Business from technology

FDS+Evac Evacuation Model: Recent Developments

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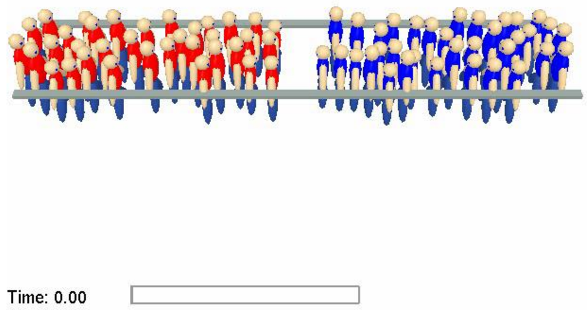
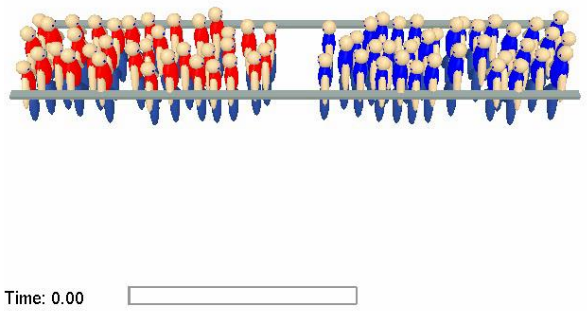
Background: FDS+Evac

- Continuous time and space
- Multiple floors
- Smoke reduces walking speed
- Purser's FED concept: CO, CO_2, and O_2 concentrations
- **Counterflow**
- Exit door selection algorithm uses smoke concentration
- Available for free (included in the FDS 5➔), source code in the public domain (**http://code.google.com/p/fds-smv/**)
- Documentation: **http://www.vtt.fi/proj/fdsevac/**

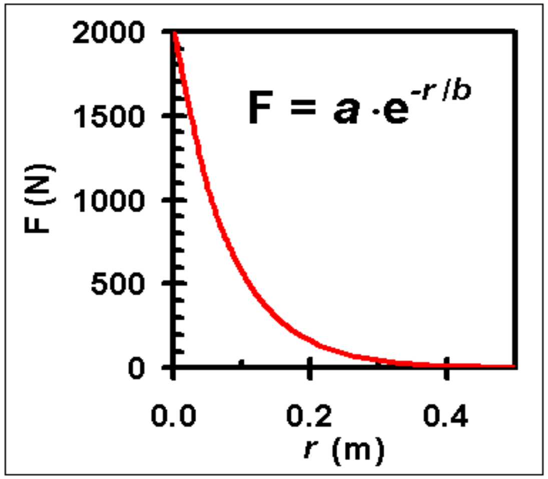


FDS+Evac
(version 2.2.0 ➔)

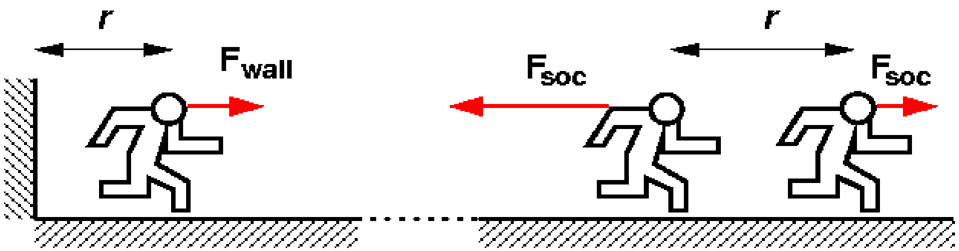


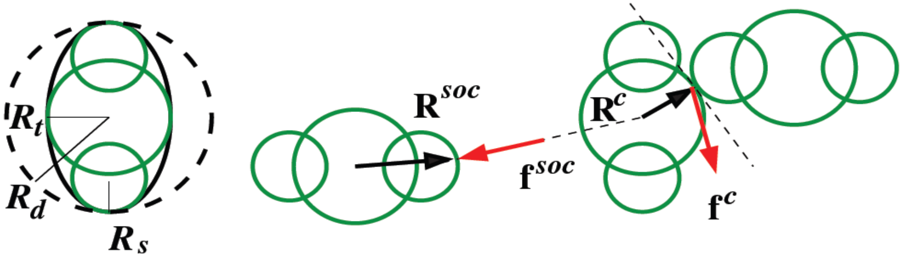
Original "Helbing" model
(Old FDS+Evac version < 2.2.0)

