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Edinburgh, UK

July 18 - 21, 2016

A Process for Capturing the Art of Systems Engineering

Skip Owens

Carrie Sekeres

Yasmeen Roumie

The “Art” of Systems Eng.

“Technical leadership, the **art** of systems engineering, balances broad technical domain knowledge, engineering instinct, problem solving, creativity, leadership, and communication to develop new missions and systems.”

- “The Art and Science of Systems Engineering” – NASA.gov Jan 2009

Carrie Sekeres

- Pursuing B.S. in Aerospace Eng. (graduates Spring 2017) with a plan for a Masters (Systems Eng)
- Embry-Riddle Aeronautical University
- Background: University technical writing lab, Women's Baja team technical integration & communications

Yasmeen Roumie

- Graduated from Stuyvesant High School in New York City
- Attending Fordham University in New York in Fall of 2016 for Computer Sciences
- Background: Computer programming & robotics
- Summer of 2016 NASA LSP intern: HoloLens Augmented Reality

Skip Owens

- B.S. in Aerospace Eng.
- Masters in Space Systems Engineering from Stevens Institute of Technology
- Discipline Expertise: Mission/Flight Design & Orbital Mechanics
- Spacecraft to launch vehicle integration with NASA LSP

History of this effort

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- Began purely as a knowledge capture and collaboration pilot for NASA's Launch Services Program (LSP) at Kennedy Space Center (KSC)
  - Introduce a new knowledge capture & collaboration tool (Confluence)
  - Test out effectiveness with 3 LSP groups
    - Integration Engineering (IE)
    - Flight Controls
    - Avionics
  - Two summer interns lead the pilot program

History of this effort

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- LSP Integration Engineering was already capturing knowledge & documenting our processes
- Introducing a new tool with leadership from the interns resulted in a more effective knowledge capture
- After the pilot was completed (Aug 2015) the potential for capturing the “why” (or the “art”) of systems engineering was fully realized and a process was reverse engineered from these efforts

Art vs Science

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- "The Art and Science of Systems Engineering" – NASA.gov Jan 2009:
  - Systems management is described as the science of systems engineering
  - Technical leadership is identified as the art of systems engineering

Art vs Science

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- Management of systems is easily captured in processes and procedures
- Technical leadership is an art that is not easily defined, cannot be easily taught and is quite challenging to bound
- Process and procedures are the “how”
- The **art** of systems engineering is the “why”

Why Confluence

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- What is Confluence?
  - Collaborative Commercial-Off-The-Shelf (COTS) wiki
  - Developed by Atlassian
- Chosen for the pilot because:
  - Successfully in use at 2 other NASA centers
    - Goddard Space Flight Center center-wide wiki
    - “JPL Wired” center-wide wiki: https://vimeo.com/8303614
  - Used by NASA to create and publish the Software Engineering Handbook:https://swehb.nasa.gov/display/7150/Book+A.+Introduction

Why Confluence

- NASA Goddard & JPL had already evaluated the wiki options and concluded that Confluence was the best option for this type of knowledge capture
- We chose to leverage the work of these other NASA centers and utilize their experience and lessons learned by using the same software
- *Will cover lessons learned at the end*

The Process

- 6 Main Steps:

1. Create a Functional Architecture
2. Identify Current Knowledge Capture Methods
3. Map Existing Knowledge Capture Methods
4. Enhance Knowledge Capture Methods
5. Introduce Enhanced Knowledge Capture
6. Evolve the Knowledge Capture

The Process

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- The following slides will walk you through the 6 steps of the process using the NASA LSP Integration Engineering group as an example
- To be an effective example, you first need to know a little bit about NASA's Launch Services Program and the role the Integration Engineering Group plays

