2012 PM Challenge – EVA SE&I Submission

Title (max 8 words, include MBSE)
An MBSE Approach to Space Suit Development

Abstract (250 words)
The EVA/Space Suit Development Office (ESSD) Systems Engineering and Integration (SE&I) team has utilized MBSE in multiple programs. After developing operational and architectural models, the MBSE framework was expanded to link the requirements space to the system models through functional analysis and interfaces definitions. By documenting all the connections within the technical baseline, ESSD experienced significant efficiency improvements in analysis and identification of change impacts. One of the biggest challenges presented to the MBSE structure was a program transition and restructuring effort, which was completed successfully in 4 months culminating in the approval of a new EVA Technical Baseline. During this time three requirements sets spanning multiple DRMs were streamlined into one NASA-owned Systems Requirement Document (SRD) that successfully identified requirements relevant to the current hardware development effort while remaining extensible to support future hardware developments. A capability-based hierarchy was established to provide a more flexible framework for future space suit development that can support multiple programs with minimal rework of basic EVA/Space Suit requirements. This MBSE approach was most recently applied for generation of an EMU Demonstrator technical baseline being developed for an ISS DTO. The relatively quick turnaround of operational concepts, architecture definition, and requirements for this new suit development has allowed us to test and evolve the MBSE process and framework in an extremely different setting while still offering extensibility and traceability throughout ESSD projects. The ESSD MBSE framework continues to be evolved in order to support integration of all products associated with the SE&I engine.

Synopsis (50 words)
The ESSD SE&I team has utilized MBSE in multiple programs. By documenting all connections within the technical baseline, ESSD experienced significant efficiency improvements in analysis and identification of change impacts. ESSD MBSE framework continues to be evolved for supporting integration of products associated with the SE&I engine.

Biography (250 words)
Miriam Sargusingh is a NASA senior systems engineer with the Johnson Space Center (JSC) Extravehicular Activities (EVA) Office. She was the Architecture and Analysis Lead for the Constellation Program EVA Systems Project and currently works Systems Engineering and Integration (SE&I) for the EVA Systems Development team. She received a BS in chemical engineering from Yale University and a MS in Mechanical Engineering from National Technological University. Miriam has over 15 years experience in SE&I; more than 10 years in
space suit development and sustaining engineering. She has accumulated more than 8 years of experience in model based systems engineering (MBSE) supporting various aerospace and aeronautical systems development projects. Miriam currently serves on the JSC Systems Engineering Forum planning team and the JSC MBSE splinter team.

Christine Kovich is a systems engineer from Wyle currently working with the Extravehicular Activity (EVA) Project Office. She has over 16 years of experience in the EVA-related discipline. Christine has 6 years experience in SE&I serving as the book manager for the EVA Systems Requirements Document (SRD). During this timeframe she has also had the unique SE&I experience of working both at the Constellation Program level as well as in the EVA Systems Project Office. In addition she supports EVA’s MBSE process development. Christine received a BSME from Tri-State University and her previous experience includes the following: project management, flight analog studies lead, ISS and Shuttle EVA flight hardware certification, and ISS EVA development hardware testing coordination/implementation.

Lauren Cordova is a systems engineer from Booz Allen Hamilton with over 2 years experience as the Book Manager for the EVA Ops Con, Architecture Description Document, and Functional Analysis Document. In addition she supports EVA’s Model Based Systems Engineering (MBSE) process development and implementation as well as advanced EVA systems development. Lauren received a mechanical engineering degree from the University of Texas at Austin, and her experience includes SE&I, manufacturing, quality engineering, and environmental compliance across the aerospace, medical, and utility industries.
An MBSE Approach to Space Suit Development

