UWE Bristol | University of the West of England

Presentation by

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CUBER
Critical Urban Buildings Emergency Response

17 June 2016

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video source: youtube.com

Critical urban facilities, such as airports, healthcare facilities, business districts, markets and shopping centres are exposed to human-induced disasters, as well as natural disasters.

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video source: youtube.com

When disasters take place, a short period of time, e.g. 5 min, may mean a significant change in the disaster environment in which rescue personnel have to operate.

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video source: youtube.com

In an emergency, up-to-date information is needed for coordination, communication and efficient decision making. This information is difficult to access or does not exists at all.

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video source: youtube.com

Unlike the existing computational models of evacuation, the proposed CUBER system is better suited for rehearsal, through simulation, of emergency preparedness and response.

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video source: youtube.com

CUBER also facilitates scenario planning for a faster and more appropriate responses to the unexpected on complex building, especially high-rise buildings.

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video source: youtube.com

CUBER is aimed for first responders to drastically shorten the time until potential survivors are found.

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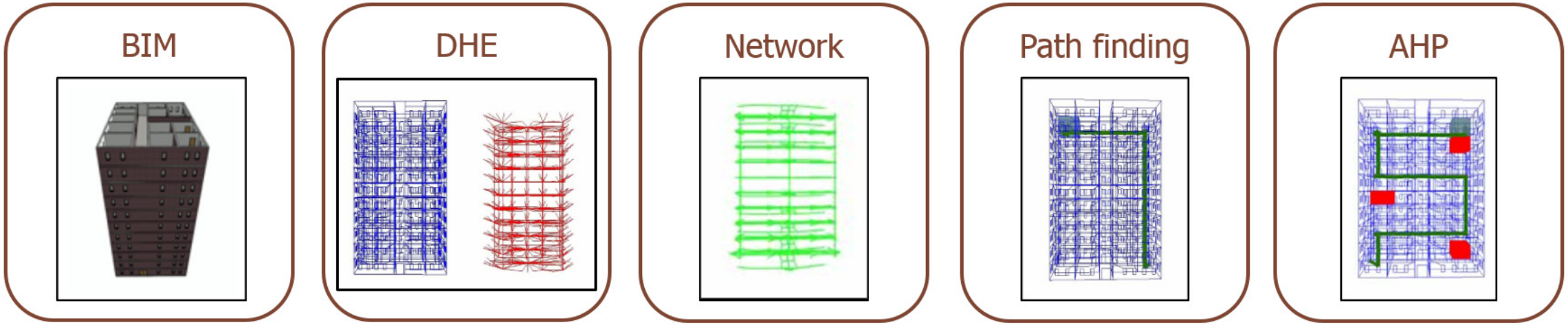

CUBER is a decision-support system for emergency preparedness and response to extreme events addressed to first responders in an emergency situation.

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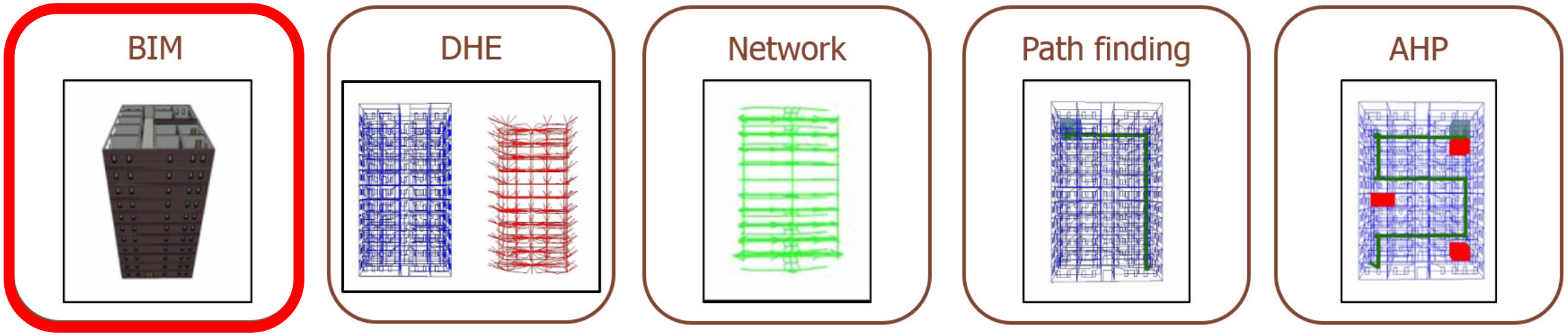

Input: a BIM model created in Autodesk Revit and exported to gbXML

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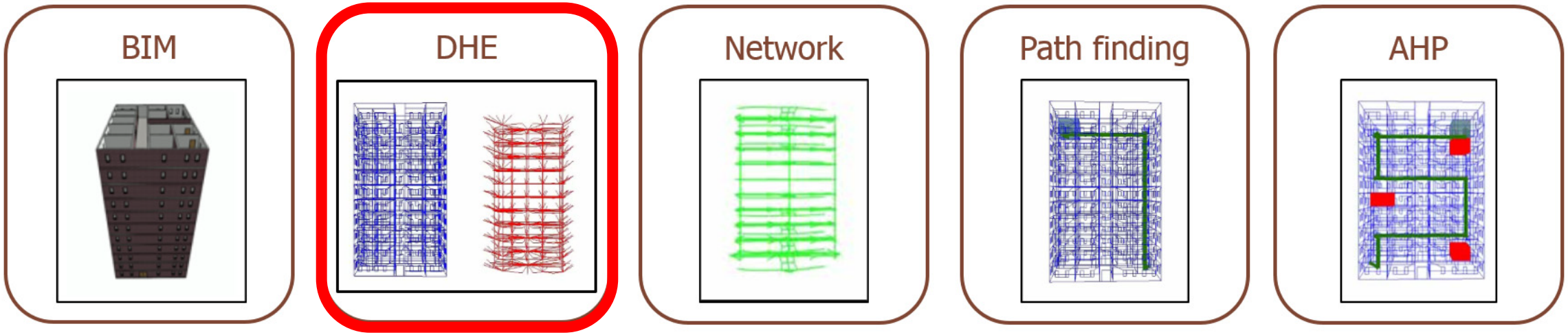