NASA LSP

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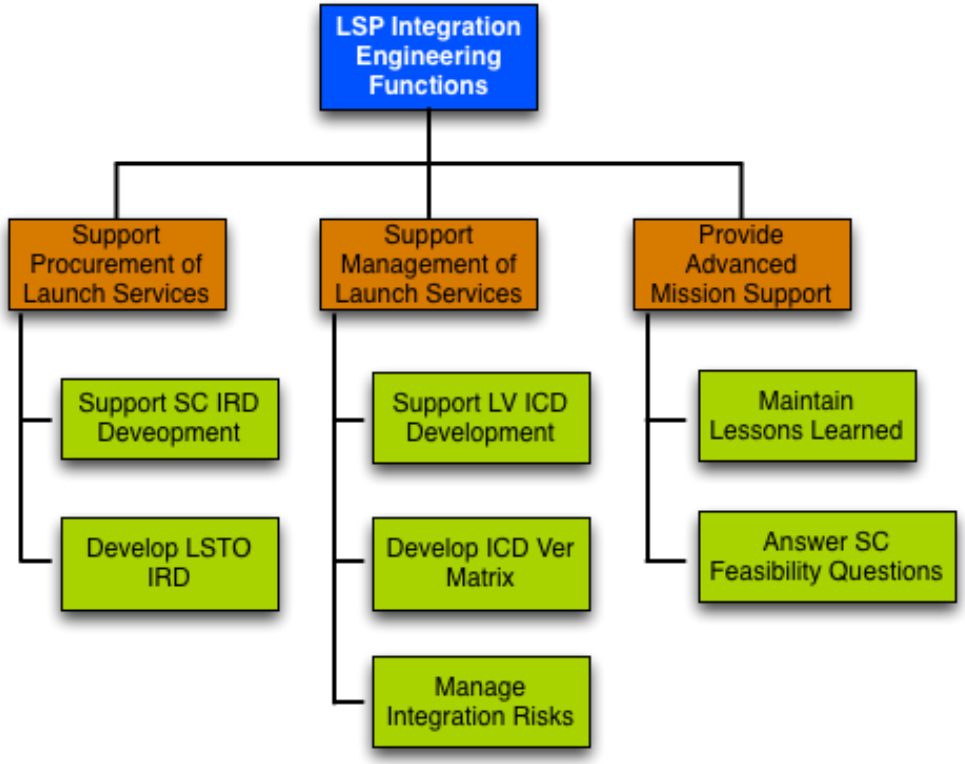
- NASA LSP buys a launch service for nearly all of NASA's robotic space missions
- LSP's primary function is to manage the launch services contract with the commercial launch vehicle provider we put on contract for each of our customers
- The Integration Engineering group are systems engineers that manage the interface between our spacecraft customer and the launch services contractor

Functional Architecture

- **<u>Step 1:</u> Create a Functional Architecture**
- Functional architecture should only include the smallest portion of your organization as possible
- If multiple groups are participating, create multiple functional architectures

Functional Architecture



Current Knowledge Capture

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- **<u>Step 2:</u> Identify Current Knowledge Capture Methods**
- Methods can include meetings, mentoring, formal means of documentation, even emails
- If just a single person has a tool or method identify that too, it could be a wealth of information
- Important to include everything

Current Knowledge Capture

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- Our LSP IE group had 2 main areas where we captured our group's knowledge:
  - Group SharePoint Site
  - FileMaker Pro database containing all of our mission's verification matrices

Current Knowledge Capture

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- **SharePoint Site**
  - Lessons Learned Database (Database within SharePoint)
  - Branch Meeting Minutes (Microsoft Word Documents)
  - IE Training Resources (Microsoft Word Documents)
  - Peer Review Meeting Invites & Documents (Microsoft Word Documents)
  - Processes & Guides (Microsoft Word Documents)
- **FileMaker Pro Template/Database (verification matrices)**

