

IN CASE OF FIRE - LIFT COVER
PULL FIRE ALARM

LIFT THEN
PULL HANDLE

PULL
FIRE

Handbook of
Hoscheywell
Warning Systems

Nicholle Gale

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Automatic Warning System

The **Automatic Warning System (AWS)** is a form of limited cab signalling and train protection system introduced in 1956 in the United Kingdom to help train drivers observe and obey signals. It was based on a 1930 system developed by Alfred Ernest Hudd and marketed as the "Strowger-Hudd" system. An earlier contact system, installed on the Great Western Railway since 1906 and known as Automatic Train Control (ATC), was gradually supplanted by AWS within the Western Region of British Railways.

Principles of operation

AWS is part of the signalling system and warns the driver about the aspect of the next signal. These warnings are normally given 200 yards (180 metres) before the signal. Information about the signal aspect is conveyed electromagnetically to the moving train through equipment fixed in the middle of the track, known as *AWS inductors*. Each inductor contains a permanent magnet and an electromagnet which 'cancels' the effect of the permanent magnet. The system is fail-safe because the electromagnet is required to be energised to give the 'clear' indication, the 'warning' indication being given by the permanent magnet alone.

When the AWS inductor is reached, the AWS sets a visual indicator in the driver's cab and gives an audible indication. If the signal being approached is displaying a 'clear' aspect, the AWS will sound a bell and leave the visual indicator black. This lets the driver know that the next signal is showing 'clear' and that the AWS system is working. If the signal being approached is displaying a restrictive aspect (red, yellow or double yellow), AWS will sound a horn continuously until the driver pushes a button to acknowledge it. The AWS will also give a warning horn on the approach to certain permanent speed restrictions and all temporary and emergency speed restrictions. When the warning is acknowledged, the horn stops and the visual indicator changes to a pattern of black and yellow spokes, which persists until the next AWS inductor and reminds the driver that they have cancelled the AWS and therefore have full responsibility for controlling the train. If the button is not pressed within six seconds, a full brake application brings the train to a halt. If the driver collapses onto the AWS cancel button, the system has a fail-safe mechanism built in, whereby it is not the press of the button that cancels the warning, it is when the driver lets go after the downward motion.

History

Early devices



Berlin S-Bahn train stop in its engaged (left) and disengaged (right) position

Early devices used a mechanical connection between the signal and the locomotive. In 1840, the locomotive engineer Edward Bury experimented with a system whereby a lever at track level, connected to the signal, sounded the locomotive's whistle and turned a cab-mounted red lamp. Ten years later, the redoubtable Colonel William Yolland of the Railway Inspectorate was calling for a system that not only alerted the driver but also automatically applied the brakes when signals were passed at danger but no satisfactory method of bringing this about was found.

In 1873, United Kingdom Patent No. 3286 was granted to C. Davidson and C.D. Williams for a system in which, if a signal was passed at danger, a trackside lever operated the locomotive's whistle, applied the brake, shut off steam and alerted the guard. Numerous similar patents followed but they all bore the same disadvantage – that they could not be used at higher speeds for risk of damage to the mechanism – and they came to nothing. In Germany, the Kofler system used arms projecting from signal posts to connect with a pair of levers, one representing *caution* and the other *stop*, mounted on the locomotive cab roof. To address the problem of operation at speed, the sprung mounting for the levers was connected directly to the locomotive's axle box to ensure correct alignment. When Berlin's S-Bahn was electrified in 1929, a development of this system, with the contact levers moved from the roofs to the sides of the trains, was installed at the same time.

The first useful device was invented by Vincent Raven of the North Eastern Railway in 1895, patent number 23384. Although this provided audible warning only, it did indicate to the driver when points ahead were set for a diverging route. By 1909, the company had installed it on about 100 miles of track.

GWR Automatic Train Control

The first system to be put into wide use was developed in 1905 by the Great Western Railway and protected by UK patents 12661 and 25955. Its benefits over previous systems were that it could be used at high speed and that it sounded a confirmation in the cab when a signal was passed at 'clear'.

In the final version of the GWR system, the locomotives were fitted with a solenoid-operated valve into the vacuum train pipe, maintained in the closed position by a battery. At each distant signal, a long ramp was placed between the rails. This ramp consisted of a metal blade set edge on, parallel to the rails, mounted on a wooden support. The ramp was curved with the highest point in the middle. As the locomotive passed over the ramp, a sprung contact shoe beneath the locomotive was lifted and the battery current holding closed the brake valve was broken. In the case of a clear signal, current from a battery energising the ramp (but at opposite polarity) passed to the locomotive through the contact and maintained the brake valve in the closed position, with the reversed-polarity current ringing a bell in the cab. When the signal was at 'danger', the ramp battery was disconnected and so could not replace the locomotive's battery current: the brake valve solenoid would then be released and a horn sounded in the cab. The driver was then expected to cancel the warning and apply the brakes under his own control.

Notwithstanding the heavy commitment of maintaining the batteries in the locomotives and signal boxes, the GWR installed the equipment on all its main lines. For many years, Western Region (successors to the GWR) locomotives were dual fitted with both GWR ATC and BR AWS system.

Strowger-Hudd system

By the 1930s, other railway companies, under pressure from the Ministry of Transport, were considering systems of their own. A non-contact method based on magnetic induction was preferred, to eliminate the problems caused by snowfall and day-to-day wear of the contacts which had been discovered in existing systems. The Strowger-Hudd system of Alfred Hudd, which used a pair of magnets, one a permanent and one an electro-magnet, was tested by the Southern Railway, London and North Eastern Railway and the London, Midland and Scottish Railway but these trials came to nothing.

In 1948 Hudd, now working for the LMS, equipped the London, Tilbury and Southend line, a division of the LMS, with his system. It was successful and British Railways developed the mechanism further by providing a visual indication in the cab of the aspect of the last signal passed. In 1956, the Ministry of Transport evaluated the GWR, LTS and

BR systems and selected the one developed by BR as standard for Britain's railways. This was in response to the Harrow and Wealdstone accident in 1952.

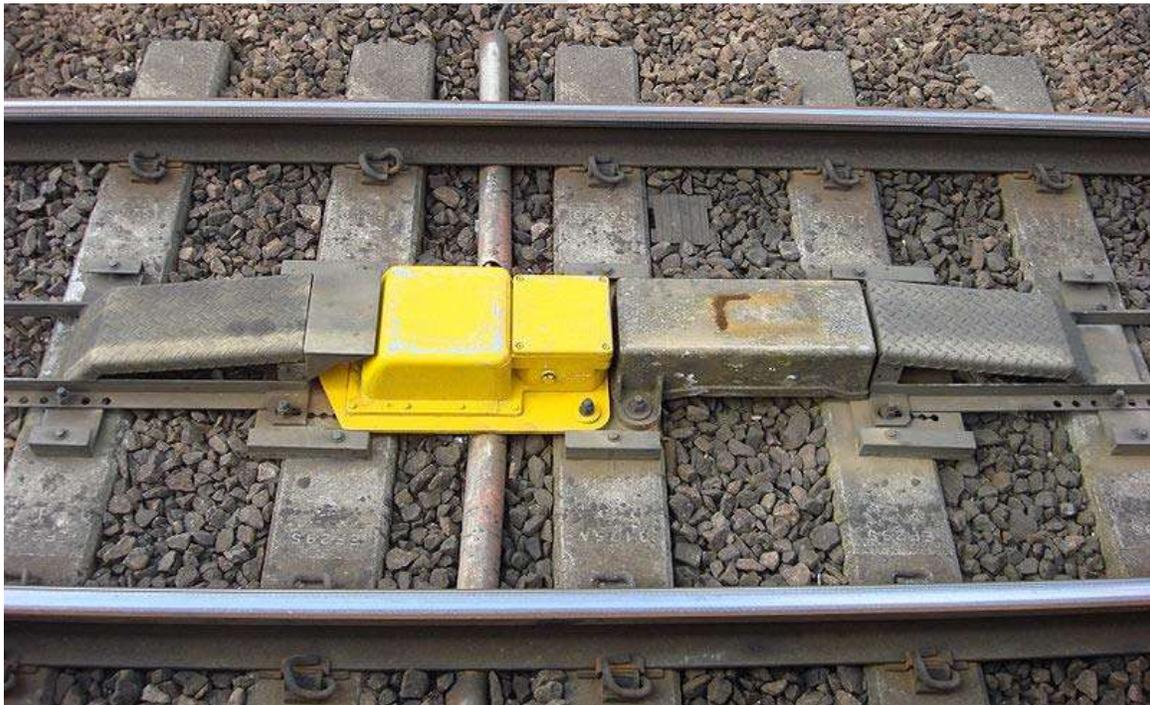
British Rail AWS

BR AWS consists of:

- a permanent magnet set centrally between the rails and usually positioned such that it is encountered before the signal to which it relates.
- an electro-magnet between the rails (with opposite polarity to the permanent magnet) positioned after the permanent magnet.
- a cab indicator that can show a black disk or a yellow and black "exploding" disk, known as the "AWS sunflower".
- a control unit that connects the system to the brakes on the train.
- a Driver's AWS acknowledgement button.
- an AWS control panel.

The system works on a set/reset principle.

When the signal is at 'clear' or green ("off"), the electro-magnet is energised. As the train passes, the permanent magnet sets the system. A short time later, as the train moves forward, the electromagnet resets the system. Once so reset, a bell is sounded (a chime on newer stock) and the indicator is set to all black if it is not already so. No acknowledgement is required from the driver. The system must be reset within one second of being set, otherwise it behaves as for a caution indication.



A BRAWS inductor (Alternative picture)

When the distant signal is at 'caution' or yellow (on), the electro-magnet is de-energised. As the train passes, the permanent magnet sets the system. However, since the electro-magnet is de-energised, the system is not reset. After the one second delay within which the system can be reset, a horn warning is given until the driver acknowledges by pressing a plunger. If the driver fails to acknowledge the warning within 2.75 seconds, the brakes are automatically applied. If the driver does acknowledge the warning, the indicator disk changes to yellow and black, to remind the driver that he has acknowledged a warning. The yellow and black indication persists until the next signal and serves as a reminder between signals that the driver is proceeding under caution. The one second delay before the horn sounds allows the system to operate correctly down to speeds as low as 1.75 miles per hour. Below this speed, the caution horn warning will always be given, but it will be automatically cancelled when the electromagnet resets the system if the driver has not already done so. The display will indicate all black once the system resets.

The system is fail-safe since, in the event of a loss of power, only the electro-magnet is affected and therefore all trains passing will receive a warning. The system suffers one drawback in that on single track lines, the track equipment will set the AWS system on a train travelling in the opposite direction from that for which the track equipment is intended but not reset it as the electromagnet is encountered before the permanent magnet. To overcome this, a suppressor magnet may be installed in place of an ordinary permanent magnet. When energised, its suppressing coil diverts the magnetic flux from the permanent magnet so that no warning is received on the train. The suppressor magnet is fail-safe since loss of power will cause it to act like an ordinary permanent magnet. A cheaper alternative is the installation of a lineside sign that notifies the driver to cancel and ignore the warning. This sign is a blue square board with a white St. Andrew's cross on it (or a yellow board with a black cross, if provided in conjunction with a temporary speed restriction).

With mechanical signalling, the AWS system was installed only at distant signals but, with multi-aspect signalling, it is fitted at all main line signals. All signal aspects, except green, cause the horn to sound and the indicator disc to change to yellow on black.

AWS equipment without electromagnets are fitted at locations where a caution signal is invariably required or where a temporary caution is needed (for example, a temporary speed restriction). This is a secondary advantage of the system because temporary AWS equipment need only contain a permanent magnet. No electrical connection or supply is needed. In this case, the caution indication in the cab will persist until the next green signal is encountered.



A photograph of the AWS indicator inside Class 27 number D5401 at the Northampton & Lamport Railway

Expansion of AWS application

- From 1971, AWS permanent magnets would be fitted at the advance warning boards installed on the approach to severe permanent speed restrictions. This was a recommendation of the inquiry into the derailment at Morpeth on 7 May 1969.
- From 1977, portable AWS permanent magnets would be fitted at the warning boards on the approach to temporary speed restrictions (TSRs). This was a recommendation of the inquiry into the derailment at Nuneaton on 6 June 1975,

which occurred when the driver missed a TSR warning board due to its lights being extinguished.

- From 1990, AWS permanent magnets were being installed immediately ahead of certain 'high risk' stop signals, as a SPAD mitigation measure. This additional AWS magnet was suppressed when the associated signal showed a 'proceed' aspect. It is no longer current practice to use AWS for this purpose.

Disadvantages

Because it was developed before multiple-aspect signalling became widespread, AWS can only indicate whether a signal is "Green" or "not Green". Even though a multiple-aspect signal can display three or four aspects, AWS has only two states.

AWS is an advisory system and can be easily overridden by habituated reactions of the driver, especially when they are proceeding at speed under a series of "double yellow" signals which indicate a signal at 'danger' two sections ahead. This has led to a number of fatal accidents. Also, there is no compulsory stop when a red signal is passed. The newer TPWS, which operates at certain stop signals and on the approach to some speed restrictions and buffer stops, overcomes some of these problems.

Two way tracks

Because the permanent magnet is located in the centre of the track, it operates in both direction, the reverse direction of which is not needed. Therefore the permanent magnetic has to be suppressed by an electric coil of suitable strength.

Liberia

One of the mining railways in this country had a more advanced AWS system that employed two or three magnets of either polarity and located near the rails to avoid the suppression problem. The system was therefore about to give more aspects than the BR version.

Use overseas

The BR AWS system is also used in

- Northern Ireland
- Hong Kong, MTR East Rail Line (Discontinued in 1998, trains now use TBL as of 2009, enhanced with ATP)
- Queensland, Australia; sometimes enhanced with ATP. At the other extreme Queensland also provides a permanent magnet at the fixed distant signal of unattended crossing loops.
- Adelaide, South Australia

Emergency Alert System



The **Emergency Alert System (EAS)** is a national warning system in the United States put into place in 1997, superseding the Emergency Broadcast System (EBS) and the CONELRAD System. It will, in turn, eventually be superseded by iPAWS - the Integrated Public Alert and Warning System. It is jointly coordinated by the Federal Communications Commission (FCC), Federal Emergency Management Agency (FEMA), and the National Weather Service (NWS). The official EAS is designed to enable the President of the United States to speak to the United States within 10 minutes (this official federal EAS has never been activated). The EAS regulations and standards are governed by the Public Safety and Homeland Security Bureau of the FCC. Each state and several territories have their own EAS plan.

The EAS covers AM, FM and Land Mobile Radio Service, as well as VHF, UHF and cable television including low-power stations. Digital television and cable providers, along with Sirius XM satellite radio, IBOC, DAB and digital radio broadcasters have been required to participate in the EAS since December 31, 2006. DirecTV, Dish

Network and all other DBS providers have been required to participate since May 31, 2007.

Technical concept

Messages in the EAS are composed of four parts: a digitally encoded SAME header, an attention signal, an audio announcement, and a digitally encoded end-of-message marker.



A Sage EAS ENDEC unit.

The SAME header (help-info) is the most critical part of the EAS design. It contains information about who originated the alert (the President, state or local authorities, the National Weather Service, or the broadcaster), a short, general description of the event (tornado, flood, severe thunderstorm), the areas affected (up to 32 counties or states), the expected duration of the event (in minutes), the date and time it was issued (in UTC), and an identification of the originating station.

Over thirty radio stations are designated as National Primary Stations in the Primary Entry Point (PEP) System to distribute Presidential messages to other broadcast stations and cable systems. The Emergency Action Notification is the notice to broadcasters that the President of the United States or his designee will deliver a message over the EAS via the PEP system. "You {AM and FM broadcasters} will hear the following Emergency Action Notification Message from the EAS decoder. This is an Emergency Action Notification requested by the White House. All broadcast stations will follow activation procedures in the EAS Operating Handbook for a national level emergency. The President of the United States or his representative will shortly deliver a message over the Emergency Alert System."

Communications links

The FEMA National Radio System (FNARS) "Provides Primary Entry Point service to the Emergency Alert System," acts as an emergency presidential link into the EAS, and is capable of phone patches. The FNARS net control station is located at the Mount Weather Emergency Operations Center.

What the national level EAS would not do

In a *The New York Times* article (correction printed January 3, 2002) the lack of news coverage by station WNYC FM, New York, was explained by the destruction of its broadcast transmitters with the collapse of the World Trade Center north tower on 9/11. "No president has ever used the current [EAS] system or its technical predecessors in the last 50 years, despite the Soviet missile crisis, a presidential assassination, the Oklahoma City bombing, major earthquakes and three recent high-alert terrorist warnings... Michael K. Powell, the then chairman of the Federal Communications Commission, which oversees the Emergency Alert System, pointed to 'the ubiquitous media environment,' arguing that the system was, in effect, scooped by CNN, MSNBC, Fox News Channel and other channels... [FEMA] activates the alert system nationally at the behest of the White House on 34 50,000-watt stations that reach 98 percent of Americans... Beyond that, the current Emergency Alert System signal is an audio message only—which pre-empts all programming—so that viewers who were watching color images of the trade center on Sept. 11 would have been able to see only a screen with a generic text message along with a presidential voice-over, if an emergency message had been activated."

Other than the on-screen scrolling message accompanying the initial activation, the Federal Communications System EAS TV Handbook - 2007 does not include any sort of visual element. Under the SAME protocol, precise emergency information would be delivered aurally.

EAS header

Because the header lacks error detection codes, it is repeated three times for redundancy. However, the repetition of the data can itself be considered an error detection and correction code—like any error detection or correction code, it adds redundant information to the signal in order to make errors identifiable. EAS decoders compare the received headers against one another, looking for an exact match between any two, eliminating most errors which can cause an activation to fail. The decoder then decides whether to ignore the message or to relay it on the air if the message applies to the local area served by the station (following parameters set by the broadcaster).

The SAME header bursts are followed by an attention signal which lasts between eight and 25 seconds, depending on the originating station. The tone is 1050 Hz (help-info) on a NOAA Weather Radio station, while on commercial broadcast stations, it consists of a "two tone" combination of 853 Hz and 960 Hz sine waves and is the same attention signal used by the older Emergency Broadcast System. The "two tone" system is no longer required as of 1998 and is to be used only for audio alerts before EAS messages. Like the EBS, the attention signal is followed by a voice message describing the details of the alert.



A Gorman-Redlich rack mounted CAP-to-EAS converter which translates CAP formatted alerts into EAS headers.

The message ends with three bursts of the AFSK "EOM", or End of Message, which is the text NNNN, preceded each time by the binary 10101011 calibration.

The White House has endorsed the migration to the Common Alerting Protocol (CAP) and FEMA is in the process of testing implementation.

Station requirements

The FCC requires all broadcast stations and multichannel video programming distributors (MVPD) to install and maintain EAS decoders and encoders at their control points. These decoders continuously monitor the signals from other nearby broadcast stations for EAS messages. For reliability, at least two other source stations must be monitored, one of which must be a designated *local primary*. Stations are to retain the latest version of the EAS handbook.

Stations are required by law to keep full logs of all received and transmitted EAS messages. Logs may be kept by hand but are usually kept automatically by a small receipt printer in the encoder/decoder unit. Logs may also be kept electronically inside the unit as long as there is access to an external printer or method to transfer them to a personal computer.

In addition to the audio messages transmitted by radio stations, television stations must also transmit a visual message. A text "crawl" is displayed at the top of the screen that contains all of the information encoded in the initial SAME header. A color coded "crawl" system is often used where the color signifies the priority of the message. Some television stations transmit only the visual message which is outside of the requirements. A television station may be used for monitoring by another station and thus the audio is necessary.



A cable system's visual message displayed during a required test. In actual emergencies, this screen would display the FCC-mandated visual message accompanying the alert.

Upon reception of an alert, a station must relay EAN (Emergency Action Notification) and EAT (Emergency Action Termination) messages immediately (US FCC 7). Stations traditionally have been allowed to opt out of relaying other alerts such as severe weather, and child abduction emergencies (AMBER Alerts) if they so choose. Under new rules published on July 12, 2007, the FCC intends to require all stations to relay state and local alerts that are approved by their states' governors (pending approval of the CAP standard).

Some stations may be *non-participating*, and do not relay messages. Instead they transmit a message instructing listeners/viewers to tune to another station for the information, and they must then suspend their operation.

EAS equipment must be FCC certified for use as described above.

System test

All EAS equipment must be tested weekly. The required weekly test (RWT) consists of the header and the end-of-message SAME bursts. The RWT does not need an audio or graphic message announcing the test, although many stations will provide them as a courtesy to the listener or viewer. Television stations are not required to transmit a video message for weekly tests. RWTs are scheduled by the station, on random days and times, and are generally not relayed.

On cable systems before the start of the EAS test, all of a system's channels, both on cable ready televisions directly connected to the coaxial cable, and those on cable boxes, are redirected to one digital channel which is received on all tiers of service, but doesn't usually give out news or weather information (such as the TV Guide Network, QVC, HSN, or a public access station), where the test occurs from the local headend office or from the system's master office elsewhere in the region. Newer technology allows cable DVR and video on demand systems to interrupt playback of a program for an EAS test. After the test ends, the one channel usually remains on screen for 5-10 additional seconds before the original station/network is returned to.

Required Monthly Tests (RMTs) are generally originated by the primary relay station or a State's EAS agency, relayed by broadcast and cable stations. Some RMT's are issued by the National Weather Service, sometimes for Statewide Severe Weather Drills. RMTs are conducted with the following procedure:

1. Normal programming is suspended (commonly during commercial breaks), and an announcement may be made such as: "The following is a monthly test of the Emergency Alert System. This is only a test."
2. The SAME Header burst is sent, perhaps followed by an attention signal.
3. Another voice message is sent, which runs something like this:

"This is a coordinated monthly test of the broadcast stations in your area. Equipment that can quickly warn you during emergencies is being tested. If this had been an actual emergency such as a tornado warning or severe thunderstorm warning, official messages would have followed the alert tone. This concludes this test of the Emergency Alert System." (many state/local plans have different scripts)

4. The SAME EOM burst is sent.

RMTs must be performed between 8:30 a.m. and local sunset during odd numbered months, and local sunset to 8:30AM for even months. Received tests must be retransmitted within 60 minutes from receipt. Additionally, an RMT cannot be scheduled or conducted during an event of great importance such as a pre-announced Presidential speech, coverage of a national election or a major sporting event such as the Olympic Games, the Super Bowl or the World Series as mentioned in individual EAS state plans.

