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NextGen Air Traffic Control and Technical Operations Alarms and Alerts Evaluation

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16. Abstract

The main objective of this project is to present the effective ways of presenting air traffic control alarms and alerts for future NextGen systems. Because there has been no comprehensive survey on NextGen air traffic control system alarms and alert, we first made a catalog of midterm NextGen controller alarms, alerts, indicators, and notifications (AAINs) based on the input from NextGen program office personnel, NextGen system engineers, and air traffic controllers, and NextGen documents. We also created the air traffic control taxonomy because there was no previous taxonomy of air traffic control AAINs. Based on the taxonomy, we then refined the AAINs in the catalog with subject matter experts. For instance, we finalized the categorization of the AAINs based on the critical features of alarms and alerts such as urgency, time to respond, and consequences if not responded. To validate the presentation methods of the selected few NextGen systems, we ran a Cognitive Walkthrough with controllers from Air Route Traffic Control Center (ARTCC), Terminal Radar Approach Control (TRACON), and Airport Traffic Control Tower (ATCT). We collected their opinions on alarms and alerts. Based on the results and human factors principles, we present effective alarm and alerts presentation methods for the future NextGen systems. In addition, we surveyed the current alarms and alerts of the En Route Automation Modernization (ERAM) that Technical Operations specialists monitor and control. For the Technical Operations domain, we recommend to devise a more effective way of monitoring and controlling alarms of ERAM at the Service Operations Center (SOC).

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We are also indebted to the supervisory controllers who volunteered for the Cognitive Walkthrough evaluation. We express our great appreciation to them. We could not have run the evaluation without their participation.

Executive Summary

The purpose of the project was to recommend NextGen alarm and alert presentation methods of safety critical messages to air traffic controllers at all air traffic control facilities (i.e., Air Route Traffic Control Center [ARTCC], Terminal Radar Approach Control [TRACON], and Air Traffic Control Tower [ATCT]).

We surveyed and created a catalog of NextGen controller alarms, alerts, indicators, and notifications (AAINs). At the same time, we created air traffic control alarms and alerts taxonomy. We then defined air traffic control alarms and alerts based on the industry standard definitions of alarms and alerts, such as ANSI/ISA-18.2-2009 (Management of Alarm Systems for the Process Industries, 2009), with the help of controller subject matter experts. We also reviewed the NextGen alarms and alerts with supervisory controllers at ARTCC, TRACON, and ATCT using Cognitive Walkthrough.

In the Cognitive Walkthrough, six supervisory controllers (two each from ATCT, TRACON, and ARTCC), evaluated the presentation methods of NextGen controller alarms and alerts proposed by the NextGen system program offices. The controllers observed a normal image first with text descriptions in the first session. They then observed an alarm or alert image without text description, which was followed with the same alarm or alert image with text descriptions about the alarm or alert. Some of the alerts and alarms had aural annunciations.

As the participants observed the images, they thought aloud. We recorded their speech and analyzed their opinions and suggestions for the NextGen alarms and alerts. We believe that our recommendations would help to improve NextGen AAIN designs.

We recommend that:

1. Air traffic control alarms and alerts must be defined clearly as either alarms or alerts.
2. The NextGen system must use a consistent coding scheme such as colors. For instance, red be used for alarms only, not for alerts.
3. When aural annunciations are used for alarms or alerts, they should be distinct from each other.
4. The salient features of alarms and alerts need to correspond to the degree of the safety severity to the controllers.
5. Alarms and alerts should not hinder other elements on the display, which will interfere with controllers performing other tasks.

In addition to the NextGen air traffic control alarms and alerts, we also surveyed alarm and alert presentations in the En Route Automation Modernization (ERAM) that technical operations specialists monitor and control. We recommend integrating the ERAM with other systems at the Service Operation Center and creating a display where they can monitor all the systems on one monitor display. We also recommend reducing the number of nuisance alarms and alerts.

For the future study of NextGen alarms and alerts, we propose collecting more controllers' opinions on NextGen alarms and alerts using Cognitive Walkthrough that we used for this project. For this report, only two controllers participated from each facility, or a total of six participants. Their inputs

were invaluable to this report. With more controllers' inputs, we will have more diverse and thorough opinions on the future NextGen alarm and alert design. We propose to run a high-fidelity experiment and test out various presentation methods of alarms and alerts using quantitative measures such as response time and error rates while performing air traffic control tasks.

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1. INTRODUCTION

The focus of this research was to examine safety critical messages to controllers in the Midterm NextGen systems (FAA, 2017), discuss their designs, and propose high-level design guidelines of them for the future NextGen systems. Controllers think ahead and work proactively to avoid a situation where automation systems would issue safety critical messages to them such as alarms and alerts (FAA, 2015 a). However, in some situations, for example, when they are engaged in a difficult task and cannot foresee various events ahead, those messages will be issued. Controllers will perceive the messages, examine the situation, prioritize their tasks, and solve the problems expressed in the messages. Thus, the manner in which the messages are presented to controllers is paramount and must be clear to controllers without causing them any confusion.

For this project, we first tried to learn about the current air traffic control safety critical messages focusing on alarms and alerts. We surveyed them, and we found out that in the air traffic control domain, safety-critical messages were not categorized well. To learn the categorization of safety critical messages in other domains, we surveyed military, flight deck, and other industries. Because air traffic control is a unique domain, we decided to create our own method of categorizing the safety critical messages into alarms, alerts, indicators, and notifications (AAINs), which we described in detail in the following sections. To consider the controllers' opinions on the presentation methods of alarms and alerts, which are more safety critical than indicators and notifications, we ran a Cognitive Walkthrough evaluation using major NextGen systems. In this report, we present an effective AAIN design for the future NextGen systems based on the controllers' opinions, past research reports, and industry practices, including alarm and alert standards (International Society of Automation, 2009; Engineering Equipment and Materials Users Association, 2013). In addition, we present recommendations to improve the display design of En Route Automation Modernization (ERAM) alarms and alerts that technical operations analysts monitor and control.

1.1 Objectives

The purpose of this research was to recommend effective display methods of safety critical messages in air traffic control and alarms and alerts of ERAM system at service operations center (SOC) of technical operations.

1.2 Background

In the air traffic control domain, engineers and researchers did not define, prioritize, and categorize safety-related display messages. Because of this, controllers might have experienced confusion in deciding what actions to take and what priorities to give after perceiving the messages. Outside of the air traffic control domain, they are well defined and are prioritized based on the safety severity, such as military (Department of Defense, 1997) and flight deck (FAA, 2011; FAA, 2010).

In the flight deck domain (FAA, 1997), critical safety messages are more clearly differentiated. For example, they were categorized in the order of safety priority: first is safety warning, second is caution, and third is advisory message. Safety warning should be present until "causative condition has been corrected." Caution messages are above "advisory messages and routine display information" in significance and should be present until either the operator corrected the situation or store it for later recall. Advisory is the least significant. These three types of messages are to be prioritized based on urgency and are coded by different colors (i.e., red for warnings, yellow for caution, and a third color [green preferred with blue and white as no-flight deck options] for advisory. It also required the duration warning and caution messages to be at least 3 seconds long. It also mentioned display luminance, contrast, and character dimensions quoting MIL-STD-1472. From the same MIL-STD-1472, they also quoted the non-verbal audio warning signals to have fundamental frequency from 700 to 1,700 Hz in 0.85 seconds with interruption interval to be 0.12 seconds. They listed and defined other audio signals such as bailout signal, wheels-up signal, angle-of-attack/airspeed/stall warnings. However, they did not present the rationale or research findings to support these specific presentation requirements.

In the flight-deck domain, alerts were well defined and categorized, giving pilots immediate awareness of the alert situations (FAA, 1981). They used four categories—Warning, Caution Alerts, Advisory Alerts, and Information—in hierarchical steps based on the priority of urgency and safety. The FAA later dropped the Information category and kept the remaining three (FAA, 2009: FAA, 2011). They did not use the term "alarm" except when mentioning "false alarm."

Thus, both military and flight-deck guidelines used alerts to represent safety critical messages and created different categories of alerts such as warning, cautions, and advisories in the order of priority. They did not name any category as alarm.

We noticed that in the FAA manuals for controllers (FAA, 2015a), for instance, not many alarms were mentioned. We found 263 alerts and 15 alarms by using the term search. Many alerts could have been categorized as alarms such as Minimum Safety Altitude Warning (MSAW) if they were categorized based on safety criticality. Incidentally, all the alarms had audio warnings.

In the human factors research area in aviation, there have been a few research reports on alarms and alerts (Newman & Allendoerfer, 2000; Ahlstrom & Panjwani, 2003; Allendoerfer, Friedman-Berg, & Pai, 2007; Pritchett, 2009; Stanton, 1994). However, alarms and alerts were not defined and categorized distinctly and were used interchangeably. For example, Obermayer & Nugent (2016) mentioned:

> "the terms 'alert', 'warning', and 'alarm' are often used interchangeably for systems that involve attention-getting and presentation of information about significant, abnormal, or threatening situations. While sharp distinctions can be drawn between these terms, we have chosen to operationally define all three as: Any system- or human-generated message that needs to be brought to the attention of the operator in conjunction with ongoing, pending, or future tasks."

However, they suggested differentiating them from Level 1 to Level 5 by using a stepwise decision tree of needs such as "Immediately devote full attention? Quick response? Emergency response? Make aware but allow continuance of work? No intrusion needed." Pritchett's (2009) review on alerts on flight deck also did not formally differentiate alarms and alerts.

Even though alarms and alerts were not clearly defined, a few researchers presented proposals to improve the designs of safety critical messages. For instance, Seagull, Xiao, Mackenzie, & Wickens (2000) proposed that a better alert or alarm design comprised of not just the issuance of simple alerts but also the addition of meanings to them. Ahlstrom & Panjwani (2003) reported technical operations specialists' opinions on auditory alarms. They were:

- The alarms sounded alike and were thus confusing.
- There were too many false alarms.
- The alarms were annoying—excessively long and continue even after acknowledgment.
- The alarms were hard to locate.
- There were too many alarms sounding off at the same time.

Based on them, Ahlstrom and Panjwan suggested:

1. Using broad bandwidth alarms instead of pure tones.
2. Using intermittent alarm sound instead of continuous sound.
3. Differentiable alarms instead of using similar sounds or frequencies.

Newman & Allendoerfer (2000) reviewed audio alarms in Terminal Radar Approach Control (TRACON) and proposed new detailed features of audio alarms, such as some specific frequencies for STARS audio alarms. Allendoerfer, Friedman-Berg, & Pai (2007) presented "attributes of effective alerts":

1. Detect potential hazards,
2. No activation when there are no potential hazards,
3. It gives a new information,
4. Perceptible and salient,
5. Distinguishable from one another,
6. Easy to locate,
7. Legible,
8. Communicate urgency,
9. Communicate appropriate actions,
10. Draw attention but no disruptions.

Ho, Cummings, Wang, Tijerina, and Koehhar (2006) reported that their participants preferred distinct alarms for different systems in car driving, but there was no statistical difference in reaction time and accuracy between single and multiple alarms for different systems. Simons, Fredricks, & Tappel (1997) also reported that in the hospital, alarms were difficult to distinguish from one another. Wickens (1984) proposed four ways to present effective alarm aural annunciations: 1) sequencing to show the progression of the alarm states that can be used to deduce the "primal default"; 2) grouping and prioritizing (such as grouping by location and functions); 3) color to be used in a consistent way; and 4) information because people can process "a smaller number of information-rich stimuli more efficiently than a large number of stimuli of small information content." In a complex work environment that is evolving such as nuclear power plant, he mentioned that innovative displays would be helpful to an operator. He suggested using predictive displays, feedback, well-designed annunciator and alarm, sequencing that shows the history of alarm progress, and proper and consistent color use.

