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Developing City Infrastructure Ontologies to Support Complex Decision Making

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My Goal

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- Share experience
- Provide an alternative view
- Provoke thoughts

Bias

- Background
  - Human-centred AI
- Experience
  - Stakeholder engagement, challenges
- Relevant Projects
  - Urban infrastructure decision support systems

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Human-centred Artificial Intelligence

Building intelligent systems that help people do things better:
take decisions in complex settings, preserve knowledge,
learn from experience, and change behaviour

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Modelling Human Conceptual Structures

Knowledge Models (ontologies)

Intelligent Interactive Systems

Personalisation (nudges)

Modelling Individuals or Groups

User/Group Models (dialogue / analytics)

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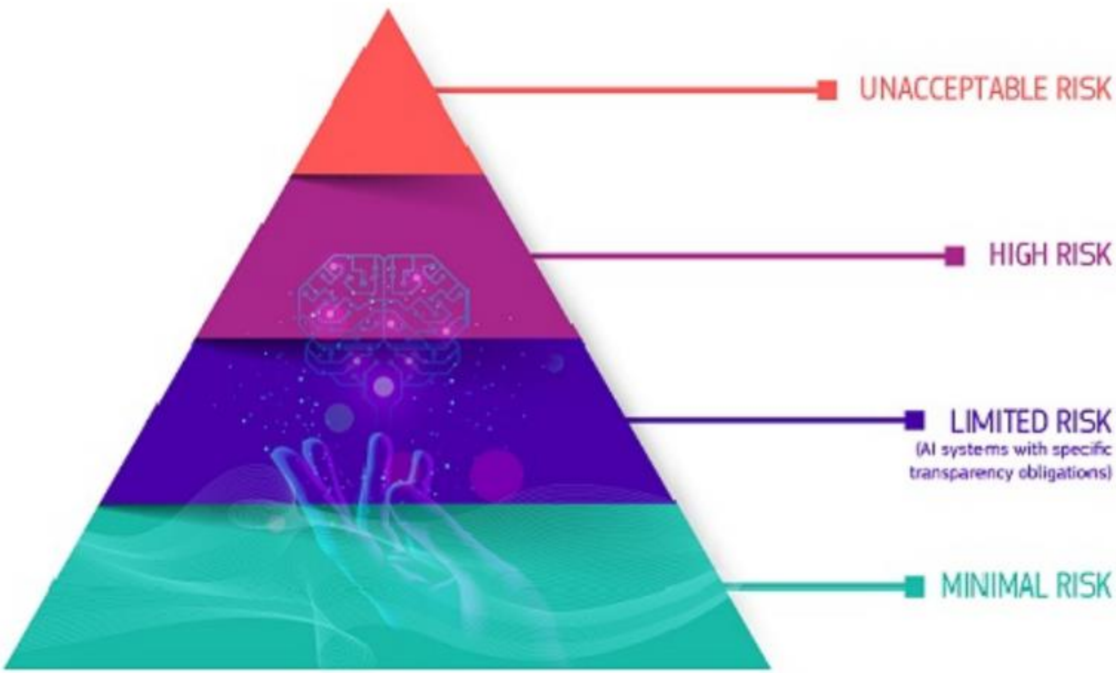
EU AI Act
Regulation (EU) 2024/1689



URBAN INFRASTRUCTURES

EU AI Act
Regulation (EU) 2024/1689

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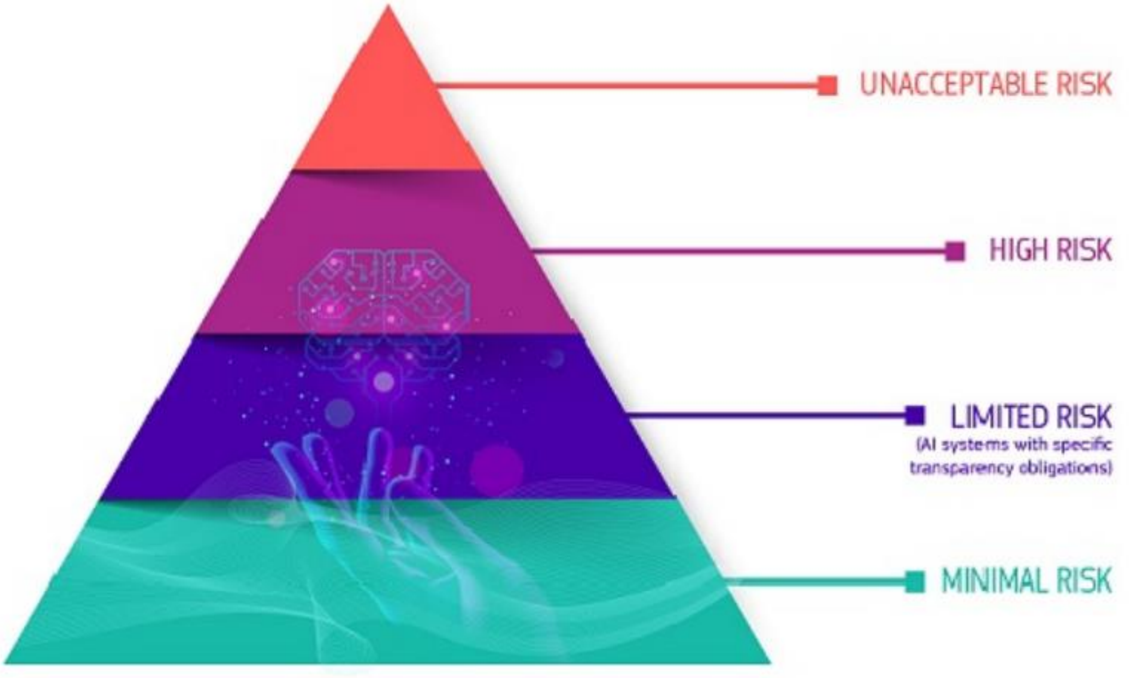

URBAN INFRASTRUCTURES

- adequate risk assessment and mitigation
- appropriate human oversight
- traceability of results

Street Works:
Complex Decision Making

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Street Works: Complex Decision Making

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Street works are second highest concern of residents and businesses

2.2 million reinstatements per year

30% fail to meet the two year legal performance criteria

Direct costs to local authorities are about £50m per year

17% reduction in the lifetime of a road

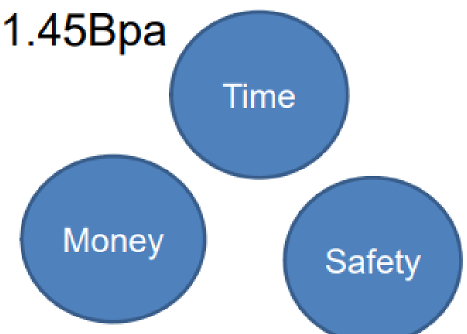
Annual highway maintenance £2.5Bpa

Annual carriageway maintenance £1.45Bpa

Compensation claims £0.95Bpa

Potholes 1.5m

Utility openings 1.4m



Street Works:
Complex Decision Making

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A Decision Support System
to Proactively Manage
Street works

System Architecture

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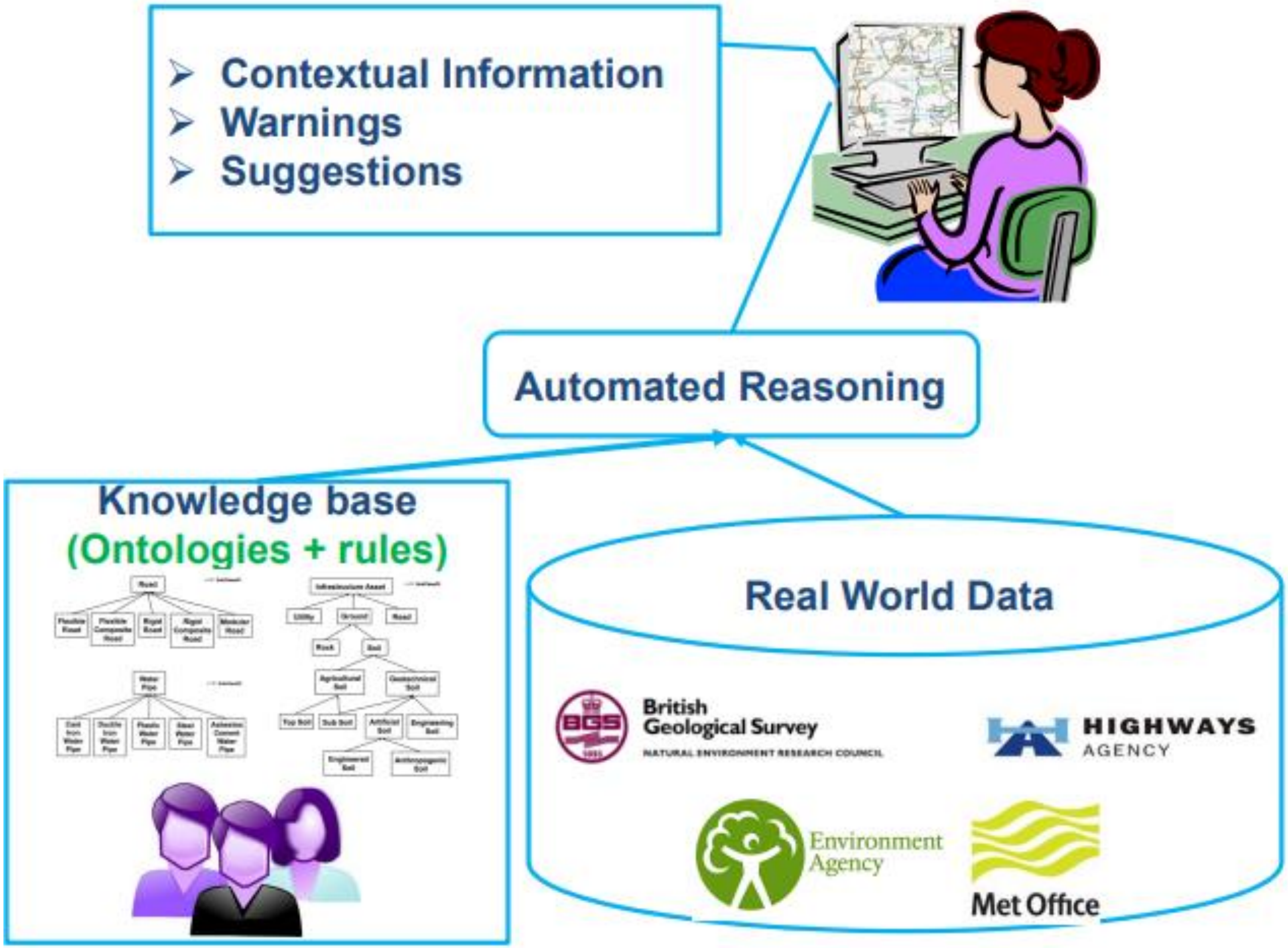

