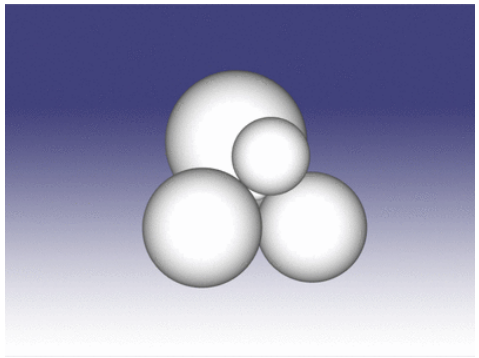
intelligent spatial computing for the underworld

Carl Schultz

Department of Engineering
Aarhus University

http://think-spatial.org/



The DesignSpace Group

http://www.design-space.org/Next

discover
what people do

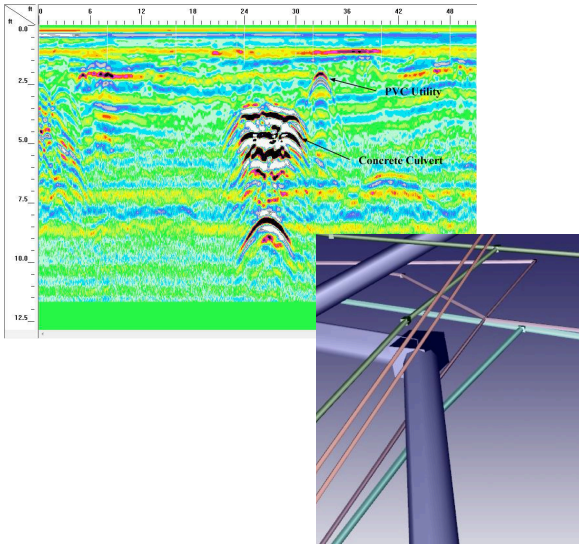
user data analysis,
qualitative research

discover
what people do

discover
what's in the ground

user data analysis,
qualitative research

GPR analysis,
data modelling



discover
what people do

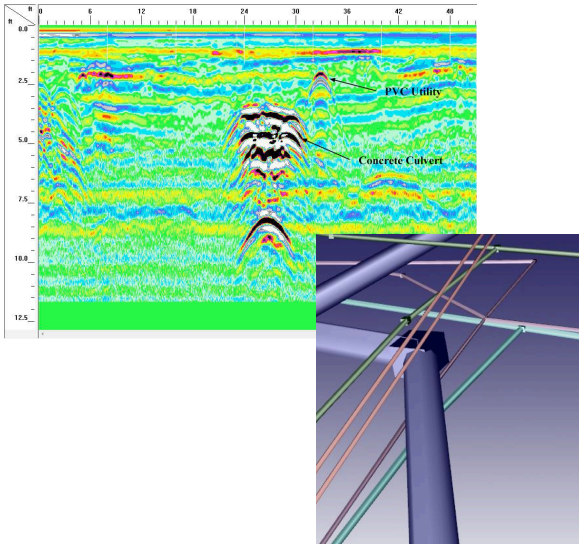
discover
what's in the ground

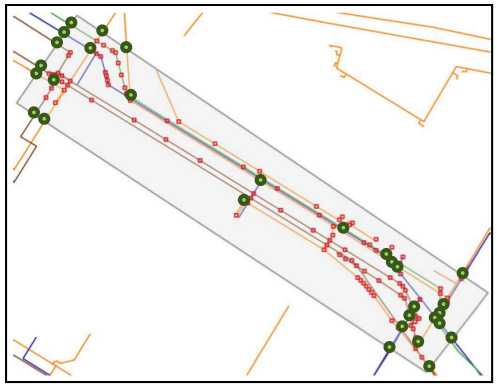
provide
decision support

user data analysis,
qualitative research

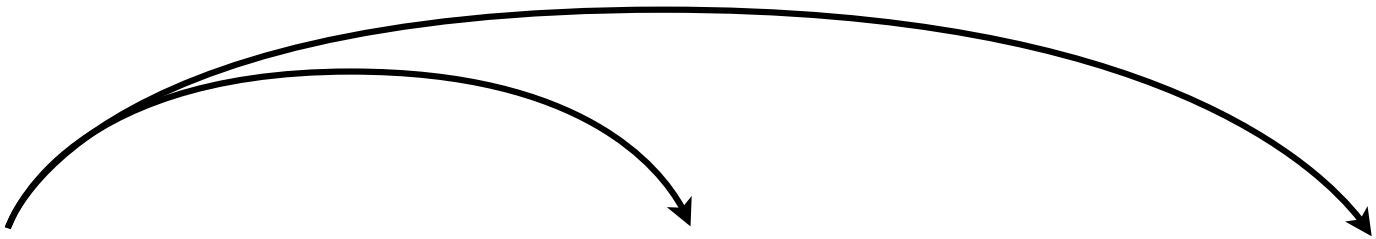
GPR analysis,
data modelling

logic-based systems,
simulation





explainable AI



discover
what people do

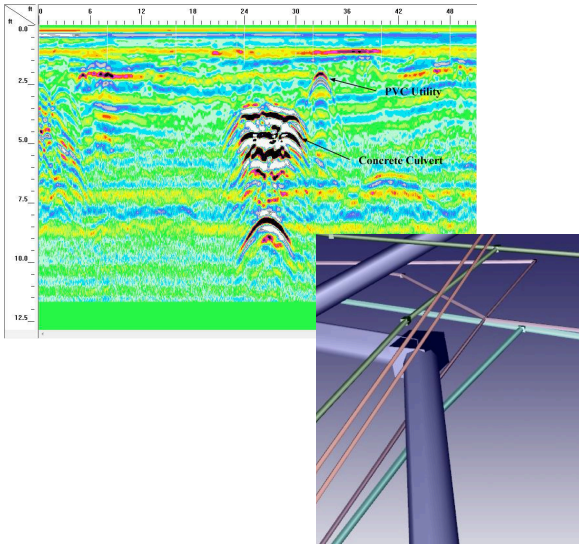
discover
what's in the ground

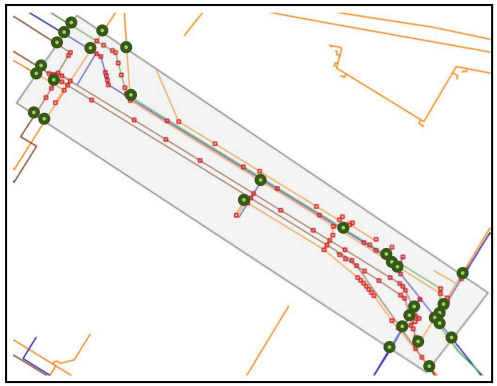
provide
decision support

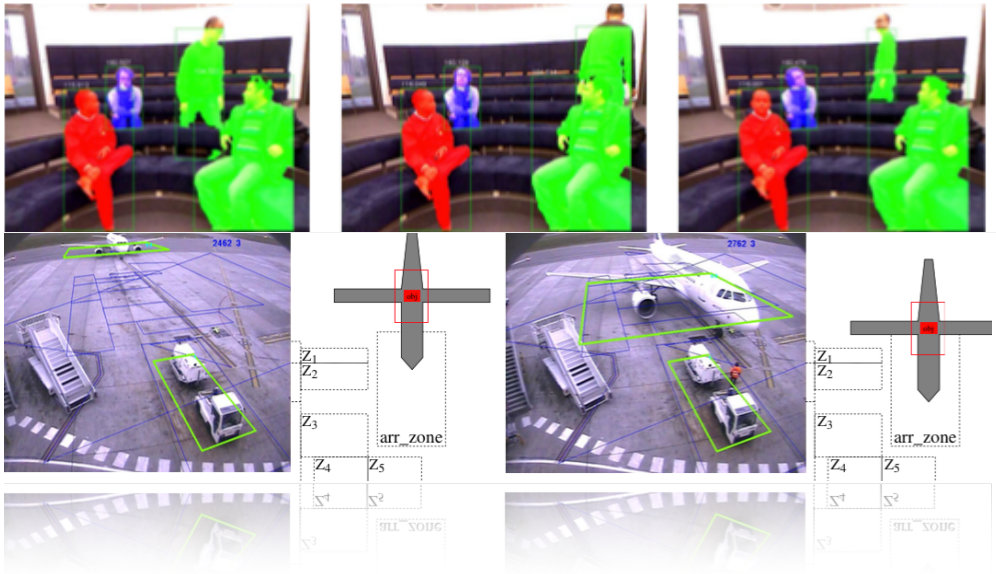
user data analysis,
qualitative research

GPR analysis,
data modelling

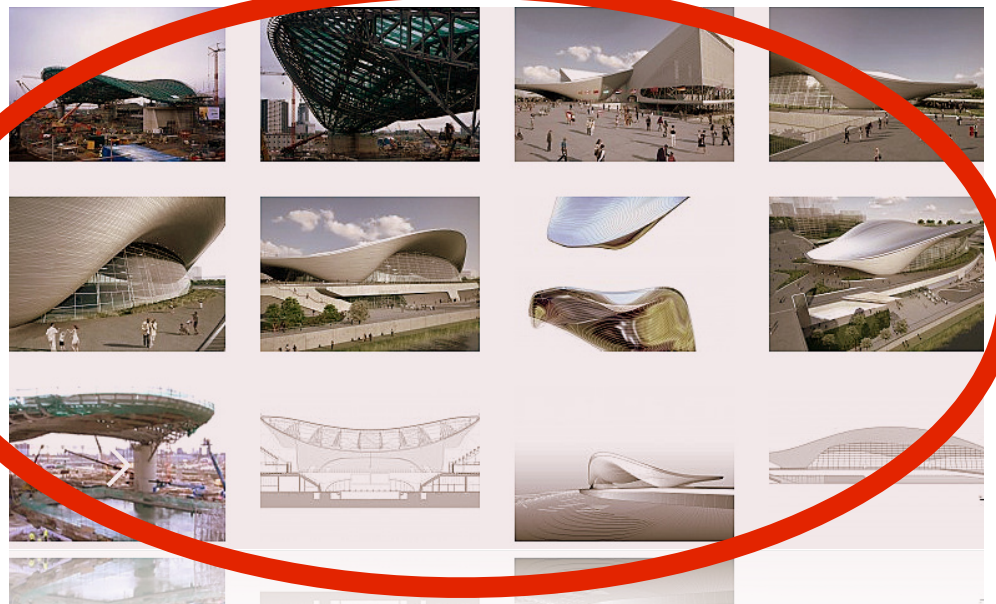
logic-based systems,
simulation

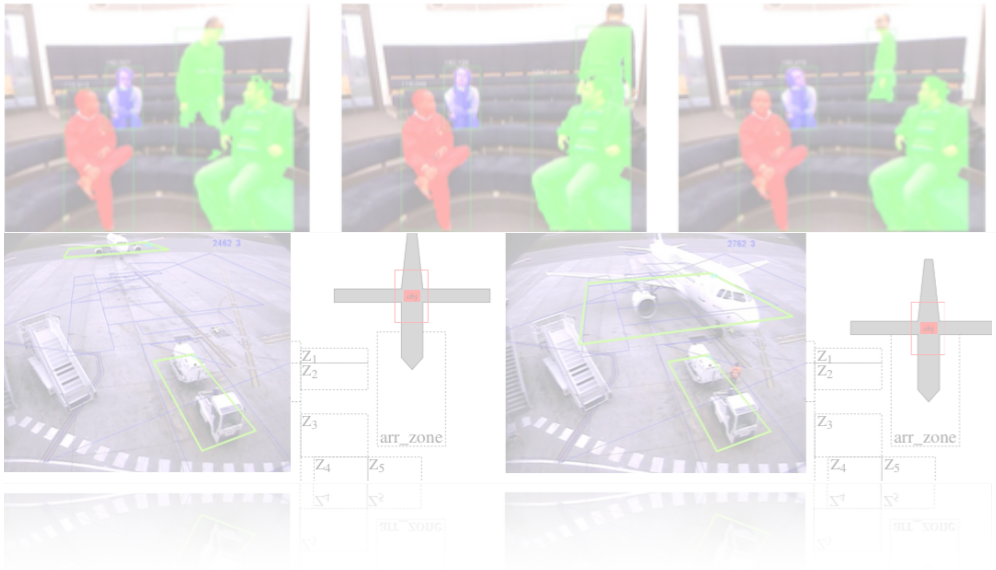






Visuo-Spatial Thinking



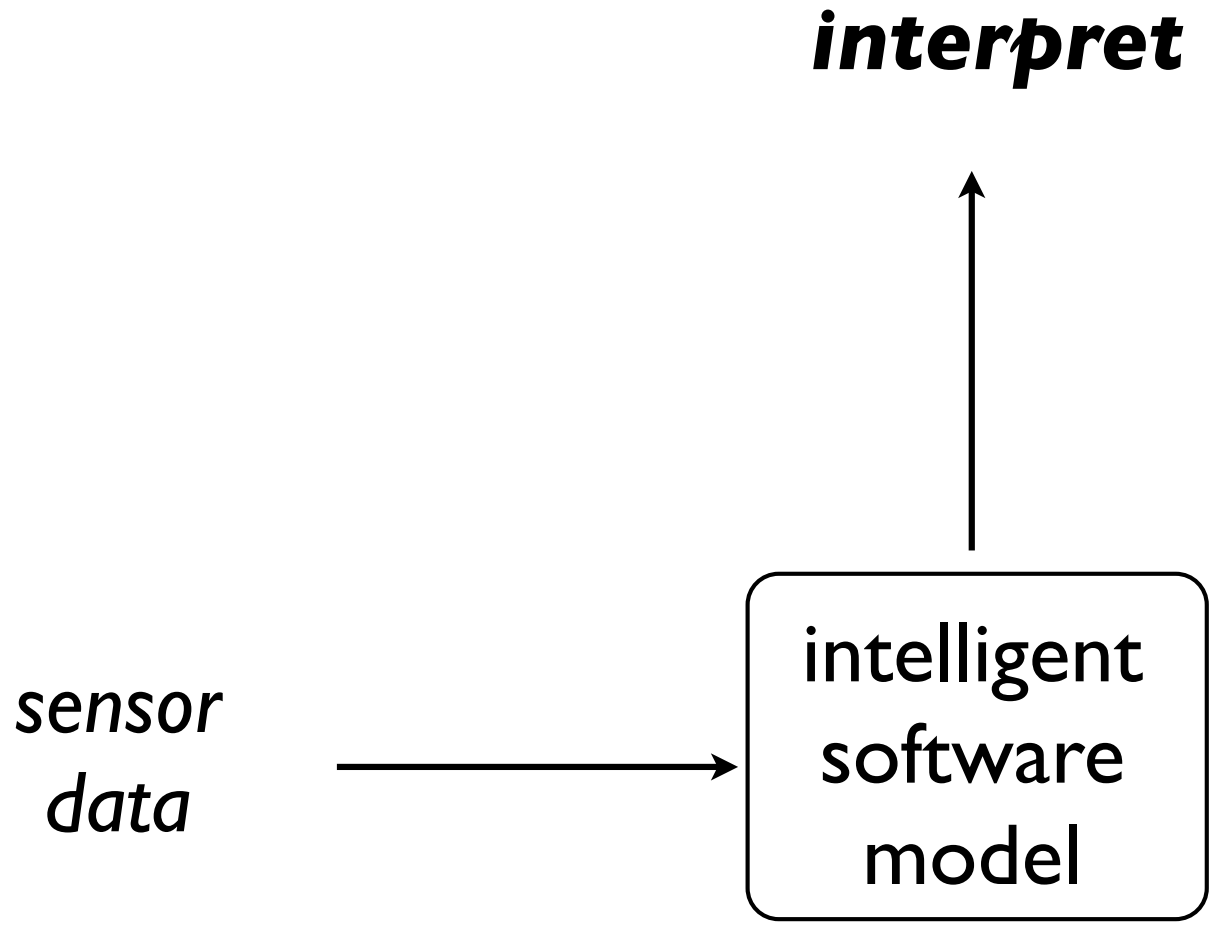


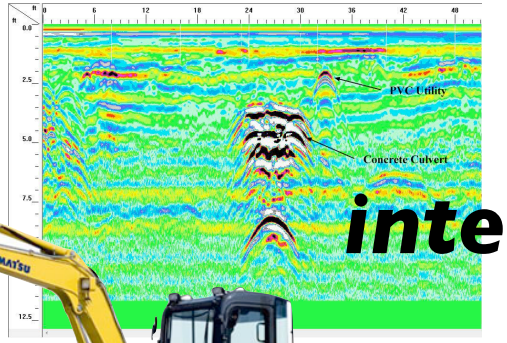
Visuo-Spatial Thinking

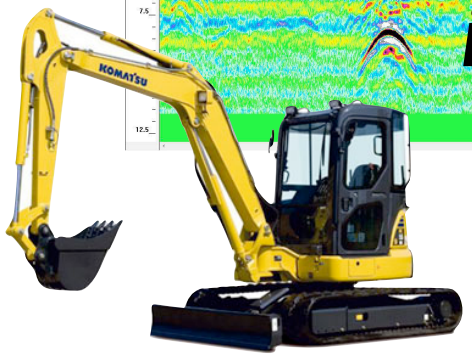
New Parkland Hospital Project

wayfinding studies (2015)

