Simulating Geodesign:
Designers as Agents, Buildings as Agents

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… designing for change cannot be a solitary activity. Rather, it inevitably is a team endeavor with many participants (from the design professions and geographic sciences) …

Carl Steinitz (2012) **A Framework for Geodesign**, ESRI Press, p. ix

… Geodesign is based on a network of shared intelligence …

Bran Ferrens (2013) **GeoDesign Summit**, Esri

What Are Agents?

They can be any object that is well defined –a person, a building, a land parcel … a type of atomic unit ?

They are also objects that have mobility

The most literal agent-based models are things like models of pedestrian flow or traffic flow

But my talk shifts the focus to agents as designers , as stakeholders, agents as buildings, as streets, etc.

The focus is on the process of design or decision, rather than the product

I will talk about a model of how agents combine their conflicting views of a design solution to a consensus

They do this by pooling their opinions and if they do this systematically and rationally by averaging their views, they reach a consensus which is the ideal type

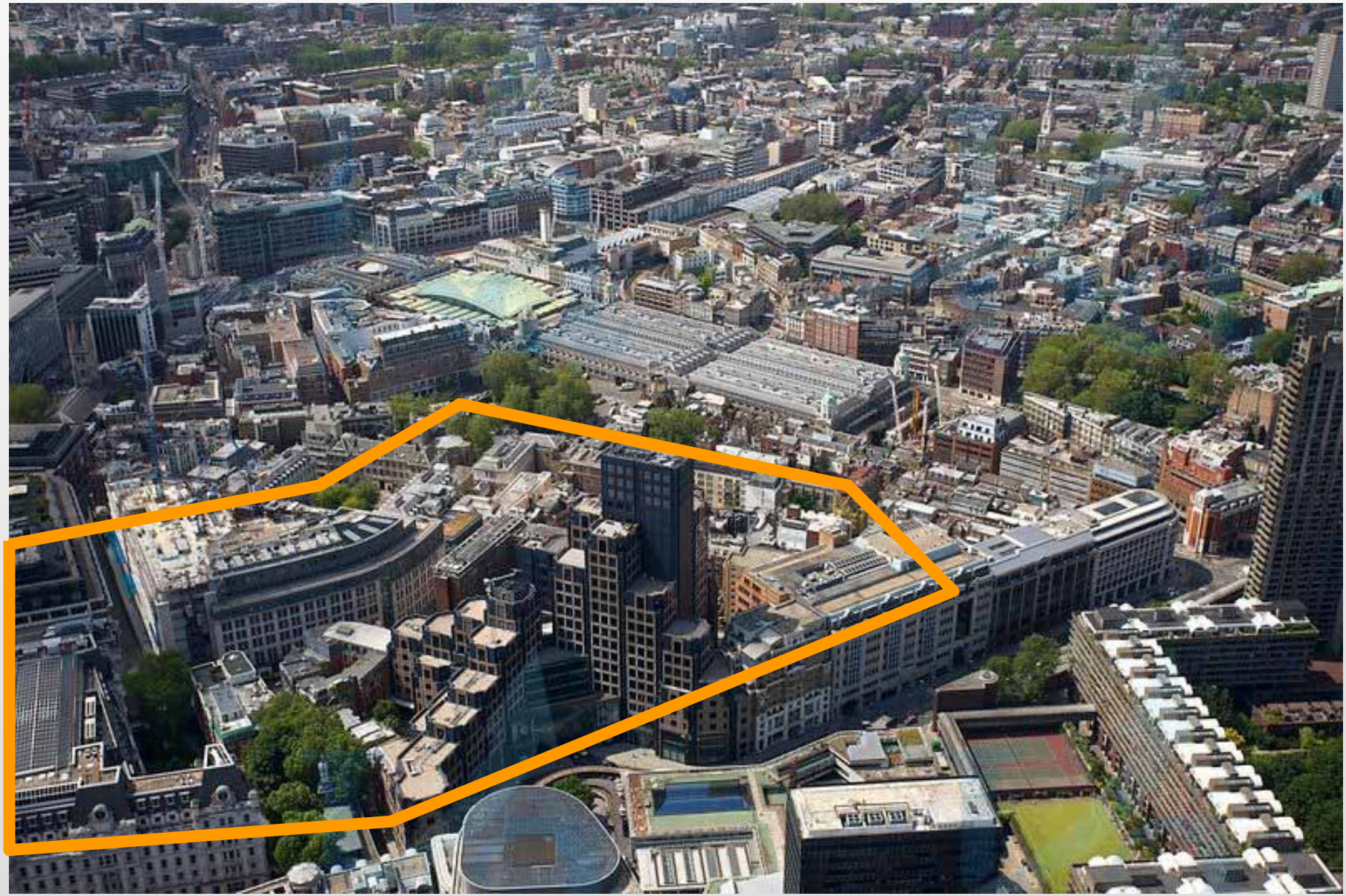
They require to be connected by some network which is strongly connected to effect a consensus

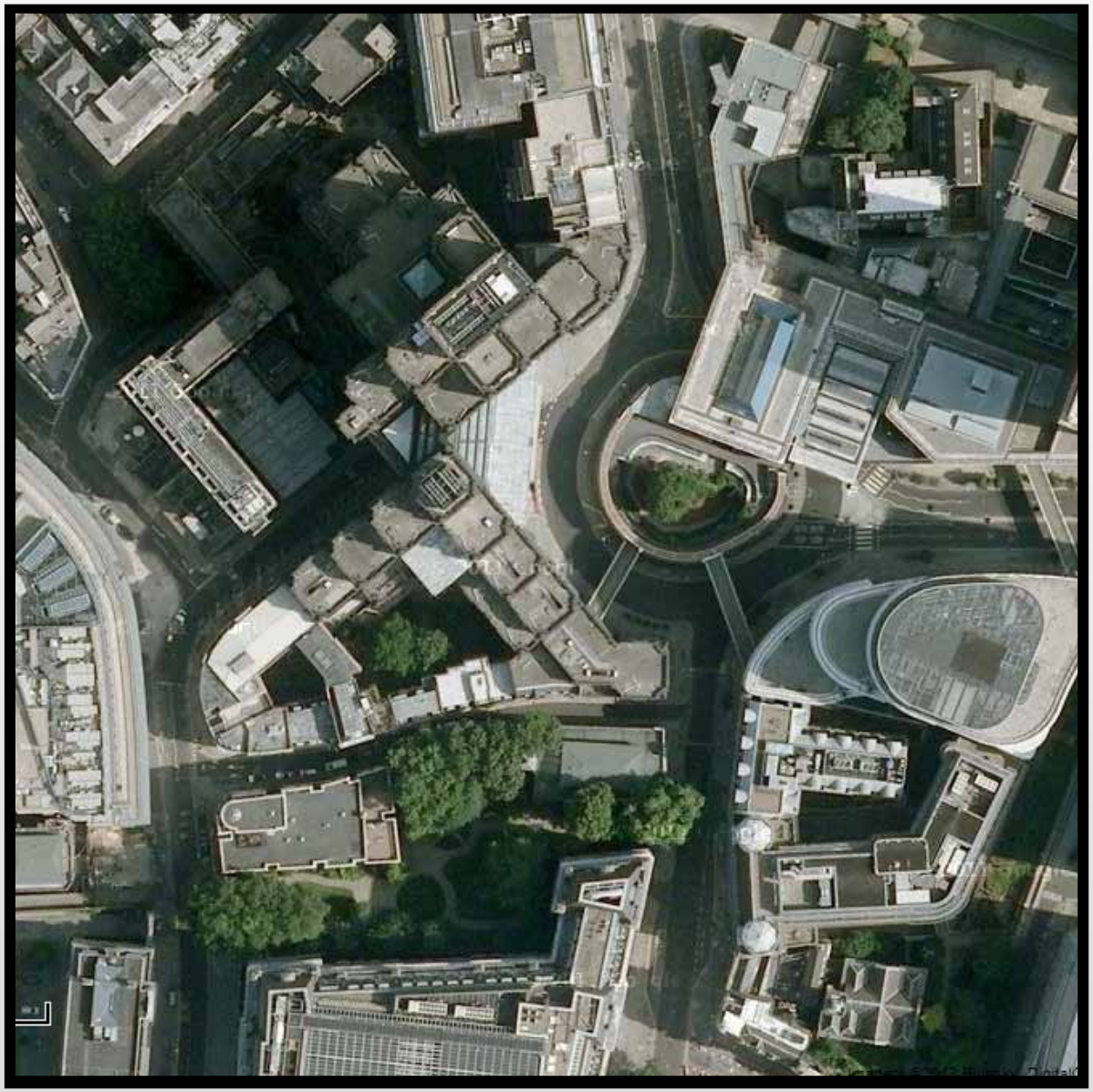
Of course reality is not an ideal type – agents do not converge their views but this baseline gives us a basis for discussion of the process

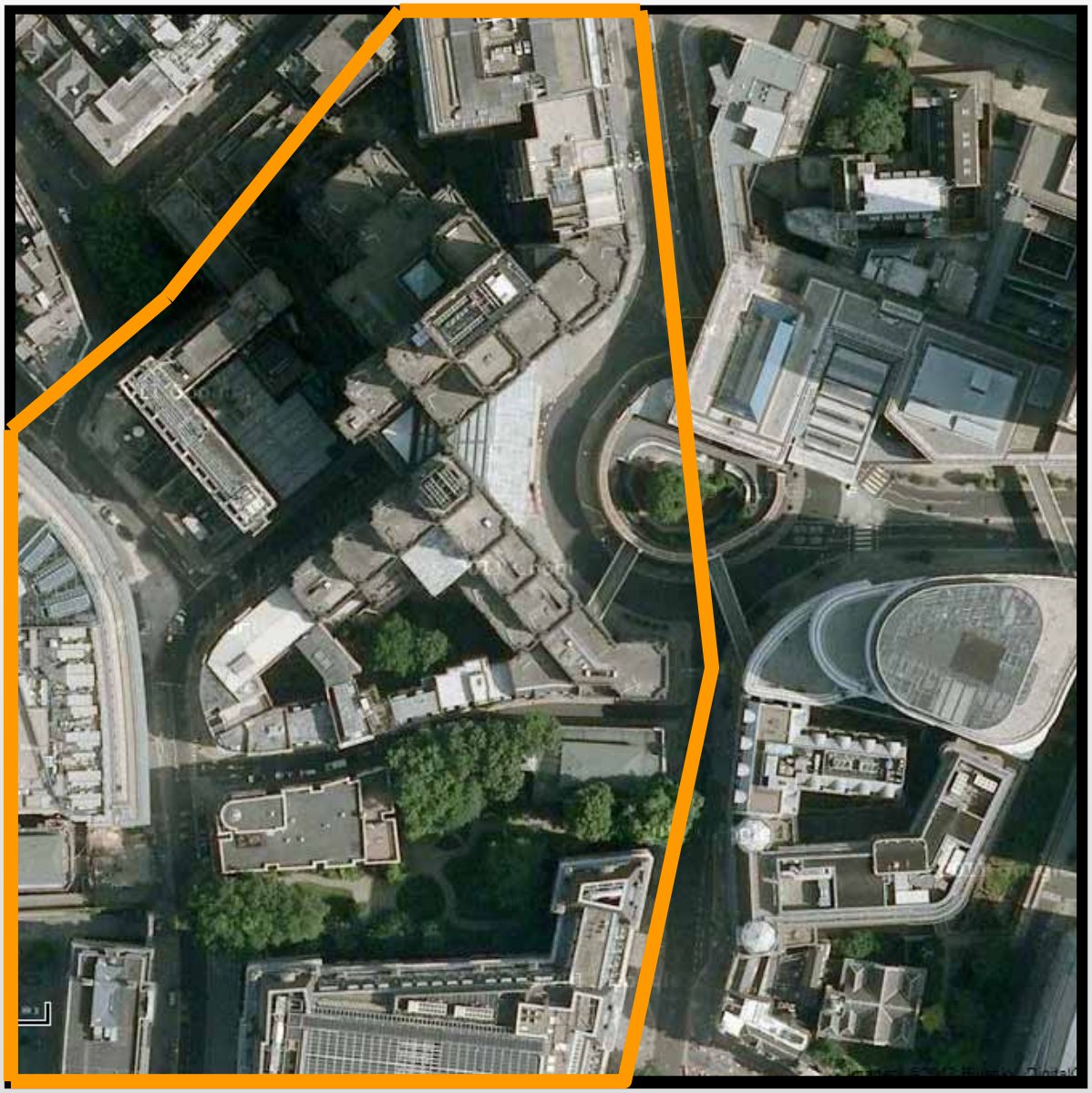
I will outline the problem – a toy problem – first

