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DATA SOLUTIONS

White Paper

VoIP Crash Phone Systems

John Purnell

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1.0 Executive Summary

This white paper briefly describes crash phone systems; their current implementations and problems, and solutions using Voice over IP (VoIP) technology. Crash phones are emergency automated ring-down telephone systems used by airports and other operators in transportation and emergency responders.

The airport crash phone system can be upgraded with Voice over IP (VoIP) technology without sacrificing performance and still maintain conformance with current Federal Aviation Administration (FAA) Advisory Circulars. Further, VoIP technology can deliver resilience and survivability that is unmatched by existing analog and digital solutions.

This approach can solve many problems that airports are experiencing with an aging copper cable infrastructure, a shrinking availability of products and expertise to support analog ring-down implementations. Those airports that utilize common carrier services to bridge their airport crash phone system may find that a VoIP solution is also very cost effective.

Finally, VoIP implementation of a crash phone system can deliver status indication to the participants, which improves response time and situational awareness in the FAA tower.

This discussion paper may also serve the needs of entities other than airports, such as information desks, hotels, power plants and hospitals, where automated ring-down functions are to be found.

2.0 Abbreviations and Definitions

The following three-part glossary is provided to assist the reader.

Abbreviation	Full Name	Definition
A/A1	A and A1	These are the 3rd and 4th wires of the RJ11 interface for analog telephones which indicate via contact closure when the handset is on-hook or off-hook.
ARFF	Airport Rescue and Fire Fighting	A designated airport fire and rescue group trained and equipped specifically to deal with accidents involving aircraft.
ATC	Air Traffic Control	Ground-based controllers responsible for the organization and flow of airborne aircraft traffic to ensure adequate separation between aircraft and provide support.
ATCT	Air Traffic Control Tower	A facility that is operated by the FAA or a third-party contractor operating under FAA rules that manages the approach, landing, taxi, take-off and departure phases of flight. The ATCT usually initiates crash phone calls.
E&M	Earth and Magneto	A type of supervisor line signaling originally used between PBXs.
FAA	Federal Aviation Administration	An agency of the United States Department of Transportation responsible for oversight and regulation of all aspects of domestic civil aviation.
LAN	Local Area Network	A computer network covering a smaller physical space, such as an airport terminal, without the need for long-distance cabling.
LEC	Local Exchange Carrier	A regulatory designation of a telecommunications company usually referring to the original or incumbent local telephone company in a given region.
PBX	Private Branch Exchange	A switch that supports telephone connectivity within an airport and provides access to the outside PSTN. It is owned and operated by the airport.
QoS	Quality of Service	The ability to apply different priorities to the transmission of certain packets on networks. For time-sensitive information, such as voice or video transmission, QoS ensures that speed will not be reduced by less vital packets.

Abbreviation	Full Name	Definition
VLAN	Virtual Local Area Network	Virtual segregation of a single physical LAN into multiple LANs operating on the same infrastructure.
VoIP	Voice over Internet Protocol	VoIP technology treats a voice call as a data transmission, allowing voice conversations to be sent over the data network. VoIP is used as a telephone system to eliminate the need for a separate telephony infrastructure. VOIP often reduces/eliminates toll charges of copper wire system.
TDM	Time Division Multiplexed	The second generation of signal encoding of voice - analog voice data is converted to digital data. Multiple voice signals are combined through a time sharing algorithm.

3.0 What is a Crash Phone System?

Airports that are FAA Part 139[1] certified must have procedures and equipment that, in the event of an actual or potential aircraft accident, alert Airport Rescue and Fire-Fighting (ARFF) personnel who must then respond to specific staging points within a matter of minutes. Guidance on such types of Airport Emergency Communications is provided in FAA Advisory Circular 150/5210-7D[2]. The majority of airports use a crash phone system to meet this purpose although some others use two-way non-Air Traffic Control (ATC) radio channels.

