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Information Requirements Analysis for Remote Maintenance Monitoring Interfaces

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16. Abstract
In this paper, we identify user requirements for Remote Maintenance Monitoring (RMM) and identify high-level RMM tasks based on the Cognitive Task Analysis results. RMM is a primary means of maintaining the National Airspace System. Technical Operations Specialists have specific information that they need to see to do their jobs effectively and efficiently when using RRM systems. Thus, Technical Operations Specialists requested an evaluation of information requirements for RMM systems. Human Factors Researchers collected data from Technical Operations Specialists at four facilities. Twelve participants performed think-aloud exercises and cognitive walk-through exercises, and 28 participants completed a survey. The resulting data led to a Cognitive Task Analysis list of tasks and 29 recommendations regarding information requirements, including ways to better tailor the amount and form of presented information to better meet the needs of the user and the organization. For RMM to be an effective tool for performing maintenance, the RMM system must have an effective user interface. When asked what they would change about the RMM system, specialists responded (a) that they would like RMM to be quicker (i.e., closer to real time), (b) that they would like to have default settings that would let each user pick which sites and units to monitor, and (c) that they would like to remove or reduce the number of false alarms that occur.

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Executive Summary

Remote Maintenance Monitoring (RMM) refers to the ability to monitor and perform maintenance on a system from a distance. RMM is currently the preferred means of performing maintenance on the National Airspace System. For RMM to be an effective tool for performing maintenance, however, the RMM system must have an effective user interface. The Federal Aviation Administration Technical Operations organization identified the need for a human factors evaluation of RMM information requirements with the intent of creating a more effective RMM interface. In evaluating the information requirements for RMM, we addressed the following specific questions:

- What information is used for which tasks?
- Which information sources were used in conjunction with one another?
- What information had to be obtained from another source or screen?
- Which information was specifically ignored?
- What are potential sources of confusion (or error paths)?

Participants included Airway Transportation Systems Specialists (ATSSs) at two Operations Control Centers and two Air Route Traffic Control Centers. To identify information requirements, we used a combination of observational and analytic methods, including videotaped think-aloud sessions, cognitive walk-through sessions, and survey questionnaires. Twelve participants took part in the think-aloud sessions and nine participated in the scripted walk-through sessions. Twenty-eight participants provided data on the survey.

We created a high-level Cognitive Task Analysis (CTA) based on the collected behavioral data. Observational data collected during the videotaped sessions and cognitive walk-through sessions and self-reported data collected by the surveys dictate different information requirements for the ATSS interacting with the system. During the initial think-aloud observational data collection, specialists tended to limit themselves to a small number of controls and data fields. This is an artifact of the technique—one cannot hope to observe infrequent events in a short series of over-the-shoulder observations. This problem was overcome through the use of cognitive walkthrough sessions, in which we could script scenarios that included a wider variety of events. Cognitive walkthrough sessions revealed a broader range of RMM usage. Although we observed that users make use of only a small range of interface elements, self-report data elicited in the survey responses suggest that almost all elements are seen as useful.

One of the last questions in the survey asked the specialists if they could change anything about the RMM system, what they would change. In response to this question, specialists said that they would like RMM to be quicker (closer to real time). They said that they would like to adjust and validate the criticality levels of the Logical Unit Identifier (LUIDS) so that the criticality level matches the criticality of the situation. Specialists also said that they would like user default settings that would let them pick which sites and LUIDS to monitor. Finally, they said that they would like to remove or reduce the number of nuisance alarms that occur.

We found a fair amount of variability in the setup preferences and working styles of the ATSSs we interviewed. Setup preferences included which fields to filter, how to sort alarms, even how

many screens to use and how. For instance, one specialist may use three screens for monitoring but use one screen just for one equipment type and put all other equipment types on another screen.

The RMM tool provides abundant information, but we identified a number of cases on which its data could be better tailored to the user's task. For instance, in some cases there was too much (or too little) information available. In other cases, data needed to be recalled from other sources or mathematically transformed—both of which can add mental effort. In still other cases, data were presented as absolute parameter values without reference to any system-relevant criteria. This report contains 29 recommendations for modifying the RMM interface so as to better meet user information requirements. Any interface change, however, has a potential to introduce unforeseen errors. We, therefore, recommend that changes be implemented on a prototype and tested for usability before implementing them in an operational setting.

1. INTRODUCTION

In recent years, Technical Operations (Tech Ops), which is the organization within the Federal Aviation Administration (FAA) responsible for maintaining the National Airspace System (NAS), has been under mounting pressure to increase the availability of systems while decreasing costs. In addition, Tech Ops has been faced with changes in the types of systems and equipment that they maintain based on recent shifts in technology. As technology has changed in the last 10-15 years, the NAS has undergone a shift from mechanical to electronic systems. Most of these newer electronic systems are equipped with integrated sensors, which help to monitor system health. The sensors are interconnected through a secure communications network that allows specialists to monitor the systems remotely.

This Remote Maintenance Monitoring (RMM) is a primary way that specialists interact with many of the systems. As a primary tool for maintenance, it is critical that the RMM systems be effective in supporting the specialists in their tasks. Thus, the Tech Ops organization asked Human Factors Specialists to examine the human factors aspects of RMM. Specifically, the researchers were asked to identify user information requirements for RMM. In order to determine what information was important to the RMM users in performing their tasks, we also needed to determine what tasks the users performed. Therefore, even though our primary purpose was to identify user requirements for RMM, our secondary purpose was to identify (at a high level) RMM tasks.

1.1 Background

Technological advances in the past decade have spurred a new era in maintenance where systems contain integrated monitors connected to an information network. No longer do system maintainers have to travel to a remote site to check the status of a system or piece of equipment. Instead, maintainers can get up-to-the-minute system status through RMM. There are many reasons for using RMM. Some of the common reasons include decreasing time spent traveling by limiting the number of site visits, decreasing response time, increasing diagnostics, increasing situational awareness, decreasing restoration time, centralizing expertise, and providing a more equitable distribution of workload.

RMM refers to the ability to monitor and perform maintenance on a system from a distance. Instead of the maintainer being collocated with the system or piece of equipment, with RMM, the maintainer is able to monitor systems and perform maintenance tasks while physically separated from the actual system. Maintainers receive system information and perform maintenance functions through computer interfaces. In the NAS, the RMM system consists of the hardware on the remote system to be monitored, the Maintenance Automation System Software (MASS) Monitoring and Control Function (MCF), and the Maintenance Management System (MMS; see FAA, 2007a, 2007b). Some of these components are scheduled to be changed or replaced with new systems in the near future.

As the preferred means of performing maintenance on the NAS, RMM is an increasingly important concept in the NAS (FAA, 2010b). The FAA's Concept of Operations for the Tech Ops workforce emphasizes the use of RMM specifically by control centers to "monitor the health of the NAS and take immediate action when abnormalities are detected in order to maximize availability, minimize costs, and reduce equipment caused delays" (FAA, 2005, p. 10). It is likely that RMM will become even more important in the future as the Next Generation Air Transportation System (NextGen) is implemented (FAA, 2010a).

Recently, members of the Tech Ops community have expressed concern that the lack of standardization among RMM interfaces could negatively impact current systems and also create problems for future systems. The Tech Ops organization identified the need for a human factors evaluation, with an eye toward standardizing the RMM interface. This standardization was to be based on the identification of information requirements for RMM users.

1.1.1 RMM and the MASS Interface

The RMM system used by the Tech Ops Specialists is a collection of hardware and software subsystems to automate maintenance of the NAS. The primary interface used by these specialists is the MASS. MASS is the front end for Tech Ops at Service Operations Centers (SOCs) and Operations Control Centers (OCCs). A secondary system used in conjunction with the MASS is the Event Manager of the Remote Maintenance Logging System (RMLS). Event Manager is used in conjunction with MASS for such tasks as creating a maintenance ticket, logging, and data entry. It functions largely as a look-up and logging interface. However, for our current purposes it was not directly considered, except as its use impacted the interaction with MASS. Currently, MASS and RMLS are two physically discrete software systems that reside on different hardware platforms. For this research project, we confined our efforts to the MASS interface only.

The primary view in MASS is the MASS MCF (FAA, 2007a, 2007b). Directly beneath the title bar on the primary window is a menu bar that provides navigation to subfunctions. Beneath this is the window bar, which provides a set of four buttons to allow navigation between the System Monitor and subsystem views. The operator bar, which is directly beneath this, varies by selected window.

Figure 1 shows the System Monitor (Alarm List view) of the MASS interface (Figure 1 adapted from Technical Operations Human Factors Standardization Team meeting with permission of B. Clark.) In the System Monitor view, 17 operator buttons are presented. In the Subsystem views, the operator bar consists of 24 buttons. We provide details of the MASS interface in Appendix A.

