RequirementsExperts

Training and Services for Project Success

Getting Started on the Right Foot – Developing Requirements for Constellation's Next Generation Space Suit

Presented at INCOSE 2010

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System Engineering
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Overview

- Part 1: The Basics
  - Risk and Requirements
  - Requirement Validation
- Part 2: Application Case Study
  - Constellation Program Suit Requirement Development Process
  - Results
  - Constellation Program Suit Continuing Requirement Management Process
  - What we could have done better
  - Closing Thoughts

Note: This paper is based on a presentation made by the authors at NASA's PM Challenge, Galveston, Texas, February 2010.

- Risk and Requirements

NASA OIG

- "Program risks increase when contracts are awarded before developing a sound business case and clearly defining requirements placing the project at risk of significant cost overruns, schedule delays, and performance shortfalls."

  NASA's Most Serious Management and Performance Challenges – 2008

GAO

- "The start of product development represents the point at which program managers make a commitment to provide a product that will perform as required and be delivered on time and within estimated costs."
- "Programs are more likely to succeed if program managers are able to achieve a match between user needs, which eventually become requirements, and resources (technology, design and production knowledge, money, and time) at the start of product development."
- "Conversely, if they do not match requirements with resources, cost overruns and schedule delays are likely to occur, reducing the organization's buying power in other areas."

GAO-03-598

Setting Yourself Up for Failure

- Project success is “improbable” for 68% of the companies Ellis studied
- “Projects might succeed – but not by design. Based on the competencies present, these companies are statistically unlikely to have a successful project.”
- While these companies indicated they recognized that requirements are important to project success, they still failed to take effective actions to insure a good set of requirements.
- By doing so, they tripled their chances of project failure

2008 Study by Keith Ellis, IAG Consulting of 100 companies with projects in excess of $250,000

No Surprises

People who write bad requirements
should not be surprised
when they get bad products…

but they always are.

Ivy Hooks

A Winning Product

- Delivers what's needed
- Within budget
- Within schedule
- With desired quality

Risk: Anything that can prevent you from delivering a winning product!

- Requirement Validation

Requirement Validation

- Requirement validation confirms the completeness and correctness of the requirements
  - Starts with first requirement and continues through life cycle
  - Makes sure you are building the right thing
- Helps ensure requirements are:
  - Needed, verifiable, achievable
  - Clear, concise
  - Correct, consistent, and complete
- Two types
  - Continuous
  - Discrete

Who Does Requirement Validation?

Continuous Validation Process

- Continuous validation holds everyone responsible
  - Requires standards and checklists
  - Requires training
  - Management has to enforce discipline and accountability
- Benefits
  - Stops the creation of BIG bad documents
  - Most effective way to realize process improvement
  - Reduces time for milestone reviews
  - Prevents lost time due to rework

Continuous Validation Process

- Requirement Writer:
  - Write requirement and associated attributes
  - Check requirements against standards
  - Submit to gatekeeper for review in “chunks”
- Gatekeeper (person or inspection points)
  - One or more experts
  - Reviews requirements against standards
  - Accepts defect-free requirements for input to database or document
  - Return requirements to author if defects found

Discrete Validation Process

- Key milestone that requires time and resources
  - Formal process
  - Complete document
  - Involves a wide range of stakeholders
  - Requires standards and feedback mechanisms
  - Requires training
  - Management has to ensure responsiveness
  - System Requirements Review (SRR) results in a requirement baseline
- Effective IF
  - The right people are involved
  - The products are ready for review
  - The participants know what to do
  - Management ensures compliance

- Constellation Program Suit Element Requirement Development Process

Suit Element Requirement Development Challenge

- The Task
  - The team was asked to develop an Initial Capability (and Lunar surface requirements when common hardware would be used) requirement set for the Space Suit Element in time to support the Suit Element SRR and for release with the RFP for a prime contractor in mid-fall.
- Schedule
  - Very Short Schedule – 3 Months from initiation of requirements generation to Major Project Milestone review and 5 months to baseline set of Suit system requirements.

Suit Element Requirement Development Challenge

- The Philosophy
  - Learn from past project's mistakes in how and when requirement are written
  - Clean sheet approach to developing a space suit and writing the requirements
  - Exercise the text book methodology of Systems Engineering and Requirement generation in a NASA project
  - Produce quality requirements that are verifiable in a cost effective manner that address the functionality and performance defined in the Constellation EVA System Operations Concept and EVA Systems Architecture documents.

