

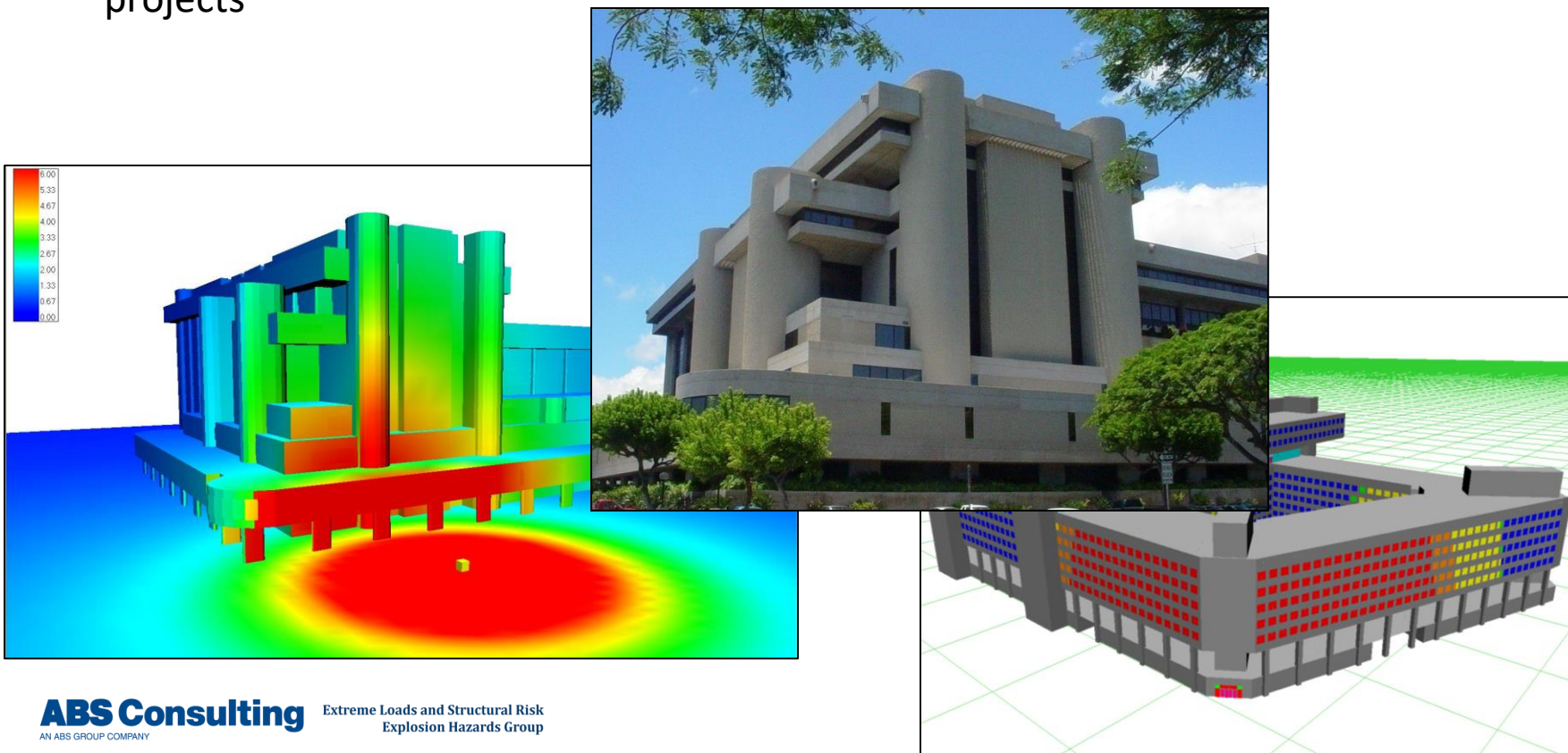
FACET3D

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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



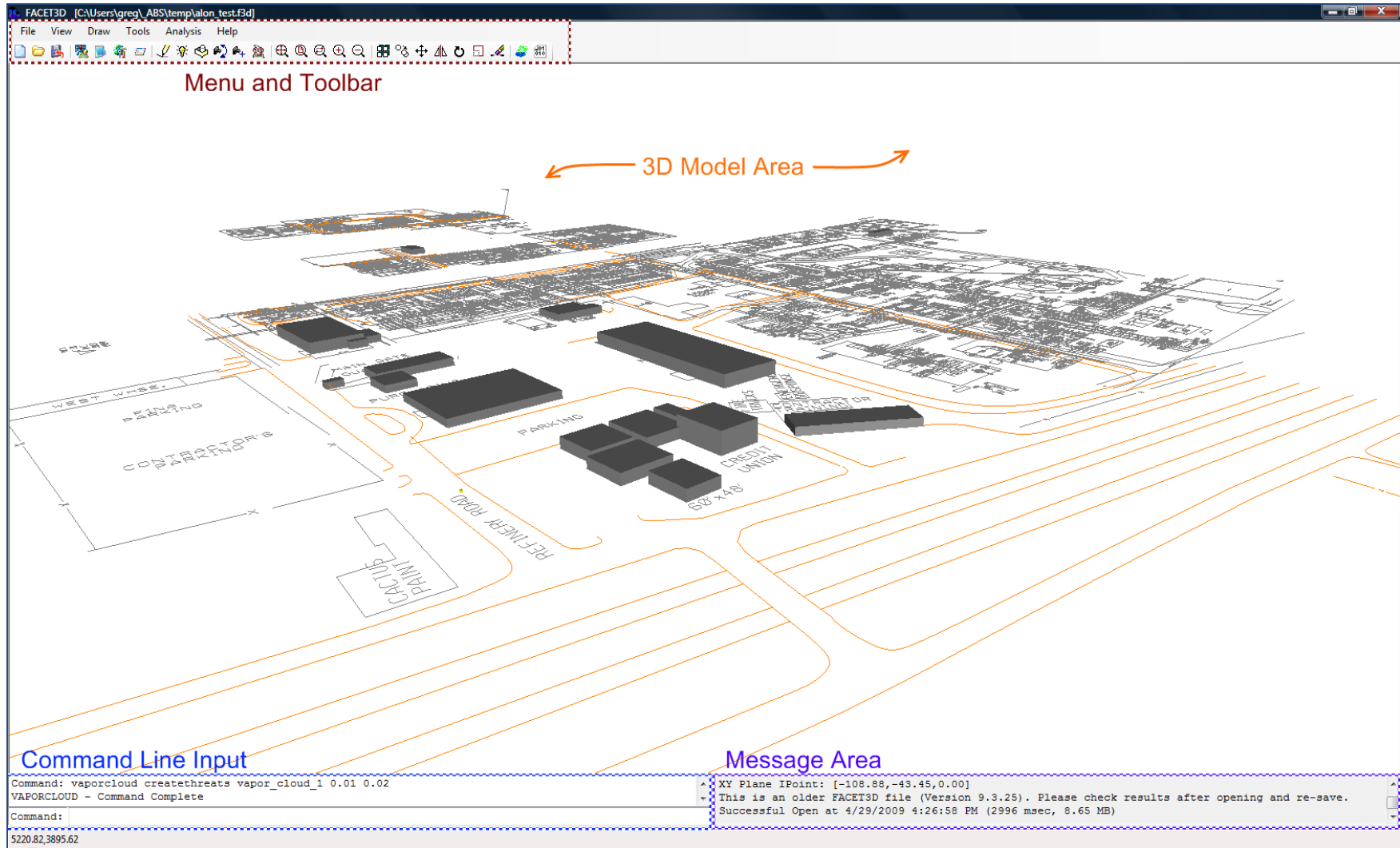
Summary of Features

- 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

Objects						
User Defined Meshes						
Create New Mesh	Mesh Name	Color	Calc Type	Transparency	Enabled	MaterialCalc
Edit Mesh	_site	128,128,128	Automatic	Solid	True	None
Delete Mesh(s)	msh_zone1_2	255,0,0	Automatic	Solid	False	None
Copy Mesh						
Toggle Enabled						
Set Color						
Set Calc Type						
Set Transparency						
User Defined Meshes						
Predefined Buildings						
Threats						
Gauges						
Labels						
Congestion Blocks						
Vapor Clouds						
Ignition Sources						
Jet / Pool Fires						
Toxics						
Regions						

