"Built-In" Action/Issues Tracking and Post-Ops Analysis Tool for Realtime Console Operations

Marshall Space Flight Center's (MSFC) Payload Operations Integration Center (POIC) for the International Space Station (ISS) uses a number of formal databases to manage and track flight plan changes, onboard and ground equipment anomalies, and other events. However, individual console positions encounter many action items and/or occurrences that don't fit neatly into the databases, and while console logs are comprehensive, manual or automated searches do not always yield consistent results. The Payload Communications Manager (PAYCOM) team, whose members speak directly with the ISS onboard crew with respect to NASA payload operations, has found a creative way to reformat a mandatory Daily Report to organize action items, standing reminders, significant events, and other comments. While the report keeps others appraised of PAYCOMs activities and issues of the moment, the format makes it easy to capture very brief summaries of the items in a "Roll Off Matrix", including start and stop dates, resolution, and possible applicability to future ops. The matrix provides accountability for all action items, gives direct insight into the issues surrounding various payloads and methods of dealing with them, yields indirect information on PAYCOM priorities and processes, and provides a roadmap that makes it easier to get back to extensive details if needed. This paper describes how the ISS PAYCOM Daily Report and Roll Off Matrix are organized, used, and inter-related to each other and the PAYCOM operations log. While the application is for a manned vehicle, the concepts could apply in a wide spectrum of operational settings.

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Abstract - At Marshall Space Flight Center's (MSFC) Payload Operations Integration Center (POIC) for the International Space Station (ISS), the Payload Communications Manager (PAYCOM) team, whose members speak directly with the ISS onboard crew with respect to NASA payload operations, has found a creative way to reformat a mandatory Daily Report to organize action items, standing reminders, significant events, and other comments. While the report keeps others apprised of PAYCOM's current activities and issues, very brief summaries of the items are put into a "Roll Off Matrix", including start and stop dates, resolution, and possible applicability to future ops. The matrix provides accountability for all action items, gives direct insight into issues regarding payloads, control center operations, and methods, yields indirect information on PAYCOM priorities and processes, and provides a roadmap for locating extensive details if needed. This paper describes how the Daily Report and Roll Off Matrix are organized, used, and inter-related to each other and the PAYCOM operations log. While the application is for a manned vehicle, the concepts could apply in a wide spectrum of operational settings.

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Introduction

Operational log-keeping has been practiced for millennia. A log can be a powerful tool for maintaining continuity between shifts, reconstructing events, resolving anomalies, and distilling better ways of doing things. Early spaceflight programs relied on handwritten logs, and even though console operators developed unique symbols or shorthand, the pace of operations was such that operators could only jot down the bare essentials of what they observed. Because logs were handwritten, searching for either specifics or trends was very time-consuming.

Today, inexpensive computers, office automation software, and "instant-replay" voice communications archive systems allow console operators to prepare extremely detailed logs by the end of their shifts. This is obviously helpful if event reconstruction is needed to analyze a specific incident whose date(s) is/are known, and for assessment of a relatively short flight lasting one or two weeks.

Long-duration missions such as those flown on the International Space Station present some new challenges:

- System or payload activities may span weeks or months, and a series of closely related activities may span years.

- Crew members fly for months, and their task loading can make it difficult for them to remember nuances and "gotchas" between performances.

- Ground support personnel are often involved with three or four ISS increments concurrently – while one is flying, others are in preparation or post-flight. (An increment is a complement of payloads and activities associated with a given ISS expedition, as well as the time frame that the expedition crew is onboard.)

- The sheer number of log entries related to a given topic can make analysis difficult, even if a text search is used to reduce the number of entries under consideration.

- Formal databases document details upon details of planning criteria, equipment anomalies, ground team anomalies, and so forth, but in terms of ready reference to help console operators get through their shift, they may provide so much background that the foreground goes underground.

- As international partners begin flying their modules, systems, payloads, and flight crews, handshakes across different partners' hardware, software, and organizations will become more complex, no doubt leading to more idiosyncrasies and "unadvertised features".