Background: ”Social Force” Method



- Introduced by Helbing et al., modified human body by Langston et al.
- Humans avoid walking too close to each other
- Humans avoid walls
- Angle (and speed) dependent
- Relatively short ranged force





FDS+Evac: Recent developments

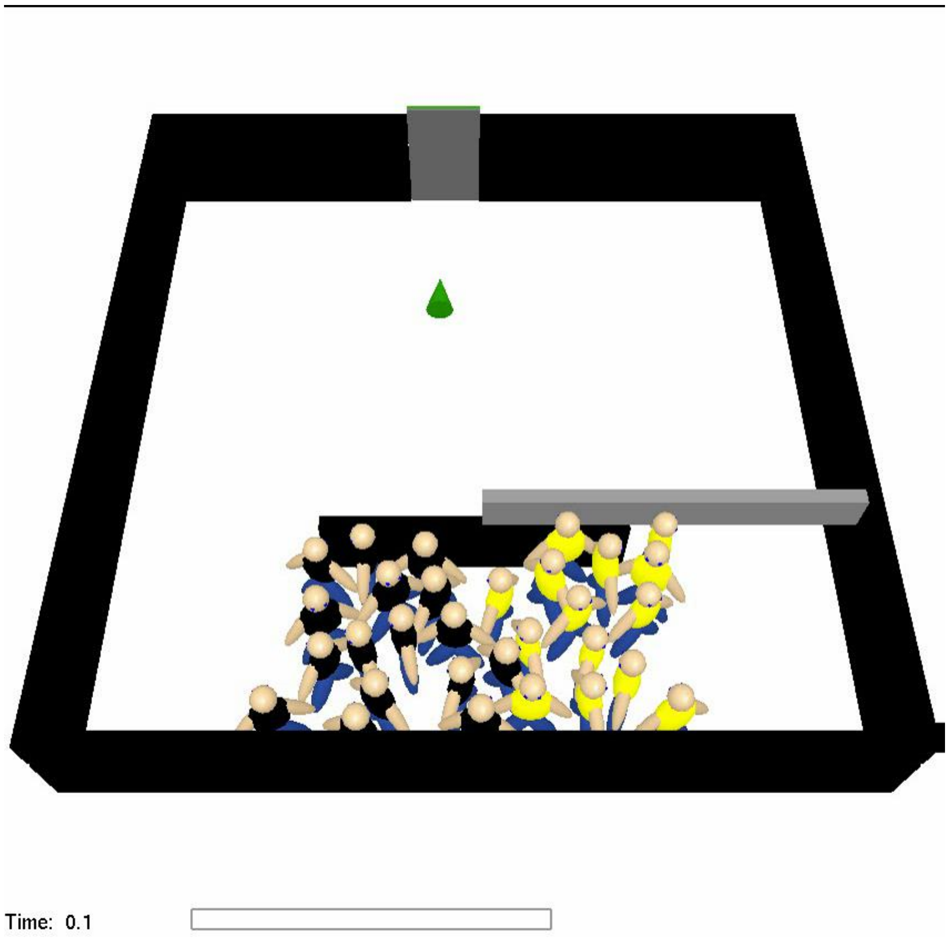
- Easier user input
  - Many things are now automatic compared to earlier versions
  - An easy to use staircase model
- Two z-levels: One for the movement and one for the visibility
  - Better treatment of low obstacles (like chairs and tables) and glass walls: Shops, auditoriums, etc.
- Counterflow model: bi-directional flows
- Way-finding: Better/different treatment of how the agents aim towards visible exits
- Herding behaviour and lost agents

