

EVA Wiki – Transforming Knowledge Management for EVA Flight Controllers and Instructors

Stephanie S. Johnston¹, and Brian K. Alpert.²

NASA, Johnson Space Center, Houston, Texas, 77508, USA

Edwin James Montalvo³, Lawrence Daren Welsh³, Scott Wray³, and Costa Mavridis²

Stinger Ghaffarian Technologies, Inc., Johnson Space Center, Houston, TX, 77058, USA

The EVA Wiki was recently implemented as the primary knowledge database to retain critical knowledge and skills in the EVA Operations group at NASA's Johnson Space Center by ensuring that information is recorded in a common, easy to search repository. Prior to the EVA Wiki, information required for EVA flight controllers and instructors was scattered across different sources, including multiple file share directories, SharePoint, individual computers, and paper archives. Many documents were outdated, and data was often difficult to find and distribute. In 2011, a team recognized that these knowledge management problems could be solved by creating an EVA Wiki using MediaWiki, a free and open-source software developed by the Wikimedia Foundation. The EVA Wiki developed into an EVA-specific Wikipedia on an internal NASA server. While the technical implementation of the wiki had many challenges, one of the biggest hurdles came from a cultural shift. Like many enterprise organizations, the EVA Operations group was accustomed to hierarchical data structures and individually-owned documents. Instead of sorting files into various folders, the wiki searches content. Rather than having a single document owner, the wiki harmonized the efforts of many contributors and established an automated revision controlled system. As the group adapted to the wiki, the usefulness of this single portal for information became apparent. It transformed into a useful data mining tool for EVA flight controllers and instructors, as well as hundreds of others that support the EVA. Program managers, engineers, astronauts, flight directors, and flight controllers in differing disciplines now have an easier-to-use, searchable system to find EVA data. This paper presents the benefits the EVA Wiki has brought to NASA's EVA community, as well as the cultural challenges it had to overcome.

Nomenclature

<i>EMU</i>	= Extravehicular Mobility Unit
<i>EVA</i>	= Extravehicular Activity
<i>FOD</i>	= Flight Operations Directorate
<i>IOPT</i>	= Integrated Operations Product Template
<i>ISS</i>	= International Space Station
<i>JSC</i>	= Johnson Space Center
<i>lbm</i>	= pound mass
<i>NASA</i>	= National Aeronautics and Space Administration
<i>PGT</i>	= Pistol Grip Tool
<i>SMW</i>	= Semantic MediaWiki

¹ EMU Sub-System Manager, Crew & Thermal Systems Division, 2101 NASA Parkway, Houston, TX, 77058/ EC5.

² EVA Systems Flight Controller and Instructor, EVA, Robotics, and Crew Systems Division, NASA Johnson Space Center, 2101 NASA Parkway, Houston, TX, 77058 / CX351.

³ EVA Task Flight Controller and Instructor, EVA, Robotics, and Crew Systems Division, NASA Johnson Space Center, 2101 NASA Parkway, Houston, TX, 77058 / CX321.

I. Introduction

IN 2011, the EVA Operations branch at NASA's Johnson Space Center had a problem. The same problem that is common in many large organizations and enterprises: knowledge management. In a branch like EVA Operations, knowledge is critical. EVA Operations houses all of NASA's EVA flight controllers and instructors. They plan and execute EVAs from Mission Control, teach astronauts about the Extravehicular Mobility Unit (EMU) spacesuit, and train astronauts how to complete a spacewalk. Knowledge in EVA Operations is also continuously evolving. The International Space Station (ISS) is changing and growing, new visiting vehicles are delivering more EVA-compatible hardware, and as the EMU grows older the community is learning more about its limits. All that changing and increasing information was hard to keep up with and it was even more of a challenge to get new employees up to speed. Many documents were outdated, and data was often difficult to find and distribute because it was spread out between various shared file directories and websites, or, even worse, the information was not recorded anywhere.

To create a solution, a small team within EVA Operations recognized that these knowledge management problems could be solved by creating a knowledge-base using MediaWiki, a free and open-source application developed by the Wikimedia Foundation. Starting in 2011, the knowledge-base, nicknamed the EVA Wiki, developed into an EVA-specific Wikipedia - a single portal of EVA information housed on an internal NASA server. This paper provides an overview of what the EVA Wiki team did to create a successful knowledge database, including the cultural shift it took to make the EVA Wiki effective. It will also highlight the benefits of using a Semantic MediaWiki based system for EVA Operations, from training flight controllers, instructors, and astronauts to planning a successful spacewalk.

II. Implementation: Creating the EVA Wiki and Changing Organizational Standards

Over the course of five years, the EVA Wiki grew from an interesting idea to a valuable database used by hundreds of people supporting ISS EVA. The following sections highlight several key implementation stages that the EVA Wiki went through to become a successful knowledge management system.

