

# Use of *\_Reasoner\_* for automated building code compliance assessment

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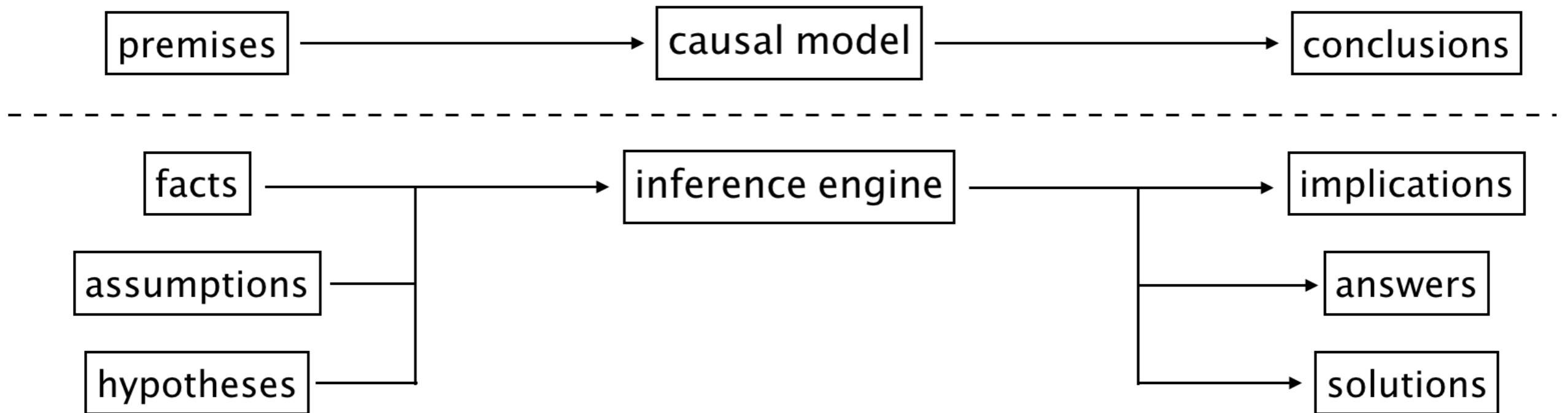
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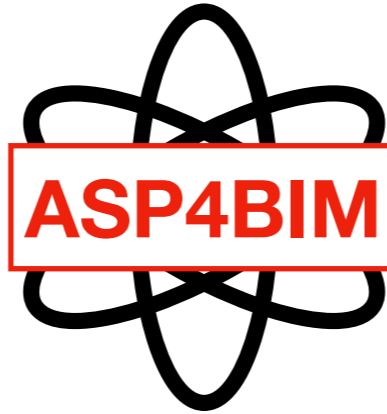
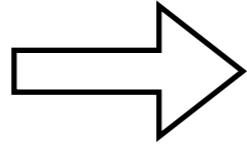
# Causal model and inference engine



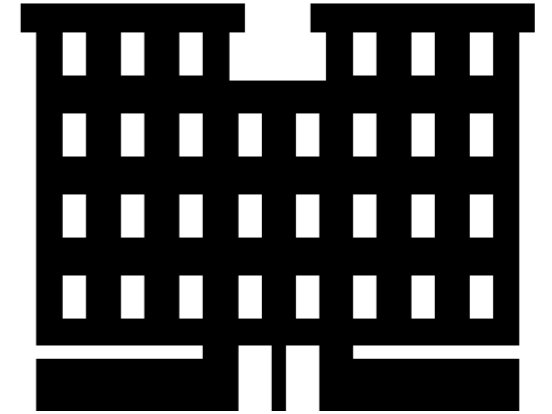
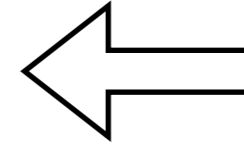
# ASP4BIM - A declarative spatial reasoner



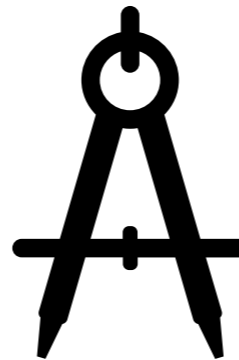
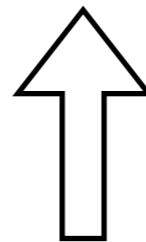
**Building regulations**



**Spatial reasoner**

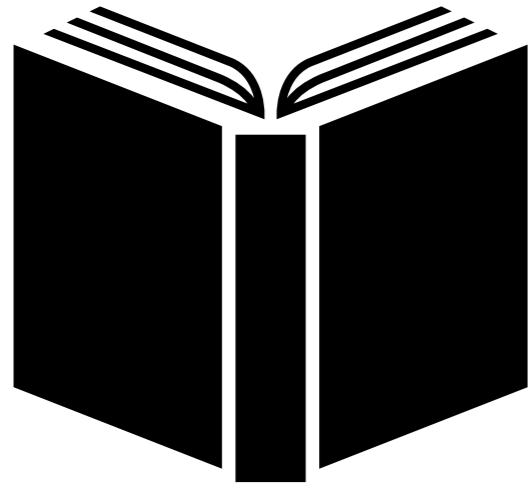


**Building models**



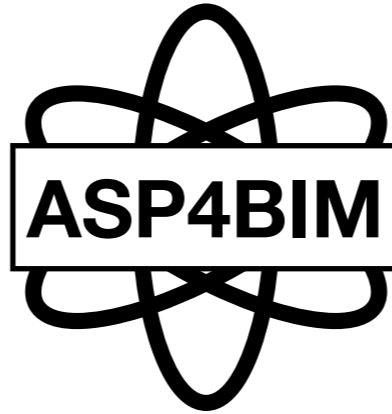
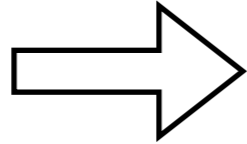
**Domain knowledge**

# Building regulations - Challenges

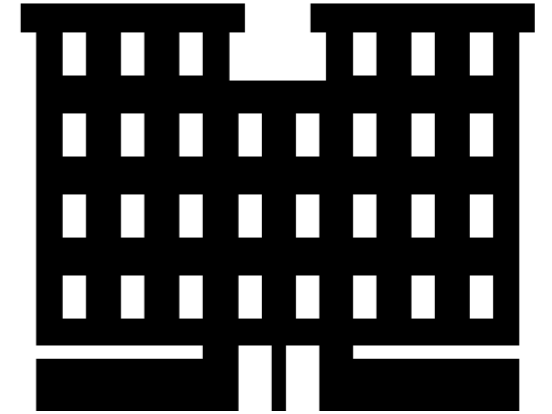
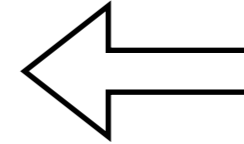


**Building regulations**

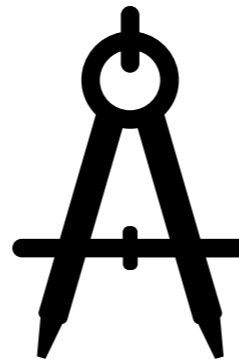
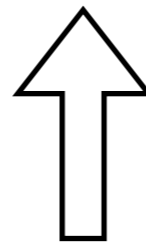
**Ambiguity**  
**Defeasibility**



**Spatial reasoner**



**Building models**



**Domain knowledge**

# Building regulations

IF-Condition

THEN-Condition

Exception

Ambiguity

[BR10-3.2.1(3)] *In building open to the public which offers citizen services, important information about the layout and use of the building **must** be **easy to read** and understand.*

[BBR18-3:1425] *Electronic signage **should** be designed to **ensure** people with **limited orientation capacity** **are able to** **perceive** and **understand** it.*

3. *Signs and other guidance markings for evacuation **shall** be provided **unless** manifestly **unnecessary**. Guidance markings **shall** **if** necessary be illuminated or translucent. Signs and other markings **shall** be placed at **appropriate** points and be made to last.*

4. *On an **escape route**, signs **may** be particularly **necessary** **where** there is a **risk of error**, e.g. at a change of direction or at a **junction**.*

[NZBC-DS1/AS1-1.1.1] *Accessible routes **shall** be provided to give direct access to the **principal entrance** to the building **where** practical. **If it is not** practical, the alternative most **direct** **practical** route to the space **served by** the principal entrance **shall** be used.*

[NZBC-DS1/AS1-1.3.1] **Except** in household units or where permitted by Paragraph 1.3.2, a single isolated step shall not be **permitted** but the **change of level** shall be constructed as a ramp **complying** with Paragraph 3.0.