The dual half-edge (DHE) data structure is used to represent the 3D geometry and topology (logical network) of the model

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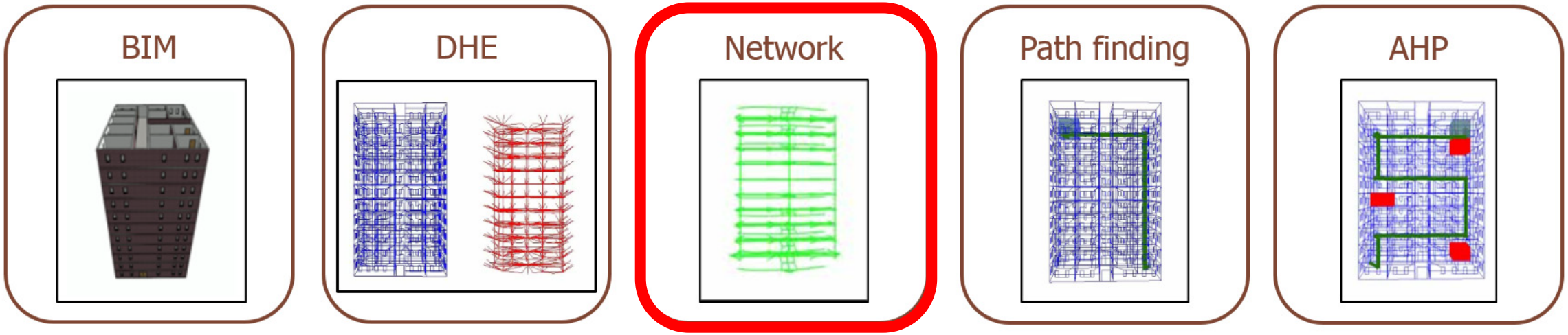

Navigable network is generated for a building based on Voronoi Diagram calculation.

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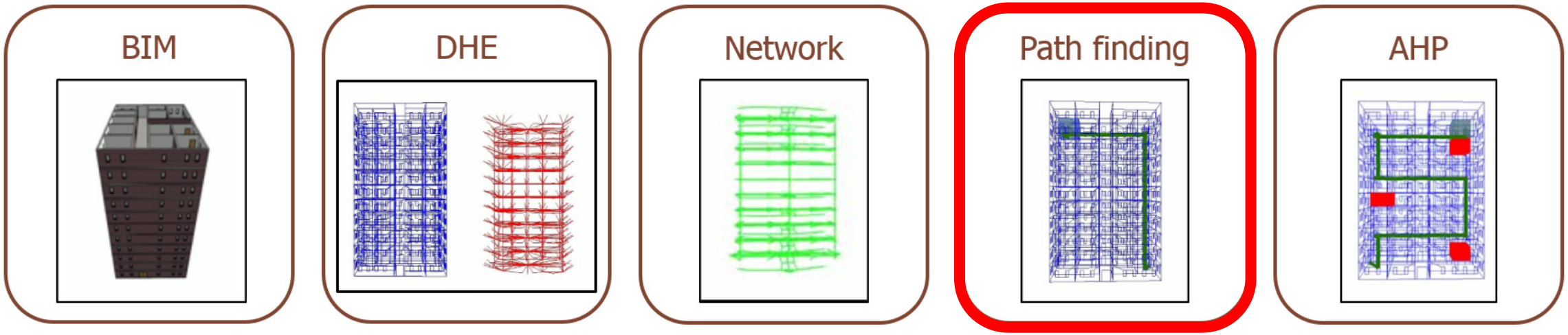

Dijkstra's algorithm is used to find indoor based on three criteria: distance/travel time, hazard proximity and route complexity

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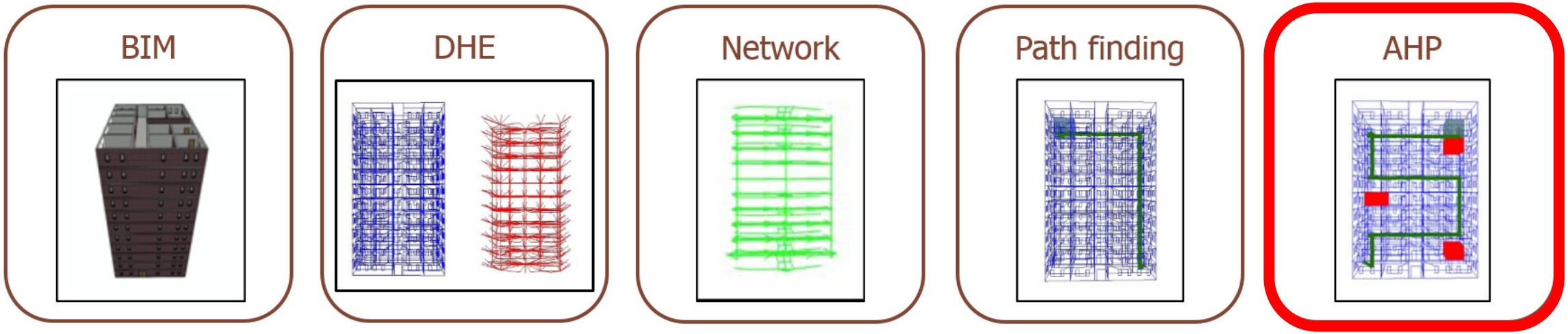

The decision-making technique, Analytic Hierarchy Process (AHP), is used for optimal path finding.

