Modeling of Physical Protection Systems: an *EPIC* project

Outline

- **Context**

- **The BIM2SIM technology brick**

- **What's next?**

This project has received funding from

SECURIT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101005292".
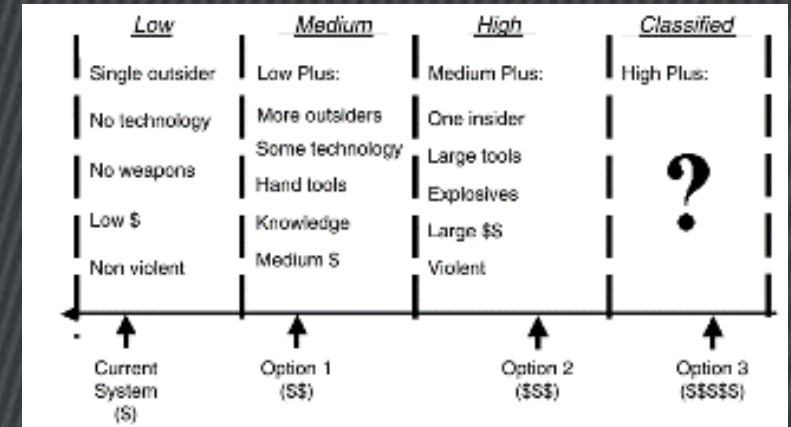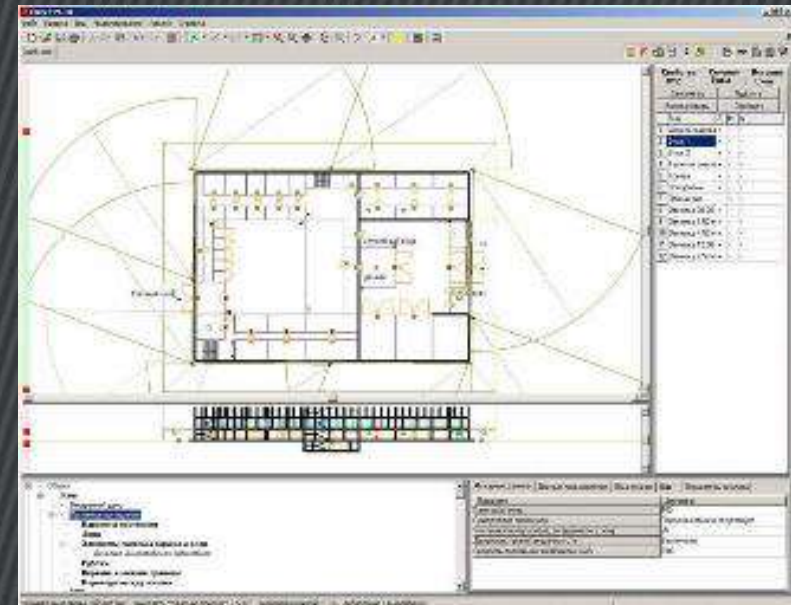
Context

Physical protection of infrastructures

Context
Back to basics

Threat levels (Garcia, 2008)

- **Threat level ➔ level of preparation**
  - From politics (Greenpeace) to terrorism...
- **Space organization: "onion " of protection**
  - Complex to achieve on certain sites.
- **Principles of protection - the 4 Ds**
  - (DETER) / DETECT / DELAY / DENY (or DEFEAT)
- **Principles of attack - the 4 P's (APEX)**
  - (PLAN) / PROGRESS / PERPETRATE / (PUSH OFF)
- **Theorizing and modeling**
  - *Sandia National Laboratories* in the 1980s
  - Still the roots of recent approaches

Example of an HMI (SPRUT, 2009)

Context
Why modeling a PPS?

- **Because it's fun** ☺

- **Conventional approach**
  - Perform a threat analysis (or outsource it).
  - Produce a risk matrix (Probability vs. Impact) .
  - Find the weak spots / critical paths (rule of thumb)...
  - Purchase a PPS (cameras and the IT stuff + some AI) from a provider.
  - Update your risk matrix and convince youself that you did well...

- **No TOOL to <u>quantify</u> the current state and potential improvement**
  - No way to check if you will throw money away.
  - No measure of possible alternative solutions.

Likelihood	Harm severity			
	Minor	**Marginal**	**Critical**	**Catastrophic**
Certain	High	High	Very high	Very high
Likely	Medium	High	High	Very high
Possible	Low	Medium	High	Very high
Unlikely	Low	Medium	Medium	High
Rare	Low	Low	Medium	Medium
Eliminated	Eliminated			

Risk matrix (from Wikipedia)

Context
RED and BLUE teams

APEX SOLUTIONS
THINKING OUT OF THE BOX

Context
Simulation elements

BLUE TEAM

Site and buildings
- Enclosures, floors, rooms, access...

Protection elements
- Physical / cyber

Detection systems
- Point, linear, volumetric...
- Cameras...

Guards
- Fixed/mobile guards...
- Behavior (policy...)

RED TEAM

Attackers
- On site / accomplices / off site
- Behavior (objectives...)

Knowledge
- Site (floorplans...),
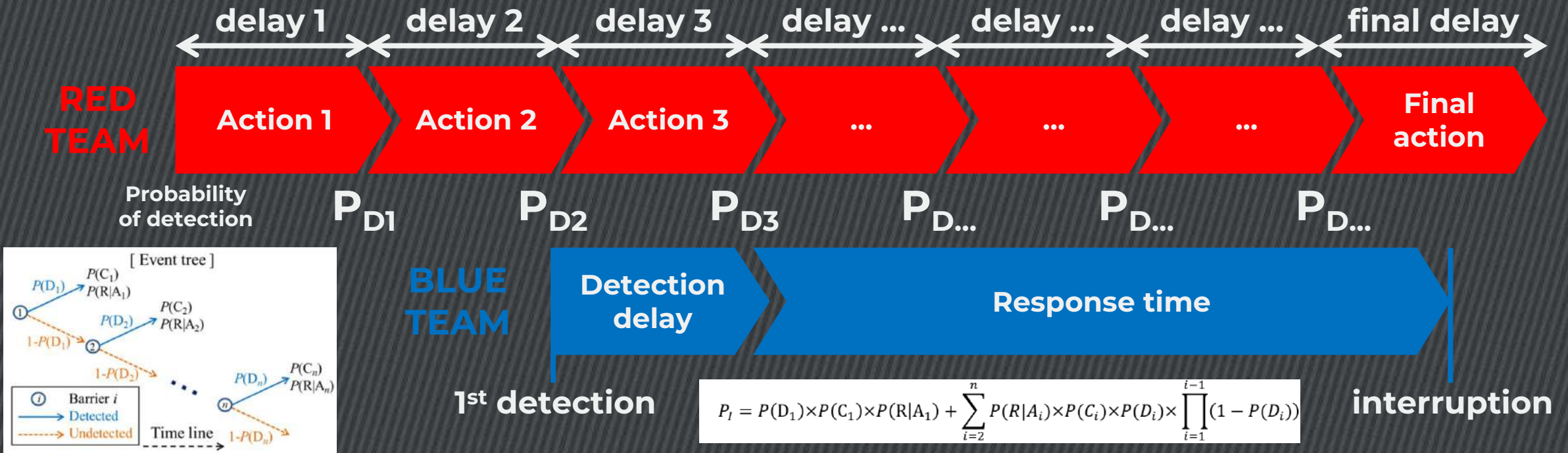- Protection & detection,
- Guards...