An RWT is not required during a calendar week in which an RMT is scheduled. No testing has to be done at all during a calendar week in which the EAS has been legitimately activated. Coordinated national tests are planned to be conducted at least once every year, beginning in 2011, and are very similar to RMTs

Additions and proposals

The number of event types in the national system has grown to eighty. At first, almost all but three of the events (civil emergency message, immediate evacuation, and emergency

action notification (national emergency)) were weather-related (such as a tornado warning). Since then, several classes of non-weather emergencies have been added, including, in most states, the AMBER Alert System for child abduction emergencies.

In 2004, the FCC issued a Notice of Proposed Rulemaking seeking comment on whether EAS in its present form is the most effective mechanism for warning the American public of an emergency and, if not, on how EAS can be improved, such as mandatory text messages to cellphones, regardless of subscription. As noted above, rules implemented by the FCC on July 12, 2007 provisionally endorse replacing the SAME protocol with CAP and allow governors to compel universal activation of the system within their own states.

EAS for consumers

EAS is designed to be useful for the entire public, not just those with SAME-capable equipment. However, several consumer-level radios do exist, especially weather radio receivers, which are available to the public through both mail-order and retailers including Radio Shack and several others. Other specialty receivers for AM/FM/ACSSB(R)(LM(R)) are available only through mail-order, or in some places from federal, state, or local governments, especially where there is a potential hazard nearby such as a chemical factory. These radios come pre-tuned to a station in each area that has agreed to provide this service to local emergency management officials and agencies, often with a direct link back to the plant's safety system or control room for instant activation should an evacuation or other emergency arise.

The ability to narrow messages down so that only the actual area in danger is alerted is extremely helpful in preventing false warnings, which was previously a major tune-out factor. Instead of sounding for all warnings within a station's area, SAME-decoder radios now sound only for the counties they are programmed for. When the alarm sounds, anyone with the radio *knows* that the danger is nearby and protective action should be taken. For this reason, the goal of the National Weather Service is that each home should have both a smoke detector and a SAME weather radio.

The United States Military has recently employed emergency notification technologies at The United States Academy at West Point, The United States Air Force Academy and numerous military installations to assist in critical and mass notification to base personnel using alert software designed by Desktop Alert.

Currently under development is new infrastructure called the Digital Emergency Alert System. This system would allow the transmission of emergency alerts directly to citizens and responders. These alerts would be sent to users of computers, mobile phones, pagers, and other devices.

Incidents

- During the September 11 attacks in 2001, "... the EAS was not activated nationally or regionally in New York or Washington during the terrorist attacks on the nation." Richard Rudman, then chairman of the EAS National Advisory Committee explained that near immediate coverage in the national media meant that the media itself provided the warning or alert of what had happened and what might happen as quickly as the information could be distributed. "Some events really do serve as their own alerts and warnings. With the immediate live media coverage, the need for an EAS warning was lessened." 34 PEP stations were kept on high alert for use if the President had decided to order an Emergency Action Notification. "PEP is really a last-ditch effort to get a message out if the president cannot get to the media."
- On February 1, 2005, someone activated an EAS message over radio and television stations in Connecticut telling residents to evacuate the state immediately. Officials at the Office of Emergency Management announced that the activation and broadcast of the Emergency Alert System was in error due to possibly the wrong button being pressed. "State police said they received no calls related to the erroneous alert."
- On June 26, 2007, the EAS in Illinois was activated at 7:35AM CDT and issued an Emergency Action Notification Message for the United States. This was followed by dead air and then WGN radio (the station designated to simulcast the alert message) being played on almost every television and radio station in the Chicago area and throughout much of Illinois. The accidental EAN activation was caused when a government contractor installing a new satellite receiver as part of a new national delivery path incorrectly left the receiver connected and wired to the state EOC's EAS transmitter before final closed circuit testing of the new delivery path had been completed.
- On October 19, 2008 KWVE-FM of San Clemente, California was scheduled to conduct a Required Weekly Test; however, it conducted a Required Monthly Test by mistake, causing all stations and cable systems in the immediate area to relay the test. In addition, the operator aborted the test midway through, leading the station to fail to broadcast the SAME EOM burst to end the test, causing all area outlets to broadcast KWVE-FM's programming until those stations took their equipment offline. On September 15, 2009, the Federal Communications Commission fined its licensee, Calvary Chapel of Costa Mesa, \$5000 for the botched EAS test. After the fine was levied, various state broadcast associations in the United States submitted joint letters to the FCC, protesting against the fine, saying that the FCC could have handled the matter better. On November 13, 2009, the FCC rescinded its fine against KWVE-FM, but had still admonished the station for broadcasting an unauthorised RMT, as well as omitting the code to end the test.
- On May 20, 2010, The NOAA All-Hazards radio EAS was activated at a little after 5PM on Wednesday. Wednesday is the day that all NOAA National Weather Service offices send test messages over NOAA Weather Radio stations. The message transmitted was a Severe Thunderstorm Warning, issued by the National Weather Service in Pendleton, Oregon, but the transmission was somehow

botched. The audio portion of the message was silent for a moment, followed by a few words in Spanish.

EAS event codes

Specific Area Message Encoding

Specific Area Message Encoding or **SAME** is the protocol used to encode the Emergency Alert System (EAS) and NOAA Weather Radio's Public Warning System in the U.S. and Weatheradio Canada in Canada.

History

From the 1960s to the 1980s, a special feature of the NOAA Weather Radio system was the transmission of a single tone at 1050 Hz prior to the broadcast of any message alerting the general public of significant weather events. This became known as the Warning Alarm Tone (WAT). Although it has served NOAA Weather Radio well, there were many drawbacks: without staff at media facilities to manually evaluate the need to rebroadcast a Weather Radio message using the Emergency Broadcast System (EBS), automatic rebroadcasting of all messages preceded by just the WAT was unacceptable and impractical. Even if stations and others with that type of need were willing to allow for this type of automatic capture, assuming the events for activation were critical, there was no way for automated equipment at the station to know when the message was complete and restore it back to normal operation.

In 1985, the National Weather Service forecast offices began experimenting with putting special digital codes at the beginning and end of every message concerning life- or property-threatening weather conditions targeting a specific area. The intent of what became SAME was to ultimately transmit a code with the initial broadcast of all Weather Radio messages. The NWS started implementing SAME on the full NOAA Weather Radio system in 1988. The SAME technique was later adopted by the FCC for regular broadcasters on radio, television, and cable, as well as by Environment Canada for its Weatheradio Canada service. Much like the original EBS alert tone, this produces a distinct sound which is easily recognized by most Americans due to its use in weekly and monthly broadcast tests, and in weather emergencies. During the said events, viewers and/or listeners will hear these digital codes in the form of buzzes, chirps, & clicking sounds (or what broadcast engineers affectionately call "duck farts") just before the attention signal is sent out and at the conclusion of the voice message.

Functionality

In the SAME system, messages are constructed in four parts, the first and last of which are digital. The first part is a header message, which is transmitted three times, so that

decoders can pick "best two out of three" for each byte, thereby eliminating most errors which can cause an activation to fail.

The header is an AFSK data burst, with each individual bit lasting 1920 μ s (1.92 ms) each, giving a bit rate of 520⁵/₆ bits per second. A mark bit is four complete cycles of a sine wave, translating to a mark frequency of 2083¹/₃ Hz, and a space bit is three complete sine wave cycles, making the space frequency 1562.5 Hz.

The data is encoded in 7-bit ASCII but uses all 8 bits, with no parity bit and no stop bit ("8-N-0"). The least-significant bit of each byte is transmitted first, including the preamble.

The text of the header code is a fixed format of Preamble-*ZCZC-org-eee*(up to 32 of -*pssccc*)+*tttt-jjjhhmm-lllllll*:

1. A preamble of binary 10101011 (0xAB in hex) repeated sixteen times, used for "receiver calibration" (i.e., clock synchronization), then the letters *ZCZC* as an attention to the decoder
2. *org*: Originator code; programmed per unit when put into operation
 - EAN - Emergency Action Notification Network (President or other authorized national officials. No longer officially used)
 - PEP - Primary Entry Point Station (President or other authorized national officials)
 - CIV - Civil authorities (i.e. Governor, state/local emergency management, local police/fire officials)
 - WXR - National Weather Service (or Environment Canada. Any weather-related alert)
 - EAS - Broadcast station or cable system (Broadcasters. Generally only used with test messages)
3. *eee*: Event code; programmed at time of event
4. *pssccc*: Location codes (up to 31 locations); programmed at time of event
 - In the United States, designated by FIPS state code and indicating the county (parish in Louisiana, borough or census area in Alaska), but which may be designated for the whole state by using county number 000
 - In Canada, designated by Canadian Location Code, which corresponds to a specific forecast region as used by the Meteorological Service of Canada
5. *tttt*: Duration of alert in the format *hhmm*, normally in increments of 15 minutes from time of issue
6. *jjjhhmm*: Exact time of issue, in UTC, without time zone adjustments
 - *jjj* is the Ordinal date day of the year, with leading zeros
 - *hhmm* is 24-hour hours and minutes, in UTC, with leading zeros
7. Eight-character station callsign identification, with / used instead of - (such as the first eight letters of a cable headend's location, *WABC/FM* for WABC-FM, or *KLOX/NWS* for a weather radio station programmed from Los Angeles).

Each field of the header code is terminated by a dash character.

Full message breakdown

An EAS message contains these elements, in this transmitted sequence:

1. Header
2. Attention signal: Sent if any message is included (normally sent with all messages except RWT on commercial radio/TV); must be at least eight seconds long
 - Single 1050 Hz (help-info) audio tone for Weatheradio
 - Combined 853 and 960 Hz (help-info) tones for commercial radio/TV
3. Message - audio, video image or video text
4. Tail: (Preamble) NNNN (EOM)

There is one second of blank audio between each section, and before and after each message.

SAME on weather radio receivers



An example of a SAME alert weather radio receiver.

There are many weather/all-hazards radio receivers that are equipped with the SAME alert feature. It allows users to program SAME/FIPS/CLC codes for their designated area or areas of their interest and/or concern rather than the entire broadcast area (Examples given: If a person were to live in Irving, Texas, he or she would program a FIPS code for Dallas County. However, if he or she needs to be in the know of severe weather from the west and northwest ahead of time, the user would program additional FIPS codes for Denton and Tarrant Counties. On a more specialized receiver, a user has the option to eliminate any SAME alert codes that may not apply to their area such as a "Special Marine Warning" or a "Coastal Flood Warning"). Once the SAME header is sent by NOAA/NWS and if it matches the desired code(s), the receivers then decode the event, scroll it on their display screens, and sound an alarm.

Receivers receive on one of the following National Weather Service network frequencies (in MHz): 162.400, 162.425, 16

WWT

Chapter- 3

Fire Alarm System



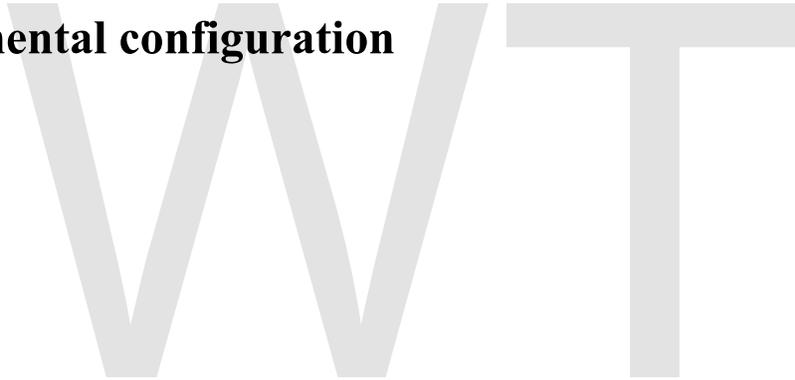
A fire alarm notification appliance with a strobe light.

An automatic **fire alarm system** is designed to detect the unwanted presence of fire by monitoring environmental changes associated with combustion. In general, a fire alarm system is classified as either automatically actuated, manually actuated, or both. Automatic fire alarm systems can be used to notify people to evacuate in the event of a fire or other emergency, to summon emergency services, and to prepare the structure and associated systems to control the spread of fire and smoke.

Design

After the fire protection goals are established - usually by referencing the minimum levels of protection mandated by the appropriate model building code, insurance agencies, and other authorities - the fire alarm designer undertakes to detail specific components, arrangements, and interfaces necessary to accomplish these goals. Equipment specifically manufactured for these purposes are selected and standardized installation methods are anticipated during the design. In the United States, NFPA 72, *The National Fire Alarm Code* is an established and widely used installation standard.

Fundamental configuration





A Honeywell DeltaNet FS90 fire alarm control panel.

Fire alarm control panel



A Siemens MXL fire alarm control panel (top) and graphic annunciator (bottom) for Potomac Hall, at James Madison University.

A **fire alarm control panel** (FACP), or **fire alarm control unit** (FACU), is an electric panel that is the controlling component of a fire alarm system. The panel receives information from environmental sensors designed to detect changes associated with fire, monitors their operational integrity and provides for automatic control of equipment, and transmission of information necessary to prepare the facility for fire based on a

predetermined sequence. The panel may also supply electrical energy to operate any associated sensor, control, transmitter, or relay. There are four basic types of panels: coded panels, conventional panels, addressable panels, and multiplex systems. A fire alarm control panel is required under the building code for a majority of new commercial building construction in most countries.

Coded panels



A Simplex 4247 fire alarm control panel.

Coded panels were the earliest type of central fire alarm control, and were made during the 1800s to the 1970s. A coded panel is similar in many ways to a modern conventional panel (described below), except each zone was connected to its own code wheel (Ex: An alarm in zone 1 would sound code 1-2-4 [through the bells or horns in the building], while zone 2 would sound 1-2-5), which, depending on the way the panel was set up,

would either do sets of four rounds of code until the initiating pull station was reset (similar to a coded pull station) or run continuously until the panel itself was reset. Large panels could take up an entire wall in a mechanical room, with dozens of code wheels. Lists of codes had to be maintained, sometimes with copies being posted above certain pull stations (this setup is commonly seen in older wings of hospitals). Smaller panels could be set up in one of two ways. Most of the time, the panel would only have one zone, and therefore, only one code. Common one-zone codes were 4-4-0 and 17-0-0 (which is similar to the 120 bpm March Time setting found on modern panels). Alternatively, the panel could be made with no code wheels, using only what was called the gong relay. Normally, this would be used in a system with coded pull stations to retransmit the coding strikes from the pulls. However, it could also be used as its own zone, with the connected horns or bells sounding continuously instead of in a particular code. These panels are not very common today, but can sometimes be found in older buildings such as those on college campuses or hospitals.

Conventional panels

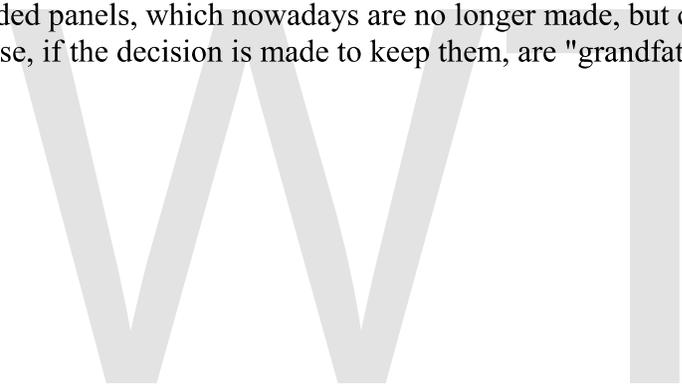


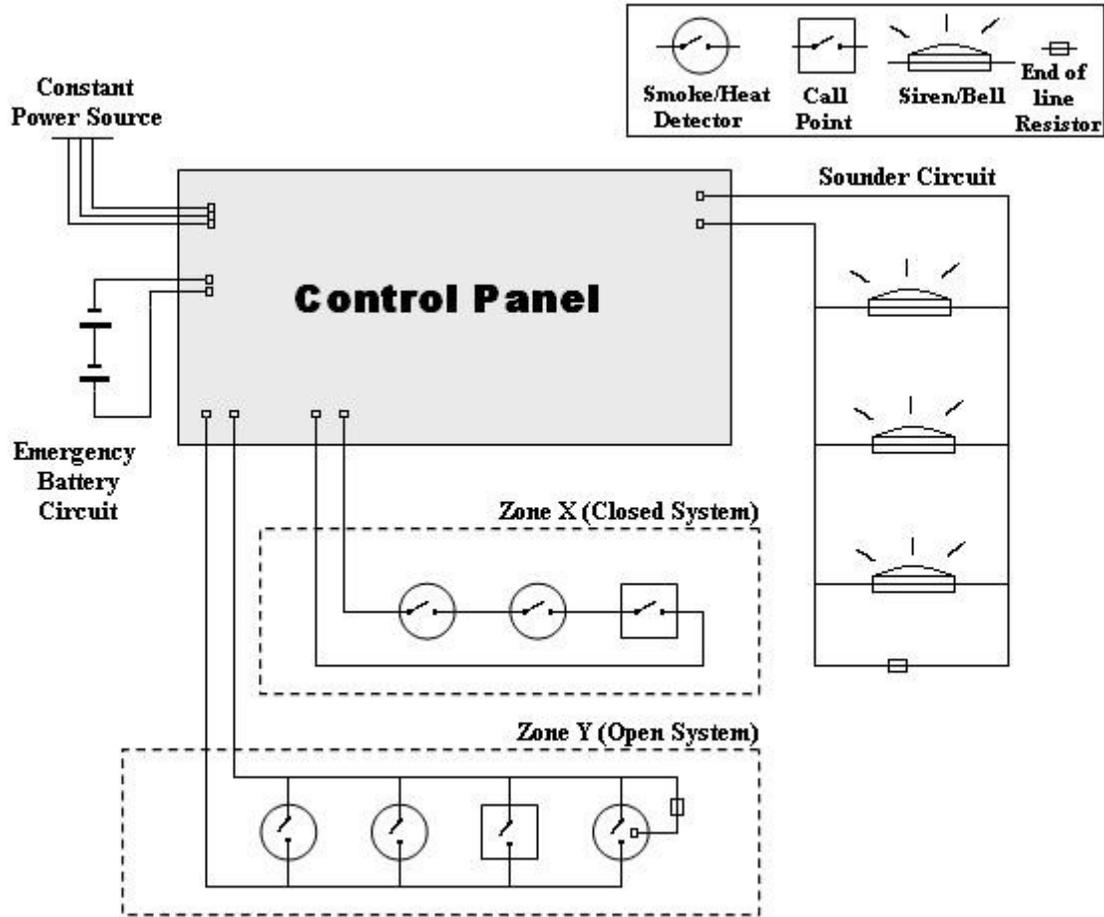
A Simplex 4002 conventional FACP

Conventional panels have been around ever since electronics became small enough to make them viable. They are no longer used frequently in large buildings, but are still used on smaller sites such as small schools, stores, restaurants, and apartments.

A conventional system employs one or more initiating circuits, connected to sensors (initiating devices) wired in parallel. These sensors are devised to decrease the circuits resistance when the environmental influence on any sensor exceeds a predetermined threshold. In a conventional system the information density is limited to the number of such circuits used. A small map of the building is often placed near the main entrance with the defined zones drawn up, and LEDs indicating whether a particular circuit/zone has been activated. Another common method is to have the different zones listed in a column, with an LED to the left of each zone name, or to use an LCD interface to display information.

The main drawback with conventional panels is that one cannot tell *which* device has been activated within a circuit. The fire may be in one small room, but as far as emergency responders can tell, a fire could exist anywhere within a zone. The same applies to coded panels, which nowadays are no longer made, but can be found in old systems. These, if the decision is made to keep them, are "grandfathered" in under NFPA regulations.





A wiring diagram for a simple fire alarm system consisting of two input loops (one closed, one open)

Multiplex systems



Simplex 2120 (left) next to a Simplex 4100 classic.

Multiplex systems, a sort of transition between conventional and modern addressable systems, were often used in large buildings and complexes from the mid to late 1970s into the late 1980s. Early on, these systems were programmed to function as large conventional systems. Gradually, later installations began to feature components and features of modern addressable systems. These systems were often capable of controlling more than a building's fire alarm system (i.e. HVAC, security, electronic door locks...) without any type of alarm or trouble condition present. While the main panel was the brains of the system and could be used to access certain functions, fire alarm controls were usually accessed through transponders. These were smaller conventional panels programmed to 'communicate' the status of part of the system to the main panel and also could be used to access basic fire alarm control functions. The original Simplex 4100 was meant to be used this way.

Releasing panels

Releasing panels are capable of using solenoids to disperse fire-fighting chemical agents such as halon or water from piping located throughout a building. A releasing panel usually will have a manual abort switch to abort an accidental release which could

damage property or equipment. Releasing capability can be part of both addressable or conventional panels.

Addressable panels



A Simplex 4100U InfoALARM addressable fire alarm control panel: note the voice-evacuation microphone built into it.

Addressable panels are usually much more advanced than their conventional counterparts, with a higher degree of programming flexibility and single point detection. Addressable fire alarm panels were introduced by many manufacturers during the microcontroller boom in the mid 1980s.

Signaling line circuit loops

Panels usually have a number of signaling line circuit loops - usually referred to as **loops** or **SLC loops** - ranging between one and thirty. Depending on the protocol used, a loop can monitor and control several hundred devices. Some protocols permit any mix of detectors and input/output modules, while other protocols have 50% of channel capacity restricted to detectors/sensors and 50% restricted to input/output modules. Each SLC polls the devices connected, which can number from a few devices to several hundred, depending on the manufacturer. Large systems may have multiple SLCs, and SLCs are further divided into sub-groups through the use of fault-isolation modules.