Map Current Knowledge Capture

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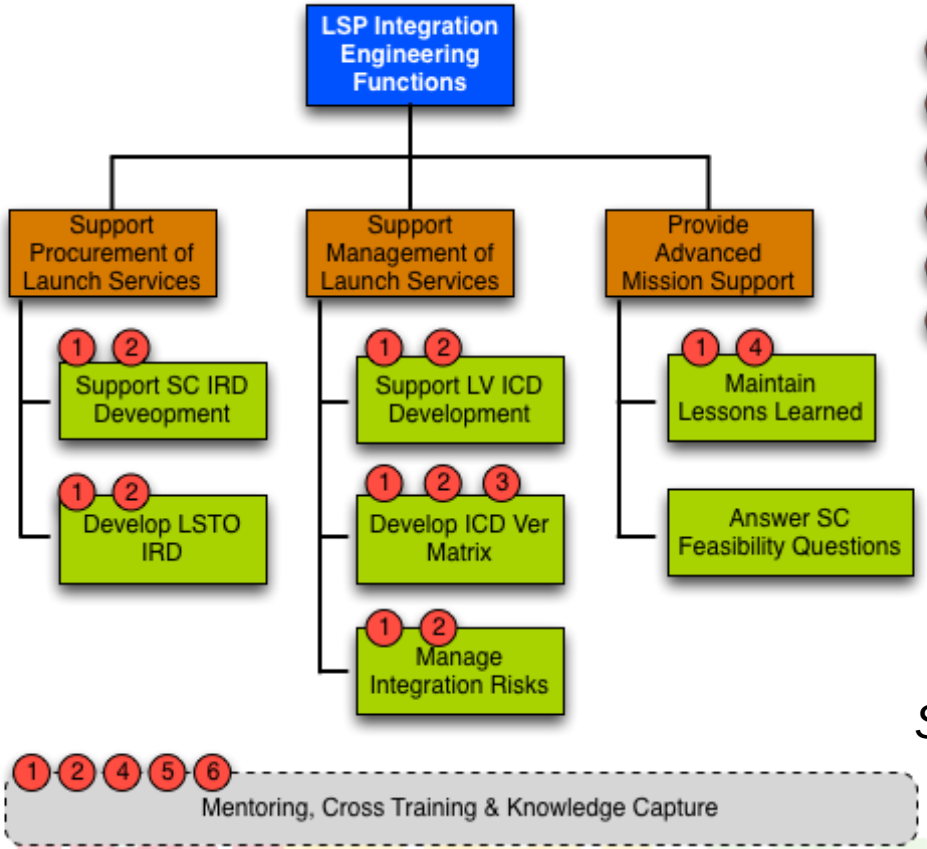
- **<u>Step 3:</u> Map Existing Knowledge Capture Methods**
- Map each existing knowledge capture method to all functions in your functional architecture that are supported by that method
- Start with the lowest level functions and only include higher level functions if knowledge capture methods for that function are significantly different

Map Current Knowledge Capture



1. SP Peer Review
2. SP Processes & Guides
3. FileMaker Pro Ver Template
4. SP Lessons Learned DB
5. SP Meeting Minutes
6. SP IE Training Resources

SP = SharePoint

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Enhance Knowledge Capture

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- **<u>Step 4:</u> Enhance Knowledge Capture Methods**
- Identify enhanced methods to capture knowledge and map the new methods on top of the map created in Step 3
- Our organization added a new tool (Confluence) but enhancements can be made even without adding a new tool
  - Improve an existing process
  - Add new knowledge capture activities and processes
  - Link together existing methods and processes in new ways

Enhance Knowledge Capture

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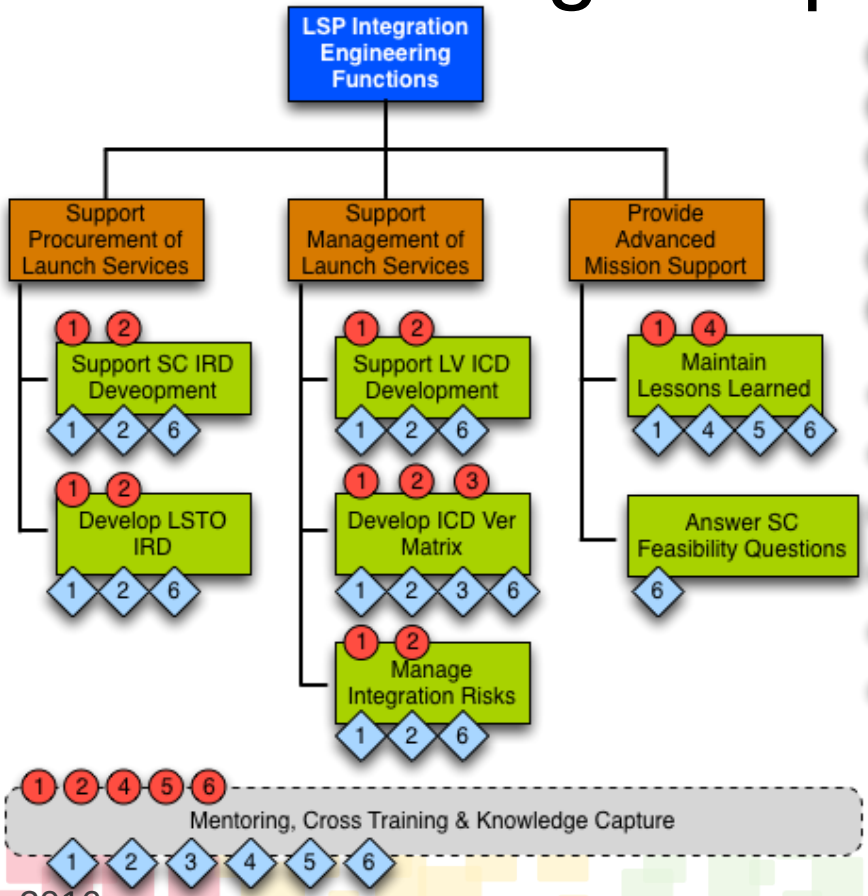
- **Knowledge Capture Enhancement Tips:**
  - Make sure you have a quick and easy way to capture the "why" behind everything you do
  - Capture the "why" contextually with the "what", they must be linked somehow
  - Enhancements should be minimally disruptive to current processes or they will not be adopted
  - Eliminate any barriers that exist for users to contribute
    - Simple user interface
    - Convenient and fast access