Easier User Input

```
&HEAD CHID='Test', TITLE='Test'/
&MESH IJK=54,54,1, XB=-0.2,10.4,-0.2,10.4,0.1,1.2,ID='EvacG'
  EVAC_Z_OFFSET=0.65,EVACUATION=.TRUE.,EVAC_HUMANS=.TRUE. /
&TIME T_END=200.0,DT=0.05 /
&OBST XB=-0.2, 0.0, -0.2,10.2,  0.0,2.0 /
&OBST XB=-0.2,10.2, -0.2, 0.0,  0.0,2.0 /
&OBST XB=10.0,10.2, -0.2,10.2,  0.0,2.0 /
&OBST XB=-0.2,10.2, 10.0,10.2,  0.0,2.0 /
&HOLE XB= 9.9,10.3, 4.99,6.01,-0.01,2.01 /
 obsts for movement only
&OBST XB=  3.0,3.2, 3.0,7.0, 0.0,1.2 /
 obsts for visibility only
&OBST XB=  3.0,3.2, 0.0, 5.0, 1.3,2.0 /
&EXIT ID='ERight',IOR=+1, XYZ= 6.9,5.5,0.65,
  XB= 10.2,10.2, 5.0,6.0, 0.1,1.2, /
&PERS ID='Male', DEFAULT_PROPERTIES='Male',
  PRE_EVAC_DIST=1, PRE_LOW=1.0, PRE_HIGH=10.0,
  DET_EVAC_DIST=0, DET_MEAN=0.0, EVAC_FDS6=.TRUE. /
&EVAC ID='Males', NUMBER_INITIAL_PERSONS=30, PERS_ID='Male',
  XB=0.2,2.8,2.5,7.5,0.1,1.2, KNOWN_DOOR_NAMES='ERight' /
&TAIL /
```

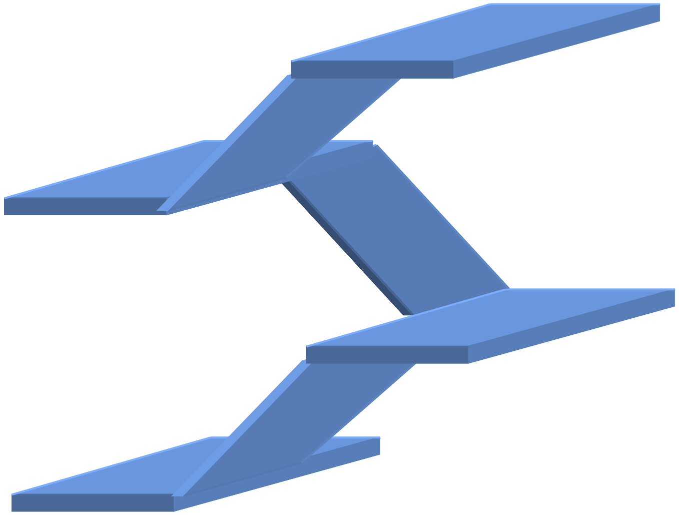
Easier User Input

- Just one evacuation mesh per one “floor” of the building
    - No “door flow field meshes”
    - No mesh for STRS
- DOOR/EXIT is enough
    - No “outflow” vents
    - Automatic OBSTs behind doors/exits if needed
- Visibility vs movement OBSTs:
    - No “tricks” needed, e.g., for auditoriums etc.



Easier User Input: STRS-Model for Stairs

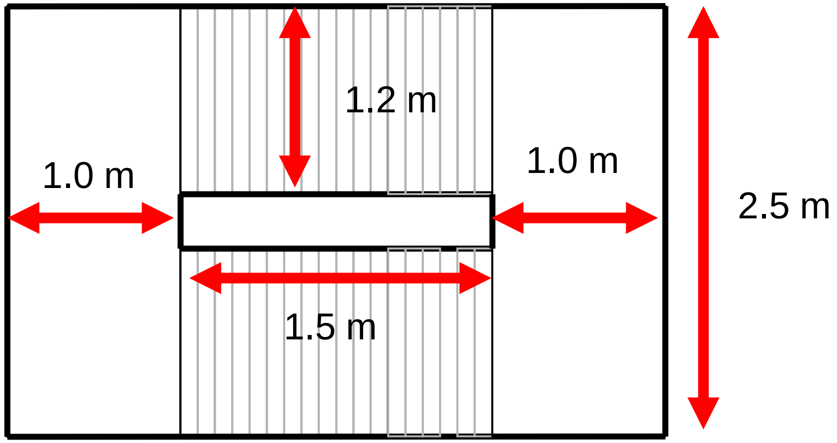
- Limited geometrical alternatives.
- Assumed structure:
  landing-stair-landing-stair-landing
- As many repeats as necessary.
- Automatic detection of connected doors and exits.
- Automatic detection of “target” door.



