Improving Systems Engineering Process Through Value Stream Mapping

By
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Overview

- **More than 5,000 design changes per year have been made to the C-17, for the past three years (more than 1,000 major design changes per year)**
- **Formal systems engineering (SE) process established in 1998, instrumental in design development**
- **Integral tie between C-17 SE process and overall Process Based Management (PBM)**
- **Mission Assurance philosophy embedded in culture and processes**
- **Open communication and shared vision support true USAF/Boeing system engineering partnership**

Integration of Processes, Tools and Training to Reinforce the Role of SE in the C-17 Product Development Process

Vision:

- The C-17 Enterprise is the World Class Leader in Systems Engineering:
  - Robust, standardized, effective, & efficient Systems Engineering products, processes, & tools are applied & integrated across the C-17 Program to enable mission success
  - For all system development there are thoroughly defined and validated requirements, at all levels that are fully traceable from customer needs through verification and validation
  - Risks are defined and managed to ensure balanced technical, schedule, and cost performance throughout the product life cycle (Develop, Produce, Operate, Support)

Mission:

- To define & ensure common application of SE processes using a controlled tailored approach, that will facilitate C-17 program and mission success

Driving Forces for Change ~ Where We Were

- People
  - Gain greater Systems Engineering (SE) understanding
  - Initiate common SE focus
- Improve Customer satisfaction (external)
  - Systems Engineering (SE) Imperative
  - Customer Involvement
- Need to Institutionalize systems engineering
  - Greater Process discipline
  - Internal customer satisfaction
- Increase Focus on Supplier Systems Engineering (SE)
  - Requirements
  - Quality

Priorities

- Institutionalize systems engineering
  - People: Training / rotation / communication / knowledge transfer
  - Process discipline, metrics
- Strategic roadmap
  - Near term actions / address customer concerns
  - Long range vision to keep focus
  - Supplier SE roadmap

Systems Engineering Imperative Context

External Influences

- USAF C-17 Upgrades
- Industry Initiatives (INCOSE, CMMI, LAI, …)
- Enterprise Value Stream Mapping (identifies SE as focus area)
- SE Survey

Internal Influences

- Process (ISO, PBM, …)
- Organization (IPTs)
- People resources
- C-17 baseline
- SE HILT
- Tool capabilities

SE Process

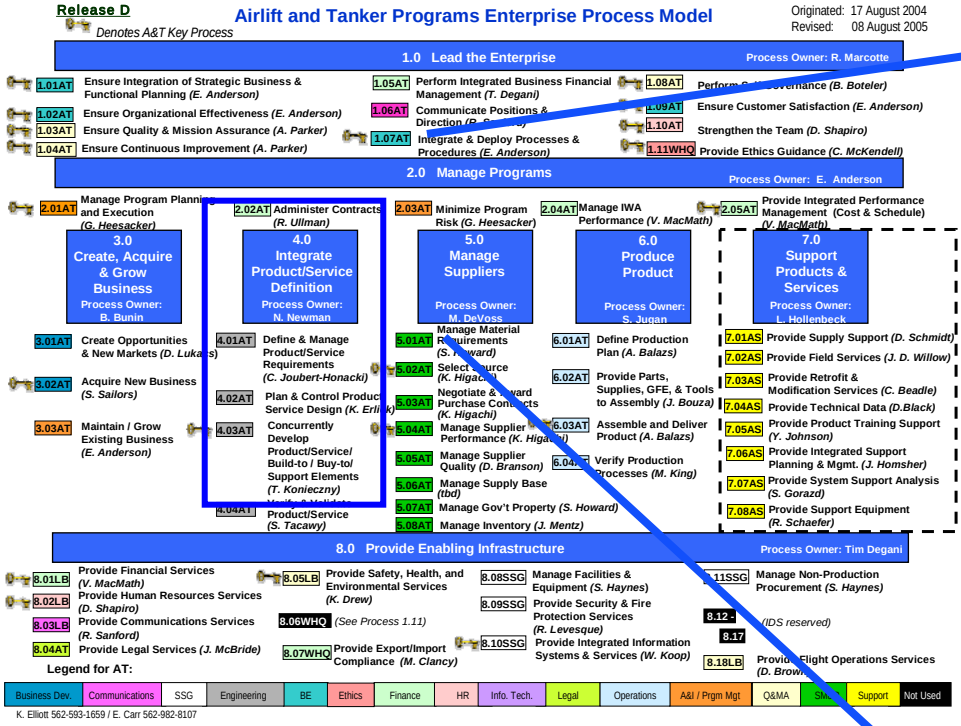
- Understand situation
- Define requirements
- Perform trade study
- Develop and implement plan