This paper is written from the ISS Payload Communicator (PAYCOM) perspective. PAYCOMs are responsible for ISS crew communication for NASA payloads, which includes:

- Space-to-Ground (S/G) communication with crew for NASA payload issues

- Preparing written material for the Daily Summary based on ground team inputs

- Managing voice and/or video conferences between the crew and payload ground teams

- Reviewing procedures and operations documents with an emphasis on crew issues

- Tracking crew questions and/or requests related to NASA payloads. Some of these are handed off to other positions based on intra-team coordination, but PAYCOM is the default actionee.

The PAYCOM console is nominally staffed during crew awake hours on normal workdays. This is typically 16 hours a day, 5 days a week, and the gaps in continuous coverage accentuate the need for good handover and "cheat sheet" materials.

Body

Daily Report and Rolloff Matrix Evolution

In the course of operating since 2001, PAYCOMs tried several methods for keeping up with questions and actions. Items that could be resolved within 1-3 days could usually be managed via handover entries in the console log, but longer-term items tended to "drop through the cracks". The "Tasks" feature of the email system (Microsoft Outlook) was used for a while, but problems included subfolder management, disappearance of items due to inadvertent mouse clicks on checkboxes, frustration/wasted motion due to nesting of messages and enclosures, and how easy it was to forget to check the system, especially on hectic days. Filing schemes for email messages outside of the "Tasks" structure yielded similar results.

At a PAYCOM meeting in early 2007, someone noted that all of the methods attempted were internal to the PAYCOM team – no other console position had insight into what we were tracking unless they'd made a note of it themselves, and their notes might not agree with ours.

It occurred to us that a Daily Report (DR) that we're required to submit (on any day that the console is staffed) to the Payload Operations Director (POD) and the Payload Operations Manager (POM) had a place for "Forward Actions", but the section was not well-defined. Other

sections had been defined early in the ISS program, but hadn't been validated and/or updated with respect to current operations. The scheme that evolved has these features:

- Since the DR is mandatory, we can guarantee that PAYCOM will open and look at it every day on console.

- New DRs are created via a "Save As" of the previous report. This eliminates errors from cutting and pasting from one console log entry to another.

- New or modified information is entered in blue text, and changed to black in the following report. Entries being closed are put back into blue text for their last appearance in the report. Authors and editors include date/initials on revisions.

- Separate sections exist for Actions (discrete tasks, usually of a one-time nature) and Reminders (tasks or things to remember tied to recurring events or circumstances, e.g. "gotchas").

- The section originally titled Malfunctions and Recoveries now includes all Significant Events, including notable successes. Sections covering info that "belongs" to other teams have been eliminated.

- POD/POM are now aware of what we think is important, and can ask us to 1) delete items they're working and/or 2) add items they'd like us to take on. "Trim the overlaps, fill in the underlaps."

These modifications helped a great deal for day-to-day ops, but the question arose, "If someone asked us to account for all of our unique action items (e.g., those not covered in formal databases), could we summarize what they are/were, and how they were resolved?" Well, we could . . . but digging through all the DRs would take an incredibly long time, and one would have to sort through repetitive entries from the date an item appeared to the date it was removed. Someone suggested that we "roll off" the action items into a matrix for future reference, including start and stop dates to show the time frame. We concluded that summarizing Reminders, Significant Events, and other Comments would also be useful.

Organization and Content

The DR and Rolloff Matrix formats that emerged are shown in Figures 1 and 2, respectively. The Rolloff Matrix example shows several but not all types of entries. As of October, 2007, the actual matrix covered approximately 1.5 years of operations and contained about 350 entries.

PAYCOM Daily Report – SOP 1.3

Submit to POD via email within one hour scheduled beginning of crew sleep. This report covers hours that the PAYCOM position was staffed:

Start Time (GMT Day/Time):	271/13:30 GMT
End Time (GMT Day/Time):	271/ 21:30 GMT
Calendar Day (DD-MMM-YYYY):	28 Sep 2007
Submitted By (Operator Name):	Dave Scott

PAYLOAD CREW ACTIVITIES – OSTPV AND TASK LIST EXECUTION

Performed per OSTP (Note any duration delta given by crew or observed, and items based on negative reporting)
- MSG-SAME-STARTUP S1
- SAME-SAMPLE-CHGOUT
- SAME-IMPACTOR-EXCHG

OSTP - Aborted, Not Performed, or Deleted
-

Added to OSTP
-

Performed per Task List (marked complete)
- None

Available on Task List (not marked)
- CEO-OPS

SIGNIFICANT PAYLOAD EVENTS / RESOLUTION (Include ops prep implications)
(New items in Blue text. Usually in DR for just one day)

Notable Successes
- SAME Sample Changeout and Impactor Changeout very smooth. SAME PD told LIS Rep everything seems to be working fine – have run another Kapton test point, received data, and initial analysis seems to confirm one of their hypotheses.