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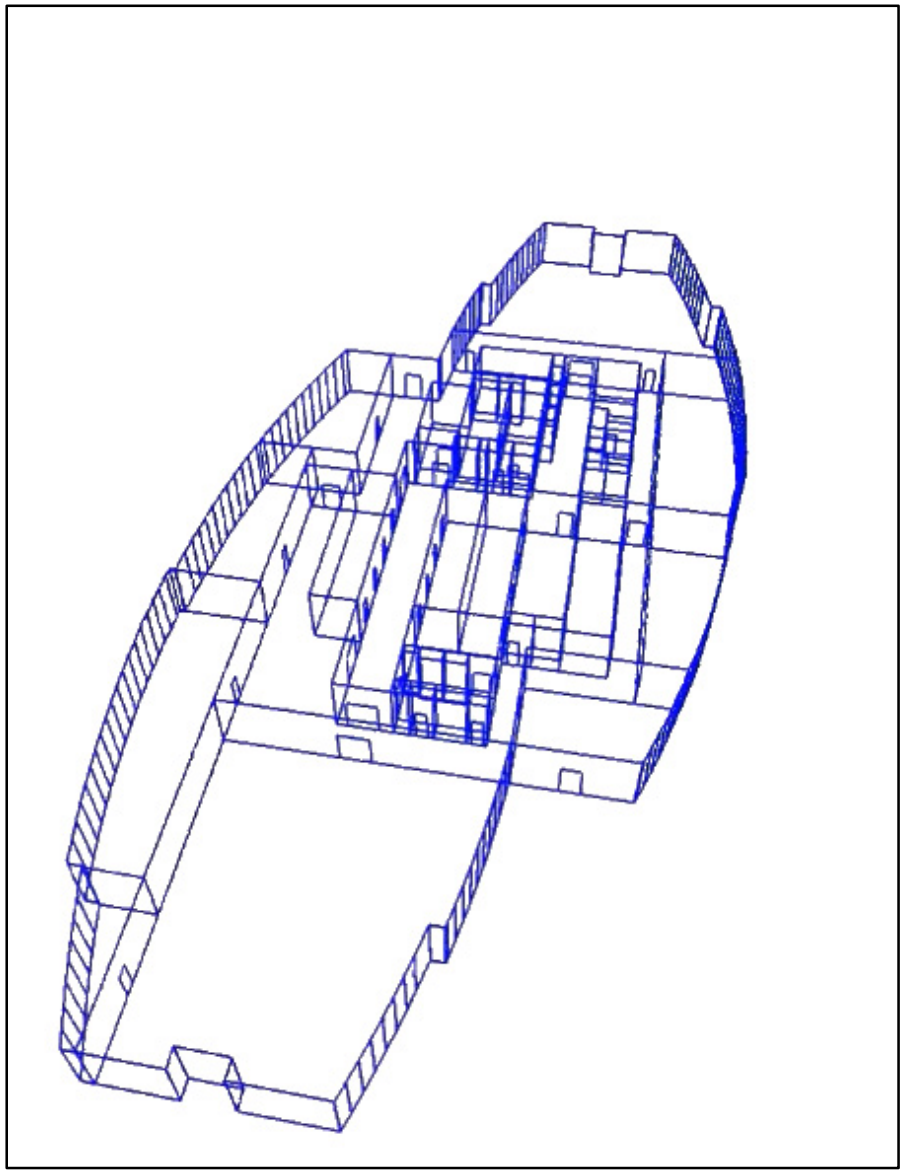
Full 3D model is reconstructed and consists of the following elements:

- Primal structure – represents the model geometry
- Dual structure – represents the model topology (logical network)
- Tessellation – critical spaces are tessellated in order to create a navigable network
- Navigable network is used for path finding



