

Complexity identification in major infrastructure project information systems using graph theory

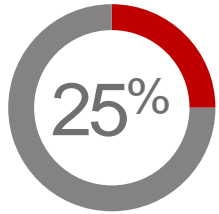
Pre-selecting the digitisation effort

Who am I?

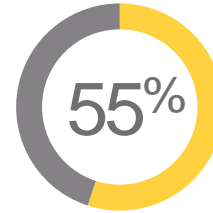
- Engineering Doctorate researcher
 - Loughborough University
 - High Speed 2 – Largest infrastructure project in Europe
- Civil Engineering undergraduate degree
- Passion – data driven design



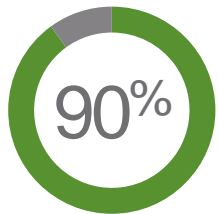
Need for change



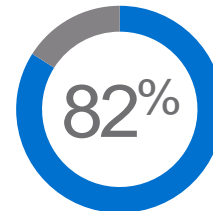
Deficit in infrastructure spend globally



Urbanisation globally



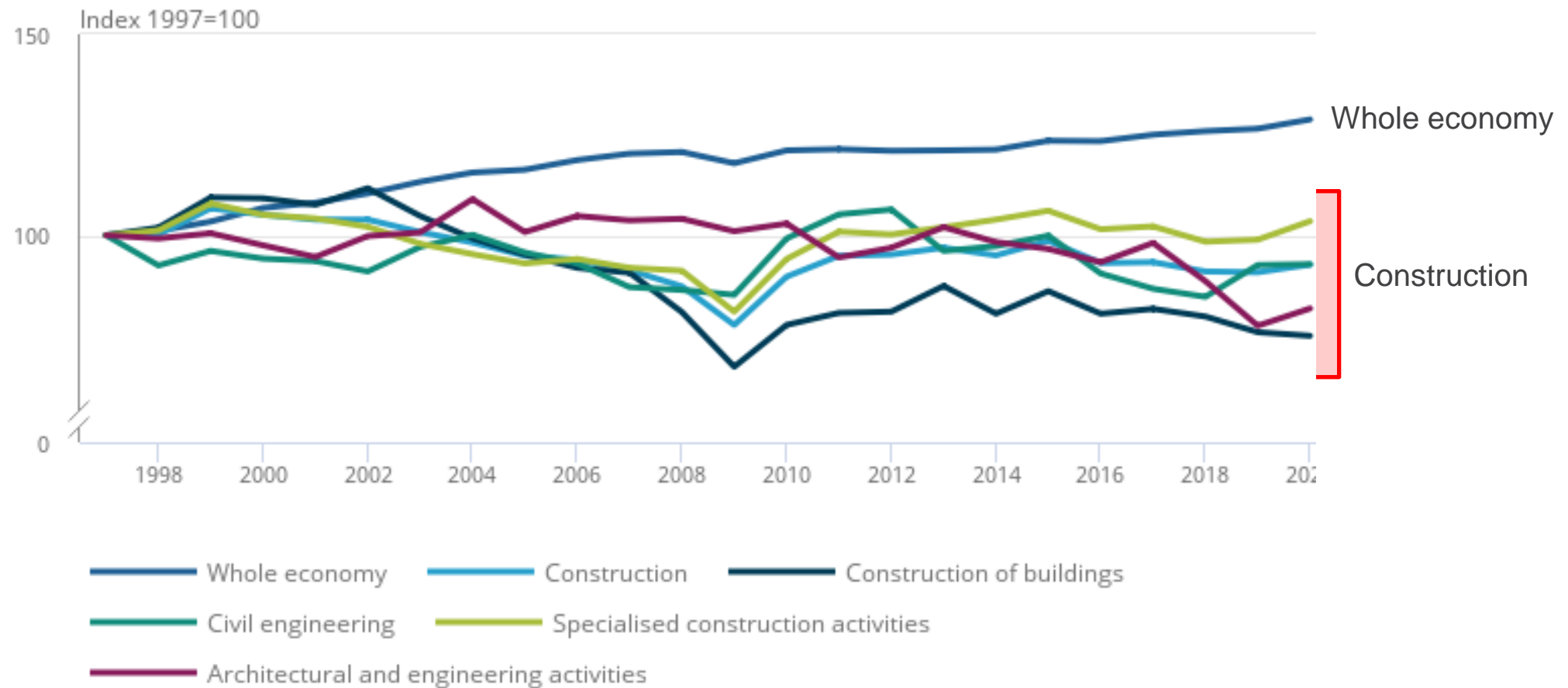
Cost overrun for transport infrastructure



