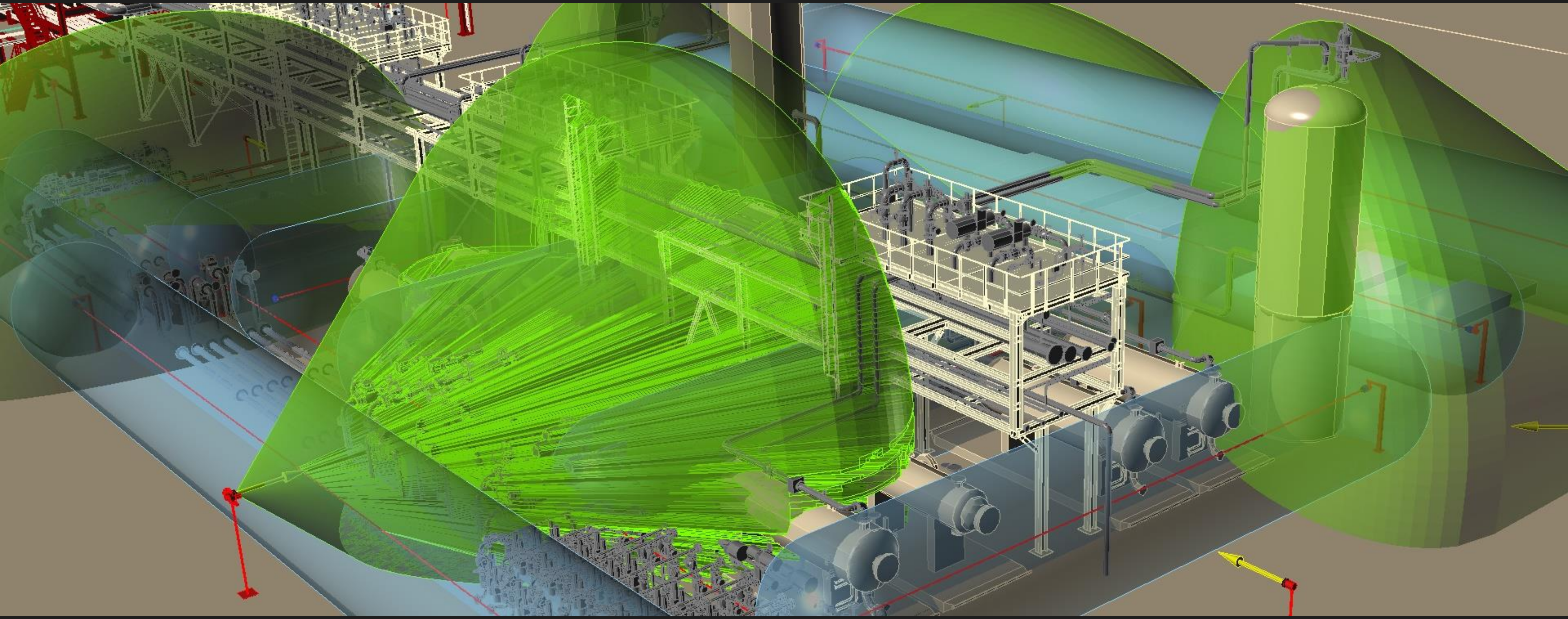

Detect3D Fire and Gas Mapping

Developed by Insight Numerics

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insightnumerics

Detet3D Implementation

- Detect3D has been designed to work with any performance standard.
  - BP GP 30-85, Shell DEP 32.30.20.11, TR84.00.07 etc.

- Hazards or events (e.g. fire sizes and gas clouds) need to be identified prior to the fire and gas mapping (FGM) analysis.
  - Industry standards can be used if a QRA or hazard identification analysis information is not available.

- Performance targets for the FGM analysis are set by the hazard identification.

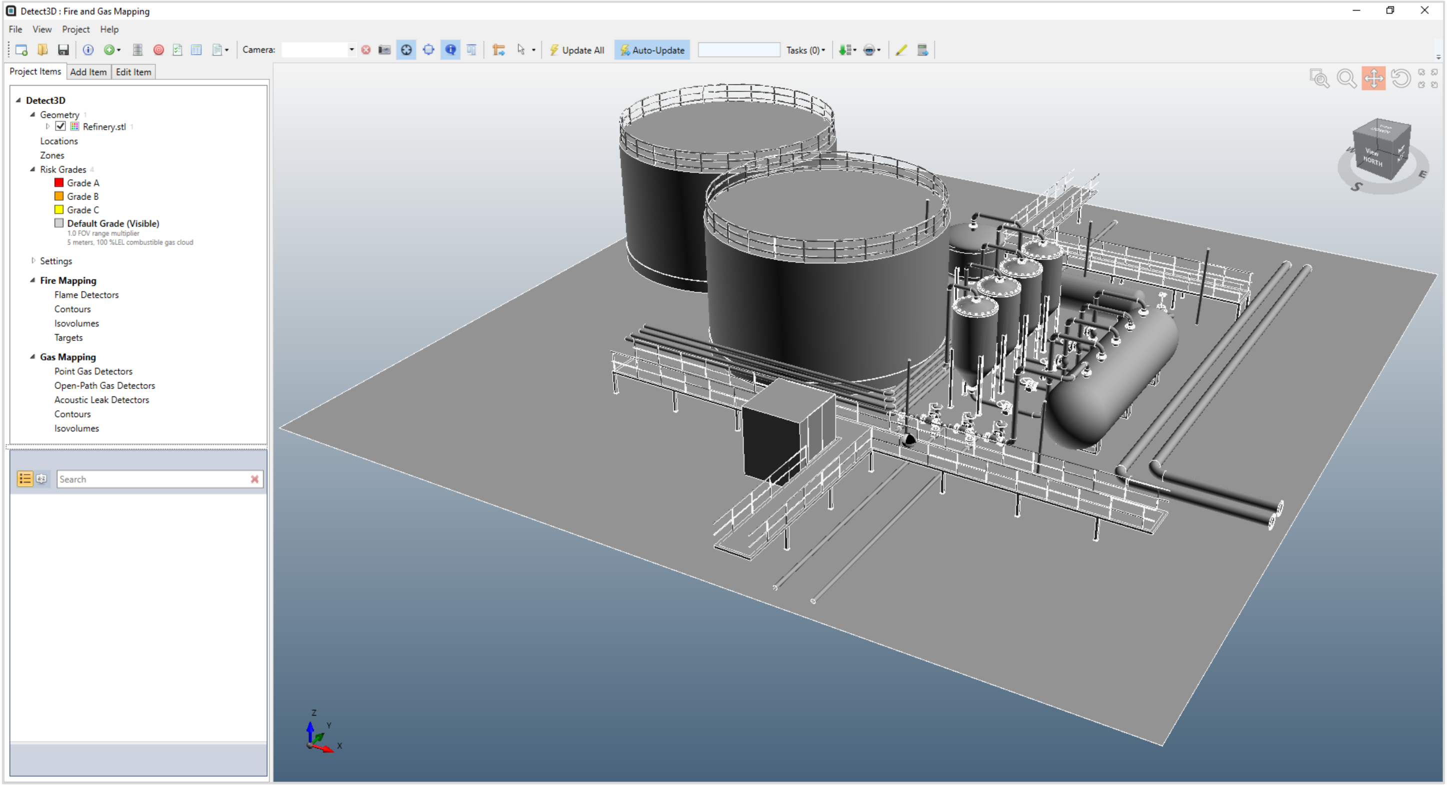
- Detector effectiveness is maximized, reducing the overall number of detectors needed to achieve the performance targets.

Detect3D FGM Analysis Steps

1. Import or create 3d model.
2. Define fire and/or gas zones.
3. Identify hazardous events to detect and set performance targets
    a. Fire sizes, gas cloud sizes (both toxic and combustible), coverage targets for each
4. Define and place flame detectors based on manufacturer data and performance targets.
    a. Field-of-View (FOV) distances using the inverse square law
5. Define and place gas detectors (both combustible and toxic) based on gas cloud size.
    a. Determine congestion in each zone
6. Review coverage results for each zone.
7. Assess if edits need to be made to the layout based on coverage results and number of devices used.
    a. Detect3D provides ranking tools and automated optimization features
8. Output results to Excel or PDF.
9. Provide associated screenshots from Detect3D to support and convey detector layouts achieving performance targets.