- Internal logic is based on “noding”:
  1 = landing, 2 = stair, 3 = landing, ...

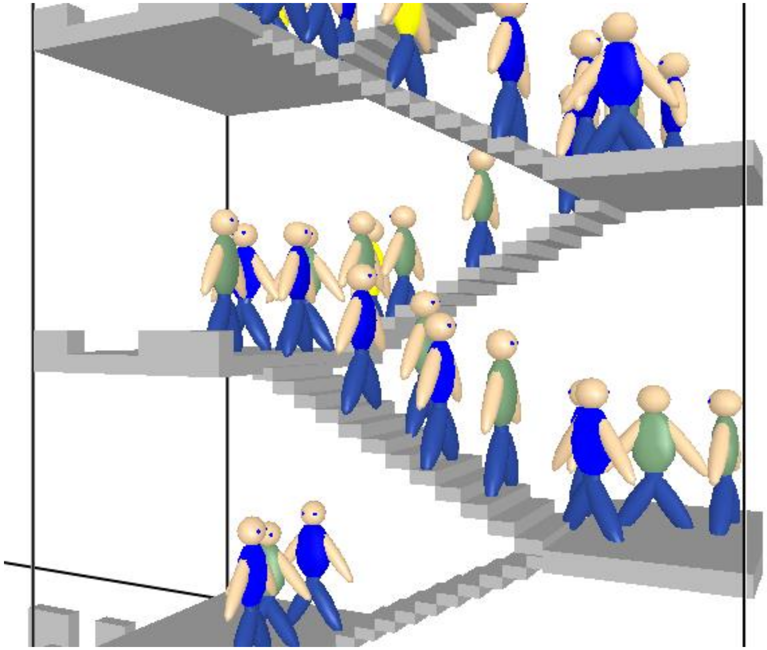
Easier User Input: STRS-Model

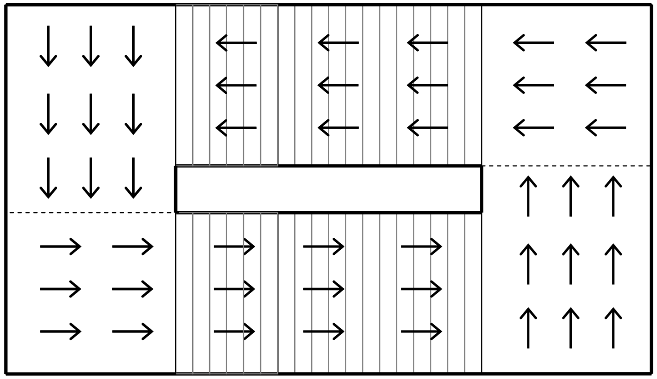
```
&STRS ID = 'Stairs', COLOR='BLACK',
      XB = 5.0,8.5, 0.0,2.5, 0,13,
      XB_CORES(1,:) = 6.0,7.5, 1.2,1.3, 0,13,
      IJK=35,25,1, EVAC_Z_OFFSET=.10,
      RIGHT_HANDED = .TRUE., N_LANDINGS = 7,
      VERTICAL_LANDING_SEPARATION = 1.5,
      XB_LANDINGS(1,:)=5.0,6.0, 0,2.5, 0.9,1.1,
      XB_LANDINGS(2,:)=7.5,8.5, 0,2.5, 2.4,2.6
      FAC_V0_UP=0.4, FAC_V0_DOWN=0.7, FAC_V0_HORI=1.0,/
```



