Fluid dynamics of urban tall building clusters for resilient built environments (FUTURE)

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Outline

- Background
- Objectives & strategy
- Team & Partners
- Plan & Work Package structure
- Communication & management

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Tall buildings and structures

- Historically – for the greater glory of rulers, religions, empires.

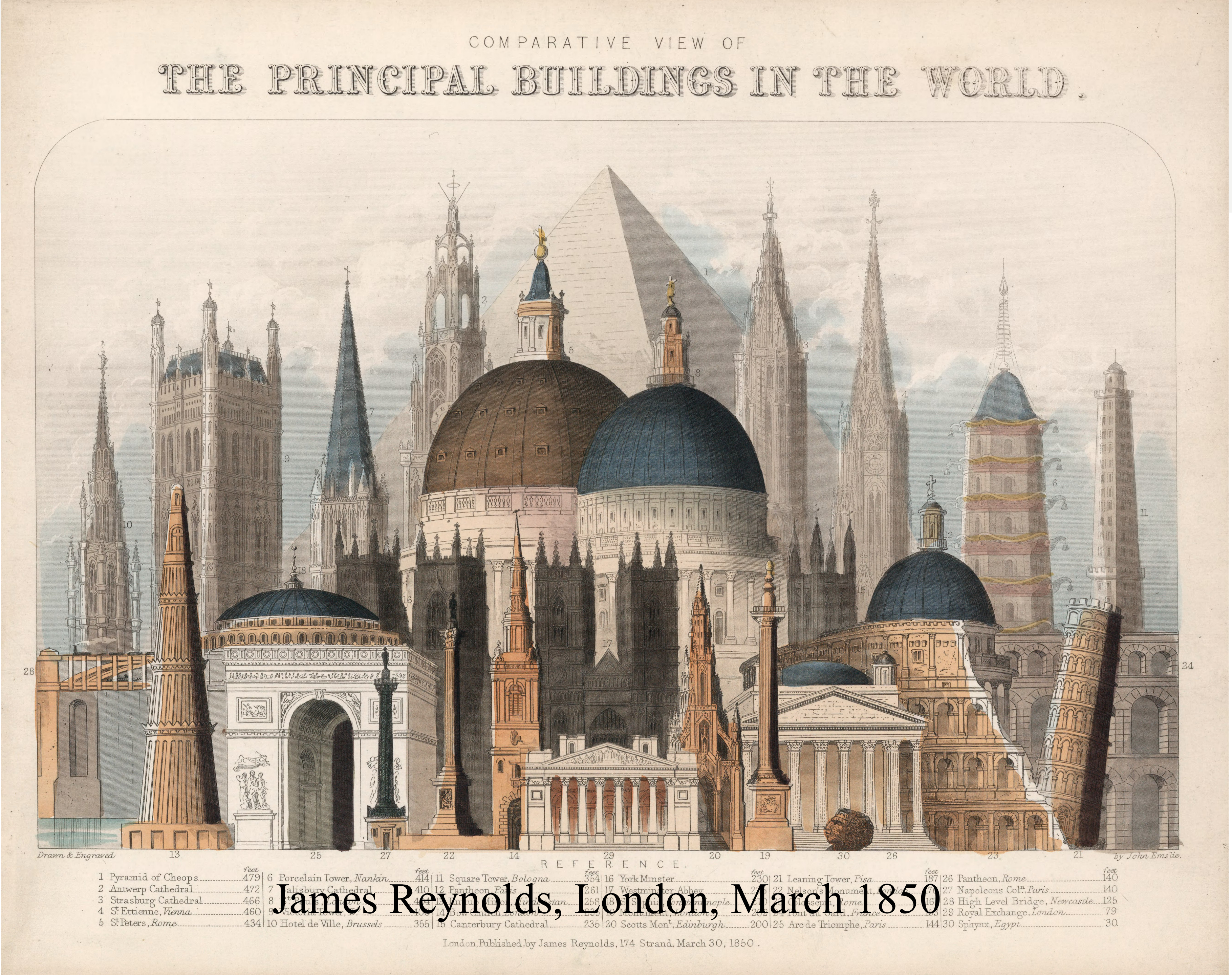
- Great Pyramid of Giza ~ 145 m high, for almost 4,000 years, the tallest man-made structure.

- 1311-1549, 160 m Lincoln Cathedral spire.

- 1885-1931, First skyscraper: Home Insurance Building, Chicago; 42 → 55 m.

    - 1957, Frank Lloyd Wright, Mile-High Illinois

- 2010, Burj Khalifa in Dubai, 828 m.