with Mehul Bhatt, Jakob Suchan, Vasiliki Kondyli


interpret
intelligent
software
model
sensor
data

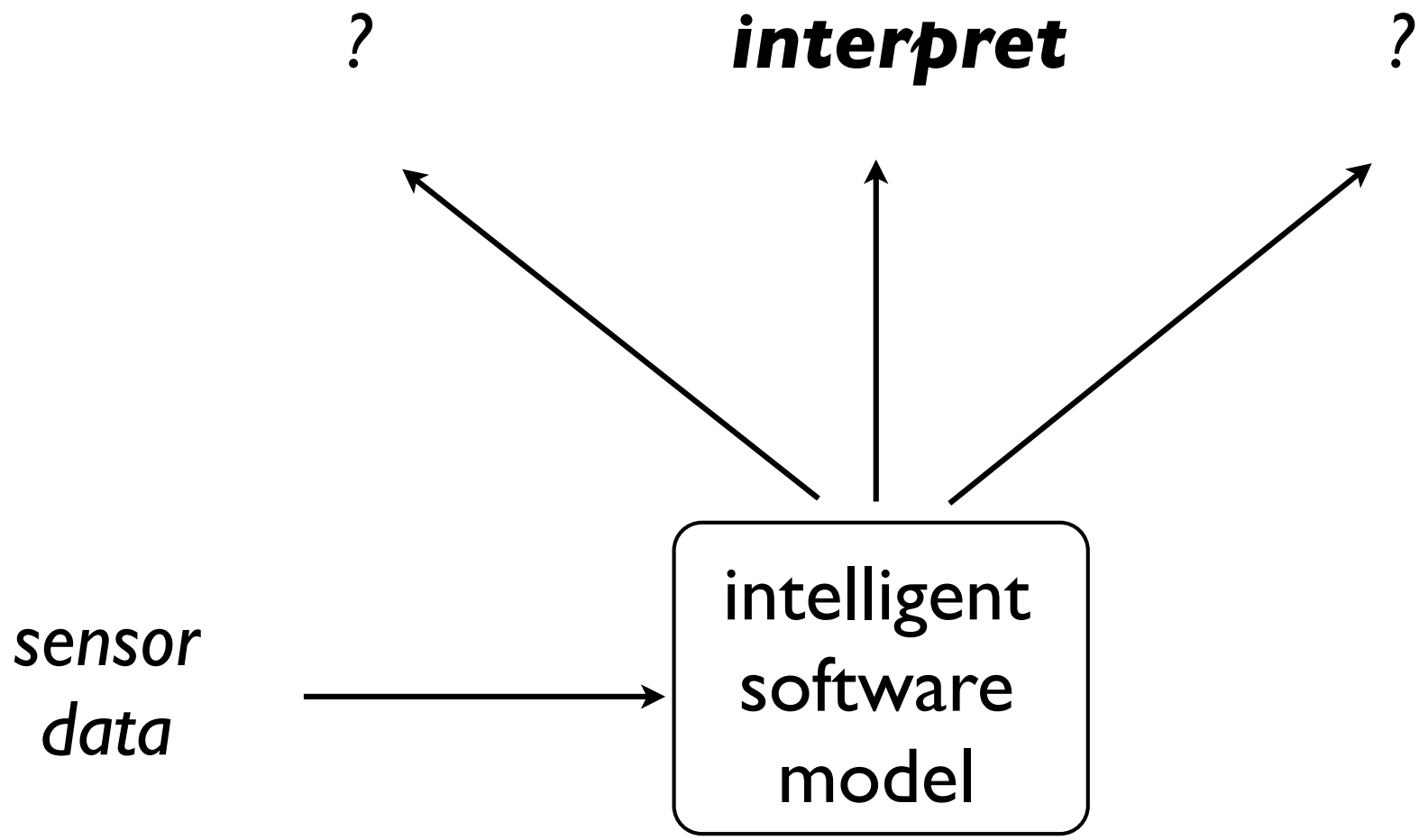




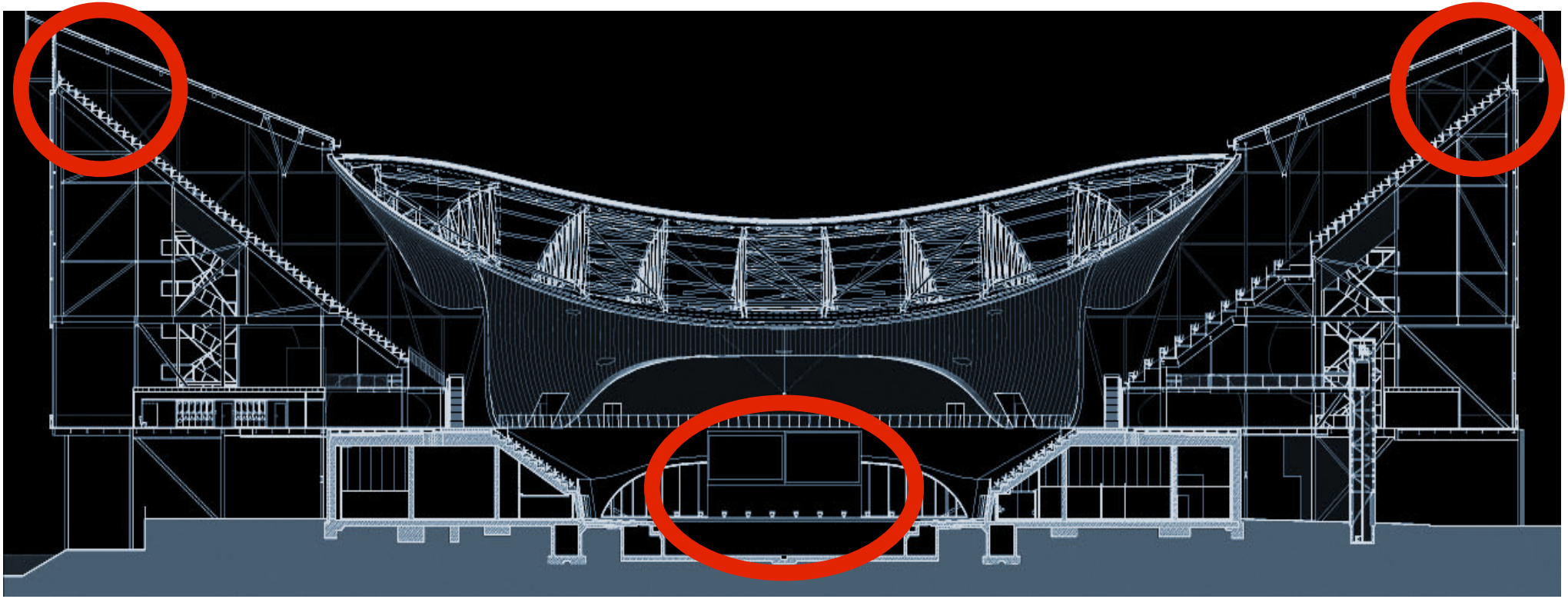
interpret

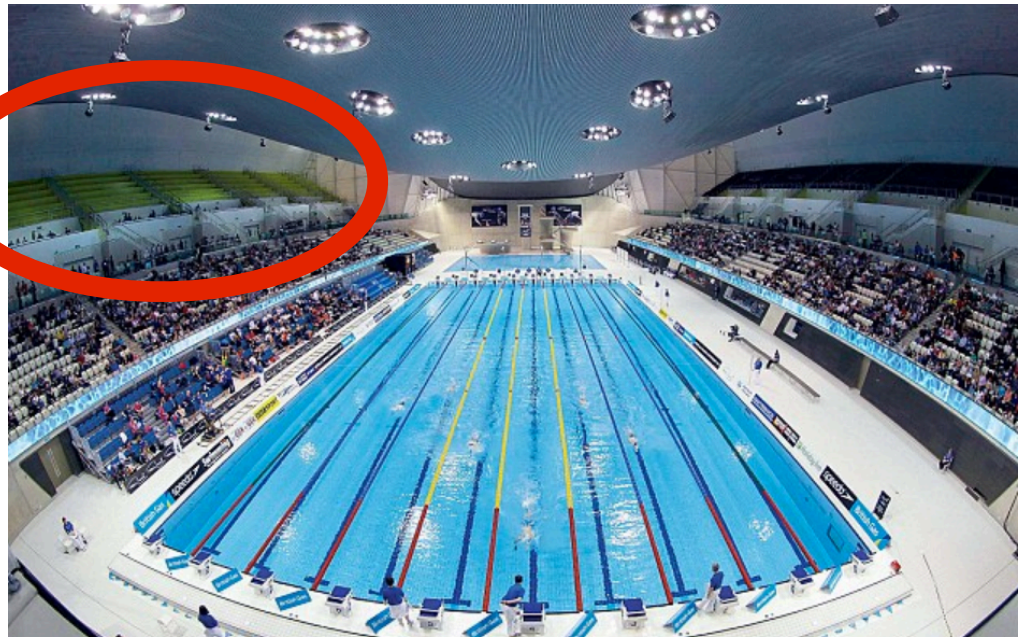
sensor data

intelligent software model

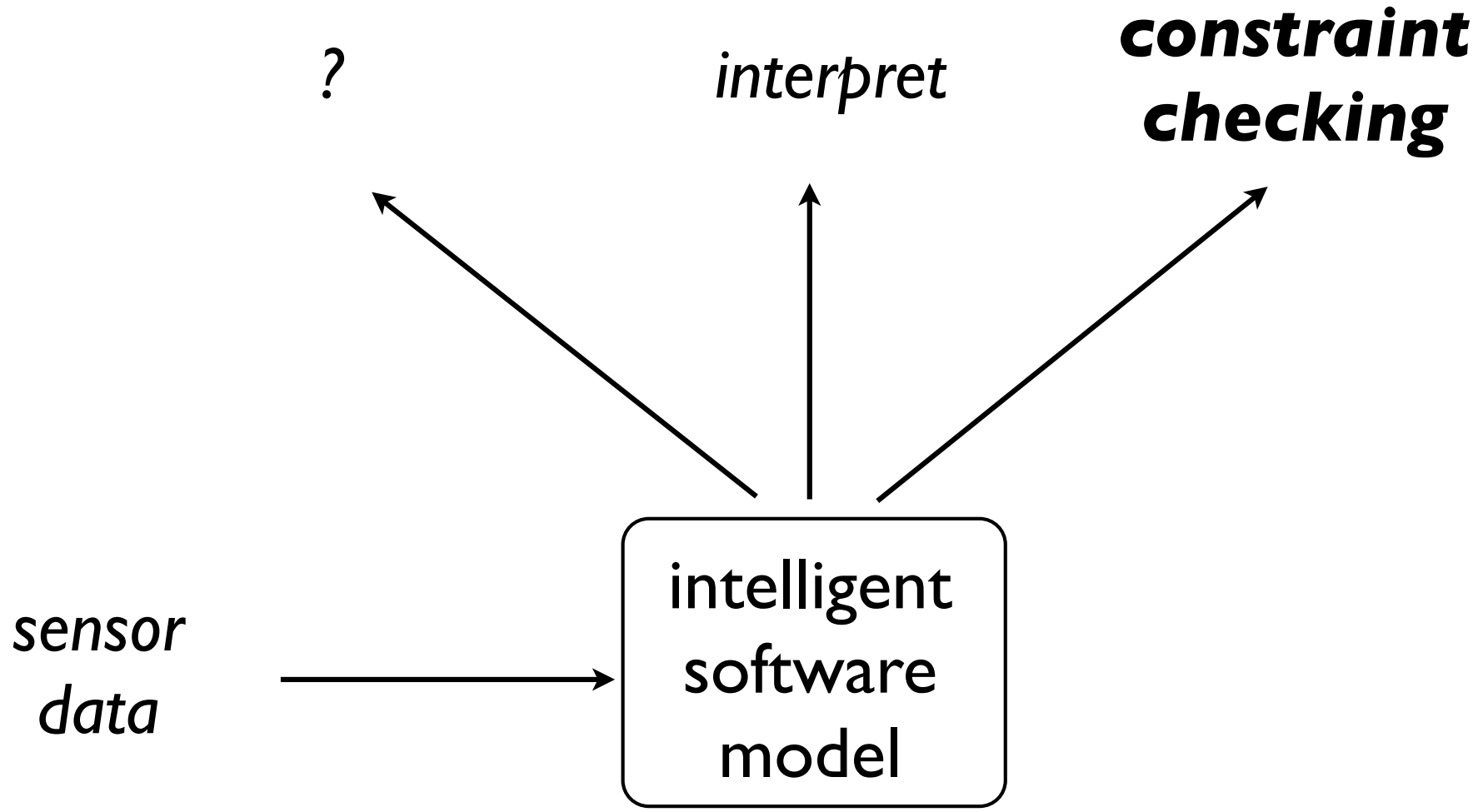

?
interpret
?
sensor
data
intelligent
software
model

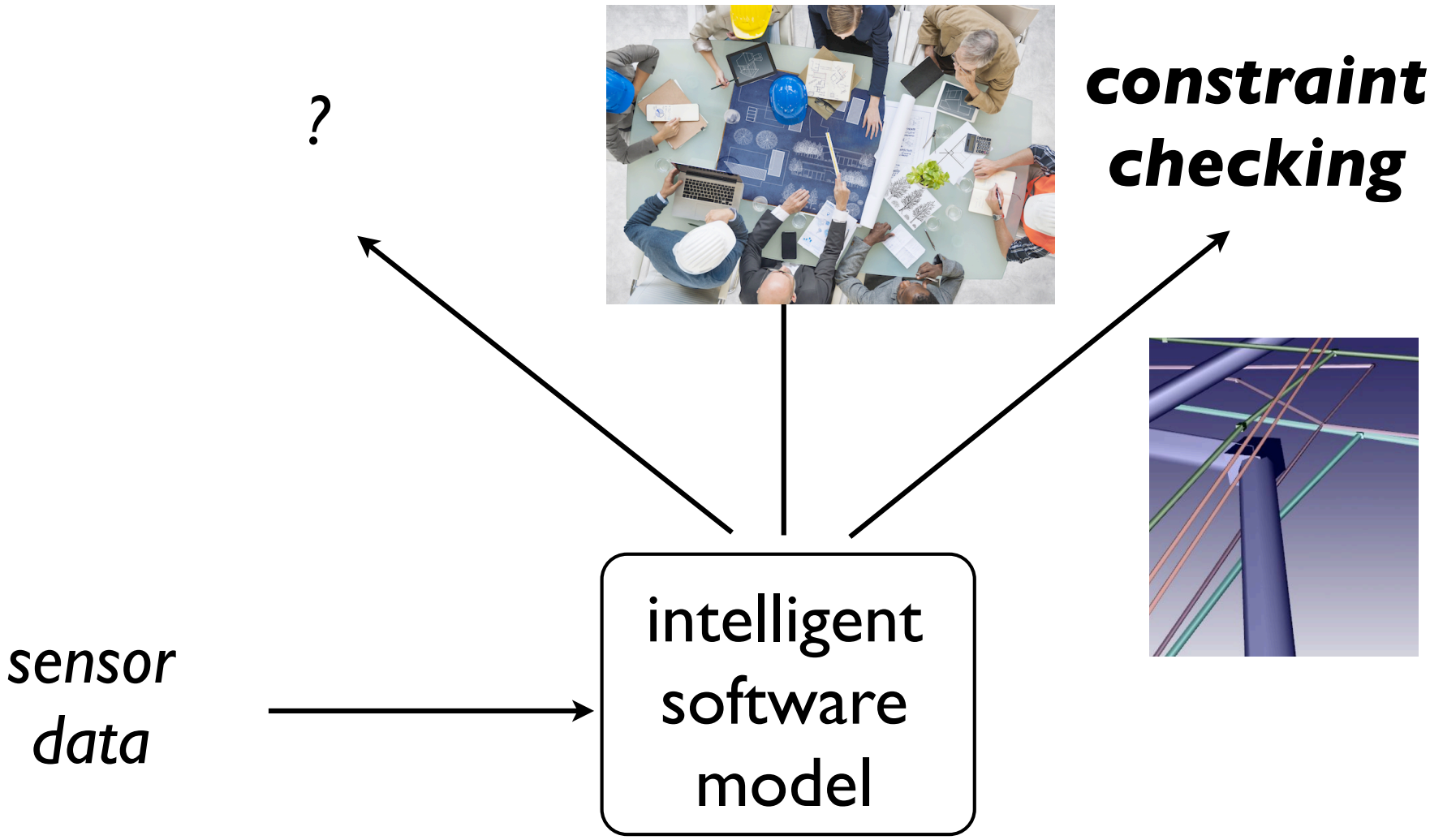
London Olympics 2012 Aquatic Center

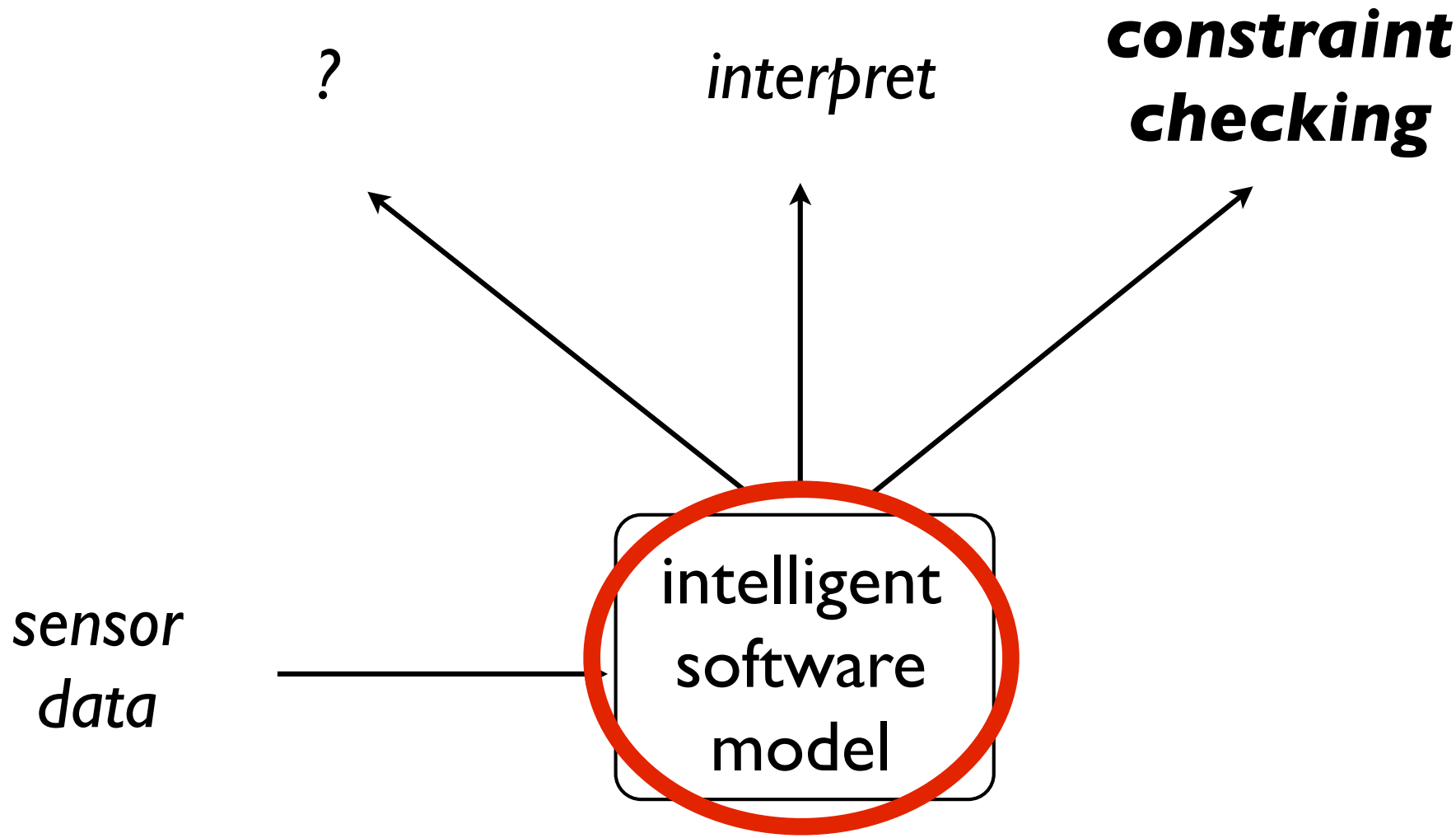




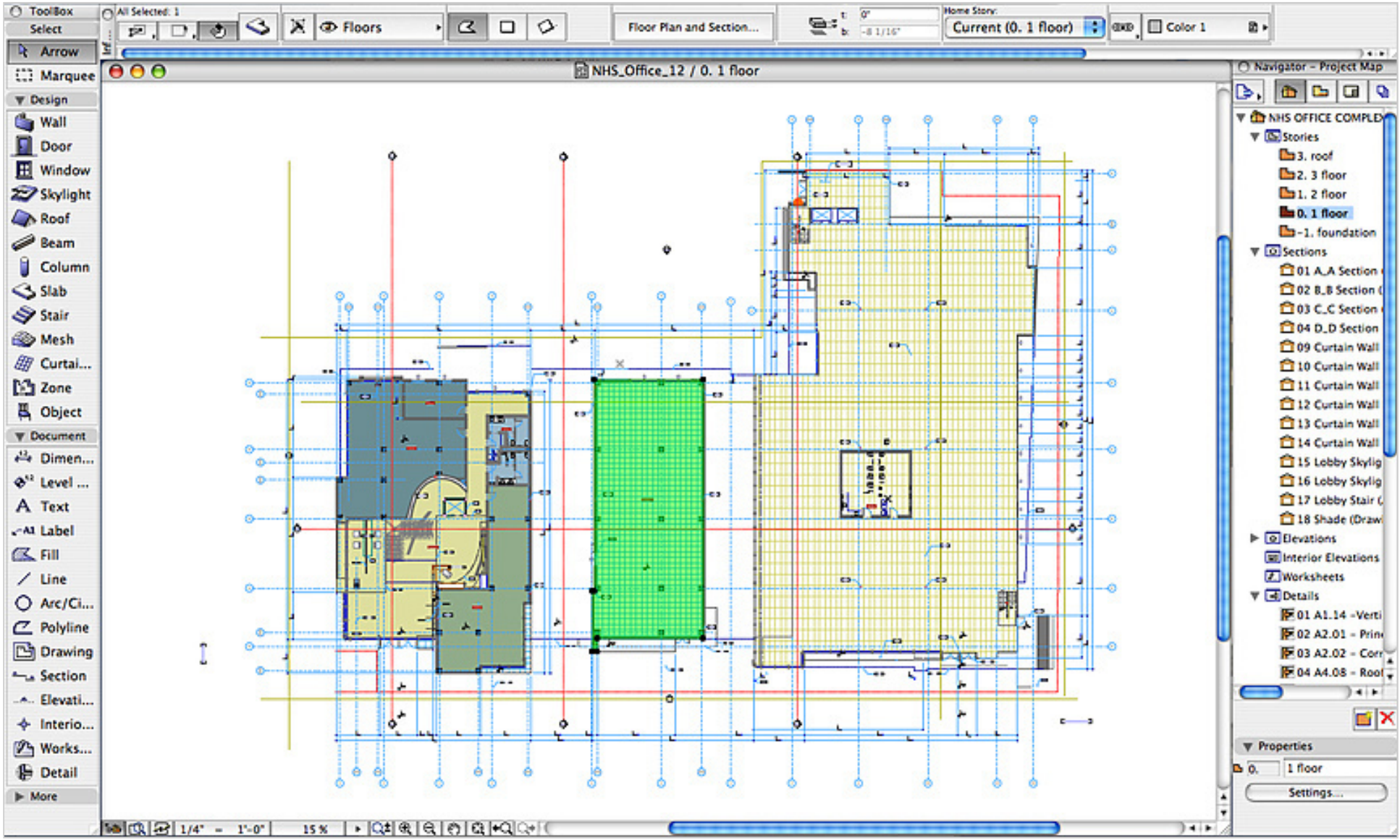
"Doors must not open **onto areas** where a person might **be located** while occupied with some activity."