Enhance Knowledge Capture



1. SP Peer Review
2. SP Processes & Guides
3. FileMaker Pro Ver Template
4. SP Lessons Learned DB
5. SP Meeting Minutes
6. SP IE Training Resources

1. CON Peer Review
2. CON Processes & Guides
3. CON Ver Baseline Effort
4. CON Meeting Minutes
5. CON IE Training Space
6. CON Questions

SP = SharePoint
CON = Confluence

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Introduce Enhancements

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- **<u>Step 5:</u> Introduce Enhanced Knowledge Capture**
  - Slowly introduce the enhancements
  - Where possible, introduce one at a time
  - Some enhancements may be integrated with others & will need to be introduced together
  - Start with enhancements that are already “required” work
  - Introduce the least disruptive enhancements first
  - Quick and drastic changes could lead to loss of knowledge & be a step backwards instead of an improvement
  - Strategy highly dependent on each group/situation

Evolve the Knowledge Capture

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- **<u>Step 6:</u> Evolve the Knowledge Capture**
  - Implement all enhancements before evolving any previously implemented enhancements
  - Knowledge capture of “art” requires tight integration, so any evolution of a single enhancement will most likely impact multiple areas of your knowledge capture
  - Significant capture of systems engineering “art” could lead to group function or process changes
  - Any function and process changes should be captured again back at Step 1 and then flowed through Steps 2-6

Lessons Learned

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- Improvement ≠ Adoption
  - Improving something does not mean it will be used
  - A brand new activity/capture technique is even more difficult for people to adopt than a small enhancement
  - Develop an adoption strategy
  - Assign an adoption advocate to lead the implementation of the change (lead by example)