System Architecture

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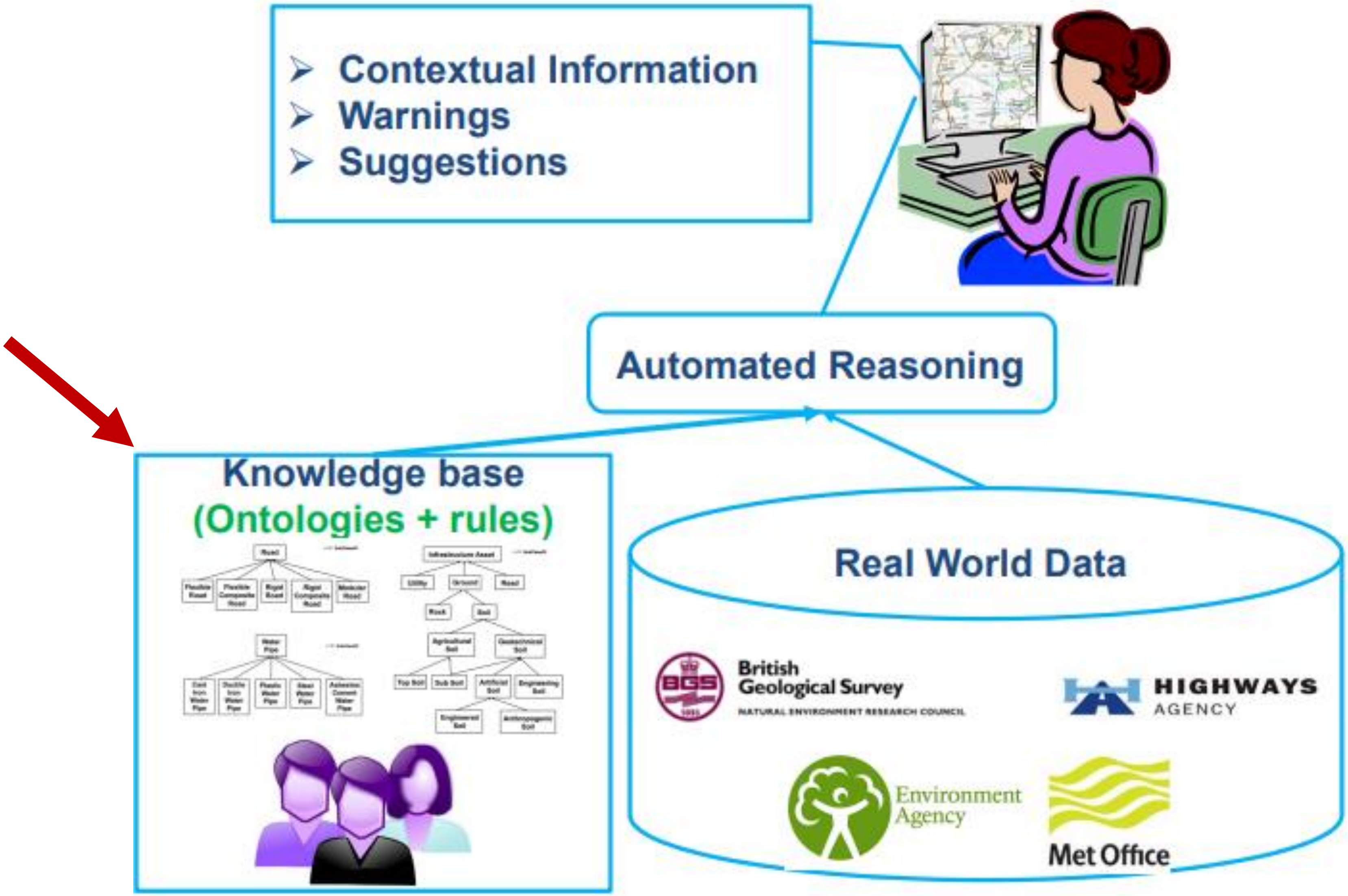

Stakeholder Engagement: Challenges

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Lack of a unified decision approach – there is no one authority to plan and manage underground space, dependencies between assets are easily overlooked.

Lack and dispersion of knowledge about asset managemen – often in the form of ‘tacit knowledge’ developed with extensive experience, new approaches not embedded into routine practice.

Lack of a holistic costs analysis – impact on other assets, as well as economic, environmental and societal impact.

Stakeholder Engagement: Interdependencies

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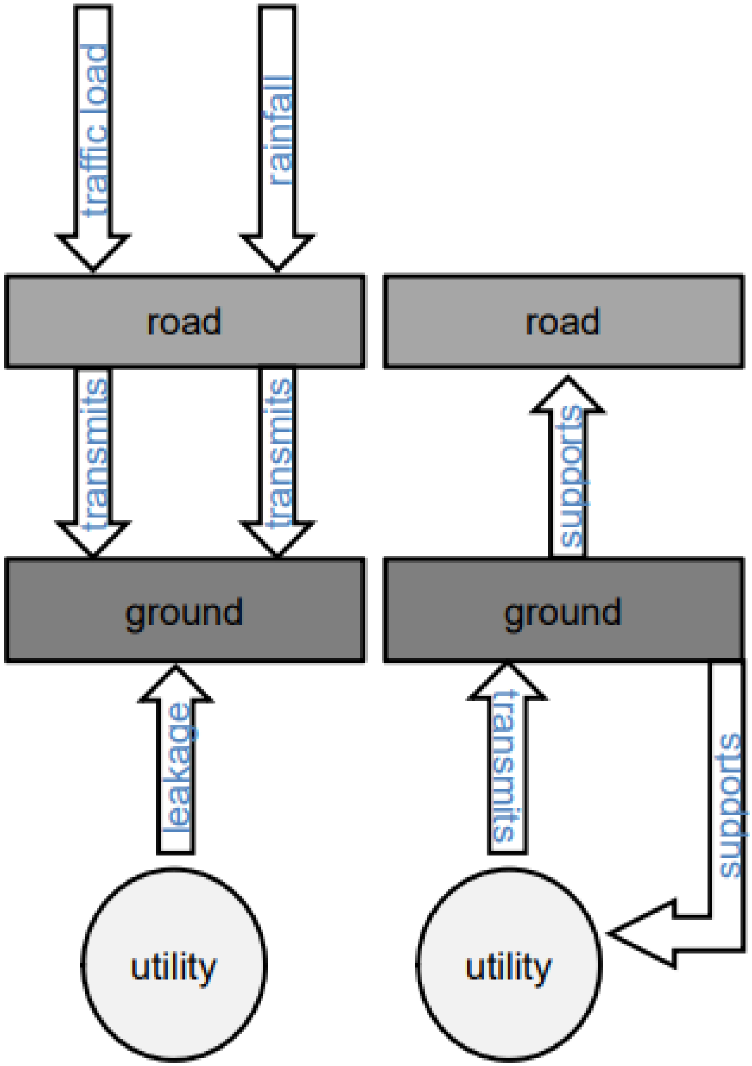

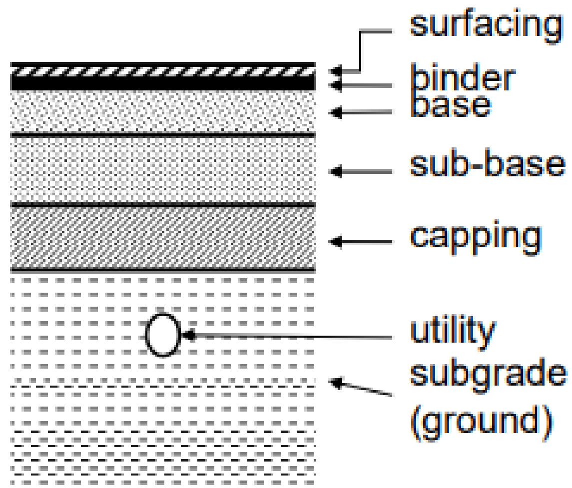

Interdependencies between Ontologies

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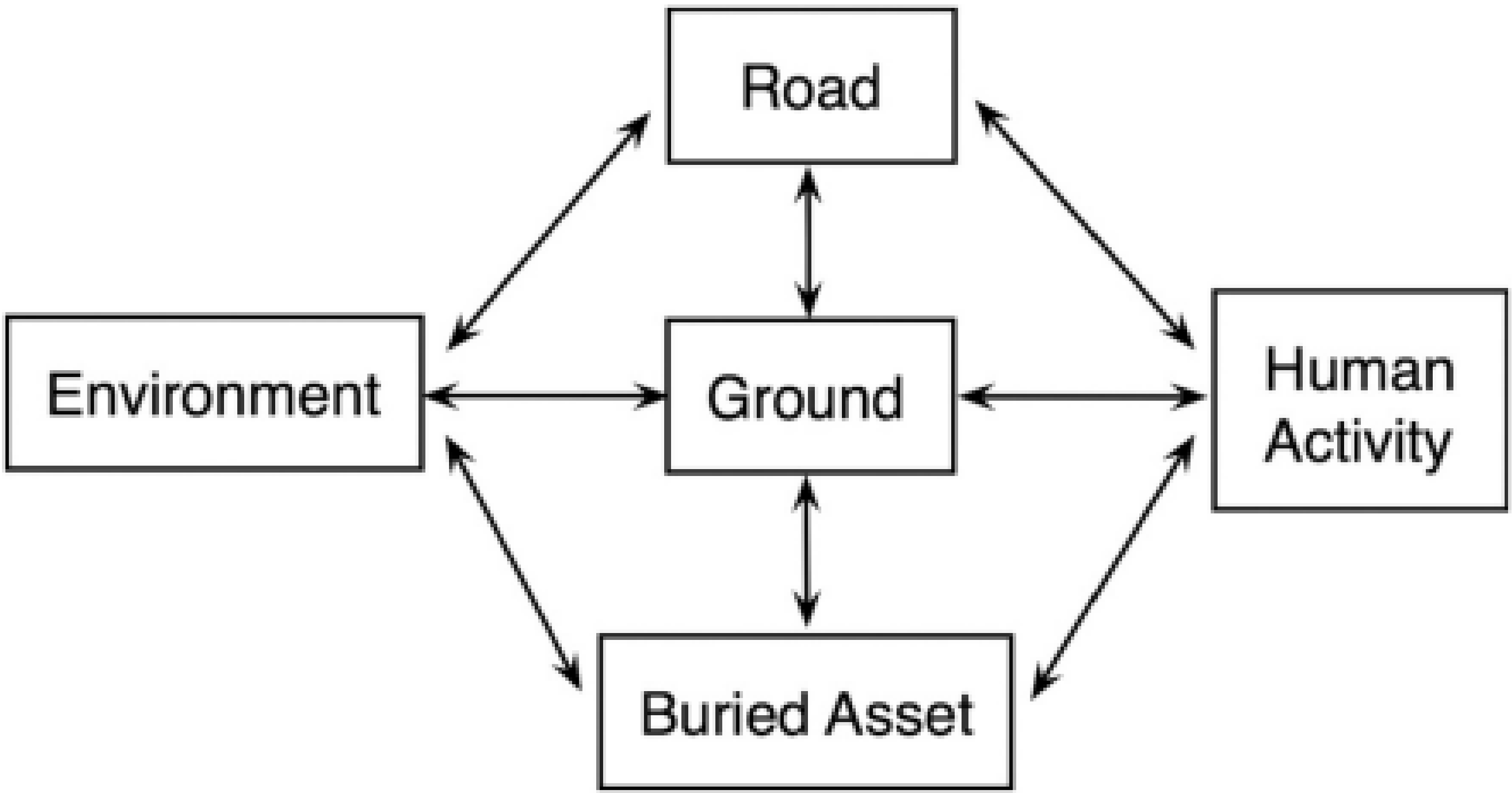

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Conceptual Model

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1. The model should provide a vocabulary covering various properties and processes of different infrastructure assets (e.g., the ground, roads and water pipes), as well as some terminologies for describing the natural environment and human activities which have close relationships with infrastructure assets.
2. For an individual infrastructure asset, the model should represent relationships between its properties and processes. For example, soil water content affects soil strength.
3. The model should represent relationships between properties and processes of *different* infrastructure assets. For example, pipe cracking is affected by soil deformation.
4. The model should represent how properties and processes of infrastructure assets affect and are affected by the natural environment and human activities. For example, soil water content is affected by evapotranspiration, and traffic affects soil deformation.