?
interpret
constraint checking
sensor data
intelligent software model

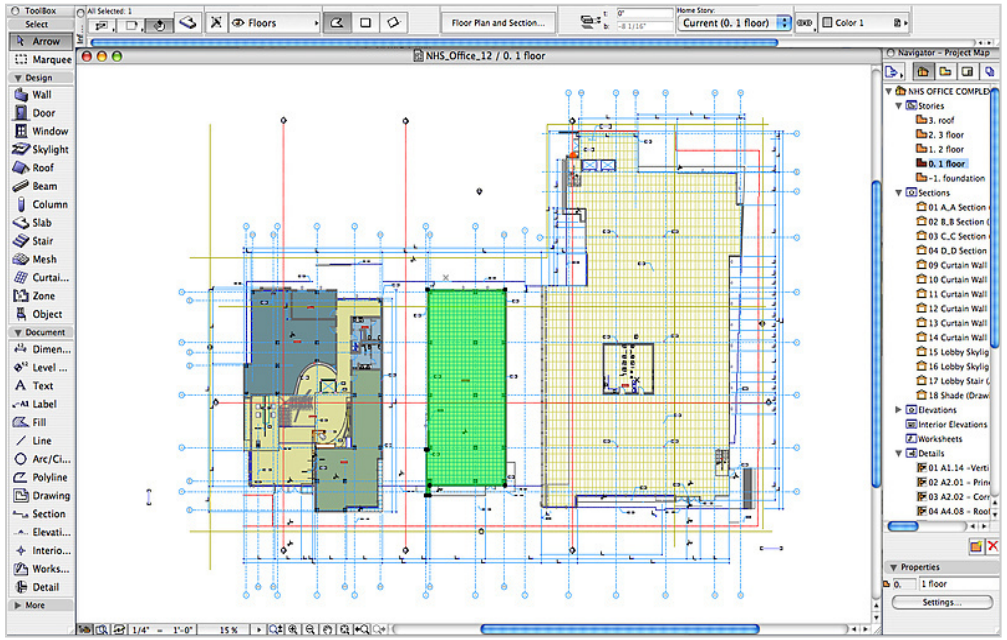

?
constraint checking
sensor data
intelligent software model

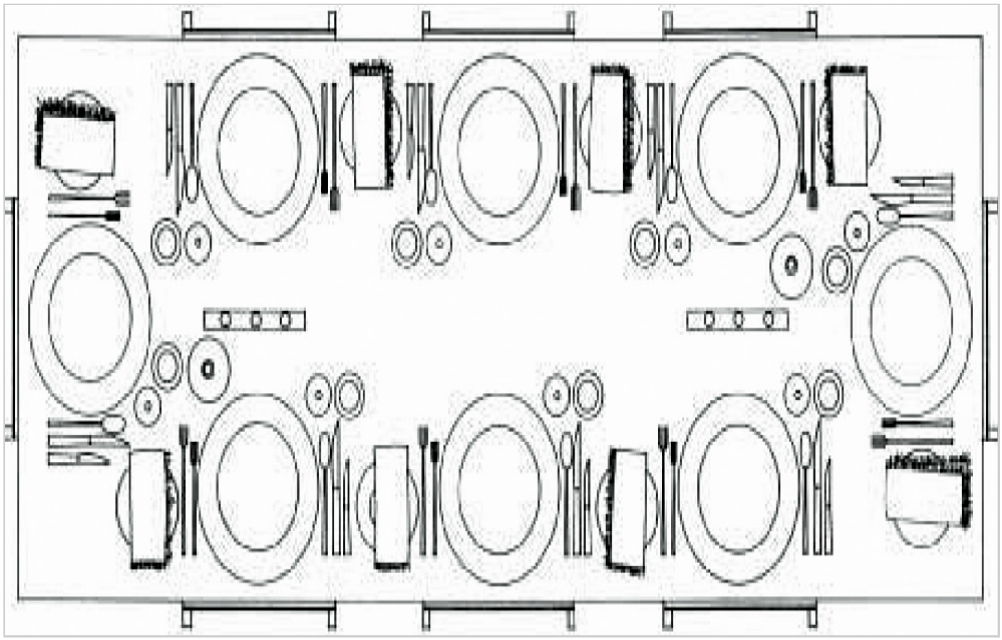

?
interpret
constraint checking
sensor data
intelligent software model

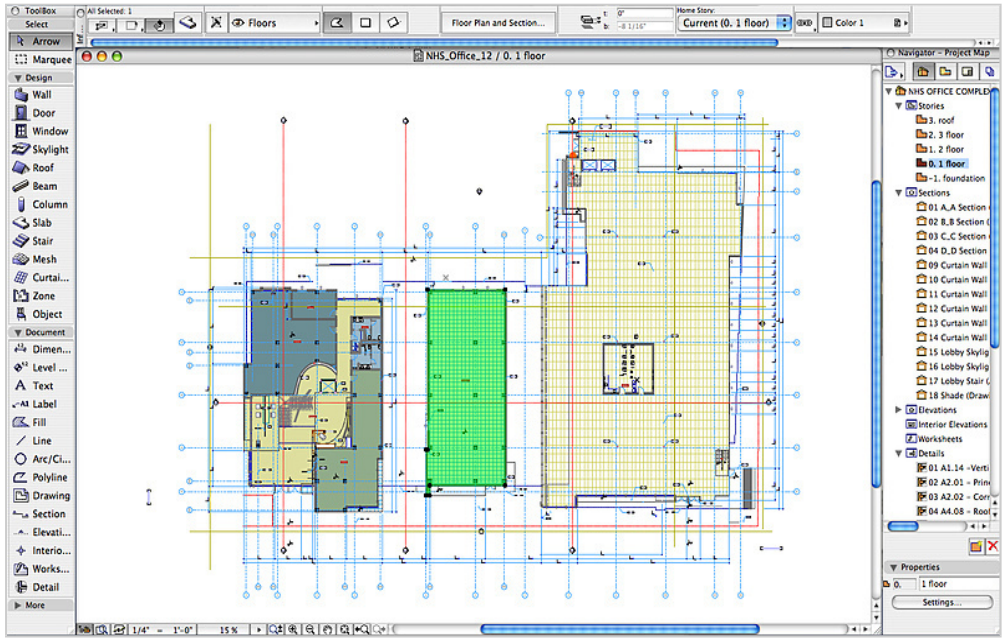
Contemporary CAAD Tools

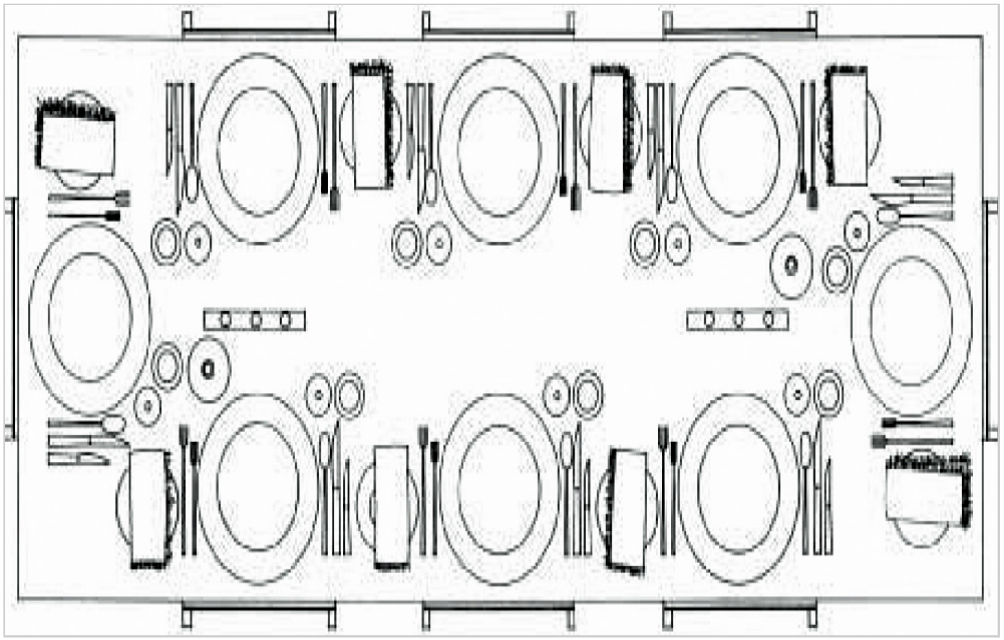


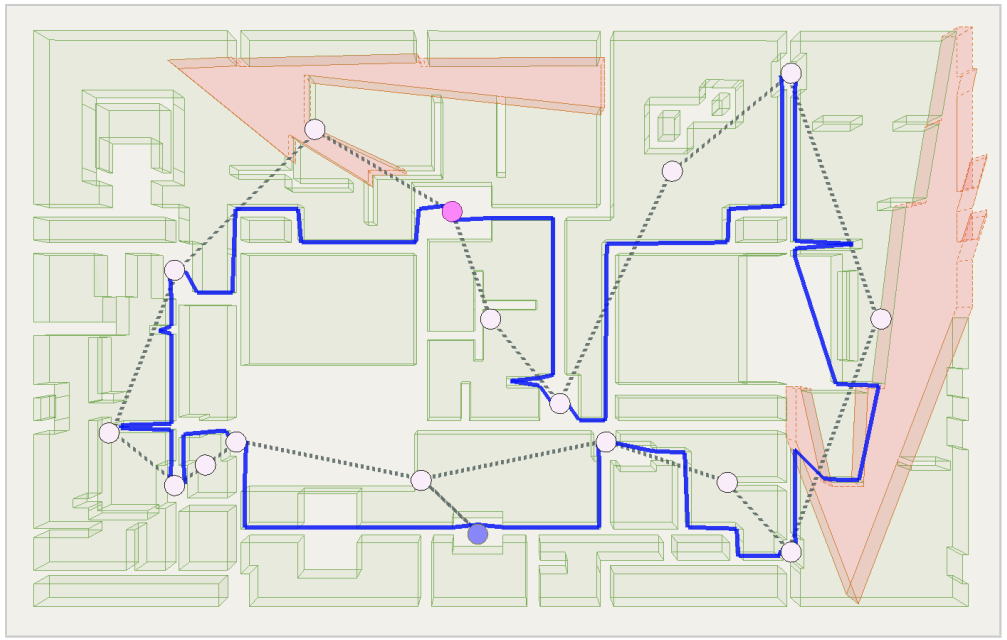
ArchiCAD., Graphisoft

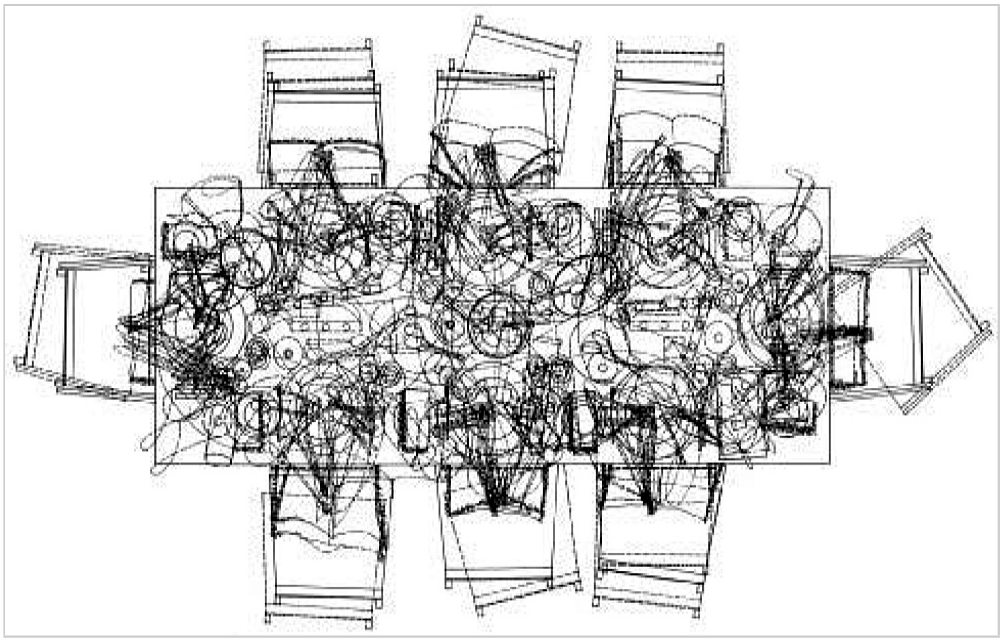

ToolBox
Select
Arrow
Marquee
Design
Wall
Door
Window
Skylight
Roof
Beam
Column
Slab
Stair
Mesh
Curtai...
Zone
Object
Document
Dimen...
Level ...
Text
Label
Fill
Line
Arc/Ci...
Polyline
Drawing
Section
Elevati...
Interio...
Works...
Detail
More
Floors
Floor Plan and Section...
Home Story:
Current (0. 1 floor)
Color 1
NHS_Office_12 / 0. 1 floor
Navigator - Project Map
NHS OFFICE COMPLEX
Stories
3. roof
2. 3 floor
1. 2 floor
0. 1 floor
-1. foundation
Sections
Elevations
Interior Elevations
Worksheets
Details
Properties
1 floor
Settings...
1/4" = 1'-0"
15 %



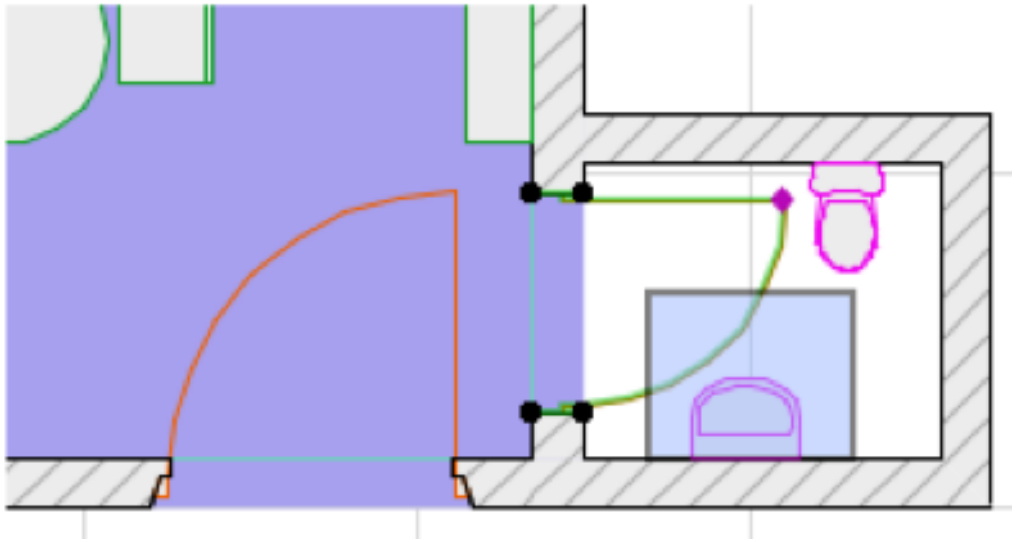

NHS_Office_12 / 0. 1 floor
Navigator – Project Map
Properties



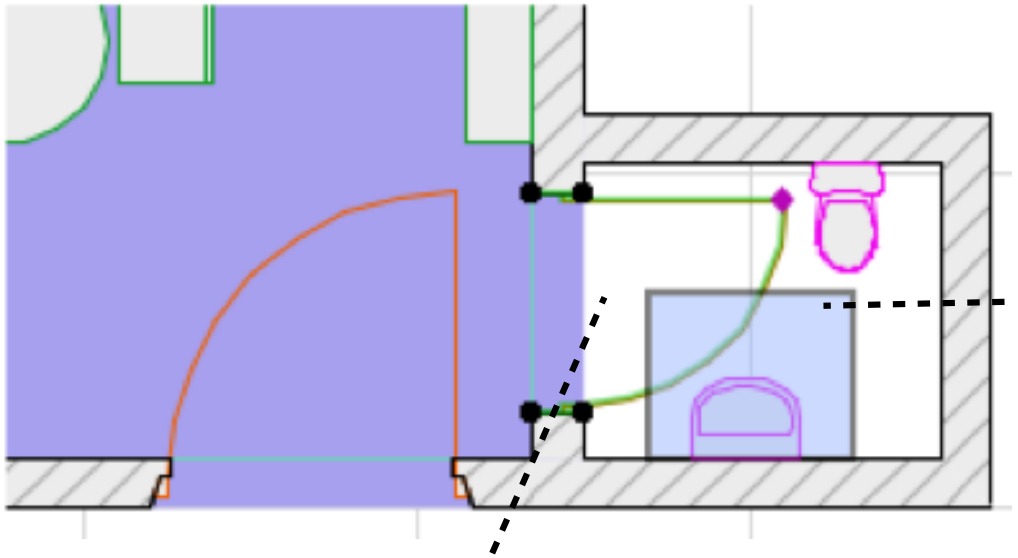


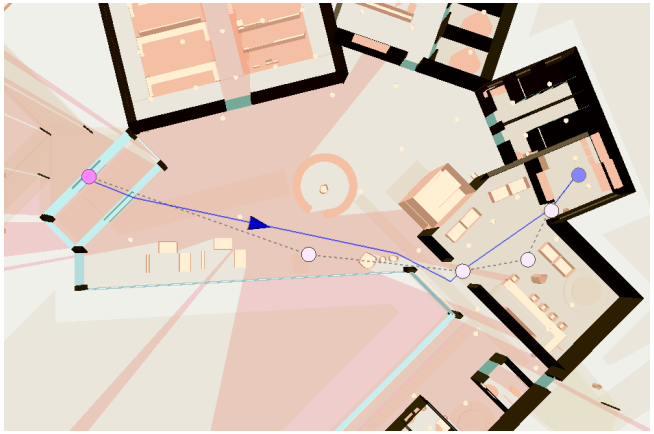


not all regions of “empty space” are equal ...