Malfunctions, Anomalies & Recoveries
-

Other
-

ACTION ITEMS

Opened Today (Blue text)

-

Pending / In-Work (Show changes in blue text for one day only)

- Reference OCA message 15-xxxx (when uplinked per approved fcolall000015) in DS for Big Picture words on upgrading ER4 ELC to an A31p. (NWP 193) GMT 198—Still waiting on JEDI Message to be created and action assigned on OCR. SLJ

- Give feedback to Clay on results of ANITA trouble shooting once it's working properly. During ANITA troubleshooting GMT 264 Clay expressed interest in seeing/knowing the results. Passed request to PD, who said see what they could do. (comm ~264/21:58). (NWPGMT 265) DS 268 advised Clay ANITA appears to be working OK. Close action after we tell him what we think caused the anomaly – PD still thinking about this. (Consolidated by Scotty GMT 267).

Closed Today (Blue text)

- Track - CEO owes Clay words regarding the quality of the photos he took of his Eastern China target on GMT 235. (NWP GMT 236) CEO provided feedback in target list for GMT 270. (Closed by DWS GMT 271)

OTHER COMMENTS – ISSUES, CONCERNS, KUDOS
(New items in Blue text. Usually in DR for just one day)
-

REMINDERS

Added Today (Blue text)
-

Current (Alphabetically by payload name. Show changes in blue text for one day only)

- **CEO Targets** – Unless otherwise directed that there has been a philosophy change – give the crew a heads up in DPCe when there are targets in their post-sleep. (SOP 7.13)

- Any **HRF** activity requiring laptop – Advise crew in mDPC if powered via UOP or rack. Originated 2007/089.

- **Stowage** - Ask crew for S/N, P/N, and/or Name Labels for items we're not certain about as they're being handled by crew whenever possible to avoid "go-backs", e.g. crew shows video of or mentions something they found. (Based on EFN F017562 related to DS 2007/200 Q&A).

Removed Today (Blue text)

Note - This is a composite built from several reports for the purpose of illustrating features. Since the thrust of this paper is a method and not the actual content, acronyms are not listed.

