TECHNICAL REPORT

GTCEC2007-0002
Public Release
Printed February 2007

Contextual Inquiry of a 50 Aircraft Regional Airline Systems Operation Center

Karen M. Feigh

Prepared by
The Cognitive Engineering Center
Georgia Institute of Technology Atlanta, Georgia 30332-0150

Acknowledgment

Thanks to Steve Altus at Jeppesen for coordinating my visit and for the SOC personnel for their patience and enthusiasm for their jobs.

Contents

Figures

Tables

Executive Summary

A contextual inquiry was conducted at the Systems Operations Control (SOC) of a regional airline with approximately 50 aircraft from the 8th-11th of November 2006. A total of 35 hours of direct observation were conducted with various members of the SOC Staff including the System Operations Control Shift Manager (SOCSM), the System Customer Service Manager (SCSM), the Dispatchers, and the Line Maintenance Planners (LMP). During the inquiry a wide variety of situations occurred: unscheduled maintenance delays, estimated ready time slips, a lightning strike, aircraft damage from a ground vehicle, a system-wide gate printer outage during a departure push, ATC delays, internet and subsequent ACARS outage, an unruly passenger disruption and turn back, and a sick dispatcher.

The vast majority of these situations were handled as if they were no different from routine operations; however, there were moments when the SOC personnel were fully involved in the situation, and other minor tasks were being ignored or transferred to other personnel. The majority of high impact problems faced by the the airline's SOC on a daily basis came from unscheduled maintenance or IT glitches. Unlike other airlines, ATC restrictions are not often an issue for this airline, although station curfews in southern California do place an additional constraint on the schedule recovery process. Similarly, weather was also only a minor issue during the contextual interview.

Beyond the inevitable weather and maintenance interruptions, the majority of problems stemmed from software tools which limited the efficiency of the SOC personnel, and from procedures that required the SOCSM to do certain steps multiple times. For example, in order to keep the non-SOC personnel informed about the state of the airline, the SOCSM is required to run reports after each routing change and paste them into both email and the shift log. Additionally, the SOCSM is required to manually enter flight data to create new flights or to maintain existing ones. Similarly, the SOCSM is also required to manually enter and maintain maintenance segments for aircraft.

The solution to these problems includes making better use of the current software's functionality, investigating the actual information needs of the routing change recipient list, and incorporating additional automation to automatically create routing change reports and shift logs. The current software includes a capability to create new flights or maintenance segments using a correctly formatted text file. Using this capability would save much time in manual entry and minimize the number of typographical errors. Additional software should also be created to transition the incident reporting system and the shift log to an electronic database to facilitate data analysis. The SOCSM is currently responsible for posting any routing changes to a preset list via email. The actual information needs of these recipients should be reviewed to determine how frequently this information is actually required and whether or not a more scheduled reporting of all routing changes during a given time period might be adequate. Depending on the outcome, it might be possible to consolidate reports to once or twice a shift. Regardless, additional software should be created to automate the reporting process.

Nomenclature

ASD Aircraft Situation Display

ATC Air Traffic Control

SOC Systems Operation Control

SOCSM Systems Operation Control Shift Manager

SCSM Systems Customer Service Manager

LMP Line Maintenance Planner

MEL Minimum Equipment List

ACARS Aircraft Communication Addressing and Reporting System

TDM Tower Duty Manager

1 Introduction to the Airlines

The is a regional airline connecting destinations primarily in the west coast and mid-west to its hub in the West and its international destinations in Mexico. At the time of this contextual inquiry, the airline had approximately 55 aircraft split between Airbus aircraft. All of the aircraft have crew compatible flight decks; however, only a limited number of the aircraft are equipped with high thrust engines or with equipment required to travel over water. Consequently not all aircraft are appropriately equipped to travel all routes. Also at the time of this inquiry, the newest aircraft had not yet received their Mexican certification, limiting their use to domestic destinations.

2 SOC Organization and Personnel

The Systems Operations Center at the airline is located in a single room with five functional areas: Systems Ops Group, Dispatch, Line Maintenance Planning, Crew Scheduling, and SOC Support Group. Each group is physically co-located, often being clustered around a group of desks. The Systems Ops Group, Dispatch and Line Maintenance Planning are all located in what is essentially the bridge of the SOC. The bridge is physically separated from the rest of the SOC by a series of filing cabinets and a large set of six LCD display screens, see Figure 13.

The Systems Ops Group consists of two individuals, the Systems Operations Center Shift Manager (SOCSM) and the Systems Customer Service Manager (SCSM) and is sometimes augmented by a dispatchers seated in the Dispatch 1 position.

System Operations Control Shift Manager (SOCSM) There is one systems operations control manager in the SOC who sits between the Line Maintenance Planners and the SCSM. The SCSM is responsible for the conduct of all SOC personnel during his/her shift as well as the smooth operation of the airline during his/her shift. The SOCSM has final authority over any decision to delay, cancel or swap aircraft, etc; however, the SOCSM works in close coordination with the Tower Duty Manager (TDM) at the airline's main hub and often defers to the TDM in cases that primarily impact hub operations. The SOCSM is aided by all of the individuals in the SOC, particularly the SCSM. Most of the other individuals help funnel and filter information to the SOCSM in an efficient manner, only elevating those issues which cannot be handled locally or which may have a larger system impact. The SOCSM and the SCSM are the only individuals who have the appropriate authority to actually swap equipment, delay or cancel flights. Often, once a solution has been devised, the SOCSM may ask the SCSM to aid him by posting the delay. The SOCSM is also the chief dispatcher and has responsibility for maintaining adequate dispatcher staffing. Aiding the SOCSM with these roles are several software tools. The SOCSM uses a Gantt chart schedule visualization tool, made by SABRE called Flight Trac Plot most, as it is her means to visualize, monitor, and manipulate the schedule. This tool is referred to by the

Table 1. SOC Operations Control Group Roles

Position	Roles
System Operation Control Shift Manager (SOCSM)	Sending out routing changes (due to equipment swaps) out via email Pairing aircraft to scheduled trips Maintaining the published schedule Coordinating irregular operations recovery Communicating irregular events to the entire organization ATC coordinator Dispatch coordinator – must have dispatch rating
System Customer Service Manager (SCSM)	Coordinator of large-scale customer issues including reaccommodation Aid for SOCSM with problem solving Advocate for customers Pet restriction calculation

SOC personnel as "The Plot."

The SOCSM maintains a shift log in MSWord following a specified template. He also uses a shift checklist to ensure that all of the different tasks for the shift have been completed, and the Flight Explorer ASD mostly for weather information. In addition, they use standard email tools and internet browsers. They send and receive ACARS messages via a web interface.

System Customer Service Manager (SCSM) There is one customer service representative in the SOC who sits between the dispatchers and the SOCSM. The SCSM is responsible for aiding the SOCSM, fielding all of the customer service related calls, issuing accompanying animal, "pet", restrictions (due to weather) and advising field offices of cancelation impact on customers. Additionally, the SCSM also has access to the reservation system which is used to help station personnel rebook passengers who are impacted by irregular operations. The SCSM often steps in to aid the SOCSM when an unusual or prolonged disruption occurs, and the SOCSM must attend to additional disruptions as they develop. As the SCSM sits next to the SOCSM, she is often able to begin addressing an issue while the SOCSM is still on the phone gathering information about a situation from the original reporting source. The SCSM also uses the Flight Trac Plot. Additionally, the SCSM also has access to the reservation system via SABRE's GUI interface which the SCSM finds cumbersome, which means that when he can, he uses means other than the GUI interface to access information. He uses the Flight Explorer ASD, primarily for weather information. In addition, the SCSM uses standard email tools and internet browsers and send and receive ACARS messages via a web interface. The SOCSM's and the SCSM's primary roles are summarized in Table 1

Line Maintenance Planing (LMP) Group There are as many as four LMPs in the SOC during any shift, although all four spots are not always staffed. They are responsible for creating and clearing minimum equipment list restrictions (MELs), advising the SOCSM about scheduled maintenance issues required to make swap decisions, and for monitoring out of service aircraft. They serve as an interface between maintenance and the SOC, as well as a resource for line maintenance workers who meet each aircraft upon landing. Often if a mechanic meeting an aircraft spots a problem, he will call into the LMPs to have them assess the implications of the MEL while simultaneously advising the SOC of the issue.

Dispatch Group There are five dispatchers who are tasked with flight plan generation, flight plan filing and flight monitoring. Their tools primarily include the SABRE Dispatch Monitor which allows them to plan all aspects of their flights. The tool is a bit cumbersome, as they must manually select each task separately for each flight, when often they need to complete 5-7 tasks in a row. However, despite the extra work required by the interface, the dispatchers have thoroughly adapted to the extra steps. The dispatchers also use an ASD called Flight Explorer, which is linked in to the SABRE Dispatch Monitor. In addition they also use standard email tools and internet browsers. They send and receive ACARS messages via a web interface. Free text ACARS messages also print out on a dot matrix printer located in the middle of the dispatchers. The printer makes a distinctive noise alerting the dispatchers to the presence of an ACARS message, which might otherwise be overlooked.