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Agenda

• Introduction
• Model Based Requirements Development & Management Approach
  – Ops Con/models
  – Environments
  – Architecture
  – Interfaces
  – Functions
  – Decomposition
  – Performance Measures
  – Requirements / Verification
  – Functional Analysis
  – Technical Planning
  – Documentation
• Conclusion
• What is Model-Based Systems Engineering?
  – 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 (INCOSE-TP-2004-004-02, Version 2.03, September 2007)

• Why is it important?
  – Ensures traceability and completeness of systems engineering products (e.g., Ops Con, Requirements, Verifications, etc.)
  – Is an approach to systems engineering where information about the system is defined, standardized, and interdependent during the lifecycle process
  – Is a key step in moving from a “document-based” configuration management approach to a “data object or model-centric” approach
The NASA Johnson Space Center EVA Office Systems Engineering and Integration (SE&I) team utilizes MBSE to develop and manage requirements for an evolving, complex system that spans multiple programs.

The space suit architecture must meet various and often conflicting mission objectives while optimizing mass, volume, reliability and maintainability.

- Seated vehicle operations
- Occupant protection
- Post-landing suited ops
- Contingency crew survival
  - Fire & Tox protection
  - Water survival
  - Rapid cabin depress
  - Unpressurized 144 hr return

- Pressurized μ-g mobility
- Environmental protection
- Vehicle supported or independent life support
- Vehicle Maintenance/Reconfiguration

- Mobility to perform partial-g surface EVA
- Environmental protection
- Independent Life Support
The original design solution developed for Constellation involved a modular, reconfigurable, component-based architecture.

**LEA/Microgravity EVA Suit**
- (aka Configuration 1)
- Common Components:
  - Suit Multiple Connector (not shown)
  - Vehicle Multiple Connector (not shown)
  - Pressure Garment Materials & Design

**Interchangeable Components:**
- Helmet, Visor Assemblies
- Pressure Garment Segments
- Emergency Oxygen
- Life support umbilicals
- Thermal Undergarments

**Lunar Surface EVA Suit**
- (aka Configuration 2)
- Modular Components
  - Torso Assemblies
  - Gloves

*Notional picture does not include: Life Preserver and Emergency Breathing systems*

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Lunar Crewed Mission

- In the Constellation Program Lunar Design Reference Mission (DRM), the suited crewmember, and therefore the space suit, is involved in all phases and interfaces with multiple systems.
Space Suit Interfaces

- The space suit interfaced with every crewed vehicle included in the Constellation architecture.
MODEL BASED REQUIREMENTS DEVELOPMENT & MANAGEMENT APPROACH
Implementation of the SE Engine

Agency, Center, & Program Requirements

- Model-centric approach helps to keep this as robust yet nimble as possible.
- Ops cons will be used to help determine D&C spec applicability; DRM derived functionality will be used to support agency mission architecting activities.

Requirements flow down from level above

SYSTEM DESIGN PROCESSES

1. Stakeholder Expectations Definition
2. Technical Requirements Definition

Technical Solution Definition Processes
3. Logical Decomposition
4. Design Solution Definition

Perform and/or support hardware trades & analysis such as mass assessments and design compliance

Realized products from level below

System design processes applied to each work breakdown structure model down and across system structure

Hardware specs, and the necessary ICDs; additional levels of documentation will be created if needed

Requirements flow down to level below

TECHNICAL MANAGEMENT PROCESSES

Technical Planning Process
10. Technical Planning

Technical Control Processes
11. Requirements Management
12. Interface Management
13. Technical Risk Management
14. Configuration Management
15. Technical Data Management

Technical Assessment Process
16. Technical Assessment

Technical Decision Analysis Process
17. Decision Analysis

The integrated system will have to be evaluated to verify that the hardware will be safe enough for EVA

Evaluation Processes
7. Product Verification
8. Product Validation

Design Realization Processes
5. Product Implementation
6. Product Integration

Occurs in Hardware Team and below (i.e. prime contractor)

Product realization processes applied to each product up and across system structure

Realized products to level above

Figure 2.1-1 The systems engineering engine

Figure: NASA/SP-2007-6105 Rev1
Model Based Data Infrastructure

Provides Data & Documentation to support EVA Systems Operations and Hardware Development

Maintains data and traceability to support future analysis and requirements development efforts

Allows us to better trace the requirements synthesis process and logic (i.e. why we have the requirements we have)

Makes data accessible to various stakeholders

Program Management
Designers
Mission Architects
Safety
Contractors
Mission Ops

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The Space Suit System Model includes definitions of the three basic parts of the technical baseline (aka the Tri-Force): operational concepts, architecture/design, and requirements.