Equipment / tools
- Physical / Cyber

Context
Reference approach: EASI

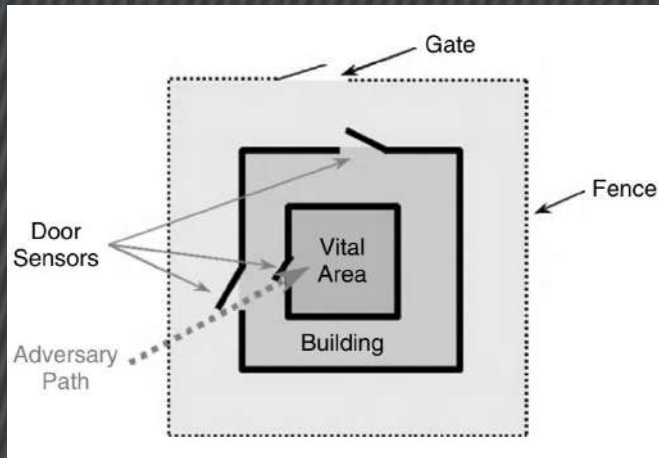**EASI (Bennet, 1977) -** *Estimate of Adversary Sequence Interruption*
- Probability of interruption P_i for a single path, always at the heart of the PPS analysis.
- Use: *Most Vulnerable Path,* sensitivity analyses, etc...

| delay 1 | delay 2 | delay 3 | delay ... | delay ... | delay ... | final delay |

RED TEAM

| Action 1 | Action 2 | Action 3 | ... | ... | ... | Final action |

Probability of detection

P_{D1} P_{D2} P_{D3} $P_{D...}$ $P_{D...}$ $P_{D...}$

[Event tree]

$P(D_1)$ $P(C_1)$ $P(R|A_1)$

$P(D_2)$ $P(C_2)$ $P(R|A_2)$

$1-P(D_1)$

$1-P(D_2)$ $P(D_n)$ $P(C_n)$ $P(R|A_n)$

(i) Barrier i
→ Detected
- - → Undetected   Time line $1-P(D_n)$

BLUE TEAM

| Detection delay | Response time |

1st detection

$$P_I = P(D_1) \times P(C_1) \times P(R|A_1) + \sum_{i=2}^{n} P(R|A_i) \times P(C_i) \times P(D_i) \times \prod_{i=1}^{i-1} (1 - P(D_i))$$

interruption

Context
EASI example

Excel^TM worksheet from (Garcia, 2008), recoded by APEX solutions

Simple test – (Garcia, 2008)

Estimate of Adversary Sequence Interruption	Probability of Guard Communication		Response Force Time (in Seconds)	
			Mean	Standard Deviation
	0.95		300	90

Task	Description	P(Detection)	Location	Delay (in Seconds) : Mean	Standard Deviation
1	Cut Fence	0	B	10	3
2	Run to Building	0	B	12	3.6
3	Open Door	0.9	B	90	27
4	Run to Vital Area	0	B	10	3
5	Open Door	0.9	B	90	27
6	Sabotage Target	0	B	120	36
7					
8					
9					
10					
11					
12					

Probability of interruption	47.6%	APEX solutions

APEX SOLUTIONS
THINKING OUT OF THE BOX

Context
Less EASI (!) example

Finding the critical paths by trials and errors may not be possible

ASD - *Adversary Sequence Diagram*

- Systematic approach for path generation.
- Application of the EASI method on each path.
- **It may help!**
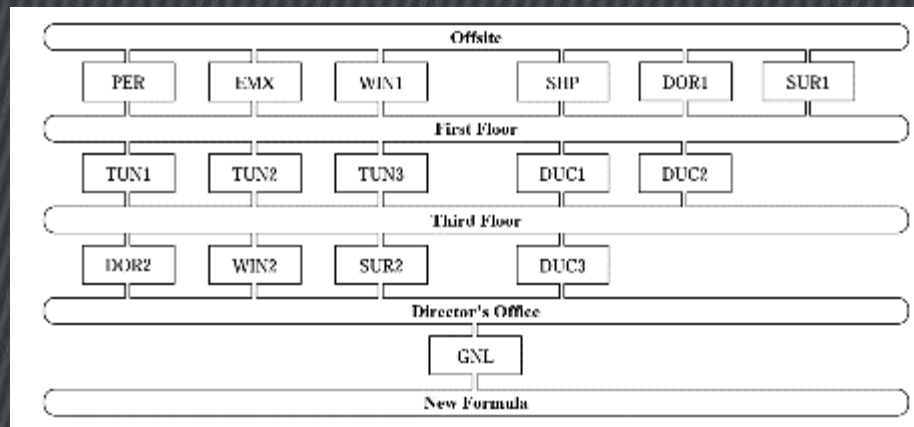
Adversary Sequence Diagram **(Garcia, 2006)**

Complex test – (source: Facebook)

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The BIM2SIM brick
Preliminary work @ APEX solutions

- **EPIC project (on equity)**
  - **SoA analysis + theorization**
  - **Networking (partners & end-users)**
  - **Physical protection code - EPIC**
    - EASI / ASD automation, *Most Vulnerable Path...*
    - Long pre-processing time ☹

IT'S UGLY BUT IT WORKS

Proof of concept with the IGO company
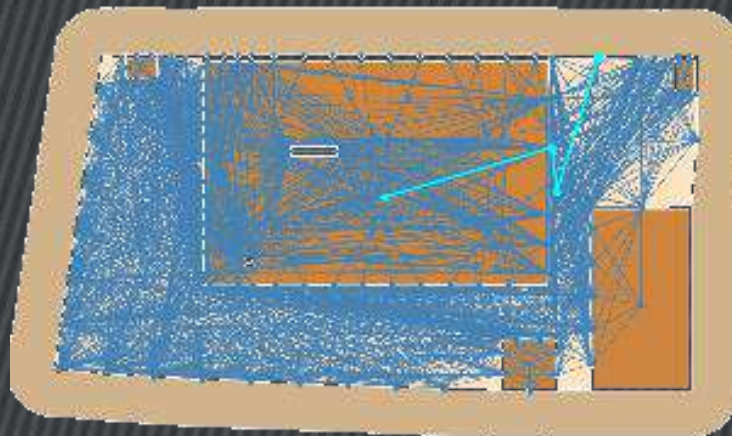
Previous EPIC prototype

Then came the SecurIT EU project...

