FACET3D

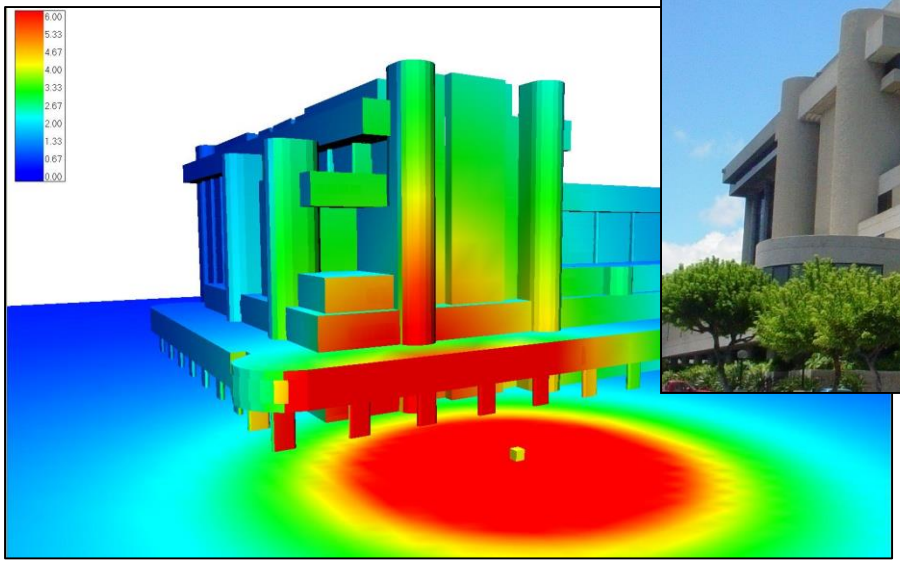
Greg Knight, Technical Manager

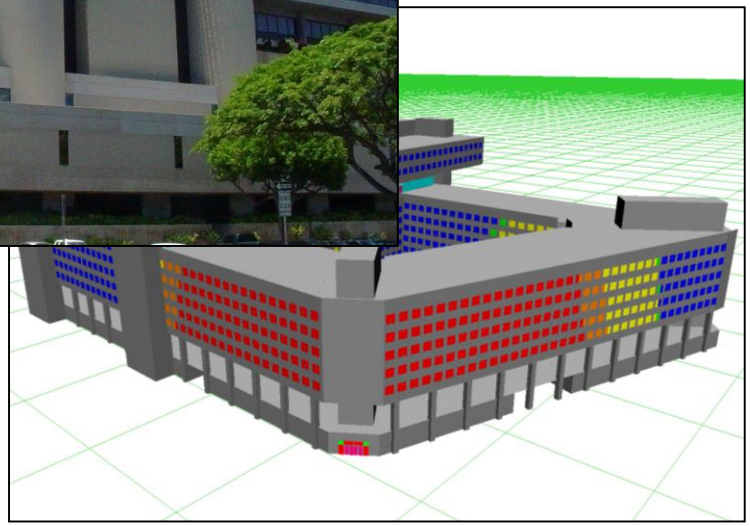
ABS Consulting
AN ABS GROUP COMPANY
Extreme Loads and Structural Risk
Explosion Hazards Group

OVERVIEW

History

- FACET3D was developed by ABS Consulting's San Antonio office to assess structures and sites for extreme loading scenarios
- In development since 2001
- Extensively used for public and private sector AT/FP work since 2002 (GSA, Federal Bldgs, Singapore)
- Extensively used for petrochemical facility siting work starting in ~2004 – 100's of projects





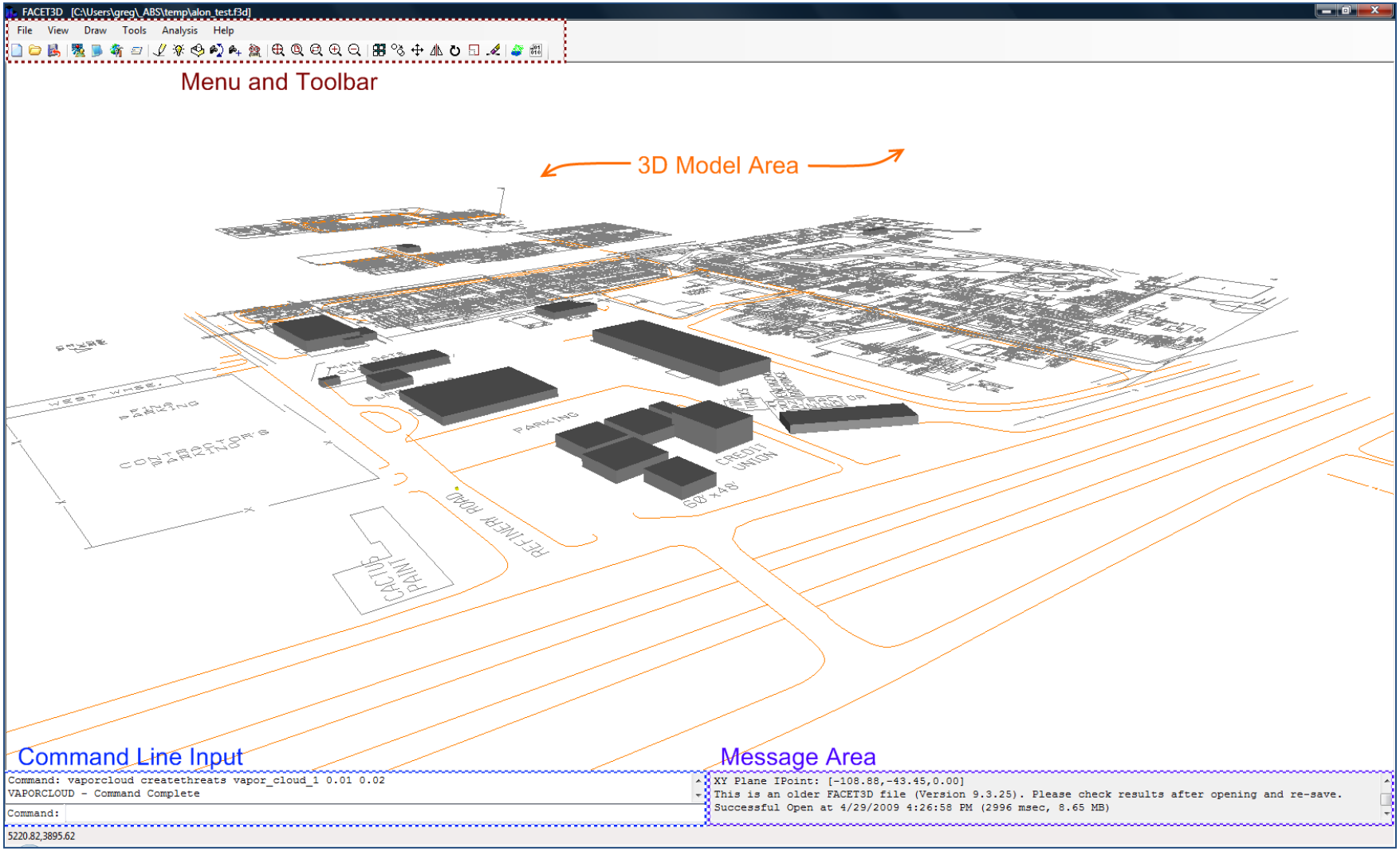
Summary of Features

- Features include
  - High explosive, vapor cloud, BLEVE, PVB models
  - Jet/Pool fire hazards
  - Toxic dispersion hazards
  - Structural assessments of occupied buildings
  - Import of PHAST dispersion and fire results
  - Risk assessments
- Support Website: http://www.facet3d.com
- Users Guide: http://facet3d.com/wiki/index.php?title=Documentation
- 100% VB .NET 4.5 framework desktop application

USER INTERFACE AND GEOMETRY DEFINITION

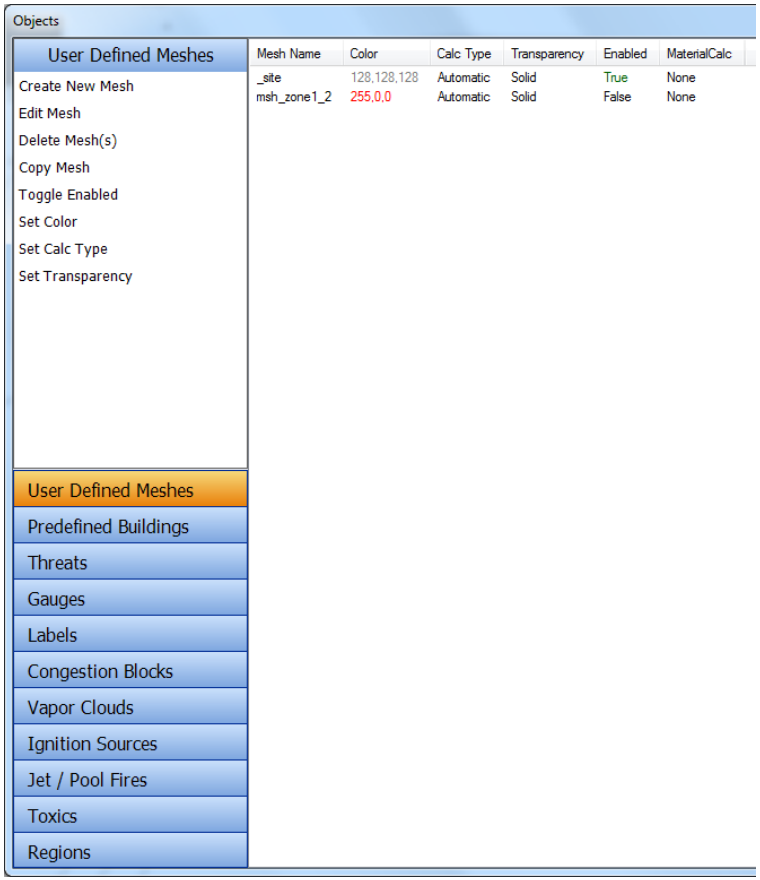
User Interface

- FACET3D is developed for Microsoft Windows (XP,Vista,7)
- Uses OpenGL for 3D rendering
- Allows for dialog form, 3D user selection, and command line inputs