typical floor in World Trade Centre, Doha, Qatar

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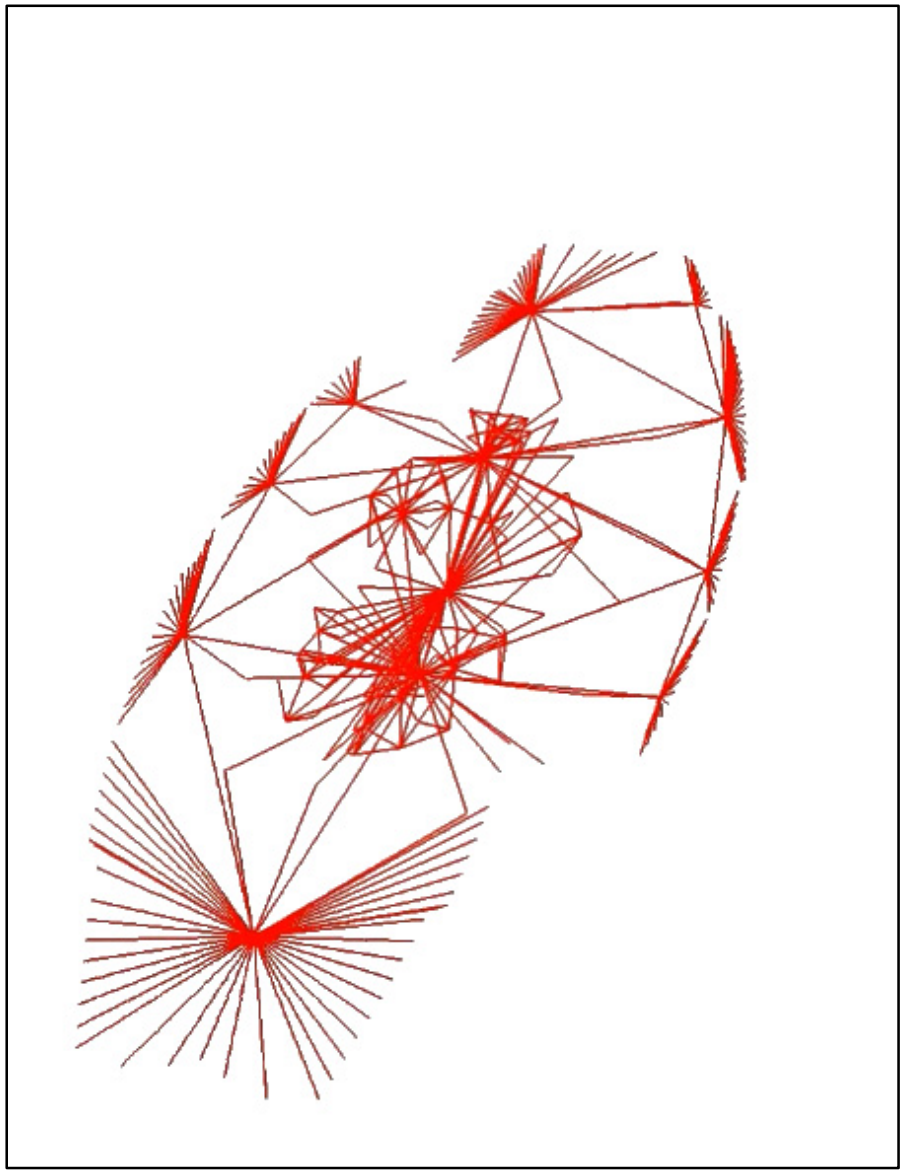

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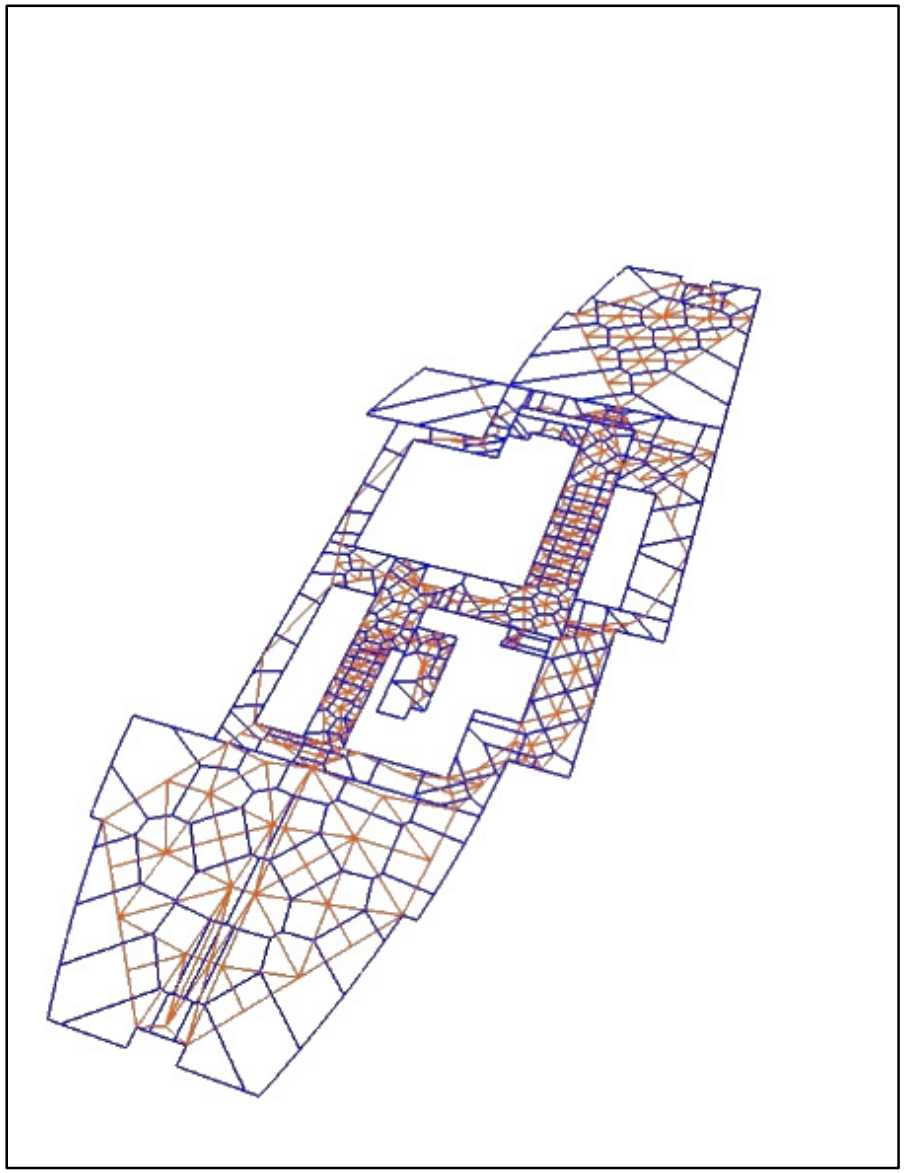

