

Enhancing DSN Operations Efficiency with the Discrepancy Reporting Management System (DRMS)

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Overview

The DRMS is the Discrepancy Reporting Management System used by the Deep Space Network (DSN). It uses a web interface and is a management tool designed to track and manage:

- *data outage incidents during spacecraft tracks against equipment and software known as DRs (Discrepancy Reports),*
- *to record "out of pass" incident logs against equipment and software in a Station Log,*
- *to record instances where equipment has be re-started or reset as Reset records, and*
- *to electronically record equipment readiness status across the DSN.*

Tracking and managing these items increases DSN operational efficiency by providing:-

- *the ability to establish the operational history of equipment items,*
- *data on the quality of service provided to the DSN customers,*
- *the ability to measure service performance,*
- *early insight into processes, procedures and interfaces that may need updating or changing,*
- *the capability to trace a data outage to a software or hardware change.*

The items listed above help the DSN to focus resources on areas of most need. Resources are scarce and one key benefit to the DSN is the ability to watch over the same type of equipment and practices at four different locations across the globe to maximize the use of those resources. Taking "best practice" input from a specific site and applying it elsewhere has improved work practices and resultant costs. The DSN is improving its utilization of the collected data; and it is envisaged that the greatest savings

are yet to be achieved as the corporate knowledge of the organization improves with each record entered. Easily accessible corporate knowledge saves technician's time by providing them with a complete chronological "history" of the item being worked and more effectively focusing their attention to the problem area. The retention of this knowledge within the network is also a significant outcome of the DRMS.

The ability to compare the performance of several identical equipment items at a site has allowed technicians to concentrate on the poorer performing items rather than potentially wasting resources on a system that is achieving its nominal function and performance levels.

The tool provides the DSN Operations Managers across the network with enhanced visibility of their Station real time performance, equipment readiness, and data output. As a result the Stations are able to provide a better service to their flight project customers with the provision of improved data quality and delivery.

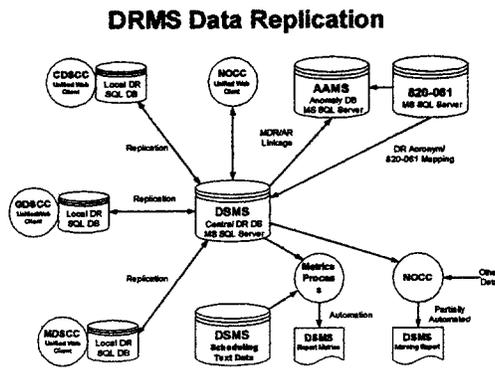
The Web Interface and Data Replication

The DRMS is compatible with both mainstream web browsers Netscape and Internet Explorer (IE). It includes remote scripting to dynamically populate pick-lists within the system, (requiring the later browser versions). Additional functionality that makes use of some IE features not available in Netscape has been incorporated into the DRMS making the system user-friendly.

All DR, Master DR, and Reset data is replicated to a master server, Master DR data is replicated to all the DSN sites, Station Logs are internal to each of the DSN sites and are not replicated.

DISCREPANCY REPORTS (DRs)

The DRs segment of the DRMS provides the capability to collect, distribute, process, and communicate discrepancy information. The DRMS is also used for performance analysis; data accountability; and the generation of reports for engineering, operations, maintenance, and management personnel. A DR record contains all pertinent information regarding a DSN system deficiency that occurred during committed or scheduled support. A DR is opened by real-time operations personnel at the Signal Processing Centers (SPCs) or the Network Operations Control Center (NOCC), and contains information related to the failure. This information is distributed within the DRMS for others to view and take action accordingly. When the discrepancy has been corrected or the capability has been restored, the DR information is updated and the DR is closed. A closed DR record will contain the full history of the discrepancy.



