Development R&D Review

Automated Grouping
Model Extraction from BIM Data
Unified Fire-Egress Visualization

Pathfinder

PyroSim

Recent Development Work

- PyroSim
  - Updated Simulator Support: FDS 5.5, 5.6, 5.7
  - Preview Support for FDS 7 Complex Geometry
  - AutoCAD 2018 File Import
  - Support for Complex Reactions
  - Combined Fire/Evac Results Viewer Application

Recent Development Work

- Pathfinder
  - Assisted Evacuation
    - Vehicle Agents, Assistance Teams
    - Refuge Rooms
    - Maximum Room Capacities
  - Simulator Enhancements
    - Occupant Sources
    - Movement Groups
    - Optional Radius Reduction for Narrow Geometry (Stadium Seating)
    - Time-Based One-Way Doors
    - Door Wait Times
    - FED Calculation Improvements
    - Console Scripting – Multiple Randomized Runs (Monte Carlo)

Recent Development Work

- Pathfinder (more)
  - Enhanced Behaviors
    - Wait-Until
    - Behavior Switching
  - Enhanced Profiles
    - Control of Stair/Elevator/Component Use
    - Profile Libraries
  - Elevator Improvements
    - Automatic Agent Use
    - Park Location and Call Distance
    - Double-Deck Elevators
  - User Interface
    - Re-randomize Occupant Location
    - Reduce Room Population

Recent Development Work

- Bundled Results Viewer
  - Integrated Fire/Movement Visualization
  - Unified View/Section/Tour Specification
  - New 3D Occupant Models
  - Time Offset for Result Datasets
  - Improved Lighting
  - Hardware GPU Shaders
  - Dedicated GPU Priority
  - Preview Support for VR Headsets

Technical Background

- Grouping in Pathfinder
- BIM-Based Auto Model Generation
- Unified Fire & Movement Visualization

Movement Groups

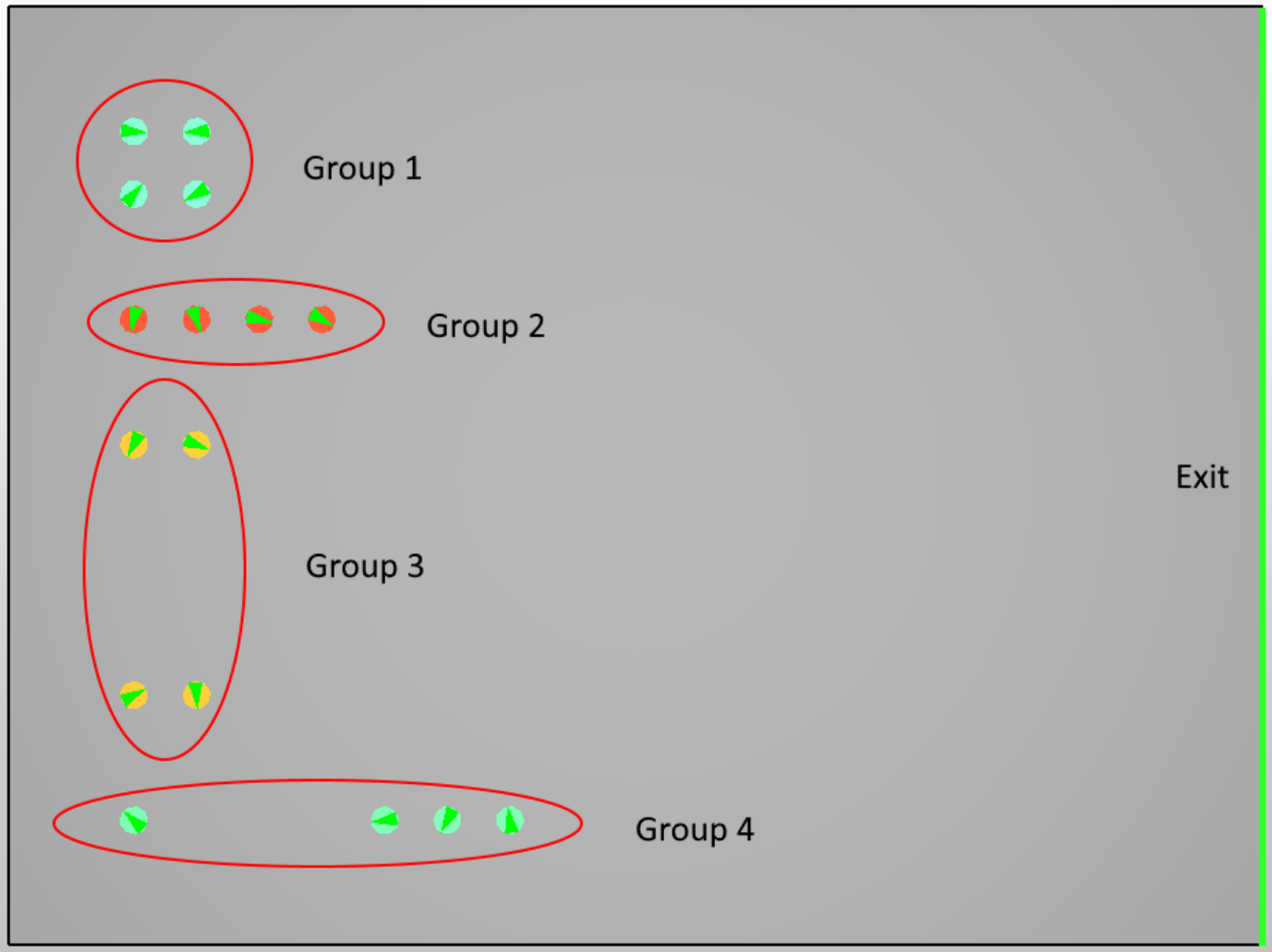
- Introduced in Pathfinder 2018.1
- Implemented a Model of Group Movement
- Occupants with Common Goal
- Supports Automatic Group Creation
- Works with Large Crowds
- Presented at PED 2018 (Lund, Sweden)

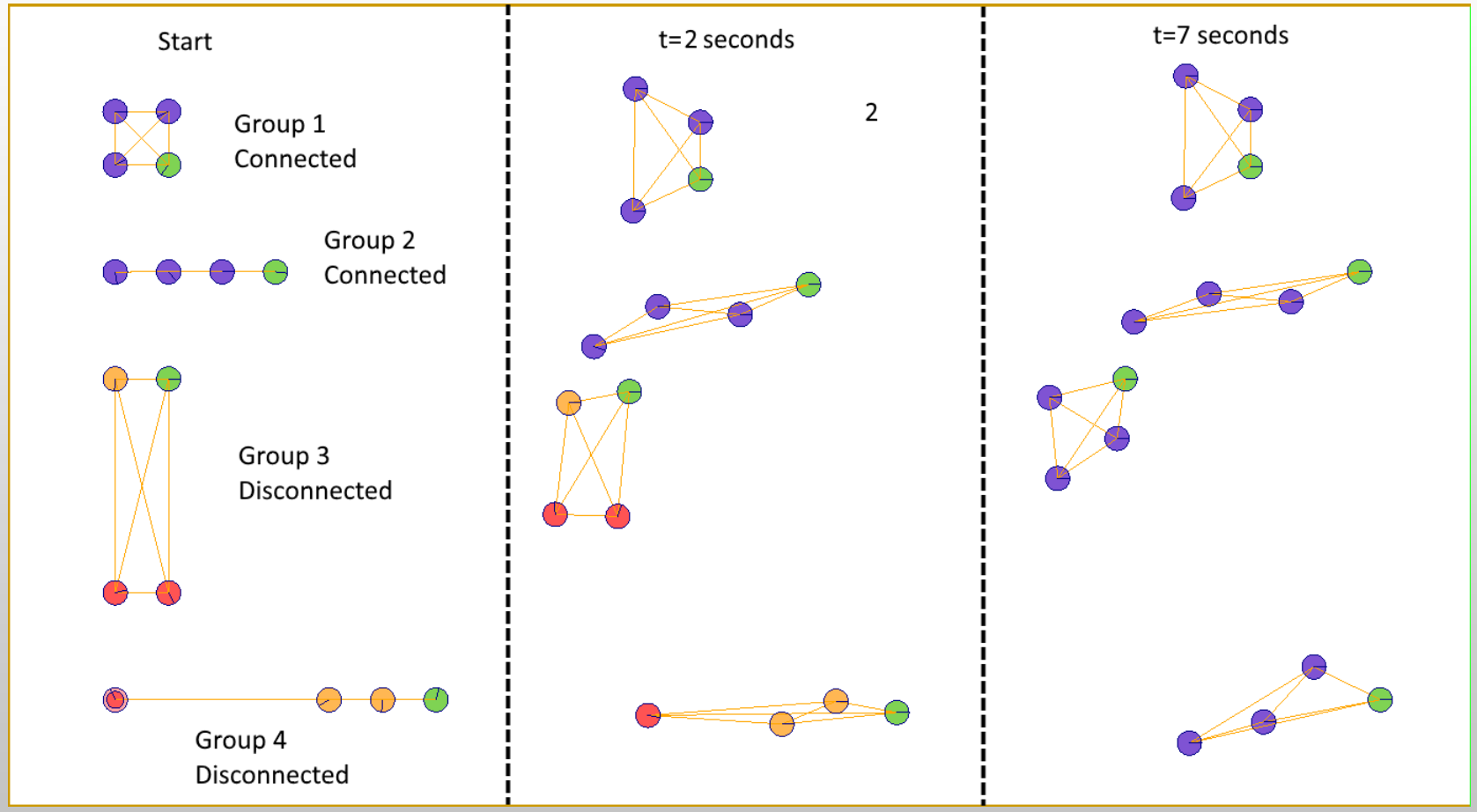
Group Movement Model

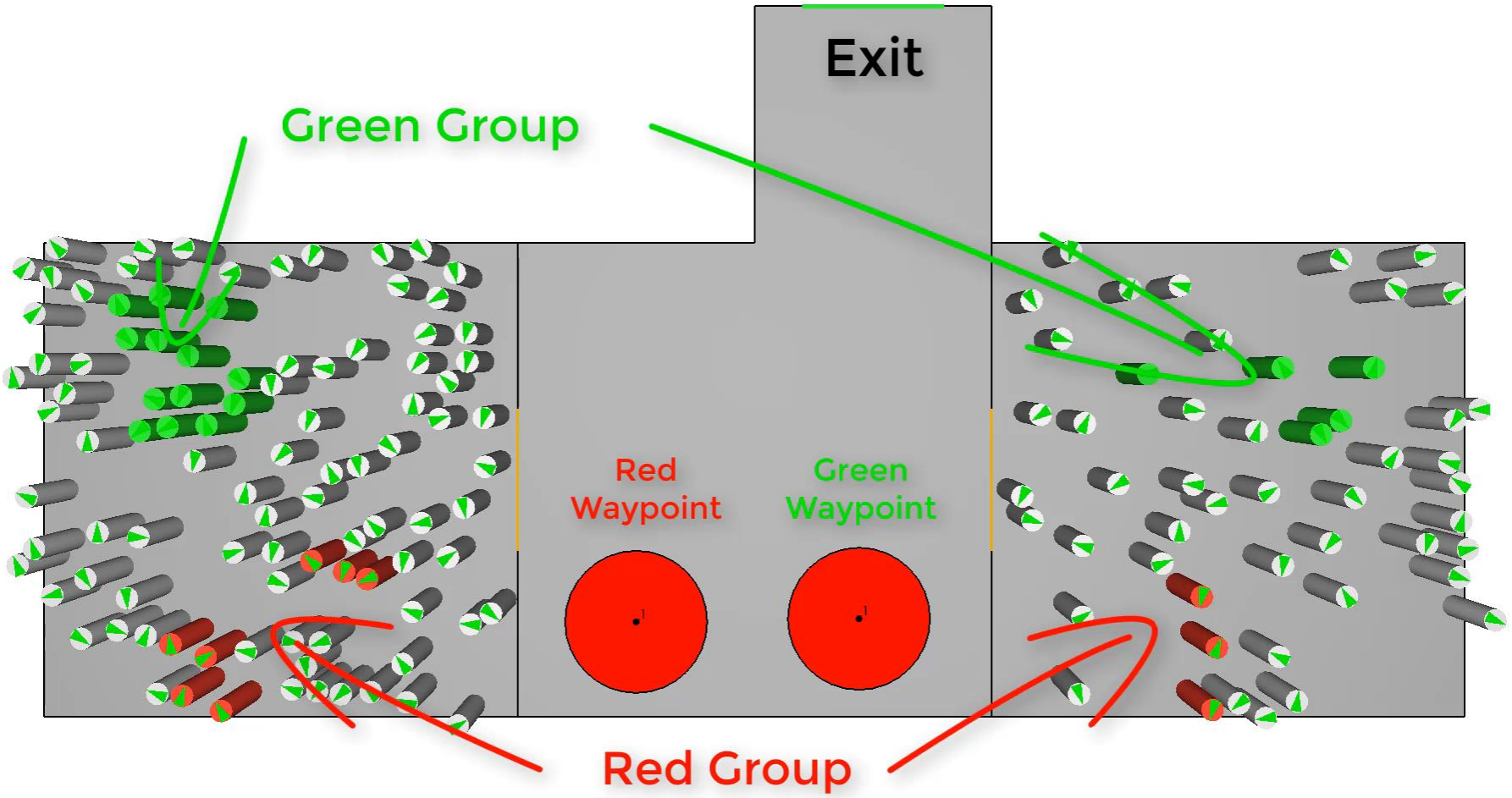
- Leader-Follower Movement Model
  - Leader (can be automatic)
  - Members
  - Maximum Connection Distance
  - Group Moves at Slowest Member Speed

