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URBAN FLOWS OBSERVATORY

RISE
Resources, Infrastructure Systems & built Environments

Multi-Scale, circular economic potential of a nation's building stock

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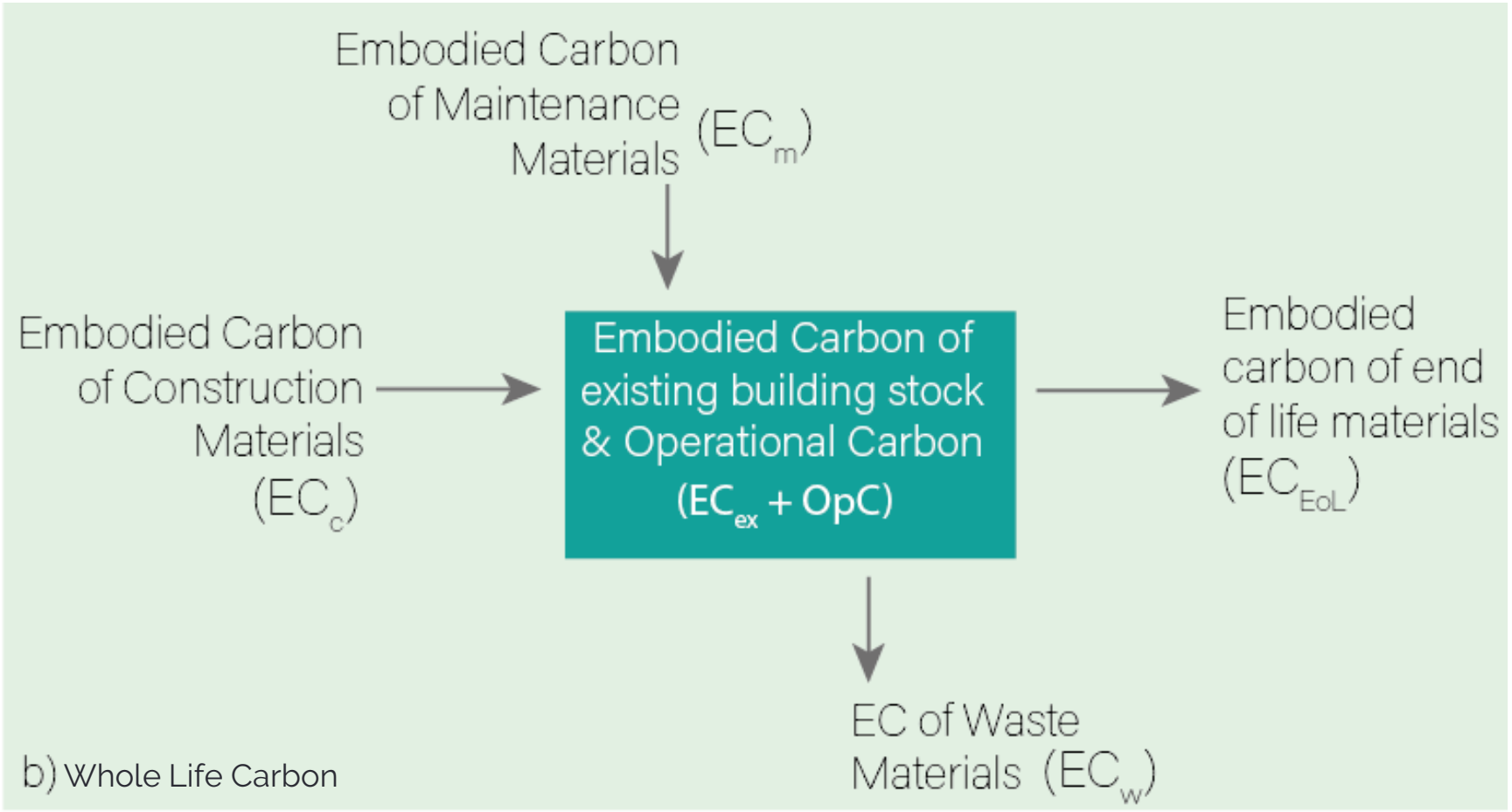
Long Term Research Vision

- Generate detailed, multi-scale understanding of material flows and stocks in the built environment
- Provide evidence & estimates of opportunities for embodied carbon reduction & circular economic flows
- Leverage CE opportunities to develop component/material reuse/recycle roadmaps to reduce demand for new materials
- Inform design of individual buildings & local and national planning policy

Resource Efficient Cities & Nations

Interdependencies of Material & In-use Energy Systems (long term goal)



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Urban Flows Observatory Sheffield Case Study

urbanflows.ac.uk

@urbanflowsObs

What is Sheffield made of?