Figure 1. Maintenance Automation System Software (MASS) interface (System Monitor – Alarm List view).

1.1.2 Tasks of Airway Transportation Systems Specialists

The primary users of MASS for RMM are the ATSSs. The main tasks of the ATSSs can be broadly grouped into four categories:

1. Preventive maintenance (including routine scheduled maintenance, preventive maintenance inspections, alignment and calibration);
2. Corrective maintenance (including restoration of service, troubleshooting, repair, and replacement);
3. Equipment modification activities (functional checkout, documentation); and
4. Certification (including initial system certification, periodic certification, prior to system restoration).

This study focused on the first three of these task categories, which, according to subject matter experts, were the primary categories of interest for current RMM. We did, however, solicit information in debriefs and informal discussion on certification tasks as they relate to RMM.

1.2 Research Questions

In evaluating the information requirements of RMM users, we addressed the following specific questions.

- What information is used for which tasks?
- Which information sources were used in conjunction with one another?
- What information had to be obtained from another source or screen?
- Which information was specifically ignored?
- What are potential sources of confusion (or error paths)?

2. METHOD

We set out to identify RMM information requirements through a combination of observational and analytic methods. The following were at the core of this effort.

- **Observations**: A series of field observations in which a group of representative and consenting ATSSs were recorded individually during normal interactions with the MASS interface and were later debriefed in video review.
- **Cognitive Walkthrough**: An exercise built on scripted scenarios worked through by ATSSs while pausing to explain their goals, decisions, and sources of information.

2.1 Participants

The participants were all ATSSs who support Automation, Communication, Navigational Aid (NAVAID), and Surveillance systems. Participants were drawn from four facilities: two OCCs and two Air Route Traffic Control Centers (ARTCCS). A total of 12 participants took part in "think-aloud" and "walk-through" sessions. Seven participants took part in the think-aloud exercise, and five participants took part in the cognitive walk-through exercise. These numbers were limited by staff availability. A number of other participants took part in questionnaires, debriefs, and informal discussions. We collected survey data from 28 respondents.

2.2 Site Visit Procedure

During January and February 2010, two researchers from the FAA William J. Hughes Technical Center Human Factors Branch conducted two-day site visits to each of four sites. The chosen sites represented both OCCs and SOCs. During each site visit, and during the course of normal operations, the researchers conducted three separate activities:

1. Administered the survey questionnaire,
2. Video-recorded Think-aloud session, and
3. Scripted Walk-through session.

Shortly before each site visit, management of the given facility identified volunteers based on scheduling and willingness. Participants did not have to take part in all three activities. Participation was entirely voluntary. Our general procedure was as follows: After being introduced by management to each of the volunteers, we outlined the aims of the study, the rights of the participants, and the main data collection activities scheduled for our visit. After reconfirming willing participation, we asked each volunteer to read and sign a statement of informed consent. We then read to the participant the instructions specific to his or her scheduled activity. The procedures for these activities, as well as for the questionnaire administration, are summarized in the sections that follow.

2.3 Questionnaire

The researchers developed a 15-item questionnaire combining closed- and open-ended items (see Appendix B). This questionnaire focused on the uses of RMM, including broad information requirements (What information must be constantly displayed? What information is typically ignored?), and interface preferences (masking or filtering). Volunteers were asked to complete the paper-and-pencil questionnaire. This typically required 5-10 minutes.

2.4 Think-Aloud Exercise

The researchers observed ATSSs in the course of normal operations. With the permission of participants, a video camera was also used to capture the RMM screens. The camera was positioned on the screen and not on the specialist's face. Most ATSSs used a two-screen setup, with MASS on one screen and Event Manager on the other. Where possible, the view was panned between screens synchronously with the specialist's activity. ATSSs were instructed, in advance, to point out for the camera where on the screen they were looking (time and other operational considerations permitting) and to think aloud by describing their actions in real time. Video recordings were limited to 20 minutes.

ATSSs provided running commentary in real-time during recorded sessions. Thinking aloud in activities like this is something that often takes a bit of practice, so the researchers occasionally provided some prompting during the session if it was not clear what the participant was looking at or doing at the time (e.g., What were you thinking at this point? Why did you click on this item?). Feedback from specialists indicated that this procedure was not disruptive to task performance.

2.5 Cognitive Walk-Through Exercise

On the basis of the initial literature review, information-gathering visits to Tech Ops facilities, and early think-aloud exercises, we developed a series of scripted scenarios that, together, aimed to present situations that were

- frequent and typical, or
- critical in their potential impact, irrespective of frequency.

On the basis of user input, we then narrowed down the list to two scenarios: (a) Engine generator running and (b) Very High Frequency Omnidirectional Radar (VOR) Out of Service.

2.5.1 Scenario 1: Engine Generator Running

According to Tech Ops Specialists, this is a frequent event but not, generally, a critical event. In this scenario, an engine generator is detected running at a VOR. The task of the ATSS is to verify this event, start an event ticket (if necessary), and diagnose the underlying situation. A typical first step is to confirm that there is an open ticket on the event. Once they determine from the Subsystem view that the engine generator is running, they try to determine why it is running. They will generally let the generator run for some period of time, say 15 minutes, before responding. This will help them to determine whether there is a power issue—and whether there is a transient "power bump"—or an ongoing issue. Next, they must determine whether commercial power has been lost and whether it has been restored. If commercial power has been restored but the system is still running on the engine generator, then there may be a problem with the transfer switch. They will typically run a history report to determine whether this condition has happened repeatedly. If the specialist has been away for some time, he or she will also ask the outgoing shift to report on any handover problems.

Diagnosis is wholly aimed at determining whether to (a) call a Field Specialist, (b) call law enforcement or other outside agencies, or (c) attempt a reset of the facility. Although the task structure is straightforward, we were interested in knowing what information specialists sought to confirm their diagnosis and decide on a course of action. For instance, would specialists "drill down" to explore the Subsystem facilities? Would they try to contact Air Traffic Control or try to contact a Field Specialist for confirmation?

2.5.2 Scenario 2: VOR Out of Service

This is a less frequent but potentially very critical event. A VOR has shut down. The specialist would usually wait for a few minutes to allow a VOR automatic reset. At the same time, the specialist would try to diagnose the event. The diagnostic process is more subtle than that of Scenario 1 and requires that the specialist use his or her knowledge of the site history (e.g., Is it prone to outages?), the site's operational criticality to the NAS, and even meteorology (e.g., Has drifting snow incapacitated the VOR azimuth?). The general steps are

1. Check for an existing event ticket,
2. Go to Subsystem 1,
3. Send commands to check history and state status for both VOR monitors,
4. Wait for automatic reset,
5. Determine whether another reset is permitted, and
6. Reset as appropriate.

Each scenario script described a hypothetical situation, including daily duties and anomalies, equipment status, and so forth. During this exercise, the specialist was prompted to walk through these scenario scripts and to talk aloud about (a) the tasks themselves and (b) the decisions and strategies that apply to the tasks. In particular, they were instructed to explore each of the following:

- Data (Which controls and data fields were used, and which were ignored?)
- Decisions
- Goals and strategies
- Potential confusion and error points

During each session, the researchers interrupted (as necessary) to ask questions or to request clarification about decisions, strategies, onscreen area(s) of interest, and so forth. Standard prompts were used throughout to elicit information on (a) the impact (and interaction) of their decisions, (b) the impact of their actions and inactions, and (c) potential what-if events that could impact task performance. This think-aloud session was scheduled to last no more than 60 minutes (typically lasted about 30 minutes).

3. RESULTS

In this section we summarize the results of the observational data, the questionnaire data, and the cognitive walk-through analysis.

3.1 Observed MASS Usage

From mouse activity and participant point outs, we were able to derive hit counts and durations for various Areas of Interest (AOIs), which included both system control activations (e.g., buttons presses, menu selections) and data field fixations. Figure 2 shows the counts for all observed AOI hits, expressed as relative frequencies. Notice that many of the button controls were never used by the specialists. Of the buttons that were used, the primary buttons were the monitor and Subsys1 buttons.