# Building regulations - Defeasibility

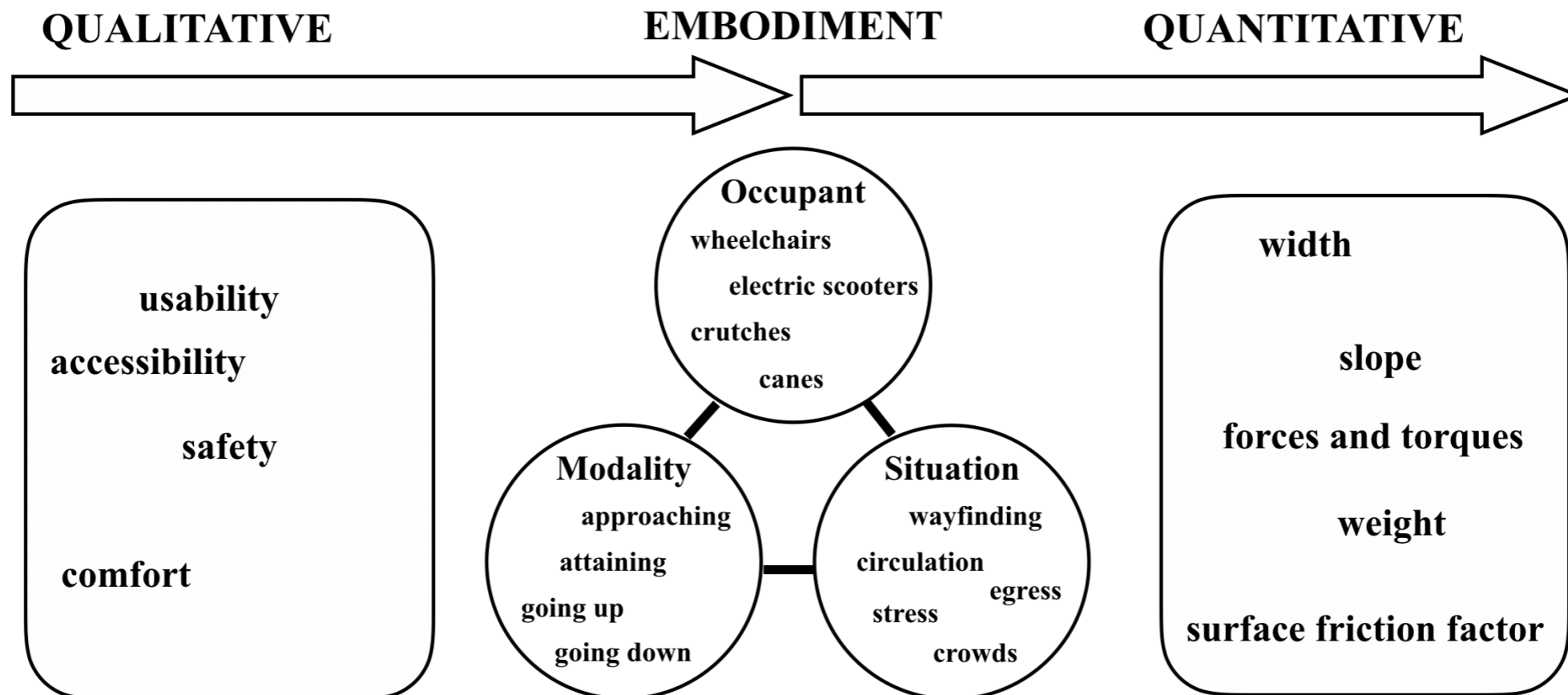
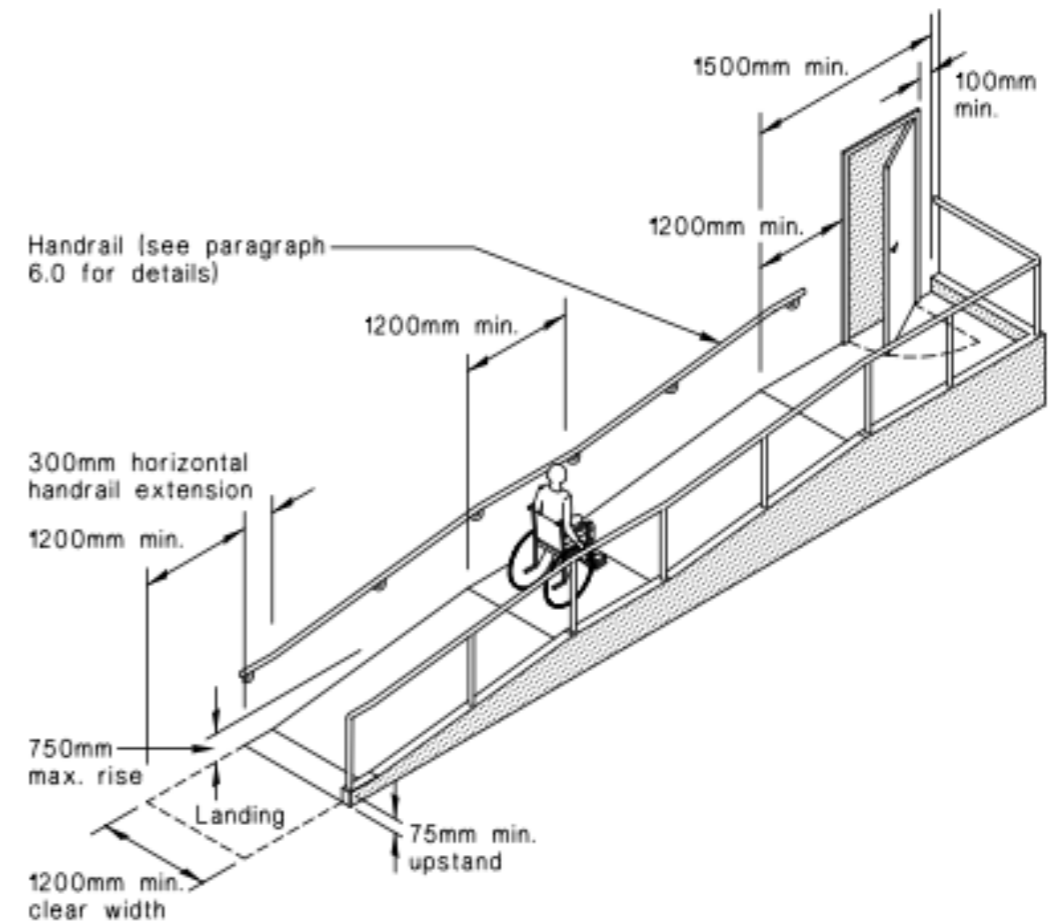
*if* **Condition** ...

*except* **Exception** ...

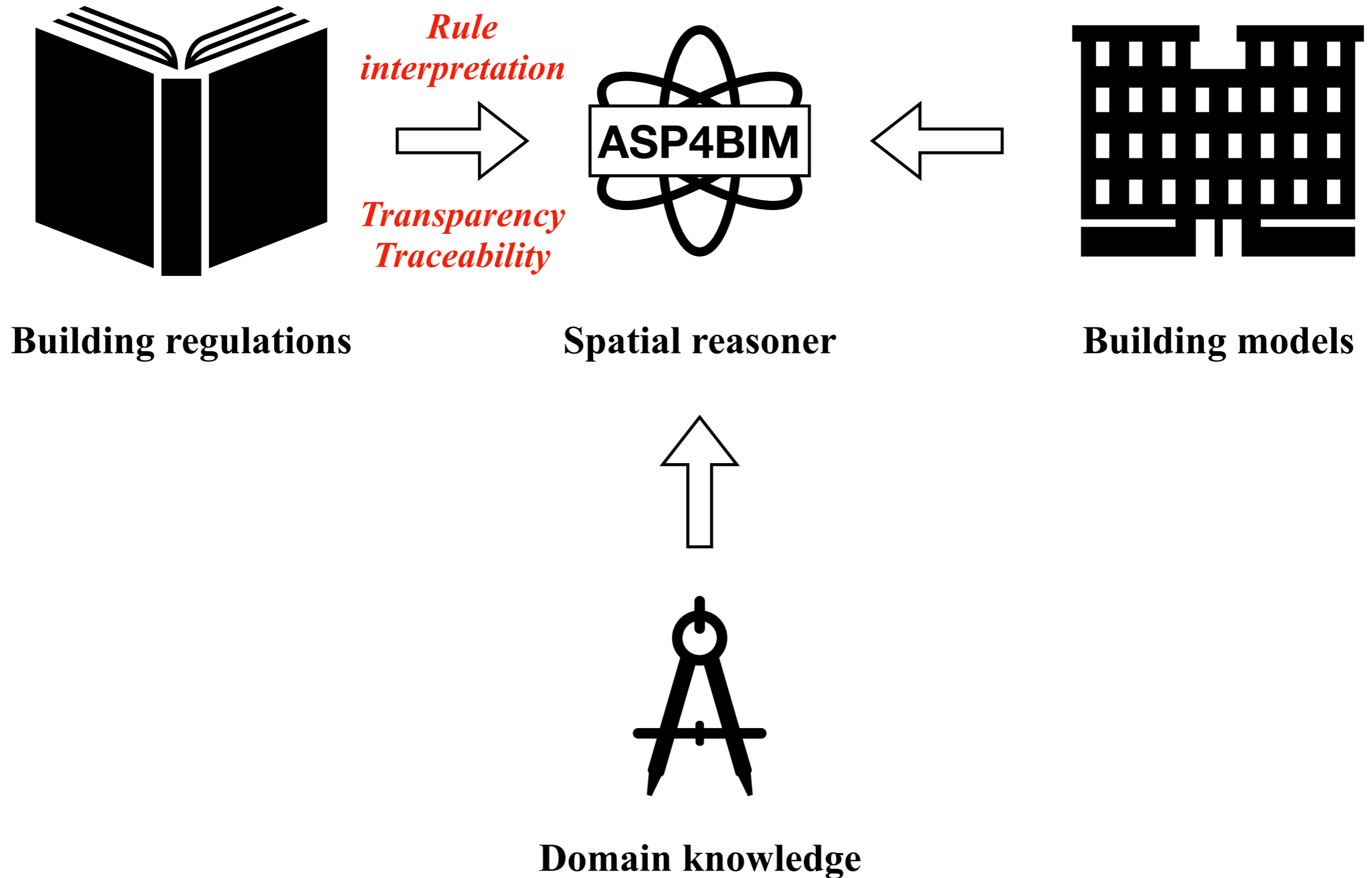
*then* **Requirement** ...

