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The Knowledge Management System of Real-Time Flight Operations

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Abstract

As modern satellite systems grow in complexity, more is being asked of satellite operations teams. The demands placed upon operational control centers only increased during the pandemic leading to higher stress levels and burn out among the staff, putting the mission at a higher than normal risk. MOA the Mission Operations Assistant Tool is a real-time mission operations Knowledge Management System. It is used by the United States of America National Environmental Satellite, Data, and Information Service division within NOAA. MOA was designed as a knowledge management system to help assist users by broadly distributing key insights about the system and allowing the users to be more self-sufficient. To do this, MOA ingests mission system logs and allows users to customize and append to these messages allowing for greater clarity and understanding. MOA helps capture subject matter expert knowledge into a consolidated database and presents this information autonomously to system users when it's needed most. By providing clear guidance on how to handle certain system error messages, MOA empowers onsite staff, reduces outbound support phone calls, and greatly assists in the anomaly troubleshooting process leading to increased effectiveness and shorter recovery times. Additionally, MOA simplifies operations by reducing complex tasks into simple button presses making troubleshooting and investigation results repeatable between different operations crews regardless of experience or individual skill levels. These simple to use buttons reduce the chance of miscommunication and accelerates the overall process of relaying important information to off-site personnel that are trying to diagnose a problem. Furthermore, because MOA has access to the system log messages, it is able to easily notify off-site support automatically when certain thresholds are crossed, such as a dangerous event error message. The messages provided by MOA can be fully customized so that the exact details needed for any given situation are always available. And lastly, MOA was built to enable secure remote operations. To achieve this, MOA leverages a cloud-scale microservice architecture to assure that it can scale appropriately regardless of mission complexity. Overall, MOA is an effective knowledge management system that helps extend existing human capabilities in real time by improving situational awareness and empowering operations team members.

Keywords: MOA, SatOps, Satellite Operations, GOES, NOAA, NESDIS

Acronyms/Abbreviations

Mission Operations Assistant (MOA)
Arctic Slope Regional Corporation (ASRC)
National Oceanic and Atmospheric Administration (NOAA)
Geostationary Operational Environmental Satellite (GOES)
National Environmental Satellite, Data, and Information Service (NESDIS)
Space Weather Follow On - Lagrange 1 (SWFO-L1)
Joint Polar Satellite System (JPSS)

1. Introduction

MOA was created to address a number of challenges on the GOES mission. The first challenge is the complexity of the spacecraft and its equally complex ground system, making it difficult to interact and find relevant data on the system. The second challenge is the lack of operational tools to handle the big data generated by the mission, which can overwhelm the users with system alarms. Lastly, the pandemic forced the team to learn how to operate the satellites remotely, which increased the need to simplify the communication process and avoid errors. In this situation it is very possible for key subject matter experts to get burnt out from being overly relied on to perform nearly constant mission support. MOA was created to help users of the mission by providing them with subject matter knowledge that is easily

accessible, reducing common troubleshooting tasks to a single button press, and providing relevant notifications to targeted audiences.

2. Design Approach

The overall objective of MOA is to help empower all users of the system to take meaningful actions and be more self-sufficient. With this in mind several design choices were made.

First and foremost, it was critical to identify what data would be most relevant to assist the users with respect to their nominal troubleshooting methods. As the log messages were identified, it became clear that a scalable solution would be required. The GOES mission creates a lot of data so the MOA tool would need to be robust enough to handle this volume of data.

Next, the relevant information needed to be easily accessible at all times regardless if the user could access the system or not. The MOA solution would need to be available from the cloud to ensure compatibility with remote support.

Finally, the MOA solution would need to be simple to use. For this, the team focused on isolating the most common of troubleshooting methods used when interfacing with log messages. By working with the end users, it was made clear that finding answers to the following questions would be highly desirable:

- When was that message last seen?
- How often are we receiving that message?
- Do we have any additional information about that message?
- Can you send that message to me?

With these questions in mind, it was possible to formulate the key features of MOA.

3. Application and Feature Sets

3.1 Advanced Search

The Advanced Search feature in the Mission Operations Assistant (MOA) tool allows users to perform complex searches of the log data stored in the cloud. With this feature, users can define multiple search criteria using different parameters such as time, spacecraft name, instrument product, site, or event type.