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- What materials & where?
- – Using MARVeL (Multispectral Advanced Research VEhicLe) to capture remote sensing data & applying machine learning

Also, need to know:

- New build rate, construction types & material demand
- Where are unused buildings?
  - How could these be repurposed?
- Demolish rate & construction types
  - Reuse potential

MARVel
Multispectral Advanced Research VehicLe

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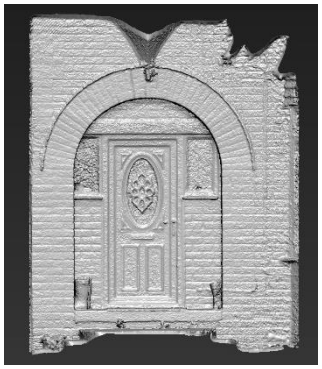
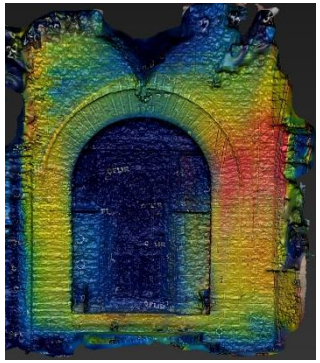
LiDAR Unit x 4
- 100m Range
- Up to 600,000 Points per Second

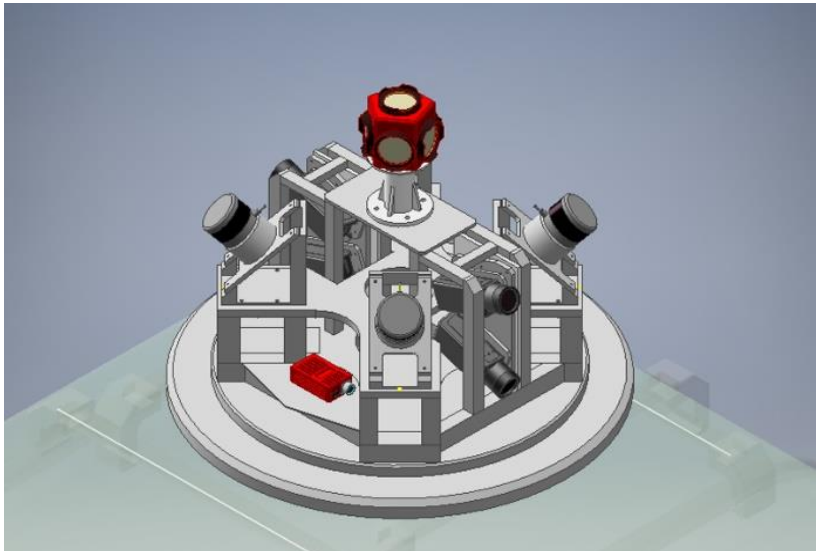
Visual Camera Unit
- A 360º spherical camera, 90% of full sphere.
- 30 MP (5 MP x 6 sensors)

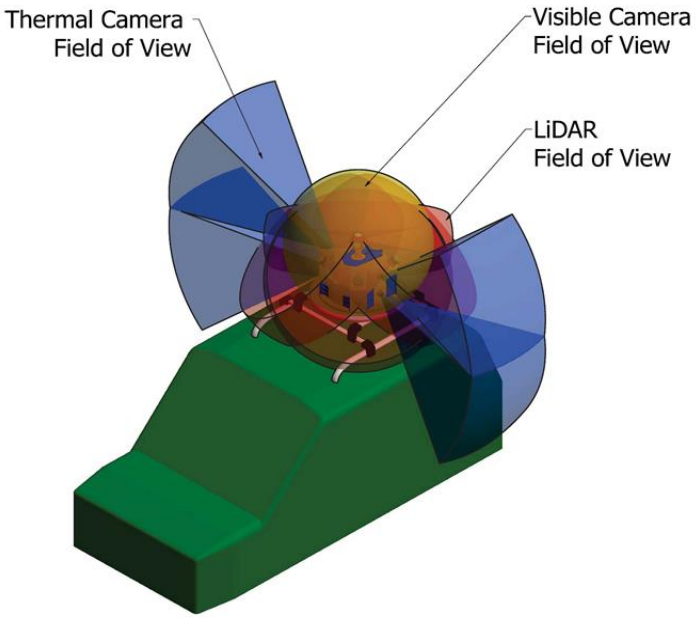
Thermal Camera x 4
- Resolution of 640 × 512