Figure 1 – PAYCOM Daily Report Format

	A	B	C	D	E	F	G	H I J K L
1	Facility	P/L Name	Type	GMT Date Open	GMT Date Closed	Description	Disposition	Audited through 2007/271 - dws 12 Oct 2007
3	MSG	PFMI	A	2006/118	2006/122	During PFMI crew conference, PI agreed to provide details of previous PFMI results to crew.	Info from PI uplinked in message 13-0157. Referenced in DS 123	
4	MSG	PFMI	A	2006/118	2006/123	Ask Jeff the S/N and B/C of the touchpad in MSG airlock at GMT 123 DPC.	Touch pad S/N 01-360 deployed. DR 123 includes additional info about 4 MSG video arms.	
5	MSG	PFMI	SE	2006/124	2006/124	It appeared that MSG could not command recorders. Crew checked wires, all seated; got beep sound when trying to press record, tapes used; replaced tapes, proceeded OK.	Problem caused by connectivity issue at MSG TSC.	
6	Earth Obs	CEO	A	2006/129	2006/137	Question from DPCe for CEO: Some targets in world map are hard to find. Any plan to put all targets in world map?	Detailed CEO answer submitted for DS 138. Interesting reading.	
7	MSG	PFMI	A	2006/131	2006/136	For PFMI on 136, advise Jeff if PFMI Sample Removal, PFMI Tape Removal, and MSG Shutdown can be done back-to-back. Won't know until <24 hours prior.	DPCm 136 - Told Jeff he can do them back to back like last time. (File already downlinked.)	
8		BCAT	A	2006/138	2006/143	Jeff's BCAT setup differs from procedure, but PD team likes it, has questions about parts used, requests photo.	PAYCOM sent explanation to PD on 142, photo on 145. Close action when BCAT satisfied.	
9	POIF	POIF	A	2006/138	2006/139	Actions related to Power Outage GMT 140-141	Words placed in DS 140.	
10		SPHERES	A	2006/138		Per POD, on Sat morning 140, ask Jeff to be sure camera/camcorders in manual mode (138 DPCe Jeff hadn't checked)	(Check DRs and logs to verify done.)	
11	BCSS	CBOSS-FDI	C	2006/184		Crew didn't have good "big picture" objectives, found words to set him at ease during run.	Good sportsmanship all the way around. Event was scheduled last-minute due to STS scrub.	
12	HRF	HRF PC	SE	2007/100		2 anomalies during IP address update. New h/w detected, LAN Connection 5 (expected 3 or 4)	PAR HRF2 S/W 9. No residual impact. Could happen again in HD changeout if IP address reset.	
13	HRF	CCISS	R	2007/176		On Day 2 CCISS Ops, tell FE-2 he needs to physically power off emerald brick. (Skips step on Day 1.)	[Re-classify as action, or will this hold true for all CCISS ops?]	
14	STOWAGE	STOWAGE	R	2007/200		Ask for S/N, P/N, and/or Name Labels for items we're not certain about as they're being handled by crew.	Goal is to prevent go-backs. Based on EFN F017562 related to DS 2007/200 Q&A	
15	Earth Obs	CEO	A	2007/236	2007/271	CEO words to Clay regarding quality of Eastern China photos taken GMT 235.	Feedback in CEO target list GMT 270.	
16	MSG	SAME	SE	2007/271		Sample Changeout & Impactor Changeout very smooth. Everything seems to be working fine.	PD has run another Kapton test point. Initial analysis seems to confirm one of their hypotheses.	
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Note - This is an edited excerpt from the production matrix.
Since the thrust of this paper is a method and not the actual content, acronyms are not listed.

Figure 2 – Rolloff Matrix Format

In the DR, content entries appear with bullet symbols under the appropriate heading. Visual organization, including header and content text color, is important for navigation and clarity. New and changed content are in blue text in the first report in which they appear. Text is changed to black for subsequent reports, then back to blue in the last report in which it appears. This makes it easy to see what is changing, and the "Opened Today' and "Closed Today" headings act as prompts for   a) drafting the next day's report (with a "Save As" command), and   b) moving Actions and Reminders to the Rolloff Matrix.

Content in the DR should summarize each topic very briefly. Wholesale copying and pasting from detailed console log entries tends to clutter things up. Instead, a simple reference to " log DDD/hhhh" (DDD -> Day of year, hhh -> GMT 24-hour time) can guide the reader to in-depth information.

Some challenges encountered in preparing DRs include:

Making sure Actions suggest what the console operator needs to do, not merely describe an issue or status.

Obtaining consistency among operators, e.g., establishing what constitutes a Significant Event, when an action should be carried in the DR vs. handling it in handover notes within the console log.

Keeping the entries brief. This was mentioned in a separate paragraph above. It's important enough to emphasize again . . . and again.

Following through on protocol for manipulating text – colors, moving, deleting. In some cases, especially during fast-paced operations, 2 or 3 days may elapse before the "right" thing happens to a block of text. However, this can be compensated for during Rolloff Matrix processing.

The Rolloff Matrix is essentially a collection of index tabs, so brevity is critical. Description and Disposition should be kept to 1-3 lines, 5 lines maximum. Start and stop dates tell the reader which DRs and/or console logs to examine for details, and of course the DR entries may point to specific log entries. Significant Events and Comments typically appear just once in the DR, so "Date Closed" for these is usually blank.

Formally speaking, "Facility" refers to a rack or collection of racks onboard ISS that hosts equipment for specific types of scientific investigations, and "Payload" refers to a specific experiment, whether the experiment uses a Facility or not. In addition to these meanings, the columns serve to group non-payload items into major categories and sub-categories.