In large North American airports, crash phone events occur several times per week, though few result in actual fire-fighting and rescue activities. In smaller Part 139 airports, these events are infrequent. In all airports, however, the crash phone system is tested at least once each day.

Crash phone systems, following three decades of FAA guidance, now generally have these characteristics:

Figure 1 Sample Crash Phone

- The system uses automatic ring-down technology (i.e. no dialing is required)
- The station equipment is red in color (see photo at right)
- Transmission typically uses underground copper cables
- The system instantly bridges 2 to 30 stations together
- The system is present in the following locations:
  - The FAA Air Traffic Control Tower (ATCT)
  - All ARFF stations at the airport
  - Airport Operations Center
  - Other locations and facilities involved in the ARFF response
- The stations have a unique ring

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[1] 14 CFR Part 139 FAA certification is required for airports that serve scheduled aircraft of 9 seats or more, unscheduled aircraft of 30 seats or more or are otherwise designated as Part 139 certificated by the FAA.

[2] The “7D” version of 150/5210 Advisory Circular was issued in April 2008 and replaced the “7C” version issued in 1999. The original “7A” version was issued in April of 1984.

- The system is often interconnected to some or all of the following:
  - Emergency Medical Service Radio Systems
  - Fire Station Alerting System
  - Local Law Enforcement Agencies.

Operation of a crash phone system is automatic and extremely simple which is important and appropriate for an emergency communications system. The emergency crash call is typically initiated by FAA personnel in the ATCT at the airport where the endangered aircraft is being controlled. The ATCT controller simply picks up the phone handset and all of the other phones ring. After a few seconds to allow the parties to answer, the ATCT provides information necessary for the response: alert type, location, runways affected, aircraft type, number of passengers and crew on board, fuel levels, airline flight number, and estimated time of arrival if the aircraft is still inbound. The ARFF personnel will respond immediately by going to their designated staging position while the airport operations staff typically will repeat the particulars of the alert in a radio dispatch.

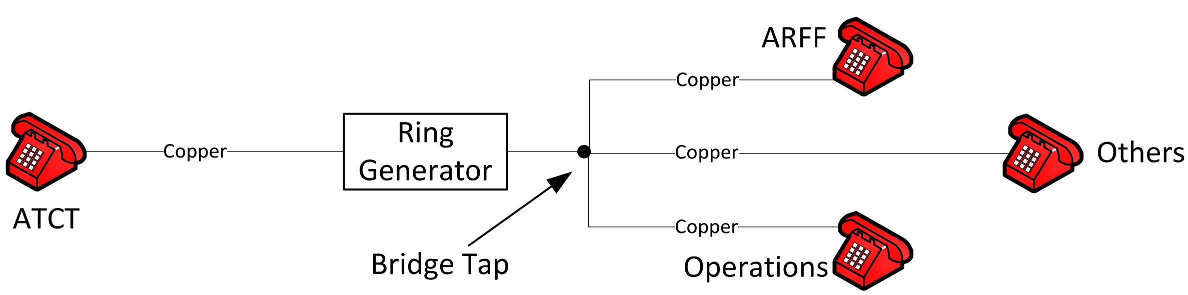
4.0 Technology in Use Today

Over the last thirty years, crash phone system implementations have varied considerably from one airport to the next. The specific solution for an airport is determined by:

- The locations of the ATCT, Airport Operations Center, the ARFF(s) and any other emergency responders
- The airport's cable plant which connects the crash phone locations
- The number of locations to be bridged together.

Simple implementations - with a few locations all on a small campus with adequate airport cable infrastructure - can utilize inexpensive ring regenerators and distribute the signal on their own copper cables. A bridge tap[3] connects the various stations to the output of the ring generator as shown in the figure below.