Disconnected Groups

- Group is in *Disconnected* state when a member has exceeded the *Maximum Distance*
- Leader Identified if Automatic
  - Member closest to goal
- Leader Slows and Waits
  - *Slowdown Time* parameter controls Leader
  - Exception in Dense Crowds
- Seek Closest Connected Member
- Continue Movement at Slowest Speed after Connection


Group 1
Group 2
Group 3
Group 4
Exit


Start
Group 1
Connected
Group 2
Connected
Group 3
Disconnected
Group 4
Disconnected
t=2 seconds
2
t=7 seconds

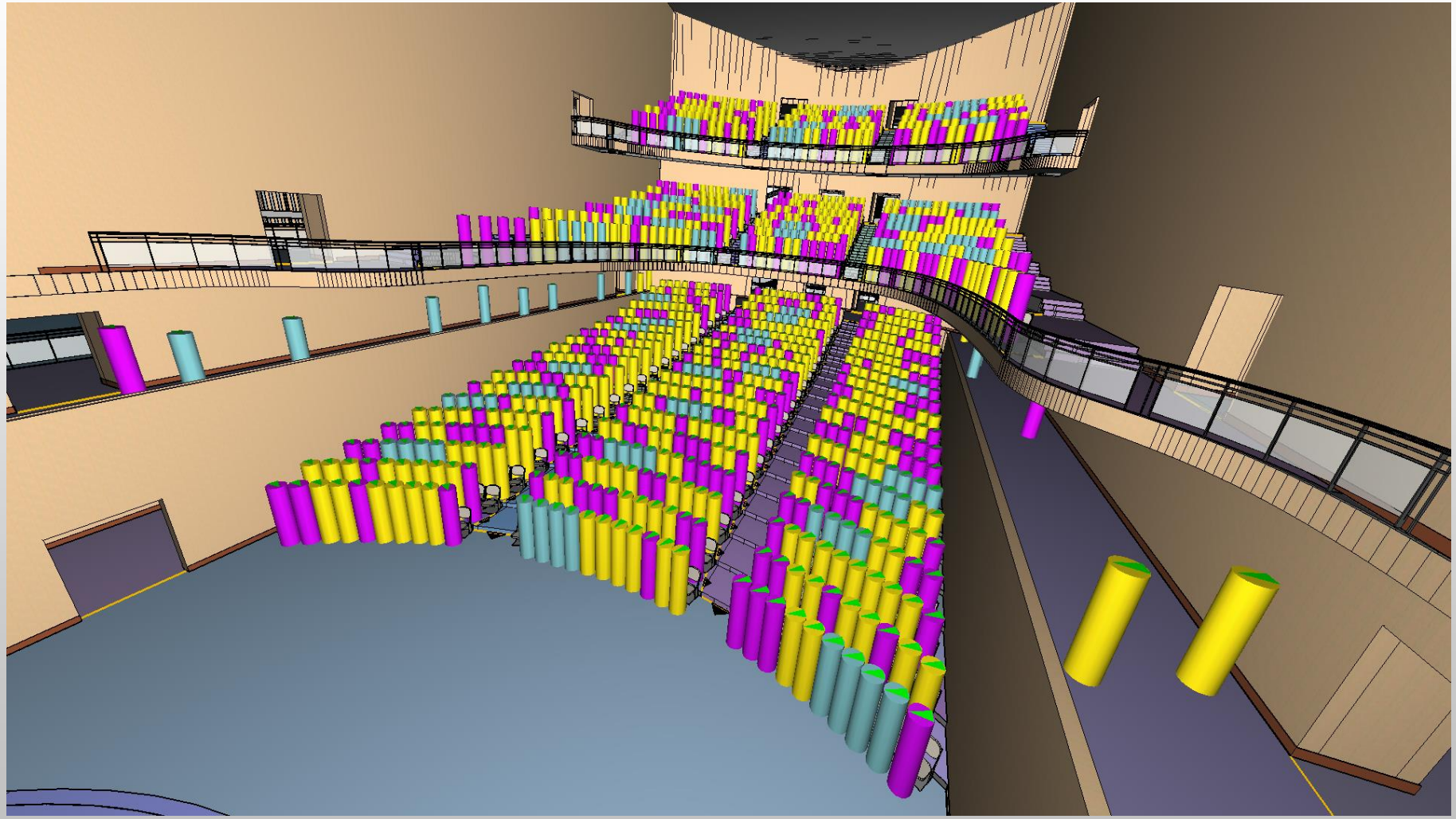

Exit
Green Group
Red
Waypoint
Green
Waypoint
Red Group

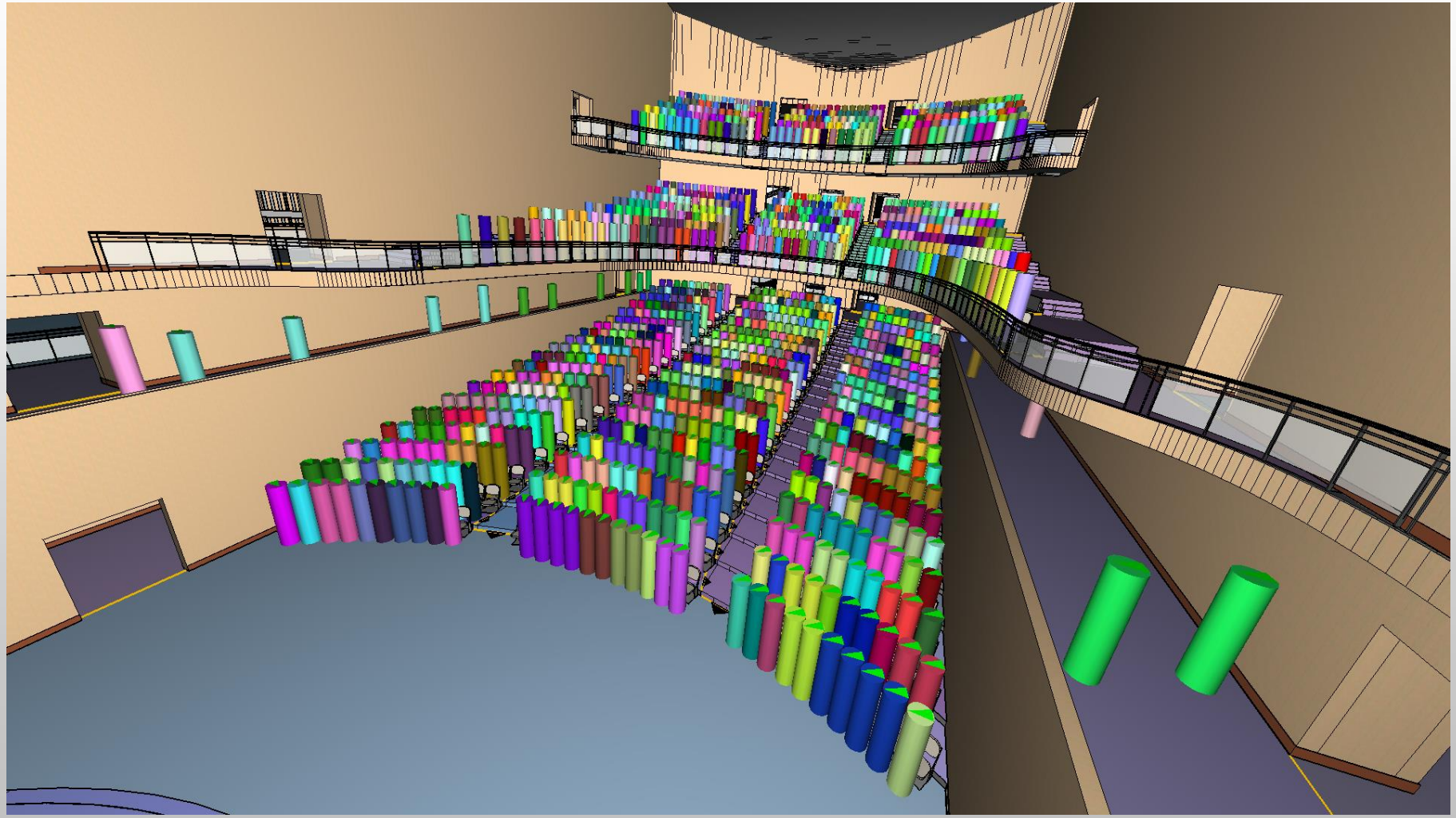
Automatic Group Definition

- Based on K-means clustering data mining algorithm
- Data Points added to Clusters based on similarity
  - Data Points assigned to most similar cluster
  - Clusters adjusted to best fit assigned points
  - Iterate to until convergence
- Uses *same-size k-means* variant
  - Groups as clusters, Occupants as data points
  - Similarity measure is Euclidian or Travel Distance
  - Constrained by Room or Reachability

Automatic Grouping

- Minimizes Mutual Group Distance
- Ensures Members Can Reach Each Other
- Group Membership Can Be Defined
  - Ex: 2 Adults, 2 Children
- Distribution of Groups Can Be Defined
- Fast Creation of Thousands of Groups





Model Generation from BIM Data

- What is BIM?

- From Autodesk…

AEC / OVERVIEW INDUSTRIES CONTENT HUB

What is BIM?

BIM (Building Information Modeling) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure.

Get started with BIM

What is BIM?

Definition
The US National Building Information Model Standard Project Committee has the following definition:

Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.[19]

Essentially: BIM is a full, 3-dimensional, digital model of a building, including data and attributes – a building database.

Model Generation from BIM

- Previously, Used Flood-Fill Algorithm
  - Extract one large room
  - User must break apart and create doors
- From BIM
  - Import IFC File
  - Build Geometry Using BIM Object Types

BIM Object Types

Object Type	Pathfinder Type
Slab Covering / FLOORING Transport Element / MOVINGWALKWAY	Room
Door	Door
Stair Transport Element / ESCALATOR	Stair

General Extraction Method

1. Find all Walking Surfaces (slope < tol)
2. Find Obstructions and extrude / intersect / remove
3. Delete disconnected Walking Surfaces inside objects
4. Close small gaps
5. Delete small rooms
6. Generate Stairs
7. Generate Doors
8. Cleanup

Generate Stairs

1. Identify Steps from Walking Surfaces
2. Project to find unobstructed, connected edges of Steps
3. For runs with equal rise/run, create Pathfinder Stair