Lessons Learned

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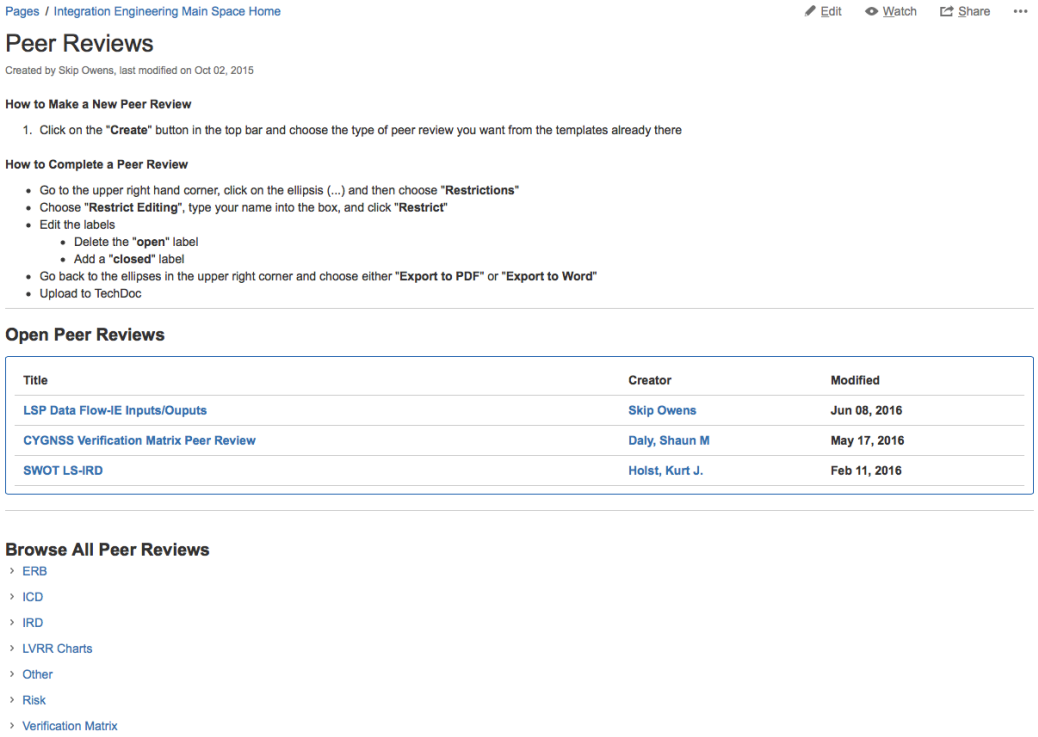
- Don’t Underestimate Ease of Use
  - Critical to eliminate any barriers between the user and the knowledge capture mechanism
  - Even small inconveniences can result in enough friction to deter a user from contributing
  - Small training sessions can help overcome system interface and ease of use hurdles

Examples

- Peer Reviews
- Confluence Questions
- Processes & Guides

Peer Reviews



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Peer Reviews

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How to Make a New Peer Review

1. Click on the "**Create**" button in the top bar and choose the type of peer review you want from the templates already there

How to Complete a Peer Review

- Go to the upper right hand corner, click on the ellipsis (...) and then choose "**Restrictions**"
- Choose "**Restrict Editing**", type your name into the box, and click "**Restrict**"
- Edit the labels
  - Delete the "**open**" label
  - Add a "**closed**" label
- Go back to the ellipses in the upper right corner and choose either "**Export to PDF**" or "**Export to Word**"
- Upload to TechDoc

