Flame detection through the use of 3D mapping to aircraft hangars – Part 2

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

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Case Study Using a Group I Aircraft Hangar

In this case study, a design for a hypothetical "Group I" aircraft hangar using commercially available 3D modelling software and a range of industrial flame detectors is used. The software will provide coverage assessments based on individual flame detector characteristics.

Please note the case study will largely ignore the provisions of the United Facilities Criteria (UFC) that in some cases allows for activation of the foam system if a single optical flame detector goes into alarm and the system also detects that water is flowing through overhead fire water / sprinkler systems. Furthermore, we will not consider the use of ceiling mounted smoke and heat detection systems as thermal stratification and other issues sometimes encountered within structures with very high ceilings can delay activation.

Detector Modeling and Desensitization

The case study compares the coverage achieved by an "industry standard multi spectrum infrared" (MSIR) flame detector to that of two intelligent visual flame detectors (iVFD). As noted previously, the MSIR selected is currently specified for use in the US Military's UFC.

The Field of View (FOV) of the detector is one of the most important features of a detector in determining coverage, second, perhaps, only to the effective detection range to a 1 ft² pan fire. Table 1 below gives a summary of the maximum FOV achieved by each detector.

As discussed in previous articles, the effective range of a detector can be reduced by a wide range of environmental factors and its necessary to account for this sensitivity loss when assessing the coverage, a detection system can be expected to provide.

One method, with wide industrial acceptance, for determining the effective detection range of a detector uses three desensitization factors.1,2 These factors, often called F1, F2, and F3, adjust the detection range to account for blinding / interference sources, the impact of dirty optics and loss of off-axis sensitivity respectively.

Table 2 provides a breakdown of the desensitization factors for each detector and the effective ranges used in the assessments. The value "X" is approved by FM Global (FM3260 data) and can be taken from product manuals. In the case of the MSIR, the desensitization factors depend on the sensitivity setting used so Table 2 lists these by sensitivity. Visual Flame Detectors are spatially sensitive and have one only sensitivity setting.

As noted previously, iVFDs are far more resistant to blinding and desensitization than MSIR units. As a result, the iVFDs only suffer a 9.75% loss of effective range where the MSIR loses between 37 and 52% depending on the sensitivity setting.

As the FOV cone for the MSIR and iVFD's are accurately modeled in the modelling tool used no adjustment is necessary, a value of 1.00 is used for F3.

Table 1: Effective range and FOV for selected detectors

Detector Model	Detector Type	Field of View	
		Horizontal	Vertical
"Industry Standard MSIR"	MSIR	90°	75°
iVFD-Type 1	iVFD	120°	90°
iVFD-Type 2	iVFD	90°	65°

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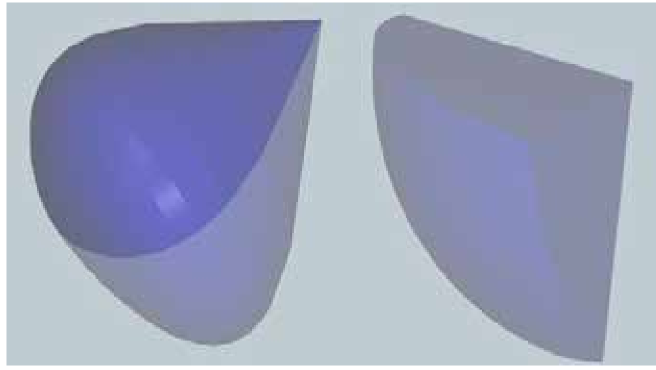


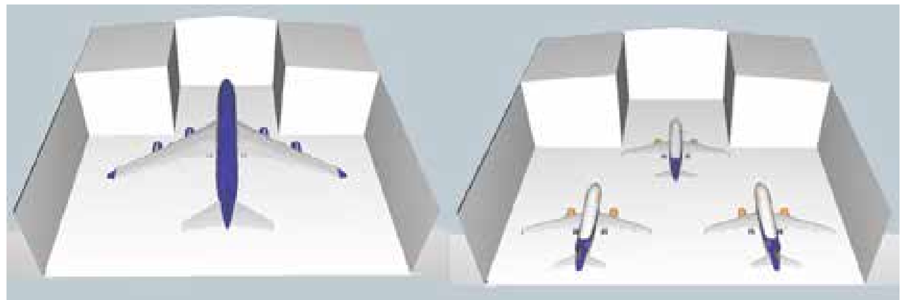
▶ Figure 1: FOV representation in HazMap3D of MSIR (LHS) and iVFD-Type 2 (RiHS).