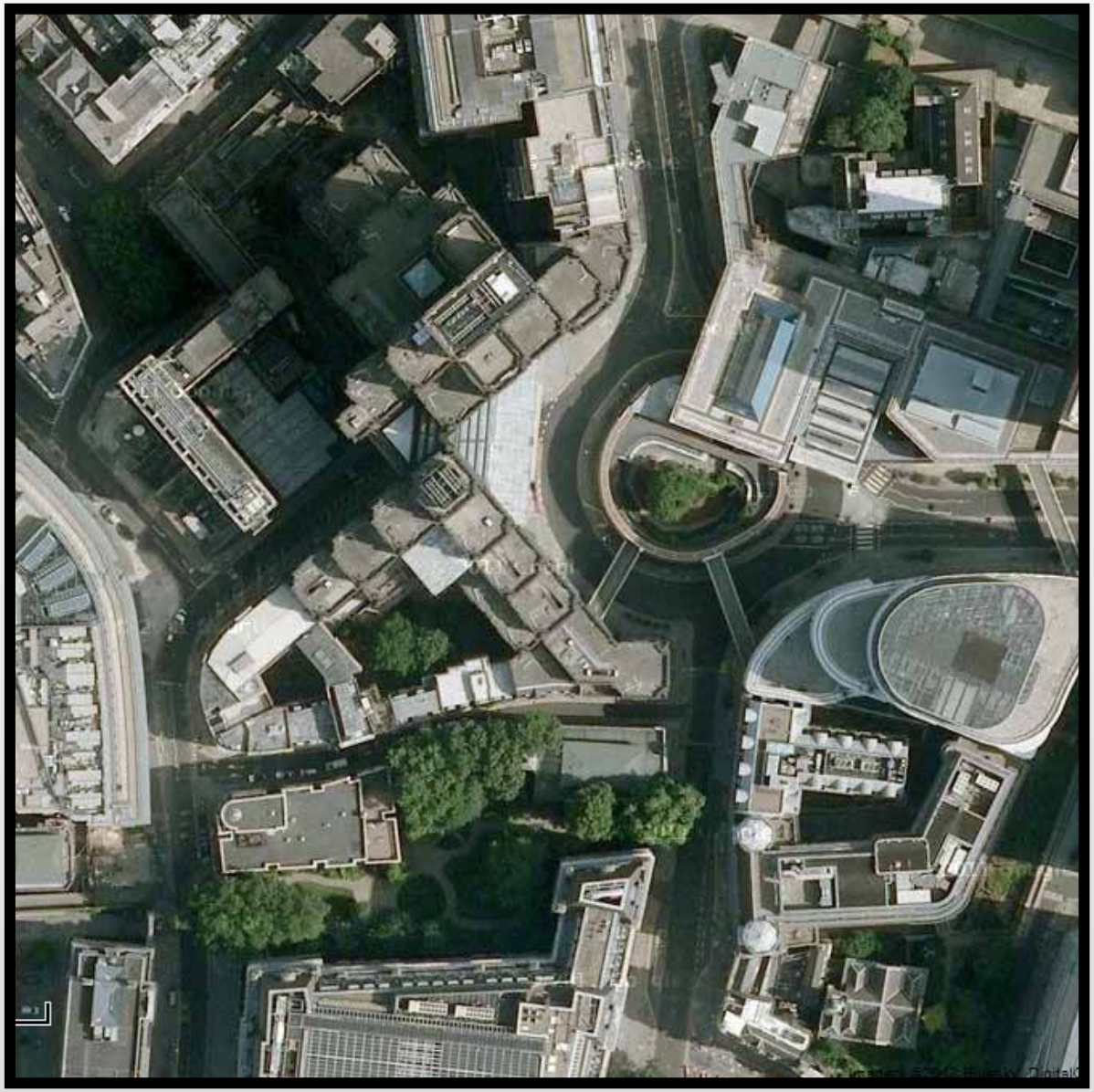
An Outline

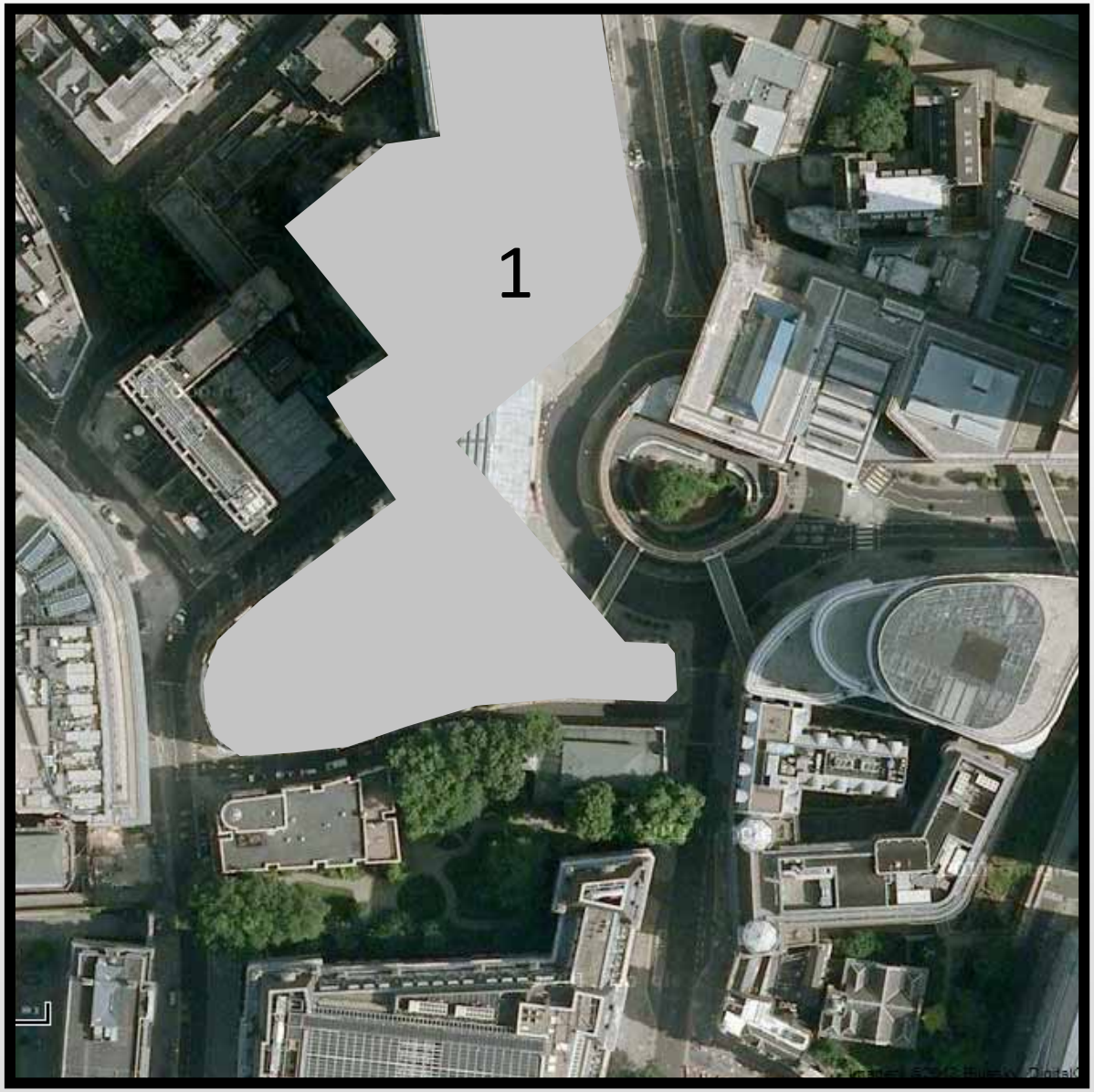
- The problem – the resolution of conflict over a change in use of land in a dense urban area – design maybe decision yes
- The agents in the models – actors, stakeholders versus sites/buildings
- The way the agents interact across the maps of what they consider significant to change of use
- The way the agents effect compromise – two problems which are duals of one another