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Infrastructure Assets

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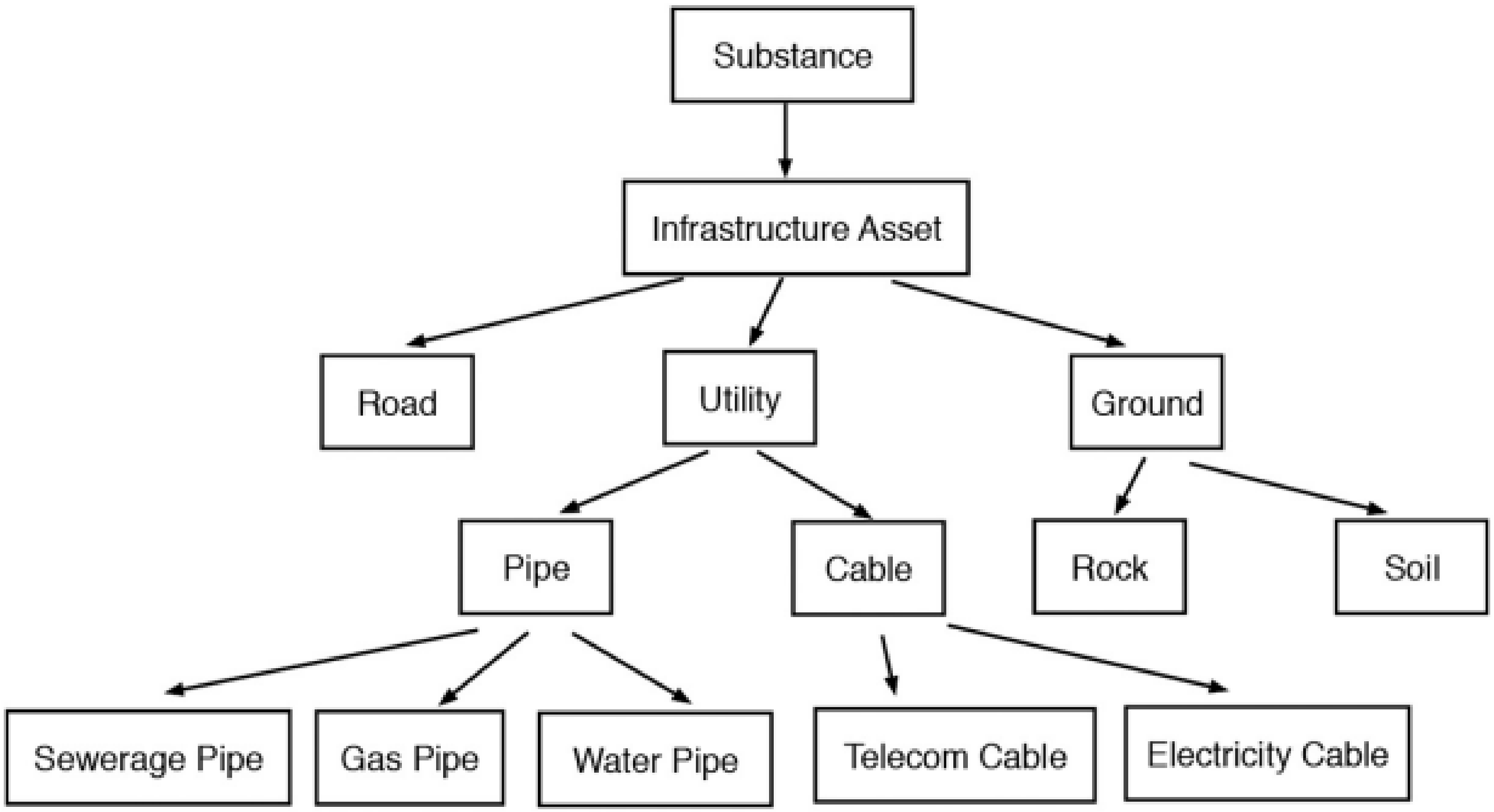

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Properties and Processes

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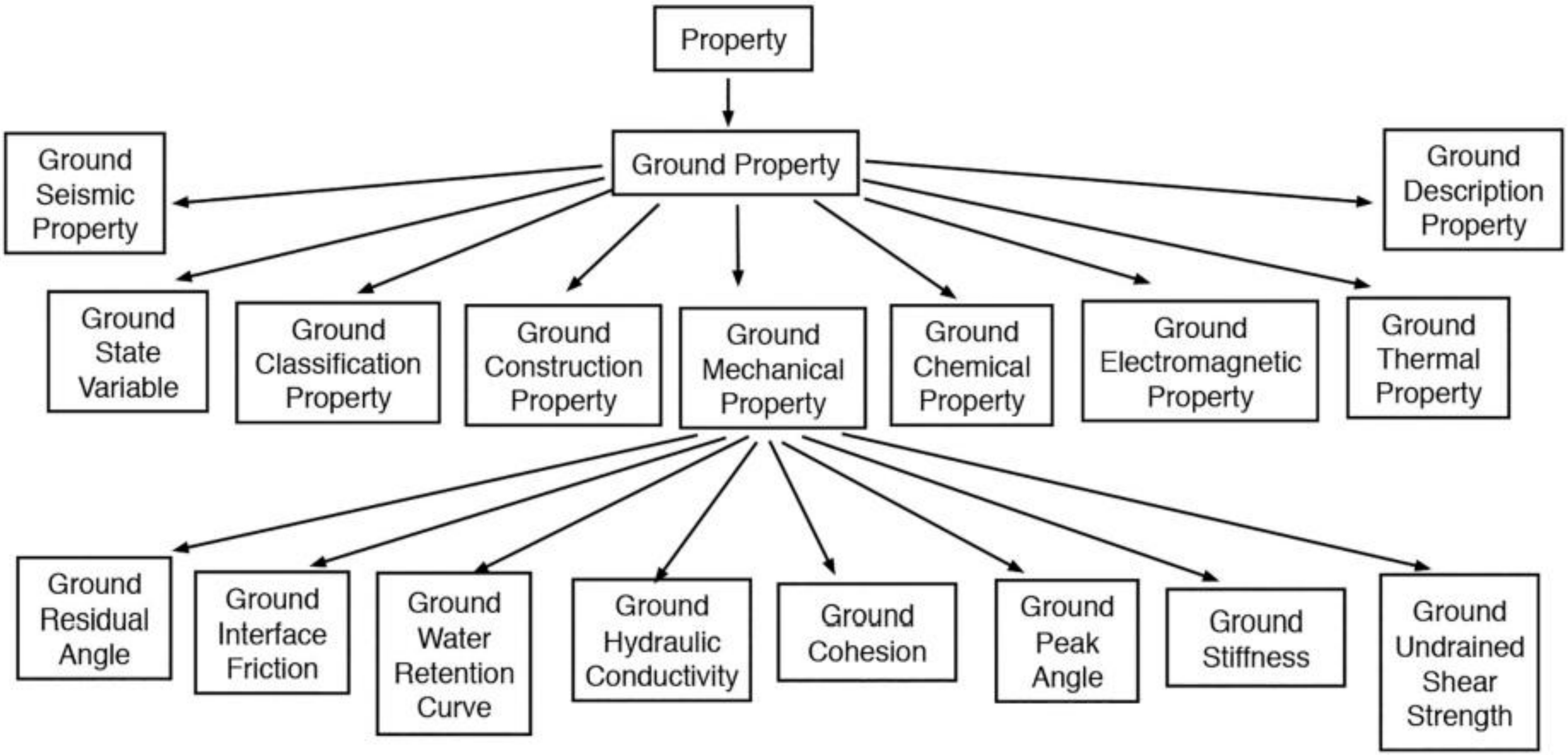

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Properties and Processes

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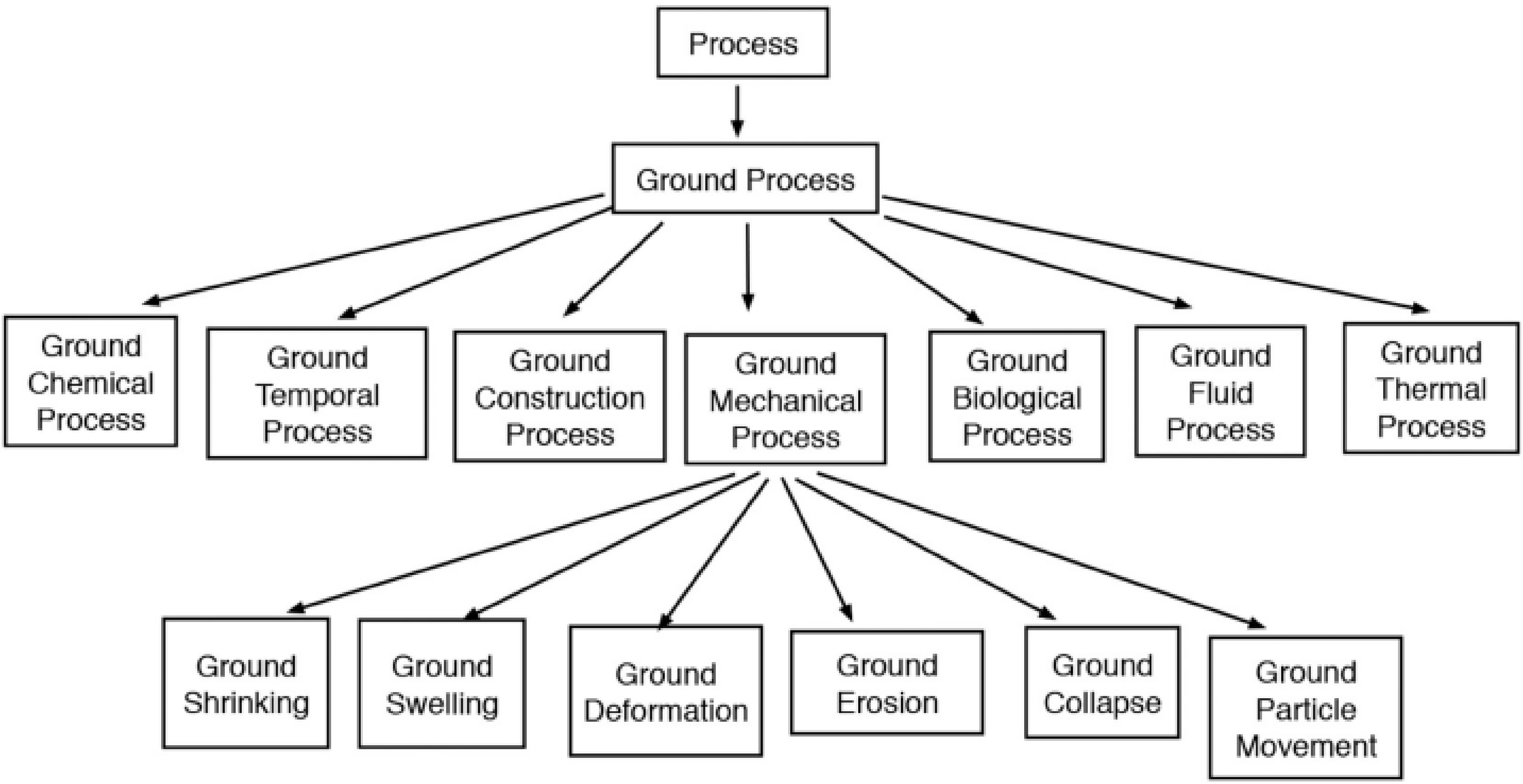

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Defining Properties

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Categories and priorities of ground properties. The letters P, C, M, K stand for *Physical*, *Compositional*, *Mechanical*, *Chemical*, respectively, referring to the corresponding categories defined in the concept hierarchy of *GroundProperty*. Properties with lower numbers in the column 'Priority' have higher priorities, e.g., 1 means the highest priority.

	Ground Property	Priority	Category
1	GroundWaterContent	1	P
2	GroundPorosity	1	P
3	GroundClayMineralogy	1	C
...	...	...	...
40	GroundFabric	2	C
41	GroundOrganicMatterContent	2	C
42	GroundThermalConductivity	2	M
...	...	...	...
56	GroundAirContent	3	C
57	GroundOxygenConcentration	3	K
58	GroundBufferingCapacity	3	K
...	...	...	...