Hyperspectral Camera
Spec TBC









Machine Learning Workflow

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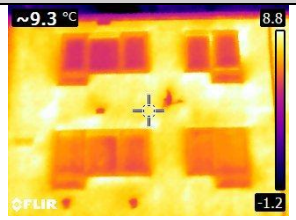
ML can recognise buildings and materials.

ML cannot currently recognise IR image.

Initial training with Tensorflow successful.

ML workplan in development.

Tensorflow

FOUR WINDOWS TESTS							
5	FLIR0009.jpg		Four windows but of different shapes.	0.11753	0.88247	0.01661	0.98339

Overview

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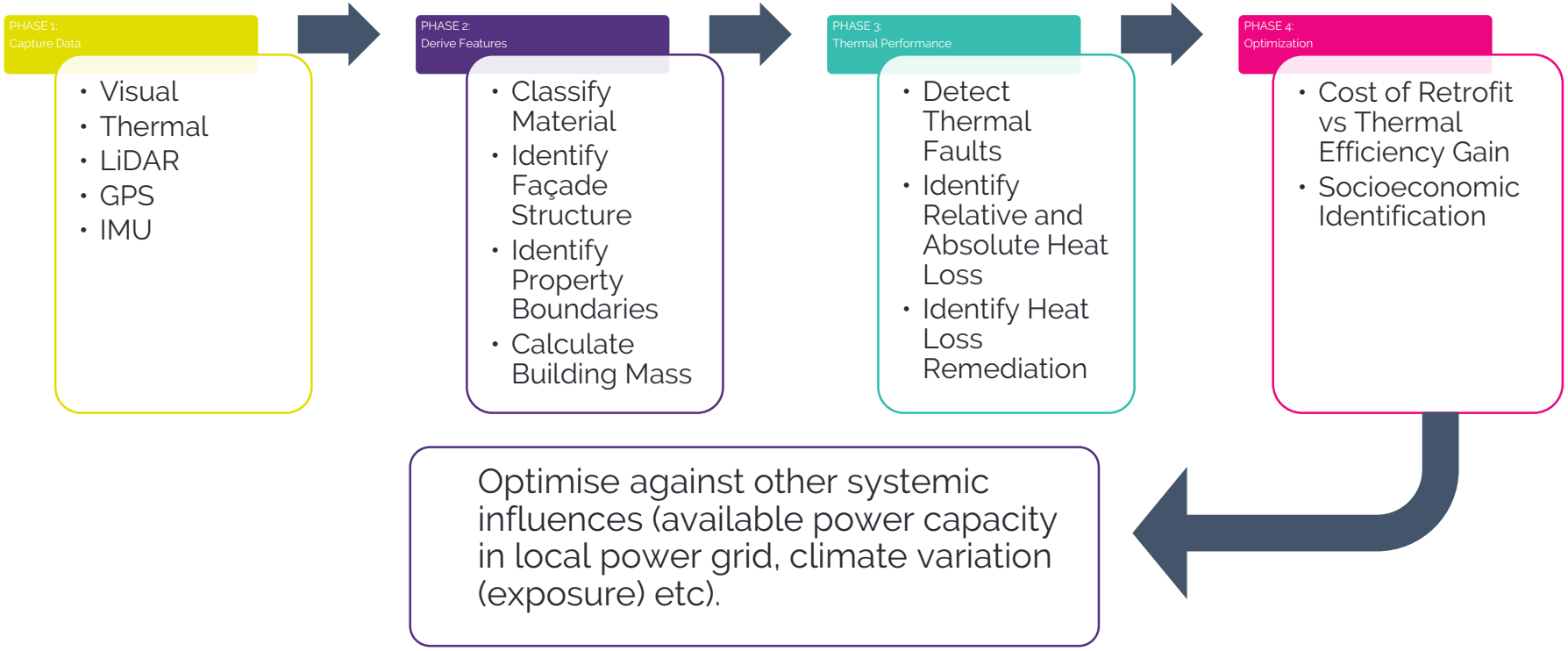
Develop an “integrated mobile sensing platform that creates high resolution, mutli-spectral 3D urban surface maps, to classify materials and thermal performance, and prioritise retrofit investment.”