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

Objects						
Vapor Clouds						
Name	Gas	Position	Angle	Extents	Height	
Create New Vapor Cloud	02e	N-Hexane	302 631 0	0	140	1
Edit Vapor Cloud	03c	N-Hexane	240 631 0	0	164	1
Delete Vapor Cloud(s)	04c	N-Hexane	132.7 800.7 0	310	220.5	7.2
Copy Vapor Cloud	05c	N-Hexane	192.5 799.5 0	180	116.9	5.3
	06c	N-Hexane	184.5 797.5 0	180	116.9	5.3
Toggle Enabled	07down	N-Hexane	174.5 781.5 0	310	296.2	7.1
Set Color	08b	THF	127 781.5 0	10	82.9	3.4
Set Transparency						
User Defined Meshes						
Predefined Buildings						
Threats						
Gauges						
Labels						
Congestion Blocks						
Vapor Clouds						
Ignition Sources						
Jet / Pool Fires						
Toxics						
Regions						

Options

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

The screenshot shows the 'File Options' dialog box with the 'Analysis' tab selected. The dialog is organized into several sections:

- General:**
 - Analysis Type: **Consequence** (dropdown)
 - ☒ Calculate Vertex Loads
 - ☐ Disable Calculation Of All Ground Contours
- Path Finding Method:**
 - ☒ Linear Straight Line Distance
 - ☐ Dijkstra's Path Finding
 - Dijkstra Settings:**
 - Grid Type: **ByNode** (dropdown)
 - Node to Node Delta: **5** (text box)
 - ☒ Optimize Paths
 - ☐ Show Grid (i,j,k): **0** **0** **0** **?** (text boxes)
- Clearing:**
 - ☐ Clearing
 - Clearing Lines Mesh: (dropdown)
- Buildings:**
 - ☐ Render Building Damage As BDL
 - ☒ Show Contours On Doors And Windows
 - BDL Model: **Version2** (dropdown)
 - Internal Explosion LFL Fraction: **0.5** (text box)
- Fire Settings:**
 - Modeled Fires:**
 - View Factor Error Tolerance: **1** % (text box)
 - ☐ Include Occlusion Testing
 - ☒ Include Transmissivity
 - ☒ Truncate Using Ground Plane
 - ☒ Increase SEP Accordingly
 - ☐ Use Cylinder Flame Shape Models If Possible
 - ☐ Use PreCalc'd Radiation for All Directions
 - ☐ Translucent Surfaces Reduce Radiation
 - Structured Grid Evac Path: **StraightLine** (dropdown)
 - Lethality:**
 - N: **1.3333** (text box)
 - Model: **Lees** (dropdown)
 - User Defined Model:**
 - Probit A: **-14.9** (text box)
 - Probit B: **2.56** (text box)
 - Probit values assume kW/m2 for I and seconds for t in the equation $Pr=A+B*\ln(t*I^N)$.
 - Safe Radiation Level: **1.6** kW/m2 (text box)
- Toxics:**
 - Toxic Concentration:**
 - ☐ Toxic Conc. Results As Equiv. Conc.
 - Concentration Transform: **None** (dropdown)
 - Reference/Avg Time: **60** min (text box)
 - ☒ Use Log-Linear Interpolation for Data Lookups
 - Toxic Lethality:**
 - Lethality Model: **Crosswind** (dropdown)
 - Stationary Duration: **5** min (text box)
 - ☒ Use Monotonically Decreasing Curves
 - ☐ Worst Case Time for Evac
 - Flammable Dispersions:**
 - ☐ Use Flattened Dispersion

Buttons: **OK** **Cancel**

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
	Name	Length	Width	FloorHeight	LengthBays	WidthBays	Floors	XPos	YPos	ZPos	Angle	PeoplePerBay	RoofAngle	RoofDirection	Windows	Exits	Visibility	CalcType	MaxIndividualOccupancy
1	01_admin	64	92	12	6	9	1	553	125	0	0	0	0	0	11	4	Solid	Automatic	0
2	02_drum_bldg	112	169	12	11	17	1	376	183	0	0	0	0	0	0	0	Solid	Automatic	0
3	03_non-haz_processing_bldg	71	121	12	7	12	1	92	178	0	0	0	0	0	0	0	Solid	Automatic	0
4	04_utility_bldg	60	41	12	6	4	1	53	592	0	0	0	0	0	0	0	Solid	Automatic	0
5	05_lab_trailer	12	60	12	1	6	1	538	135	0	0	0	0	0	0	0	Solid	Automatic	0
6	06_drum_receiving	53	81	12	5	8	1	323	142	0	0	0	0	0	0	0	Solid	Automatic	0
7	07_pump_bldg	34	28	12	4	3	1	-58	820	0	0	0	0	0	0	0	Solid	Automatic	0
8	08_cam_bldg	252	122	12	25	12	1	344	1131	0	0	0	0	0	0	0	Solid	Automatic	0
9	boiler_bldg	27	41	12	3	4	1	113	592	0	0	0	0	0	0	0	Solid	Automatic	0
10	control_bldg	41	25	12	4	2	1	288	758	0	0	0	0	0	0	0	Solid	Automatic	0
11	decant_bldg	164	86	12	16	8	1	325	352	0	0	0	0	0	0	0	Solid	Automatic	0
12																			
13																			
14																			
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Select One or More Reports

Filter

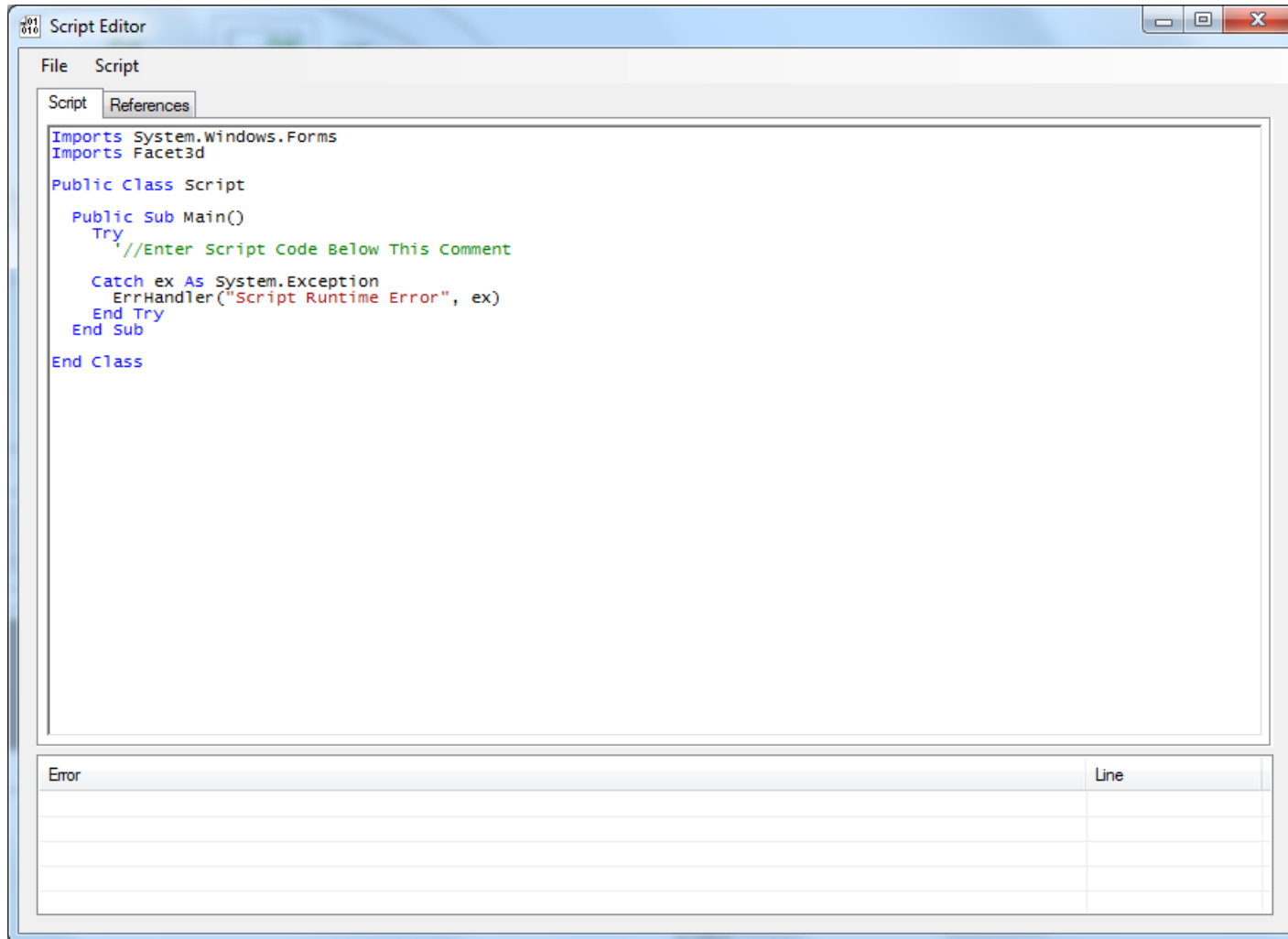
- Building Summary Loads
- Building Wall Applied Loads
- Building Roof Applied Loads
- Building Applied Loads
- Building Window Loads
- Building Door Loads
- Building Window Loads for PT
- Building Door Loads for PT
- Building Damage Levels
- Building Component Damage Levels
- Building Window Damage Levels
- Building Door Damage Levels
- Building Risk
- Building Exceedance
- Building Fire
- Building Screening
- Building Toxic