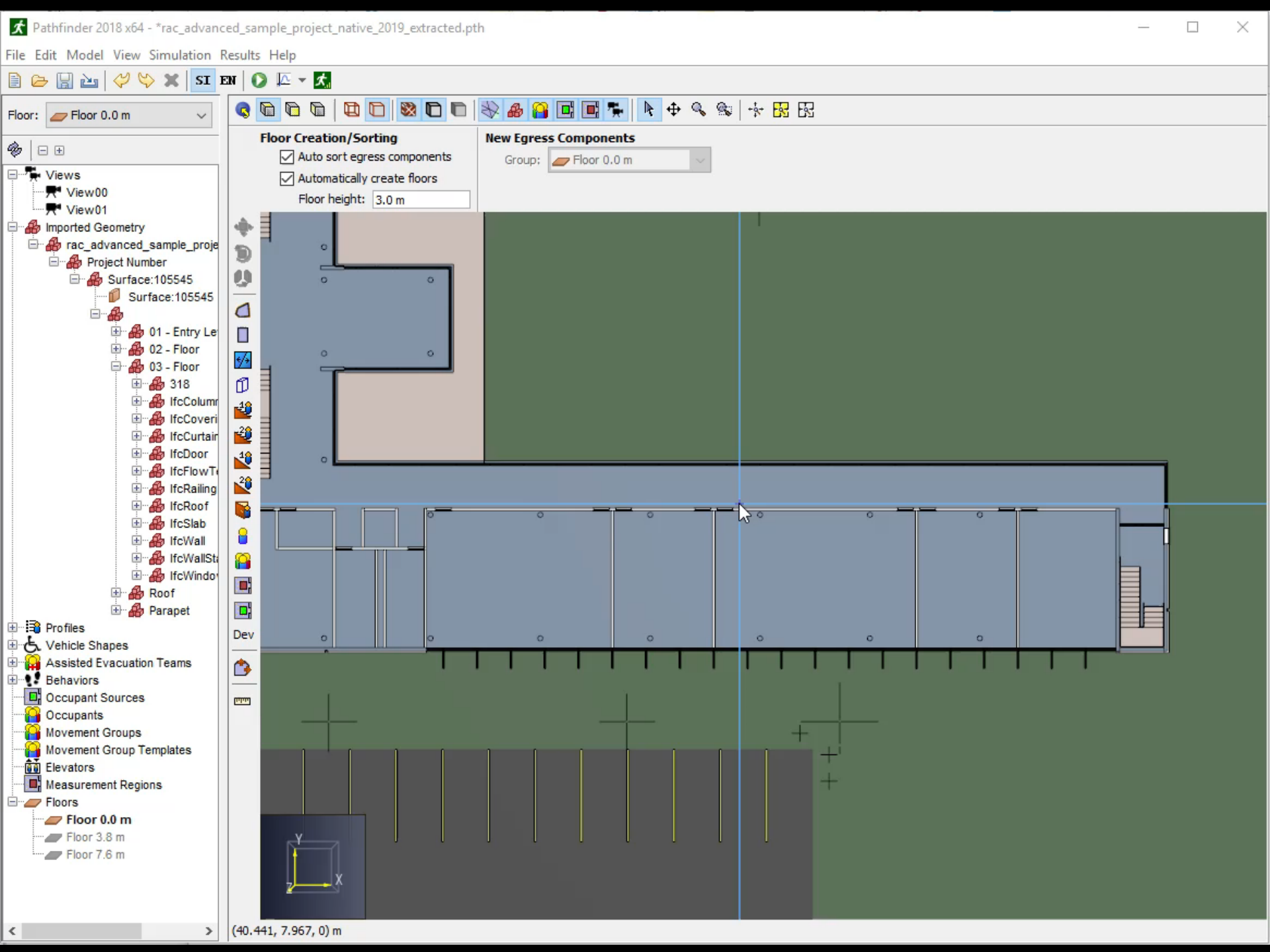
Generate Doors

1. Get geometry for imported Door objects
   a. Wall Opening <or> Door Geometry
2. Obtain Door bounding box from geometry
3. Modify bounding box for door thickness
   a. IFC local y-axis
   b. Minimum door dimension
4. Subtract extruded geometry from Walking Surfaces
5. Connected resulting intersected edges with a Pathfinder Door

Future Model Generation Work

- Automatic generation for non-BIM files
  - Can manually tag objects now
  - Automatically detect stairs, doors, etc.
- Support future BIM data for movement models
  - Occupancy information
  - Other movement metadata

BIM Import Examples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Profiles
Vehicle Shapes
Assisted Evacuation Teams
Behaviors
Occupant Sources
Occupants
Movement Groups
Movement Group Templates
Elevators
Measurement Regions
Floors
Floor 0.0 m
Floor 3.8 m
Floor 7.6 m
Floor Creation/Sorting
Auto sort egress components
Automatically create floors
Floor height: 3.0 m
New Egress Components
Group: Floor 0.0 m
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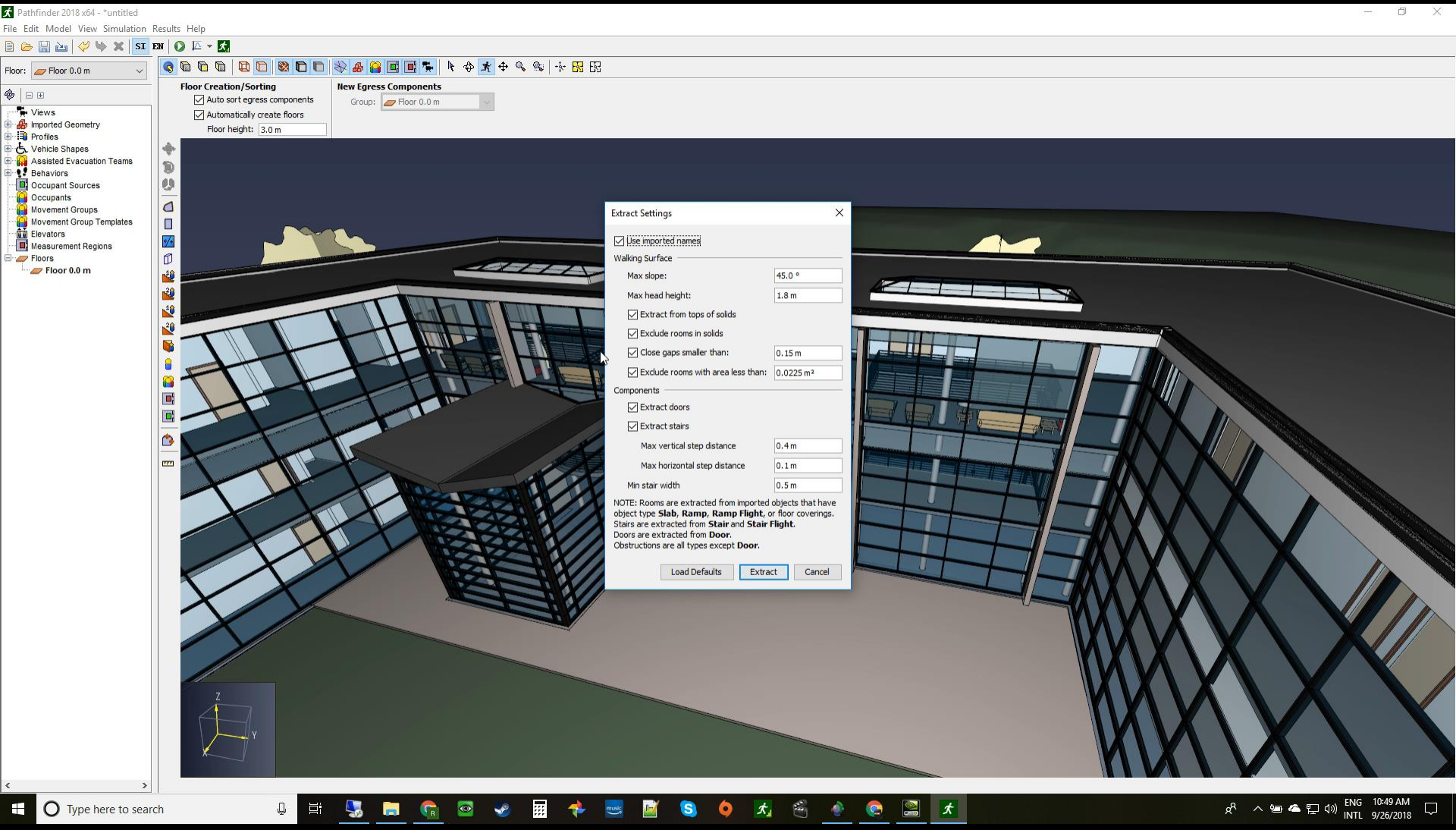
(40.441, 7.967, 0) m


Pathfinder 2018 x64 - *untitled
File Edit Model View Simulation Results Help
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Vehicle Shapes
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Floor height: 3.0 m
New Egress Components
Group: Floor 0.0 m
Extract Settings
Use imported names
Walking Surface
Max slope: 45.0 °
Max head height: 1.8 m
Extract from tops of solids
Exclude rooms in solids
Close gaps smaller than: 0.15 m
Exclude rooms with area less than: 0.0225 m²
Components
Extract doors
Extract stairs
Max vertical step distance 0.4 m
Max horizontal step distance 0.1 m
Min stair width 0.5 m
NOTE: Rooms are extracted from imported objects that have object type Slab, Ramp, Ramp Flight, or floor coverings.
Stairs are extracted from Stair and Stair Flight.
Doors are extracted from Door.
Obstructions are all types except Door.
Load Defaults
Extract
Cancel
Z
Y
X
Type here to search
ENG INTL
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9/26/2018

Pathfinder 2018 x64 - untitled

File Edit Model View Simulation Results Help

Floor: Floor 0.0 m

- Views
- Imported Geometry
- Profiles
- Vehicle Shapes
- Assisted Evacuation Teams
- Behaviors
- Occupant Sources
- Occupants
- Movement Groups
- Movement Group Templates
- Elevators
- Measurement Regions
- Floors
  - Floor 0.0 m

Floor Creation/Sorting

Auto sort egress components

Automatically create floors

Floor height: 3.0 m

New Egress Components

Group: Floor 0.0 m

Movement Speed Factor: 1 (Ctrl+scroll wheel to change); Click-drag to look; [W][S][A][D] to move; [C] to move down; [Space] to move up

Pathfinder 2018 x64 - *untitled

File Edit Model View Simulation Results Help

Floor: Floor -3.0 m

- Views
- Imported Geometry
- Profiles
- Vehicle Shapes
- Assisted Evacuation Teams
- Behaviors
- Occupant Sources
- Occupants
- Movement Groups
- Movement Group Templates
- Elevators
- Measurement Regions
- Floors
  - Floor -3.0 m
  - Floor 0.0 m
  - Floor 3.0 m

