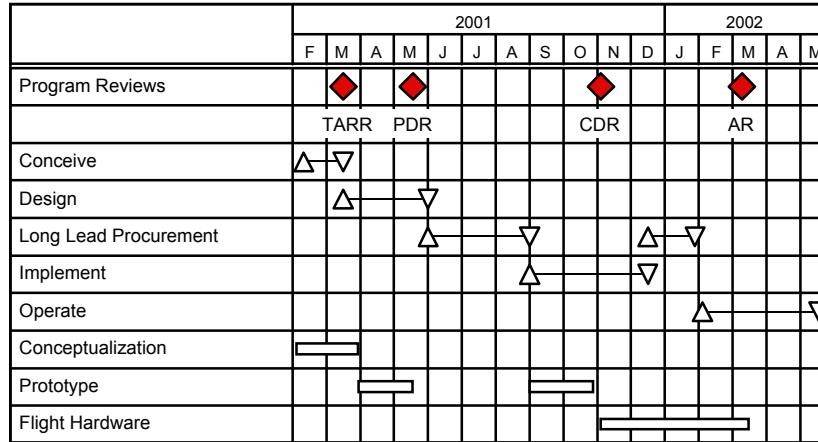
Ensure that your Resources are Adequate

- Personnel
  - Ensure that the number of people as well as their skill mix satisfies the needs of the program. Consultants, subcontractors, and research divisions can be used to fill gaps.

- Funding
  - Funds are needed to pay personnel (salaries, employee benefits), operate facilities (taxes, utilities, overhead), acquire hardware, and communicate with team and customer (travel, telephone).

- Schedule
  - Identifies when analyses or products need to be delivered.

- Technologies
  - Available technology is cheaper than invented technology

  Don't underbid a program or promise "unobtanium"

Tools for Schedule Management

- ## Schedules

	2001											2002				
	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
Program Reviews		◆		◆						◆			◆			
		TARR		PDR						CDR			AR			
Conceive	△▽															
Design		△		▽												
Long Lead Procurement				△		▽				△	▽					
Implement							△		▽							
Operate										△					▽	
Conceptualization	▭															
Prototype		▭				▭										
Flight Hardware								▭								

- Coordinate the activities of the team to maximize productivity
- Allocate resources - identify dependencies - manage costs

- ## Milestones

- Events which force the team to communicate the current form of the product in a coherent fashion
- Opportunity to solicit outside critiques from experts
- Often required by customer to ensure progress is on schedule, on cost, and meeting performance requirements

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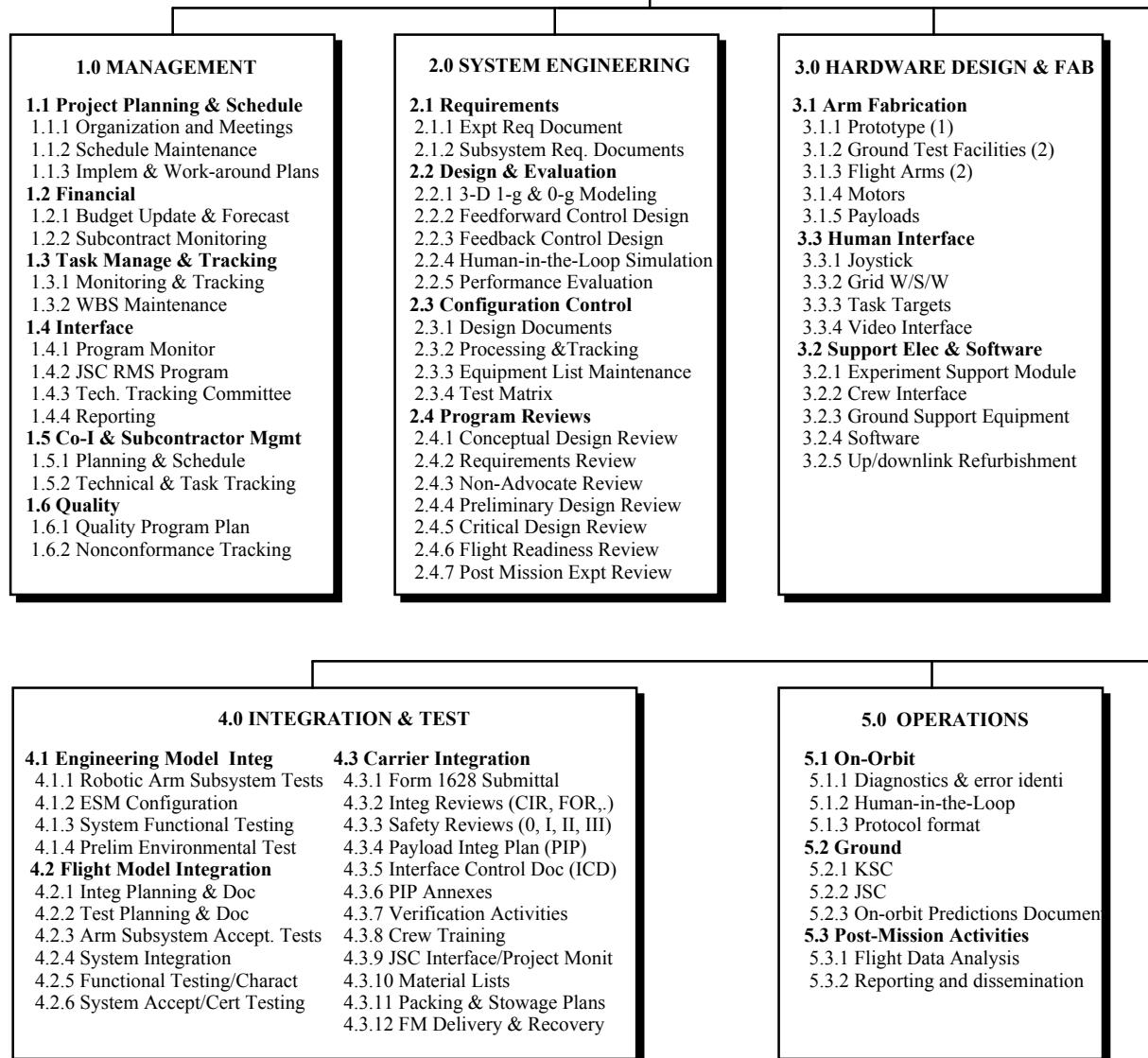
Manage the Margins