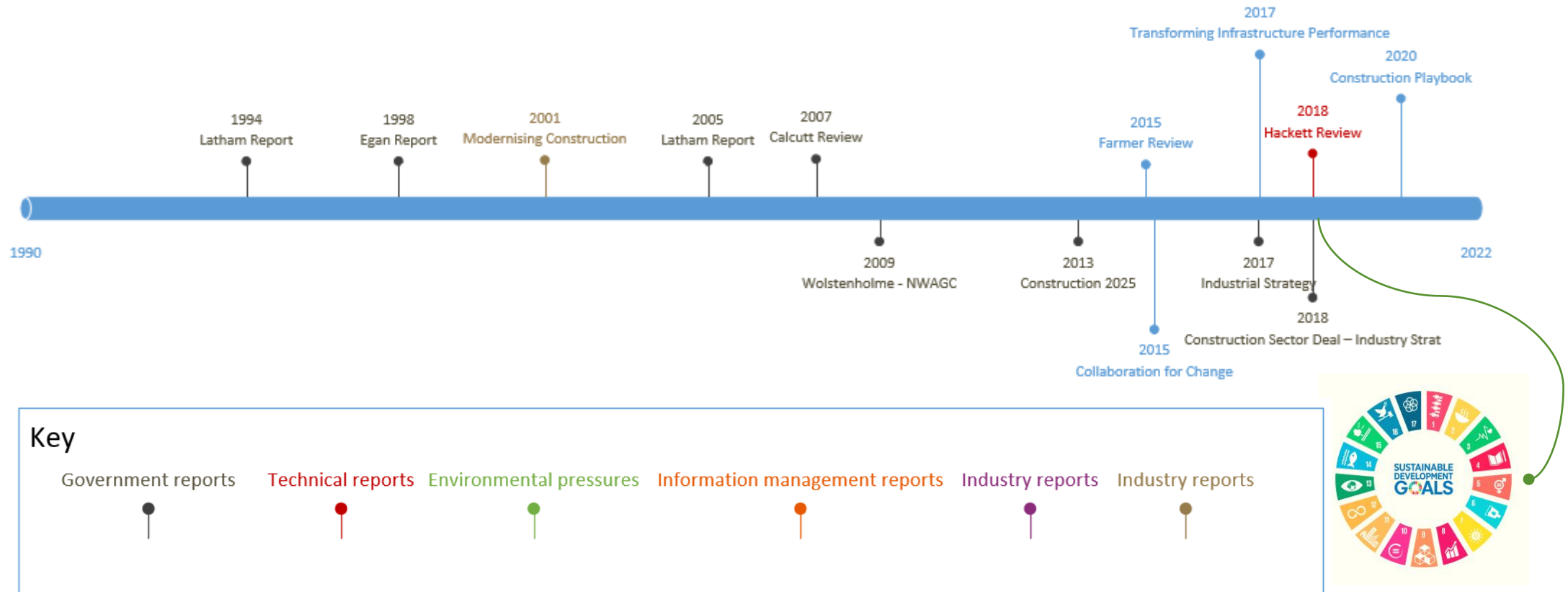
Urbanisation in the UK

Construction industry need

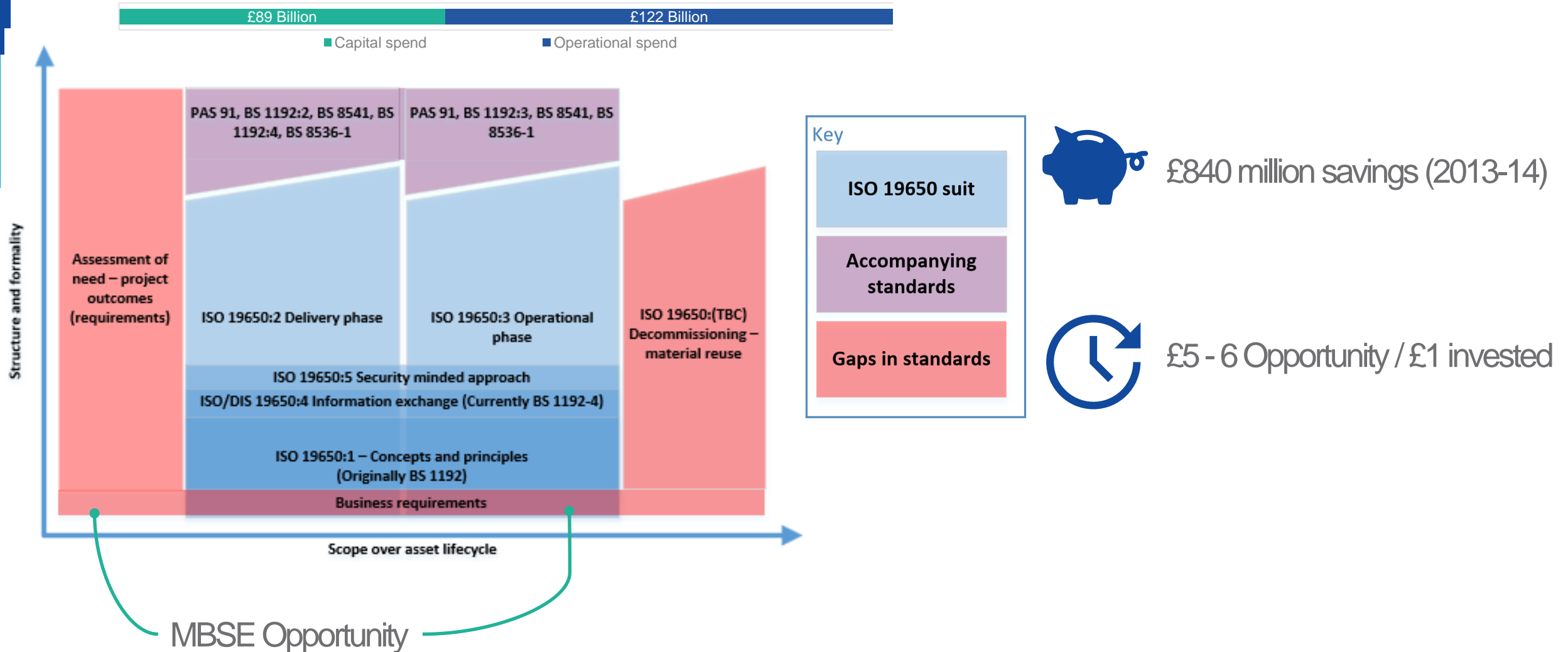
Output per hour worked, construction industry and sub-industries and whole economy, UK, 1997 to 2020, index 1997 = 100