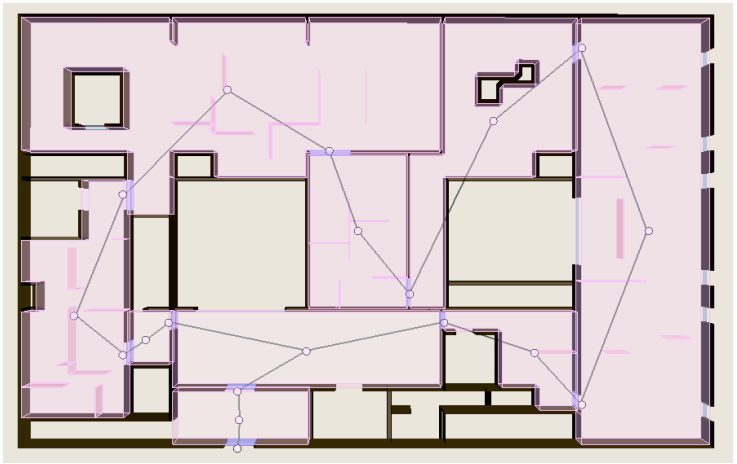


not all regions of “empty space” are equal ...

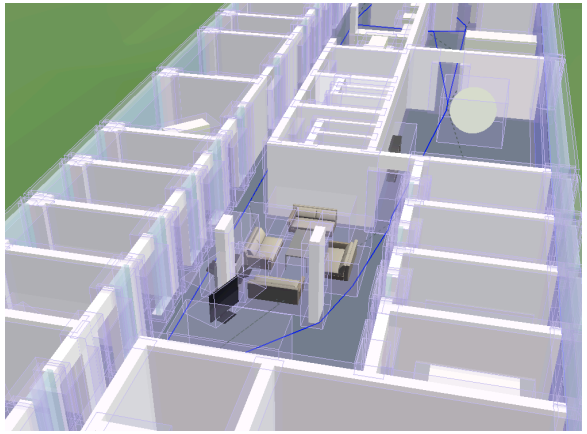




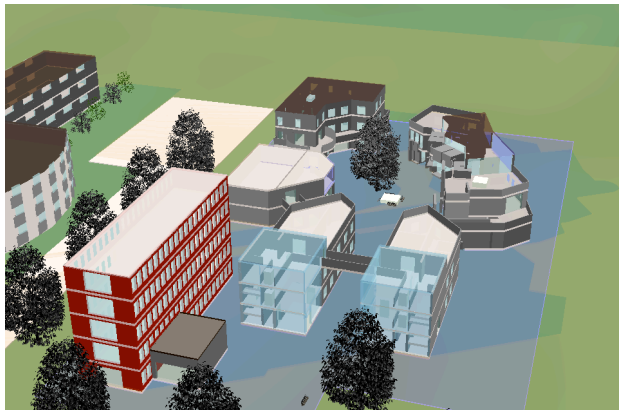
visibility

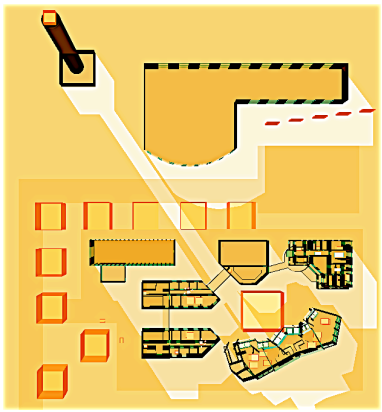


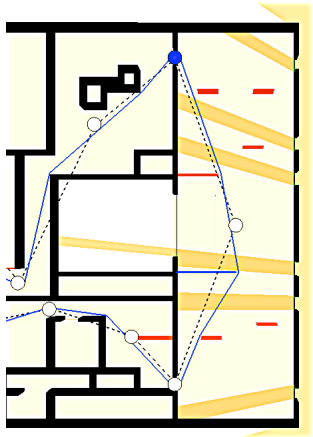
movement



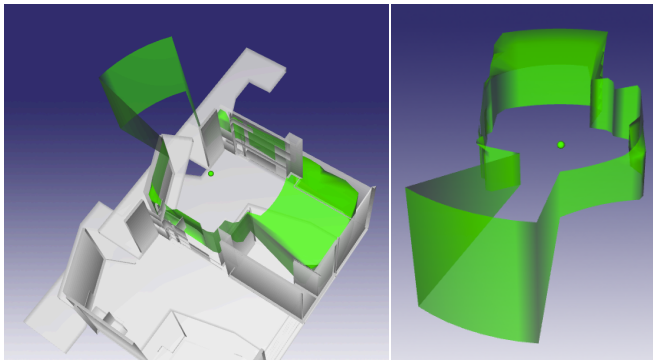
function





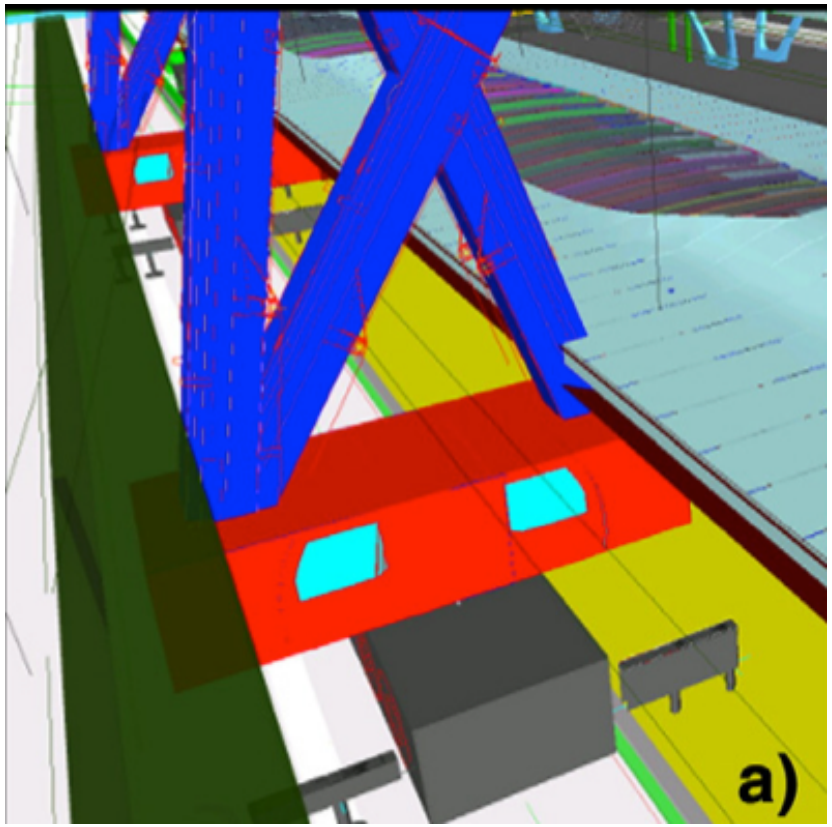


light and shadow

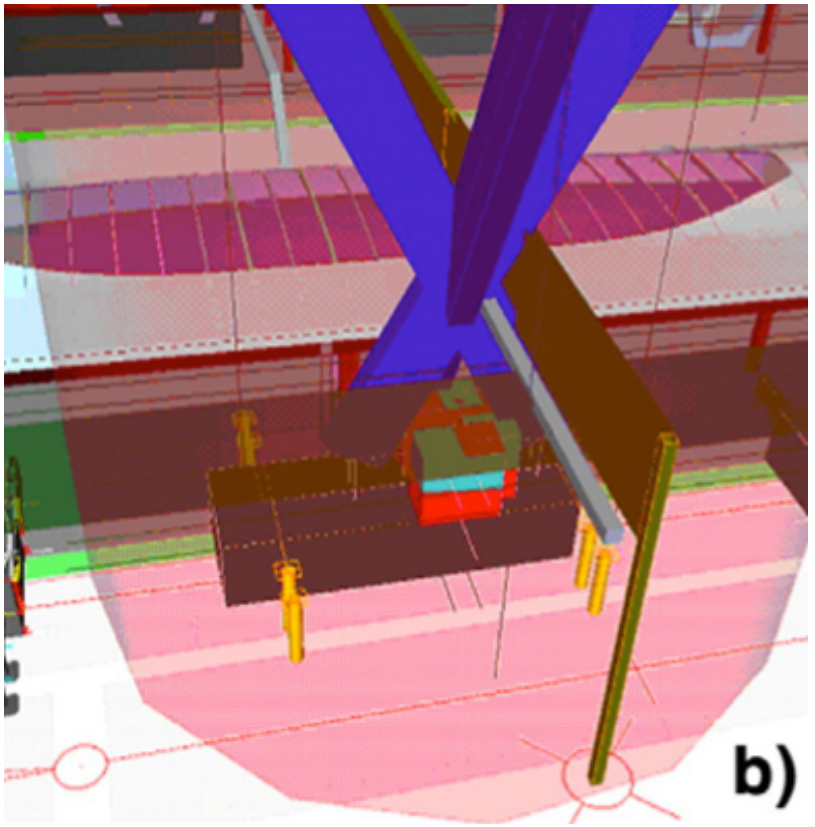


3D visibility

boom positions,
track-based crane

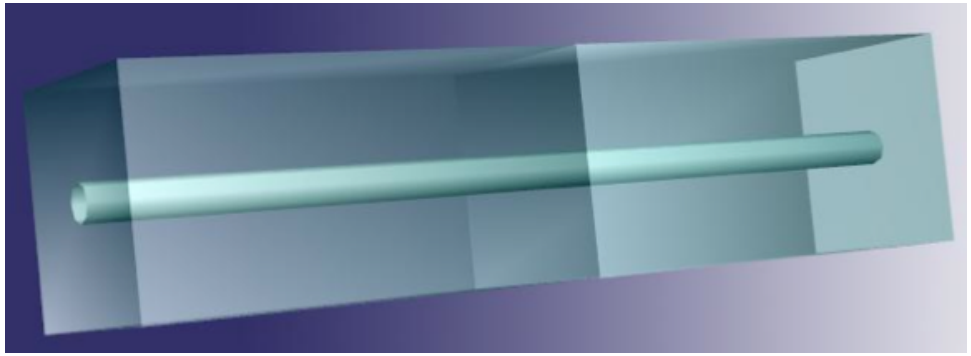


crane lift-operation space

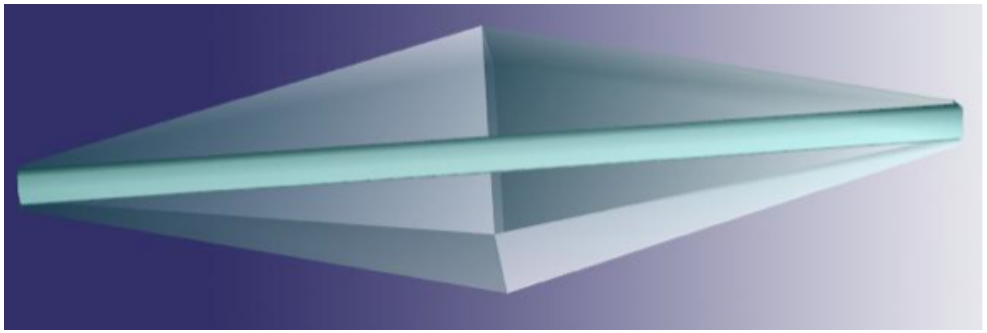


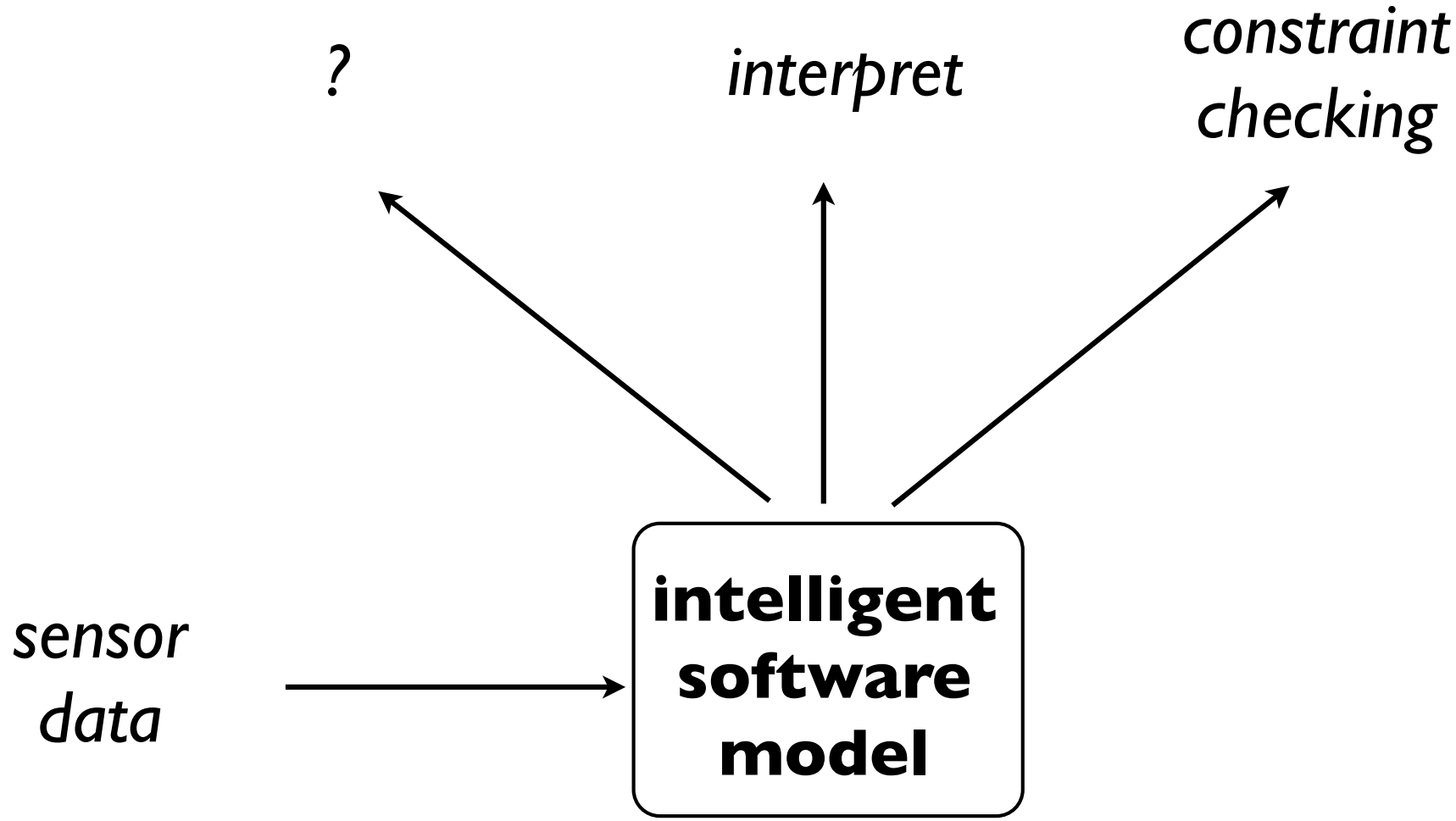
Martijn Trebbe, Timo Hartmann, and André Dorée. "4D CAD models to support the coordination of construction activities between contractors." *Automation in construction* 49 (2015): 83-91.

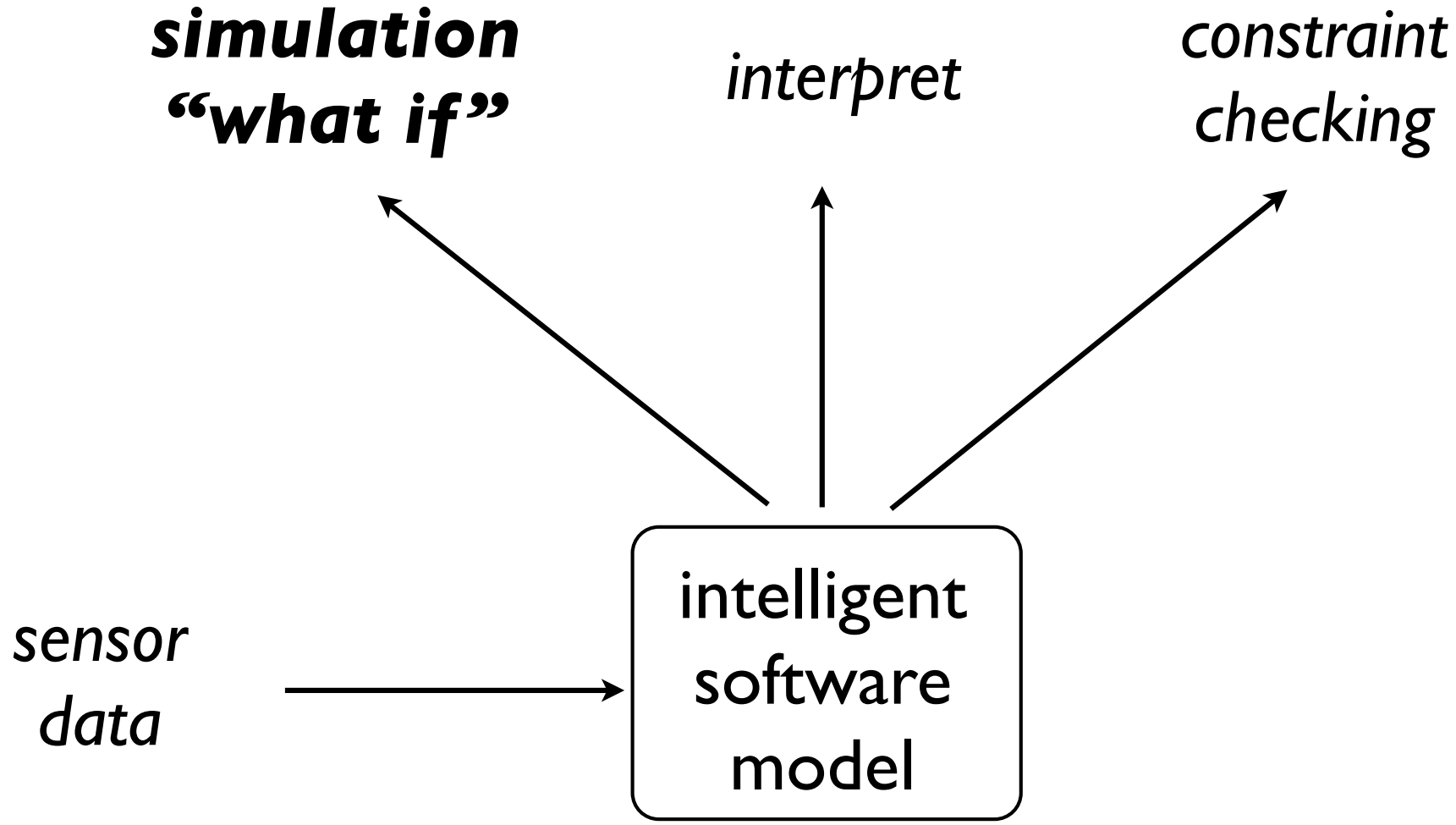
uncertainty space of position of utilities
(dynamic)