Infrastructure

- Common vision buy-in
- Management commitment
  - Participation
  - Resources
- PBM framework
- Project participation
- Employee Involvement
- Lessons learned database

World class leader in systems engineering enabling mission assurance

Process Based Management Enterprise Model



- **Boeing Benchmark**
- **Institutionalized**
- **Involves Customer Throughout**

4.0
Integrate Product / Service Definition

4.01
Define and Manage Product / Service Requirements

4.02
Plan & Control Product / Service Design

4.03
Concurrently Develop Product / Service / Build-to / Buy-to / Support Elements

4.04
Verify / Validate Products/Services

SE Strategy Implementation Plan

- Near term actions (6 months) and long term vision will be integrated into single SE improvement plan.
  - Nine focus areas identified in early self assessment
  - Best practice implementation based on internal (Boeing) systems engineering survey (external to C-17)
  - 22 improvement projects from the 3 VSMs
  - Discipline to process
    - Metrics, Training, Communication, updated processes and command media
  - Engineering Best Practices corrective action plan
  - SE Manual updates
  - Implementation of IDS Command Media and SE HILT Common Tools and Processes

Plan Development/Status

We Are Here

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	
Initial Self-Assessment	Initially Identified Current State	Set Vision	Initial Focus Areas Identified	SE Survey (external to C-17)	Evaluation & Planning (for VSM)	Value Stream Mapping	Develop Implementation Plan	Implement Plan

Recent Accomplishments

- Two sessions of Value Stream Mapping (VSM) Completed in 2005
  - Phase A Jun 05, Customer needs – CDR
  - Phase B Dec 05, CDR - Verification)
- Technical Flowdown to Suppliers VSM Completed (Feb 2006)
- SE Tool Training @ SG
- OSS&E Training by SG & Boeing in LB

Current Focus Areas:

1. 22 Improvement Plans (from VSMs)
   - Requirement definition
   - Key opportunities to improve cycle time reduction suppliers
2. Program Level Metrics
   PMBP (SE) Improvement Plan
3. Training Engineering in SE Processes

Maturing from “breakthrough” to “strengthening” SE processes

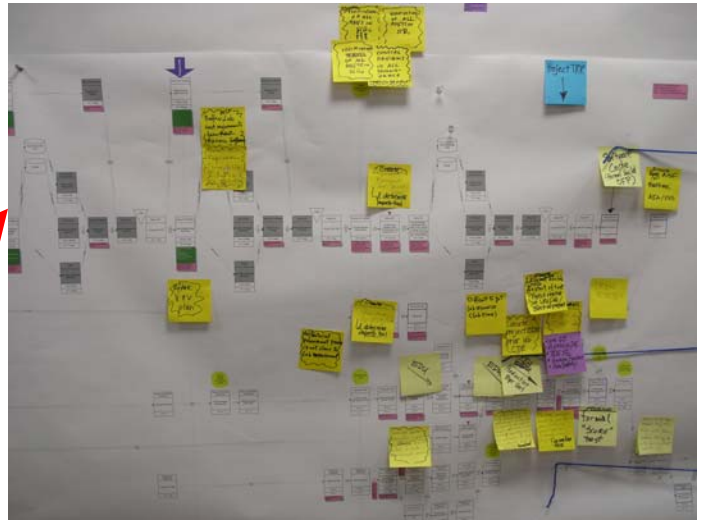
VSM Workshop

Participation

- **Systems Group – 7** (Avionics, Conf Mgt, Structures, Lean, Production Ops, Support Systems, Systems Eng)
- **Boeing Systems Engineers (non C-17) – 6** (AFS, Anaheim, C-130, Canoga Park, Huntington Beach, 767 Tanker)
- **C-17 Engineering IPT – 29** (Systems Eng, Aircraft Systems, Processes and Tools, Airframe & Mission Systems, Avionics, Project Mgt, Test & Evaluation, AVI/SS)
- **Analysis and Integration – 4** (Block Integration, Configuration Mgt, Change Mgt, Program Mgt Systems)
- **DCMA - 2**
- **Supplier Management - 2**
- **Support Systems – 1**
- **Production Operations - 1**
- **Lean Enterprise – 3**