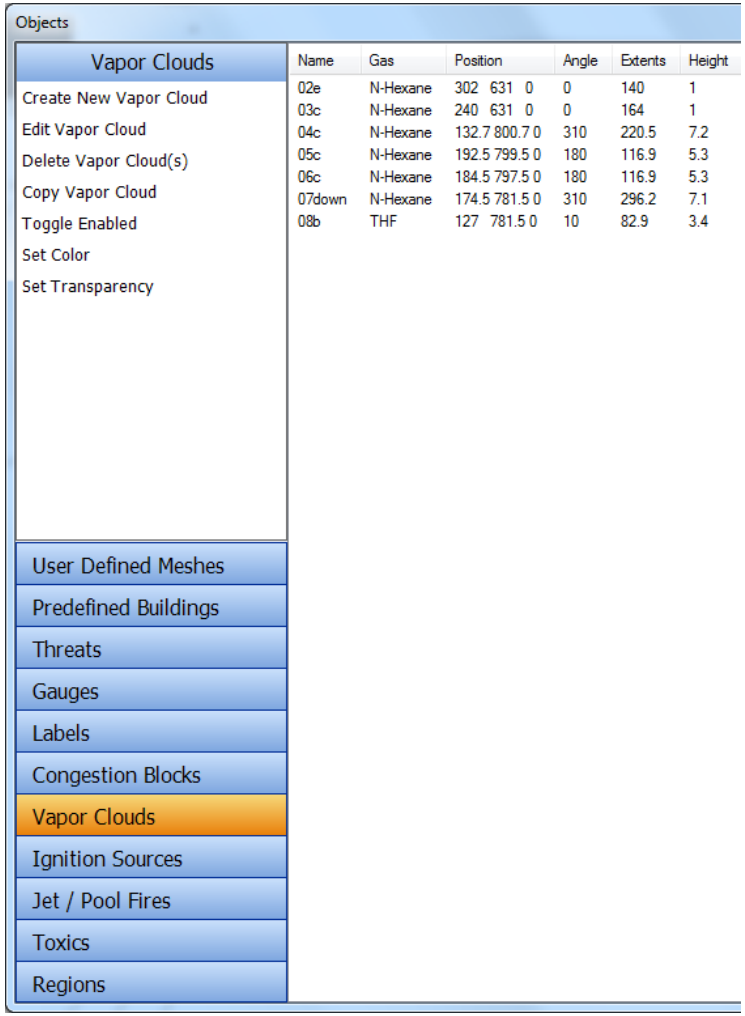
User Interface

- Data objects in FACET3D include
  - User Defined Meshes – Analogous to AutoCAD layers, meshes contain 3D surfaces and 2D lines, circles, arcs, and text objects used for defining free form buildings. Each mesh has independent material (structural) P-I diagrams.
  - Predefined Buildings – Easy to define rectangular structures. Multiple materials assigned by wall face/roof
  - Threats – source definition of high explosive and vapor cloud threats
  - Gauges – Used to measure incident pressure/impulse without underlying geometry
  - Labels – 3D labels with markers and leaders useful for annotation
  - Congestion Blocks – definitions of MEM or BST congestion regions for eventual vapor cloud explosion threat creation



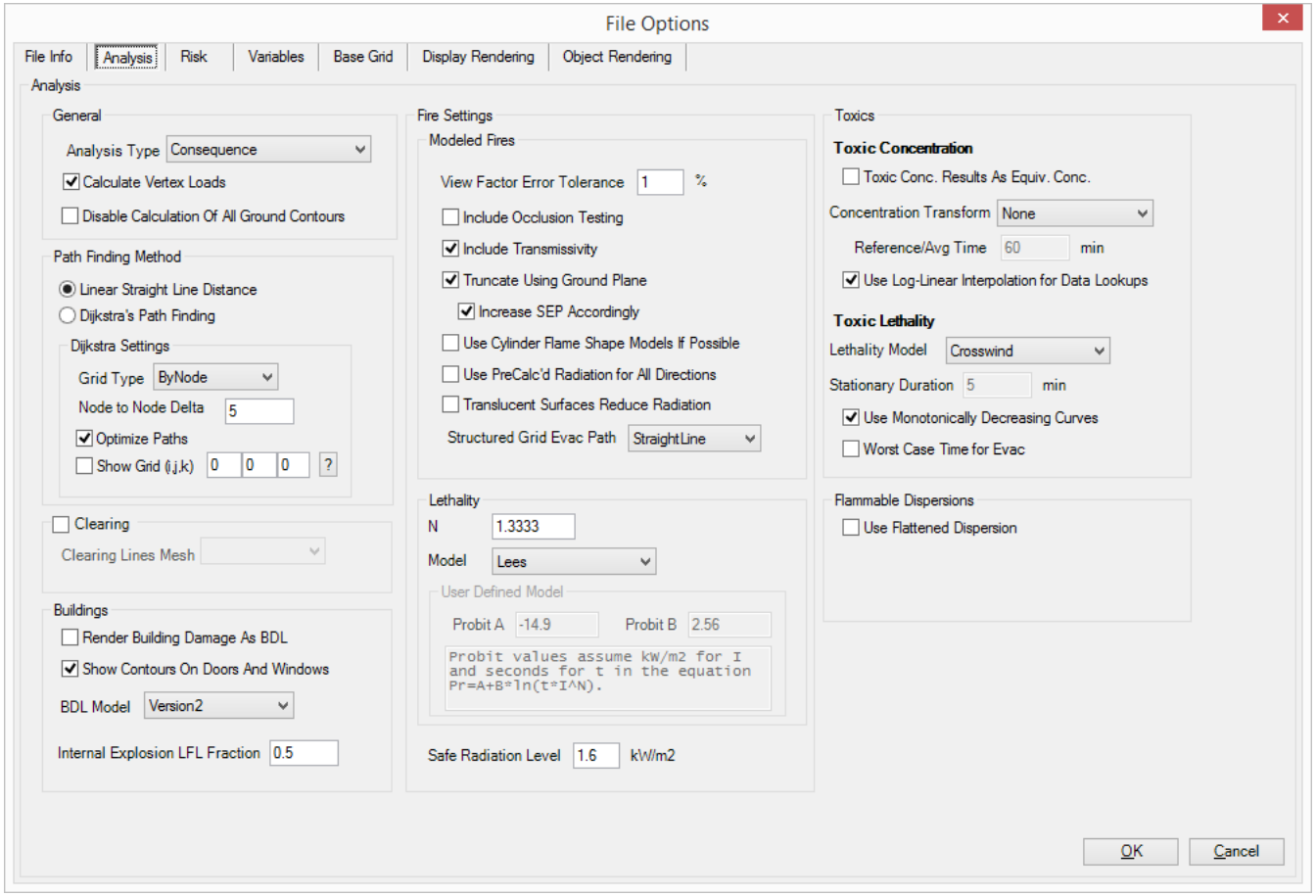
User Interface

- Data objects in FACET3D include
  - Dispersions– dispersion data imported from PHAST
  - Scenarios – collections of dispersion, fire, explosion cases with frequency data
  - Ignition Sources – open flame locations used to limit vapor cloud size when overlapping vapor clouds with congestion blocks
  - Jet/Pool Fires
    - Imported radiation vs. distance data used for evacuation modeling
    - Flame surface and emissive power for detailed fire modeling (view factors, radiation shielding)
  - Regions – generic 2D polygon areas used for any graphical representations



Options

- Extensive options controlling analysis modes, line contours creation, legends, rendering, etc…



Reporting

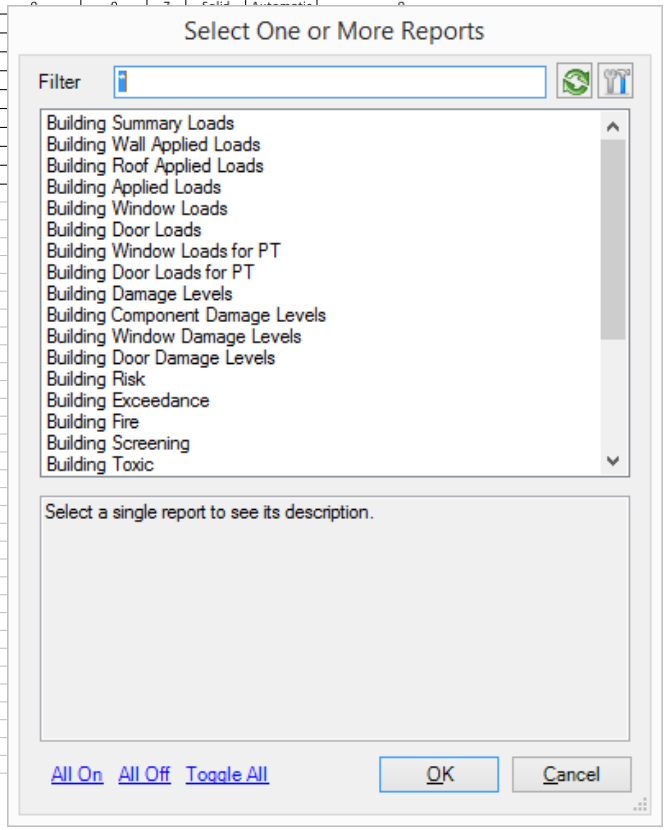
- Multiple XLS or CSV reports for building and surface damage percentages, input summary tables, etc…

Report Viewer - [Book1]

