Maritime shipping digital twin for construction waste distribution

Dr. Evi (Evangelia) Manola
Prof. Liz Varga

Industrial Partner: National Highways

Infrastructure Systems Institute | UCL Department of Civil, Environmental and Geomatic Engineering

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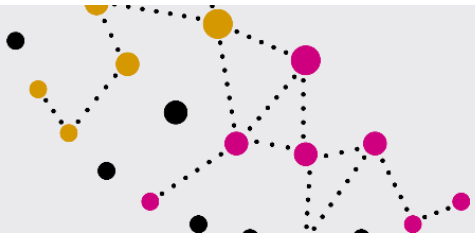
The Interdisciplinary Circular Economy Centre for Mineral-based Construction Materials (ICEC-MCM)



MCM flows, stocks & impacts

- 1A. Material flow analysis (MFA)
- 1B. Data needs
- 1C. Impact & risk characterisation
- 1D. Environmental & social life cycle assessment (LCA)
- 1E. Socio-economic impact modelling

Technological innovation for MCM demand Reduction, circularity & impact reduction

- 2A. Design
- 2B. Material processing
- 2C. Manufacture
- 2D. Service
- 2E. Closing the Loop

Systemic enablers for MCM circularity

- 3A. Circular Economy Business models (CEBMs)
- 3B. Eco-design
- 3C. Decision-making
- 3D. Accounting & Finance
- 3E. Standards, policy & regulation

UKRI Interdisciplinary Circular Economy Centre for Mineral-based Construction Materials

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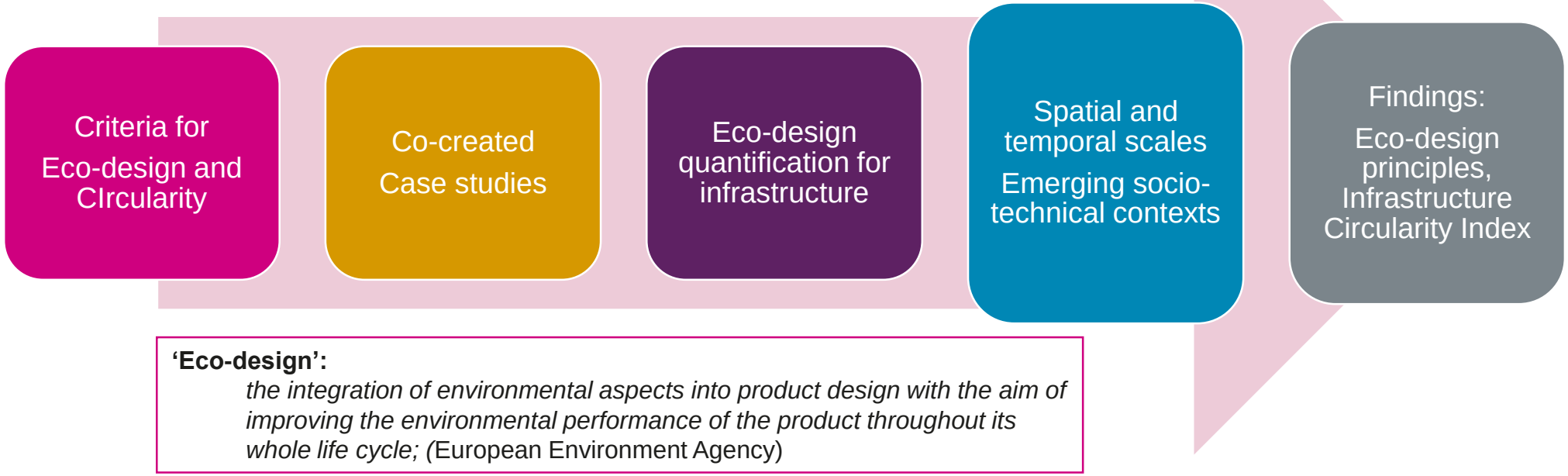
PROJECT AIM, OBJECTIVES

Project aim: Eco-design characterisation of MCM use in infrastructure, engineering and construction with the application of Circular Economy principles

Objective: To provide eco-design characterisation of MCMs and use this to develop eco-design principles applicable for different relevant spatial and temporal scales, and socio technical contexts.