A. Selecting MediaWiki as the platform for the EVA Wiki.

Before the EVA Wiki was created, a small team of EVA flight controllers and instructors were frustrated with the lack of proper knowledge management in their group. It was a chore to find updated information on the various servers and file directories, so they asked themselves, *why don't we have an internal Wikipedia for NASA?* The team started the search for a practical wiki platform. By definition, a wiki is simply a website which allows collaborative editing directly from a web browser. Many types of wikis exist, each varying in their composition and capabilities. The team found several wiki applications already available at NASA that could provide basic wiki pages, however, they ultimately chose a free, open-source application that had a lot flexibility and power: MediaWiki.¹ MediaWiki was developed by the Wikimedia Foundation and is the same platform Wikipedia uses. Creating a knowledge management system that looks and functions similar to Wikipedia was an immediate advantage – it is already familiar. The initial setup was convenient since MediaWiki had the same requirements as existing EVA servers, including the same scripting language (PHP) and the same database management system (MySQL).^{2,3}

MediaWiki was also selected due to the flexibility of easily creating or integrating additional extensions throughout the life of the EVA Wiki. One of the most significant extensions the team installed on the EVA Wiki is called Semantic MediaWiki (SMW).⁴ In the standard MediaWiki load, content is managed on individual pages. Through templates, users can share common content and formatting across multiple pages. This helps to reduce duplication and standardizes content across the wiki. The SMW extension takes that a step farther – it allows users to set, store, and utilize metadata through semantic relationships. For example, say you have 100 pages about different EVA tools. MediaWiki allows you to create a template for each individual tool, so that each of those 100 pages contains the same kind of content (e.g. tool name, dimensions, mass, etc.). SMW enables that template to store values for the property “mass.” You can now query all EVA tool pages with mass greater than 25 lbm and less than 75 lbm. This simple example shows how a flexible wiki application can utilize the power of a structured database. Using MediaWiki and its extensions like SMW, the EVA Wiki is able to grow and adapt as the needs of the EVA community change.

B. Importing a critical mass of data and extensions into the EVA Wiki.

After the EVA Wiki was created, the wiki team spent the next year importing data and setting up useful extensions, templates, and forms. Since the EVA Wiki was still an unofficial database on a NASA development server, the team started to add information in the wiki as a side project. The majority of the data was imported during annual proficiency training. Once a year certified EVA flight controllers and instructors go through annual proficiency training, which consists of reviewing critical EVA knowledge. Since this knowledge was spread out across different websites and

buried in several shared file directories, the team began importing information into the EVA Wiki and adding links to related websites while studying for their annual proficiency. For every piece of EVA hardware (EVA tools and EMU components), the team created a separate page on the wiki. For instance, an EVA handheld drive tool called the Pistol Grip Tool (PGT) has its own page with data directly entered in, such as a description, pictures, and other details about the hardware. The PGT page also links directly to other useful websites, such as standardized procedures and drawings, so it's used as a single portal of information rather than a host for redundant data. When the proficiency training was complete a lot of fundamental EVA knowledge had been integrated into the wiki.

While the team imported data, they also found patterns and similarities that allowed them to create templates and forms. MediaWiki uses special markup to format texts and pictures, so using forms makes editing complex pages easy even for people new to editing in MediaWiki. Creating extensions and templates that accompany a form also allows wiki pages to automatically assign semantic properties values. One of the most frequently used forms today is called Meeting Minutes. The Meeting Minutes form allows everyone in the EVA Operations branch to write notes during meetings. Meeting Minutes are easily shared through email and the wiki to the rest of the group. Each meeting topic has a "related article" property that makes the Meeting Minutes form remarkably useful. If during a meeting the PGT is mentioned, the person taking the notes during the meeting simply adds "PGT" to the related articles tab. The meeting summary is automatically pulled into the "Meeting References" section on the bottom of the PGT page, as illustrated in Figure 1. Anyone looking for the latest information about the PGT simply scrolls to the bottom of the PGT wiki page to reference a list of the meetings the PGT has been discussed during, starting with the most recent date. Once the critical mass of information had been imported and several useful extensions, templates and forms were created, the team was able to demonstrate the usefulness of the EVA Wiki to the rest of the EVA Operations branch.

C. The cultural shift to the "Wiki Way"

For the EVA Wiki to be successful it would require organizational change. As the EVA Wiki increased in popularity due to its convenience, the EVA Operations group slowly started a cultural shift to "the wiki way." For some the transition was effortless - they saw the benefits of the EVA Wiki and quickly became active users and contributors. For many, however, one of the biggest hurdles was learning how to change the way they record and share information. Like many enterprise groups, EVA Operations branch was accustomed to hierarchical data structures and familiar tools, e.g. standard Microsoft Office products. The branch needed a more efficient and robust form of knowledge capture and data management which allowed for more of a "living" web-based database instead of the traditional windows network folders and Microsoft SharePoint, which had proven to be cumbersome and was not user-friendly. On the contrary, the "wiki way" focuses on searching instead of filing, crowd-sourcing instead of document ownership, and uses semantic linking. The biggest issue when rolling out the new EVA Wiki solution was getting people to use the new system and stop using the old ones. Henry Hornstein, Professor in Organizational Behavior at Algoma University states, "*Change projects fail because of organizational resistance almost twice as often as they do because of any technical issue, including poor project management.*"⁵ When the EVA Wiki was first introduced, many workers thought, "why should I change the way I've been doing things for years?" They felt it would be counterproductive to spend hours learning a new system when the current way of doing things was adequate. Overcoming this initial resistance to change required a focused approach. The wiki team had to demonstrate many ways the new EVA Wiki could streamline the branch's workflow to cut down on time spent digging for hard-to-find information.