By capturing all of the connections between the technical baseline, we experienced a significant efficiency improvement in analysis and identification of change impacts.
Generic tech baseline would be available for basic families of hardware

Design & Construction Specs

Capabilities

Function A

Class A

Program Specific Capabilities

DRM

Ops Con

Env.

Perf 1

Perf 2

Function A

Arch A

Config 1

Config 2

Req A.1

Ver A.1

Allocated ➔ Derived •• Relational
Operational Models

- The Space Suit DRM decomposes program-level operations into suit-focused activities and adds contingency operations/ transitions.
Operational Concepts

• The Space Suit Operational Concepts (Ops Con) serve as the basis for communication between our stakeholders and designers
  – Stakeholders help us to understand their expectations on what the suit capabilities are and how it will be used
  – Designers provide information on how the suit is expected work

• Operational concepts are currently presented in document format:
  – Multi-Purpose Crew Vehicle (MPCV) Flight Suit Element Operational Concept provides Ops Con associated with Block 0 and Block 1 MPCV operation
  – International Space Station (ISS) Detailed Test Objective (DTO) Design Reference Document contains Ops Con associated with the Extravehicular Mobility Unit (EMU) Demonstrator
  – Advanced EVA Operations will contain the Ops Con associated with the Capability Driven Framework DRMs
Generic tech baseline would be available for basic families of hardware

Design & Construction Specs

Capabilities ➔ Function A ➔ Class A

DRM ➔ Program Specific Capabilities ➔ Function A ➔ Arch A ➔ Config 1 ➔ Config 2

Ops Con ➔ Env.

Perf 1 ➔ Perf 2 ➔ Req A.1 ➔ Ver A.1

Allocation Arrows ➔ Derived Arrows ➔ Relational Arrows
Hardware “Classes”

• The “class” hierarchy defines the scope of the project

• A “class” of hardware defines a generic technical baseline
  – Default set of standards & specifications
  – Supports a generic set of operational scenarios
    • Generic functions
    • Generic hardware

• Provides a platform for mission specific systems engineering
The Architecture is further defined with Physical Architecture Diagrams (PADs) showing the system interfaces.
Generic tech baseline would be available for basic families of hardware

Design & Construction Specs

- Capabilities
- Function A
- Class A

Program Specific Capabilities

- Function A
- Perf 1
- Perf 2

- Arch A
- Config 1
- Config 2

- Req A.1
- Ver A.1

Allocated ➔ Derived ➔ Relational
Requirements – SRD Structure

• The class hierarchy produces a requirements set that is easily extensible to future suit developments
  – Establishes a set of generic space suit reqs/standards
  – Builds upon generic reqs by allowing for vehicle/mission specific reqs to be captured

• Linking requirements to higher level classes limits “starting from scratch” when new programs are stood up

• This structure was created to maintain horizontal integration across all suited efforts
The WMS shall prevent direct contact of contained urine with the crew’s skin.
The WMS shall prevent direct contact of contained urine with the crew’s skin.

Physical constraint:
The 12-hr MAG shall fit within the allocated stowage volume.
The WMS shall prevent direct contact of contained urine with the crew’s skin.

Standard:

Physical constraint:

Functional/Performance:

The 12-hr MAG shall fit within the allocated stowage volume.