Select a single report to see its description.

All On All Off Toggle All OK Cancel

Scripting

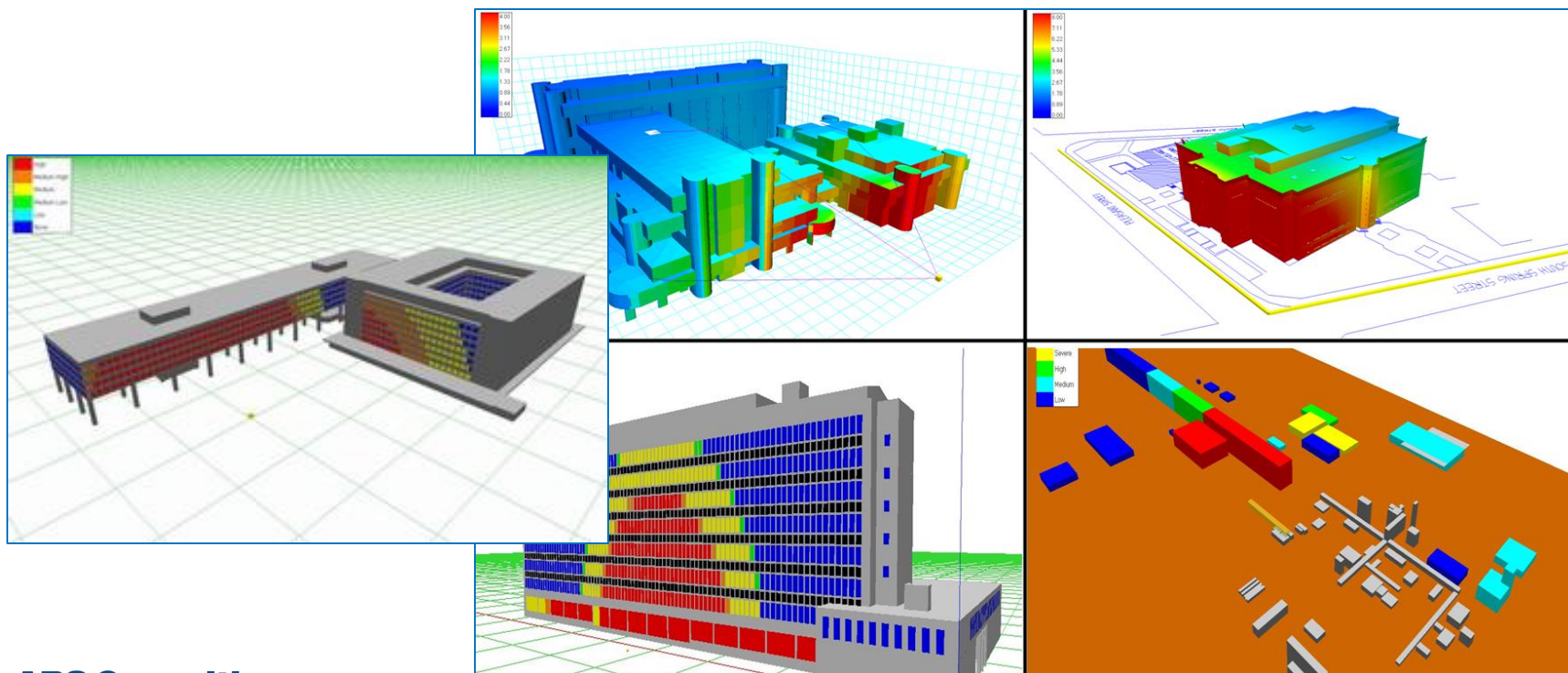
- Full scripting engine using VB.NET code allows the use full access to all internal data and raw power for manipulating objects, creating custom outputs, etc...



GEOMETRY

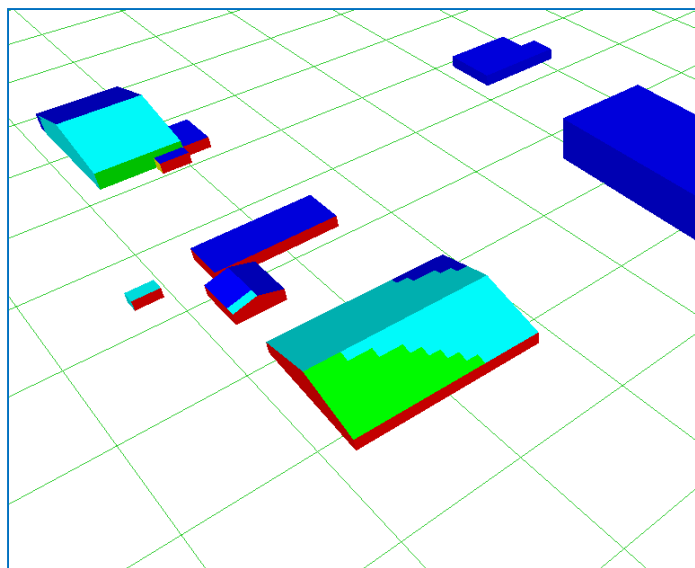
Geometry – Meshes

- 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



Predefined Buildings

Name: 01_admin

Length: 64 # Bays: 6 Position: 553 125 0

Width: 92 # Bays: 9 Angle: 0

Floor Height: 12 # Floors: 1 People/Bay: 0

Roof Angle: 0 Transparency: Solid

Roof Direction: NS Calc Type: Automatic Shelter Type: None

Exits ? Windows

Exits	Windows
E 0.1	E 0.3
E 0.9	E 0.6
S 0.2	E 0.9
W 0.9	S 0.6
	S 0.9
	W 0.3
	W 0.6

North = +Y

Diagram showing building dimensions: Length, Width, Position (x,y,z), Angle.

PI Data: **Siting Analysis**

Name	Enabled	PI Curves	Building Face	Component Class
e-w lb walls.grf	True	2	E,W	Primary
n-s walls.grf	True	4	S,N	Secondary
owsj.grf	True	4	R	Secondary
roof deck.grf	True	4	R	Secondary