- Hold margin in all resources
    - Resources required by the product tend to increase due to unforeseen problems, better understanding of the design, etc.
    - Margin allows the manager to accommodate such resource requirement growth without renegotiating resources with the customer.

- How much margin should be held?
    - Reduces as the product design matures
    - Suggest holding 30% at TARR, 20% at PDR, and 10% at CDR.

Tools (cont.)

- Work Breakdown Structure (WBS)
  - The list of tasks that need to be completed in order to accomplish the job
  - Tree-structure
  - Defined to lowest level that makes sense for a particular group/system.
  - Often includes the expected labor hours and calendar schedule to form a baseline for managing the effort

FLEX

1.0 MANAGEMENT

1.1 Project Planning & Schedule
 1.1.1 Organization and Meetings
 1.1.2 Schedule Maintenance
 1.1.3 Implem & Work-around Plans
1.2 Financial
 1.2.1 Budget Update & Forecast
 1.2.2 Subcontract Monitoring
1.3 Task Manage & Tracking
 1.3.1 Monitoring & Tracking
 1.3.2 WBS Maintenance
1.4 Interface
 1.4.1 Program Monitor
 1.4.2 JSC RMS Program
 1.4.3 Tech. Tracking Committee
 1.4.4 Reporting
1.5 Co-I & Subcontractor Mgmt
 1.5.1 Planning & Schedule
 1.5.2 Technical & Task Tracking
1.6 Quality
 1.6.1 Quality Program Plan
 1.6.2 Nonconformance Tracking

2.0 SYSTEM ENGINEERING

2.1 Requirements
 2.1.1 Expt Req Document
 2.1.2 Subsystem Req. Documents
2.2 Design & Evaluation
 2.2.1 3-D 1-g & 0-g Modeling
 2.2.2 Feedforward Control Design
 2.2.3 Feedback Control Design
 2.2.4 Human-in-the-Loop Simulation
 2.2.5 Performance Evaluation
2.3 Configuration Control
 2.3.1 Design Documents
 2.3.2 Processing &Tracking
 2.3.3 Equipment List Maintenance
 2.3.4 Test Matrix
2.4 Program Reviews
 2.4.1 Conceptual Design Review
 2.4.2 Requirements Review
 2.4.3 Non-Advocate Review
 2.4.4 Preliminary Design Review
 2.4.5 Critical Design Review
 2.4.6 Flight Readiness Review
 2.4.7 Post Mission Expt Review

3.0 HARDWARE DESIGN & FAB

3.1 Arm Fabrication
 3.1.1 Prototype (1)
 3.1.2 Ground Test Facilities (2)
 3.1.3 Flight Arms (2)
 3.1.4 Motors
 3.1.5 Payloads
3.3 Human Interface
 3.3.1 Joystick
 3.3.2 Grid W/S/W
 3.3.3 Task Targets
 3.3.4 Video Interface
3.2 Support Elec & Software
 3.2.1 Experiment Support Module
 3.2.2 Crew Interface
 3.2.3 Ground Support Equipment
 3.2.4 Software
 3.2.5 Up/downlink Refurbishment

4.0 INTEGRATION & TEST

4.1 Engineering Model Integ
 4.1.1 Robotic Arm Subsystem Tests
 4.1.2 ESM Configuration
 4.1.3 System Functional Testing
 4.1.4 Prelim Environmental Test
4.2 Flight Model Integration
 4.2.1 Integ Planning & Doc
 4.2.2 Test Planning & Doc
 4.2.3 Arm Subsystem Accept. Tests
 4.2.4 System Integration
 4.2.5 Functional Testing/Charact
 4.2.6 System Accept/Cert Testing

4.3 Carrier Integration
 4.3.1 Form 1628 Submittal
 4.3.2 Integ Reviews (CIR, FOR,.)
 4.3.3 Safety Reviews (0, I, II, III)
 4.3.4 Payload Integ Plan (PIP)
 4.3.5 Interface Control Doc (ICD)
 4.3.6 PIP Annexes
 4.3.7 Verification Activities
 4.3.8 Crew Training
 4.3.9 JSC Interface/Project Monit
 4.3.10 Material Lists
 4.3.11 Packing & Stowage Plans
 4.3.12 FM Delivery & Recovery

5.0 OPERATIONS

5.1 On-Orbit
 5.1.1 Diagnostics & error identi
 5.1.2 Human-in-the-Loop
 5.1.3 Protocol format
5.2 Ground
 5.2.1 KSC
 5.2.2 JSC
 5.2.3 On-orbit Predictions Documen
5.3 Post-Mission Activities
 5.3.1 Flight Data Analysis
 5.3.2 Reporting and dissemination

Systems Engineering Management

Leadership and Authority

- Lead through example, not dictatorship
- Delegate not only responsibility but also authority
- Manage through informed trust, not detailed familiarity
- Be a problem solver, not a problem creator
- Some of the quietest people can be the best managers
    - The first rule of management is communication
    - The first rule of communication is listening
- Encourage, complement and motivate your team and provide constructive criticism