Crew Scheduling Group The largest amount of space in the SOC is dedicated to crew scheduling. During this contextual inquiry I did not sit with any members of the crew scheduling group. During my time at the airline, there were no experiences of crew shortages, and very few instances of requiring additional crew due to irregular operations.

SOC Support Group The SOC Support Group consists of the AOG part supplier, the Flight Operations Engineer, the Dispatch Manager and the Director of Systems Operations Control. These positions do not directly interact with the moment-by-moment running of the airline, but instead provide support to the Systems Ops, Dispatch and Line Maintenance Planning Groups. All of these individuals have experience in one or more of the groups that they now support. Their location within the SOC allows for a close working relationship.

3 Information Flow Model

/labelsec:InfoFlow The purpose of a flow model is to show the flow of information between individuals and artifacts within the system, and to note any breakdowns in information flow. The flow model for the SOCSM involved both individuals and computer systems. Individuals are represented by ovals. Artifacts (tangible pieces of information) are represented by small rectangular boxes, and areas of information storage are represented by shaded boxes. The flow of information between these elements is illustrated by arrows. Breakdowns in information flow are represented by lightning bolts.

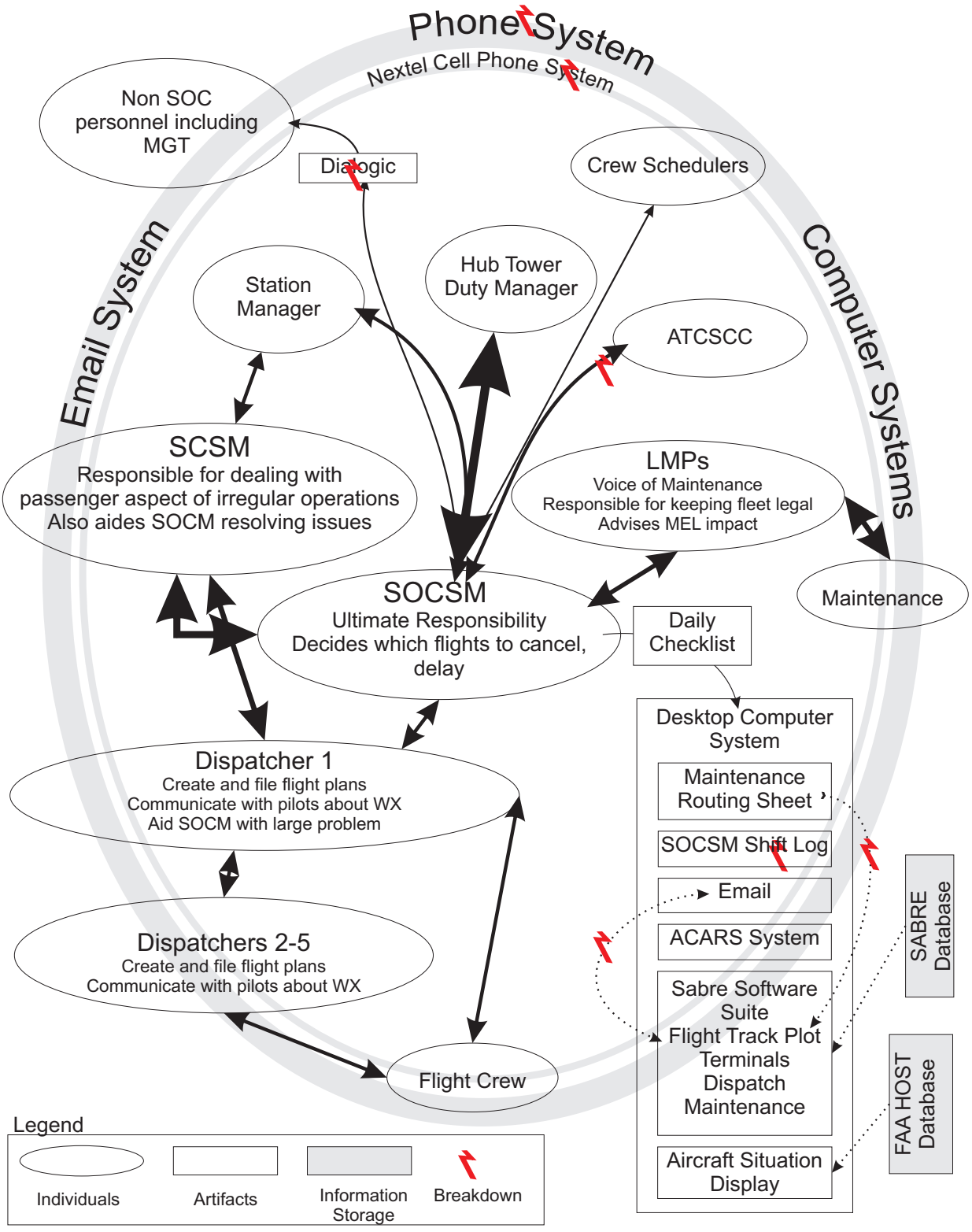


Figure 1. Information Flow Model

Figure 1 contains the information flow model for the entire SOC in general with a focus on capturing all of the individuals actively involved with "day-of" operations. At the center of the information flow is the SOCSM because the majority of information flows through the SOCSM position. The SOCSM is surrounded by the other members of the SOC, with the SCSM, LMPs, and Dispatchers featuring most prominently. As everyone was connected via the computer systems, the phone system, and the email system, these have been indicated as a gray oval surrounding the information flow model.

The SOCSM primarily corresponds with the SCSM and the LMPs. The SOCSM also corresponds heavily with the Hub Tower Duty Manager who has responsibility for gate assignment and hub operations. It is quite common for the SOCSM to discuss decisions with the Tower Duty Manager, especially if they impact hub operations. Depending on the weather, the SOCSM may also coordinate heavily with the the ATC System Command Center in Herndon, VA. Often this coordination is done via telephone as the airline may only have a single aircraft affected, rendering the slot-swapping software useless. Both the SOCSM and the SCSM communicate regularly with the Station Managers or Station personnel via the Nextel cellular phone. Unfortunately many of the calls made on these phones go unanswered as many of the station personnel assigned to carry the phones do not carry them consistently. Often the Nextel phone is used because the SOCSM or SCSM need to communicate time sensitive information to the station personnel, and when the phone is not answered by the correct personnel this creates more problems for the SOCSM and the SCSM.

At present both the SCSM and the SOCSM receive more phone calls than they place. However, when they do need to contact individuals, before placing the call they must often locate the correct phone number first either via an online source, or via one of the many phone reference lists placed strategically around their workstations . An additional drawback to the phone system is the need to enter a code before making long-distance phone calls, which greatly limits the utility of these phones in busy situations. All of these different phone systems should be consolidated into a single phone system.

The SOCSM has responsibility for communicating any previous or ongoing incidents, including any schedule changes to the rest of the airline management. The method for reporting incident is done by filing a "Dialogic," using the phone system to record an incident report. The report is created following a template and written up in a binder. The SOCSM then "files" the report by reading it into the phone system. This method of double filing creates additional work for the SOCSM and, because neither of the methods for creating or filing the reports are easily searchable, the information appears to be mostly lost, unless someone else performs a third step of transcribing the incident into a database or other searchable electronic medium. While the voice message delivery system is convenient for many of the non-SOC airline personnel, I believe that an incident report which is filed electronically could automatically trigger a voice mail alert. The method for alerting non-SOC personnel about routing changes, i.e. aircraft swaps due to ATC delays or unexpected maintenance, is to send out an email. Again, this requires many additional steps by the SOCSM. First the SOCSM must make the change to the system. Then she must ask the

Flight Trac Plot software to issue a report based on the most recent changes. Finally, she must cut and paste this report into an email which is then sent out. This again takes time, and may distract the SOCSM from subsequent tasks, such as recording the action in the SOCSM Shift Log which requires the same information to be included. As the number of aircraft swaps can be large and may change multiple times before the flight departs, I question the utility of assigning the SOCSM the responsibility of reporting after every swap, instead of enabling those individuals who need access to the flight-tail assignment data on an as-needed basis, and provide individuals needing to stay apprised in a more aggregate sense with the end of shift reports.

The incident reporting system and routing change reporting systems are not the only place where duplications of effort are required. The maintenance of the flight schedule and the entry of additional flights in the Flight Trac Plot software is very labor intensive. The entry of flights (other than the once-a month initial entry) requires the SOCSM to access several different windows and to enter flight information primarily via keyboard, while the SOCSM glances back and forth from one window to another. Additionally, the airline's current commuter airline (Horizon) sends changes to its flight schedule via email. The SOCSM must then manually make the changes based on the block of text contained within the email. Other changes to the airline's mainline flight schedule require that the SOCSMs on every shift check the next few day's schedule to make sure that both maintenance requirements and performance restrictions are upheld. This often necessitates the manual entry of maintenance checks into the Flight Trac Plot tool. While there appears to be a method for uploading information such as the scheduled maintenance checks from a appropriately formatted text file, this method has never been introduced to either the SOCSMs or the Line Maintenance Planners. This leads to the SOCSMs spending time both manually entering and then manually updating the schedule during every shift. This level of manual entry leaves a lot of room for typographical and transcription errors.