Industry need for change



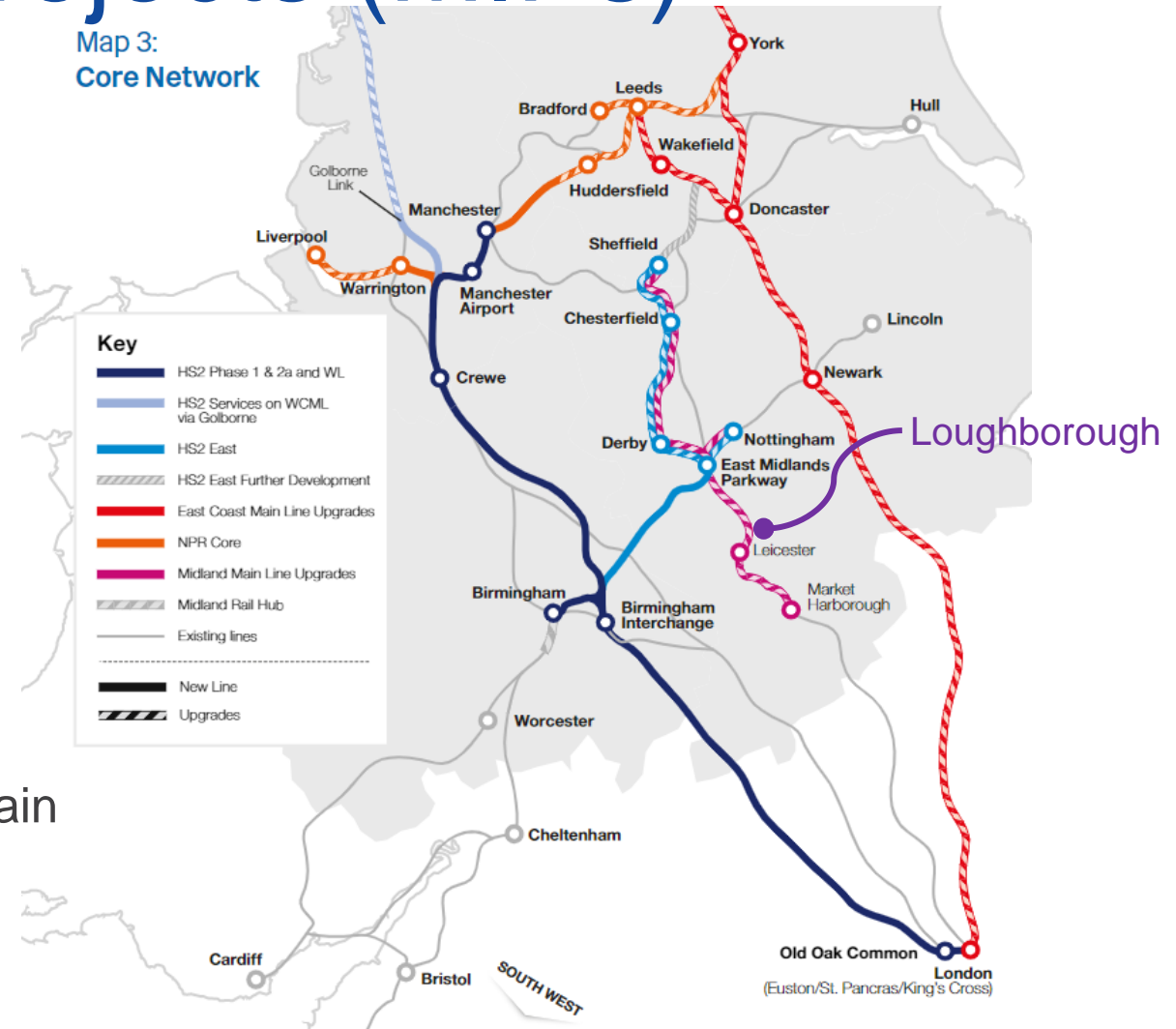
BIM! (Building Information Modelling)