# Building regulations - Ambiguity

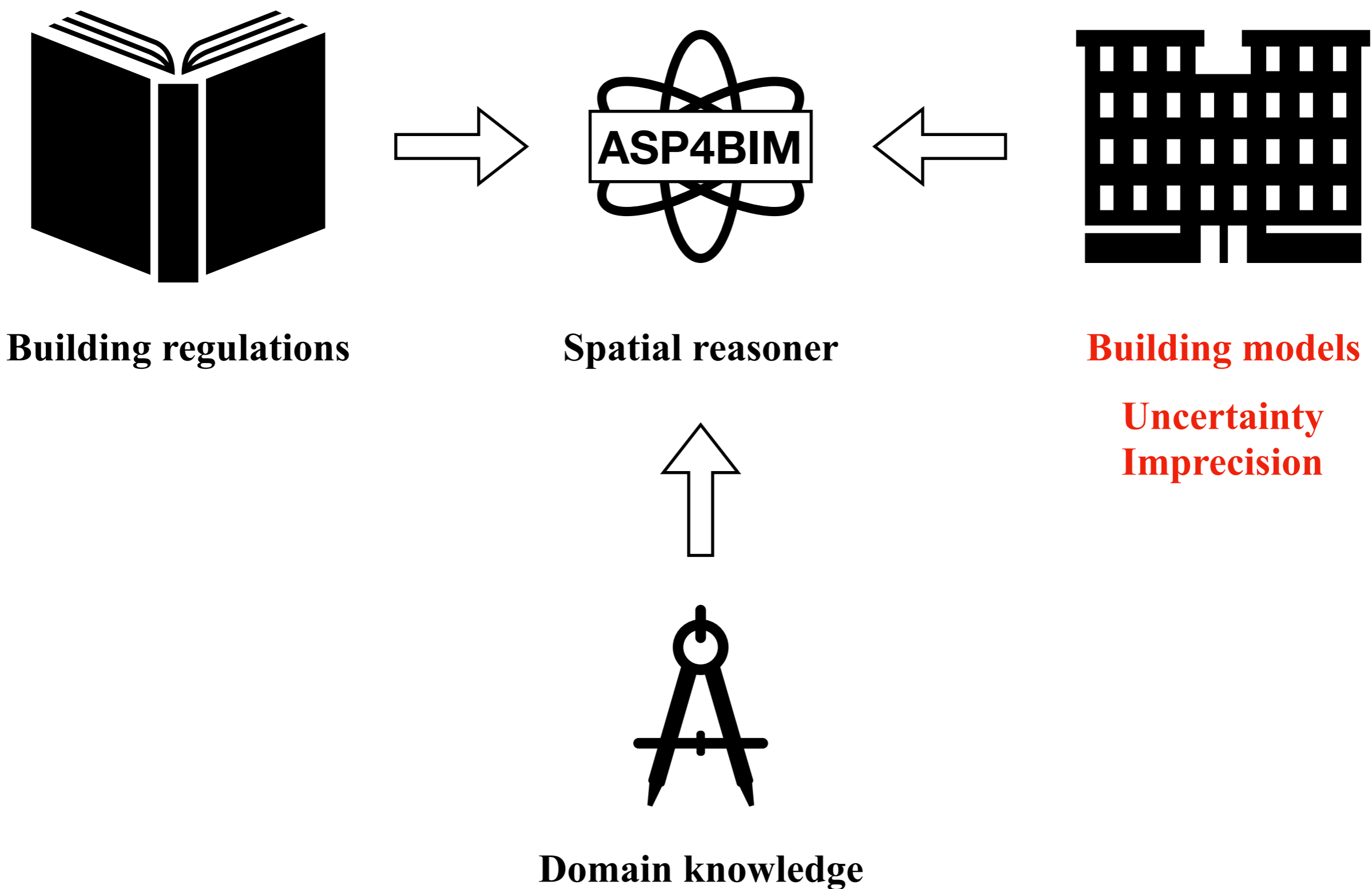
*Ramps shall be able to be used by people with limited mobility*



# Rule interpretation - Desired properties



# Building models - Challenges



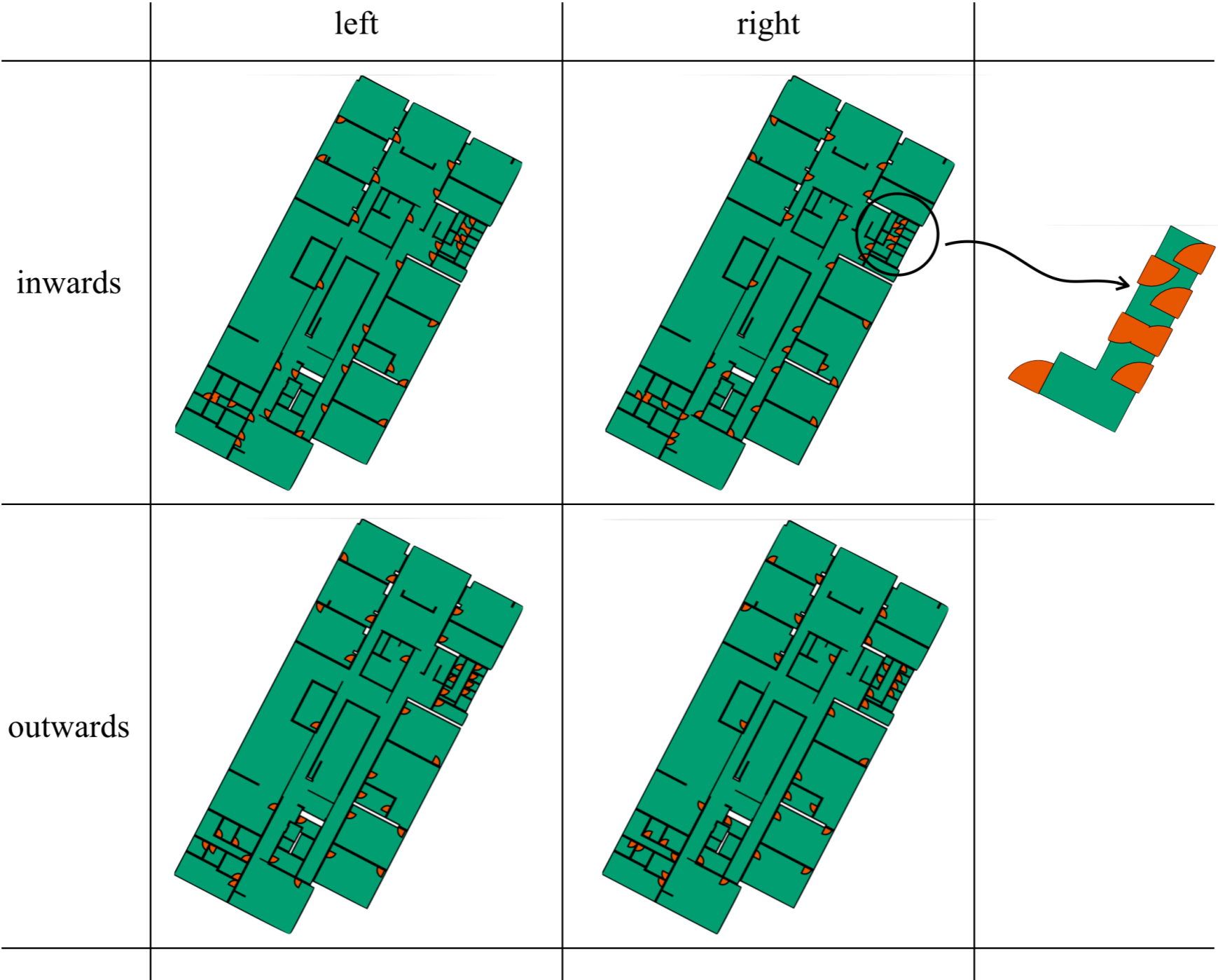
# Building models

1) **Swing direction**

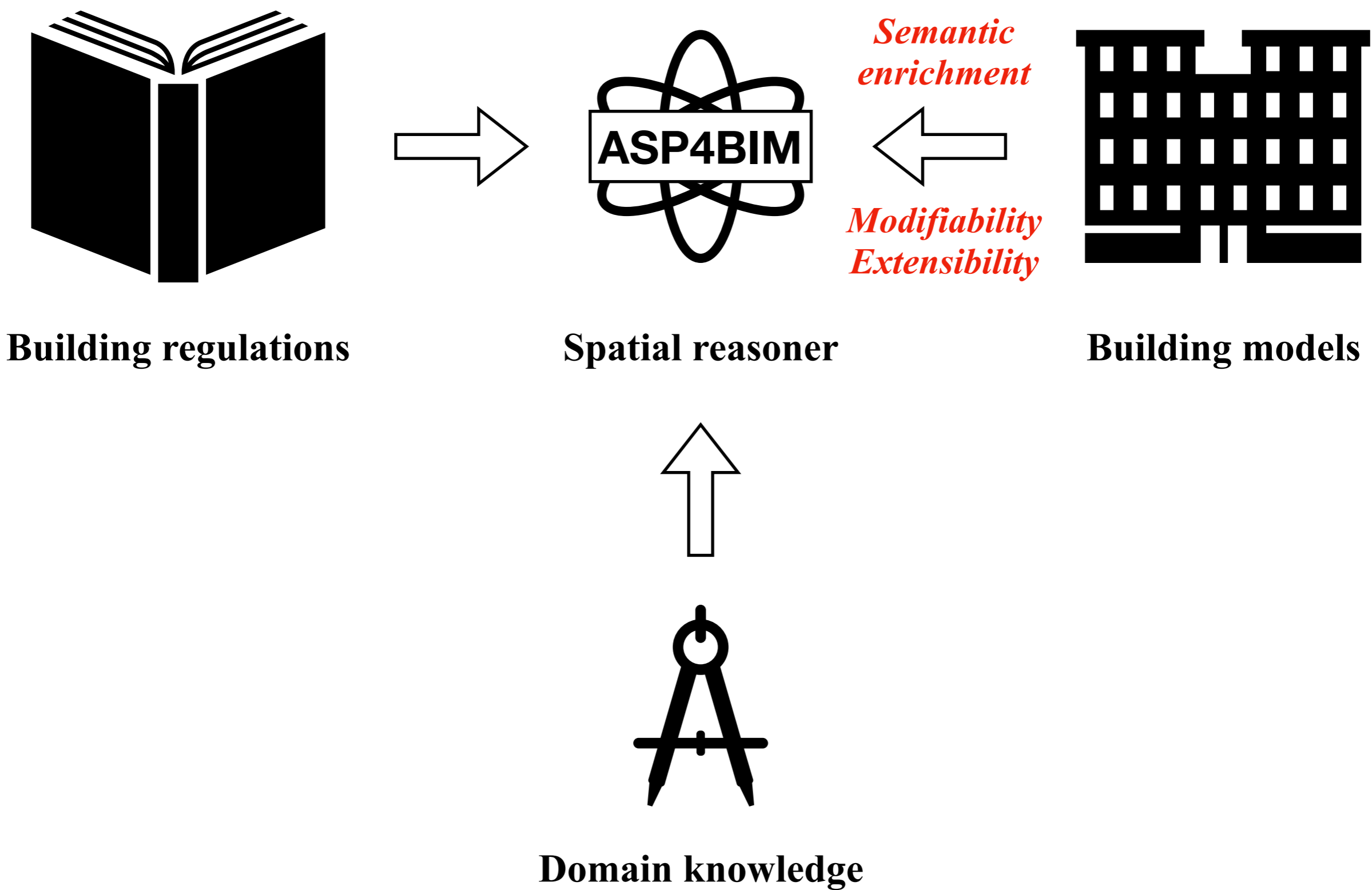
IfcDoorStyle.OperationType =  
SingleSwingLeft; SingleSwingRight.