4 Artifact Models

The majority of the software tools used in the SOC belongs to the SABRE suite of flight operations tools. In addition to these tools, the SOC personnel also rely on the Microsoft Office suite for communication and record keeping and Flight Explorer's Aircraft Situation Display. The maintenance personnel use a supplemental set of tools including the AuRA maintenance planning tool and the SABRE Maintenance Control. A summary of the tools in use are listed below:

- SABRE Flight Trac Plot, "The Plot"
- SABRE Terminals
- SABRE Dispatch Monitor
- ACARS message send/receive (Web-based)

- Flight Explorer's ASD
- Shift Log (MS Word Template)
- SOC Shift Manager Checklist (MS Word Template actually printed out)
- Email (for sending routing updates to different areas of the airline)
- AuRA maintenance planning tool
- SABRE Maintenance Control
- Maintenance Routing Schedule (MS Excel)

This section will present and discuss artifact models which have been created for the software tools that the SOC personnel used most frequently.

4.1 Flight Trac PLot

The SOCSM and the SCSM get the majority of their information about the state of the airline and its schedule adherence through SABRE's Flight Trac Plot, commonly called "The Plot." A screen capture of the Plot can be seen in Figure 2. The Plot is a Gantt-chart presentation of the airline's schedule organized by aircraft tail number and time. The Plot represents each scheduled flight as a horizontal rectangle, which is arranged in a row corresponding to its assigned aircraft. The flight number, origin and destination are available in small text on the display. The flight bars are nominally colored green, but will change color to indicate problems such as over 15 minutes past scheduled departure time and still at the gate, delayed, out of service, etc. By selecting a specific flight, more information appears at the bottom of the screen in small designated boxes. Additionally, the display can be arranged to show this information underneath the flight boxes, as is the case in Figure 2. The Plot has the added feature of indicating the status of individual flights by using a yellow bar at the top of each flight box. The bar has five states (25%, 50%, 75%, 100% of the flight box) corresponding to the aircraft states of (Out, Off, In, On). The Plot has the additional feature of small circles which can be placed at the beginning of each flight block, and which are used here to represent the presence of high thrust aircraft on a high thrust routing.

The plot serves three primary purposes: 1) the realtime organization and representation of the airline schedule, 2) the efficient monitoring of the airline schedule, and 3) the alteration of the schedule when necessary. All of the features mentioned previously allow the SOCSM and SCSM to efficiently monitor the airline performance. The Plot can also be configured to display a scrolling message containing real-time DOT arrival and departure statistics for the airline. The flight schedule is easily manipulated using the Plot by utilizing a number of function buttons located at the top of the window, however direct manipulation is not supported. The Plot can be sorted and filtered by calling a dedicated function and filling in a form on a secondary window.

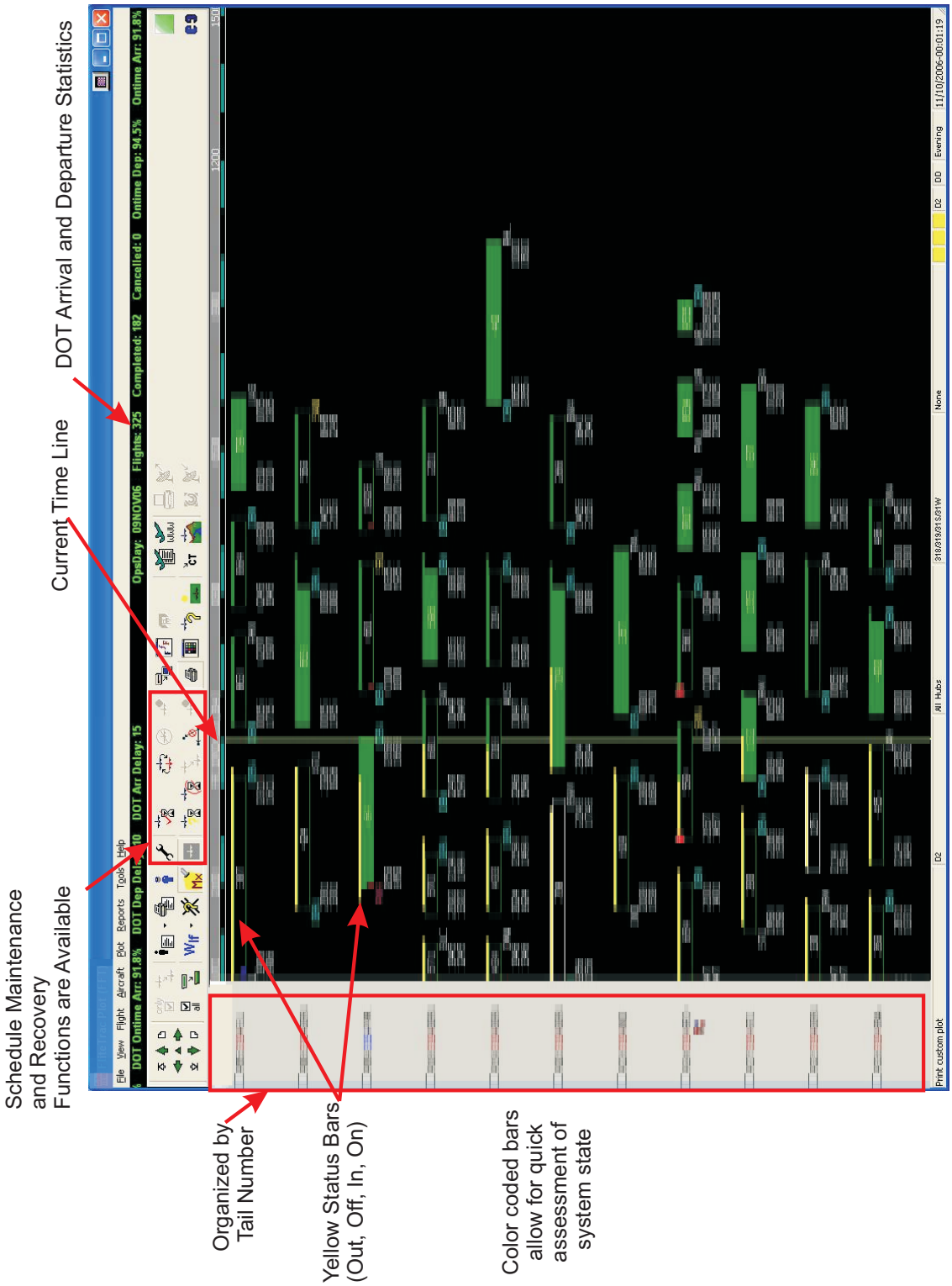


Figure 2. Flight Trac Plot Artifact Model

4.2 Dispatch Monitor

The SABRE Dispatch Monitor is the primary tool used by the dispatchers to dispatch aircraft. The artifact model for it is included in Figure 3. The tool is divided into three sections: Status, Function Buttons, and Flight Information. The Status section rows correspond to individual flight numbers and the columns correspond to specific steps in the dispatch procedure. The boxes are then color coded to indicate the completion or warnings associated with each step. The Flight Information section is similarly organized in that each row corresponds to a specific flight number (unlike the Plot in which rows correspond to tail number) and each column corresponds to some flight parameter such as: origin, destination, load, extra fuel etc. The final section contains the function buttons. Each one corresponds to a specific set of functions most of which are required to correctly dispatch the flight. The dispatcher must go through the entire set (by manually clicking on each button) for each flight. There is no way to move from one set of functions to another other than by closing out the secondary function window and then opening the next function window by clicking on the corresponding function button. This leads to a lot of repetitive and interruptive mouse use in an otherwise keyboard driven software environment.

4.3 Maintenance Control

The SABRE Maintenance Control Program is primarily used by the LMPs to plan and monitor the maintenance schedule. Figure 4 contains the artifact model for the Maintenance Control program. It is especially useful because it organizes the maintenance by tail number, and displays an icon indicating the impact (if any) of each problem, such as CAT limitations. Each row in the spreadsheet style tool corresponds to a specific maintenance issues, often with multiple maintenance issues assigned to the same tail number. The issues are normally sorted by tail number making it easy to see how much work is required for each aircraft. The columns correspond to the tail number, the aircraft location, the MEL number, a description of the issue and the number of days left until the MEL expires. Unfortunately, the estimated date that the MEL expires is often incorrect because of a discrepancy between when the software considers the MEL issued and when FAA considers an MEL issued.