Major infrastructure projects (MIPs)

Infrastructure complexity (HS2)

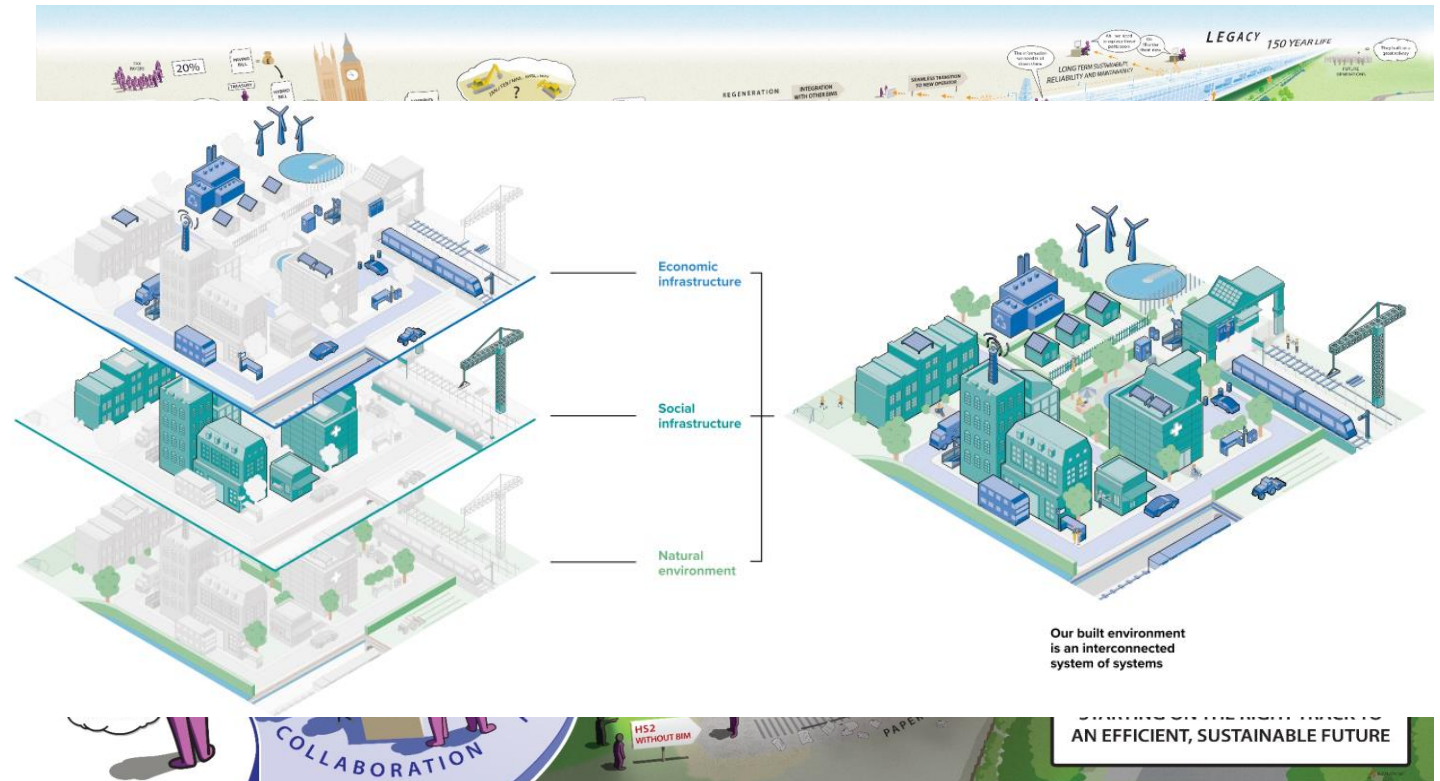
- £106Bn investment
 - largest infrastructure project in Europe
- Second UK High Speed Rail
 - 210 miles new HSR track + 7 cities
- Why
 - Capacity and Connectivity
- Multiple large contractors
 - 2,434 suppliers in a fragmented supply chain
 - 99% employ less than 49 people