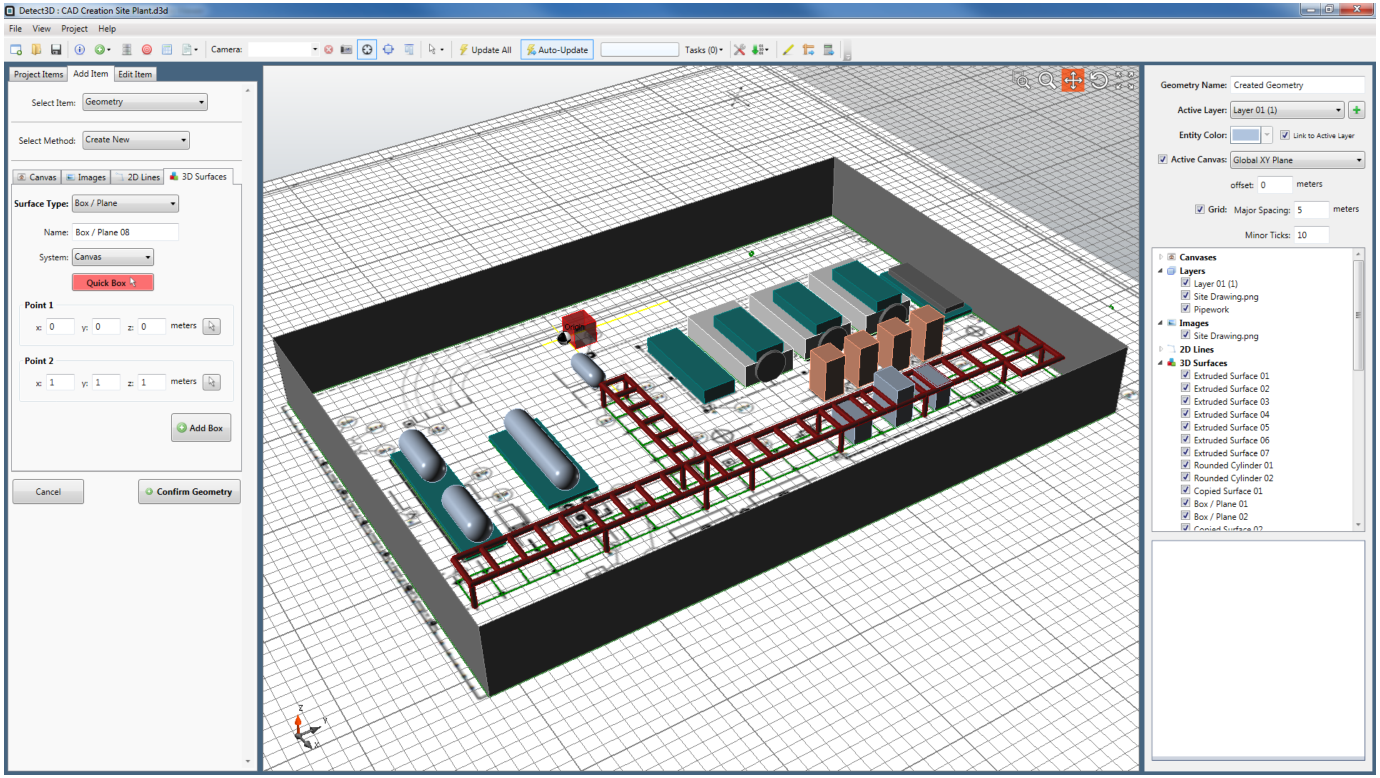
1. 3D Model Import

- Via the DGN file import, Detect3D can load **PDMS** and **SmartPlant3D** CAD models. **Navisworks (NWD)** files can be imported via DWF files. AutoCAD DWG, DXF and other standard CAD formats (STEP, IGES, OBJ and STL) are also accepted.



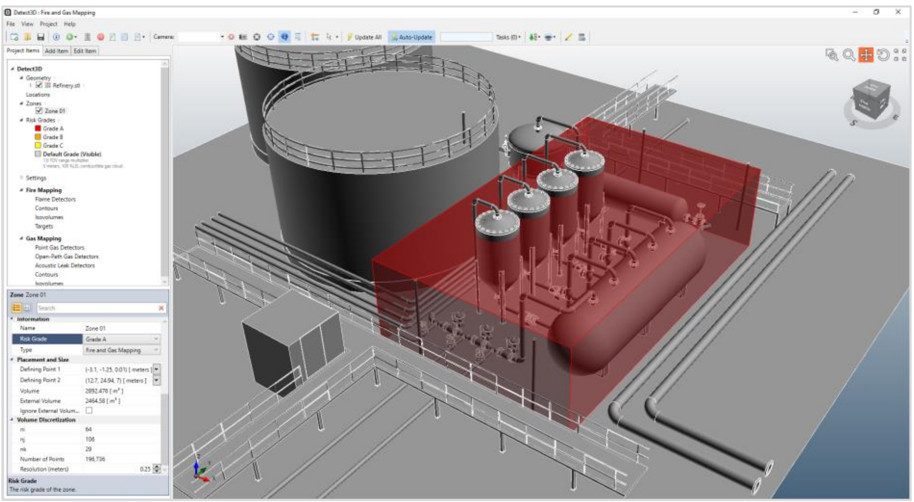
1. 3D Model Creation

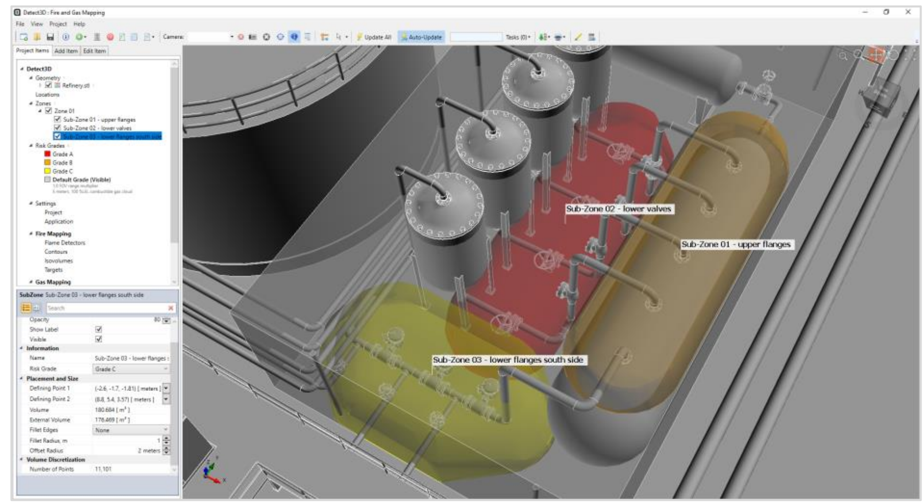
- Geometry can be created directly in Detect3D – simple models can be built from drawings or plot plans when CAD files are not available. The created geometry can also be merged with CAD imported into the project.



2. Zone Definition

- Based on the facility, one or more zones may be defined. This is an important step as the coverage results will be based on the size and definition of the zone.
- Detect3D allows for cuboid zone regions (left) to be defined but also sub-zone regions (right) around specific pieces of equipment.