4.4 SOCSM Shift Log

The shift log provides a structured way for the SOCSM and the SCSM to record the decisions made during their shift. Figure 5 contains the artifact model for the SOCSM shift log template. The SCSM shift log is different in form, but has the same functionality. Only one shift log is kept per day, with each SOCSM adding information from their own shift. As seen in Figure 5, the shift log heavily emphasizes on time arrival and departure rates by including them at the top of the log. The next section contains the operational impact

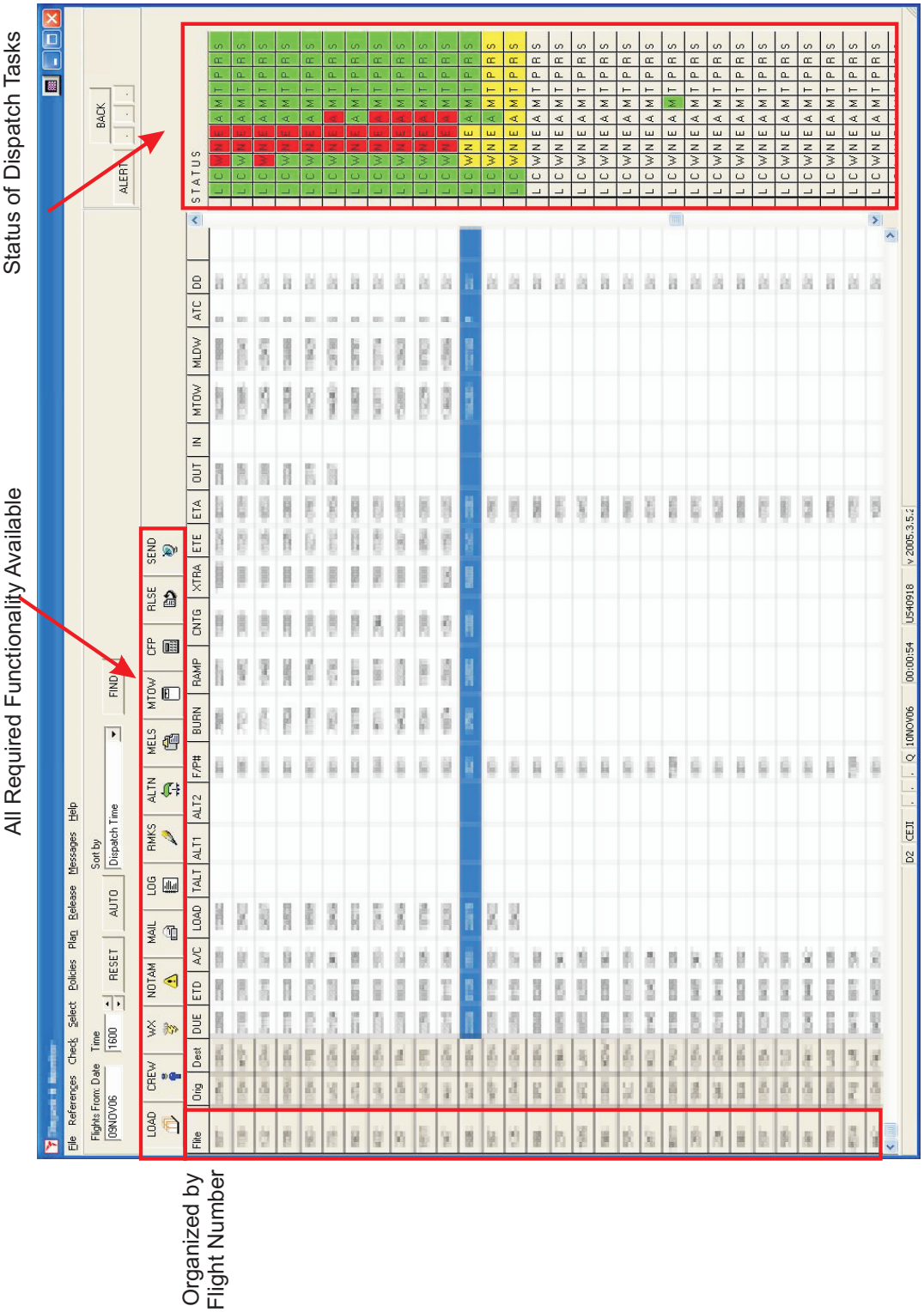


Figure 3. Dispatch Program Artifact Model

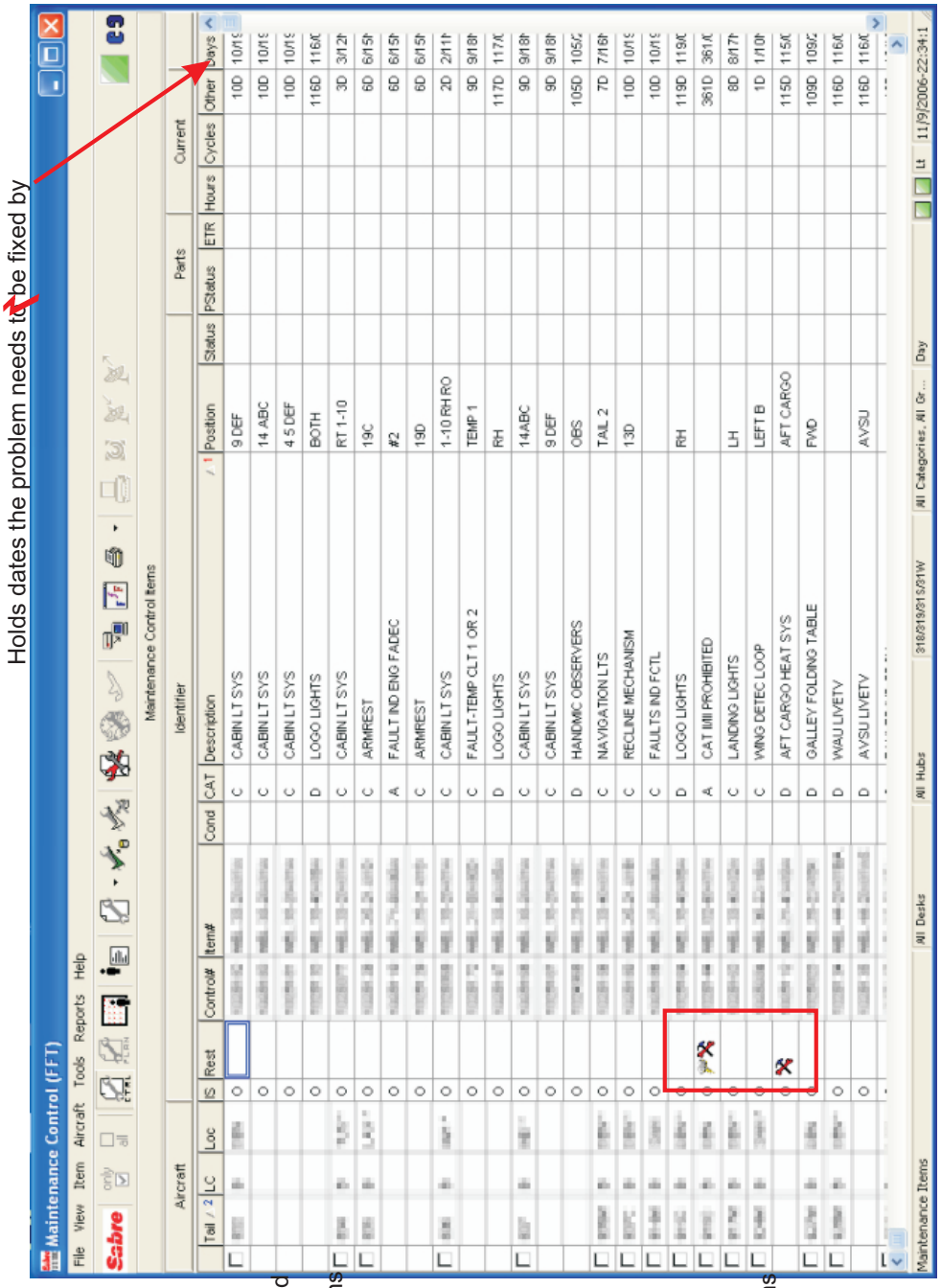


Figure 4. Maintenance Control Program Artifact Model

issues with designated spots to list all cancelations and diversions, weather or ATC delays which impact operations, and a hub overview. There are also designated places for each of the three SOC shifts to summarize their own shift. The next sections include headings for mechanical, safety, security and subsidiary issues. The headings provide both structure to the report and a reminder to the SOCs of the type of issues that are important to log in some way. The shift log serves the SOCSM well; however, because of its present format, a MS Word Document, the data contained within it is not easily analyzable. For example if the data were to be placed in a database, then it would be much easier to locate and retrieve data to create longitudinal reports to look for patterns such as the impact of maintenance ready time slips over the course of a week or a month.

4.5 SOCSM Daily Check List

The daily check list provides a reminder for the SOCSM of what daily tasks have and have not been completed. As most of these tasks are done everyday and are often interrupted, this external memory store is very valuable. On the left hand side, the checklist is divided into three distinct sections each corresponding to a specific shift. The right hand side also has three distinct lists corresponding to high impact events such as flight cancelations or diversions. The check list also includes the phone numbers for the ATCSCC, the hub tower and the SOC Director which would be needed to complete the checklist associated with a high-impact event such as the ones listed above. The specific steps in the check list also illustrate some breakdowns in terms of effort duplication and the use of the Dialogic for incident reporting system.

