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Assessment of Current and Proposed Audio Alarms in Terminal Air Traffic Control

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16. Abstract

The National Airspace System Human Factors Branch (ACT-530) has been engaged in research on the characteristics and use of audio alerts and alarms in Air Traffic Control. In support of this program, Federal Data Corporation performed a comparative study of current audio alarms used in airport towers and Terminal Radar Approach Controls (TRACONs) with those proposed for use with the Standard Terminal Automation Replacement System. This study involved a review of relevant documents and extensive discussions with personnel at the Detroit Wayne County Metropolitan Airport (DTW) Tower and TRACON. We evaluated the current and proposed audio signals relative to studies on discriminability and audio signal use and existing design standards. In addition, we examined several operational issues raised by the DTW personnel. We present recommendations for initial implementation and long-term studies and modifications.

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Executive Summary

The National Airspace System Human Factors Branch (ACT-530) has been engaged in research on the characteristics and use of audio alerts and alarms in Air Traffic Control (ATC), including a database of current and proposed signals. The Standard Terminal Automation Replacement System (STARS) will provide a common equipment suite to replace the three different systems currently in use at airport towers and Terminal Radar Approach Controls (TRACONs). The STARS presents a good opportunity to use the results of the audio studies. It will provide significantly improved display capability to towers and TRACONs. The Federal Aviation Administration Office of Air Traffic Systems Development is guiding the development of the STARS. As part of the development, Raytheon Systems Company has proposed a set of audio signals to replace those currently used to alert personnel to problems that need immediate attention. The selected audio frequencies and tonal patterns of the proposed STARS audio alarms are different from those in use at present.

In support of this program, the Federal Aviation Administration and Federal Data Corporation researchers performed a comparative study of the current and proposed audio alarms. We conducted this research to determine whether changes in the signal characteristics would prove beneficial to tower and TRACON personnel in controlling aircraft. The audio signals are not used independently but in conjunction with the visual displays. This is a significant consideration in evaluating the use of the audio. The research involved a review of relevant documents and extensive discussions with airport personnel at the Detroit Wayne County Metropolitan Airport (DTW) Tower and TRACON.

We evaluated both the current and proposed audio signals relative to studies on discriminability and audio signal use and to existing design standards. In addition, DTW personnel identified several issues as operational problems. We have included a discussion of these issues in this study. We also provide recommendations for short-term changes and for studies to address long-term considerations.

Key conclusions include the following:

a. The goal of an auditory/visual signal pair is to minimize the time for an accurate controller response.

b. The priorities and use of alarms will vary between the tower and TRACON environments.

c. There are no standards for the uniqueness and discriminability of alarms in ATC.

d. Audio alarms go off too often, and there are too many false alarms.

e. Visual flight rules landings at smaller airports trigger Minimum Safe Altitude Warning (MSAW) alarms at TRACONS.

f. Current MSAW and Conflict Alert (CA) alarms are often confused because they are identical in ARTS II and IIIA. In STARS, they will be different.

g. TRACON controllers note that the CA alarm is often too late, leaving them little time for action. An earlier caution alarm would provide more time to prevent separation loss.

h. STARS offers color-coding to speed visual search once the audio alarm has activated.

Recommendations for short-term modifications and for studies to address long-term issues include:

a. Use frequency separation as the primary source of discriminability for different alarms. Use 800 and 1600 hertz tones for the CA and Mode C Intruder alarms, respectively, and the two-tone warble for MSAW.

b. Limit the time duration of audio alarms. The operator should not have to terminate the alarm.

c. Reduce the frequency of irrelevant/false alarms.

d. Research the use of too many alarms and design for the minimum number required.

e. Where possible, code severity of the situation into the alarm.

f. Limit the audience of audio alarms to those who need to hear them.

1. Introduction

The National Airspace System Human Factors Branch, ACT-530, of the Federal Aviation Administration (FAA) William J. Hughes Technical Center is researching the characteristics and use of audio alerts and alarms in Air Traffic Control (ATC), including a database of current and proposed signals (Ahlstrom, 1999a). The database provides a basis for comparative analysis and can serve as an input to simulation. The studies and database serve as a foundation for applied studies that can predict effectiveness of audio alarms in ATC operations. ACT-530 tasked Federal Data Corporation to research the audio alarms currently used in airport towers and Terminal Radar Approach Controls (TRACONs) and the proposed audio alarms for the Standard Terminal Automation Replacement System (STARS). The FAA Office of Air Traffic Systems Development is guiding the development of the STARS. This study examines the current tower and TRACON audio alarms and proposed STARS audio alarms and identifies possible improvements to the use of audio signals in the tower and TRACON environments.