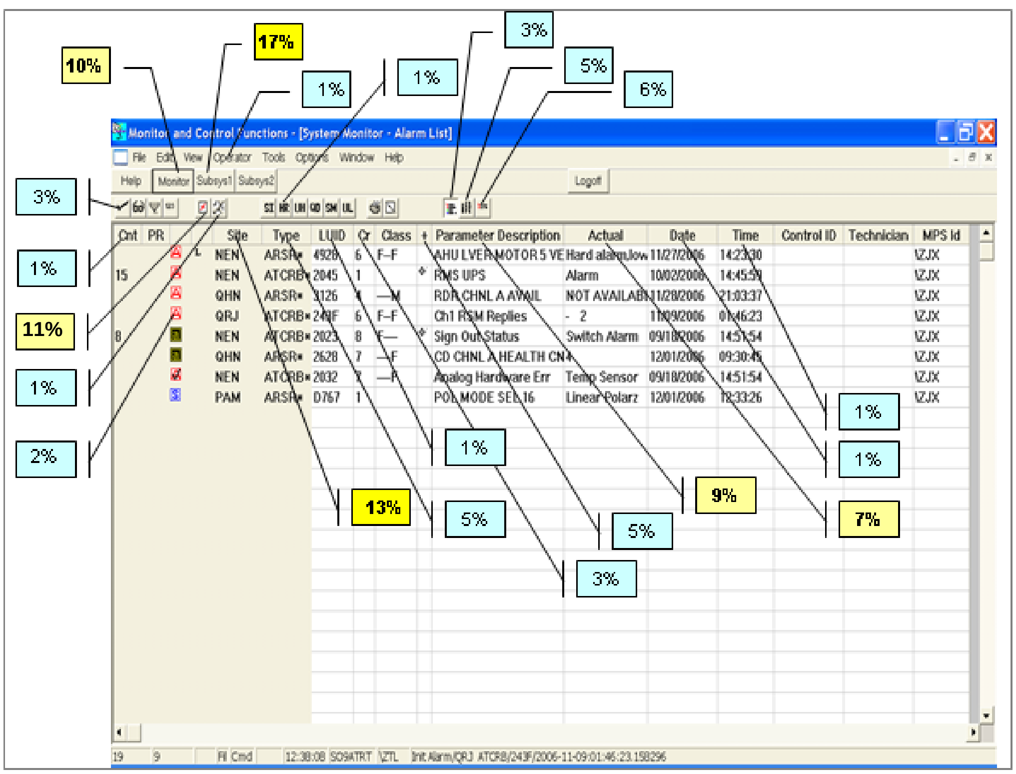

Figure 2. Area of interest (AOI) hits. System monitor view (relative frequency percentage).

The vast majority of time on MASS was spent in either the System Monitor (default) view (74%) or the Subsystem view (22%). This is not surprising given that the most frequently observed task of the specialist was in responding to events (i.e., alarms and alerts). They generally did this by identifying an event (from System Monitor view), then probing it (Subsystem view). Remaining time was largely spent on the Subsystem Quick Look and System Monitor Site List views.

Figure 3 shows the distribution of hits on the MASS Subsystem view screen. Fewest hits were recorded on the Criticality (column Cr) column. Notice as in Figure 2 that the Parameter Description and Actual columns played primary roles. In the Subsystem view, though, specialists tended to use Date and Time data fields more than in the System Monitor view—as specialists reported that they were concerned with getting fresh status data for their subsystem diagnosis. These observational results match with survey and debrief results. The typical observed activity involved working through alarms to check site, parameter, and actual status, then sending a command. Interestingly, the Alarm column itself shows a low fixation count. This is perhaps due in part to under-reporting, but at least as much to the task. Specialists reported working through all alarms irrespective of alarm/alert status. That is, they respond the same to either an alarm or alert and, therefore, tend to rely on actual status and parameter description more than whether the event is an alarm or alert.

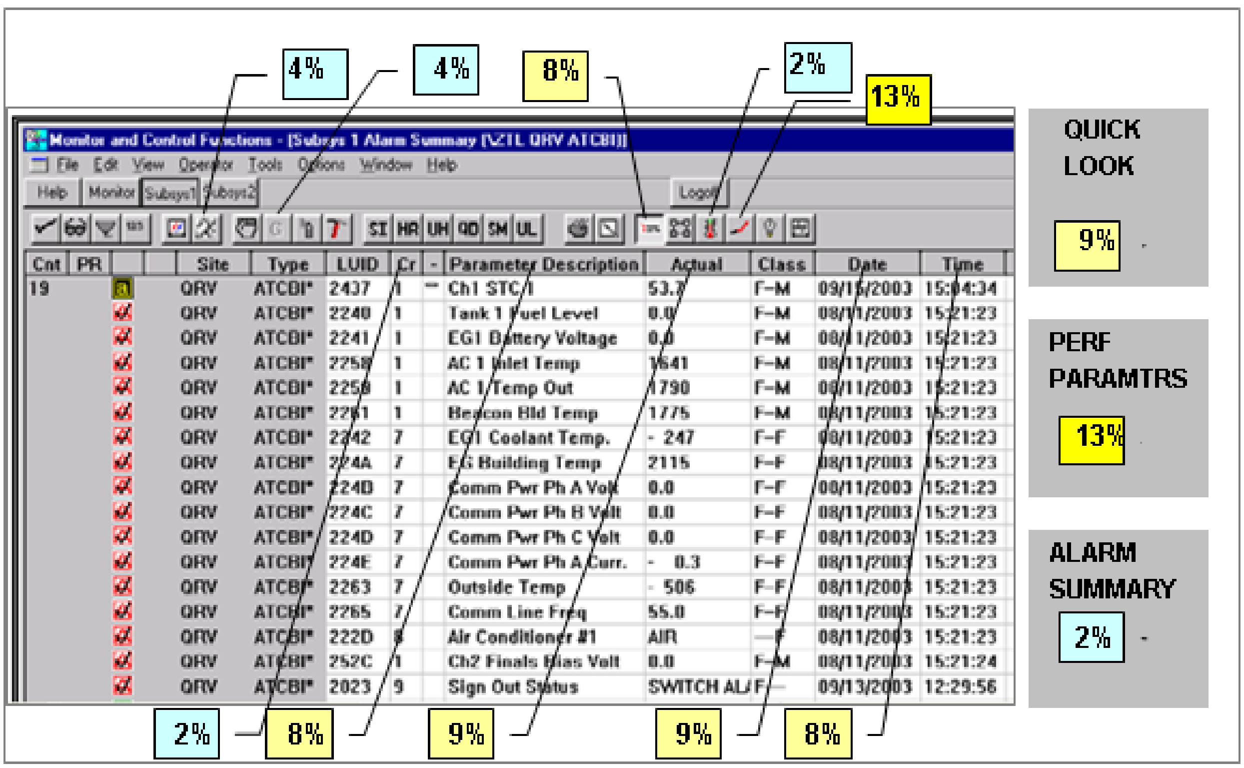

Figure 3. Area of interest (AOI) hits, subsystem views (relative frequency percentage).

There are a few caveats in considering these data. Observational data is inherently limited to that which can be observed. Even with the protocol in which participants talked out loud explaining their thoughts and actions, not all data field fixations may be pointed out. Specialists often have multiple paths (menu, buttons, and shortcut keys) available to a function. Shortcut key usage was not generally observable. Based on the participants observed, however, this does not seem a significant source of concern, as only one of the participants in the study appeared to use shortcut keys. Finally, even with hours of observation, we saw a very limited subset of system controls in use. Infrequently used controls were not likely to be observed in normal operations.

3.2 Survey Responses

A total of 28 specialists responded to the survey questionnaire. Not every participant answered every question. Of these, roughly half (14 of 27) reported having preferred settings for RMM. The vast majority (14 of 15) listed VOR as their most frequently monitored facility, followed by Glideslope, Localizer, Airport Surveillance Radar, and Distance Measuring Equipment (DME). Following are responses to the closed-ended questions. Open-ended survey responses and other feedback (debriefs and informal discussions) are included in the Discussion section.

With respect to filtering, 78% (22 of 28) of the respondents reported filtering on one or more parameters. The most common filters reported were the following:

- Status condition (71%)
- Alarm criticality levels (48%)
- Site and type (38%)
- Date and time (38%)
- Primary responsibility (33%)

There were also individual reports of filtering by Class, Maintenance Processor Subsystem (MPS) ID, Alarm Condition, and Control ID.

Masking is reportedly used far less frequently than filtering. Slightly under half of the respondents (44%) reported using masking. Out of those who used masking, the most commonly masked parameters were, in order, the following:

- Site and type (33%)
- Status condition (25%)
- Site (17%)
- Date and time (17%)
- Alarm criticality level (17%)
- Primary responsibility (17%)

Specialists reported ignoring or disregarding a number of parameters, including the following:

- Primary responsibility (39%)
- Alarm criticality level (11%)
- MPS ID
- Class

Specialists reported that certain parameters had to be displayed all the time while using RMM. Of the 24 respondents who answered this question, the following parameters were most often identified as needing to be displayed all the time when using RMM:

- Site (96%)
- Alarm status, Time and date (all 88%)
- Logical Unit Identifier (LUID) and Parameter (both 75%)
- Criticality (38%)
- Classification (33%)[1]

Finally, 21 of the 28 specialists reported that certain data fields be understood with a quick glance. Most often mentioned were the following:

- Alarm status (86%)
- Site (71%)
- Date (48%)
- Time (48%)
- LUID (38%)
- Criticality (38%)
- Parameter ID (38%)

3.3 Cognitive Task Analysis

Task analysis refers to a family of techniques used to describe and analyze operator tasks (Kirwan & Ainsworth, 1992). Various task analysis techniques exist, and they share a similar basic approach of decomposing system tasks, elaborating a description of the system, and identifying information and action flows within the system (Crandall, Klein, & Hoffman, 2006; Militello & Hutton, 2000; Polson, Lewis, Rieman, & Wharton, 1992; Schraagen, Chipman, & Shalin, 2000).