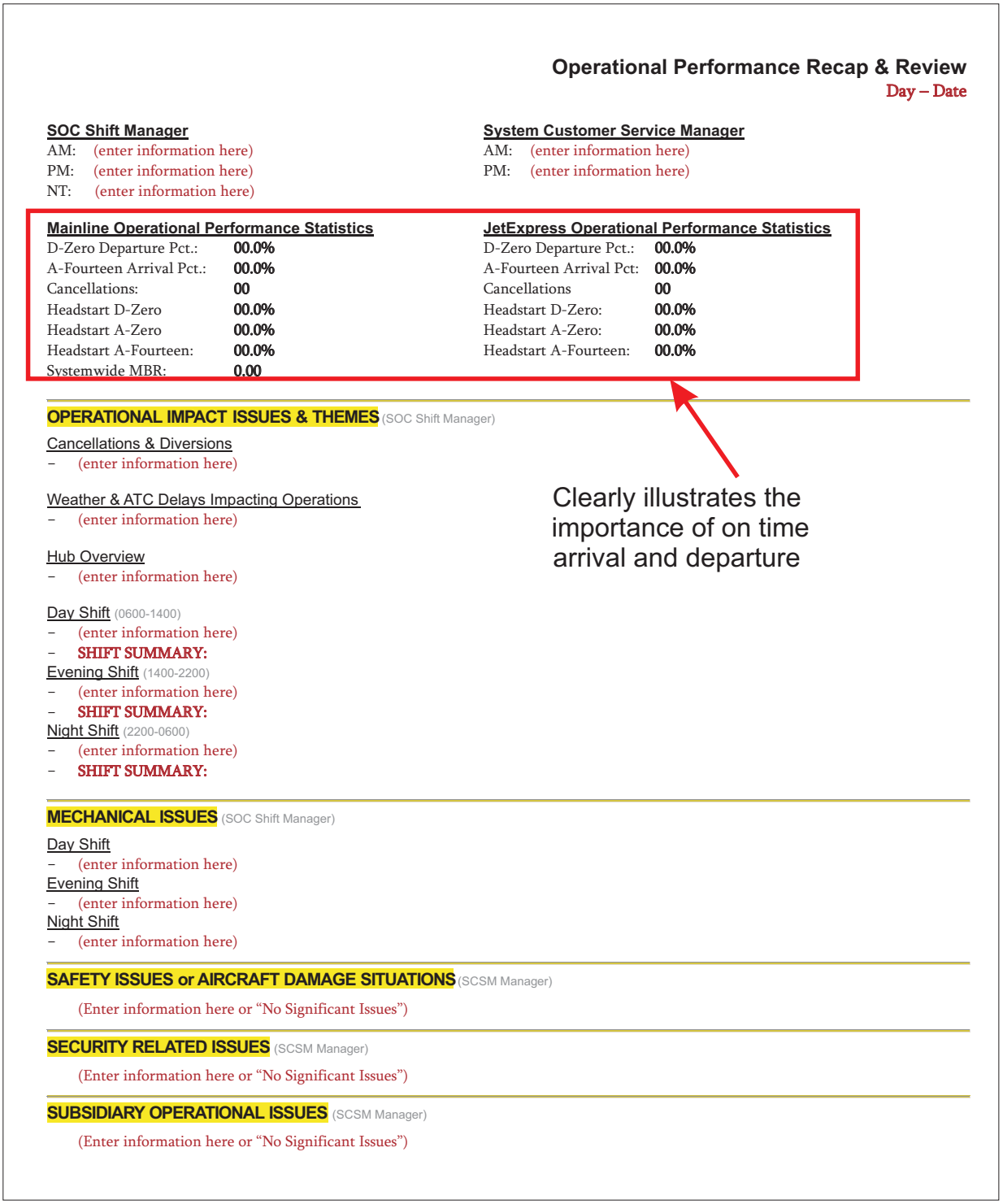
5 Cultural Model

The purpose of a cultural model is to understand the cultural forces which impact both the work environment and the work itself. In a cultural model, the main influencers on a position are represented, be they people, policies, values, preferences, or points of pride. In addition, the specific topic of influence and direction of that influence are shown.

The culture at the airline's SOC is one of optimism and casualness. Most of the SOC personnel have approximately 3-7 years experience with the airline, and with notable exceptions, few have more than 15 years total in the aviation industry. The individuals are fairly open to automation and new more powerful computational tools – if they make life easier and require few button clicks/key strokes. However, recent upgrades in a few key software tools have created more work to perform routine tasks and consequently, generated some pessimism about future upgrades. There is, likewise, a lack of confidence with the IT staff. Thus there is a perceived increased risk to take on new technology for fear their IT support will not be up for the challenge. The relationship between the different functional groups within the SOC was very relaxed and professional. Everyone understands

Provides a structured log to capture the day's events

Also illustrates how central the SOCM's role is in coordinating the airline,



Operational Performance Recap & Review

Day – Date

SOC Shift Manager
AM: (enter information here)
PM: (enter information here)
NT: (enter information here)

System Customer Service Manager
AM: (enter information here)
PM: (enter information here)

Mainline Operational Performance Statistics

D-Zero Departure Pct.:	00.0%
A-Fourteen Arrival Pct.:	00.0%
Cancellations:	00
Headstart D-Zero	00.0%
Headstart A-Zero	00.0%
Headstart A-Fourteen:	00.0%
Systemwide MBR:	0.00

JetExpress Operational Performance Statistics

D-Zero Departure Pct.:	00.0%
A-Fourteen Arrival Pct:	00.0%
Cancellations	00
Headstart D-Zero:	00.0%
Headstart A-Zero:	00.0%
Headstart A-Fourteen:	00.0%

Clearly illustrates the importance of on time arrival and departure

OPERATIONAL IMPACT ISSUES & THEMES (SOC Shift Manager)

Cancellations & Diversions
- (enter information here)

Weather & ATC Delays Impacting Operations
- (enter information here)

Hub Overview
- (enter information here)

Day Shift (0600-1400)
- (enter information here)
- **SHIFT SUMMARY:**

Evening Shift (1400-2200)
- (enter information here)
- **SHIFT SUMMARY:**

Night Shift (2200-0600)
- (enter information here)
- **SHIFT SUMMARY:**

MECHANICAL ISSUES (SOC Shift Manager)

Day Shift
- (enter information here)

Evening Shift
- (enter information here)

Night Shift
- (enter information here)

SAFETY ISSUES or AIRCRAFT DAMAGE SITUATIONS (SCSM Manager)

(Enter information here or "No Significant Issues")

SECURITY RELATED ISSUES (SCSM Manager)

(Enter information here or "No Significant Issues")

SUBSIDIARY OPERATIONAL ISSUES (SCSM Manager)

(Enter information here or "No Significant Issues")