Floor Creation/Sorting

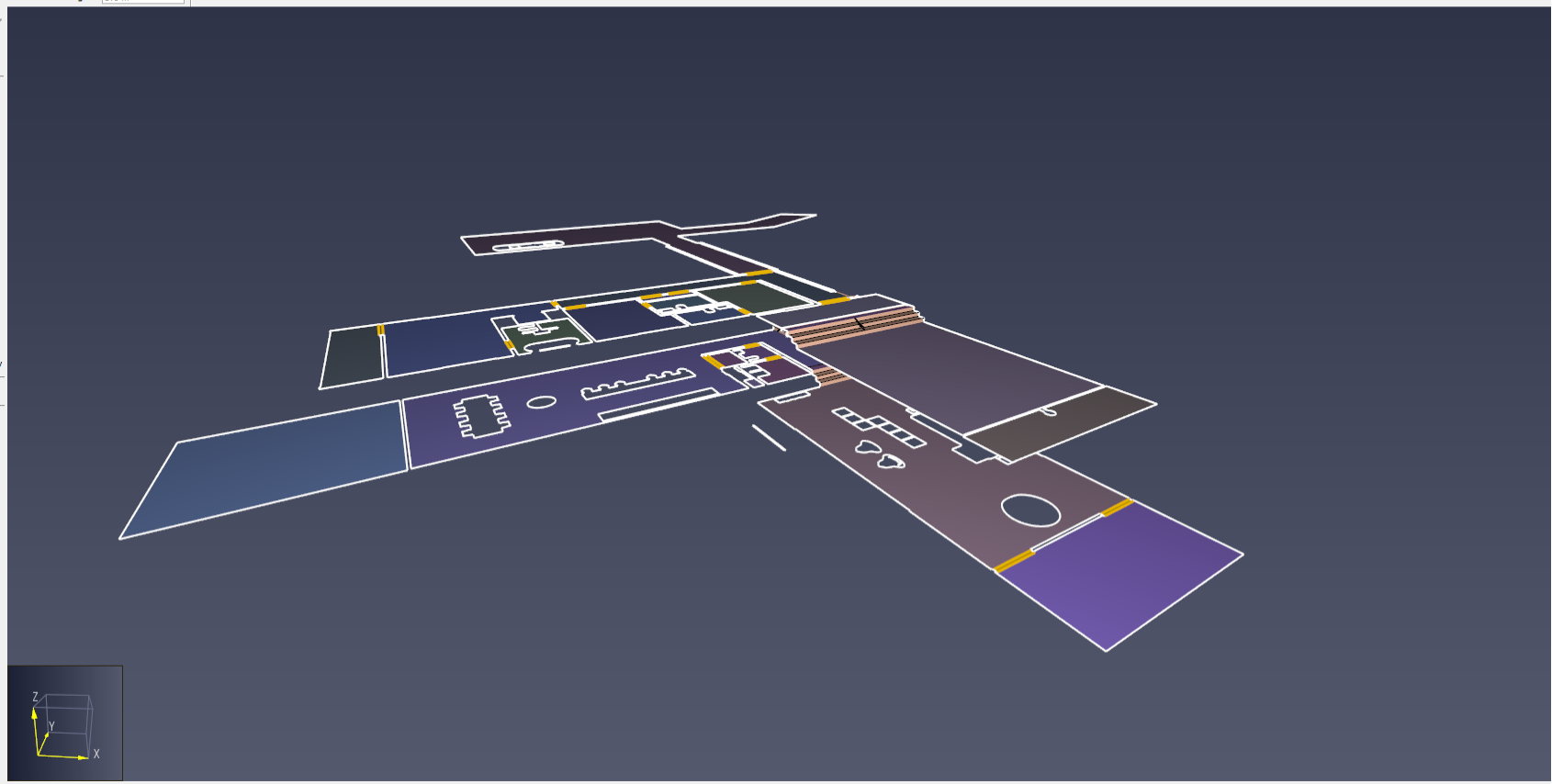
Auto sort egress components

Automatically create floors

Floor height: 3.0 m

New Egress Components

Group: Floor -3.0 m



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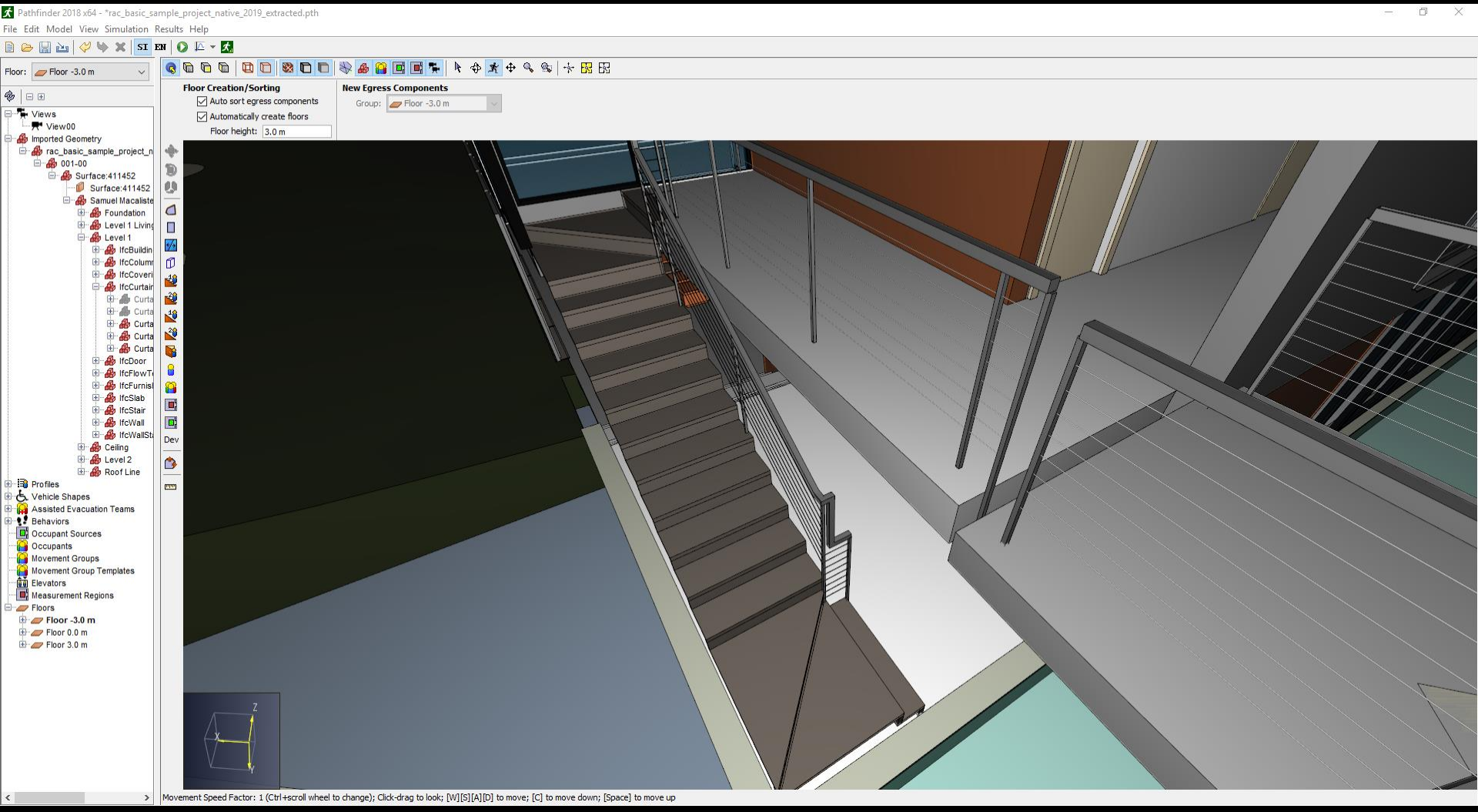
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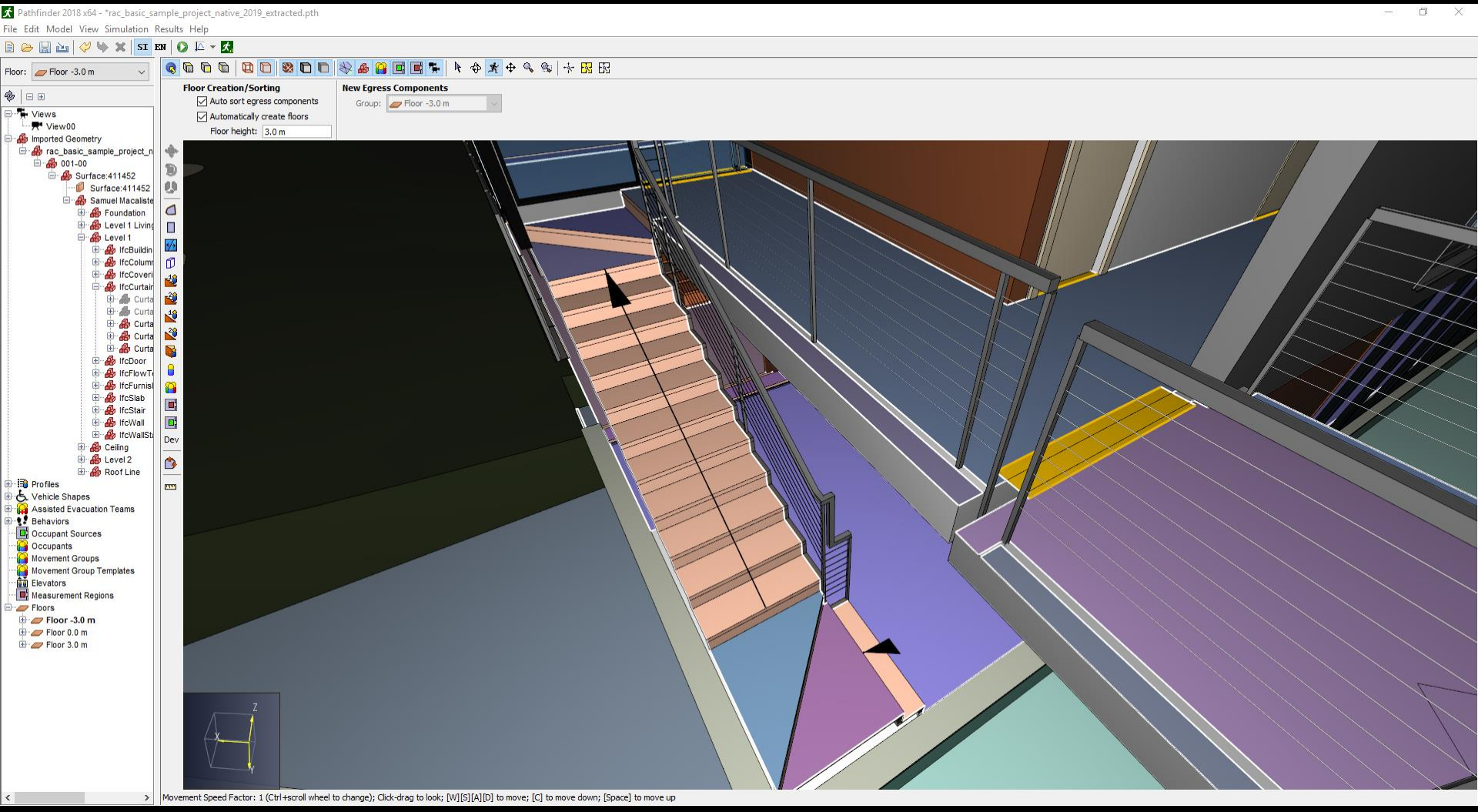
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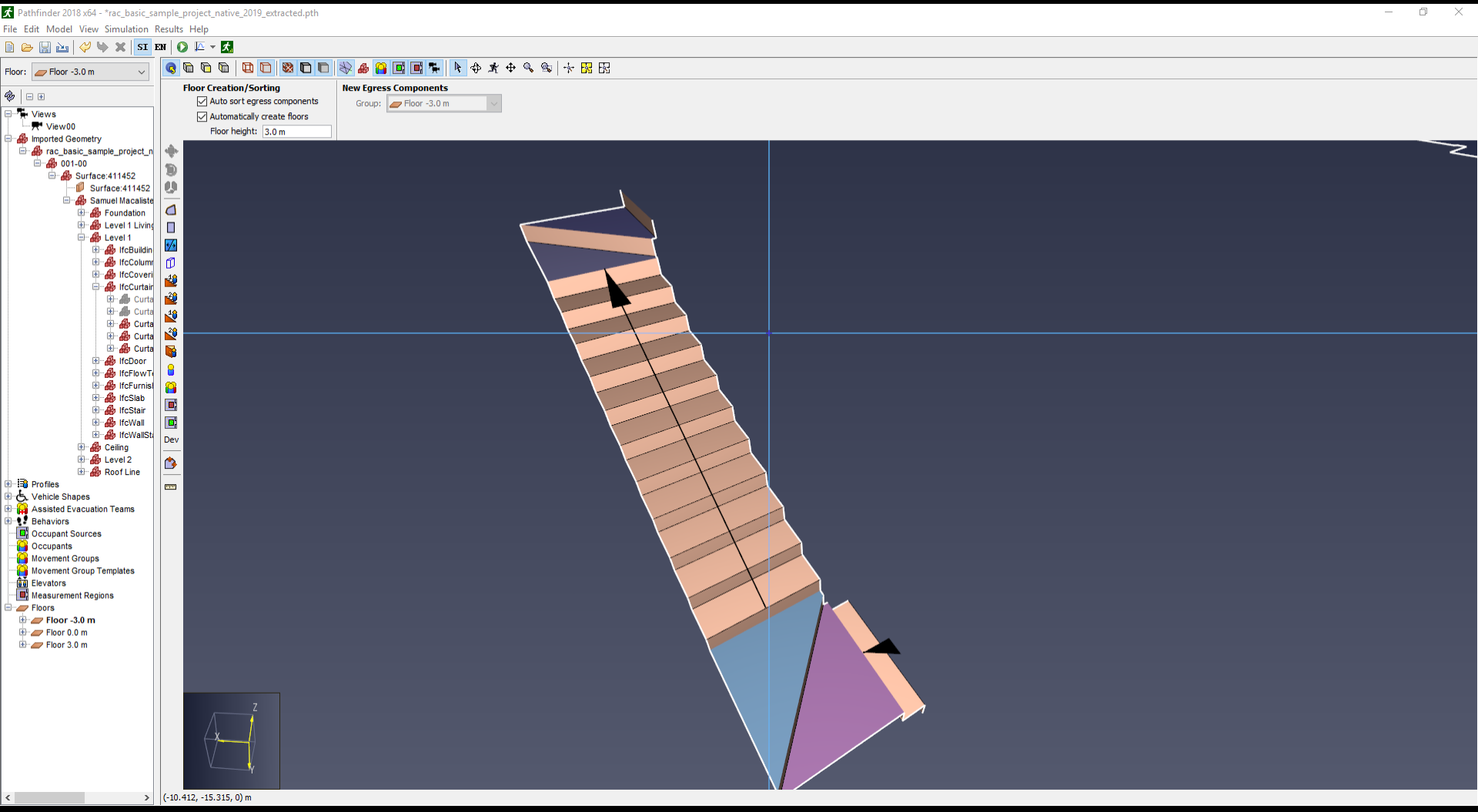
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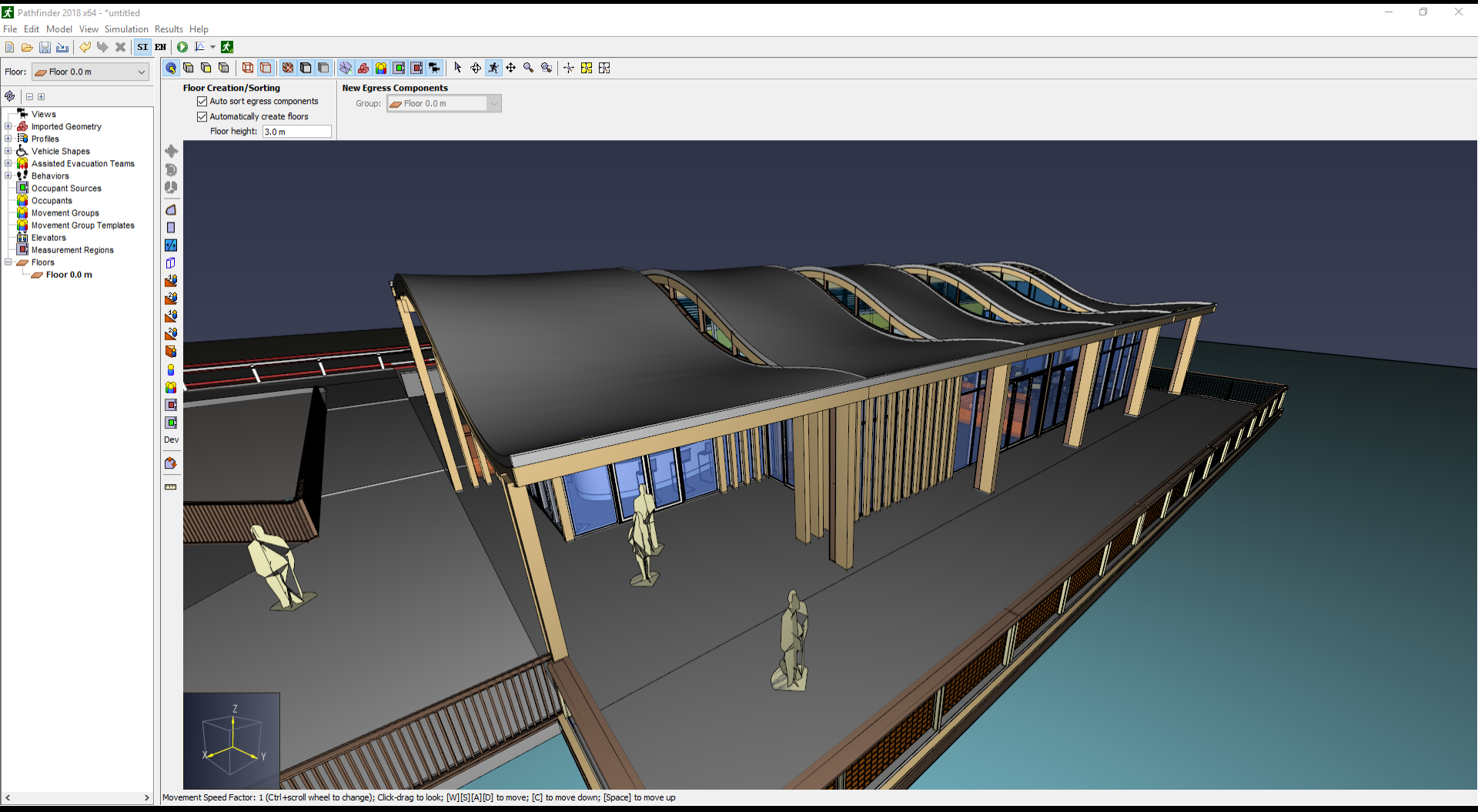
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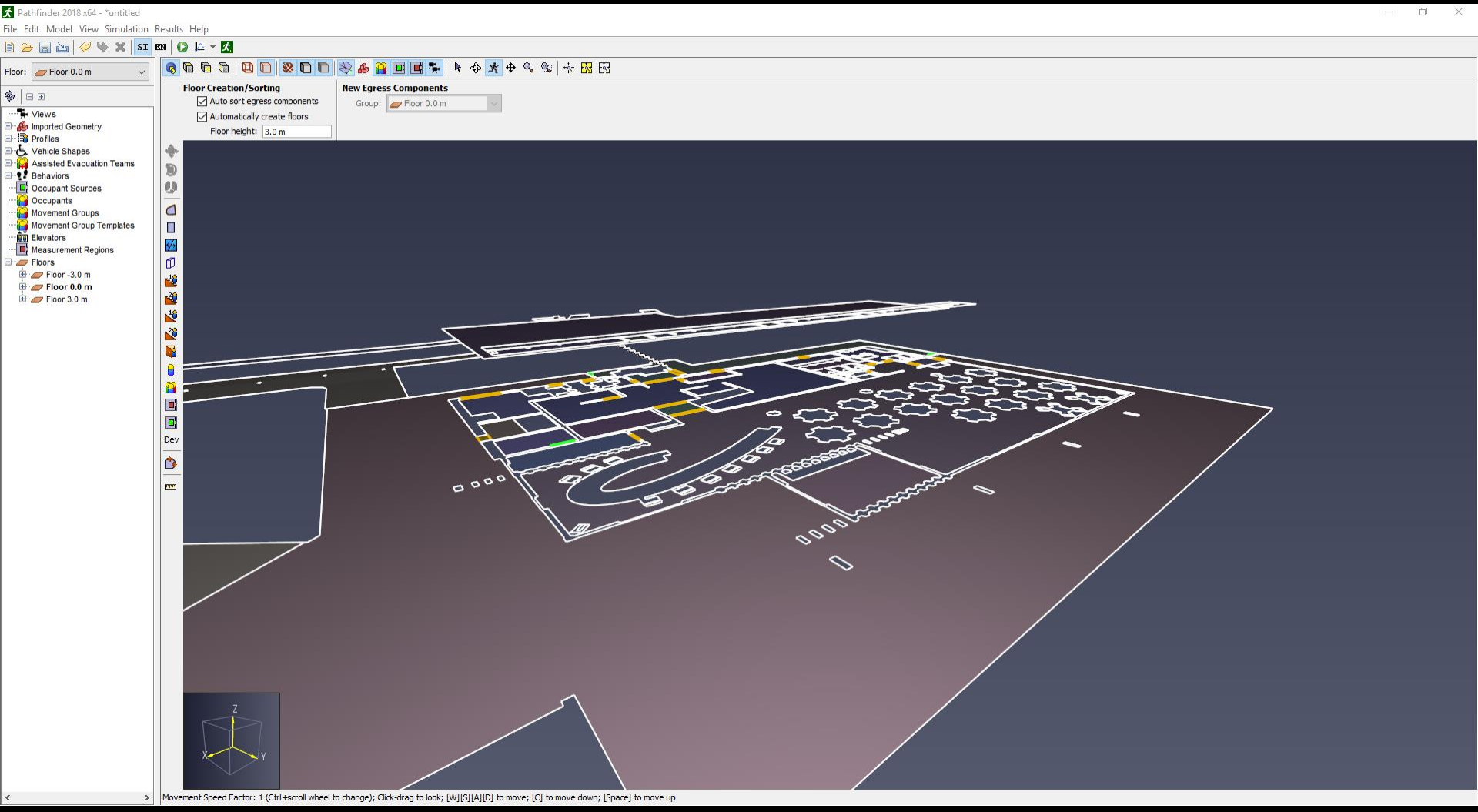
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Unified Visualization