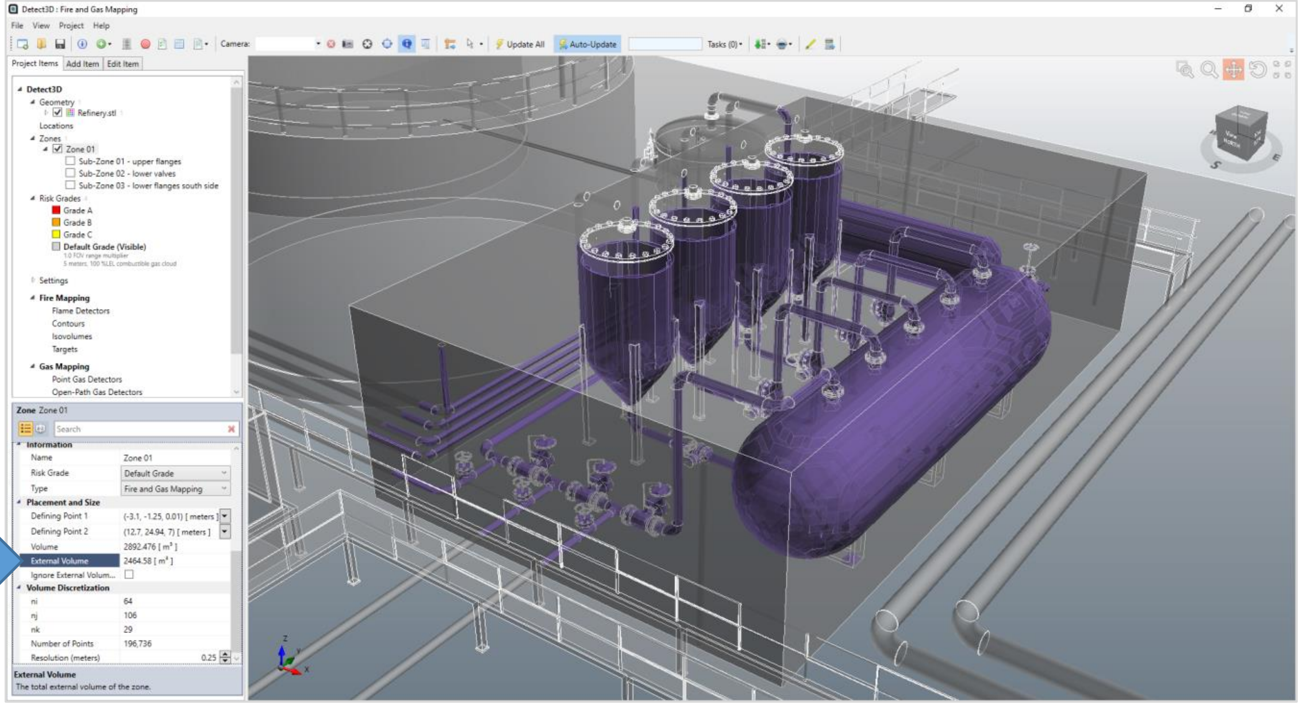




2. Zone Definition

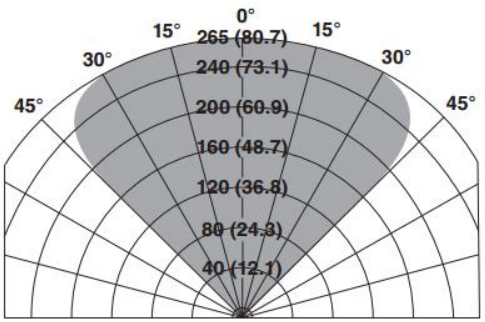
- In order to correctly calculate coverage statistics, Detect3D automatically recognizes internal equipment volume within the zone. Points that are “internal” are not considered as part of the coverage calculation (shown in purple below).

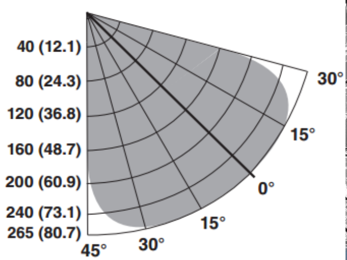
Reported volume of zone and volume of external region (with internal spaces removed)

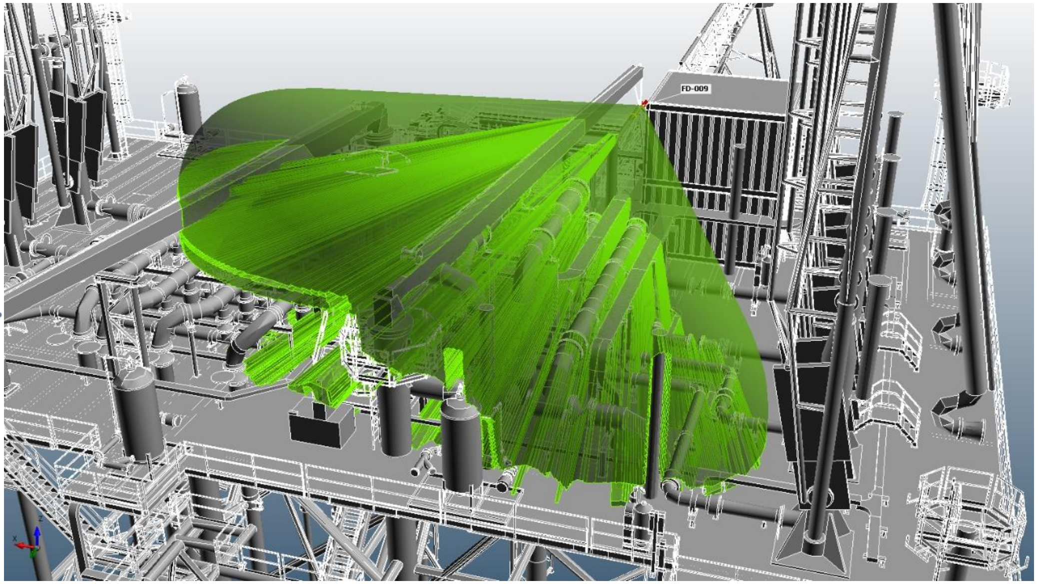


3. Flame Detector Field-Of-View

- Input manufacturer specification data for desired detector model.
  - Some manufacturer data is included in Detect3D.
- The FOV ranges are based on the sensitivity of the device, the fire type, and fire size to be detected.
- Manufacturer specified data can be scaled using the inverse square law tool for varying fire sizes.







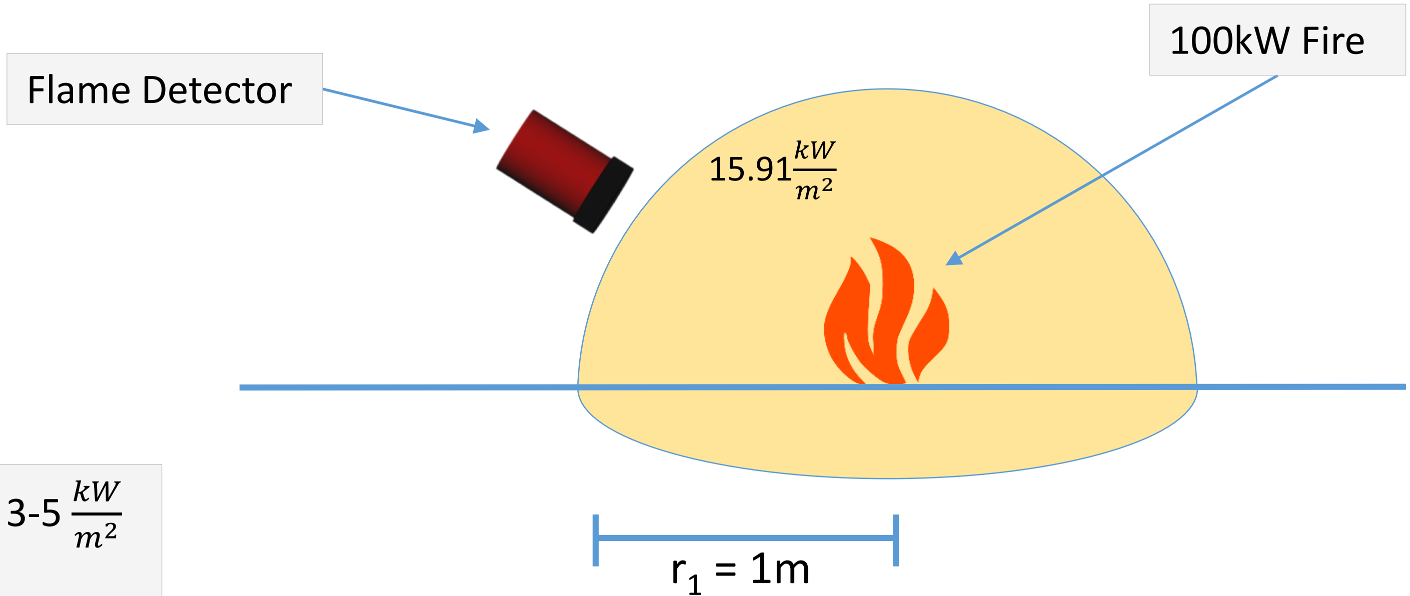
Above
Manufacturer's data for a flame detector FOV

Right
An obstructed FOV (green) calculated by Detect3D

3. Inverse Square Law

- The intensity of a fire at a given distance can be estimated using the inverse square law, shown below.

Intensity for detector at distance $r_1 \rightarrow \Phi_r \cong \frac{Heat\ Release}{2\pi {r_1}^2} = \frac{100kW}{2\pi(1m)^2} = \frac{100kW}{6.28m^2} = 15.91\,\frac{kW}{m^2}$



Note: it takes only 3-5 $\frac{kW}{m^2}$ to inflict pain

3. Inverse Square Law

- The radiative power is distributed equally over the area of the dome. As the distance from the fire is increased, the dome area increases by r^2, reducing the intensity by $\frac{1}{r^2}$.