In developing the Rolloff Matrix concept, there was much

discussion as to when items should be transferred from the DR to the Matrix – when they start vs. when they're finished, as part of the daily console-keeping routine vs. offline by an off-duty console operator, etc.   Greater consistency has been achieved by updating or "auditing" the Matrix offline, processing several DRs in one sitting. This allows time and a relatively unstressed environment step back from the operations tempo, compare successive reports for progression and consistency, discern the essence of each given entry, and clean up the wording and/or Start/Stop dates. It takes about 2 to 3 hours to process a month's worth of DRs.

If one has a situation with round-the-clock staffing and a reasonable amount of low-pressure time on at least one shift, maintaining a Rolloff Matrix might be feasible on-console, but this is not workable for PAYCOM, and there's much to be said for the "let it soak in" phenomenon intrinsic to processing the Matrix offline. If less than a month's latency is desired, reports could be processed weekly.

As with many endeavours, the Rolloff Matrix isn't perfect, but therein lies potential for raising questions that can improve operations. While populating the matrix, it's useful to include comments about what's in the matrix in red and within brackets, [like this]. Such comments might flag data inconsistencies, suggest followup activity, or state insights gained while reviewing the information.
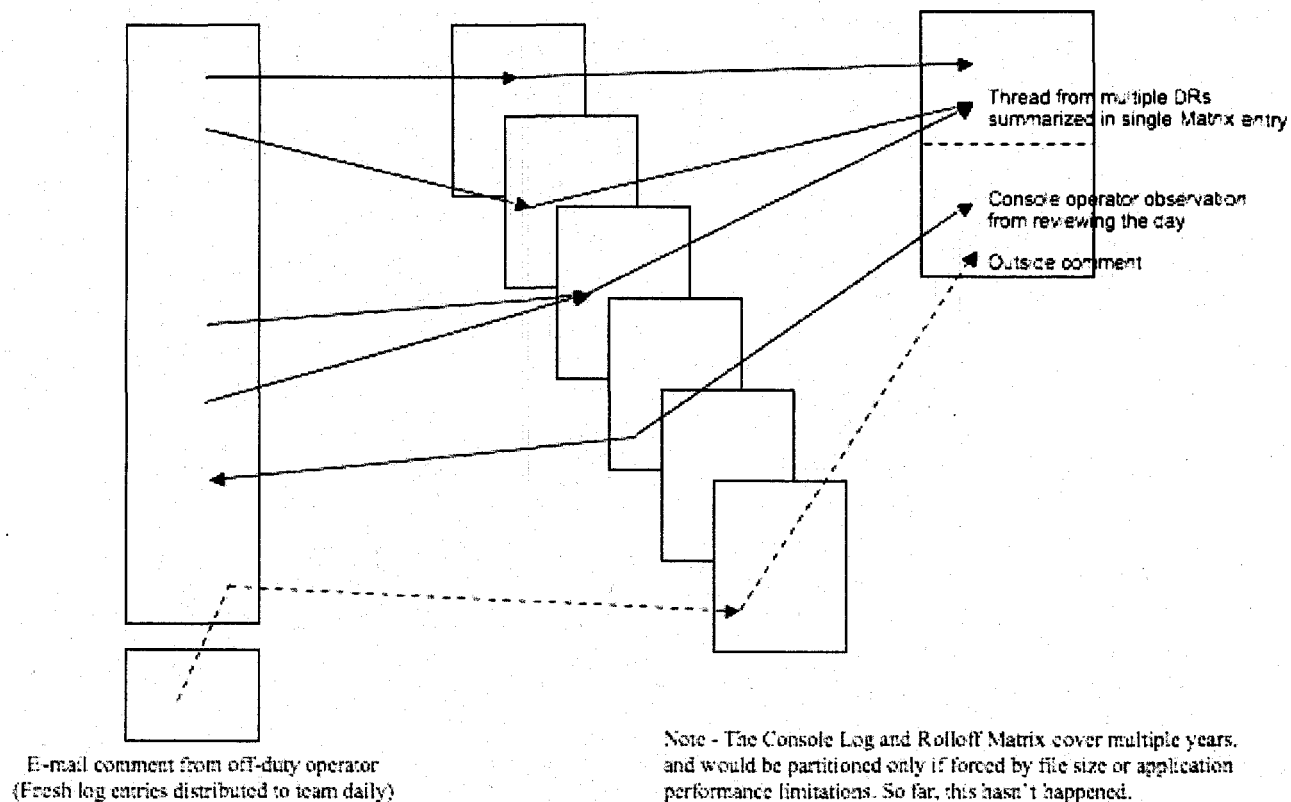
A recently conceived idea (October, 2007) is to allow and encourage off-duty console operators to send comments or observations (based on reading the daily console log or on meetings relevant to current ops) to the on-duty operator for inclusion in the DR (labeled as an outside comment), and eventual transfer to the Rolloff Matrix. If practiced in moderation, this could enhance corporate consciousness.