However, we should not apply the display methods of other domains to the air traffic control domain hastily because air traffic control tasks are very different from the tasks operators face in other domains. In general, controller tasks are more dynamic and time critical than the tasks in other domains. The display elements on their monitor screen moves constantly in various directions. Controllers also interact with pilots, other controllers, and technical operations specialists verbally or using non-verbal communication systems while controlling air traffic. For now, there is no classification scheme in prioritizing and presenting safety critical messages to controllers. The FAA Human Factors Design Guide (FAA, 2016) presented the alert categories, but it followed the military standards (DOD, 1997), which had the same categories as those in the FAA flight deck domain (FAA, 2010).

A good human factors design is to create a product that attunes to human limitations and capabilities, not forcing human to adapt to the product (Wickens & Hollands, 2000). In that regard, we decided to use alarms as one of the safety critical message categories to controllers because the general public uses the term 'alarms' regularly as 'warning of a danger' (https://en.oxforddictionaries.com/definition/alarm). We used alarms and alerts as two major categories defined by Management of Alarm Systems for the Process Industries (2009) and Engineering Equipment and Materials Users Association (2013):

1. Alarms signify that an abnormal situation occurred and that an operator's reaction is required to correct it.
2. Alerts inform operators of an abnormal situations that may require an operator's acknowledgment but not necessarily operator's inputs to correct them.

1.2.1 Taxonomy of Controller Alarms and Alerts

Because safety critical messages in air traffic control were not well defined, we decided to survey them first and then categorize them based on the safety criticality. To help this classification, we created air traffic control taxonomy. One way of creating taxonomy suggested by Allendoerfer, Friedman-Berg, and Pai (2007) was to view clusters of attributes of alarms and alerts and using those clusters as taxonomy groups. However, air traffic control alarms and alerts were not defined well enough to form clusters.

In the taxonomy, we described information that matters to controllers in maintaining air traffic control safety. It included the following. The detailed descriptions of taxonomy are in Appendix A.

- Situations when the safety critical messages were issued
    - Type of messages.
    - Urgency.
    - Current or Projected.
    - The event that triggered.
    - Task the controller was involved.
- Controller responses.
    - Required responses.
    - Consequence due to no response.
- Location and position of the message.
- Description of the signals.
- Performance of the message.

1.2.2 Characterization and Categorization of AAINs

Controllers' priorities can change depending on the task at hand because air traffic control is dynamic. For instance, Allendoerfer, Pai, and Friedman-Berg (2008) reported that controllers at Air Route Traffic Control Centers (ARTCCs) and Terminal Radar Approach Control (TRACON) responded to various alerts in a wide range of response times because controllers' priorities change as they control air traffic. They reported that the range of response times of conflict alert (CA) was from 3 to 294 seconds and that of the Minimum Safety Altitude Warnings (MSAW) from 3 to 339 seconds. This tells that a critical safety message in one situation may not be so in a different situation. Keeping that in our minds, we still believed that we could prioritize and categorize each of AAINs based on **Consequence for not responding, Urgency to respond, and Time to respond to the messages**. Urgency was the source of prioritizing the different categories of alerts in the military and the flight deck domains (DOD, 1997; DOD, 2012; FAA, 1981; FAA, 2010; FAA, 2011).

Our subject-matter-expert controllers also pointed out that consequence if not responding to urgent safety messages is one of the major criteria when prioritizing their tasks on hand. They also recommended to use 'the time to respond' as a source of prioritizing their task on hand to safety messages because in air traffic control, time is very critical because of the dynamic nature of air traffic control. We believe that this led to the wide-range of controller response times to CA and MSAW reported by Allendoerfer, Pai, & Friedman-Berg (2008).

We asked our controller subject-matter-experts to give an equal weight of safety-criticality to each of these three categories and asked them to select one significance value in the category for each AAIN. For **Consequence Not to Respond**, we had three values in order: Very Severe, Severe, and Not Severe. For **Urgency to Respond**, we had three values in order: Very Urgent, Urgent, and Not Urgent. For **Time to Respond**, we had 10 seconds, 20 seconds, 30 seconds, 1 min, 5 min, and beyond 5 min. We called it an alarm if a particular AAIN had two or three high levels in the above three categories. For example, if one of the AAINs had the levels of a very severe consequence (the highest level in the category of **Consequence Not to Respond**), urgent (the second highest in the category of Urgency to Respond), and to respond within 10 seconds (the highest in the category of **Time to Respond**), we defined it as an alarm even though "urgent" was not the highest level in the **Urgency to Respond** category.

We define that Indicators and Notifications are less safety critical than alarms and alerts. We grouped these two into one cluster without ranking them in safety severity. Indicators give controllers useful information for better situational awareness for an operational change. Notifications are all the other safety-related information the system sends to controllers' display. For instance, in Figure 1, we show an indicator, a green axis with two arcs located in the aircraft list of the Radar Associate (RA) position, indicating that the aircraft is manually marked on-frequency at the receiving sector. This tells to the controller that the status or the communication mode of the aircraft has changed. In the next figure (see Figure 2), the aircraft is in Hold status and "HOLD" is displayed in Field E of the data block as the position symbol becomes "H". We classified this as a notification. It means that there is no changes form one state to another, but it gives a new information about the aircraft status. Any indicators and notifications can be alarms or alerts depending on the combination of the three safety critical characteristics mentioned above.

Figure 1. Indicator example: A green axis with double arcs showing the aircraft is on the receiving sector frequency in Data Comm.

Figure 2. Notification example: "Hold" notification in ERAM.

The following table shows the formula we used to categorize AAINs into Alarms, Alerts, Indicators, and Notifications (see Table 1). Our subject matter experts (SMEs) selected a specific value among the three for each AAIN based on their previous experience as controllers and the descriptions of relevant NextGen documents.

Table 1. Categorization Method for AAINs

Type	Consequences (Very Severe, Severe, Not Severe)	Urgency (Very Urgent, Urgent, Not Urgent)	Time to Respond (10 seconds, 20 seconds, 30 seconds, 1 min, 5 min, and beyond 5 min)
Alarms	Very Severe	Very Urgent	10 seconds
	Very Severe	Very Urgent	20 seconds
	Very Severe	Very Urgent	30 second
	Very Severe	Urgent	10 second
	Severe	Very Urgent	10 seconds
Alerts	Severe	Urgent	20 seconds
	Severe	Urgent	30 seconds
	Severe	Urgent	1 min
Indicators/Notifications	Not Severe	Urgent	30 seconds or longer
	Severe	Not Urgent	30 seconds or longer
	Not Severe	Not Urgent	30 seconds or longer

1.3 When is Midterm NextGen?

Our research focus was on the NextGen systems in the midterm NextGen period, which is up to 2018 according to GAO (GAO, 2014). However, according to the most recent document titled "National Airspace System Enterprise Architecture" (NAS EA) by Office of NextGen (ANG)

(NAS-EA-AV-1-Mid_Term-v4.0-013015.pdf), they projected the Mid-Term architecture "to be available in the 'Mid-Term' timeframe (through 2020)." (FAA, 2015b)

Based on the above information, we tried to include a few major NextGen systems that would be around up to 2020. We did not include the NextGen systems that will be available after 2020. Even if we decided to include those systems, it would have been almost impossible for us to gather necessary information about them because the descriptions about those systems must not be available.

1.4 Selecting NextGen systems for the project

In our project, we tried to cover as many major NextGen systems as possible. Some of them exist now and will be used by controllers for a few more years, including National Airspace System (NAS) Information Display System (NIDS), which will be replaced eventually by the NextGen system Enterprise Information Display System (E-IDS) in 2025. We made sure that we selected at least one major system from each facility. We had Tower Flight Data Management (TFDM) for ATCT, STARS G4 for ATCT and TRACON, and ERAM for ARTCC, respectively. We also selected other systems based on the documents available to us. From the documents, we extracted AAINs and made a catalog. We described each AAIN's characteristics based on the taxonomy and categorized them into alarms, alerts, indicators, and notifications.

Below are the alphabetical lists of the systems for each facility in the catalog. The most critical system at each facility is identified in bold. Some of the systems will be used at multiple facilities and appear more than once in the catalog such as National Airspace System Voice System (NVS).

a. TOWER: NIDS, NVS, **STARS G4**, TAMR, TDLS, **TFDM**
b. TRACON: NIDS, NVS, **STARS G4**
c. ARTCC: Data Comm, **ERAM**, ERIDS, GIM-S, NVS

2. COGNITIVE WALKTHROUGH OF AIR TRAFFIC CONTROL ALARMS AND ALERTS

As part of our effort to propose better alarm and alert presentation methods, we ran Cognitive Walkthrough and collected controllers' opinions on NextGen alarm and alert presentation methods as they observed them on a monitor display. Because of our limited resources, we selected a couple of major NextGen systems only and showed them to two controllers from each of ATCT, TRACON, and ARTCC. We used STARS G4 (Note: Will be called STARS from this point onwards because G4 stands for a new version of STARS) for both ATCT and TRACON, and ERAM and Data Comm for ARTCC. We also created normal images by deleting specific alarm and alert images. We used Cognitive Walkthrough with "think aloud" to elicit the controllers' spontaneous opinions. Researchers have been using Cognitive Walkthrough and "think aloud" methods to study usability of interfaces (Andre, Hartson, & Williges, 2003; Nielsen, 1993; Polson & Lewis, 1990). We presented normal images first before presenting the alarm and alert images, which showed participants the contrast between alarm and alert images and the normal images. Some of them had aural annunciation. We asked the participants to express their opinions aloud as they observed the images, and we recorded their opinions. In the following, we describe the method of the evaluation.

2.1 Method

We present below the detailed information about the method we used to run the Cognitive Walkthrough.

2.2 Participants

We visited Philadelphia ATCT/TRACON and Atlanta ARTCC (ZTL). At each facility, we worked with two Certified Professional Controllers (CPCs) for the evaluation.

2.3 Hardware and Software

We used an Alienware X64-based laptop with an Intel® Core™ i7-4910 MQ processor and 32 GB DDR3L at 1600MHz memory, running Microsoft® Windows® 7 Ultimate. The display size of the laptop was 17 inches at a resolution of 1920 x 1080 pixels with a refresh rate of 60 Hz and color depth of 32 bits per pixel. We used two laptop monitors placed side by side for each participant (see Figures 3 and 4). The NVIDIA GeForce® GTX 880M graphics card of the laptop controlled both monitors. The 22-inch monitor on the right side (Dell P2210) was connected to the laptop via High-Definition Multimedia Interface (HDMI). Its resolution was 1680 x 1050 pixels with a refresh rate of 60 Hz and color depth of 32 bits per pixel. The images had the approximate dimensions of 405 x 282 pixels or 2.7 inches in width by 1.9 inches in length. The images had RGB color space and were in the Joint Photographic Experts Group (JPEG compression format and file type.