None of this would be possible without management buy-in and participation. The wiki team learned the importance of changing people's mindset, not only at the worker level, but also within the management chain. A case study performed by Lisa Bodell, CEO for Future Think, on several companies going through organizational change found that many organizations suffer from change fatigue. Bodell concluded that change initiatives fail mostly because change cannot be forced on people, instead, the change must occur with them.⁶ Therefore, the wiki team spent several meetings brainstorming with coworkers. They asked coworkers about their biggest knowledge management complaints, and then developed a solution within the MediaWiki platform that capitalized on those problems. Once the wiki team was able to present a clear solution to the current problem, their coworkers began to get on-board. The team needed the entire branch to have direct participation in the development and success of the new EVA Wiki. Instead of force feeding the branch a new system, everyone directly or indirectly assisted in developing the new knowledge-base. This fostered ownership in the final product. It wasn't just 'their' wiki, it was now 'our' wiki. Together, the entire branch, wiki administrators and users alike, all own and maintain the wiki. In addition, the more user-ship and interaction with the content, the better vetted, mature, and trusted the material will be. In the past, coworkers were reluctant to edit a document if they were not the original author. While that ownership works well in a revision controlled environment, the documents were not actively reviewed or updated, which created a lot of stale and redundant documents in the branch's old system.

Meeting Minutes Form

Meeting Details

Meeting name: EBOT Monthly Meeting

Meeting date: 21 January 2016

Start time: 14:00 (24-hour time, please)

Notes taken by: Brian Alpert

Meeting Files

Local File Name or URL: File:EBOT Monthly IPT January2016.pptx

Alternate name:

Add File

Meeting Topics

PGT Adapter

PGT, PGT Battery, LPGT.

The update of the PGT Battery from NIMH to Li-Ion has also led to the need for an adapter to be installed on the PGT. This adapter will be installed on the ground and will not be removable on-orbit. I don't see any issues with this, since PGTs will be rotated such that there won't be any NIMH PGT

Related Article Page (the PGT page)

Meeting References | EVA References | SODF References | Applicable OCADs | Applicable Notes, Ca

PGT Adapter

The update of the PGT Battery from NIMH to Li-Ion has also led to the need for an adapter to be installed on the PGT. This adapter will be installed on the ground and will not be removable on-orbit. I don't see any issues with this, since PGTs will be rotated such that there won't be any NIMH PGT Batteries on-orbit much longer anyways.

Date: 21 January 2016

Meeting: EBOT Monthly Meeting

Related articles: Pistol Grip Tool, PGT Battery, LPGT

Logistics and Rotation Plan

After the meeting, discussed with Chris Vande Zande about tagging up on the overall logistics and rotation plan away from NIMH batteries (EHIP, REBA, PGT Batt), chargers (BCM), and hardware (Helmet Lights, PGT, etc.) to the Li-Ion batteries (LPGT, LREBA), chargers (EBOT), and hardware. Expect XA to take the lead on coordination with CX on the forward plans.

Date: 21 January 2016

Meeting: EBOT Monthly Meeting

Related articles: EVA Helmet Interchangeable Portable Battery, Rechargeable EVA Battery Assembly, PGT Battery, Battery Control Module, EVA Helmet Interchangeable Portable Light, EMU Glove Heaters, Wireless Video System, Pistol Grip Tool, LPGT, LREBA, EVA Battery Operations Terminal

Figure 1. Example of a Meeting Minutes form and associated Related Article page.

Moving away from hierarchical data structures was one of the biggest organizational changes the team faced. Like many companies, the EVA Operations branch still relied on the traditional Microsoft Office suite of tools to manage their email, documents, presentations, and spreadsheet needs. However, as the world is becoming more web-based,

the ability to search for information on the internet becomes faster and more intuitive due to elastic and google search capabilities, and hierarchical knowledge management systems in the enterprise environment remain antiquated. In these outdated environments, users have a long learning curve and orientation required before they can fully understand where to find information and data needed to perform their job. Often, they must attend training or read user guides to become familiar with the multiple data repositories their organization uses. In the wiki environment, multiple data repositories are brought together and displayed in one place. Instead of digging through documents in a folder structure, wiki users find information by searching. Searching is a more intuitive way to find information. If the user wants to learn about a particular subject, they just type it in the search bar and browse the results.

D. Making ‘crowdsourcing’ reliable and accountable.

A major concern for both Management and EVA Wiki users was the reliability of using crowdsourcing to update information on the wiki. Anyone with contributor access could edit any page on the EVA Wiki. How do pages stay accurate? What if someone puts the wrong information on the wiki or accidentally deletes a page? How do you control editing information that needs special approvals? Fortunately, MediaWiki already came with basic configuration management and the wiki team built upon that structure to make information on the wiki even more accountable.