Suit Element Requirement Development

- Approach:
  - Co-located the team off-site in a conference room facility to enable a concentrated effort – this reduces the risk of day-to-day distractions which is a risk to product quality and schedule.
  - Provided training in requirement development and writing processes – this reduces the risk to quality.
  - Reduced risk to requirement development by contracting out the training and using consultation
    - standard training as provided to the Constellation Program,
    - an independent "fresh set of eyes" on how requirements could be interpreted and implemented – this reduces the risk to quality.
  - Used CRADLE tool to develop requirements prior to baseline.
    - Post baseline, the requirements were managed out of CRADLE, but draft revisions were handled outside of CRADLE until change approval.

Suit Requirement Development

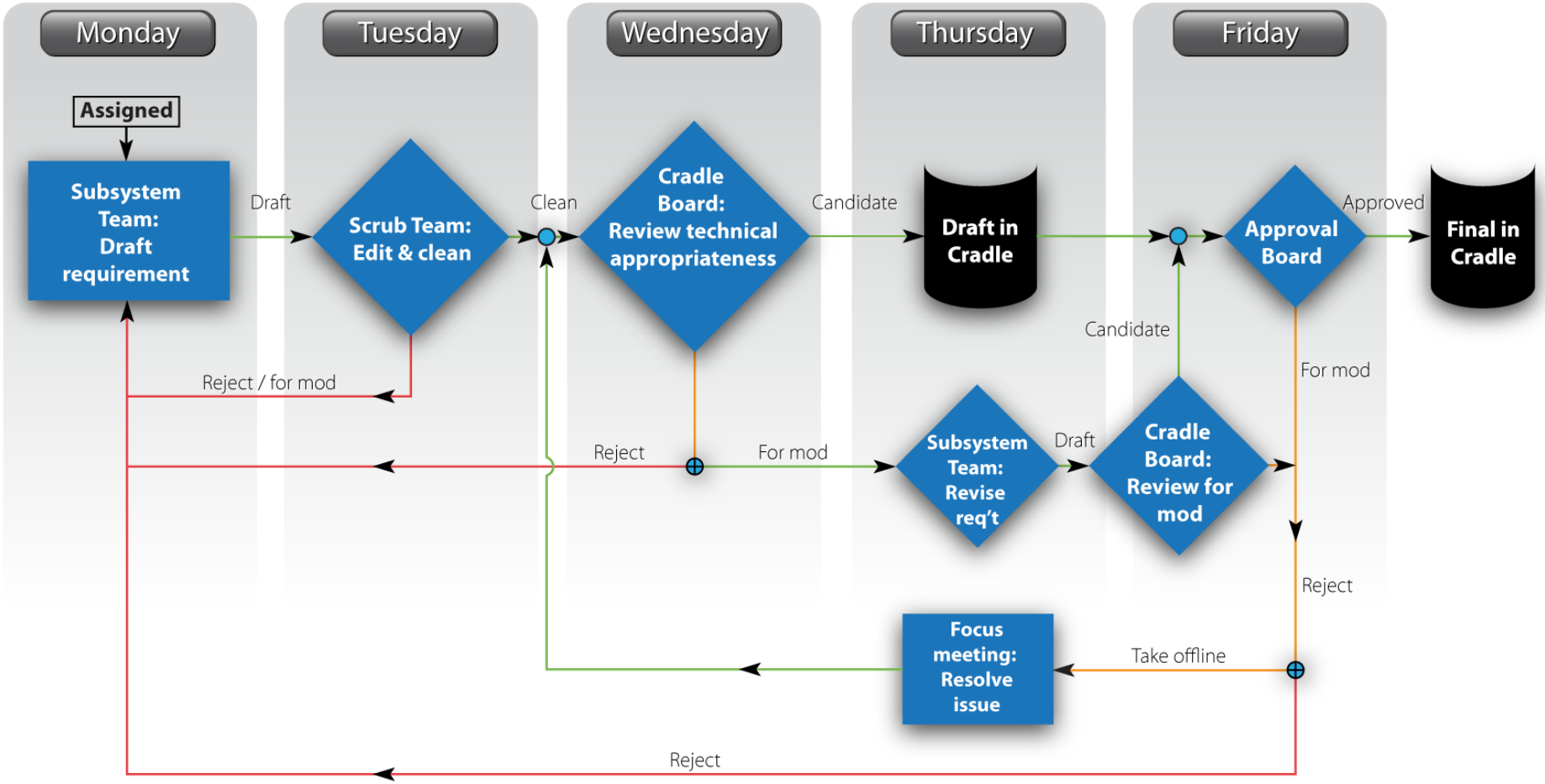
- Ground rules
  - Requirements must meet the criteria for good requirements in the “Checklist for Good Requirements”,
  - Include rationale for each requirement,
  - No copying parent requirement with a noun change as a method of allocation,
  - All requirements are verifiable, clear, concise
    - If it can be interpreted in more than one way or is not verifiable it is not ready for acceptance.