'Eco-design':
*the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle; (*European Environment Agency)

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EXPECTED IMPACT

- Validated eco-design framework with actionable interventions in transport infrastructure
- Business practice changes
- Digital technology use
- MCM wastage management
- Natural resources management
- Over-design problems
- Collaboration of stakeholders

ECO-DESIGN PRINCIPLES

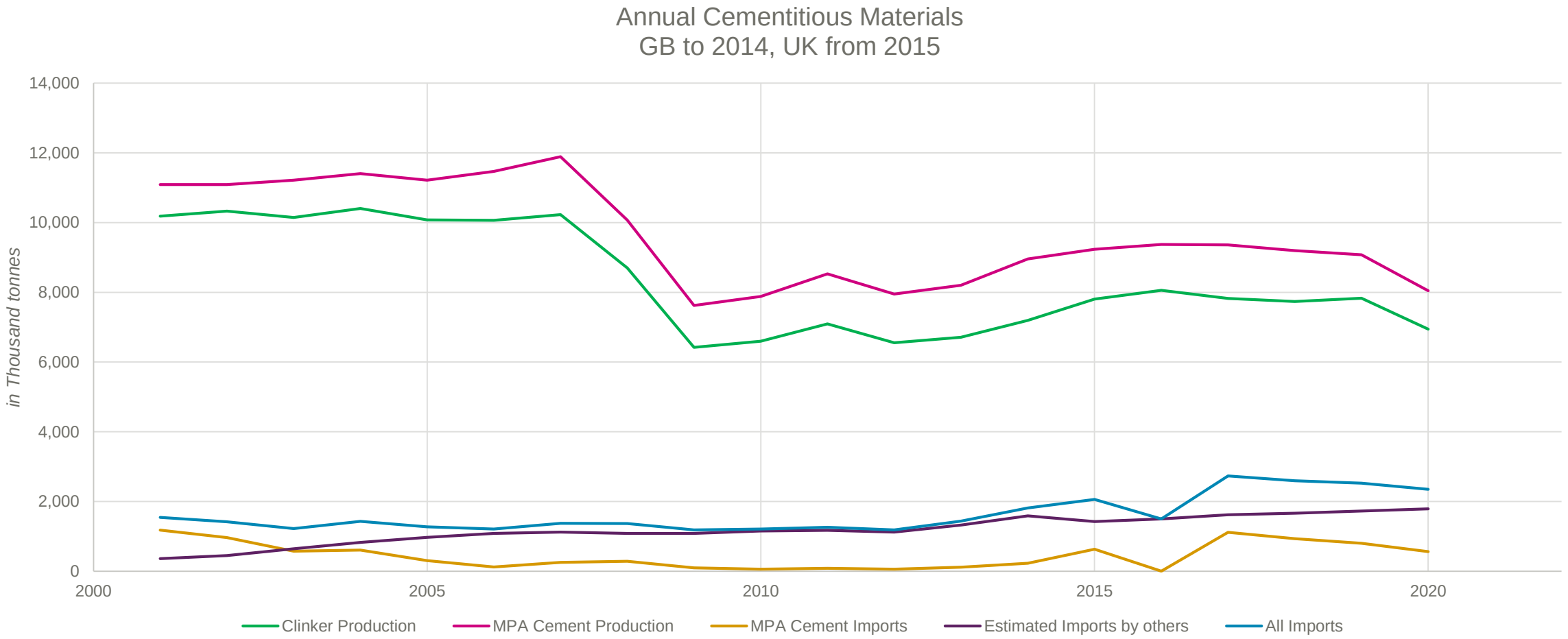
- Modular design & construction
- Reuse of waste products & assets
- Use & distribution of waste materials
- Data & Intelligence
- Modal integration
- Natural environment impact
- Maintenance & Durability
- Human factor

Principles relevant to maritime shipping case study

- Use & distribution of waste materials
- Data & Intelligence
- Modal integration
- Natural environment impact