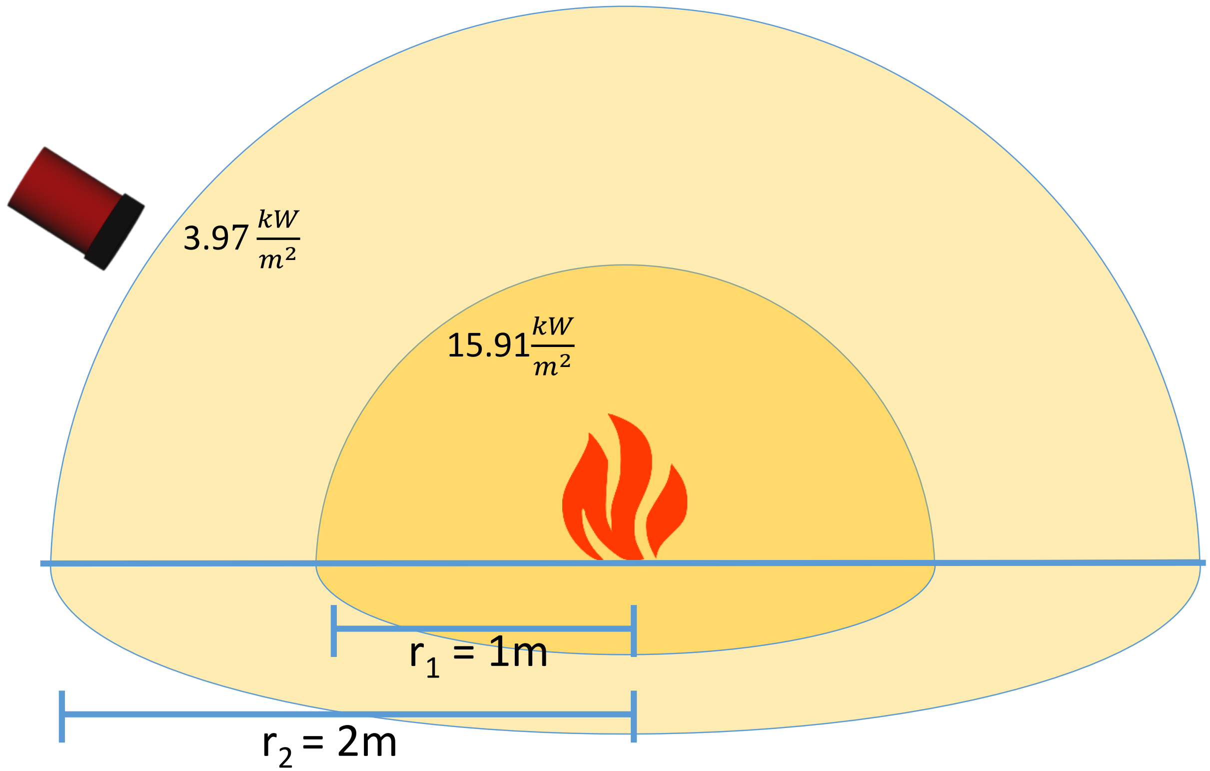
Intensity for detector at distance r_2,

$$\Phi_{r_2} \cong \frac{Intensity}{2\pi {r_2}^2}$$

$$= \frac{100kW}{2\pi(2m)^2}$$

$$= \frac{100kW}{25.13m^2}$$

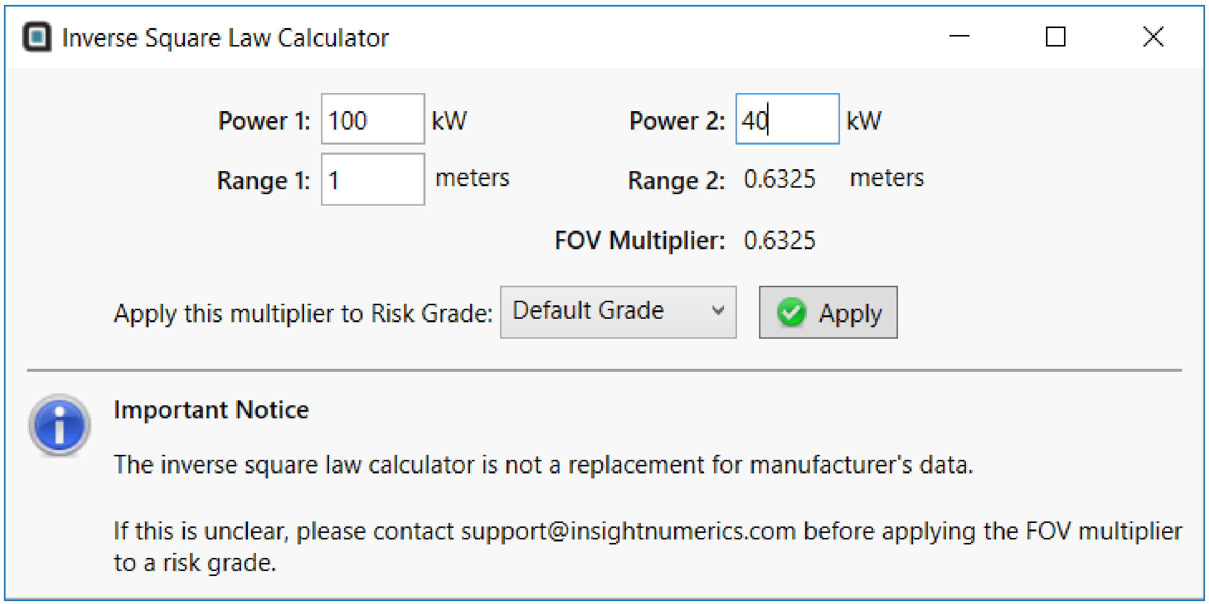
$$= 3.97\frac{kW}{m^2}$$

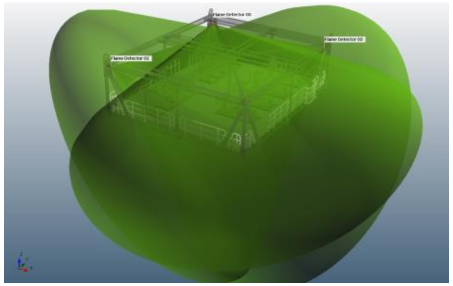


3. Inverse Square Law

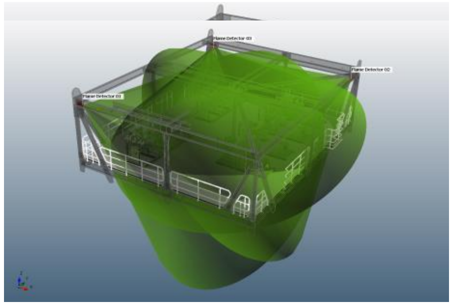
- Using the Inverse Square Tool, Detect3D can calculate the corresponding field-of-view ranges for varying fire powers. The example below shows the calculated FOV multiplier for a 10kW fire.

$$\frac{P_1}{P_2} = \frac{{D_1}^2}{{D_2}^2} \rightarrow \frac{100kW}{40kW} = \frac{1m^2}{{D_2}^2} \rightarrow {D_2}^2 = 0.4m^2 \rightarrow D_2 = 0.632m$$





FOV Multiplier = 1



FOV Multiplier = 0.632

3. Gas Cloud Size

- Detect3D generates three-dimensional assessment of IR point and open-path gas detectors by considering a spherical gas cloud at the LEL concentration. The approach is to use this gas cloud to generate a "field of influence" for each detector type; i.e. if the center of the gas cloud is located in the field of influence, the detector will alarm.
- Without consequence analysis, industry standards[1] like the below figure, use 5 meter diameter gas cloud for congested areas, 7 meters for semi-open areas, and 10 meter for fully open areas.

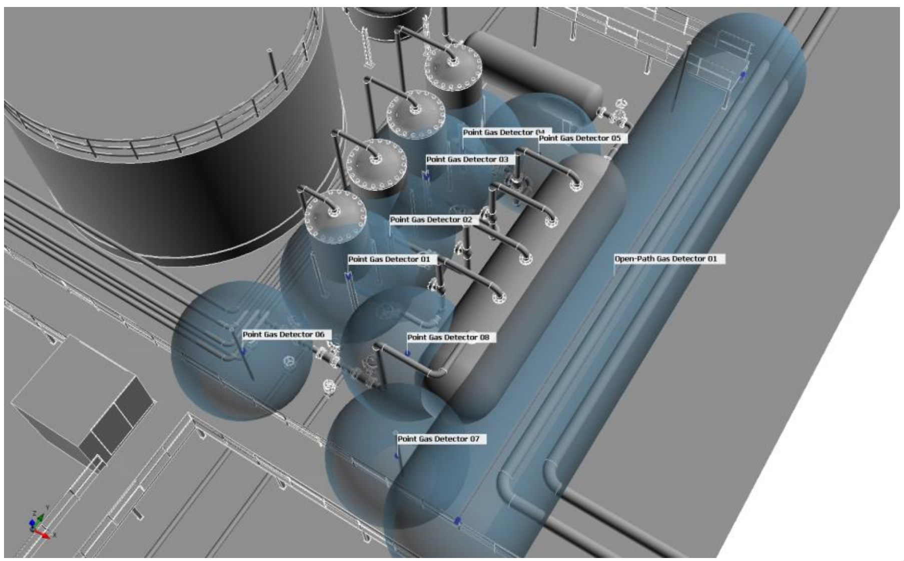


Table 6-1 Flammable gas cloud sizes

Zone characteristic	Cloud Size to use
Enclosed area[1] or Mostly-enclosed area[2]	5 m (16 ft) diameter sphere[6]
Part-enclosed area[3] or Congested area[4]	7 m (23 ft) diameter sphere[6]
Open area[5]	10 m (33 ft) diameter sphere[6]