The BIM2SIM brick
Reasons why...

Buildings are key elements for safety / security issues
- Path planning (intrusion, evacuation, accessibility...)
- Optimal positioning of safety (fire hydrants...) and security (cameras...) elements.
- Indoor hazard modelling (fire, explosion, toxic release...) and structural effects...

BIM (Building Information Modelling) standards are routinely used by architects
- Wikipedia: "digital representations of physical and functional characteristics of places"
- Highly detailed representations of building, including material data, technical networks...
- But BIM standards were designed for the construction industry, <u>not for security</u>.

➔ **BIM2SIM could bridge the gap between BIM data and security models**
1. New open security-BIM standard (additional requirements / parameters) and guidelines.
2. First application to "feed" physical security models (APEX solutions' EPIC software).

The BIM2SIM brick
Proposal for SecurIT Open Call #1

Challenges (non-exhaustive)

DOMAIN #1 — Sensitive infrastructure protection

1. Cybersecurity solutions
2. Communication & alert
3. Access control
4. Detection of intruders

DOMAIN #2 — Disaster resilience

5. Disaster prediction
6. Communication & warning
7. Solutions for better recovery

DOMAIN #3 — Public spaces protection Major events

8. Manage real-time information
9. Analyse / extract data
10. Communication & post-event
11. Detection

Prototyping project – expected final TRL 6

- System/subsystem model/prototype in relevant environment

Primary domain and challenge:

- Domains 1 : Critical infrastructure protection.
- Challenge 4: Solutions to detect / locate intruders...

However BIM2SIM has a much wider global scope!

- All 3 domains are concerned.
- Challenges 3, 4, 5, 7, 8, 9 and 10 can be addressed.

The new open BIM standard will allow private and public building models to be used easily and seamlessly in safety / security models.

BIM2SIM will thus open the way to a security-by-design analysis for new buildings.

- A growing number of countries requires "digital twins" to be delivered in every public construction contract.

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The BIM2SIM brick
Partnership

APEX solutions (security solutions provider)
- R&D SME developing innovative security and safety models and data processing.
- Emmanuel Lapébie (CEO) has a strong expertise in managing R&D projects.
- Will lead the BIM2SIM project and develop scripts to extract relevant BIM data.
- Will perform physical security analysis of BIM sites with its EPIC software.

Scott Brownrigg Limited
- International design firm (SME) using BIM from project inception to delivery, ranked within the top 100 world architects.
- Global BIM level 2 certification (ISO 19650) and dedicated "digital twins" unit.
- Will provide BIM models of increasing complexity with specific requirements.
- Will bring its market / sales skills to prepare a post-project strategy.

APEX and Scott Brownrigg will define together a new BIM standard

SCOTT BROWNRIGG

Scott Brownrigg is an international design practice specialising in architecture, masterplanning, urbanism and interior design.

We enrich lives through the built environment.

← **Element properties**

Project tree view ➔
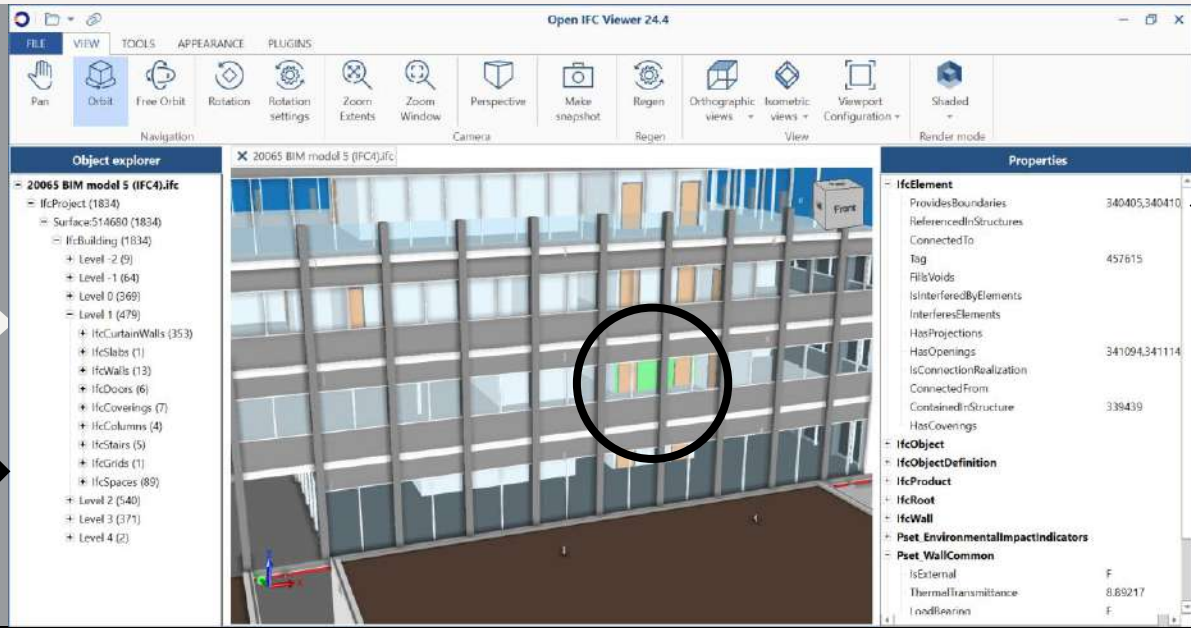
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APEX solutions is a private R&D laboratory acting in the development of fast-running, innovative algorithms and models for Defence, Security and safety applications.