File Edit View Insert Format Tools Data Windows Help

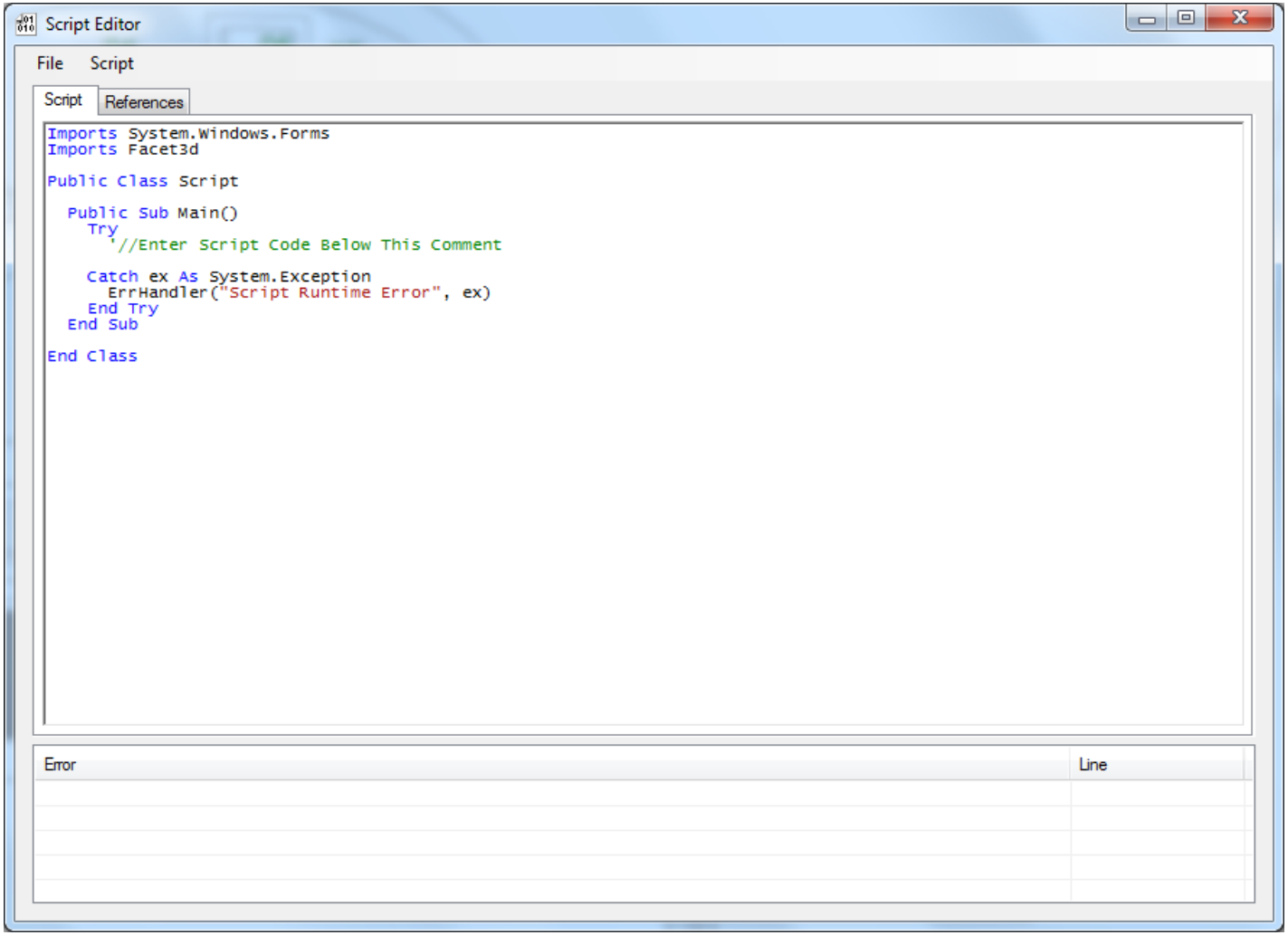
A1 Name

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Name	Length	Width	FloorHeight	LengthBays	WidthBays	Floors	XPos	YPos	ZPos	Angle	PeoplePerBay	RoofAngle	RoofDirection	Windows	Exits	Visibility	CalcType	MaxIndividualOccupa
2	01_admin	64	92	12	6	9	1	553	125	0	0	0	0	0	11	4	Solid	Automatic	0
3	02_drum_bldg	112	169	12	11	17	1	376	183	0	0	0	0						
4	03_non-haz_processing_bldg	71	121	12	7	12	1	92	178	0	0	0	0						
5	04_utility_bldg	60	41	12	6	4	1	53	592	0	0	0	0						
6	05_lab_trailer	12	60	12	1	6	1	538	135	0	0	0	0						
7	06_drum_receiving	53	81	12	5	8	1	323	142	0	0	0	0						
8	07_pump_bldg	34	28	12	4	3	1	-58	820	0	0	0	0						
9	08_cam_bldg	252	122	12	25	12	1	344	1131	0	0	0	0						
10	boiler_bldg	27	41	12	3	4	1	113	592	0	0	0	0						
11	control_bldg	41	25	12	4	2	1	288	758	0	0	0	0						
12	decant_bldg	164	86	12	16	8	1	325	352	0	0	0	0						



Scripting

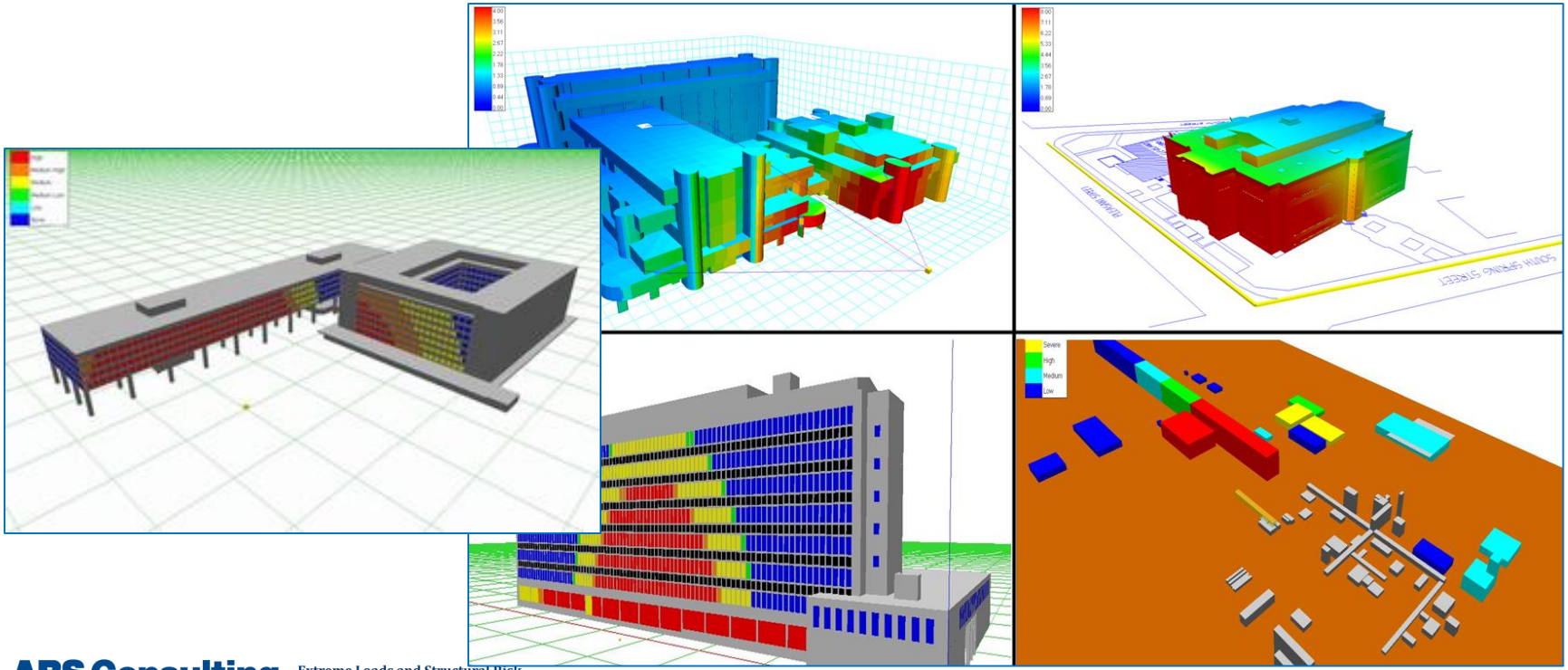
- Full scripting engine using VB.NET code allows the use full access to all internal data and raw power for manipulating objects, creating custom outputs, etc…



GEOMETRY

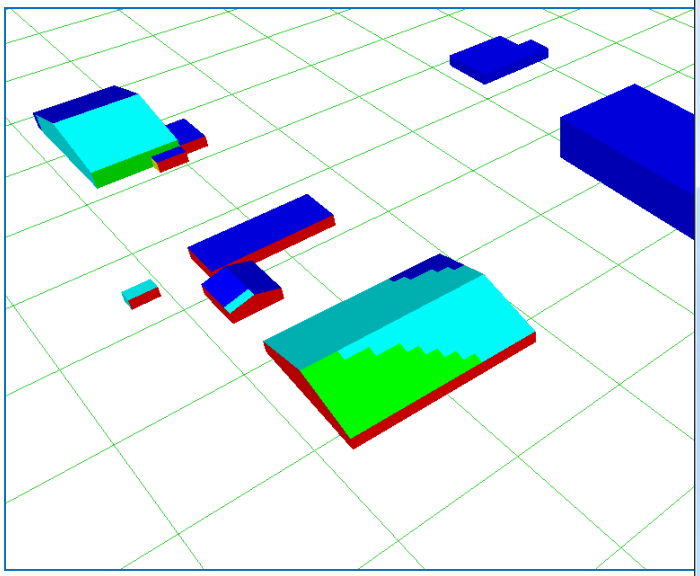
Geometry – Meshes

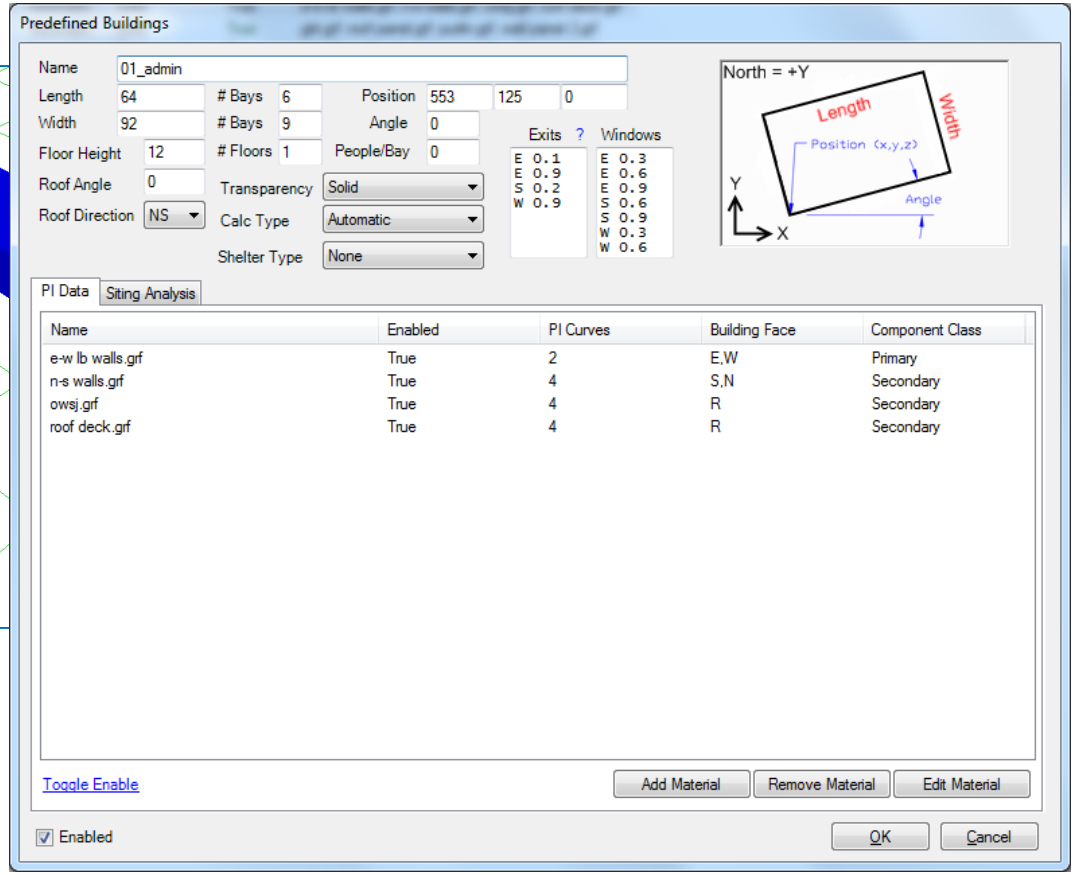
- Basic geometric building block is the 3D surface, a planar triangular or rectangular surface on which calculations take place and results are presented
- Surfaces are grouped into meshes, which are analogous to AutoCAD layers
- Support for import of DXF files allows surfaces to be created in AutoCAD as 3DFACE objects and then imported into FACET3D along with select 2D geometry for scene enhancement
- Export of FACET3D models back to DXF is also supported, including select results