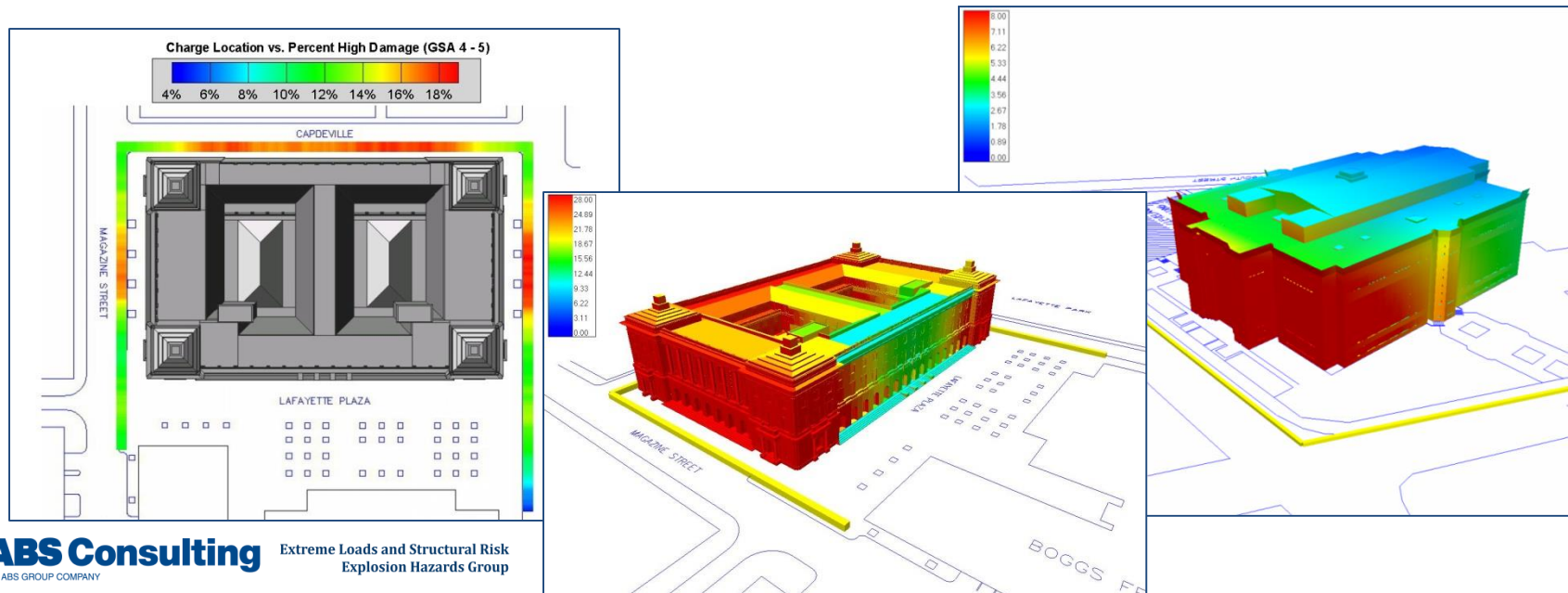
[Toggle Enable](#) [Add Material](#) [Remove Material](#) [Edit Material](#)

☒ Enabled [OK](#) [Cancel](#)

BLAST LOAD CALCULATION METHODS

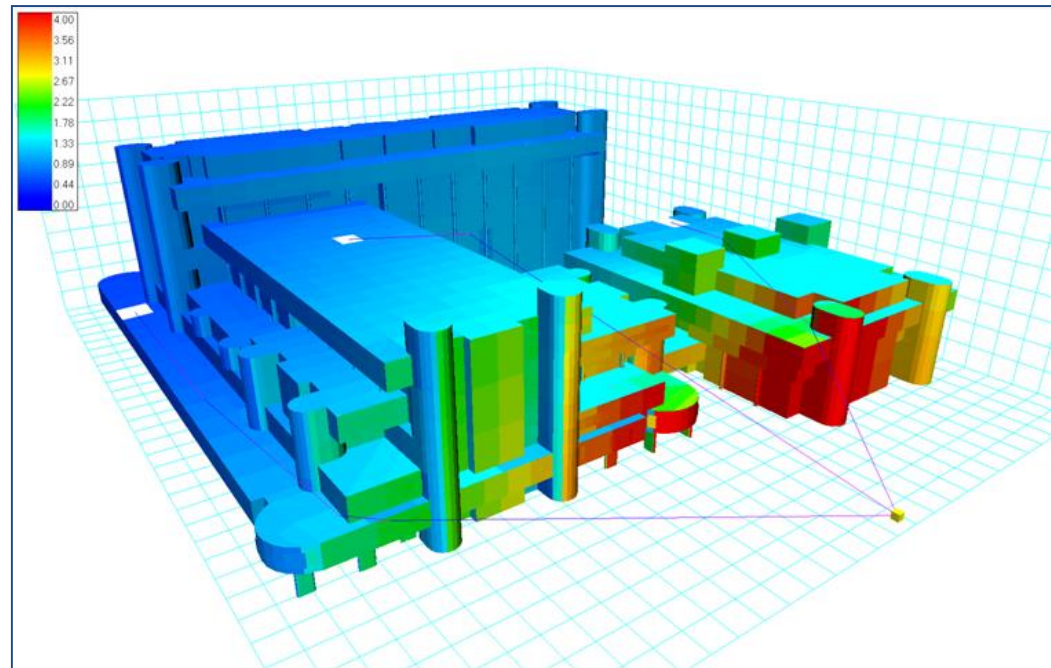
High Explosives

- 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)

The screenshot displays the ABS Consulting software interface for Vapor Cloud Explosions (VCE) calculations. The main window is titled "Threat" and shows the "Threat Name" as "05_180deg" and "Threat Type" as "Vapor Cloud (MEM)". The "Multi-Energy Method Parameters" section includes "Vapor Cloud Gas" (N-Hexane), "Volume Blockage Ratio" (5%), "Avg Pipe Diameter" (3 in), and "Confinement" (D30). The "Energy" is set to 2.25362E+09 in-lbf, and the "Severity Level" is 4.5942. The "Cloud Center Position/Dimensions" section shows X coord (159.5 ft), Y coord (793.105 ft), Z coord (2.75 ft), Length (75 ft), Width (32.07 ft), Height (5.5 ft), and Angle (0 deg). The "Energy Reduction Factor" is 0.20. The "Threat" window is checked as "Enabled".

The "Chemical Database" window shows a list of chemicals with their properties. The "Flammable" section is expanded, showing properties for N-Hexane: MW (g/mol) 116.21, Boil Pt [Dippr] (K) 341.9, Boil Pt [VapPress] (K) 341.9, Melt Pt (K) 90.8, Critical Temp (K) 507.6, Critical Pressure (Pa) 30.2, LBV (cm/sec) 45, LFL (%) 1.1, UFL (%) 7.6, Ct (fraction) 0.143884892, and At (fraction) 0.965277778.

The "Dippr Equation Editor" window shows the equation for Vapor Pressure (EqNo. 101) with coefficients A through E and Tmin and Tmax values. The equation is: $\ln(P) = A + \frac{B}{T} + C \ln(T) + D T + E T^2$, where T is in Kelvin. The coefficients are: A = 90.483, B = -4669.7, C = -11.607, D = 0.017194, E = 1, Tmin = 195.41, and Tmax = 405.65.

The "XY Plot" window shows a graph of Vapor Pressure (EqNo. 101) versus Temperature (K). The X-axis ranges from 200 to 400 K, and the Y-axis ranges from 0 to 1e+07 Pa. The plot shows a curve that increases exponentially with temperature.

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

Congestion Block

ID: 1

Type: MEM

Transparency: 70%

Color: [Color Picker]