Cognitive Task Analysis (CTA) is a relatively recent outgrowth of task analysis techniques, which tries to address the mental skills and processes (e.g., critical decisions) underlying observable behavior (Schraagen et al., 2000). CTA typically involves three steps:

1. Describing the task using traditional task analysis;
2. Identifying the cognitive elements, or critical decision points; and
3. Describing the decisions with respect to potential error mechanisms.

For even relatively simple tasks, an exhaustive CTA can quickly become unwieldy. To keep within the scope of the current effort, we decomposed task performance only to the level needed to facilitate discussion of information requirements.

[1] Notice the split opinion with respect to the Classification parameter. Although 33% report it as necessary, a small percentage claims to ignore this parameter altogether.

During and after site visits, we developed a CTA task flowchart on the basis of walkthroughs and observations. As stated earlier, this CTA was meant to capture the high-level monitoring and control tasks of the ATSS' job specific to RMM. The resulting CTA captured high-level tasks and information, including the walk-through scenarios as well as other aspects of the job (e.g., startup). The CTA decomposes the task of "Monitor and Control" into 177 subtasks. The five highest level subtasks are performing shift setup, updating site status, identifying an event (as alarm or alert), evaluating an event, and responding to an event. The CTA (including subtask order and task flow contingencies) is presented in Appendix C.

4. IDENTIFIED ISSUES AND RECOMMENDATIONS

In this section we summarize results from the data collection as they relate to information requirements, timing, workload impacts, and potential error points framed in terms of the CTA. Task references (in parentheses) link these findings to specific tasks within the CTA (see Appendix C). Where applicable, we provide recommendations for improvements:

1. **Count (Cnt) increments can be missed (Tasks 4.6.1; 4.6.1.2).** When exploring underlying Logical Unit Identification (LUID), the parent Count can increment. This potentially critical change is subtle and can be missed.

   Recommendation: Provide a more salient indication of the updated Count Field.

2. **Routine keystroke sequences are time-consuming (Tasks 2 – 2.6.3).** Updating site status is a frequent task that involves a cycle of five sequential steps, requiring, roughly, 10 seconds and a number of keystrokes:

   a. from System Monitor Alarm List, identify site (usually next in line);
   b. activate Command dialog box by mouse shortcut command button;
   c. in Command dialog box, choose parameter on the left side of screen
   d. choose "Immediate or Rapid Send" radio button; and
   e. press the "Send and Close" button.

   Recommendation: Provide a means to automate routine keystroke sequences.

3. **Interrupted tasks require follow-up reminders (Task 5.4.2.1).** Specialists will often acknowledge an alarm but have to make a note to themselves as a memory jog to follow up later. For instance, if the Field Specialist is on-site and the specialist acknowledges, the specialist still wants to verify afterward that the original alarm has cleared. Specialists can use the comments field but, typically, rely on paper notes.

   Recommendation: Provide on-screen reminder capability such as a toggle flag.

4. **Field Specialist (TECH) field character limitations (Tasks 5.6.1.3; 5.6.2.3).** The Field Specialist field is limited to seven characters for entering notes. Specialists resort to using abbreviations (e.g., *Sch* for "Scheduled Maintenance," or *TOS* for "Technician on Site"). Specialists reported that even with abbreviations there are occasions when a seven character field limit is too small (e.g., wanting to paste in an eight character log ID from Event Manager).

   Recommendation: Increase field length.

5. **Data field scan prone to error (Tasks 4.3.2; 4.4.1; 4.5.2).** Scanning across rows of data (e.g., from Alarm column to corresponding Actual Status column) is perceptually demanding and error prone.

   Recommendation: Use of color banding (e.g., alternating gray and white fill) could help with horizontal scanning (Ahlstrom & Kudrick, 2006).

6. **Time-consuming login and setup (Tasks 1.1; 1.2).** Personalized and saved settings can save several minutes at login. Use of default settings could be improved. Some specialists felt that the system should better remember their last-used configuration, thereby saving several minutes at startup.

   Recommendation: Allow users to save settings to a profile, which can be activated upon login.

7. **Actual parameter value with no criterion (Task 4.4.2).** Parameter values are often presented as absolute values (e.g., volts, amps), but these can be meaningless to an operator in the absence of a reference or threshold.

   Recommendations: Present both actual and threshold values. Use visual indicator instead of (or in addition to) values.

8. **Actual parameter value not meaningful (Task 4.4.2).** Some Subsystem LUIDs have associated Parameter Descriptions unsuited to the task. For instance, an ATSS might be presented with volume of fuel remaining but needs to know remaining hours of run time for an engine generator. In this instance the burn rate is needed to calculate remaining hours of run time.

   Recommendation: Transform data to better fit ATSS task.

9. **Actual parameter value requires extra computation (Task 4.4.2).** Some parameters require extra computation before use. For example, the VOR antenna monitor information is in hexadecimal format and must be converted before a faulty antenna can be identified.

   Recommendation: Convert actual values into data more meaningful to specialists.

10. **Routine text entry is time-consuming (Task 5.3.5).** In creating event tickets, specialists rely heavily on a set of recurrent phrases and have created a workaround in "cheat sheet" text files from which they cut and paste.

    Recommendations: Provide customizable keyboard shortcuts for the most frequently used phrases. Provide predictive auto-fill data fields for previously used text.

11. **Infrequently used icons are not intuitive (various tasks).** Infrequently used button icons on the Operator bar are not intuitive or easily recalled. Specialists reported unfamiliarity with some icons and often seemed to rely more on location than iconography.

    Recommendations: Place less frequently used icons in a menu as text. Redesign icons to be more intuitive.

12. **CLASS not understood (Task 4.5).** The relationship between Classification and other severity indications (e.g., Alarm and Alert status, Criticality value) is not clear, and is generally disregarded.

    Recommendation: Remove CLASS.

13. **CLASS adds extra tasks (Task 4.5).** For a given LUID status, CLASS presents static classification indications for both Alarms and Alerts. This forces the ATSS to take the extra step(s) of scanning or recalling this Alarm or Alert status.

    Recommendations: Suppress display of the unnecessary indication. Remove CLASS.

14. **Quick Look not available for all facility types (Task 5.1.2).** Some Subsystem views have no Quick Look overview, which can add time and effort to subsystem exploration.

    Recommendation: Add Quick Look views for subsystems that need them.

15. **Terminology differences between OCC/SOC ATSS and Field Specialists (Task 5.6.2.2).** RMM used by SOC/OCC ATSSs has LUIDs, which the Field Specialists are not familiar with. When SOC/OCC ATSSs are discussing an outage with a Field Specialist, terminology differences can hamper coordination. LUIDs differ across facility types and can lead to communication difficulties.

    Recommendations: Provide a translation table. Standardize LUID terminology and usage.

16. **Inefficient and error-prone masking (Task 5.5).** When a specialist is interested in only a small subset of sites, it is more efficient to select the minority than to deselect the majority. In this case, the ability to select specific LUIDs from specific sites or types (rather than having to monitor all sites and types and mask unwanted LUIDs) would facilitate monitoring.

    Recommendation: Add some form of anti-masking.

17. **Criticality data is misleading (Tasks 4.3.4 – 4.3.6).** Criticality is seen as unclear, unintuitive and sometimes misleading, and its relationship to other indications (e.g., Class, Alarm and Alert status) is seen as inconsistent. ATSSs are sometimes confronted by highly critical alerts, other times by low criticality alarms. The impact of this is that some specialists report always ignoring Criticality. Policies reportedly differ across visited sites as to criticality trigger values.

    Recommendation: Reconsider use of criticality data.

18. **Criticality depends on context (Tasks 4.1; 4.2.3; 4.3.4 – 4.3.6).** Criticality can be misleading if not weighed against the ATSS's own knowledge of a given site's operational significance and history.

    Recommendation: Reconsider usefulness of the Criticality indication.