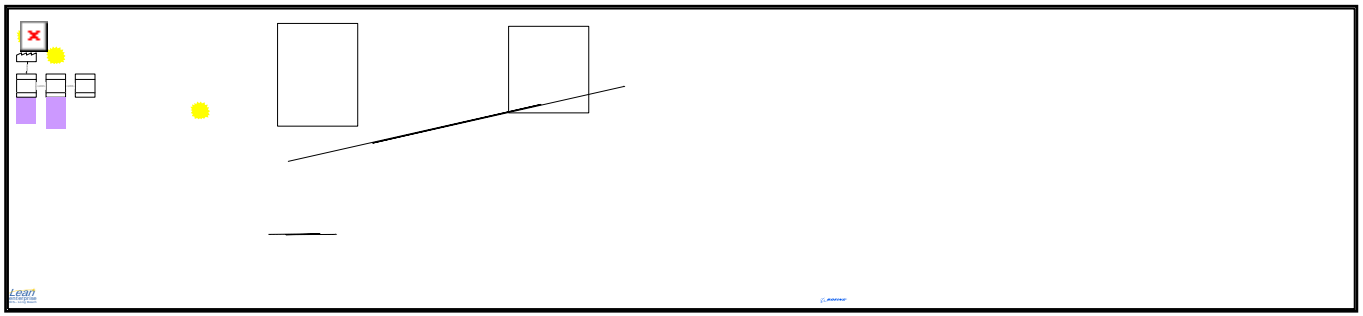
Apply Lean Techniques to Identify Improvements

1. Define the boundaries
2. Define the objectives
3. "Walk" the process
   - Identify tasks and flows of material and information between them
4. Gather data
   - Identify resources for each task and flow
5. Create the "current state" map
6. Analyze current conditions
   - Identify value added and waste
   - Reconfigure process to eliminate waste and maximize value
7. Visualize "ideal state"
8. Create the "future state" map
9. Develop and track action plans



Systems Engineering (Phase A) VSM

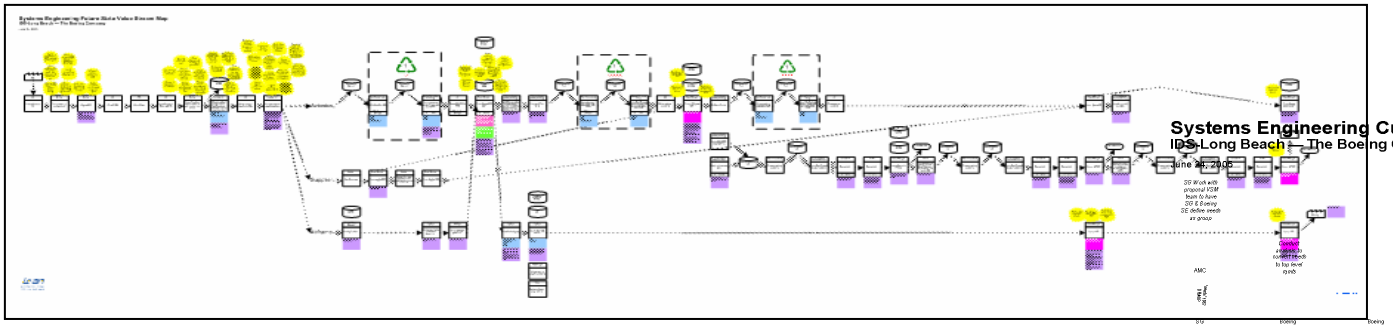
Current State



Near Term Improvement Projects identified

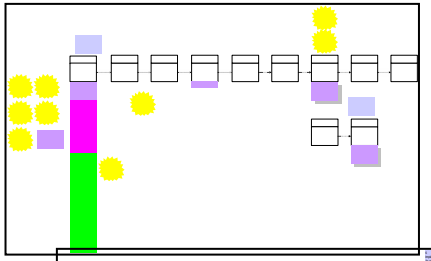
- ❑ Interface Management
- ❑ Project Reviews
- ❑ Requirements Process Enablers
- ❑ Needs Definition
- ❑ Systems Integration
- ❑ Trade Study Improvement
- ❑ Verification Improvement
- ❑ Project Team Memberships
- ❑ Statement of Requirements (SOR) Development Improvement

Future State

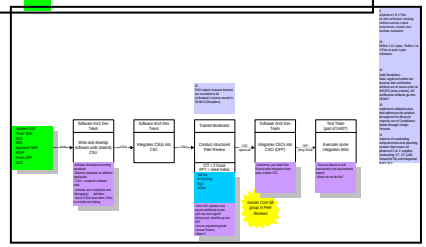


Systems Engineering Imperative Phase B VSM

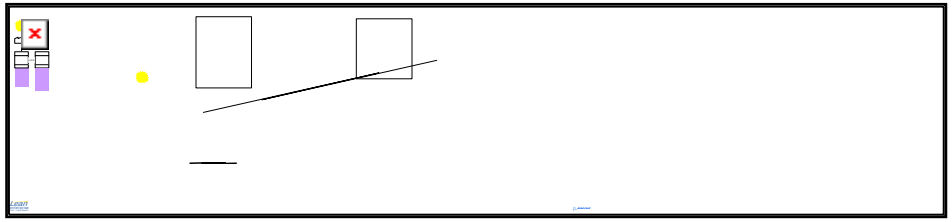
- Stitched 3 existing maps together
  - Systems Engineering Phase A
  - Flight test
  - Avionics Labs (AISF, AIA, FHS)
- Mapped 3 current state value streams
  - Software
  - Avionics Hardware
  - Airframe and Aircraft Systems Hardware