Table 2: Summary of Detector Desensitization Calculation

Detector Model	X	F1	F2	F3	% max range	Effective Range, D
"Industry standard MSIR" (L)	15.24 m	0.84	0.75	1.0	63 %	9.7 m
"Industry standard MSIR" (M)	30.5 m	0.78	0.75	1.0	59 %	18.0 m
"Industry standard MSIR" (VH)	61.0 m	0.64	0.75	1.0	48 %	38.7 m
iVFD-Type 1	60.0 m	0.95	0.95	1.0	90 %	54.1 m
iVFD-Type 2	44.0 m	0.95	0.95	1.0	90 %	39.7 m

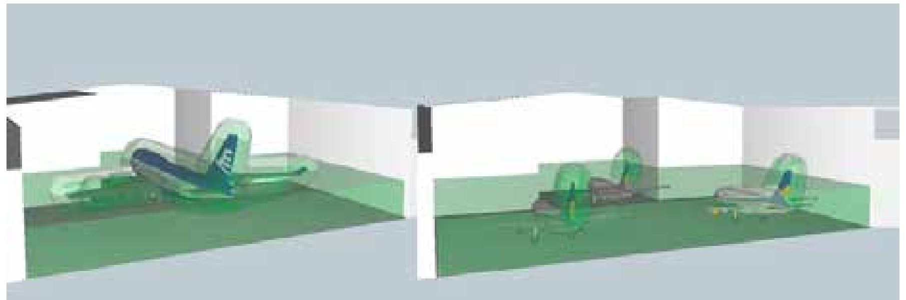
Model overview

The aircraft hangar is approximately 90 m wide, 80 m deep in the center, and 50 m deep at the sides with a 23 m ceiling. With a fire zone of approximately 5,500 m² and room for aircraft having a tail height greater than 28 feet, this hangar would be classed as a Group 1 hangar. Figure 2 shows how the hangar might accommodate different aircraft. Commercial aircraft are used in this example, as the overall form factor of large commercial aircraft and larger military cargo planes, like the C-5 galaxy, are sufficiently similar to use for illustrative purposes.



▲ Figure 2: Two hangars are considered, a single, four-engine, "jumbo" jet & three smaller two-engine planes.

▼ Figure 3: Graded areas for a single, four-engine, "jumbo" jet and three smaller two-engine planes.



Grading

The modelling tool allows the user to assign a risk grade to the aircraft as well as indicating that fires are thought possible in the surrounding area too. How far the graded area extends can vary but 1 to 5m is typical. Ungraded areas represent spaces where fire is either not expected, or not expected to result in significant consequences. Figure 3 shows the graded volumes selected for assessment.

Note that the entire area of the hangar is part of the graded fire zone up to 8 m above the local deck (ALD). The volume within 5 m of the planes that is assigned to the same risk grade, even if that space is more than 8 m ALD. This grading is reasonable given that the principle fire hazard is the release and ignition of liquid hydrocarbons, which can burn on the deck, any aircraft surface or on equipment brought into the hangar for fueling or maintenance activities.

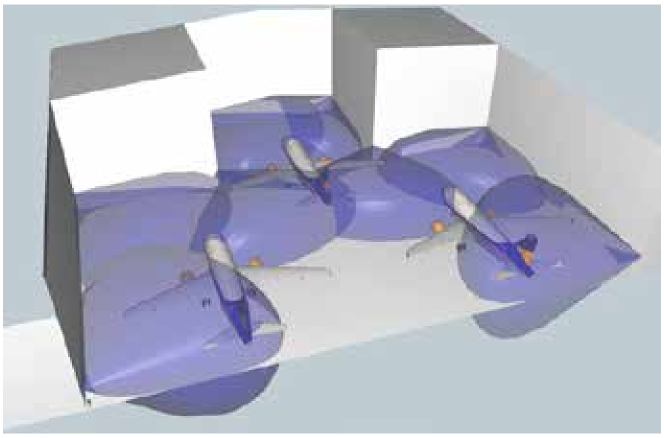
Having assigned grades, detectors can be positioned to provide optimal coverage. Hazard mapping software shines at this stage as it allows users to change detector position, run new assessments and immediately see the impact in coverage.