1.1 Background

Nonverbal audio signals are used in towers and TRACONs to alert personnel to conditions that represent potential safety risks or other conditions requiring attention. The personnel must then obtain detailed information about the problem from a visual display. This means that the audio signals are not independent but operate in conjunction with the visual presentation (i.e., a bimodal display, see Obermayer, 1999).

Currently, the audio signals being used vary according to which equipment is present at the facility. Each system has its own set of audio signals that vary not only in their aural characteristics but also as to what conditions generate the signals. Tower and TRACON personnel have indicated that there are problems associated with the current audio signals.

The STARS is intended to provide all towers and TRACONs with a standard equipment set. It will replace the current three versions of the Automated Radar Terminal System (ARTS), the ARTS II, ARTS IIIA, and ARTS IIIE. STARS includes two user consoles, the Tower Display Workstation and the Terminal Controller Workstation. This system offers significantly enhanced display and control capability over the ARTS with improved color, data coding, the ability to separate data blocks, and many other improvements. Of significance to this study is that, with the introduction of the STARS, a common set of audio signals will be present for the alarms generated by aircraft control problems.

1.1.1 Current Audio Alarms

Currently, the ARTS II uses a single audio alarm for Conflict Alert (CA) and Minimum Safe Altitude Warning (MSAW). ARTS IIIA uses separate CA and MSAW alarms, but they are effectively indistinguishable from each other. ARTS IIIE CA and MSAW alarms use the same frequency (2800 Hz) and use on/off patterns that may not be easily differentiated from each other. The ARTS II hijack alarm is a continuous tone at 2770 Hz, which makes it easily recognized. The ARTS IIIE scatter alarm is close in frequency to the CA and MSAW alarms at 2730 Hz. Its on/off timing cycle ranges between the CA and MSAW alarms.

There are also several equipment failure alarms that are present as stand-alone alarms for specific equipment. Instrument Landing Systems (ILS) and runway lights are examples of equipment and systems that are alarmed. There is no coordination of parameters among these equipment system alarms or between the equipment alarms and the ARTS alarms. Personnel must often take significant time to determine which equipment has alarmed because the different alarms are not clearly discriminable. Further, some of these alarms are not self-limiting or cannot be turned off by simply acknowledging them. They continue until action is taken. The frequency and on/off pattern for the independent equipment alarms appear to be similar to the ARTS alarms, but we did not obtain exact frequencies and patterns.

1.1.2 Proposed STARS Alarms

The proposed STARS CA, MSAW, and Mode C Intruder (MCI) alarms serve the same purposes as the current ones. The Special Transponder Emergency Codes (SPC) alarm is a special code alarm for hijack, radio failure, and emergency codes (7500, 7600, and 7700). It appears to be similar in function to the ARTS II Hijack alarm. None of these STARS alarms uses the same frequency and pattern as the current versions. The Critical Subsystems Failure alarm is intended for the STARS self-monitoring. It appears to be similar to the ARTS IIIE Scatter alarm. The Default alarm was added to cover any audio alarm requirements not covered by the other five.

The proposed STARS alarms should be more readily identifiable than the current alarms. The CA uses a 1600 Hz tone with a rapid 60-ms/60-ms period. The MCI also uses 1600 Hz but with a longer 130-ms/130-ms period. The STARS MSAW alarm is the only one in either the current or the proposed sets to use a two-tone “warble” signal. This provides a unique and highly discriminable signal.

1.1.3 Current and Proposed Alarm Summary

Table 1 provides a summary of alarms that are currently used and those proposed for STARS implementation (Ahlstrom, 1999b).

2. Methodology

We based our analysis on a review of relevant documents and on discussions with personnel at the Detroit Wayne County Metropolitan Airport (DTW) Tower and TRACON. We also held conversations with personnel from Raytheon Systems Company. We conducted interviews at DTW because of the availability of personnel.

2.1 Documentation

Primary documentation sources included descriptive documents and audio files of the current and proposed audio alarms provided by ACT-530 (Ahlstrom, 1999b), audio alarm/alert standards used by the Department of Defense (DOD) and by NASA (DOD, 1989a; DOD, 1989b; NASA, 1995), and research reports on human acoustic capabilities and use of audio signals in operational systems (Boff & Lincoln, 1988; Boucek, Veitengruber & Smith, 1977; Fitts, 1951; Obermayer, 1999; Seminara, 1965; Siegel & Crain, 1960; Wagner, Birt, Snyder, & Duncanson, 1996).