Phase 1: Capture Data

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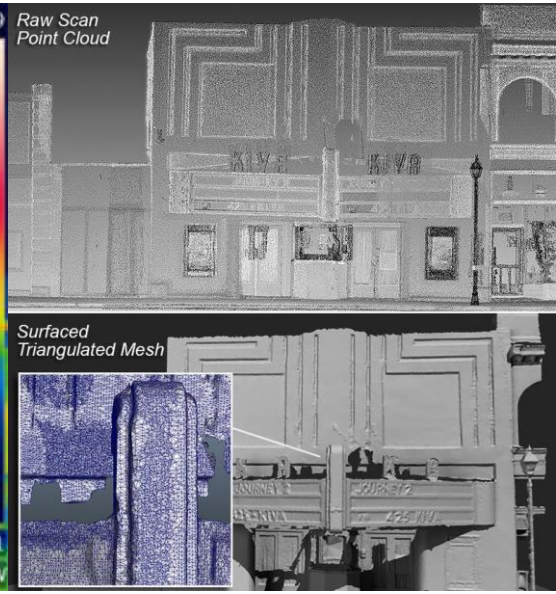
Develop an integrated mobile sensing platform to collect visual, thermal and 3D image capture (i.e. laser scanning) data.

Visual

Thermal



LiDAR

Phase 2: Derive Features

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Develop a workflow for automatic detection of buildings with heterogeneous appearance, classification of building materials and identification of building façade structures.

Phase 3: Thermal characteristics

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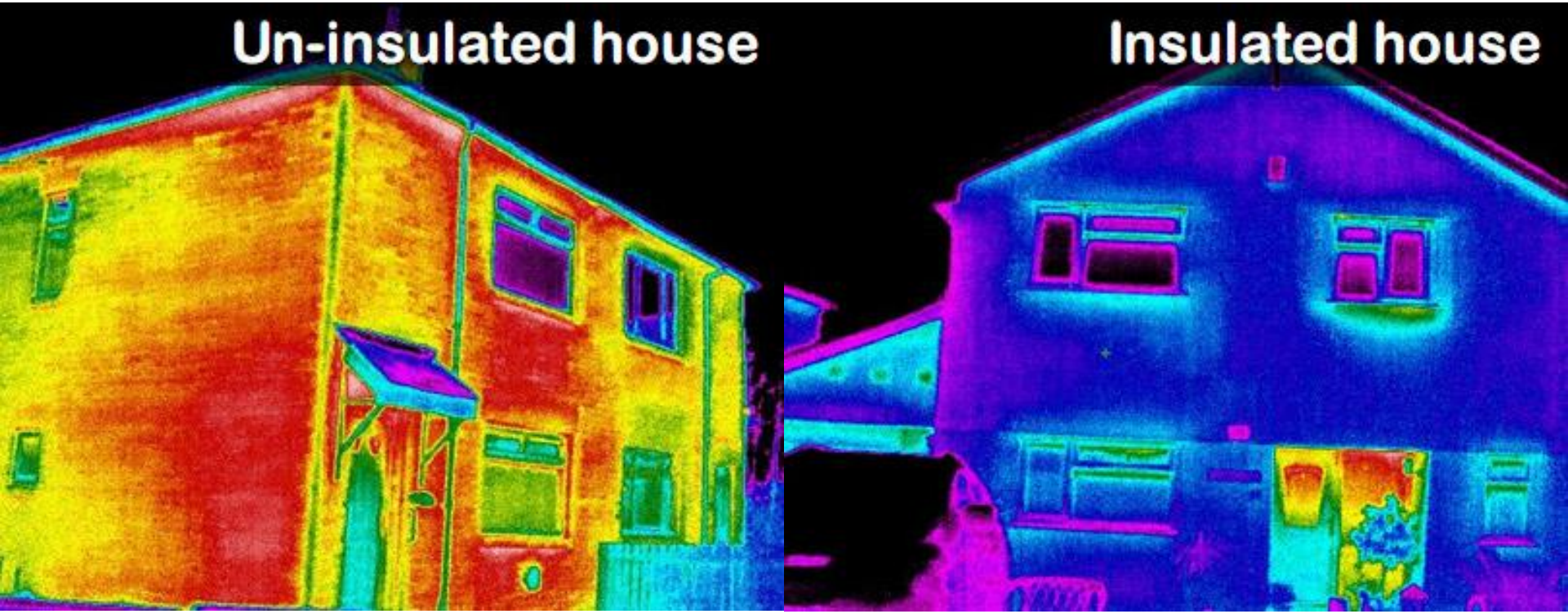
Develop a workflow for automatic classification of the thermal characteristics of the built environment.