We are not only **researchers**, we are also **finders** ;-)
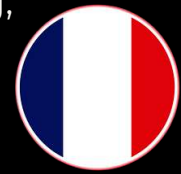
The BIM2SIM brick
How about a serious game?
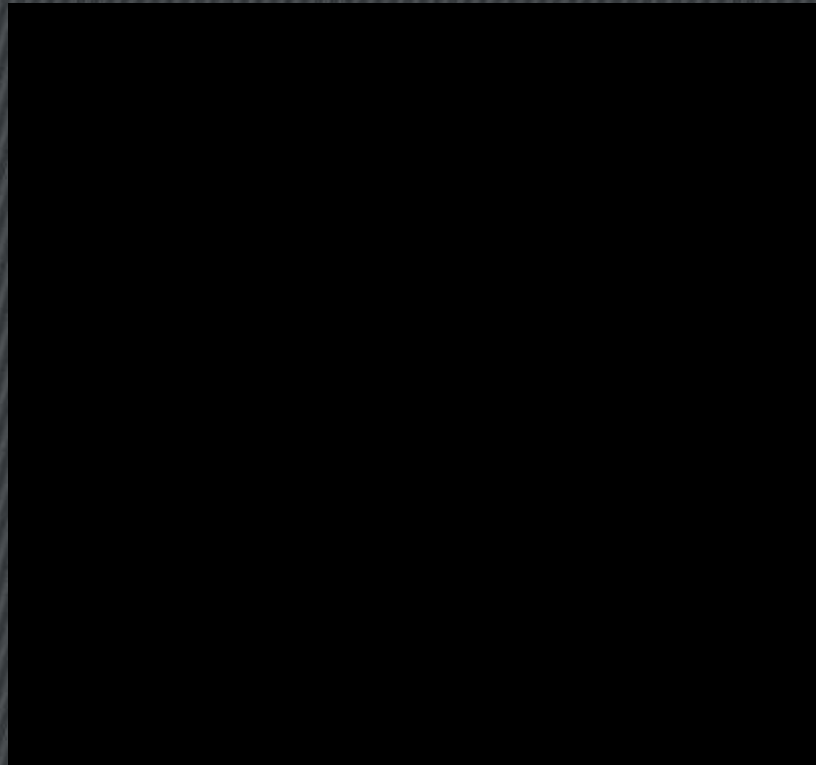
**The Serious Game Engine:
Unreal Engine**

**The Serious Game developer:
Dylan Nedelec (APEX solutions)**

The BIM2SIM brick
Bob and the NavMesh

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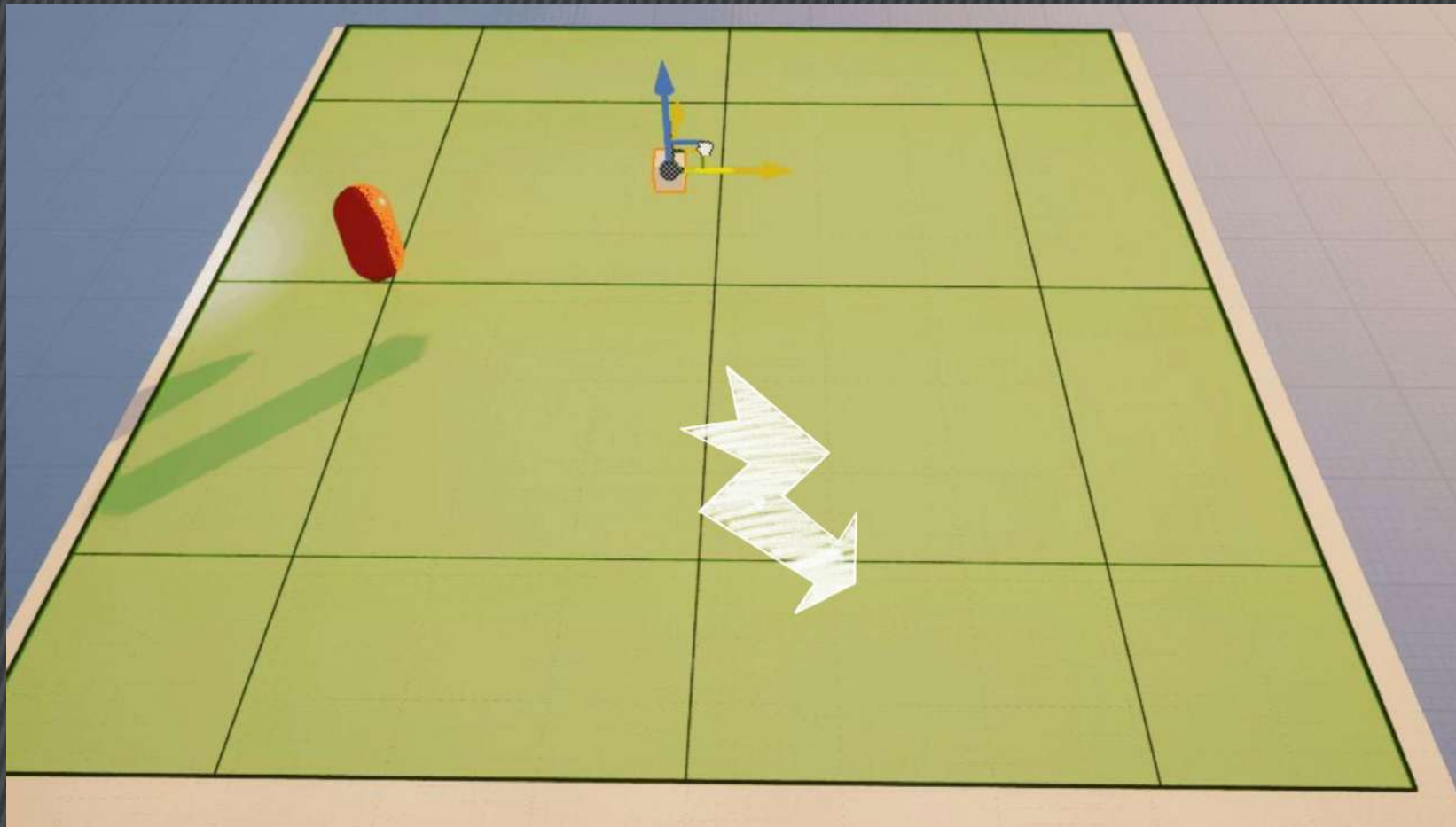
The BIM2SIM brick
About teleporters

BIM2SIM is able to detect doors, windows and other passageways, and it creates automatically the corresponding teleporters.