Each device on a SLC has its own address, and so the panel knows the state of each individual device connected to it. Common addressable input (initiating) devices include

- Smoke detectors
- Heat Detectors (Rate of Rise and Fixed Temperature)
- Manual call points or manual pull stations
- Notification appliances (Simplex systems with TrueAlert signals only)
- Responders
- Fire sprinkler system inputs
- Switches
 - Flow control
 - Pressure
 - Isolate
 - Standard switches

Addressable output devices are known as relays and include

- (Warning System/Bell) Relays
- Door Holder Relays
- Auxiliary (Control Function) Relays

Relays are used to control a variety of functions such as

- Switching fans on or off
- Closing/opening doors
- Activating fire suppression systems
- Activating notification appliances
- Shutting down industrial equipment
- Recalling elevators to a safe exit floor
- Activating another fire alarm panel or communicator

Mapping

Also known as "cause and effect" or "programming", mapping is the process of activating outputs depending on which inputs have been activated. Traditionally, when an input

device is activated, a certain output device (or relay) is activated. As time has progressed, more and more advanced techniques have become available, often with large variations in style between different companies.

Zones

Zones are usually made by dividing a building, or area into different sections, and placing each device in the building in a different zone.

Groups

Groups contain multiple output devices such as relays. This allows a single input, such as a smoke detector or MCP, to have only one output programmed to a group, which then maps to between two to many outputs or relays. This enables an installer to simplify programming by having many inputs map to the same outputs, and be able to change them all at once, and also allows mapping to more outputs than the programming space for a single detector/input allows.

Boolean logic

This is the part of a fire panel that has the largest variation between different panels. It allows a panel to be programmed to implement fairly complex inputs. For instance, a panel could be programmed to notify the fire department only if more than one device has activated. It can also be used for staged evacuation procedures in conjunction with timers.

Networking

The principle of networking involves connecting several panels together to form a system. Inputs on one panel may activate outputs on another, for example, or the network may allow monitoring of many systems. Networking is often used in situations where one panel is not large enough, or in multiple-building situations. These are often done with manufacturers' "top of the line" control panels.

Although quasi-standards exist that allow panels from different manufacturers to be networked with each other, they are not in favor with a lot of companies. One of the most common protocols used BACnet which is used for various type of industrial networks.

More recently, some panels are being networked with standard Ethernet, but this is not yet very common. Most organizations choose to create their own proprietary protocol, which has the added benefit of allowing them to do anything they like, allowing the technology to progress further. However, a bridging layer between the proprietary network and BACnet is usually available.

Networking may be used to allow a number of different panels to be monitored by one graphical monitoring system.

Monitoring

In nearly every state in the USA, the International Building Code requires fire alarm and sprinkler systems to be monitored by an approved supervising station.

A fire alarm system consists of a computer-based control connected to a central station. The majority of fire alarm systems installed in the USA are monitored by a UL listed or FM Global approved supervising station.

These systems will generally have a top level map of the entire site, with various building levels displayed. The user (most likely a security guard) can progress through the different stages. From top level site → building plan → floor plan → zone plan, or however else the building's security system is organised.

A lot of these systems have touch screens, but most users tend to prefer a mouse (and a normal monitor), as it is quite easy for a touch screen to become misaligned and for mistakes to be made. With the advent of the optical mouse, this is now a very viable option.

System functions



A police officer resets the fire alarm control panel for Potomac Hall at James Madison University.

There are many functions on a fire alarm panel. Some of these are:

System reset

This resets the panel after an alarm condition. All initiating devices are reset, and the panel is cleared of any alarm conditions. If an initiating device is still in alarm after the system is reset, such as a smoke detector continuing to sense smoke, or a manual pull station still in an activated position, another alarm will be initiated. A system reset is often required to clear supervisory conditions. A system reset does not usually clear

trouble conditions. Most trouble conditions will clear automatically when conditions are returned to normal.

On UK and most US panels, a "Silence" or "Acknowledge" is usually required before a "System Reset" can be performed.

Acknowledge

This function, also abbreviated to "ACK", is used to acknowledge an abnormal situation such as an alarm, trouble or supervisory. The acknowledge function tells the panel that building personnel or emergency responders are aware of the alarm, trouble, or supervisory condition. Acknowledging the alarm or trouble condition also normally silences the panel's own sounder, but does not silence any Notification Appliances.



Fire alarm panel, showing drill switch (at top)

Drill

Also known as "manual evacuation" or "evacuate". On panels that have this function, the drill function activates the system's notification appliances, often for purposes of conducting a fire drill. Using the drill function, an alarm is normally not transmitted to the fire department or monitoring center. However, building personnel often notify these agencies in advance in case an alarm is inadvertently transmitted.

Walk test

Walk test allows the functional testing of the system's devices without the assistance of additional people at the control panel itself. It is also designed to allow initiating devices to be tested without setting off the building's alarms. Most panels offer the option for a silent walk test (no alarms activate) or an audible walk test (alarms activate for a brief period when a device is initiated). A system trouble is typically generated while the panel is in walk test mode. On European panels, this is usually an engineer-only function and cannot be activated by a user.

Signal silence

Also known as "alarm silence" or "audible silence". Depending on the configuration of the alarm system, this function will either silence the system's notification appliances completely, or will silence only the audible alarm, with strobe lights continuing to flash. Audible silence allows for easier communication amongst emergency responders while responding to an alarm. This can also be used during construction as a means of a preliminary test, before the final full test.

Lamp test

Also known as "flash test". This button is known to have become obsolete, but is still used on many panels. This function is used to check the condition of the LEDs themselves. A "Lamp Test" button is required by code on multi-zone panels installed in Canada. Many panels do a lamp test when the system is reset.

Alarm circuit supervision

Various forms of alarm circuit supervision have been used to indicate trouble with an alarm circuit. Possible alarm circuit faults on a two wire circuit include one of the conductors being shorted to ground, open circuit (conductor continuity break), or a short circuit between the conductors. Also the circuits could be tampered with by having an external AC or DC voltage applied with various duty cycles or waveforms. There are a number of US patents that address this issue and some have been implemented in available system products. One of the first to address this issue was Patent No. 3,588,890 "Resistance Sensing Supervisory System" issued on June 28, 1971 and assigned to

General Motors Corporation. General Motors used this supervision on all circuits installed in GM plants starting in 1970 . An improvement to this basic "Resistance Sensing Supervisory System" can be obtained by providing a pulsed or time dependent variable voltage applied to the alarm circuit and is addressed in US patent numbers 4,030,095 and 4,716,401 .

Panel alerting

Many panels today have the capability of alerting building personnel of a situation which can arise into a potentially serious problem. Fire alarm panels indicate an abnormal condition is via a solid or flashing LED. Some panels also contain a small sounder, used in conjunction with the visual alert. A number of indicators are shown below. Note that not all fire alarm panels have all of these indicators.

Alarm

Also known as "Fire" or "General Alarm". This indicator is lit when an alarm condition exists in the system, initiated by smoke detectors, heat detectors, sprinkler flow switches, manual pull stations, manual call points, or otherwise. Along with the indicator on the panel, notification appliances, such as horns and strobes, are also activated, signaling a need to evacuate to building occupants. In an alarm condition, the fire alarm panel indicates where the alarm originated. The alarm panel can be reset once the device which initiated the alarm is reset, such as returning the handle of a manual pull station to its normal position.

Audible silence

The Audible Silence indicator is used in conjunction with the "Alarm" indicator. It indicates that the fire alarm panel is still in an alarm condition, but that notification appliances have been silenced. While the alarm is silenced, other functions in an alarm condition continue to operate, such as emergency service for elevators, stairway pressurization, and ventilation functions. A new alarm initiation while the alarm is silenced will take the panel out of Audible Silence and reactivate the notification appliances.

Report

Also known as "Brigade Called". This indicator is activated when emergency responders have been automatically notified by the fire alarm system. A variant of this LED known as "kissoff" activates when the monitoring center replies back to the panel, indicating a successful communication. Requirements vary depending on jurisdiction regarding whether a direct connection to the fire department is required, optional, or prohibited. If a connection to the fire department is optional, or is prohibited, a fire alarm system is often connected to a monitoring center at the building owner's discretion.

Drill

Also known as "Manual Evacuation" or "Evacuate". On panels containing this function, the "Drill" indicator shows that the alarm condition was activated from the fire alarm panel, often in order to conduct a fire drill. When an alarm is initiated for a drill, the fire department or monitoring company is usually not notified automatically. However, building personnel preparing to conduct a fire drill often will provide advance notice of a drill to the fire department and monitoring center in case an alarm is unintentionally transmitted.

Prealarm

This LED is often used in conjunction with a two-stage system, in which the panel requires two devices to be activated (and/or a predetermined time limit to run out after one device is activated) in order to go into full alarm. This is mostly used in areas where false alarms are a common problem, or in large applications (such as hospitals) where evacuating the entire building would not be efficient. The prealarm LED is lit when one device has tripped. The prealarm LED may also be used if an analog smoke detector registers low levels of smoke in the detection chamber, but not enough to trigger a full alarm. Depending on the system's layout, the NAC's may or may not activate for prealarm conditions. In a two-stage system, the NAC's are typically coded to a special first-stage coding, or in some situations where a loud alarm signal could be disruptive, chimes will activate. If there is a voice evacuation system, it will usually instruct building occupants to await further instructions while the alarm is being investigated.

Priority 2 alarm

Also known as "Security". This LED is common on top-of-the-line intelligent panels. This LED can only activate if there is a secondary device hooked into the "Priority 2 Alarm" terminals. This secondary device could be a security system, building management system, or another fire alarm control panel. Depending on how the panel is programmed, the panel's alarms may or may not activate when a condition like this is present.

Trouble

Also known as "Fault" or "Defect". When held steady or flashing, it means that a trouble condition exists on the panel. Trouble conditions are often activated by a contaminated smoke detector or an electrical problem within the system. Trouble conditions are also activated by a zone being disabled (disconnected from the system), a circuit being disabled, low power on the backup battery, the disabling of a notification appliance, the ground faults, or short or open circuits. Usually the alarm panel's sounder will activate if a trouble condition exists, though older systems would sometimes activate a bell or other audible signal connected to the panel. In a trouble condition, the panel displays the zone or devices causing the condition. The "Trouble" indicator goes out automatically when the situation causing the trouble condition is rectified and some panels have more specific

indicators such as 'Trouble-PSU' which shows when the panel itself is compromised and 'Trouble-Bell' ('Sounder fault' on UK panels) which shows that the sounders are not functioning correctly.

Supervisory

This signal indicates that a portion of the building's fire protection system has been disabled (such as a fire sprinkler control valve being closed and, consequentially, a sprinkler tamper switch being activated), or, less frequently, that a lower priority initiating device has been triggered (such as a duct smoke detector). Depending on the system's design, the supervisory point may be latching, meaning the panel must be reset to clear the supervisory condition, or non-latching, meaning the indicator automatically goes out when the condition has cleared. However, some panels require a reset regardless if the supervisory is latching or non-latching.

AC power

Also known as "Normal". When this indicator is lit, power is being provided to the system from the building's electrical system, and not from the backup battery. When an AC power condition changes, the Trouble indicator comes on and the AC power indicator goes off and the screen alerts building personnel of a power failure. If the AC power indicator is lit without any other indicators also lit, then the system is in a normal condition. If no LEDs are lit, there is no power source feeding the panel.

DC power

This is used to tell the operator that DC power (batteries) are being charged or used. While using DC power, the system remains in a trouble condition.

Highrate

This LED is on when there are unusual power-line conditions.

- **Primary Power supply:** Commonly the non-switched 120 or 240 Volt Alternating Current source supplied from a commercial power utility. In non-residential applications, a branch circuit is dedicated to the fire alarm system and its constituents. "Dedicated branch circuits" should not be confused with "Individual branch circuits" which supply energy to a single appliance.
- **Secondary (backup) Power supplies:** This component, commonly consisting of sealed lead-acid storage batteries or other emergency sources including generators, is used to supply energy in the event of a primary power failure.
- **Initiating Devices:** This component acts as an input to the fire alarm control unit and are either manually or automatically actuated. Examples would be devices like pull stations or smoke detectors.

- Notification appliances: This component uses energy supplied from the fire alarm system or other stored energy source, to inform the proximate persons of the need to take action, usually to evacuate. This is done by means of a flashing light, strobe light, electromechanical horn, speaker, or a combination of these devices.
- Building Safety Interfaces: This interface allows the fire alarm system to control aspects of the built environment and to prepare the building for fire and to control the spread of smoke fumes and fire by influencing air movement, lighting, process control, human transport and exit.

Initiating devices

- Manually actuated devices; Break glass stations, Buttons and manual pull station are constructed to be readily located (near the exits), identified, and operated.
- Automatically actuated devices can take many forms intended to respond to any number of detectable physical changes associated with fire: convected thermal energy; heat detector, products of combustion; smoke detector, radiant energy; flame detector, combustion gasses; carbon monoxide detector and release of extinguishing agents; water-flow detector. The newest innovations can use cameras and computer algorithms to analyze the visible effects of fire and movement in applications inappropriate for or hostile to other detection methods.

Notification appliances

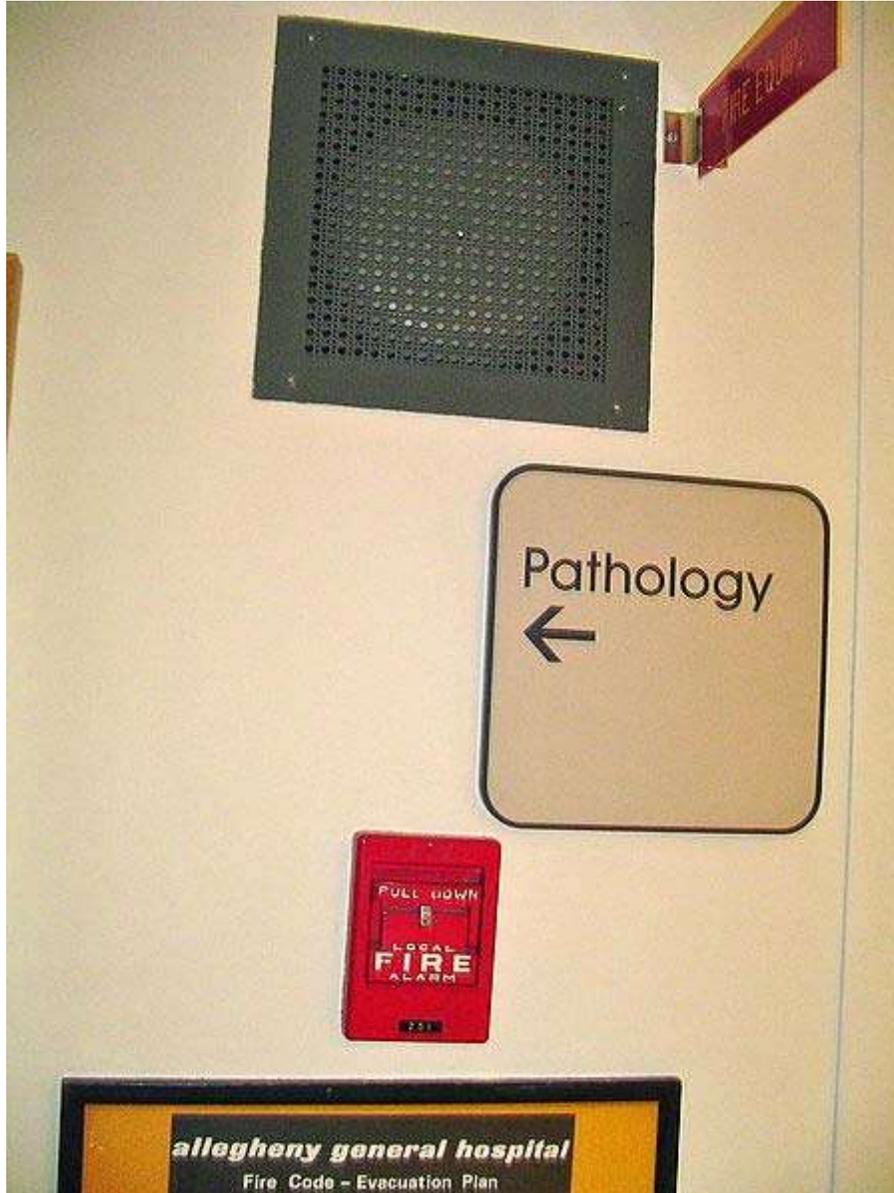


A Honeywell speaker and a Space Age Electronics V33 remote light.

- Audible, visible, tactile, textual or even olfactory stimuli (odorizer). to alert the occupants. Audible or visible signals are the most common and may utilize speakers to deliver live or pre-recorded instructions to the occupants. In the United States, fire alarm evacuation signals are required to use a standardized interrupted four count temporal pattern to avoid confusion with other signals using similar sounding appliances. Other methods include:
- Audible textual appliances, which are employed as part of a fire alarm system that includes Emergency Voice Alarm Communications (EVAC) capabilities. High reliability speakers are used to notify the occupants of the need for action in connection with a fire or other emergency. These speakers are employed in large facilities where general undirected evacuation is considered impracticable or undesirable. The signals from the speakers are used to direct the occupant's response. The system may be controlled from one or more locations within the building known as Fire Wardens Stations, or from a single location designated as the building Fire Command Center. Speakers are automatically actuated by the fire alarm system in a fire event, and following a pre-alert tone, selected groups of speakers may transmit one or more prerecorded messages directing the occupants to safety. These messages may be repeated in one or more languages. Trained personnel activating and speaking into a dedicated microphone can suppress the

replay of automated messages in order to initiate or relay real time voice instructions.

Building safety interfaces



S.H. Couch F5GX non-coded fire alarm pull station below a Couch 10" bell.

- Magnetic Smoke Door Holders: Wall or floor mounted solenoids or electromagnets controlled by a fire alarm system or detection component that magnetically secures spring-loaded self-closing smoke tight doors in the open position. Designed to de-magnetize to allow automatic closure of the door on command from the fire control or upon failure of the power source,

interconnection or controlling element. Stored energy in the form of a spring or gravity can then close the door to restrict the passage of smoke from one space to another in an effort to maintain a tenable atmosphere on either side of the door during evacuation and fire fighting efforts.

- **Duct Mounted Smoke Detection:** Smoke detection mounted in such a manner as to sample the airflow through duct work and other plenums specifically fabricated for the transport of environmental air into conditioned spaces. Interconnection to the fan motor control circuits are intended to stop air movement, close dampers and generally prevent the recirculation of toxic smoke and fumes produced by fire into occupiable spaces.

UK fire alarm system categories

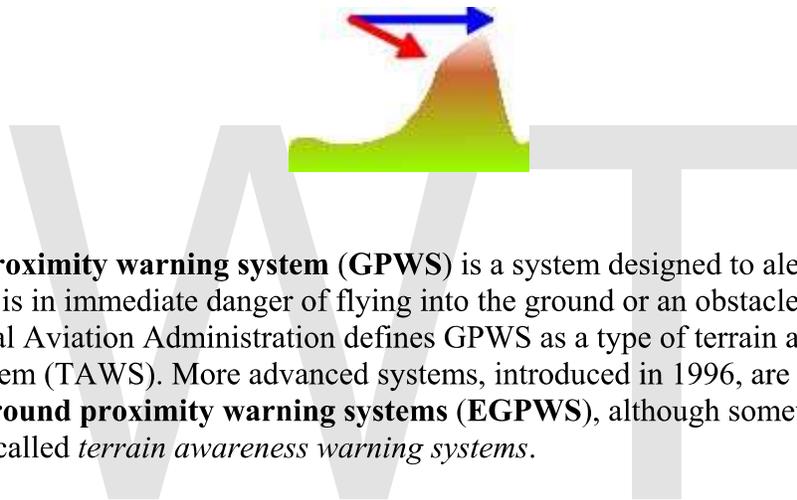
There are many types of fire alarm systems each suited to different building types and applications. A fire alarm system can vary dramatically in both price and complexity, from a single panel with a detector and sounder in a small commercial property to an addressable fire alarm system in a multi-occupancy building. Systems have to protect both buildings and occupants.

The categories of fire alarm systems are L if they are designed to protect life, P to protect buildings and M if they are manual systems.

M	Manual systems, e.g. hand bells, gongs, etc. These may be purely manual or manual electric, the latter may have call points and sounders. They rely on the occupants of the building discovering the fire and acting to warn others by operating the system. Such systems form the basic requirement for places of employment with no sleeping risk.
P1	The system is installed throughout the building - the objective being to call the fire brigade as early as possible to ensure that any damage caused by fire is minimized. Small low risk areas can be excepted, such as toilets and cupboards less than 1m ² .
P2	Detection should be provided in parts of the building where the risk of ignition is high and/or the contents are particularly valuable. Category 2 systems provide fire detection in specified parts of the building where there is either high risk or where business disruption must be minimised.
L1	A category L1 system is designed for the protection of life and which has automatic detectors installed throughout all areas of the building (including roof spaces and voids) with the aim of providing the earliest possible warning. A category L1 system is likely to be appropriate for the majority of residential care premises. In practice, detectors should be placed in nearly all spaces and voids. With category 1 systems, the whole of a building is covered apart from minor exceptions.
L2	A category L2 system designed for the protection of life and which has

	automatic detectors installed in escape routes, rooms adjoining escape routes and high hazard rooms. In a medium sized premises (sleeping no more than ten residents), a category L2 system is ideal. These fire alarm systems are identical to an L3 system but with additional detection in an area where there is a high chance of ignition, e.g., kitchen) or where the risk to people is particularly increased (e.g., sleeping risk).
L3	This category is designed to give early warning to everyone. Detectors should be placed in all escape routes and all rooms that open onto escape routes. Category 3 systems provide more extensive cover than category 4. The objective is to warn the occupants of the building early enough to ensure that all are able to exit the building before escape routes become impassable.
L4	Category 4 systems cover escape routes and circulation areas only. Therefore, detectors will be placed in escape routes, although this may not be suitable depending on the risk assessment or if the size and complexity of a building is increased. Detectors might be sited in other areas of the building, but the objective is to protect the escape route.
L5	This is the "all other situations" category, e.g., computer rooms, which may be protected with an extinguishing system triggered by automatic detection. Category 5 systems are the "custom" category and relate to some special requirement that cannot be covered by any other category.