Systems

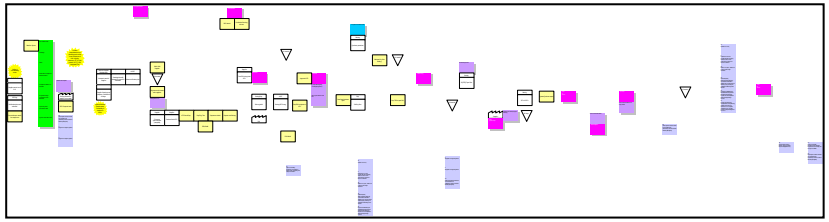


Software



Phase B
Current State

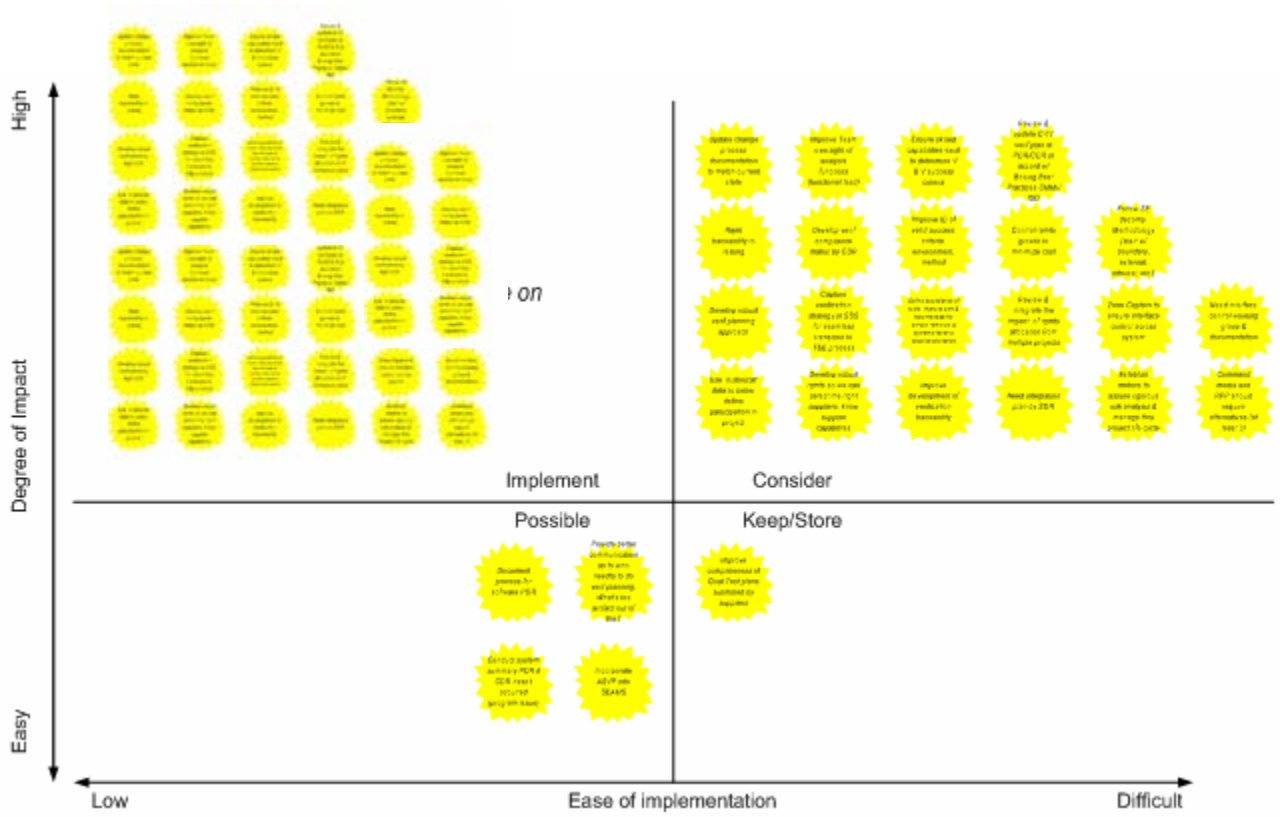
Avionics



By working jointly significant SE progress improvements have been made

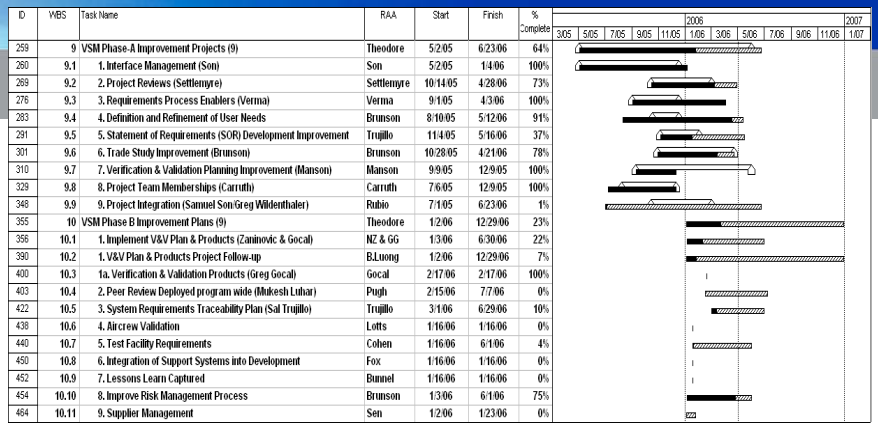
Improvement Selection

- Use PICK process
  - Possible
  - Implement
  - Consider
  - Kill

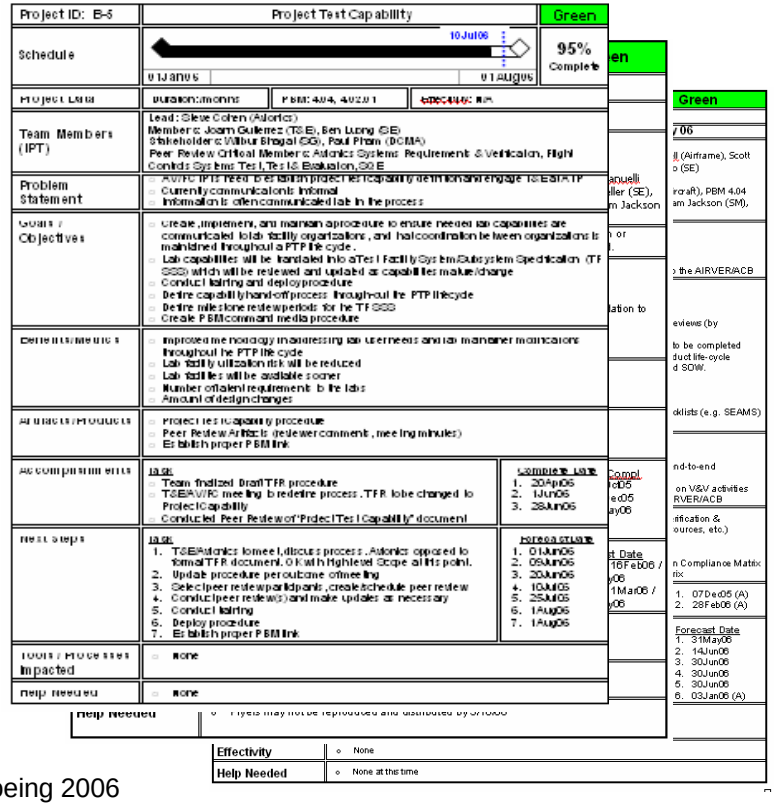


SE VSM Project Schedule & Plan

#	Title	Team Leader	ECD	% Comp	Rating
A-1	Design Review Template	Jim Settlemyre	8/25/2006	100%	BLUE
A-2	Interface	Samuel Son	3/28/2006	100%	BLUE
A-3	Requirements Enablers	Sunil Verma	3/27/2006	100%	BLUE
A-4	User Needs Meeting	Ralph Brunson	1/4/2006	100%	BLUE
A-5	SOR Development	Sal Trujillo	9/14/2006	100%	BLUE
A-6	Project Integration	Cecilia Rubio	5/28/2006	100%	BLUE
A-7	Team Members NAR	Kim Carruth	3/28/2005	100%	BLUE
A-8	Trade Study	Ralph Brunson	8/2/2006	100%	BLUE
A-9	Verification & Validation Plan	Ben Luong	12/9/2005	100%	BLUE
B-1	Verification & Validation Plan and Products	Ben Luong	10/27/2006	90%	GREEN
B-2	Peer Review Deployed program wide	Dana Pugh	10/15/2006	50%	GREEN
B-3	System Requirements Traceability Plan	Sal Trujillo	N/A	N/A	Combined with R-1
B-4	Aircrew Validation	Dave Lotts	11/3/2006	10%	RED
B-5	Project Test Capability (formally TFR)	Steve Cohen	9/1506	95%	GREEN