Window teleporter

Window teleporter

Door teleporter

Bay window teleporter

Fence teleporters

Fence teleporters

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SCOTT BROWNRIGG⁺
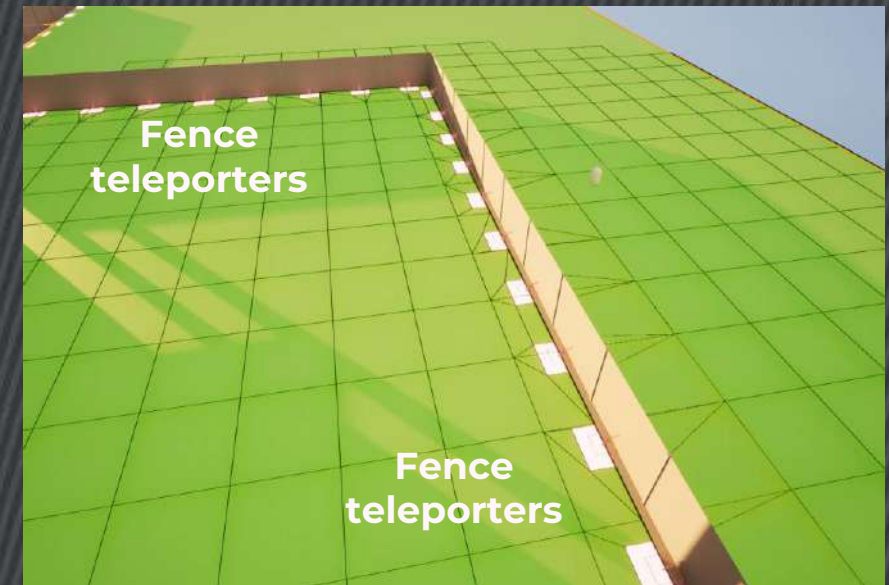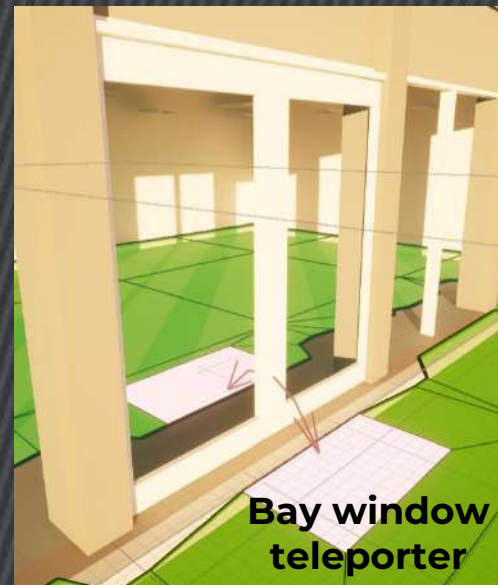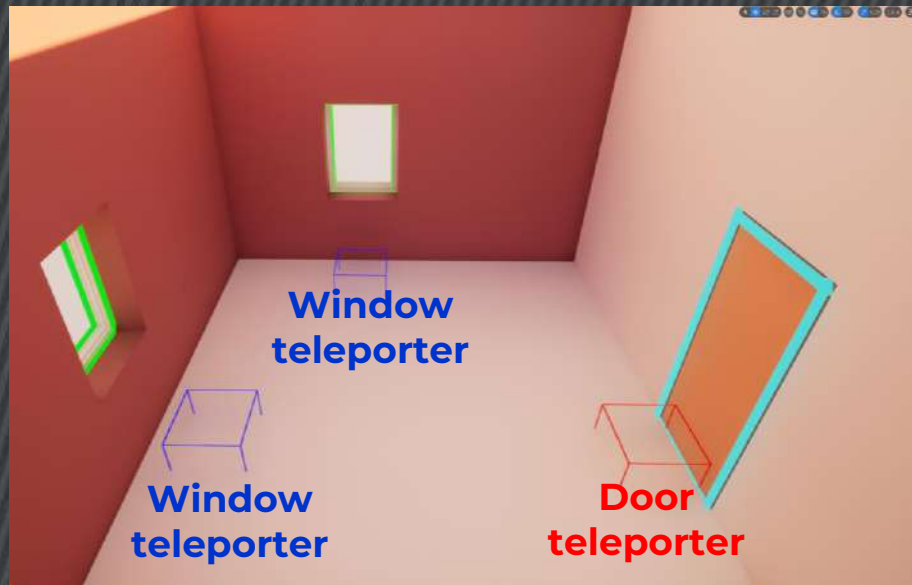
The BIM2SIM brick
Adding delays...

Passing through teleporters has a cost (delay), depending on the nature of the passageway and of the Red Team equipment.
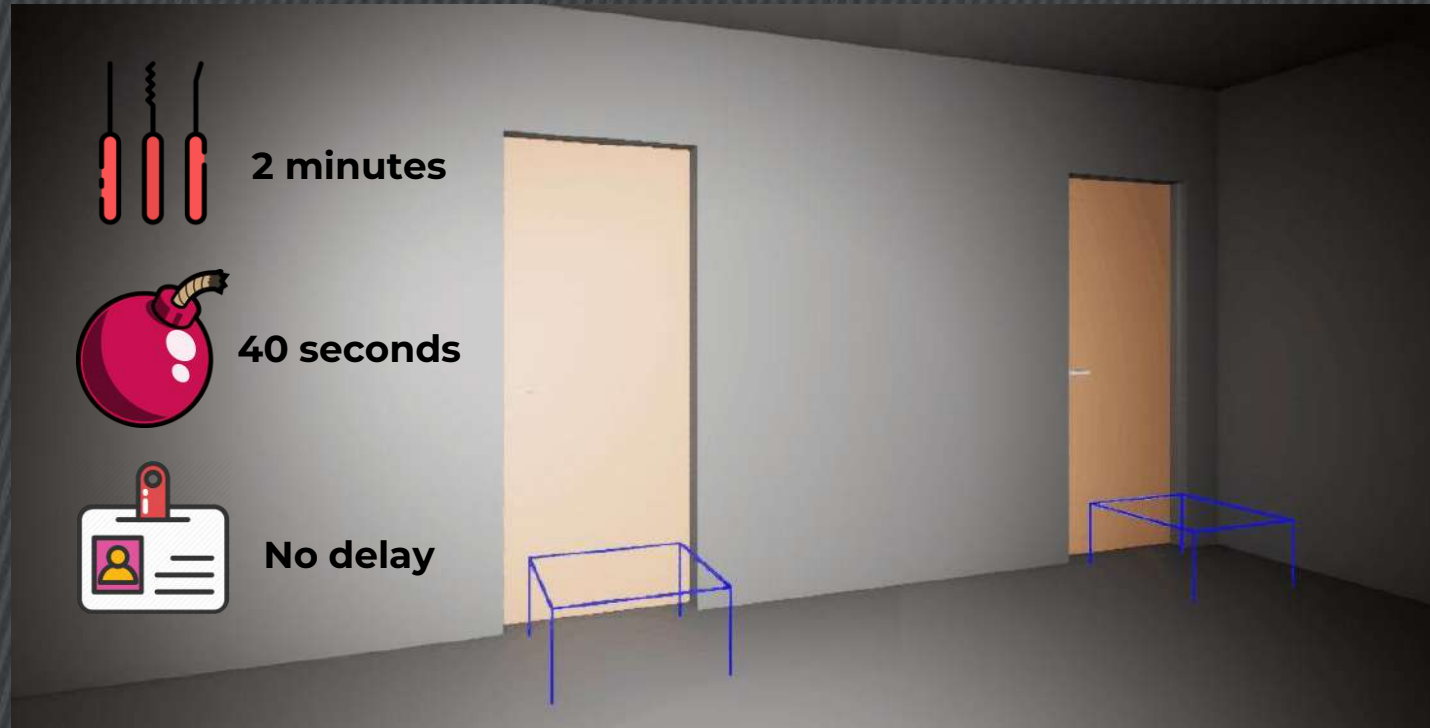
The BIM2SIM brick
Test 1: First come, first served