To begin with, the wiki has several different permission categories, as described in Table 1. Everyone who has access to the EVA Wiki (i.e. viewers, contributors, etc.) can watch individual wiki pages. If a wiki page is edited, anyone watching that page will receive an email notification and can quickly see the exact changes that were made. Every page also has an automatic history log including a time stamp with the editor’s user name. The history log allows contributors to easily switch back to an older version of the page if necessary. See Figure 2 for the history log on the 'Keep Out Zone' page. As for deleting pages, only a small group of people (wiki administrators and curators) have the ability to delete a page. If a wiki administrator or curator does happen to delete a page unintentionally, that page can still be restored. MediaWiki also allows everyone, even those with basic viewer permissions, to add questions and comments to the discussion tab on any wiki page. If someone sees that wrong data was posted, information is missing, or a clarification is needed on the 'Keep Out Zone' page, he or she can post a comment on the 'Keep Out Zone' discussion tab. Since there are currently eight people watching the 'Keep Out Zone' page, all eight watchers will receive an email once the comment is posted. This helps keep information credible and current.

Table 1. Wiki User Rights Groups

Wiki User Rights Group	Description	Number for Members (February 21, 2016)
Viewers	Viewers have the ability to use the EVA Wiki, but have limited editorial capabilities. Viewers are able to create and edit discussion pages, and edit their own preferences and watch list. Everyone with access to the EVA Wiki has “viewer” access.	958
Contributors	Contributors have basic editorial permissions to, such as creating and editing pages, and uploading files.	114
Curators	Curators have editorial capabilities beyond those of normal contributors, mainly the ability to delete and undelete pages.	7
Managers	Managers can change a user’s permissions in the wiki by changing their user rights group.	3
Administrators	Administrators have additional authority to modify the EVA Wiki.	6

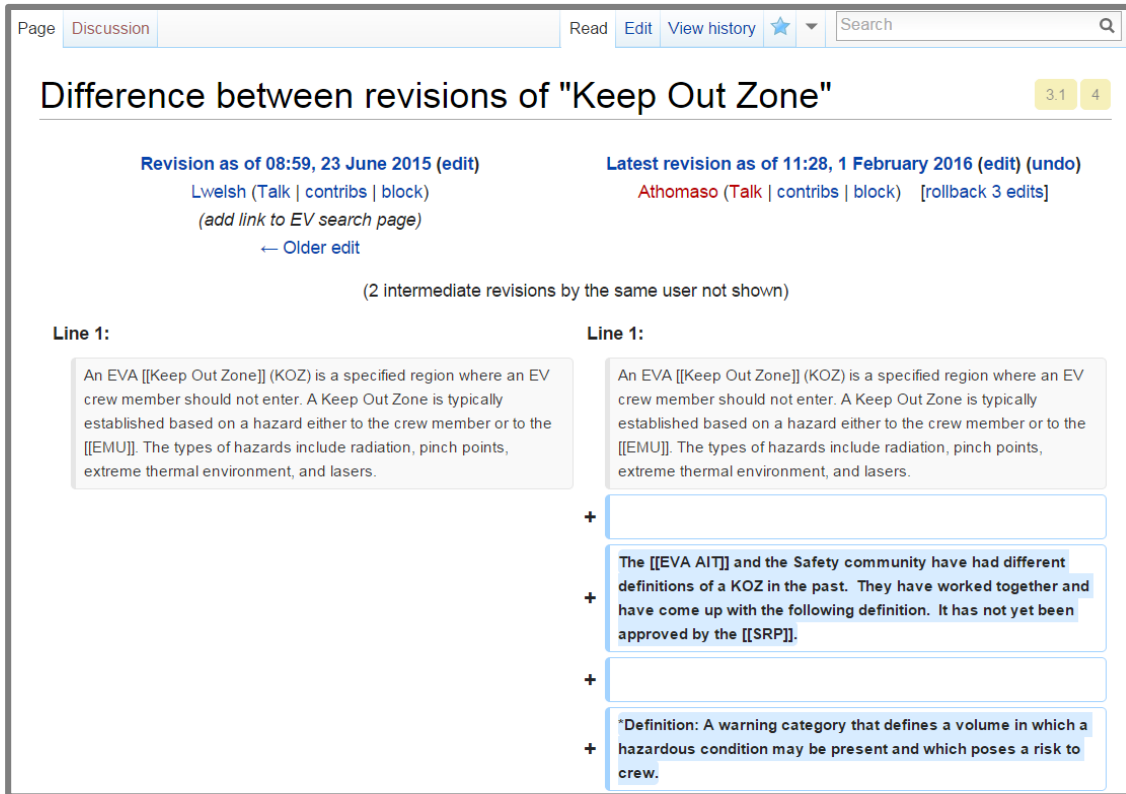


Figure 2. Revision differences between two instances of the 'Keep Out Zone' wiki page.

To address the issue that certain pages, e.g. lesson plans and console handbooks, needed a more secure approval process, the wiki team was able to assign owners to those pages. For example, on a lesson plan page, contributors are still allowed to edit the page, but only the lesson plan owners have the ability to approve their edits. Wiki users can choose to view the unapproved version of the page, which allows instructors to see new information on a lesson plan as early as possible. The unapproved page will have a warning so that EVA instructors can verify that the new information is correct before using it to teach a class. This prevents instructors from teaching outdated information.