Table 1. Characteristics and Use of Current and Proposed Audio Alarms for Towers and TRACONs

		Current			Proposed
ALARM	**USE**	**ARTS II**[a]	**ARTS IIIA**[b]	**ARTS IIIE**	**STARS**
Conflict Alert	Loss of separation between aircraft	f: 1400 Hz 100 ms/100 ms	f:1355 Hz 90 ms/80 ms	f:2800 Hz 250 ms/40 ms	f:1600 Hz 60 ms/60 ms double beep
Minimum Safe Altitude Warning	Aircraft below defined IFR approach path	f:1400 Hz 100 ms/100 ms	f: 1360 Hz 90 ms/80 ms	f:2800 Hz 650 ms/100 ms	f:1600/to 2000 Hz warble 260 ms at 1600 Hz, 180 ms at 2000 Hz
Mode C Intruder	Possible conflict between tracked and untracked aircraft altitudes	---	---	---	f: 1600 Hz 130 ms/130 ms
Hijack Alarm – 7500	Transponder warning of possible hijack	f: 2770 Hz continuous	---	---	---
Scatter Alarm	Beacon system problem	---	---	f: 2730 Hz 140 ms/90 ms[c]	—
Default	Not defined – available for future use	---	---	---	f: 800 Hz 60 ms/60 ms
Special Transponder Emergency Codes (includes Hijack, Emergency, RF)	Transponder emergency warning	---	---	---	f: 1400 Hz 600 ms/250 ms
Critical Subsystem Failure (Similar in function to Scatter)	Warning of STARS equipment problem	---	---	---	f: 800 Hz 250 ms/500 ms[c]

[a] one alarm for both CA and MSAW
[b] CA and MSAW alarms essentially indistinguishable
[c] STARS Critical Subsystem Failure alarm function is similar to ARTS III E Scatter alarm

2.2 Discussions

We held nearly 5 hours of discussions with key personnel at the DTW Tower and TRACON. Due to the operational environment and limited time, we did not use a formally structured interview process. We interviewed personnel at or near their work areas, discussing the audio alarms and their use. We asked specific questions about frequency of occurrence, importance of alarms to operations, workload associated with the alarms, how the auditory alarms interacted with the visual displays, and problems in using the alarms. The interviewees were free to spend as much time as they wished on any of the questions or on related issues such as differences in operations between the tower and TRACON. Additionally, Raytheon Systems Company provided information about the proposed STARS alarm parameters and data on what would be involved to modify the alarm parameters.

3. Results

The following sections describe the results of the analyses performed for this study. They identify operational, personnel-related, and STARS alarm issues.

3.1 Operating Differences Between the Tower and TRACON

Based on discussions with DTW Tower and TRACON personnel, there is a significant difference between their operations that affects the way personnel respond to the alarms. Tower personnel spend much of their time looking out the windows at specific aircraft near the airport. They are less dependent on the radar displays available to them. In the TRACON, the radar displays are the major tool. Further, the TRACON is involved with a much greater volume of space and will normally control many more aircraft than the tower. These task and environmental differences lead to different priorities relative to the audio alarms. Tower personnel tend to consider the MSAW as requiring more immediate attention than the CA. In the TRACON, the CA is given higher priority. This difference in relative ranking does not imply that the lower ranked alarm is ignored or considered unimportant. Rather, it reflects the immediate requirements of the tower and TRACON. The DTW personnel expect that when the Airport Movement Area Safety System (AMASS) is installed, it will become the top priority alarm. However, AMASS uses voice messaging for possible low altitude and ground conflicts. It will not replace the CA alarm. Because these differences are task based, similar priorities could be expected at other towers and TRACONs.

Additionally, using three different versions of the ARTS with different audio alarms, there must necessarily be differences in procedures in respect to the alarms. These are in addition to the differences between the tower and TRACON operations. The DTW personnel indicated that procedures differed among airports, but this was not covered in detail. Introduction of the STARS as a common equipment suite should reduce these differences and provide better procedural standardization. However, some differences will remain, for example, differences between airports that perform synchronized landings (two aircraft landing simultaneously on adjacent parallel runways, usually with less than normal separation, during high-density conditions) and those that do not have that capability. This study discusses the procedures used at DTW, which include synchronized landings.