- Technical Objectives
  - Integrated Fire and Movement Results
  - Support for Large Datasets
  - Support all FDS Output Types
  - Smooth, High-Framerate Rendering
  - VR Capability

Data Optimization

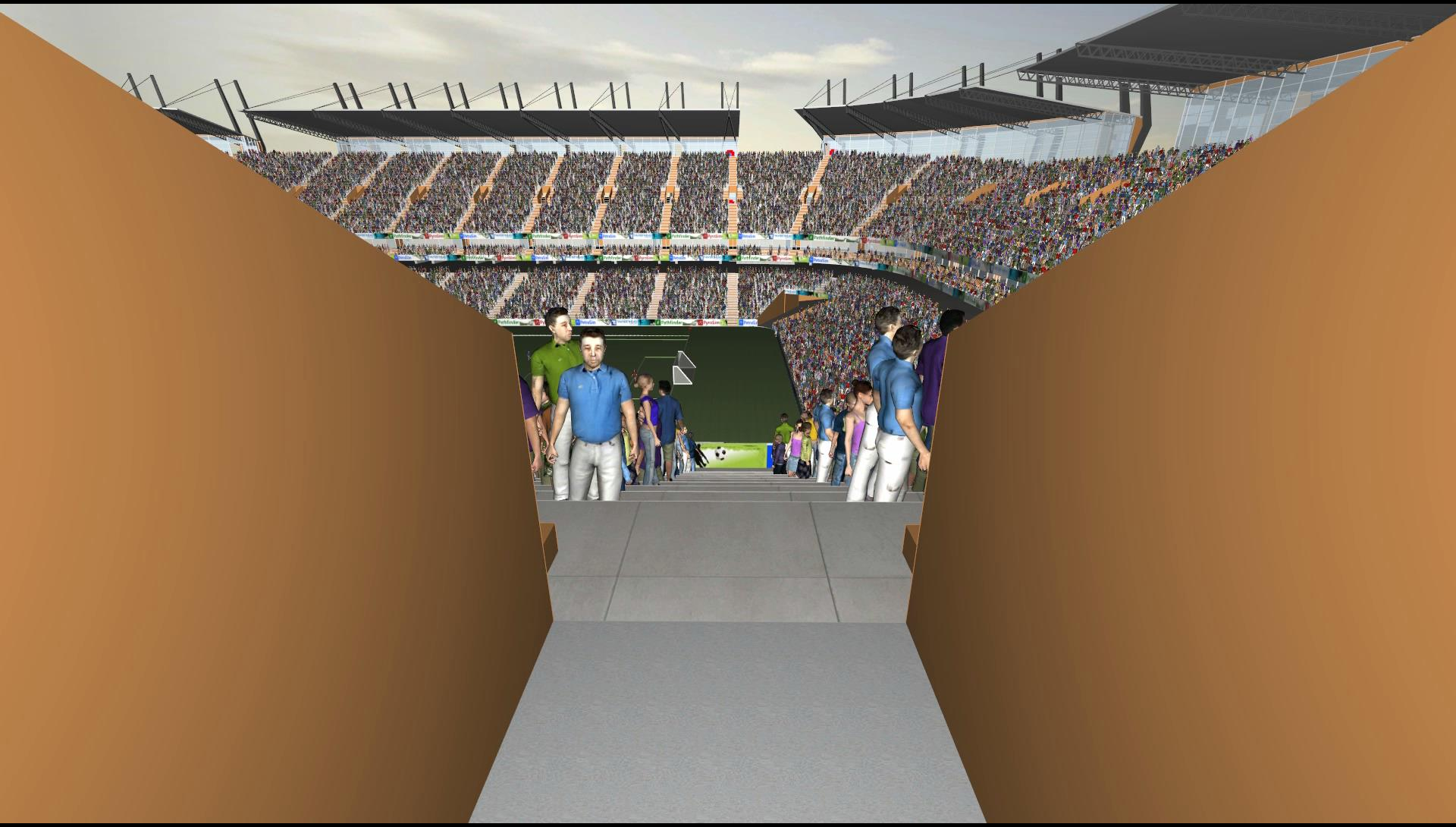
- File Streaming
  - File is scanned, but only selected frames are loaded into memory as needed for rendering
  - Data file size effectively unlimited
  - Limiting factor is size of a few frames of data
  - Supports fast load and seek-to
  - Data loaded asynchronously