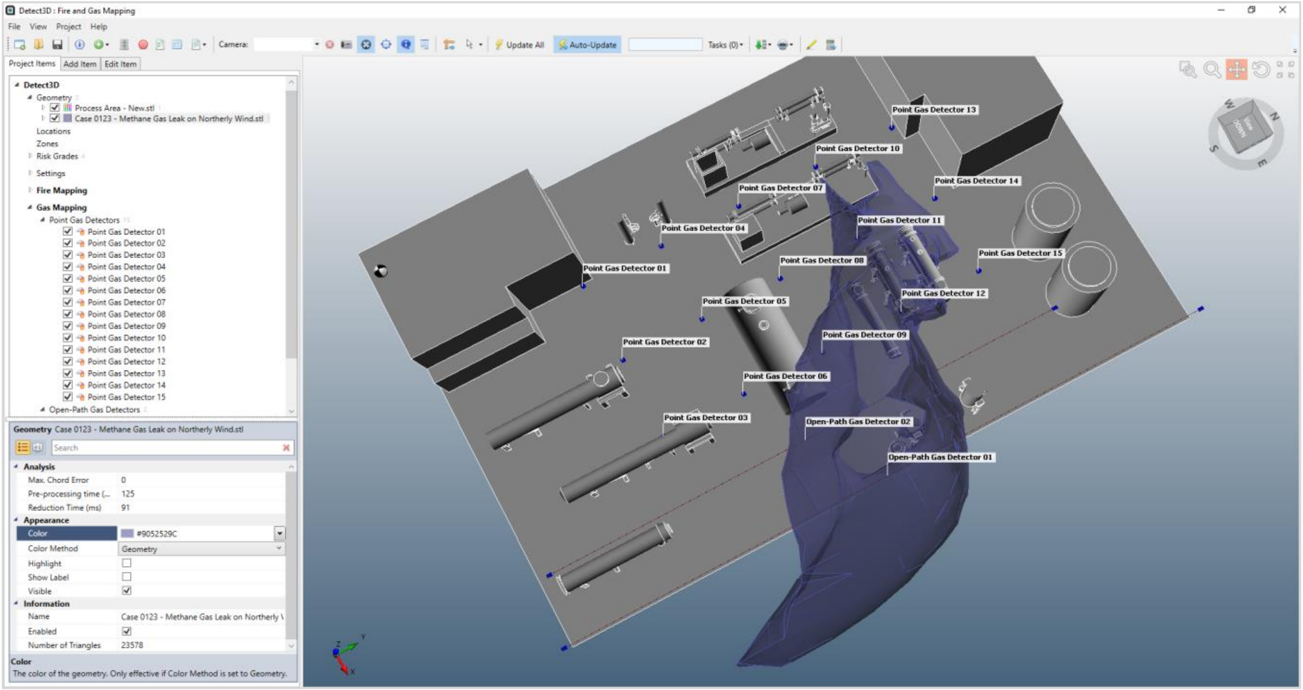
NOTES

1. Fully walled/floored area with or without forced ventilation or vents.
2. A congested area with one open side.
3. A congested area with two or more open sides and grated floor/ceiling or more than two open sides.
4. Process plant that has closely installed piping/equipment.
5. Open lightly congested areas without walls.
6. The sphere diameter is based on a LFL concentration or greater within the diameter.

1. Shell DEP 32.30.20.11 Fire, Gas and Smoke Detection Systems

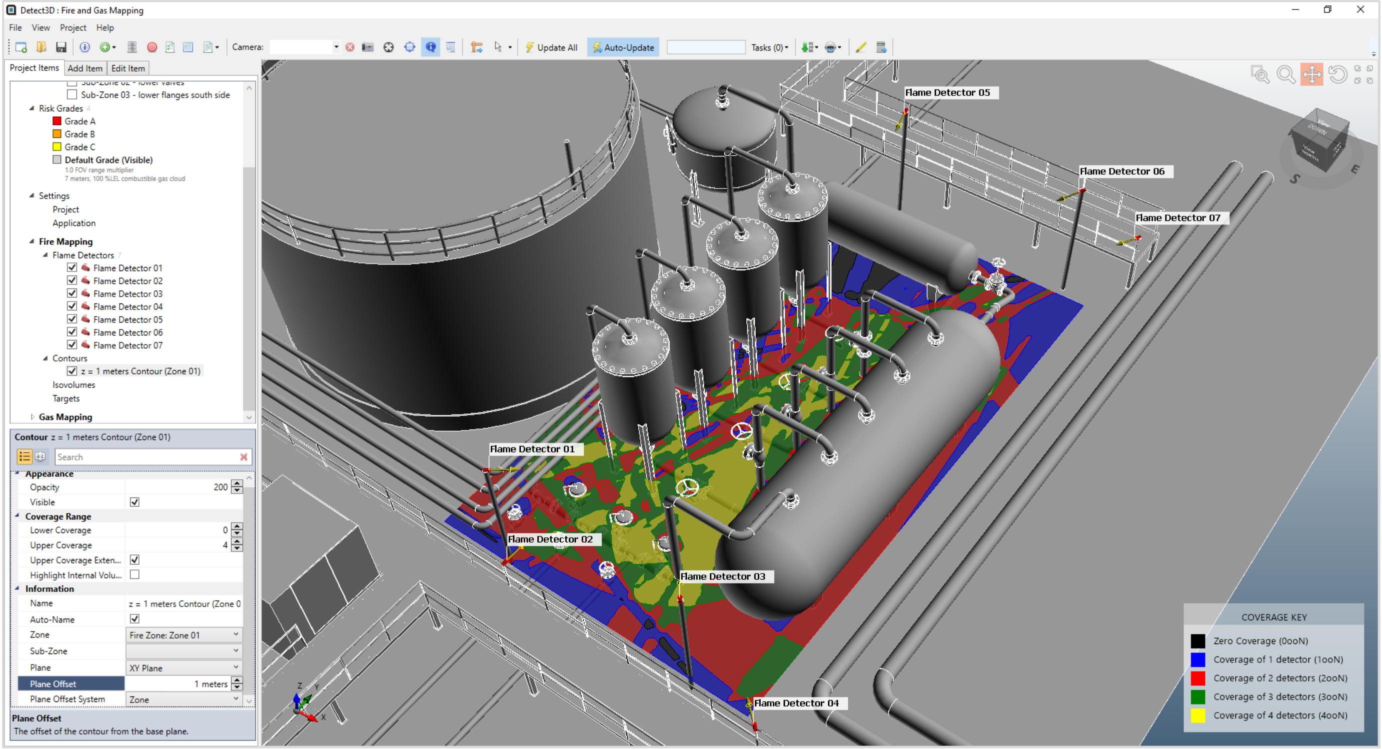
3. Gas Cloud Size

- CFD tools like in:Flux can generate dispersed gas clouds based on site conditions, which can be imported to Detect3D as a gas cloud size or the specific dispersion cloud.
- The imported dispersion cloud can then be used to determine which detectors may go into alarm, as shown below.



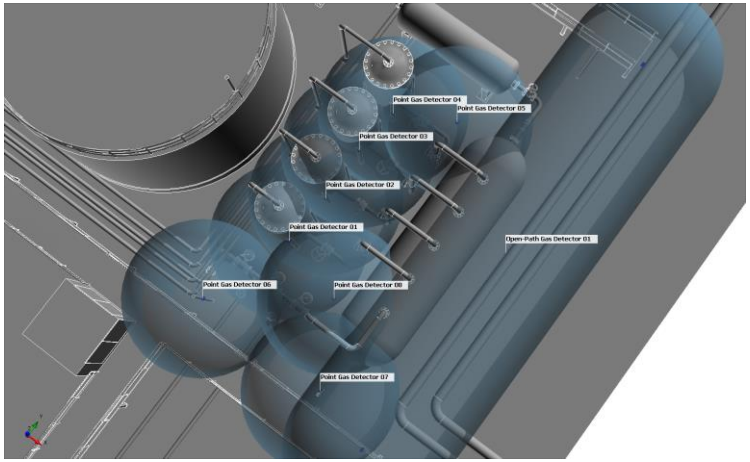
4. Flame Detector Placement

- Flame detectors are placed around the facility based on chosen performance targets within defined zones. Coverage contours can be defined to view quality of the layout at a specified height. 3D contours called isovolumes can also be used to view the quality of the layout.