Digital arena

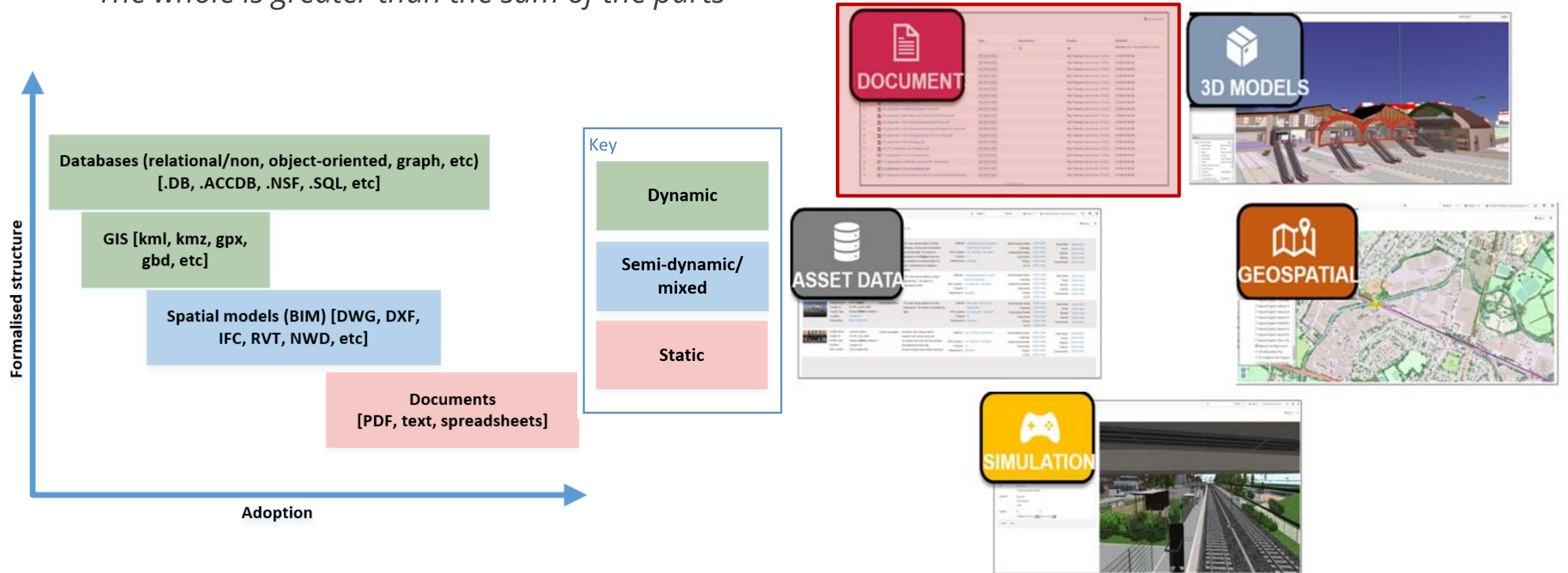
Digital context

- 1 000 000's documents and data points
- 1 500+ requirements
- Digital Twins aspiration



Integration of systems

"The whole is greater than the sum of the parts"



Where to begin?

Starting the journey



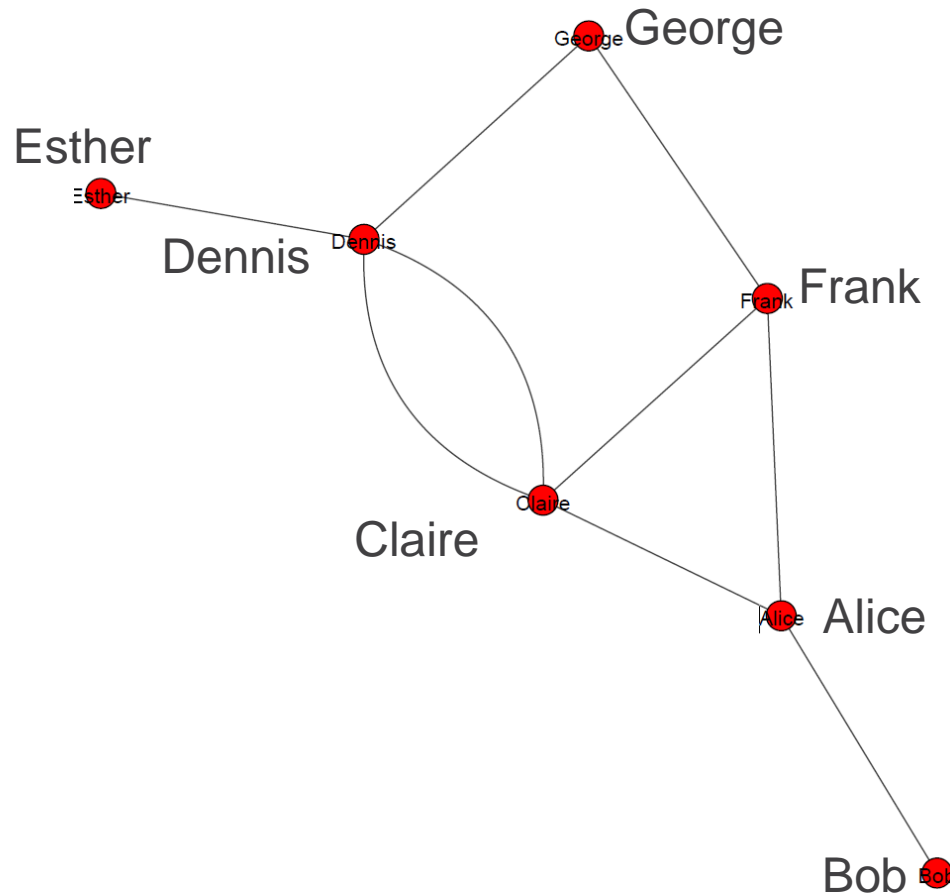
The opportunity (Finding the ring)