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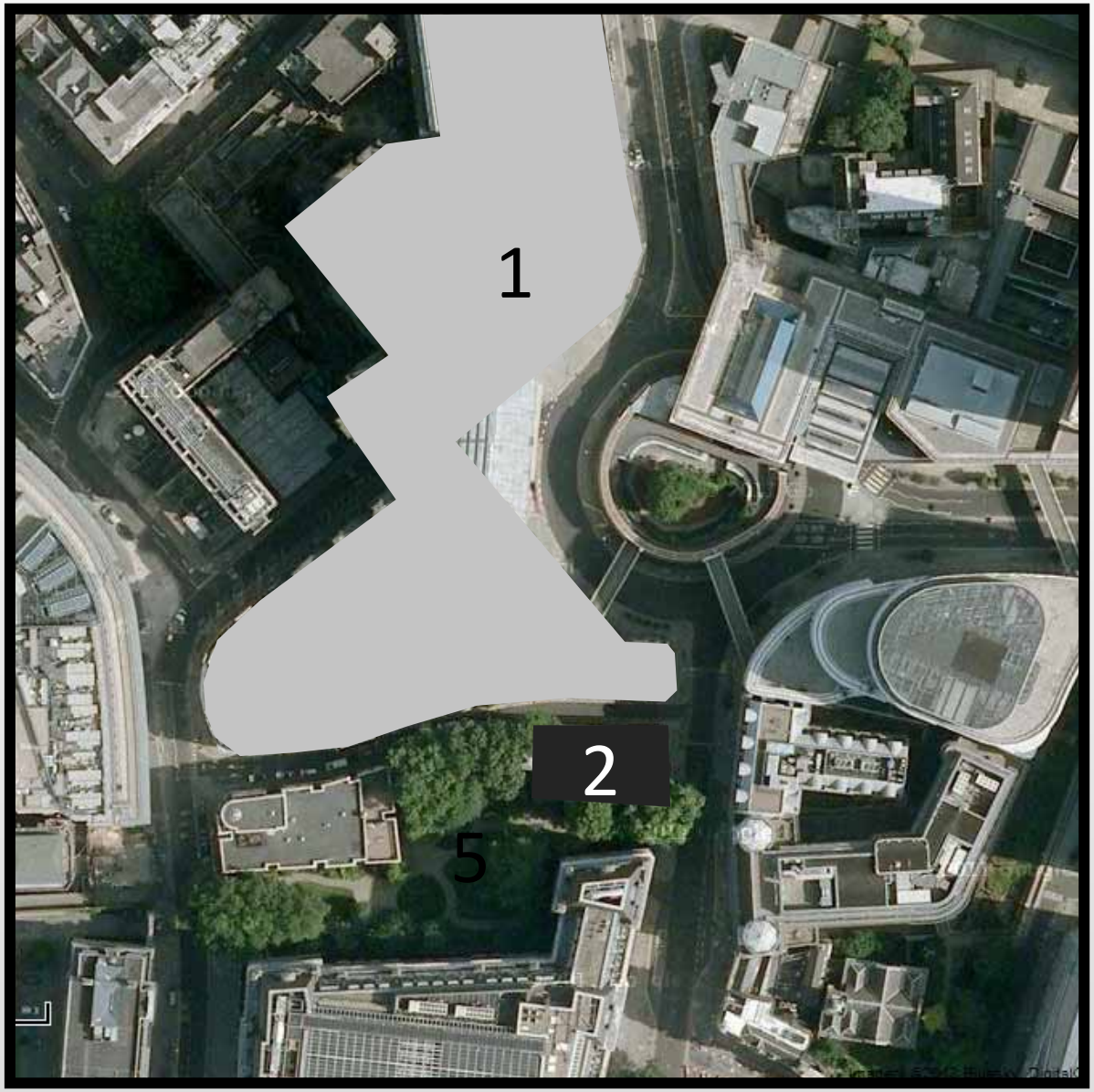
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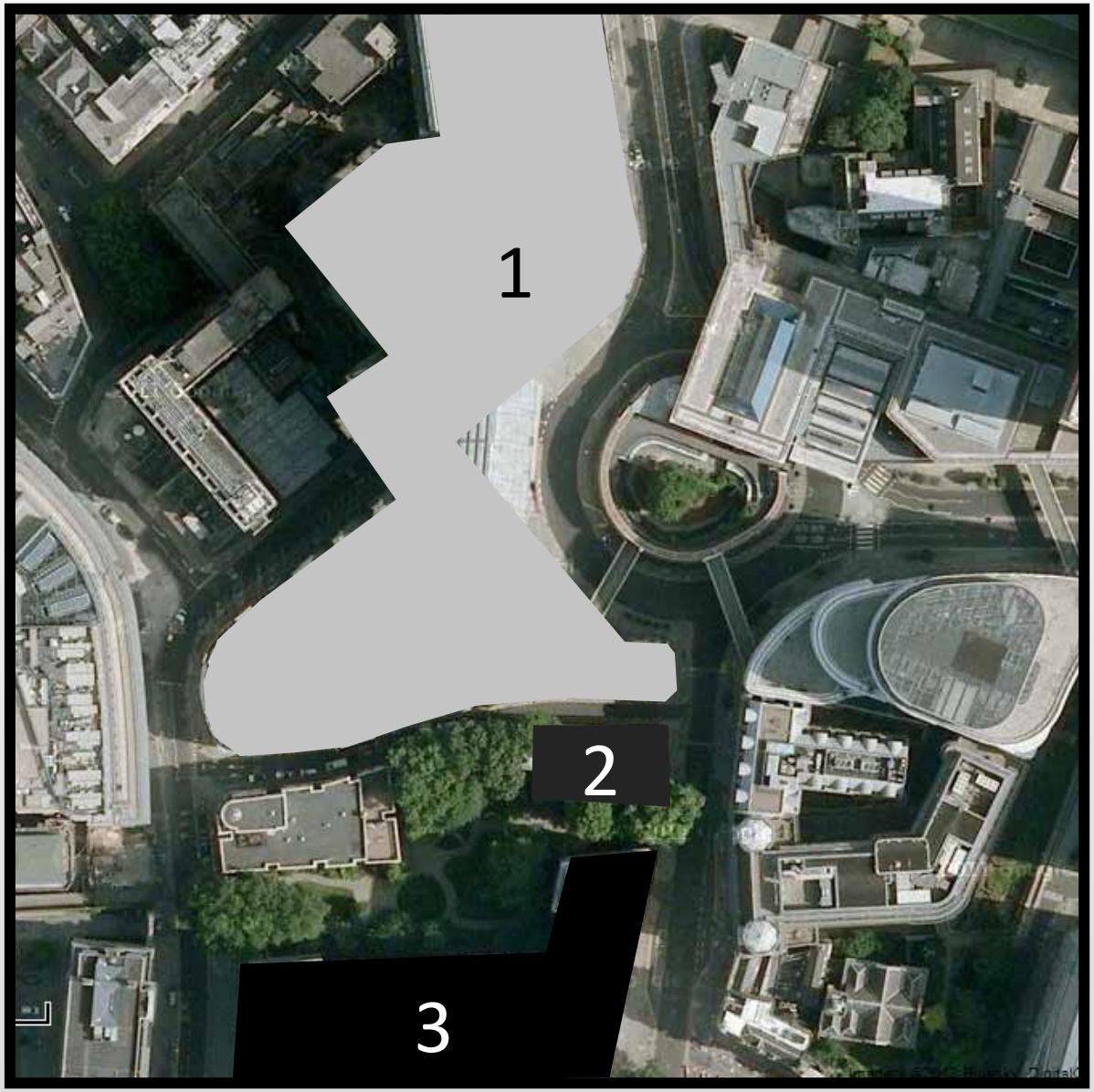
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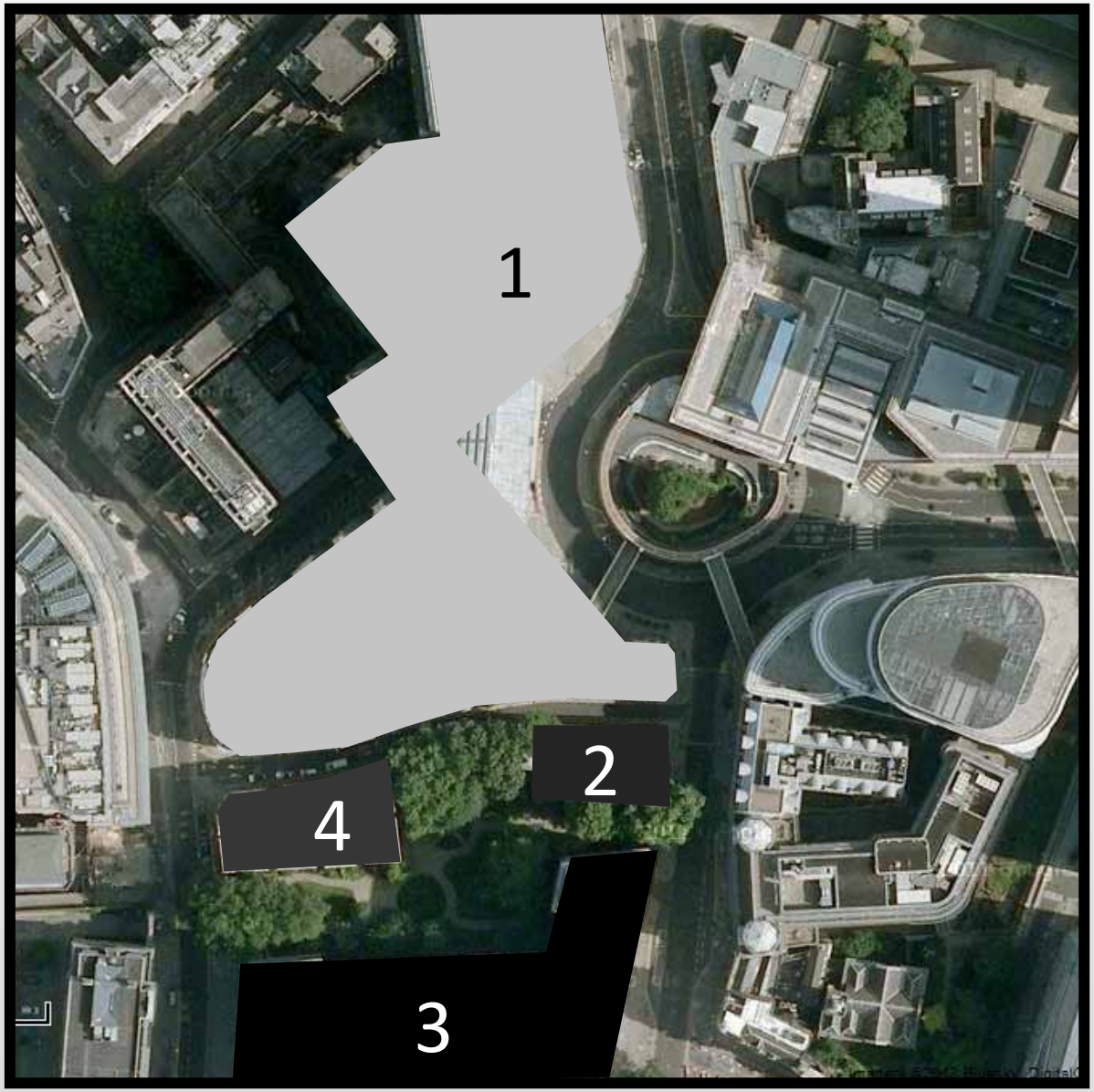
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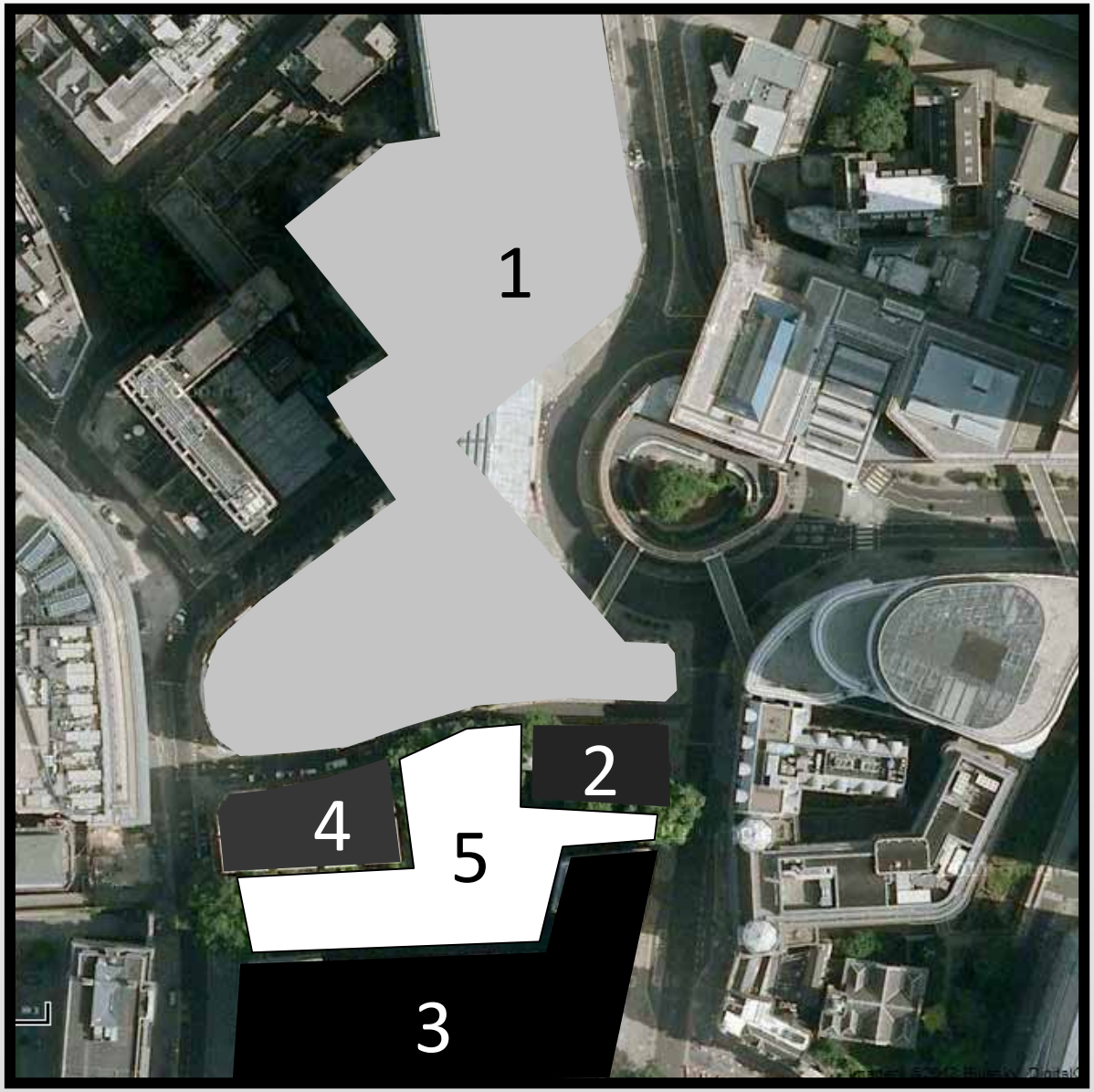
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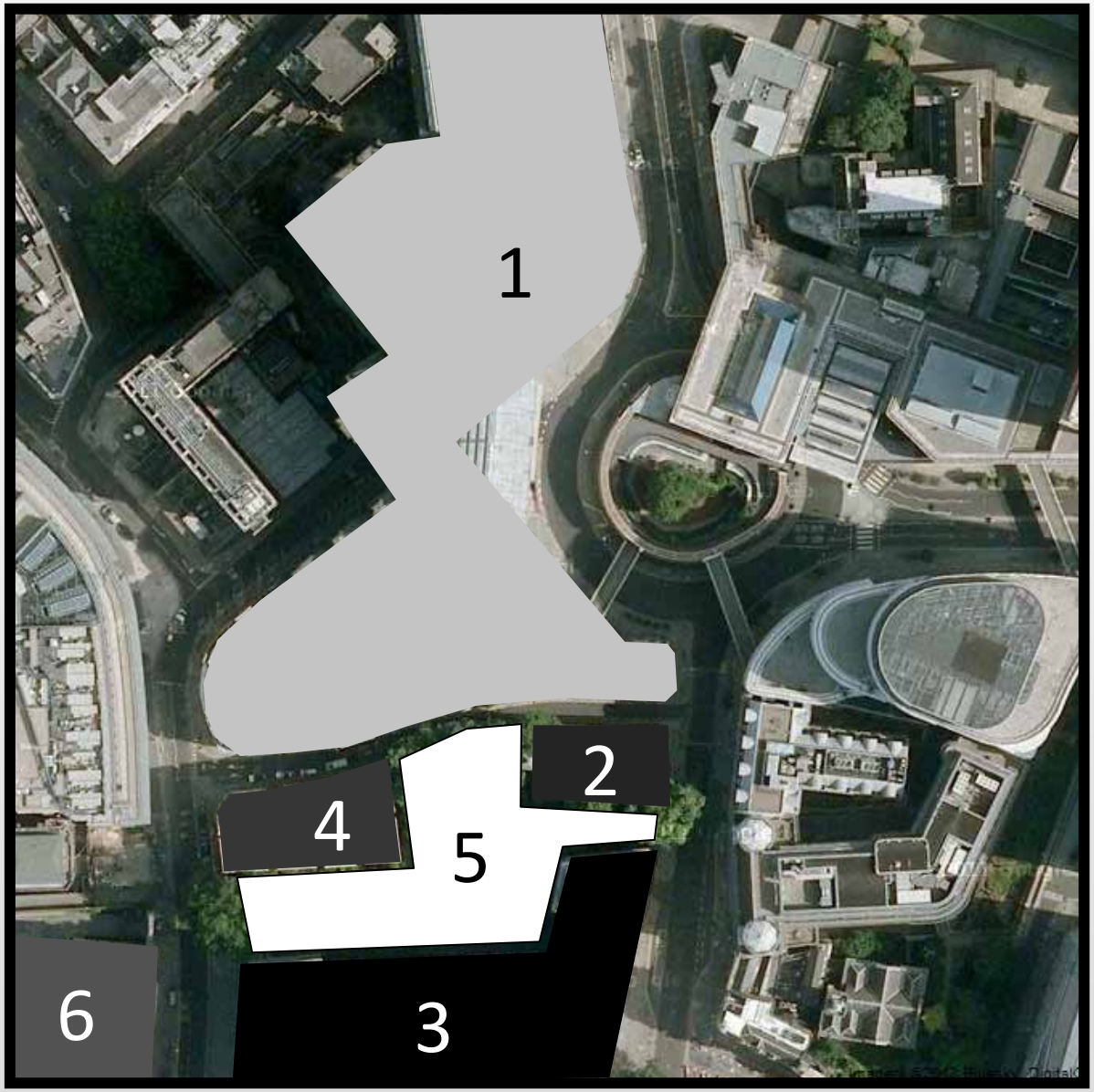