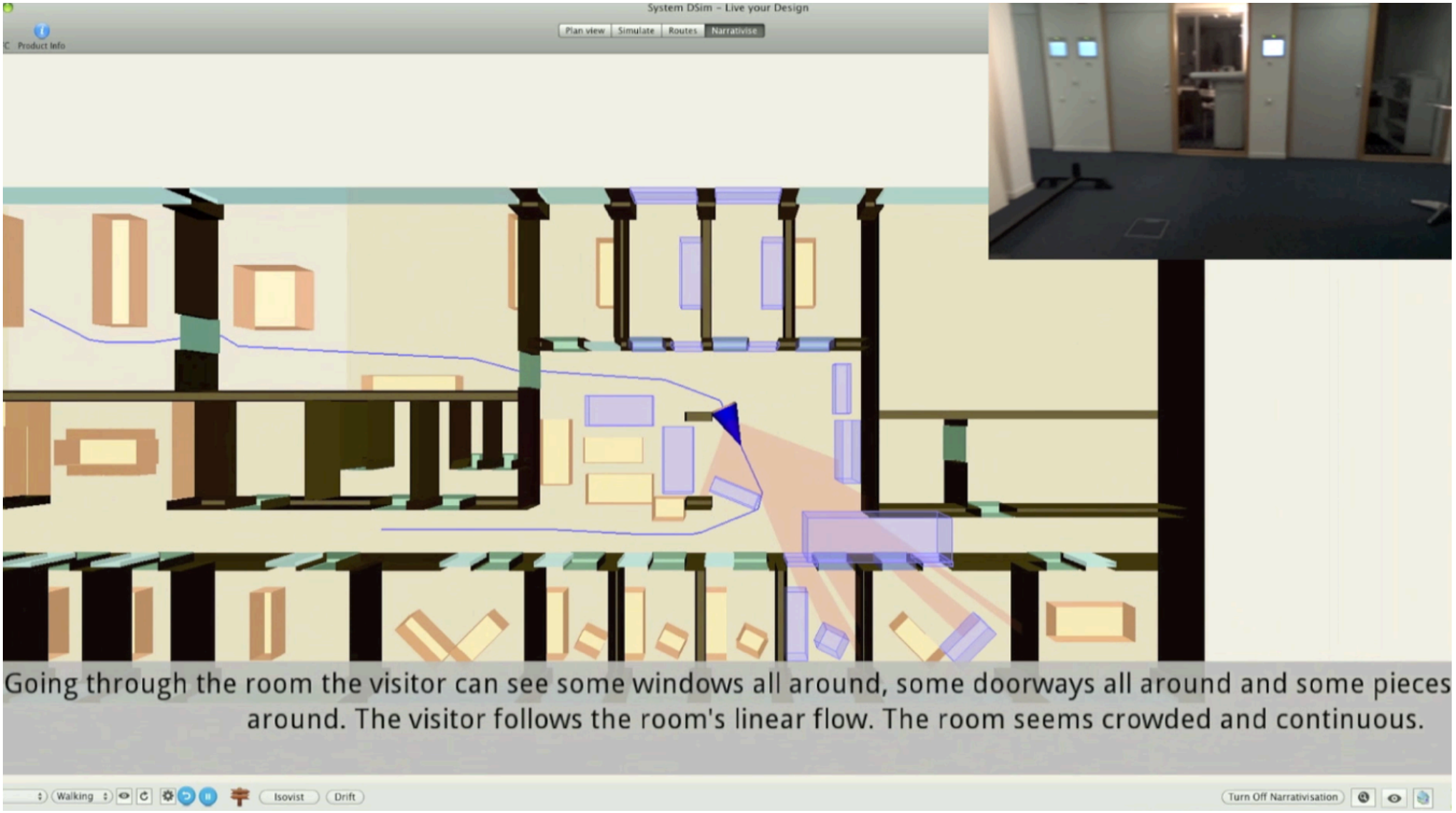


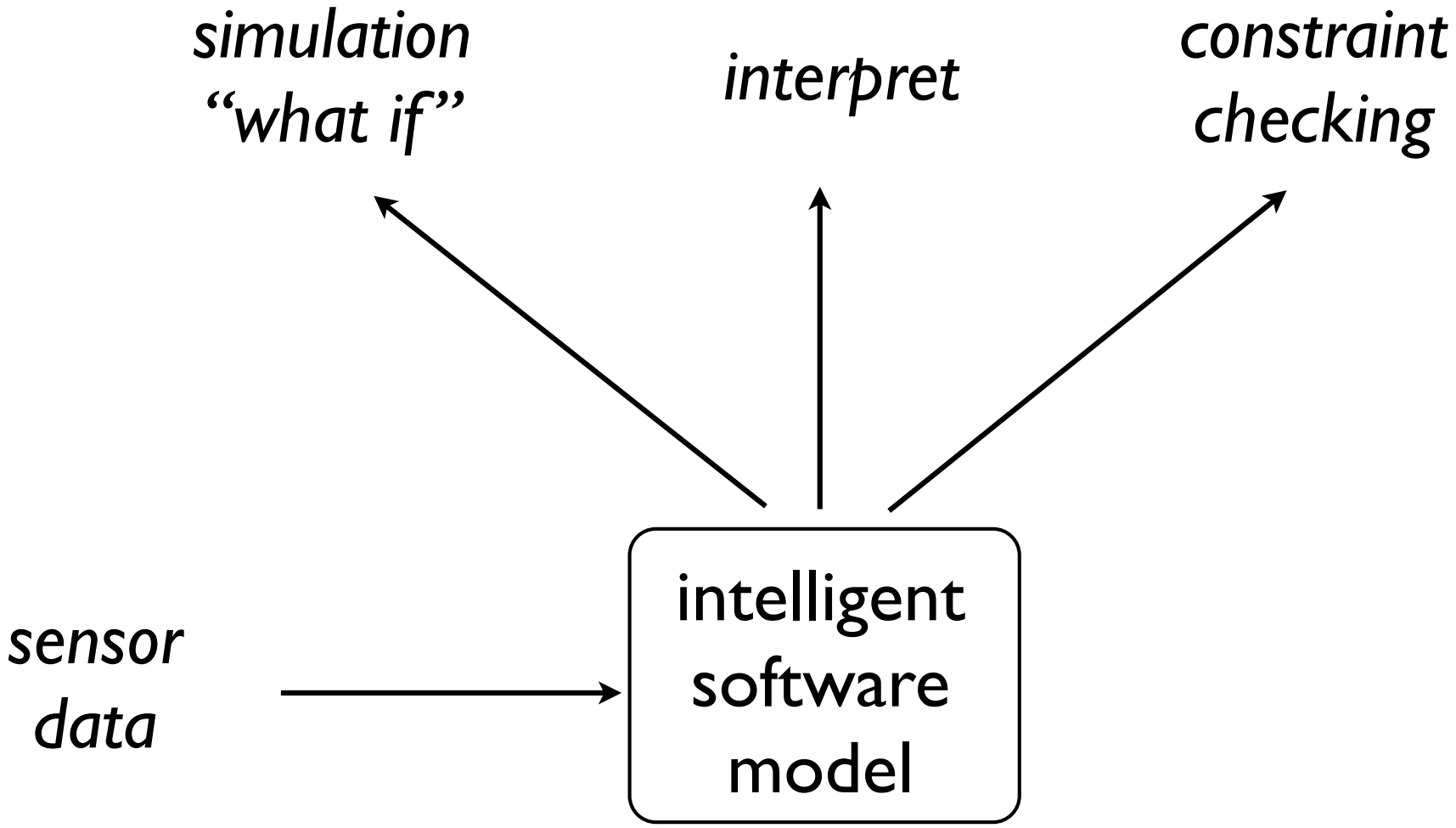
update after test trenchs...




?
interpret
constraint checking
sensor data
intelligent software model


simulation
"what if"
interpret
constraint
checking
sensor
data
intelligent
software
model


System DSim – Live your Design
Product Info
Plan view
Simulate
Routes
Narrativise
Going through the room the visitor can see some windows all around, some doorways all around and some pieces
around. The visitor follows the room's linear flow. The room seems crowded and continuous.
Walking
Isovist
Drift
Turn Off Narrativisation



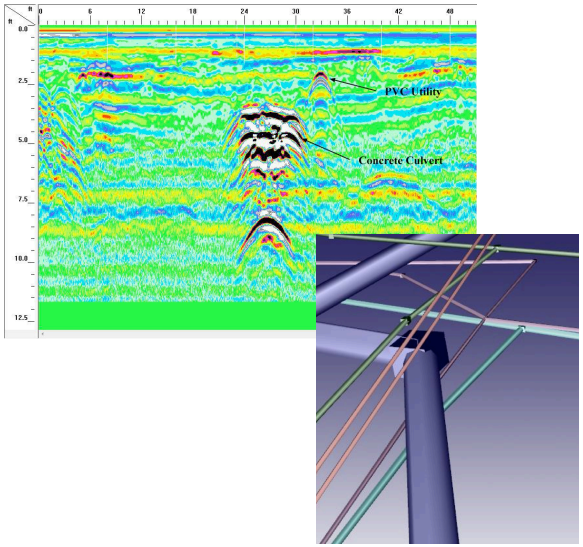
some examples in subsurface construction

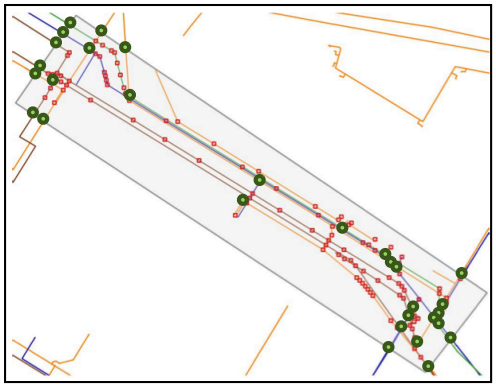
explainable AI

discover
what people do

discover
what's in the ground

provide
decision support





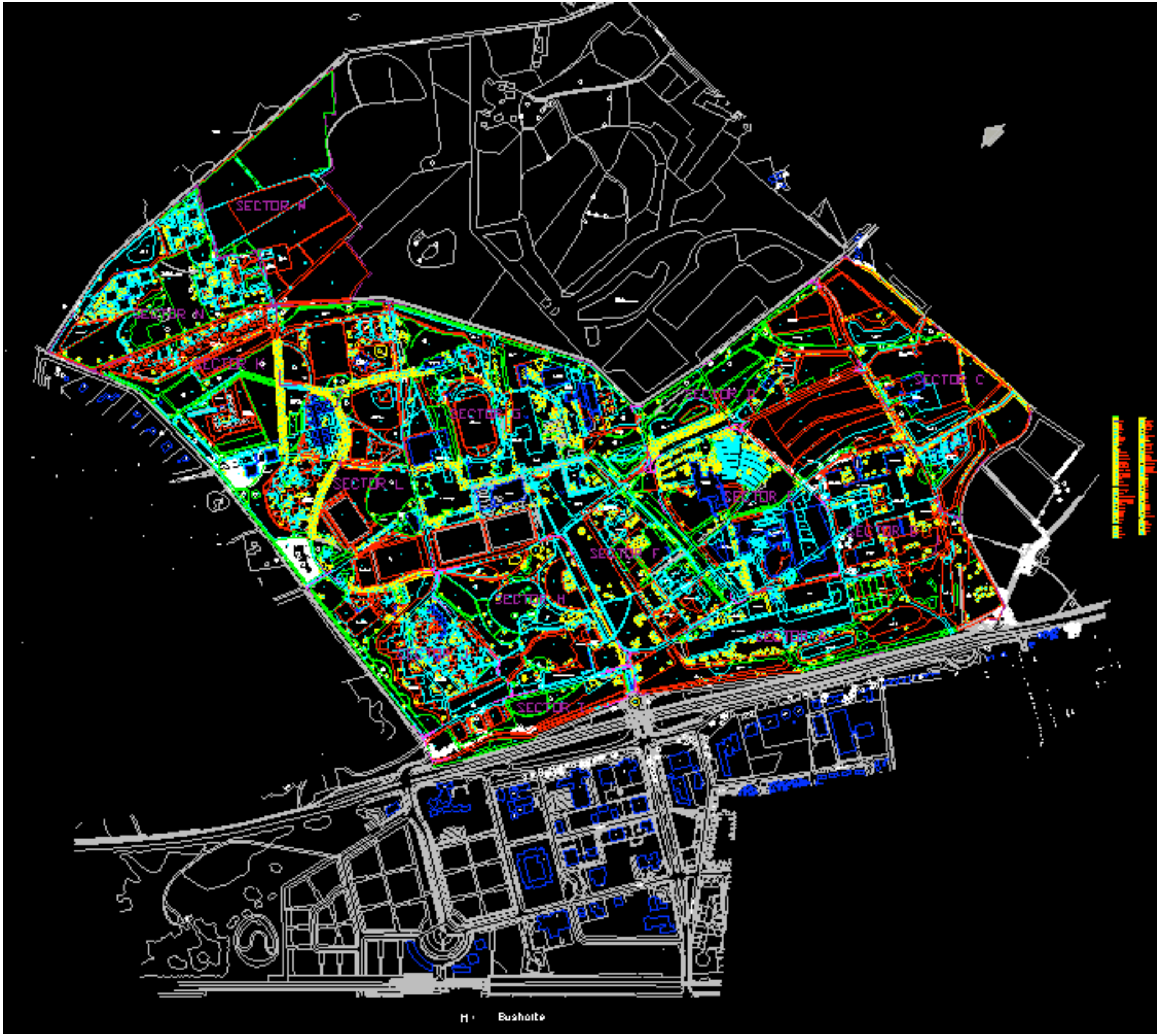
Decision Support for Test Trench Location Selection with 3D Semantic Subsurface Utility Models

P. Racz[1], L. Syfuss[2], C. Schultz[2], M. van Buiten[1], L. olde Scholtenhuis[1], F. Vahdatikhaki[1], and A. Dorée[1]

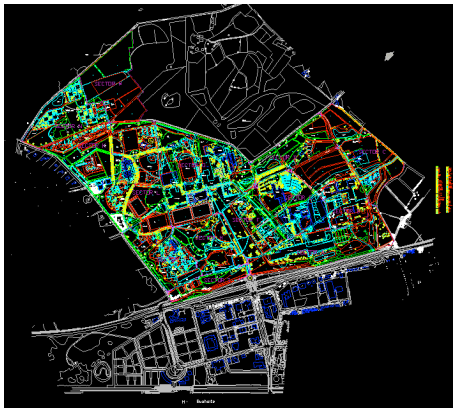
[1] Construction Management and Engineering, University of Twente
[2] Institute for Geoinformatics (IFGI), University of Muenster

ABSTRACT

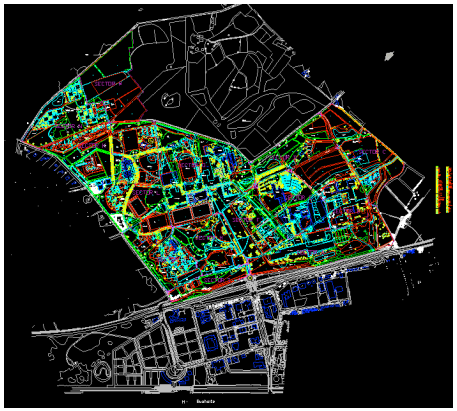
Subsurface utility construction work often involves repositioning of, and working between, existing buried networks. While the amount of utilities in modern cities grows, excavation work becomes more prone to incidents. To prevent such incidents, excavation workers request existing 2D utility maps, use detection equipment and dig test trenches to validate their accuracy and completeness. Although test trenches are of significant importance to reveal information about subsurface conditions, the process of determining their location, number and size is not explicated by experts to date. This study therefore aimed to explicate the reasoning and logic behind the selection of utility test trenches, and to formalize this in a semantically-rich utility model. To this end, we conducted interviews with experienced excavator operators. We then derived heuristics and rules that the experts used to determine trench locations. Such rules related to, for example, the layout of the excavation site, and the type of utilities, and accuracy of available data. Based on these rules, we integrated various incomplete sources of data, and



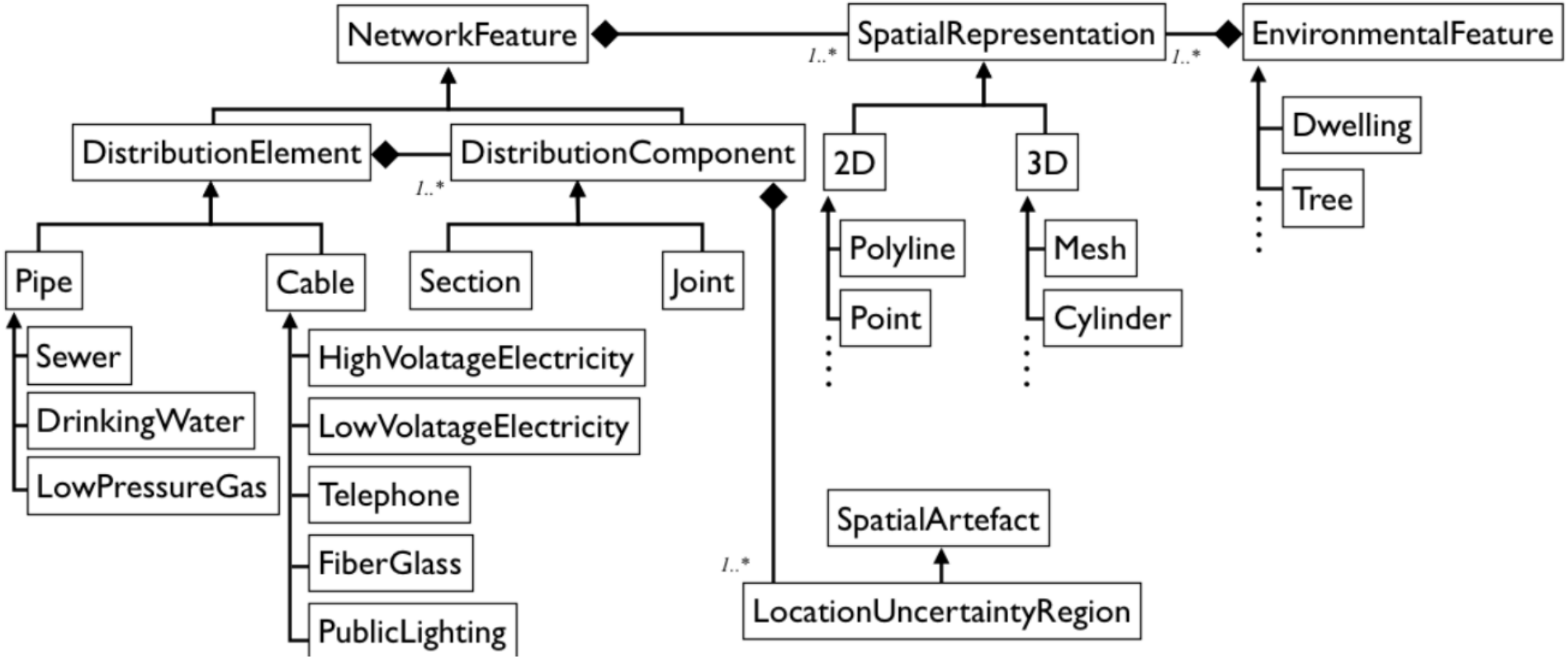
no depth, no diameter

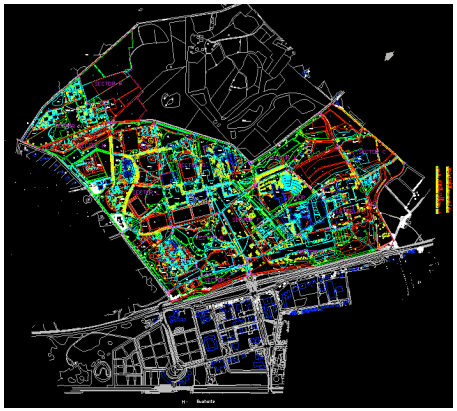


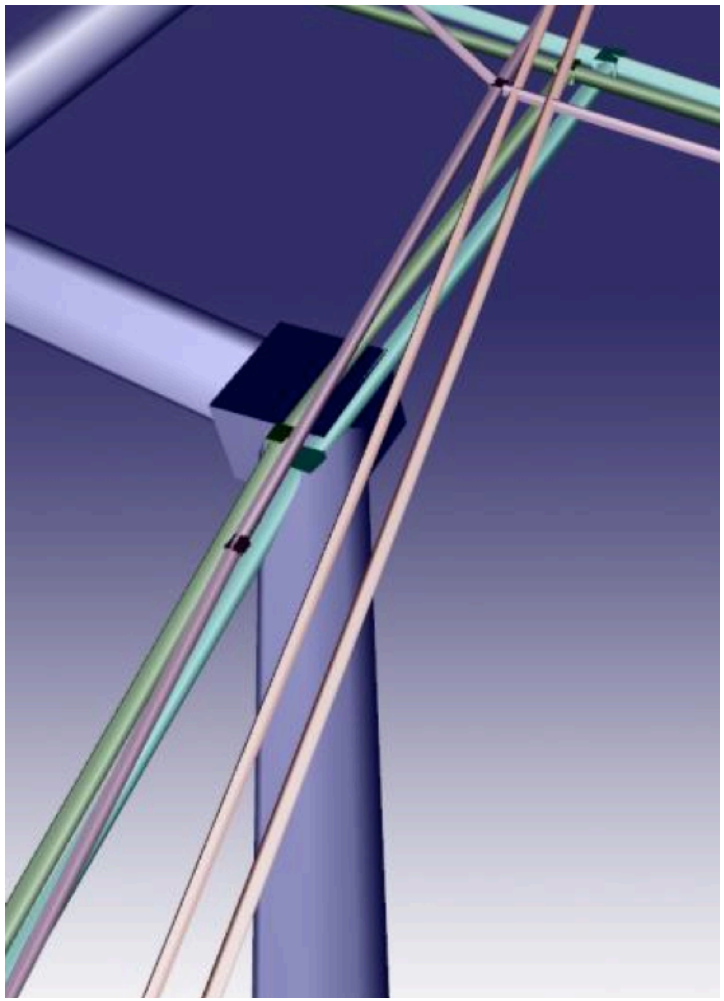
- water pipes have inclination
- pipe type: expected diameter, depth
- expect no physical clash