The participant sat about 2 feet away from the monitors and viewed the images and text. We presented the images at the center of the screen. The background color of both monitors was dark gray and had the color value of #404040 in hexadecimal. The font used for the text was Garamond, plain, with the point size of 42. The text color was white.

Most of the images did not have aural warning except five images. Their sound was in mono, 1 channel, and 22,050 Hz sample rate at 16 bits per sample. The audio files were compressed in .WAV file format.

We wrote the program in Java SE 7.79. The program configurations consisted of a data file, configuration, data output file, and the application. The program was extremely versatile and durable. The configuration file contained the format, order, and origin of the data being presented. This allowed an experimenter to configure how to run the program. The configuration file was loaded into the system by responding to a prompt, such as facility type or participant number.

Figure 3 shows a normal image without an alarm or alert. Figure 4 shows an alarm with text description.

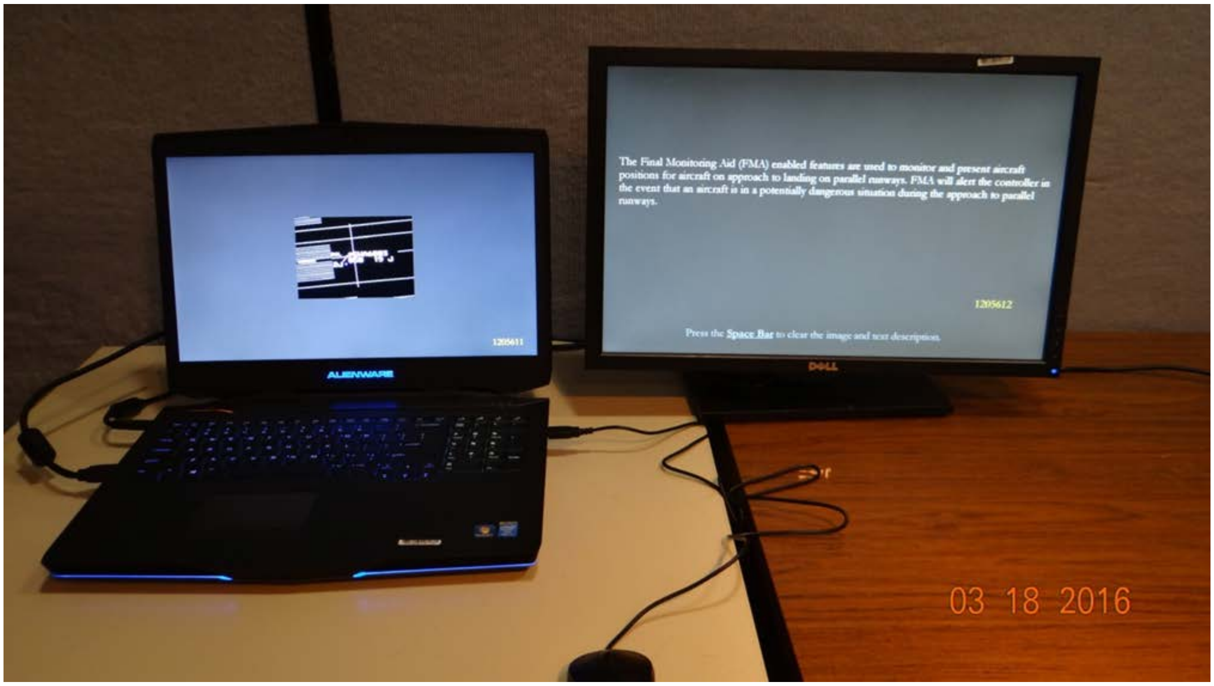

Figure 3. This figure shows the Cognitive Walkthrough setup. A normal configuration image is on the left, and the description about it is on the right.

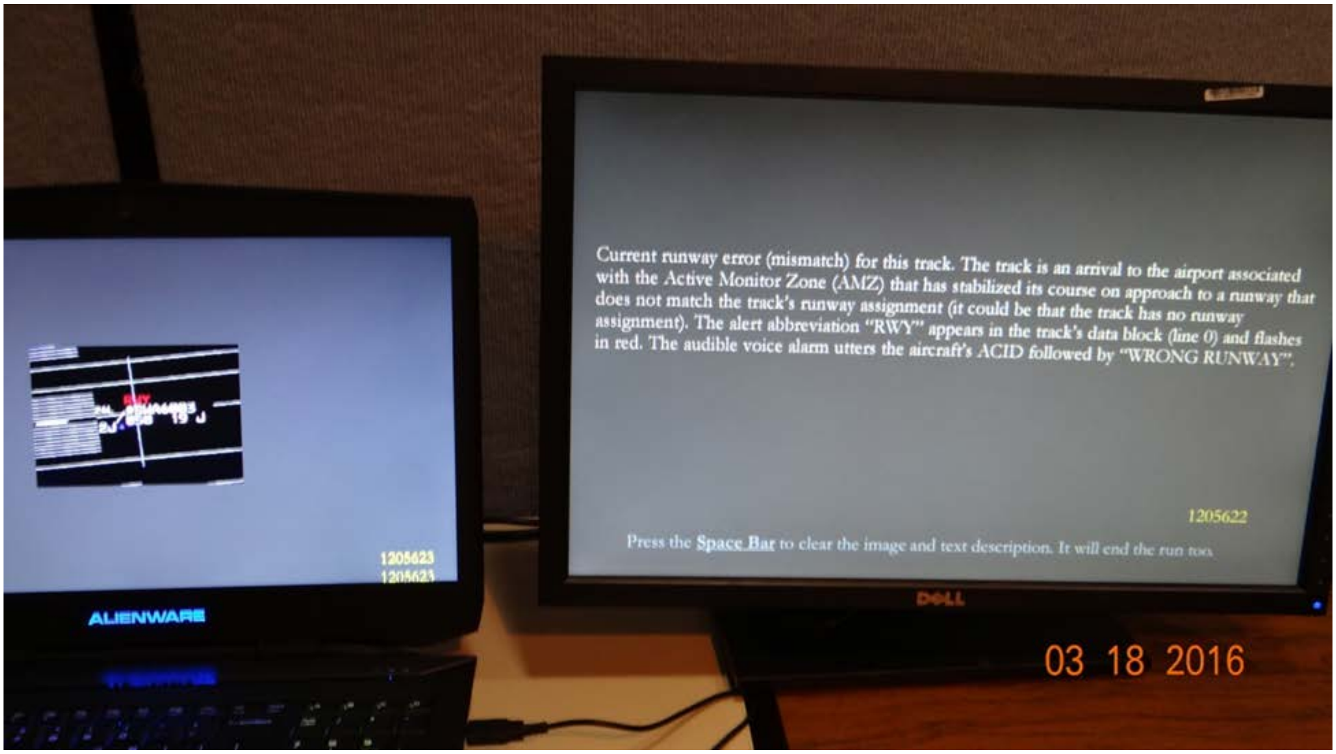

Figure 4. RUNWAY alarm is shown on the left display monitor and the text description is shown on the right display monitor.

The data file contained image file names, text file names, audio file names, run numbers, and session numbers. The program captured all user inputs such as keyboard key presses, mouse clicks, images, texts displayed, and audios. These events were saved in a .json format and written to a log file with a time stamp for each event.

Table 2 shows 14 alarms and 13 alerts for ATCT and TRACON. For ARTCC, we had 20 alarms (17 ERAM alarms and 3 alarms in Data Comm) and 12 alerts (seven alerts in ERAM and five alerts in Data Comm). Because it took a participant more than 2 hours to finish the evaluation, we decided to divide each list into four segments and present segments to participants in a random order. By dividing the list into four segments and presenting them in different orders of the segments to participants, we minimized a possible sequential presentation effect of the alarms and alerts. Using this scheme, we presented Segment 1, Segment 2, Segment 3, and Segment 4 to one participant, and Segment 4, Segment 3, Segment 2, and Segment 1 to the other participant at each facility. We called the sequence in the segment as a run. After each run, they took a 15-minute break.

In segmenting the list, we tried to balance out the allocations of the alarms and alerts evenly across segments. We also had Data Comm image set in addition to ERAM image set for the ARTCC runs. We distributed the Data Comm sets to the ARTCC segments evenly to some extent. In creating the distribution table, we did not differentiate alarms that emitted sound from those that did not.

Table 2. The Frequency of Alarm/Alert Sets across Segments at ATCT/TRACON

	Segment #	**STARS Alarm**	**STARS Alert**	**Total**
ATCT/ TRACON	1	3	4	7
	2	4	3	7
	3	4	3	7
	4	3	3	6
	Total	14	13	27

Table 3. The Frequency of Alarm/Alert Sets across Segments at ARTCC

		Alarm		**Alert**		**Total**	
	Segment #	**ERAM**	**Data Comm**	**ERAM**	**Data Comm**	**ERAM**	**Data Comm**
ARTCC	1	5		1	2	6	2
	2	4	1	2	1	6	2
	3	5	1	1	1	6	2
	4	3	1	3	1	6	2
	Total	**17**	**3**	**7**	**5**	24	8
		20		**12**		**32**	

2.4 Procedure

We recruited two volunteer controllers each at ATCT, TRACON, and ARTCC. Controllers spent about 2 hours to finish the experiment. We had one participant in the morning and one in the afternoon. Each participant signed an informed consent form and filled out a biographical questionnaire before the evaluation (see Appendices B & C). The informed consent form described the study and explained to participants that their participation was strictly voluntary, their personal information would be protected, and their rights were not waived. They were also told that they could withdraw for any reason without any consequence.

Figures 1 and 2 showed the experimental setup showing a laptop and an extra monitor placed in a quiet room specifically for the experiment. We had a 15-minute break after each segment. Participants observed a normal image first with text descriptions in the first session (see Figure 3). The image was on the left-side monitor, and the text was displayed on the right monitor. In this figure, the altitude (700 ft) and ground speed (110 knots) are displayed. The data block color of the aircraft is white, which means it is under my control, (i.e., I own it). If it were in green, it is not under my control.

In the second session, they observed an alarm or alert image without text description first. They then observed the same alarm or alert image with text description (see Figure 4). These were two matching sessions to examine the display methods of a particular NextGen alarm or alert. We considered these two sessions as one trial. After each trial, we gave each participant a questionnaire about the presentations' clarity in severity, urgency, and time to respond (see Appendix D). At the end of the evaluation, we handed out an exit questionnaire to collect the participants' overall opinions on the NextGen alarms and alerts (see Appendix E).

Some alarms or alerts had aural annunciation, and some alerts and alarms blinked such as Low Altitude (LA) in Figure 6. Some had a component in a data block to time share. For instance, the "AMB alert" shared the same position with "020" (see Figure 7). It was about an aircraft target location not corresponding to the track update. AMB also blinked. The alert also had an aural annunciation.

Attached to a position symbol, the data block includes textual information about the aircraft including cleared and actual altitudes, speed, destination, aircraft type, aircraft category, beacon code, and Aircraft ID (ACID).

Figure 5. STARS image with text descriptions about the image.

	Safety alarm for when an aircraft reaches a minimum unsafe adapted altitude. Flashing red Low Altitude (LA) in line 0 of the data block for a limited amount of time before turning steady red. Safety audible alert can be suppressed by controller acknowledgment.

Figure 6. STAR-G4 LA alarm image with text descriptions. LA blinked.

Figure 7. The image on the left is a normal image, and the image on the right is an alert, Ambiguous Interfacility Handoff (AMB).