Position: 0 0 0

Size: 10 10 15

Angle: 0

BST

Congestion: Medium

Confinement: D30

☐ CoOp Methods

☒ Enabled

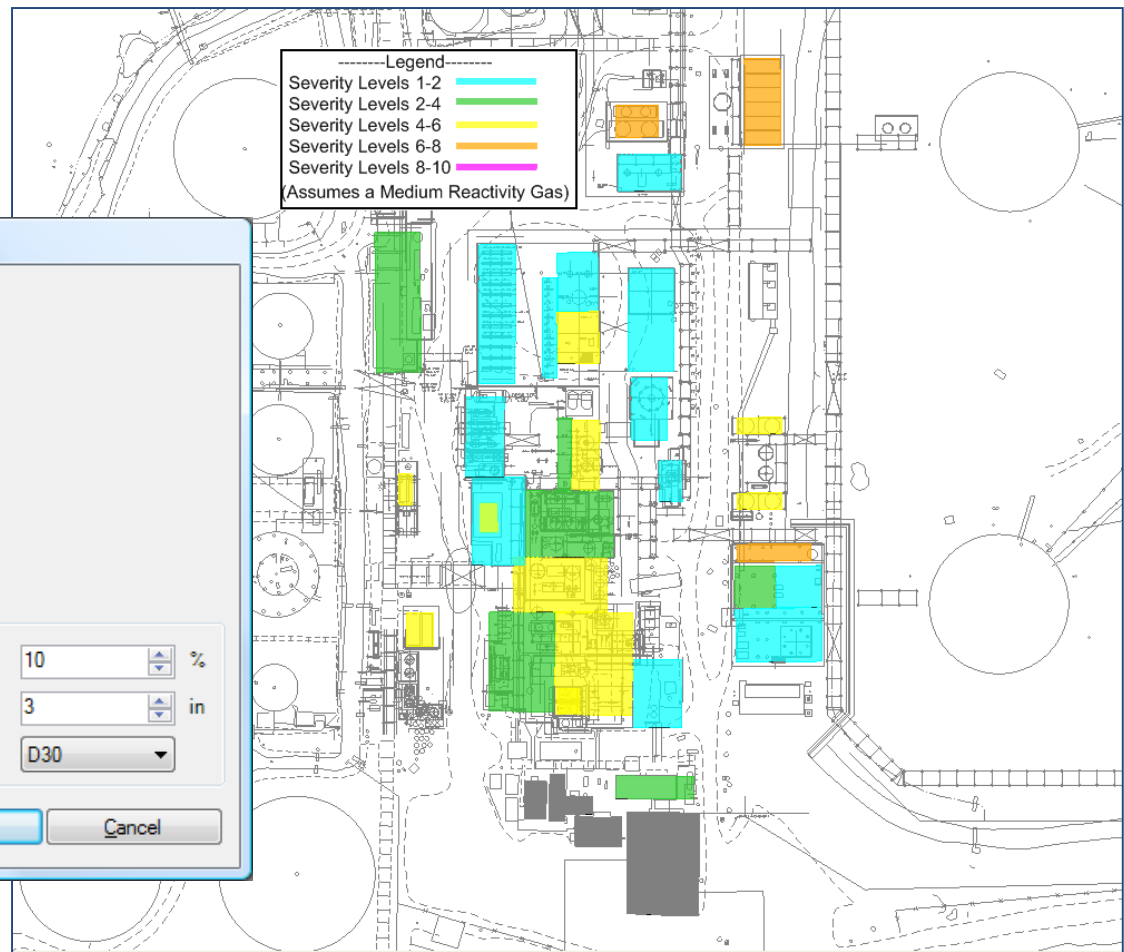
MEM

Volume Blockage Ratio: 10 %

Avg Obstruction Diameter: 3 in

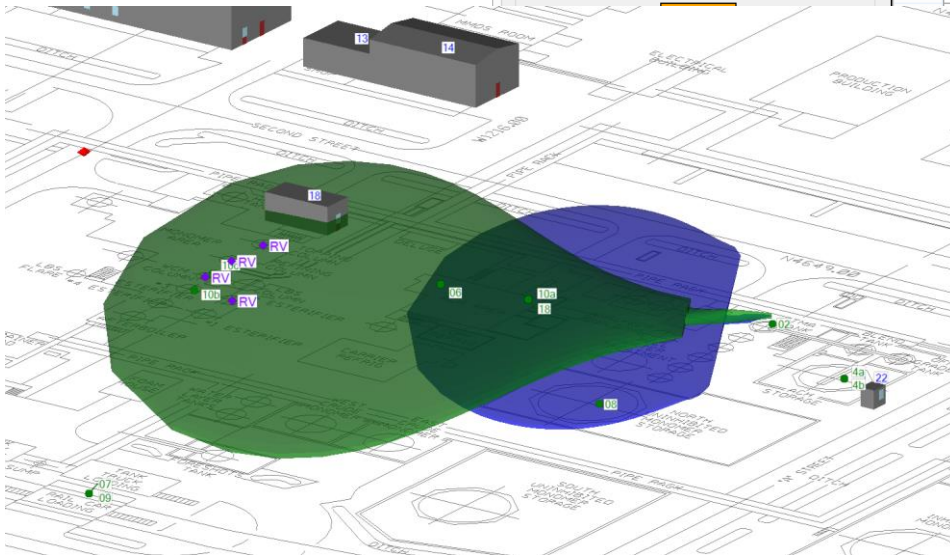
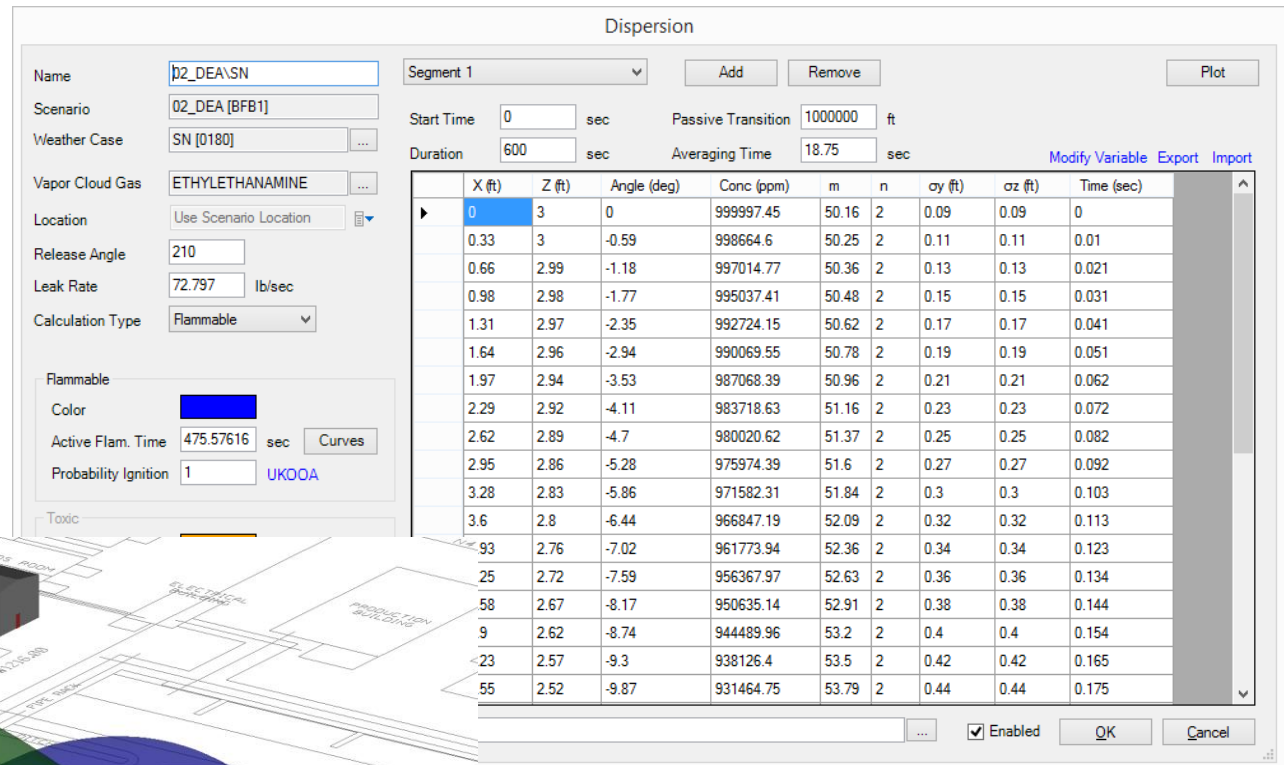
Confinement: D30