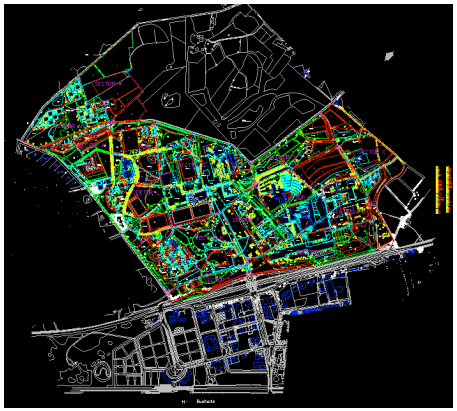
- water pipes have inclination
- pipe type: expected diameter, depth
- expect no physical clash



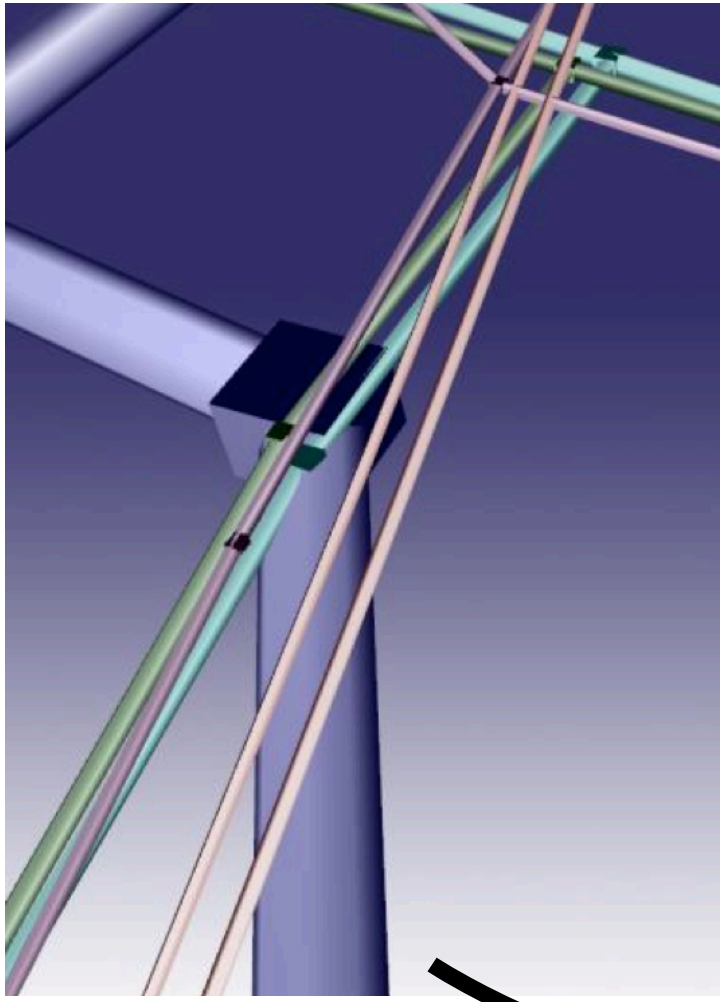


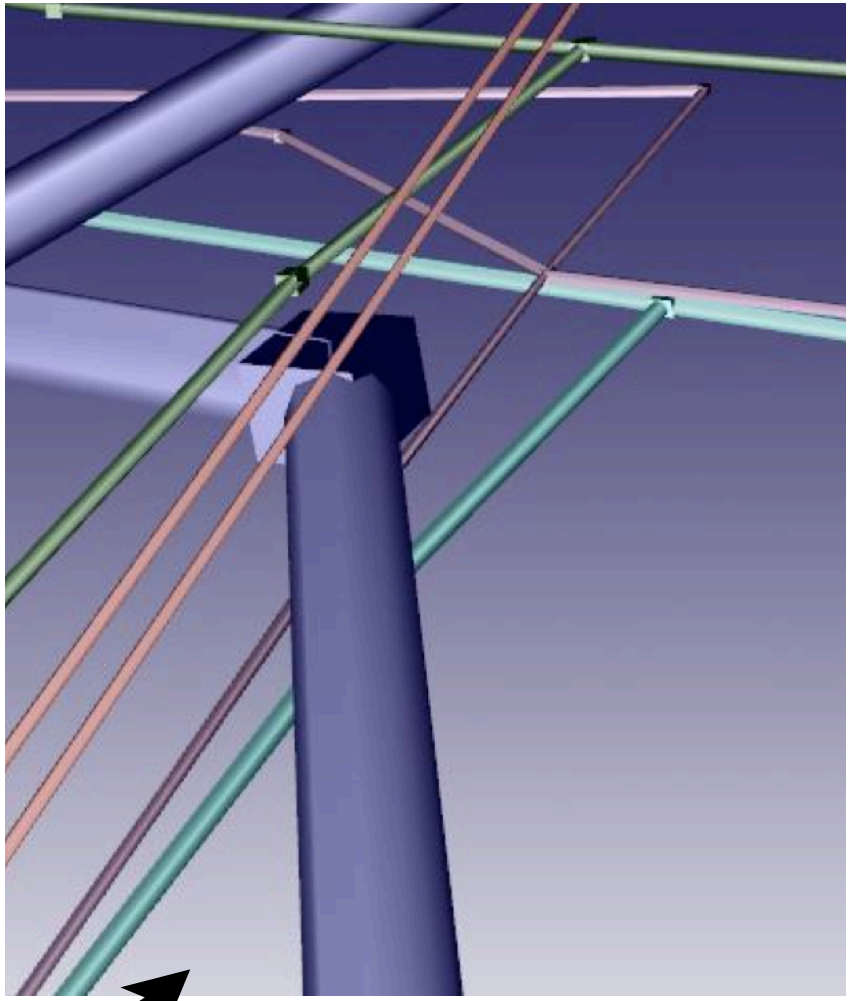


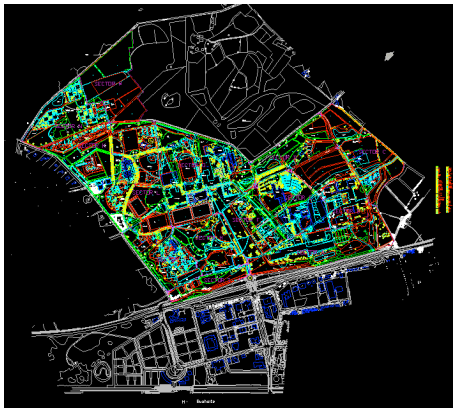
- water pipes have inclination
- pipe type: expected diameter, depth
- expect no physical clash



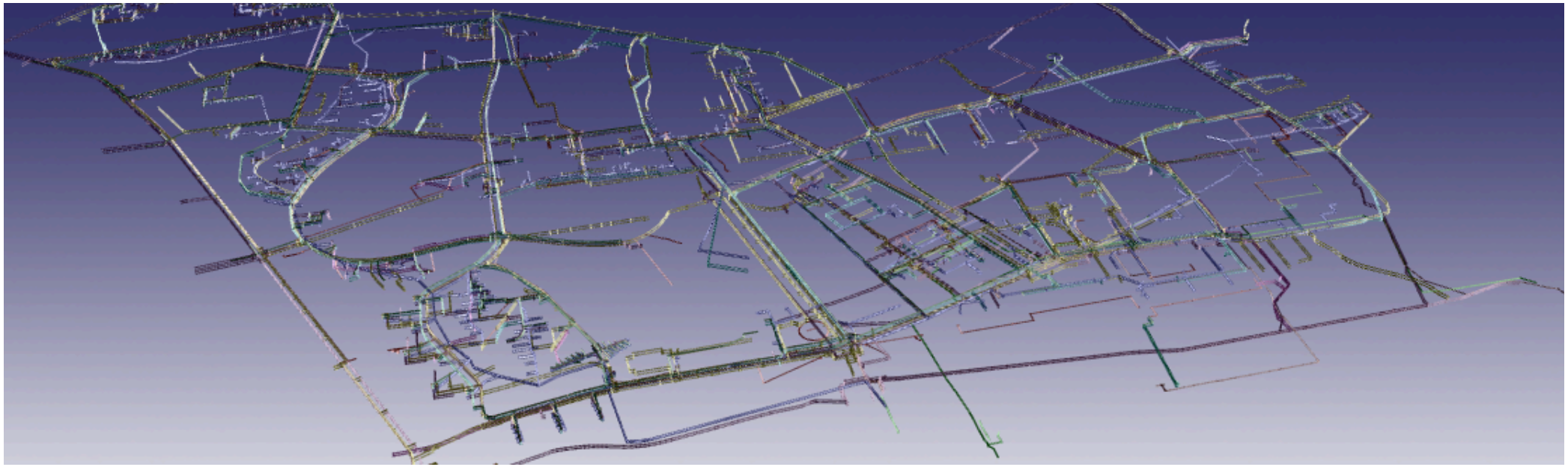
- water pipes have inclination
- pipe type: expected diameter, depth
- expect no physical clash

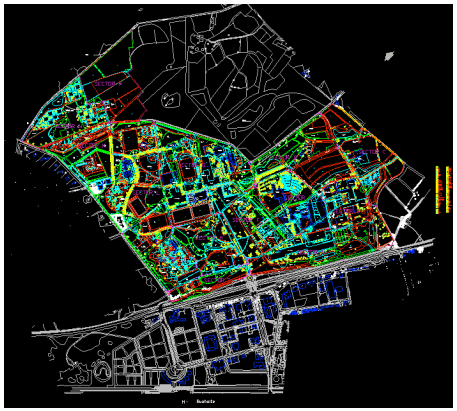




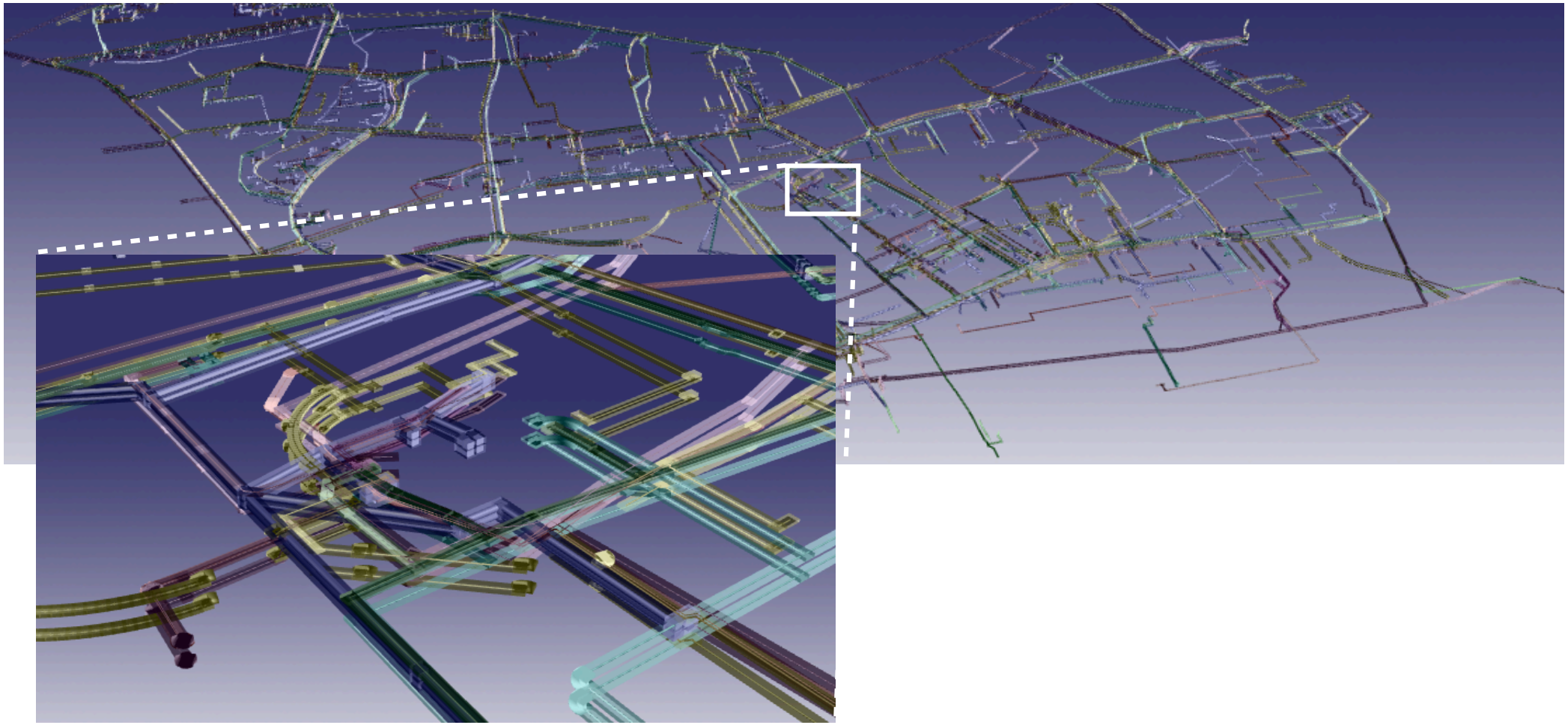


Input: Fresh water, sewer, gas, high and low voltage cables, telephone line, fiber optic cables, street lightning
Generated: 43,499 utility sections, 42,059 joints (~5 min)





Input: Fresh water, sewer, gas, high and low voltage cables, telephone line, fiber optic cables, street lightning
Generated: 43,499 utility sections, 42,059 joints (~5 min)