While the built in configuration management in MediaWiki was an improvement over the group's previous knowledge management methods, several additions were added to make the EVA Wiki even more accountable. In 2014, the EVA Wiki team noticed that many users were not regularly reviewing pages that changed on the EVA Wiki. The lack of user participation seemed to stem from a reluctance in the group to make the cultural shift to the wiki. To foster more user participation and increase accountability the wiki team created a WatchAnalytics extension, which increased accountability in three key ways.⁷ First, it found all the pages that only had 0-2 watchers. To increase the number of watchers on those pages, WatchAnalytics creates a customized watch suggestions list for each user based on related articles in his or her watchlist. As the number of watchers increases on each page, the page's accountability also increases. Second, WatchAnalytics tracks when people review pages and provides a simpler interface for watchers to see what pages have changed. On the top of the each page in the wiki, users have a "pending reviews" link. That link opens a list of all the changed pages a user is watching, as shown in Figure 3. To prevent users from being overwhelmed by a long list of pending reviews, the list of pending reviews are ordered by how well the changes are being watched and are color coded correspondingly in red, yellow, or green. Third, WatchAnalytics adds two ratings (a 'scrutiny' rating and a 'reviews' rating) on the top of each wiki page to indicate how well a page is being watched. An example is shown on Figure 2— on the upper right corner of the 'Keep Out Zone' page there are two yellow boxes, one for scrutiny (3.1) and one for reviews (4). The scrutiny rating is a function of how many people are watching a particular page and how good those people are at reviewing pages in general. A higher number means that the page is likely to be reviewed quickly and by a greater number of people. The reviews rating is simply the number of people who have reviewed that particular page since the last edit. Overall, the WatchAnalytics extension increases accountability and data integrity in the EVA Wiki.

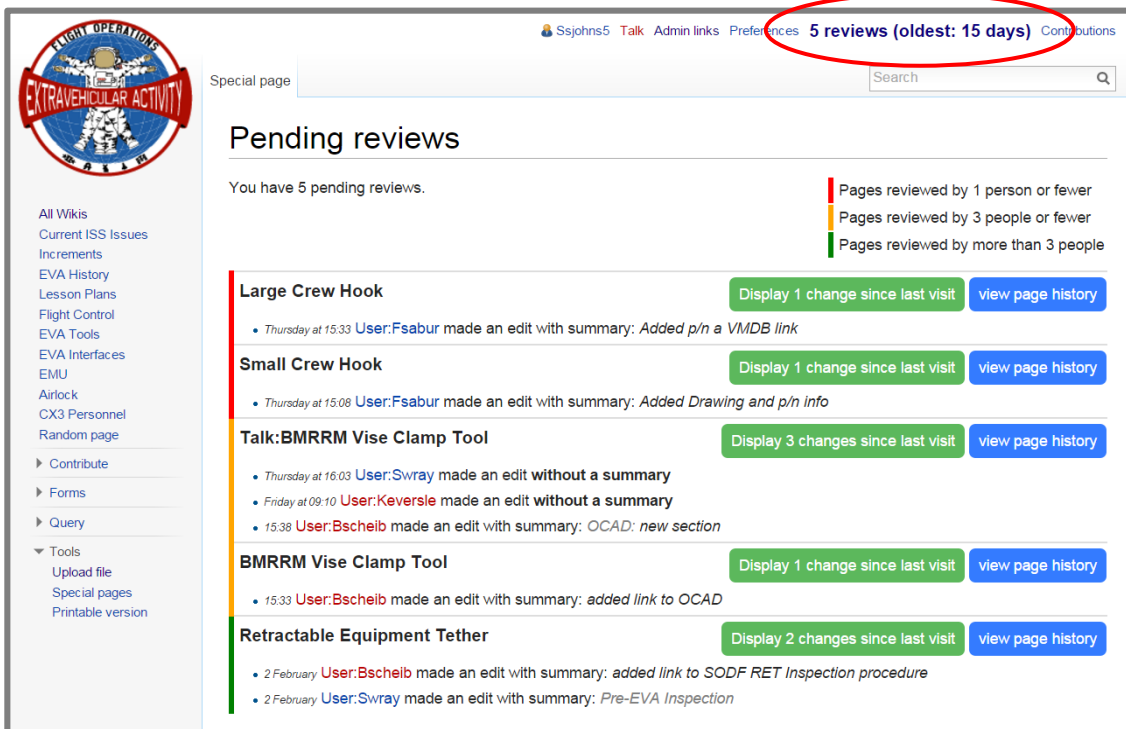


Figure 3. An individual user’s Pending Reviews page using WatchAnalytics to prioritize the order.