The MPCV Flight Suit shall contain urine for 12 hours during Flight Test Missions.
The WMS shall prevent direct contact of contained urine with the crew’s skin.

Physical constraint:
The 12-hr MAG shall fit within the allocated stowage volume.

Functional/Performance:
The MPCV Flight Suit shall contain urine for 12 hours during Flight Test Missions.

Environment Definition:
The WMS shall function after stowage in the Orion pressurized volume.
Verification

• Verification planning
  – Begins early in the project life cycle
  – Updates to verification planning will continue throughout the logical decomposition and design development phases, especially as design reviews and simulations shed light on items under consideration in the requirements development phase

• Our verifications were drafted along with the requirements to ensure that we had verifiable requirements
  – All verifications are linked to their respective requirement
  – The Environments map to specific operations from the Ops Con model which was intended to support the verification planning
    • Certification is a classification applied to environments if the verification for the requirement calls for ‘certification’ in a specified environment

Without a verifiable baseline and appropriate configuration controls, later modifications could be costly or cause major performance problems for your system
Verification Roles & Responsibilities

• A need to clarify verification roles and responsibilities was realized during discussion regarding requirements that were applicable to the prime contract:
  – Which party is responsible for developing detailed verification objectives (DVO)
  – Which party is responsible for executing per the DVO

• Approach
  – Responsibility categories were developed to group verifications of similar scope and complexity. Establishing categories (buckets) ensured that approaches were consistently applied and that any exceptions to the philosophy were noted

• Assumptions
  – Requirements/children sharing equivalent scope will not duplicate verification efforts (this is based on similar/equal requirements residing at multiple levels)
  – Requirements sharing equivalent scope and functionality (noun changes) need to share a verification approach
Functions

Generic tech baseline would be available for basic families of hardware

Design & Construction Specs

Capabilities ➔ Function A ➔ Class A

Program Specific Capabilities

Function A

Perf 1 ➔ Arch A

Perf 2

Req A.1 ➔ Arch A

Ver A.1

DRM

Ops

Con

Env.

Allocated ➔ Derived ➔ Relational

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Functional Decomposition

• Functions provide the link between operations, architecture, and requirements (Tri-Force)

• Functions were created using two methods:
  1. Decomposition from Program allocated “capabilities” through a hierarchical approach
  2. Derivation from the operations
• Capabilities are high level/programmatic functions
  – Capabilities decompose into lower level functions specific to the system of interest
  – Capabilities were included to show traceability to Program allocated functionality
Derivation from Operations

Suit Up

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Indicates a specific range of motion and torque at 1.0 psid

Mobility to mate an umbilical unpressurized

Provide mobility

Indicates a leak threshold at 2.0 psid

Leak check pressure

Mobility to demate an umbilical unpressurized

Operation

Function

Interface

Performance Measure

FFBD

Don suit

OR

OR

AND

AND

AND

Pressurize suit

Maintain total pressure

Perform controlled depressurization

Connect to services

Provide services

Maintain relative humidity

Provide adjustable temperature control

Maintain breathing air concentrations

Provide two-way communication to crewmember

AND

AND

Conduct pressure

Provide mobility

Disconnect from services

If cooling is required

Provide portable cooling

Provide adjustable temperature control

Indicates a specific range of motion and torque at 1.0 psid

If cooling is required

Indicates a leak threshold at 2.0 psid

LEA/GS Audio

GS/LEA Breathing Gas

GS/LEA Power

LEA/GS Audio
Requirements Validation

• Requirements were initially developed from Subject Matter Expert (SME) input and decomposition/flow down of program allocated requirements
  – Though the Ops Con was used to derive some requirements, they were not initially linked

• Audits were used to show that program allocated requirements were answered in our requirements set (traceability report)

• The “Tri-Force” allowed for validation of the requirements set from a functional perspective (did we have the right requirements)