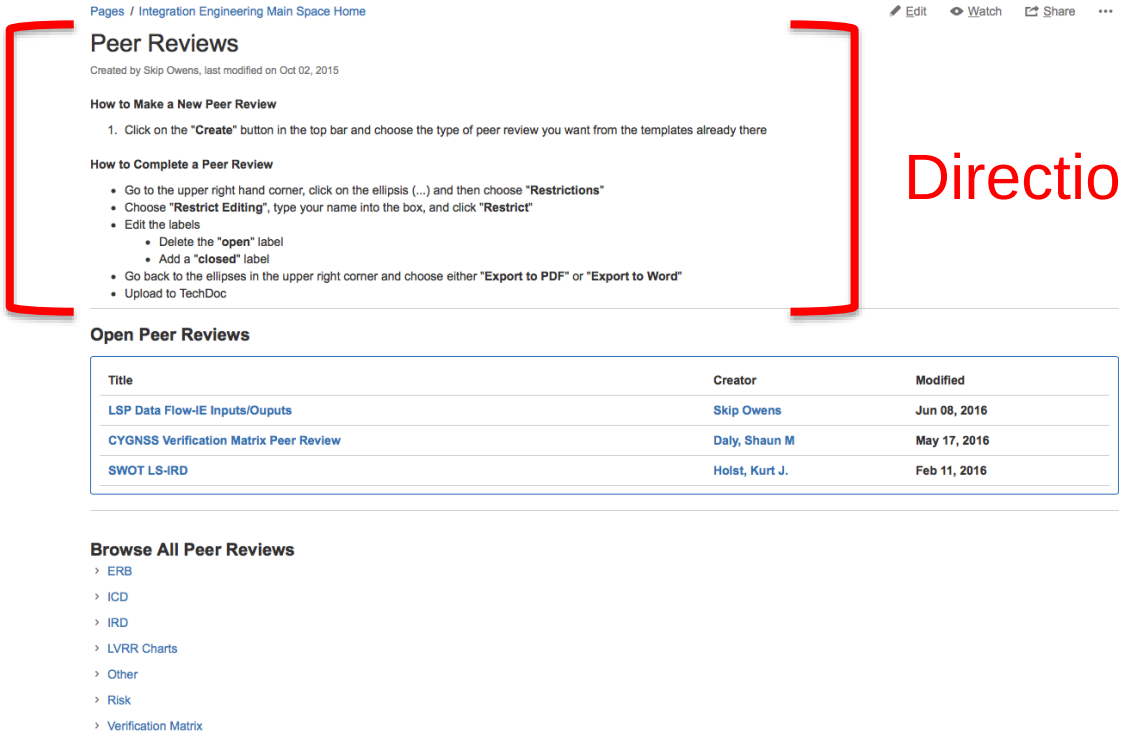
Open Peer Reviews

Title	Creator	Modified
LSP Data Flow-IE Inputs/Ouputs	Skip Owens	Jun 08, 2016
CYGNSS Verification Matrix Peer Review	Daly, Shaun M	May 17, 2016
SWOT LS-IRD	Holst, Kurt J.	Feb 11, 2016

Browse All Peer Reviews

- ERB
- ICD
- IRD
- LVRR Charts
- Other
- Risk
- Verification Matrix

Peer Reviews



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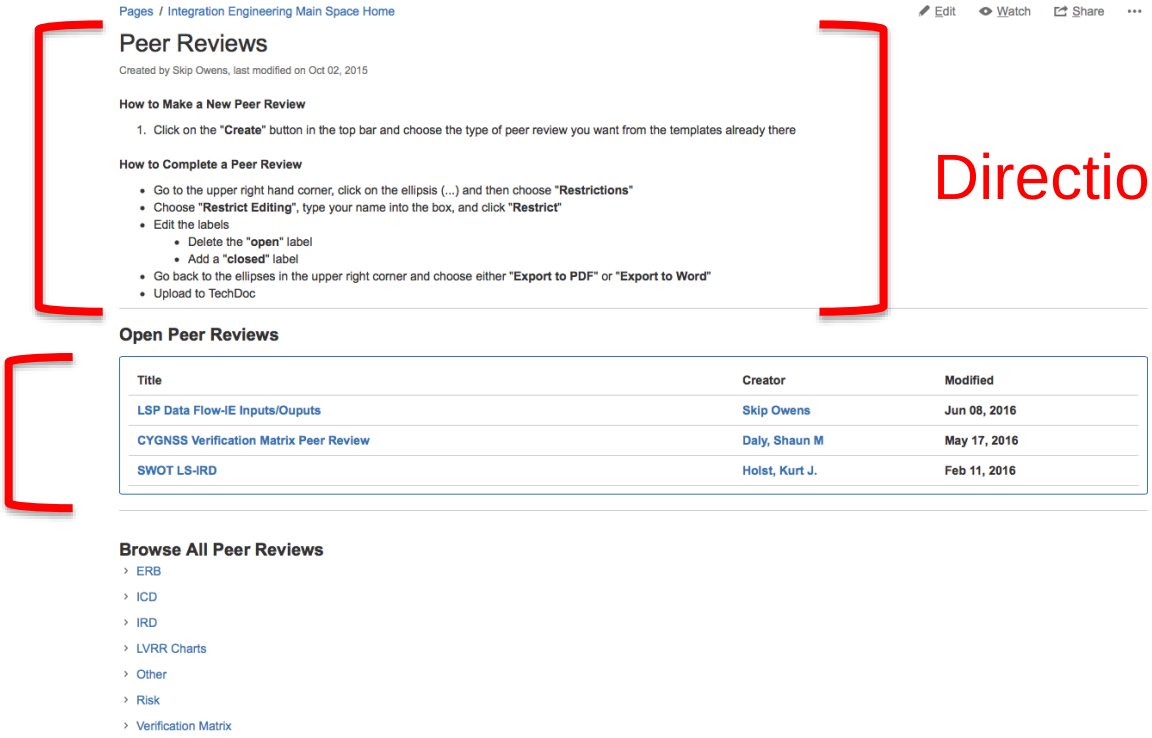
Directions