Ground Proximity Warning System



A **ground proximity warning system (GPWS)** is a system designed to alert pilots if their aircraft is in immediate danger of flying into the ground or an obstacle. The United States Federal Aviation Administration defines GPWS as a type of terrain awareness warning system (TAWS). More advanced systems, introduced in 1996, are known as **enhanced ground proximity warning systems (EGPWS)**, although sometimes confusingly called *terrain awareness warning systems*.

History

In the late 1960s, a series of controlled flight into terrain (CFIT) accidents killed hundreds of people. (A CFIT accident is one where a properly functioning airplane under the control of a fully qualified and certificated crew is flown into terrain (or water or obstacles) with no apparent awareness on the part of the crew.)

Beginning in the early 1970s, a number of studies looked at the occurrence of CFIT accidents. Findings from these studies indicated that many such accidents could have been avoided if a warning device called a ground proximity warning system (GPWS) had been used. As a result of these studies and recommendations from the U.S. National Transportation Safety Board (NTSB), in 1974 the FAA required all large turbine and turbojet airplanes to install TSO-approved GPWS equipment.

C. Donald Bateman, a Canadian-born engineer, developed and is credited with the invention of GPWS.

In March 2000, the U.S. FAA amended operating rules to require that all U.S. registered turbine-powered airplanes with six or more passenger seats (exclusive of pilot and copilot seating) be equipped with an FAA-approved TAWS. The mandate affects aircraft manufactured after March 29, 2002.

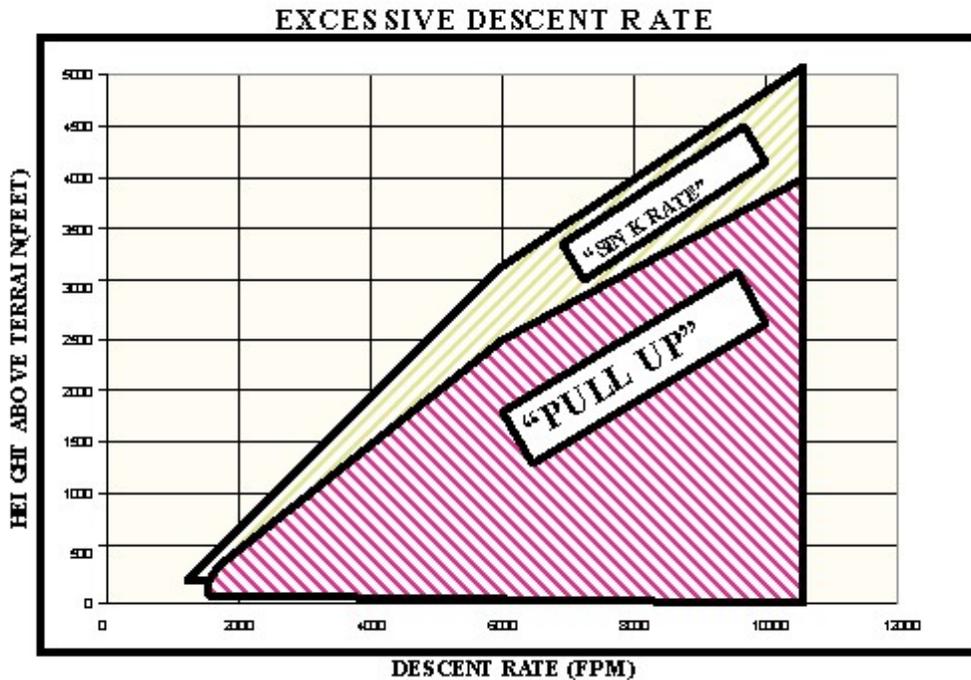
Effects and statistics

Prior to the development of GPWS, large passenger aircraft were involved in 3.5 fatal CFIT accidents per year, falling to 2 per year in the mid-1970s. Since 1974, when the U.S. Federal Aviation Administration made it a requirement for large aircraft to carry such equipment, there has not been a single passenger fatality in a CFIT crash by a large jet in U.S. airspace.

After 1974, there were still some CFIT accidents which GPWS was unable to help prevent, due to the *blind spot* of those early GPWS systems. More advanced systems were developed.

Older TAWS systems, or deactivation of the EGPWS system, or ignoring its warnings when airport is not in its database still leave aircraft vulnerable to possible CFIT incidents. In April 2010, a Polish Air Force Tupolev Tu-154M aircraft crashed near Smolensk, Russia, in a possible CFIT accident killing all passengers and crew. The aircraft was equipped with TAWS made by Universal Avionics Systems of Tucson. According to the Russian Interstate Aviation Committee TAWS was turned on. However, the airport where the aircraft was going to land (Smolensk (XUBS)) is not in the TAWS database. In January 2008 a Polish Air Force Casa C-295M crashed in a CFIT accident near Mirosławiec, Poland, despite being equipped with EGPWS; the EGPWS warning sounds had been disabled, and the pilot-in-command was not properly trained with EGPWS.

Commercial aircraft



The FAA specifications have detailed requirements for when certain warnings should sound in the cockpit.

The system monitors an aircraft's height above ground as determined by a radio altimeter. A computer then keeps track of these readings, calculates trends, and will warn the captain with visual and audio messages if the aircraft is in certain defined flying configurations ("modes").

The modes are:

1. Excessive descent rate ("PULL UP" "SINK RATE")
2. Excessive terrain closure rate ("TERRAIN" "PULL UP")
3. Altitude loss after take off or with a high power setting ("DON'T SINK")
4. Unsafe terrain clearance ("TOO LOW - TERRAIN" "TOO LOW - GEAR" "TOO LOW - FLAPS")
5. Excessive deviation below glideslope ("GLIDESLOPE")
6. Excessively steep bank angle ("BANK ANGLE")
7. Windshear protection ("WINDSHEAR")

Traditional GPWS does have a blind spot. Since it can only gather data from directly below the aircraft, it must predict future terrain features. If there is a dramatic change in terrain, such as a steep slope, GPWS will not detect the aircraft closure rate until it is too late for evasive action.

In the late 1990s improvements were made and the system was renamed "Enhanced Ground Proximity Warning System" (EGPWS/TAWS). The system was now combined with a worldwide digital terrain database and relies on Global Positioning System (GPS) technology. On-board computers compared its current location with a database of the Earth's terrain. The Terrain Display now gave pilots a visual orientation to high and low points nearby the aircraft.

EGPWS software improvements were focused on solving two common problems; no warning at all, and late or improper response.

No Warning: The primary cause of CFIT occurrences with no GPWS warning is landing short. When the landing gear is down and landing flaps are deployed, the GPWS expects the airplane to land and therefore, issues no warning. EGPWS introduces the Terrain Clearance Floor (TCF) function, which provides GPWS protection even in the landing configuration.

Late Warning or Improper Response: The occurrence of a GPWS alert typically happens at a time of high workload and nearly always surprises the flight crew. Almost certainly, the aircraft is not where the pilot thinks it should be, and the response to a GPWS warning can be late in these circumstances. Warning time can also be short if the aircraft is flying into steep terrain since the downward looking radio altimeter is the primary sensor used for the warning calculation. The EGPWS improves terrain awareness and warning times by introducing the Terrain Display and the Terrain Data Base Look Ahead protection.

Incidents

In Commercial and Airline operations there are legally mandated procedures that must be followed should an EGPWS caution or warning occur. Both pilots must respond and act accordingly once the alert has been issued. An Indonesian captain has been charged with manslaughter for not adhering to these procedures .

General aviation

TAWS equipment is not required by the U.S. FAA in piston-engined aircraft, but optional equipment categorized as **TAWS Type C** may be installed. Depending on the type of operation, TAWS is only required to be installed into turbine-powered aircraft with six or more passenger seats.

A smaller and less expensive version of EGPWS was developed by AlliedSignal (now merged with Honeywell) for general aviation and private aircraft.

Military fast jet

For military fast-jets, the high speed and low altitude which may frequently be flown, make traditional GPWS systems unsuitable as the “blind spot” becomes the critical part. Thus an enhanced system is required, taking inputs not only from the radar altimeter but also from Inertial navigation system(INS), Global Positioning System(GPS), and Flight Control System(FCS), and using these to accurately predict the flight path of the aircraft up to 4 to 5 miles (6.4 to 8.0 km) ahead. Digital maps of terrain and obstacle features are then used to determine whether a collision is likely if the aircraft does not pull up at a given pre-set g-level. If a collision is predicted a cockpit warning may be provided. This is the type of system deployed on such aircraft as the Eurofighter Typhoon.

WWT

Traffic Collision Avoidance System



TCAS and IVSI Indicator

A traffic collision avoidance system or traffic alert and collision avoidance system (both abbreviated as **TCAS**) is an aircraft collision avoidance system designed to reduce the incidence of mid-air collisions between aircraft. It monitors the airspace around an aircraft for other aircraft equipped with a corresponding active transponder, independent of air traffic control, and warns pilots of the presence of other transponder-equipped aircraft which may present a threat of mid-air collision (MAC). It is a type of airborne collision avoidance system mandated by the International Civil Aviation Organization to be fitted to all aircraft with a maximum take-off mass (MTOM) of over 5700 kg (12,586 lbs) or authorized to carry more than 19 passengers.

Official definition from PANS-ATM (Nov 2007): ACAS / TCAS is an aircraft system based on secondary surveillance radar (SSR) transponder signals which operates independently of ground-based equipment to provide advice to the pilot on potential conflicting aircraft that are equipped with SSR transponders.

In modern glass cockpit aircraft, the TCAS display may be integrated in the Navigation Display (ND); in older glass cockpit aircraft and those with mechanical instrumentation, such an integrated TCAS display may replace the mechanical Vertical Speed Indicator (which indicates the rate with which the aircraft is descending or climbing).

Impetus for a collision prevention system

Research into collision avoidance systems has been ongoing since at least the 1950s. ICAO and aviation authorities such as the Federal Aviation Administration were spurred into action after several major mid-air collisions involving great loss of life. Some of these mid-air accidents include:

- Grand Canyon midair collision in 1956;
- The New York air disaster in 1960;
- The Asheville midair collision in 1967;
- The Zagreb mid-air collision in 1976;
- PSA Flight 182, a Boeing 727 which collided with a Cessna 172 in 1978;
- The Ukraine Aeroflot mid-air collision, between two Tupolev Tu-134 in 1979;
- Aeroméxico Flight 498, a 1986 collision similar to PSA Flight 182, which finally spurred the US Congress and other regulatory bodies into action and led to mandatory collision avoidance equipment.
- Chakri Dadri midair collision over a town near New Delhi, India in 1996;

The implementation of TCAS added a safety barrier to help prevent mid-air collisions. However, further study, refinements, training and regulatory measures were still required, because the limitations and misuse of the system still resulted in other incidents and fatal accidents, which include:

- The Japan Airlines near miss incident in 2001;
- The Überlingen mid-air collision, between a Boeing 757 and a Tupolev Tu-154 in 2002, where the Tupolev pilots disobeyed their TCAS RA, instead following the

- directions of the air traffic controller; by the time the crews of the two planes actually saw each other, it was too late and the planes collided, killing 61;
- The Gol Flight 1907 collision with an Embraer Legacy 600 in 2006;

TCAS basics

TCAS involves communication between all aircraft equipped with an appropriate transponder (provided the transponder is enabled and set up properly). Each TCAS-equipped aircraft "interrogates" all other aircraft in a determined range about their position (via the 1030 MHz radio frequency), and all other craft reply to other interrogations (via 1090 MHz). This interrogation-and-response cycle may occur several times per second.

Through this constant back-and-forth communication, the TCAS system builds a three dimensional map of aircraft in the airspace, incorporating their bearing, altitude and range. Then, by extrapolating current range and altitude difference to anticipated future values, it determines if a potential collision threat exists.

TCAS and its variants are only able to interact with aircraft that have a correctly operating Mode C or Mode S transponder. A unique 24-bit identifier is assigned to each aircraft that has a Mode S transponder. These identifiers can be decoded online using tools such as those at Airframes.org.

The next step beyond identifying potential collisions is automatically negotiating a mutual avoidance maneuver (currently, maneuvers are restricted to changes in altitude and modification of climb/sink rates) between the two (or more) conflicting aircraft. These avoidance maneuvers are communicated to the flight crew by a cockpit display and by synthesized voice instructions.

Safety aspects of TCAS

Safety studies on TCAS estimate that the system improves safety in the airspace by a factor of between 3 and 5.

However, it is well understood that part of the remaining risk is that TCAS may induce midair collisions: "In particular, it is dependent on the accuracy of the threat aircraft's reported altitude and on the expectation that the threat aircraft will not make an abrupt maneuver that defeats the TCAS Resolution Advisory (RA). The safety study also shows that TCAS II will induce some critical near midair collisions...".

One potential problem with TCAS II is the possibility that a recommended avoidance maneuver might direct the flight crew to descend toward terrain below a safe altitude. Recent requirements for incorporation of ground proximity mitigate this risk. Ground proximity warning alerts have priority in the cockpit over TCAS alerts.

Some pilots have been unsure how to act when their aircraft was requested to climb whilst flying at their maximum altitude. The accepted procedure is to follow the climb RA as best as possible, temporarily trading speed for height. The climb RA should quickly finish. In the event of a stall warning, the stall warning would take priority.

Relationship to automatic dependent surveillance-broadcast (ADS-B)

Automatic dependent surveillance-broadcast (ADS-B) messages are transmitted from aircraft equipped with suitable transponders, containing information such as identity, location, and velocity. The signals are broadcast on the 1090 MHz radio frequency. ADS-B messages are also carried on a Universal Access Transceiver (UAT) in the 978 MHz band.

TCAS equipment which is capable of processing ADS-B messages may use this information to enhance the performance of TCAS, using techniques known as "hybrid surveillance". As currently implemented, hybrid surveillance uses reception of ADS-B messages from an aircraft to reduce the rate at which the TCAS equipment interrogates that aircraft. This reduction in interrogations reduces the use of the 1030/1090 MHz radio channel, and will over time extend the operationally useful life of TCAS technology. The ADS-B messages will also allow low cost (for aircraft) technology to provide real time traffic in the cockpit for small aircraft. Currently UAT based traffic uplinks are provided in Alaska and in regions of the East coast of the USA.

Hybrid surveillance does not include the use any of the aircraft flight information in the TCAS conflict detection algorithms; ADS-B is used only to identify aircraft that can safely be interrogated at a lower rate.

In the future, prediction capabilities may be improved by using the state vector information present in ADS-B messages. Also, since ADS-B messages can be received at greater range than TCAS normally operates, aircraft can be acquired earlier by the TCAS tracking algorithms.

The identity information present in ADS-B messages can be used to label other aircraft on the cockpit display (where present), improving situational awareness.

Drawbacks to TCAS and ADS-B

The major demonstrated problem of the ADS-B protocol integration is this added verbosity of the extra information transmitted, which is considered unnecessary for collision avoidance purposes. The more data transmitted from one aircraft in accordance with the system design, the lesser the number of aircraft that can participate in the system, due to the fixed and limited channel data bandwidth (1 megabit/second with the 26/64 data bits to packet length bit capacity of the Mode S downlink data format packet). For every Mode S message of 64 bits, the overhead demands 8 for clock sync at the

receiver and Mode S packet discovery, 6 for type of Mode S packet, 24 for who it came from. Since that leaves only 26 for information, multiple packets must be used to convey a single message. The ADS-B "fix" proposal is to go to a 128 bit packet, which is not an accepted international standard. Either approach increases channel traffic above the level sustainable for environments such as the Los Angeles Basin.

Versions of TCAS

PASSIVE

Collision Avoidance systems which rely on transponder replies triggered by ground and airborne systems are considered passive. Ground and airborne interrogators query nearby transponders for mode C altitude information, which can be monitored by third-party systems for traffic information. Passive systems display traffic similar to TCAS, however generally have a range of less than 7 nautical miles (13 km). Portable Collision Avoidance System.

TCAS I

TCAS I is the first generation of collision avoidance technology. It is cheaper but less capable than the modern TCAS II system, and is mainly intended for general aviation use. TCAS I systems are able to monitor the traffic situation around a plane (to a range of about 40 miles) and offer information on the approximate bearing and altitude of other aircraft. It can also generate collision warnings in the form of a "Traffic Advisory" (TA). The TA warns the pilot that another aircraft is in near vicinity, announcing "*traffic, traffic*", but does not offer any suggested remedy; it is up to the pilot to decide what to do, usually with the assistance of Air Traffic Control. When a threat has passed, the system announces "*clear of conflict*".

TCAS II

TCAS II is the second and current generation of instrument warning TCAS, used in the majority of commercial aviation aircraft (see table below). It offers all the benefits of TCAS I, but will also offer the pilot direct, vocalized instructions to avoid danger, known as a "Resolution Advisory" (RA). The suggestive action may be "corrective", suggesting the pilot change vertical speed by announcing, "*descend, descend*", "*climb, climb*" or "*Adjust Vertical Speed Adjust*" (meaning reduce vertical speed). By contrast a "preventive" RA may be issued which simply warns the pilots not to deviate from their present vertical speed, announcing, "*monitor vertical speed*" or "*maintain vertical speed*". TCAS II systems coordinate their resolution advisories before issuing commands to the pilots, so that if one aircraft is instructed to descend, the other will typically be told to climb — maximising the separation between the two aircraft.

As of 2006, the only implementation that meets the ACAS II standards set by ICAO was Version 7.0 of TCAS II, produced by three avionics manufacturers: Rockwell Collins,

Honeywell, and ACSS (Aviation Communication & Surveillance Systems; an L-3 Communications and Thales Avionics company).

After the Überlingen mid-air collision (July 1, 2002), studies have been made to improve TCAS II capabilities. As a result, by 2008 the standards for Version 7.1 of TCAS II have been issued. This version will be able to issue RA reversals in coordinated encounters, in case one of the aircraft doesn't follow the original RA instructions (Change proposal CP112E). Another change in this version is the replacement of the ambiguous "*Adjust Vertical Speed, Adjust*" RA with the "*Level off*" RA, to prevent improper response by the pilots (Change proposal CP115).

TCAS III

TCAS III was the "next generation" of collision avoidance technology which underwent development by aviation companies such as Honeywell. TCAS III incorporated technical upgrades to the TCAS II system, and had the capability to offer traffic advisories and resolve traffic conflicts using *horizontal* as well as vertical manoeuvring directives to pilots. For instance, in a head-on situation, one aircraft might be directed, "turn right, climb" while the other would be directed "turn right, descend." This would act to further increase the total separation between aircraft, in both horizontal and vertical aspects. Horizontal directives would be useful in a conflict between two aircraft close to the ground where there may be little if any vertical maneuvering space. All work on TCAS III is currently suspended and there are no plans for its implementation.

Current implementation

Although the system occasionally suffers from false alarms, pilots are now under strict instructions to regard all TCAS messages as genuine alerts demanding an immediate, high-priority response. (Only stall warnings and Ground Proximity Warning System warnings have higher priority than the TCAS.) The FAA and most other countries' authorities' rules state that in the case of a conflict between TCAS RA and air traffic control (ATC) instructions, the TCAS RA **always** takes precedence (this is mainly because of the TCAS-RA inherently possessing a more current and comprehensive picture of the situation than air traffic controllers, whose radar/transponder updates usually happen at a much slower rate than the TCAS interrogations). If one aircraft follows a TCAS RA and the other follows conflicting ATC instructions, a collision can occur, such as the July 1, 2002 Überlingen disaster. In this mid-air collision, both airplanes were fitted with TCAS II Version 7.0 systems which functioned properly, but one obeyed the TCAS advisory while the other ignored the TCAS and obeyed the controller; both aircraft descended into a fatal collision.

Implementation of TCAS II Version 7.1 has been originally planned to start between 2009 and 2011 by retrofitting and forward fitting all the TCAS II equipped aircraft, with the goal that by 2014 the version 7.0 will be completely phased out and replaced by version 7.1.