• After developing the MBSE framework, the requirements were linked to the System level models through the functional analysis and interface definitions
  – This aided in identification of impacts for a proposed change to the technical baseline
Environments

Generic tech baseline would be available for basic families of hardware

Design & Construction Specs
- Capabilities
- Function A
- Class A

Program Specific Capabilities
- Function A
- Perf 1
- Perf 2
- Arch A
- Config 1
- Config 2

Requirements:
- Req A.1
- Ver A.1

Legend:
- Allocated
- Derived
- Relational
Environments

- The system model framework included several aspects of the space suit environments:
  - Definition of environments to which the hardware could be subjected
  - Definition of environments in which the hardware needs to operate
  - Definition of environments to which the hardware would be optimized
  - Requirements specifying the environments to be created by the space suit

- The space suit environments definitions were scattered across several documents with no mapping to operational concepts, requirements or capabilities
  - We were able to publish the definitions in 1 document

- Environments map to specific operations from the Ops Con model
  - Using the definition to Ops Con mapping, the environments could be traced to requirements and verifications
Technical Planning

• We also used Issues and Actions to aid in technical planning
  – Issues were comprised of those items considered To Be Determined (TBD) and To Be Resolved (TBR)
  – Actions were items used to track open work that was not part of the TBD/TBRs but were necessary to update the technical baseline
  – Both Issues and Actions were associated with the following items:
    • Ops Con
    • Architecture
    • Functions
    • Requirements
    • Verifications
    • Environments
• Templates were created to generate documents with particular formatting
  – Templates were hardcoded to pull in particular document sections with associated linked data
• Documents were generated by printing out specified items based on the associated links (e.g. requirements linked to architecture items)
  – Without changing our current structure, the linkages also allowed us to create documents for specific DRMs or suit configurations (e.g. SRD, ERD, contract applicable requirements)
• Data can also be extracted using a query
  – Exports can be performed in csv, rtf, or HTML formats
Other models

• Several models have been used to develop and validate system requirements
  – Wissler Model
  – Thermal Desktop CFD Model
  – Excel Pressure Drop / Flow Model
  – Macroflow Pressure Drop Model
  – EVA System Mass Tracker
• These models are configuration managed (i.e. data managed) by the analyst (except Wissler)
  – Model descriptions and results are presented to peers and stakeholders as part of analysis process
  – Results are evaluated and used to support requirements validation or change package
• There are no direct links between analytical models and SE Database
THE SPACE SUIT MBSE APPROACH PUT TO THE TEST

In response to the announcement of the cancellation of Constellation (2/1/10), the EVA Systems Engineering & Integration team was given the challenge to reduce contract scope commensurate with the redirection and minimize overhead associated with engineering the system.
Initial Scope of the Mission

- Transit
  - Dock to in-space asset
  - Dock to capture LEO Satellite
  - LEO RPOD Operations
  - Launch Operations
    - Hardware Delivery
    - Vehicle Integration
    - Pre-Launch ops
    - Day of Flight Suit-Up
  - Emergency Pad Egress
  - Pre-Mission Preparation
    - Fitchecks
    - Training
  - Production / Refurbishment
    - Manifest
      - N
      - Mission Analysis
    - Special Tool or System Mod Rqd to support mission?
    - Y
  - Return EDL, Recovery
  - Earth Entry Preparation
  - Stow CS/Flight suit for mission duration
  - ISS Departure Preparation
    - System C/O, Stow
    - Stow EVA Suit, Unstow Flight Suit
  - Pressurized Suited Ops
    - Pad / Ascent Abort
    - Emergency PAD Ops
    - Pressurized Suited Ops
    - CABIN Depress
    - Maintenance
      - Cont. EVA
    - Unrecoverable Cabin Depress
  - Configure/Reconfig Suit
  - Perform EVA
  - Prep for Return
  - RPOD
  - Transit
  - Cont. EVA
  - Unpress Survival
After the 2/1/11, the EVA System scope was reduced to include only ISS Missions.
EVA System Re-Architecting