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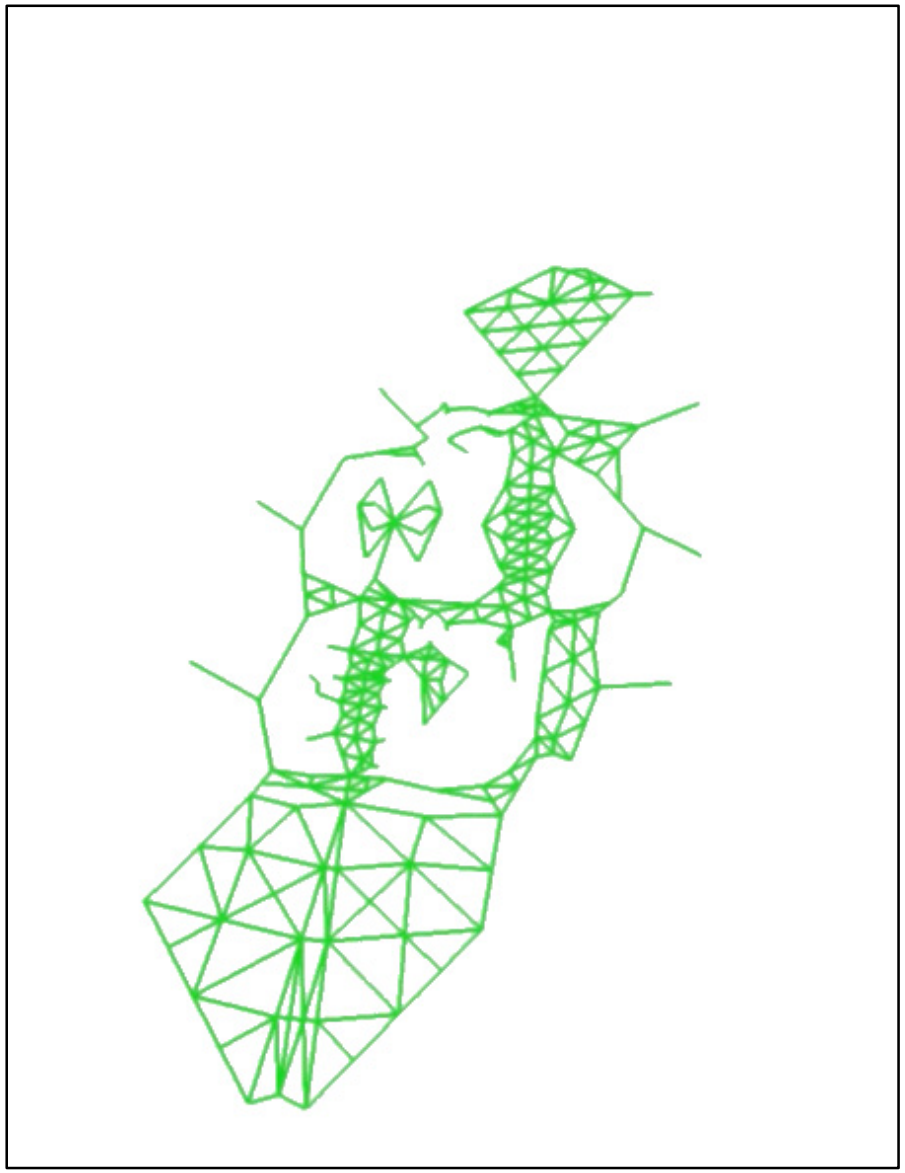