B-6	Integration of Support Systems into Development	Jim Fox	4/31/2006	100%	BLUE
B-7	Lessons Learn Captured	Marybeth Catoline	3/15/2007	50%	GREEN
B-8	Improve Risk Management Process	Ralph Brunson	10/13/2006	75%	YELLOW
B-9	Supplier Mgt - Risk and TPMs, 2nd Source Tech Review, Verify all Reqt	Santanu Sen	N/A	N/A	Transfer to C-1
BP-1	Engineering Best Practice	Samuel Son	12/21/2006	60%	GREEN
BP-2	Program Management Best Practice	Samuel Son	9/31/2006	95%	YELLOW
C-1	Technical Documentation Creation - Templates & Checklists	Willis Hamilton	11/17/2006	60%	GREEN
C-2	Control of Technical Documents released to Supplier Mgt - PE/PI	Willis Hamilton	12/15/2006	13%	GREEN
C-3	Control of Technical Documents released to Supplier Mgt - DR/MIP	Willis Hamilton	12/15/2006	13%	GREEN
C-4	Eliminate Redundant CMS Packages Reviews	Willis Hamilton	6/30/2006	100%	BLUE



ID	WBS	Task Name	RAA	Start	Finish	% Complete
259	9	VSM Phase-A Improvement Projects (9)	Theodore	5/2/05	6/23/06	64%
260	9.1	1. Interface Management (Son)	Son	5/2/05	1/4/06	100%
269	9.2	2. Project Reviews (Settlemyre)	Settlemyre	10/14/05	4/28/06	73%
276	9.3	3. Requirements Process Enablers (Verma)	Verma	9/1/05	4/3/06	100%
283	9.4	4. Definition and Refinement of User Needs	Brunson	8/10/05	5/12/06	91%
291	9.5	5. Statement of Requirements (SOR) Development Improvement	Trujillo	11/4/05	5/16/06	37%