Current TCAS Limitations

While the safety benefits of current TCAS implementations are self-evident, the full technical and operational potential of TCAS is not fully exploited due to limitations in current implementations (most of which will need to be addressed in order to further facilitate the design and implementation of Free flight):

- TCAS is limited to supporting only vertical separation advisories, more complex traffic conflict scenarios may however be more easily and efficiently remedied by also making use of lateral resolution maneuvers; this applies in particular to traffic conflicts with marginal terrain clearance, or conflict scenarios that are similarly restricted by vertical constraints (e.g. in busy RVSM airspace)
- ATC can be automatically informed about resolution advisories issued by TCAS only when the aircraft is within an area covered by a Mode S, or an ADS-B monitoring network. In other cases controllers may be unaware of TCAS-based resolution advisories or even issue conflicting instructions (unless ATC is explicitly informed by cockpit crew members about an issued RA during a high-workload situation), which may be a source of confusion for the affected crews while additionally also increasing pilot work load. In May 2009, Luxembourg, Hungary and the Czech Republic show downlinked RAs to controllers.
- In the above context, TCAS lacks automated facilities to enable pilots to easily report and acknowledge reception of a (mandatory) RA to ATC (and intention to comply with it), so that voice radio is currently the only option to do so, which however additionally increases pilot and ATC workload, as well as frequency congestion during critical situations.
- In the same context, situational awareness of ATC depends on exact information about aircraft maneuvering, especially during conflict scenarios that may possibly cause or contribute to new conflicts by deviating from planned routing, so automatically visualizing issued resolution advisories and recalculating the traffic situation within the affected sector would obviously help ATC in updating and maintaining situational awareness even during unplanned, ad hoc routing changes induced by separation conflicts.
- Today's TCAS displays do not provide information about resolution advisories issued to other (conflicting) aircraft, while resolution advisories issued to other aircraft may seem irrelevant to another aircraft, this information would enable and help crews to assess whether other aircraft (conflicting traffic) actually comply with RAs by comparing the actual rate of (altitude) change with the requested rate of change (which could be done automatically and visualized accordingly by modern avionics), thereby providing crucial realtime information for situational awareness during highly critical situations.
- TCAS equipment today is often primarily range-based, as such it only displays the traffic situation within a configurable range of miles/feet, however under certain circumstances a "time-based" representation (i.e. within the next xx minutes) might be more intuitive.
- Lack of terrain/ground and obstacle awareness (e.g. connection to TAWS, including MSA sector awareness), which might be critical for creating feasible

- (non-dangerous, in the context of terrain clearance) and useful resolution advisories (i.e. prevent extreme descent instructions if close to terrain), to ensure that TCAS RAs never facilitate CFIT (Controlled Flight into Terrain) scenarios.
- Aircraft performance in general and current performance capabilities in particular (due to active aircraft configuration) are not taken into account during the negotiation and creation of resolution advisories (as it is the case for differences between different types of aircraft, e.g. turboprop/jet vs. helicopters), so that it is theoretically possible that resolution advisories are issued that demand climb or sink rates outside the normal/safe flight envelope of an aircraft during a certain phase of flight (i.e. due to the aircraft's current configuration). Furthermore, as all traffic is being dealt with equally, there's no distinction taking place between different types of aircraft, neglecting the option of exploiting aircraft-specific (performance) information to issue customized and optimized instructions for any given traffic conflict (i.e. by issuing climb instructions to those aircraft that can provide the best climb rates, while issuing descend instructions to aircraft providing comparatively better sink rates, thereby hopefully maximizing altitude change per time unit, that is separation)
 - TCAS is primarily extrapolation-oriented, as such it is using algorithms trying to approximate 4D trajectory prediction using the "flight path history", in order to assess and evaluate the current traffic situation within an aircraft's proximity, however the degree of data- reliability and usefulness could be significantly improved by enhancing said information with limited access to relevant flight plan information, as well as to relevant ATC instructions to get a more comprehensive picture of other traffic's (route) plans and intentions, so that flight path predictions would no longer be merely based on estimations but rather *actual* aircraft routing (FMS flight plan) and ATC instructions. If TCAS is modified to use data that is used by other systems, care will be required to ensure that the risks of common failure modes are sufficiently small.
 - TCAS is not fitted to many smaller aircraft mainly due to the high costs involved (between \$25,000 and \$150,000). Many smaller personal business jets for example, are currently not legally required to have TCAS installed, even though they fly in the same airspace as larger aircraft that are required to have proper TCAS equipment on board. The TCAS system can only perform at its true operational potential once all aircraft in any given airspace have a properly working TCAS unit on board.

Regulatory situation around the world

Jurisdiction (Agency)	Classification of aircraft	TCAS mode	Date of mandate
USA (FAA)	All commercial turbine-powered transport aircraft with more than 30 passenger seats (or MTOW above 33000 pounds ~ 15000kg)	TCAS II	1 January, 1993

Europe (EASA)	All civil turbine-powered transport aircraft with more than 30 passenger seats (or MTOW above 15000kg)	TCAS II	1 January 2000
Europe (EASA)	All civil turbine powered transport aircraft with more than 19 passenger seats (or MTOW above 5700kg)	ACAS II (Effectively TCAS II Version 7.0)	1 January 2005
Australia (CASA)	All commercial turbine powered transport aircraft with more than 30 passenger seats (or MTOW above 15000kg)	TCAS II	1 January, 2000
Hong Kong, China (Civil Aviation Department)	All aircraft in Hong Kong with more than 9 passenger seats (or MTOW greater than 5700kg)	TCAS II Version 7.0	1 January, 2000
Brazil (National Civil Aviation Agency)	All transport category aircraft with more than 30 passenger seats	TCAS II Version 7.0	01 January, 2008
Brazil (National Civil Aviation Agency)	All transport category aircraft with more than 19 passenger seats	TCAS II Version 7.0	01 January, 2010

Tsunami Warning System, Train Protection & Warning System

Tsunami warning system



Evacuation route sign in a low-lying coastal area on the West Coast of the United States

A **Tsunami Warning System (TWS)** is a system to detect tsunamis and issue warnings to prevent loss of life and property. It consists of two equally important components: a

network of sensors to detect tsunamis and a communications infrastructure to issue timely alarms to permit evacuation of coastal areas.

There are two distinct types of tsunami warning systems: **international** and **regional**. Both depend on the fact that, while tsunamis travel at between 500 and 1,000 km/h (around 0.14 and 0.28 km/s) in open water, earthquakes can be detected almost at once as seismic waves travel with a typical speed of 4 km/s (around 14,400 km/h). This gives time for a possible tsunami forecast to be made and warnings to be issued to threatened areas, if warranted. Unfortunately, until a reliable model is able to predict which earthquakes will produce significant tsunamis, this approach will produce many more false alarms than verified warnings. In the correct operational paradigm, the seismic alerts are used to send out the watches and warnings. Then, data from observed sea level height (either shore-based tide gauges or DART buoys) are used to verify the existence of a tsunami.

Other systems have been proposed to augment the warning paradigm. For example, it has been suggested that the duration and frequency content of t-wave energy (which is earthquake energy trapped in the ocean SOFAR channel) is indicative of an earthquake's tsunami potential. The first rudimentary system to alert communities of an impending tsunami was attempted in Hawaii in the 1920s. More advanced systems were developed in the wake of the April 1, 1946 (caused by the 1946 Aleutian Islands earthquake) and May 23, 1960 (caused by the 1960 Valdivia earthquake) tsunamis which caused massive devastation in Hilo, Hawaii.

Animal Infrasound

The elephants in the 2004 Indian Ocean Tsunami fled for the hills. They sensed the tsunami due to their ability to hear the soundwaves outside of the range of human hearing range of 20Hz and 20,000Hz. In addition to hearing within the human range, elephants can also hear in the range of Infrasound, beneath 20 Hz down to 0.001 Hz.

International warning systems (IWS)

Pacific Ocean

Tsunami warnings for most of the Pacific Ocean are issued by the Pacific Tsunami Warning Center (PTWC), operated by the United States's NOAA in Ewa Beach, Hawaii. NOAA's West Coast and Alaska Tsunami Warning Center (WCATWC) in Palmer, Alaska issues warnings for the west coast of North America, including Alaska, Canada, and the western coterminous United States. PTWC was established in 1949, following the 1946 Aleutian Island earthquake and a tsunami that resulted in 165 casualties on Hawaii and in Alaska; WCATWC was founded in 1967. International coordination is achieved through the International Coordination Group for the Tsunami Warning System in the Pacific, established by the Intergovernmental Oceanographic Commission of UNESCO.

Indian Ocean (ICG/IOTWS)



Tsunami Early Warning Tower board in Hikkaduwa, Sri Lanka

After the 2004 Indian Ocean Tsunami which killed almost 230,000 people, a United Nations conference was held in January 2005 in Kobe, Japan, and decided that as an initial step towards an International Early Warning Programme, the UN should establish an Indian Ocean Tsunami Warning System. This then resulted in a system of warnings in Indonesia. This will also save the lives and the livelihood of the people.

North Eastern Atlantic, the Mediterranean and connected Seas (ICG/NEAMTWS)

The First United Session of the Inter-governmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and connected Seas (ICG/NEAMTWS), established by the Intergovernmental Oceanographic Commission of UNESCO Assembly during its 23rd Session in June 2005, through Resolution XXIII.14, took place in Rome on 21 and 22 November, 2005.

The Meeting, hosted by the Government of Italy (Italian Ministry of Foreign Affairs and Ministry for Environment and Protection of the Territory), was attended by more than 150 participants from 24 countries, 13 organizations and numerous observers.

Caribbean

A Caribbean wide tsunami warning system has been planned to be set up by 2010 by member nations representatives who met in Panama City in March 2008. Panama's last major tsunami killed 4,500 people in 1882. Barbados has said it will review or test its Tsunami protocol in February 2010 as a regional pilot.

Regional warning systems

Regional (or local) warning system centres use seismic data about nearby earthquakes to determine if there is a possible local threat of a tsunami. Such systems are capable of issuing warnings to the general public (via public address systems and sirens) in less than 15 minutes. Although the epicenter and moment magnitude of an underwater quake and the probable tsunami arrival times can be quickly calculated, it is almost always impossible to know whether underwater ground shifts have occurred which will result in tsunami waves. As a result, false alarms can occur with these systems, but due to the highly localised nature of these extremely quick warnings, disruption is small.

Conveying the warning



Japanese TV warning of tsunamis, September 2004

Detection and prediction of tsunamis is only half the work of the system. Of equal importance is the ability to warn the populations of the areas that will be affected. All tsunami warning systems feature multiple lines of communications (such as SMS, e-mail, fax, radio, texting and telex, often using hardened dedicated systems) enabling emergency messages to be sent to the emergency services and armed forces, as well to population alerting systems (e.g. sirens).

Shortcomings

No system can protect against a very sudden tsunami, where the coast in question is too close to the epicenter. A devastating tsunami occurred off the coast of Hokkaidō in Japan as a result of an earthquake on July 12, 1993. As a result, 202 people on the small island of Okushiri, Hokkaido lost their lives, and hundreds more were missing or injured. This tsunami struck just three to five minutes after the quake, and most victims were caught while fleeing for higher ground and secure places after surviving the earthquake.

While there remains the potential for sudden devastation from a tsunami, warning systems can be effective. For example if there were a very large subduction zone earthquake (moment magnitude 9.0) off the west coast of the United States, people in Japan, for example, would have more than 12 hours (and likely warnings from warning systems in Hawaii and elsewhere) before any tsunami arrived, giving them some time to evacuate areas likely to be affected.

Train Protection & Warning System

The **Train Protection & Warning System (TPWS)** is a train protection system deployed across the entire UK passenger railway network, as well as in Victoria, Australia. It automatically activates brakes on any train that has passed a signal at danger or is overspeeding. It is fitted at selected sites, including lines where automatic train protection (ATP) is installed.

Unlike ATP, it does not aim to stop trains at or before a signal that is at "danger" - it aims to stop the train before the point at which a collision with another train could occur, excluding rear-end collision with a train in front. According to the UK's Health and Safety Executive, TPWS is estimated to prevent between 65% and 80% of fatalities that would be stopped by a full ATP system.

A standard installation consists of an on-track transmitter placed adjacent to a signal and activated when the signal is at 'danger'. Any train that tries to pass the signal will have its emergency brakes activated. If the train is travelling at speed, this may be too late to stop it before the point of collision, therefore a second transmitter may be placed on the approach to the signal that applies the brakes on trains going too quickly to stop at the signal, and this is positioned to safely stop trains approaching at up to 75 mph (120 km/h).

At around 400 high-risk locations, a third transmitter is used even further before the signal and this increases the effectiveness to 100 mph (160 km/h). An installation with three transmitters is known as **TPWS+**. When installed in conjunction with signal controls such as 'double blocking' (i.e. two red signal aspects in succession), TPWS can be fully effective at any realistic speed.

TPWS is not to be confused with timed train stops that accomplish a similar task with different technology.

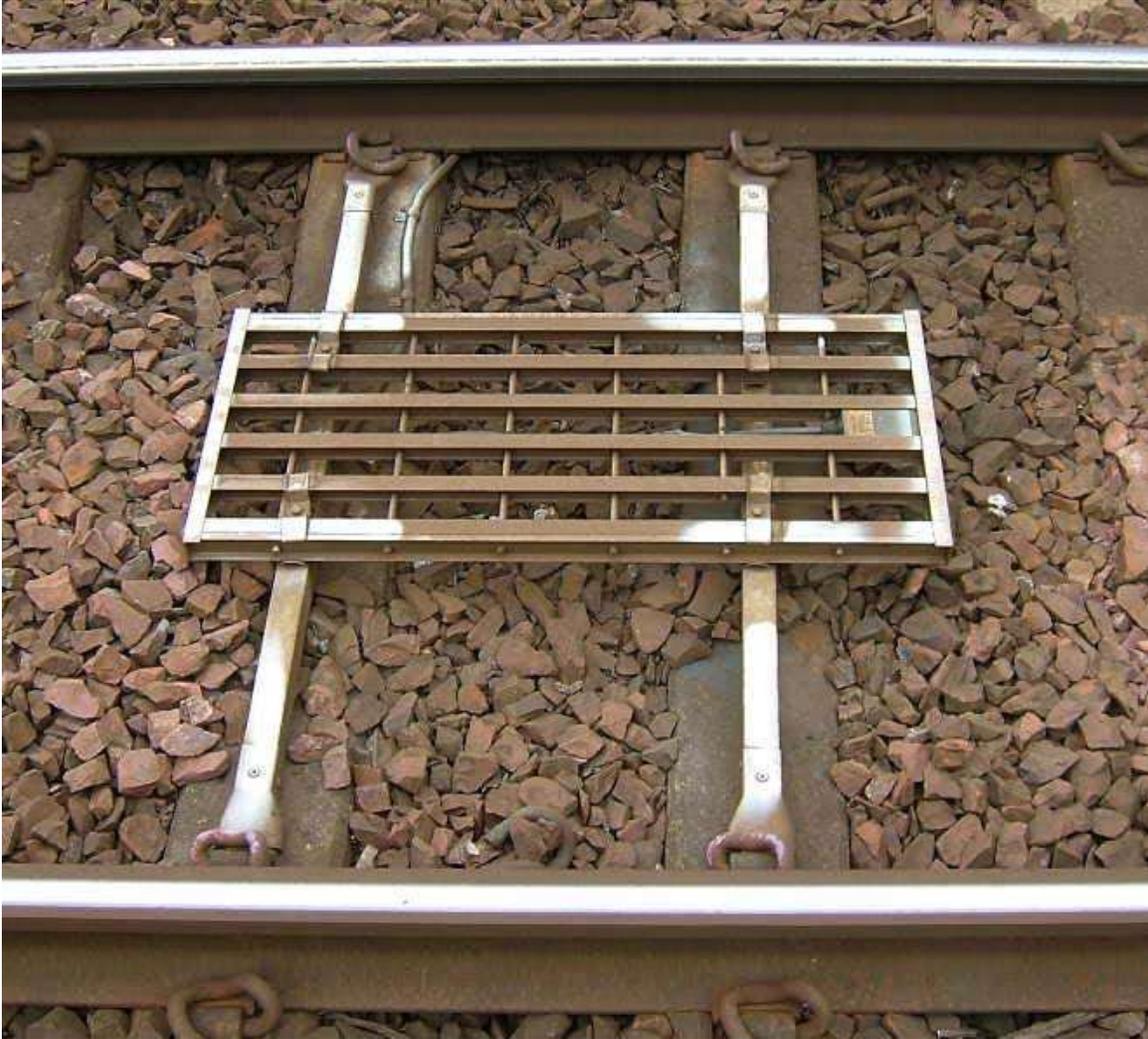
How it works

Overview

One pair of electronic loops is placed 50-450 metres on the approach side of the stop signal, energised when this signal is at "danger". The distance separating the loops is used to control the speed of the train, because at all locations the on-board equipment allows a standard amount of time between paired loops before applying the brakes: the greater the distance the loops are from the signal, the more widely spaced they will be.

There is another pair of loops at the signal, also energised when the signal is at "danger". These are always placed immediately together and will stop a train that runs past the signal, regardless of its speed.

On-track equipment



A TPWS transmitter loop, one of a pair that form an Overspeed Sensor System (OSS)

In a standard installation of TPWS there are two pairs of loops (sometimes colloquially referred to as "grids" or "toast racks"). Both pairs consist of an 'arming' and a 'trigger' loop. If the signal associated with the TPWS is at "danger", the loops will be energised. If the signal is at "proceed", the loops will de-energise.

The first pair, the Overspeed Sensor System (OSS), is sited at a position determined by linespeed and gradient. The loops are separated by a distance that should not be traversed within a pre-determined period of time (approximately 1 second) if the train is running at a safe speed approaching the signal at "danger".

The first, 'arming', loop emits a frequency of 64.25 kHz. The second, 'trigger', loop has a frequency of 65.25 kHz.

The other pair of loops is back to back at the signal, and is called a Train Stop System (TSS). The 'arming' and 'trigger' loops work at 66.25 kHz and 65.25 kHz respectively.

The brakes will be applied if the on-train equipment detects both frequencies together after having detected the arming frequency alone. Thus, an energised TSS is effective at any speed, but only if a train passes it in the applicable direction. Since a train may be required to pass a signal at "danger" during failure etc., the driver has the facility to override a TSS, but not an OSS.

For opposite-direction TPWS equipment, the frequencies are slightly different, working at 64.75, 65.75, and 66.75 kHz.

Location equipment

In the lineside location, there are two modules associated with each set of TPWS loops: a Signal Interface Module (SIM) and an OSS or TSS module. These generate the frequencies for the loops, and prove the loops are intact. They interface with the legacy signalling system.

On-train equipment

An aerial on the train picks up the frequency from the loops if they are energised, and applies the brakes if required (e.g. if it takes less than 1 second (approximate value) to travel over the OSS loops, or if the TSS loops are energised). When the train passes over the OSS loops, a timer counts the amount of time between the loops. This time is used to check the speed, and if the train is approaching too fast the brakes are applied to stop it within the overlap. If the train passes the first test but passes the signal at danger, the automatic brakes will be applied and stop it in the overlap.

In-cab equipment



TPWS panel in driving cab

The TPWS panel is located in the train cab along with a TPWS temporary isolation switch. The TPWS panel comprises two indicator lamps and a push switch. One lamp is used to indicate that a TPWS/AWS brake demand has occurred (the AWS and TPWS system are inter-linked). A temporary isolation indicator/fault indicator indicates that the system has been isolated with the temporary isolation switch or a fault has occurred with the TPWS. The push switch marked "train stop override" is used to pass a signal at danger with authority; it temporarily will ignore the TPWS TSS loops at a signal for a period of around 20 seconds or as soon as the loops have been passed.

The temporary isolation switch may be operated when the train is being operated in degraded conditions and multiple stop aspects will be required to be passed at danger with authority, after which the system must immediately be reinstated.

Variations

In some instances, due to low linespeeds, an OSS may not be fitted. An OSS on its own may be used to protect a permanent speed restriction or buffer stop. Although loops are standard, buffer stops may be fitted with 'mini loops', due to the very low approach speed, usually 10 mph. When buffer stops were originally fitted with TPWS using standard loops, there were many instances of false applications, causing delays whilst it reset (with trains potentially blocking the station throat) plus the risk of passengers standing to alight being thrown over by the sudden braking. This problem arose when a train passed over the arming loop so slowly that it was still detected by the train's receiver after the on-board timer had completed its cycle. The timer would reset and begin timing again, and the trigger loop then being detected within this second timing cycle would lead to a false intervention. As a temporary solution, drivers were instructed to pass the buffer stop OSSs at 5 mph, eliminating the problem, but meaning that trains no longer had the momentum to roll to the normal stopping point and requiring drivers to apply power beyond the OSS, just a short distance from the buffers, arguably making a buffer stop collision more likely than before TPWS was fitted. The redesigned 'mini loops', roughly a third the length of the standard ones, eliminate this problem, although due to the low speed and low margin, buffer stop OSSs are still a major cause of TPWS trips.

Recent applications in the UK have, in conjunction with advanced SPAD protection techniques, used TPWS with outer home signals that protect junctions with a higher than average risk, by controlling the speed of an approaching train an extra signal section in rear of the junction. If this fails the resultant TPWS application of brakes will stop the train before the actual point of conflict is reached. This system is referred to as TPWS OS (Outer Signal).

Limitations

TPWS has no ability to regulate speed after a train passes a signal at "stop" in accordance with **Stop and Proceed** rules. However there are strict rules governing drivers' actions and train speed when passing signals at "danger" with authority and the use of TPWS on these occasions. Thus TPWS would not have helped prevent the Glenbrook train disaster.

There are several reasons why a driver would be required to pass a signal at danger with authority, such as track circuit failure. The driver will have been advised by the signaller to pass the signal at danger, proceeding with caution and being prepared to stop short of any obstruction and to obey all other signals. The signaller would expect the driver to know the requirement of pressing the "Trainstop Override" button on the TPWS panel to pass the signal without triggering a TPWS brake demand. A signaller is not allowed to inform the driver to operate any TPWS override, only that TPWS may be present at the signal that is required to be passed at Danger.

Due to the varying conditions under which a train may need to pass a signal at danger, it is seen as best to leave the appropriate speed to the driver's discretion, rather than have a fixed speed. The appropriate speed for a heavy freight train on a curved line during heavy rain will be much lower than for a fast braking passenger train on a straight line in clear and dry conditions.

Whilst critics claim TPWS is a cheap solution and putting lives at risk compared to fitting ATP, there have been very few fatalities in modern times (since the fitting of AWS) that would have been prevented had ATP been fitted but would still have occurred despite TPWS. The Southall rail crash would not have been prevented by TPWS yet could have been prevented by ATP (ironically fitted but not in use), yet would almost certainly have been prevented had the AWS been working. A combination of TPWS and AWS is most weak against accidents like that at Purley, where a driver repeatedly cancelled the AWS warning without applying the brakes, passing the danger signal at high speed. In this particular case though, the lower speed of the train and the very effective brakes of the EMU would have meant TPWS would likely have been effective anyway. Supporters of TPWS claim that even where it could not prevent accidents due to SPADs, it would likely reduce the impact and reduce or eliminate fatalities by at least slowing the train down but, in practice, it is likely that in these cases the driver would have already applied the emergency brakes well before the overspeed sensor.