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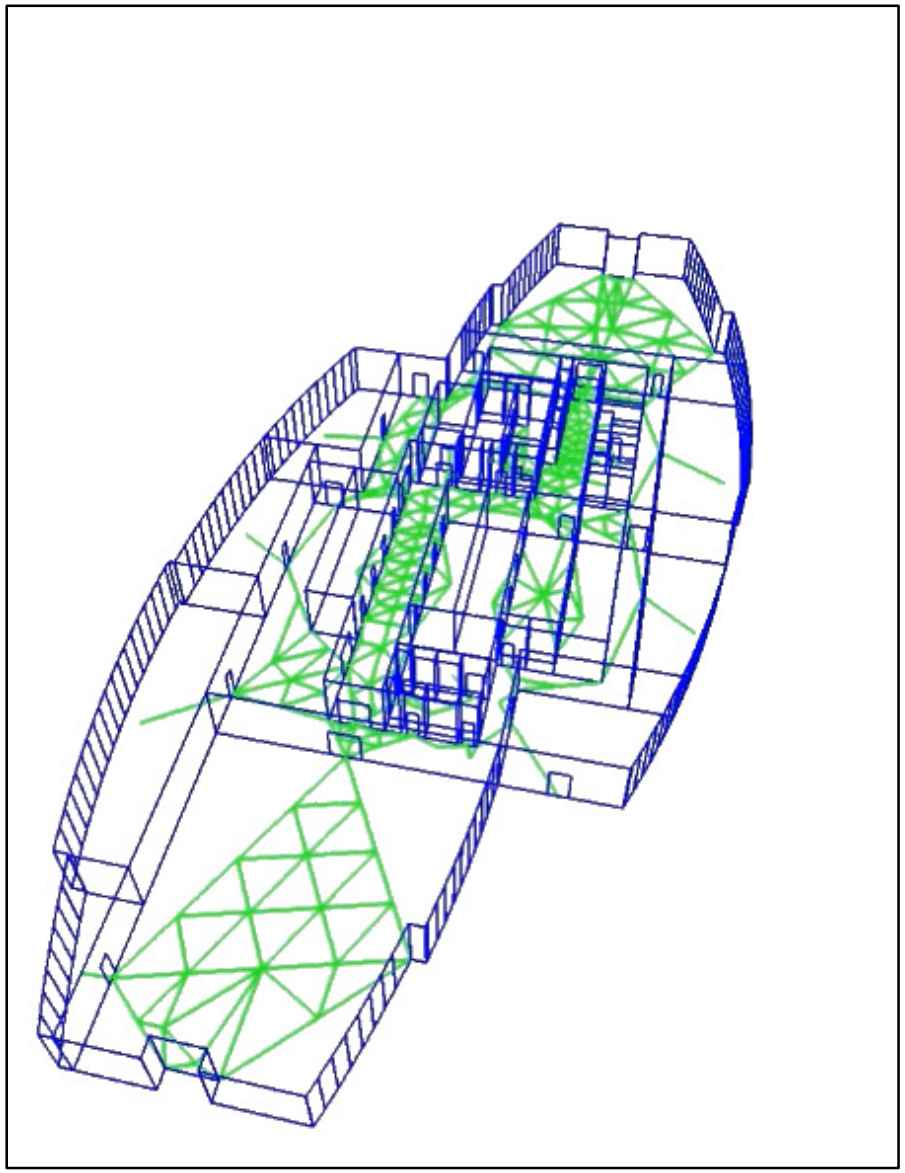

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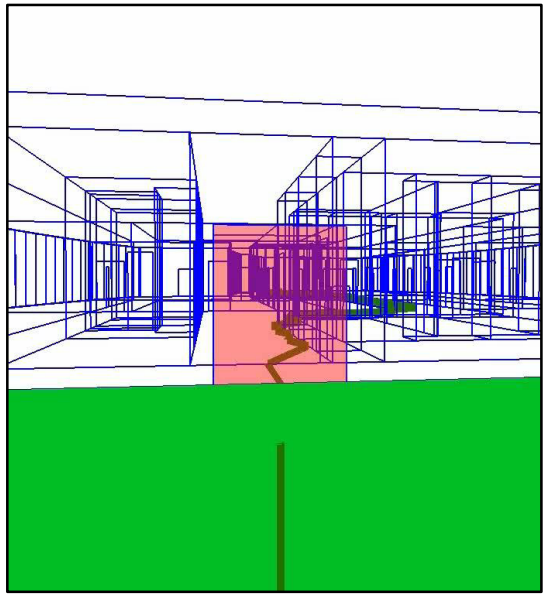

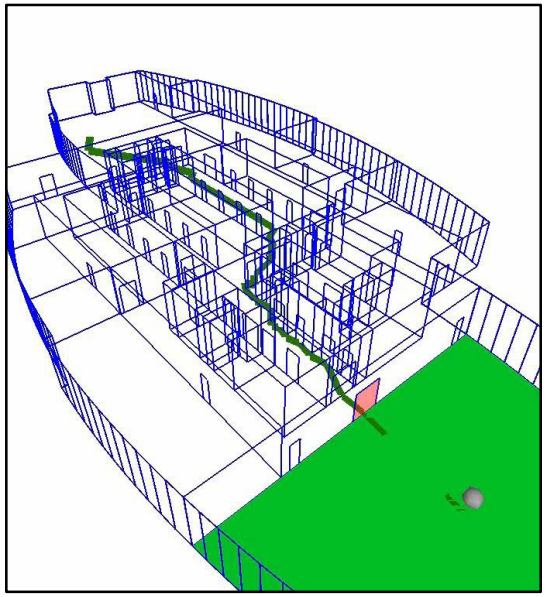

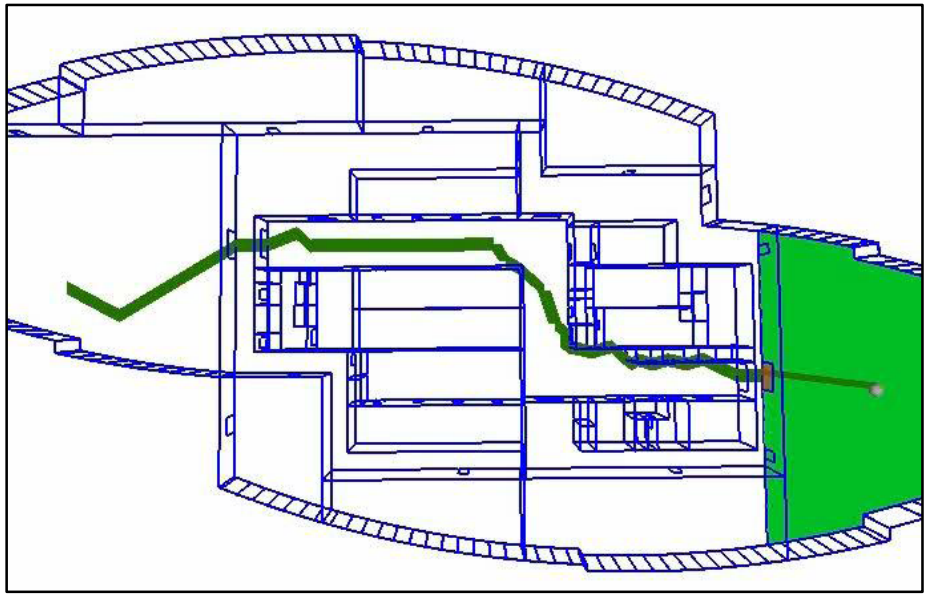

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A set of different paths is calculated taking into consideration hazard location and its propagation inside a building.

