



**26**<sup>th</sup> annual **INCOSE**  
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Edinburgh, UK  
July 18 - 21, 2016

# A Process for Capturing the Art of Systems Engineering

Skip Owens

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# 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.”

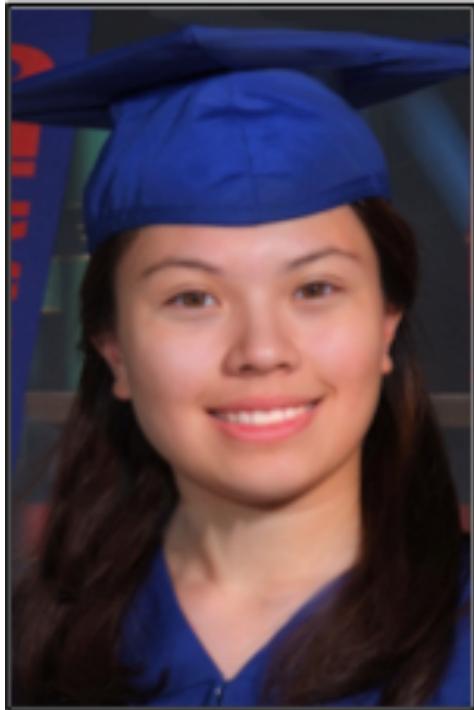
- “The Art and Science of Systems Engineering” – NASA.gov Jan 2009

# 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



- 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



- 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



- “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



- Management of systems is easily captured 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



- 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 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



- 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



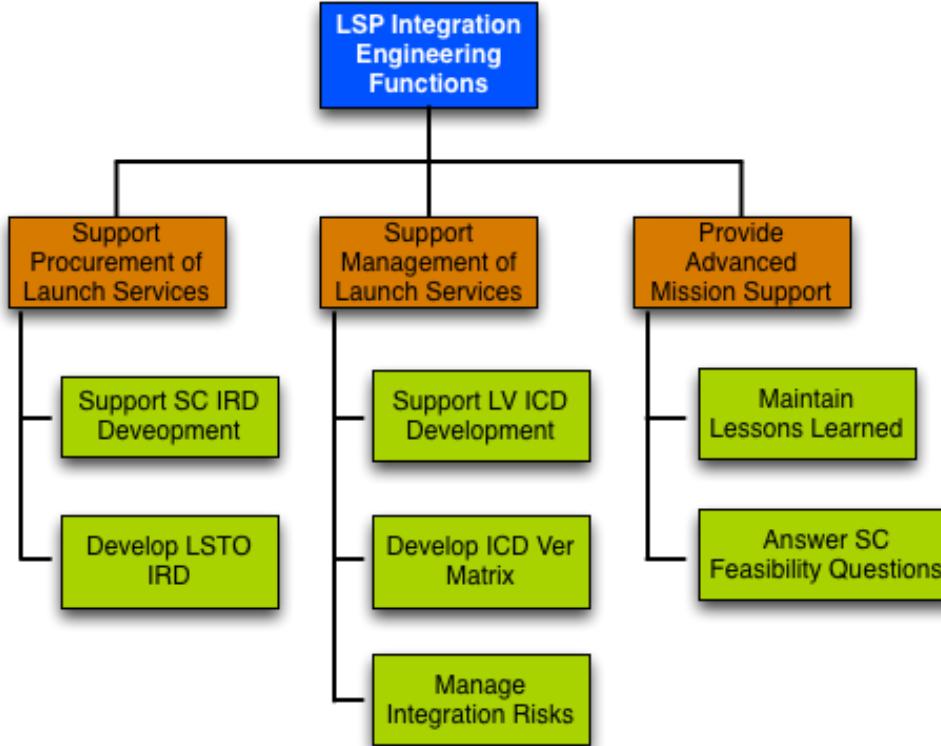
- NASA LSP buys a launch service for nearly all of NASA's robotic space missions
- LSP's primary function is to manage the launch services contract with the commercial launch vehicle provider we put on contract for each of our customers
- The Integration Engineering group are systems engineers that manage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