19. **LUID information overload (Task 5.1.2.2).** At the Subsystem level, specialists are sometimes confronted by more LUIDs than they want. The ATSS's task is (sometimes) to simply make a decision about the parent site's alarm status, and excessive information is burdensome. Some specialists (particularly those in the OCCs) requested that only situations risking an out-of-service condition need to be displayed.

    Recommendations: Provide a high-level visual indicator (such as the spider graph described later in this document) to replace or augment current data. Reevaluate the information that is displayed.

20. **Some data field descriptions are not intuitive or descriptive (Task 4.4.2).** ATSSs sometimes encounter descriptions that they find cryptic such as the Parameter data field.

    Recommendation: Review descriptions to ensure that they make sense to the user.

21. **Information void: No ticket indication for acknowledged alarm (Tasks 4.2.3; 4.7.2.1).** The system (RMLS-MASS link) does not always indicate whether there is an open ticket for a given acknowledged alarm. This can lead the ATSS to a false conclusion and prompt him or her to call a Field Specialist when one is not needed.

    Recommendation: Provide an indication of open tickets.

22. **Terminal message can be missed (Task 4.7.2.1).** The MASS indication for a terminal message is subtle and the ATSS can fail to notice that a Field Specialist is logged in. This forces the ATSS to perform additional search tasks.

    Recommendation: Make the terminal message field more conspicuous when filled.

23. **Alarms concealed by interface (Task 3.1).** A lengthy alarm list can run off the page downward, making it necessary to scroll down to view all of the alarms. Specialists may miss alarms that are off of the screen. Specialists report that this is a very frequent problem.

    Recommendation: Provide an indicator on the interface for off-screen alarms.

24. **Alarms concealed by Subsystem view (Task 5.1).** While drilling down in Subsystem views, the ATSS can miss an alarm at the higher parent level.

    Recommendation: Provide a salient indication of new alarms that can be seen even when in Subsystem views.

25. **Stale data can conceal state changes (various tasks).** If the ATSS fails to update site status (**Task 2**) and notice stale refresh time (**Task 4.1.4**), he or she may not be aware of system state changes. Information is not consistently auto-updated, which causes difficulty when some information automatically updates and other information must be manually refreshed. Stale data is also an issue, as old alarms will surface after being cleared.

    Recommendations: Provide an indication on the interface of state changes. Provide consistency in data update.

26. **Masking can silently persist beyond shift change (Task 3.2).** A specialist will normally mask only until the end of his or her shift, so as to not leave a hidden trap for the incoming ATSS. If masking is not cancelled, or if mask end time is improperly set, it can persist without easy indication.

    Recommendations: Cancel masking at log-off. Require system confirmation of masking at log-on.

27. **Possible mismatch between Field Specialist and RMM data (Tasks 6.2.2; 6.4).** Certain sensors, such as the Instrument Landing System Localizer monitor, can be calibrated in such a way that the ATSS and Field Specialist have contradictory views of site status.

    Recommendation: Identify inaccurate and inconsistent information and make it consistent and accurate.

28. **Commands silently dropped (Task 5.4.2.3).** Resetting VORs is one of the common tasks of the ATSS, but there is generally a limit of one reset per VOR per 24 hours. If additional resets are attempted, they can be dropped without any indication.

    Recommendations: Provide an indication of recent resets. If a command is not available to the user, disable that command (such as reset) and clearly indicate it as disabled.

29. **Concealed data (Task 5.1.1).** At some sites, the Engine Generator (EG) LUID is under RADAR, not the beacon, although EG feeds both sides. ATSS must know to look under both facilities.

    Recommendation: Provide cross-referencing information for LUIDs.

5. DISCUSSION

Observational data and self-report data provide slightly different perspectives of the information requirements for the ATSS interacting with MASS. During observational data collection, specialists tended to limit themselves to a small number of controls and data fields within the MASS. To some extent, this is an artifact of the observational technique- one cannot hope to observe the rare and esoteric events in a short series of over-the-shoulder observations. This problem was overcome using cognitive walk-through sessions, in which we could script non-routine scenarios. Cognitive walk-through sessions revealed a broader range of control and data field usage.

The MASS tool provides a good deal of information, but the information that is needed depends not only on the task but also on the specialist's role. For example, MASS can provide voltage levels or gallons remaining for specific systems; however, in many cases, the specialists reported that this was not the level of information that they needed to accomplish their tasks. Instead, specialists at an OCC reported that they usually need a high-level indication of system status, without detailed subsystem parameter data. Similarly, a specialist at a SOC may want to know that a RADAR is out of service but is not, typically, concerned about the voltage level of an underlying subsystem. Too much information that is not directly related to the task can increase the complexity of the task.

Although the specialists often work within their own domain, there are episodes of "joint diagnosis" when a specialist at an OCC, or a SOC, and a Field Specialist have to work cooperatively to solve a problem. For this reason, a move toward less information across the board might present problems. The answer would seem to lie in

- an ability to limit information when desired;
- an access to deeper information for drill-down capability, as needed; and
- a simplified presentation of information to facilitate trend analysis.

Several solutions to this problem were discussed in debriefs and informal discussions. Some potential solutions include high-level indicators such as the following:

- indicator light (similar to an auto's Check Engine light) to indicate status;
- "stoplight" tri-color approach to indicate status, such as normal, alert, and alarm;
- dashboard-like dials or gauges; or
- multidimensional trend indicator to give an at-a-glance indication of how underlying parameters were trending.

The high-level indicators should allow the specialists to drill down for additional information. When specialists drill down from one of these high-level indicators for diagnosis, the sequence of Subsystem screens should guide them to the relevant LUIDs. We noted that a lack of guidance to relevant LUIDs can hinder the performance of both novices and experts in different ways. The novice can waste time drilling down fruitless avenues, whereas the expert might be led astray by relying on assumptions and heuristics to save time.

RMM has many users and uses. OCCs and SOCs have slightly different responsibilities and facilities; nevertheless, these two job tasks of ATSSs are more similar than dissimilar. Their current role centers on higher level failure analysis and diagnosis and responding to catastrophic events. As a result, they do not need the same level of detail at a glance as the Field Specialist might. Apart from excessive detail, the ATSSs also spoke more generally about the sources and dangers of information overload—such as from excessive Command options—and the display of facilities under the responsibility of other ATSSs.

This report contains 29 recommendations to change the RMM interface to better meet the user informational requirements. Any interface change, however, has a potential to introduce unforeseen errors. Thus, we recommend that any changes be implemented on a prototype and tested for usability before implementing them in an operational setting.