We describe the simplified version of the steps we used during Cognitive Walkthrough in Table 4. We used the laptop on the left to enter all the inputs. In Table 4, parts shaded in blue belong to Session 1, and parts shaded in orange belong to Session 2. A trial comprises Sessions 1 and 2 in addition to other surrounding events shaded in white.

Table 4. Steps of Cognitive Walkthrough

Sequence Number	Inputs (at the laptop)	Display 1	Display 2
1	Start.		
2		A picture of a normal situation appears.	Text describing the situation shown on Display 1 appears.
3	Start speech recording.		
4	(Controller can ask questions about the picture and description.)		
5		Picture disappears.	Text disappears.
6	Press a button for the new picture with an alarm.		
7		The image of an alarm/alert appears over the normal picture (with aural annunciation audio notification if there is one).	
8	Press a button for the next step after knowing a controller gathered enough information about the alarm/alert.		
9		Picture disappears.	
10	Press a button to get the text describing the alarm/alert		
11		Picture appears.	Text description appears.
12	Press a button to stop the session.		
13		Picture disappears.	Text description disappears.

2.5 Design and Analysis

2.5.1 Independent Variables

In this evaluation, the independent variable was the alarm or alert features in each AAIN. We found out that some alarm and alerts were not familiar to some participant controllers because we used NextGen systems.

- **Baseline:** As a baseline, we showed controllers a normal image without an alarm or an alert.
- **Evaluation Condition:** There is presence of either alarm or alert (with aural annunciation if there is one).

2.5.2 Dependent Variables

Our data consisted of the controllers' subjective opinions on the alert and alarm images. Some had aural annunciations. As they observed the images, they were instructed to think aloud. We recorded their speech. They then filled out a questionnaire (see Appendix E). In the questionnaire, we asked first if they were familiar with the alarm or the alert. We also asked them about **Consequence (Very Severe, Severe, No Severe), Urgency (Very Urgent, Not Urgent), and Time to Respond (10 seconds, 20 seconds, 30 seconds, 1 minute, 5 minutes, and beyond 5 minutes)**.

During the trial, we interacted with the controllers to encourage them to express their opinions and asked their agreements or disagreements with the intended messages of NextGen alarms and alerts.

2.6 RESULTS

As we compiled the alarms and alerts of the NextGen systems, it became clear that a few alarms and alerts did not meet the guidelines proposed by researchers and human factors principles. For instance, Allendoerfer, Friedman-Berg, and Pai (2007) presented 10 attributes of effective alerts (see Section 1.2), which some of the participants also pointed out. Figure 8 shows a red cone that depicts a loss of separation in STARS. The red cone covers other elements, making it difficult for controllers to read them.

Figure 8. An alarm that shows loss of separation in STARS.

Appendix F is the summary of the Cognitive Walkthrough results. We did not list them in any particular order. We entered the names, images, descriptions of the alarm or alert, and the comments our participants made for each of them. We did not separate comments and identify who made the comments. Thus, there were some conflicting opinions for some alarms and alerts. We wrote the controller comments in bold to make them stand out clearly.

We divided the comments into two facility categories: ARTCC and Terminal (ATCT and TRACON) because both ATCT and TRACON used the same STARS. We then grouped their comments into NO NEED TO CHANGE and NEED TO CHANGE. Under NEED TO CHANGE, we had three categories:

1. More salient presentation needed;
2. Too much attention-grabbing; and
3. More information needed.

For some alarms or alerts, we had conflicting comments from controllers. If a comment also belonged to another subcategory, we marked both with *. If some belonged to two other subcategories, we marked all three of them with **. If they had three (total of four), we marked them with ***. This lets the readers know that there were some disagreements among controllers and what those disagreements were.

2.7 Discussion

We could easily group controllers' comments into **More salient presentation needed, Too much attention-grabbing**, and **More information needed** because their comments on alarms and alerts were clearly about their immediate perception and what decision to make based on urgency. Their major concern was whether they could perceive alarms and alerts easily and whether they were able to understand their safety critical messages quickly.

It was a pleasant surprise to find out that the overall controllers' comments were not much different from each other. Because we had a small sample size of participants, this overall consensus about most of the alarms and alerts gave our results more weight than having diverse comments from the controllers. We can present the general recommendations for future NextGen alarm and alert design from the results with some confidence.

Because of the small sample size, we need to be cautious about applying our results directly to specific alarms and alerts of the future NextGen alarm and alert display design. There were also a few conflicting opinions on some alarms and alerts as shown in their detailed responses in Appendix F.

We strongly recommend collecting more controllers' opinions on the NextGen alarms and alerts using our Cognitive Walkthrough method. The method was very effective in soliciting their spontaneous responses. Most of the images we used were static images, but we could improve the method by presenting more realistic and dynamic moving images of air traffic. We could also run a high-fidelity simulation experiment focusing on alarm and alert situations as controllers control air traffic. During the simulation experiment, we can collect objective data such as all the controllers' eye movements and interactions with the systems in real time.

3. TECHNICAL OPERATIONS ERAM ALARMS AND ALERTS

3.1 Introduction

There are 22 ARTCCs in the FAA, and each ARTCC has an attached SOC. It supports ARTCC in addition to performing other technical operations. ERAM is monitored and controlled by specialists at the SOC. Our task in this tech operations research was to examine tech operations specialists monitoring and controlling ERAM alarms and alerts only.

We visited ZTL SOC in Hampton, Georgia near Atlanta and ZDC SOC in Leesburg near Washington, DC and observed technical operations specialists preforming their tasks, focusing on their work on the ERAM. The monitoring system of the ERAM was on one side wall in the SOC room.

We created a catalog of ERAM alarms and alerts from ERAM manuals for the technical operations specialists (FAA, 2016). We did not have a chance to review our catalog with technical operations SMEs or analysts at the facilities as we had done for the air traffic control alarm and alert catalog. We categorized each of the entries into alarms and alerts ourselves and noted our reasons for categorizing them in that way. We could not get images for some of them. The images in the catalog came from the manual.

3.2 Layout of the ERAM systems

At ZTL SOC, there were 10 systems on the floor for specialists to monitor including ERAM. They were Rappi Monitoring System (RMS), Time-Based Flow Management (TBFM), Voice Switching and Control System (VSCS), Weather and Radar Processor (WARP), Voice Switching and Control System Training and Backup Switch (VTABS), Enhanced Backup Surveillance System (EBUS), En Route Information Display System (ERIDS), En Route Data Distribution System (EDDS), and Display Replacement System (DSR).

When the ERAM system emitted alarms, they were highlighted in red on the event window. Analysts could see and hear it. Alerts were highlighted in yellow, and they also emitted sound. However, analysts could turn off the sound manually.

The ERAM system was not connected to other systems in the room that analysts monitored and controlled. It was located separately from the other systems. The main ERAM displays are shown in Figure 9. If any system had a problem, its problem item would be shown in red (alarm) or yellow (alert).

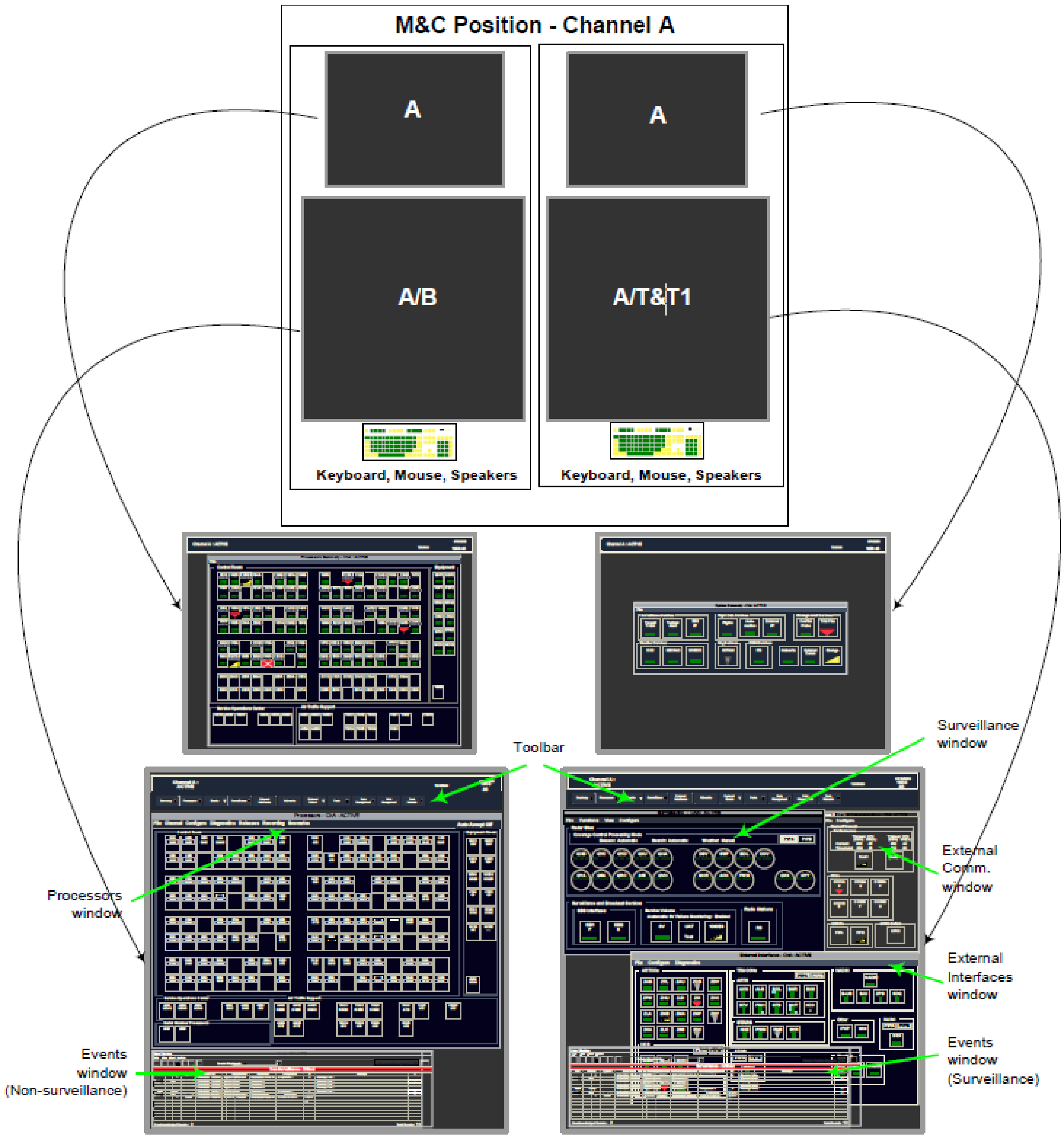

Figure 9. The main layout of the ERAM monitoring systems in the Technical Operations (FAA, 2016 August).

The busiest window was the one that showed events (see Figure 10). It uses three color highlights to differentiate three states: red for alarm, yellow for alert, and green for system recovered or normal. Analysts also monitored other systems represented as icons in Figure 11.