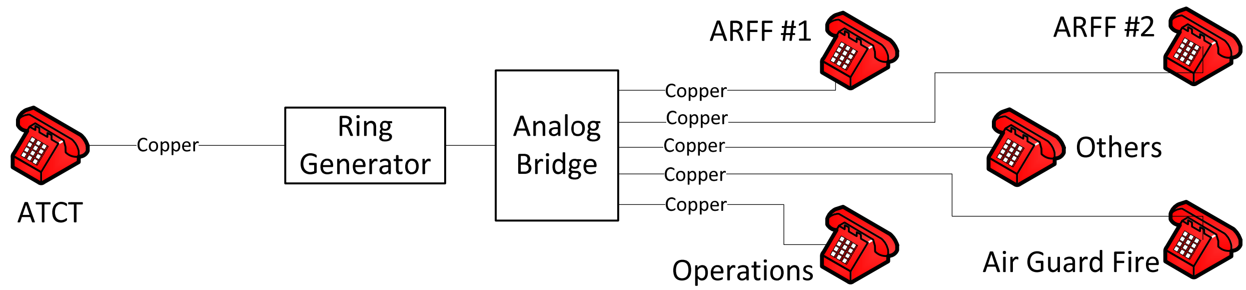
Figure 2 Simple Crash Phone System Example



[3] A Bridge Tap is a passive means of connecting multiple telephone lines in parallel. Usually, the cables from every phone are connected together using a wire nut or 66 block, one for Tip and one for Ring. No coils, amplifiers, or other active electronics are utilized resulting in an impedance mismatch. As more phone stations are added this problem is aggravated until the system no longer functions properly.

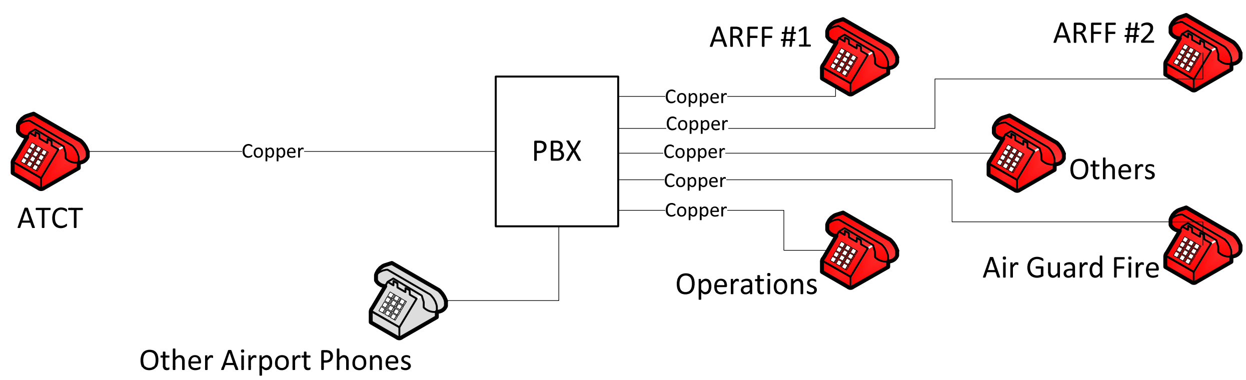
As the number of stations grows, this bridge tap approach will cause too much signal attenuation and an active bridge will be required. As shown in the illustration below, the active electronics of the analog bridge will ensure that every station gets a full strength ring and audio signal.

Figure 3 Bridged Crash Phone System Example



Some implementations use the airport's Private Branch Exchange (PBX) to accomplish the crash phone function. This eliminates the need for the ring generator and takes advantage of the internal bridge capability of the PBX. It also allows for digital signals to replace analog signals. While this generally works, it does not conform to FAA Advisory 510/5210-7D which states that "*The emergency direct-line telephone should not pass through any intermediate automated switchboard or operator that could subject the alert calls to delays.*" This type of non-conforming system is depicted below.