Bobs are powered by simple Unreal Ais, but they can find the shortest path (in time) to their target.

This is the worst case, *omniscient* assumption.
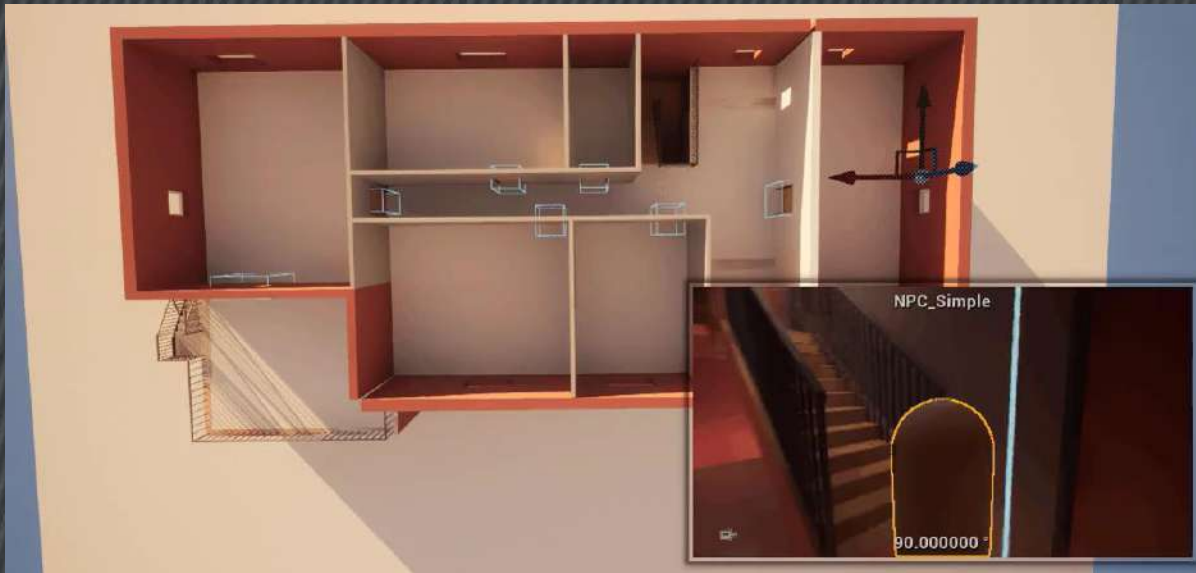
Single Bob

Competing Bobs

The BIM2SIM brick
Test 2: Cut to the chase

Blue Bob, can be programmed to chase Red Bob.

This reaction is triggered by a door detector.

Little ~~Thumb~~ Bob is leaving breadcrumbs

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The BIM2SIM brick
Test 3: Lift me up

Stairs caused no problem (they are simply « painted » with a NavMesh).

It has been far trickier to handle elevators (priorities)...
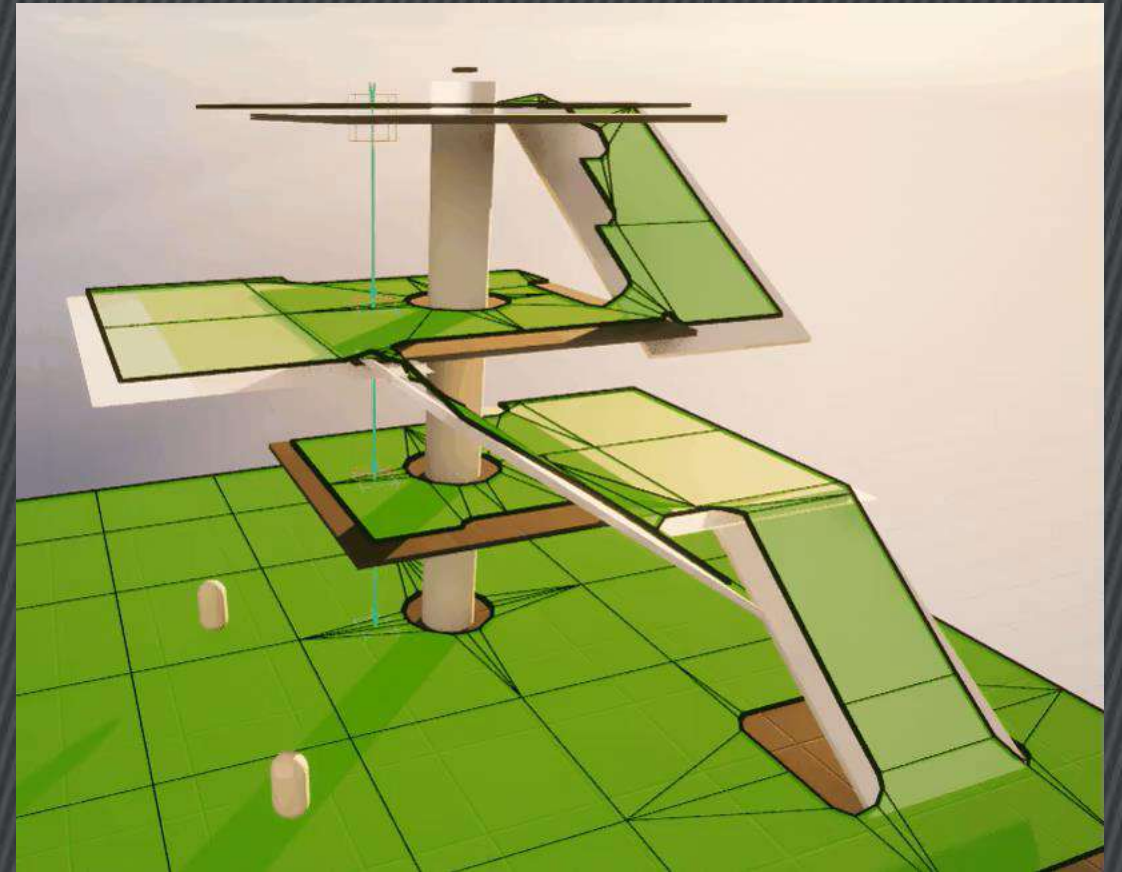
The BIM2SIM brick
Test 4: I am a camera…

BIM2SIM is able to replace cameras in the BIM model by Unreal ones. Some manual parametrization is still required for the moment…

Camera images are cast on "screens" in a virtual C² room

The BIM2SIM brick
Test 5: Round, round, get around...