# Functional Architecture



- **Step 1: 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



Mentoring, Cross Training & Knowledge Capture

# Current Knowledge Capture



- **Step 2: 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



- Our LSP IE group had 2 main areas where 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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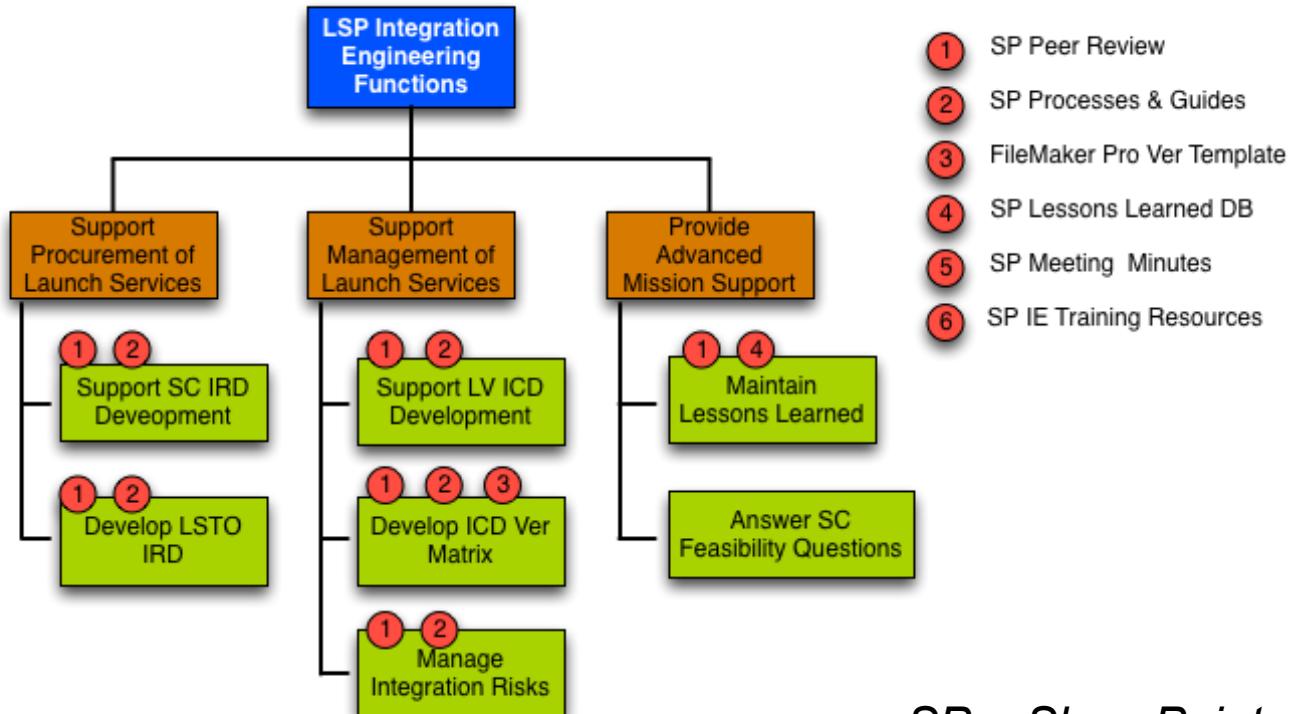
- **SharePoint Site**
  - Lessons Learned Database (Database within SharePoint)
  - Branch Meeting Minutes (Microsoft Word Documents)
  - IE Training Resources (Microsoft Word Documents)
  - Peer Review Meeting Invites & Documents (Microsoft Word Documents)
  - Processes & Guides (Microsoft Word Documents)
- **FileMaker Pro Template/Database (verification matrices)**