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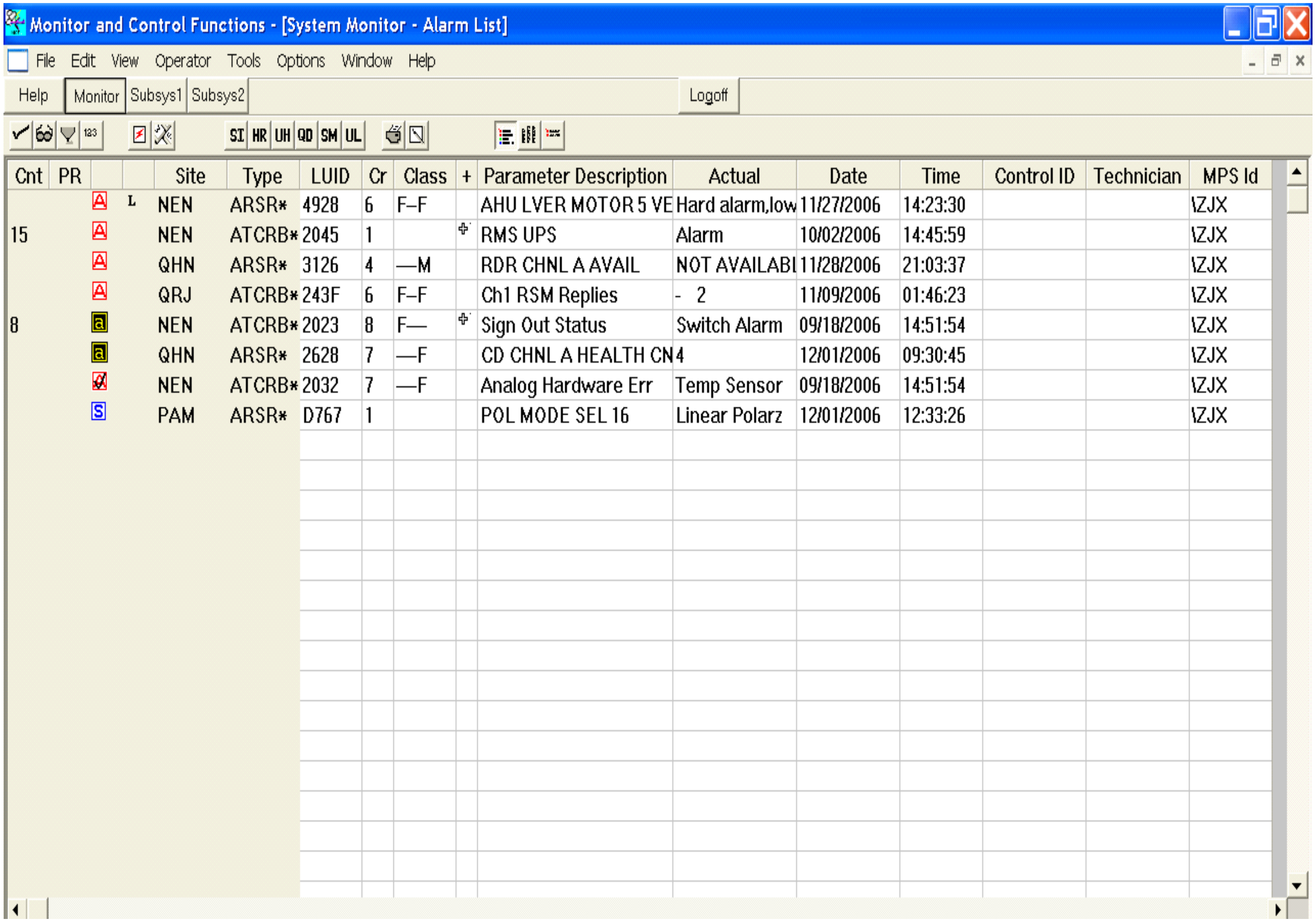
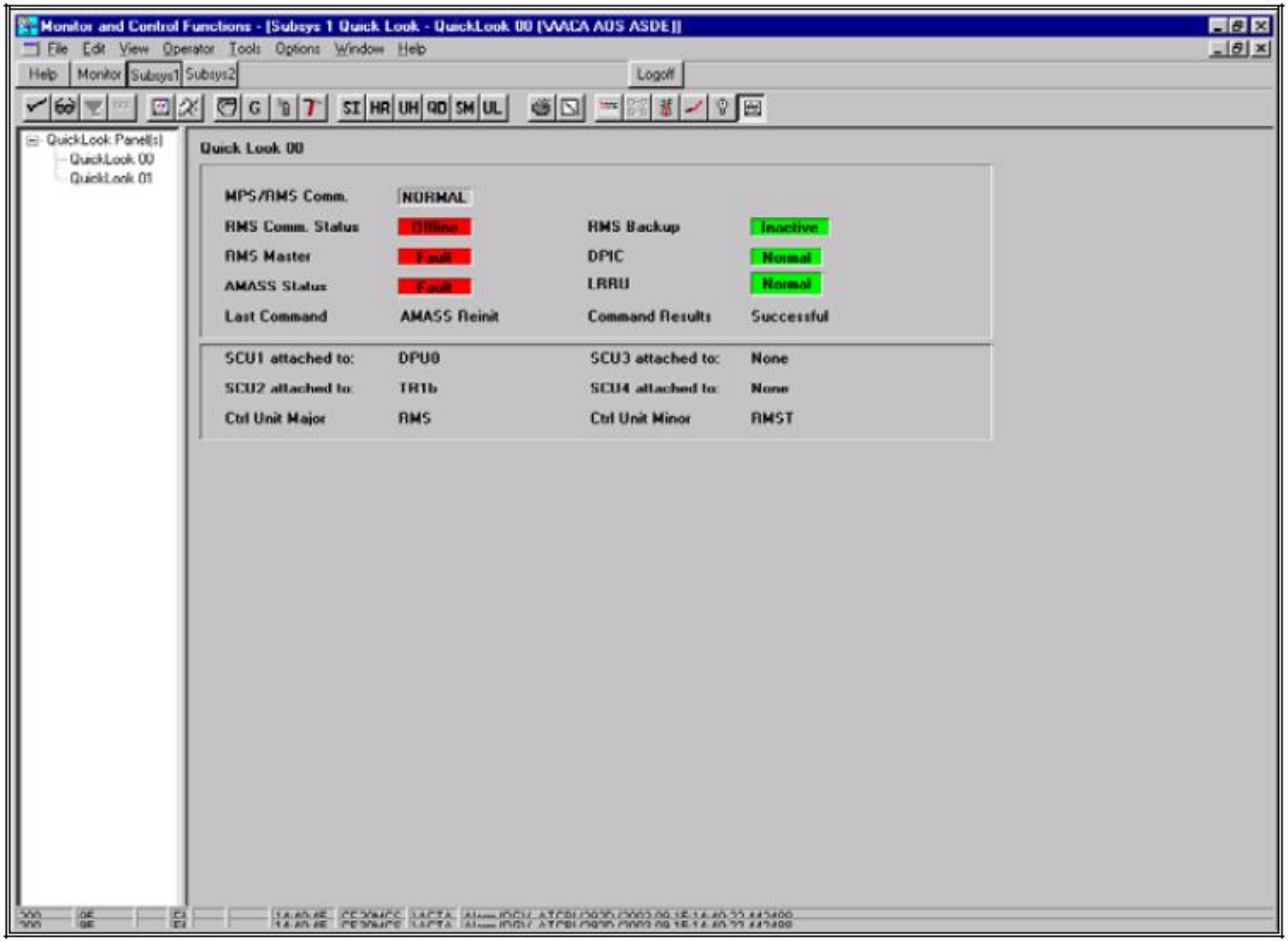
Acronyms

AOI	Area of Interest
ARTCC	Air Route Traffic Control Center
ATSS	Airway Transportation Systems Specialist
CTA	Cognitive Task Analysis
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration
LUID	Logical Unit Identifier
MASS	Maintenance Automation System Software
MCF	Monitoring and Control Function
MMS	Maintenance Management System
MPS	Maintenance Processor Subsystem
NAS	National Airspace System
NAVAID	Navigational Aid
OCC	Operations Control Center
RMLS	Remote Maintenance Logging System
RMM	Remote Maintenance Monitoring
SOC	Service Operations Center
TechOps	Technical Operations
VOR	Very High Frequency Omnidirectional Radar

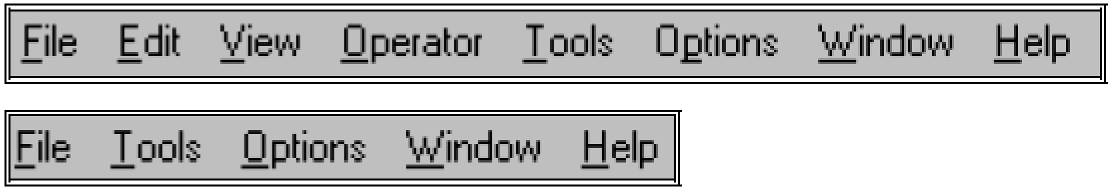
Appendix A: Elements of the MASS Interface



System Monitor – Alarm List view (default)



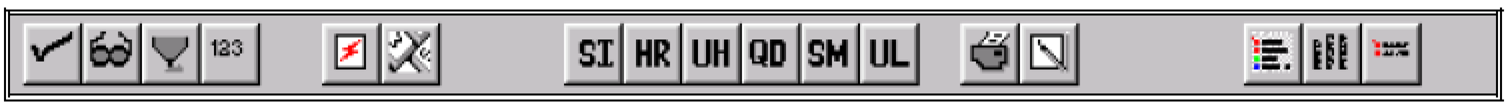
Subsystem -Quick Look view (default)