In use by

The TPWS system is used in

- The United Kingdom, with AWS magnets and with short overlaps
- Victoria, Australia, without AWS magnets and with full-length overlaps.

Airborne Early Warning and Control



United States Air Force E-3 Sentry

An **airborne early warning and control (AEW&C)** system is an airborne radar system designed to detect aircraft. Used at a high altitude, the radars allow the operators to distinguish between friendly and hostile aircraft hundreds of miles away. AEW&C aircraft are used for defensive and offensive air operations. The system is used offensively to direct fighters to their target locations, and defensively to counter attacks. It can also be used to carry out surveillance, and C2BM (command and control, battle management) functions.



Royal Australian Air Force Boeing 737 AEW&C

AEW&C is also known by the older terms "airborne early warning" (AEW) and "airborne warning and control system".

General characteristics

Modern AEW&C systems can detect aircraft from up to 250 miles (402 km) away, well out of range of most surface-to-air missiles. One AWACS plane flying at 30,000 feet (9,100 m) can cover an area of 120,460 square miles (311,990 km²). Three such aircraft in overlapping orbits can cover the whole of Central Europe. In air-to-air combat, AEW&C systems can communicate with friendly aircraft, extend their sensor range and give them added stealth, since they no longer need their own active radar to detect threats. However, by the nature of radar, AWACS aircraft can be detected by opposing forces beyond its own detection range. This is because the outgoing pulse reduces in strength the further it travels. Therefore, a signal intended to reflect back must be strong enough to cover at least twice the distance between the sender and the target—more in practice due to absorption losses.



Japan Air Self Defense Force E-767 AWACS

History of development

As part of their early use of radar, the British developed a radar set that could be carried on an aircraft for "Air Controlled Interception". The intention was to cover the North West approaches where German long range Fw 200 Condor aircraft were a threat to shipping. A Vickers Wellington bomber (serial R1629) was fitted with a rotating antenna array. It was trialled for use against aerial targets and then for possible use against German E boats. Another installation was a radar equipped Wellington used to direct Bristol Beaufighters onto Heinkel He 111s, which were air-launching V-1 flying bombs.

In February 1944 the U.S. Navy ordered the development of a radar system that could be carried aloft in an aircraft as Project Cadillac. A prototype system was built and flown in August on a modified TBM Avenger torpedo bomber. Tests proved successful, with the system being able to detect low flying formations at a range in excess of 100 miles (161 km). The U.S. Navy then ordered production of the TBM-3W, the first AEW aircraft to enter service. TBM-3Ws fitted with the AN/APS-20 radar entered service in March 1945, with some 36–40 eventually being constructed.



Saab 340AEW

In 1958, the Soviet Tupolev Design Bureau was also ordered to design an AWACS aircraft. After trying to fit the projected radar instrumentation in a Tu-95 and a Tupolev Tu-116, the decision was made to use the Tu-114 fuselage instead. This solved the problems with cooling and operator space that existed with the narrower Tu-95 and Tu-116 fuselage. To meet the flight range requirements, the plane was fitted with an air-to-air refueling receiver. The resulting plane, the Tu-126, was used by the Soviet Air Forces until it was replaced by the Beriev A-50 in 1984.

National use

Many countries have their own AEW&C systems, although the E-3 Sentry and E-2 Hawkeye are the most popular systems worldwide. The E-3 Sentry was built by the Boeing Defense and Space Group (now Integrated Defense Systems) and is widely considered^[by whom?] to be an international benchmark for AEW systems. It is based on the Boeing 707 aircraft. The E-2 Hawkeye, which entered service in 1965, is arguably the most widely used AEW system. The E-3 Sentry is not strictly an AEW system, as it has far more functionality. For the Japan Air Self-Defense Force, the E-3 technology has been fitted into the Boeing E-767.

The United Kingdom first deployed a substantial AEW capability with American A-1 Skyraiders, which in turn were replaced by the Fairey Gannet AEW3, using the same AN/APS-20 radar. When the Gannet was withdrawn, the Royal Air Force (RAF)

redeployed the radars from the Gannets on Avro Shackleton MR2 airframes, redesignated Shackleton AEW2. These became the last piston-engined aircraft in the RAF. To replace the Shackleton AEW2, an AEW variant of the Hawker-Siddeley Nimrod, known as the Nimrod AEW3, was ordered in 1974. However, after a protracted and problematic development, this was cancelled in 1986, and seven E-3Ds, designated Sentry AEW1 in RAF service, were ordered instead.



A Soviet Tupolev Tu-126 AEW aircraft in flight in 1977.



Sea King AEW.2A

The Russian Air Force is currently using around 15–20 Beriev A-50 and A-50U "Shmel" in the AEW role. The "Mainstay" is based on the military/commercial Ilyushin Il-76 airframe, with a large non-rotating radome on the rear fuselage.

The Indian Air Force ordered three IAI Phalcon systems in 2004, the first of which first arrived on May 25, 2009.

The Royal Australian Air Force and the Turkish Air Force are deploying Boeing 737 AEW&C aircraft. Unlike the E-2 and E-3, the Boeing 737 AEW&C does not have a radome. It will probably be marketed towards many existing E-2 customers, who would otherwise have no choice but to purchase a system intended for an aircraft carrier, due to lack of options.

The Swedish Air Force use the S 100B Argus as their AEW platform. The S 100B Argus is based on the Saab 340 with an Ericsson Erieye PS-890 radar.



E-2D Advanced Hawkeye

The Hellenic Air Force, Brazilian Air Force and Mexican Air Force use the Embraer R-99 with an Ericsson Erieye PS-890 radar, as on the S 100B.

In early 2006, the Pakistan Air Force ordered six Saab 2000 fitted with Erieye AEW systems from Sweden in a deal valued roughly \$1bn. In December 2006, the Pakistan Navy requested three excess P-3 Orion aircraft equipped with Hawkeye 2000 AEW systems, the overall cost of the program is \$855mn. China and Pakistan also signed a memorandum of understanding (MoU) for the joint development of AEW&C systems. A total of \$278m AWACS deal has been struck with China.

There are only four helicopter-based AEW platforms in existence. One is the Royal Navy Sea King ASaC7 naval helicopter. It is operated from the Royal Navy's *Invincible*-class aircraft carriers. The creation of Sea King ASaC7, and earlier AEW.2 and AEW.5 is the consequence of the harsh lessons learnt by the Royal Navy task force sent to the South Atlantic in the 1982 Falklands War. The lack of AEW coverage for the task force was a major tactical shortcoming at the time. Also, the Spanish Navy fields the SH-3 Sea King in the very same role, operated from the carriers Principe de Asturias and Juan Carlos I



Indian Air Force Beriev A-50EI Mainstay

Another helicopter is the Russian-built Kamov Ka-31, deployed by Indian Navy on *Krivak-III* frigates and reportedly used by the Russian Navy on its sole *Kuznetsov* aircraft carrier. It is fitted with E-801M Oko (Eye) airborne electronic warfare radar that can track up to 20 targets simultaneously with aerial detection range 90 mi (150 km) and surface warships up to 160 mi (250 km).

The most modern helicopter-based AEW is the AgustaWestland EH101 AEW of the Italian Navy.

Some AEW systems feature additional command and control functionality, airborne warning and control system aircraft. These are often referred to as airborne early warning and control (AEW&C) systems.

AWACS systems



Phalcon-based 'Condor' AWACS aircraft of the Chilean Air Force

Boeing/Westinghouse AWACS system

This is a specific system with a rotating radar dome "rotodome" radome designed and built by Boeing (Defense & Space Group) using Westinghouse (now Northrop Grumman) radar. It is mounted on either the E-3 Sentry aircraft (Boeing 707) or more recently a modified Boeing 767. Only the Japanese Air Self-Defense Force has the 767 version, calling it the E-767.

Elta/Israeli Aircraft Industries (IAI) PHALCON radar

Israel has developed the IAI/Elta Phalcon system, which uses an AESA (Active Electronically Scanned Array) in lieu of a rotodome antenna. The system was the first such advanced radar placed into service. The original Phalcon was mounted on a Boeing 707 platform and developed for the Israeli Defense Force and for export. A Boeing 707 Phalcon system was delivered to Chile in 1993 where it is known as the "Condor".

The Phalcon AEW&C aircraft is based on four sensors: phased-array radar, phased-array IFF, ESM/ELINT and CSM/COMINT. A unique fusion technology continuously cross-relates the data gathered by all sensors. When one of the sensors reports a detection, the system automatically initiates an active search of the complementary sensors.

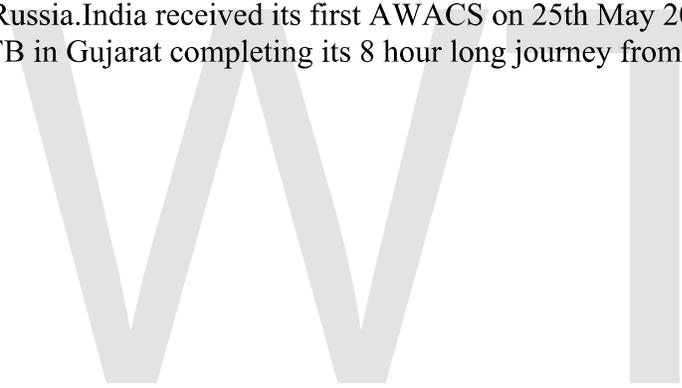
The second generation improvement of the Phalcon system was accomplished in the development of the Israeli ground based IAI EL/M-2080 "Green Pine" radar target tracking system used by the Israeli Defense Force. This system has been exported to several countries.

Israel has recently put in service a third generation variant of the Phalcon system on a highly modified Gulfstream G550 aircraft. Equipped with a more efficient and compact version of this airborne radar made by the ELTA division of Israel Aircraft Industries

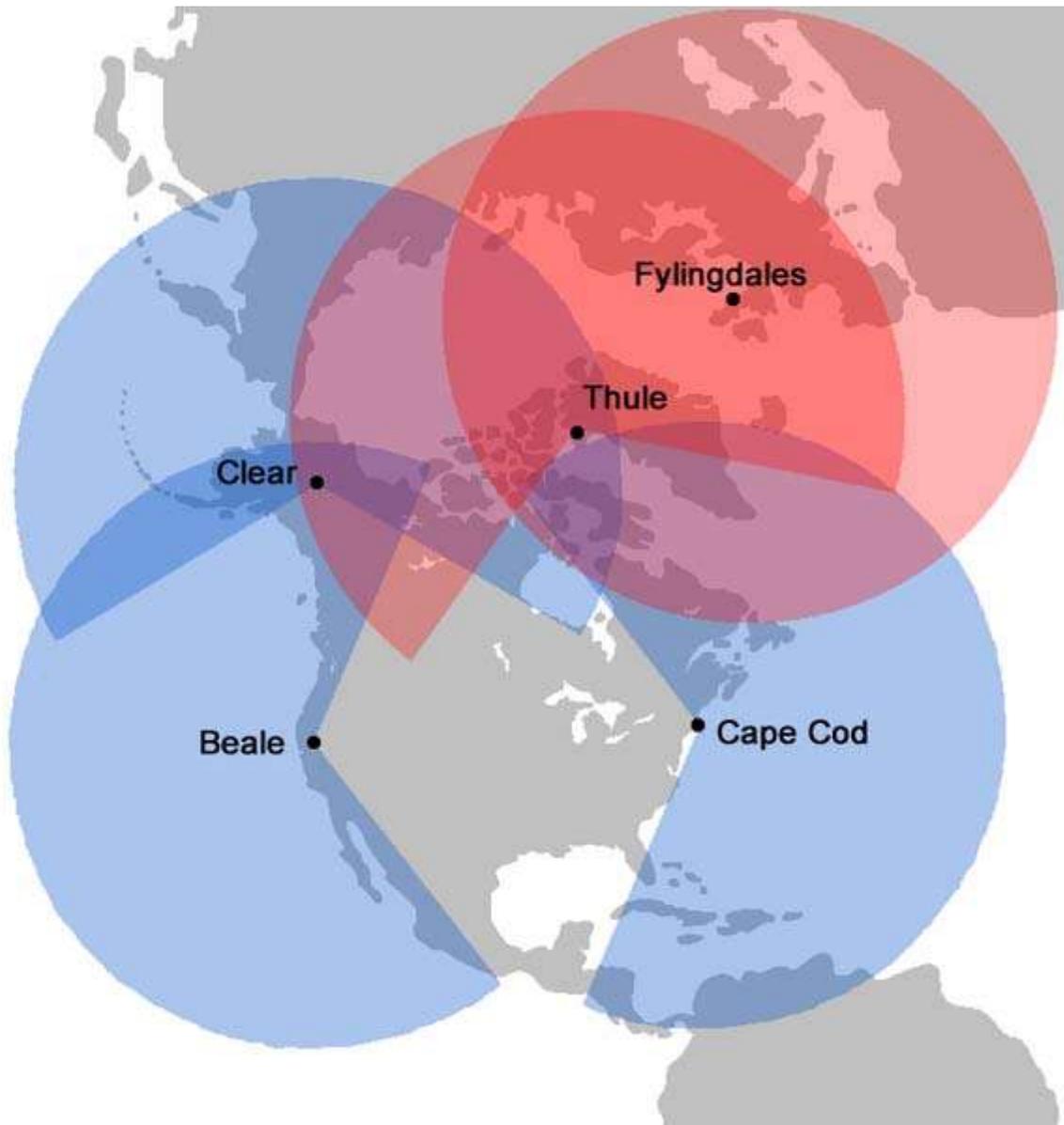
(IAI), the Gulfstream 550 CAEW is a long endurance, high altitude, rapid pop-up and descent system with unobstructed 360° coverage.

Israel Aircraft Industries (IAI) was marketing its Phalcon airborne early warning (AEW) system to China in competition with the British defense firm GEC-Marconi. In 1996 Tel Aviv and Beijing signed an agreement on purchasing the Phalcon radar system, which China insisted should be fitted onto Russian Ilyushin IL-76 aircraft. The Phalcon's triangular radar array would be mounted on the rear quarter fuselage of the IL-76 to provide full 360 degree scan coverage. Beijing was expected to acquire several PHALCON AEW systems, and reportedly could buy at least three more [and possibly up to eight] of these systems. But in July 2000 the United States pressured Israel to back out of a \$1 billion agreement to sell China four Phalcon phased-array radar systems.

The India Air Force agreed in 2004 to purchase three systems for \$1.1 billion. Russia and Israel on 10 October 2004 signed a tripartite agreement to facilitate the equipping of the Indian Air Force (IAF) with the Phalcon airborne warning and control systems. The IAF plans to mount the Phalcon radar and surveillance systems from IAI on IL-76 aircraft supplied by Russia. India received its first AWACS on 25th May 2009. It landed in Jamnagar AFB in Gujarat completing its 8 hour long journey from Israel.



Ballistic Missile Early Warning System



Coverage of BMEWS is shown in red, complementing the coverage provided by the PAVE PAWS system in blue. Coverage for both systems extends over the North Pole and both report back to Cheyenne Mountain Air Force Station in Colorado.

The United States Air Force **Ballistic Missile Early Warning System (BMEWS)** was the first operational ballistic missile detection radar. The original system was built in 1959 and could provide long-range warning of a ballistic missile attack over the polar region of the Northern Hemisphere. They also provided satellite tracking data. The three installations are:

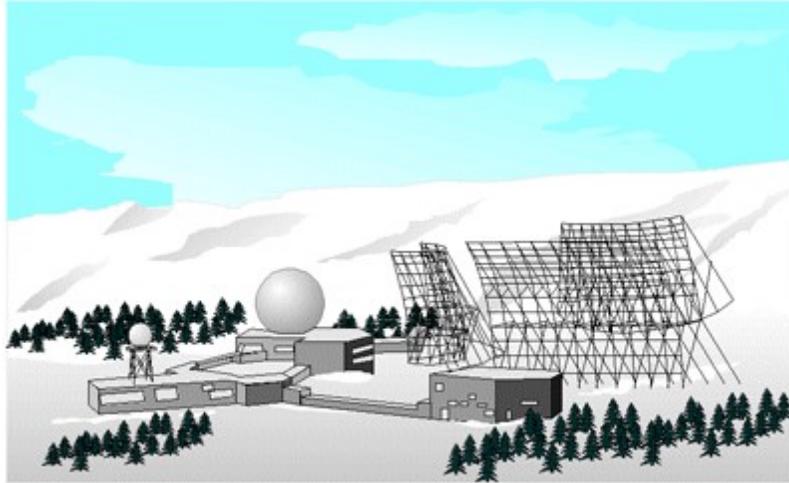
- Site I- A United States Air Force facility at Thule Air Base, Greenland, ( 76°34'08"N 68°19'05"W / 76.569°N 68.318°W) operated by the 12th Space Warning Squadron.
- Site II - A second USAF facility at Clear Air Force Station, Alaska, ( 64°17'19"N 149°11'22"W / 64.28861°N 149.18944°W)
- Site III - A Royal Air Force facility at RAF Fylingdales, in the United Kingdom ( 54°21'42"N 0°40'11"W / 54.3616°N 0.6697°W)

The three facilities operated their original 1950s vintage radars for more than four decades, but all have been upgraded with more modern phased array radars. The facility at Clear Air Force Station was the last to be upgraded and now operates a PAVE PAWS radar that was moved from Texas in 2001. Information received from the BMEWS radars is forwarded to the JFCC SPACE Missile Warning Center at Cheyenne Mountain Air Station, Colorado, where it is coordinated with data from other sensors, including other PAVE PAWS sites.

Operations



AN/FPS-92 Dish at the Tracking Station site in Chaguaramas, Trinidad and Tobago

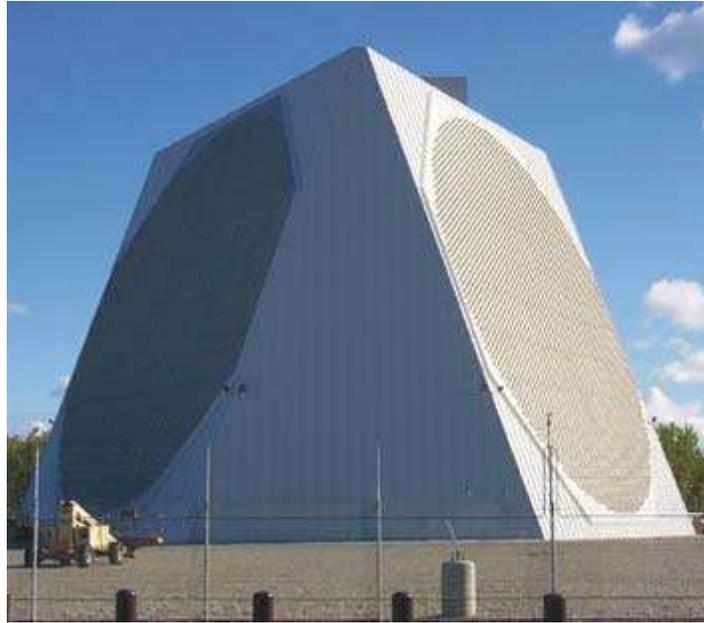


The Ballistic Missile Early Warning System (BMEWS) site
at Clear AFS, Alaska

Original 3 AN/FPS-50 detection radars (fence antennas) and single AN/FPS-92 tracking radar (large radome)



Four of the original AN/FPS-50 detection radars used at Thule, prior to the upgrade to the AN/FPS-120.



PAVE PAWS Phased array Radar that replaced BMEWS at Clear AFS, Alaska.



Air Force technicians work at tracking monitors in the Tactical Operations Room on the Thule BMEWS.

The original sites used two types of radars, the UHF range/425 MHz AN/FPS-50, with four (at Site 1) or three (at Site 2) fence antennas for initial detection, each 165 feet (50 m) tall and 400 feet (120 m) wide, and UHF range/425 MHz AN/FPS-49, later upgraded to AN/FPS-92, fully steerable tracking dish, 85 feet (26 m) in diameter, installed in a large radome. One fence antenna covered a 40-degree sector of the horizon, for a total site coverage of 120 degrees.

A prototype of BMEWS, located in Trinidad, began providing surveillance and tracking of ballistic missiles by 1958, and went operational on February 4, 1959, to gather data on missiles fired at the Atlantic Missile Range, as well as satellites and meteors. The full BMEWS radar network became operational in the early 1960s. Each site had dual IBM 7094 computers for signal processing and impact prediction.

RCA manufactured and maintained the electronics utilizing an RCA 501 computer with 32k "high speed memory", 5-76KC 556 bpi 3/4" tape drives and a 200 track random access LFE drum to maintain wire connection lists at RCA's Astro Electronics Division facility in Hightstown, NJ. Every wire was able to be traced from origin to destination with software and the weight of the cable interconnecting cabinets was automatically calculated by an RCA 501 machine language program named "signal path" written by Robert Goerss, computing facility director.

A fully characterized signal, designating an incoming missile, was known among the engineers as a "Q point". Having a "Q point" emerge on the screens meant that missile warning systems and missile defense systems would be activated. The designation arose because on the flow charts used to indicate how radar signals were processed, the full designation of an incoming missile was achieved at Point Q on the chart. Therefore, engineers rarely spoke of missiles, but instead talked about Q Points.

The system at Thule was erected on permafrost, i.e., permanently frozen ground. The antennas were built atop large concrete platforms -- about the size of a football field, for the detection antennas. Concrete cures exothermically, so that pouring that much concrete would have caused the permafrost to melt and the concrete pad thus to sink or tilt. To counter that problem, one of the largest refrigeration systems ever built was installed, with the refrigeration piping embedded in the concrete when it was poured. The refrigeration was operated steadily from the first moment of pouring concrete until the entire pour had solidified and cured. This cooling offset the heat of the concrete curing, stabilizing the platforms. Obviously, the system had no use after the concrete had cured, and this massive refrigeration system was therefore scrapped after a single use.