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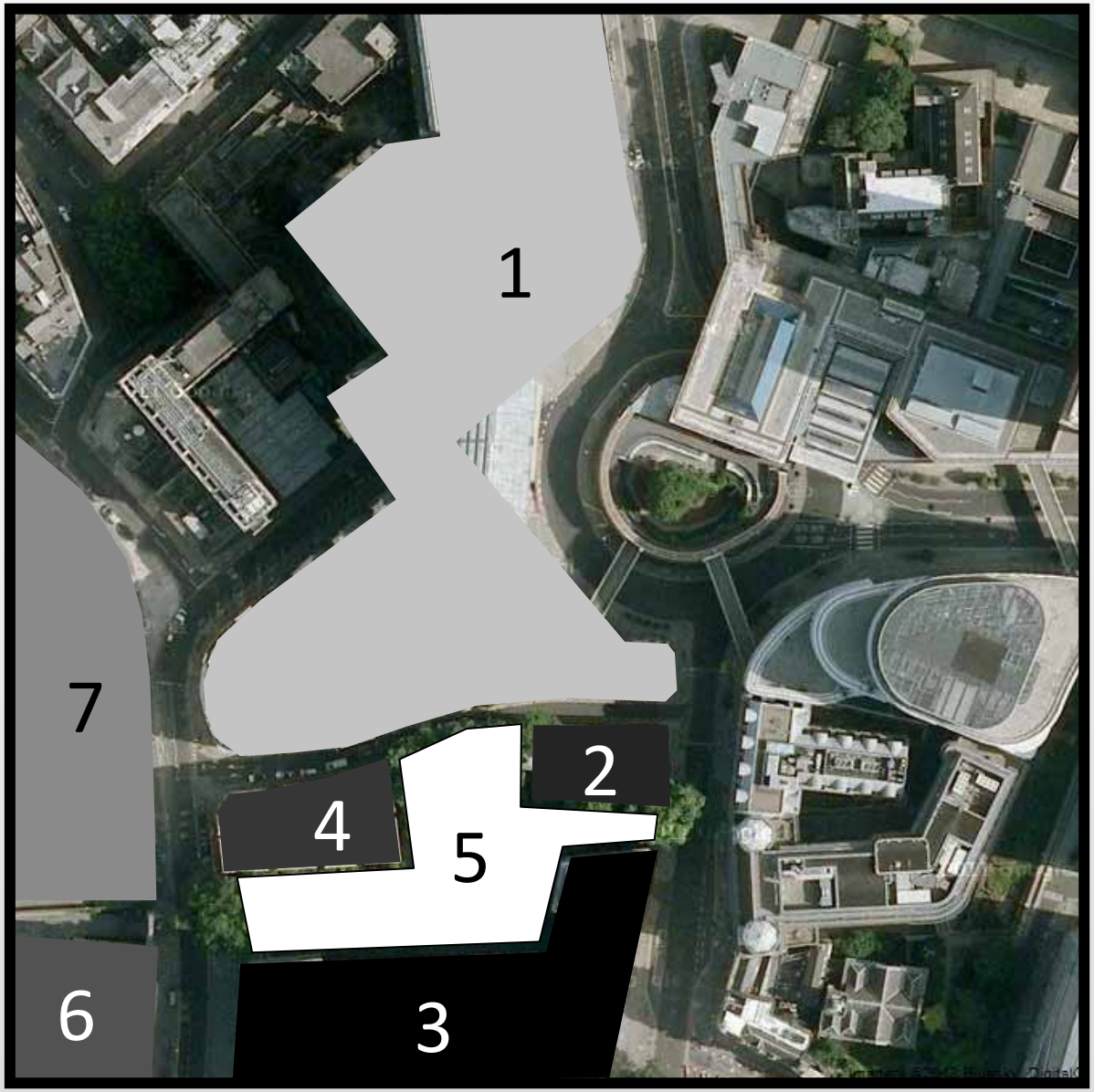
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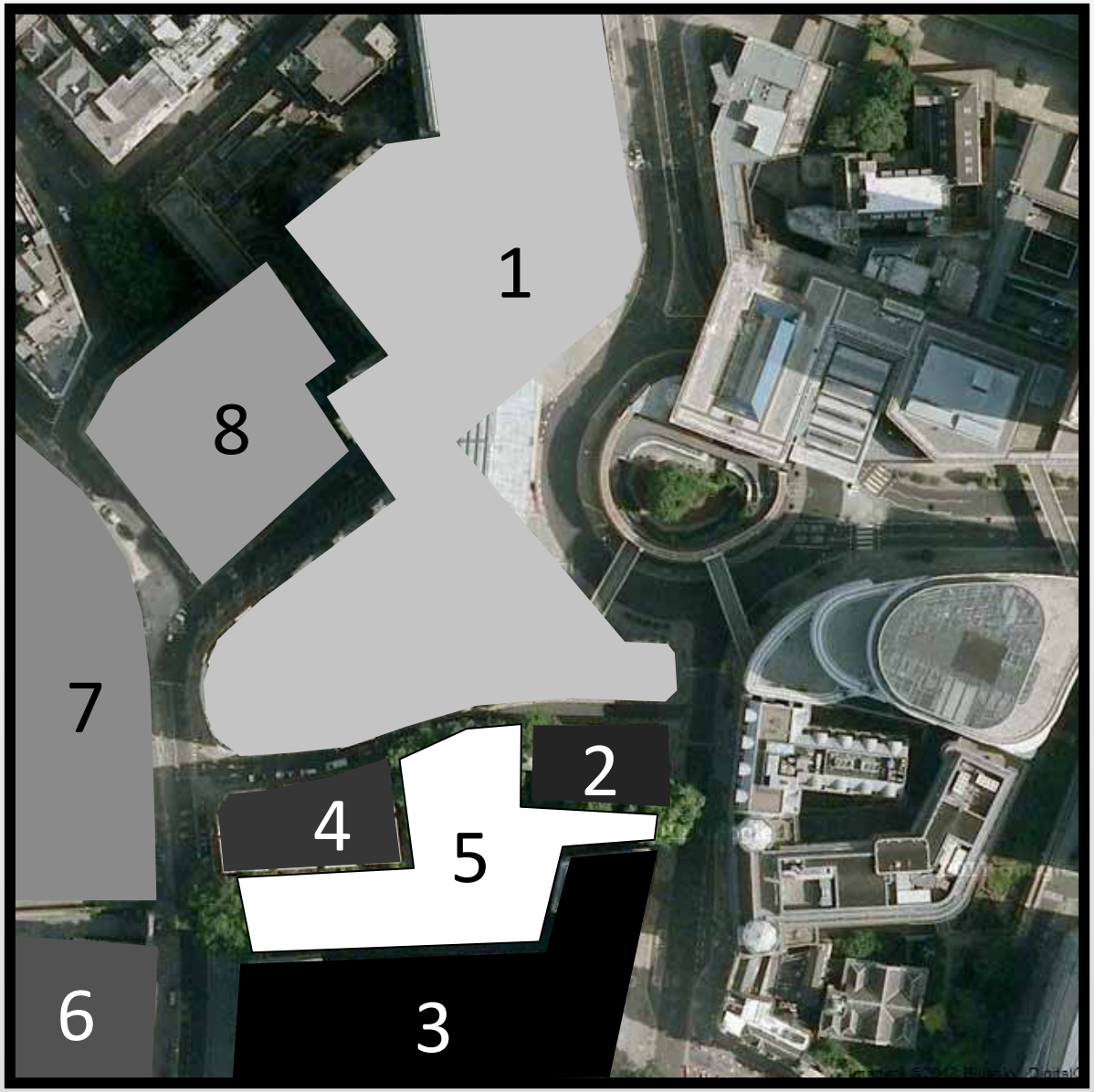
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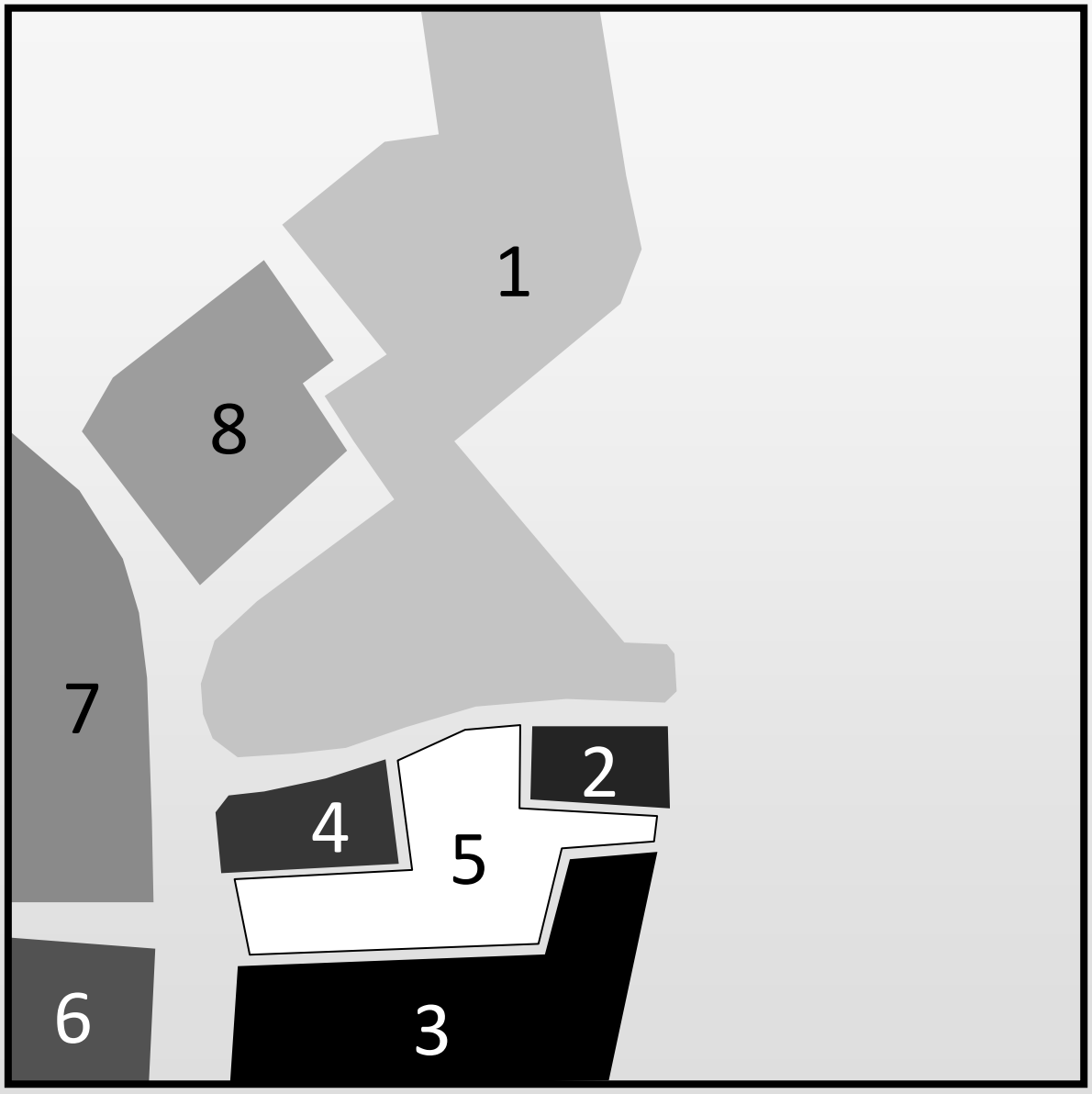
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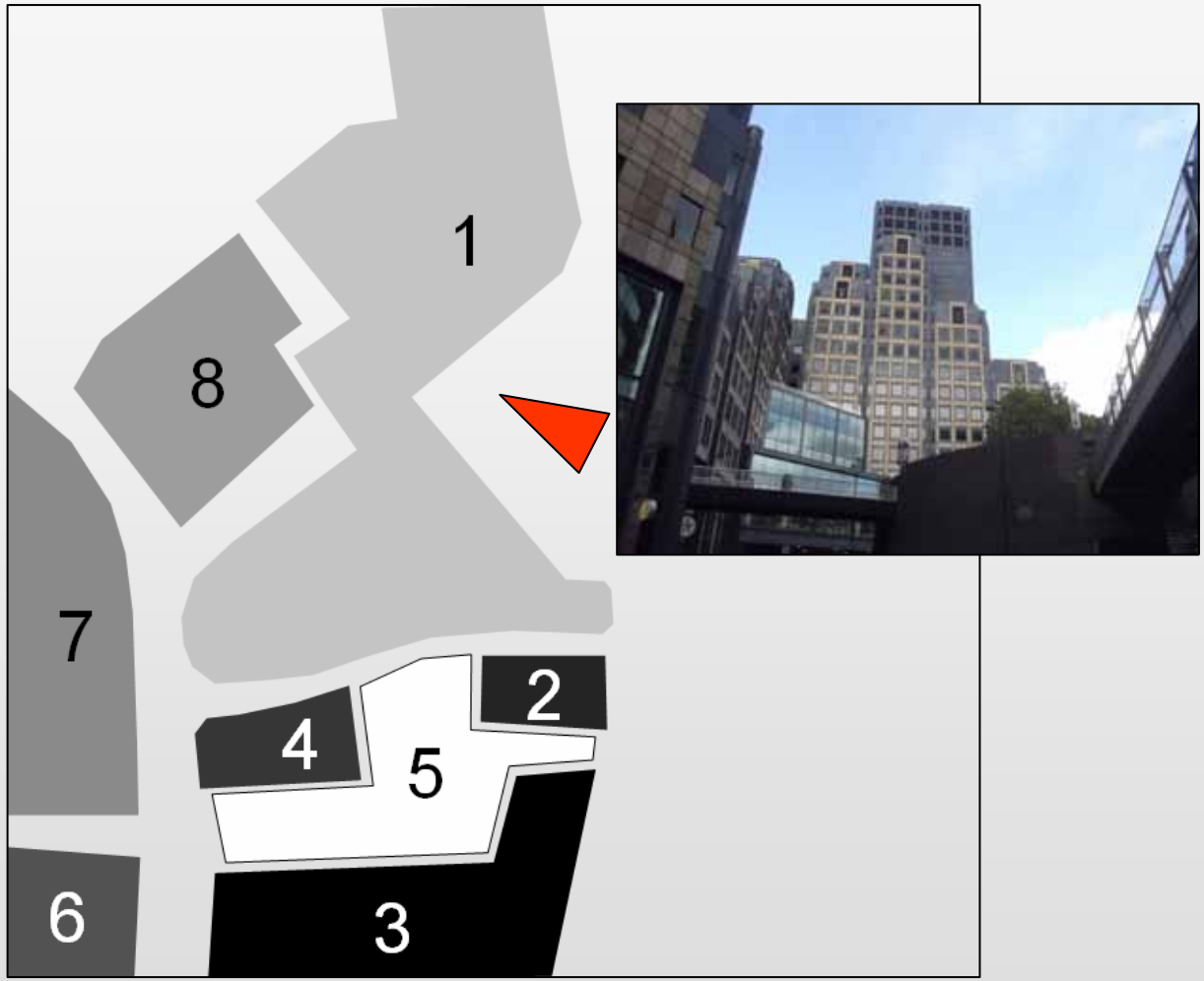
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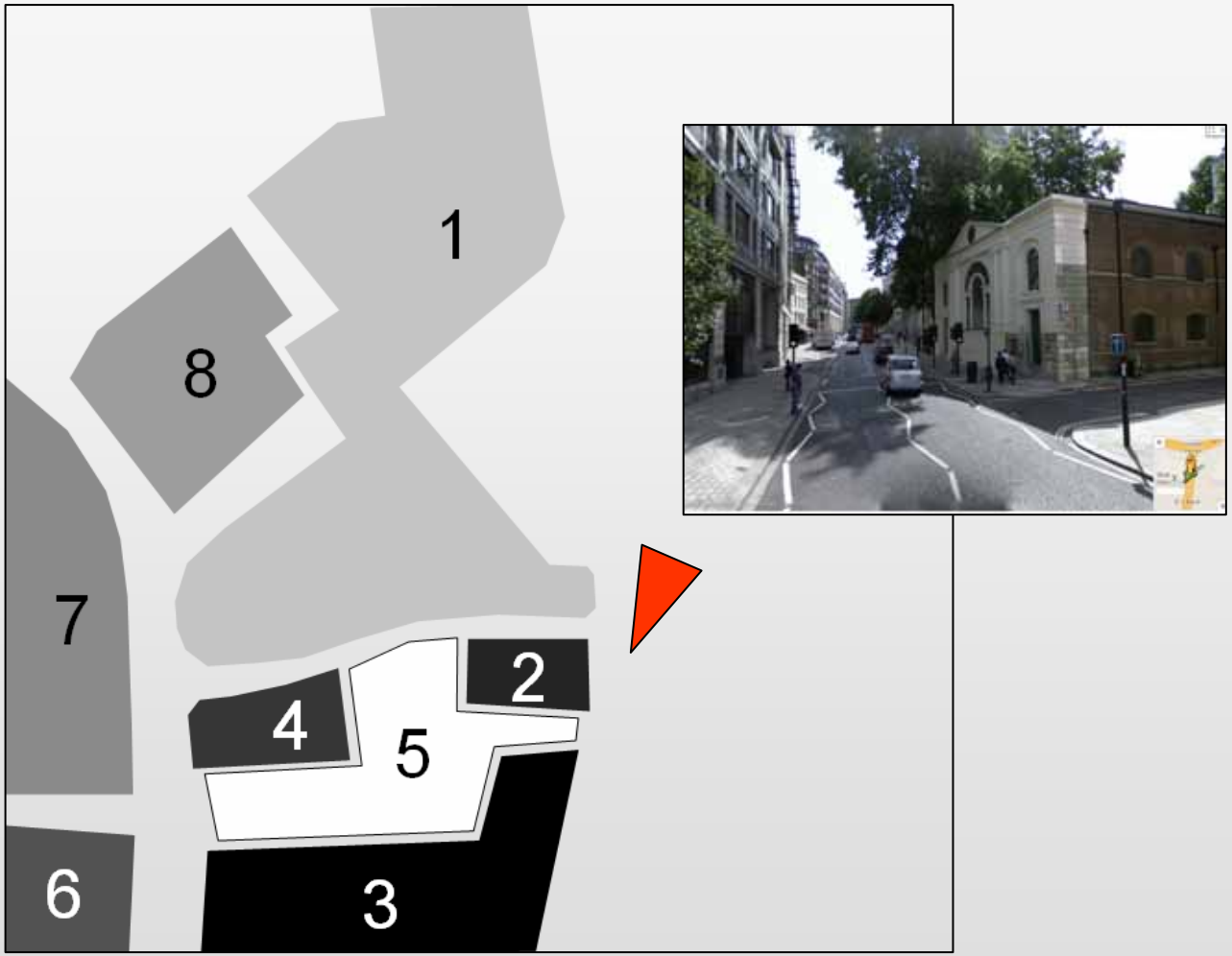