Figure 5. Shift Log Artifact Model

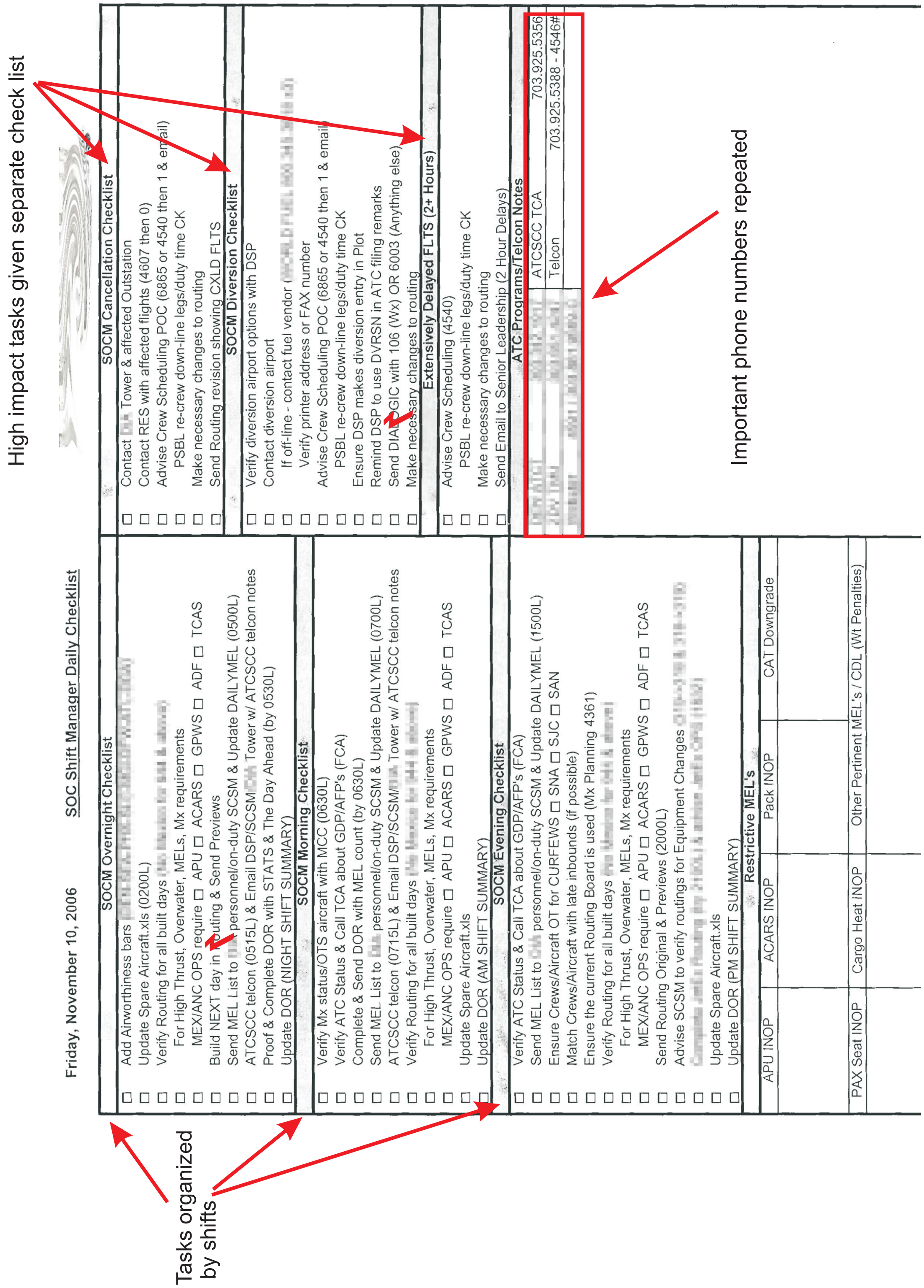


Figure 6. SOCSM Check List Artifact Model

their job, and appeared willing to help out with unusual circumstances regardless of their job description. At one point during the inquiry dispatchers were required to work overtime because of an uncovered shift; despite the limited notice, there was no grumbling.

The SOCSM is required to hold a dispatchers certificate and as a result of the many years often spent as a dispatcher and because of the job requirements, the SOCSMs often view themselves as the one of the dispatchers. The SCSM, on the other hand, has no requirement or experience as a dispatcher, and is the only member of the bridge area without such qualification. While I witnessed no awkwardness arising from this during the interview, much more emphasis might need to be given to training the SCSM position because most of the SCSM's colleagues will have received federally sanctioned training before assuming their positions.

The culture within the entire airline, and especially within the SOC, is that of schedule adherence. This manifests itself in every decision made. The level of tolerance for delayed departures are much smaller than other airlines. Often the SOCSM will go to great lengths, and probably cause much work for the station personnel, to swap aircraft so that a flight that looked like it might go 15 minutes late will go on time. One result of this intense focus on on-time performance is that all delays are charged against some code. Often the reason for the delay does not fall neatly into a single delay code (such as maintenance) and consequently the LMPs often feel that one of their primary responsibilities is to refute any delays charged against maintenance which were not strictly maintenance related.

Similarly, there is a passenger centric focus at the airline. One example of this is the level of attention paid to individual passenger itineraries and gate-side announcements. Specifically, when passengers are not going to make their connections, the SCSM makes every effort to inform the outbound gate agents to alert the passengers to the high possibility of not reaching their destinations and giving them the option to fly or not. Additionally, the gate agents go to great length to keep passengers informed of the status of their arriving flight.

6 Sequence Models

The purpose of the sequence model is to examine procedures used by individuals to complete their work and to examine the motivations behind the actions taken, similar to many forms of task analysis. As the work of the SOC Managers is more goal-driven than procedure-driven, sequence models provide only a snapshot of the more overall work structure of the SOC personnel. However, sequence models can illustrate frustrations that individuals may have with duplication of effort and can provide representative examples of the types of problems encountered on a daily basis. This section will present three sequence models, two of which will represent typical issues that are likely to be encountered multiple times a week and one of which is an unprecedented issue that may never be repeated.

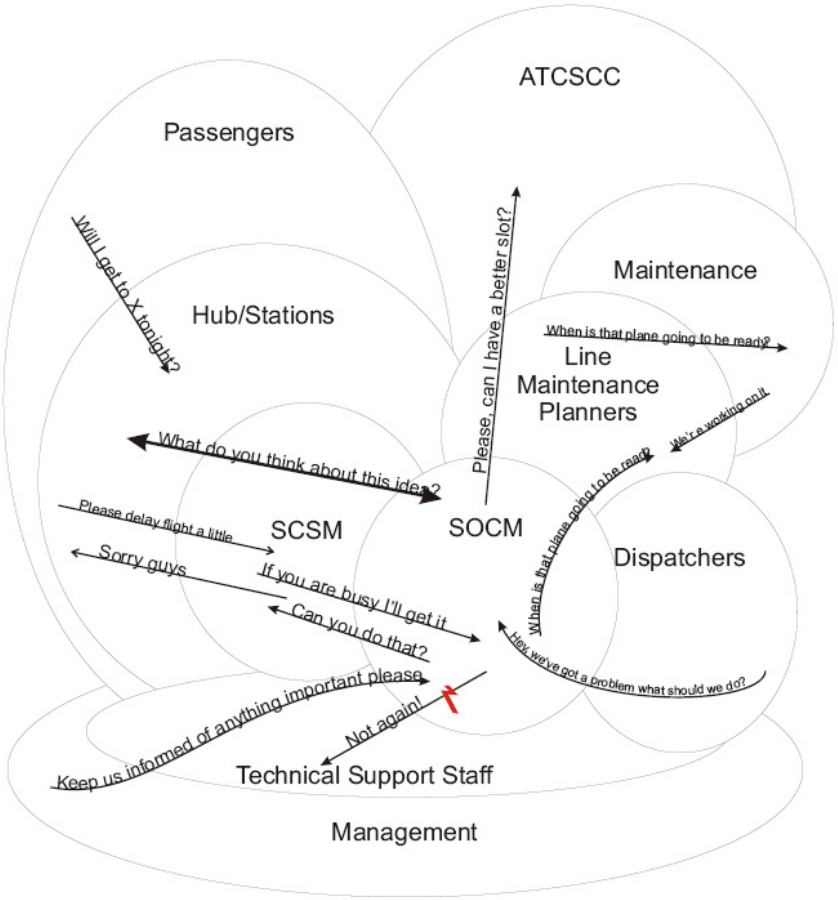


Figure 7. Cultural Model

Salt Lake Request to Push Early	SOCSM
	Trigger: Call comes in on Nextel cell phone from Salt Lake City Station with request to push early
Intent: Push plane early since everyone is already boarded and pilot is ready to leave	
Intent: To determine if gates will be available taking into account the early push and prevailing winds	SOCSM calls Hub Tower Duty Manager on land line phone
Intent: Find out estimated flight time today for SLC-DEN	Checked Sabre Flight Track Plot for estimated flight time and reported it to Hub Tower Duty Manager
	Hub Tower Duty Manager informs SOCSM that there will be no gate available for the SLC flight before ETA
Intent: To let pilot of SLC flight know that he can push early if he wishes, but no gate will be available earlier than his scheduled ETA	SOCSM relays gate availability information to SLC Station via Nextel cell phone

Figure 8. Sequence Model: Early Push Request

The first sequence model, shown in Figure 8, shows the steps taken by the SOCSM when a request comes in to push a flight early. In this case the request comes in every day – this flight rarely requires the full turn time it is given. Unfortunately, the request is only occasionally granted because bringing it in early causes problems at the arrival airport due to lack of available gates. The model also illustrates the close coordination of the SOCSM and the Tower Duty Manager. Unfortunately while the frequent occupance of the early push request is well known in the SOC, there appears to be no mechanism to relay the information to the schedule planners.

The second sequence model, shown in Figure 9, shows the steps taken when an unscheduled maintenance event occurs. Again notice the close coordination of the SOCSM and the Tower Duty Manager. This sequence also highlights the extra work involved with actively keeping non-SOC personnel apprized of a fairly routine situation. The times for each step are given in parentheses to give an idea of how long the whole process took. These times include any outside disruptions that the SOCSM allowed to disrupt him.

The third sequence model, shown in Figure 10, shows the steps taken by the SOC personnel when the gate print server went off-line during a departure push. Without the ability to print out the final paperwork, several of the aircraft could not legally depart. As

the issue was systemic and affected all of the gates, the SOCSM, SCSM and the dispatcher seated closest to the SCSM all worked on the problem simultaneously. It was quickly clear that there was not much that the SOC could do directly, so when the SOCSM received a call from a dispatcher scheduled for later in the day stating that he was ill and unable to come in, the SOCSM began to work that problem instead. This left the SCSM in charge of the printer outage issue. The problem was exacerbated because it was difficult for the SCSM to reach the gate agents by phone, as they were using their phones to communicate with others at the airport. In the end through a variety of means all of the aircraft departed within thirty minutes of their scheduled departure time. It turned out that the printer server had gone off-line because it was on a circuit that had been inadvertently overloaded by a passenger plugging an appliance into an electrical outlet in the main terminal waiting area.