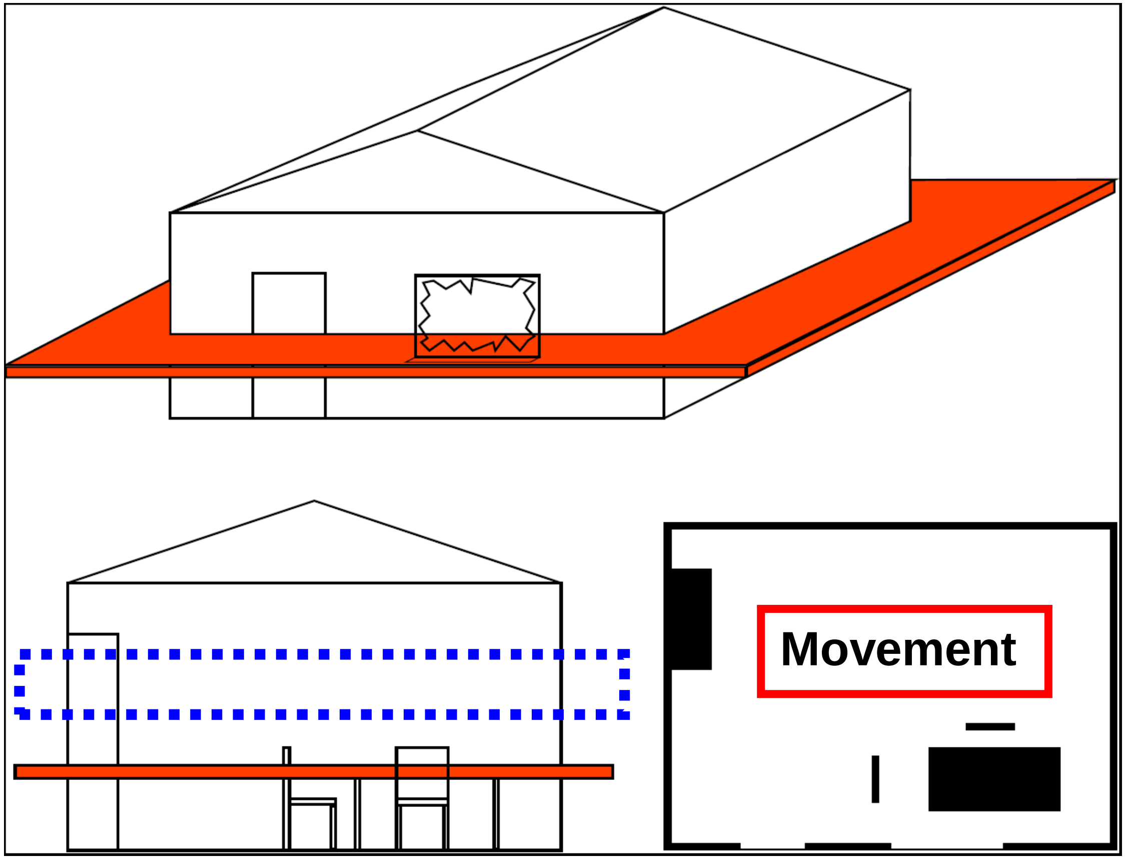
STRS-Model: Full Crowd Dynamics

- Movement of agents is handled by Helbing’s model, as usual. This includes
    - motive forces
    - social forces
    - wall forces
- Computational efficiency by limiting the human-human forces between the agents on the same or preceding staircase “nodes”
- Counterflow in stairs possible

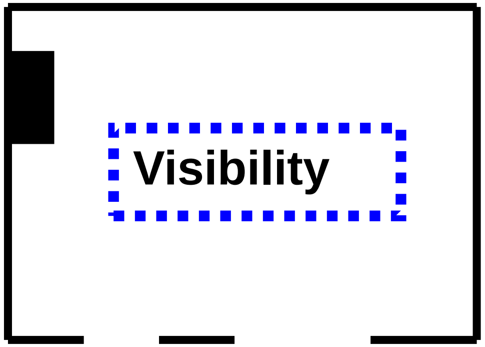




FDS+Evac: Movement vs Visibility



- “Old” FDS+Evac: Same **geometries** for movement and visibility
- “New” FDS+Evac: A **geometry** for movement and a geometry for **visibility**