Coverage achieved using MSIR

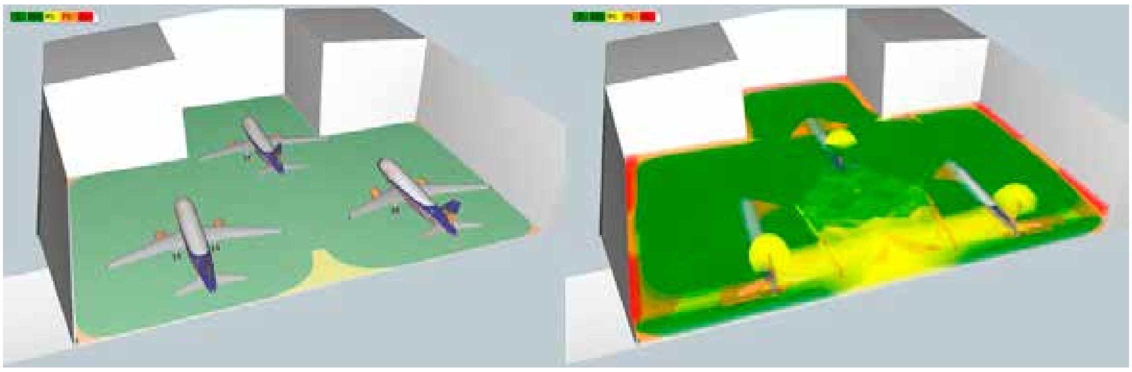
A design was produced using the MSIR using Very High Sensitivity. This sensitivity setting is generally used for military hangars where the aircraft are not permitted to move under their own power. The UFC requires detectors to be kept in Medium or Low sensitivity settings when aircraft can enter and leave a hangar under their own power. The design is shown in Figure 4.

The FOV cones shown in Figure 4 (and subsequent figures) represent the volume in which, baring visual obstruction, the detector should detect a 40 kW RHO fire in 10 seconds or less. This fire is roughly equivalent to the 1 ft^2 n-heptane pan fire used in FM 3260 testing.

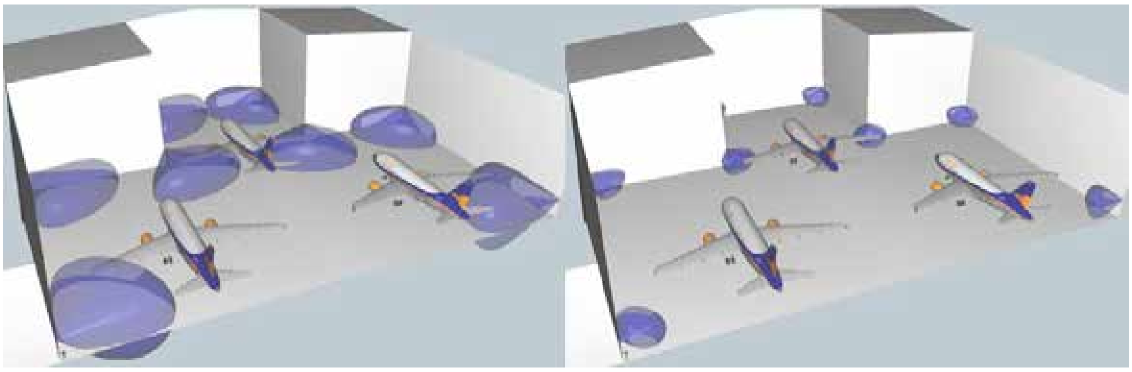
The hangar height and dimensions make it difficult to achieve good coverage in the middle of the hangar without placing detectors along the back walls. This is not ideal as six of the eight detectors are positioned to "look" beyond the hangar doors. This can be undesirable as when the doors are open the detectors might false alarm to aircraft moving under their own power outside the hangar.