7 Physical Models

The purpose of the physical model is to depict the physical environment, in which the work takes place and to detect any physical barriers to productive work. Figure 13 is the physical model of the airline's SOC. The SOC is essentially divided into three main areas. The first area, located at the bottom of the physical model, is the SOC "bridge" area which holds the Dispatch, Systems Ops, and Line Maintenance Planning Groups. The other two areas hold the Crew Planning Group in the upper left and the SOC Support Group along the far right. The physical model focuses on the bridge area and does not depict the physical location of the SOC Director, whose office would occupy the upper righthand corner of the model. The bridge area is separated from the remainder of the SOC by a series of filling cabinets and a large bank of wide-screen televisions. This bank isolates the bridge area from the rest of the SOC. At present the televisions are not operational and are due to be removed. The SOCSM can see and over hear the SCSM, the Dispatcher in the seat adjacent to the SCSM and the two Line Maintenance Planners seated in the two left-most desks. The close proximity to these positions allows the SOCSM to maintain a high level of situational awareness passively. Dispatchers seated in other positions usually phone in problems, walk over, stand up or push their chairs back to grab the SOCSM's attention, and the SOCSM performs corresponding actions when she wishes to grab the attention of one of the dispatchers.

The majority of the work stations are similar in nature. As the workstations are manned 24 hours a day by two or three shifts of people, most of the customization of the workstations is limited to the software settings, monitor angle, fan angle and on-screen placement of various software tools. However, in order to understand the basic layout of a workstation and how this layout affects the work undertaken, Figures 11 and 12 depict the SOCSM and SCSM workstations, and are fairly representative of the workstations found in the Systems Ops and Dispatch Group. The standard workstation consists of a two-tier desk where the computer and dual flat-panel monitors reside on the back portion of the desk, and the keyboard, mouse, phone and reference papers reside on the front portion of the desk. Both

Unscheduled Maintenance	SOCSM
Trigger:	Maintenance called LMP advised Flight 497 has a fault and the mechanic meeting the flight needs an hour
Intent: Going to need new AC for Flight 497 or it will push late	(0959) LMP relays information verbally to the SOCSM
Intent: To gather information about that flight	(0959) SOCSM located flight on the Flight Track Plot (FTP)
Intent: To advise of issue with AC 329 and to consult about best possible solution	(1001) SOCSM called Tower Duty Manager to advise of advise time on AC 329 -Gave suggestions to solve problem -Used FTP to search for other available AC -Checked gate location to choose between options -Decided to swap with AC 306
	(1005-1007) Received calls and worked on other issues
Intent: To keep Flight 497 on time -To let the dispatchers know that there has been an equipment change -To make sure that the AC swap will not interfere with scheduled maintenance	(1008) Swapped AC 329 and AC 306 -Advised dispatchers of change -Checked maintenance planning sheet for conflicts
Intent: Changes do not affect tonight's maintenance schedule, but will impact tomorrow's unless the an MEL can be worked on tonight	(1013) Called maintenance planning -Asked for early work on MEL tonight -Asked also for an amendment to other maintenance plan
Intent: To keep personnel outside the SOC informed about equipment change	(1016) Wrote email to routing list by cutting and pasting changes from the FTP
Intent: To understand the solution so he can check it for maintenance implications	(1020) LMP asked for clarification about changes SOCSM explained solution
	(1024) SOCM updated shift log

Figure 9. Sequence Model: Unscheduled Maintenance

Gate Printer Outage	SOCM
Trigger:	(1041) SCSM received call from Hub, all of the gate printers at the hub not working, neither are the printers working in the supervisor's offices.
Intent: To let the SOC know of problem and to enlist help	(1042) SCSM informs SOCSM (and rest of SOC as he is speaking out loud) of situation: gate printers down due to a networking problem, IT has been informed and is working on it
Intent: To let SOCSM and rest of SOC know of major problem during 1030 push – likely impact to operations is high	(1043) Dispatch1 suggests that hardline fax be tried
	(1042) SOCSM scans the Sabre Flight Track Plot to determine extent of problem
Intent: To inform that 5-7 flights were being affected and to be prepared for late push	(1044) SOCSM calls Hub Tower Duty Manager
Intent: To inform SOCSM that he could not work today and a replacement would need to be found	(1045) SOCSM received call from sick dispatcher
Intent: To find dispatcher to fill vacancy for later shift, and to leave the network problem to SCSM and dispatchers	(1046) Looked up the SOC Director's phone number, called and received no response; got up and grabbed the duty roster binder and began task of finding a replacement dispatcher, a task that would last until 1206
Intent: To advise out stations of delay.	(1057) SCSM and Dispatch began delaying flights in Sabre Flight Track Plot system
Intent: To get AC pushed as fast as possible	(1058) Dispatch1 suggests using ACARs system to send information direct to the flight deck
Intent: To tell gate agent of ACARS plan	(1103) Attempt to call gate agent; gate line busy, called adjoining gate; called gate again
	(1107) ACARS taking a long time to send; unrecoverable error – yet it success fully transmitted
Intent: To better understand situation and to brief his pilots a bout reason for the delay	(1108) Chief pilot walked in to SOC looking for information after getting call from pilots; SOCSM briefed about printer issue
Intent: To advise Concourse Supervisor of future backup plan.	(1111) Everyone else pushed on their own; SCSM devised a procedure using ACARS and called Concourse Supervisor to advise.

Figure 10. Sequence Model: Gate Printer Outage

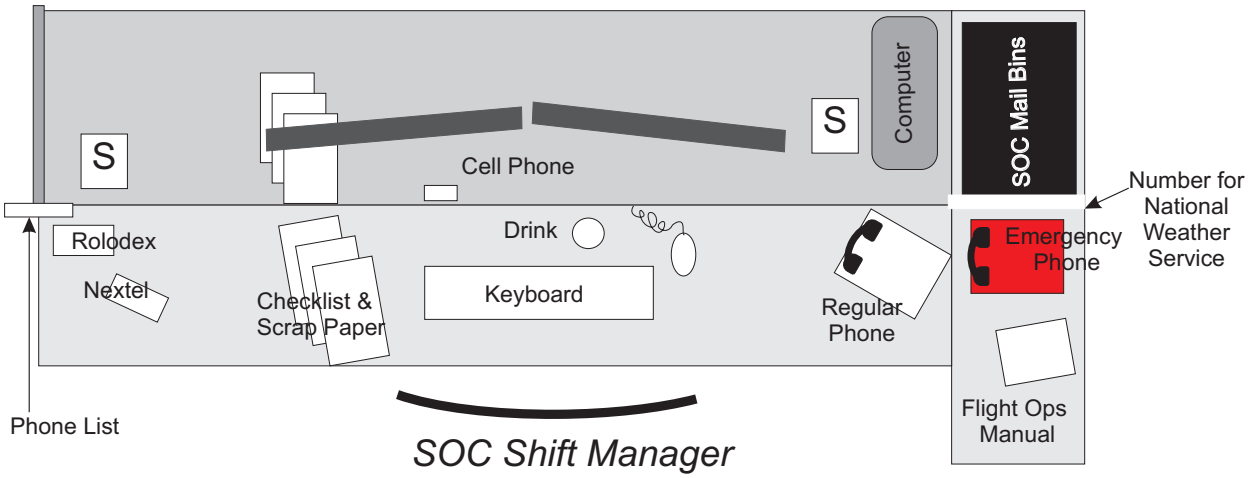


Figure 11. SOCSM Workstation Physical Model

monitors are connected to a single computer so that only one mouse and keyboard are required. In addition to the computer hardware located on the work station, there are standard office tools such as staplers, tape dispensers, pens and pencils in a cup, and a phone.

The phone system consists of a standard multi-line phone. The SCSMs have an additional wired headset for their phone which they purchased because of the large amount of time they spend on the phone while accessing information on the computer via the keyboard. Because the phone system does not support one-button calling for a majority of the numbers being dialed, the desks have phone lists and a rolodex placed for easy reference. The SOCSM desk has an additional phone for use in emergency situations. It is differentiated from the standard phones by red tape on several of its surfaces. In addition to the computer and phones, the SOCSM's workstation also has two cellular phones, one Nextel phone in walkie-talkie mode with most of the outer stations phone numbers preprogrammed, and a regular cellular phone which is rarely used. It seems that an integrated headset-base unit could be found so that duplicate stands would not be required.

In addition to the phone and computer systems, the SOCSM has a daily check list which is included in Figure 6. He keeps this along with other pieces of scrap paper on his desk for easy reference and to serve as a reminder of which standard tasks he has completed and which remain to be done. The SCSM's desk includes the addition of a desk lamp and a set of reference binders.