Background: Human Behaviour

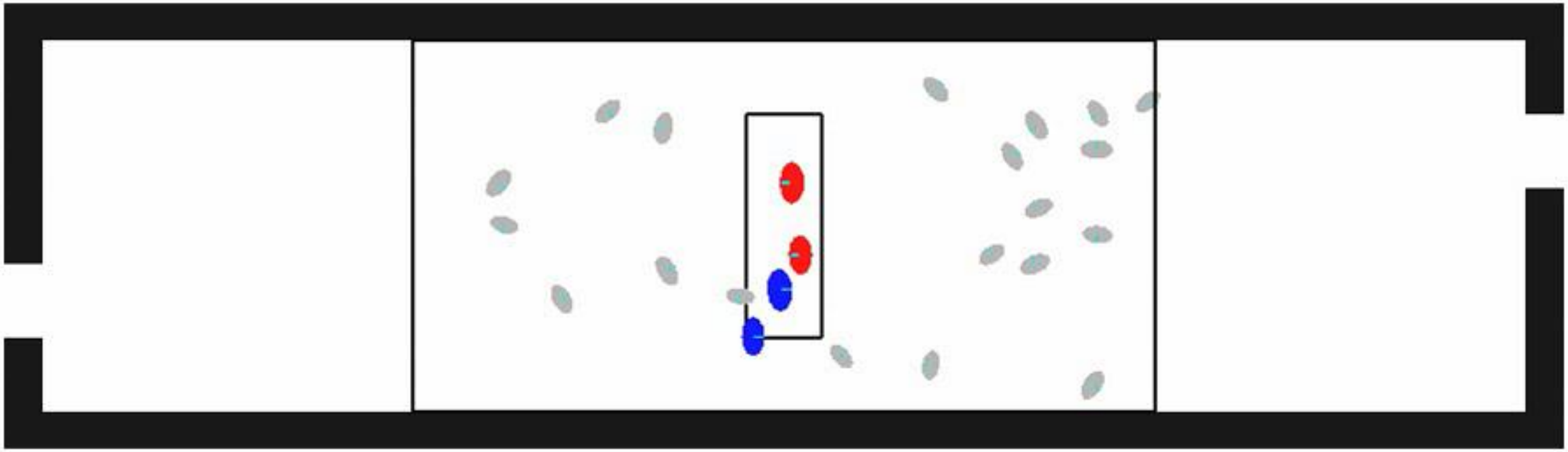
- Common observations in building evacuations
  - All evacuees do not know all possible exit paths
  - Some evacuees prefer familiar exit routes
  - Many evacuees follow the majority, “herding” behaviour
- Building codes
  - Many prescriptive fire codes assume total exit width
  - In real evacuations the full exit width is seldom used efficiently (video)
- Evacuation simulation programmes
  - Individual characteristics play a role (agents used)
  - Different behavioural types considered, like staff members and regular crowd members or senior – junior occupants, etc.

FDS+Evac: Different Behavioural Types

- We propose four different agent types to be used in the FDS+Evac evacuation simulation programme:
  - **Conservative agents:** The default (“old”) FDS+Evac type, preference order of the doors: visible and known, known, visible
  - **Active agents:** preference order of the doors: visible (known or not), known (try to find the fastest exit route)
  - **Herding agents:** Looking around and seeing what the other agents are doing and follow others if they are moving to an exit.
  - **Follower agents:** Use “conservative agents” rules but look around where the other agents (in front) are going and follow these is this seems to be feasible (in practice: regard the target exit of the other agents as “known”)