We added prescribed rounds to Blue Bobs.

They can stop and chase a Red Bob if they « see » him.

Multiple guard rounds in the most complex BIM model

The BIM2SIM brick
Bonus: Charles' intership

For the future EPIC serious game we plan to develop a « level editor ».
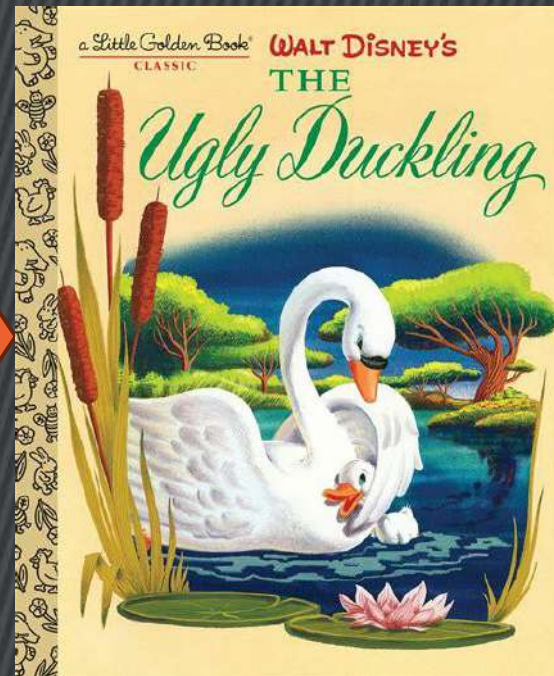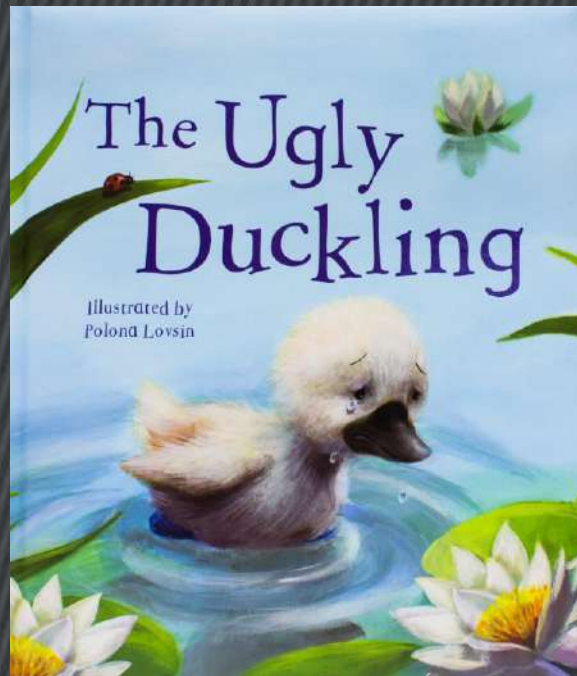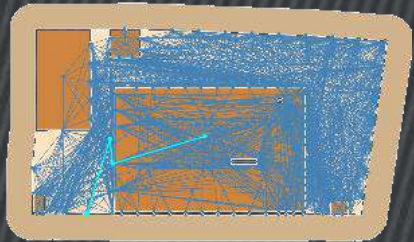**Charles began to develop a library of components during summer 2023.**
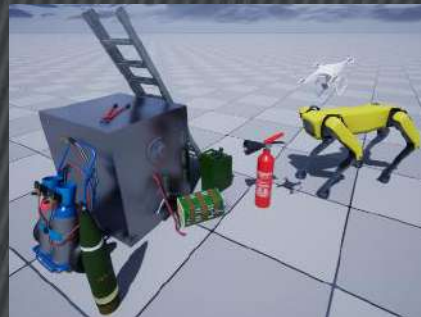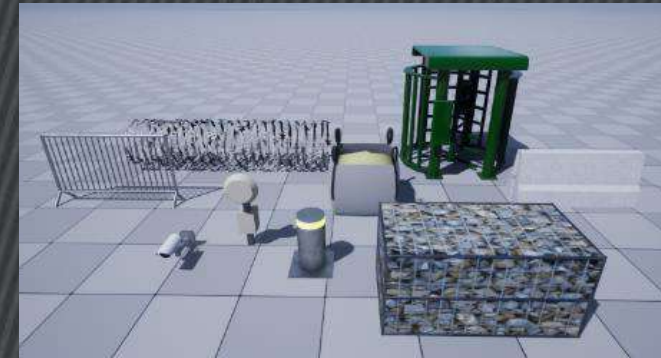
What's next?

From the PoC to the code...

What's next?
Summer 2024 internship #1: Shaza

Shaza will work will Dylan on the coupling between the BIM2SIM preprocessor and the previous EPIC code...
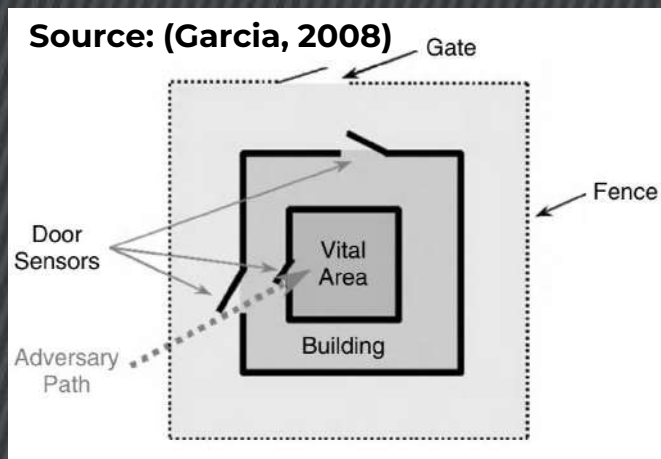