Putting Requirement Risk in the Proper Perspective

- Not to put too much pressure on you….
  - The Requirements Document is probably the single most influential piece of paper that we have control over in the entire Constellation Program.
  - This is our chance to make sure that we are asking for what we really want. Let's get it right.
  - This is a big, fat, hairy deal. If we don't get this right, folks 20 years from now will be shaking their heads and saying, "What were those yahoos thinking?"
  - I'll be around and don't want to go to that meeting.

CxP EVA Suit PGS Team Requirement Kickoff Meeting 5/2007

Suit Requirement Development Process



Results

- For the Suit Element Requirement Document (ERD) SRR, a ratio of 0.38 Review Item Descriptions (RIDs) were received per requirement.
  - In comparison, the parent EVA Systems Requirement Document had a 2.94 RID/requirement ratio at its SRR.

Potential bidders for the development of the Suit Element stated that the ERD was:

"… the most comprehensive and of the highest quality they ever remember seeing."

The JSC Engineering Directorate Crew and Thermal Systems Division Chief was also very impressed with the quality of the Suit ERD, saying:

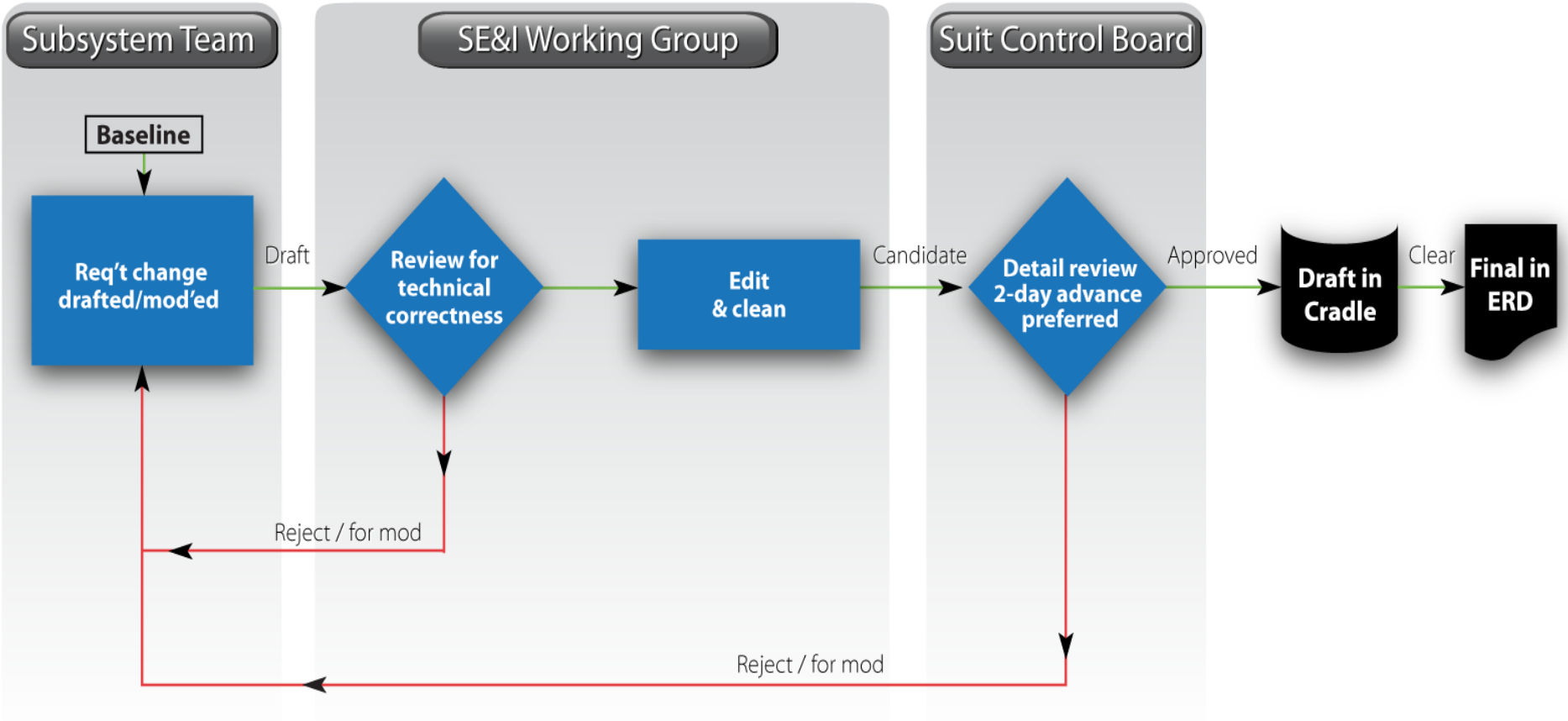
"I can't say enough about how amazed I am by this set of requirements documents. As far as I know, no other Cx project has allocated and decomposed anywhere near to this level of depth. You are the first. I have also never seen anything like these from previous programs."