Users can refine their searches by selecting specific time ranges or events, such as known spacecraft passes or instrument calibration times. They can also combine search criteria to perform more complex searches. For example, a user could search for all events related to a specific limit and instrument within a specific time range.

The Advanced Search feature also allows users to save their search queries for future use. This means that users can easily retrieve and reuse a search query that they have previously defined, without having to redefine the search criteria each time.

Overall, the Advanced Search feature in MOA provides users with powerful and flexible search capabilities, allowing them to quickly and easily locate the data they need for their mission operations tasks.

3.2 Histogram

The Histogram feature allows users to visualize data distribution for a set of log messages returned by the search feature. For every search performed, a histogram is generated and made easily available to the user. The histogram provides a graphical representation of the frequency distribution of a dataset, which helps users understand the range and distribution of messages found for a given time range for each search.

By using the histogram feature in MOA, users can analyze log message data to identify patterns and anomalies in spacecraft or ground system behavior. For example, if a search's histogram shows a gap, it suggests that there was a period of time where messages were not being received. On the other hand, if the histogram shows either an increase or decrease in frequency, it indicates that the past behavior for that search may not be consistent, and there might be some underlying issue.

Users can also use the histogram to identify outliers or data points that deviate significantly from the expected behavior. By analyzing such outliers, users can identify potential issues with the spacecraft or ground system and take appropriate action.

Overall, the histogram feature in MOA provides users with a powerful tool for quickly analyzing the log message history and gaining insights into the behavior of the spacecraft and ground system.

3.3 More Context

The More Context feature in the Mission Operations Assistant (MOA) tool allows users to view additional details and context about specific log messages that have occurred during spacecraft operations.

When a search is performed and the log message of interest is identified, the MOA tool provides a quick way to further analyze that log message by allowing the user to inspect the original log where that message was pulled from. The "more context" feature allows users to view additional information about the message by seeing what other events may have taken place in the same log around the time that the message of interest was generated. This in turn may help in understanding the cause and potential impact of the message of interest.

By providing this additional context with a single button press, the MOA tool can help users make informed decisions about how to respond to the anomaly, including whether to take corrective actions, adjust operational procedures, or request further analysis from the team. This feature can be particularly useful in situations where there is limited information available or where the cause of the anomaly is unclear, allowing users to gather more data and insights to help inform their decisions.

3.4 Last Seen

The Last Seen feature allows users to track the last time a particular event or message was seen in the logs. This feature is very useful for answering the very important question of "when is the last time we've seen this alarm". Normally this question would take some time to resolve. With MOA this action is just a simple button press that any operator or engineer can perform.

A major advantage of the last seen feature is how fast the results are returned. This allows operators and engineers to respond much faster. The team will either realize that this alarm has been seen before and thus should have some idea of how to resolve it or they will quickly know that this is a brand new alarm and an anomaly team should be formed to investigate the issue.

3.5 Notify Someone

The Notify Someone feature in the Mission Operations Assistant (MOA) tool allows users to send email notifications to specific individuals or groups. This feature can be useful in a variety of situations, such as when a non-critical event occurs but the team needs to be notified.

To use this feature, the user selects the "Notify Someone" button and enters the recipient's email address and a subject line. The message is perforated with the message of interest already captured in order to avoid any copy and paste errors. The message can be further customized to provide additional information about the event or task that requires attention. Once the notification is sent, the recipient will receive an email with the details of the event or task, along with any necessary instructions or information.

The "Notify Someone" feature is an important tool for coordinating and communicating information that otherwise would have resulted in an emergency phone call for a non-critical event. Overall, this feature is just one of the many ways MOA helps reduce burnout among the support staff.

3.6 Notes

The Notes feature in the Mission Operations Assistant (MOA) tool allows users to add digital notes to a specific log message. These notes will be attached to all similar log messages such that if a brand new similar log message is ingested by MOA the note will be available for inspection within the MOA search results each time the log message appears in the results. This feature is useful in a number of ways; an operator may want to document a particular observation or flag an anomaly that might be relevant for future reference or for other team members. Engineers are able to add customized notes that may instruct operators how to respond to a message or what external documentation should be referenced.