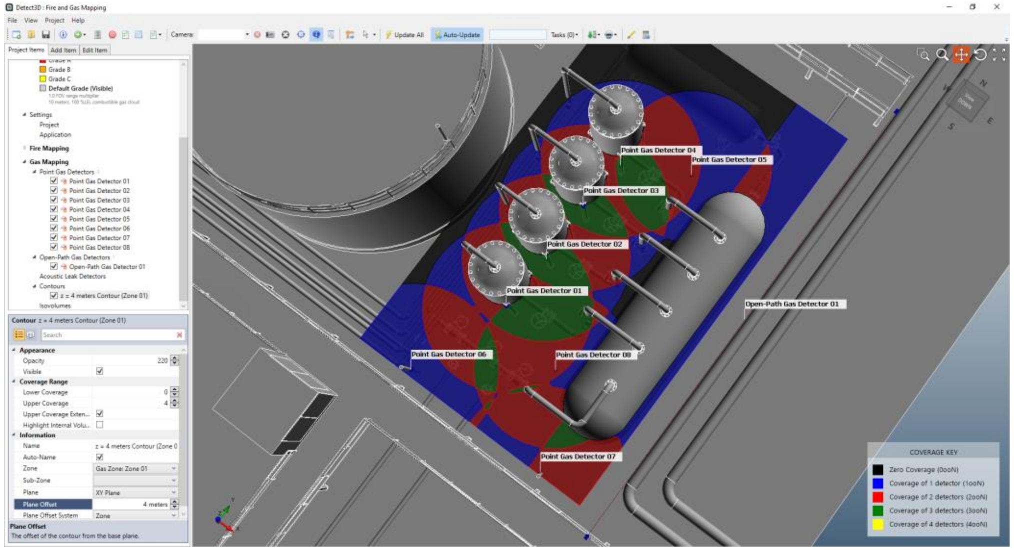


5. Combustible Gas Detector Placement

- Gas detectors are placed around the facility based on the chosen gas cloud size. The field of influence of the devices will be based on this gas cloud size.
- Contours can also be defined to view the coverage results at a specified height, however the coverage calculation is based on the volume of the zone.
- Point, open-path, and ultrasonic acoustic detectors can be defined in Detect3D.



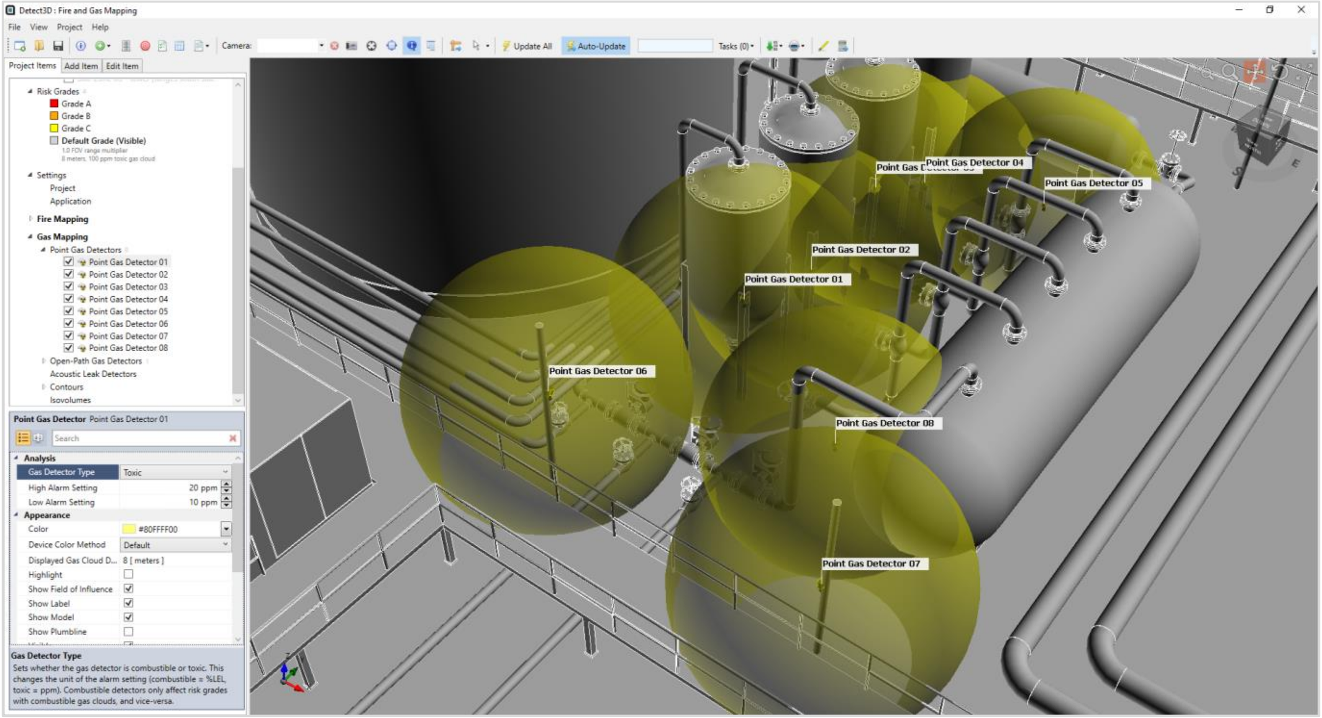
Top view of gas detector field of influences for point and open path devices



Contour at 4m height displaying generated coverage from gas detector layout.

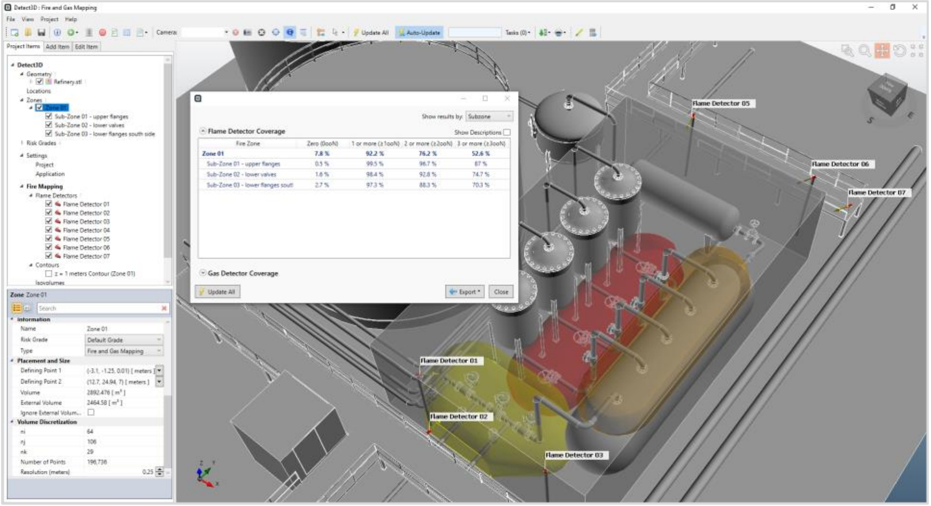
5. Toxic Gas Detector Placement

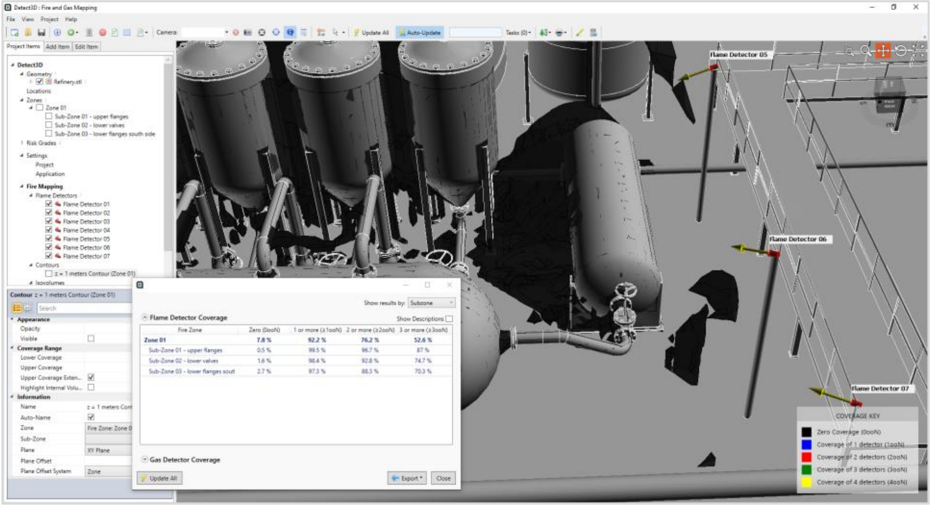
- Both combustible and toxic gas coverage can be calculated in Detect3D using the spherical cloud approach. Most industry standards set toxic gas cloud sizes to 8 meter diameter, similar to Shell's DEP for F&G mapping.
  - It is advised that toxic gas analyses be supported by CFD software (e.g. in:Flux, CFX, FLACS) or dispersion software such as PHAST