Geometry – Predefined Buildings

- Predefined buildings are rectangular structures the user defines by simple properties such as length, width, floor height, # of floors, bays, etc…
- They allow quick definition of a simple structure
- Multiple materials may be applied to wall faces and the roof
- Occupancy numbers may be entered to allow aggregate and individual risk calculations

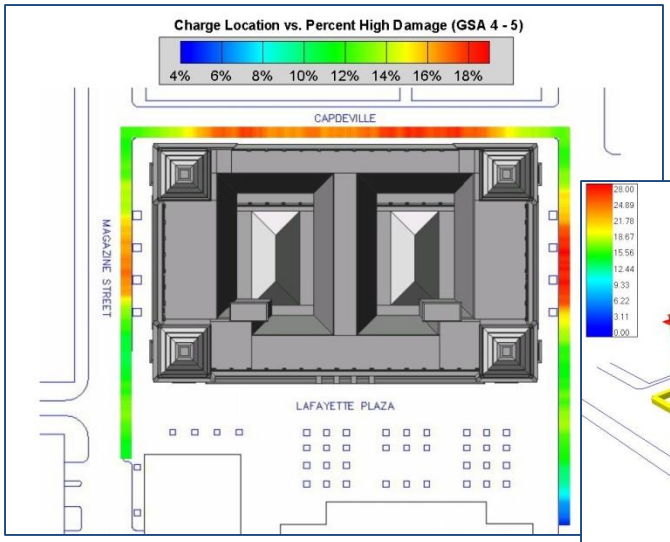


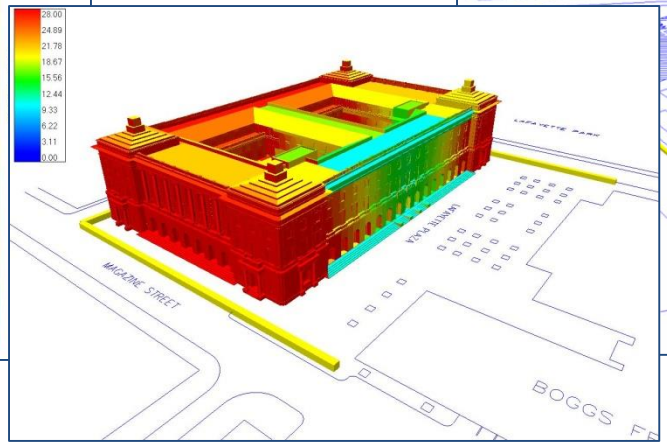


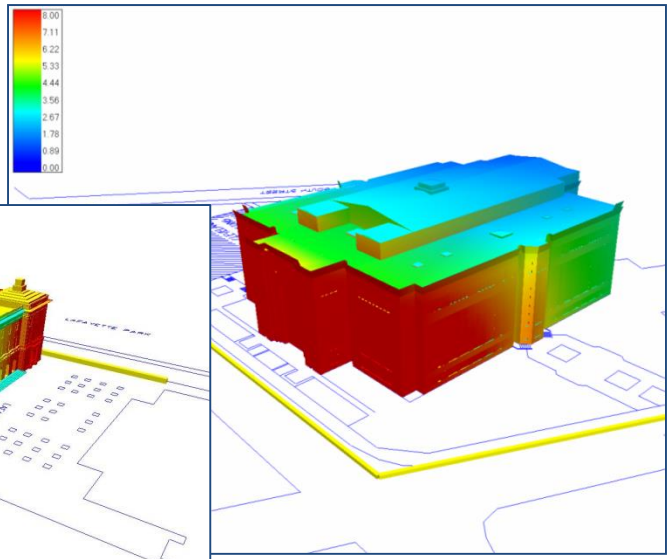
BLAST LOAD CALCULATION METHODS

High Explosives

- Uses hemispherical surface burst scaled curves and Kingery-Bulmash equations to calculate incident and reflected blast loads on surfaces
- Angle of incidence effects are included using CR and IR Alpha curves
- Results are contours on the model surface and line contours on the ground plane
- In addition to a single HE threat, a line threat can be defined which represents an envelope of possible locations for a charge

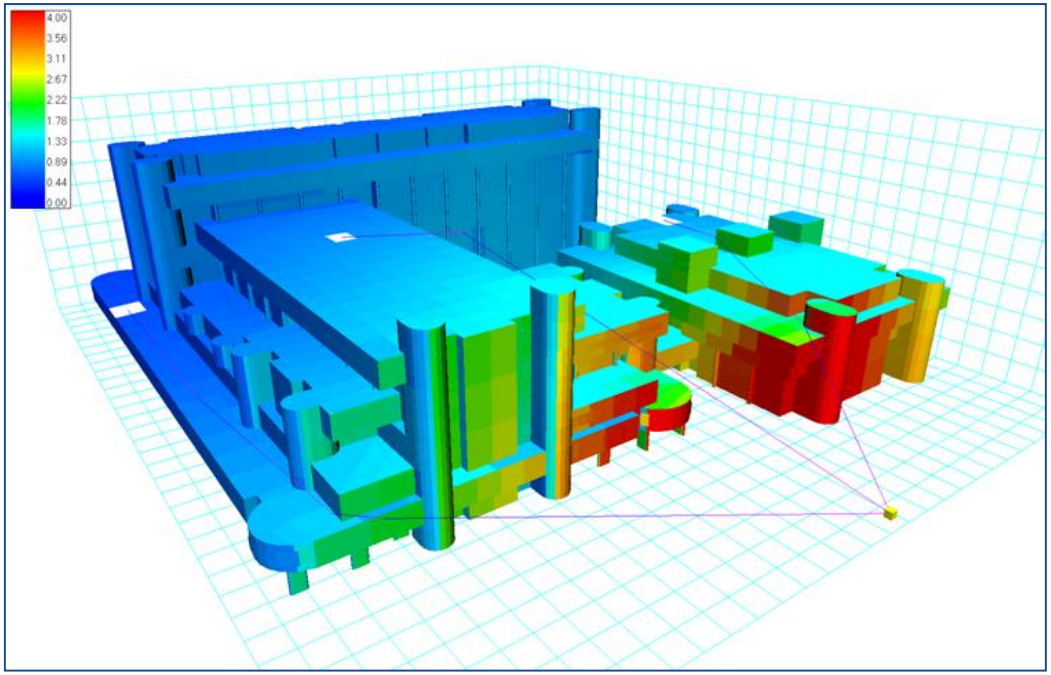






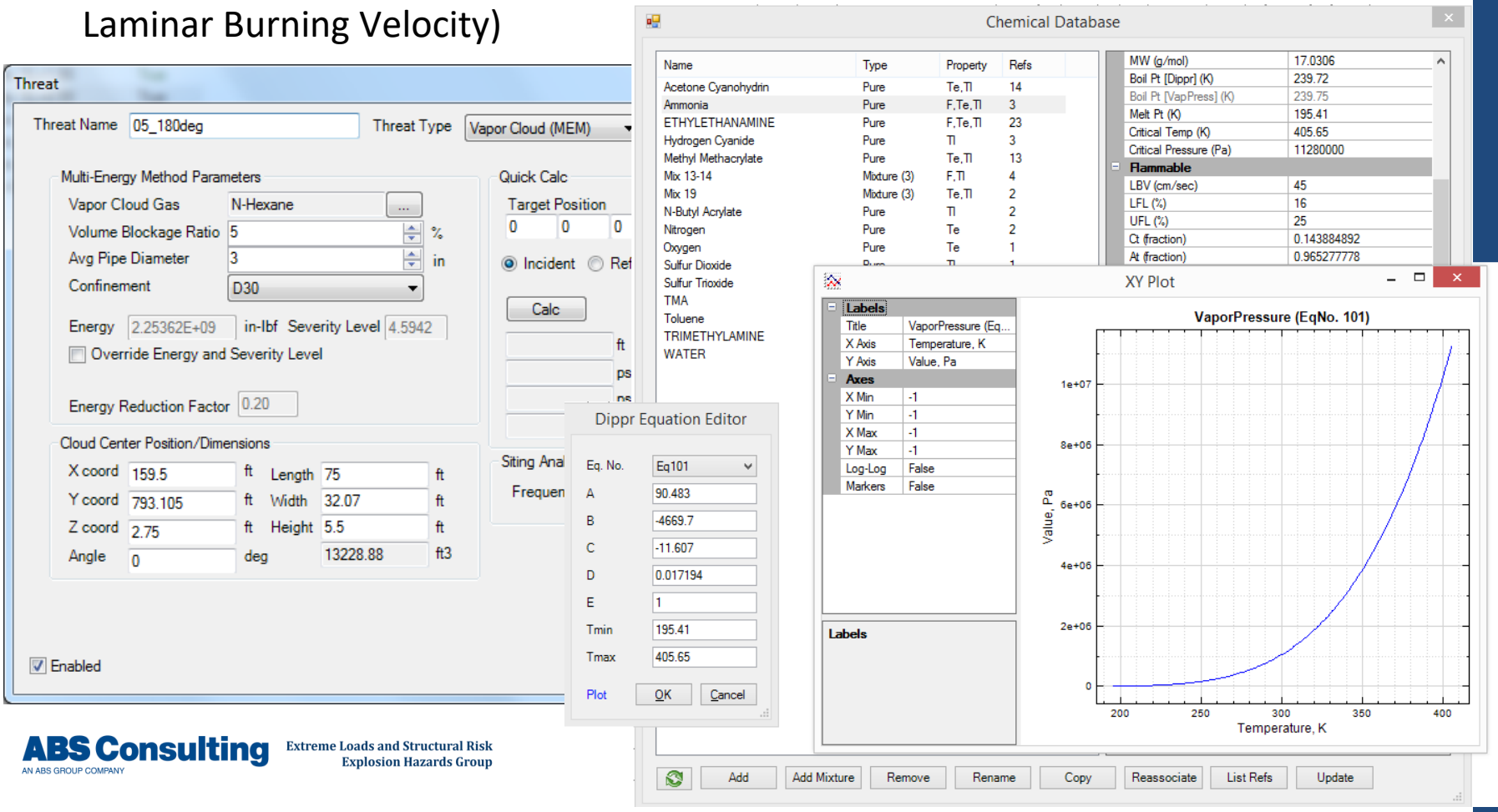
High Explosives - Path Finding

- Blast wave diffraction around objects may be accounted for using the path finding features
  - Normal methods use a straight line distance between threat and target to calculate distance
  - Path finding calculates the shortest unobstructed distance
  - This longer distance is used in blast result calculations as a pragmatic way to decrease conservatism on side and back walls as well as shielded structures
  - Straight line calculations take seconds, path finding often accomplished in a few minutes