The Soviet Union developed a Fractional Orbital Bombardment System (FOBS) in part to counteract the network of sensors covering the northern hemisphere, including BMEWS, which was only able to point in a fixed direction. FOBS placed a warhead in low earth orbit, reducing the line-of-sight ranges tremendously compared to the traditional "lofted" trajectories of a conventional ICBM. Additionally, the FOBS could be launched southward, overflying most of the globe and then approaching the U.S. from the south, where it would be invisible to BMEWS. Submarine-launched ballistic missiles also

avoided detection by BMEWS, developing into a credible threat in the 1970s. The Defense Support Program (DSP) early warning satellites were developed in part to counter this threat, detecting the infrared "bloom" from the launch rockets no matter where they occurred.

Moon alarm

On October 5, 1960, the moonrise occurred directly in the path of the Thule detection radar, producing a strong signal return. While the computer system never generated an impact prediction, the large amount of data caused enough concern that the equipment was subsequently modified to reject moon returns based on their long (2 second) delay.

Upgrades

The Thule and Fylingdales sites were upgraded with phased array radars in the 1990s. BMEWS 3, located in RAF Fylingdales, was upgraded by Raytheon/Cossor AeroSpace and Control Data Corporation at a cost of US \$100M. The new antenna was a three-faced phased array antenna providing 360 degrees of coverage. The embedded computer was a CDC-Cyber running JOVIAL. The Clear, Alaska, site was upgraded in 2001 with a PAVE PAWS radar that was originally located at Eldorado Air Force Station, Texas. The phased array radars operate in the 420-450 MHz (UHF) frequency range.

Along with the PAVE PAWS radar sites at Cape Cod Air Force Station on Cape Cod, Massachusetts  [41°45′09″N 70°32′19″W / 41.7524°N 70.5386°W](#), Beale Air Force Base, California  [39°08′10″N 121°21′02″W / 39.1361°N 121.3506°W](#) and the PARCS radar at Cavalier AFS, North Dakota  [48°43′29″N 97°53′59″W / 48.7246°N 97.8998°W](#), the BMEWS sites provide continual ground-based missile warning for the United States and Canada, with satellite surveillance as a secondary role.

Chapter- 9

National Emergency Alarm Repeater & Lane Departure Warning System

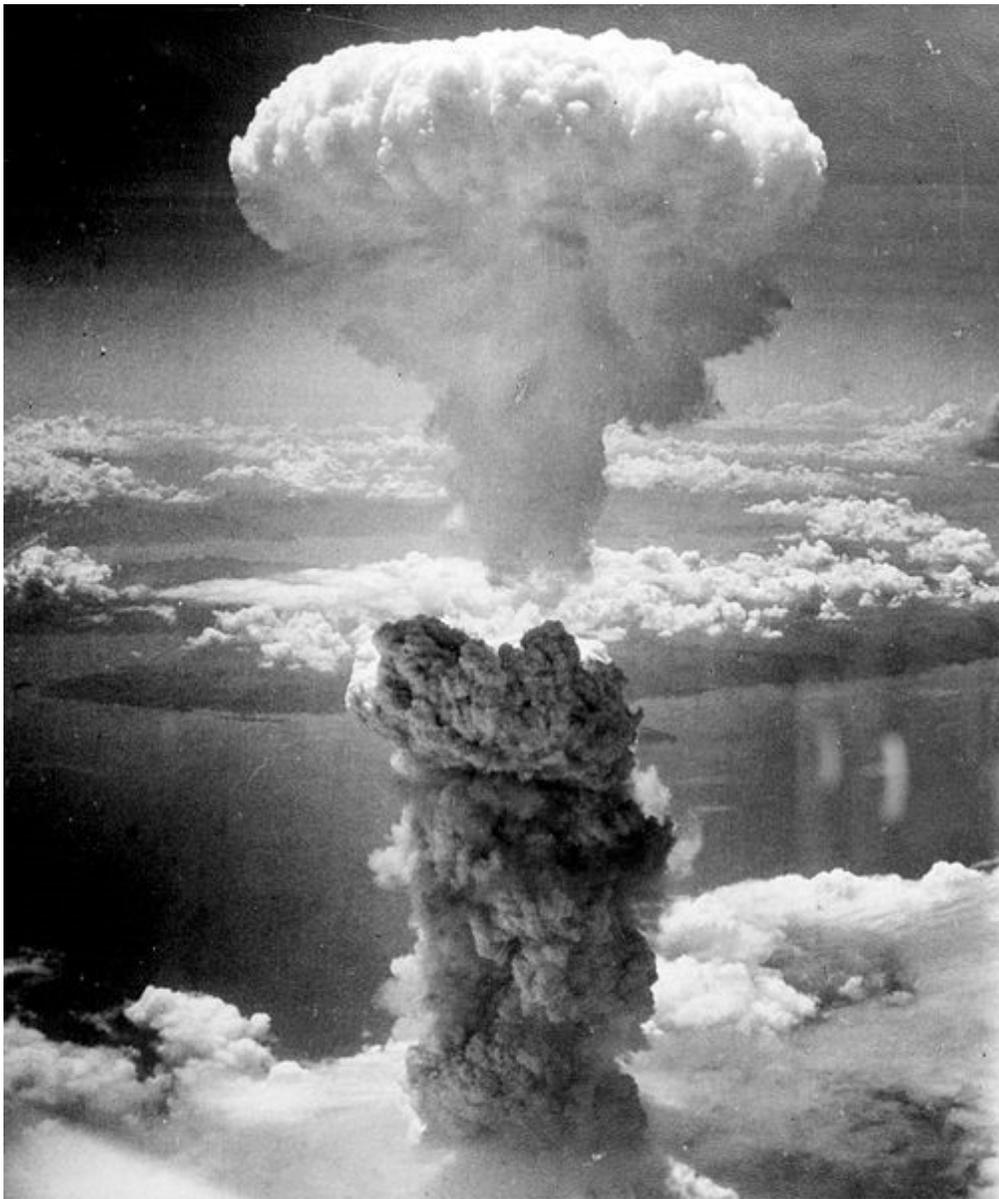
National Emergency Alarm Repeater



The N.E.A.R. Warning Device.

The **National Emergency Alarm Repeater** (NEAR) is a civilian warning device in the United States. It is a 2-3" square box that is designed to plug into a home power outlet to receive a special signal sent over the electric power transmission lines. Research and testing for the NEAR program was developed in 1956 during the cold war to supplement the existing siren warning systems and radio broadcasts in the event of a nuclear attack. For unspecified reasons, the program went defunct and the devices were destroyed by their respective manufacturers. The publicized policy of mutually assured destruction and other factors helped make the program unnecessary.

A similar program was proposed in the United Kingdom during the 1960s.



The mushroom cloud of the atomic bombing of Nagasaki, Japan in 1945 rose some 18 kilometers (11 miles) above the bomb's hypocenter.

Time magazine article

A *Time* magazine article, "Civil Defense: Buzzers Mean Bombs", in the November 14, 1960 issue is one of the only pieces of original documentation on the internet about the device and program. The article outlines a new program that supplements the then "basically unsound" warning system consisting of localized sirens and the CONELRAD radio-alert system.

The U.S. Army argued that in the age of intercontinental ballistic missiles a civil-defense warning system should be capable of warning 90% of the population within 30 seconds after a signal is given by the national civil-defense center in Colorado Springs.

The device is a buzzer installed into common outlets in homes, offices, factories and public buildings. The devices would be set off in an emergency by altering the regular AC signal being generated and transmitted by the local power companies. This would be done by having a specific alternating current of a specific frequency superimposed upon it, the imposed current would be generated by special generators and would be at 270 Hz at 3 volts RMS for 50000 cycles.



Civil Defense logo on a Thunderbolt 1003 siren.

The indoor buzzers would be supplemented with outdoor loudspeakers scattered throughout every city. In case of attack, these loudspeakers would carry a warning signal, followed by instructions on what to do.

Patent

The following text from the original patent granted in 1966 describes the device and its use:

The present invention relates to electrical control circuits for producing a delayed action and controlled duration audible alarm, and more particularly to a receiving instrument preferably designed to be used in homes, offices and other buildings as a component of the National Emergency Alarm Repeater (NEAR) system and more particularly to such a receiver incorporating a solid state device for its major control function. The task of providing a means of alerting the Nation of an impending enemy attack or other civil disaster has been given by the United States Congress to the Office of Civil Defense. This office recognized early that some means had to be devised to supplement outdoor sirens in providing more effective warning since sirens often can not be heard indoors, and many suburban and rural areas are not within range of hearing of the nearest municipal siren system. After considerable research and investigation the conclusion was reached that it would be necessary to provide an indoor system which could be coordinated with outdoor warning systems already installed. Such a system must reach the greatest possible number of homes and still not entail undue and prohibitive costs. Therefore it has been decided to use existing electrical power lines and to provide special generators to transmit an electrical signal of controlled frequency and duration over these lines in the event of a national emergency. The generators will be used to superimpose a signal at a frequency of 270 cycles per second on the 60 cycles per second power which is normally transmitted over the power lines. A receiver unit, plugged into an ordinary A.C. wall receptacle, will respond with a loud buzzer-like sound when activated by an actuation signal of sufficient duration.

An excerpt from a Nuclear Survival Manual

In order to be certain that even sleeping persons can be alerted, your government has perfected a device which plugs into any electric outlet serviced by a public utility. This box emits a very distinctive signal when our warning system determines that enemy missiles or aircraft are on their way for an attack. It will probably sell for a nominal price. The system is called the NEAR project. Some power stations have already been equipped to trigger the signal. Others are being similarly equipped and the entire system should be operational in the near future. The signal device is automatic and performs the function of a nuclear attack alarm clock. A person's chances of survival are enhanced by the careful planning and preparation which will enable him to make the best possible use of whatever warning time is available. 9.14

Featured on *History Detectives*



The FCDA logo

An episode of the PBS television program *History Detectives* (Episode 709, Story 3) in August 2009 featured the NEAR device.

History detective, Gwen Wright investigates a NEAR device marked “Essex Wire Corporation”, found by Wayne Gilbert in a box of computer parts he picked up at a hamfest in Colorado.

Gilbert is familiar with the civil defense triangle on the front of the device and thinks the device may have been intended to help Americans believe they could survive a Soviet nuclear attack. Gilbert would like Wright and the *History Detectives* to find out if the device was mass produced, and what the device was used for.

During her investigation Wright suggests that in the early 1960s the Cold War debate over civil defense policies escalated following the Berlin Crisis of 1961, initiating the age of fallout shelters and films like *Duck and Cover*. The thinking at the time suggested that people could survive a nuclear attack.

Wright visits a local historian in Charlotte, Michigan with a different looking NEAR device made by a division of General Motors. Charlotte, Michigan was selected as a near testing site in 1960 and the device comes from the archives.

In a United States Civil Defense Administration memo Wright learns the program was launched in 1956. The program tested the inexpensive internal warning system for the home and work. At the sign of an attack, NORAD in Colorado Springs would send an alert to a power company where the signal would travel through the electric transmission lines to activate the NEAR devices in homes and businesses. The device was activated by a special high frequency electric current that had to be initiated by the power company.

One of the problems with the program was there was limited instructions on what to do and no follow-up information on what was exactly happening. Also, when alarms sounded people would get in their cars and leave the area causing traffic to jam the highways. The tests, ran in different communities, identified these problems. After a full decade of Federal support for testing and development, the program was terminated.

Lane departure warning system



Roadway with lane markings

In road-transport terminology, a **lane departure warning system** is a mechanism designed to warn a driver when the vehicle begins to move out of its lane (unless a turn signal is on in that direction) on freeways and arterial roads. These systems are designed to minimize accidents by addressing the main causes of collisions: driving error, distraction and drowsiness. In 2009 the NHTSA began studying whether to mandate lane departure warning systems and frontal collision warning systems on automobiles.

There are two main types of systems:

- systems which warn the driver if the vehicle is leaving its lane. (visual, audible, and/or vibration warnings)
- systems which warn the driver and if no action is taken automatically take steps to ensure the vehicle stays in its lane.

The first production lane departure warning system in Europe was developed by the United States's Iteris company for Mercedes Actros commercial trucks. The system

debuted in 2000 and is now available on most trucks sold in Europe. In 2002, the Iteris system became available on Freightliner Trucks' trucks in North America. In all of these systems, the driver is warned of unintentional lane departures by an audible rumble strip sound generated on the side of the vehicle drifting out of the lane. If a turn signal is used, no warnings are generated.

Timeline

2001: Nissan Motors began offering a Lane Keeping Support system on the Cima sold in Japan. In 2004, the first passenger vehicle system available in North America was jointly developed by Iteris and Valeo for Nissan on the Infiniti FX and in 2005 the M vehicles. In this system, a camera mounted in the overhead console above the mirror monitors the lane markings on a roadway. A warning tone is triggered when the vehicle begins to drift over the marking to alert the driver. In 2007 Infiniti offered a newer version of this feature, which it calls the *Lane Departure Prevention* (LDP) system. This feature utilizes the vehicle stability control system to help assist the driver maintain lane position by applying gentle brake pressure to the appropriate wheels.

2002: Toyota introduced its Lane Monitoring System on vehicles such as the Cardina and Alphard sold in Japan, this system warns the driver if it appears the vehicle is beginning to drift out of its lane. In 2004, Toyota added a Lane Keeping Assist feature to the Crown Majesta which can apply a small-counter steering force to aid in keeping the vehicle in its lane. In 2006, Lexus introduced a multi-mode Lane Keeping Assist system on the LS 460 which utilizes stereo cameras along with more sophisticated object and pattern recognition processors, this system can issue an audiovisual warning and also using the Electric Power Steering (EPS) steer the vehicle to hold its lane, this system also applies counter-steering torque to help ensure the driver does not over-correct or "saw" the steering wheel while attempting to return the vehicle to its proper lane, if the radar cruise control system is engaged the Lane Keep function works to help reduce the driver's steering input burden by providing steering torque, however the driver must remain active otherwise the system will deactivate.

2003: Honda launched their Lane Keep Assist System (LKAS) on the Inspire. It provides up to 80% of steering torque to keep the car in its lane on the highway. It is also designed to make highway driving less cumbersome by minimizing the driver's steering input. A camera is mounted at the top of the windshield, just above the rear-view mirror scans the road ahead in a 40-degree radius, picking up the dotted white lines used to divide lane boundaries on the highway. The computer recognizes that you're locked into a particular lane, monitors how sharp the curve is and uses factors such as yaw and vehicle speed to calculate what steering input is required.

2005: Citroën became first in Europe to offer LDWS on their 2005 C4 and C5 models, and now also on their C6. This system uses infrared sensors to monitor lane markings on the road surface. A vibration mechanism in the seat alerts the driver of deviations. Audi began in 2007 offering its Audi Lane Assist feature for the first time on the Q7. This system unlike the Japanese "assist" systems will not intervene in the actual driving rather

vibrate the steering wheel if the vehicle appears to be exiting its lane. The LDW System in Audi is based on a forward-looking video-camera in visible range as opposed to the downward-looking infrared sensors in Citroën.

2007: General Motors introduced Lane Departure Warning on its 2008 model year Cadillac STS, DTS and Buick Lucerne models. The General Motors system warns the driver, with an audible tone and a warning indicator in the dashboard. BMW also introduced Lane Departure Warning on the 5 series and 6 series using a vibrating steering wheel to warn the driver of unintended departures. Volvo introduced the Lane Departure Warning system along with the Driver Alert Control on its 2008 model year S80 and on the new V70 and XC70 executive cars. Volvo's lane departure warning system uses a camera to track road markings and sound an alarm when drivers depart their lane without signaling. The systems used by BMW, Volvo, and General Motors are based on core technology from Mobileye

2009: Mercedes-Benz began offering a Lane Keeping Assist function on the new E-class. This system warns the driver with a vibrating steering wheel if it appears the vehicle is beginning to leave its lane. And a new feature will automatically deactivate and reactivate if it ascertains the driver is intentionally leaving his lane, for instance if the driver is aggressively cornering. However this system will not automatically correct the vehicle to ensure it stays in its lane like the Japanese "assist" systems.

2010: Kia Motors offers the 2011 Cadenza premium sedan with an optional Lane Departure Warning System (LDWS) in select markets. This system uses a flashing dashboard telltale and emits an audible warning when a white lane marking is being crossed, and emits a louder audible warning when a yellow line marking is crossed. This system is canceled when a turn signal is operating, or by pressing a deactivation switch on the dashboard. The system works by using an optical sensor on both sides of the car.

FIAT is also launching its Lane Keep Assist feature based on TRW's lane keeping assist system - also known as the Haptic Lane Feedback system. This system integrates the lane detection camera with TRW's Electric Power steering system - when an unintended lane departure is detected (the turn signal is not engaged to indicate the driver's desire to change lanes) the electric power steering system will introduce a gentle torque that will help guide the driver back toward the center of the lane. Introduced on the Lancia Delta in 2008, this system earned the Italian Automotive Technical Association Best Automotive Innovation of the Year Award for 2008. Peugeot introduced the same system than Citroën in its new 308.

Lane departure warning systems are now combining prevention with risk reports in the transportation industry. Viewnyx applies video based technologies to assist fleets in lowering their driving liability costs. By providing Safety Managers with driver and fleet risk assessment reports and tools to facilitate proactive coaching & training to eliminate high risk behaviors. The Lookout solution is currently being used by North American fleets. There are first solutions for implementing a lane departure warning system on a mobile phone.

Other Warning Systems

Earthquake warning system

An **earthquake warning system** is a system of accelerometers, communication, computers, and alarms that is devised for regional notification of a substantial earthquake while it is in progress. This is not the same as earthquake prediction, which is currently incapable of producing actionable event warnings.

Time lag and wave projection

An earthquake is caused by the release of stored elastic strain energy during rapid sliding along a fault. The sliding will start at some location and progress away from this hypocenter in each direction along the fault surface. The speed of the progression of this fault tear is slower than and distinct from the speed of the resultant pressure and shear waves, with the pressure wave traveling faster than the shear wave. The pressure wave will generate an abrupt shock while the shear waves can generate a periodic motion (at about one cycle per second) that is the most destructive in its effect upon structures, particularly buildings that have a similar resonant period, typically buildings around eight floors in height. These waves will be strongest at the ends of the slippage, and may project destructive waves well beyond the fault failure. The intensity of such remote effects are highly dependent upon local soils conditions within the region and these effects are considered in constructing a computer model of the region that determines appropriate responses to specific events.

Configuration

Earthquake warning systems consist of arrays of seismic motion sensors arranged throughout a region. High speed communications systems and computers collect the sensor readings and the computers are programmed to detect the likely strength and progression of the seismic event. If a dangerous event is detected then alarms can be signalled through the region likely to be affected, allowing warnings before local ground motion of up to and beyond twenty seconds. While short, such warnings would be

sufficient to allow many persons to move to safer areas or to take shelter under substantial furnishings.

Transit safety

Such systems are currently implemented to determine appropriate real-time response to an event in determining train operator response for urban rail systems such as BART (Bay Area Rapid Transit). The appropriate response will be highly dependent upon the warning time, the local right-of-way conditions, and the current speed of the train.

Deployment

Japan, Taiwan and Mexico have earthquake early-warning systems. The most advanced is Japan's Earthquake Early Warning system, which was put to practical use in 2006. Its scheme to warn the general public was installed on October 1, 2007. It was modeled partly on the Urgent Earthquake Detection and Alarm System (UrEDAS) of Japan Railways, which was designed to enable automatic braking of bullet trains.

Dam safety system

Dam safety systems are systems monitoring the state of dams used for hydropower or other purposes. This includes the use of differential GPS and SAR remote sensing to monitor the risks imposed by landslides and subsidence. For large dams seismographs are used to detect Reservoir Induced Seismicity that could threaten the stability of the dam . The output of these systems can provide warning to the local population ahead of a potential collapse.

Systems in the USA

Dam safety systems became a focus of multi-agency regulations during the U.S. Army Corps of Engineers construction of large flood control and hydro-electric power generation projects. To help benchmark proven practices, the Association of State Dam Safety Officials (ASDSO) formed a national non-profit organization of state and federal dam safety regulators, dam owners and operators, engineering consultants, manufacturers and suppliers, academia, contractors and others interested in dams safety. More recently public safety concerns were addressed by the Indian Dams Safety Act of 1992 during hearings before the Select Committee on Indian Affairs, United States Senate, 102nd Congress, second session, on S. 2617. The purpose was to provide for the maintenance of dams located on Indian lands in New Mexico by the Bureau of Indian Affairs through contracts with the Indian tribes. (August 4, 1992 in Washington, D.C.)

The ASDSO Conference Proceedings paper by Gary R. Holtzhausen (1991) describes the effective use of tiltmeters with remote sensing to provide reliable low-cost early warning of impending structural failures.

National Severe Weather Warning Service

The **National Severe Weather Warning Service** (shortened **NSWWS**) is a service produced by the UK Met Office which informs the public of the United Kingdom of severe weather which may damage the country's infrastructure and endanger lives. It is required for two main reasons; to inform the Ministry of Defence and civil emergency authorities to trigger plans to help protect the public; and to alert the public to make necessary preparations for the weather event, mostly through the media.

Types of warnings

There can be different types of warnings, depending on the severity of the event. Early warnings are warnings of severe or extreme weather that may occur in the next 5 days, while Flash warnings are warnings of severe or extreme weather that may occur in the next few hours.

Improvements

As of March 2008, the Met Office improved its warning system by adding an extra stage of warning, the 'Advisory'. They have also provided more colours for different stages of warnings to try and make the system clearer for the public.