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Defining All Assets

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Using Asset Property and Asset Process,
we defined all Assets:

- Ground
- Road
- Buried asset (restricted to water pipes only)

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Defining Dependencies

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
3	RoadProperty	Priority/Importance	***RoadSurfaceProperty***	RoadLocation	RoadGeometry	RoadLength	RoadWidth	RoadSurfaceType	RoadSurfaceMaterialType	RoadRutDepth	RoadSurfaceDeflectedShape	RoadDeflection	RoadRoughness	RoadTextureDepth	RoadTexture	RoadProfileUnevenness	RoadProfileEvenness	RoadSurfaceStrength	RoadSurfaceDensity	RoadSurfaceThickness	RoadSkiddingResistance	RoadSurfaceStiffness
4	***RoadSurfaceProperty***																					
5	RoadLocation				N	N	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N	N	N	Y	N
6	RoadGeometry	Geometry and Type (Key parameters that are necessary to locate the road and type of road)		N		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
7	RoadLength			N	N		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
8	RoadWidth			N	N	N		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
9	RoadSurfaceType			N	N	N	N		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10	RoadSurfaceMaterialType			N	N	N	N	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11	RoadRutDepth	Surface geometry (Critically important because this is what affects the user's view of the quality of the road; and in the case of utility repairs, is governed by law. Should be used as the criteria to assess the effect the performance of a road. It should be possible to refine the list and remove some of these criteria)		N	N	N	N	N	N		Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	N
12	RoadSurfaceDeflectedShape			N	N	N	N	N	N	Y		Y	Y	Y	Y	Y	Y	N	N	N	Y	N
13	RoadDeflection			N	N	N	N	N	N	N	Y		Y	Y	Y	Y	Y	N	N	N	Y	N
14	RoadRoughness			N	N	N	N	N	N	N	Y	Y		N	N	N	N	N	N	N	N	N
15	RoadTextureDepth			N	N	N	N	N	N	N	Y	Y	Y		N	Y	Y	N	N	N	Y	N
16	RoadTexture			N	N	N	N	N	N	N	Y	Y	Y	N		Y	Y	N	N	N	Y	N
17	RoadProfileUnevenness			N	N	N	N	N	N	N	N	N	Y	Y	Y		Y	N	N	N	Y	N
18	RoadProfileEvenness			N	N	N	N	N	N	N	N	N	Y	Y	Y	Y		N	N	N	Y	N
19	RoadSurfaceStrength			N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y		N	N	Y	N
20	RoadSurfaceDensity	Surfacing properties (These are critical from a safety point of view and to prevent surface deformation)		N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y		N	Y	Y
21	RoadSurfaceThickness			N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		N	N
22	RoadSkiddingResistance			N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		N
23	RoadSurfaceStiffness			N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	
24	***RoadBinderProperty***																					
25	RoadBinderMaterialType	Classification properties (Specification to achieve required composition and properties)		N	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
26	RoadBinderParticleSizeDistribution			N	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
27	RoadBinderVoidContent			N	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y
28	RoadBinderThickness			N	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y
29	RoadBinderDensity			N	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y
30	RoadBinderStiffness	Mechanical properties (govern performance of road)		N	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y
31	RoadBinderStrength			N	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y
32	***RoadBaseProperty***																					
33	RoadBaseMaterialType	Classification properties (Specification to achieve required composition and properties)		N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
34	RoadBaseParticleSizeDistribution			N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
35	RoadBaseVoidContent			N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
36	RoadBaseWaterContent			N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N

	A	W	X	Y	Z	AA	AB	AC	AD
3	RoadProperty	***RoadBinderProperty***	RoadBinderMaterialType	RoadBinderParticleSizeDistribution	RoadBinderVoidContent	RoadBinderThickness	RoadBinderDensity	RoadBinderStiffness	RoadBinderStrength
4	***RoadSurfaceProperty***								
5	RoadLocation		N	N	N	N	N	N	N
6	RoadGeometry		N	N	N	N	N	N	N
7	RoadLength		N	N	N	N	N	N	N
8	RoadWidth		N	N	N	N	N	N	N
9	RoadSurfaceType		Y	Y	Y	Y	Y	Y	Y
10	RoadSurfaceMaterialType		N	N	N	N	N	N	N
11	RoadRutDepth		N	N	N	N	N	N	N
12	RoadSurfaceDeflectedShape		N	N	N	N	N	N	N
13	RoadDeflection		N	N	N	N	N	N	N
14	RoadRoughness		N	N	N	N	N	N	N
15	RoadTextureDepth		N	N	N	N	N	N	N
16	RoadTexture		N	N	N	N	N	N	N
17	RoadProfileUnevenness		N	N	N	N	N	N	N
18	RoadProfileEvenness		N	N	N	N	N	N	N
19	RoadSurfaceStrength		N	N	N	N	N	N	N
20	RoadSurfaceDensity		N	N	N	N	N	N	N
21	RoadSurfaceThickness		N	N	N	N	N	N	N
22	RoadSkiddingResistance		N	N	N	N	N	N	N
23	RoadSurfaceStiffness		N	N	N	N	N	N	N
24	***RoadBinderProperty***								
25	RoadBinderMaterialType			Y	Y	Y	Y	Y	Y
26	RoadBinderParticleSizeDistribution		N		Y	N	Y	Y	Y
27	RoadBinderVoidContent		N	N		N	Y	Y	Y
28	RoadBinderThickness		N	N	N		N	Y	Y
29	RoadBinderDensity		N	N	N	N		Y	Y
30	RoadBinderStiffness		N	N	N	N	N		N
31	RoadBinderStrength		N	N	N	N	N	N	
32	***RoadBaseProperty***								
33	RoadBaseMaterialType		N	N	N	N	N	N	N
34	RoadBaseParticleSizeDistribution		N	N	N	N	N	N	N
35	RoadBaseVoidContent		N	N	N	N	N	N	N
36	RoadBaseWaterContent		N	N	N	N	N	N	N

	A	AE	AF	AG	AH	AI	AJ	AK	AL	AM
3	RoadProperty	***RoadBaseProperty***	RoadBaseMaterialType	RoadBaseParticleSizeDistribution	RoadBaseVoidContent	RoadBaseWaterContent	RoadBaseThickness	RoadBaseDensity	RoadBaseStiffness	RoadBaseStrength
4	***RoadSurfaceProperty***									
5	RoadLocation		N	N	N	Y	N	N	N	N
6	RoadGeometry		N	N	N	N	N	N	N	N
7	RoadLength		N	N	N	N	N	N	N	N
8	RoadWidth		N	N	N	N	N	N	N	N
9	RoadSurfaceType		N	N	N	N	N	N	N	N
10	RoadSurfaceMaterialType		N	N	N	Y	N	N	N	N
11	RoadRutDepth		N	N	N	N	N	N	N	N
12	RoadSurfaceDeflectedShape		N	N	N	N	N	N	N	N
13	RoadDeflection		N	N	N	N	N	N	N	N
14	RoadRoughness		N	N	N	N	N	N	N	N
15	RoadTextureDepth		N	N	N	N	N	N	N	N
16	RoadTexture		N	N	N	N	N	N	N	N
17	RoadProfileUnevenness		N	N	N	N	N	N	N	N
18	RoadProfileEvenness		N	N	N	N	N	N	N	N
19	RoadSurfaceStrength		N	N	N	N	N	N	N	N
20	RoadSurfaceDensity		N	N	N	N	N	N	N	N
21	RoadSurfaceThickness		N	N	N	N	N	N	N	N
22	RoadSkiddingResistance		N	N	N	N	N	N	N	N
23	RoadSurfaceStiffness		N	N	N	N	N	N	N	N
24	***RoadBinderProperty***									
25	RoadBinderMaterialType		N	N	N	N	N	N	N	N
26	RoadBinderParticleSizeDistribution		N	N	N	N	N	N	N	N
27	RoadBinderVoidContent		N	N	N	N	N	N	N	N
28	RoadBinderThickness		N	N	N	N	N	N	N	N
29	RoadBinderDensity		N	N	N	N	N	N	N	N
30	RoadBinderStiffness		N	N	N	N	N	N	N	N
31	RoadBinderStrength		N	N	N	N	N	N	N	N
32	***RoadBaseProperty***									
33	RoadBaseMaterialType			Y	Y	N	N	Y	Y	Y
34	RoadBaseParticleSizeDistribution		N		N	N	N	Y	Y	Y
35	RoadBaseVoidContent		N	N		Y	N	Y	Y	Y
36	RoadBaseWaterContent		N	N	N		N	Y	Y	Y

	A	AN	AO	AP	AQ	AR	AS	AT	AU	AV
3	RoadProperty	***RoadSubBaseProperty***	RoadSubBaseMaterialType	RoadSubBaseParticleSizeDistribution	RoadSubBaseVoidContent	RoadSubBaseWaterContent	RoadSubBaseThickness	RoadSubBaseDensity	RoadSubBaseStiffness	RoadSubBaseStrength
4	***RoadSurfaceProperty***									
5	RoadLocation		N	N	N	N	N	N	N	N
6	RoadGeometry		N	N	N	N	N	N	N	N
7	RoadLength		N	N	N	N	N	N	N	N
8	RoadWidth		N	N	N	N	N	N	N	N
9	RoadSurfaceType		N	N	N	N	N	N	N	N
10	RoadSurfaceMaterialType		N	N	N	N	N	N	N	N
11	RoadRutDepth		N	N	N	N	N	N	N	N
12	RoadSurfaceDeflectedShape		N	N	N	N	N	N	N	N
13	RoadDeflection		N	N	N	N	N	N	N	N
14	RoadRoughness		N	N	N	N	N	N	N	N
15	RoadTextureDepth		N	N	N	N	N	N	N	N
16	RoadTexture		N	N	N	N	N	N	N	N
17	RoadProfileUnevenness		N	N	N	N	N	N	N	N
18	RoadProfileEvenness		N	N	N	N	N	N	N	N
19	RoadSurfaceStrength		N	N	N	N	N	N	N	N
20	RoadSurfaceDensity		N	N	N	N	N	N	N	N
21	RoadSurfaceThickness		N	N	N	N	N	N	N	N
22	RoadSkiddingResistance		N	N	N	N	N	N	N	N
23	RoadSurfaceStiffness		N	N	N	N	N	N	N	N
24	***RoadBinderProperty***									
25	RoadBinderMaterialType		N	N	N	N	N	N	N	N
26	RoadBinderParticleSizeDistribution		N	N	N	N	N	N	N	N
27	RoadBinderVoidContent		N	N	N	N	N	N	N	N
28	RoadBinderThickness		N	N	N	N	N	N	N	N
29	RoadBinderDensity		N	N	N	N	N	N	N	N
30	RoadBinderStiffness		N	N	N	N	N	N	N	N
31	RoadBinderStrength		N	N	N	N	N	N	N	N
32	***RoadBaseProperty***									
33	RoadBaseMaterialType		N	N	N	N	N	N	N	N
34	RoadBaseParticleSizeDistribution		N	N	N	N	N	N	N	N
35	RoadBaseVoidContent		N	N	N	N	N	N	N	N
36	RoadBaseWaterContent		N	N	N	N	N	N	N	N

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Defining Dependencies

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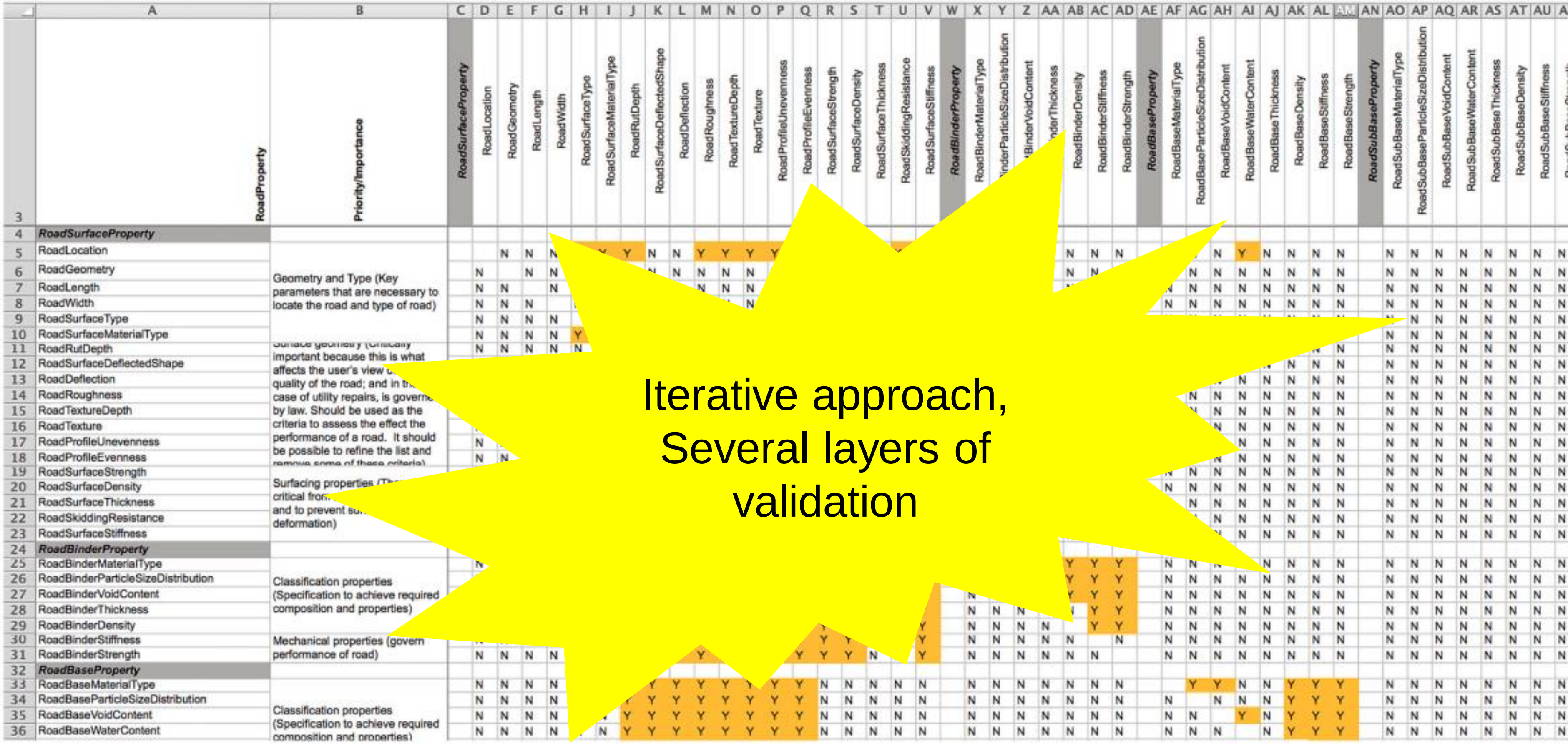