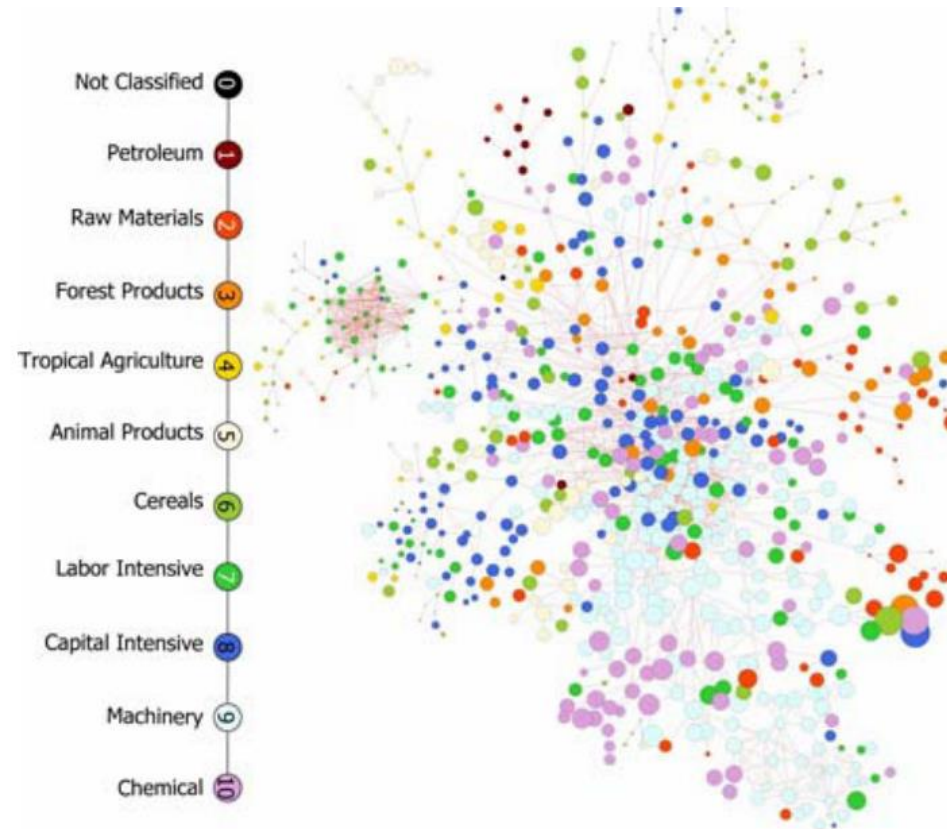
Graph theory example

Analysing relationships

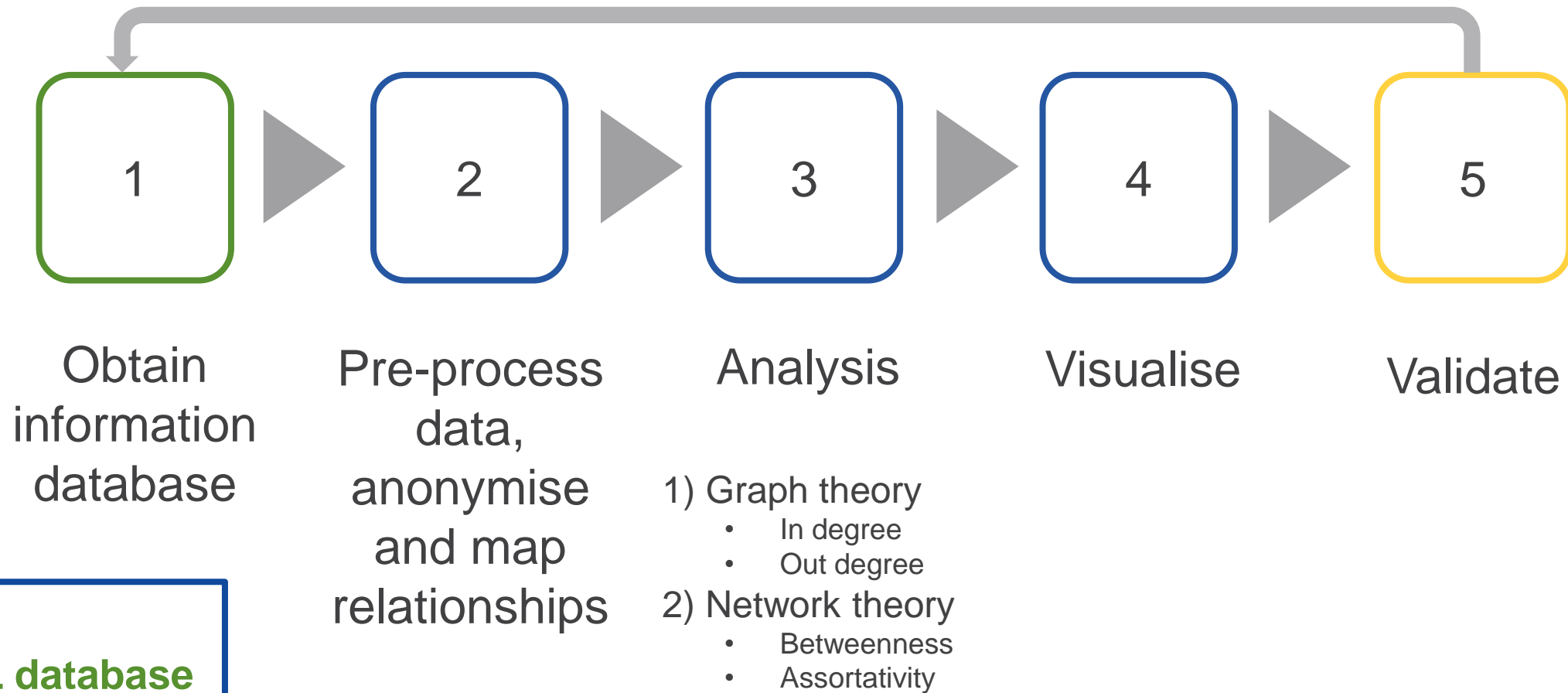


- Simple social system
- 4 queries (Optimised)
 - 9 relations

Network theory applications



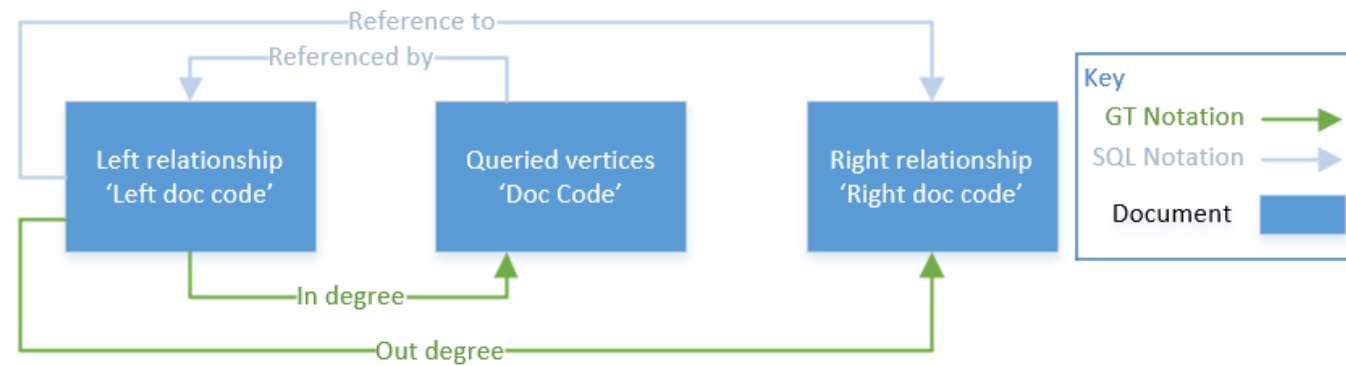
Investigation process



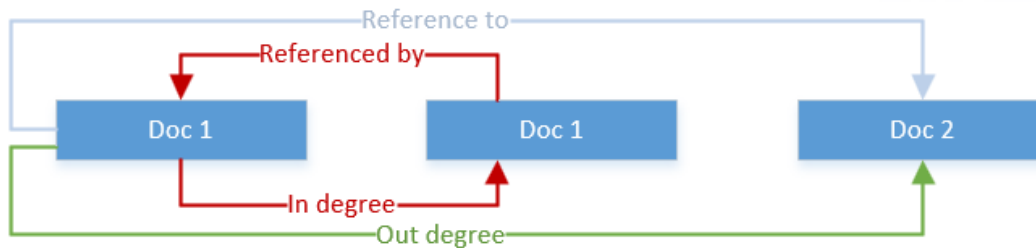
Tools

- **SQL database**
- **Python**
- **Github**
- **Discussion**

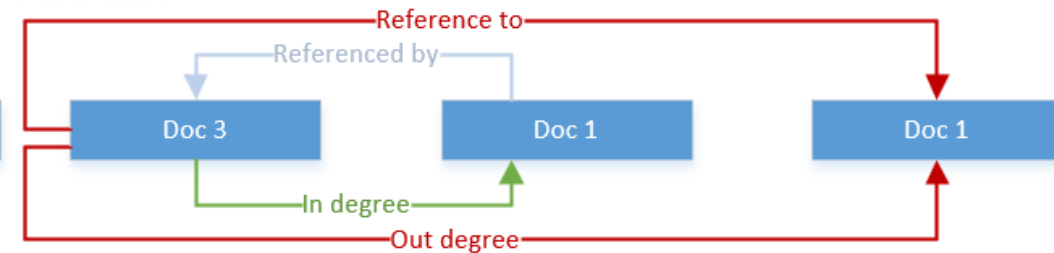
Mapping database relationships



General relationship structure



False loop at in degree



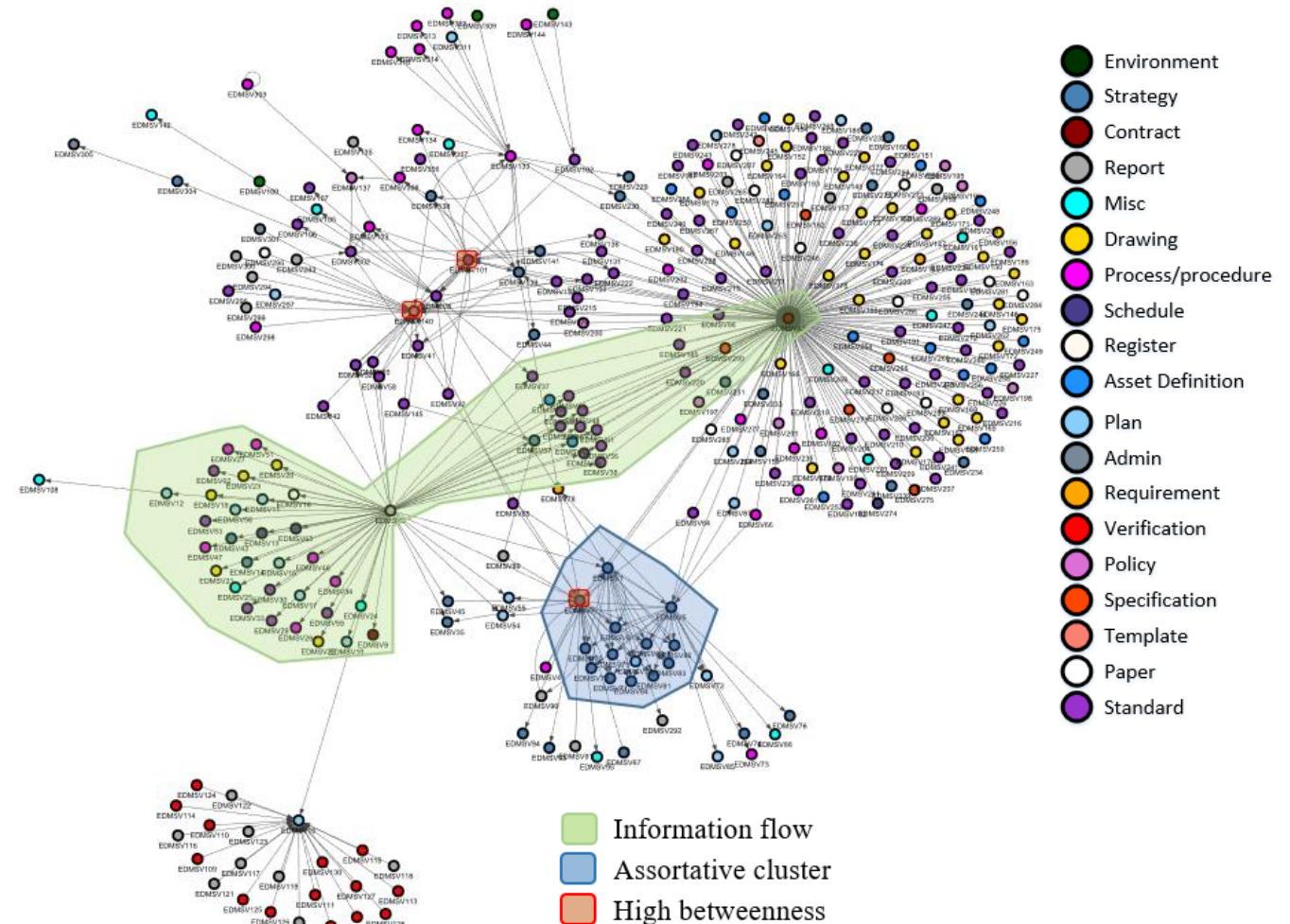
False loop at out degree

Information processing



Visualising relationships

- 20 queries
 - 314 unique documents
 - 413 relationships



Ranking importance

vertex ID	Undirected	Indegree	Outdegree	Betweenness	Type
EDMSV82	176	176	0	0	Contractual
EDMSV3	57	0	57	0	Report
EDMSV7	29	11	18	189	Strategy
EDMSV5	26	3	23	148	Strategy
EDMSV140	25	23	2	12	Policy
EDMSV101	24	10	14	750	Standard
EDMSV16	23	23	0	0	Drawing
EDMSV1	20	6	14	322	Strategy
EDMSV133	16	3	13	250	Procedure/Process
EDMSV8	11	4	7	419	Standard


Filtering importance



Source: <https://joethegreat1.github.io/joemurphy.github.io/> Web Viewer [Terms](#) | [Privacy & Cookies](#) [Edit](#)

Contributions and further research

Findings

- Novel way for identifying database complexity
 - Multi variable complexity mapping
- **Pre-selection of the existing systems for the digitisation effort**
- Data entries aren't always accurate 

Next steps

- Surgical application of MBSE
 - 'Complex' node taken and modelled using ISO15288
- System comparison and completeness mapping

Any questions



Contact details



Paper details and references





cser2022.cser.info