2) **Hinge side**

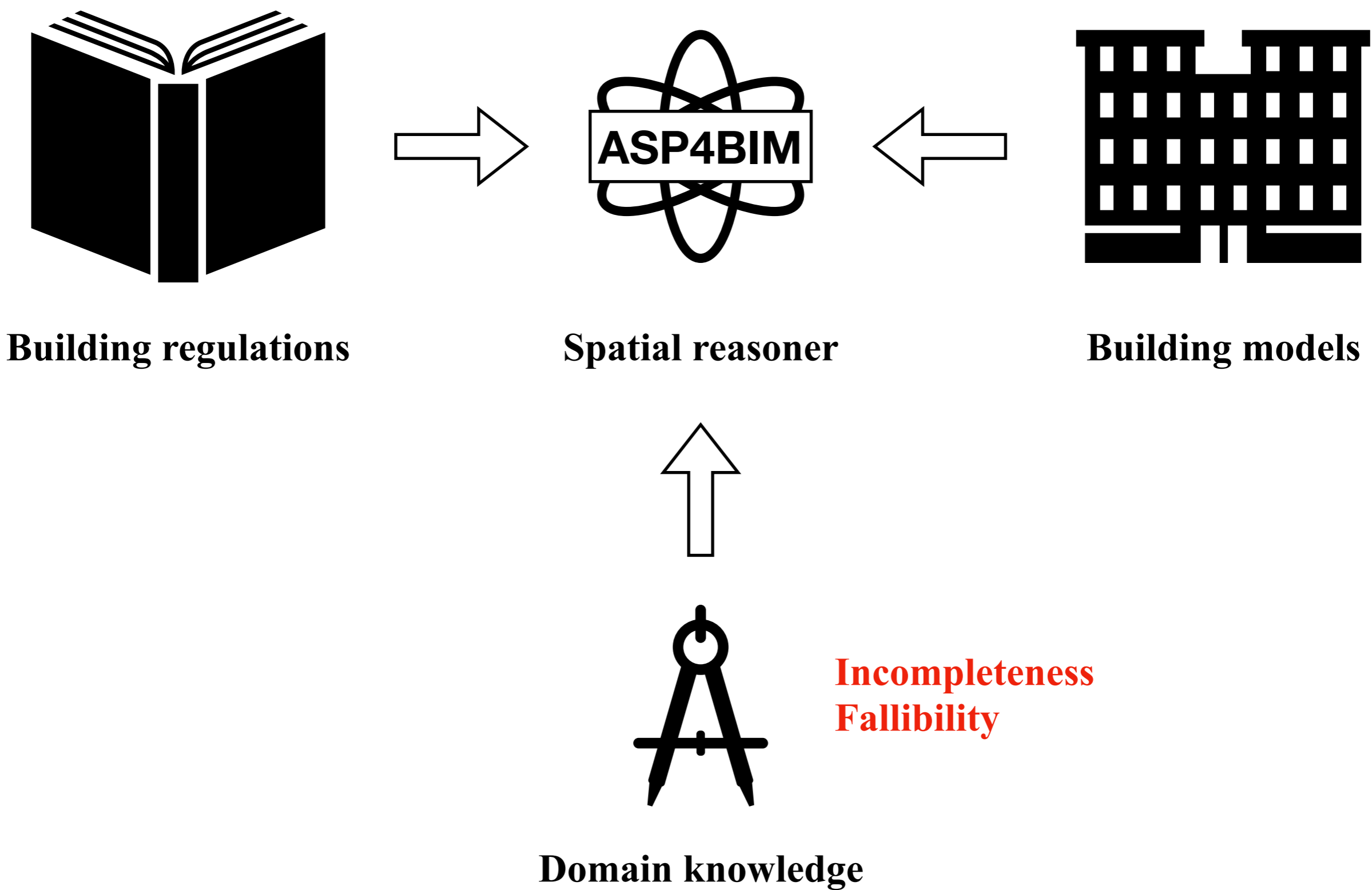
IfcDoorType.OperationType =  
SingleSwingLeft; SingleSwingRight.



# Semantic enrichment - Desired properties

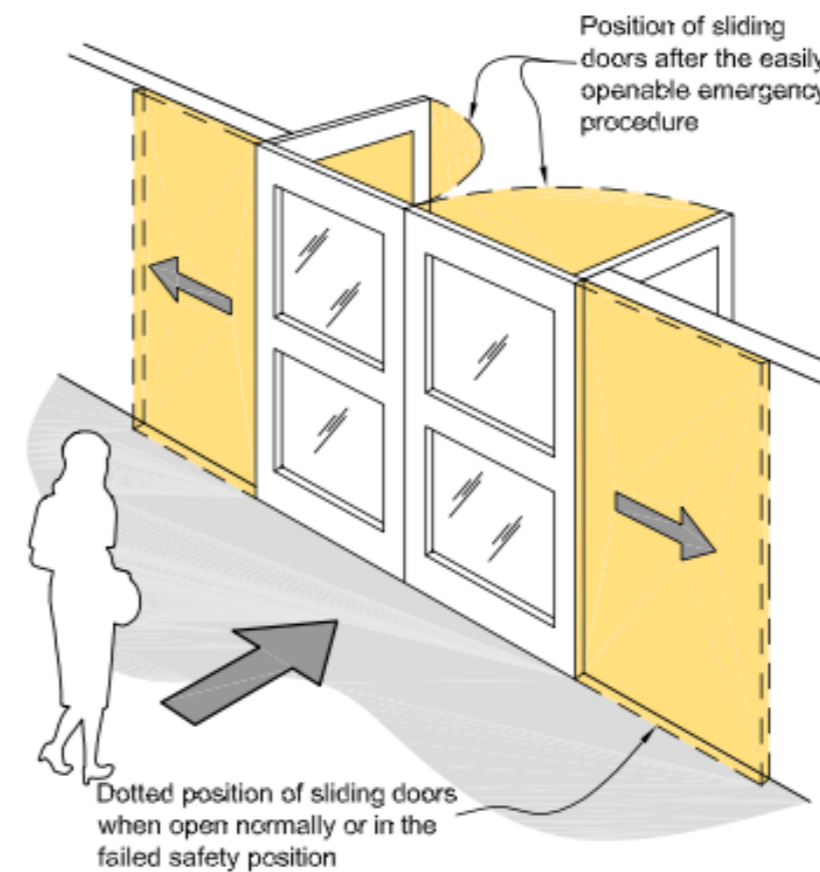
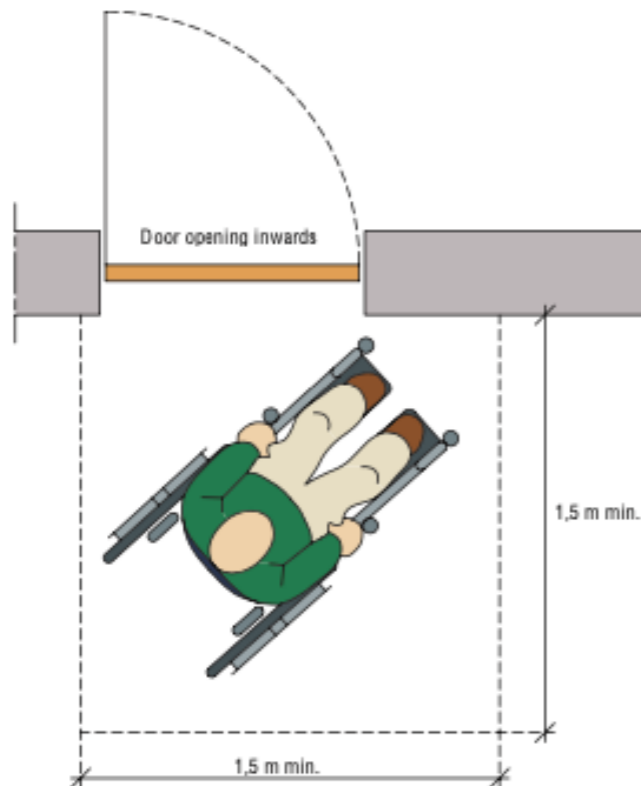
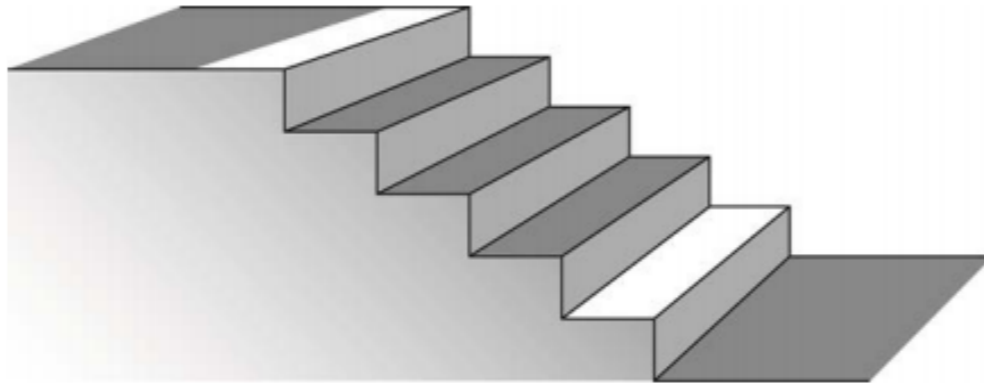