E. Expanding the EVA Wiki Community

The EVA Wiki started in the EVA Operations branch, which accounts for 46 wiki users. All the people in EVA Operations are wiki contributors and make up the majority of the watchers on each page in the wiki. Of those 46 EVA Operations people, six are EVA Wiki Administrators and three are managers. While the EVA Wiki stemmed from the EVA Operations branch, the influence of the EVA Wiki has been spreading to other groups in the EVA and Flight Operations communities. Refer back to Table 1 and you will see that as of February 2016, the EVA Wiki has a total of 114 contributors and 958 viewers. Only 46 of those contributors and viewers come of the EVA Operations branch, which means that nearly 60% of the wiki’s contributors and over 95% of the wiki’s viewers reside outside of the branch. The EVA Wiki’s community has been steadily growing to include astronauts, engineers, ISS program management, and other flight controllers and instructors. This growth can be seen in the three plots in Figure 4, where the x-axis represents the lifetime of the EVA Wiki. Each plot is a stacked area chart that distinguishes between EVA Wiki administrations (blue), EVA Operations members (orange), and the rest of the EVA Wiki Community (green). The plots used a 20 day running average and eliminated weekends to better show participation trends over time. The top plot shows what groups significant wiki contributions are coming from – wiki administrators were making the majority of the contributions in the beginning of the wiki’s life and as the EVA Operations branch began to adapt the wiki as their knowledge-base their contributions grew. The middle plot shows how frequently wiki pages are viewed throughout a day by a unique viewer. The bottom plot simply shows how many viewers go to the wiki each day. When comparing the middle and bottom plots, you can see that while the EVA Operations branch views the wiki the most often throughout the day (middle plot), there are still many people outside of that branch that go to at least one wiki page a day (bottom plot). Overall, the EVA Wiki has helped bring a large EVA community together by creating a single portal where people within NASA, including NASA contracts, can search for EVA information.

The wiki community itself has also grown in the last couple years, especially within the Flight Operations Directorate (FOD). The EVA wiki team has aided other groups to develop their own wikis, such as a Robotics Wiki, as well as an overarching FOD Wiki. There are currently eleven FOD-related wikis and three non-FOD wikis. All of these wiki administrators (~30 in all) are passionate about looking for efficient ways to share and re-use information. They communicate with each other frequently to discuss cultural shift lessons learned and wiki codes. The EVA Wiki team has attended several MediaWiki-focused conferences, which increased their involvement with the MediaWiki and SMW communities. In 2014, several EVA Wiki administrators created Enterprise MediaWiki (enterprisemediawiki.org), to share open-source MediaWiki extensions and foster collaborations with other organizations that use MediaWiki in corporate environments.

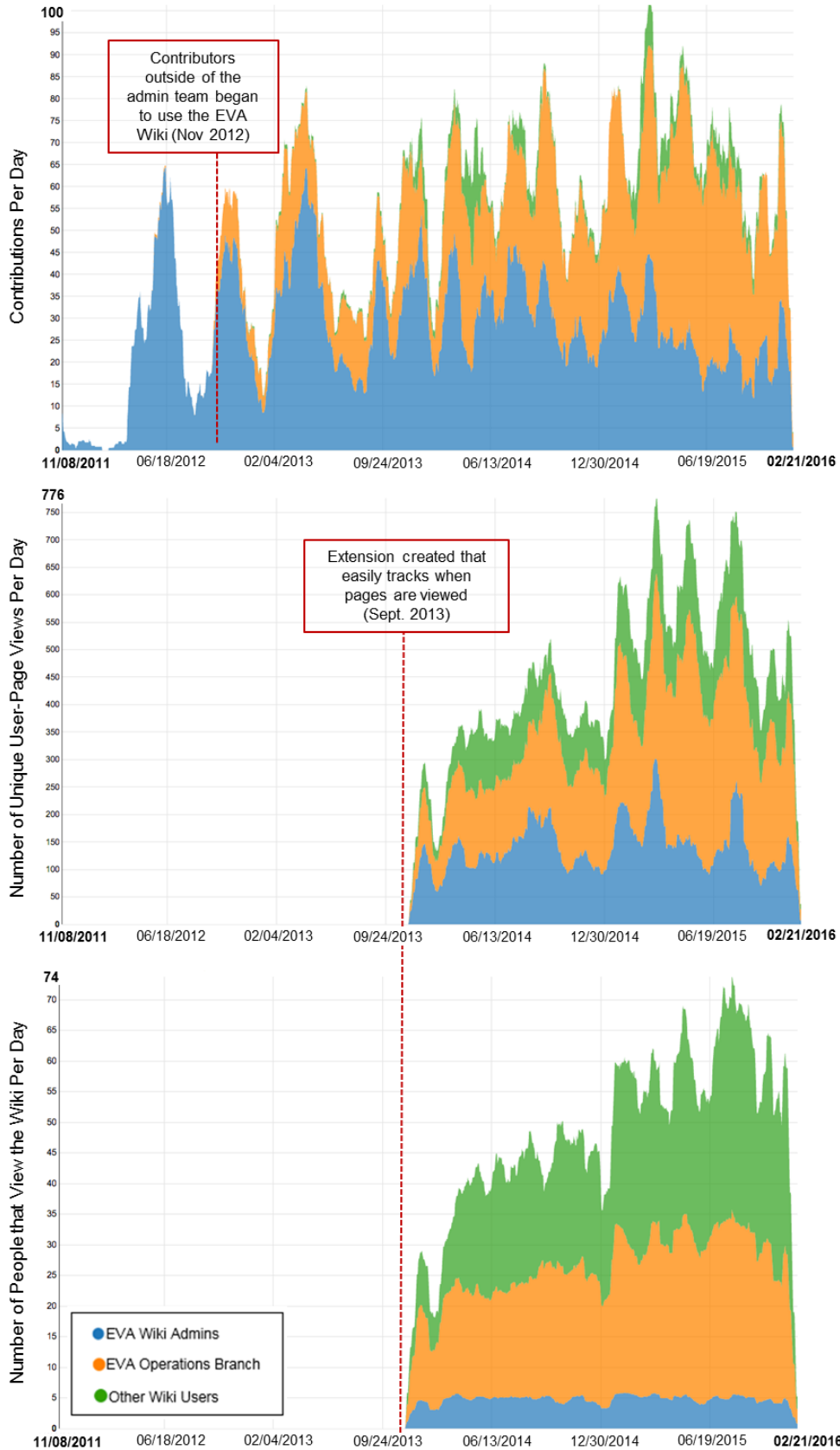


Figure 4. Stacked area charts showing 20-day moving averages of EVA wiki participation over its lifetime.