Phase 4: Optimisation

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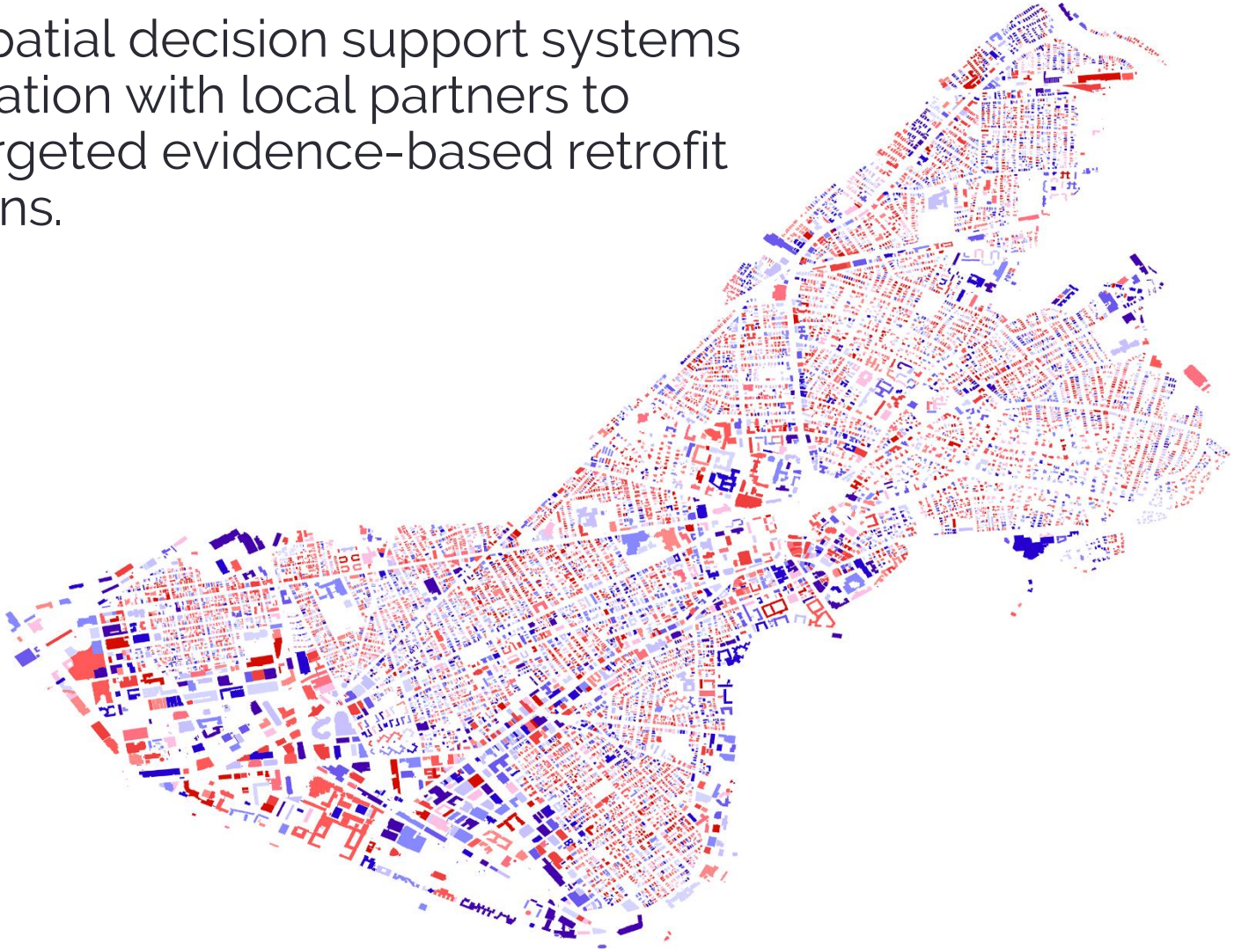
Develop spatial decision support systems in collaboration with local partners to support targeted evidence-based retrofit interventions.