# Domain knowledge - Challenges

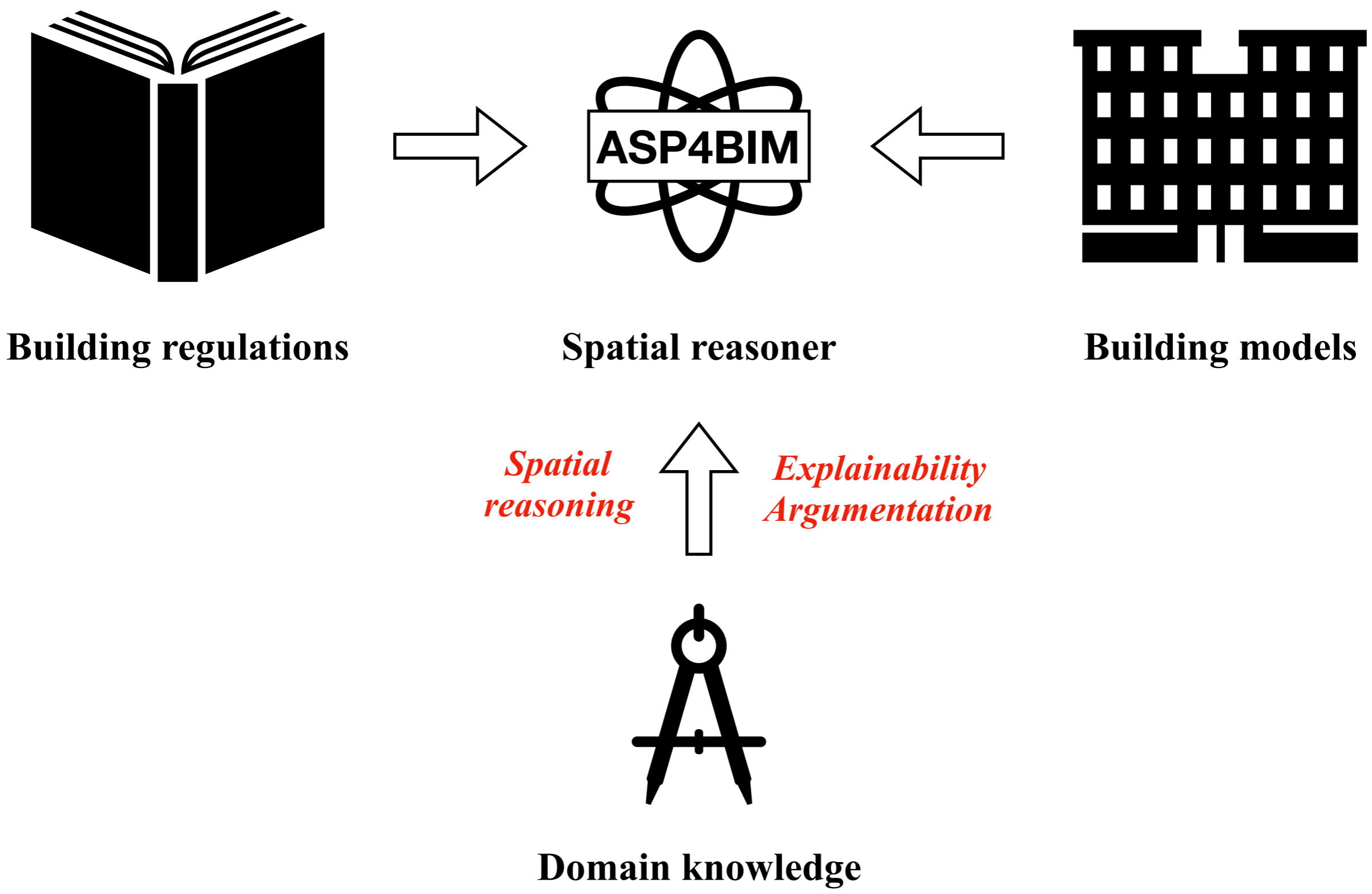


# Domain knowledge

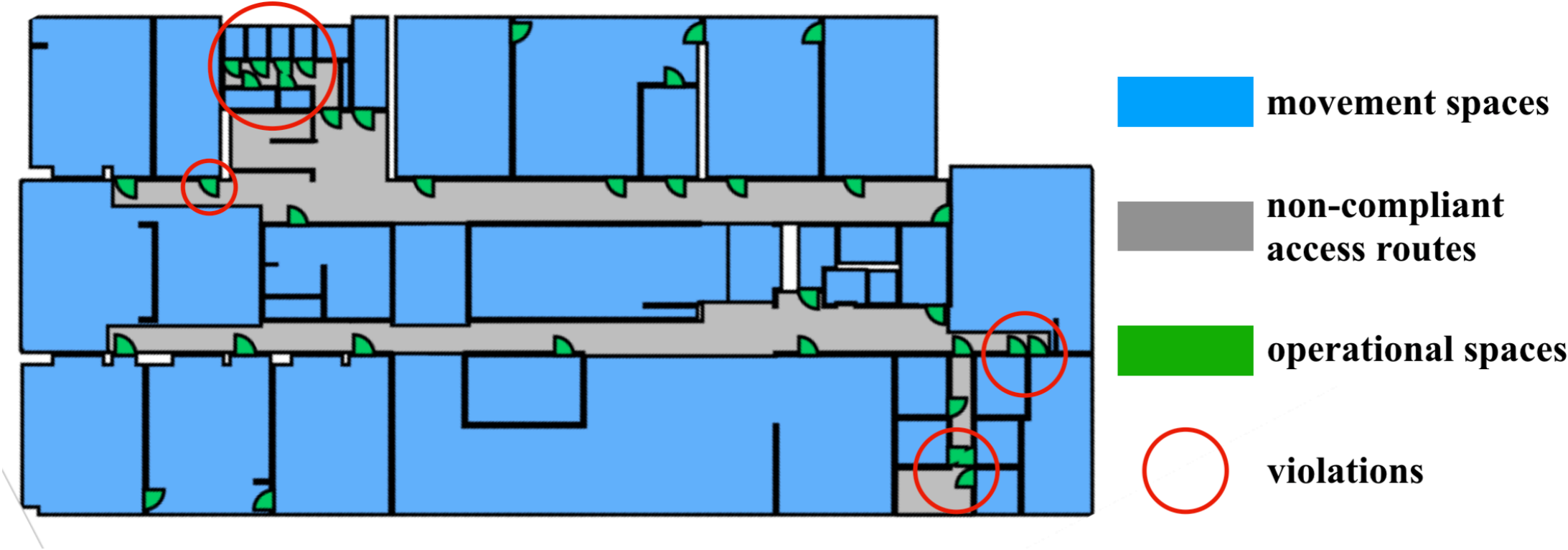
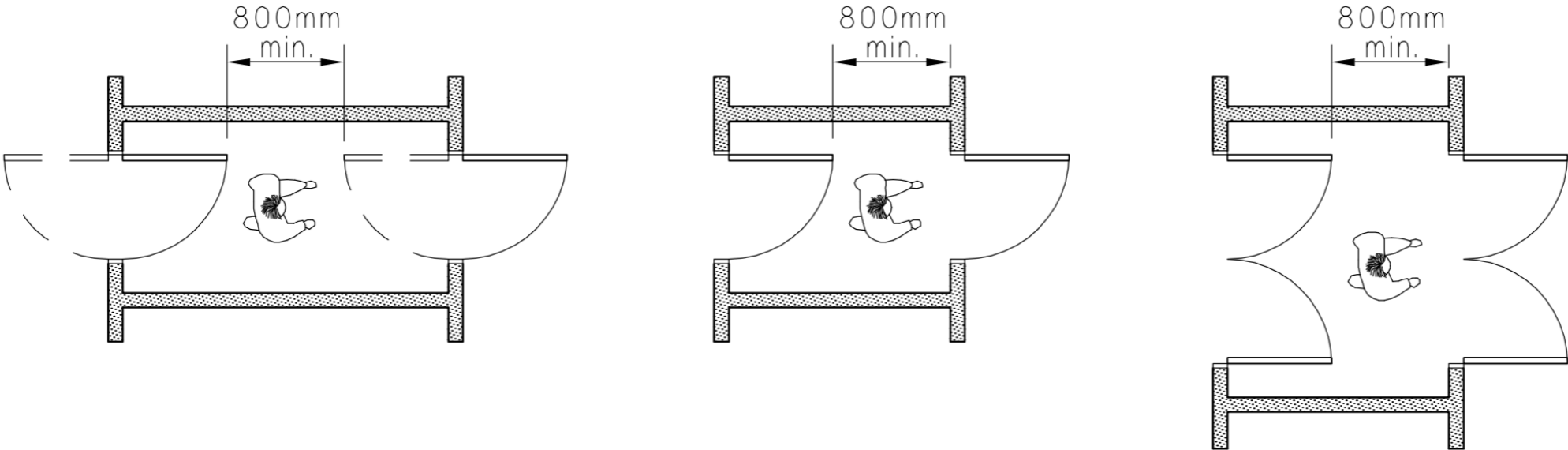
*The **principal entrance** is the largest door on the ground level **at the front of the building***