6. Review Coverage for each Zone (Fire)

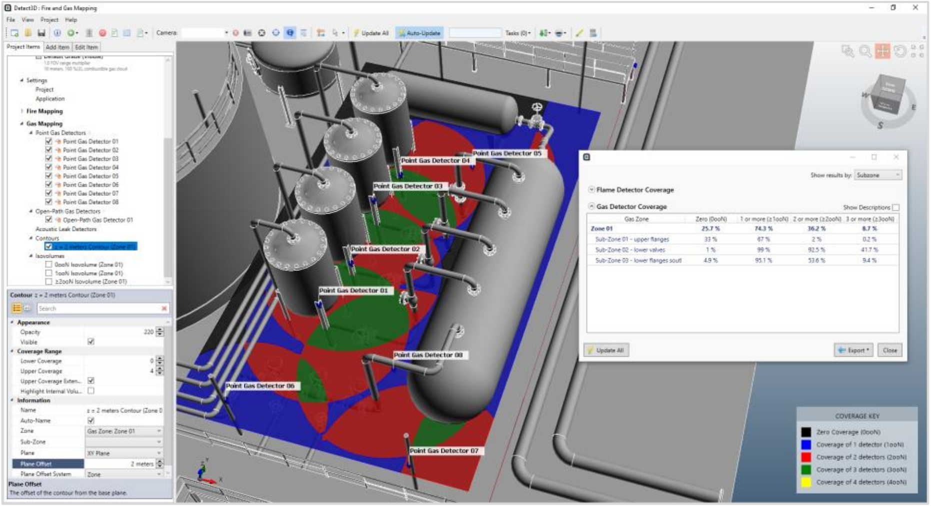
- The coverage is calculated by combining multiple detector FOVs in a volume. The resulting 1ooN, 2ooN are calculated on a volumetric basis for both zones and sub-zones.
- Coverage is reported on tables (exportable to Excel), contours, and three-dimensional surfaces (isovolumes).
- Isovolumes are particularly useful to highlight “blind spots” or zero-coverage areas.



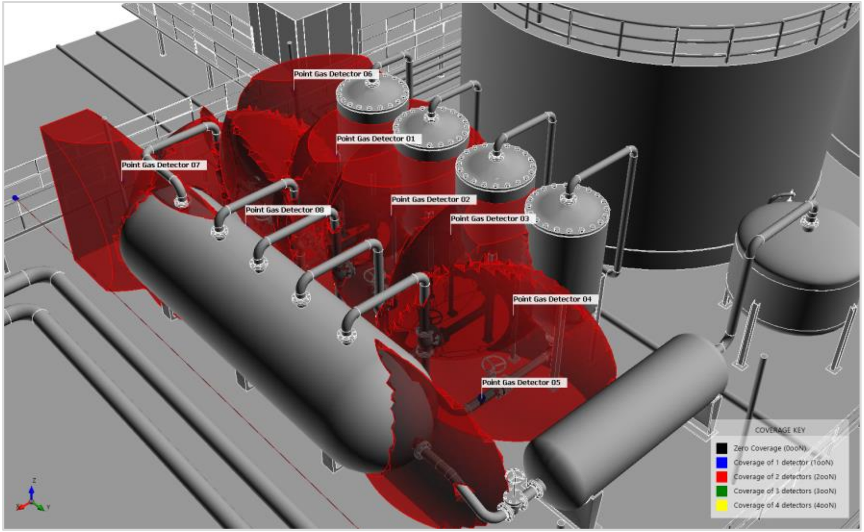


6. Review Coverage for each Zone (Gas)

- Coverage results are also calculated for the geometric volume covered by the defined gas detectors.
- Both contours and isovolumes can be defined to show the varying coverage levels of the zone.



Coverage contour at 2 meters above ground level.

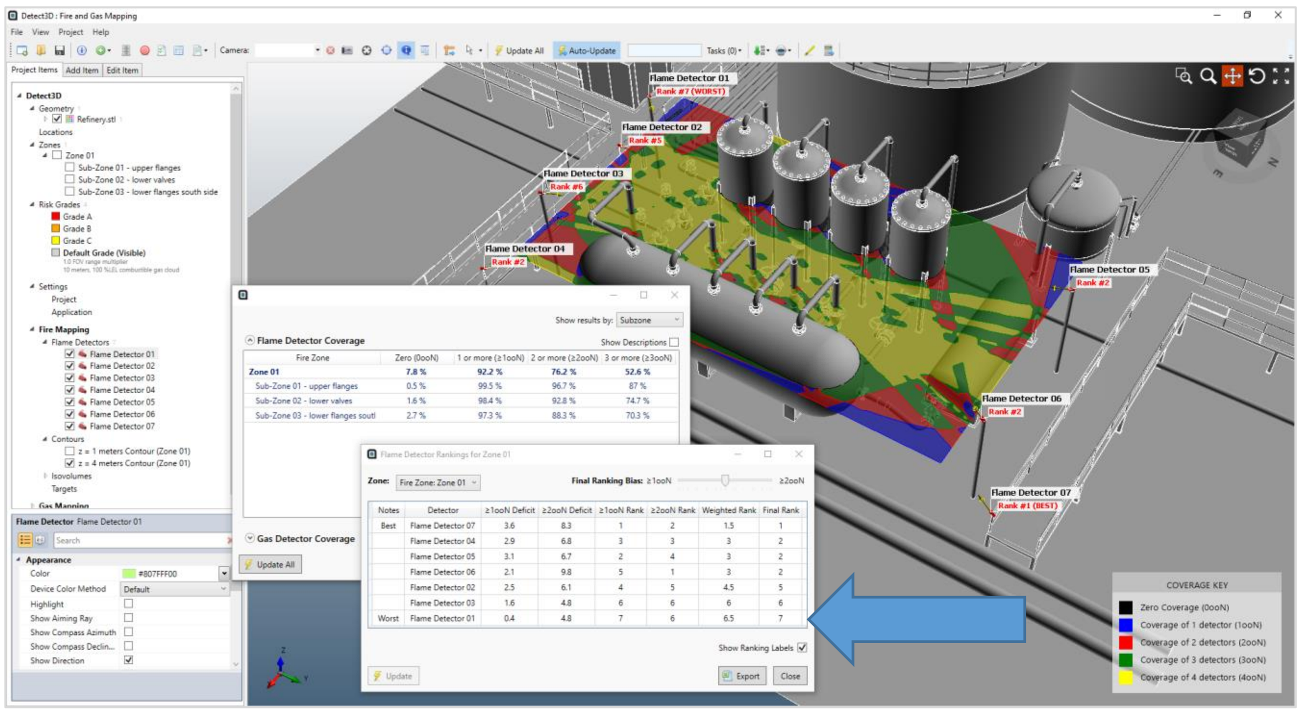


Isovolume showing 3D surface of 2ooN coverage

7. Assess Layouts for Improvement

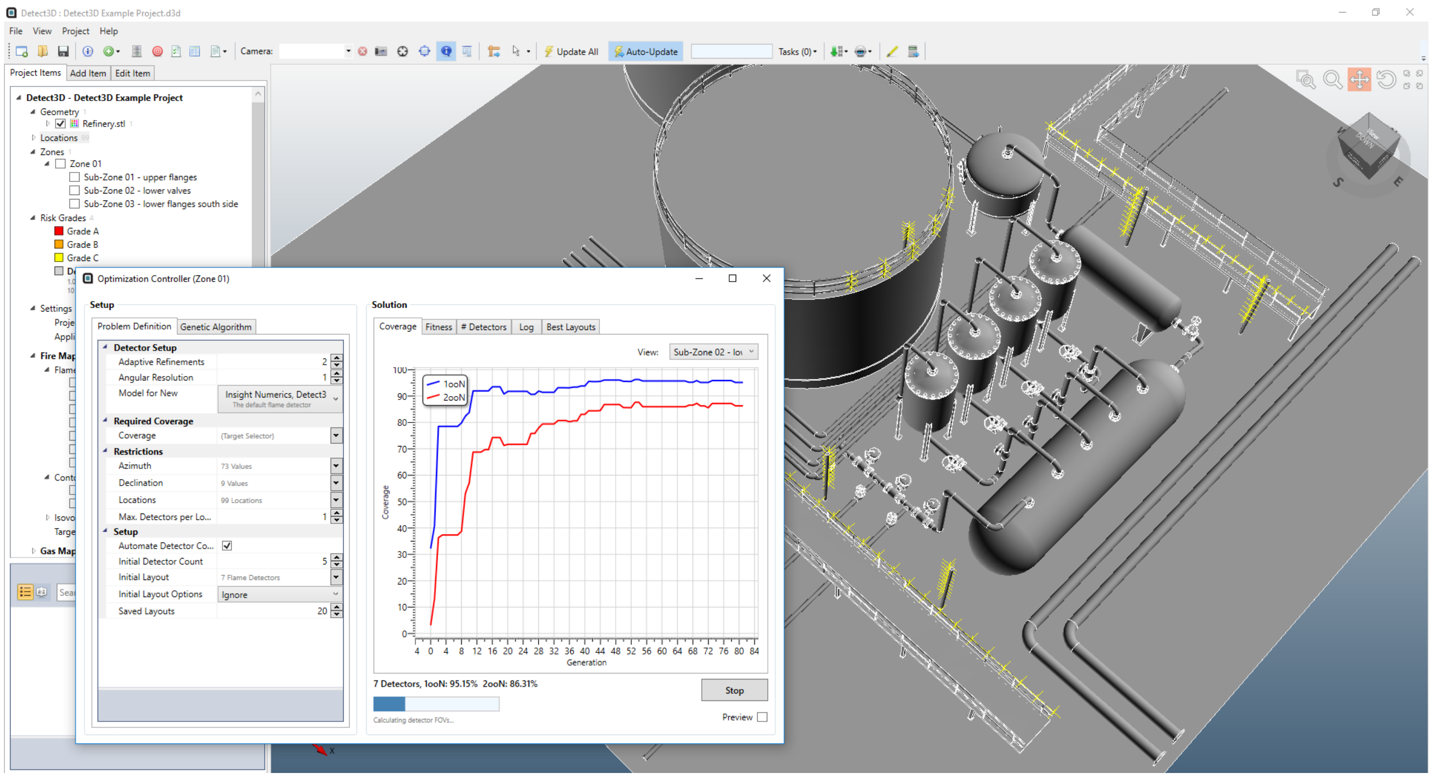
- Detect3D includes a detector rankings tool which can be used on both fire and gas layouts. The capability enables quick determination of the quality of each detector.
- The worst detectors can then be removed or repositioned in order to reduce redundancies and blind spots.