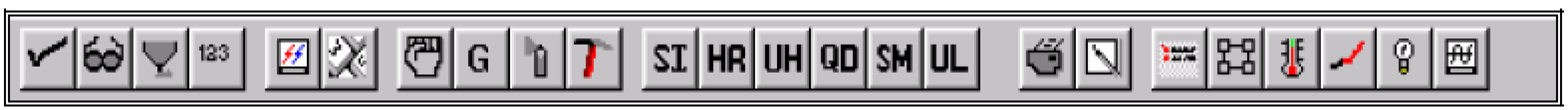


Menu bar

Window bar

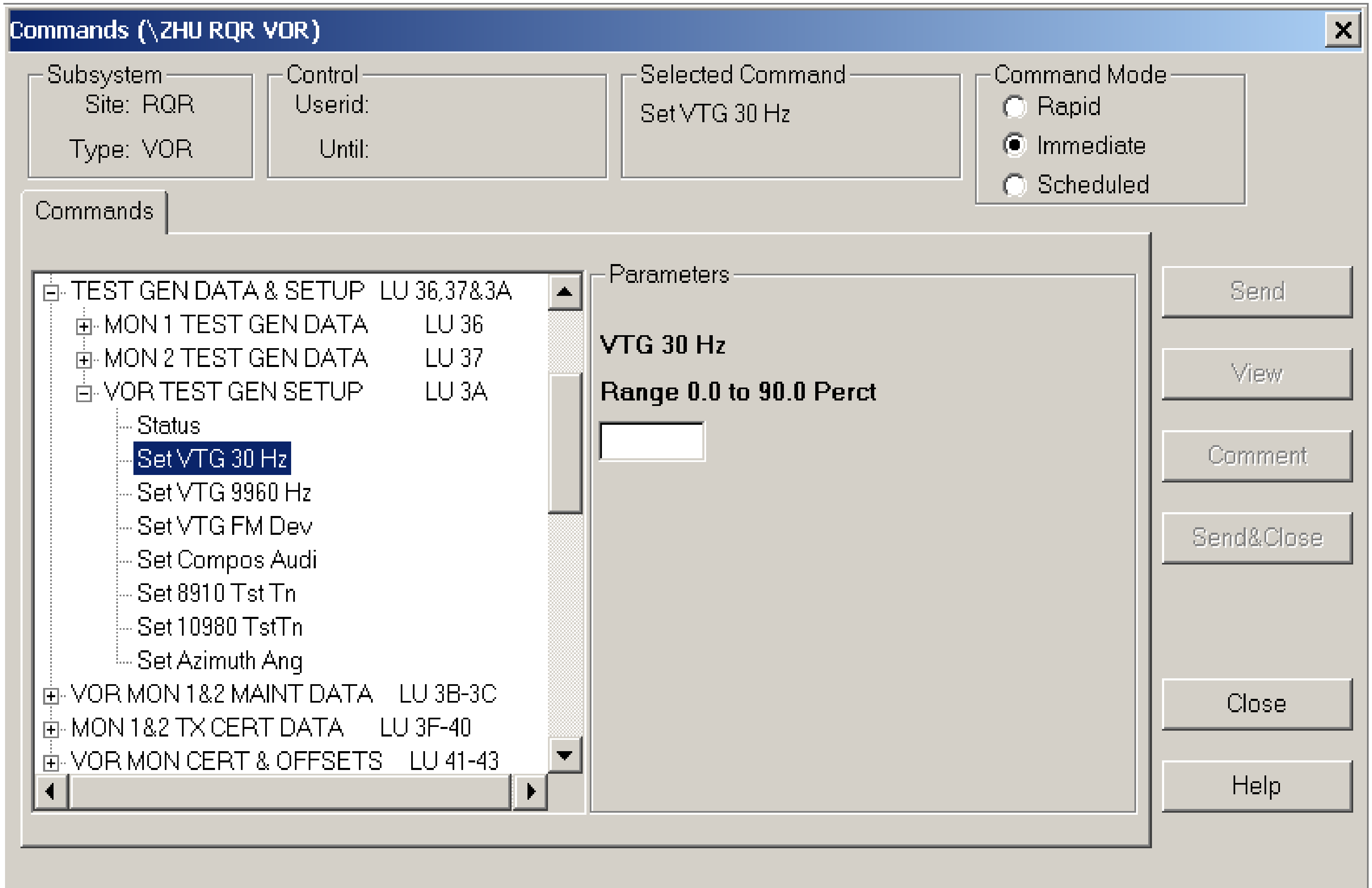
Operator bar, System Monitor views





Operator bar, Subsystem views

Status bar



COMMAND dialogue box

Appendix B: Questionnaire

Questionnaire

Date: __________ RMM Duty:_________ Facility: __________

1. What is your current job title? ___________________________

2. How long have you worked in this position? ___________ years

3. How many others with the same responsibilities currently work at your facility?________

4. For what purpose do you generally use RMMS?

If you use RMMS for more than one purpose, please indicate rank order using numbers 1,2,3.. (with 1 being the primary purpose, 2 the secondary, etc.)

___ Fault isolation and restoration
___ Managing system configuration
___ Conducting analysis of system performance
___ Performing periodic maintenance
___ Performing certification testing
___ Troubleshooting
___ Other, namely:____

5. Please indicate the percentage of time that you use RMMS for the following activities:

______% Preventive maintenance
______% Corrective maintenance
______% Other, namely:____

6. Do you have individual preferred settings for the RMMS interface?

Y___ N___

If so, please tell us about them.

7. What facilities do you monitor most often? Indicate this by ranking the top facilities (1, 2, 3, etc.) under "Common." Are certain facilities potentially the most critical when they fail? Indicate this by ranking the top facilities (1, 2, 3, etc.) under "Critical." Note that the COMMON facilities might be different than the CRITICAL facilities.

	Common	Critical
ACRB	___	___
ACSS	___	___
ALS	___	___
ARSR	___	___
ARTS	___	___
ASDE	___	___
ASDES	___	___
ASR	___	___
ATCT	___	___
BDAT	___	___
CCCH	___	___
CFAD	___	___
CRAD	___	___
DME	___	___
DSR	___	___
ETARS	___	___
GS	___	___
LOC	___	___
MALS	___	___
MALSR	___	___
MDAT	___	___
MEASRT	___	___
MODES	___	___
MSEC	___	___
NADIN	___	___

	Common	Critical
PRM	___	___
RCLR	___	___
RDAT	___	___
RMCF	___	___
RMSC	___	___
RMUC	___	___
RVR	___	___
SGS	___	___
STARS	___	___
TACR	___	___

TARS	___	___
TCOM	___	___
TDWR	___	___
TMA	___	___`
TRAD	___	___
TSEC	___	___
TVS	___	___
URET	___	___
VOR	___	___
VSCS	___	___
VSCSS	___	___
VTABS	___	___
WMS	___	___

OTHER
*(identify)*________________________
*Common:*___ *Critical:*___

8. Do you filter the RMM screen? Y___ N___

If yes, which filters do you use (please identify all)?

___Status condition (acknowledged alarms or alerts, return to normal, state change, etc.)
___Site
___Type
___Site and type
___Date and time
___Alarm criticality levels
___Primary responsibility
___Other, namely:____

9. If you answered YES to question 8, under what conditions do you apply filters? (For example, "I filter by alarm criticality when I am monitoring but type when I am troubleshooting")

Please explain:

10. Are the RMM screens that you used masked? Y___ N___

If yes, which items are masked (please identify all)?

___Status condition (Acknowledged alarms or alerts, return to normal, state change, etc.)
___Site
___Type
___Site and type
___Date and time
___Alarm criticality levels
___Primary responsibility
___Other, namely:____

11. If you answered YES to question10, under what conditions are the items masked?

Please explain:

12. Under normal conditions, which of the following do you tend to ignore?

___Site
___Type
___Site and type
___Date and time
___Alarm criticality levels
___Primary responsibility
___Other, namely:____

13. Which of the following information needs to be displayed all the time when using RMM?

___Site ___Time
___Alarm status ___LUID
___Criticality ___Date
___Parameter ID ___Classification (critical, major, fault)
___Other, namely:____

14. Which of the following can generally be gleaned with a quick glance?

___Site
___Alarm status

___LUID
___Criticality
___Date
___Time
___Parameter ID
___Classification (critical, major, fault)
___Other, namely:____

15. If you could make one change to the current RMM system, what would it be and why?
____
____
____
____
____
____
____

Appendix C: Cognitive Task Analysis - Tabular View

Cognitive Task Analysis - Tabular View

Nr	Task	Plan
	MONITOR AND CONTROL	Do all in sequence 1-3; if necessary (do all in sequence 4-6).
1	**Perform shift set-up**	Do all in sequence 1-3.
1.1	Log in	
1.2	Set preferences	
1.3	Open MCF Systems Monitor - Alrm / Unack List window	
2	**Update site status**	Do all in sequence 1-6.
2.1	Sort by TYPE	
2.2	Select first applicable TYPE	
2.3	Open COMMAND box (mouse/button/shortcut)	
2.4	Choose Parameter	
2.5	Choose Immediate or Rapid Send radio button	
2.6	Send Command	Do 1 or (2 and 3).
2.6.1	Press Send & Close button	
2.6.2	Press SEND button	
2.6.3	Close COMMAND box	
3	**Identify event (alarm or alert)**	Do all in sequence 1-3.
3.1	Scan EVENT column	
3.2	Detect indication in EVENT column	
3.3	Remember alarm event/s	
4	**Evaluate event**	**Optionally, do any 1-8.**
4.1	Evaluate operational significance	Do all in any order 1-4.
4.1.1	Consider location	
4.1.2	Consider WX	
4.1.3	Consider traffic	
4.1.4	Consider time of day	
4.2	Evaluate History	Do all in sequence 1-3.
4.2.1	Get History Report	Do all in sequence 1-5.
4.2.1.1	Get site identifier from Site List	
4.2.1.2	Press HR button	
4.2.1.3	Set date range	
4.2.1.4	Send command	
4.2.1.5	Wait for report	
4.2.2	Review History Report	
4.2.3	Consider ongoing faults	If necessary, do all in any order 1-3.
4.2.3.1	Consider long-term OTS condition	
4.2.3.2	Consider maintenance	
4.2.3.3	Consider nuisance events	
4.3	Evaluate criticality	Do all in sequence 1-7.
4.3.1	Recall event row	
4.3.2	Scan across row (possible scan problems)	
4.3.3	Find corresponding criticality value	
4.3.4	Recall criterion	
4.3.5	Compare criterion and current values	