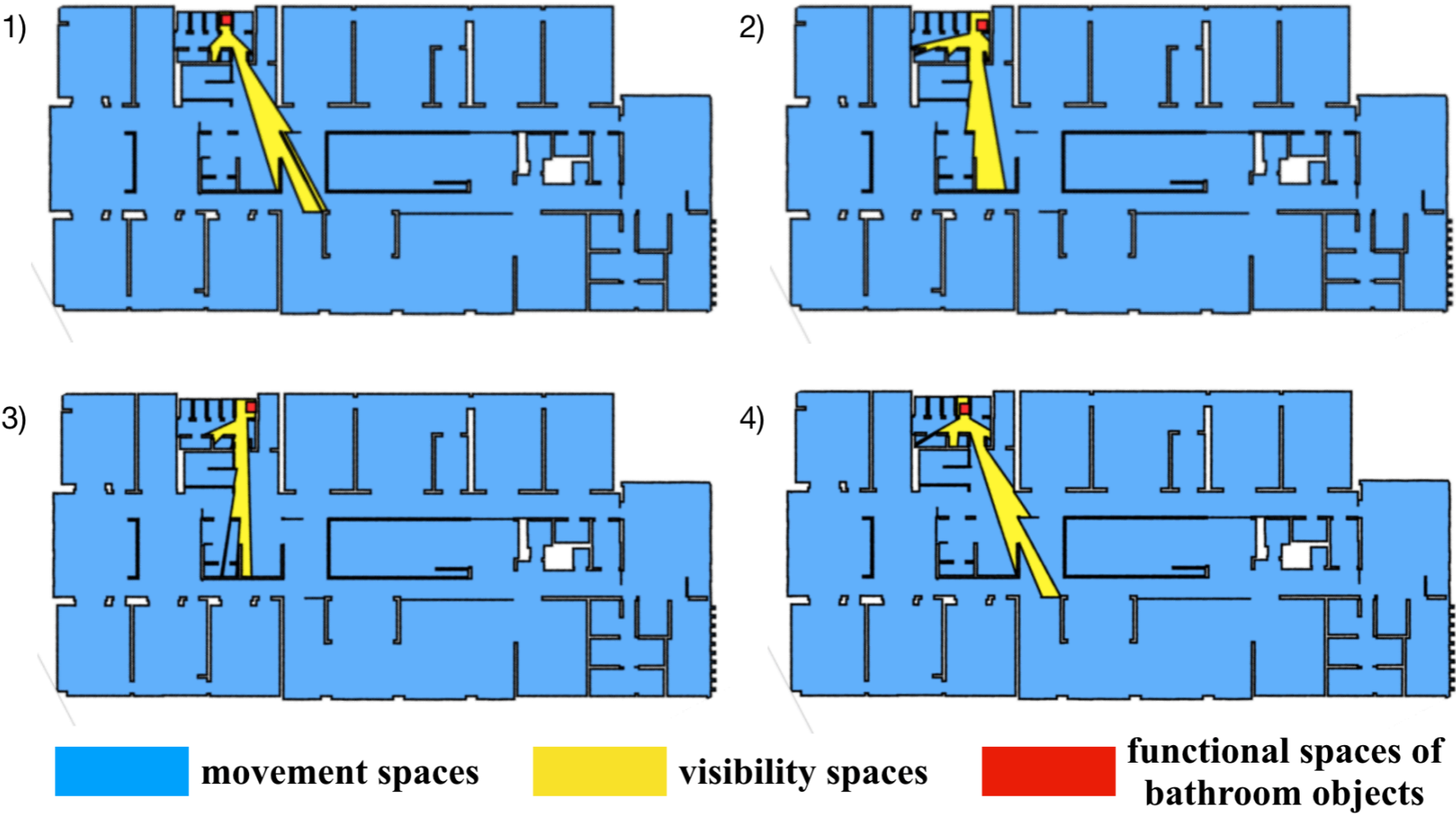
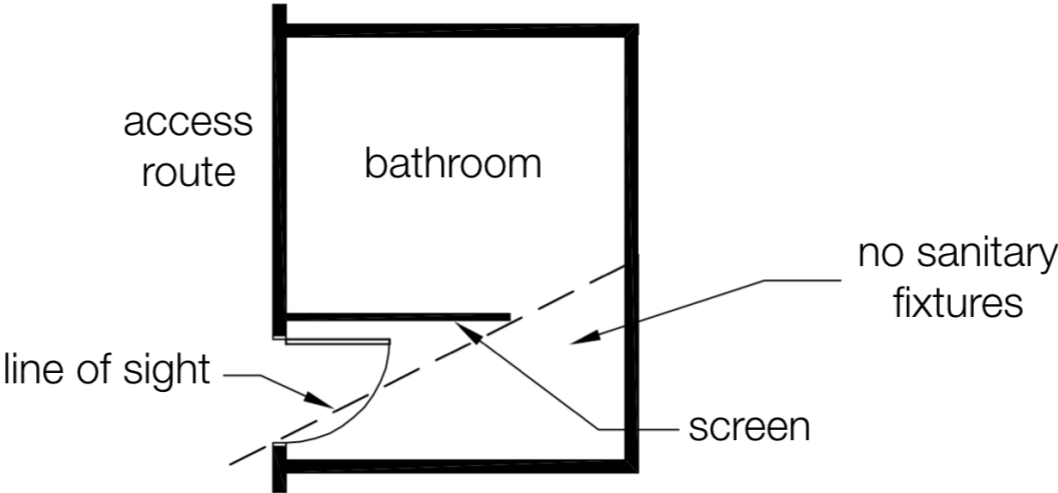
# Spatial reasoning - Desired properties



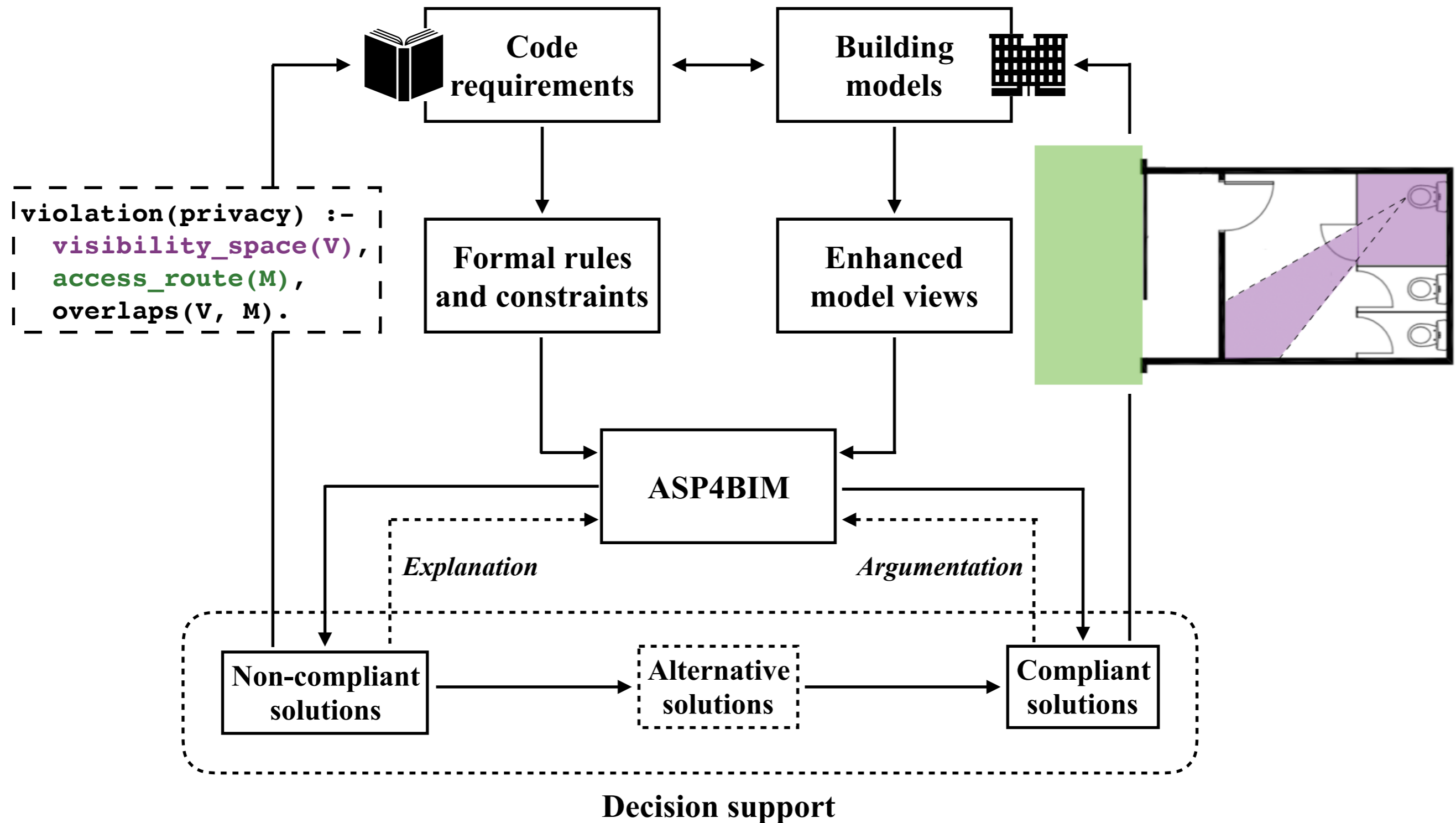
# ASP4BIM - Accessibility



# ASP4BIM - Privacy



# ASP4BIM - Workflow



# Evaluation of ASP4BIM

Code provisions	Model statistics	Runtime	References
There shall be no direct line of sight between an access route or accessible route and a WC, ...	2-storey building in NZ 8304 BIM objects	1.6 seconds	NZBC-G1-6.1.1*
Where doors open into a lobby, the clear space between open doors shall comply with Figure 27.	2-storey building in NZ 6796 BIM objects	8.4 seconds	NZBC-D1/AS1-7.0.1*
An unobstructed wall space of not less than 300 mm shall be provided at the side of the door adjacent the handle.		8.5 seconds	
The clear width of an accessible route shall be no less than 1200 mm.		0.3 seconds	NZBC-D1/AS1-2.2.1*
Access route shall have a height clearance of minimum 2100 mm		0.2 seconds	NZBC-D1/AS1-1.4.1*
Each worker constructing a leading edge 6 feet or more above a lower level must be protected by guardrail systems, safety net systems, or personal fall arrest systems.	9-storey building in DE 5415 BIM objects	0.59 seconds	OSHA 29 CFR 1926.501(b)(2)*
	4-storey building in DK 707 BIM objects	0.24 seconds	
	2-storey fire station in DE 12173 BIM objects	0.2 seconds	