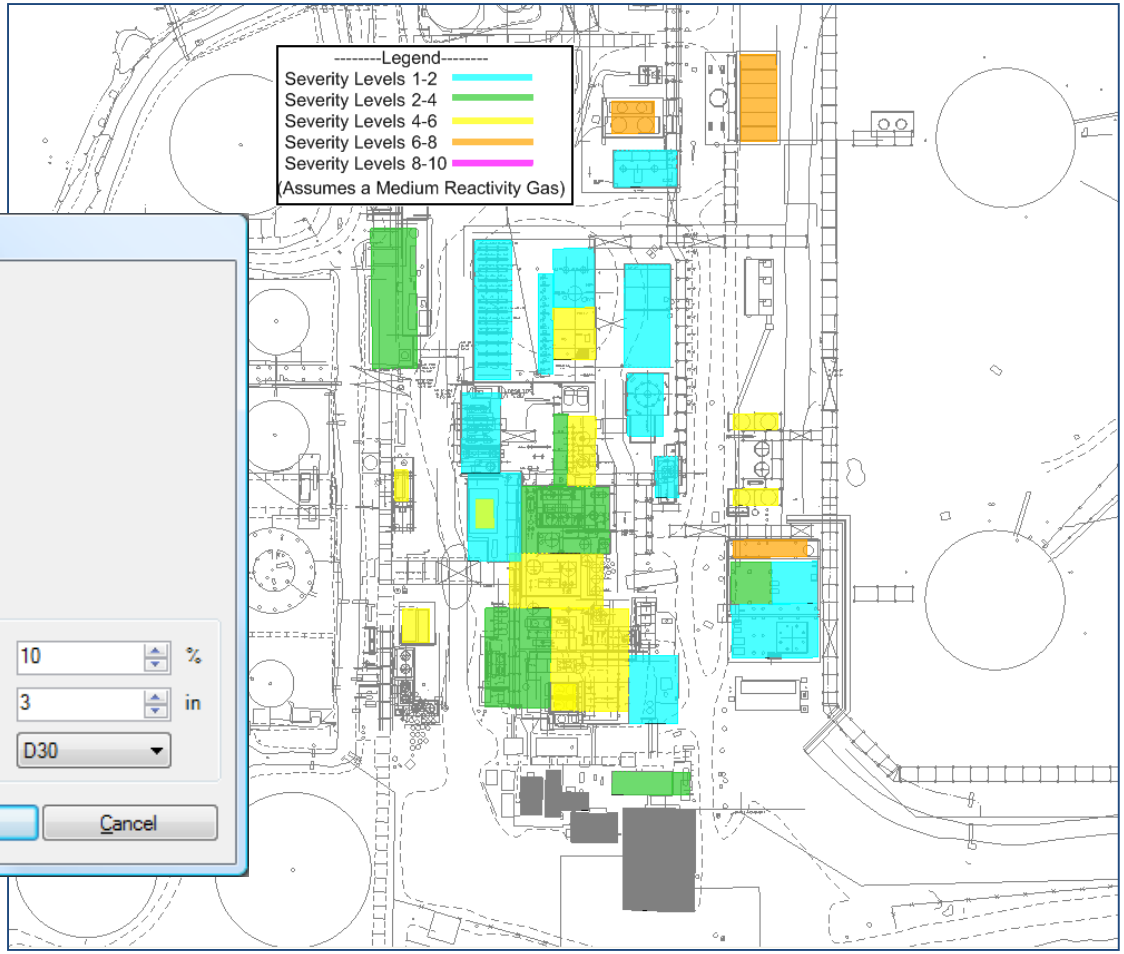
Vapor Cloud Explosions Methods

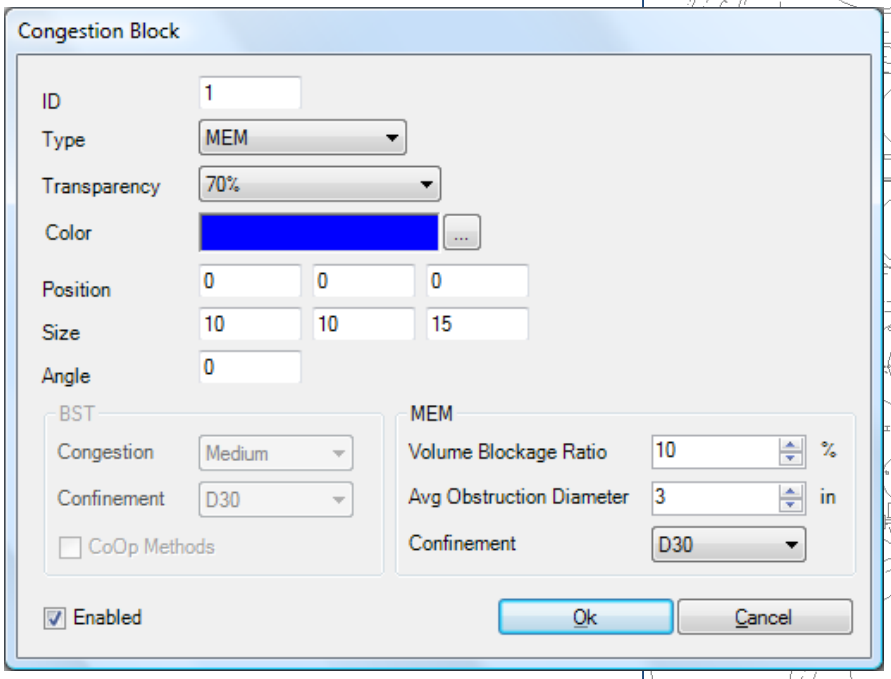
- TNO Multi-Energy Method (MEM), Baker-Strehlow-Tang (BST) Method (including Explosion Research Cooperative methods)
- Options to calculate or manually input Energy, Severity Level, and Flame Speeds
- Extensive chemical database of flammables as well as facilities to create custom mixtures of flammables and their resulting explosion properties (Energy/Volume, Laminar Burning Velocity)



Vapor Cloud Explosions Congestion Blocks

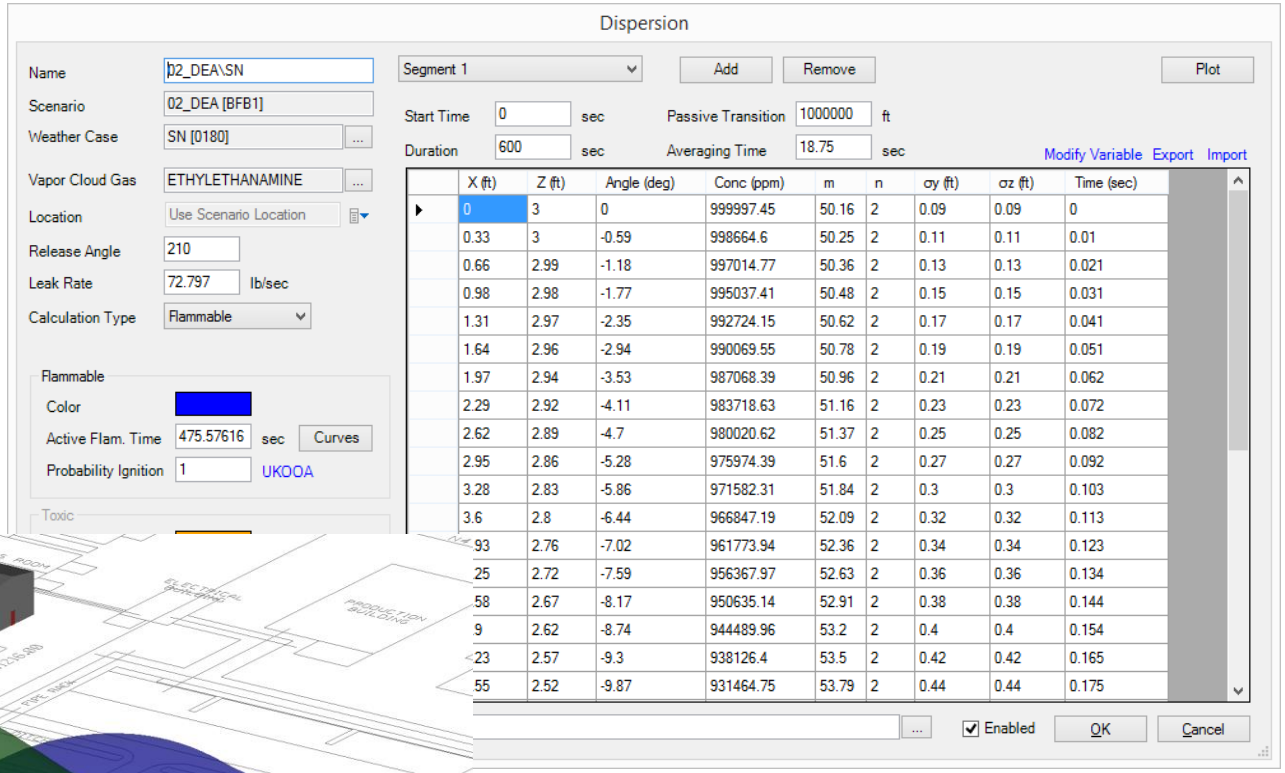
- Vapor clouds may be created directly or by defining regions of congestion and a flammable dispersion cloud and allowing FACET3D to determine the overlap regions and resulting explosion sources
- Congestion regions can be MEM (volume blockage ratio and average pipe diameter) or BST (congestion and confinement) methods
- Define using form inputs or graphically using mouse click and drag procedures