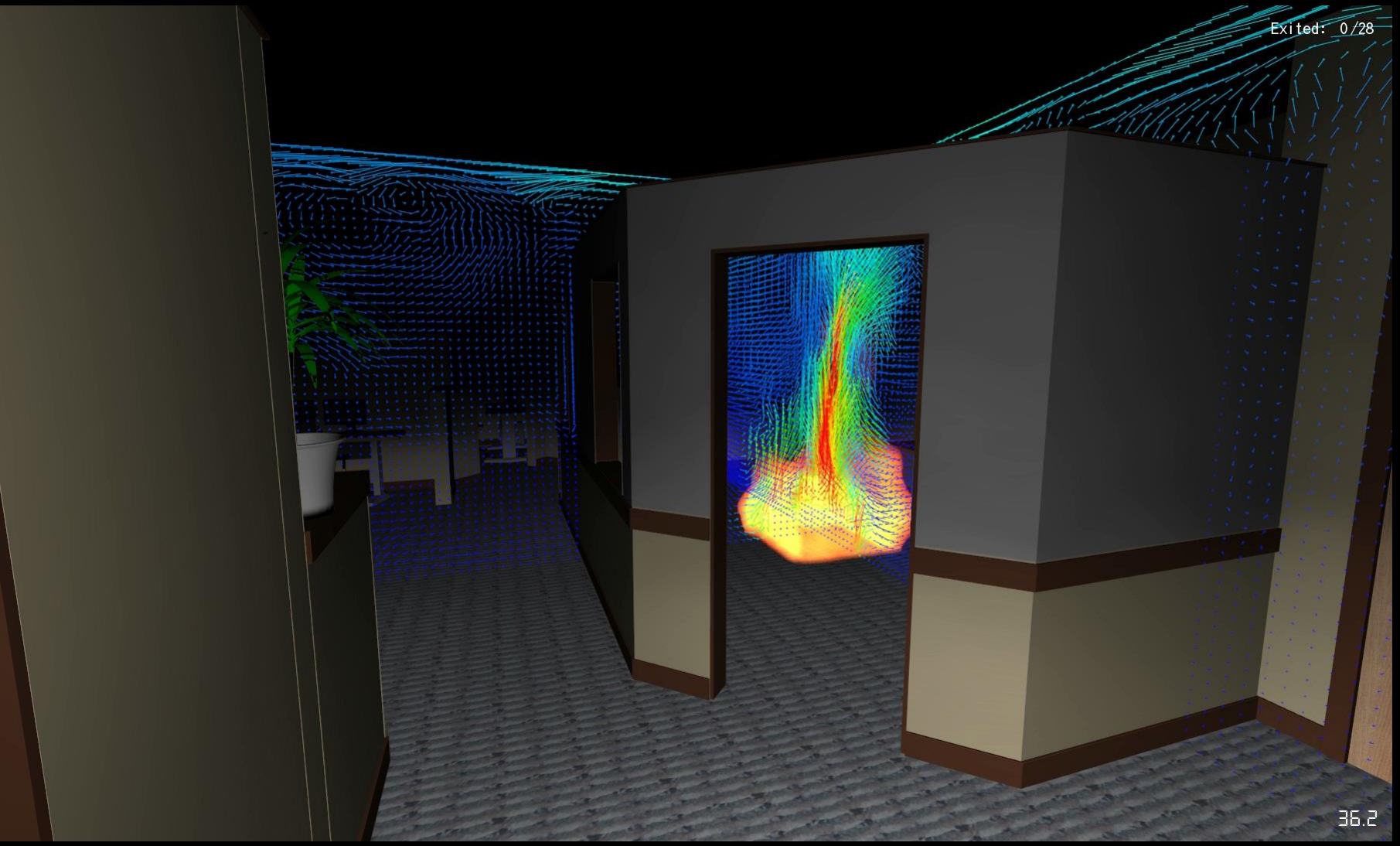
Visualization Features

- Time Interpolation for Most Data
  - Smoother rendering when display rate exceeds data interval
- Spatial Interpolation for Plot3D/3D Slice Data
- Volumetric Rendering for 3D Data
- General Surfaces and Slices for 3D Data
- Occupant Data Contours
- Views/Sections/Tours
- Easy Movie Creation

Rendering Performance

- GPU Shaders for Geometry
  - Improved Lighting Quality
  - Up to 10x Improvement
- Optimized Fire/Smoke Rendering
  - New Ray-Marching Visualization Algorithm
  - Traditional Algorithm Implemented using 3D Texture
  - Stacked Slice Method Maintained for Max Compatibility
- Leverage GPU
- Parallel Processing to Utilize CPU (Interpolation, Isosurfaces)

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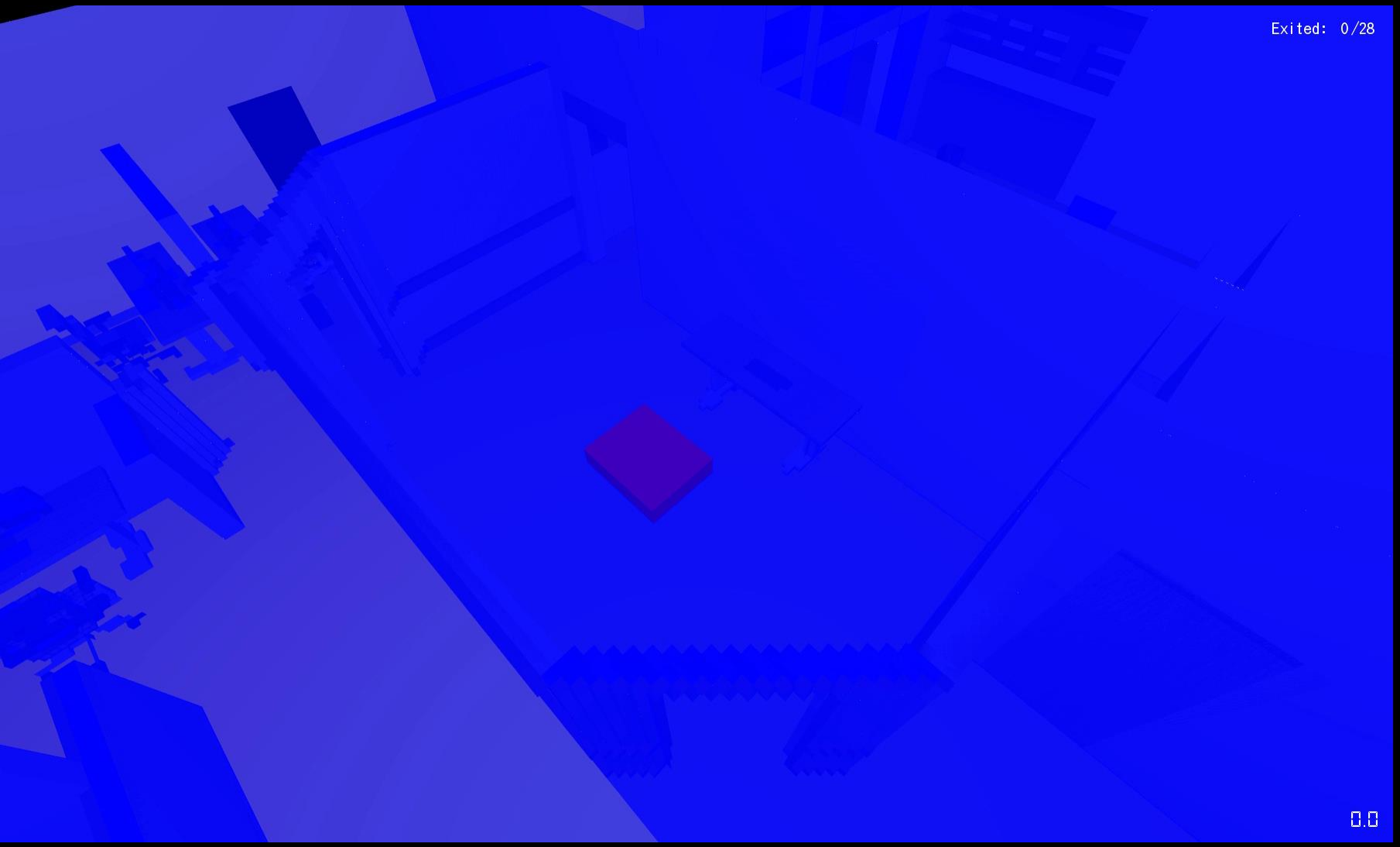
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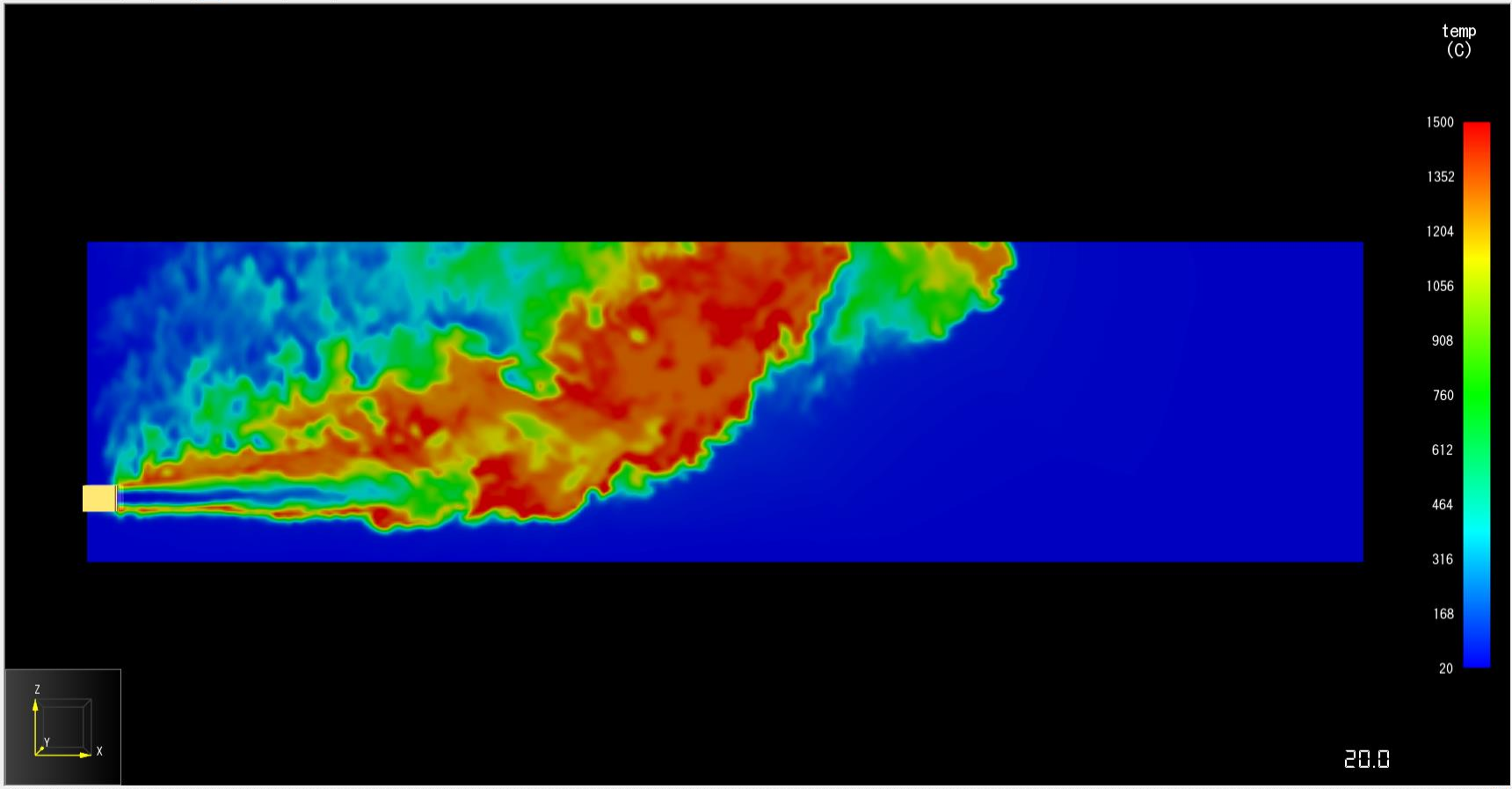
Pathfinder 2018 x64 - pipe_rupture_v3.smv