Peer Reviews



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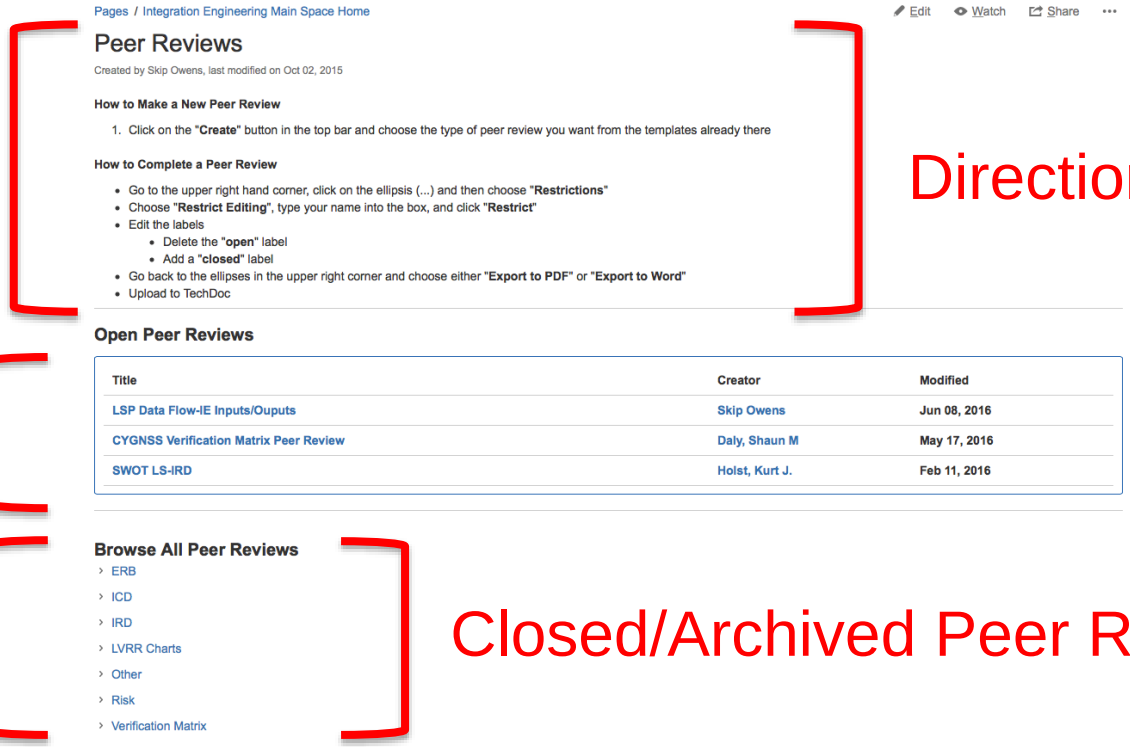
Peer Reviews