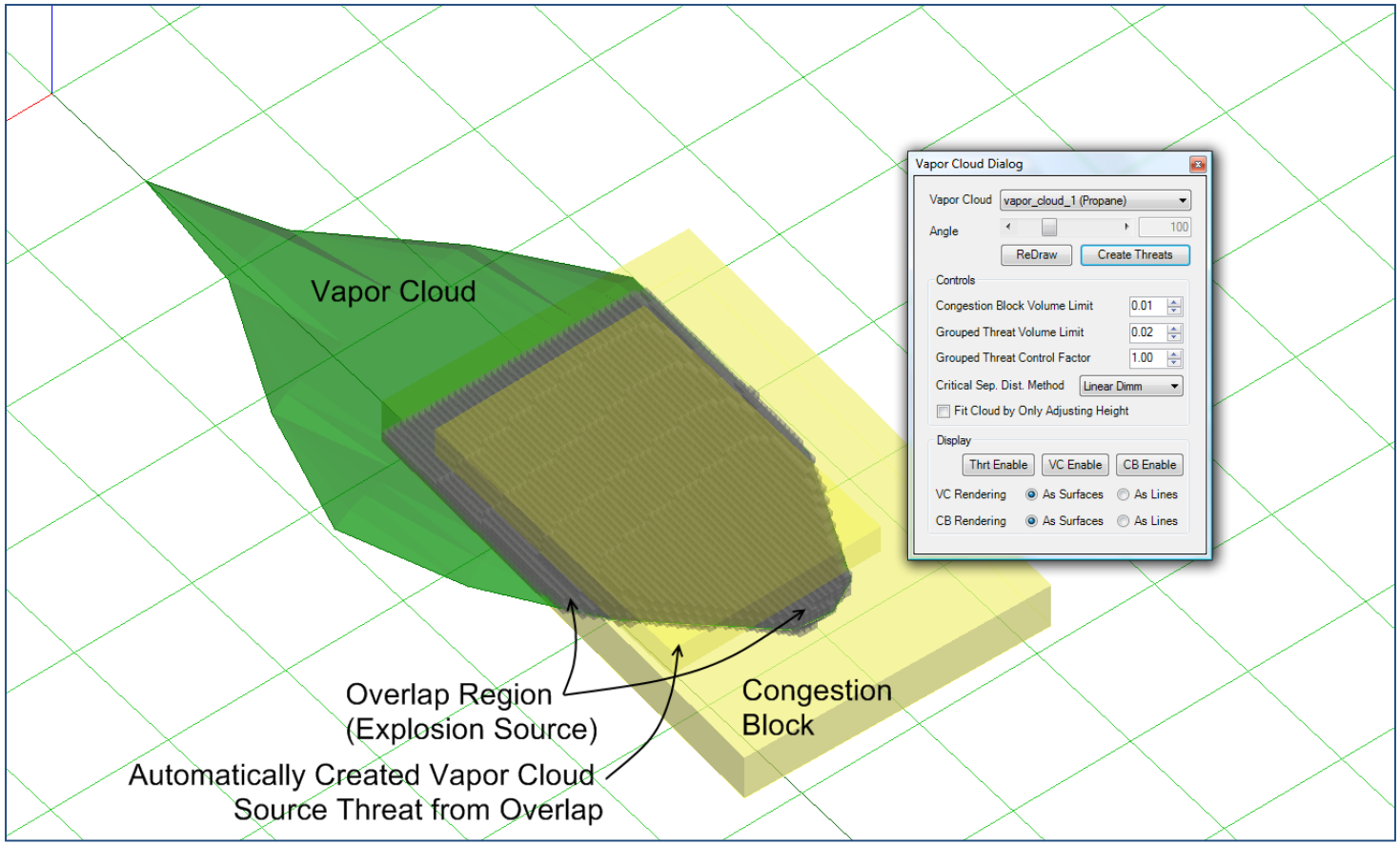
Dispersions

- Flammable dispersion vapor clouds are imported from PHAST (full time dependent Gaussian profile)
- Used for toxic and flammable effects



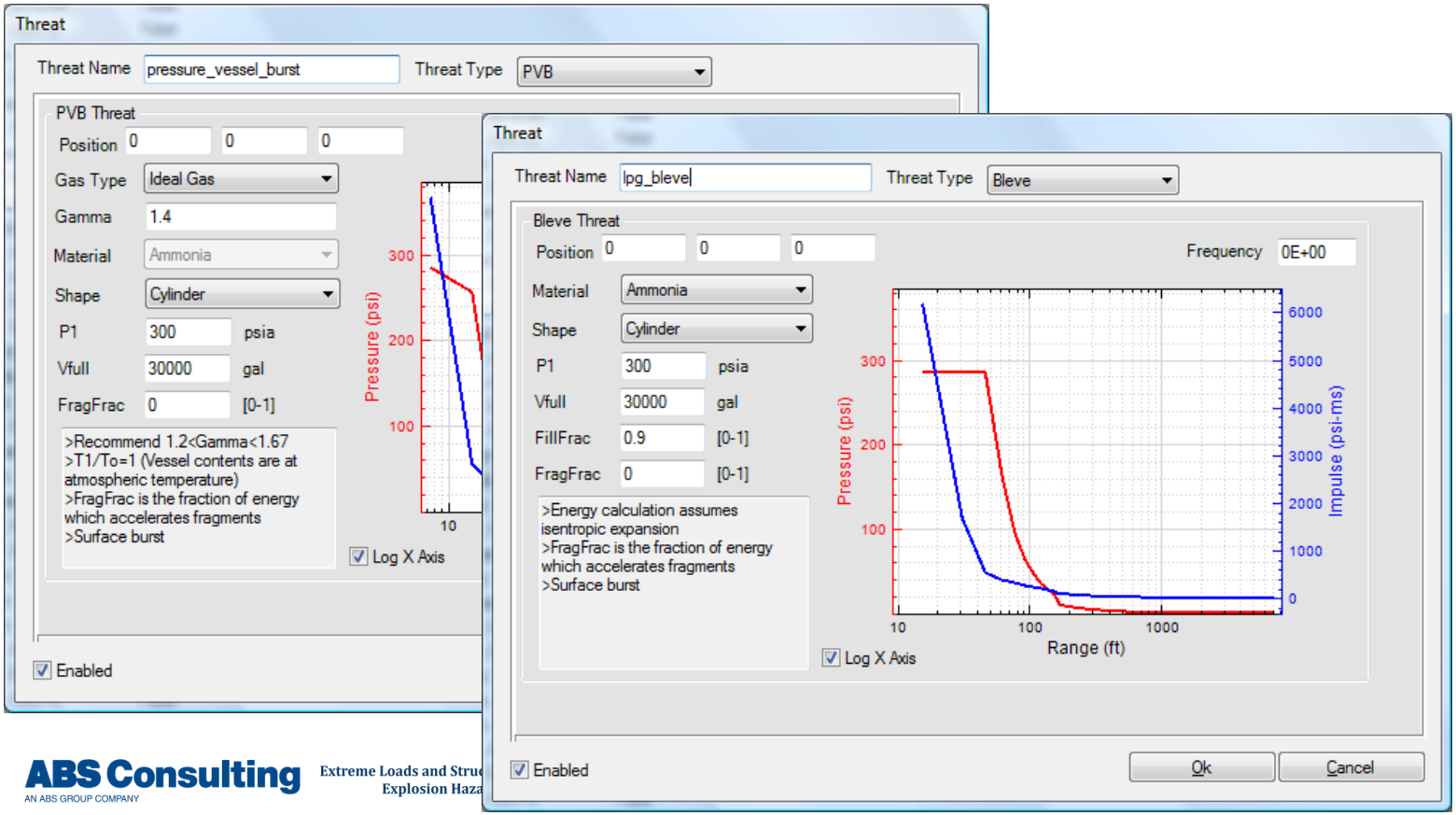
Vapor Cloud Explosions Threat Creation

- Vapor clouds and congestion blocks are intersected
- Automatic rules for combining and separating threats for multiple congestion blocks
- Extensive options to control threat creation process as well as a detailed reports
- QRA use auto rotate feature to capture threats and freq. for all directions for each weather (wind rose)



Pressure Vessel Burst, BLEVE, and User Defined Threats

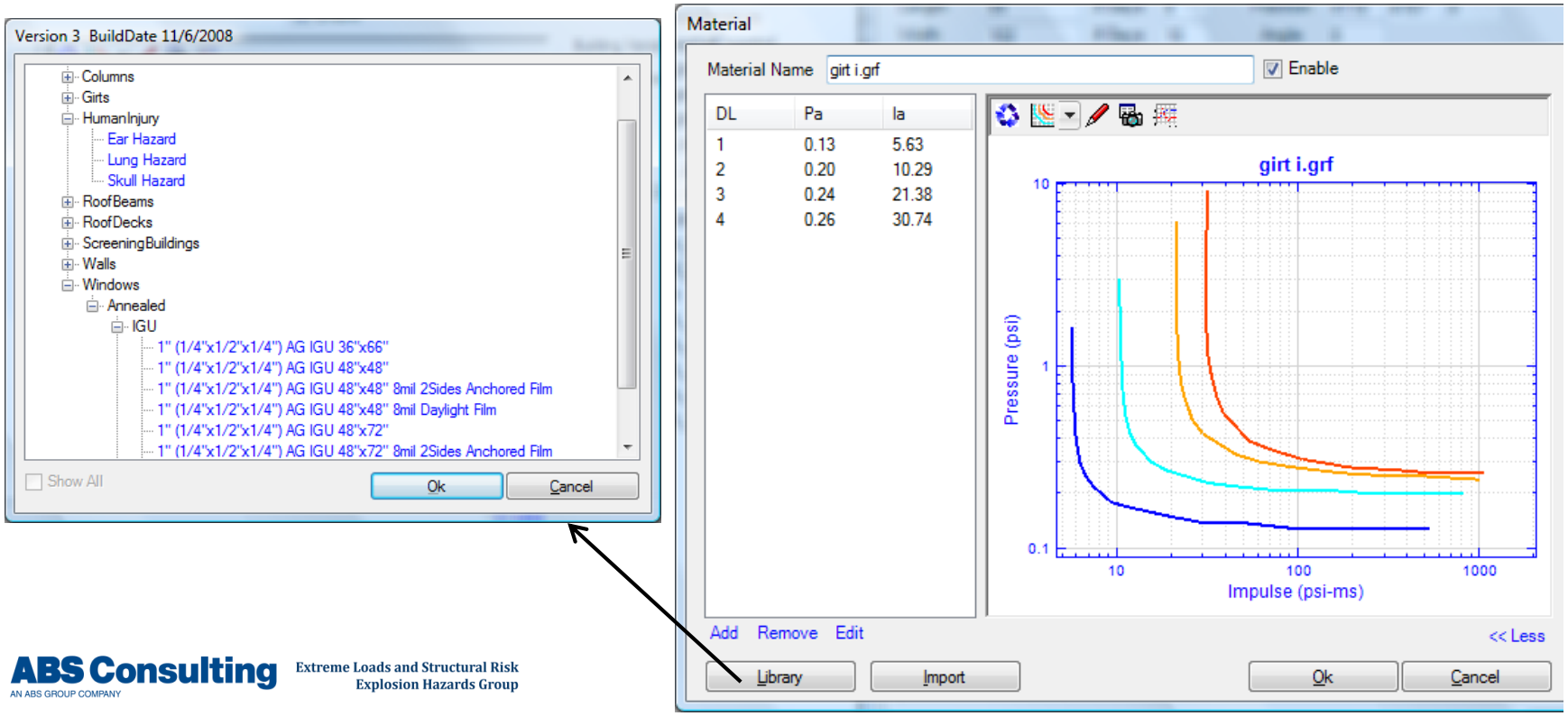
- PVB and BLEVE threats are possible using pre-defined materials
- Both use methods outlined in CCPS publications
- User defined threats are also possible by entering pressure and impulse points as a function of distance from the event
- User defined threats allow any type of complex blast event to be modeled