Severe weather

Green = No warnings issued

Yellow = Moderate risk of severe weather; moderate risk of disruption

Amber (Early) = High risk of severe weather; high risk of disruption

Amber (Flash) = Severe weather is imminent or occurring/expected in the next few hours; very high risk of disruption

Extreme weather

Green = No warnings issued

Yellow = Low risk of extreme weather; low risk of major disruption

Amber = Moderate risk of extreme weather; moderate risk of major disruption

Red (Early) = High risk of extreme weather; high risk of major disruption

Red (Flash) = Extreme weather is imminent or occurring; very high risk of major disruption and COBRA may be involved if in a highly populated area, such as London

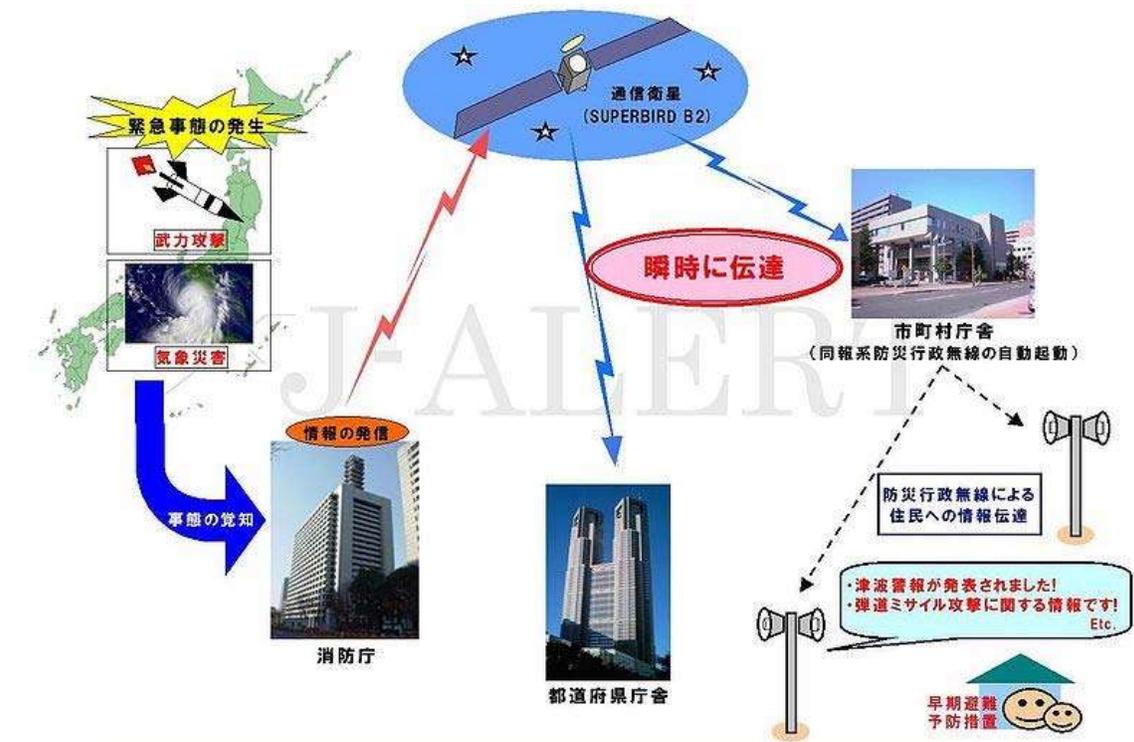
New tiers of alert

Previously, in exceptional circumstances where extremely damaging weather would have occurred, an Emergency Flash Warning would have been issued, for example when a major storm hit Scotland in January 2005. This has now been replaced by the Extreme Weather Warning, under the recent improvements. The other new tier of alert, the Advisory, is associated with the colour yellow and just indicates that the public should be aware of potential severe weather by ensuring they have access to the latest weather forecast.

Media use

The Met Office primarily use the broadcast media to inform the public of any warnings. The BBC, ITV and Channel 4 are the terrestrial networks that use the Met Office's data, so are the ones that broadcast the warnings (usually through their television services, although the BBC use their radio stations and website as well). In some cases, news companies can also be informed, especially for extreme weather, which can also advise the public of what to do.

J-Alert



J-Alert (全国瞬時警報システム *Zenkoku Shunji Keihō System?*) is a nationwide warning system in Japan launched in February 2007. It is designed to quickly inform the public of various threats, including natural disasters like tsunamis and earthquakes; but also of military threats such as North Korean missiles and terrorist attacks. The system was developed in the hope that early warnings would speed up evacuation times and help coordinate emergency response.

The system

J-Alert is a satellite based system that allows authorities to quickly broadcast alerts to local media and to citizens directly via system of loudspeakers. According to Japanese officials it takes about 1 second to inform local officials, and between 4 and 20 seconds to relay the message to citizens.

Adoption rate

Many prefectures and urban areas have been slow to adopt the system. Upon its introduction the Japanese government hoped to have 80% of the country equipped with the J-Alert system by 2009. However, under current plans, by 2011 only 36% of the nation will have been covered. Cost has been a major factor. The initial installation estimate is estimated to be around 430 million yen, and the yearly maintenance is estimated to be around 10 million yen. Local governments have been hesitant to cut other services to implement the system.

Indian Ocean Tsunami Warning System

The **Indian Ocean Tsunami Warning System** is a tsunami warning system set up to provide warning to inhabitants of nations bordering the Indian Ocean of approaching tsunamis. It was agreed to in a United Nations conference held in January 2005 in Kobe, Japan as an initial step towards an International Early Warning Programme. Nanometrics (Ottawa, Canada) and RESULTS Marine Division (Chennai, India) delivered and successfully installed 17 Seismic VSAT stations with 2 Central Recording Station to provide the seismic event alert to the scientists through SMS and E-mail automatically within 2 min.

The system became active in late June 2006 following the leadership of UNESCO. It consists of 25 seismographic stations relaying information to 26 national tsunami information centers, as well as three deep-ocean sensors. However, UNESCO warned that further coordination between governments and methods of relaying information from the centers to the civilians at risk are required to make the system effective.

Its creation was prompted by the 2004 Indian Ocean earthquake and resulting tsunami, which left some 230,000 people dead or missing. Many analysts claimed that the disaster would have been mitigated if there had been an effective warning system in place, citing the well-established Hawaii-based Pacific Tsunami Warning Center, which operates in the Pacific Ocean.

People in some areas would have had more than adequate time to seek safety if they were aware of the impending catastrophe. The only way to effectively mitigate the impact of a tsunami is through an early warning system. Other methods such as sea walls only work for a percentage of waves, but a warning system is effective for all waves originating outside a minimum distance from the coastline.

In the immediate aftermath of the July 2006 Java earthquake, the Indonesian government received tsunami warnings from the Hawaii center and the Japan Meteorological Agency but failed to relay the alert to its citizens. At least 23,000 people did evacuate the coast after the quake, either fearing a tsunami or because their homes had been destroyed.

It has been suggested that in Muslim-dominated coastal areas, the loudspeakers fitted to mosques could be used to broadcast warnings.

Famine Early Warning Systems Network

Famine Early Warning Systems Network (FEWS NET) is a lead organization in the field of prediction and response to famines and other forms of food security. Funded by the United States Agency for International Development since its creation in 1985, it analyzes a variety of data and information, such as market prices of food, precipitation and crop failures to predict when and where food insecurity will occur, and issues alerts

on predicted crises. For political reasons the Central American early warning system is titled the Mesoamerican Food Security Early Warning System, also called MFEWS. While currently monitoring approximately 17 sub-Saharan African countries, FEWS NET also has regional offices in Ouagadougou, Nairobi and Pretoria, and national offices in Guatemala, Haiti, and Afghanistan.

History

The 1984 - 1985 famines in Sudan and Ethiopia in which over a million people died was widely reported around the world. In response, the United States created the **Famine Early Warning System (FEWS)** to anticipate possible impending famines and advise policymakers on how such famines might be prevented and their effects mitigated. In the beginning of July 2000, the name was changed to the Famine Early Warning Systems Network. The name change occurred due to a new objective of helping to create and strengthen local food security information systems and famine warning and response planning systems within Africa with which the U.S. could work.

Work

FEWS NET develops its predictions by combining remote analyses of crop condition and agricultural production, often using satellite-based information, with on-the-ground monitoring—through household surveys and observation—of local socio-economic conditions. FEWS NET analyses are carried out in partnership with: 1) implementing team partners: the National Oceanic and Atmospheric Administration's Climate Prediction Center, the United States Geological Survey, the United States Department of Agriculture's Foreign Agriculture Service, and a private-sector company managing field operations, and 2) a large number of operational partners in host-countries, and regional and international organizations. This network provides a broad geographic coverage, and multi-sectoral monitoring of food insecure and vulnerable populations/regions of the world, especially where it is difficult to assess food security. FEWS NET categorizes the severity of food insecurity levels according to a global Integrated Phase Classification-like scale, which allows comparable estimations of severity across countries and continents.

Tools

Population Explorer is a FEWS NET software tool used for estimating human population down the 1 km². It is used to answer basic questions about human population, such as: How many people live in this area? What are their characteristics? How many women live here? How many men live here? What is the age structure of this population? How many people can we expect to live here in the future? These questions can be asked at a country level, sub-country level, cross-country level, or for any user-defined area. Developed to estimate populations vulnerable to food insecurity, Population Explorer extends beyond famine early warning, and is being used by professionals in disaster

response and preparedness, as well as for use in planning for health, educational, and other public services.

ROTOR

ROTOR was a huge and elaborate air defence radar system built by the British Government in the early 1950s to counter possible attack by Soviet bombers. The system was built up primarily of war-era radar systems, and was used only briefly before being replaced by more modern systems.

Post-war situation

UK radar operations were wound down late in the war, and by the time the war ended were already largely unused. It was assumed that another war was at least ten years away, and the need for any improvements in the cobbled-together system seemed remote.

Thinking changed dramatically in 1949 with the Soviet test of their first atom bomb. It was known that the Soviets had made exact copies of the B-29 Superfortress as the Tu-4 Bull, and these aircraft had the performance needed to reach the UK with a nuclear payload. Studying the problem, the Cherry Report of 1949 which suggested that the 170 existing Royal Air Force radar stations be reduced to 66 sites and the electronics extensively upgraded. East Coast sites were constructed in various 'hardened' designs in the 'R' series (R1, R2, R3 and R4 etc.), the original designs were not 'nuclear hardened' bunkers but very substantial structures protected against conventional attacks. West Coast sites were in semi-sunken hardened structures ('R6') or above ground 'Secco' type huts (Hartland Point etc.).

ROTOR

Most of the new network would be made up of 28 re-built Chain Home systems, while the rest were taken from the existing selection of Chain Home Low, Chain Home Extra Low and the various Ground-controlled interception (GCI) radars that had formerly served special purposes. This was, in part, a stop-gap measure anticipating the availability of the dramatically improved Type 80 Green Garlic radar which would replace the various early warning radars with a single system of much greater performance. Interception guidance would still be handled by existing systems in either case.

All of the radars were to be improved in terms of siting with the addition of hardened control bunkers to protect the operators from a conventional attack. On the east coast, the

coast toward which a Soviet attack would be most likely, the bunkers were underground, while those on the western side of the UK were generally above ground as a cost-saving measure. The bunkers themselves were otherwise similar, featuring 10-foot-thick (3.0 m) concrete walls with all equipment, operations generators and air conditioning located inside.

Additionally, ROTOR re-arranged the existing RAF Fighter Command structure into six "Sector Operational Commands" (SOC) with their own command bunkers (three level 'R4' protected accommodation). Only four of these were built. Additional "Anti-Aircraft Operations Rooms" were built to coordinate the British Army's AA defences in the same overall system. The entire network of bunkers, radars, fighter control and command centres used up 350,000 tons of concrete, 20,000 tons of steel and thousands of miles of telephone and telex connections.

The work was mainly carried out by the Marconi Wireless and Telegraph Company in several phases, called ROTOR 1, ROTOR 2 and ROTOR 3.

Post-ROTOR

As the anticipated Type 80 "Green Garlic" radar started testing shortly after ROTOR came online, it became clear that it could fill both early warning and interception guidance from a single site. This dramatically decreased the complexity of the ROTOR system, which otherwise required sightings from the early warning radars to be telephoned to the fighter control GCI stations for local plotting. By concentrating all of this complexity at a single site the total number of operators was greatly reduced.

As a result of the introduction of the Type 80 (Green Garlic), many of the existing ROTOR sites were rationalized into *Master Radar Stations* (MRS), while the rest were made redundant, some only two years after opening, and all of the AAOR sites were closed. A few of these were re-used for government department ('RSG's) and local authority wartime headquarters. In the mid-1960s the MRS's themselves were replaced with a new system called Linesman/Mediator.

Until the end of the Cold War many of the sites were retained by the government but now have been sold off to private buyers or converted into museums (for example 'RAF Hack Green') and some transferred to the National Air Traffic Control Centre.

Sector Operation Control centres

Custom Built:

- Bawburgh
- Kelvedon Hatch
- Barnton Quarry

World War II:

- Box, Wiltshire
- Goosnargh

Precrash system

A **precrash system** is a automobile safety system designed to reduce the severity of an accident. Most are also known as forward collision warning systems which use radar and sometimes laser sensors to detect an imminent crash. Depending on the system they may warn the driver, precharge the brakes, Inflates seats for extra support, moves the passenger seat to a better position, folds up the rear head rest for whip lash, retract the seat belts removing excess slack and automatically apply partial or full braking to minimize the crash severity. In 2009 the NHTSA began studying whether to make frontal collision warning systems and lane departure warning systems mandatory.

Function

Audi

The full version of the system (Pre-Sense Plus) works in four phases. In the first phase, the system provides warning of impending accident, while the hazard warning lights are activated, the side windows and sunroof are closed and the front seat belts are being tensioned. In the second phase, the warning is followed by light braking, strong enough to win the driver's attention. The third phase initiates autonomous partial braking at a rate of 3 m/s^2 . The fourth phase decelerates the car at 5 m/s^2 followed by automatic deceleration at full braking power, roughly half a second before projected impact.

A second system called (Pre-Sense Rear) is designed to reduce consequences of rear end collisions. Sunroof and windows are being closed, seat belts prepared for impact. The optional memory seats are being moved forward to protect the car occupants.

The system uses radar and video sensors and has been introduced in 2010 on the 2011 Audi A8.

Ford



Collision Warning with Brake Support on the 2009 Lincoln MKS

Ford's Collision Warning with Brake Support was introduced in 2009 on the Lincoln MKS and MKT and the Ford Taurus. This system provides a warning through a Head Up Display that visually resembles brake lamps. If the driver does not react, the system pre-charges the brakes and increases the brake assist sensitivity to maximize driver braking performance.

Honda

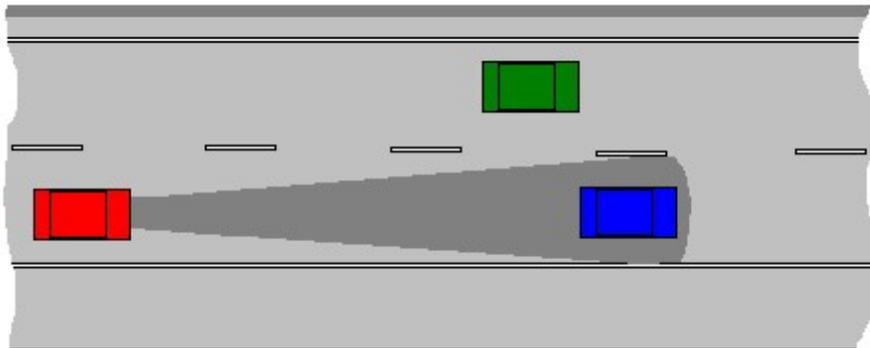
Honda's Collision Mitigation Brake System (CMBS, although originally introduced with the initials CMS) introduced in 2003 on the Inspire (and later in Honda's child company Acura) uses a radar-based system to monitor the situation ahead and provide automatic braking if the driver does not react to a warning in the instrument cluster and a tightening of the seat belts. The Honda system was the world's first production system to provide automatic braking. The 2003 Honda system also incorporated an "E-Pretensioner" which worked in conjunction with the CMBS system with electric motors on the seat belts. When activated, the CMBS has three warning stages. The first warning stage includes audible and visual warnings to brake. If ignored, the second stage would include the E-

Pretensioner tugging on the shoulder portion of the seat belt two to three times as an additional tactile warning to the driver to take action. The third stage, in which the CMBS predicts a collision is unavoidable, includes full seatbelt slack take up by the E-Pretensioner for more effective seat belt protection, and automatic application of the brakes to lessen the severity of the predicted crash. The E-Pretensioner would also work to reduce seatbelt slack whenever the brakes are applied and the brake assist system is activated

In late-2004 Honda developed an Intelligent Night Vision System which highlights pedestrians in front of the vehicle by alerting the driver with an audible chime and visually displaying them via HUD. The system only works in temperatures below 30 degrees Celsius (86 Fahrenheit). This Intelligent Night Vision first appeared on the Legend.

Nissan

Infiniti offers a laser-based system in the US market, which pre-pressurizes the braking system so maximum force can be applied early. Nissan is reportedly developing a new "magic bumper" system which raises the accelerator pedal if it senses an impending collision. Once the driver lifts off the pedal, the system then automatically applies the brakes.



Adaptive cruise control sensors provide data for precrash systems

Mercedes-Benz

Mercedes's Pre-Safe system was unveiled in the fall of 2002 at the Paris Motor Show on the 2003 S-Class. Using ESP sensors to measure steering angle, vehicle yaw and lateral acceleration and Brake Assist sensors to detect emergency braking, Pre-Safe can tighten

the seat belts, adjust seat positions including rear seats (if installed), raise folded rear headrests (if installed) and close the sunroof if it detects possible collision (including rollover) . A later version of Pre-Safe system was supplemented by an additional function that can close any open windows if necessary.

Pre-Safe Brake, Mercedes-Benz's first forward warning collision system was introduced in the fall of 2005 on the redesigned 2006 S-Class is co-operating with simultaneously introduced Brake Assist Plus and Distronic Plus systems and provides all the functions of previous Pre-Safe system while adding a radar-based system which monitors the traffic situation ahead and provides automatic partial braking (40% or up to 0.4g deceleration) if the driver does not react to the Brake Assist Plus warnings from the cockpit and the system detects a severe danger of an accident.

At the 2009 North American International Auto Show Mercedes unveiled Attention Assist on the 2010 E-class which based on 70 parameters attempts to detect the driver's level of drowsiness based on the driver's driving style. This system does not actually monitor the driver's eyes. Also in 2009 Mercedes added the first fully autonomous braking feature that provides maximum braking force approximately 0.6 seconds before impact.

Toyota



2008 LS 600h forward PCS diagram, with radar (blue) and infrared (red) coverage

Toyota Motor Corporation's Pre-Collision System (PCS), the first production forward warning collision system, is used on the manufacturer's Lexus and Toyota brand vehicles. It is a radar-based system which uses a forward facing millimeter-wave radar. When the system determines a frontal collision is unavoidable it preemptively tightens the seat belts removing any slack and pre-charges the brakes using brake assist to give the driver maximum stopping power instantly when the driver depresses the brake pedal. Toyota launched PCS in February 2003 on the redesigned Japanese domestic market Harrier and in August 2003 added an automatic partial pre-crash braking system to the Celsior. In September 2003, PCS made its first appearance in North America on the Lexus LS 430, becoming the first such system offered in the US. In 2004, Toyota advanced the system by adding to the radar a single digital camera to improve accuracy of collision forecast and warning, control levels, it was first available on the Crown Majesta.

In 2006, the debut of the Lexus LS featured a further advanced version of the PCS; this newer version dubbed Advanced Pre-Collision System (APCS) added a twin-lens stereo camera located on the windshield and a more sensitive radar to detect for the first time smaller "soft" objects such as animals and pedestrians. A near-infrared projector located in the headlights allows the system to work at night. By using the LS's Adaptive Variable Suspension (AVS) and electric Variable Gear Ratio Steering (VGRS) the system can change the suspension damper firmness, steering gear ratios and torque assist to aid the driver's evasive steering measures in a system known as "Collision-avoidance Steering Support". The Lane Keep Assist system will make automatic steering adjustments to help ensure the vehicle maintains its lane in case the driver fails to react.

Also unveiled for the 2007 model year, the world's first Driver Monitoring System was introduced on the Lexus LS, using a CCD camera on the steering column, this system monitors the driver's face to determine where the driver is looking. If the driver's head turns away from road and a frontal obstacle is detected the system will alert the driver using a buzzer and if necessary pre-charge the brakes and tighten the safety belts. A later version of the Driver Monitoring System found in 2008 on the Crown monitors the driver's eyes to detect the driver's level of wakefulness. This system is designed to work if the driver is wearing sunglasses and at night.

Other advancements to the PCS appearing on the 2007 Lexus LS include the first rearward facing millimeter-wave radar mounted in the rear bumper. This system adjusts the active head restraints by moving them upward and forward to reduce the risk of whiplash injuries if an imminent rear collision is detected.



Night View system on the 2003 Lexus LX 470

Toyota began using Night View on the JDM 2002 Toyota Landcruiser Cygnus and on the 2003 Lexus LX 470 available in US market. In 2008 Toyota added a pedestrian detection feature on the Crown which highlights pedestrians and presents them on an LCD display located in front of the driver. The latest Crown also uses a GPS-navigation linked brake assist function. The system is designed to determine if the driver is late in decelerating at an approaching stop sign, it will then sound an alert and can also precharge the brakes to provide optimum braking force if deemed necessary. This system works in certain Japanese cities and requires Japan specific road markings which are detected by a camera.

In March 2009 on the redesigned Crown Majesta, Toyota again further advanced the "PCS" adding a front-side millimeter-wave radar to detect potential side collisions primarily at intersections or when another vehicle crosses the center line. The latest version tilts the rear seat upward placing the passenger in a more ideal crash position if it detects a front or rear impact. This latest Crown also features a new rear center airbag.

Volkswagen

Front Assist on the 2011 Volkswagen Touareg can brake to a stop in case of an emergency and tension the seatbelts as a precautionary measure.

Volvo

Volvo's Collision Warning with Auto Brake (CWAB) developed in cooperation with Mobileye N.V. was introduced on the 2007 Volvo S80. This system is powered by a radar/camera fusion and provides a warning through a Head Up Display that visually resembles brake lamps. If the driver does not react, the system pre-charges the brakes and increases the brake assist sensitivity to maximize driver braking performance.

WWT