Notes can be added by clicking on the "Add Note" button in the MOA interface that is available for every search result. Once clicked, the user simply enters the necessary text and saves the note. Notes are easily accessible for all users. This helps better distribute system expert knowledge to the broader team, enabling all team members to take meaningful action.

The note feature is particularly helpful for collaboration and communication within a mission operations team. It allows team members to share information about potential issues or observations, ensuring that everyone is aware of the latest developments and that important information is not lost or forgotten. Furthermore, as MOA accumulates notes, MOA becomes a centralized knowledgeable for the mission which lowers the risk of mission brain-drain as veteran team members leave the mission.

3.7 Triggers & Automatic Notifications

The Triggers and Notifications feature allows users to set up alerts and notifications based on specific log messages or conditions. These notifications can be sent to individuals or groups via email or text message, and can be customized to meet the needs of each user or team.

For example, users can set up a trigger to receive a notification when a certain event occurs, such as a spacecraft entering a specific region of space or when a particular instrument on the spacecraft has a malfunction. Users can also set up triggers based on time or schedule, such as receiving a notification at a specific time each day or week.

These triggers and notifications can help ensure that users are aware of important events or issues as they arise, and can enable them to take timely action to address any problems or concerns. This feature is particularly useful in mission-critical situations where timely and accurate information is essential for success.

4. Results

The initial impact of deploying MOA onto the GOES mission was felt swiftly. Within the first 2 hours of deployment the satellite operators uncovered a use case that we, the designers, never foresaw. In satellite operations, it is very easy to identify when an alarm has triggered, however, it is much more difficult to identify when an alarm has not triggered when it was expected to have triggered. Using the MOA histogram the operators were able to quickly identify a data gap for a daily expected alarm that had unexpectedly stopped occurring. Prior to MOA, determining the exact size of this data gap would have taken several hours for an engineer. Now this action can be completed in under 2 minutes by an operator.

MOA is routinely used for historical trending of log messages, something that again was a previously non-trivial task to perform. The engineers are able to quickly assess various messages produced by the spacecraft and ground system in a straightforward way.

5. Discussion

The overall goal of MOA was to help empower all users of the system to take meaningful actions and be more self-sufficient. As user adoption continues to grow, MOA becomes a more valuable asset to the GOES mission. MOA was built using GOES data, however, the MOA tool was built to be generic. It only requires log files, they don't even have to be related to satellite operations. MOA is a tool meant to assist real-time operations.

As previously discussed, the logs are generated on the system and then pushed out onto the cloud to be processed by MOA. There is no way for MOA to push data back to the GOES system and that is by design to help maintain good security boundaries for the operational system. By putting MOA in the cloud, engineers are able to easily access vital system log messages used to diagnose critical messages when they are away from the system. This also helps easily facilitate conversations between the operator and engineers during support phone calls. Because the log messages are available in the cloud, both operator and engineer can feel secure that they are both talking about the same information, something that was previously a struggle for remote operations.

Over time as MOA gains traction and notes continue to accumulate, MOA will be able to act as additional training fodder for new team members. Those new to GOES will be able to sit down with MOA and begin to look at true mission logs. If they are unable to understand the mission logs, they can reference the attached note if one exists; or in there is no note, then they can add a new one helping future new team members to better understand the system.

6. Conclusions

Overall, the GOES mission is secretly a big data mission in need of big data tools to help operate it. MOA is a big data tool that can help but other big data tools are needed because all modern spacecraft missions are secretly big data missions as well.

MOA allows users to quickly access information within the historical mission logs. It greatly simplifies common troubleshooting techniques to simple single-button-press features. This increases the base skill level of all users of the GOES system. Key information is made available to the users fingertips right as it's needed through the various customized notes attached to the log messages. And lastly, MOA is able to notify offline users through various notification methods that can be sent manually or triggered autonomously to help further reduce troubleshooting time and enhance overall team communication.

MOA is a relatively new tool to the GOES mission but it's highly desirable by operations staff as it helps decrease the risk of burnout to key team members. As GOES continues to adopt MOA and find new use cases, other missions

within NESDIS have begun looking to adopting MOA as well. Both SWFO-L1 and JPSS have been impressed by what the tool can do and are investigating how MOA may be integrated into their respective missions.