\*NZBC New Zealand Building Code

\*OSHA Occupational Safety and Health Administration

# **ASP4BIM - A declarative spatial reasoner**

- Three-value logic (True, False, Unknown)**
- Spatial data structures**
- User-defined geometry libraries**
- Dynamic link to reference documents**

**Thank you for your attention!**

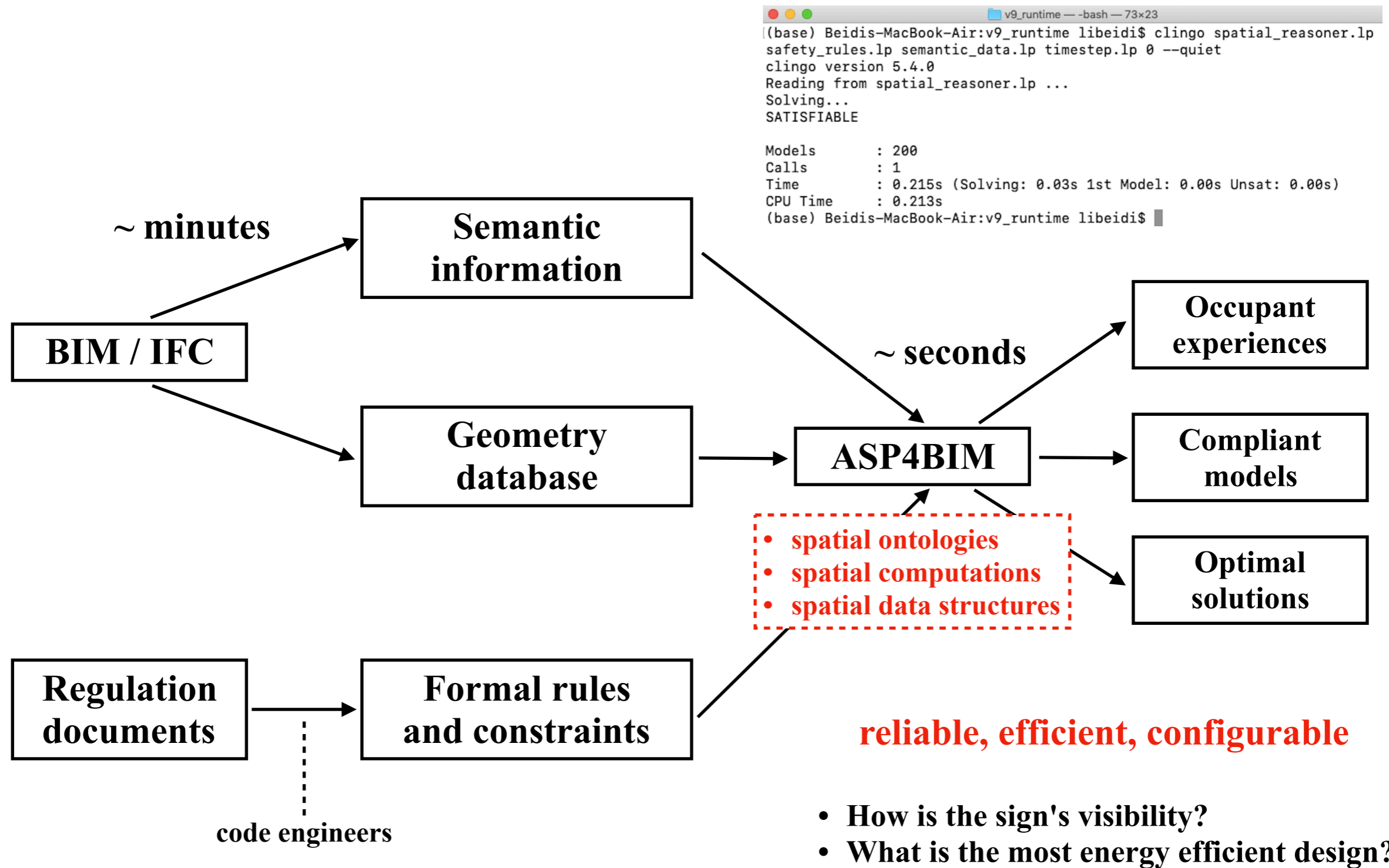
**Questions?**

**beidi.li@ece.au.dk**

**<https://github.com/libeidihuhuhu/ASP4BIM>**

**Back-up slides**

# ASP4BIM - Operational performance



**reliable, efficient, configurable**

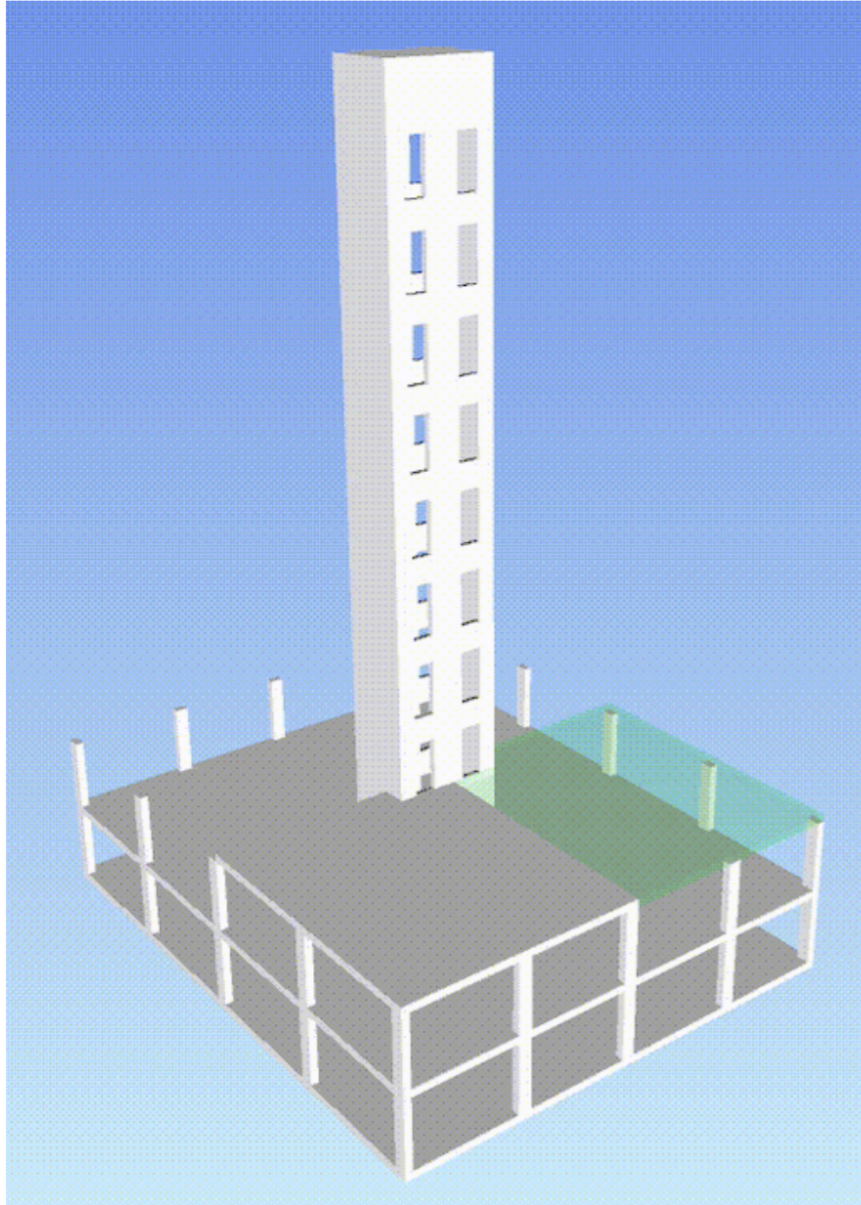
- How is the sign's visibility?
- What is the most energy efficient design?

clingo and gringo: <https://potassco.org/clingo/>

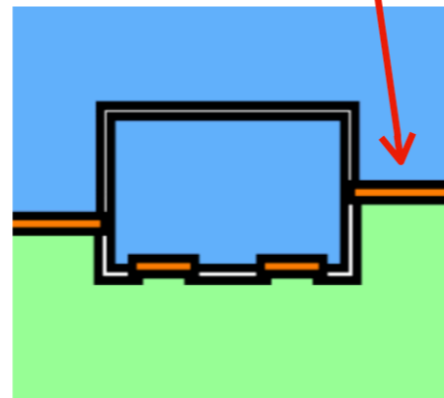
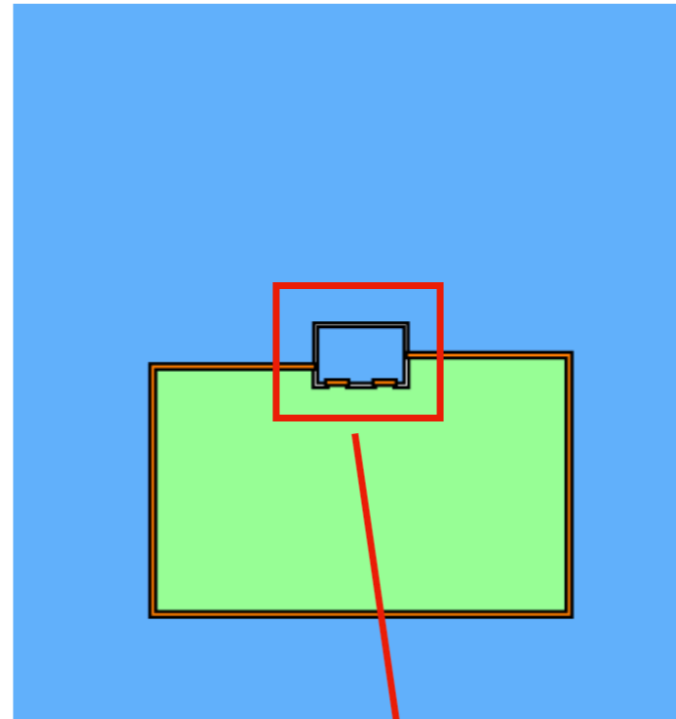
clingo API documentation: <https://potassco.org/clingo/python-api/5.4/>