STRUCTURAL RESPONSE

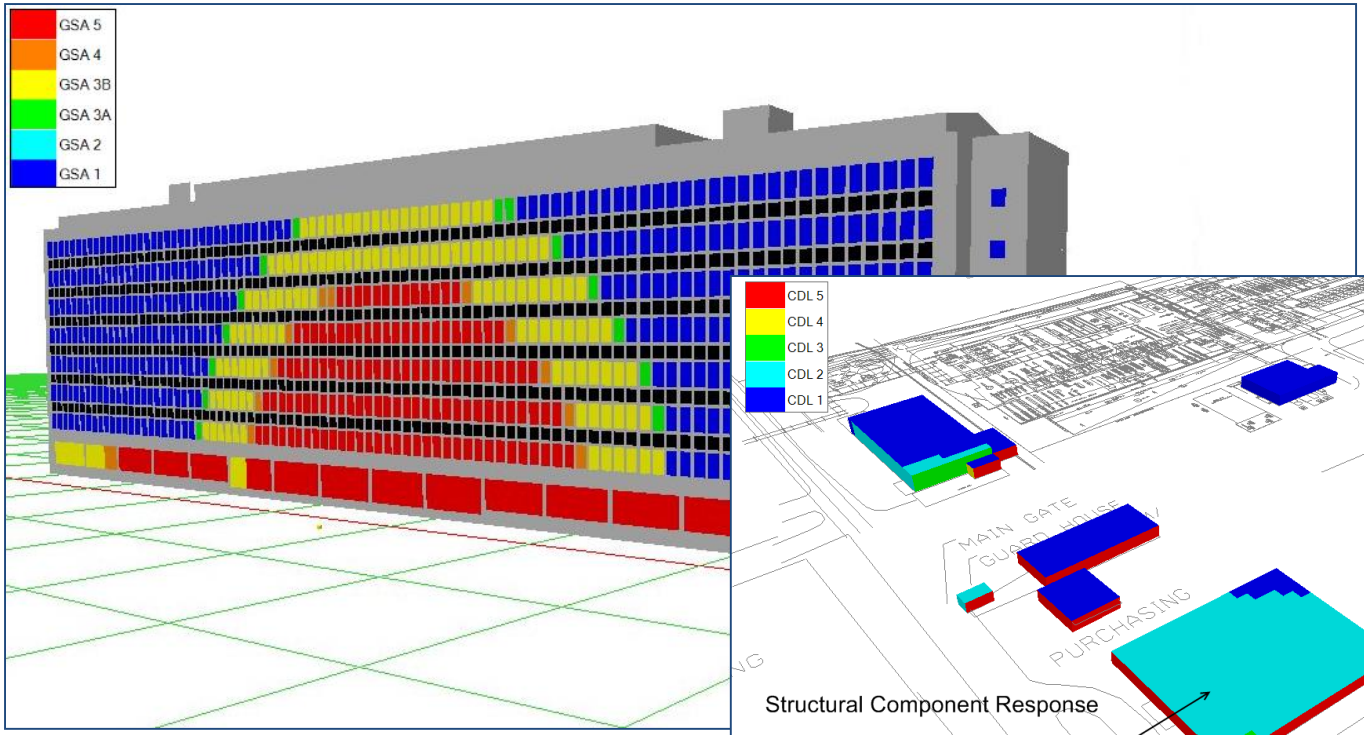
Material Definition

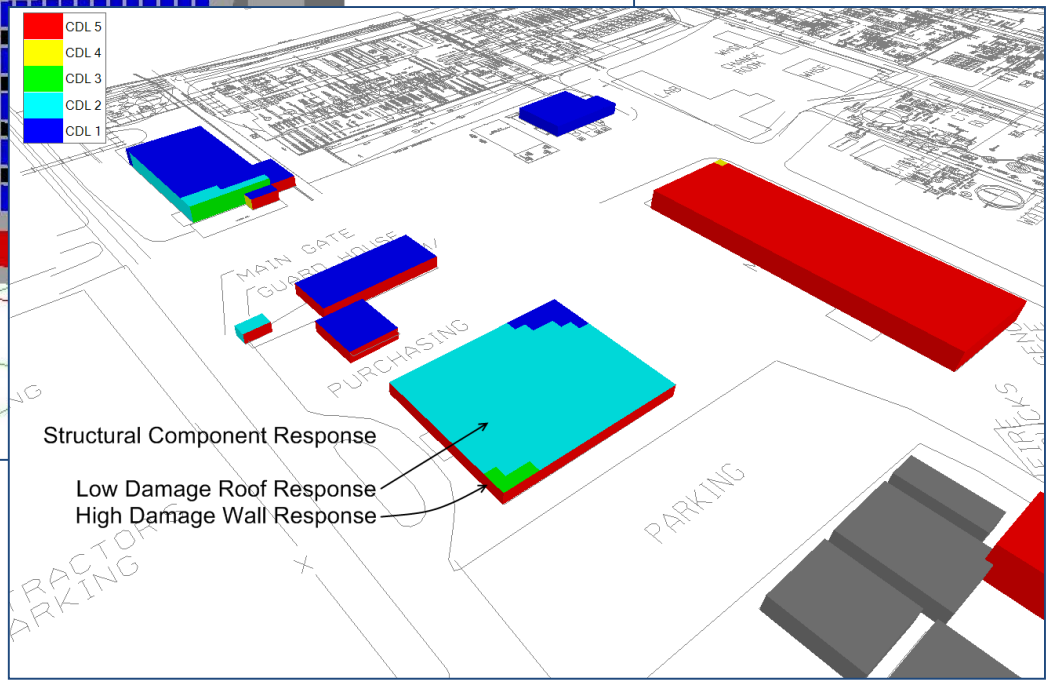
- Structural response is modeled using pressure-impulse (P-I) diagrams
- P-I diagrams can be created from many 3rd party tools from SDOF to FEA
- FACET3D has a built in library of common structural component P-I diagrams often seen in the process industries
- P-I diagrams can be imported from DPLOT files



Material Definition

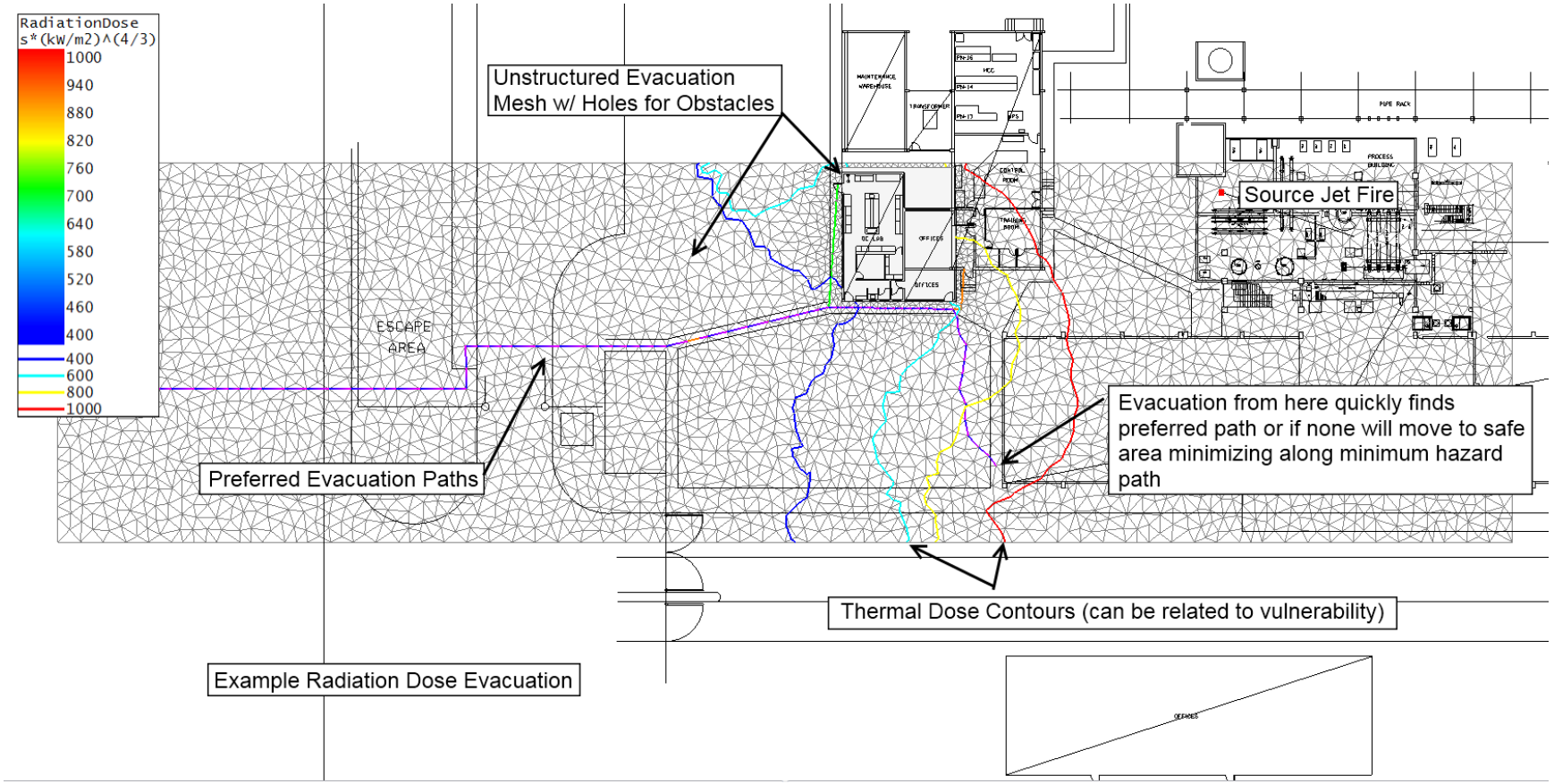
- Examples of P-I diagram usage are for window response to blast loads and component response of petrochemical buildings to overpressures
- For petrochemical buildings, FACET3D can generate a building damage level (BDL) from multiple wall and roof components based on their importance to the structure and individual component damage level (CDL)