◀ **Figure 4: FOV cones for 8 MSIR detectors.**



◀ **Figure 5: Assessment results using eight MSIR detectors set to "very high" sensitivity; at deck level (LHS) and at higher elevations (RHS).**



◀ **Figure 6: MSIR FOV cone for medium (LHS) & low (RHS) sensitivity settings.**

The design was assessed based on the detectors ability to detect a 90 kW RHO fire, which roughly corresponds to a 2 ft square JP-4 or JP-5 fire. The results are shown in Figure 5.

The results using 8-detectors are good with 2ooN coverage achieved for 83% of the graded volume and nearly complete 2ooN coverage for the hangar floor. Most of the areas of low coverage are along the outer edges of the hangar and in the middle, near the hangar door. Most of the coverage loss results from the visual obstruction from the aircraft and the effective range used.

Covering an aircraft hangar becomes more challenging if the aircraft can enter and leave under their own power. Per the requirements of the UFC the detectors must use the "medium" or "low" sensitivity setting. Figure 6 shows how the FOV cone for the MSIR shrinks relative to the size of the hangar when the lower sensitivity settings are used.

Table 3 provides a summary of the coverage provided using each sensitivity setting using the 8-detector MSIR layout.

Coverage Achieved Using iVFDs

By comparison, Figure 7 shows a six-detector layout using iVFD–type 2 detectors. This design eliminates two detectors from the previous example by employing visual flame detectors.

Figure 7: FOV cones for six iVFD–type 2 detectors arrayed to cover the model hangar.

The six-detector layout achieves 87% 2ooN coverage and provides at least 1ooN coverage for all but 1% of the graded volume. Even with two fewer detectors, the layout achieves better coverage than the 8-detector MSIR layout, using the "Very High" sensitivity setting.

Table 3: Assessment results for the 8-MSIR detector layout by Sensitivity

	2ooN coverage of Target Fire Size	1ooN Coverage	No Effective Coverage
Low	-	31%	69%
Medium	49%	16%	9%
Very High	83%	7%	3%

The coverage provided using iVFD–type 2's can be improved by swapping for the VFD – type 1 devices. Using six iVFD–type 1 detectors, and the same device locations the 2ooN coverage rises to 93%.

For context, Figure 9 shows the coverage achieved using six MSIR's in the same layout as for the iVFDs. Table 4 summarizes and compares the coverage of all the devices examined.

The 2ooN coverage of the MSIR drops to 70%, falling well below the coverage achieved by the iVFDs with the same detector count. This layout cannot provide timely activation in response to a 90 kW RHO flame in the center of the hangar. The iVFD-Type 1, on the other hand, can detect a 90 kW RHO fire at roughly 81 m, even after desensitization. So, if two iVFD-Type 1s have a line-of-sight to the fire, the system will alarm in a timely fashion.

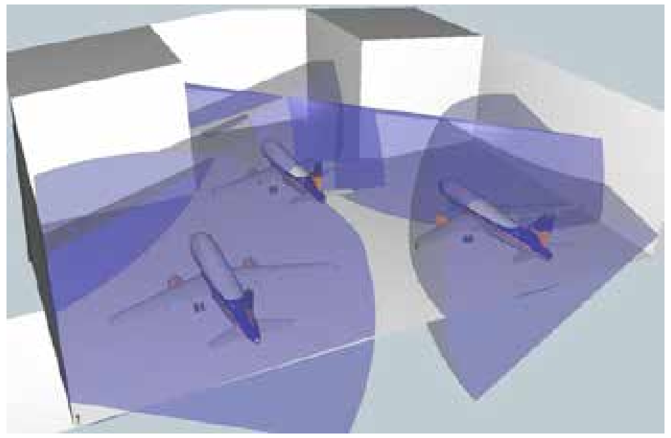


Figure 7: FOV cones for six iVFD–type 2 detectors arrayed to cover the model hangar.