File Debug Analysis View Help

Realistic

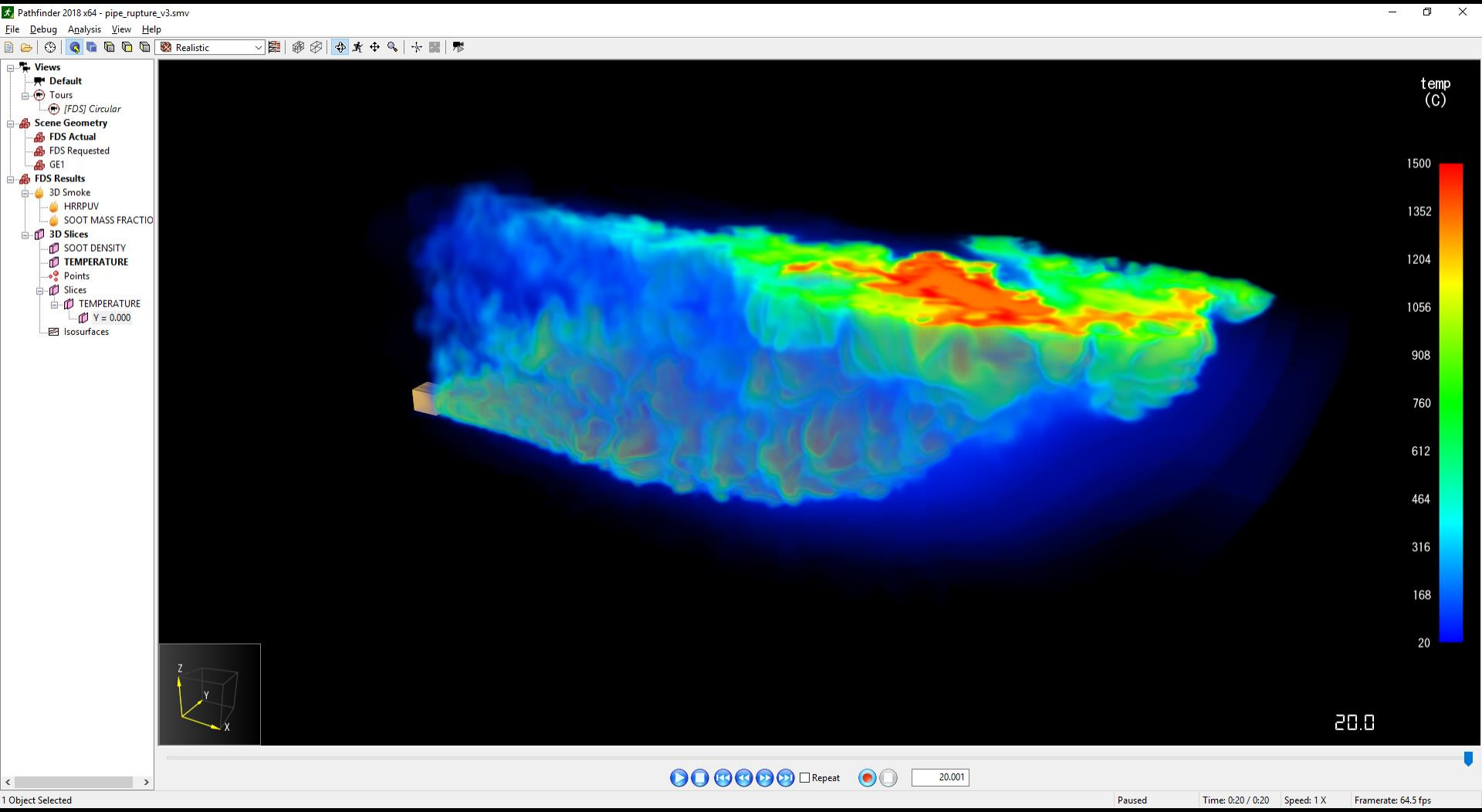
- Views
  - Default
  - Tours
    - *[FDS] Circular*
- Scene Geometry
  - FDS Actual
  - FDS Requested
  - GE1
- FDS Results
  - 3D Smoke
    - HRRPUV
    - SOOT MASS FRACTIO
  - 3D Slices
    - SOOT DENSITY
    - TEMPERATURE
  - Points
  - Slices
    - TEMPERATURE
      - Y = 0.000
  - Isosurfaces



Slice Offset (m): 0

Repeat 20.001

1 Object Selected | Playing | Time: 0:20 / 0:20 | Speed: 1 X | Framerate: 90.5 fps


Pathfinder 2018 x64 - pipe_rupture_v3.smv
File Debug Analysis View Help
Realistic
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[FDS] Circular
Scene Geometry
FDS Actual
FDS Requested
GE1
FDS Results
3D Smoke
HRRPUV
SOOT MASS FRACTIO
3D Slices
SOOT DENSITY
TEMPERATURE
Points
Slices
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Paused
Time: 0:20 / 0:20
Speed: 1 X
Framerate: 64.5 fps

Pathfinder 2018 x64 - pipe_rupture_v3.smv

File Debug Analysis View Help

Realistic

- Views
  - Default
  - Tours
    - *[FDS] Circular*
- Scene Geometry
  - FDS Actual
  - FDS Requested
  - GE1
- FDS Results
  - 3D Smoke
    - HRRPUV
    - SOOT MASS FRACTION
  - 3D Slices
    - SOOT DENSITY
    - TEMPERATURE
    - Points
    - Slices
  - Isosurfaces
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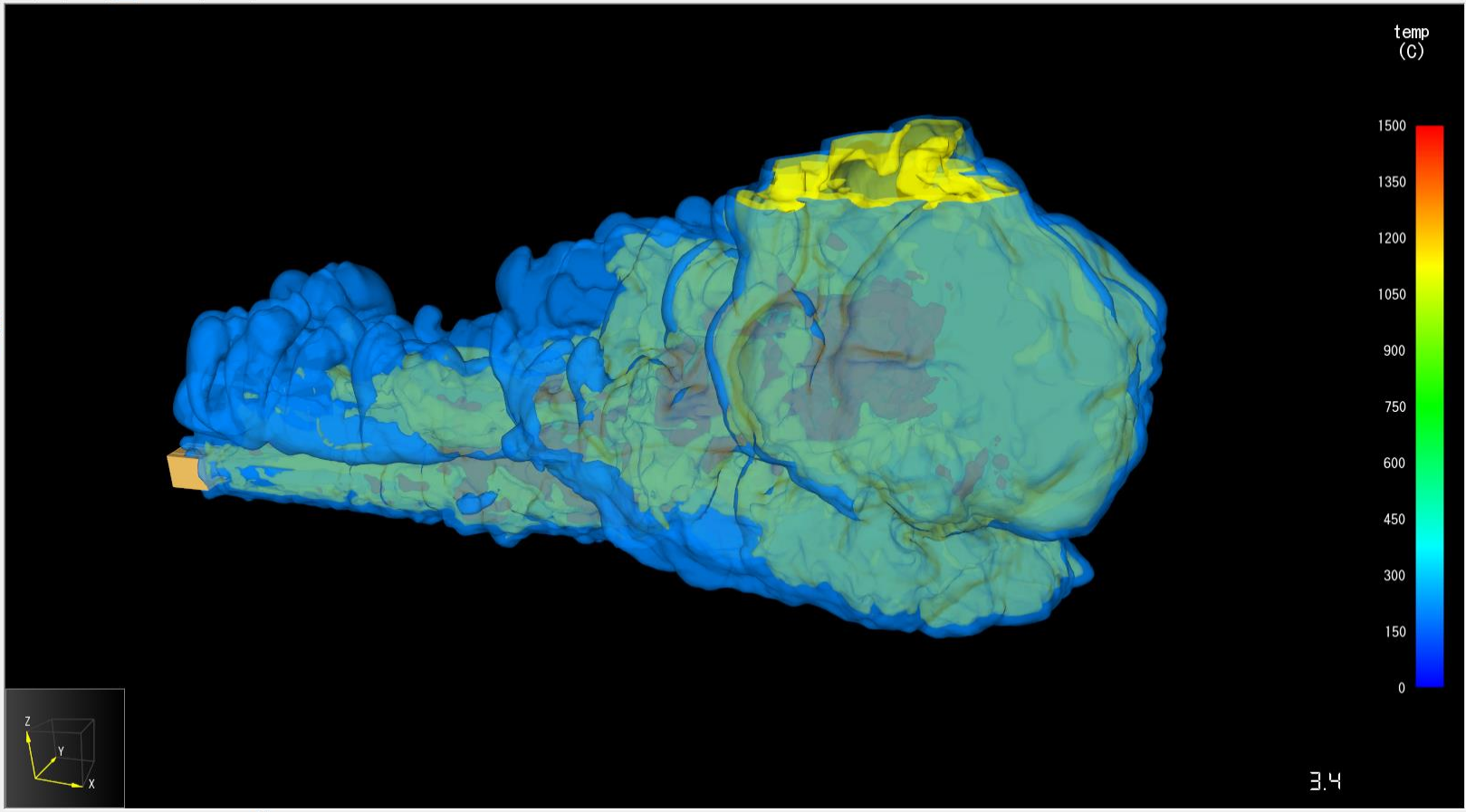
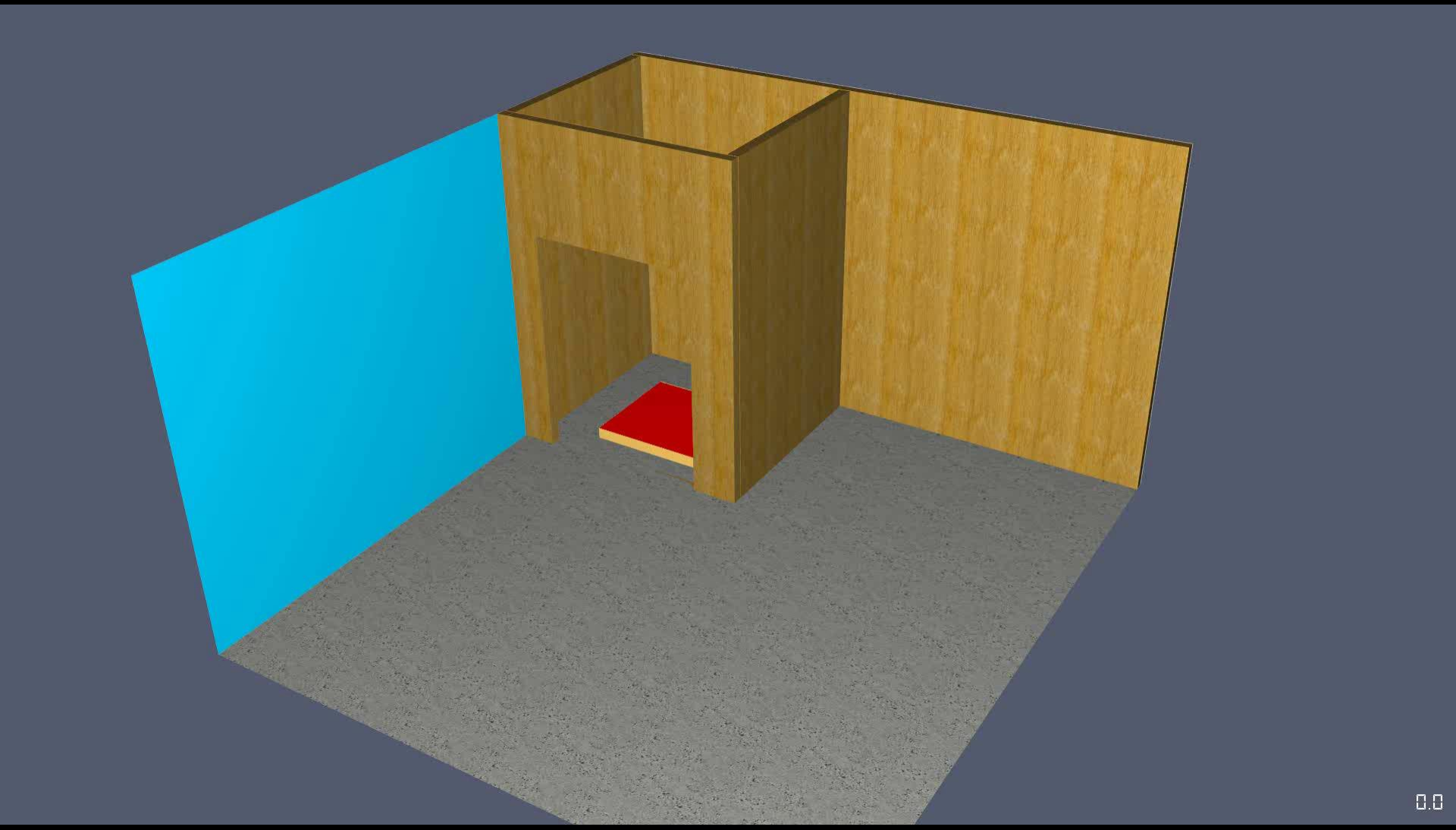
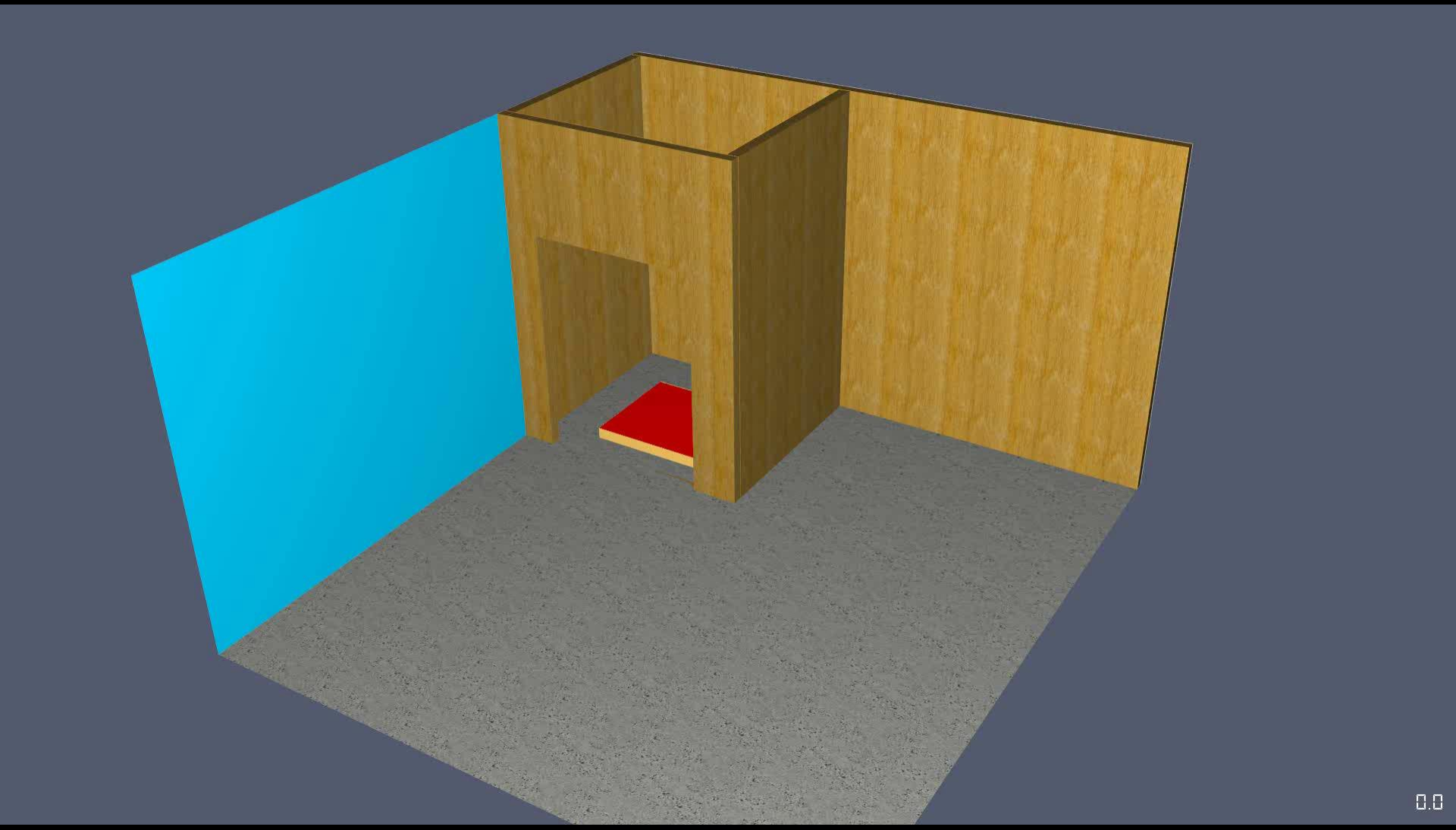
      - TEMPERATURE=1500.000000 C
      - TEMPERATURE=200.000000 C
      - TEMPERATURE=1117.788452 C