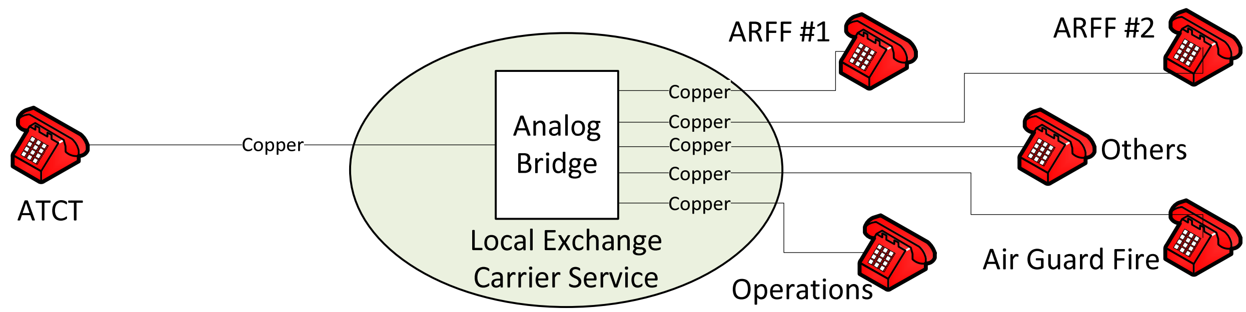
Figure 4 PBX-Based Crash Phone System Example



The possibility that voice traffic from the other airport phones could block the call or tie up the bridge puts this design at risk by subjecting the alert call to delays. The PBX is, in fact, an intermediate automated switchboard.

When crash phone locations are not on the airport's cable infrastructure, the Local Exchange Carrier (LEC) may be contracted to provide the transmission service, for a fee, using their existing telecommunications network. In these cases, the LEC typically uses a dedicated analog bridge with a built-in ring generator. Using this architecture, the system can span many miles between locations. This type of system, depicted below, typically is provided at a significant monthly cost.

Figure 5 LEC Bridged Crash Phone System Example



There are, of course, implementations which combine two or more of these design solutions.

5.0 Issues with Legacy Technology

There are a number of issues with these approaches that suggest this is the time to re-engineer existing crash phone systems.

First, the existing implementations typically utilize underground copper cables for the transmission of the signals. In most airports, this cable plant is from thirty to sixty years old. It is no longer water-tight and is subject to spurious electrical signals, especially during electrical storms. It is an expensive process to dig up and replace buried copper cable.

Second, the bridging technology of most of today's crash phone systems is now severely antiquated. While analog communications still exist, they are becoming far less common. Consequently, the hardware which supports crash phone system implementation in an analog environment is becoming rare and expensive. The LECs which employ this technology in their bridged crash phone services are having difficulty finding parts, will not accept new service orders, and are pricing the service to persuade customers to migrate to other services.

Third, the existing architectures pictured above are all vulnerable to single points of failure. In today's IT environment, it seems unusual that a safety-of-life system, such as the crash phone system, would not have inherent resilience based on a redundant architecture.

Fourth, the analog implementations provide no indication of the status of the other call participants. This is a benefit of a PBX-based system which can provide call participants with a status indication of the other stations (i.e., who has picked up and who has not). Status indication can cut significant seconds off the start of the information flow from the ATCT.