301	9.6	6. Trade Study Improvement (Brunson)	Brunson	10/28/05	4/21/06	78%
310	9.7	7. Verification & Validation Planning Improvement (Manson)	Manson	9/9/05	12/9/05	100%
329	9.8	8. Project Team Memberships (Carruth)	Carruth	7/6/05	12/9/05	100%
348	9.9	9. Project Integration (Samuel Son/Greg Wildenthaler)	Rubio	7/1/05	6/23/06	1%
355	10	VSM Phase B Improvement Plans (9)	Theodore	1/2/06	12/29/06	23%
356	10.1	1. Implement V&V Plan & Products (Zaninovic & Gocal)	NZ & GG	1/3/06	6/30/06	22%
390	10.2	1. V&V Plan & Products Project Follow-up	B.Luong	1/2/06	12/29/06	7%
400	10.3	1a. Verification & Validation Products (Greg Gocal)	Gocal	2/17/06	2/17/06	100%
403	10.4	2. Peer Review Deployed program wide (Mukesh Luhar)	Pugh	2/15/06	7/7/06	0%
422	10.5	3. System Requirements Traceability Plan (Sal Trujillo)	Trujillo	3/1/06	6/29/06	10%
438	10.6	4. Aircrew Validation	Lotts	1/16/06	1/16/06	0%
440	10.7	5. Test Facility Requirements	Cohen	1/16/06	6/1/06	4%
450	10.8	6. Integration of Support Systems into Development	Fox	1/16/06	1/16/06	0%
452	10.9	7. Lessons Learn Captured	Bunnel	1/16/06	1/16/06	0%
454	10.10	8. Improve Risk Management Process	Brunson	1/3/06	6/1/06	75%
464	10.11	9. Supplier Management	Sen	1/2/06	1/23/06	0%



- Identified 22 projects from 3 VSMs
- Closed 11, Transferred 2
- Stimulating IPT integration
- Enterprise-wide collaboration