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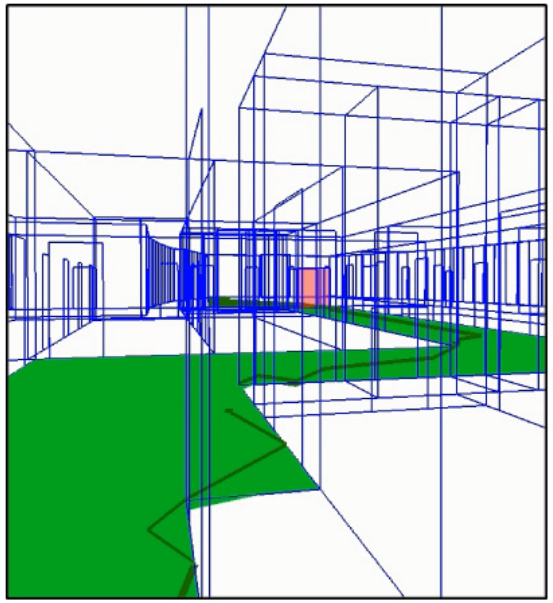

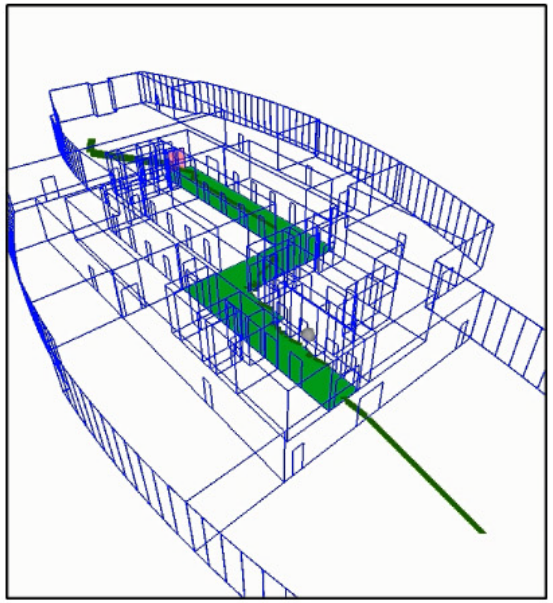

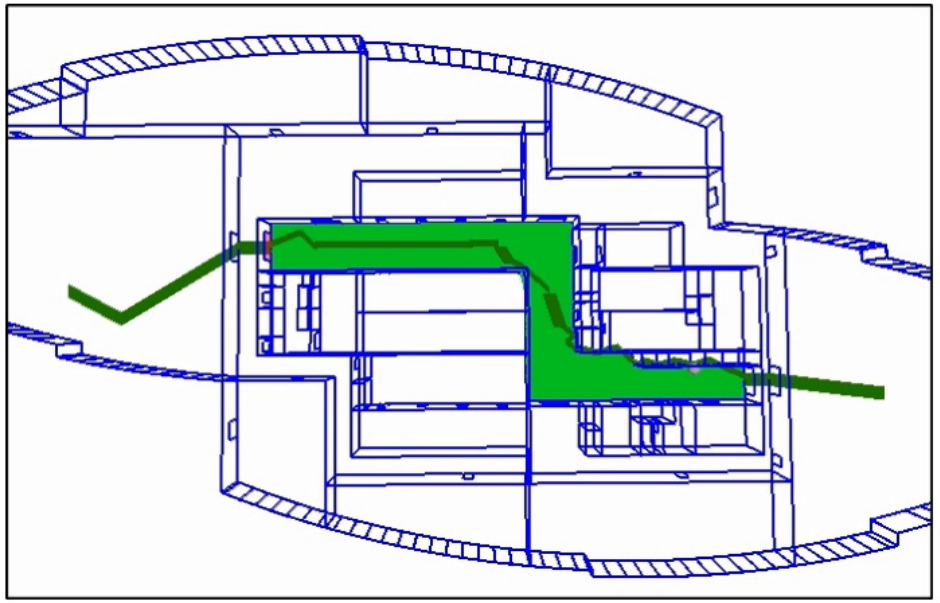

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The same path-finding algorithm, Dijkstra's algorithm, is used for different criteria, where different link weights in the navigable network are attached.