III. Using the Wiki for EVA Operations

The EVA Wiki has been beneficial in many aspects of EVA Operations. This section describes several examples of how the wiki has been used in three major areas: (A) training new EVA flight controller and instructors, (B) training astronauts for EVA, and (C) planning an EVA. The EVA Wiki is also frequently used during real-time activities on-orbit, such as EVA maintenance activities or executing an EVA, as a quick reference. Even though the wiki is not yet a mission critical database, flight controllers often use it because it is faster and easier to search for information.

A. Training New EVA Flight Controllers and Instructors

In every organization or company, training new employees takes time and resources. The EVA Operations branch is no exception. To become a certified front room EVA flight controller it takes about 8-10 years of training, which includes at least two instructor certifications and five backroom flight controller certifications as well as annual proficiency training to maintain each certification. Since employees in EVA Operations are constantly studying for a new certification, they were also wasting a lot of time trying to locate information or unintentionally studying documents that were outdated. Consolidating information with the EVA Wiki saved the entire branch time training their employees.

With the EVA Wiki, new employees can quickly find answers by using it like Wikipedia or Google. Not sure what a certain acronym is? Just search for it in the wiki. Need to know what the different types of EVA handrails look like? Just search 'EVA handrail' in the wiki to find pictures. The wiki is also used as a single portal of information. Instead of hunting down several different files and websites or asking experienced flight controllers to find the latest information about EVA hardware, new employees now just search for the hardware's wiki page. Let's use the Pistol Grip Tool (PGT) as an example again. The PGT page contains or directly links to all the latest information about the PGT. If the page happens to be outdated or is missing information, the remarkable thing about the EVA wiki is that the new employee has the ability simply update the page, or ask for help on the PGT Discussion page. Both options have automated revision control. In addition, everyone who watches the PGT page will get a notification that the page has been updated or that a discussion thread has been started. Those watchers can undo the edit or revise it if necessary, or they can respond to the discussion. In both cases, the action of the new employee helps the wiki stay updated and prevents the same issue from happening again with another new employee. New employees also need to learn both the technical aspects of EVA (EMU components, EVA Tools, external configuration of ISS) as well as the tacit knowledge (*how* to move in the EMU, *how* to properly handle certain EVA Tools, *how* to repair external ISS hardware). The wiki enables both technical and tacit knowledge to be added into the same knowledge-base. Overall, consolidating information in a single source and allowing users to frequently make updates has enabled the EVA Wiki to become an incredible time-saver for both inexperienced and seasoned personnel.

Using semantic properties in the SMW extension, the branch can also use the wiki to expose gaps in knowledge and they can better connect dependencies between their training products and operational procedures. The wiki gives the branch the ability to quickly sort for pages that need more information. Want to know what EVA Tool pages are missing an image? Want to see what EMU hardware pages have not been edited since 2013? Semantic properties in the EVA Wiki allows the team to quickly find where information needs to be added or updated.

B. Training Astronauts for EVA

To be a member of the EVA Operations branch, half of your job is a flight controller and the other half is training astronauts. There are several different EVA training flows that an astronaut goes through, from the basic training for new astronaut candidates to experienced crewmembers assigned to an upcoming expedition. Their training flows, and many of the associated lesson plans have been integrated into the EVA Wiki. Several classes are taught directly from the lesson plan page on the wiki either on a projector for classroom settings or from an iPad for dynamic, hands-on classes with EVA hardware. Each lesson plan has at least one lesson plan owner. If changes are made by a wiki contributor to a lesson plan page, the lesson plan owner must approve the revision in the wiki.

Astronauts assigned to an expedition start their training about two years before their mission with three assigned EVA instructors. The EVA Wiki helps to track the astronaut's training. The astronaut also has his or her own "Person" page, where instructors can quickly reference what EVA experience the astronaut has, as well as their tool or suit configuration preferences. The "Person" pages for crewmembers help instructors prepare for training events and help flight controllers plan an EVA.