- CxP Suit Continuing Requirement Management Process

Post-baseline Requirement Development and Validation

- As a result of the extremely compressed requirement development schedule, there remained several areas that needed more work and issues that needed to be resolved prior to preliminary design taking place.
- These open areas included:
  - resolving TBDs/TBRs in the requirement set,
  - finishing the verification requirements,
  - defining the internal interfaces and maturing applicable interface requirements
  - and adding Ground Support Equipment (GSE) requirements to the ERD.
- Therefore, a requirement development and maturation process was needed to continue the development of the requirements.

Requirement Review Process
Post-ERD Baseline



- Wrap up

What we could have done better

- Challenging schedule resulted in a lot of open work post baselining of ERD.
  - Large number of TBDs/TBRs
  - Interfaces identification and definition incomplete
    - Some of the external interfaces just didn't exist due to sister projects were evolving in parallel and at times without the same rigor demonstrated in the Suit Element effort.
  - Traceability incomplete
  - Verification requirements incomplete
  - Ground Support Equipment (GSE) requirements needed to be developed
- Difficult to keep requirements at the right level
  - Some requirements may not have been needed
  - Some requirements reflected or assumed a design where NASA was clear there was only one desirable functional solution.

Parting Thoughts

- Address Requirement Risk at the beginning of your project
- Develop a formal requirement development process that includes continuous requirement validation
- Include continuous requirement validation into your requirement change management process
- Train your team
- Enforce the process
- Allocate the time and resources needed to do the job right – the first time!!

- Presenter Biographies

Terry Hill

NASA/JSC Constellation Space Suit System Engineering Project Manager

Terry Hill is NASA's Johnson Space Center's Engineering Project Manager and deputy CxP EVA Suit Lead for the CxP Suit Element, responsible for the development of the functional, performance, and quality requirements and preliminary design of NASA's next generation space suit system.

Terry has a BS in Aerospace Engineering and a MS in Guidance, Navigation & Control Theory with a minor in Orbital Mechanics and Mathematics from the University of Texas at Austin.

He began his career at NASA while working on his masters thesis project in developing banks of simplified Kalman filters integrated into an artificial neural network to obtain an optimal state solution for precision landing on Mars.

While at NASA ,Terry has worked on projects and programs spanning verification of ISS navigation software, Shuttle Design Test Objectives (DTO) and back room mission support, X-38 Crew Return Vehicle navigation algorithm development, Space Launch Initiative technology development, Orbital Space Plane project office ISS-Prime integration, STS-107 Return to Flight Tile Repair capability development, to Constellation Program Space Suit System leadership.

In leading the CxP Suit Element engineering team, Terry has facilitated the development of system requirements for space suit development and a clean-sheet design approach that has widely recognized within and outside of NASA.

Lou Wheatcraft

Compliance Automation – Senior Consultant Trainer

Lou Wheatcraft is a senior consultant/instructor for Compliance Automation, who has over 40 years experience in the aerospace industry, including 22 years in the United States Air Force. Lou has taught over 120 seminars in requirement development and management for NASA's APPEL Program and industry over the past nine years. He has worked with, and provided intact team training and consultation to multiple NASA project teams at many of the NASA Centers.

Lou has had articles published in the International Council of Systems Engineering (INCOSE) INSIGHT magazine and in DoD's magazine, CrossTalk. Lou has made presentations at NASA's PM Challenge, INCOSE's International Symposium, and at the local Project Management Institute (PMI) Chapter Meetings.

Lou has a BS degree in Electrical Engineering, an MA degree in Computer Information Systems, an MS degree in Environmental Management, and has completed the course work for an MS degree in Studies of the Future.

Lou is a member of INCOSE, co-chair of the INCOSE Requirements Working Group, a member of PMI, the Software Engineering Institute, the World Futures Society, and the National Honor Society of Pi Alpha Alpha. Lou is the recipient of NASA's Silver Snoopy Award and Public Service Medal and was nominated for the Rotary Stellar Award for his significant contributions to the Nation's Space Program.