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Defining Human Activity and Environment

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- Utilised concepts from SWEET

Semantic Web for Earth and Environment Technology Ontology

Last uploaded: July 14, 2022

Summary | Classes | Properties | Notes | Mappings | Widgets

Details

Acronym	SWEET
Visibility	Public
Description	The Semantic Web for Earth and Environmental Terminology is a mature foundational ontology that contains over 6000 concepts organized in 200 ontologies represented in OWL. Top level concepts include Representation (math, space, science, time, data), Realm (Ocean, Land Surface, Terrestrial Hydroshere, Atmosphere, etc.), Phenomena (macro-scale ecological and physical), Processes (micro-scale physical, biological, chemical, and mathematical), Human Activities (Decision, Commerce, Jurisdiction, Environmental, Research). Originally developed by NASA Jet Propulsion Labs under Rob Raskin, SWEET is now officially under the governance of the ESIP foundation.
Status	Production
Format	OWL
Contact	ESIP Semantic Team, esip-semanticweb@lists.esipfed.org.

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Overview of the ATU Ontology

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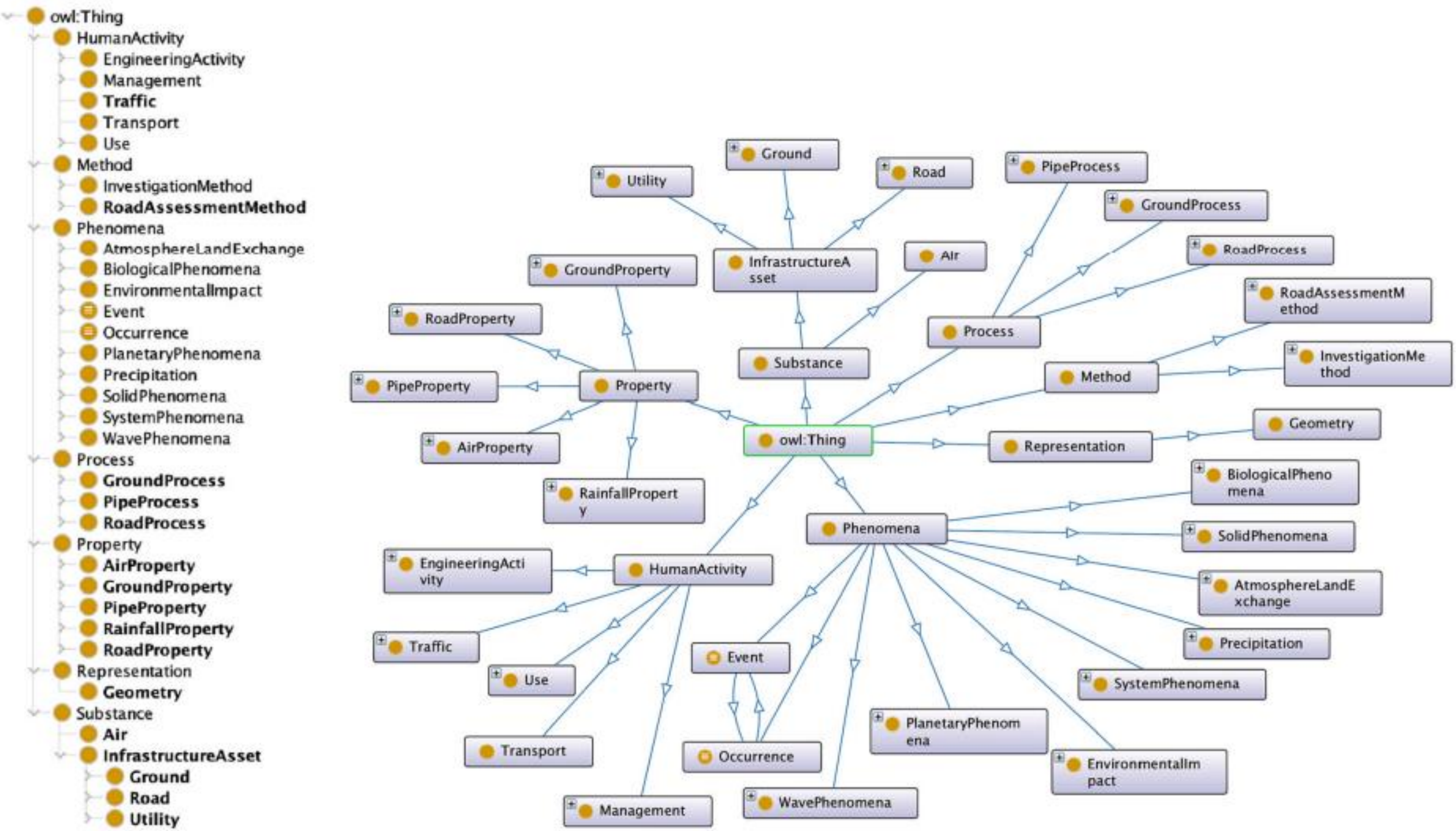

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Overview of the ATU Ontology

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	Classes	Axioms
Ground Ontology	110	3,337
Road Ontology	110	4,545
Water Pipe Ontology	66	894
Human Activity Ontology	55	140
Method Ontology	78	269
Investigation Ontology	45	183
Phenomena Ontology	178	382
ATU Ontology	620	10,117

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Lessons Learnt from Ontology Development

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Stakeholders (engineers in our case) bring a wealth of domain knowledge – **tacit knowledge**

Keep it simple and agree on the core concepts – e.g. **properties and processes**

Spreadsheets seen as a ‘natural’ way to define concepts and dependencies – **iterative approach**

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Lessons Learnt from Ontology Development

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Stakeholders (engineers in our case) bring a wealth of domain knowledge – **tacit knowledge**

Keep it simple and agree on the core concepts – e.g. **properties and processes**

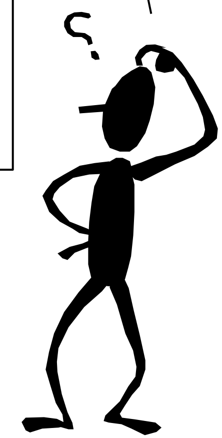
Spreadsheets seen as a ‘natural’ way to define concepts and dependencies – **iterative approach**

Expert availability – **think broadly and creatively**

Extendibility is crucial – **embed in design**

Slow process, experts often lost in detail or changing their opinions – **patience**

Tacit knowledge is hard to articulate– **link to data**



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System Architecture

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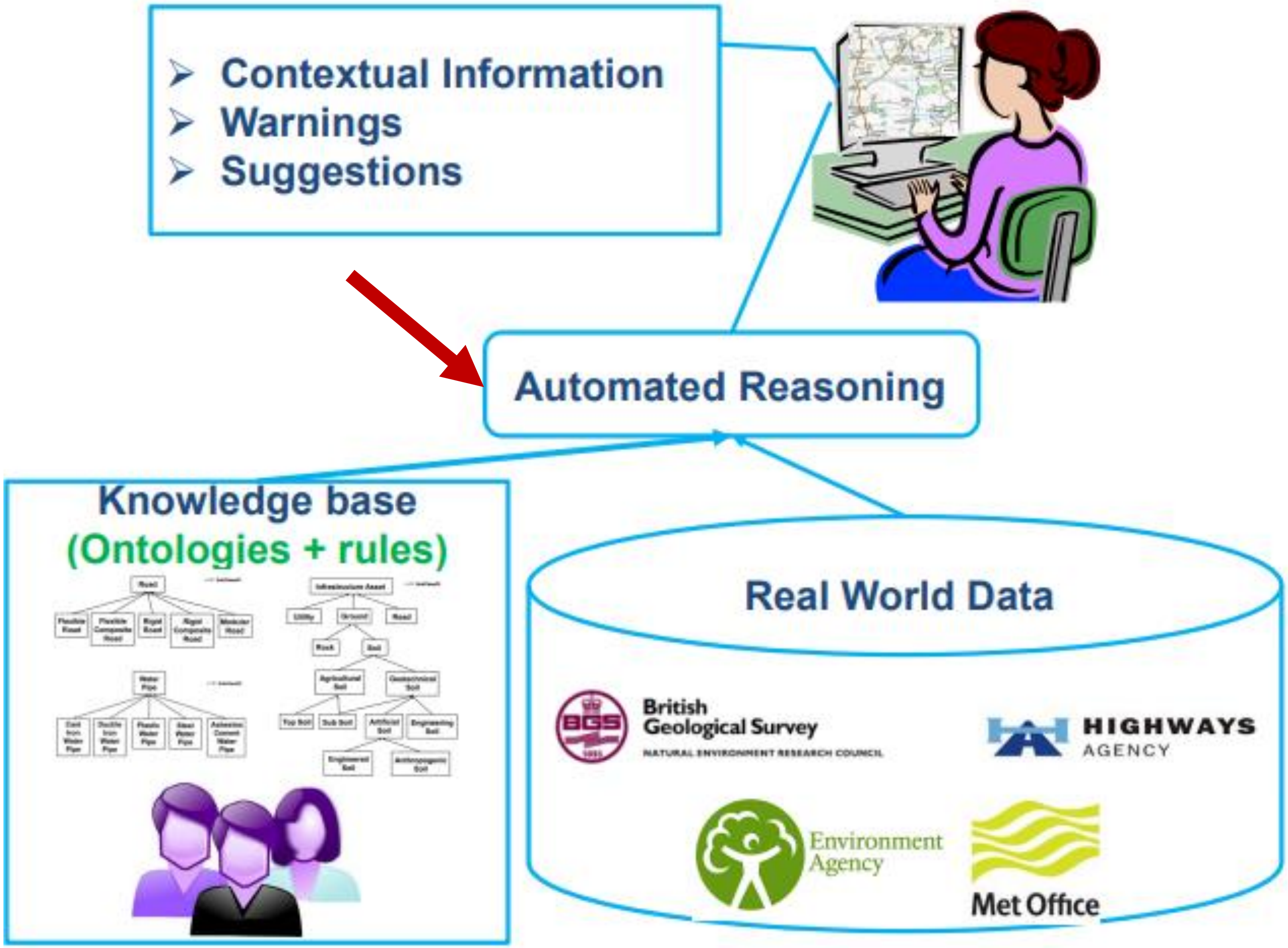