COMPONENTS, BUSINESS LOGIC AND PROCESSES

The DRMS in the broadest terms, includes the following components:

- Equipment Pick Lists
- Notification Tools – E-mail and To Do Lists
- DR records
- Station Log records
- Reset records
- Electronic Equipment Status records

Equipment Pick Lists

The DRMS uses a three tiered pick list structure common to each record type. The lowest level is called the Assembly level - this is the most common level of usage - and assemblies can be either dedicated to an antenna or assignable across a range of antennae. A group of assemblies combine together to make up a Subsystem and a group of related Subsystems combine to make up a System. The pick list for recording equipment resets is further constrained to those Assemblies that can actually be reset or re-started. Users originating records commonly do so at the assembly level, often combined with an antenna.

Notification Tools – E-mail and To Do Lists

The DRMS makes use of stringent business logic to control via roles the "work flow" of the processing and analysis of an incident. It makes use of targeted e-mail messages and includes a built in "To Do List" (TDL) to focus attention on matters awaiting a user's input. Entered data is validated where necessary. The on-line help including pop up suggestions assist the user to operate the system properly. The usefulness of the collected data is significantly improved by the capability to attach files and link URLs to records, and by robust reporting.

THE STATION LOG

The Station Log (the Log) enables users within each DSN site to record and manage informal "events" and incidents. The Log is site specific and is not replicated back to the central database. It provides the capability of recording site events or incidents against the same equipment item list as is used for the DRs. It is a simple system, yet includes very useful capabilities as an internal communication medium and event logger. Log entries are also used to "declare" a piece of equipment or an antenna's availability status. Whilst not as stringent as is the case with a DR, the Station Log and Electronic Status records include a history of activities and actions.

RESETS

Resets are simple originate only actions that record on a non interference basis the details of equipment resets that have been required to be made (other than scheduled reset activity). The information is useful in pointing towards possible emerging problems that could thus be avoided or in troubleshooting. The information recorded is minimal, simply an Assembly (a subset of the DR pick-list – only those items that can be reset), a number of times the item was reset, and the "phase" of the pass along with a timestamp.

ELECTRONIC EQUIPMENT STATUS

The Electronic Status Board details equipment status on both a site and global basis. Items may be declared to have a status of Red, (out of service), Orange (reduced capacity and/or not operating to expected specifications), or Blue (removed from service to allow for other work to be undertaken), in addition to the nominal Green. The records are managed with e-mail notifications and

Estimated Time of Return to Operation (ETRO) adjustment capability.

THE BUSINESS PROCESSES

The DRMS has built-in business rules and processes to enable a systematic work flow in the relevant DR, Station Log and Equipment Status records. When such a record is originated against an item of equipment, roles tables are used to advise the relevant site Maintenance and Installation (M&I) personnel by e-mail of the problem. There are no limits to how many personnel that can have the role for an item allowing for teams of maintenance technicians. The e-mail message contains useful abbreviated details of the incident, indicates the action required and includes a hyperlink to the record. Concurrently an entry is also placed on the maintenance personnel's TDL. When a user logs on to the DRMS, if there are items on their TDL, it is automatically displayed.

It is important to segregate the input of the incident observers from the problem analysis entries made by the technical personnel. Observers are restricted to a problem description and details of corrective actions attempted and any relevant outcomes of these attempts. The engineering and technical maintenance personnel provide the incident technical analysis in a separate analysis field. Third parties have the ability to add comment and all users may add file attachments or URL links. Record numbers identify the origin site.

The ability to extract information from both the DR and the Log record streams offers users a full chronological history of all recorded incidents and events attributed to an equipment item or group of items. Users can also make use of Reset information to further expand on the equipment history. This constantly growing and developing corporate knowledge is thus available in a consistent format and is efficiently retrievable.

WORK FLOWS FOR THE VARIOUS RECORDS

The DRMS uses defined actions linked to roles to "enforce" proper processing of the data contained within it. These processes differ depending on the record type and are described in detail below. There are some "global" actions available to DRs and Logs. Any user may add comment against DR and Log records (there are some notifications in the case of the Station Logs when this occurs) and users may attach files or URL links to these records. The attachment capability enables screen dumps and other graphical or textural material related to the record to be associated with it. Attachments can only be removed by the user who initially attached them.