- An SE&I Tiger Team was stood up and given three weeks to update the technical baseline per the reduced scope:
  - Update to the operational concepts
  - Identify the relevant requirements from Level 2 (CARD), Level 3 (SRD), Level 4 (ERDs), HSIR, and IRDs
  - Updating the deliverable components list
  - Update to technical resource allocations (mass, volume)
  - Update verification responsibility
  - Update the Applicable Documents List

- Reports of requirements with mission phase applicability and parent-child relationships identified helped to expedite this process

- Existing models defining mass helped to expedite update to mass allocations
Model Updates

• Changes to the model instigated by this effort:
  – Implemented linkage of requirements to hardware configurations instead of mission phase “technical points of contact”
  – Separating out of functional requirements with mission / configuration dependent performance specs

• Documents can be generated by printing out requirements linked to certain architecture items

• Without changing the current structure, these additional links will allow creation of LEA-focused documents:
  – J-19
  – SRD
  – ERDs
Requirements Streamlining Effort

• In order to minimize systems engineering overhead, a restructuring effort was undertaken to reduce the number of requirements in the EVA System requirements set; this would save resources by reducing unnecessary requirements management and verification activity
  – Delete redundant requirements
  – Merge related requirements where appropriate
  – Goal was to maintain each “requirement” only once in the entire technical baseline; i.e. Do not duplicate an Interface Requirement Document (IRD) requirement in the SRD

• At this time, the requirements were also leveled
  – We took the existing SRD and 2 Element Requirement Documents (ERDs) and combined them into one document. Goals of this effort included the following:
    • Levied the requirements at the level appropriate for verification, i.e. pushed Contract End Item (CEI) specific requirements down to the CEI Specification Documents

• We updated the model framework to produce a requirements set that is easily extensible to future suit developments
  – Established a set of generic space suit standards in the EVA SRD
Requirements Leveling Approach

• **EVA SRD System-level requirement**
  – Functions that include multiple elements
  – Standards that apply to multiple suit developments

• **EVA SRD Element-level requirement**
  – Decompositions specific to suit development
  – Allocations where Project-level margins are desired
  – Requirements necessary to bound contract scope

• **LEA Suit ERD-level requirement**
  – Decompositions that are appropriate for the Element-level
  – Element-level details where contractor ownership is desired

• **Subsystem-level requirement**
  – Section removed; allocation directly to CEIs from the Element-level
  – Rely on the assignment of technical owners to track responsibility for applicable requirements

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Push to Data-Centric

- The EVA Systems Engineering Model inherently captures the SE definition in a data centric manner (as opposed to document-centric)
- Through use of publishing software, this data is sorted and presented in document format per the customers requirements
- A data-centric configuration management approach was developed but never implemented by the EVA Office due to resource constraints
- Things yet to be considered
  - Linkage to applicable documents
  - Implementation of document-centric requirements and other systems definition artifacts applied by the Program or other authoritative sources
NEXT STEPS
Develop “Generic” Models

• Utilize the system model developed for Constellation to develop a generic space system model
• Development of a generic model would reduce “start-up” cost and time and time for a new program
  – Basic operational concepts, capabilities and even requirements would already be defined
  – The time to establish the data infrastructure would be significantly reduced
• A generic system model would aid in mission architecting studies
  – Basic capabilities would be defined to support high level functional analyses
  – Basic operational concepts would be defined to support high timeline analyses
  – Resource utilization could be defined to support trade studies and help size supporting systems
• Capturing basic design features will help lead to suit design standards
Generic Operational Models

Mission Preparation

Launch

Transportation to Destination

CDDT

Flight Ops Training

Crew Worn

Stowed

Destination Activities

Emergency Vehicle Egress

Earth Entry / Landing

Return Transportation

Crew Worn

Stowed

Stowed

EVA

Unpressurized cabin survival

Contingency EVA

Stowed

Stowed

Stowed

Assembly, Test, Fitcheck, etc.