Shaza
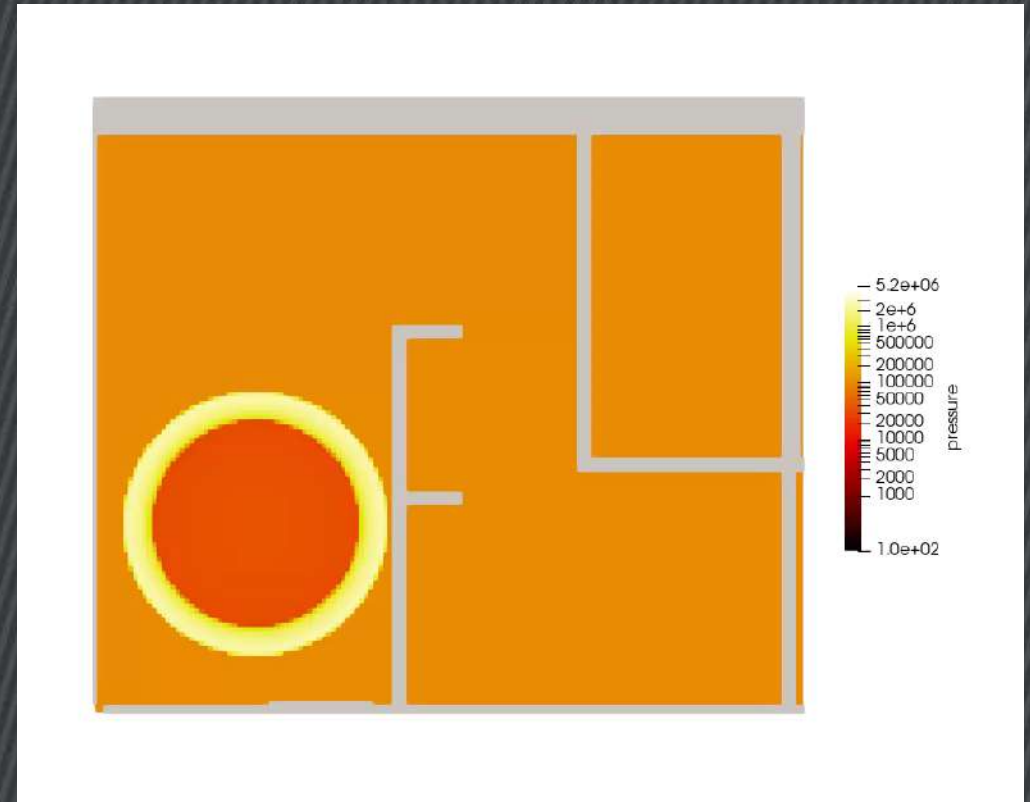
What's next?
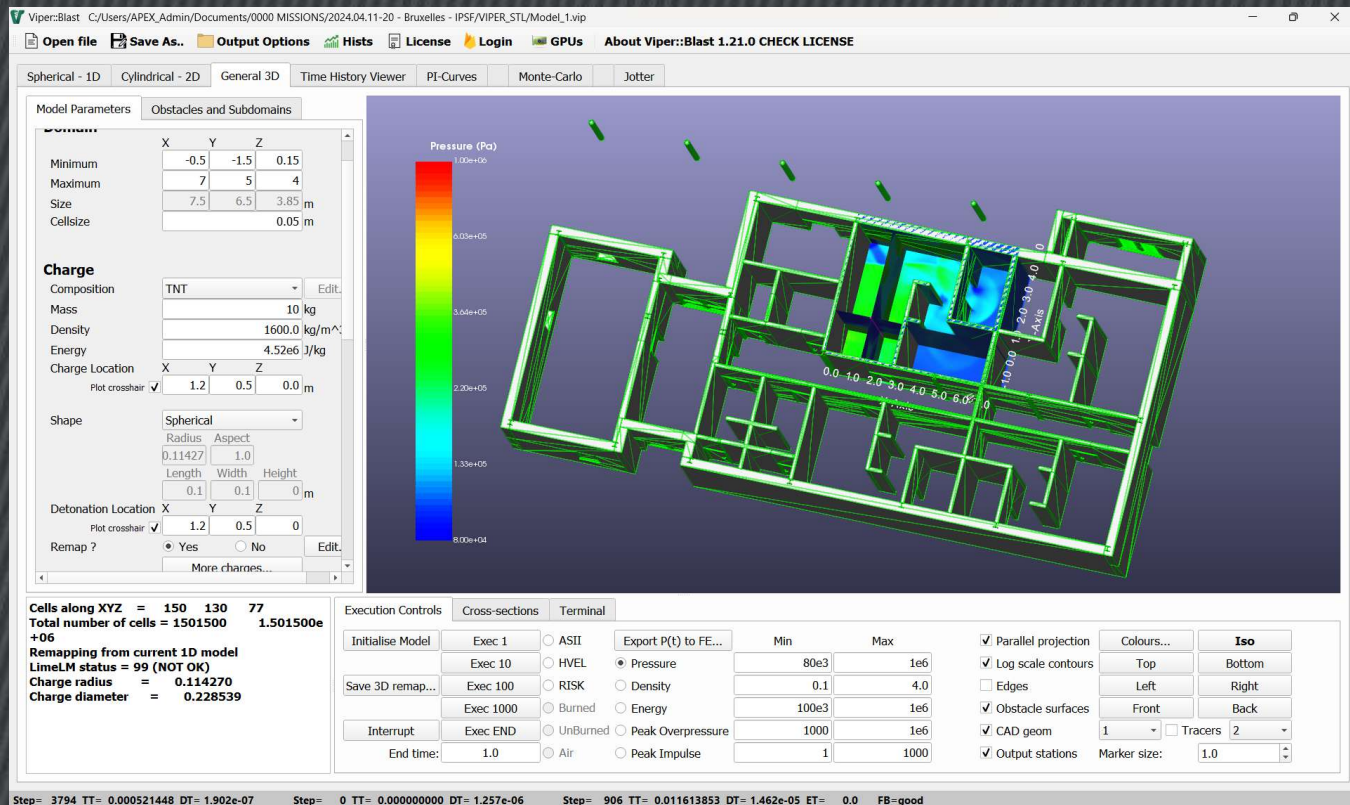## Summer 2024 internship #2: Pierre

In the EASI approach, all red Bobs are following the same path, and blue Bobs are only defined by a constant response time.

This is simplistic: we need Pierre and some AI magic to improve that!

Source: (Garcia, 2008)

Source: www.sciencefocus.com

Pierre

What's next?
Bonus: at last, an explosion!

BIM model #1 imported in Viper::Blast
(www.viper.as)

Post-processing
In Paraview (www.paraview.org)

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Qu