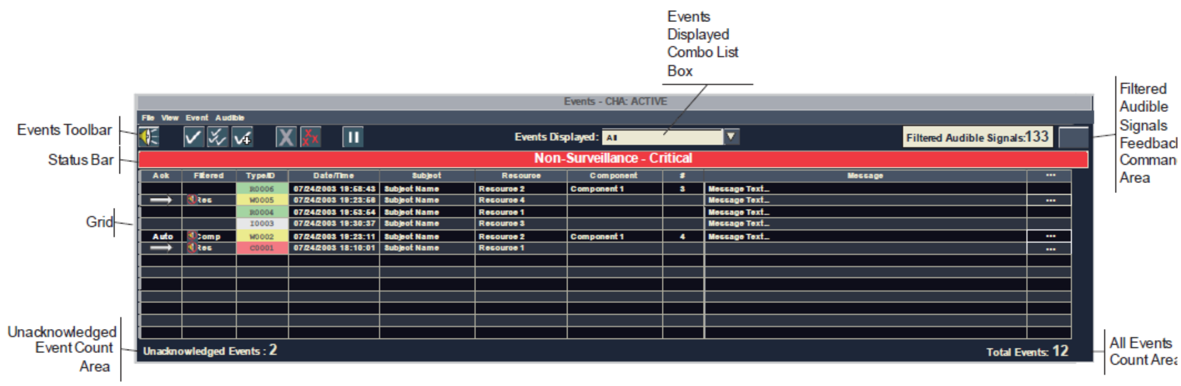

Figure 10. The event display window showing normal states in green, alert states in yellow, and alarm state in red (FAA, 2016, May).

Figure 11. External Interface Windows (FAA, 2016 August).

3.3 Results and Discussion of ERAM in Technical Operations

We did not review our technical operations catalog of alerts and alarms with SMEs or technical operations analysts. The technical operations manuals for the technical operations analysts used three colors—read, yellow, and green—to represent three states—alarm, alert, and normal, respectively (FAA, 2016, May; FAA, 2016, August). We propose to review the events with the current categorization in the manuals and examine if the categorization is effective. After that, we can propose what would be the optimal presentation methods for Technical Operations ERAM alarms and alerts.

Monitoring ERAM alarms and alerts at the SOC must be difficult for specialists because they cannot monitor them exclusively. They had to monitor other systems as mentioned above. All the systems in the SOC had separate displays to be monitored, and the specialists needed to scan through the displays or hear the warning sounds. Some systems did not have auditory warnings. We did not notice any unusual ERAM alarm and alert presentation methods. However, the specialists' major concern was the high number of alerts that were not for the SOC specialists to solve. We recommend reducing nuisance alerts and alarms, which has been a chronic issue in air traffic control and technical operations as pointed out by Ahlstrom & Panjwani (2003) and Allendoerfer, Friedman-Berg, and Pai (2007). We suggest creating a system that can scan all the systems that the specialists need to monitor and informing the specialists of any important alarms or alerts by presenting them on one monitor in front of them. Specialists can investigate them further at the respective monitor and examine the system if necessary.

4. DISCUSSION AND RECOMMENDATIONS

We propose to define air traffic control AAINs clearly using the three important safety characteristics in air traffic control: consequence for not responding, urgency, and time to respond. We recommend collecting more controllers' opinions on display methods of AAINs using the Cognitive Walkthrough method, which was very effective in soliciting their spontaneous responses. We also recommend running a high-fidelity simulation experiment focusing on AAINs only and collecting objective data such as controller response time and eye-movement data. With objective data, we may be able to discern the relative effectiveness of various AAIN features such as colors, size, and blinking.

Based on our participants' opinions, we present the following general recommendations for future NextGen air traffic control alarm and alert designs.

1. The visual and auditory features of the alarms and alerts shall be decided in the order of red and yellow with the additional feature of flashing if needed. The size of the alarm or alert element must also be considered in addition to changing the limited block to the full data block if necessary, such as HIJK in the limited data block in ERAM.
2. Consistent naming conventions should be used. In ERAM, HIJK is used, but in STARS, HJ is used.
3. If an alarm or alert has an aural announcement, it should be different from the others regardless of how often it occurs. For instance, in STARS, EM, HJ, and RF issue the same warning tone.
4. The visual presentation of an alarm and an alert must be clearly distinguishable from the background, and the contrast level must be high.
5. Use a more pronounced feature in displaying any altitude-related alarms and alerts.

6. Instead of issuing a general status warning such as OUTAGE in ERAM, issue it with a detailed list or more information so that a controller does not have to do extra steps to learn about it.
7. For technical operations specialists who monitor and control ERAM at the SOC, integrate the ERAM with other systems and create a display where they can monitor all the systems on one monitor display. Also, reduce the number of nuisance ERAM alerts.

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Acronyms

AAIN	Alarm, alert, indicator, and notification
ACID	Aircraft Identification
ANSI	American National Standards Institute
ANG	Office of NextGen
ARTCC	Air Route Traffic Control Center
AS	Altimeter Setting
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
BC	Beacon Code
CPC	Certified Professional Controller
Data Comm	Data Communication
DSR	Display Replacement System
EBUS	Enhanced Backup Surveillance System
EDDS	En Route Data Distribution System
E-IDS	Enterprise Information Display System
ERAM	En Route Automation Modernization
ERIDS	En Route Information Display System
GI	General Information
HDMI	High-Definition Multimedia Interface
ISA	International Society of Automation
LA	Low Altitude
MSAW	Minimum Safe Altitude Warning
NAS	National Airspace System
NAS EA	National Airspace System Enterprise Architecture
NextGen	Next Generation Air Transportation System
NIDS	National Airspace System (NAS) Information Display System
NOTAM	Notice to Airmen
NVS	National Airspace System Voice System
RMS	Rappi Monitoring System
SIGMET	Significant Meteorological Information
SME	Subject Matter Expert
SOC	Service Operations Center

STARS	Standard Terminal Automation Replacement System
TAMR	Terminal Automation Modernization Replacement
TBFM	Time-Based Flow Management
TFDM	Tower Flight Data Management
TFM	Traffic Flow Management
TRACON	Terminal Radar Approach Control
VSCS	Voice Switching and Control System
VTABS	Voice Switching and Control System Training and Backup Switch
WARP	Weather and Radar Processor

Appendix A: Taxonomy of ATC Alerts and Alarms

Taxonomy of ATC Alerts and Alarms

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Date: October 24, 2014
Modified on November 3, 2015

- Situation: This category describes the general characteristics of the situation when an alert/alarm triggered:
  - Alarm or Alert
    - According to (ANSI/ISA-18.2-2009), alarm is defined as "an audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a response."
    - The same document defined alert as "an audible and/or visible means of indicating to the operator an equipment or process condition that requires awareness."
    - A warning is a general term used for both alert and alarm situations. It may signal a situation that needs a controller's attention, such as a warning area for a potential danger, and may trigger an alert. It may require a controller's corrective action such as "minimum safe altitude warning" (FAA 7110.65V, *p*. PCG M-6). In our taxonomy, warning is not categorized separately: It is either alert or alarm in our taxonomy.
    - Indicators give controllers useful information for better situational awareness such as in Terminal Automation Modernization Replacement (TAMR), beacon code mismatch occurs when it does not correspond to the beacon code reported. Beacon assigned/Beacon code reported flashes white in the data block under this condition.
    - Notification is information to help controller's operations such as in ERAM, font size error message. Font size can be adjusted in the Notice to airmen (NOTAM), General Information (GI) Messages, Significant Meteorological Information (SIGMET), Weather Station Report, Altimeter Settings (AS), Status, or Outage View menus. The trackball circle E cursor appears (and a single error tone sounds) when the user presses the left trackball button, and there is no valid decrement value. The trackball circle P cursor appears (and a single error tone sounds) when the middle trackball button is selected, and there is no valid increment value. The right trackball button is never valid for this view. The trackball circle I (invalid) cursor appears, and a single error tone sounds when the right trackball button is selected.
  - Urgency: How soon must action be taken. We can have three levels of urgency: **very urgent** (where an immediate corrective action is required), **urgent** (where a corrective action is required as soon as possible when the situation allows), and **not urgent** (where a

controller monitors the progress of the situation and decides when to take a corrective action if necessary.)

- Current or projected: Some alerts/alarms are about the current state such as equipment failure. Some are about projected situations such as conflict probe.

- Trigger event
  - System, failure, or outage: A system failed, such as ADS-B failure, was taken offline, malfunctioned, or has function degraded
  - Weather: A hazardous weather situation such as microburst
  - Runway: Closed or out-of-service runway
  - An ADS-B Airspace: An aircraft entered or was projected to enter an air space with some type of restriction (e.g., Special Use Airspace, Flow Constrained Airspace).
  - Incorrect Flight Data: An error in aircraft flight plan or other flight data that needs to be corrected, an invalid beacon code, or a duplicate call-sign.
  - Restriction: An aircraft violated (about to violate) a restriction, such as speed restriction.
  - Conflict. Two or more aircraft are (or are projected to be) closer than the minimum separation standard allowed.
  - Conformance. An aircraft was not (or is projected to be) conformant with its route, flight plan, or trajectory.
  - Low Altitude. An aircraft has violated or was about to violate a designated safe altitude parameter or was descending to such as the Minimum Safe Altitude Warning (MSAW)
  - Required Procedure: The operational situation has changed so that a particular procedure must be used.
  - Traffic Volume: The number of aircraft in a sector or region exceeded or was being projected to exceed a predetermined value.

- Task: What task a controller was performing when an alert/alarm was issued. For example, we could use the major air traffic control tasks presented by Alexander, Alley, Ammerman, Hostetler, and Jones (1998):
  - Identify aircraft
  - Issue clearances
  - Monitor air traffic situations
  - Resolve aircraft conflicts
  - Manage air traffic sequences
  - Route or plan flights
  - Assess weather impact
  - Manage sector/position resources

- Controller Responses:

  - Required Responses
    - Investigate: Whenever alerts/alarms are issued, controllers investigate them first: They examine situation, collect more information, and determine if any action is necessary.
    - Acknowledgment: Some alarms/alerts require a controller’s acknowledgment. Controllers take an action on the system (e.g., clicks a symbol on the display) to indicate that they are aware of the situation.
    - Control Action: Controllers must respond to a system failure. They also respond to conflict alerts by issuing an altitude, speed, heading, or route clearance to a pilot.
    - Need to Inform Other Parties: Controllers may need to inform other people of the alerts or alarms, such as notifying Data Comm failure of an aircraft to a pilot or notifying a system failure to Technical Operations personnel.
    - Ignore: No action required because an alert/alarm stays on due to the alarm or alert system malfunction.
    - Turn off: A controller turns off an alert/alarm after noticing its malfunction.

  - Consequences Due to No Response:
    - Operational safety risks such as operational errors
    - Operational deviations
    - Reduced service quality
    - Reduced efficiency
    - Distraction to the controller because the alert/alarm issued was not corrected and it stays on
    - Situation worsens

- Location and Position of Alerts/Alarms:

  - Facility: En Route, Tower, or TRACON
  - Position of the alert/alarm: R or D side, arrival or departure, local or ground control, supervisor, flight data
  - Systems: Specific system where alerts or alarms was emitted such as ERAM or Data Comm.

- Descriptions of Signals:
  - Sensory mode to detect: visual, auditory, or tactile.
  - Signal details: Visual (color, shape, text, size, animation, flashing, etc.), Aural (frequency, volume, periodicity), or Tactile.