The arrow shows how 'Flame Detector 01' is the worst performing device in the analysis. It can then be removed from the layout. This is also apparent by the large yellow region of the contour which indicates there is too much coverage there.



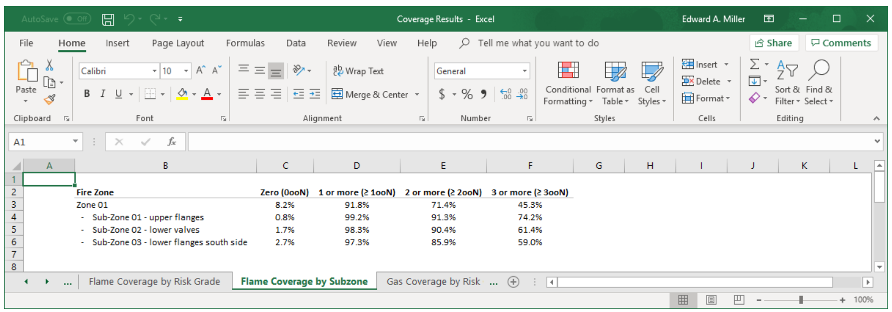
7. Assess Layouts for Improvement

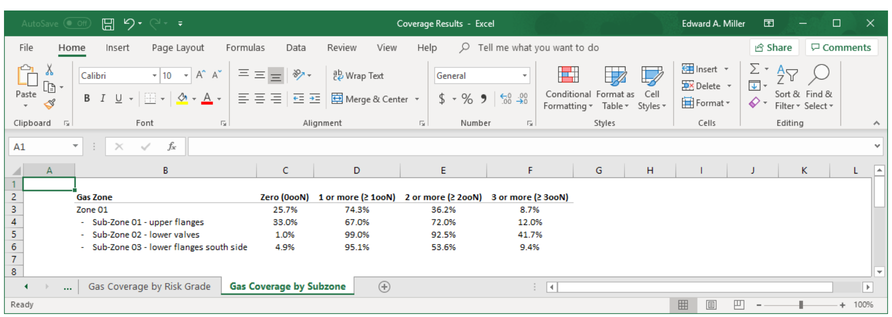
- Further analysis can be performed for flame detector layouts in using Detect3D’s automated optimization tool.
  - Existing layouts can have the detector orientations optimized or the algorithm can optimize the entire layout based on user defined plausible installation locations.

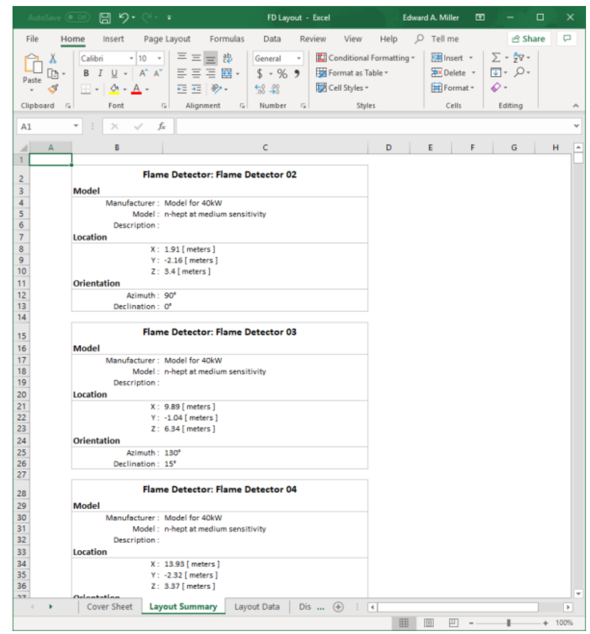


8. Output Results

- Once layouts have been optimized and performance targets achieved, information can be exported from Detect3D.
  - There are 6 automatically generated reports in Detect3D.
- The coverage results table can be exported directly to Excel for copying to Microsoft Word or other reporting software.
- Both flame and gas detector layouts can also be exported to PDF or Excel

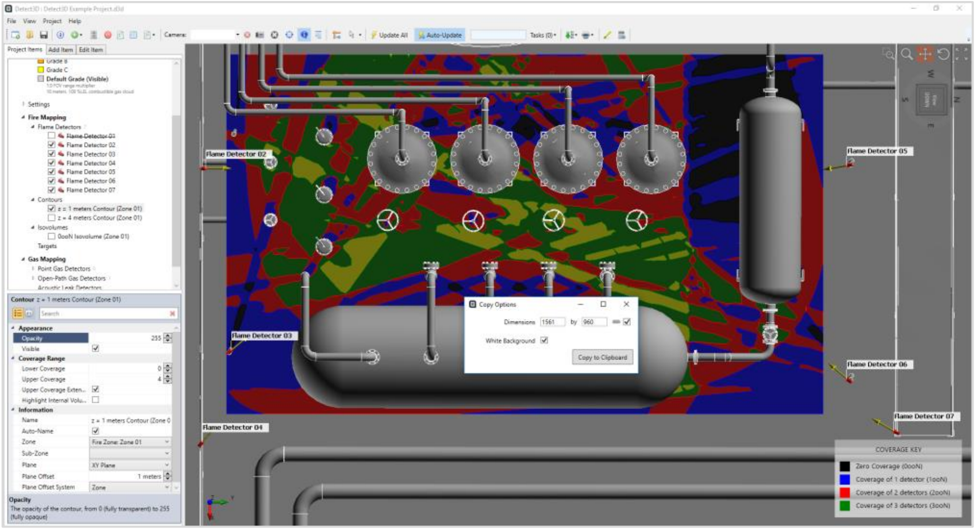






9. Output Screenshots

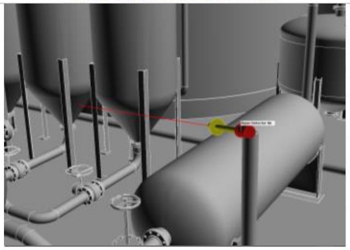
- Any view in the 3D window of Detect3D can be saved to the clipboard as a screenshot.
- Camera positions of the 3D window can be saved to quickly return to the exact views of exported figures or images.
- Screenshots can be combined with Excel reports to generate appendices or work packs for detector layouts.



Appendix A – Revised Flame Detector Layout Work Pack

Note that the images for re-oriented or re-positioned detectors also include the laser aiming ray for additional validation.

Flame Detector: FD-001 (reoriented)



Model

Manufacturer :	Honeywell Analytics
Model :	SS4
Description :	High Sensitivity

Location

X :	-47.37 [meters]
Y :	47.62 [meters]
Z :	21.53 [meters]

Orientation

Azimuth :	-55°
Declination :	10°

Detect3D
Fire and Gas Mapping. Optimized.

Developed by Insight Numerics
www.insightnumerics.com

Summary

- Any performance standard can be used with Detect3D.
- Coverage values are calculated based on the volume of zones defined.
  - Contours and isovolumes can be used to visualize the achieved coverage of both flame and gas detector layouts.
- The detector rankings tool can be used to assess quality of individual detectors.
- Automated optimization can be used to determine the minimal number of detectors needed for a performance target.

For questions about Detect3D or licensing options, please visit www.insightnumerics.com or email us at info@insightnumerics.com