Cataloguing City Assets

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- 475,000 bricks in a street
- 75% of area pre-1925 construction, 3% 1925-1955, 22% Post 1955
- Can estimate that 364,800 bricks could be salvaged in the future
- Price of a new face brick approx. 75p
- Asset value: £273,600
- Embodied Carbon stock: 200,640 $kgCO_2$

Age	Mortar types in Europe	Assumed reusability
Pre-1925	Likely to be lime mortar	100%
1925-1955	Could be lime, cement, or a mixture	60%
Post-1955	Likely to be cement	0%

Adapted from Nordby et al. (2009)

Understanding 'What Sheffield is made of' leverages:

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- An estimation of the circular economic potential of current stocks
  - Identification of buildings with high reuse potential – deconstruct rather than demolish
- An understanding of how embodied carbon is distributed across the city
  - Maintain asset value of buildings with high embodied carbon – extend life & retrofit
- Adapt disused space instead of new build
  - Reduce material demand

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Multi-Scale CE of Non-Residential Stock

(Research Proposal Under Review)

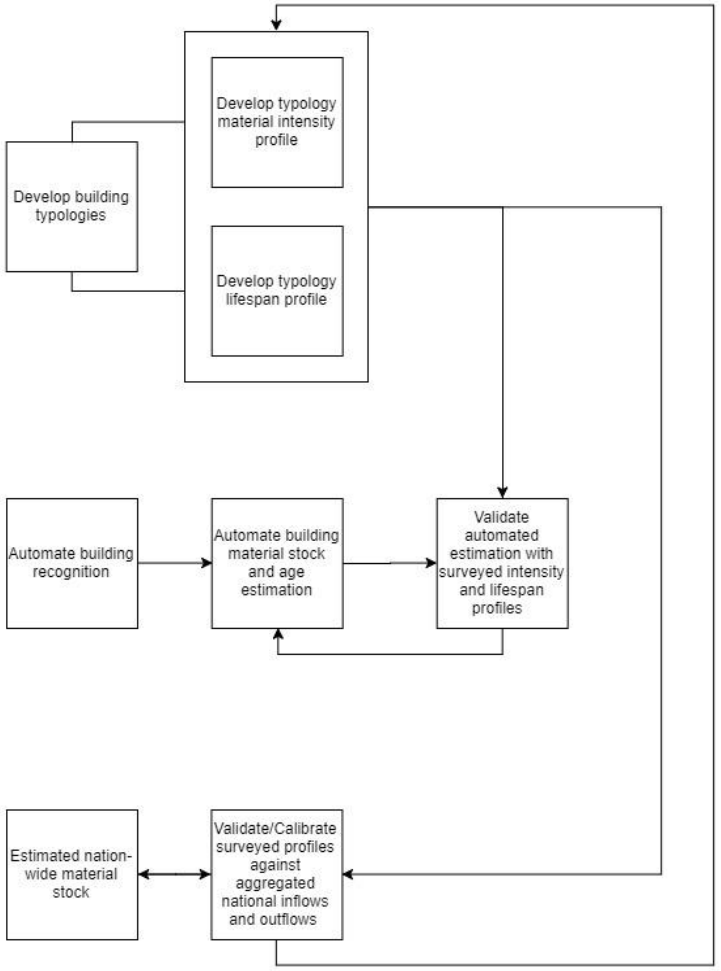
Circular Economy Across Scales

Bottom up MFA of Case Study Buildings, assess:: material intensity, embodied carbon & CE potential