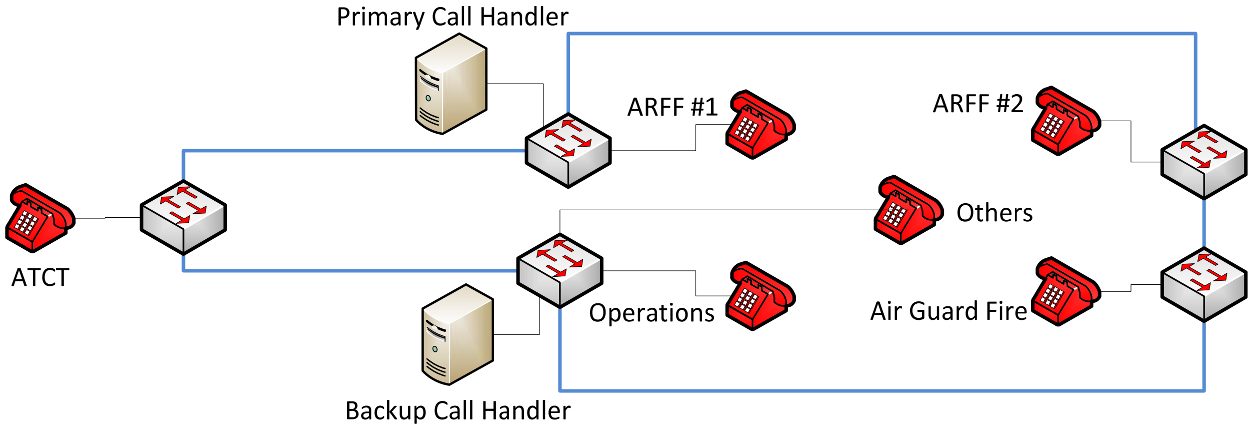
6.0 Available VoIP Technology

Over the past ten years airports have been installing fiber-optics and migrating from Time Division Multiplex (TDM) to Voice-over-IP (VoIP) communications. There are many benefits from this next generation of technology that can be used to upgrade the crash phone system.

Fiber-Optic cables are not sensitive to moisture or electrical interference. This state-of-the-art infrastructure can be used with confidence decades into the future.

Voice over IP (VoIP) allows voice signals to be transmitted over an Ethernet network which can be designed with redundant paths and call handlers. This puts resilience into the system. The drawing below shows a crash phone system constructed as a self-healing loop (blue lines) with redundant call handlers.

Figure 6 VoIP Crash Phone System Example



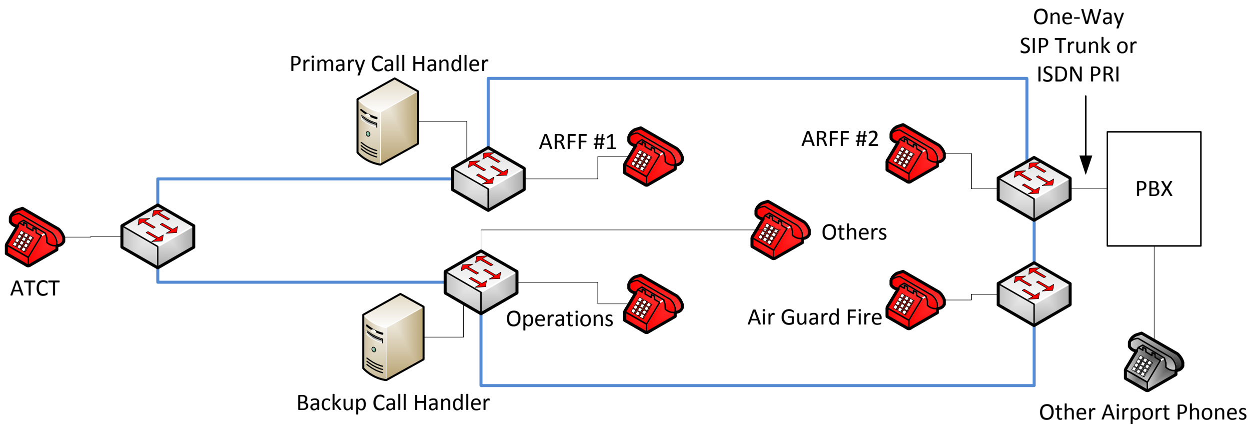
This architecture is highly reliable and survivable. If the backbone loop is cut at any point, the traffic can reroute over the other paths. The backbone links can be shared with data, voice, and video signals provided that the crash phone has the highest class of service and is in its own secure virtual LAN (VLAN)[4].