- Performance – How well does this alert do its job?
  - Meaning of the content: Was the meaning of the alert/alarm accurate or ambiguous for a controller to extract necessary information and decide what action to be taken? For instance, was red instead of green used for a dangerous situation?
  - Perceptual quality: Was it easy to detect and perceive? Was the text legible? Was the auditory sound too weak to hear?
  - Confusability: Is the auditory or visual quality of the alerts/alarms clear to an operator? For instance, does the verbal alert have a distinct voice? It also needs to be significantly louder (e.g., 10 dB higher) than ambient noise.
  - Rate of occurrence: The frequency of the alert/alarms per hour. More than 10, between five and 10, or fewer than five. (Note: In the air traffic control environment, we do not know what would be the reasonable categories of occurrence rates. In the technical report (ISA-TR 18.2.6-2012: Alarm Systems for Batch and Discrete Processes), they recommended an alarm system not to annunciate more than six alarms per hour on average.)
  - Detection performance: Hit or false alarm rates: What is the alert's/alarm's correct hit or false alarm rate?

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Appendix B: Informed Consent Form

Informed Consent Statement

I, ______________________________, understand that this experiment , entitled "Cognitive Walkthrough of NextGen Controller Alarms and Alerts," is sponsored by the Federal Aviation Administration (FAA) and directed by Dr. Sehchang Hah.

Nature and Purpose:

I have been recruited to volunteer as a participant in this experiment that will evaluate presentation methods of NextGen controller alarms and alerts in the NextGen systems. The results of the study will be used to propose better presentation methods.

Experimental Procedures:

Two Certified Professional Controllers (CPCs) from each of ATCT, TRACON, and ARTCC will participate in the experiment. The experimental routines will be loaded into a laptop computer with two monitors. Researchers will take them to each of the facilities and run the experiment at the facility. Each participant will spend about two hours to complete the experimental run.

Participants will observe a normal situation image first and then an alarm or alert image. They will go through this routine for all the alarms and alerts one by one for a NextGen system. For ATCT and TRACON controllers, they will observe TAMR alarms and alerts. For ARTCC controllers, they will observe ERAM and Data Comm alarm and alerts. During the experimental runs, researchers will ask participants to 'think aloud' while examining the displayed images. Between the image presentations, researchers will ask participants about their opinions on the displayed images. For example, researchers will ask participants how well they understood the alarm and alert images and if they could decide on the degree of urgency to respond easily.

After the participants have completed all the alarm and alert images, researchers will discuss the overall characteristics of the NextGen alert and alert images with participants and collect their opinions on them.

Anonymity and Confidentiality:

My participation in this simulation is strictly confidential. Any information I provide will remain anonymous: no individual names or identities associated with the data will be released in any reports. I understand that no Personally Identifiable Information [PII] will be disclosed or released, except as may be required by statute. I understand that situations when PII may be disclosed are discussed in detail in FAA Order 1280.1B "Protecting Personally Identifiable Information [PII].

Benefits:

I understand that the only benefit to me is that I will be able to provide the researchers with valuable feedback and insight in presenting effective NextGen controller alarms and alerts to controllers.

Participant Responsibilities:

I am aware that to participate in this study I must be a certified professional controller who is qualified at my facility and holds a current medical certificate. I must also have normal or corrected-to-normal (20/20) vision. I will answer the questions asked during the study to the best of my abilities. I will not discuss the content of the experiment with anyone until the study is completed.

Participant Assurances:

I understand that my participation in this study is completely voluntary and I can withdraw at any time without penalty. I also understand that the researchers in this study may terminate my participation if they believe this to be in my best interest. I understand that if new findings develop during the course of this research that may relate to my decision to continue participation, I will be informed. I have not given up any of my legal rights or released any individual or institution from liability for negligence. The research team has adequately answered all the questions I have asked about this study, my participation, and the procedures involved. I understand that Dr.

Sehchang Hah or another member of the research team will be available to answer any questions concerning procedures throughout this study. If I have questions about this study or need to report any adverse effects from the research procedures, I will contact Dr. Sehchang Hah at (609) 485 5809.

Discomfort and Risks:

I understand that I will not be exposed to any foreseeable risks or intrusive measurement techniques. I agree to immediately report any injury or suspected adverse effect to Dr. Sehchang Hah at (609) 485 5809.

Signature Lines:

I have read this informed consent form. I understand its contents, and I freely consent to participate in this study under the conditions described. I understand that, if I want to, I may have a copy of this form.

Research Participant:____ Date:__________

Investigator:____ Date:__________

Witness:____ Date:__________

Appendix C: Biographical Questionnaire

Participant # ___________ **Date** ___________

Biographical Questionnaire

Instructions:
This questionnaire is designed to obtain information about your background and experience as a certified professional controller (CPC). Researchers will only use this information to describe the participants in this study as a group. Your identity will remain anonymous.

1. What is your **gender**?	O Male	O Female

2. What is your **age**?	_____ **years**

3. How long have you worked as **an Air Traffic Controller (include both FAA and military experience)**?	_____ **years** _____ **months**

4. How long have you worked as a **CPC for the FAA**?	_____ **years** _____ **months**

5. How long have you **actively controlled traffic** in the en route environment?	_____ **years** _____ **months**

6. How many of the **past 12 months** have you actively controlled traffic?	_____ **months**

Appendix D: Post-Trial Questionnaire

Participant # ___________ **Date** ___________

Post-Trial Questionnaire

A. Presentation Clarity in Delivering the intended Information

For each of the following questions, please select the degree of alarm of alert shown in the previous image (and aural annunciation).

- **How familiar are you with the alarm or alert you just saw? Please rate it on the scale from 0 to 10.**

(**)**

A. severity of consequence if not responding to it	Not Severe Severe Very Severe

B. How urgent	Not Urgent Urgent Very Urgent

C. Time to Respond	10 Sec	20 Sec	30 Sec	1 Min	5 Min	Beyond 5 Min

If you have any additional comments on the images (and aural annunciation) such as detectability, clear information, etc., please give us your feedback/opinions.

Appendix E: Exit Questionnaire

Exit Questionnaire

1. About your past experience with the legacy system alarms and alerts in your air traffic control, please rate their general usefulness in your controlling air traffic.

The rating of -5 represents that you thought the system limited or hindered your performance very much. The rating of 5 represents that it helped your air traffic control very much.

Hindered greatly greatly										Helped
-5	-4	-3	-2	-1	0	1	2	3	4	5

Justification for your ratings:

2. Based on your experience today, please compare the presentation methods of the NextGen alarms and alerts with those of the legacy systems you have experienced at your work. Please fill in the system you prefer on the right and the other system on the left use the scale of (-5) to the scale of (+5) as shown below.

(		)						(		)
-5	-4	-3	-2	-1	0	1	2	3	4	5

Justification for your choice:

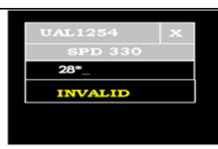
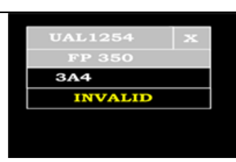
3. What aspects of the current version of the NextGen alarms and alerts you like or dislike?

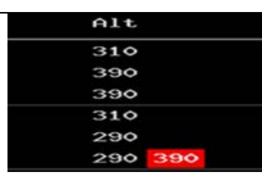
4. Can you suggest any display methods or features such as colors, sizes, and aural annunciations of the NextGen system alarms and alerts for improvements?

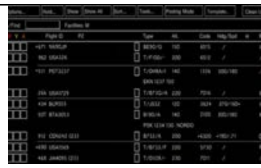
Appendix F: Controller Opinions Expressed During Cognitive Walkthrough

ARTCC

NO NEED TO CHANGE

Name	Images	Descriptions
	Comments	
Radio Failure (RDOF)		An alerting condition in which beacon code 7600 is returned. A blinking Radio Failure (RDOF) is displayed in Field E of the data block.
	Not so critical, the same color is fine.	
Handoff Failure (FAIL)		Flash. A failed handoff is indicated by a blinking "FAIL" in Field E of the data block.
	No special comments	
Heading Value Input Error		The Heading Area displays the current heading that is associated with the FDB 4th line heading data. If the controller enters an invalid heading value, an error tone sounds and "INVALID" appears in the Heading Input Error Area.
	A tone warning for a wrong input. It draws attention. We do not use the heading boxes that much. Typically, there are just some key strokes that you can do instead, and most people are faster that way. Most controllers do things the fastest way they know how, and bringing up text boxes is probably not the fastest way.	
Speed Value Input Error		A controller can enter an FDB 4th Line speed command for a flight with the speed text box. When the controller invokes the speed text box menu from the speed menu, it contains valid speed values when it matches one of the valid formats. When the speed value entered by the controller is not valid, the Speed Input Error Area is displayed with the text "INVALID."
	A tone warning for a wrong input. It draws attention.	
Altitude Value Input Error		The Altitude text menu box enables controllers to enter a flight plan assigned altitude or an interim altitude for a flight using the Altitude Text Box Menu. The controller can enter an altitude value for a flight plan assigned altitude or an Interim Altitude with as many as seven characters. If the controller enters an invalid altitude value, an error tone sounds and "INVALID" appears in the Altitude Input Error Area.
	A tone warning for a wrong input. It draws attention.	

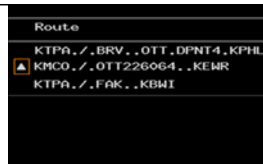
Mismatch Indicator (MISM)		"MISM" flashes. During an inter-facility handoff to an ERAM facility, a discrepancy or mismatch in the target position causes "MISM" to time share in Field E of the data block at the receiving ERAM facility. The receiving ERAM facility can show "MISM" during handoffs from another ERAM, HOST, or TRACON facility.
	Fine.	
Track Data Timed Out (OLD)		When cross-tell track data has timed out, "OLD" blinks when eligible for display as a data block Field E display item.
	We do not see this often anymore in ERAM.	
Abnormal Uplink/Abnormal Response to Route Uplink – Data Comm		An abnormal response to a route uplink is indicated by an orange box outline of a white CID. Abnormal responses include: UNABLE, FAILURE, or ERROR. Voice contact with the pilot is required to ensure common understanding of the current route assignment. To see the message status, left-click on the session symbol to bring up mini-mo.
	The presentation is okay, as it is just about route.	
Abnormal Uplink/Abnormal Response to Altitude Uplink – Data Comm		There is a mismatch between what the controller sent and what the pilot is doing in altitude. An abnormal response to an altitude uplink is indicated by an orange box outline of a white altitude. Abnormal responses include: UNABLE, FAILURE, or ERROR. Voice contact with the pilot is required to ensure common understanding of the current altitude assignment. To see the message status, left-click on the session symbol to bring up mini-mo.
	Orange box is good.	
Initial Contact (IC) Mismatch - Mode-C In Conformance with Assigned – Data Comm		A red rectangle with white text indicates an IC Mismatch (Mode-C not in Conformance with Assigned). If a mismatch occurs, voice contact with the pilot is required to verify a common understanding of the assigned altitude. The controller must clear the mismatch coding prior to using any Data Comm functions for that aircraft.
	Red color for altitude mismatch – Draws attention.	
Lost Mode C Indicator		An unexpected condition in which the indicator is displayed for an aircraft that previously had Mode C when an adapted number of returns have been received with no Mode C. Once Mode C is received, ERAM will remove the lost Mode C indicator. "XXXX" is displayed to the right of the altitude in line 2 of the data block.
	Exceeding parameters when an aircraft is descending.	
Initial Contact (IC) Mismatch (Wrong Altitude) – Data Comm		A red rectangle with white text located in the Aircraft List of the Radar Associate (RA) position indicates an IC Mismatch. If a mismatch occurs, voice contact with the pilot is required to verify a common understanding of the assigned altitude. The controller must clear the mismatch coding prior to using any Data Comm functions for that aircraft.
	Anything about altitude must be red, which is good here.	