3.2 Personnel-Identified Issues

The primary problems expressed by personnel at DTW are an excessive number of alarms and the occurrence of irrelevant alarms. This is consistent with earlier data (Ahlstrom, 1999b). Irrelevant alarms are CA, MSAW or MCI alarms that occur, although there is no operational problem for the aircraft generating the alarm. These alarms do meet the algorithmic criteria for generating the alarm. However, they have no operational value.

For example, when two aircraft are performing synchronized landings, they may violate the minimum separation criteria for generating a CA and do so continuously during the landing. Because synchronous landing is done routinely during heavy traffic periods, there are repeated

CA alarms as each pair of aircraft lands. Although the audio alarm stops after several seconds, the data blocks continue to blink for the entire landing. There is no exclusion zone capability for the CA alarm that would prevent the alarm from occurring along the runway. The CA, therefore, becomes an annoyance factor. The Air Traffic Control Specialist (ATCS) must perform a search each time the CA occurs to confirm that it is a landing-generated alarm rather than a potential conflict elsewhere. This could potentially lead to a minimum separation problem not being recognized quickly if a controller assumes the alarm is due to a synchronized landing.

A second example involves the MSAW. Typically, a TRACON area includes smaller commercial and private airfields in addition to a major airport. Smaller aircraft land at these fields under Visual Flight Rules (VFR) conditions much of the time. The MSAW algorithm criteria are oriented toward large commercial aircraft landing at the major airport under Instrument Flight Rules (IFR). Many of the VFR aircraft at the ancillary fields violate those criteria routinely and safely. However, these aircraft will generate an MSAW alarm. ATCSs must take time to identify which of the many data blocks is involved. This takes time on a high-density radar display, and controllers find the large number of irrelevant alarms annoying and possibly distracting. Current exclusion areas do not appear to correct the problem. Reducing the number of irrelevant audio alarms should prove valuable.

3.3 STARS Alarm Issues

The STARS Human Factors Review (STARS Human Factors Team, 1997) briefly addressed audio alarm issues in the STARS. Here, we consider alarm issues in detail. There appear to be two immediate essential issues relating to the current and proposed STARS alarms. These are the uniqueness and discriminability of the alarms and the frequency of occurrence and usability of the alarms. For longer-term consideration, there are issues relating to the type of alert/alarm, the coordinated use of audio and visual alarms and signals, and possible integration of alarms. Both NASA and the DOD have established guidelines and standards for audio alarms and alerts (DOD, 1989a; DOD, 1989b; NASA, 1995). The FAA has performed studies of audio alarms and alerts for aircraft cockpits, but it has not established comparable standards for air traffic control environments. Section 7.3.2 of the FAA Human Factors Design Guide (Wagner et al., 1996) provides design guidelines; however, these are not a design standard.

3.3.1 Discriminability of Alarms

Comments obtained by ACT-530 indicate that confusion between current CA and MSAW alarms is a problem (Ahlstrom, 1999b). The short tones and presence of masking noise from the background make the alarms less discriminable. Operationally, it appears that controllers often count on the radar display data block to make certain what alarm has activated, especially in the TRACON. Discriminability requirements have long been established for human response to sound, both in the laboratory and in operational environments (Fitts, 1951; Seminara, 1965; Siegel & Crain, 1960). Overall, the proposed STARS alarms offer a more discriminable set of tones and patterns than the current signals.

3.3.2 Use and Frequency of Alarms

The problem of alarm discriminability can usually be resolved by selection of the physical parameters of the signal, but the problems of excessive alarms and use of the alarms is more complex. Audio alarms in the tower and TRACON are used to get the attention of personnel and to give them an indication of the type of problem involved. They are not used to provide specific track data. That is provided in the data block. The audio alarms are not used independently but in conjunction with the visual displays available to the ATCS. In this, they differ from voice message systems such as AMASS, where the data are provided by the audio message as well as by a visual display. The goal of the alarm/visual display combination should be to permit the controller to identify, respond to, and correct the problem that generated the alarm as quickly as possible, without errors, and with minimum added workload. Audio alarms are usually intended to indicate one of three levels of required response (DOD, 1989b; NASA, 1995; Seminara, 1965):

a. Advisory: These indicate a marginal condition that needs to be addressed but that there is no immediate danger.
b. Caution: These indicate some out-of-tolerance conditions that need immediate correction to prevent a more serious condition from occurring.
c. Warning: These indicate an immediate response is mandatory to prevent a dangerous problem from occurring or continuing.