Ok Cancel



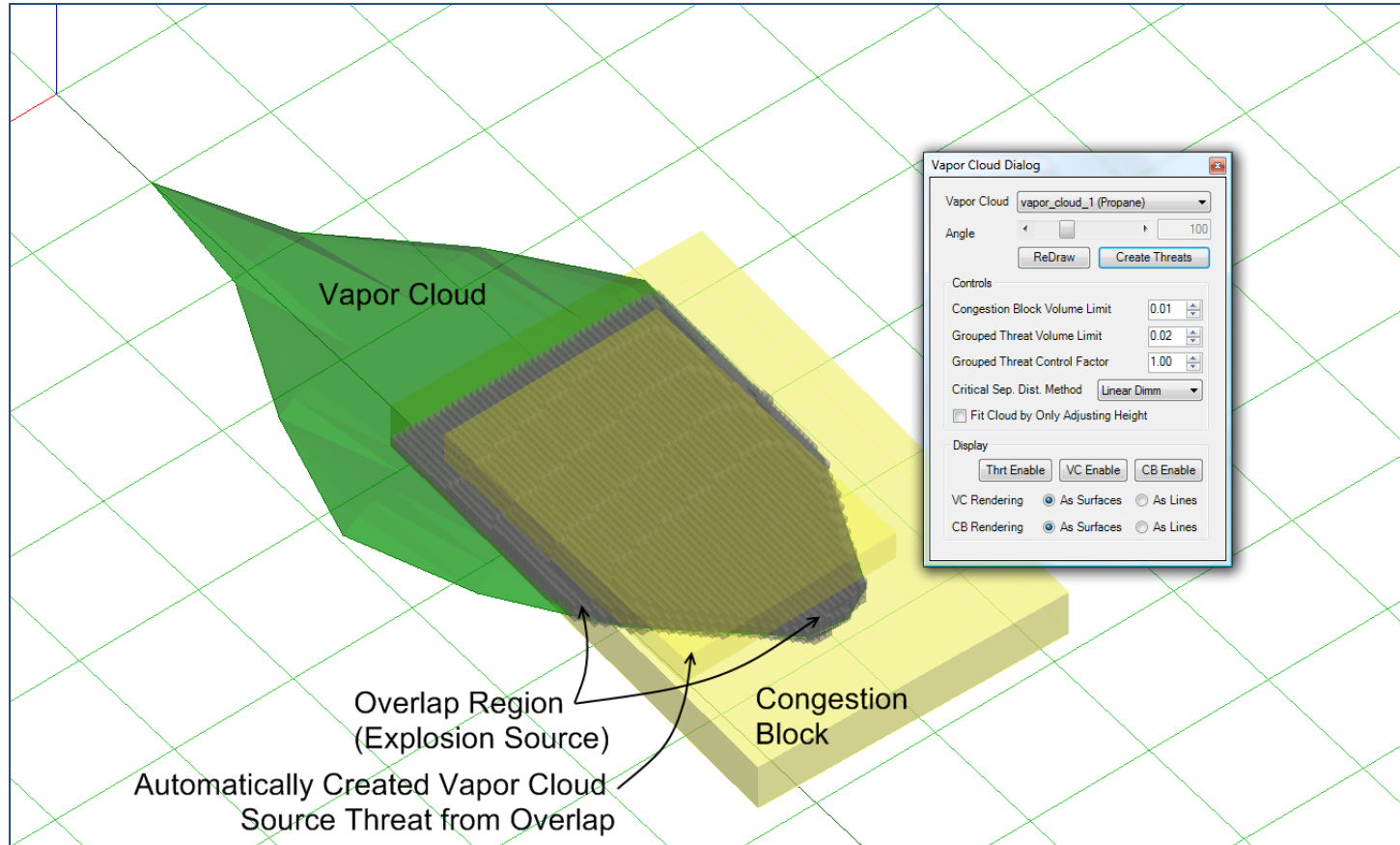
Dispersions

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



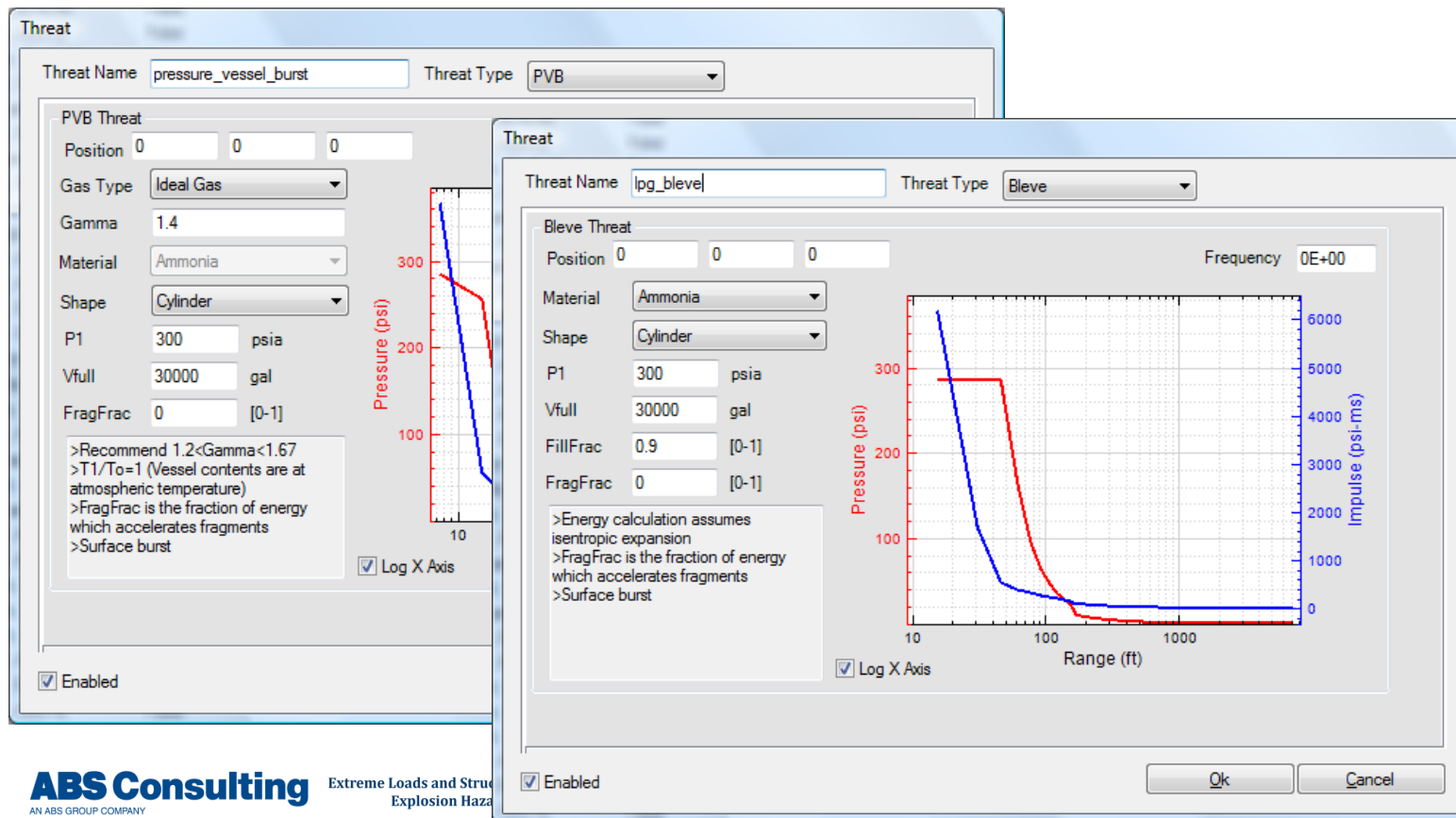
Vapor Cloud Explosions Threat Creation

- 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

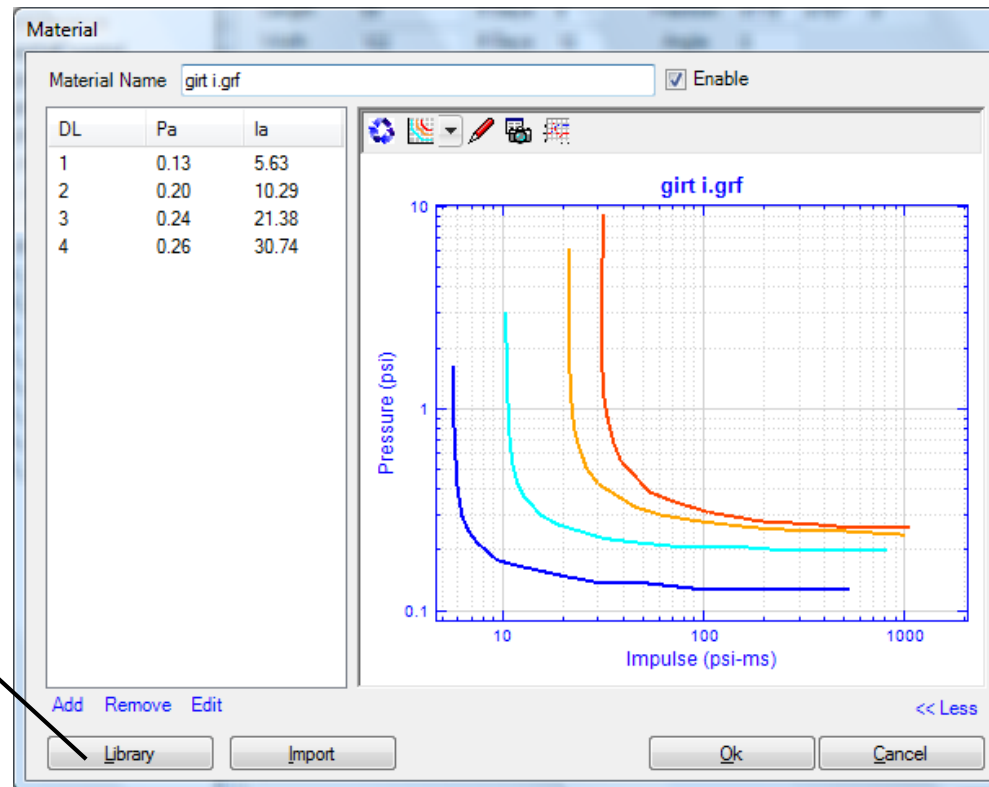
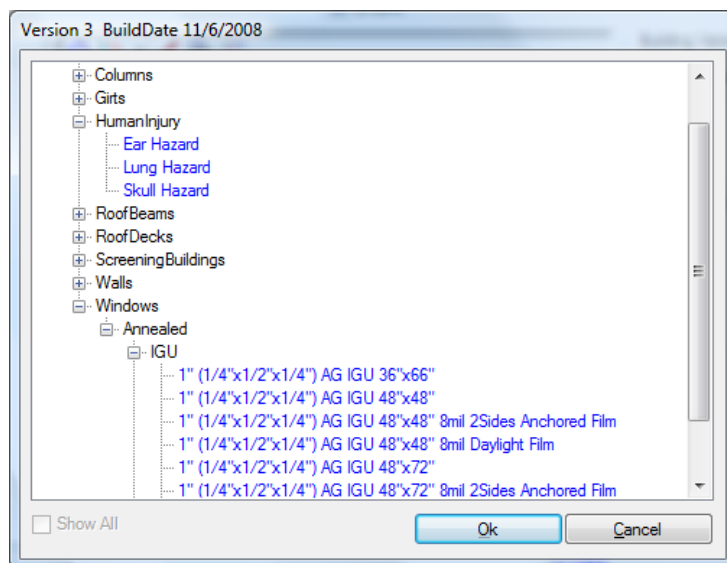
- PVB and BLEVE threats are possible using pre-defined materials
- Both use methods outlined in CCPS publications
- User defined threats are also possible by entering pressure and impulse points as a function of distance from the event
- User defined threats allow any type of complex blast event to be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