DR WORK FLOW

DRs are originated primarily by link operators and shift leaders. The data collected includes required fields Cause, Spacecraft, Antenna, Incident Duration and Description. Additionally available are Assembly, (required for specific causes), Error Message, Data Outages, and Corrective Action. The originator may temporarily hold the DR for up to 12 hours, and participate in the closure process by indicating that they want to concur with the closure. The originators are required to concisely and precisely describe the incident / outage detail, what corrective actions were attempted and what outcomes were achieved. They determine the cause and equipment involved to the best of their ability and experience. On origination the notification process commences.

The originator may modify the DR record or withdraw it prior to any access by the maintenance personnel. Once analysis commences, this action is no longer available to the originator.

The maintenance personnel are expected to provide DR analysis and have several actions available to them:

- Review or Reassign
- Review and Close
- Link to a Master DR (MDR)

Problems requiring a higher degree of analysis and investigation are commonly initially "reviewed" by the relevant maintenance personnel whilst incidents that are "cut and dried" are reviewed and closed in the one action. The ability to close out an incident as another instance of a problem recorded as a Master DR enables users to see all such instances from the one location as such instances are included in the "parent" Master DR as "child" DRs with bi-directional links.

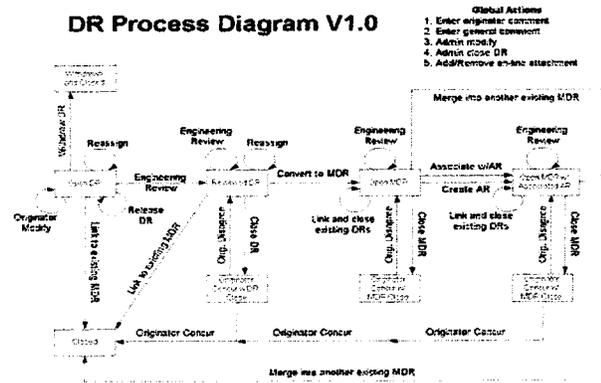
The maintenance personnel initially advised of an incident may determine that the fault is with a different equipment item and use the ReAssign action to update the record. The reassignment triggers another notification process (e-mail and TDL) to the maintenance personnel responsible for the new equipment item.

For DRs with a cause of SW (software), HW (hardware) and UN (unknown), the notification processes continues once the "local" site maintenance personnel have provided their initial reaction/response. The DR record is then brought to the attention of the cognizant development engineer (CDE) and the Operational Engineer, (OE) for the equipment item via e-mail and a TDL entry.

The CDE / OE can provide advice and assistance to the remote site staff or they may determine that the problem is one that will recur and that requires some form of formal action to correct the situation, such as a software fix. In this scenario the CDE / OE can raise the status of the DR to that of a Master DR. The actual corrective process can

then be tracked through the related Automated Anomaly Management System (AAMS). If this path is followed the records within both systems are interlinked allowing users to switch between both systems. Master DRs are replicated to ALL DSN sites and thus available to them to report incident recurrences. The system is designed in such a way that if a master DR is raised from a DR against one of several similar assemblies (sites have 6 or 8 receivers for example), similar recurrences against these other "like" items can also be linked to the master DR.

Further business logic is applied in respect of incidents where there is no possible intervention, for example incidents caused by weather. In such cases, the record is created but is automatically closed out. Such incidents do not require the originator to identify an equipment item because in reality the cause affects many assemblies (and being specific in such an instance is not useful) although an antenna is identified.



STATION LOG WORK FLOW

The minimum requirement for a user to generate a Log entry is a simple descriptive text. The author and the origination time are automatically inserted as part of the record. Typically, such entries are of general interest to the entire site or are of an informational nature. Extending the functionality of the Log is accomplished by increasing the scope of the content, and by the author selecting from equipment and spacecraft pick lists, and "manipulating" defaulting assignees.

Selecting an assembly or antenna / assembly combination from the pick lists automatically places all the site maintenance personnel responsible for that assembly (excluding the author) in the "Inform" field of the Log form as assignees. The author is then able to move the defaulted Inform assignees to the "Action" field – signifying that the author expects that one or more of these assignees to perform an action as a result of the Log entry. The Log entry is created with the "Log Opened" action being the first entry in the Chronological Activity field of the record.