Starting from Triggers and Deriving Consequences

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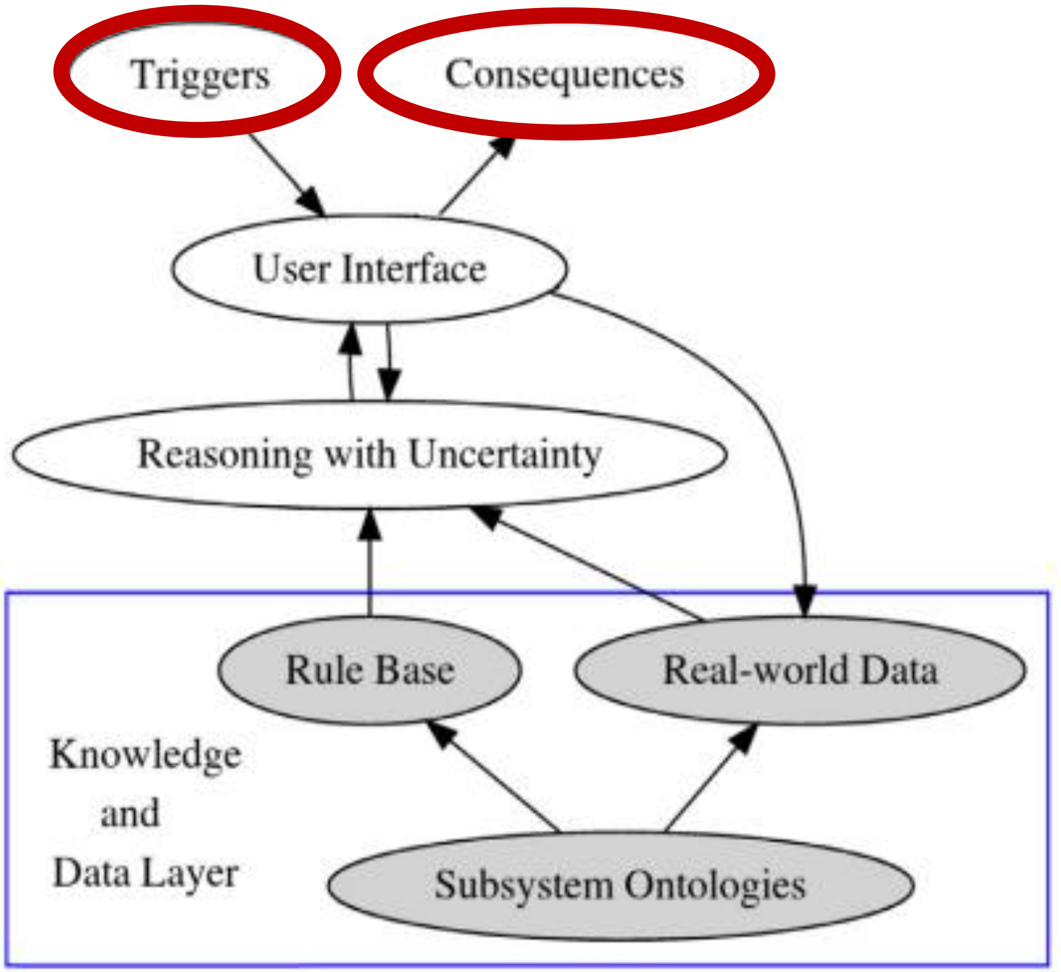

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Starting from Triggers and Deriving Consequences

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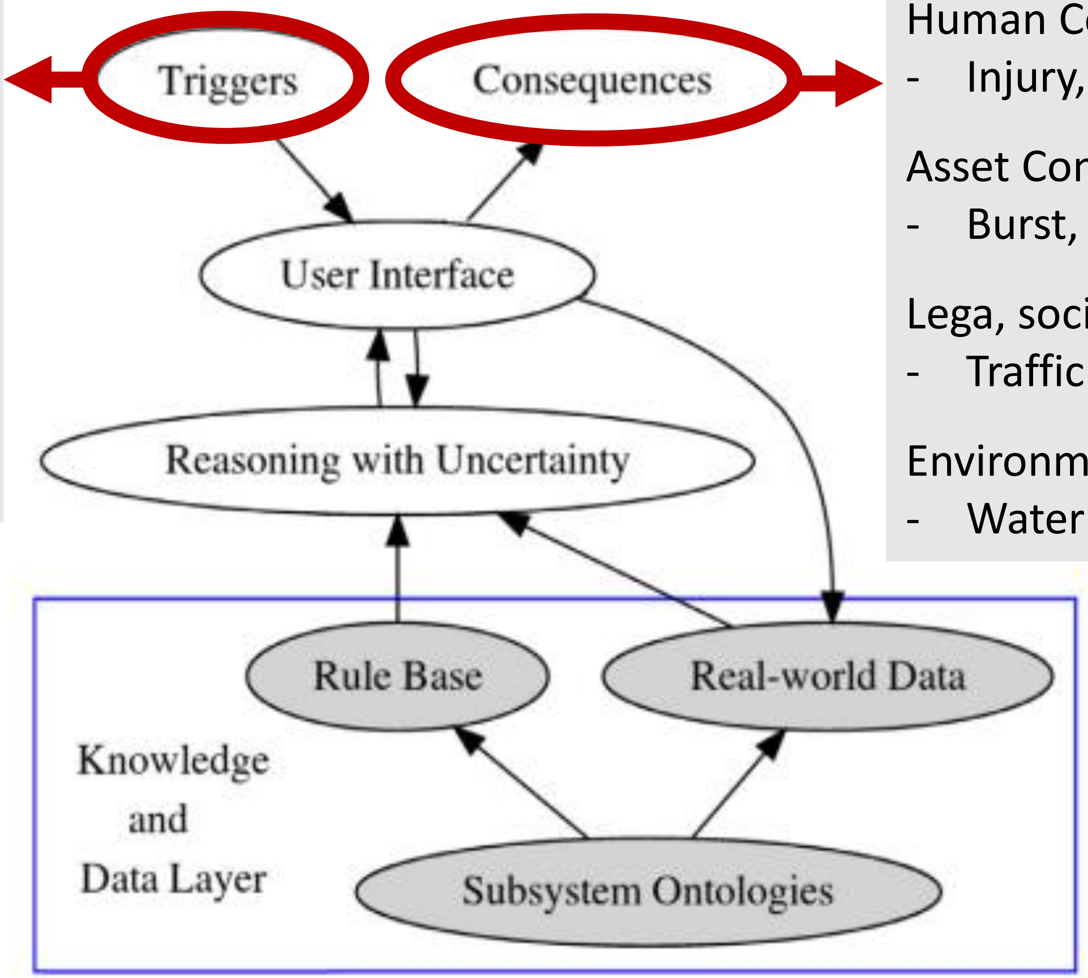
Human Activity
- Traffic
- Roadworks
- ….

Phenomena
- Flood
- Drought
- ….



Human Consequences
- Injury, Cost, …

Asset Consequences
- Burst, collapse, …

Lega, social, economical
- Traffic disruption, …

Environmental Consequences
- Water pollution, …

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Integrating in the Decision Support System

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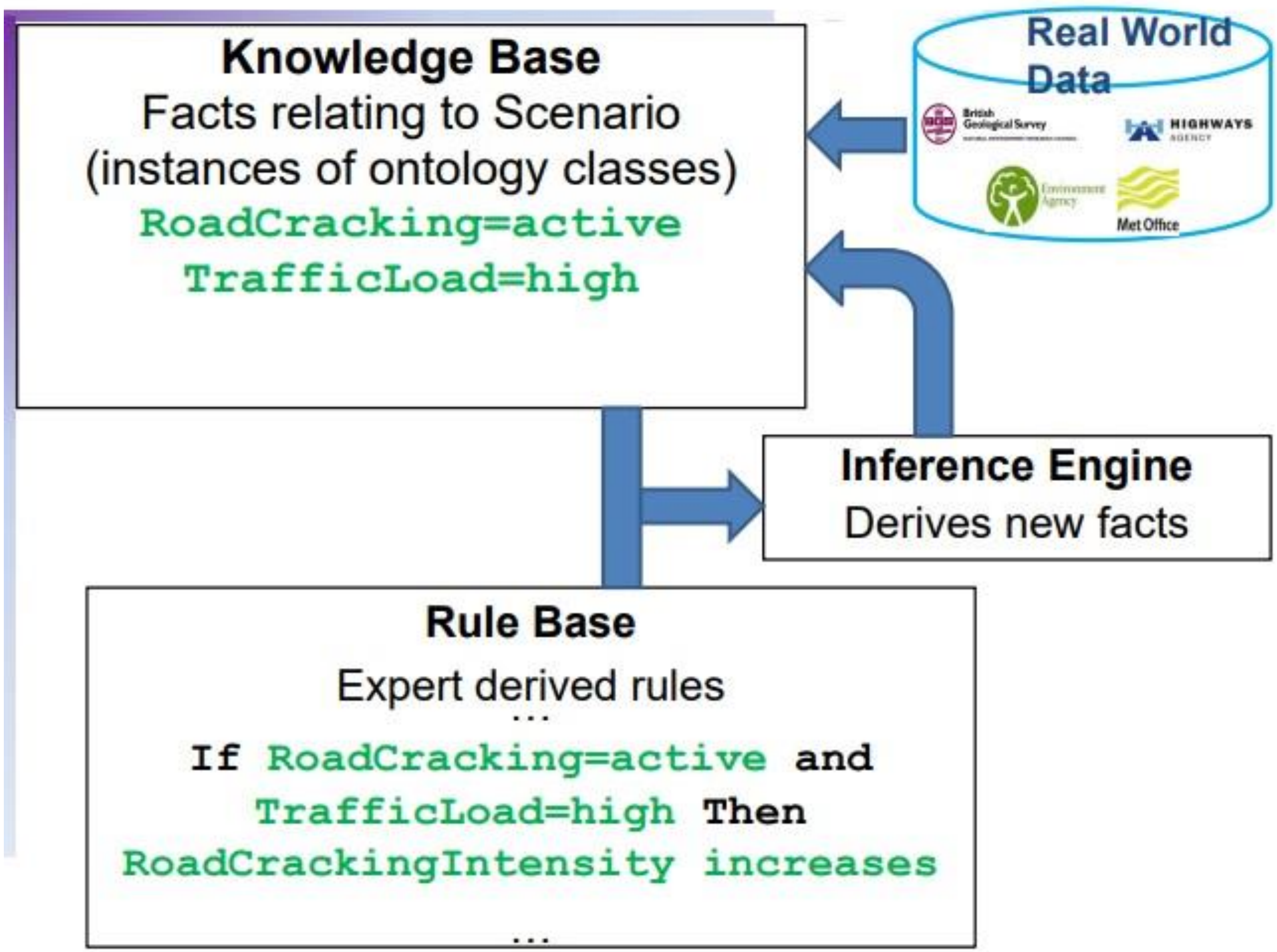

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Defining Rules

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Conclusions of many rules are only (very) likely rather than definite.

```
If      Pipe Leak is small
then [Very Likely]
        Soil Wetting increased
```

How to represent likelihoods?

- Unable to obtain quantitative probabilities (e.g. 0.9)
- Preferred linguistic terms:

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Confidence level	Definition
Definite (D)	100% sure that E will happen
Very likely (V)	not 100% but only rarely will E not happen
Likely (L)	E happens more than 50% of the time but it is not surprising if E does not happen
Unlikely (U)	E happens less than 50% of the time but it is not surprising if E happens
Very unlikely (VU)	not 0% chance of E happening but it will happen rarely
Impossible (I)	E never happens

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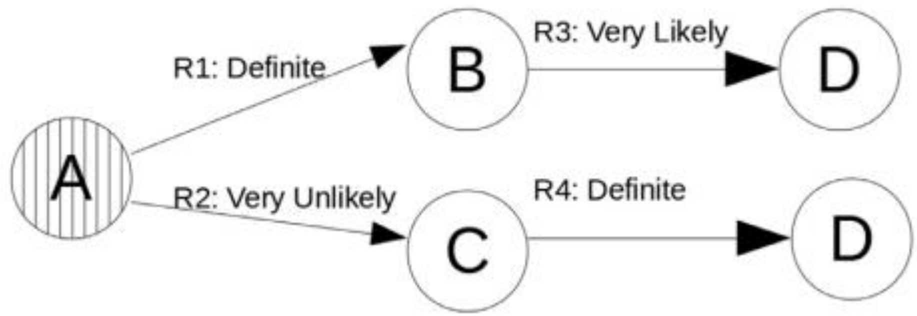

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Example:
Inferred Consequences