# Map Current Knowledge Capture



- **Step 3: 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



*SP = SharePoint*

1 2 4 5 6

Mentoring, Cross Training & Knowledge Capture

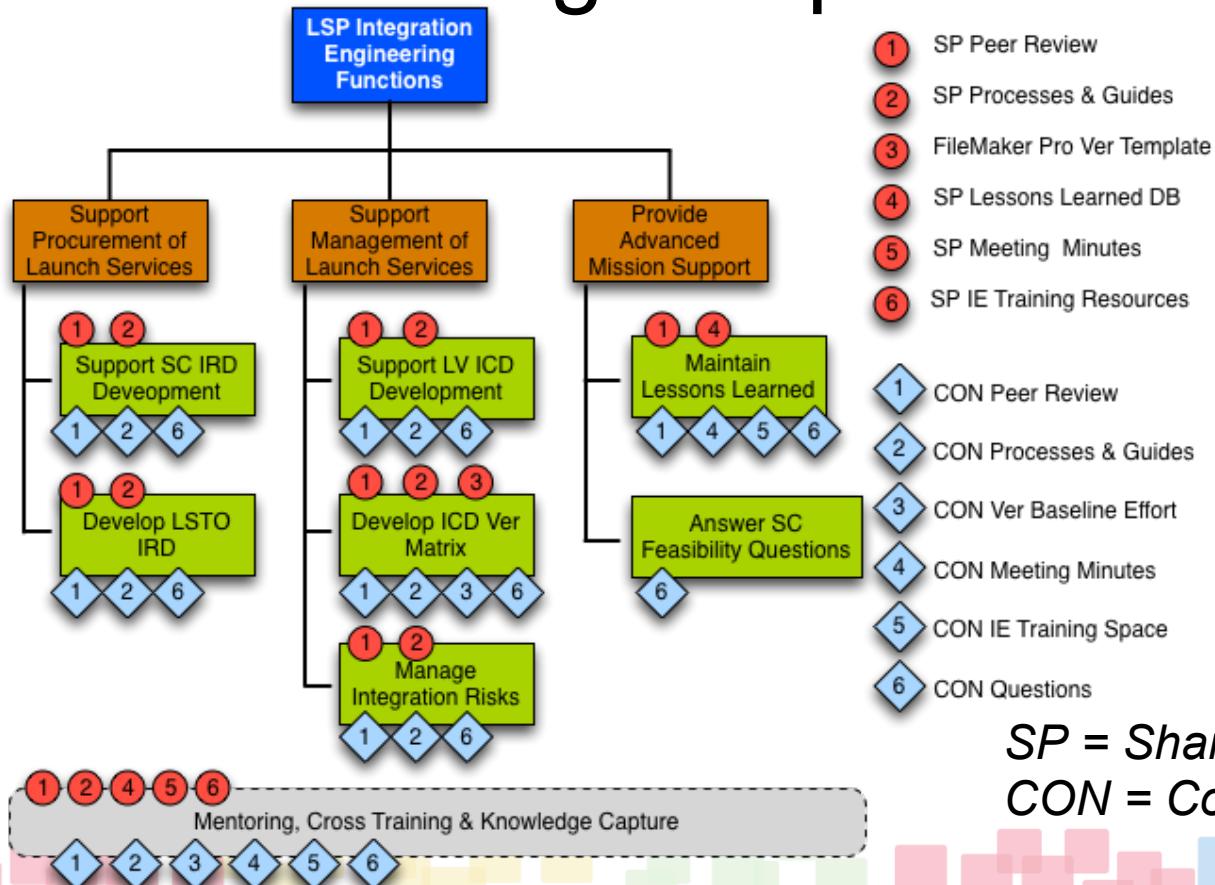
# Enhance Knowledge Capture

- **Step 4: 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

- **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*

# Introduce Enhancements



- **Step 5: 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



- **Step 6: 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



- 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



- 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

Created by Skip Owens, last modified on Oct 02, 2015

### 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"
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### Open Peer Reviews

Title	Creator	Modified
LSP Data Flow-IE Inputs/Outputs	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

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- > ERB
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- > IRD
- > LVRR Charts
- > Other
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Directions



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Directions

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Open  
Peer  
Reviews

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Closed/Archived Peer Reviews

# Peer Reviews

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## Example ICD Peer Review

Created by Skip Owens just a moment ago

### Summary

#### Virtual Reviewers

#### Face-to-Face Reviewers

#### Virtual Review Comments

#### Face-to-Face Comments

VRN	Reviewer	Comment	Disposition

VRN	Reviewer	Comment	Disposition

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# Confluence Questions



What do you want to know?

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Questions Topics Experts

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0 Cost of a T-0 Purge (Grade B)  
votes 0 answers • Ulrich, Laura A. • Apr 18, 2016

cost purge t-0

1 Do we use the \_\_\_\_\_ as an incremental verification for the end to end resistance requirement in  
vote the ICD?

5 answers • Skip Owens • Mar 08, 2016

verificaiton

0 What Workflow/Dataflow Do You Use to Close Spacecraft ICD Verifications?  
votes 5 answers • Skip Owens • Nov 20, 2015

icd verification data

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## YOUR STATISTICS



Skip Owens

Senior Integration Engineer,  
Kennedy Space Center

10 Points | 9 Answers | 1 Accepted

Recent contributions

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Do we use the \_\_\_\_\_ as an  
incremental verification for the  
end to end resistance  
requirement in the ICD?

What Workflow/Dataflow Do You  
Use to Close Spacecraft ICD

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

# Questions

- Any questions?