On origination, all assignees receive "View New Log Entry" e-mail and an appropriate TDL entry. The TDL process for Action and Inform assignees differs in that once an Inform user views the Log entry, it is removed from their TDL list, whilst the entry remains on the Action assignees TDL until the Log Closure action occurs. In a similar fashion to DRs the originator may make modifications to a Log entry within 2 hours of origination, provided no response has been made.

The next logical action is that the Log entry is received and read by one of the assignees. There are two scenarios dependant on if there are Action assignees:

- If there are no Action assignees then the time that the first Inform assignee views the entry is entered into the chronological activity field as a "Noted" action.
- If there are Action assignees this "Noted" action is entered when the first of the Action assignees reads the entry.

There are a number of next actions possible for a Log entry. The most common is an assignee responds or an assignee responds and closes. In each case a new entry is made in the chronological activity field of the record with suitable headings. The possible options are detailed below

- **An Action assignee user adds comment / response.** This common action results in a "View Log Response from Action Assignee" e-mail is sent to all assignees except the responding user, and their TDLs are updated in a similar manner.
- **An Inform assignee or other (third party) user adds comments to an Open Log entry.** If it is a third party commenting then the third party is added to the Inform assignees. A "View Log Comment" e-mail is sent to all assignees except the responding user, and TDLs are updated accordingly.
- **An Inform assignee or other (third party) user adds comments to a Closed Log entry.** The Log entry is Re-Opened by this action. If it is a third party commenting then the third party is added to the Inform assignees. A "View Log Comment – Log ReOpened" e-mail is sent to all assignees except the responding user, and TDLs are updated accordingly.
- **A user starts a related Log entry.** In the newly created Log entry the usual log Opened chronological activity line is created with the text altered to "Related Log started from Log N###". The log number part of the text is a link to the related Log and the assignees and equipment details are carried forward to the new entry. E-mail and TDL actions for this related log are the

same as for any new Log entry. On origination there is a "Started Related Log N#### " entry placed in the original Log chronological record, however there are no new e-mail or TDL actions.

- **An Action assignee responds and closes a log entry.** This action is only available to Action assignees (and db administrator). A "View Log – Log Closed" e-mail is sent to all assignees except the responding user and their TDLs are updated in a similar manner.

Station Log entries declaring equipment status have additional actions and notifications. For consistency the processes mirror those of the Station Log where possible.

Station Log (Fictional) Example

Comment/Respond Respond/CLOSE Add/Remove Attachment Start Related Log

Log No	CL021234 (Closed) Ops Chiefs Advised: N		
Author	Mark Chatillon	Originated at: 2002 033 22:10	
Antenna	DSS43		
Assembly	UGC – Microwave Group Controller		
Assigned Users			
Action	Inform		
Ric Gutierrez	Basilio Ormeno		
Kevin Piechowski	Len Ricardo		
	Alan Robinson		
Chronological Activity			
Mark Chatillon Opened Log at 2002 033 22:10 Please check the Rain Blower as it appears to have no air flow. This was noticed during the VGR2 pass.			
Kevin Piechowski Read / Noted at 2002 034 23:12			
Kevin Piechowski at 2002 034 23:20 Rain blower will be checked in maintenance period commencing 035 21:00.			
Ric Gutierrez at 2002 035 21:52 Blower checked, found intermittent fault with XYZ. Blower left on for continued monitoring.			
Ric Gutierrez at 2002 035 21:54 Attachment added: Related Log entry http://cmmaster2.jpl.nasa.gov/dr/view.asp?no=NL020007			
Ric Gutierrez Log Closed : 2002 037 23:12 Monitoring completed – blower performing to specifications.			

ELECTRONIC STATUS RECORDS WORK FLOW

Station Logs that declare an equipment status also generate an Electronic Status record. This record is replicated back to the central database to facilitate a global view of equipment at the DSN control center. Effectively, all e-mail notifications and To Do Lists relevant to an items equipment status point to this status record, rather than the Log record that "wraps" the process. The "wrap"

Log entries created are automatically updated by status changes effected at the Status record and the normal response actions are not available.