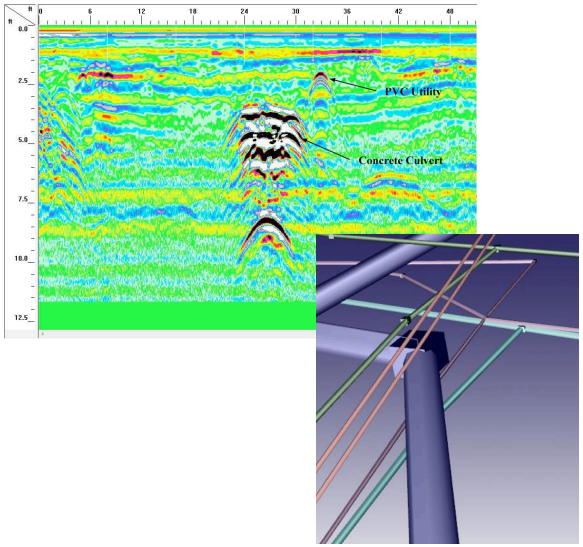


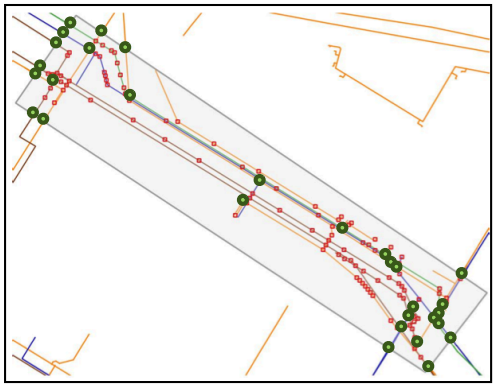
explainable AI

discover
what people do

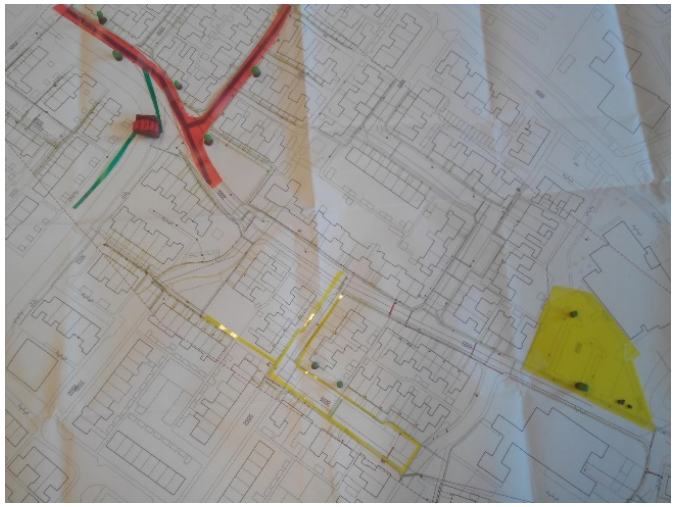
discover
what's in the ground

provide
decision support

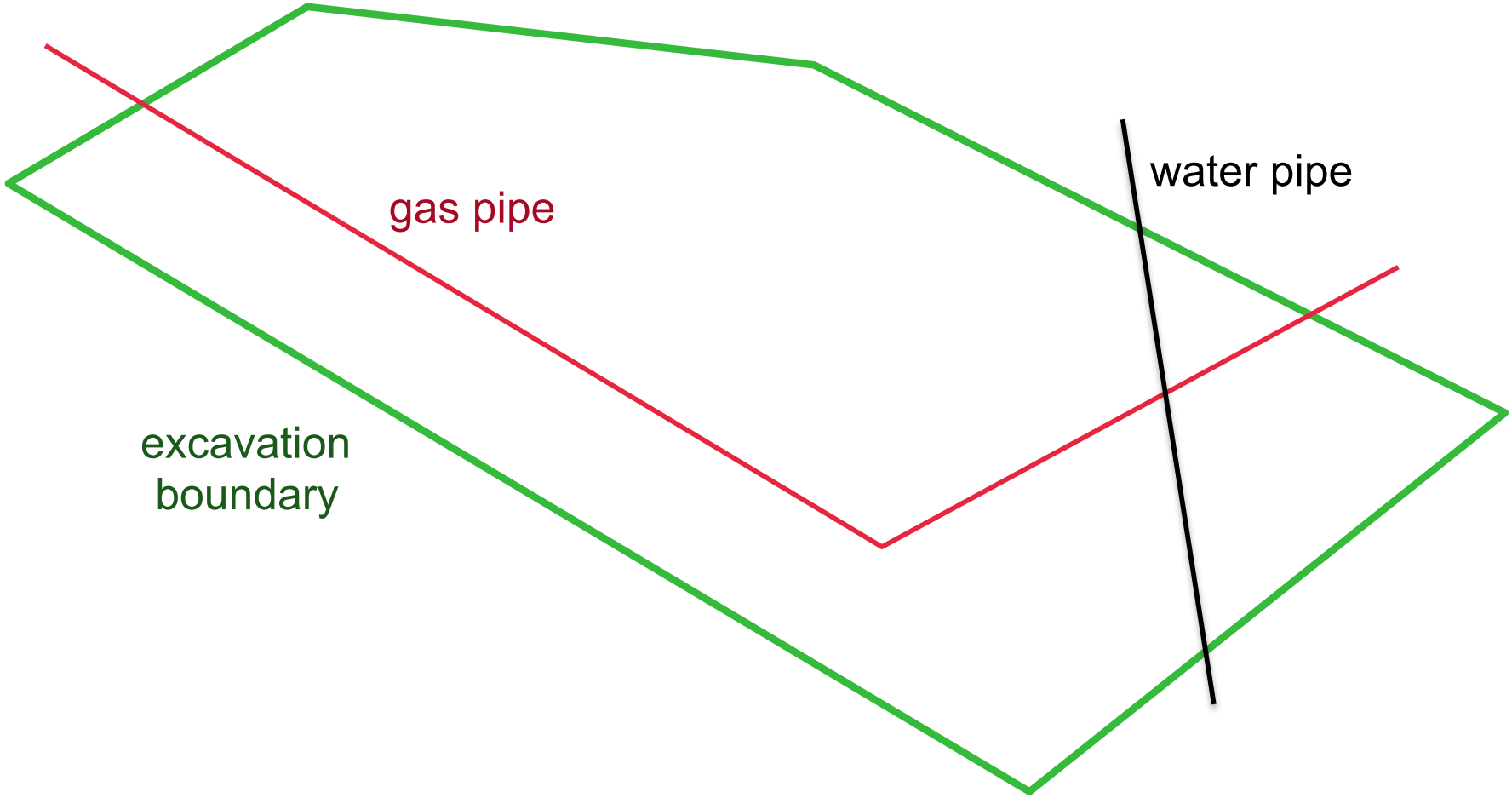




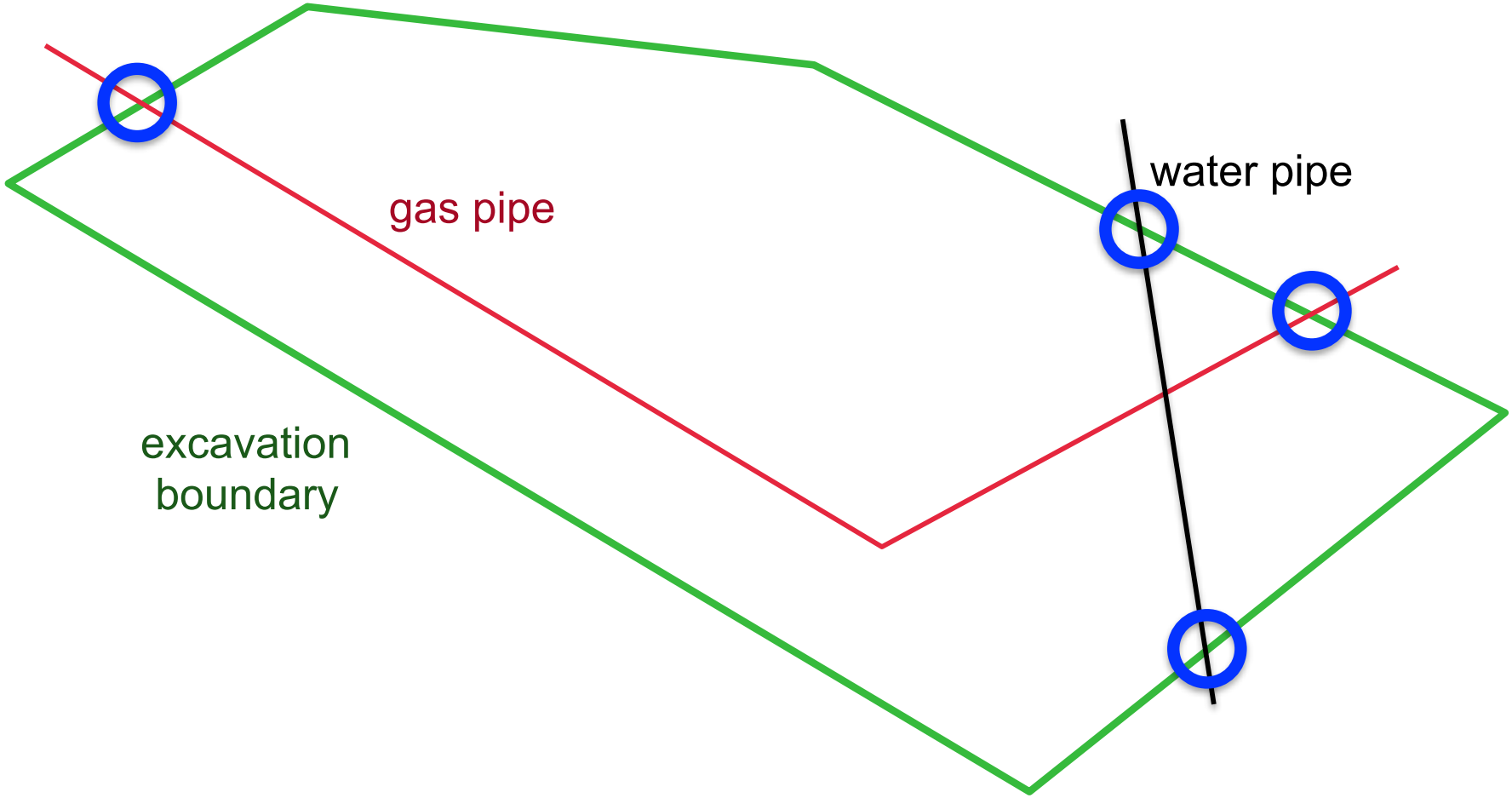
Paulina Racz
semi-structured interviews, workshops



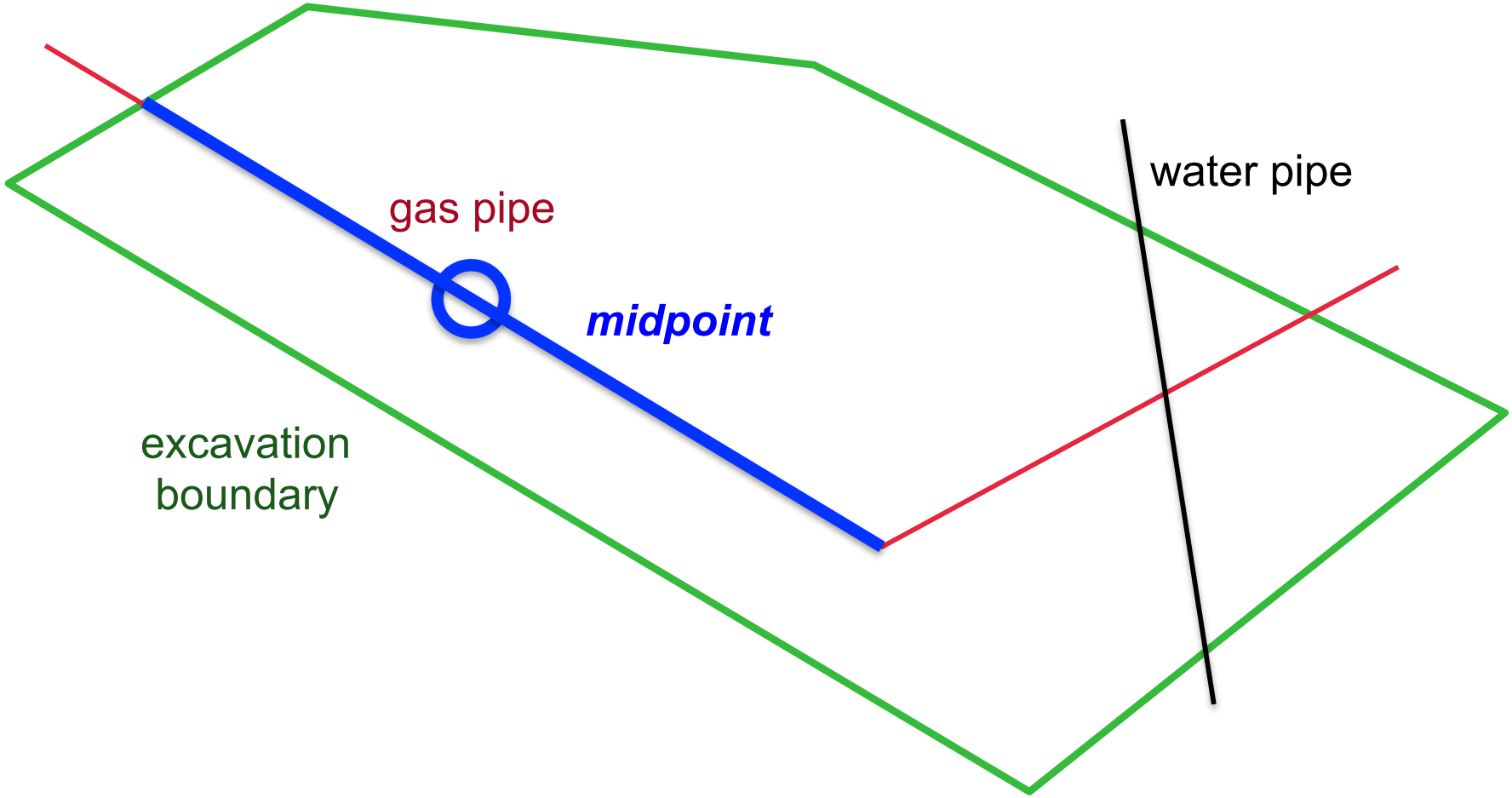
If … Intersection with excavation polygon (priority 3)
If … > 20m long linear section (priority 2)
If … > 20° direction change between sections (priority 1)
If … utility crossing in planar view (priority 1)
If … safety critical utility line (priority 1)



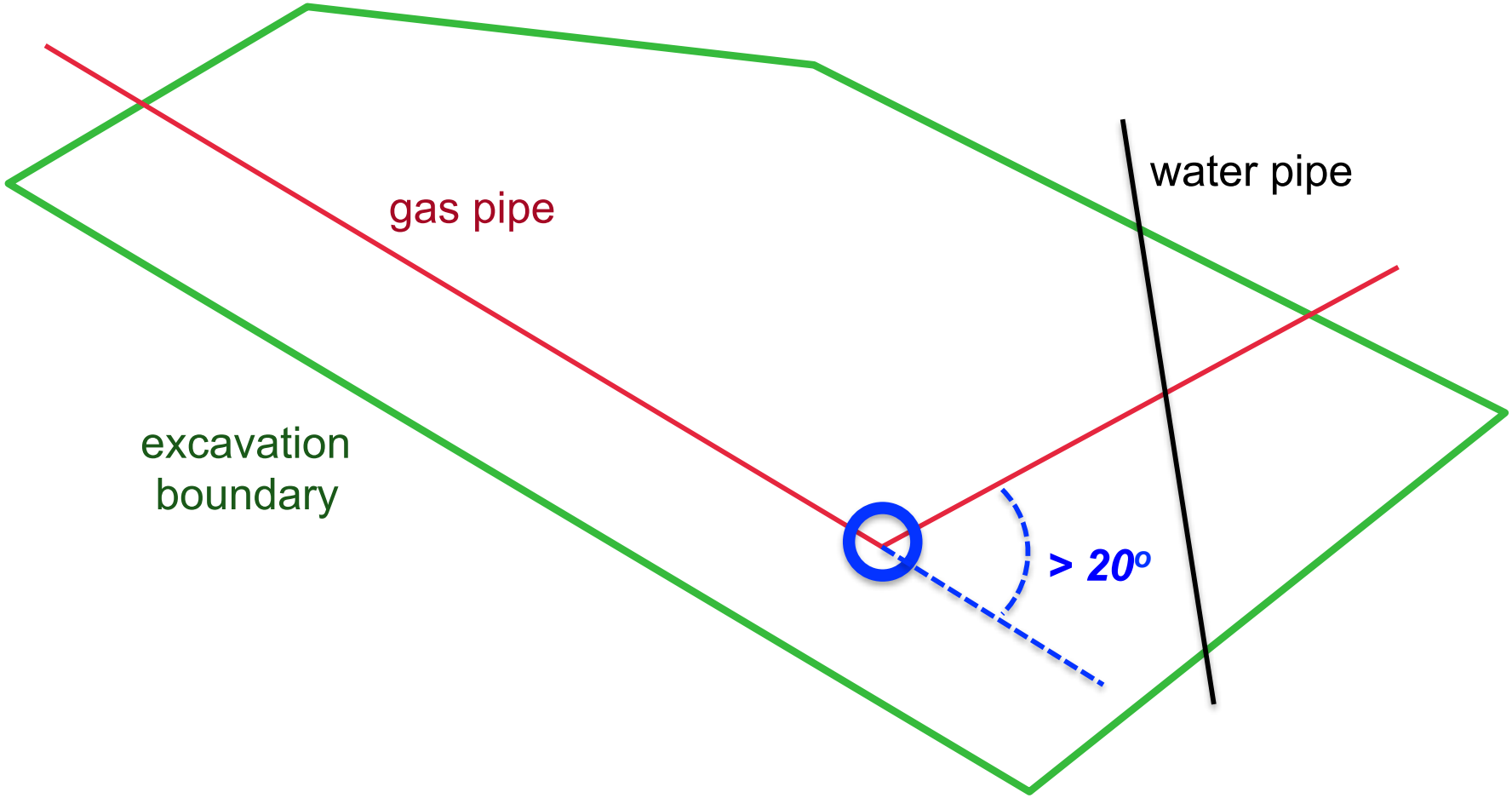
If … Intersection with excavation polygon (priority 3)
If … > 20m long linear section (priority 2)
If … > 20° direction change between sections (priority 1)
If … utility crossing in planar view (priority 1)
If … safety critical utility line (priority 1)



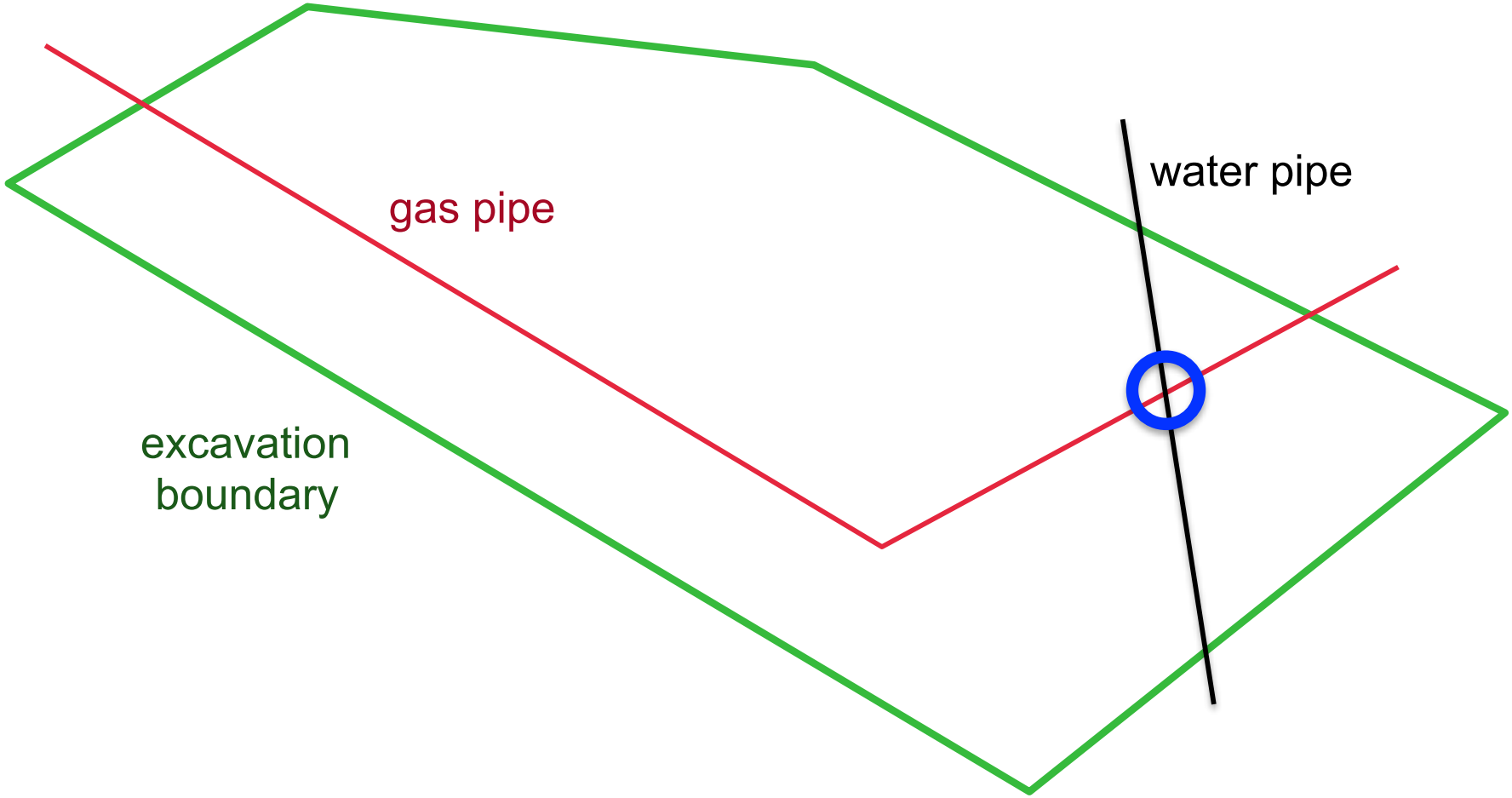
If … Intersection with excavation polygon (priority 3)
If … > 20m long linear section (priority 2)
If … > 20° direction change between sections (priority 1)
If … utility crossing in planar view (priority 1)
If … safety critical utility line (priority 1)