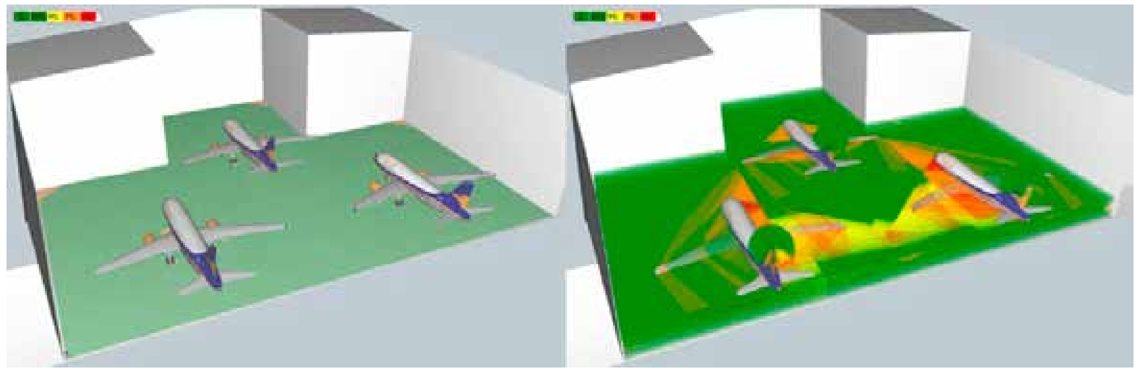


Figure 8: Assessment results for the layout using six iVFD–type 2 detectors; at deck level (LHS) and at higher elevations (RHS).

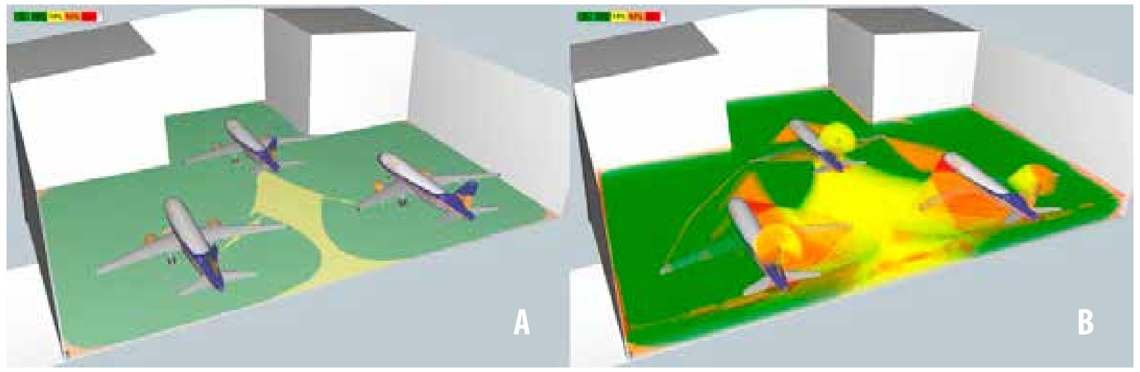


Figure 9: Assessment results for the layout using six MSIR detectors set to the "very high" sensitivity setting a) at deck level and b) at higher elevations.

Conclusions

Optical flame detectors have recognized utility in improving the performance of fire suppression systems in aircraft hangars and protecting the extremely expensive assets inside them. MSIR detectors currently dominate aircraft hangar installations, however, MSIR performance can be bettered using alternative optical flame detection technologies.

The iVFDs can achieve detection at longer ranges with fewer false alarms than MSIR units, even when the MSIR units are set to higher sensitivity settings. This ultimately means that iVFDs can provide adequate coverage of larger hangars with fewer detectors, which lowers upfront and maintenance costs. When MSIRs are used in lower sensitivity settings, as is sometimes required by the UFC, the performance swing is enhanced.

This article has discussed how 3D flame detector modelling techniques can be used, in combination with good engineering practice, and detector selection, to provide a cost-effective design and aid compliance with standards.

Table 4: Comparison of 6 detector layout by detector type

	2ooN coverage of Target Fire Size	1ooN Coverage	No Effective Coverage
MSIR (VH)	70%	12%	3%
VFD – type 2	87%	7%	1%
VFD – type 1	93%	6%	1%

For more information, go to www.micropackfireandgas.com

References
Refer to Part 1 of Article, Gulf Fire Issue 17.