- Human factor

MPA DATA – CEMENT IMPORTS



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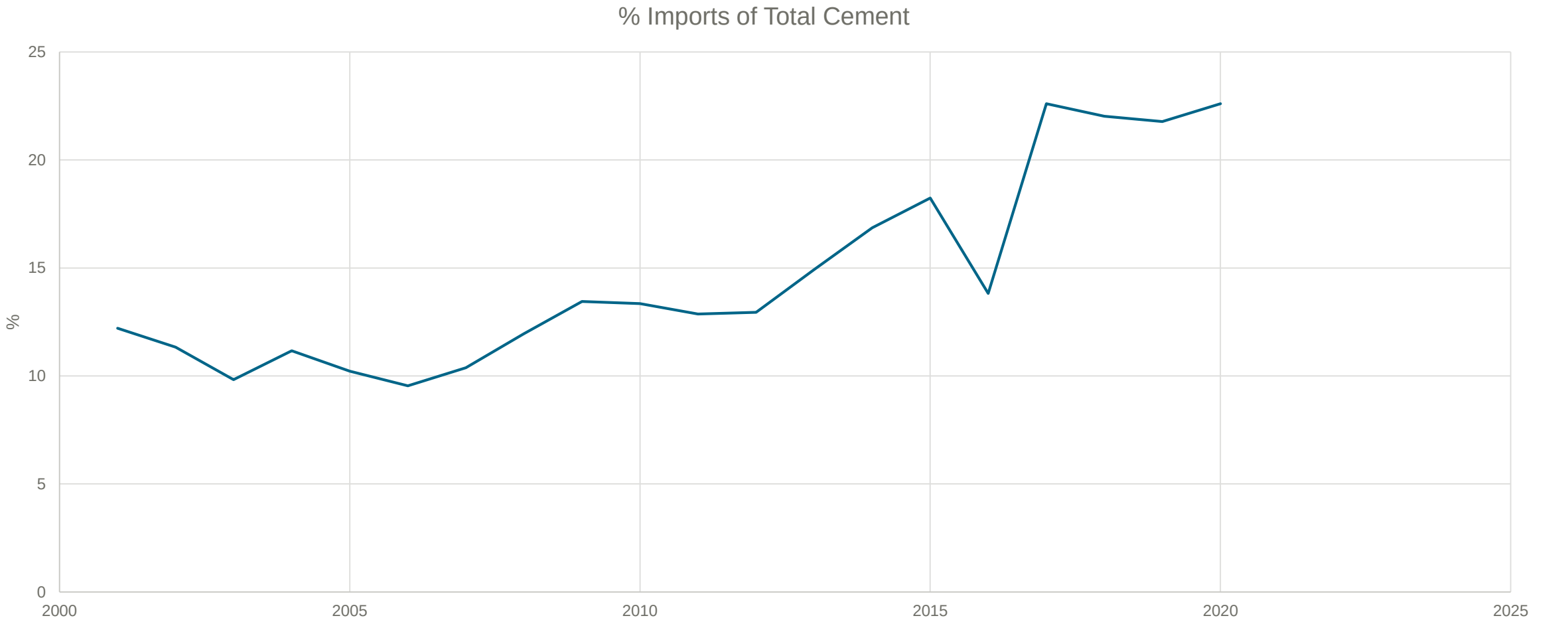
MPA DATA – CEMENT IMPORTS



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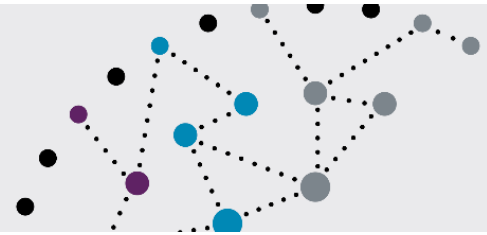
IMPACT ON ROADS

- Rule of thumb 1950s
- Road damage estimation - Generalized Fourth Power Law
- Comparing the amount of pavement damage caused by vehicles with different weights, in terms of axle loads:

$$\left(\frac{W_1}{W_2}\right)^4$$

3rd Pillar in maritime shipping: DECARBONISATION



International maritime trade currently rests on two contractual pillars:
Safety & commercial orders.
3rd Pillar: Decarbonisation, i.e. *'a contractual framework for decarbonisation actions and measures that will trump commercial orders, but will yield to safety.'*

Need for a new contractual structure for Maritime decarbonisation

"Steam Fast, Then Wait" (SFTW): '*ships sail to their port of destination at their service speed, without regard for the conditions at that port. Largely as a result of this, dry bulk carriers and tankers spend about 8-10% of their entire life at anchorage.'*

Just-in-Time (JiT) practices, *'which are widely adopted in supply chains, would result in emissions' savings in the order of 20-25%.'*

https://www.gard.no/web/updates/content/32513672/the-third-pillar-a-contractual-architecture-for-maritime-decarbonisation

INNOVATIONS IN SHIPPING

Autonomous electric maritime shipping →
Common policy framework as autonomous vehicles