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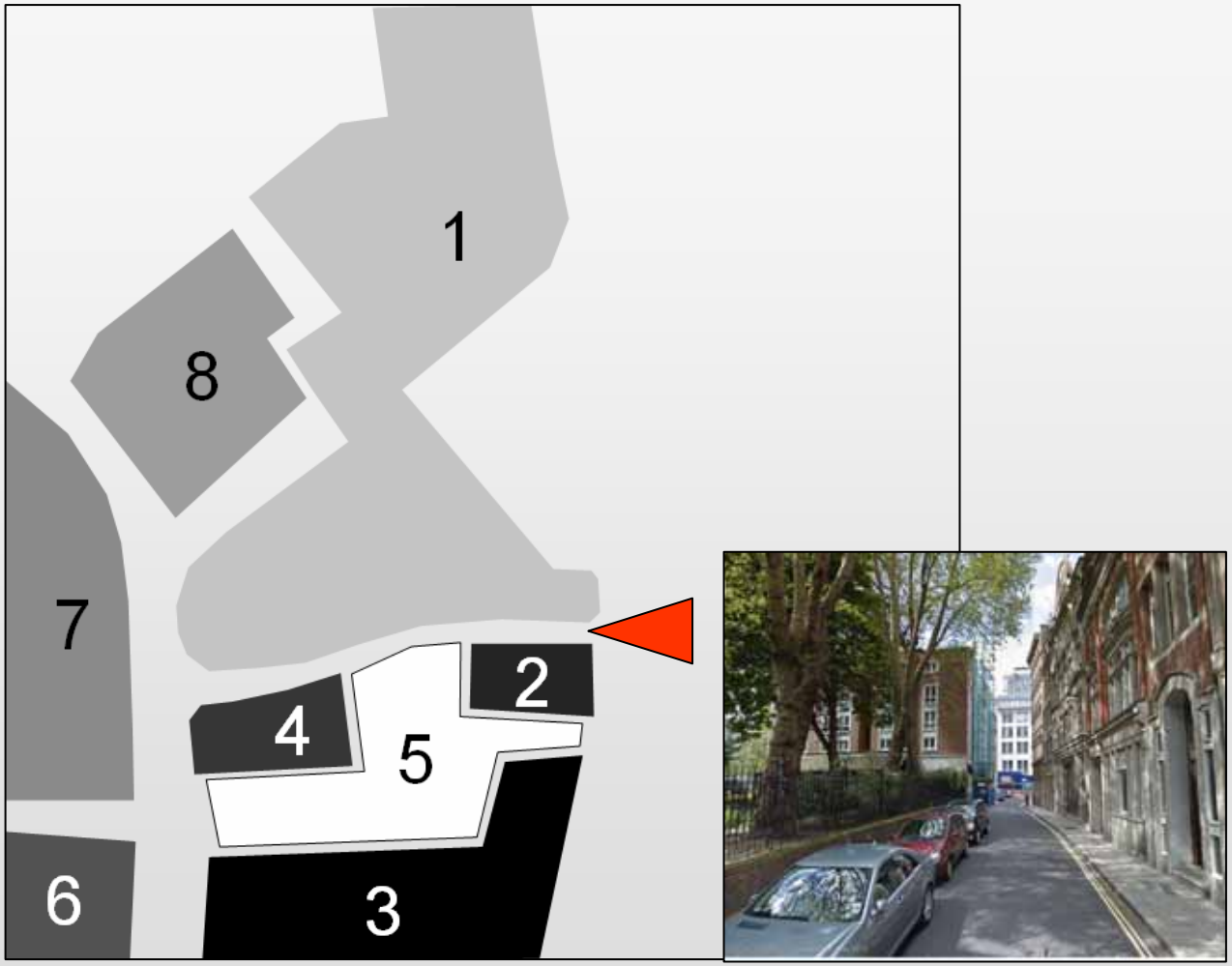
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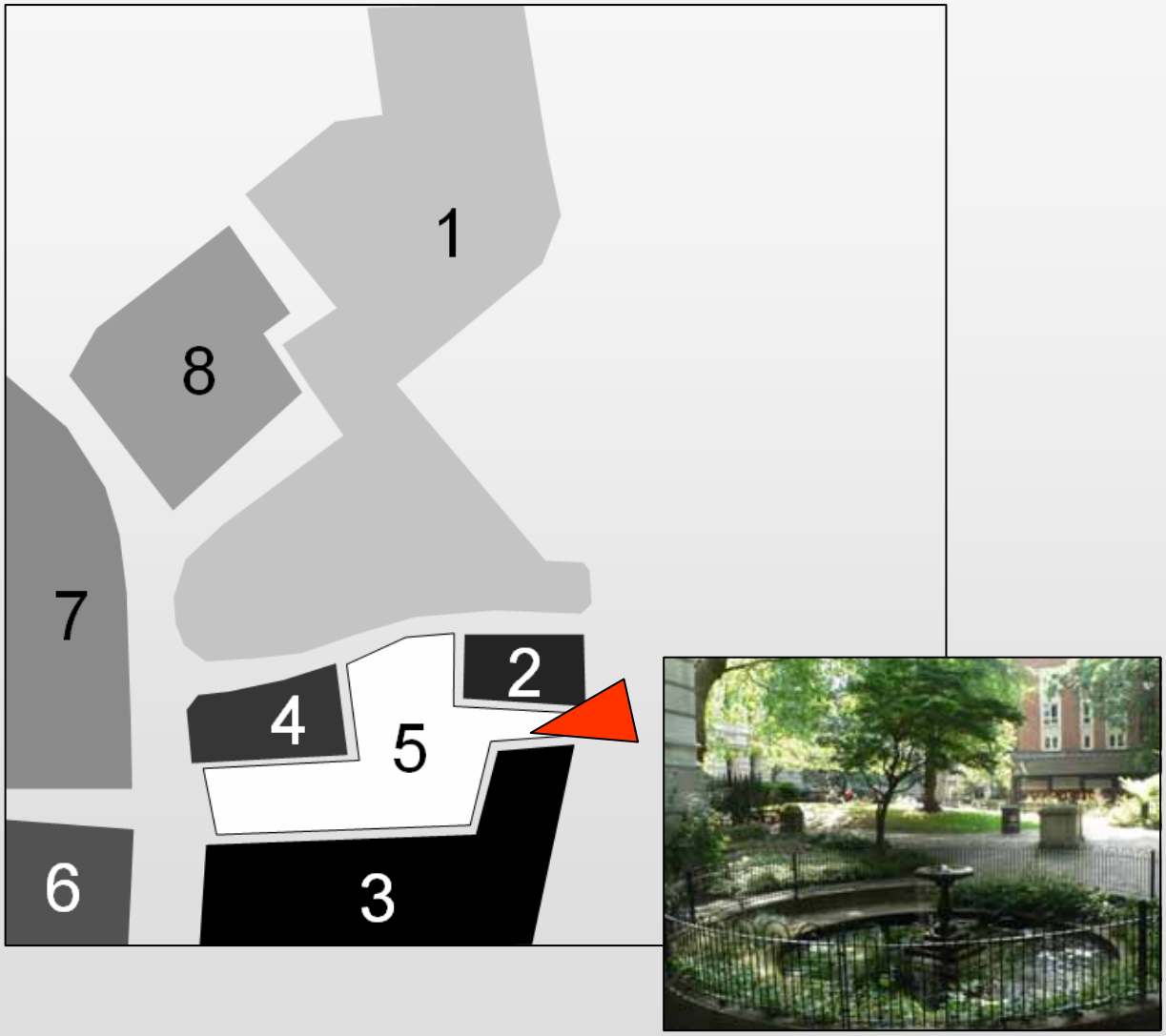
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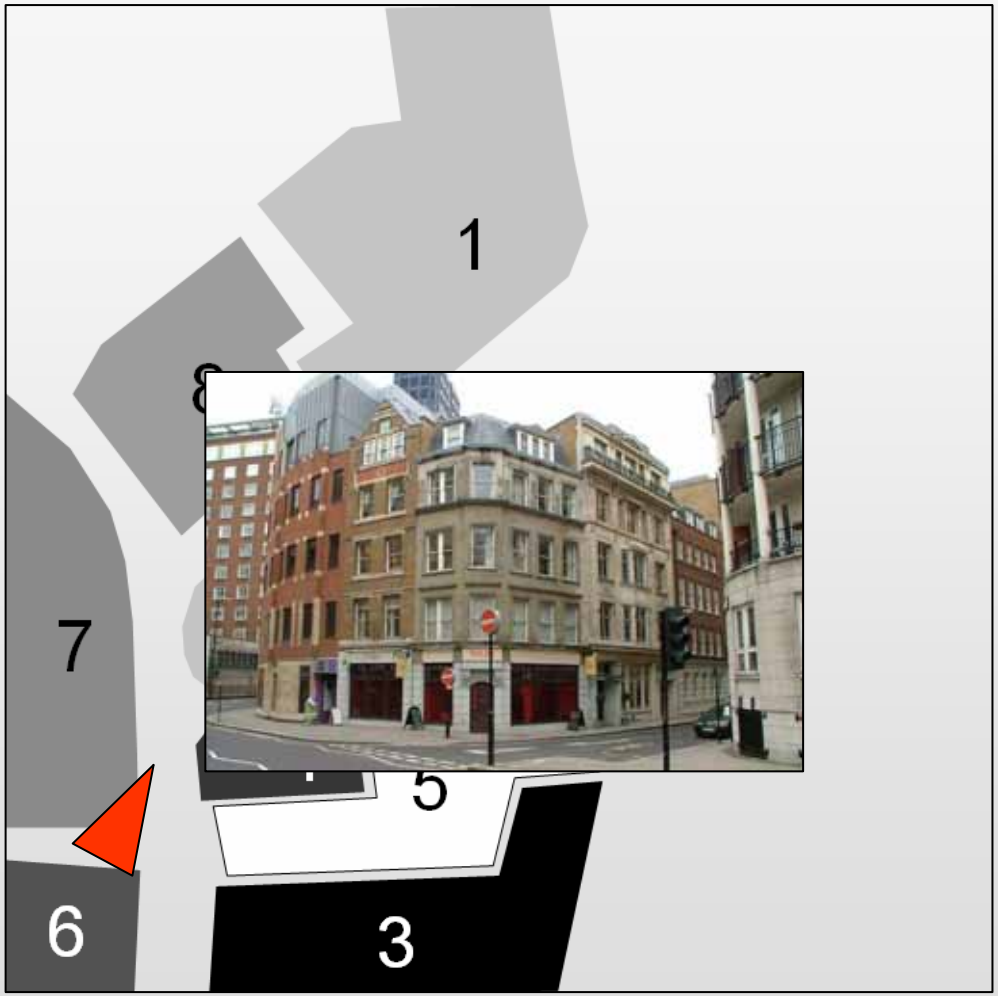
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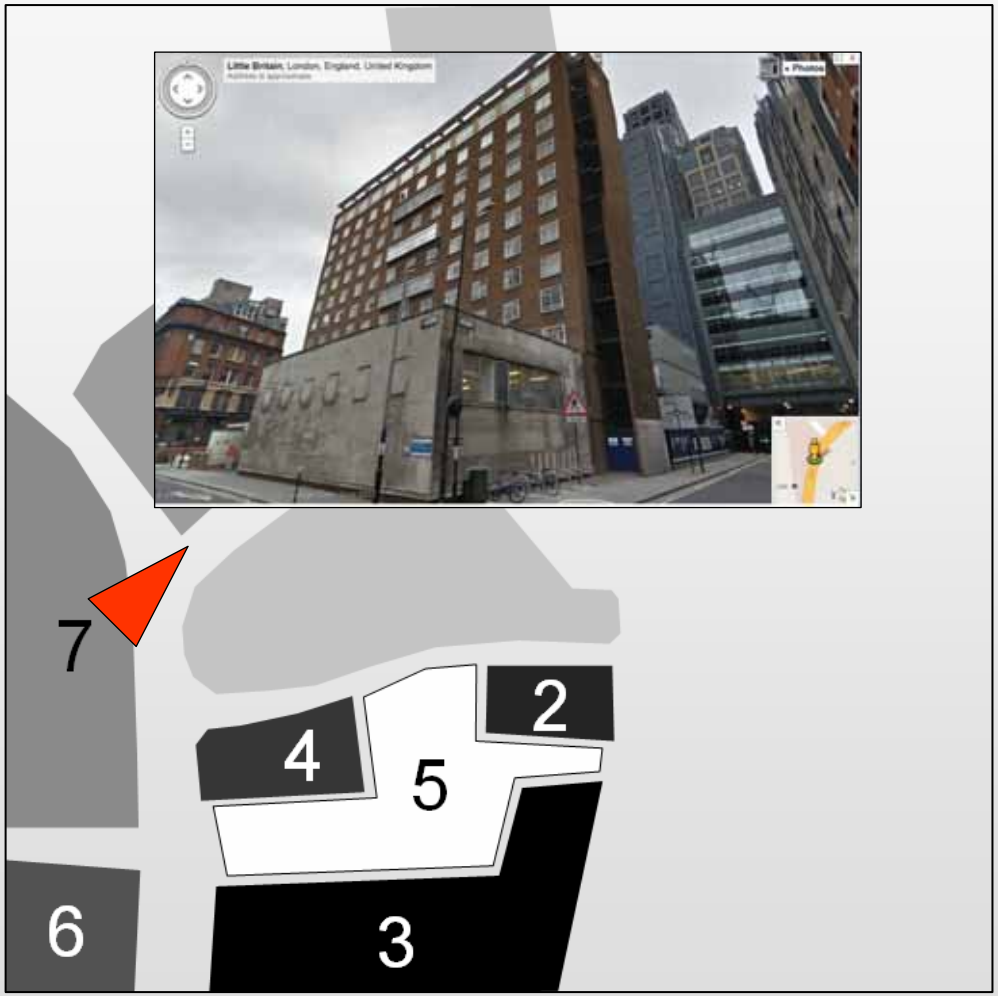
The Spectator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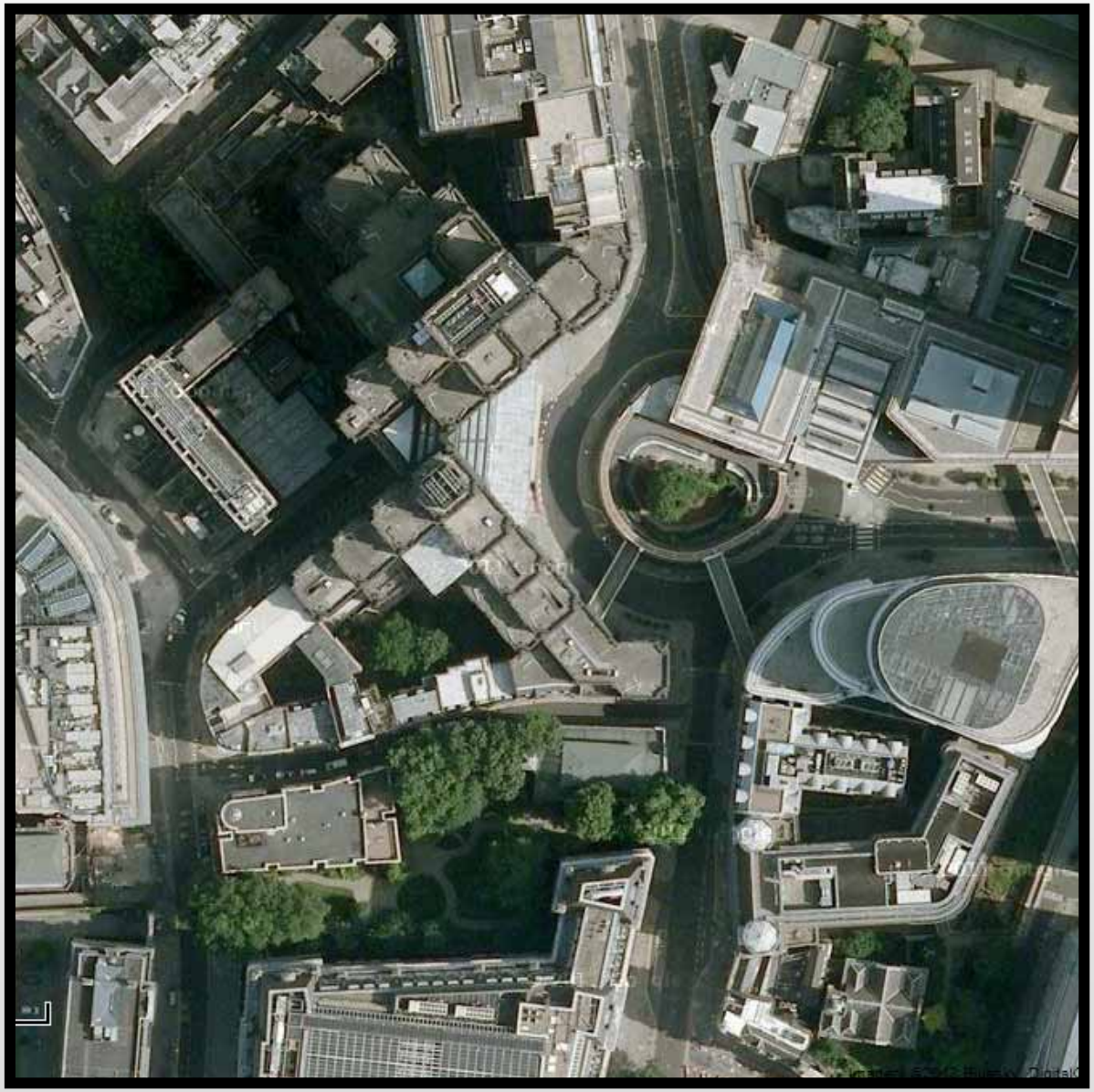