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Directions

Open Peer Reviews

Closed/Archived Peer Reviews

Peer Reviews

Example ICD Peer Review

Created by Skip Owens just a moment ago

Summary

Virtual Reviewers

Face-to-Face Reviewers

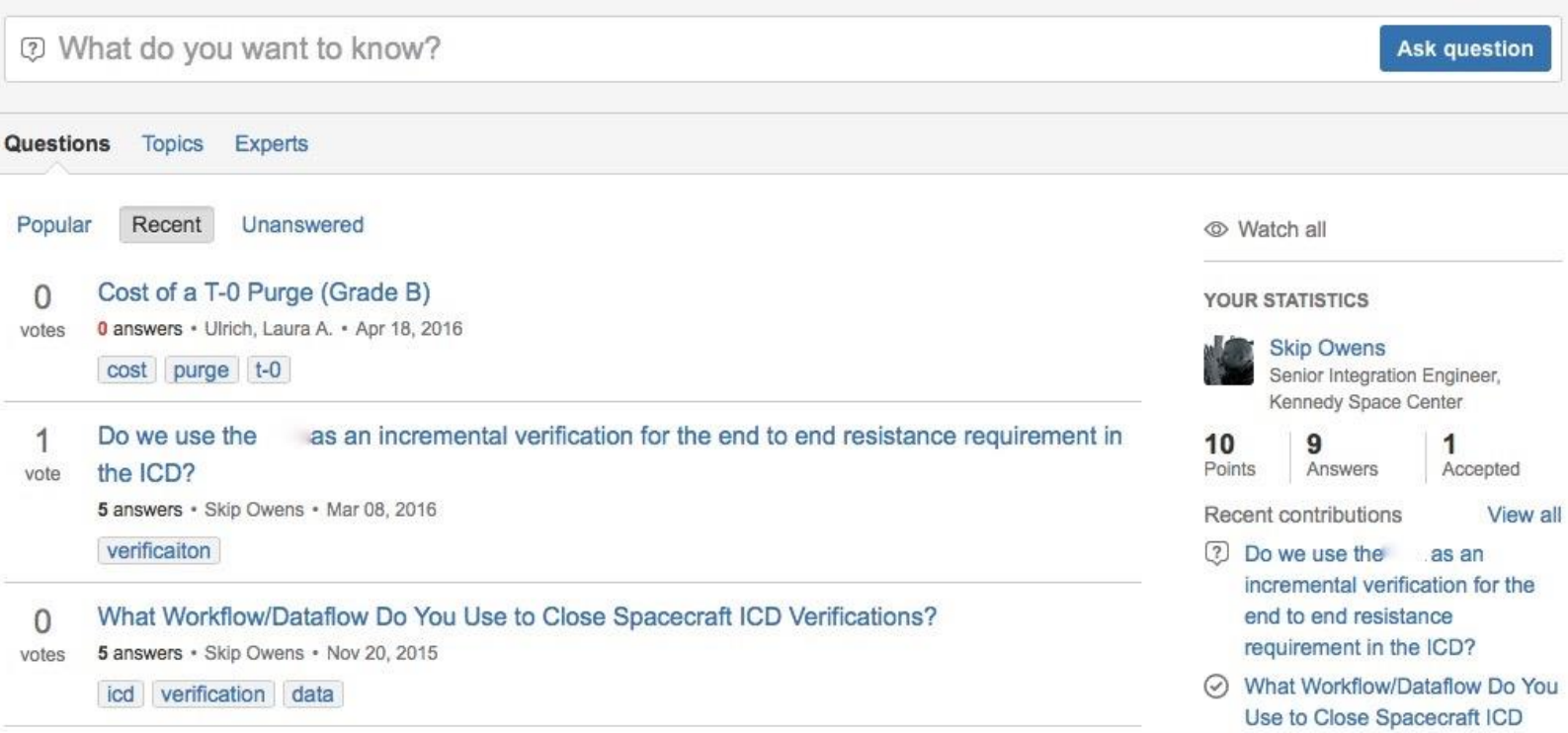
Virtual Review Comments

VRN	Reviewer	Comment	Disposition

Face-to-Face Comments

VRN	Reviewer	Comment	Disposition

Confluence Questions



Guides & References

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Guides/References

Created by Yasmeen Roumie, last modified by Holst, Kurt J. on Mar 24, 2016

Watching Pages
Those interested in keeping track of the changes being made on these pages can refer to a tutorial on watching pages and setting up email settings.

Search Guides/References

Guide/Reference Pages

- Acronyms & Vocabulary
- Atlas V Integrated Procedures
- Change in KSC Controlled Burn Policy
- Conference Determination Forms
- Desk Phone Instructions
- Entering Data into ERBIS
- ERBIS Query Guide
- Fairing options (static envelope) by class as of 3/8/16
- Federal Standard 209E -vs- ISO Standard 14644-1
- General Rules for Entering NLS-II submittals from LVC's into TechDoc

Attached Guide/Reference Documents

(Scroll to bottom of list to add new documents)

File	Modified
Connector Deadfacing Analysis.pdf	Jul 02, 2015 by Carrie Sekeres
Filemaker Verification Matrix Users Guide.docx	Jul 02, 2015 by Carrie Sekeres
GOES-R Contamination requirements flow.pptx	Apr 21, 2016 by Holst, Kurt J.
GOES-R - purge bracket design-silicone-feb-10-2016-final.pptx	Feb 17, 2016 by Holst, Kurt J.
ICD Mass properties guide.pdf	Jul 02, 2015 by Carrie Sekeres
LSIM and IE Roles and Responsibilities.xls	Feb 17, 2016 by Ulrich, Laura A.

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Questions

- Any questions?