Figure 3 summarizes how the Console Log, Daily Reports, and Rolloff Matrix inter-relate.

Console Log (Filemaker)
- ~12,500 Entries per year
Can select records via text search

Daily Reports (Word)
- 260 Reports per year

Rolloff Matrix (Excel)
- 250 Categorized Entries per year

Thread from multiple DRs
summarized in single Matrix entry

Console operator observation
from reviewing the day

Outside comment

E-mail comment from off-duty operator
(Fresh log entries distributed to team daily)

Note - The Console Log and Rolloff Matrix cover multiple years,
and would be partitioned only if forced by file size or application
performance limitations. So far, this hasn't happened.

Figure 3 – Relationships Among Products

Conclusions

Including Actions and Reminders in a mandatory Daily Report ensures that:

Console operators view the information daily.

Ops management personnel receiving the report are aware of items being tracked, and can compare them to their notes to eliminate duplication of effort and/or fill in gaps appropriate to the function of the reporting console position.

Transferring Actions, Reminders, Significant Events, and Comments from the Daily Report (DR) to a Rolloff Matrix provides a categorized synopsis of issues and events (good, bad, and indifferent), that have risen above the noise level. The transfer is best accomplished in an offline mode, e.g., by an off-duty console operator processing a week or a month of Daily Reports in one sitting of 30 minutes to 3 hours. Visual layout and color-coding within the Daily Report make preparing the report and transferring data to the matrix easier.

Information contained in the Rolloff Matrix has several uses:

Prepare to operate a given payload. Check its history for trends, issues, and/or "gotchas". Start/stop dates and/or console log references (in Matrix or Daily Report entries) provide quick navigation to supporting details.

At the beginning of a payload increment, determine which Reminders to continue, discontinue, or resurrect.

At the end of an increment, identify lessons learned. (Two mechanisms are at work here. If a lesson is recognized at the time something happens, it can be put in the DR and hence the matrix, for ready recall later, as opposed to getting buried so deep in a console log that it's not recalled months later. If a lesson is not noticed in the moment, it may be distilled in the process of reviewing all the items that rose above the noise.)

Identify topics for "go-back" discussions and/or further research.

Demonstrate thorough accountability and/or traceability of action items not covered in formal databases.

Gain insight about and improve consistency of console operations themselves. Examples of things to look at: Types of actions tracked, and how long they're typically carried; When an item is complete as opposed to when it's actually removed from the DR; Consistency of what different operators include in the DR.

Generically, post-ops and/or in-ops analysis for long-term operations can be significantly enhanced by having a <u>daily</u>

means of capturing actions and "above the noise" issues that are not covered by primary ops databases, first because they <u>are</u> actions or <u>are</u> above the noise in their own right, and just as importantly because trends may develop over time that provide useful insight. Performing the capture via a report viewed by others enables feedback, validation, and reduction of gaps and/or overlaps, Routine harvesting, such as a rolloff matrix, summarizes and indexes the actions and issues so that they are not lost in the abyss of a comprehensive console log or hidden in reams of daily reports.

References

[Will provide in final version.]

Biography

David W. Scott, alias "Scotty", is a Payload Communications Manager for the International Space Station, and is also involved with training development for NASA's next-generation launch and manned exploration vehicles. He's been involved with several console technology projects, especially in space-go-ground videoconferencing and audio archiving. He was a payload communicator for the ATLAS-1 Spacelab mission in 1992, and helped design the payload training program for Space Station. developing full-motion television uplink to Space He holds a B.S. in Physics and Mathematics from Principia College, and spent 6 years as a Naval Officer, including flight duty in F-14s.