A change in an items status, i.e. a change from Red to Orange or Orange to Green for example is treated as the closure of that status. This allows the measurement and tracking of the duration that an item was either out of service (red) or not fully functional / operating at a reduced capability (orange). These durations are important to evaluate equipment and personnel performance.

The system performs a daily analysis of the Electronic Status records (tied in with normal working hours) and assesses the ETRO time (Estimated Time of Return to Operation), in each record with the current time. Where an ETRO is within 12 hours of the current time a "reminder" email is sent to the assignees involved, with copies to the originator of the record and the site DRMS system administrator(s). Once the ETRO is passed, a similar "ETRO expired" message is sent until the item's status is updated. This helps manage technicians' time.

HOW HAS VALIDATION BEEN IMPLEMENTED?

The scope of the industry and the rapid technical changes inherent within it, necessitates that data validation be of a very high order. Data must be consistent to instill confidence in the decision makers at the DSN sites. The DRMS approaches validation in a variety of ways.

Naturally there are the standard validations performed at the field level to ensure such things as negative durations or negative data losses do not occur. These are predominantly in the DR records and suitable conflict warning messages are provided to the user who errs against one of these validation rules. Validation is taken past the simply numeric by the implementation of a suitable table schema that provides the capability to validate cause and assemblies, e.g., you cannot write a software cause DR against an assembly that is an item of hardware (and vice versa). Complimenting these validations are ones for those selections that are made less frequently where the system validates "suggestively" by prompting the originator to confirm their selection, and offering potential alternatives.

REPORTING & METRICS CAPABILITIES

The reporting capability starts with canned reports that enable users to instantly see recent originations over the last 24, 72, 96 hours, the last 10 days, and since the users last login to the system. By using these canned reports the user is able to quickly catch up with what has occurred in the relevant period. Each of these canned reports / queries displays the DRs, Station Log entries, Equipment Status declarations and Resets. The output can be displayed in

either most recent to oldest or the reverse. These capabilities are expanded by the ability to select either originations or activities as a basic filter, and by the provision of from / to time fields to allow the user to specify a precise period for their query.

Capability to query each record type – DRs, Logs, Resets and Equipment Status as well as a combination of the Log and DRs is provided. Important from a managerial standpoint, the capability to filter and extract data is a strong point of the system design. Recognising that there are complex relationships between the equipment items and how the assemblies, subsystems and systems inter-react, special attention has been given to the user interface utilized to extract information. Because of this complexity, the parameters relating to the equipment, sites and antennas are identical in format for all the record type queries.

The parameters available for querying are extensive in the case of the main record type (DRs). Whilst the query parameters are not as extensive for other record types (the records themselves are simpler in nature), all components (fields) of a record can be queried. The DR query parameters are summarised in the list below:

Equipment	"Time" durations	Keyword Text Search	Other
Facility	Number range (from-to)	All text fields	Originator
System	Outage period (from-to)	MDR Title	Status
Subsystem	Outage duration (from-to)	Description	Cause
Assembly	Originated date (from-to)	Corrective Action	Phase
Antenna	Closed date (from-to)	Analysis	Lost data type
type	Pass number (from-to)	Comment	Data category
Antenna	Record type		Spacecraft/USER
			Error message

Powerful time variables are included for use with most of the time-duration parameters. The variables are \$TDY (Today), \$FTW / \$FLW (first day of this week / last week), \$FTM / \$FLM (first day of this month / last month), \$FTY / \$FLY (first day of this year / last year) and \$LLG (since time of last login). The user simply enters the desired variable into the relevant field and the variable is automatically interpreted. To further refine these capabilities the user is able to use offset days between -99 and 365. Thus by selecting \$TDY in the origination date with -25 will extract data based on records originated in the past 25 days.