Yara Birkeland (Norway):
"The first ever zero emission, autonomous ship"

https://www.kongsberg.com/maritime/support/themes/autonomous-ship-project-key-facts-about-yara-birkeland/

Oceanbird, wing sails
Reducing cargo carbon emissions by 90%

https://newatlas.com/marine/oceanbird-wallenius-wing-sail-cargo-ship/

MARITIME SHIPPING DIGITAL TWIN

Modifying the way waste is distributed:
Minimizing trucks off the roads
Modal integration of roads and sea transportation

Data from website – live tracking

Daily location update connected to our database

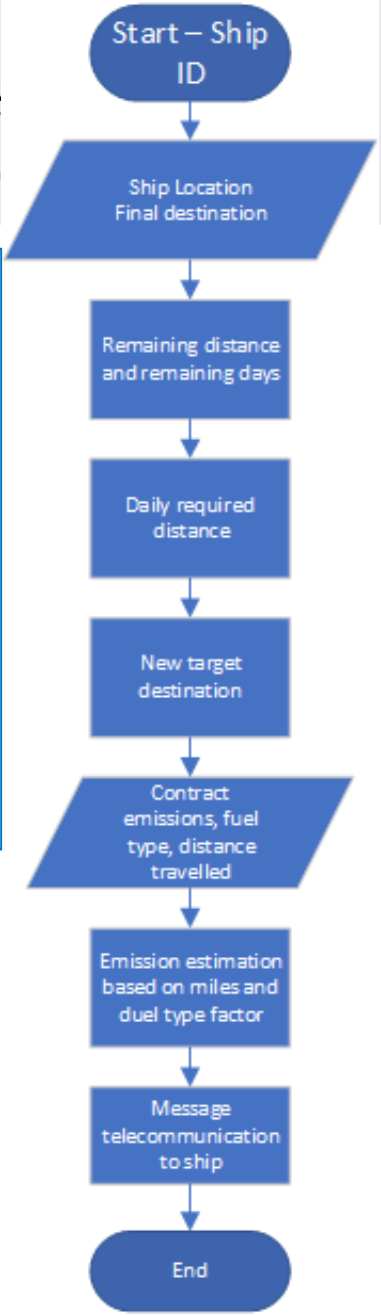
Estimation of daily distance travelled and emissions produced

Calculation of required daily travel

Checking if it is rushing!!

Giving feedback to the ship with emissions value and if they need to go slower or not

- Ships that carry construction materials (cement carriers)
- Bringing in required materials
- Getting rid of materials not needed
- Digitalization of ports
- Autonomous electric ships
- Focus on domestic transportation of construction materials via sea (port to port)



API services for maritime data

‘Marinetraffic.com’ API services

Vessel Positions of a Static Fleet

Vessel AIS Identifier (MMSI)
Position Data (LAT, LON)
Navigation Data (Heading/Course/Speed)
Timestamp
Key Vessel Particulars (flag, dimensions, type etc.)
Voyage Information (destination, ETA, etc.)

API – Data scraping

mmsi	imo	ship_id	lat	lon	speed	heading	course	timestamp	shipname	callsign	flag	length	width	draught	year_built	type_name	destination	eta
224655000	8012267	167790	43.80758	-7.4546	113	274	276	2022-06-24 T05:21:42	ENCOFRADOR	EASS	ES	107	17	70	1982	Cement Carrier	ESVIG	2022-06-25 T01:00:00
255806478	9884655	6518982	52.01331	-5.79166	134	359	359	2022-06-24 T05:29:19	CEMCOASTER	CQET3	PT	97.98	15.62	46	2021	Cement Carrier	DUBLIN	2022-06-24 T15:00:00
224655000	8012267	167790	43.81936	-7.8554	103	267	268	2022-06-24 T06:55:32	ENCOFRADOR	EASS	ES	107	17	70	1982	Cement Carrier	ESVIG	2022-06-25 T01:00:00
255806478	9884655	6518982	52.39397	-5.81713	121	356	356	2022-06-24 T07:13:08	CEMCOASTER	CQET3	PT	97.98	15.62	46	2021	Cement Carrier	DUBLIN	2022-06-24 T15:00:00
224655000	8012267	167790	43.77353	-8.17294	105	256	256	2022-06-24 T08:15:22	ENCOFRADOR	EASS	ES	107	17	70	1982	Cement Carrier	ESVIG	2022-06-25 T01:00:00
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255806478	9884655	6518982	52.9193	-5.84496	86	359	359	2022-06-24 T10:43:08	CEMCOASTER	CQET3	PT	97.98	15.62	46	2021	Cement Carrier	DUBLIN	2022-06-24 T15:00:00
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Outcome intelligence of digital twin