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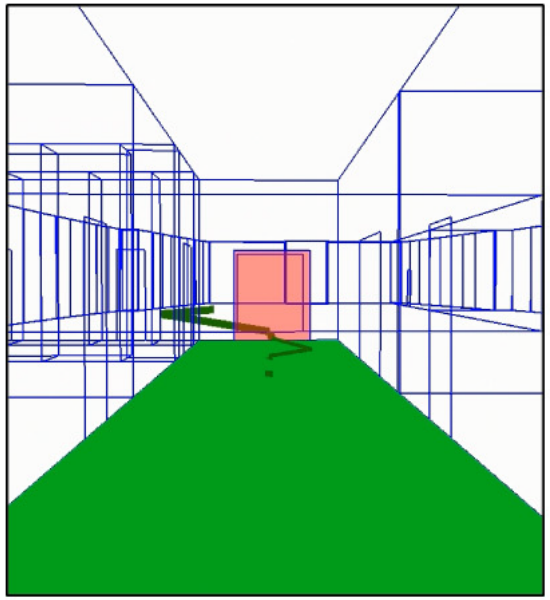

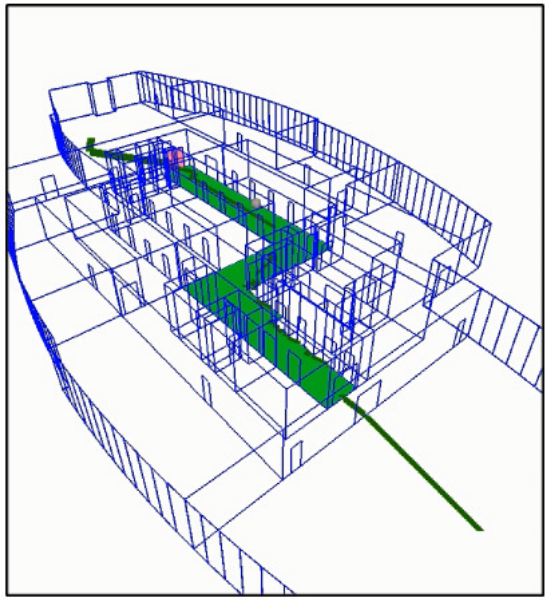

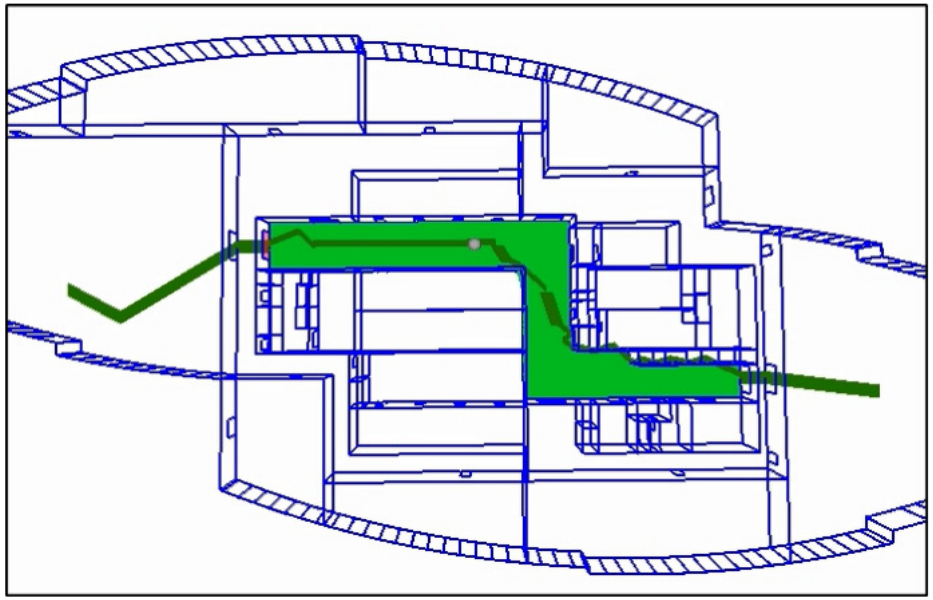

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An optimal path is selected using decision-making technique, which can be used by rescue personnel to avoid dangerous areas.

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Analytic Hierarchy Process (AHP) is an advanced decision-making technique developed for the US Government.

We developed a new stochastic version of AHP for optimal route finding based on three criteria: distance/travel time, hazard proximity and route complexity.

The algorithm produces the optimal route which is reasonably safe, short/quick and simple.

#	Source	Destination	Total Weight	Criterion	Tau	Length	Travel Time	Proximity Index	Complexity	AS
1	1627 VIP Office	ext	17075.535534	safest	1	154.607870676	170.755355347	1.804414969	6.027056852	0.0849842207
2	1627 VIP Office	ext	423.8563804	safest	1.424778775	222.793590231	227.391077509	4.189940143	8.560282454	0.0944414506
3	1627 VIP Office	ext	2673.435638	safest	1.188601985	206.517880626	213.809877905	3.629830783	7.685276175	0.0838643396
4	1627 VIP Office	ext	9839.374043	safest	1.057678222	183.304374625	194.639693670	3.610386773	7.348687384	0.0930768627
5	1627 VIP Office	ext	2974.741562	safest	1.177034169	206.375146576	213.690774058	3.630743410	7.652233623	0.0840778413
6	1627 VIP Office	ext	1196.998786	safest	1.283329018	222.584149601	227.216310628	4.137320210	8.275519238	0.0934435572
7	1627 VIP Office	ext	568.2689330	simplest	1	157.661447542	173.303400128	1.698964776	5.682689330	0.0856129693
8	1627 VIP Office	ext	59.82305345	simplest	1.300178672	207.352510205	214.506331159	3.892905606	7.250380524	0.0935544407
9	1627 VIP Office	ext	223.5623618	simplest	1.106245398	185.729099256	196.662995265	3.799850287	6.712226585	0.1013841227
10	1627 VIP Office	ext	340.5687638	simplest	1.058776855	198.380967650	207.220295327	3.158722285	6.364008519	0.0828061020
11	1627 VIP Office	ext	62.37127253	simplest	1.292355971	184.440675787	195.587875547	3.821523984	6.685939483	0.1027540926

Typical output with the optimal path