C. Planning an EVA

Using the wiki for planning EVAs has been immensely helpful. It is a central location where users can add content and discussion topics, and page watchers will quickly be notified by email when the page is edited. Rather than having

information passed around in emails, which becomes old and is hard to follow, the EVA Wiki is a single, collaborative source where people can discuss important aspects of EVA planning. As for a particular example, the EVA Wiki took an existing Excel spreadsheet called the Integrated Operations Product Template (IOPT) and created an Analysis Request form that uses semantic properties to track, link, and query data entered. Historically, the IOPT was used for Shuttle and ISS EVAs to define all of the analyses that are required to conduct a specific EVA, such as load limits for certain EVA tools or bolt analysis for installing new ISS external hardware. The analysis is normally requested by the EVA Operations branch, answered by supporting engineering groups, and is managed within the ISS Program Office. Transitioning these analysis requests from several different IOPT spreadsheets to a single wiki form enabled better communication between all the different groups involved. The form includes analysis request details, deadlines, and relevance to the different groups. All of these properties can now be queried easily. If a specific task moves from one EVA to another EVA, the associated analysis request and data entered in the wiki can easily shift to the appropriate EVA timeline. This prevents information from getting lost between EVAs and between the different groups within the EVA community.

IV. Future Plans for the EVA Wiki

As discussed in the implementation section, the EVA Wiki went through several major stages to transform the EVA Wiki into a successful knowledge management system for the ISS EVA community. However, there is one final and crucial stage: continue improving the EVA wiki to adapt to the needs of the EVA community. As the needs of the ISS EVA community change, the EVA Wiki team is constantly developing new ways to make the wiki more user-friendly, more efficient, and more robust. Since a database is not effective without active users and contributors, the team is also continuing to teach people about the benefits of using MediaWiki and the ways the EVA Wiki can be utilized.

The EVA Wiki team is currently working on several improvements, including two big application upgrades: (1) adding a function called ElasticSearch, and (2) incorporating an extension called VisualEditor. ElasticSearch is a search application used by major companies like Netflix that adds flexible real-time search capabilities and powerful analytic tools.⁸ VisualEditor is a rich-text editor, created by MediaWiki.⁹ Currently, wiki contributors need to know basic wiki markup to edit a page. While the team has created useful tutorials and forms to make editing pages easier, contributors still need to have an understanding of basic wiki markups. With VisualEditor, contributors will be able to visually see the changes they make, similar to writing a document using basic tools in Microsoft Word or Google Docs. The goal with VisualEditor is to encourage contributors to edit pages and add more information to the wiki without having to learn MediaWiki formatting.

The EVA Wiki team also has some big ideas that could revolutionize knowledge management for JSC's Flight Operations Directorate (FOD), namely the part of FOD that supports ISS operations. First is the idea of a "Wiki Farm." Since the EVA Wiki was created in 2011, other flight control disciplines, like Robotics Operations and Trajectory Operations, created their own wikis. These different wikis use the same FOD server and use the same MediaWiki platform, but contain different information and have different contributors. Since every flight control discipline supports ISS, there are many times when information between two different wikis overlap because they all support ISS operations. To reduce having redundant information on multiple wikis, ideally the wiki teams could create what is called a "wiki farm" where all of the FOD wikis would be integrated together for the sake of data sharing but could still keep their system independent. Second is the idea of being able to securely access the EVA Wiki offline on a mobile device, which would allow users the flexibility to use the wiki during meetings, fieldwork, or even create the opportunity for astronauts to use the wiki while in space.

V. Conclusion

Starting with the idea to make an "EVA Wikipedia" and a free, open source application called MediaWiki, a small team of EVA flight controllers and instructors redefined what knowledge management looks like at JSC. The EVA Wiki amplifies JSC's goals to promote knowledge transfer and collaborative sharing, which is required for the success of NASA missions. The wiki team worked along management and coworkers to culturally transition the EVA Operations branch from a hierarchical data structure to the "wiki way." Despite cultural challenges, the EVA wiki has become a powerful knowledge management tool both for the EVA Operations branch and the ISS EVA community.

References

- ¹MediaWiki, Ver. 1.23.9, URL: <https://www.mediawiki.org/wiki/MediaWiki> [cited 23 Feb 2016].
- ²PHP, Ver. 5.4.34, URL: <http://www.php.net/> [cited 23 Feb 2016].
- ³MySQL, Ver. 5.6.26-log, URL: <http://www.mysql.com/> [cited 23 Feb 2016].
- ⁴MediaWiki, Semantic MediaWiki, Ver. 2.2.2, URL: https://www.semantic-mediawiki.org/wiki/Semantic_MediaWiki [cited 23 Feb. 2016].
- ⁵Hornstein, Henry. "The need to integrate project management and organizational change." *Ivey Business Journal*, March/April 2012. URL: <http://iveybusinessjournal.com/publication/the-need-to-integrate-project-management-and-organizational-change/> [cited 3 Feb. 2014].
- ⁶Bodell, Lisa. "Why Companies Resist Change, with Lisa Bodell." *Big Think*, 2014. URL: <http://bigthink.com/videos/why-companies-resist-change-with-lisa-bodell> [cited 18 Feb. 2016].
- ⁷MediaWiki, Extension WatchAnalytics, Ver. 0.3.0, URL: <https://www.mediawiki.org/wiki/Extension:WatchAnalytics> [cited 23 Feb. 2016].
- ⁸ElasticSearch, Ver. 2.2, URL: <https://www.elastic.co/products/elasticsearch> [cited 23 Feb. 2016].
- ⁹MediaWiki, VisualEditor, URL: <https://www.mediawiki.org/wiki/VisualEditor> [cited 23 Feb. 2016].