

Improving Systems Engineering Process Through Value Stream Mapping

By Brent Theodore



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

• 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





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



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)

We Are

Here

- 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



- 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

11/1/2006



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



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





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





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, 2 nd 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

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

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259	9	VSM Phase-A Improvement Projects (9)	Theodore	5/2/05	6/23/06	64%	- 1	<u>^</u>						Antima				
260	9.1	1. Interface Management (Son)	Son	5/2/05	1/4/06	100%		<u>^</u>			7	4						
269	9.2	2. Project Reviews (Settlemyre)	Settlemyre	10/14/05	4/28/06	73%				6	5	-	Amun					
276	9.3	3. Requirements Process Enablers (Verma)	Verma	9/1/05	4/3/06	100%				í –	/	-						
283	9.4	4. Definition and Refinement of User Needs	Brunson	8/10/05	5/12/06	91%				_		-						1
291	9.5	5. Statement of Requirements (SOR) Development Improvement	Trujillo	11/4/05	5/16/06	37%					â	- efina		223				
301	9.6	6. Trade Study Improvement (Brunson)	Brunson	10/28/05	4/21/06	78%					۵	-	min	i i				
310	9.7	7. Verification & Validation Planning Improvement (Manson)	Manson	9/9/05	12/9/05	100%					-	1		÷a				
329	9.8	8. Project Team Memberships (Carruth)	Carruth	7/6/05	12/9/05	100%			$\overline{\Delta}$									
348	9.9	9. Project Integration (Samuel Son/Greg Wildenthaler)	Rubio	7/1/05	6/23/06	1%				mada	ànnana		hhanna	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				
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%							umum	mun		umumu	77773	
400	10.3	1a. Verification & Validation Products (Greg Gocal)	Gocal	2/17/06	2/17/06	100%						1						
403	10.4	2. Peer Review Deployed program wide (Mukesh Luhar)	Pugh	2/15/06	7/7/06	0%									2			
422	10.5	3. System Requirements Traceability Plan (Sal Trujillo)	Trujillo	3/1/06	6/29/06	10%							umu	mm				
438	10.6	4. Aircrew Validation	Lotts	1/16/06	1/16/06	0%						h						
440	10.7	5. Test Facility Requirements	Cohen	1/16/06	6/1/06	4%						2222						
450	10.8	6. Integration of Support Systems into Development	Fox	1/16/06	1/16/06	0%						h						
452	10.9	7. Lessons Learn Captured	Bunnel	1/16/06	1/16/06	0%						h						
454	10.10	8. Improve Risk Management Process	Brunson	1/3/06	6/1/06	75%						_	_	22228				
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Metrics Summary Overview Program-Level Metrics Review: Measuring Effectiveness of SE Process

Metric Titles	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
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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	В	
Predictive Metrics			
1. Requirements Quality (Engineering-Quality)	N/A	N/A	
2. After-Initial Release/Initial Release (Engineering-Quality)	G	G	
Design Reviews: Critical Action Items (IMP/IMS)	G	G	
Reactive Metrics			

		_
1. Advanced Assembly Orders (Production-Quality)	G	
0 I DII Tan Tuan I (Droduction Quality)		

- 2. LRU Tag Trend (*Production-Quality*)
- 3. Deviations & Waivers (Production-Quality)

G	G		
G	G		
G	G		

Operational Metrics									
1. MTBM (I), Inherent (Aircraft Reliability)	В	В							
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



Systems Engineering Training Burndown

11/1/2006





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