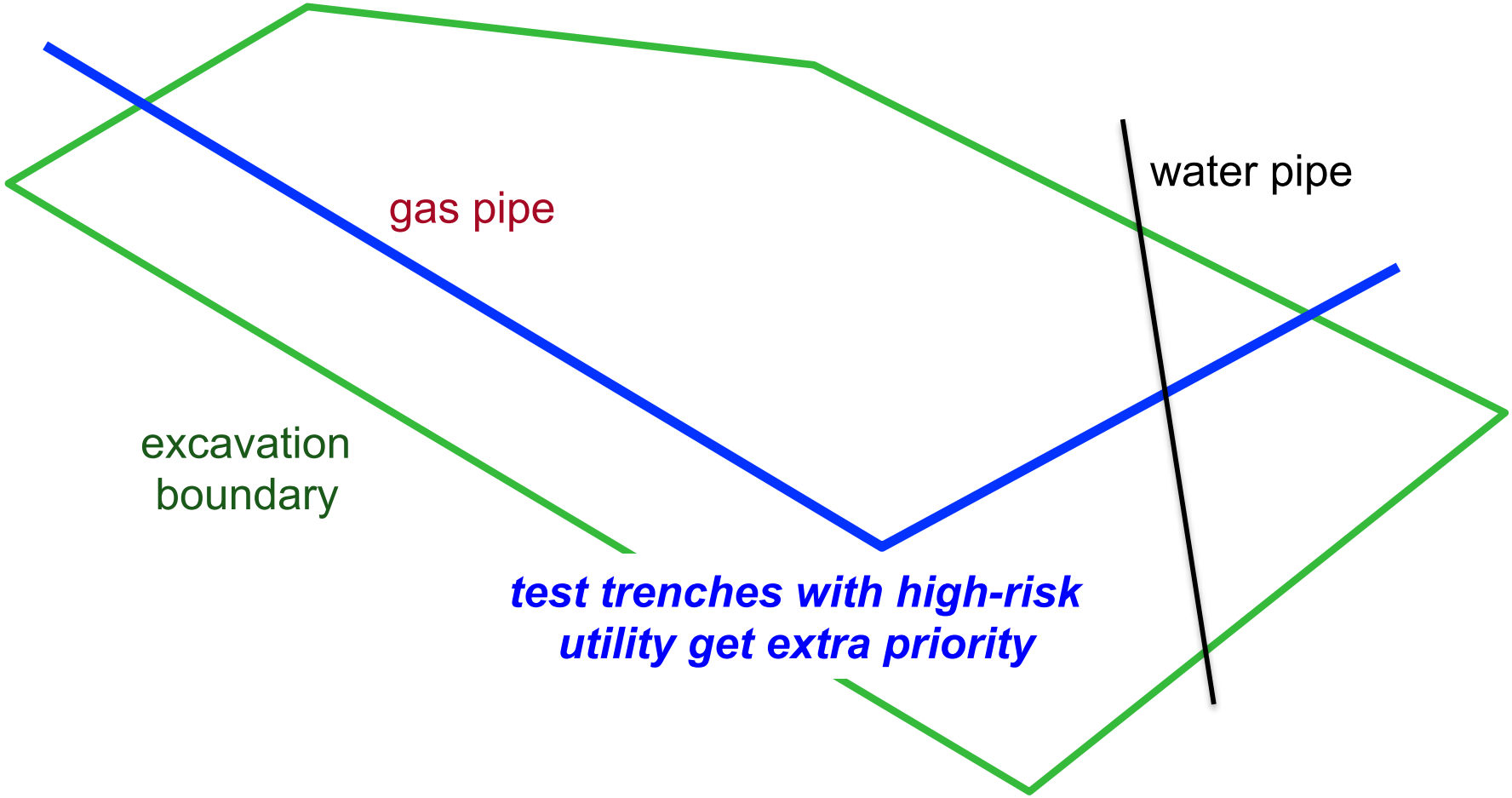
If … Intersection with excavation polygon (priority 3)
If … > 20m long linear section (priority 2)
If … > 20° direction change between sections (priority 1)
If … utility crossing in planar view (priority 1)
If … safety critical utility line (priority 1)

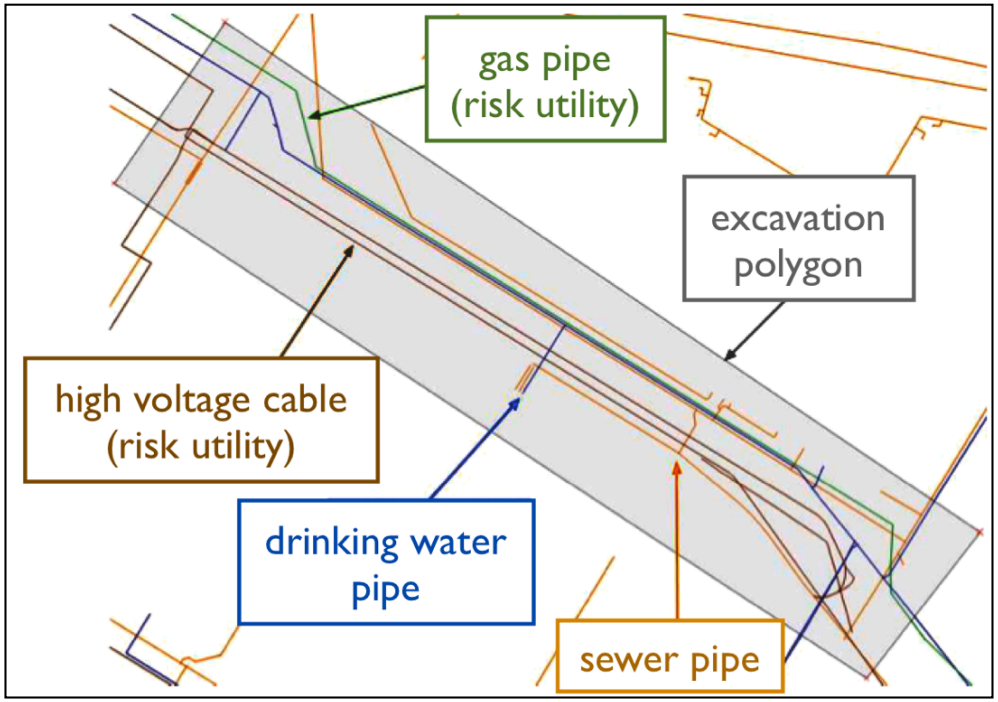


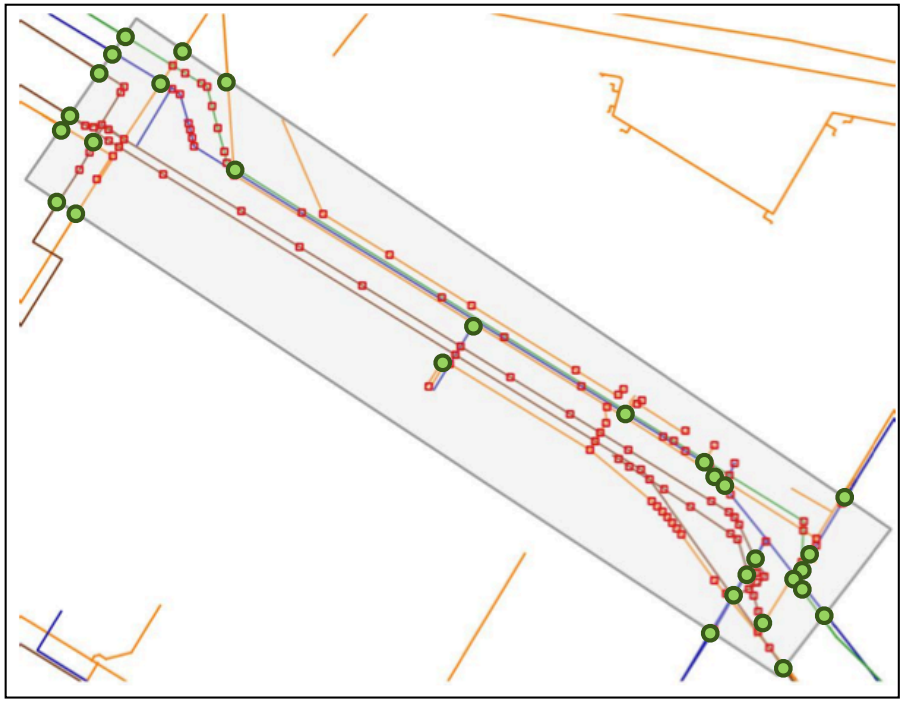
If … Intersection with excavation polygon (priority 3)
If … > 20m long linear section (priority 2)
If … > 20° direction change between sections (priority 1)
If … utility crossing in planar view (priority 1)
If … safety critical utility line (priority 1)



If … Intersection with excavation polygon (priority 3)
If … > 20m long linear section (priority 2)
If … > 20° direction change between sections (priority 1)
If … utility crossing in planar view (priority 1)
If … safety critical utility line (priority 1)





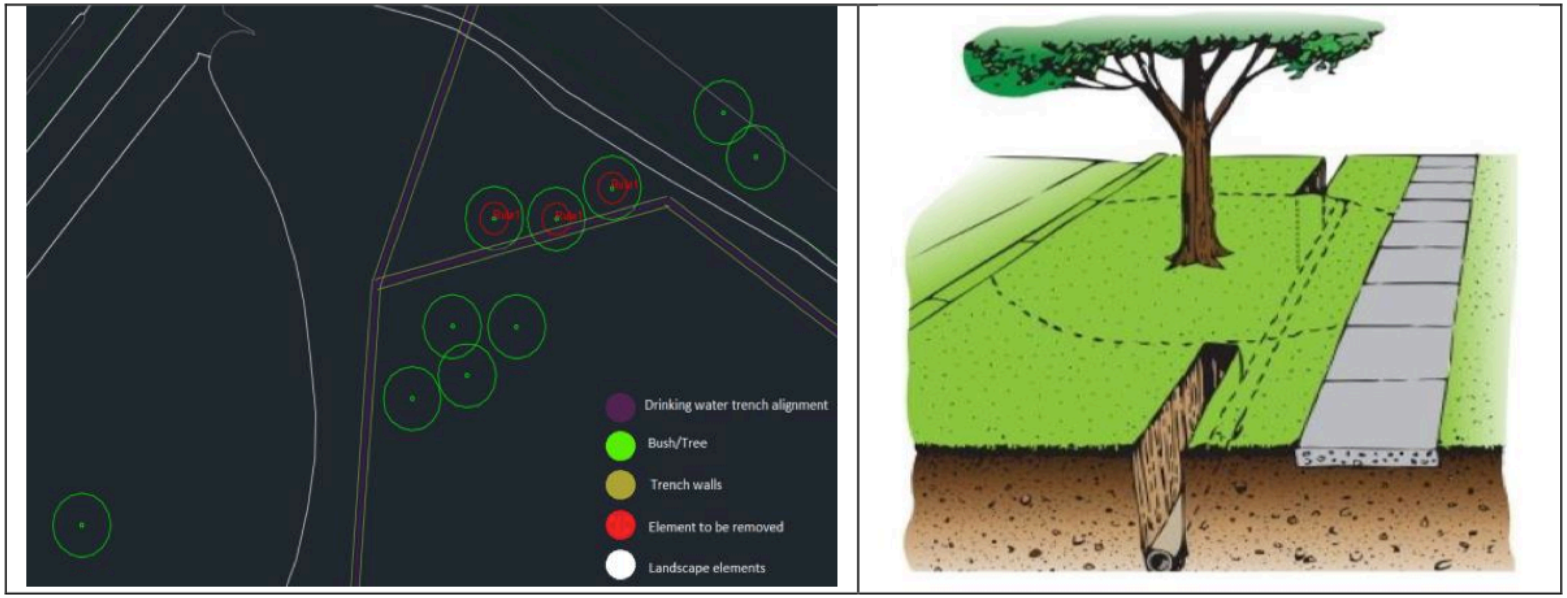


Identified 135 locations, ranked top 30 (~3.5 sec)

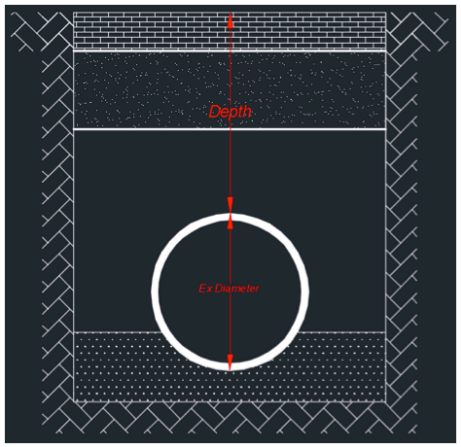
Diego Armando Morales

1. **Rule1**: Any element located to at least 0.6 meters from the walls of the excavation must be removed.
2. **Rule2**: In a vehicle zone a water pipe with medium/high complexity, must be at least to 1.2 meters horizontally from both electricity or communication pipes.
3. **Rule3**: In a vehicle zone a water pipe with medium/high complexity, must be at least to 0.5 meters vertically from both electricity or communication pipes.
4. **Rule4**: Pipe material allowed depending on the distribution network
5. **Rule5**: External minimum diameter pipe allowed in main network.
6. **Rule6**: External maximum diameter pipe allowed in main network.
7. **Rule7**: Actual minimum diameter pipe allowed in main network.
8. **Rule8**: Actual maximum diameter pipe allowed in main network.
9. **Rule9**: minimum depth pipe allowed in main network.
10. **Rule10**: maximum depth pipe allowed in main network.
11. **Rule11**: Manual excavation method, workers distribution.
12. **Rule12**: Excavation fenced location.
13. **Rule13**: Maximum width allowed in a trench.
14. **Rule14**: Equipment location checking position.
15. **Rule15**: Dug soil piled perimeters limit.
16. **Rule16**: Dug soil piled point checking.
17. **Rule17**: Vehicle construction path distance checking.
18. **Rule18**: Type of soil classification (a, b, c).
19. **Rule19**: Type of soil trench classification regardless slope structure
20. **Rule20**: Overlaid soil layer level organization by height, upper soil, lower soil. Layer structure.
21. **Rule21**: Trench located in multiple layers.
22. **Rule22**: A specific location has a single soil classification inside other soil classification.
23. **Rule23**: Embankment structure in trenches with overlaid soil layers.
24. **Rule24**: Embankment structure in trenches with overlaid soil layers when trench intersects a single layer
25. **Rule25**: Embankment structure in trenches with single soil layers
26. **Rule26**: Embankment structure in trenches with single soil layers when trench intersects a overlaid layer
27. **Rule27**: Time limit to reused soil as fill material.
28. **Rule28**: Reused soil as fill material checking location.

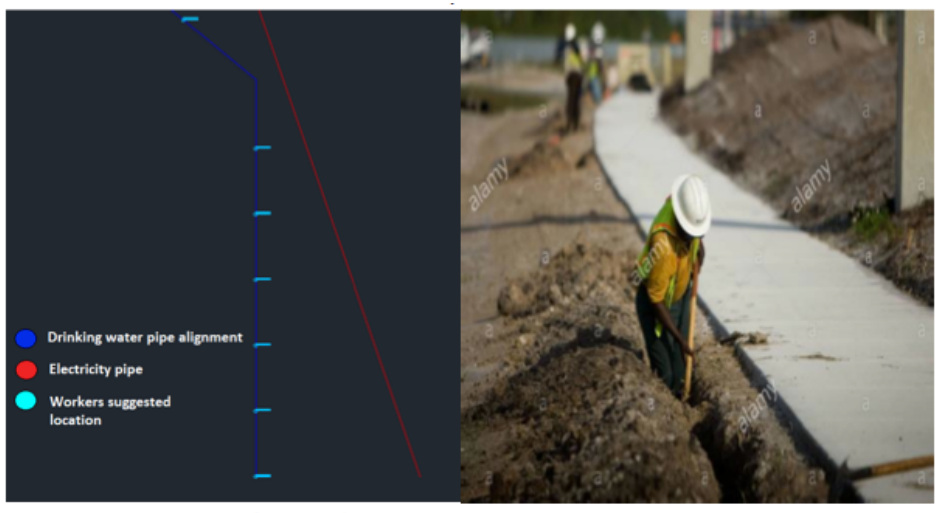
Colombian construction practices



removing obstacles



depth constraints



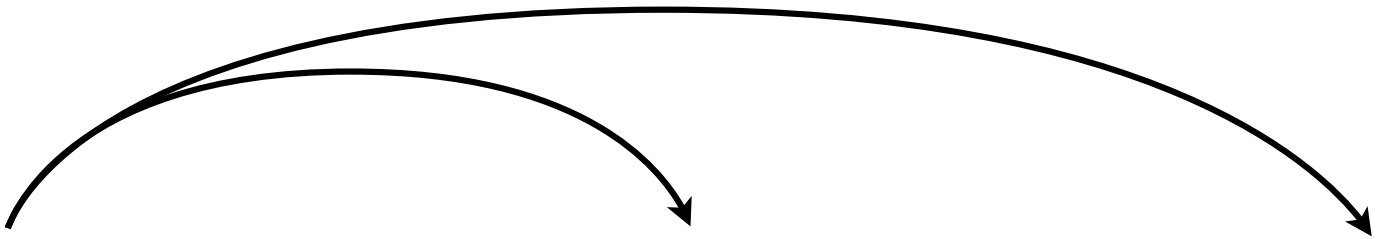
placing workers

placing fence posts

vehicle path constraints

placing dug soil piles

explainable AI



discover
what people do

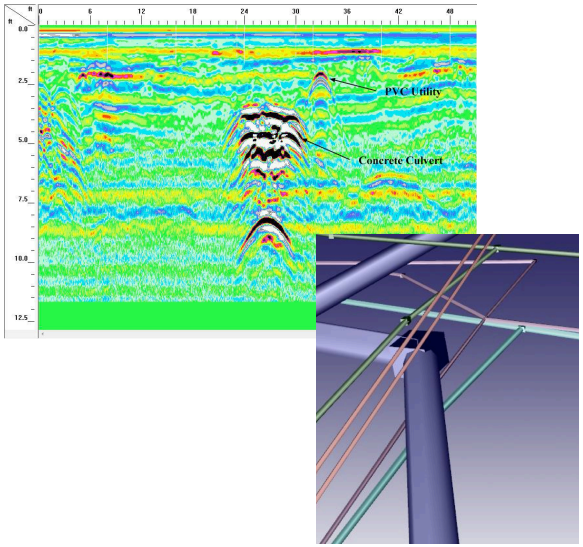
discover
what's in the ground

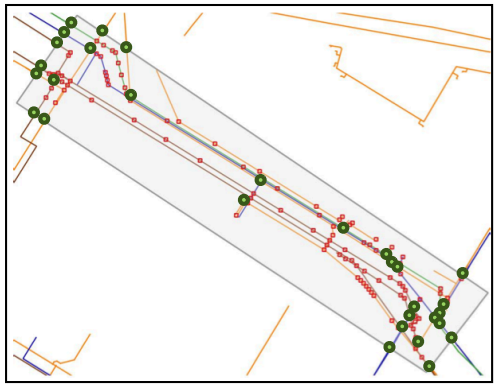
provide
decision support

user data analysis,
qualitative research

GPR analysis,
data modelling

logic-based systems,
simulation



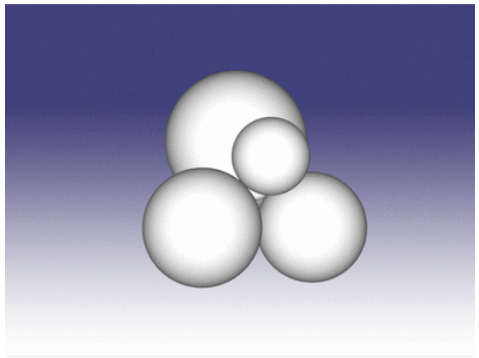


intelligent spatial computing for the underworld

Carl Schultz

Department of Engineering
Aarhus University

http://think-spatial.org/



The DesignSpace Group

http://www.design-space.org/Next