Actors/ Stakeholders

1 City Corporation

2 Residents

3 Hospital NHS

4 Developers

5 Property Spec

6 Banks

Sites/Buildings/ Locations

1 Aldersgate Complex

2 St Botolph's

3 Nomura House

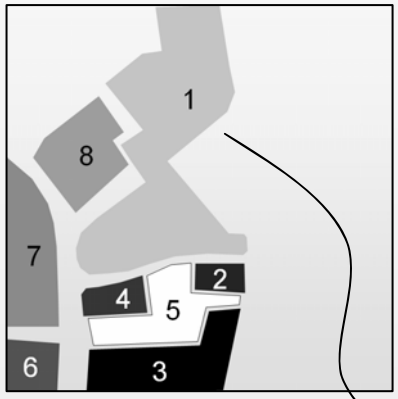
4 Milton House

5 Postmans' Park

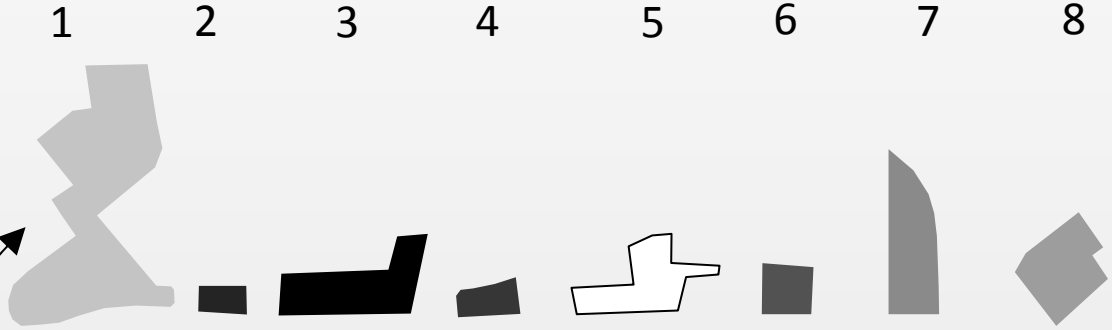
6 Bank of America

7 Barts New Building

8 Barts Old Building

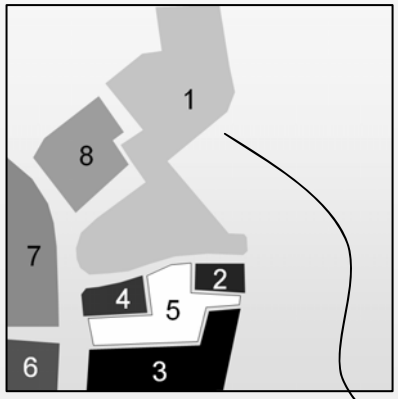


Sites/Buildings

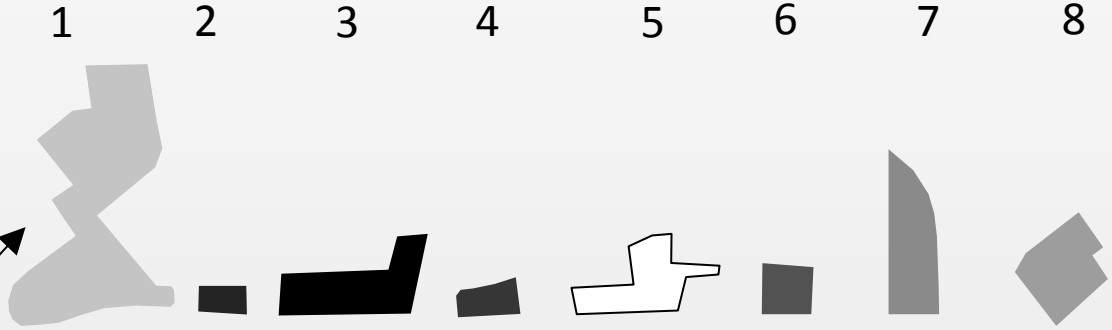


Agents

1 City Corporation	0	0	1	0	0	1	0	1
2 Residents								
3 Hospital NHS								
4 Developers								
5 Property Speculators	●	●	●	●	●	●	●	●
6 Banks								

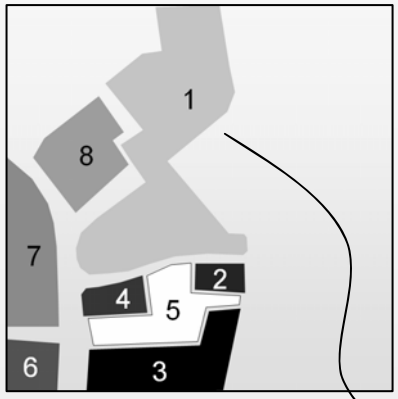


Sites/Buildings



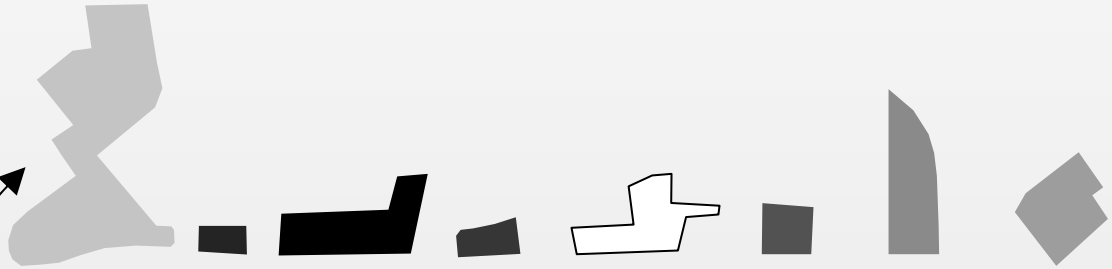
Agents

	1	2	3	4	5	6	7	8
1 City Corporation								
2 Residents	0	0	0	0	0	0	0	1
3 Hospital NHS								
4 Developers								
5 Property Speculators	●	●	●	●	●	●	●	●
6 Banks								



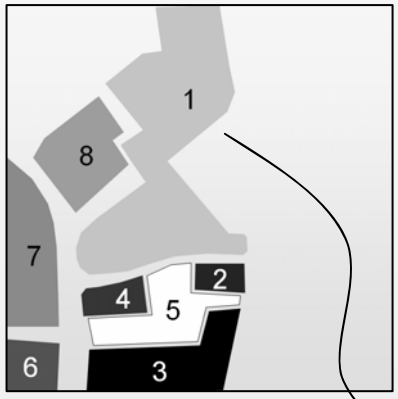
Sites/Buildings

1	2	3	4	5	6	7	8

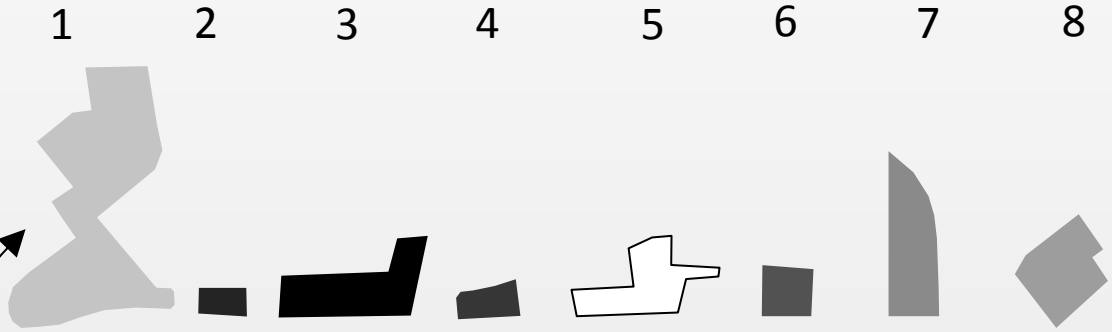


Agents

1 City Corporation								
2 Residents								
3 Hospital NHS	0	0	1	0	0	1	0	1
4 Developers								
5 Property Speculators	●	●	●	●	●	●	●	●
6 Banks								



Sites/Buildings

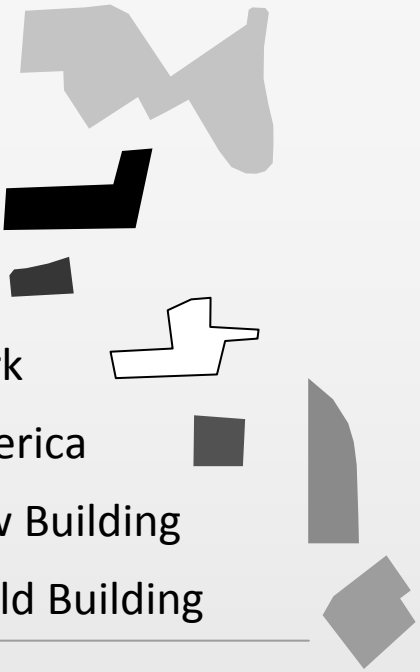


Agents

	1	2	3	4	5	6	7	8
1 City Corporation	0	0	1	0	0	1	0	1
2 Residents	0	0	0	0	0	0	0	1
3 Hospital NHS	0	0	1	0	0	1	0	1
4 Developers								
5 Property Speculators	●	●	●	●	●	●	●	●
6 Banks								

Sites/Buildings

1 Aldersgate Complex
2 St Botolph's
3 Nomura House
4 Milton House
5 Postmans' Park
6 Bank of America
7 Barts New Building
8 Barts Old Building



Agents

1 City Corporation
2 Residents
3 Hospital NHS
4 Developers
5 Property Spec
6 Banks

$$\begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \end{bmatrix} = M(ap)$$