Post-Landing Processing

Generic model overlaid by Generic flight suit and EVA suit operational models

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Update Model to Capitalize on Class Definitions

Flight Test DRM

ISS DRM

Lunar Transit DRM

Fcn: Contain Waste

... for 12 hrs

... for 48 hrs

... for 144 hrs

Pressure Garment

MPCV Flight Suit

PGA

LSS

Helmet

PAS

Gloves

Vent Kit

Thermal Kit

Biomed

MAG

CCA

LCVG

AIU

FRCL

LPU

12-hr MAG

48-hr MAG

144-hr WMS

3/21/11

M. Sargusingh / NASA JSC-XX, L. Cordova / BAH
We realized that multiple requirements were required for each function based on the specific performance required for a particular mission / program.

We are currently exploring the best method for implementing performance items:

- Performance items would link to functions in accordance with specific ops con
- Functions would continue to link to architecture items, and performance specifications would be linked to specific configurations.
Data-centric Configuration Management

- Control data not documents
- Allows contextual data (e.g. concepts of operations, functional analysis, etc) to be reviewed along with controlled data such as requirements
- Data objects can be published in various reports customized to the stakeholder without compromising the integrity of the data
- Allows for more comprehensive stakeholder review
- Shifts emphasis on content of the data instead of the scope of a document
LESSONS
Lessons Experienced...

• Tools and processes for complex systems need to be architected just as carefully as the hardware being developed
  – Want to implement something before folks get comfy
• Fancy tools are only useful if people use them
  – Grandfathered processes
  – Parallel processes
• Data-centric is great... in theory
  – People think in documents
  – Determination of what data needs to be controlled is not as intuitive as with documents
• Communication interfaces are just as important as the data being provided
  – Not everyone needs to handle the data in its native/source environment
  – We need to show it the way that people can read it

... time will tell if these lessons were learned
QUESTIONS
BACK-UP
Mass Tracker Spreadsheet

MEL and MGA multipliers feed the component Mass spreadsheet

Mass Spreadsheet feeds manually assembled configuration spreadsheets

Configuration totals feed a page which contains historical data

TPM graph is generated from the historical data worksheet

We want to get this in the SE database as soon as we can get it to do math!!!
Design Compliance

• Requirements Design Compliance purpose is to objectively determine if the preliminary design can be expected to meet requirements to an acceptable level of risk
• The objectives of requirements design compliance include
  – Identify and establish resolution paths for architectural performance/design issues as early in the design cycle as possible
    • Proactively manage ‘acceptable level of risk’
    • Early issue resolution/prevention reduces cost and schedule impacts
    • End-to-End mission perspective
  – Utilize objective design evidence to determine success of design cycle, from architecture perspective of the design reference mission (DRM) and operations concepts (ops con)
  – Facilitate vertical integration of design compliance data with Projects and horizontal integration across level II
  – Report and track significant design compliance issues (design compliance matrix is only one part of design compliance)
  – Engage architecture requirement owners in design aspects in preparation for requirement verification (‘get our hands dirty’)

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Verification Logic Network (VLN)

• VLN is:
  – A strategy to provide evidence of closure for each Detailed Test Objective (DTO)
  – Bottoms-up plan by which verification events can be efficiently executed (ensures efficient grouping of requirements)
    • Will logically group multiple requirements that can be verified with one activity
    • Verification event can be a DAC cycle closure, MEIT, FEIT, DSIL event, Flight Test, Mission Sim
  – Graphical representation of the verification events to close out the applicable requirements set (i.e. CARD, IRD, SRD)
  – Aid in identifying gaps and/or any overlaps in the verification planning process
    • Schedule conflicts
    • Delivery conflicts with hardware or software
    • Clarify test configurations and processes
• In summary, a VLN is an integrated system verification activity network