# ASP4BIM - Construction safety analysis

1)

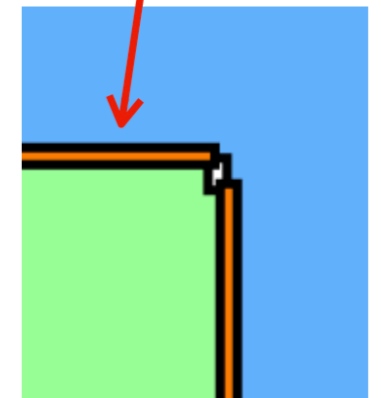
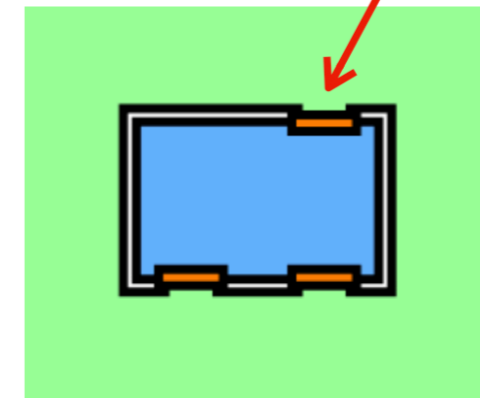
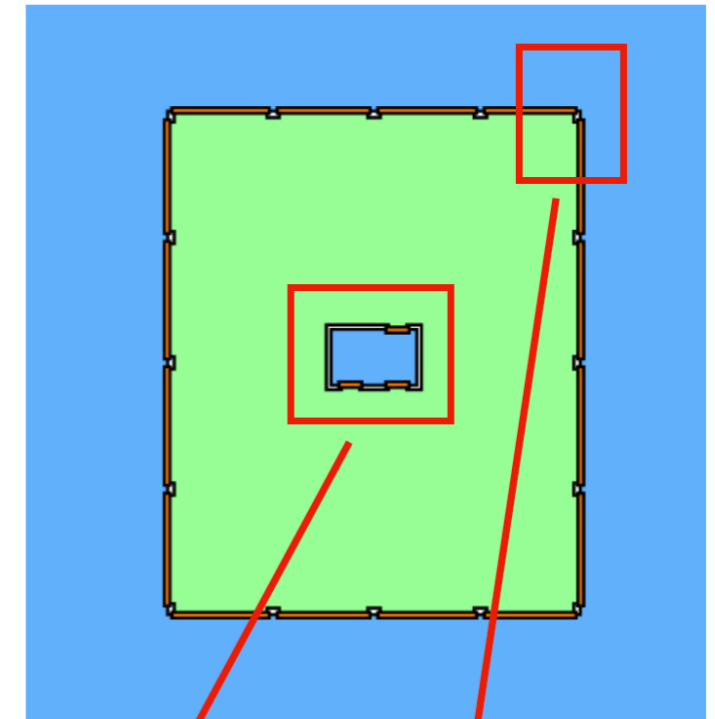


2a)

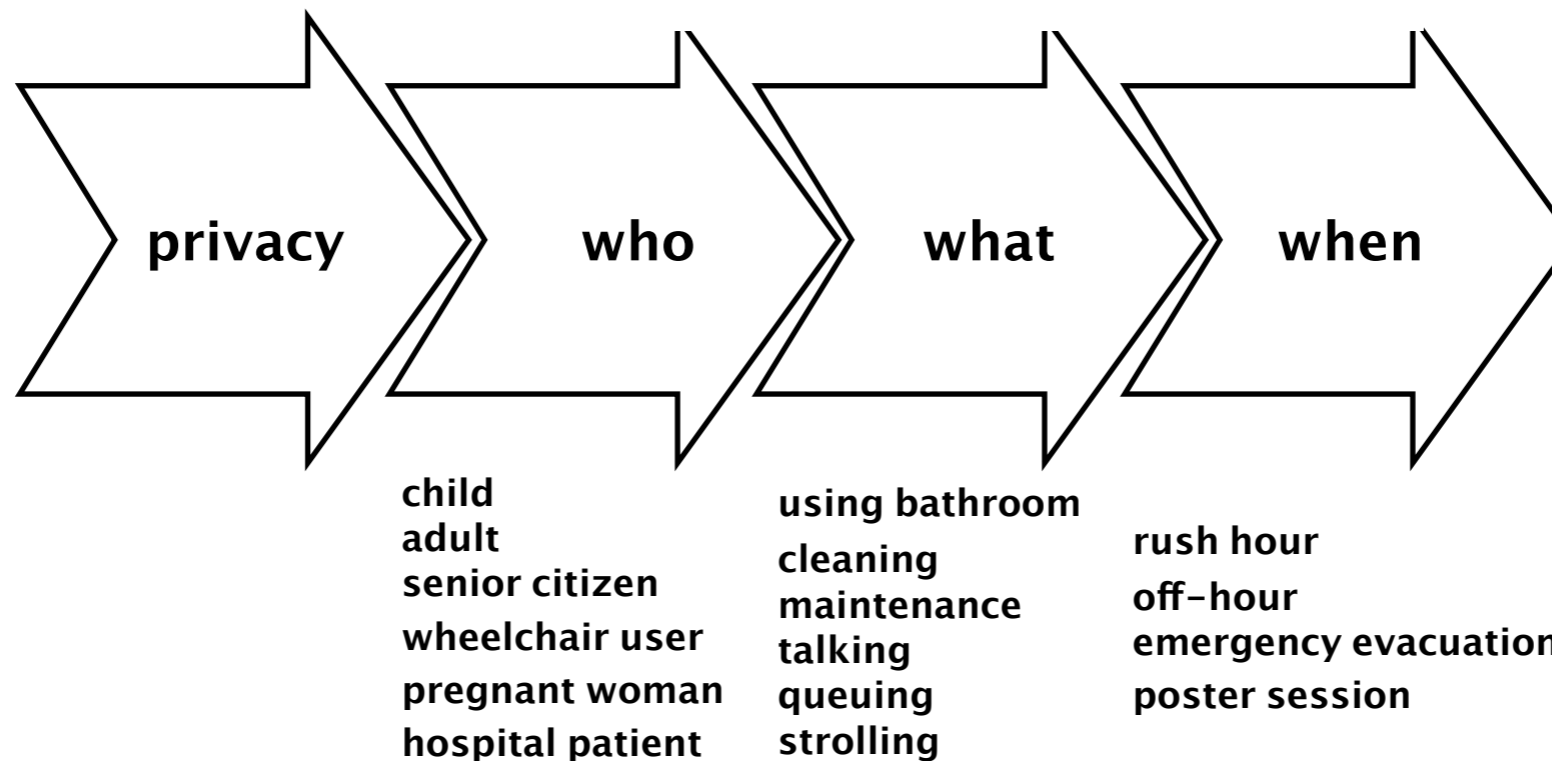
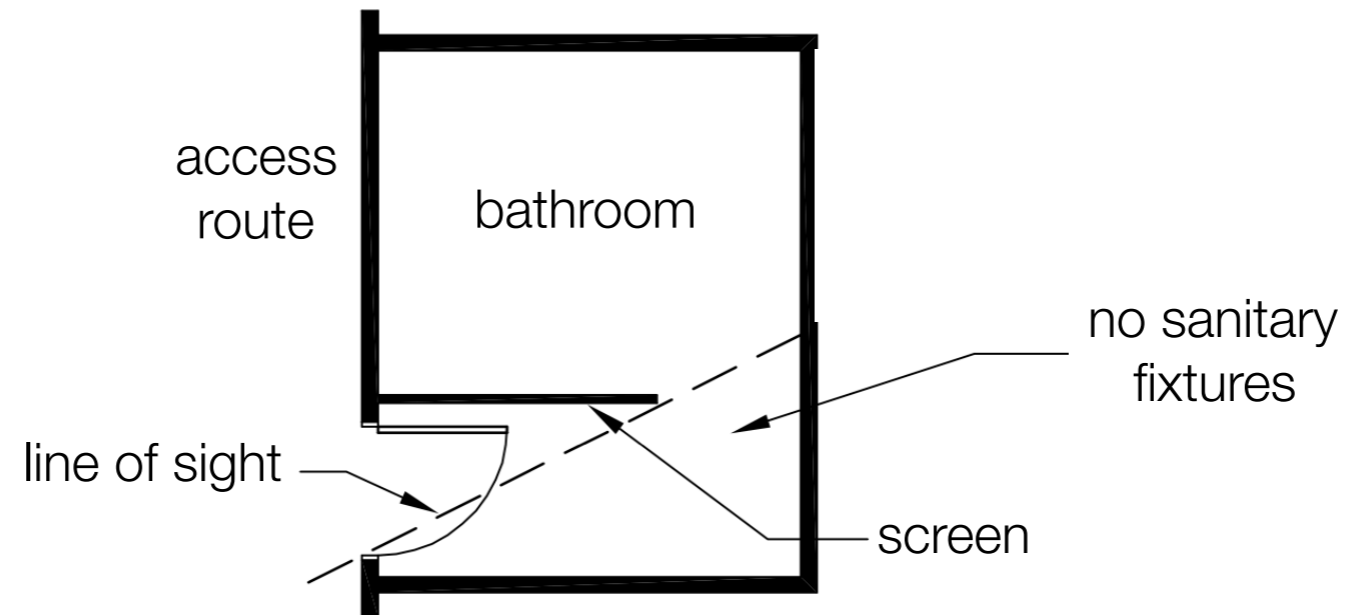


2b)

*leading edges*



# ArchReqDM - Disambiguating architectural requirements



# Documenting and maintaining design intents and rationales