	Unsuccessful Transmission Message (UTM) Indicator	  (close-up image)	A yellow “U” will appear in the Unsuccessful Transmission Message (UTM) indicator field in the Aircraft List (ACL) View at the Radar Associate (RA) position to signify a UTM. It will change to white once it is acknowledged.	
		U. No need to change. Not so urgent.		
	Abnormal Uplink/Abnormal Response to Generic Uplink – Data Comm		Data Comm uplink problem. An abnormal response to a generic uplink is indicated by an orange box outline of a white triangle to the left of the ACID. Abnormal responses include: UNABLE, FAILURE, or ERROR. Voice contact with the pilot is required to ensure common understanding of the current generic assignment. To see the message status, left-click on the session symbol to bring up mini-mo.	
		Okay for a general problem.		

NEED TO CHANGE

More Salient Presentation Needed

<table>
<tr><td rowspan="2">Conflict Alert
(CA)</td><td></td><td>A conflict alert is produced when the criteria for separation is predicted to be lost. Conflict alert produces FDB blinking bright/dim when the flight is eligible for conflict alert display at the sector. Better availability of flight data with ERAM will allow some conflicts that would have been displayed previously as Mode-C Intruder (MCI) alerts to be displayed as conflict alerts between two paired aircraft.</td></tr>
<tr><td colspan="2">In 3 miles, data block color change from yellow to red suggested. 10 seconds to respond.</td></tr>
<tr><td rowspan="2">Minimum Safe Altitude Warning (MSAW)</td><td>
</td><td>During a Minimum Safe Altitude Warning (MSAW) alert for an aircraft. MSAW and the warning altitude characters blink in a time share in Field E of the data block.</td></tr>
<tr><td colspan="2">Flash the whole data block in red.</td></tr>
<tr><td rowspan="2">Coast
(CST)</td><td>
</td><td>The aircraft is in coast status and blinks when a flight's position is frozen, and “CST” is eligible for display in Field E of the data block. The position symbol becomes #.</td></tr>
<tr><td colspan="2">Red and flashing because it can be serious.</td></tr>
<tr><td rowspan="2">Emergency
(EMRG)</td><td>
</td><td>An alerting condition in which beacon code 7700 is returned. A blinking “Emergency (EMRG)” is displayed in Field E of the data block.</td></tr>
<tr><td colspan="2">Change to red color. Flashing.</td></tr>
<tr><td rowspan="2">Hijack
(HIJK)**
(Limited Data block)</td><td>
</td><td>(in the limited data block)
An alerting condition in which beacon code 7500 is returned. A blinking “Highjack (HIJK)” is displayed in Field E of the data block.</td></tr>
<tr><td colspan="2">Make the limited data block into full data block. Change the color of HIJK from the baseline color to a different color.</td></tr>
<tr><td rowspan="2">Hijack
(HIJK)** (Full data block)</td><td>
</td><td>(in the full data block)
“HIJK” blinks. An alerting condition in which beacon code 7500 is returned. A blinking “Highjack (HIJK)” is displayed in Field E of the data block.</td></tr>
<tr><td colspan="2">The whole data block to flash. Make HIJK red.</td></tr>
</table>

	System Status Condition (Status Active)*		The STATUS Button displays the mode of the selected channel (ACTIVE, BACKUP, PENDING, or TEST). The STATUS Button changes to yellow when there is a change to the Status View. Selecting the STATUS Button opens the STATUS View where unacknowledged conditions are underlined.
		More information. Okay format.	
	Outage Condition (Outage)*		There are five states of the OUTAGE Button along with color-coding convention for each outage. If an outage occurs when the Outage List is not displayed, the OUTAGE Button will be emphasized: Yellow background/black text indicates an outage change occurred and the Outage List is suppressed.
		Click to get more information, and it works fine. More Information.	
	Abnormal Uplink/Abnormal Response to Route Uplink		An abnormal response to a route uplink is indicated by an orange box outline of a white triangle to the left of the associated route in the Aircraft List of the Radar Associate (RA) position. Abnormal responses include: UNABLE, FAILURE, or ERROR. Voice contact with the pilot is required to ensure common understanding of the current route assignment.
		The whole ROUTE information needs to be in red, not just one component,	

Too Much Attention-Grabbing

	Hijack (HIJK)** (Limited Data block)		A paired LDB alert condition displays ACID and Mode C altitude with no position symbol, leader line, or velocity vector and is displayed at LDB brightness. An unpaired LDB displays the same except a Beacon Code instead of ACID. Blinking is produced when the beacon code is 7600, 7700, or one of the two adapted special beacon codes.
		In the limited data block, no need to make it flashing. Make the limited data block into full data block. Change the color of HIJK from the baseline color to a different color.	

More Information Needed

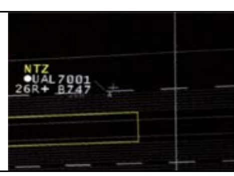
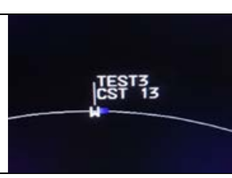
	System Status Condition (Status Active)*		The STATUS Button displays the mode of the selected channel (ACTIVE, BACKUP, PENDING, or TEST). The STATUS Button changes to yellow when there is a change to the Status View. Selecting the STATUS Button opens the STATUS View where unacknowledged conditions are underlined.
		Okay format. More information.	
	Outage Condition (Outage)*		There are five states of the OUTAGE Button along with color-coding convention for each outage. If an outage occurs when the Outage List is not displayed, the OUTAGE Button will be emphasized: Yellow background/black text indicates an outage change occurred, and the Outage List is suppressed.
		Click to get more information, and it works fine. More Information to be shown.	

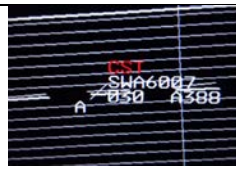
ATCT/TRACON (STARS)

NO NEED TO CHANGE

Low Altitude Alert Condition (LA)		Flashing. A safety alert for when an aircraft reaches a minimum unsafe adapted altitude. A flashing red “Low Altitude (LA)” is produced in line 0 of the data block for a limited amount of time, before turning steady red. A safety audible alert is also present that can be suppressed by controller acknowledgement.
	Fine. The sound is good. That makes me look it up immediately.	
Increased Separation Required (ISR)*		Limited data block. “Increased Separation Required (ISR)” is displayed in yellow on line 0 of the data block. In fused mode, this represents a loss of radar quality and position uncertainty.
	This is good information saying a sensor is not working, and I need to increase a separation. Yellow is good too. We do not have this now. Yellow is good enough. No need to flash.	
Track Position Uncertainty (TRK)		Track position is uncertain, and yellow “TRK” is shown in line 0 of the data block. In single sensor, if the positional uncertainty of the track exceeds the intermediate separation threshold, the target symbol is not displayed, and “TRK” is displayed in the data block. In addition, if the track is beyond the range of any sensor or radar that can support standard or increased separation, the target symbol is similarly not displayed, and “TRK” is displayed in the data block. In fused mode, non–radar separation is required.
	Yellow is good to draw attention to this TRK. No flashing is fine.	
Radio Failure (RF)		Sound. Squawk code 7600 (Radio Failure) is received from the aircraft. The Primary Special Condition Code produces a flashing red “RF” in line 0 of the data block for a limited amount of time, before turning steady red. Also, a Special Condition Code audible alert is present that can be suppressed by controller acknowledgement.
	The same sound as EM.	
Minimum Fuel (MF)*		The Secondary Special Condition Code defined in adaptation data produces a flashing yellow “MF” in line 0 of the data block for a limited amount of time, before turning steady yellow. Also, a Special Condition Code audible alert can be suppressed by controller acknowledgement.
	We put Min in the scratch pad and tell Tower Min. It happens often. More pronounced. Audio. No flashing is fine.	

	Emergency (EM)		Squawk code 7700 (Emergency) is received from the aircraft. The Primary Special Condition Code produces a flashing red “EM” in line 0 of the data block for a limited amount of time, before turning steady red. Also, a Special Condition Code audible alert can be suppressed by controller acknowledgement.
		We have it. Alarm everywhere. The audio warning is better than just flashing. It flashes and then goes steady.	
	Unreasonable Altitude (XXX)		A white flashing “XXX” in line 2 of the data block indicates an invalid altitude in the data block. The condition is due to an unreasonable altitude (Mode-C data is being received, but at an unreasonable change rate).
		It looks ok. Altitude is unverified. Normally, the only time you will see something like that is if it is an aircraft that is rapidly climbing and they cannot receive a good indication on the altitude.	
	Hijack (HJ)		Squawk code 7500 (Hijacking) is received from the aircraft. The Primary Special Condition Code produces a flashing red “HJ” in line 0 of the data block for a limited amount of time, before turning steady red. Also, a Special Condition Code audible alert can be suppressed by controller acknowledgement.
		Standard. All good. We have it.	
	No Weight Category (NOWGT)		No weight category produces a yellow “NOWGT” in line 3 of the data block, indicating a lack of aircraft type in the flight plan.
		We do not have it. Good to have it.	
	Point Out (PO)		A flashing yellow “PO” to the receiver (turns steady yellow on acknowledgment) indicates an aircraft is close to the receiver's airspace under sender's control.
		Saw many times. It is not automatic now.	
	Radar only (RDR)*		A white “RDR” in line 2 of the data block indicates primary radar track only, no beacon code/Mode-C altitude.
		Make RDR in red and flashing. The same color is fine. Flashing will be good.	

	Runway Error (RWY)*		Current runway error (mismatch) for this track. The track is an arrival to the airport associated with the Active Monitor Zone (AMZ) that has stabilized its course on approach to a runway that does not match the track's runway assignment (it could be that the track has no runway assignment). The alert abbreviation "RWY" appears in the track's data block (top line) and flashes in red. After acknowledgment, the indication no longer flashes. The audible voice alarm utters the aircraft's ACID followed by "WRONG RUNWAY." The voice alert is generated once at the onset of the alert condition. Acknowledging this condition silences the aural indications if in progress.
		We do not have it. Useful. Clearer descriptions than simply showing RWY in red. It caught my eyes.	
	Service Level Not Available Banner*		The appearance of this banner indicates the selected Service Level (FSL, EFSL, or ESL) has been set to unavailable at the Maintenance Control Position (MCP) for that service level. If this banner appears, the radar window is not frozen.
		We do not have it. Useful banner. More information about it is better. I expect Tech Ops would work on it.	
	Full Service Level Banner Failure (QIE)		Red banner message at the top of the display to indicate Full Service Level (FSL) is defective, go to Emergency Full Service Level (EFSL).
		Not emergency, but a bigger notice will be better. This big notification is good.	
	Non-Transgressional Zone Indicator (NTZ)*		Limited. "NTZ" flashing. Voice. Non-Transgression Zone (NTZ) Warning indicates the track has entered the NTZ after being detected in the Normal Operating Zone (NOZ) and produces a Final Monitoring Aid (FMA)-enabled aural (voice alert - aircraft's Aircraft ID (ACID) followed by "Warning") alarm and visual alert for zones between the runways. A Current NTZ violation results in a red zone border, and the alert abbreviation "NTZ" appears in the track's data block (line 0) and flashes in red.
		We do not have it. Useful. More red. Voice is good.	
	Non-Transgressional Zone Indicator (NTZ)*		Limited. "NTZ" not flashing. No Transgression Zone (NTZ) Caution indicates predicted NTZ violations and produces visual (yellow "NTZ" in the track's line 0 and yellow zone border) and audible (Aircraft ID [ACID] followed by "Caution").
		We do not have it. Make it red.	
	Coasting (Non-Final Monitoring Aid)*		White "CST" in line 2, field 1 of the data block indicates the beacon is lost due to landing or bad/deactivated transponder.
		It can be temporary, so let's wait for two sweeps and then make it in yellow with auditory warning. Ninety percent of the time it will come back. No need to to have a different color or make it flash.	