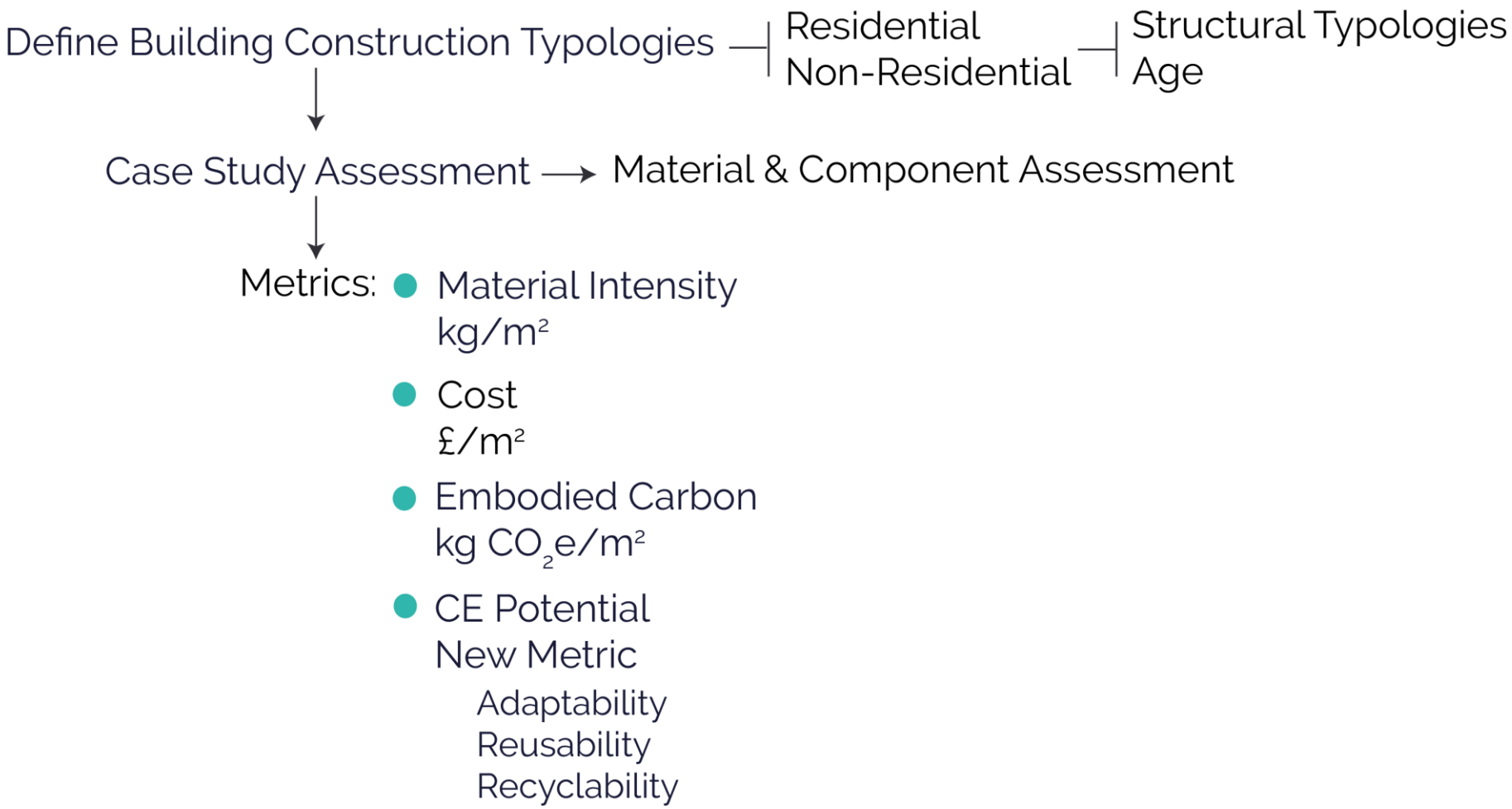
Estimate city level material stock – comparison with Urban Flows Sheffield assessment

Extrapolate country wide UK stocks

Demand Modelling to predict future material demand – what % could outflows meet?