The Primal: Interactions between actors wrt sites

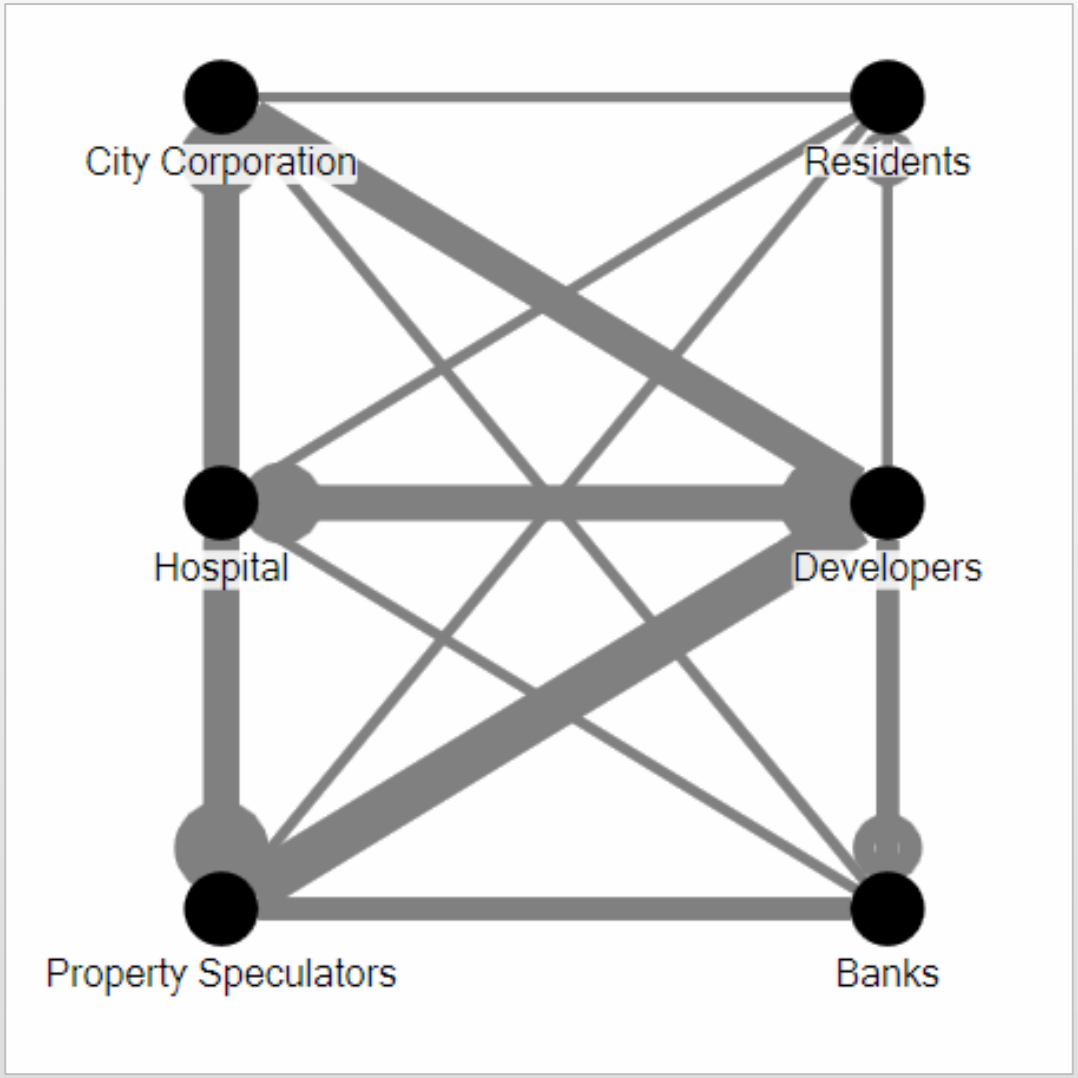
$$\begin{bmatrix} 3 & 1 & 3 & 3 & 3 & 1 \\ 1 & 1 & 1 & 1 & 1 & 0 \\ 3 & 1 & 3 & 3 & 3 & 1 \\ 3 & 1 & 3 & 5 & 4 & 2 \\ 3 & 1 & 3 & 4 & 7 & 2 \\ 1 & 0 & 1 & 2 & 2 & 2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

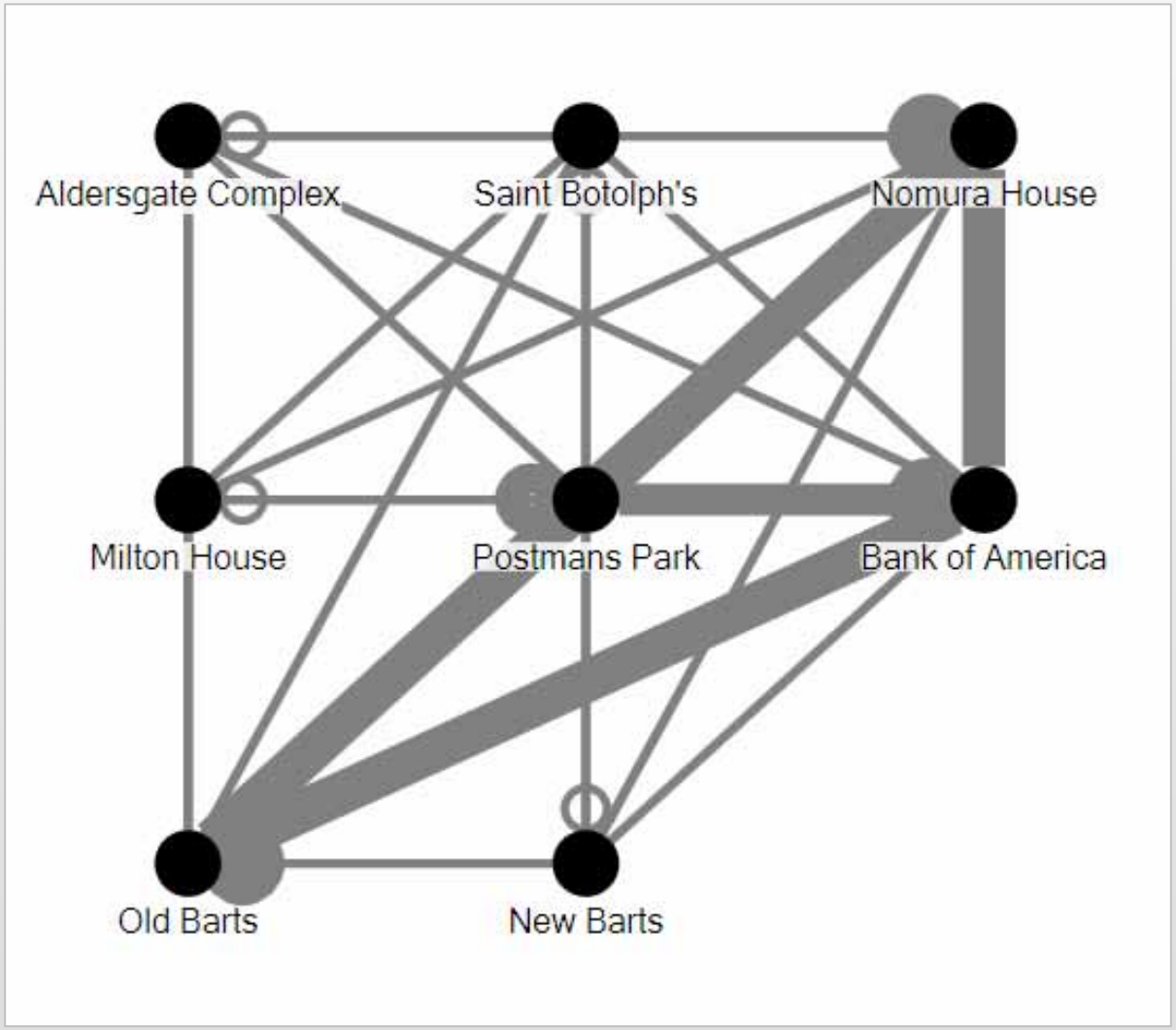
$$A = M \quad M^T$$

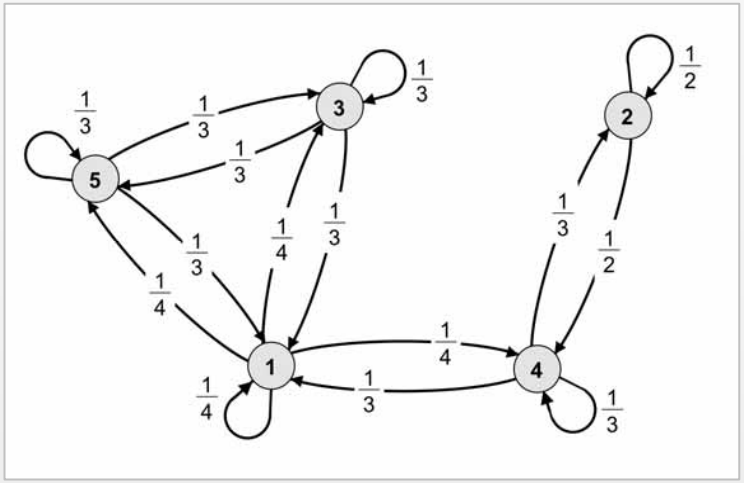
The Dual: Interactions between sites wrt actors

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 4 & 1 & 2 & 4 & 1 & 4 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 2 & 1 & 3 & 3 & 1 & 2 \\ 1 & 0 & 4 & 1 & 3 & 5 & 1 & 4 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 4 & 1 & 2 & 4 & 1 & 5 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \end{bmatrix}$$

$$S = M^T M$$


City Corporation
Residents
Hospital
Developers
Property Speculators
Banks


Aldersgate Complex
Saint Botolph's
Nomura House
Milton House
Postmans Park
Bank of America
Old Barts
New Barts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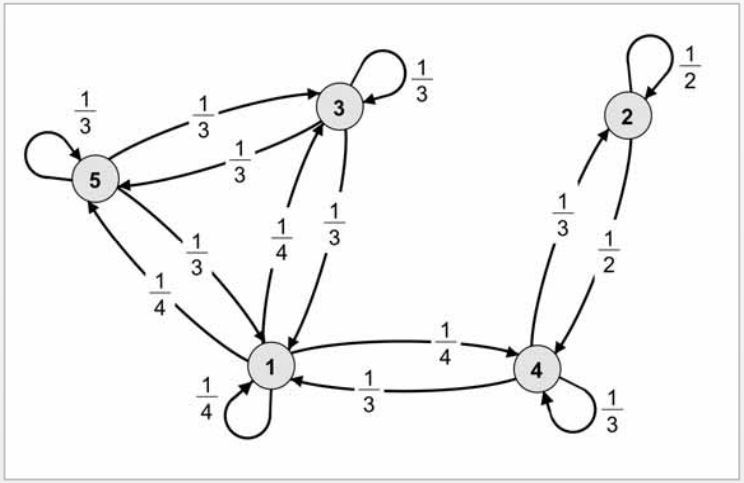
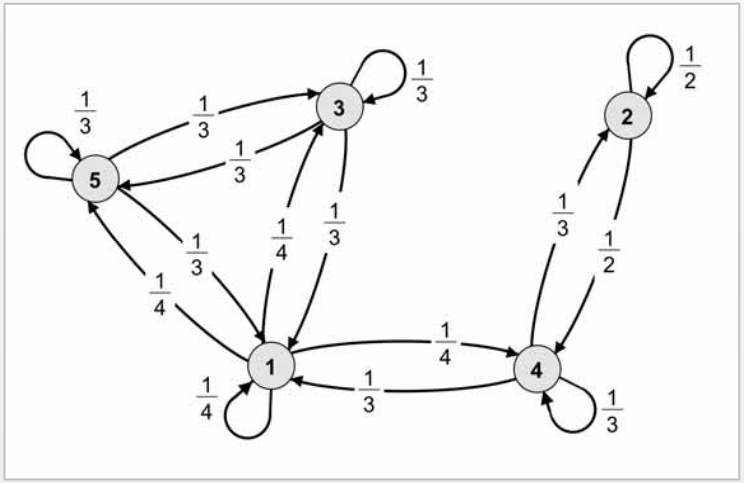
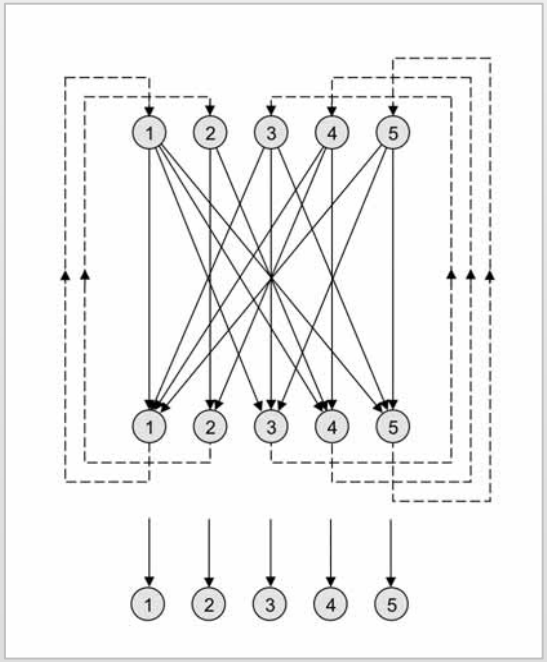
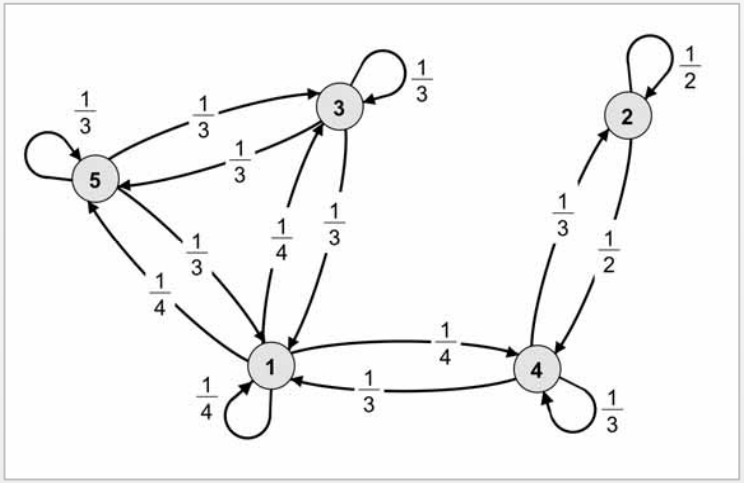


$$\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1/4 & 0 & 1/4 & 1/4 & 1/4 \\ 0 & 1/2 & 0 & 1/2 & 0 \\ 1/3 & 0 & 1/3 & 0 & 1/3 \\ 1/3 & 1/3 & 0 & 1/3 & 0 \\ 1/3 & 0 & 1/3 & 0 & 1/3 \end{bmatrix}$$