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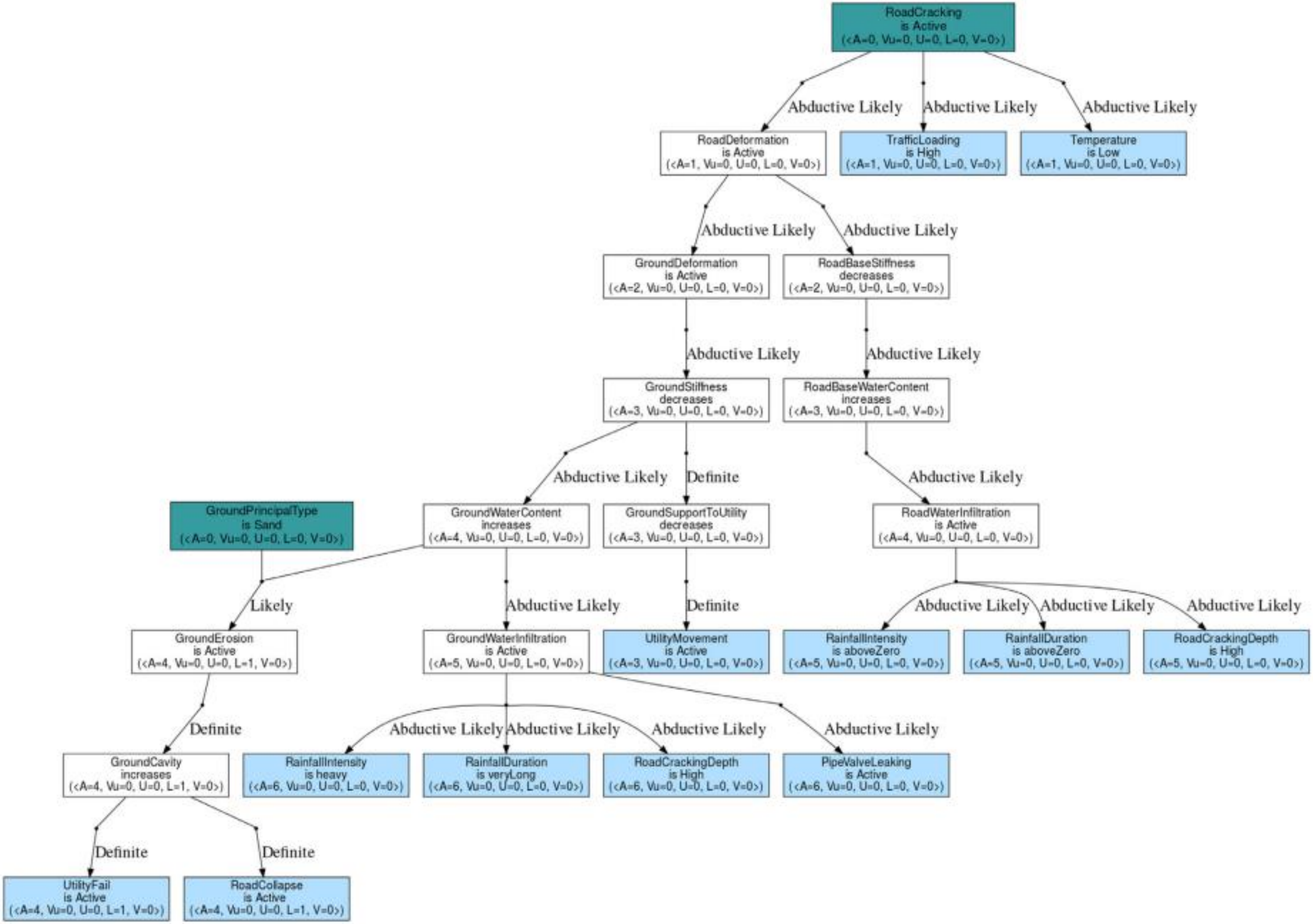

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Putting it all Together: ATU Decision Support System

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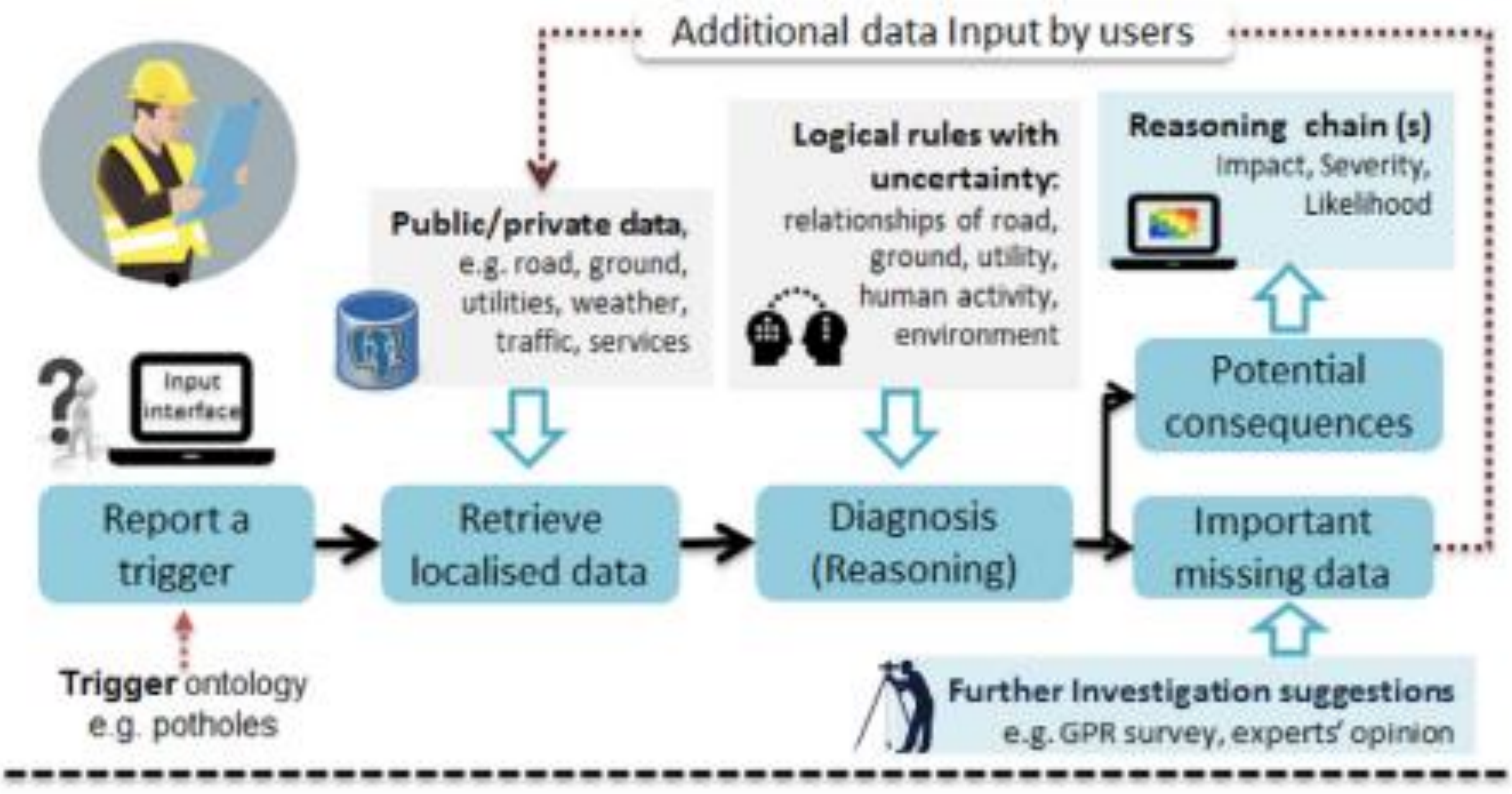

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ATU Decision Support System: The User Reports a Trigger

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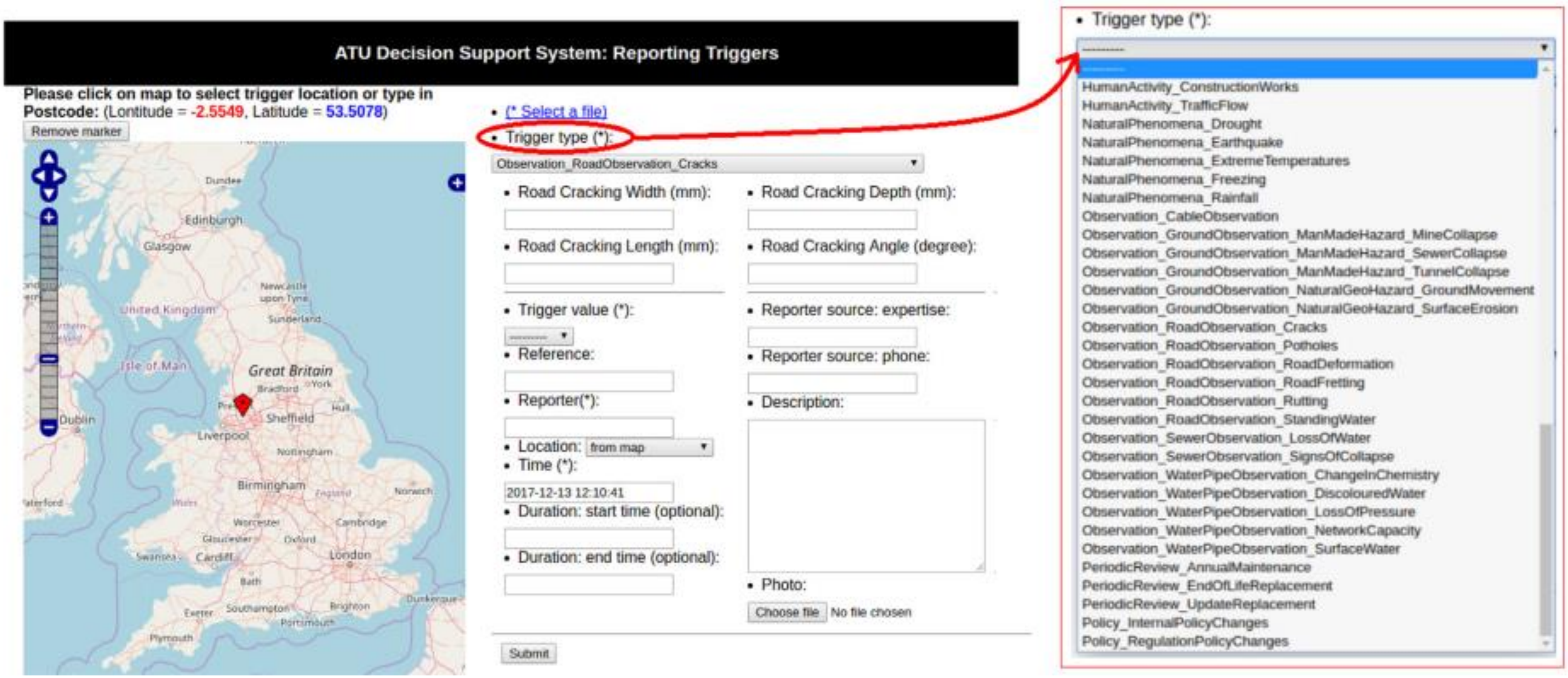

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ATU Decision Support System: Underground Utilities Detected

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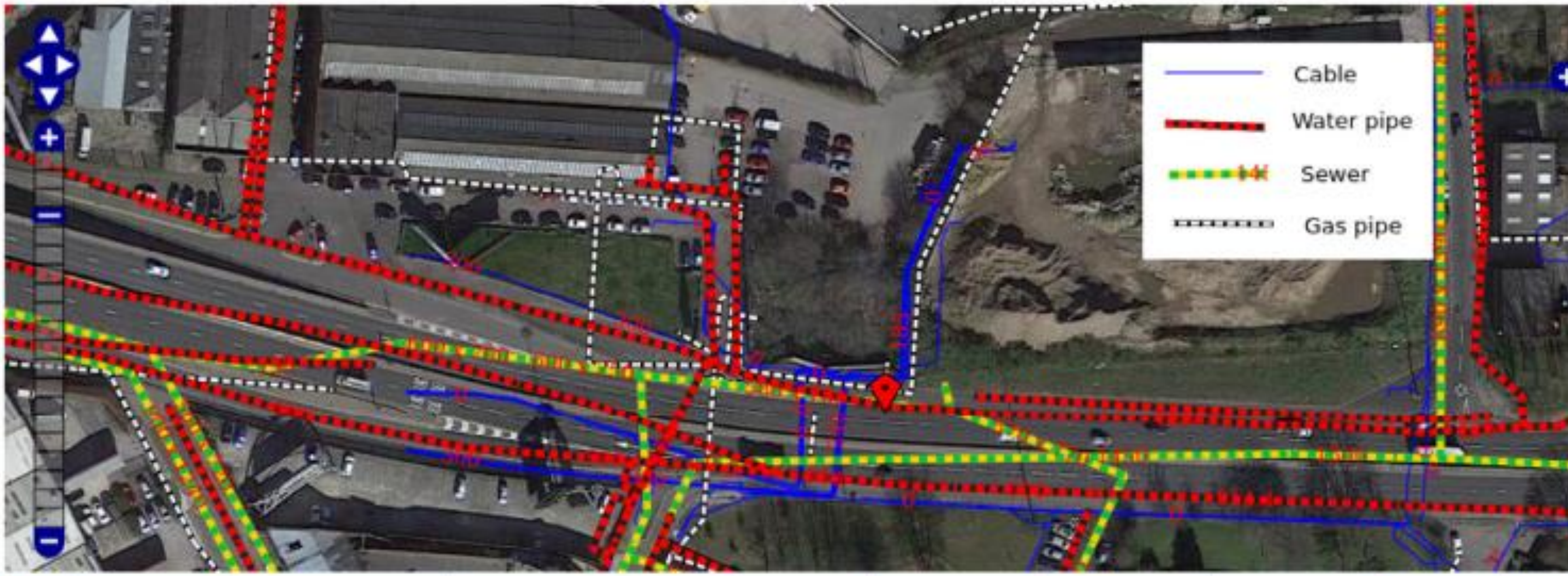