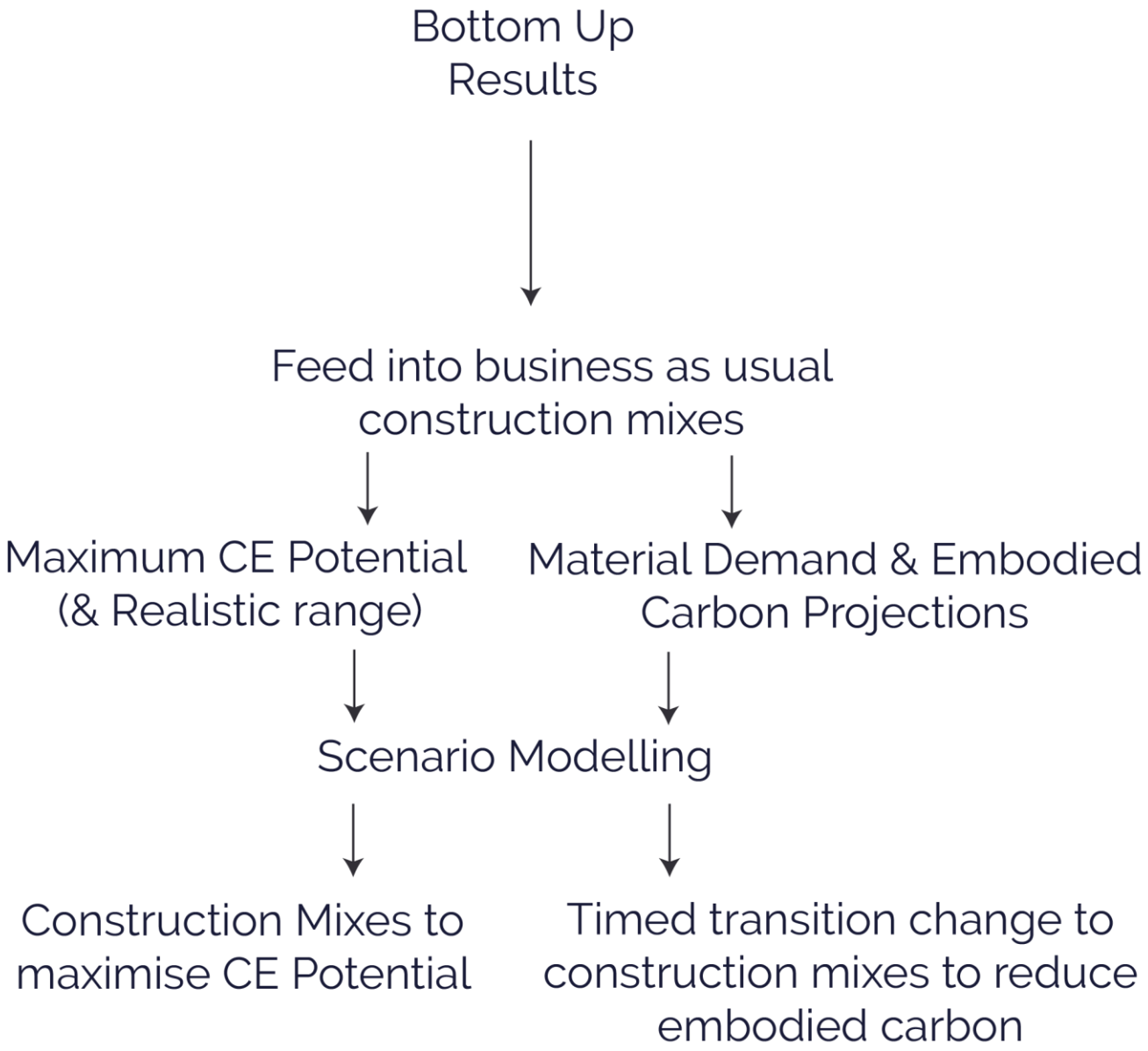
Bottom-up MFA



City Level Approach

- Sheffield, UK case study
- Cross-validation – bottom-up modelling with Urban Flows Remote Sensing Data (particularly façade materials)
- Compare high resolution remote sensing data with satellite data
  - can you apply machine learning techniques to satellite data to automate recognition of roof & façade materials?

Future Demand Modelling



Key Research Questions

- Is a national stock model representative of individual cities? Or do different cities have their own typology patterns?

- How does the building stock affect a country's consumption patterns?

- To what extent could CE reduce a country's built environment material consumption?

- What are the impacts & future implications of built environment resource consumption on a country's carbonisation pathways?

Key Planned Outcomes

- Multi-scale framework developed & applied to UK non-residential buildings
- Understanding of relationship between individual building design & long term material demand projects & embodied carbon for construction in UK
- Implications for building design
- Implications for local & national planning