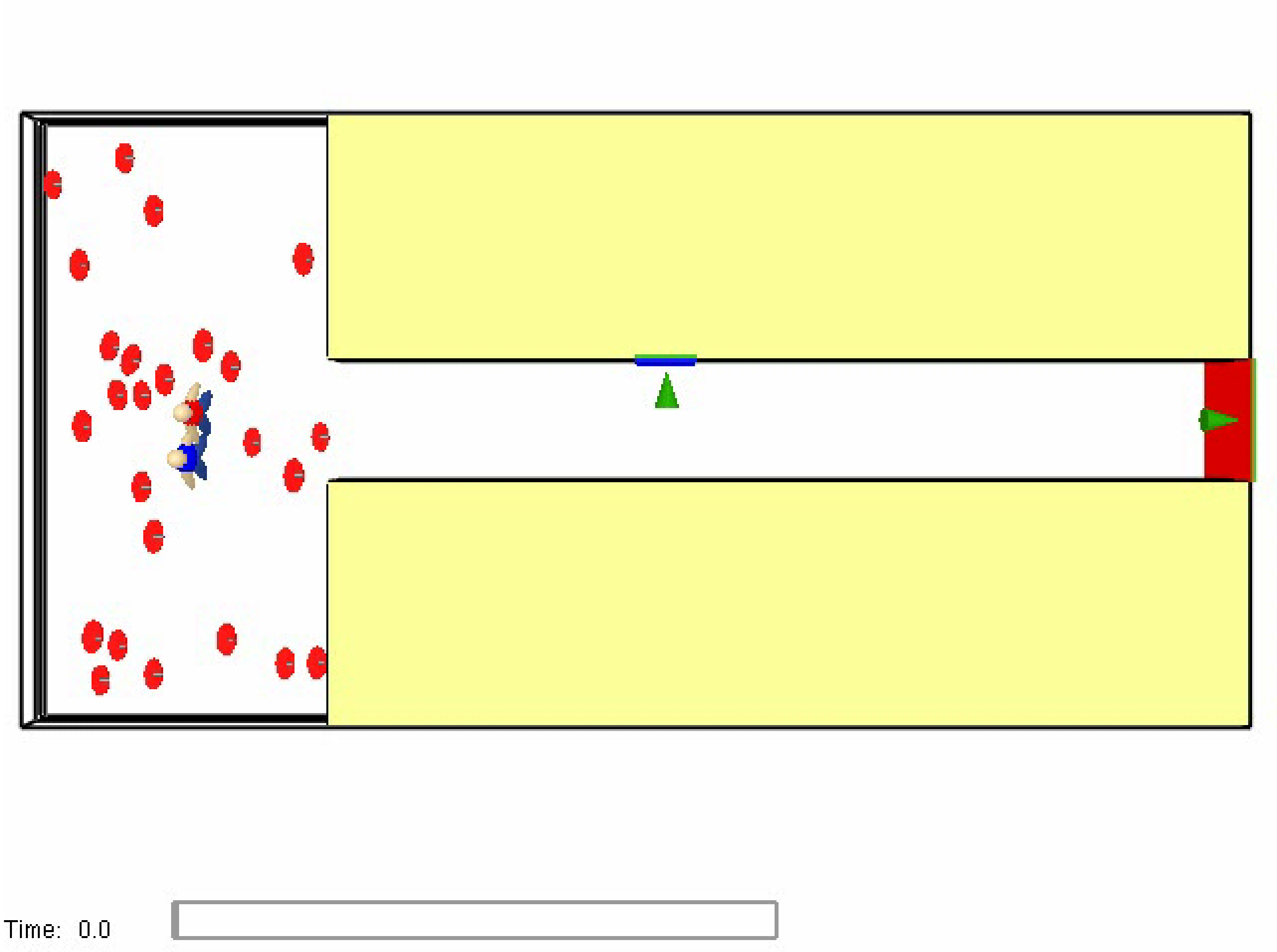
A Simple Verification Case: Herding agents

- Two 1.5 m wide doors at opposite ends of a room. The **blue** agents go to the **right door** and the **red** agents to the **left door**. **Gray** agents are herding agents that have not yet chosen a door. Herding agents are shown as smaller ellipsis as the active agents.



A Simple Verification Case: Followers

- **Red** agents head to the right door and **blue** ones to the middle door
- The follower agents are shown as disks and the active agents (one going to the **middle door** and one going to the **right door**) as more human shaped avatars.



Conclusions

- FDS+Evac version 2.4.1 will be in the next major release version of the CFD fire simulation programme FDS (version 6.0.0)
- “New” features of the FDS+Evac evacuation module:
  - Easier user input
  - Visibility treated better
  - Different type agents including “herding” behaviour
  - Better treatment of bi-directional flows (counterflow)
  - Better way-finding towards visible doors
- Still to do
  - Inclines (&EVSS): OBSTs should be taken from the correct z-level
  - STRS stair model: Different geometries at different floors, smoke effects

Conclusions

- Different evacuation scenarios: A key factor for the outcome might be the distributions of the different agent types
- New agent types defined for agent based evacuation simulations
  - These are tested using FDS+Evac programme
  - Active agents (like staff, floor wardens, etc, and/or frequent fire drills) could lead to more comprehensive use of all exits and minimise the egress time
  - Herding agents do not necessarily increase the egress time

Thank you !

Acknowledgements

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