4.3.6	Determine critical event(s)		
4.3.7	Remember critical events		
4.4	Evaluate Parameter Description	do all in sequence 1-2	
4.4.1	Scan over to PARAMETER DESCRIPTION column		
4.4.2	Read and process		
4.5	Evaluate Classification (CLASS often not used / understood)	do all in sequence 1-4	
4.5.1	Recall event row		
4.5.2	Scan across row		
4.5.3	Find corresponding cell in CLASS column		
4.5.4	Determine whether right /left hand character present (for event)	do any one 1-2	
4.5.4.1	Determine blank		
4.5.4.1.1	Abandon cross check		
4.5.4.2	Determine character present	do all in sequence 1-4	
4.5.4.2.1	Choose character		
4.5.4.2.2	Read character		
4.5.4.2.3	Remember associated Classification		
4.6	Evaluate multiple messages	do any one 1-2; do all in sequence 3-4	
4.6.1	Scan COUNT column	do all in sequence 1-2	
4.6.1.1	Identify highest count		
4.6.1.2	Scan over to Expand ("+") column		
4.6.2	Scan down EXPAND ("+") column	do all in sequence 1-2	
4.6.2.1	Identify "+" icon		
4.6.2.2	Verify high count	do all in sequence 1-4	
4.6.2.2.1	Scan across row to CNT column		
4.6.2.2.2	Scan up/down for higher counts		
4.6.2.2.3	Scan back to initial "+" cell		
4.6.2.2.4	Select uppermost expandable cell		
4.6.3	Click to expand number of messages		
4.6.4	Evaluate multiple messages		
4.7	Evaluate scheduled maintenance	do all in sequence 1-2	
4.7.1	Check COMMENT field for indication	do all in sequence 1-4	
4.7.1.1	Conclude scheduled maint underway		
4.7.1.2	Check end time for scheduled maintenance		
4.7.1.3	Compare shift end time to maintenance end time		
4.7.1.4	Consider masking / filtering alarm		
4.7.2	Determine whether Field Specialist onsite	do all in any order 1-2	
4.7.2.1	Check FIELD SPECIALIST field for TOS indication		1
4.7.2.1.1	Read field		
4.7.2.1.1.1	detect indication that Field Specialist onsite		
4.7.2.1.1.2	detect no indication of Field		

	Specialist onsite	
4.7.2.2	Check EVENT column	
4.7.2.2.1	Conclude Field Specialist onsite	
4.7.2.2.1.1	Detect indication of tech onsite (T)	
4.7.2.2.1.1.1	Conclude Field Specialist on-site	
4.7.2.2.1.2	Detect indication of tech onsite (L)	
4.7.2.2.1.2.1	Conclude Field Specialist onsite, LCL control	
4.7.2.2.1.3	Detect no indication of tech onsite	
4.7.2.2.1.3.1	Conclude no tech onsite	
4.7.2.2.1.3.2	Check RMLS for ticket	
4.8	Cross check RLMS Event Manager comments	
5	**Respond to alarm**	**do all in any order 1-2; if necessary (optionally do any 3-6)**
5.1	Probe Subsystem	do all in sequence 1-5
5.1.1	Open Subsystem Query screen	
5.1.2	Open Quick Look	optionally do any 1-2
5.1.2.1	Evaluate overall status	
5.1.2.2	Evaluate LUIDs	
5.1.3	Open desired view	do any one 1-4
5.1.3.1	Open Alarm Summary view	
5.1.3.2	Open Configuration view	
5.1.3.3	Open Environment view	
5.1.3.4	Open Performance View	
5.1.4	GET status update	
5.1.5	Confirm alarm	do all in sequence 1-7
5.1.5.1	Scan EVENT column	
5.1.5.2	Select appropriate alarm row	optionally do any 1-2
5.1.5.2.1	Consider number of unacknowledged subsystem alarms	
5.1.5.2.2	Detect ALARM icon	
5.1.5.3	Expand parameter view	
5.1.5.4	Scan underlying LUIDs	
5.1.5.5	Detect underlying alarm	
5.1.5.6	Remember on-screen line (LUID, position, etc)	
5.1.5.7	Confirm Alarm	
5.1.6	Probe subsystem unacknowledged alarms	optionally do any 1-2; 3
5.1.6.1	Identify high unack count events	
5.1.6.2	Scan CNT column for high unack count	
5.1.6.2.1	Identify highest CNT event	
5.1.6.3	Determine unack count priority	optionally do any 1-5; do any one 6-7
5.1.6.3.1	Scan SITE	
5.1.6.3.2	Scan TYPE	
5.1.6.3.3	Scan CRIT	
5.1.6.3.4	Scan PARAMETER DESCRIPTION	
5.1.6.3.5	Scan ACTUAL	
5.1.6.3.6	Scan CLAS	

5.1.6.3.7	Confirm high priority event	
5.1.6.3.8	Confirm lower priority event	
5.2	Acknowledge alarm	do all in sequence 1-4
5.2.1	Open unacknowledged list	
5.2.2	Select subsystem	
5.2.3	Open acknowledge dialog box	
5.2.4	Highlight or acknowledge alarm	do any one 1-4
5.2.4.1	Via ACK button	
5.2.4.2	Via Subsystem menu	
5.2.4.3	Via R mouse click	
5.2.4.4	Via double click	
5.3	Open / check for corresponding alarm ticket	do all in sequence 1-3; do any one 4-5
5.3.1	Check RMLS Event Manager for existing ticket	
5.3.2	Recall SITE from MASS	
5.3.3	RMLS query for corresponding LUID ticket	
5.3.4	Conclude existing ticket	do all in sequence 1-2
5.3.4.1	Evaluate indicated adjudication	
5.3.4.2	Decide to acknowledge event	
5.3.5	Create ticket	do all in sequence 1-5
5.3.5.1	Scan from Comments (right data field) to Site (left data field)	
5.3.5.2	Bring up facility in RMLS	
5.3.5.3	Paste RMM acknowledge text into RMLS	
5.3.5.4	Paste RMLS ticket nr into MASS comments field	
5.3.5.5	Evaluate site-specific RMLS data (e.g., POCs)	
5.4	Reset / adjust system parameters	if necessary (optionally do any 1-4)
5.4.1	Change RADAR channels	do all in sequence 1-3
5.4.1.1	Access Command screen via CMD button	
5.4.1.2	Change channel A and B	
5.4.1.3	Send CMD	
5.4.2	Change NAVAID frequencies	do all in sequence 1-3
5.4.2.1	Access Command screen via CMD button	
5.4.2.2	Change to backup frequency	
5.4.2.3	Send CMD	
5.4.3	Start EG	do all in sequence 1-3
5.4.3.1	Access Command screen via CMD button	
5.4.3.2	Switch Generator on / off	
5.4.3.3	Send command	
5.4.4	Reset site	do all in sequence 1-3
5.4.4.1	Access Command screen via CMD button	
5.4.4.2	Select System Reset command	
5.4.4.3	Send command	

5.5	Mask site / parameter	
5.6	Coordinate	optionally do any 1-4
5.6.1	Notify Air Traffic	do all in sequence 1-3
5.6.1.1	Phone call	
5.6.1.2	Follow-up email	
5.6.1.3	Log entry	
5.6.2	Dispatch Field Specialist	do all in any order 1-3; if necessary (4)
5.6.2.1	Identify site tech from RMLS database	
5.6.2.2	Phone call	
5.6.2.3	Log entry	
5.6.2.4	Notify Area Manager for OEP event	
5.6.3	Contact emergency services	
5.6.4	Coordinate with other entities (e.g., DOD, small airports)	

Cognitive Task Analysis - Tabular View

Abbreviations used in the CTA tabular view:

ACK	Acknowledge
CLAS	Classification
CLASS	Classification
CMD	Command
CNT	Count
CRIT	Criticality
EG	Engine Generator
HR	History Report
LCL	Local
LUID	Logical Unit Identifier
MCF	Monitoring and Control Function
OTS	Out of Service
TOS	Technician on Site
WX	Weather