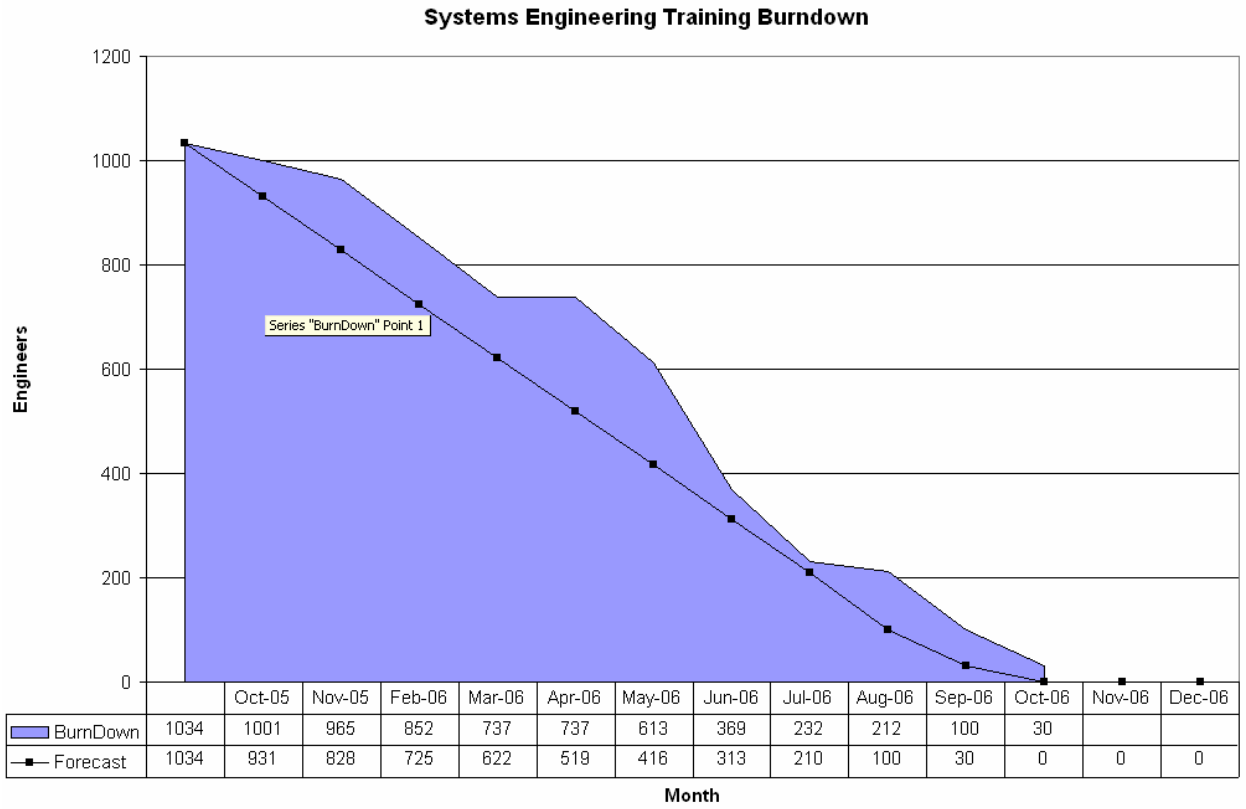
Metrics Summary Overview

Program-Level Metrics Review: Measuring Effectiveness of SE Process

Metric Titles	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
Systems Engineering Health					
1. SE Scorecard	G	G			
2. Best Practices Assessment (SE Unique)					
2a. Program Management Best Practices	G	G			
2b. Engineering Best Practices	G	G			
3. Risk Management Effectiveness	G	G			
3a. Project Approved Within Normal Lead Time	G	B			
Predictive Metrics					
1. Requirements Quality *(Engineering-Quality)*	N/A	N/A			
2. After-Initial Release/Initial Release *(Engineering-Quality)*	G	G			
3. Design Reviews: Critical Action Items *(IMP/IMS)*	G	G			
Reactive Metrics					
1. Advanced Assembly Orders *(Production-Quality)*	G	G			
2. LRU Tag Trend *(Production-Quality)*	G	G			
3. Deviations & Waivers *(Production-Quality)*	G	G			
Operational Metrics					
1. MTBM (I), Inherent *(Aircraft Reliability)*	B	B			
2. # of Work Packages with RHI >= 10 *(Aircraft Safety)*	G	G			