The CA, MSAW, and MCI alarms all indicate a loss of separation, either between aircraft or between an aircraft and the ground or airspace. TRACON personnel indicated that the CA alarm is often too late, meaning that it does not occur until a larger loss of separation occurs than is desirable. This implies that the available time to respond to the alarm and correct the problem is shorter than the controllers feel is needed.

The alarms are currently interpreted as warnings. In part, this is related to the apparent lateness of occurrence reported by TRACON ATCSs. It would be preferable if the alarms were issued as cautions. That is, they should occur well before separation criteria are violated. If a controller then issues instructions to an aircraft to correct a loss of separation and the problem persists or gets worse, the alarm system does not now make any differential response. Moving from a caution to a warning does not occur. The only way the controller knows that the corrective action was not taken is by monitoring the data block values. Under high-density conditions, this adds significantly to the workload and potentially could lead to operational errors.

Because it is necessary to identify the source of an alarm on the radar display once it has sounded and the goal is rapid response, a means to speed the visual identification of the aircraft generating the alarm should be considered. In this respect, the enhanced displays in the STARS, which provide the capability for color-coding, variable alphanumeric sizes, and the ability to separate overlapping data blocks, can prove valuable.

4. Recommendations

The following sections provide recommendations for short-term implementation and for consideration for use in the STARS.

4.1 Near-Term Implementation

The following recommendations address some of the problems present in the current ARTS II and III environments and a recommended approach. It should be feasible to incorporate these suggestions into the initial installations of the STARS. Making these changes to existing ARTS installations does not appear to be cost effective.

1. For improved discriminability of the alarm signals, the use of the STARS frequencies of 800 Hz and 1600 Hz for the CA and MCI alarms and the two-tone "warble" alarm for the MSAW alarm should be implemented. In the STARS, the tones are generated from audio files, which can be changed easily if different frequencies are selected.

   Approach: *These exact frequencies are not critical, but there should be at least a 400 Hz separation in frequency between any two alarms. The ability to discriminate tone or pitch differences is significantly better than this, but the use of short tones and operation in noisy environments degrades pitch discrimination (Fitts, 1951; Seminara, 1965). This large a tonal separation should ensure that there is little probability of identification error under any likely tower or TRACON operational conditions.*

2. Tone duration (periodicity) can provide a redundant coding dimension for identification. However, in this case, good tonal separation should prove sufficient for identification. Use of equal on/off intervals for the tones is a good choice (Wagner et al., 1996).

   Approach: *It is recommended that the intervals be at least 250 ms each.*

3. All audio alarms should be time limited.

   Approach: *We recommend a maximum duration of 5 to 10 seconds. It should not be necessary to actively acknowledge the alarm or to correct the condition to turn off the alarm (DOD, 1989b). ATCSs normally respond to the alarm by sending voice instructions to the aircraft. Pushing buttons or otherwise taking an additional action to acknowledge the alarm would only add to the workload and will almost certainly be objected to by the controllers. This duration limit is long enough to assure that personnel will hear the alarm and have time to respond if otherwise involved when the alarm sounds. However, it is not so long that it becomes an annoyance or a background noise. The continuation of the tone beyond this time may become distracting and annoying to personnel and will make it impossible to identify any new audio alarm conditions that occur while the alarm is active. The visual display of the problem on the data block should remain until the problem is corrected. If the condition is not cleared after a period of time, the alarm will sound again. Of course, if the condition is corrected in less than the 5 to 10 seconds, the alarm should stop immediately. This capability should be incorporated into the STARS.*

4. The problem of irrelevant alarms is a high priority.

   Approach: *There should be provision of exclusion zones for the CA and greater flexibility in MSAW alarming. DTW personnel requested this or some similar means of obtaining better control of where and when the alarms were triggered. It does not appear feasible to modify existing ARTS for these changes. For example, excluding the parallel runways from triggering CA alarms could be done either by changing the separation criteria for that area or by creating an exclusion zone. The advantage of changing the criteria is that it would prevent alarms during synchronous landings when both aircraft are properly aligned. If one aircraft drifted towards the parallel runway, this could then trigger a CA. This change will reduce the number of irrelevant alarms. Modifying the MSAW exclusion zones to reduce the number of irrelevant alarms from small VFR aircraft will also improve operations in the TRACON. The time needed to locate an irrelevant alarm and determine that there is no need to respond serves as a negative workload factor and may take attention away from more critical situations.*

4.2 Future Considerations

The enhanced capabilities of the STARS provide potential opportunities to make some significant improvements in the tower and TRACON operations. We have identified a few issues associated with alarms that may be worth investigation for future implementations. These may require research and development effort to fully evaluate and implement. These should be addressed prior to the STARS implementation.