	Coasting (Final Monitoring Aid). *		The condition occurs when surveillance has been lost, as sensor updates are missing for an adapted number of seconds for a track that is in an Active Monitor Zone (AMZ) and has an assigned runway. "CST" appears in the track's data block (line 0) and flashes in red. The audible voice alarm utters the aircraft's Aircraft ID (ACID) followed by "COAST." The voice alert is generated once at the onset of the alert condition.
		An auditory warning is not needed because we are visual people. Red is good. We do not have it. Both voice and red are good. Red and flashing fine.	
	Ambiguous Interfacility Handoff (AMB)*		An Ambiguous Interfacility Handoff indicates an aircraft target location does not correspond with the track update. The condition produces "AMB" in a toggle/time share in line 2 of the data block.
		We have it now. The same color is fine. A different color would be better.	
	Track Radar Blind Area or Freeze Region (ZZ)		A white flashing "ZZ" in line 2 of the data block indicates no altitude is being received.
		This is new. Good to look and know that there is no Mode C. Blank works fine too. We have it here - 185.	
	WHO Patch Zones/Areas(WHO) *		WHO Patch Zones/Areas can contain beacons or ACID with a flashing (white, if owned / green, if unowned) "WHO" in the data block. The condition can occur due to aircraft departing without a flight plan or auto-association has not yet occurred.
		It looks okay. At the facility, the whole data block with this WHO flashes in yellow, not here. Green if owned. White if not owned.	
	Conflict Alert (CA) or Mode C Intruder (MCI) condition (CA)		A safety alert for when an owned aircraft or an aircraft of interest is involved in conflict or MCI, a condition which is an existing or pending situation between a tracked target and an untracked target. A flashing red "CA" or "MCI" is produced in line 0 of the data block for a limited amount of time, before turning steady red. A safety audible alert is also present that can be suppressed by controller acknowledgement.
		The picture is wrong, showing aircraft on the top of each other (NOTE: We should not have presented this image to the controllers.). I liked the different sound from LA sound, which is the same now in the field.	
	Minimum Fuel (MF)*.		In yellow. The Secondary Special Condition Code defined in adaptation data produces a flashing yellow "MF" in line 0 of the data block for a limited amount of time, before turning steady yellow. Also, a Special Condition Code audible alert can be suppressed by controller acknowledgement.
		We put Min in the scratch pad and tell Tower Min. It happens often. More pronounced with audio. No flashing is fine.	

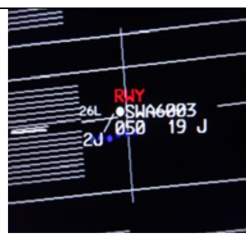
	Non ARTS Track (NAT)		No data update from our sensors. Non-ARTS Track produces a white "NAT" in line 2 of the data block. The data block freezes due to no data updates.
		We have it. No need for flashing or a different color. I will talk to the facility it is coming from, to take a hand off or to hand it off.	
	Duplicate Beacon (DB)*		Limited data block. A white "DB" in line 2 of the data block occurs when two aircraft with the same beacon are in the airspace. A slash symbol (/) will also appear in the flight plan.
		We have it. Okay presentation. It is important and should flash. The same color and no flashing is fine.	
	Automatic Terminal Proximity Warning Cone (Yellow Cone)*		An optional command is available for the controller to display a Terminal Proximity Alert (TPA) Cone. TPA Cones can be used to assist controllers in maintaining separation between aircraft. A yellow visual indicator cone represents a warning of predicted loss of separation parameters.
		No need to have a cone. Because two same things, the cone and the number. **We have it now. The color could change from yellow to red depending on the distance between two aircraft. A brighter color will be better.**	
	Automatic Terminal Proximity Warning Cone (Red Cone)**		An optional command is available for the controller to display a Terminal Proximity Alert (TPA) Cone. TPA Cones can be used to assist controllers in maintaining separation between aircraft. A red visual indicator cone represents a loss of separation parameters.
		We have it. No overlapping is better. More red and direct line instead of a cone. **It looks fine.**	
	Call Sign Mismatch (CSMM)*		A white "CSMM" in line 3 of the data block is produced when the call sign reported does not correspond to the call sign in the flight plan/assigned.
		Never saw. You know, the call sign is generated from the beacon. So if the call sign is wrong, how does it know what to associate a call sign with?	

NEED TO CHANGE

More Salient Presentation Needed

Automatic Terminal Proximity Warning Cone (Yellow Cone)*		An optional command is available for the controller to display a Terminal Proximity Alert (TPA) Cone. TPA Cones can be used to assist controllers in maintaining separation between aircraft. A yellow visual indicator cone represents a warning of predicted loss of separation parameters.
	No need to have a cone. Because two same things, the cone and the number. We have it now. The color could change from yellow to red depending on the distance between two aircraft. A brighter color will be better.	
Automatic Terminal Proximity Warning Cone (Red Cone)**		An optional command is available for the controller to display a Terminal Proximity Alert (TPA) Cone. TPA Cones can be used to assist controllers in maintaining separation between aircraft. A red visual indicator cone represents a loss of separation parameters.
	We have it. No overlapping is better. More red and direct line instead of a cone. It looks fine.	
Duplicate Beacon (DB)*		Limited data block. A white "DB" in line 2 of the data block occurs when two aircraft with the same beacon are in the airspace. A slash symbol (/) will also appear in the flight plan.
	We have it. Okay presentation. It is important and should flash. The same color and no flashing are fine.	
WHO Patch Zones/Areas(WHO) *		WHO Patch Zones/Areas can contain beacons or ACID with a flashing (white, if owned / green, if unowned) "WHO" in the data block. The condition can occur due to aircraft departing without a flight plan or auto-association has not yet occurred.
	It is okay. At the facility, the whole data block with this WHO flashes in yellow, not here. Green if owned. White if not owned.	
Ambiguous Interfacility Handoff (AMB)*		An AMB indicates an aircraft target location does not correspond with the track update. The condition produces "AMB" in a toggle/time share in line 2 of the data block.
	We have it now. The same color is fine. A different color would be better.	

	Non-Transgressional Zone Indicator (NTZ) (red)*		NTZ flashing. NTZ Warning indicates the track has entered the NTZ after being detected in the Normal Operating Zone (NOZ) and produces a Final Monitoring Aid (FMA) -enabled aural (voice alert - aircraft's Aircraft ID (ACID) followed by "Warning") alarm and visual alert for zones between the runways. A Current NTZ violation results in a red zone border, and the alert abbreviation "NTZ" appears in the track's data block (line 0) and flashes in red.	
		We do not have it. Useful. More red. Voice is good.		
	Non-Transgressional Zone Indicator (NTZ) (yellow)*		NTZ no flashing. NTZ Caution indicates predicted NTZ violations and produces visual (yellow "NTZ" in the track's line 0 and yellow zone border) and audible (Aircraft ID [ACID] followed by "Caution") alerts.	
		We do not have it. Make it red.		
	Coasting (Non-Final Monitoring Aid)*		White "CST" in line 2, field 1 of the data block indicates the beacon is lost due to landing or bad/deactivated transponder.	
		It can be temporary, so let us wait for two sweeps and then make it in yellow with auditory warning. Ninety percent of the time it will come back. No need to to have a different color or make it flash.		
	Coasting (Non-Final Monitoring Aid)*		Flashing and voice. Limited. The condition occurs when surveillance has been lost, as sensor updates are missing for an adapted number of seconds for a track that is in an Active Monitor Zone (AMZ) and has an assigned runway. "CST" appears in the track's data block (line 0) and flashes in red. The audible voice alarm utters the aircraft's Aircraft ID (ACID) followed by "COAST." The voice alert is generated once at the onset of the alert condition.	
		An auditory warning is not needed because we are visual people. Red is good. We do not have it. Both voice and red good. Red and flashing fine.		
	Minimum Fuel (MF)*.		In yellow. In yellow. The Secondary Special Condition Code defined in adaptation data produces a flashing yellow "MF" in line 0 of the data block for a limited amount of time, before turning steady yellow. Also, a Special Condition Code audible alert can be suppressed by controller acknowledgement.	
		We put Min in the scratch pad and tell Tower Min. It happens often. More pronounced with audio. No flashing is fine.		
	Radar Only (RDR)*		A white "RDR" in line 2 of the data block indicates primary radar track only, no beacon code/Mode-C altitude.	
		Make RDR in red and flashing. The same color is fine. Flashing will be good.		

Too Much Attention-Grabbing			
	Coasting (Non-Final Monitoring Aid)*		Flashing and voice. Limited. Flashing and voice. Limited. The condition occurs when surveillance has been lost, as sensor updates are missing for an adapted number of seconds for a track that is in an Active Monitor Zone (AMZ) and has an assigned runway. "CST" appears in the track's data block (line 0) and flashes in red. The audible voice alarm utters the aircraft's Aircraft ID (ACID) followed by "COAST." The voice alert is generated once at the onset of the alert condition.
		An auditory warning is not needed because we are visual people. Red is good. We do not have it. Both voice and red good. Red and flashing fine.	
	Increased Separation Required (ISR)*		Limited data block. "ISR" is displayed in yellow on line 0 of the data block. In fused mode, this represents a loss of radar quality and position uncertainty.
		This is good information saying a sensor is not working, and I need to increase a separation. Yellow is good too. We do not have this now. Yellow is good enough. No need to flash.	
More Information Needed			
	Runway Error (RWY)*		Current runway error (mismatch) for this track. The track is an arrival to the airport associated with the AMZ that has stabilized its course on approach to a runway that does not match the track's runway assignment. The alert abbreviation "RWY" appears in the track's data block (top line) and flashes in red. After acknowledgment, the indication no longer flashes. The audible voice alarm utters the aircraft's ACID followed by "WRONG RUNWAY." The voice alert is generated once at the onset of the alert condition. Acknowledging this condition silences the aural indications if in progress.
		We do not have it. Useful. Clearer descriptions than simply showing RWY in red. It caught my eyes.	
	Call Sign Mismatch (CSMM)*		New. A white "CSMM" in line 3 of the data block is produced when the call sign reported does not correspond to the call sign in the flight plan/assigned.
		Never saw. You know, the call sign is generated from the beacon. So if the call sign is wrong, how does it know what to associate a call sign with?	
	Service Level Not Available Banner*		The appearance of this banner indicates the selected Service Level (FSL, EFSL, or ESL) has been set to unavailable at the Maintenance Control Position (MCP for that service level. If this banner appears, the radar window is not frozen.
		We do not have it. Useful banner. More information about it is better. I expect Tech Ops would work on it.	