Repeat 3.4

1 Object Selected | Paused | Time: 0:03 / 0:20 | Speed: 1 X | Framerate: 11.1 fps


0.0


0.0

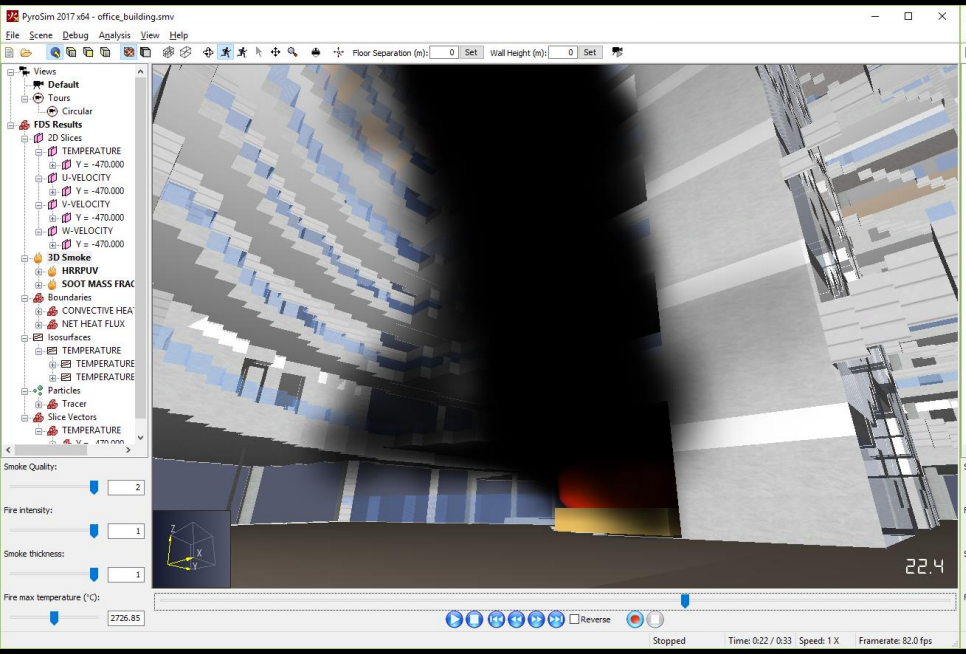
temp
(C)

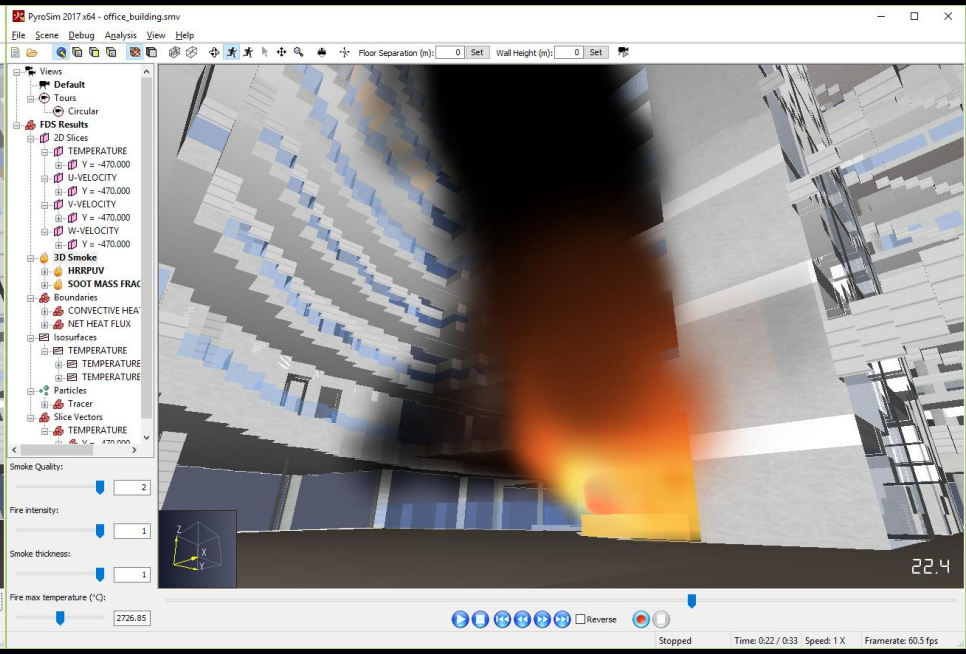
1500
1352
1204
1056
908
760
612
464
316
168
20

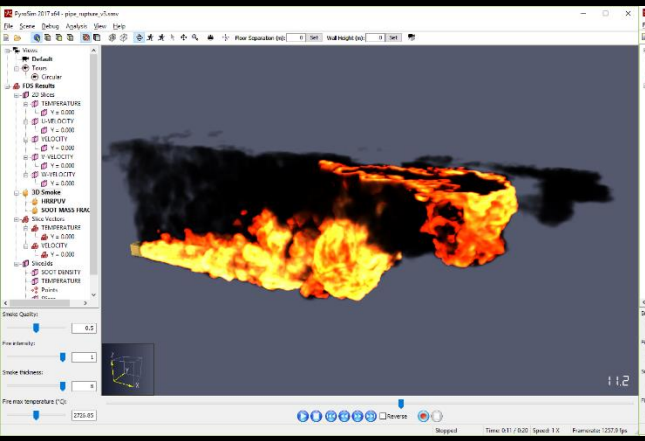
0.0

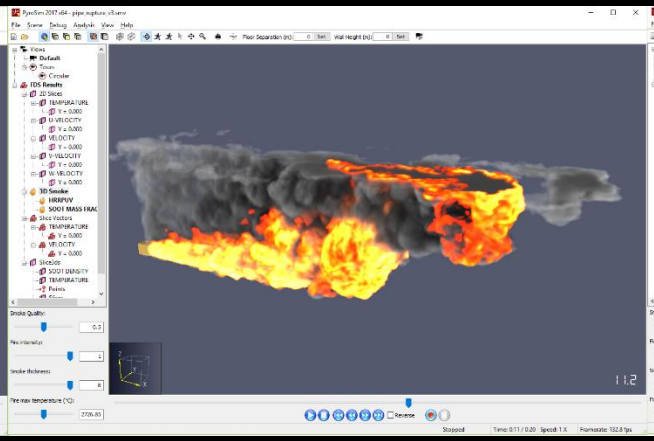
Future Visualization Work

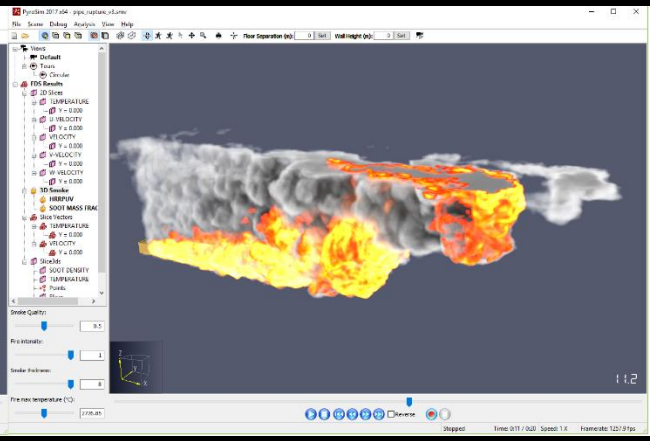
- Leverage GPU More
  - Still CPU-bound in some cases
- Additional Fire/Smoke Lighting
  - Using Fire to Light Smoke
  - Ambient Lighting of Smoke


PyroSim 2017 x64 - office_building.smv
File Scene Debug Analysis View Help
Floor Separation (m): 0 Set Wall Height (m): 0 Set
Views
Default
Tours
Circular
FDS Results
2D Slices
TEMPERATURE
Y = -470.000
U-VELOCITY
Y = -470.000
V-VELOCITY
Y = -470.000
W-VELOCITY
Y = -470.000
3D Smoke
HRRPUV
SOOT MASS FRAC
Boundaries
CONVECTIVE HEA
NET HEAT FLUX
Isosurfaces
TEMPERATURE
TEMPERATURE
TEMPERATURE
Particles
Tracer
Slice Vectors
TEMPERATURE
Smoke Quality: 2
Fire intensity: 1
Smoke thickness: 1
Fire max temperature (°C): 2726.85
22.4
Reverse
Stopped
Time: 0:22 / 0:33
Speed: 1 X
Framerate: 82.0 fps


PyroSim 2017 x64 - office_building.smv
File Scene Debug Analysis View Help
Floor Separation (m): 0 Set Wall Height (m): 0 Set
Views
Default
Tours
Circular
FDS Results
2D Slices
TEMPERATURE
Y = -470.000
U-VELOCITY
Y = -470.000
V-VELOCITY
Y = -470.000
W-VELOCITY
Y = -470.000
3D Smoke
HRRPUV
SOOT MASS FRAC
Boundaries
CONVECTIVE HEA
NET HEAT FLUX
Isosurfaces
TEMPERATURE
TEMPERATURE
TEMPERATURE
Particles
Tracer
Slice Vectors
TEMPERATURE
Smoke Quality: 2
Fire intensity: 1
Smoke thickness: 1
Fire max temperature (°C): 2726.85
22.4
Reverse
Stopped
Time: 0:22 / 0:33
Speed: 1 X
Framerate: 60.5 fps







0.0

0.0

Oculus VR Demo

Thank You

Questions?