STRUCTURAL RESPONSE

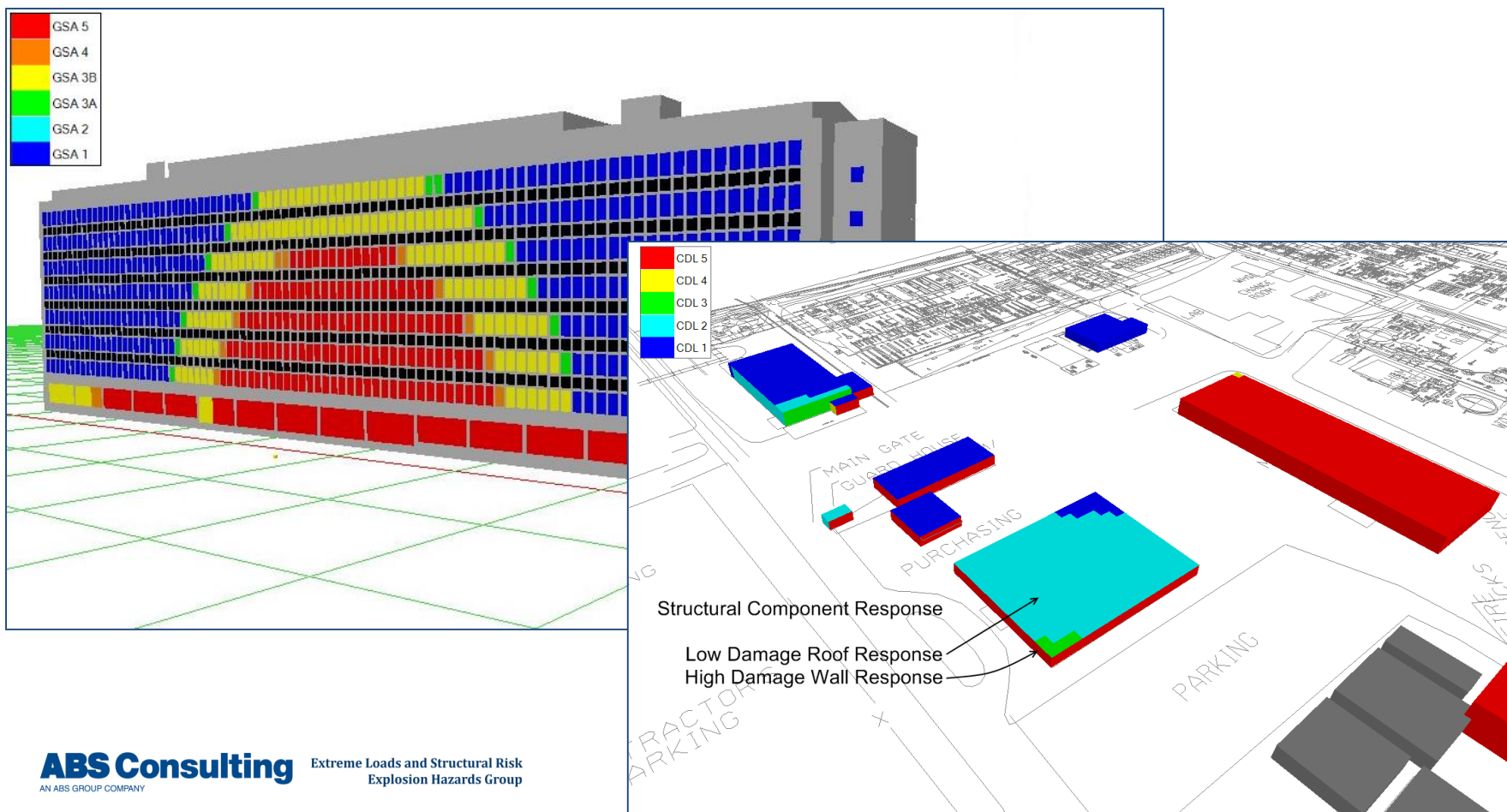
Material Definition

- 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



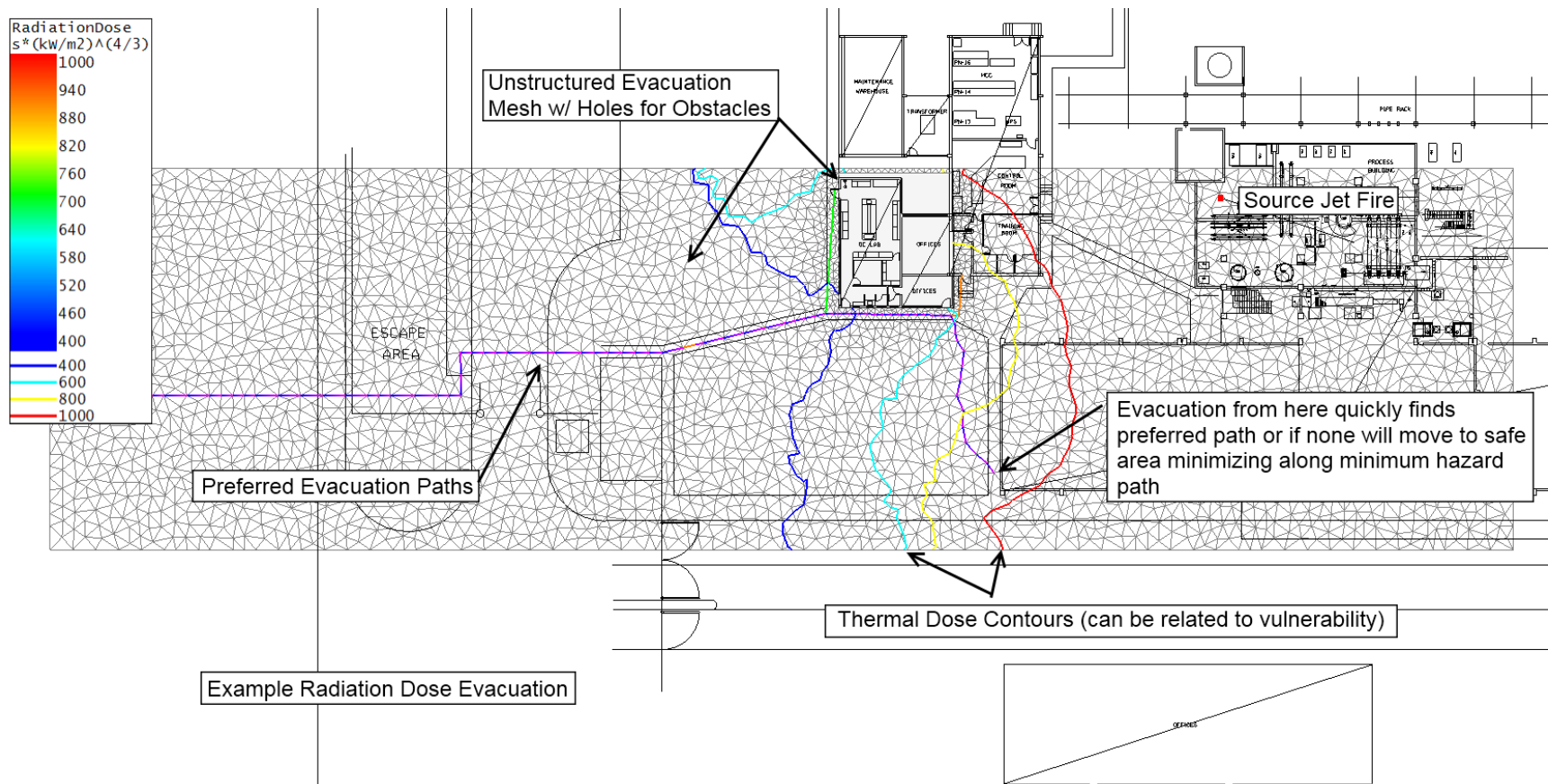
Material Definition

- 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)

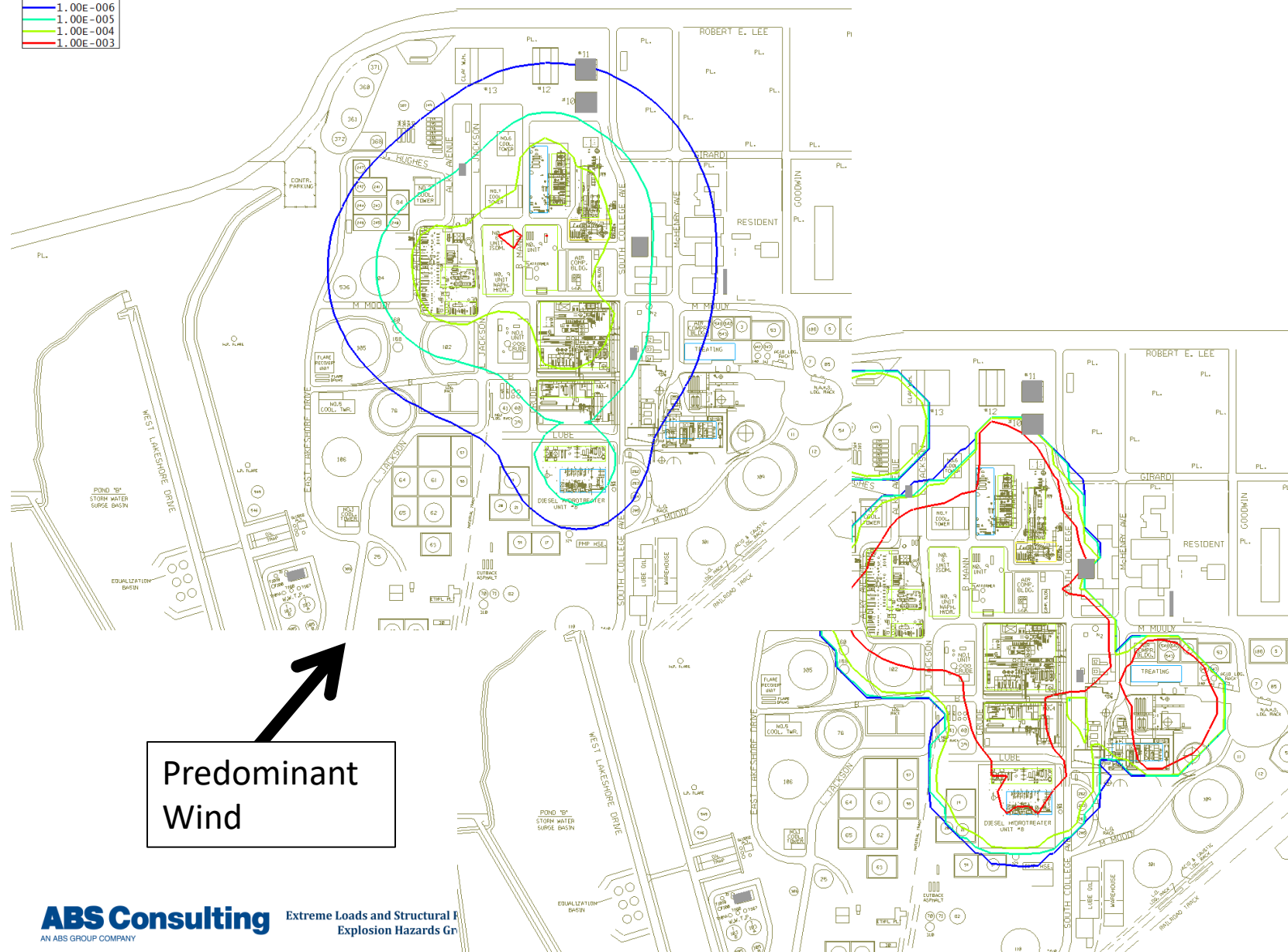
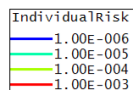


RISK ANALYSIS

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

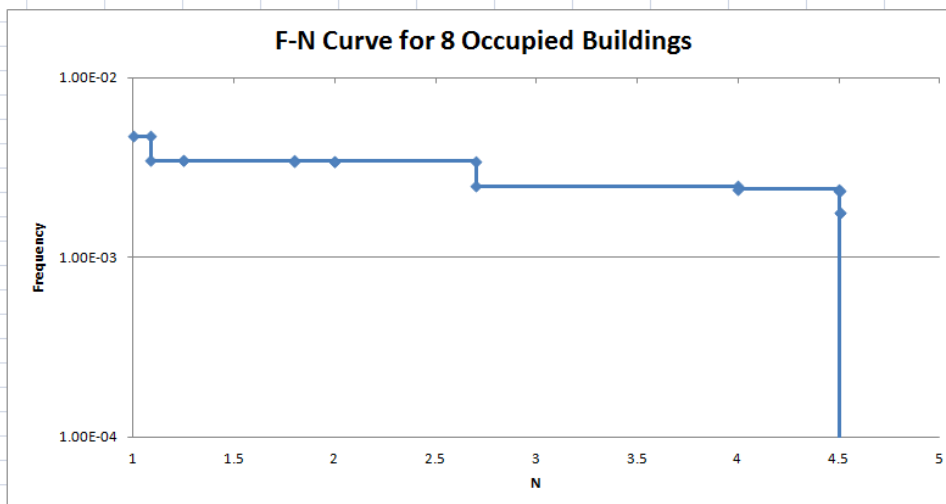


Risk Output

	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 Risk							
8		day	night	day	night	day	night	day	night								
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							

Aggregate Risk FN Curve Data

N	F
1	0.004721
1.08905144	0.004721
1.08905144	0.003451
1.246679156	0.003451
1.246679156	0.003447
1.801295862	0.003447
1.801295862	0.00342
2	0.00342
2	0.003418
2.700846929	0.003418
2.700846929	0.002497
4	0.002497
4	0.002387
4.50061146	0.002387
4.50061146	0.002358
4.502249918	0.002358
4.502249918	0.001785
4.504290518	0.001785
4.504290518	9.36E-05



Raw FN data

<-- Raw dump all sources and building combinations (27,000 lines here) allowing detailed risk analysis

Bldg	VarType	SourceID	Vuln	Freq	Hours	Timefrac	Persons	IsDay	F	N
01 OCC	Exp	44F637D4f	0.000676	3.59E-05	40	0.238095	10	TRUE	8.54E-06	0.006765
01 OCC	Exp	51EA122Ff	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