Id	Utility type	Sub Type	State	Date Installed	Owner	Material	Voltage / Pressure	Depth (Mm)	Source	Size (
203	water pipe	Distribution Main - PressurisedMain	operation	1997	united utilities	Polyethylene	—	—	desktop-survey	900
192	water pipe	Distribution Main - PressurisedMain	operation	1932	united utilities	cast iron	—	—	desktop-survey	101.6

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ATU Decision Support System: Nearby Services Detected

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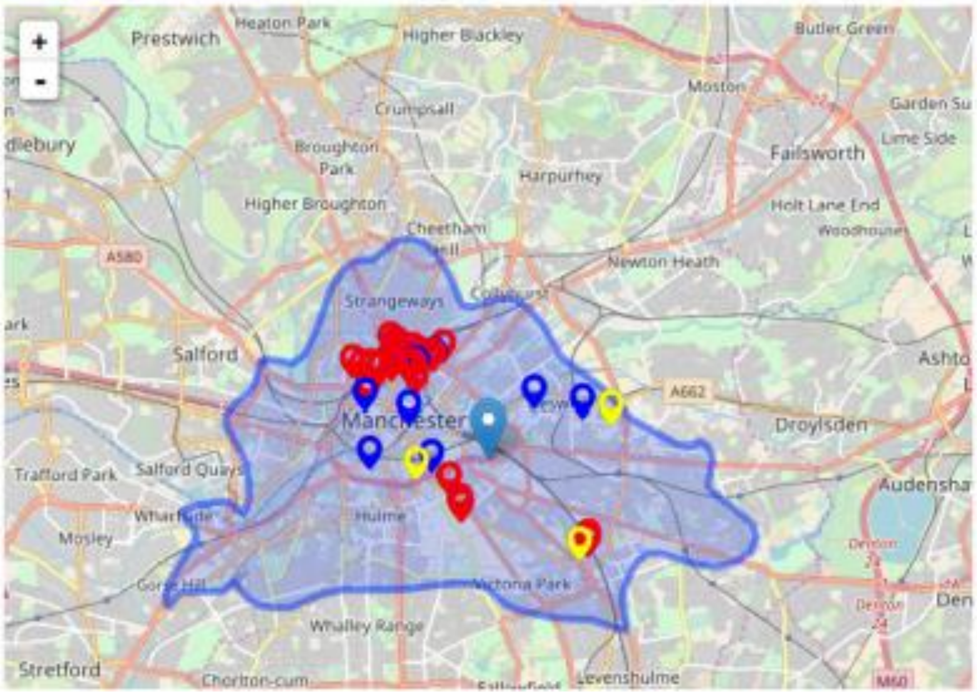
> Nearby services:

The blue region indicates the area which can be accessed in 10 minutes by driving from the trigger. The nearby services within 2km are displayed by coloured marks. Red marks: bank; Yellow marks: hospital; Blue marks: schools.



> There are 32 banks around the trigger, the area is close to city center.

- Direct distance: as the crow flies (straight line between two points);
- Routing distance: the shortest routing distance along road by driving.

ID	Service	Name	Direct_Distance (Km)	Routing Distance (Km)
10639	university	Manchester Business School	1.254	2.0916
10675	university	MMU 70 Oxford Street	1.6293	2.2092
10677	university	University of Law	1.59	2.2074
10652	school	—	1.2393	2.5913
10661	school	Instituto Cervantes	2.6441	3.2483
10649	school	Berlitz Language Centre	1.3161	1.9325
10651	school	—	2.3197	3.2785
10660	kindergarten	—	2.5618	2.9568
10641	hospital	Cornerstone Centre	2.9858	3.9
10638	hospital	Boundary Medical Centre	1.5953	2.0113

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ATU Decision Support System: Potential Consequences

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localhost:8000/triggerowl/3/consequencelist/?sort=likelihood

You're looking at the Potential Consequence List view!

Q_PipeDepth: ☑ Deep ☑ Shallow | **Q_RoadSlope:** ☑ High ☑ Medium ☑ Slight | **Q_Subgrade:** ☑ Clay ☑ Sand ☑ SolubleRock | **Q_TrafficLoad:** ☑ Active | **Q_PipeLeaking:** ☑ Active | **Q_PipeLeakingRate:** ☑ Severe | **Q_RoadType:** ☑ A |

Version	Consequence	Confidence Vector	Severity	Likelihood	missingFacts	Given Missing Facts	Type
1	SolubleRockCavitiesFormation	<VU=00, U=00, L=00, V=00>	Critical	definite	1	['PipeLeaking Active', 'PipeLeakingRate Severe', 'Subgrade SolubleRock']	Ground
1	RoadCracking	<VU=00, U=00, L=01, V=02>	Critical	likely	1	['PipeLeaking Active', 'PipeLeakingRate Severe', 'TrafficLoad Active', 'Subgrade Sand']	Road
1	DamageToProperty	<VU=00, U=00, L=08, V=02>	Critical	likely	1	['PipeLeaking Active', 'PipeLeakingRate Severe', 'TrafficLoad Active', 'RoadType A', 'Subgrade SolubleRock']	Social/Economic
1	SuddenRoadCollapse	<VU=00, U=00, L=07, V=02>	Catastrophic	likely	1	['PipeLeaking Active', 'PipeLeakingRate Severe', 'TrafficLoad Active', 'Subgrade SolubleRock']	Road
1	LossOfUtilityService	<VU=00, U=00, L=01, V=03>	Critical	likely	1	['PipeLeaking Active', 'PipeLeakingRate Severe', 'TrafficLoad Active', 'Subgrade SolubleRock']	Social/Economic

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ATU Decision Support System: Consequences and Impact

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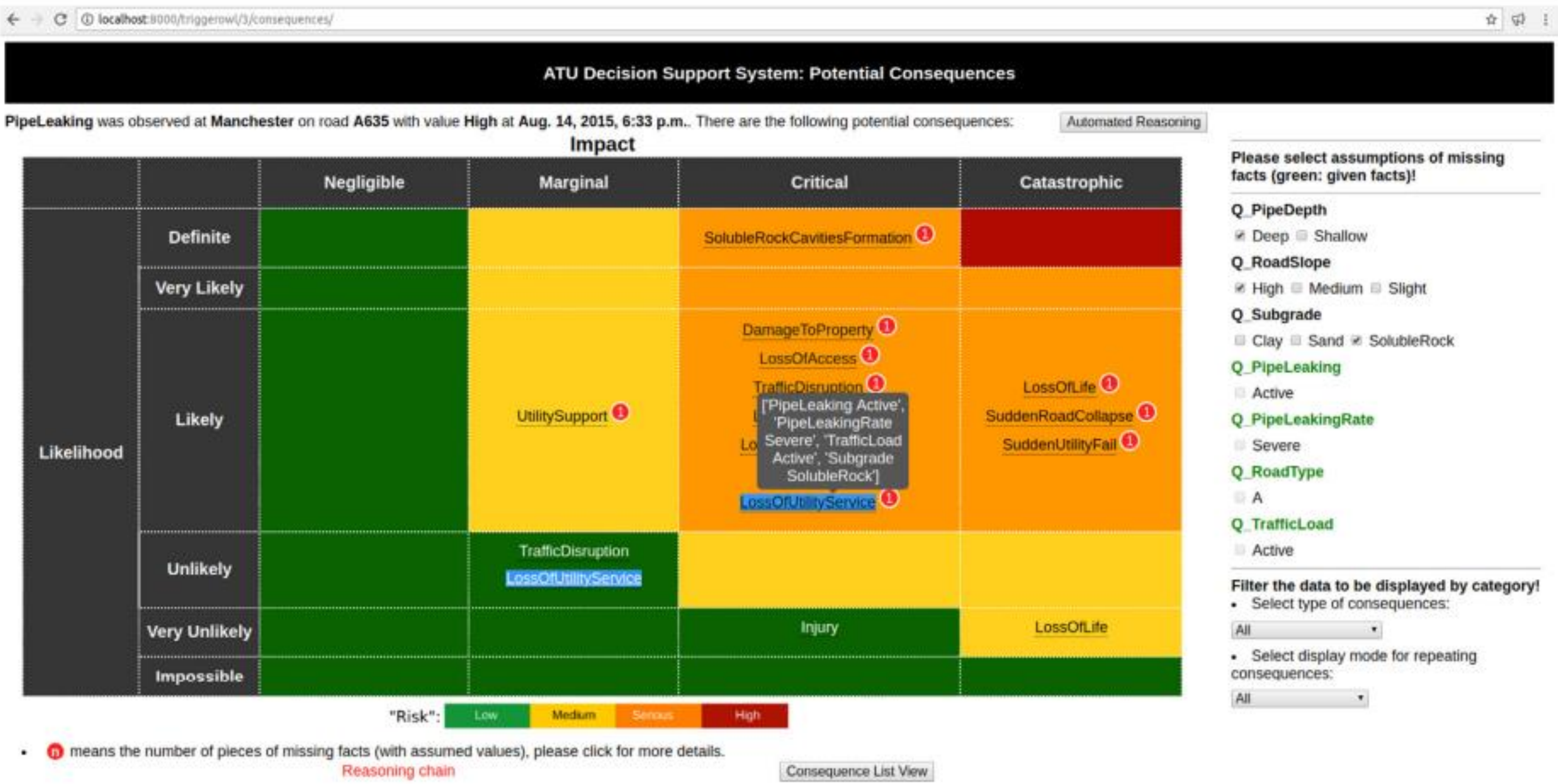

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Lessons Learnt from ATU System Development

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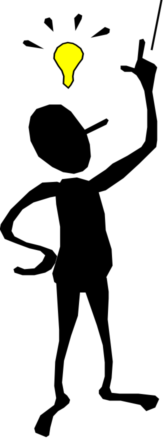
Scenarios illustrate Functionality and enable engagement – **prototype early**

Uncertainty is inevitable and stakeholders should understand – **intuitive approach**

There is plenty of available data – **location links data**



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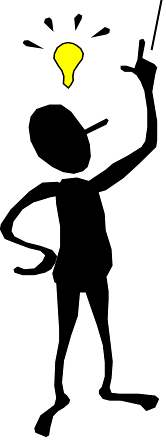
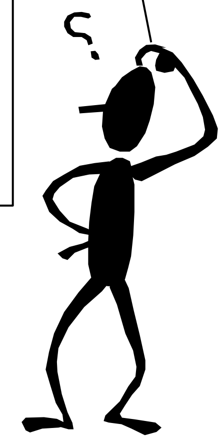


Uncertainty validation by humans is hard – **data-driven approach**

Understand what decisions are being made – **flexible / ‘open-minded’**

Many data would be unavailable – **creative ways to exploit ‘missing data’**



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Take Home Message:
Human-in-the-loop

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EU AI Act

- adequate risk assessment and mitigation
- appropriate human oversight
- traceability of results

Stakeholder engagement from the start

Holistic models – link knowledge and data

Use data to validate/tune knowledge models

Acknowledgements

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- University of Leeds
- University of Birmingham
- British Geological Survey
- Balfour Beatty PLC (UK)