# Flame detection through the use of 3D mapping to aircraft hangars

In this first, of a two-part article, William Pittman, PhD discusses the challenges posed by aircraft hangars in relationship to flame detector selection. In the next edition of Gulf Fire William discusses how 3D flame detector modelling techniques can be used, in combination with good engineering practice, to provide a cost-effective design and aid compliance with standards.

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Aircraft hangars combine a set of features that make it both paramount to achieve rapid flame detection and uniquely difficult to do so reliably with a minimum of false alarms. Hangars are frequently occupied by personnel, and extremely valuable equipment and aircraft. The hangars, fuel depots and terminals are also necessarily home to large quantities of jet fuel and other hydrocarbons that pose a major fire hazard if released from containment.

Optical flame detection has been applied in both civilian and military hangars for years. Rapid detection and activation of suppression systems is crucial to protecting lives and assets in the event of a fire. A single hangar can cost anywhere from less than $150,000 to a few million dollars depending on the size of the hangar, the equipment inside and the type of aircraft it's designed to service.[1] This seems but a pittance however when compared to the costs of the aircraft themselves. A single F-35A Lightning II costs the military about $102 Million as of 2017,[19] which is still lower than the $135-149 Million estimated fly-away cost of an F-22 as of 2009.[22] Each of the military's 21, B-2 Spirit bombers cost over $1 Billion and would be exceedingly hard to replace.[20,21] This makes protecting the aircraft from damage during a fire paramount, and far more important than protecting the hangar structure itself.

Aircraft can sustain damage in less than a minute when exposed to fire,[1] but the high expansion foam systems that are used to protect them in the event of a hangar fire can take more than two minutes to fill the hangar and suffocate fires near the top of even relatively small aircraft.[23] This race against time makes it critical to detect fires quickly and optical flame detection is ideally suited for this.

In addition to speed of response, a host of possible false alarm sources can cause spurious activations of suppression systems which can, in turn, have expensive or tragic consequences. It is critical that appropriately designed flame detectors are installed with the highest possible level of false alarm immunity.

## The role of optical flame detection

Optical flame detection provides faster detection of flames than traditional smoke or heat detection systems, especially where aircraft hangars are concerned. The high ceilings of the structures and potential for thermal stratification can significantly delay detection with traditional ceiling mounted detectors in a grid-based array. Optical detectors with wide horizontal and vertical fields of view and detection ranges of 40 metres or more can detect small fires over a large section of a hangar in 10 seconds or less[25,26]. This is significantly better than traditional systems.

Fire Protection Systems for aircraft hangars specifically are handled under the NFPA 409 'Standard on Aircraft Hangars,[27,28] which categorizes hangars into four groups or divisions based on the size of the hangars, the height of access doors, and the materials of construction. It provides for performance-based protection of hangars with the requirements for each group sometimes depending on what activities occur inside the hangar. Much of NFPA 409 focuses on what type of fire suppression system is appropriate for use with each hangar group. It refers to NFPA 72 for guidance on the design of the detection systems.

▲ **Hangar with small aircraft.**

NFPA 72 and ISA TR 84.00.07 require that selected detectors are appropriate for the application, detecting jet fuel fires, and that the detector layout be chosen based on an appropriate engineering study by qualified individuals.[1] Geographic coverage assessments (GCAs) conducted in a manner consistent with the guidance in ISA TR 84.00.07 are one way to demonstrate the system has been designed to meet the required level of performance with adequate documentation of the detector layout and expected level of performance. These assessments are sometimes referred to as "hazard mapping."

Military hangars are required to comply with ETL 02-15,[31] which references NFPA 409 among several other NFPA standards, as well as UFC 4-211-01, the Unified Facilities Criteria (UFC) for Aircraft Maintenance Hangars. [32] The 2002 version of ETL 02-15 requires the use of either UV/IR or multi-frequency-IR flame detectors proven to be able to detect a 9 $m^2$ jet fuel fire at a distance of 45 metres and that any fire under any aircraft in the hangar must be detectable by at least one optical flame detector. The UFC requires that a fire be confirmed by a 2nd detector or by traditional fire protection systems before foam suppression systems automatically activate.