Query output is also comprehensive. The user is able to output in the basic formats of tables with and without borders, Tab delimited and as a chart. The output can have a two dimensional data outage matrix at the group and/or total level. Query output can be grouped by items that

grouping makes sense for, and output can be sorted by multiple items. A set of output fields and sort order is defaulted to the user when specifying a query however the user can select the sort and output "fields", and can promote or demote them in precedence. The system cleverly allows the user to update the pick list options by moving rows up or down the lists to alter the sort priority of output position. Ascending and descending sorts are provided.

The user can format their output by including a report title and a report header that provides a simplified SQL version of what has been specified. This plain English header is useful in jogging users memory of how a result set was specified.

Users can save their query specifications which then become listings on that users specific query menu. Saved queries can be edited by their owner to make minor alterations and these can then be saved as a new query or can overwrite the current one. By combining the use of time variables with saved queries users can have a "management watch" set of report queries that keep them informed about relevant activities specific to their needs. A user can delete a query at any time. Future plans include the ability for users to "publish" users defined queries so that other users might make use of them should they so wish.

HOW REPORTING CAN HELP – CASE STUDIES

The system has allowed the development engineers for particular systems to maintain an overview of how their equipment and/or software are actually performing in the field. Examples of this action include: -

- The developers of automation software designed to aid the link operators conduct a track of a spacecraft, monitor all problems reported against their software and take appropriate steps to improve their product.
- The engineering team responsible for transmitters have recently broadened the components of the transmitter systems so that they may more correctly identify which parts of their system are causing the most problems.
- The cross-functional support team for tracking data maintain a close monitoring of specific outages in an effort to improve data capture and reliability.
- The performance of more recently installed X band transmitters are being examined through the use of the DRMS records, in particular at the Canberra station.

- Operations management make extensive use of metrics to identify trends both in equipment performance and staffing performance in the differing sites and apply statistical analysis to the collected data.

These types of investigation are often being done at all three sites. Such comparisons can highlight subtle differences between the installations. In one case it has highlighted a problem with commanding equipment at one site that is not evident at the two others, resulting in continued work to identify why this is occurring.

FILE ATTACHMENT AND URL LINKS

The functionality and capacity to store incident related data of the system is enhanced by the ability to attach any form of file to a record (DR or Log) and by being able to also attach or link to a URL. Typically equipment logs and support products such as antenna pointing and telemetry predicts might be attached to assist in the problem evaluation by maintenance. Related records across the system can be linked to each other for example there may be 2 or 3 Log entries that relate to a DR and the user can place URLs to these 2 or three records within the DR record.

UTILITIES

The system contains a broad set of utilities for both the everyday user and the system administrators. In addition to a password change utility, there are the standard lists of assemblies and spacecraft and two sets of personnel lists available to users. Each utility has a search capability to compliment the lists that make use of wildcards to narrow down the result sets returned. The assembly listings also show which site maintenance staff are responsible for the item as well as the development and operational engineers. The subsystem involved is also available. For spacecraft the flight teams are available with each position identified.

From a user standpoint one of the most useful utilities is the proxy capability. Users can assign their rights and roles to others to allow for ongoing responses during vacation periods etc. A user can assign several persons to act as their proxy. The To Do List (TDL) screen of the person(s) acting as proxy will have the name of the individual(s) who designated them, clicking on that individuals' name will bring up that persons' TDL. The user would then use the utility to act as proxy, choosing who to act for from the listing provided. Once invoked the user is able to perform all actions for that individual. In each case the historical record clearly indicates that a proxy performed the action.

From an administrative point of view the DRMS administrator can use another set of utilities to update the user capability. They can add a new user, update a user's profile allowing the user originate rights, deactivate a departed user and reset a forgotten password. In recognition of the fact that roles change, the administrators can assign roles to maintenance personnel at the assembly, subsystem or system level to match site needs.

CONCLUSION

Since the introduction of the DRMS, sites have benefited from the availability of data that has been collected and maintained with great integrity. This has led to more efficiency in addressing incidents, more effective communication between the partners resulting in improved outcomes. As time passes and the corporate knowledge contained within the DRMS increases further efficiencies will be achieved.

From a management perspective the DRMS is also used at the Canberra site to assess some components of the performance of the site management contract. The capability to similarly assess performance can also be used by the mission / spacecraft teams to monitor performance.

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