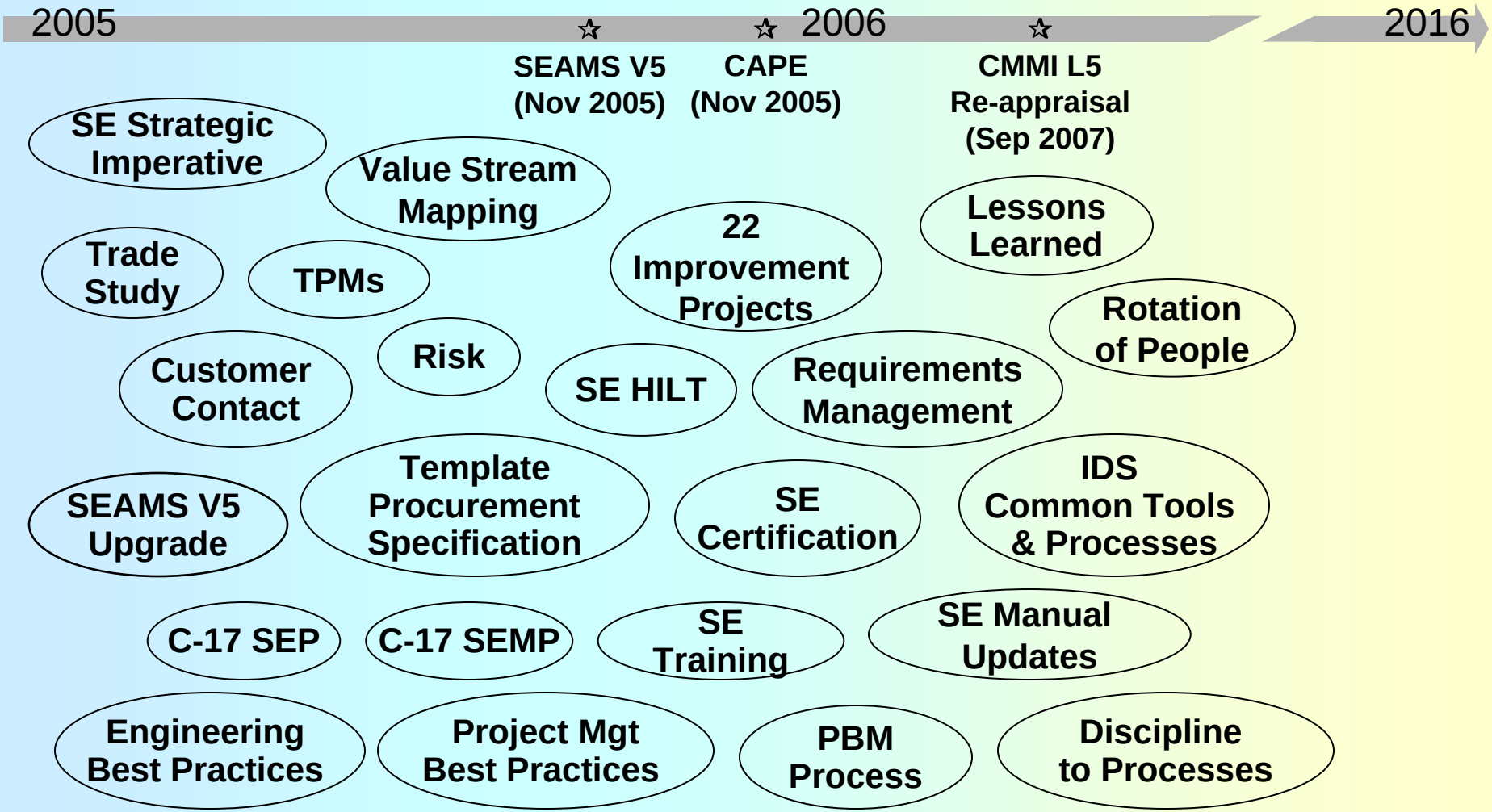
Systems Engineering Training

- Operational, Suitability, Survivability & Effectiveness conducted by SG and Boeing in Long Beach
- SE tool training provided on site to SG
- SE Overview training scheduled for all Air Vehicle engineers & project managers



		Oct-05	Nov-05	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
BurnDown	1034	1001	965	852	737	737	613	369	232	212	100	30		
Forecast	1034	931	828	725	622	519	416	313	210	100	30	0	0	0

Integrates Short-Term and Long-Term Actions



We are moving toward our vision of Systems Engineering Excellence

Summary

- Number of driving forces for change
- Used a structured, lean engineering analysis of systems engineering to take Systems Engineering on C-17 Program to the next level
  - Performed value stream map on product development process from customer need through verification
    - Identify key improvement areas
    - Integrated plans into System Engineering Strategic Imperative
- Built on our strong Process Based Management (PBM) foundation
- Change the culture
- Training is essential to deployment / sustainment
- Process application is key to institutionalization
- Application of Systems Engineering process execution encompasses everyone
- Communicate at all levels

Application of Lean techniques is key in supporting our journey to Systems Engineering Excellence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