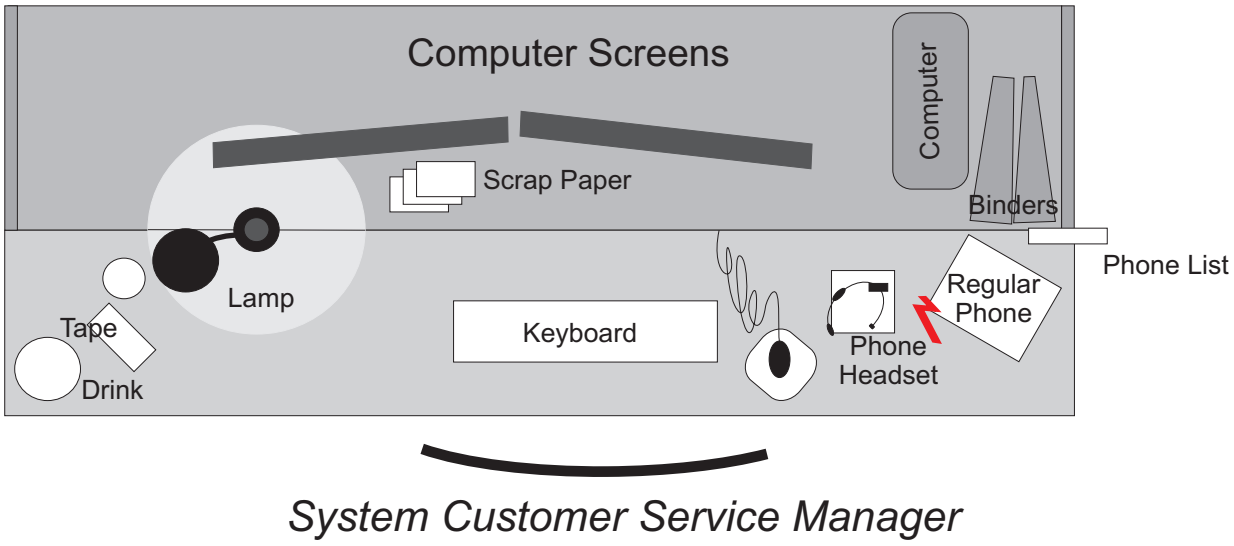


Figure 12. SCSM Workstation Physical Model

8 Design Implications

Unlike many other airlines, this one did not have problems with lack of reserve crews and only occasionally had problems due to lack of available aircraft. The majority of problems with aircraft availability stemmed from a lack of over-water type rating or the proper paperwork to service Mexican destinations. These issues were somewhat eased during the inquiry with the arrival of the certification of all new aircraft from the Mexican government. Additionally, as the airline was using a consistent suite of software tools for much of its operation, there were very few issues with data discrepancies.

This inquiry has two major findings which are interlinked. First the SOCSM's work results in much duplication of effort, some of it caused by poorly designed procedures and some of it caused by the second finding, software tool limitations. It appears that some of the duplication could be remedied by either taking better advantage of the software that currently exists or by investing in some minor software improvements.

Often the software was not being used to its full advantage – increasing the manual data entry as each item of information needs to be entered by hand using a large number of different windows and text fields. It appears that large changes to the schedule and the incorporation of the required maintenance segments could be more efficiently entered using an import wizard and properly formatted text files. The use of text files is fairly convenient since most of the schedule information is transferred via email or Excel spreadsheets. A more automated system for including maintenance segments and updating changes to maintenance segments would significantly reduce the time spent doing these tasks manu-

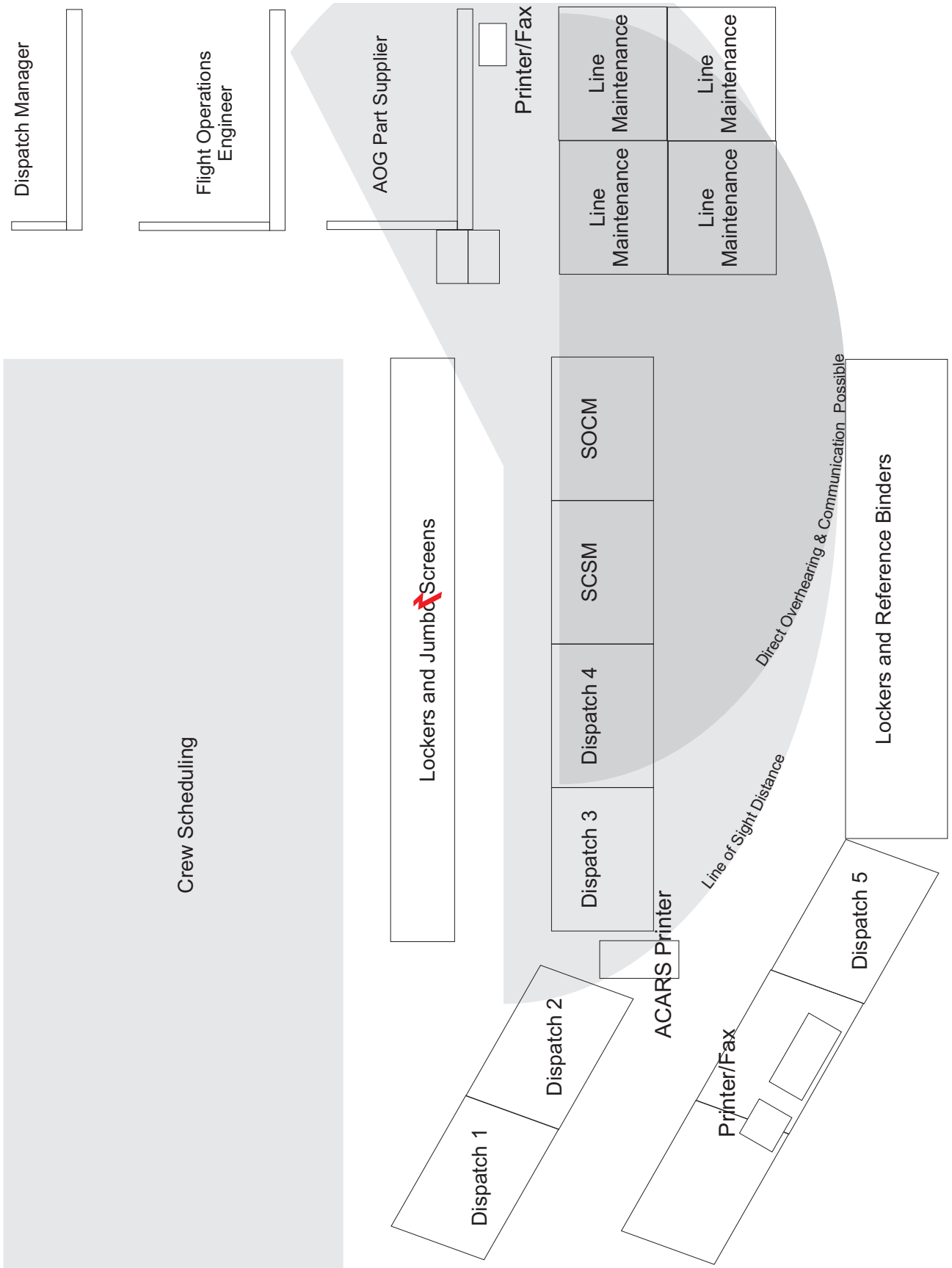


Figure 13. Physical Model of SOC

ally, in addition to reducing the likely errors associated with the manual entry and checking. A similar system should also be employed to allow the schedule updates received from the airline's regional subsidiary to be easily integrated into the Plot.

The manual entry and upkeep of the maintenance segment data are just two examples of a duplication of effort. Currently the maintenance personnel create a nightly maintenance schedule and send it over to the SOCSM in the form of an Excel spreadsheet. The SOCSM then takes this spreadsheet and manually checks the current maintenance entered in the Plot, making any changes as he finds them. Then he adds in the additional data that has been included in the new maintenance schedule. So the schedule is essentially created twice, once by the maintenance personnel and once by the SOCSM. While better utilization of the software tools may reduce the effort expended in this case, procedural changes may also help. Perhaps the maintenance personnel could be given the access necessary to build the original maintenance segments and then only the amendments to the current night's operations would need to be amended by the SOCSM. Other examples of effort duplication include the Dialogic Incident Reports, the reporting of any routing changes via email and the reporting of any routing changes in the Shift Log.

The Dialogic Incident Reports should be replaced by an electronic incident report built on a database to facilitate easier data analysis. The system should be designed such that any individual wishing to receive an alert to a new report could request one be sent via email or phone. Additionally, the reporting of routing change requirements need, to be better understood and automation implemented to facilitate the reporting. To begin, the actual information needs of these recipients should be reviewed to determine how frequently the routing change information is required and whether or not a more scheduled reporting of all routing changes during a given time period might be adequate. Depending on the outcome, it might be possible to consolidate the information and only report it once or twice a shift. Further, the SOCSM should not need to copy and paste the routing changes into an email then actively send them out; this information should be automatically collected and distributed at the touch of a single button. Similarly, much of the data for the shift log should be automatically generated at the end of every shift directly from the Plot. The shift log should also be transitioned to a database format for more efficient storage and analysis.

9 Summary

In summary then the airline's SOC works well during periods of low disruption and is very focused on maintaining the published schedule. However, some of the more major operational challenges that I witnessed, such as the printer disruption, required almost all of the time and attention of SOCSM and SCSM. After a while the SOCSM gave control of the problem to the SCSM and began to attend to another fairly significant problem that had arisen. The multiple issues left little time for the required email reporting to be accomplished in a timely manner. As the airline continues to grow, the SOC must become more efficient by shedding some of the data entry tasks and more effectively using software tools.

GEORGIA TECH COGNITIVE ENGINEERING CENTER