The VoIP call handlers, which have dropped significantly in price compared to the previous generation of PBXs, now can be dedicated to the crash phone function. Therefore, call handlers cannot "subject the alert calls to delays" bringing them into conformance with the FAA advisory circular. The redundant call handlers monitor one another to ensure that if the primary does not act on the call initiation, the backup will. As a further enhancement, some VoIP manufacturers offer their call handlers as software which can operate in a virtual server environment. This adds an additional level of hardware redundancy and resilience/survivability to the system.

This paper recommends not to share the VoIP call handlers with administrative phone service so as to avoid blocking. However, it would be acceptable to tie the crash phone system to the administrative phone system so that other interested parties may hear the broadcast. These secondary users could be anyone other than the FAA ATCT, Airport Operations/Dispatch or any responding fire/recue station. The interface would allow crash phone calls to transit the administrative phone system, but not allow any calls in the other direction into the crash phone system.

[4] A VLAN is a secure subset of ports within a larger Ethernet network. The VLAN is not visible to any of the other data ports on the network and has its own traffic characteristics.

Figure 7 VoIP Crash Phone System with PBX Interface Example



VoIP telephony also delivers status indication, one of the desirable benefits of PBX and digital telephony. In large crash phone system implementations where there may be multiple stations in a given building (e.g. an ARFF building), each station can be configured to display the on-hook, off-hook, or ringing status of the other crash phone stations.

The crash phone system should be monitored at all times so that problems can be identified before the daily test call.

There are some important design points to be considered when implementing a crash phone in a VoIP system:

1. All crash phone stations must be configured to point to both call handlers for redundant operations
2. The network's Quality of Service (QoS) settings for the crash phone should be set at a level above any other traffic in the system to conform to the FAA advisory
3. The call handlers, switches and phone stations should all be on protected emergency power and otherwise located in data centers or well-equipped and secured data closets
4. The call handlers must be dedicated to the crash phone function with internal digital bridges; if interconnected to the administrative phone system, that connection should be configured for outbound only
5. All Ethernet switches, call handlers and VoIP stations should be monitored by a LAN management system or other IT device monitoring system.

If the crash phone system is to be connected to a Fire-Station Alerting System, Radio System, or Public Address System, this can be done through analog gateways or router ports. Care should be taken to ensure that positive signaling is used to enable the connected device when the initiating phone goes off-hook or disable it when back on-hook. Acceptable signaling methods would include A/A1 leads or 4-wire E&M signaling. As a last resort, voice energy detection can be used.

The VoIP system can also provide notification to any number of airport or airline staff through the airport's PBX without interfering with the emergency communications required by the FAA for Part 139 certification.

7.0 Non-Aviation Applications

As mentioned above, the application of multi-party automated ring-down functions is not exclusively for use by the FAA and airports. The technology solution discussed in this paper and the benefits that can be derived are applicable to any multi-party ring-down system currently using copper cabling.

Any other public safety venue could implement this technology solution for their emergency communications system. Fire and police stations occasionally use automated ring-down systems for rapid, reliable alerting of other stations.

The stock market industry and the automotive parts industry both use this type of technology for "hoot-n-holler" multi-party circuits. These could be replaced effectively by VoIP ring down circuits at far less expense than satellite systems or multi-drop private lines.

The emergency health care industry can use this technology for mobilizing emergency rooms and other crisis responses.

8.0 Conclusion

This white paper demonstrates that VoIP-based crash phone systems can meet the requirements of FAA Advisory Circulars, improve operations and reliability, and function exactly as their analog counterparts do today. In some cases, they will save money over current LEC-bridged crash phone systems.

At the issuance of this white paper, the author is aware of several VoIP equipment providers that offer products that can implement this type of solution. Contact John Purnell (John.Purnell@InspiredDataSolutions.com) at 410-951-9081 for further information.

About IDS

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