- Carbon emissions estimation on each ship journey
- Potential emission savings if following digital twin advice (ETA journey estimation to adjust speed)
- Potential emission savings with electric ships

Dr. Evi Manola
e.manola@ucl.ac.uk
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l.varga@ucl.ac.uk

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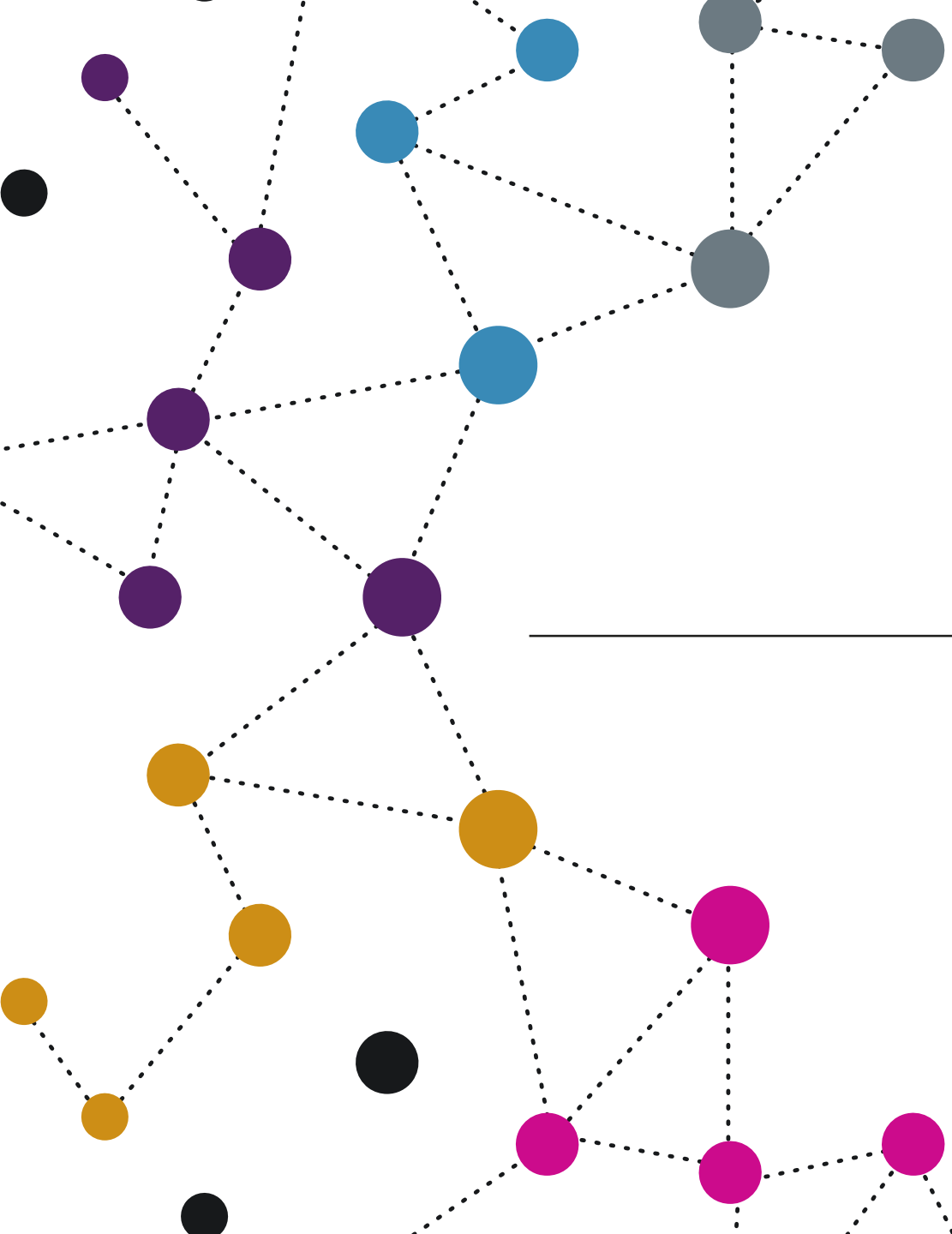

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