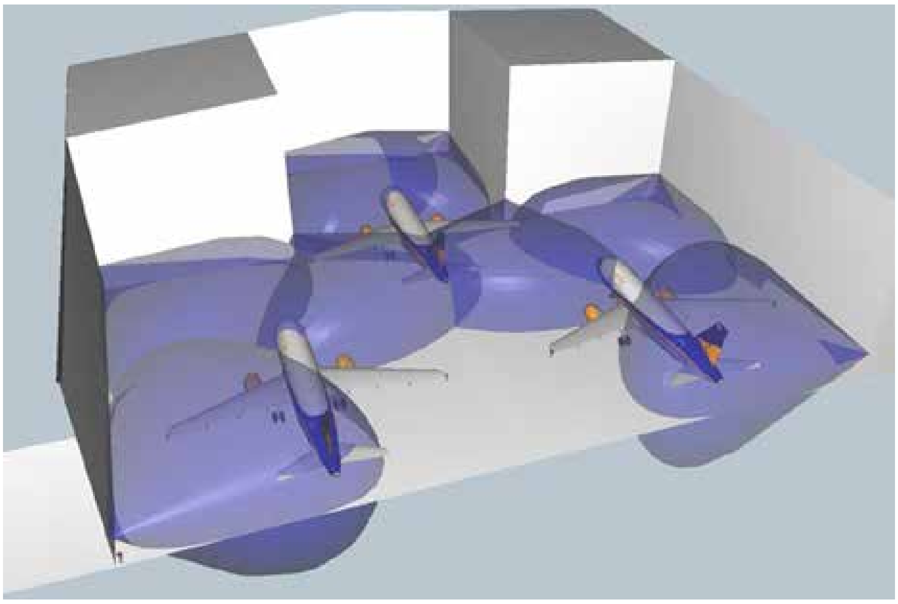
## Which optical flame detector?

There is no such thing as a perfect flame detector and no single detector is the best for all applications. Multi-spectrum infrared (MSIR, sometimes called triple IR) detectors have been employed for many years, but recently we have seen some hangars using Intelligent visual-based flame detectors (iVFDs) as these can overcome many of the false alarm stimuli that challenge MSIR units[1,2].

An intelligent visual flame detector is essentially a camera with an onboard mechanism to spatially analyze video for fires. Some models also have the ability record events, be they genuine fires or false alarms.[7]

Remote viewing of a video feed allows personnel to quickly confirm a fire in the event of an alarm or activation of suppression systems. On board recordings of the event video allows investigators to review it and identify the origin and cause of a fire. This is particularly useful given that fires tend to destroy much of the evidence of how the fire began, sometimes resulting in so-called "black-hole" fires, with nothing surviving to indicate cause or precise point of origin.[8] The cause of many fires remains "undetermined" indefinitely simply because of a lack of definitive evidence.[8,9]

▼ **3D representation of a hangar showing aircraft and flame detector field of view.**




▲ **Intelligent Visual Flame Detector.**

Where a false alarm occurs, the video can be reviewed to determine the cause and possibly prevent future false activations.

Aircraft hangars have very large doors that are often left open during operating hours to allow for ease of egress for personnel and aircraft. While Sunlight is generally not expected to trigger false alarms with MSIR units, some are significantly impaired by it and the detectors will only be effective at much shorter ranges while the sun is within the detector's FOV. MSIR detectors avoid false alarms due to sunlight by employing "guard band" frequencies to distinguish genuine flames from false alarm sources. Unfortunately, the guard bands are not solar blind and therefore MSIR detectors will suffer significant desensitization in the presence of a sunlight, modulated or not.

Flame detectors that primarily detect flames in the region of 4.4 microns (like MSIR / IR3's) are responding to hot CO2, these units can false alarm to engine or generator exhaust which can be a significant problem when jet engines and motors associated with maintenance equipment are used in hangars.

A major advantage of iVFD detectors is they cannot see hot $CO_2$ emissions; the technology therefore does not false alarm due to the exhaust gases jet engines or diesel generators. iVFD has also been third party tested to show no desensitization due to sunlight, modulated or not.

## Conclusions

The paper has detailed ways in which intelligent visual flame detectors (iVFDs) can improve the performance of a detection systems by reducing false alarms. In the second part of this article results for coverage assessments conducted on a model aircraft hangar will demonstrate the potential for hazard mapping to be used to demonstrate ways to improve system performance and reduce the number of detectors required to fully cover a hangar.

**For more information, go to www.micropackfireandgas.com**

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