1. The large number of audio alarms, including the separation alarms, equipment failure alarms, and special condition (e.g., hijack) alarms, present a problem (DOD, 1989b; Wagner et al., 1996). For example, the DOD recommends the use of no more than four audio alarms.

   Approach: *These alarms should be integrated and coordinated into a single status alerting system. The single status alerting system will still require obtaining detailed data from a visual display. Because the audio alarms work in conjunction with visual displays of detail data, the enhanced STARS display capability should support better integration of alarms and data. An integrated system should also help take into account the differences in operational modes and priorities in the tower and TRACON.*

2. Currently, the separation loss audio alarms (CA, MSAW, and MCI) are single condition alarms. That is, they offer no indication of the severity of the loss of separation. The alarm is the same if separation is 2 miles or ½ mile. If an ATCS issues instructions to an aircraft to correct the loss of separation but the problem continues or becomes worse, there is no specific indication of the increasing severity of the problem provided by the audio system.

   Approach: *Investigate using a two-stage alarm for these critical warnings. If the separation loss is sufficient to trigger the audio but is greater than some threshold identified by the generating algorithm, then the basic 250-ms on/off ratio is used. If separation is less than the threshold (e.g., 1 mile), then the alarm uses a more rapid period such as 60 ms. The associated data block would then provide some visual indication such as enlarging the blinking portion of the affected data blocks. This provides an initial caution signal, and, if* *the problem is more severe, it provides a warning signal. This also means that the tone would provide the primary coding for type of problem, and alarm period would provide severity information. This would require modification to the generating algorithms. The STARS uses parameters set in a software file to determine the length of a tone and its repetition. Some software modification will be required to implement a two-stage alarm capability. We recommend a laboratory study to determine the preferred values for the criteria and alarm parameters.*

3. Not all personnel need to hear all audio alarms. Although not identified by DTW personnel as a problem, the presence of audio signals heard by personnel who are not involved serves as an additional perceptual workload. If the alarms can be limited to the ATCS or supervisor involved with the problem, the number of alarms each person hears would be reduced with a corresponding reduction in auditory workload.

   Approach: One possibility is placing the audio on the console with the algorithm determining which consoles are alerted. This is the design used in the STARS. The required loudness level of alarms used this way should also be reduced, further reducing the number of alarms heard by each person. The STARS design permits a wide range of output levels for its audio. Some study will be necessary to determine the proper way to partition the alarms and the proper loudness level for the alarms. Where all personnel need to hear an alarm, the current loudspeaker system could be used or all console audio triggered. Currently, the STARS does not include a room loudspeaker output. The possibility of using headphones for audio alarms may also be worth investigating. We also recommend that the STARS Critical Subsystem Failure alarm and the independent equipment alarms be limited to the supervisor's position.

5. Summary

The results of this study were based on the ACT-530 audio alarm database (Ahlstrom, 1999a) and on the observed use of audio alarms at the DTW Tower and TRACON. This initial evaluation of the current audio alarms and the proposed STARS audio alarms indicated several problems. The proposed STARS alarms can offer an initial degree of improvement, but some larger issues remain. The recommended near-term improvements address current significant operational issues. These modifications should be of real value to personnel and should offer performance improvements. The items listed for future consideration will require additional study but, potentially, could permit greater safety of operations for larger numbers of aircraft.

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Acronyms

AMASS	Airport Movement Area Safety System
ARTS	Automated Radar Terminal System
ATCS	Air Traffic Control Specialist
CA	Conflict Alert
DTW	Detroit Wayne County Metropolitan Airport
FAA	Federal Aviation Administration
IFR	Instrument Flight Rules
ILS	Instrument Landing Systems
MCI	Mode C Intruder
MSAW	Minimum Safe Altitude Warning
SPC	Special Transponder Emergency Codes
STARS	Standard Terminal Automation Replacement System
TRACON	Terminal Radar Approach Control
URET	User Request Evaluation Tool
VFR	Visual Flight Rules