FIRE AND TOXIC EVACUATION

- Fire and toxic evacuation using intelligent “path finding” on unstructured mesh.
- Path finding will minimize vulnerability by choosing best path to nearest safe zone
  - Muster point or shelter in place building
- Full user control to designate preferred paths or obstructed zones (high congestion unit)

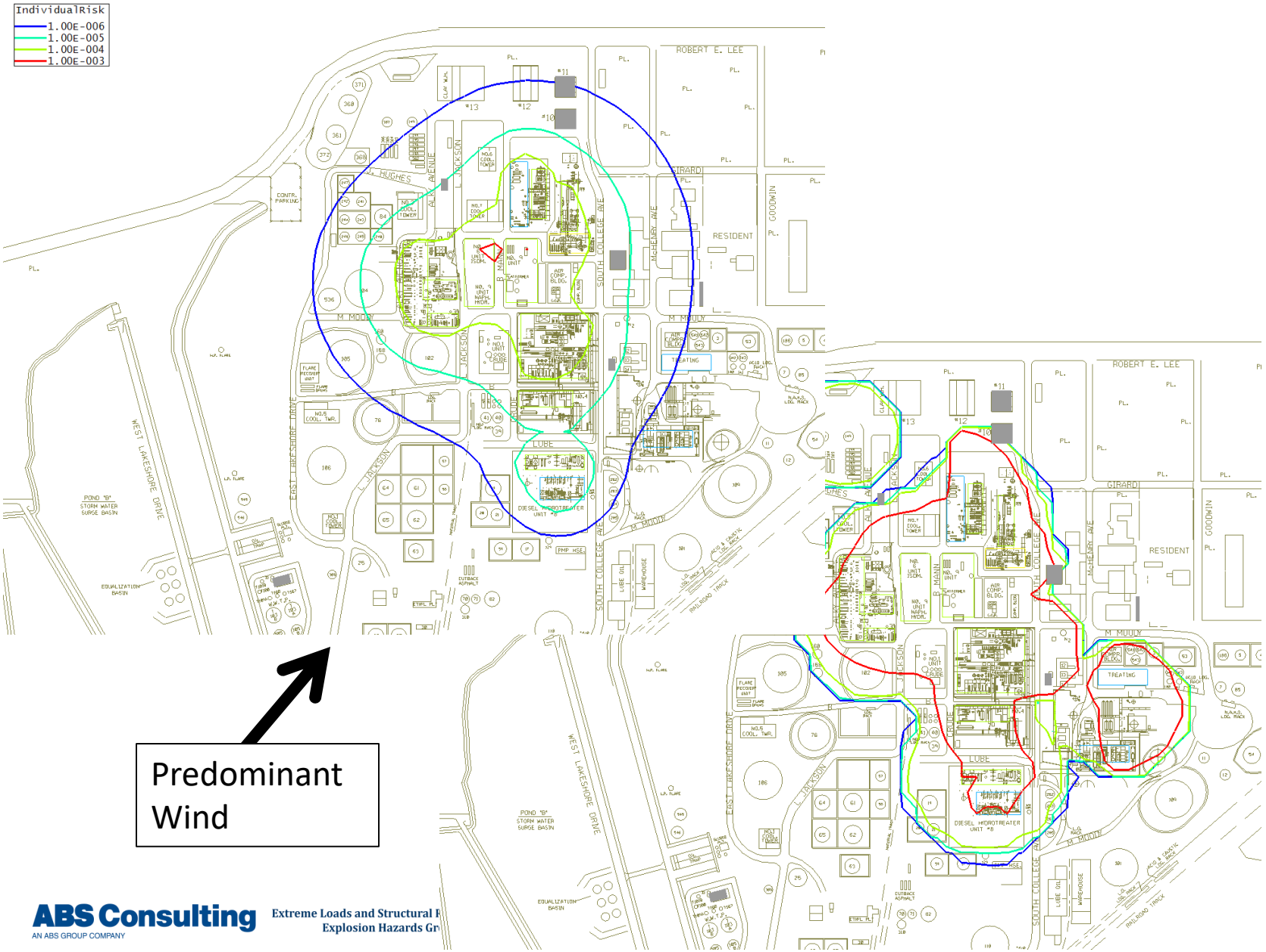


RISK ANALYSIS

Features

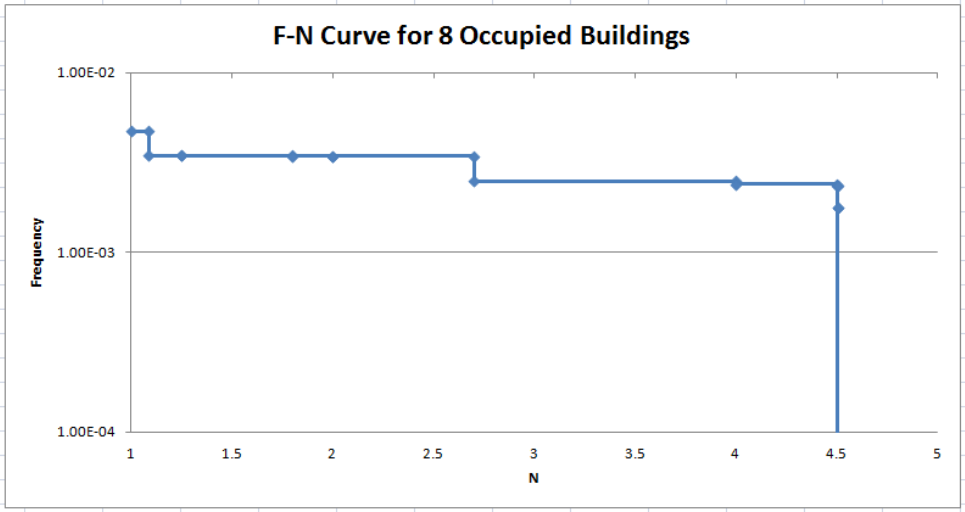
- Extensive import of PHAST dispersion, fire and toxic results
  - 6.7
  - 7.x
- Define scenarios with equipment type/counts and a frequency database for determining base leak frequencies (DNV Leak database built-in)
- Weather module with wind rose data
- Models for calculating lethality from all consequence hazard types (explosion, fire, and toxics)
- Individual risk results and aggregate risk results
  - Occupied buildings
  - People outside (via 2D polygon regions) - Beta feature

Risk


IndividualRisk
1.00E-006
1.00E-005
1.00E-004
1.00E-003
Predominant Wind

Risk Output

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Active Sources:																
2	Explosion	558 of 558 Active		<-- Summary of active hazard sources in this report													
3	Dispersion	62 of 62 Active															
4	Fire	88 of 88 Active															
5																	
6	**Individual Risk**																
7	Building	Time Frac.		Blast		Thermal		Toxic		Total							
8		day	night	day	night	day	night	day	night	Risk							
9	01 OCC	0.238095		1.22E-06				1.20E-11		1.22E-06	0%						
10	03 Lab Washing	0.238095		5.51E-05						5.51E-05	2%						
11	04 MBI Fieldhouse	0.059524		7.08E-07		1.44E-05		5.29E-07		1.56E-05	1%						
12	07 West Guardhouse	0.25		2.14E-07						2.14E-07	0%						
13	08 WWTP	0.238095		4.52E-04						4.52E-04	15%						
14	09 MBI Boilerhouse		0.357143		1.64E-05		5.22E-04		1.61E-06	5.40E-04	18%						
15	10 Machine Shop	0.238095		1.31E-03				6.17E-09		1.31E-03	44%						
16	11 Welding Shop	0.238095		5.87E-04				1.99E-09		5.87E-04	20%						
17				81.28%	0.55%	0.49%	17.61%	0.02%	0.05%	2.97E-03							
18																	
19	**Aggregate Risk FN Curve Data**																
20	N	F															
21	1	0.004721															
22	1.08905144	0.004721															
23	1.08905144	0.003451															
24	1.246679156	0.003451															
25	1.246679156	0.003447															
26	1.801295862	0.003447															
27	1.801295862	0.00342															
28	2	0.00342															
29	2	0.003418															
30	2.700846929	0.003418															
31	2.700846929	0.002497															
32	4	0.002497															
33	4	0.002387															
34	4.50061146	0.002387															
35	4.50061146	0.002358															
36	4.502249918	0.002358															
37	4.502249918	0.001785															
38	4.504290518	0.001785															
39	4.504290518	9.36E-05															
40																	
41																	
42	**Raw FN data**			<-- Raw dump all sources and building combinations (27,000 lines here) allowing detailed risk analysis													
43	Bldg	VarType	SourceID	Vuln	Freq	Hours	Timefrac	Persons	IsDay	F	N						
44	01 OCC	Exp	44F637D4E	0.000676	3.59E-05	40	0.238095	10	TRUE	8.54E-06	0.006765						
45	01 OCC	Exp	51EA122F0	0.000633	4.95E-05	40	0.238095	10	TRUE	1.18E-05	0.006332						



ADDITIONAL FEATURES / SUMMARY

Features

- Automatic online updating
- Extensive command line support for more advanced features
- Import line and surface iso-contours from CFD calculations
- Secure licensing from web server that's easy for users and non-intrusive

Summary

- In summary, FACET3D is an excellent platform for performing a wide array of calculation types on a set of 3D geometry
- Built in 3D visualization of setup and results means easy use and quick generation of results for clients
- Easily extendable to future tasks to meet market demands

Future

- Aggregate risk which includes outdoor population sets (mostly done)
- PHAST v7 file format conversion (mostly done)
- Discharge and dispersion internal models
- Jet and pool fire models
- Time dependent ignition probability model