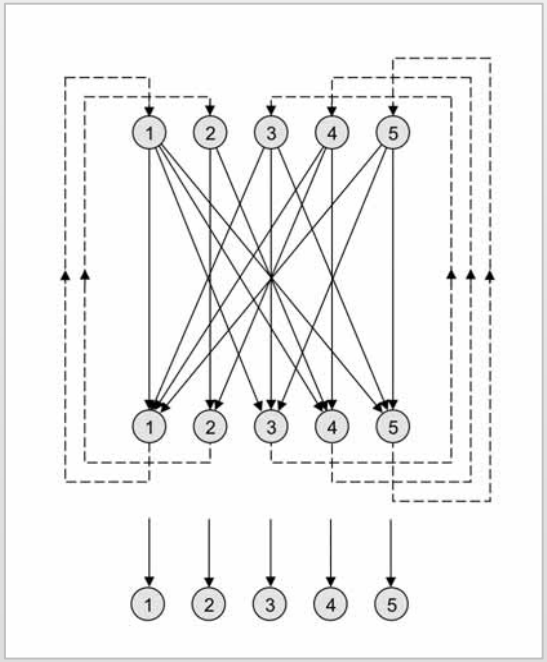


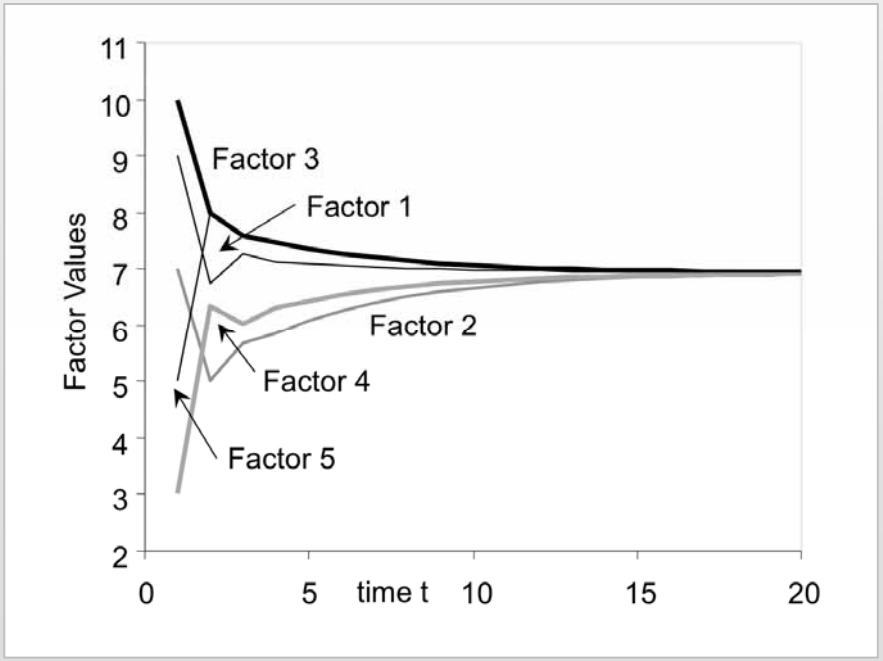
$$\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1/4 & 0 & 1/4 & 1/4 & 1/4 \\ 0 & 1/2 & 0 & 1/2 & 0 \\ 1/3 & 0 & 1/3 & 0 & 1/3 \\ 1/3 & 1/3 & 0 & 1/3 & 0 \\ 1/3 & 0 & 1/3 & 0 & 1/3 \end{bmatrix}$$





$$\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1/4 & 0 & 1/4 & 1/4 & 1/4 \\ 0 & 1/2 & 0 & 1/2 & 0 \\ 1/3 & 0 & 1/3 & 0 & 1/3 \\ 1/3 & 1/3 & 0 & 1/3 & 0 \\ 1/3 & 0 & 1/3 & 0 & 1/3 \end{bmatrix}$$





The Network Averaging X Set of Maps

3/14	1/14	3/14	3/14	3/14	1/14
1/5	1/5	1/5	1/5	1/5	0
3/14	1/14	3/14	3/14	3/14	1/14
3/18	1/18	3/18	5/18	4/18	2/18
3/20	1/20	3/10	4/20	7/20	2/20
1/8	0	1/8	2/8	2/8	2/8

0	0	1	0	0	1	0	1
0	0	0	0	0	0	0	1
0	0	1	0	0	1	0	1
0	0	1	0	1	1	1	1
1	1	1	1	1	1	0	1
0	0	0	0	1	1	0	0

yields

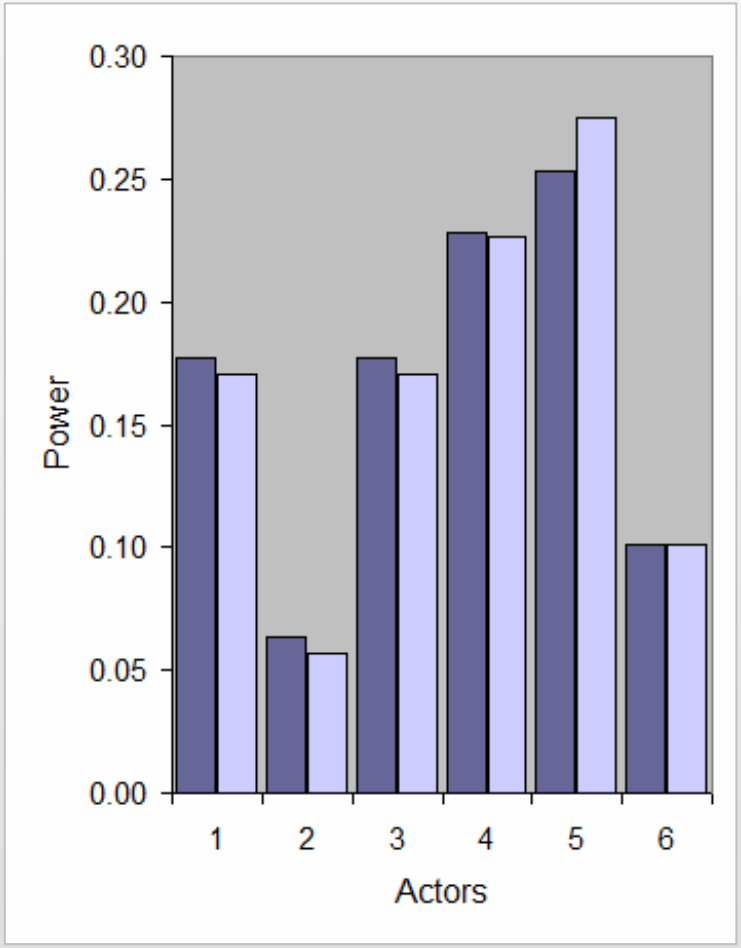
A New Averaged Set of Maps

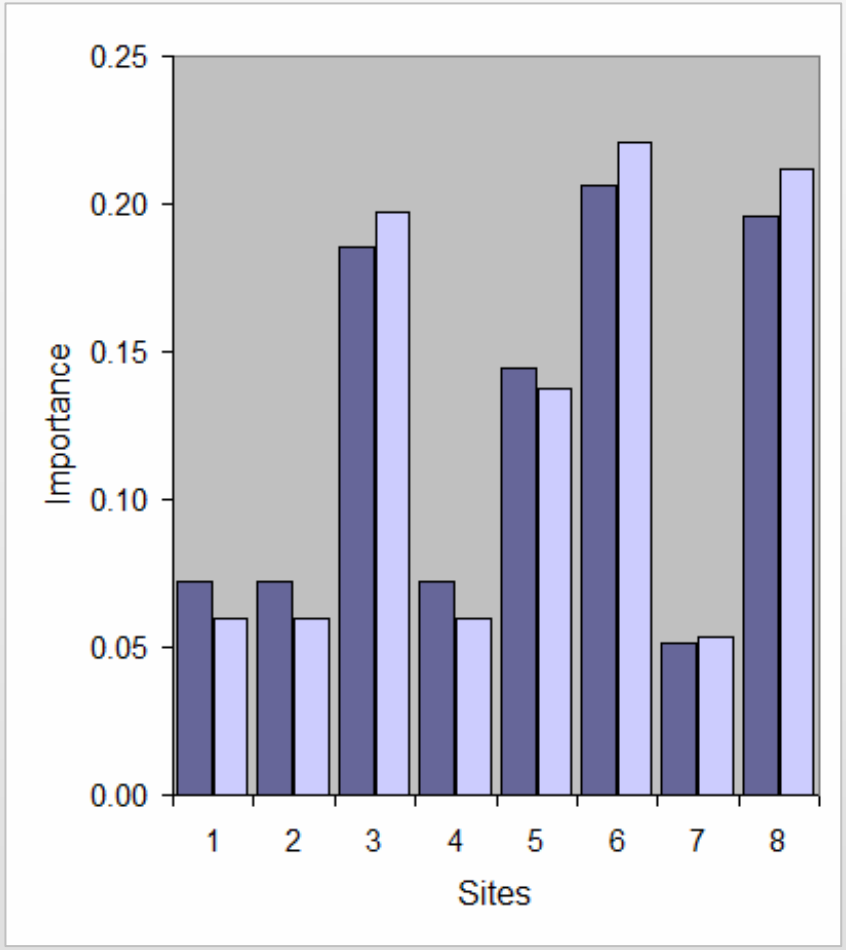
0.21	0.21	0.86	0.21	0.50	0.93
0.20	0.20	0.80	0.20	0.40	0.80
0.21	0.21	0.86	0.21	0.50	0.93
0.22	0.22	0.83	0.22	0.61	0.94
0.35	0.35	0.85	0.35	0.65	0.95
0.25	0.25	0.75	0.25	0.75	1.00

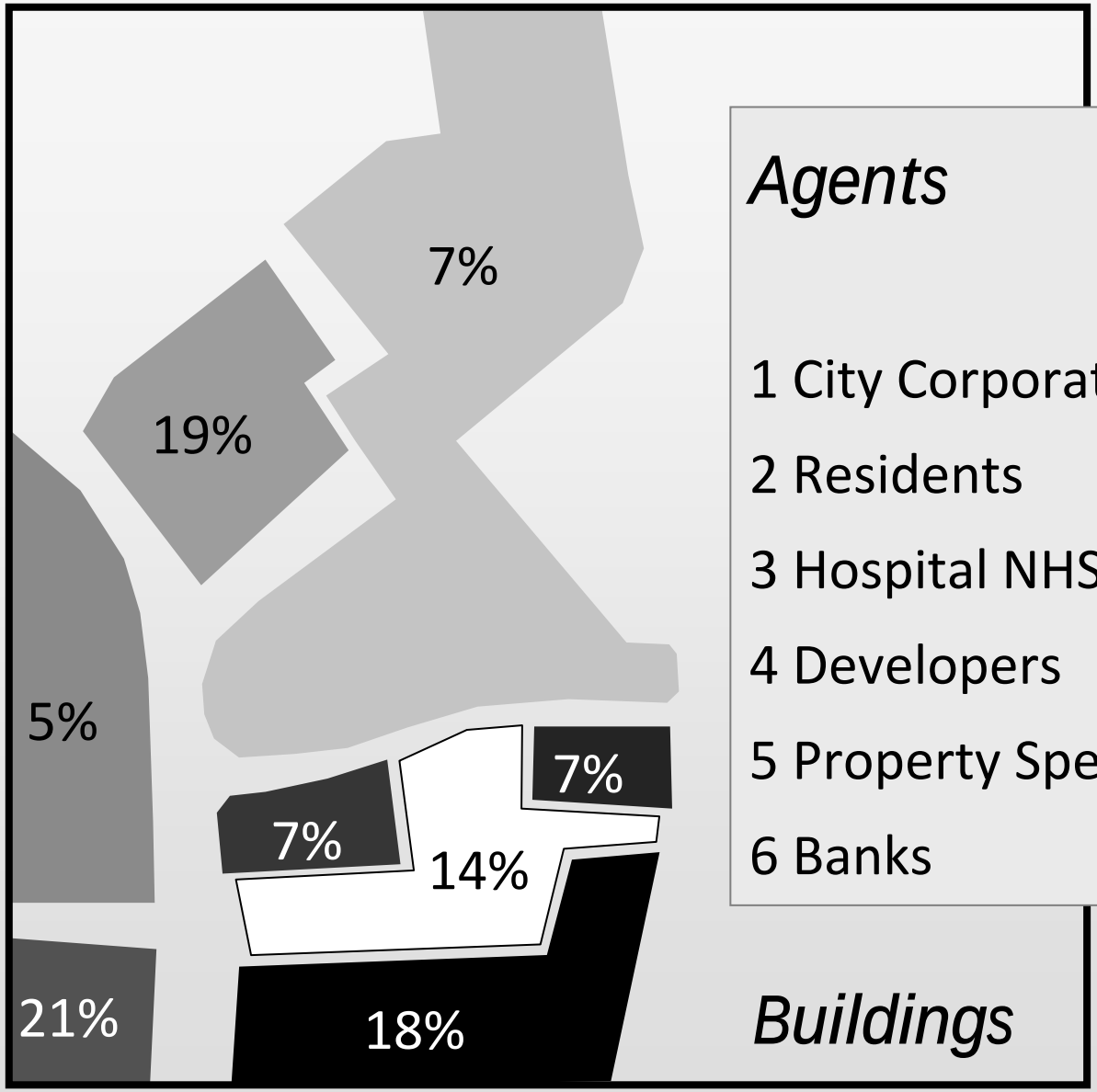
And then we average them again using the same network And this yields a new map, And so on until all the differences between the actors with respect to their maps are ironed out and we get the following map

0.25	0.25	0.84	0.25	0.58	0.94
0.25	0.25	0.84	0.25	0.58	0.94
0.25	0.25	0.84	0.25	0.58	0.94
0.25	0.25	0.84	0.25	0.58	0.94
0.25	0.25	0.84	0.25	0.58	0.94
0.25	0.25	0.84	0.25	0.58	0.94

We can do this on the dual problem, on the sites and iron out the differences between sites with respect to their actors


0.30
0.25
0.20
0.15
0.10
0.05
0.00
Power
1
2
3
4
5
6
Actors


0.25
0.20
0.15
0.10
0.05
0.00
Importance
1
2
3
4
5
6
7
8
Sites



Agents

1 City Corporation	17%
2 Residents	6%
3 Hospital NHS	17%
4 Developers	23%
5 Property Spec	25%
6 Banks	10%

Next Steps

Real problems – very large networks, types of connection

Intensity or desirability maps

Rational averaging, simple averaging, weighting averaging, dominance, and other strategies of compromise or not

The model is longstanding – not new, what is new is the dual primal and the embedding of maps into it

References over Many Yeaars

French, J. R. P. (1956) A Formal Theory of Social Power, Psychological Review, **63**, 181-194.

Batty, M. (1971) An Approach to Rational Design: Part 1: The Structure of Design Problems, Part 2: Design Problems as Markov Chains, **Architectural Design**, **41**, 436-439, 498-501

Batty, M. (1984) Plan Design and Committee Decision-Making, **Environment and Planning B**, **11**, 279-295.

Blondel, V. D., Hendrickx, J. M., Olshevsky, A., and Tsitsiklis, J. N. (2005) Convergence in Multiagent Coordination, Consensus, and Flocking, In **Proceedings of the Joint 44th IEEE Conference on Decision and Control, European Control Conference**, Seville, Spain, December 12-15, 2005,