James Reynolds, London, March 1850

… for many practical reasons

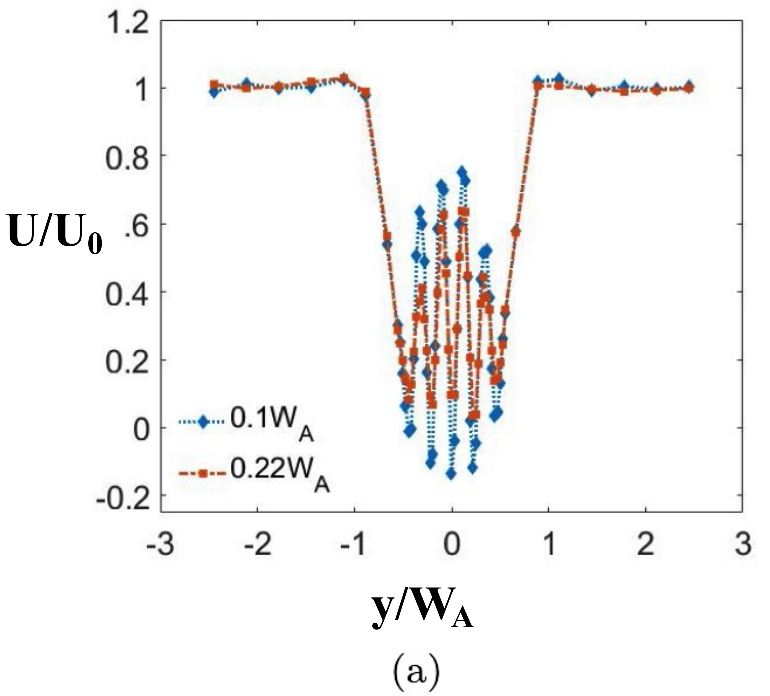
… large buildings

… often come together in groups

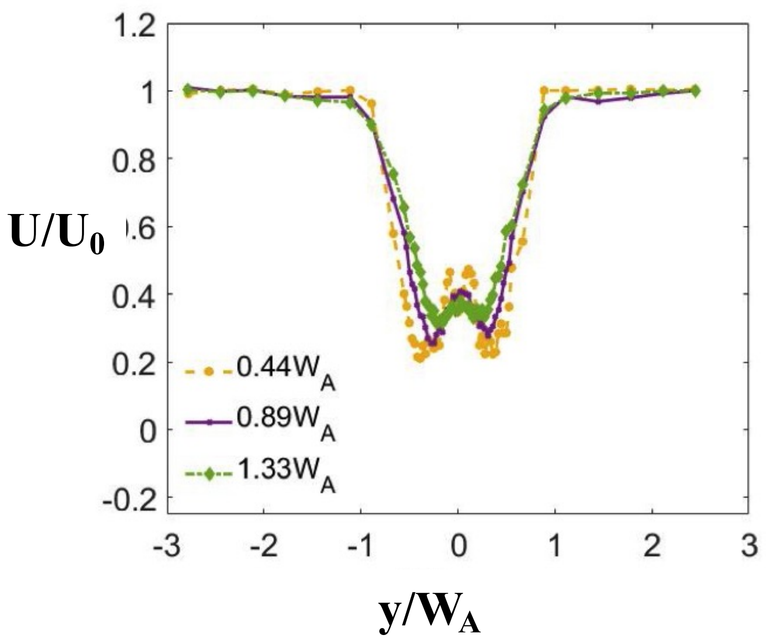
… and there's the rub.

London skyline

- Tall: height not less than 6 storeys or 18 m to upper storey floor level (London plan, 2021).
- Not very tall, really …
- New London Architecture (2020):
- At outset of FUTURE, 587 tall buildings proposed, approved or under construction.
- Average height 29 storeys (more than 100 m).



(a)

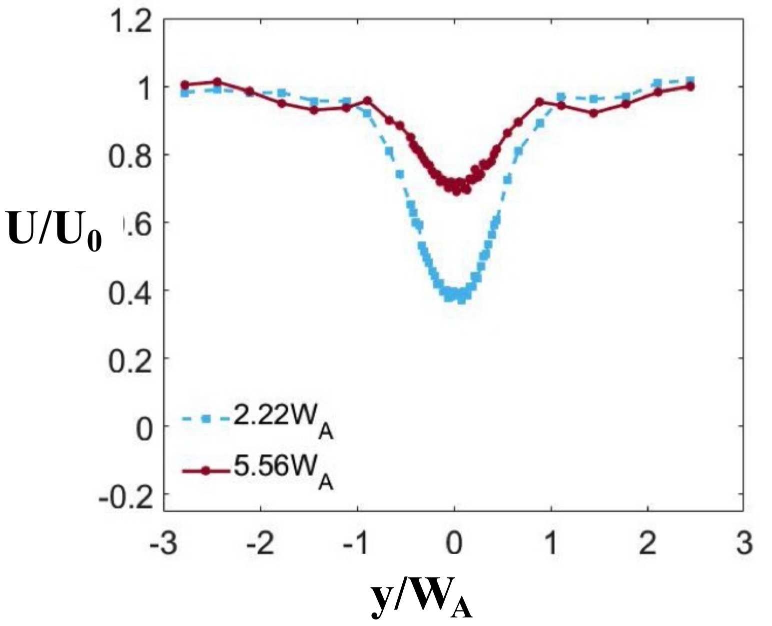


(b)

5 x 5 aligned array, 25% area density

Lateral profiles of mean flow at $z = H/2$

W_A = array width = $9W_B$.



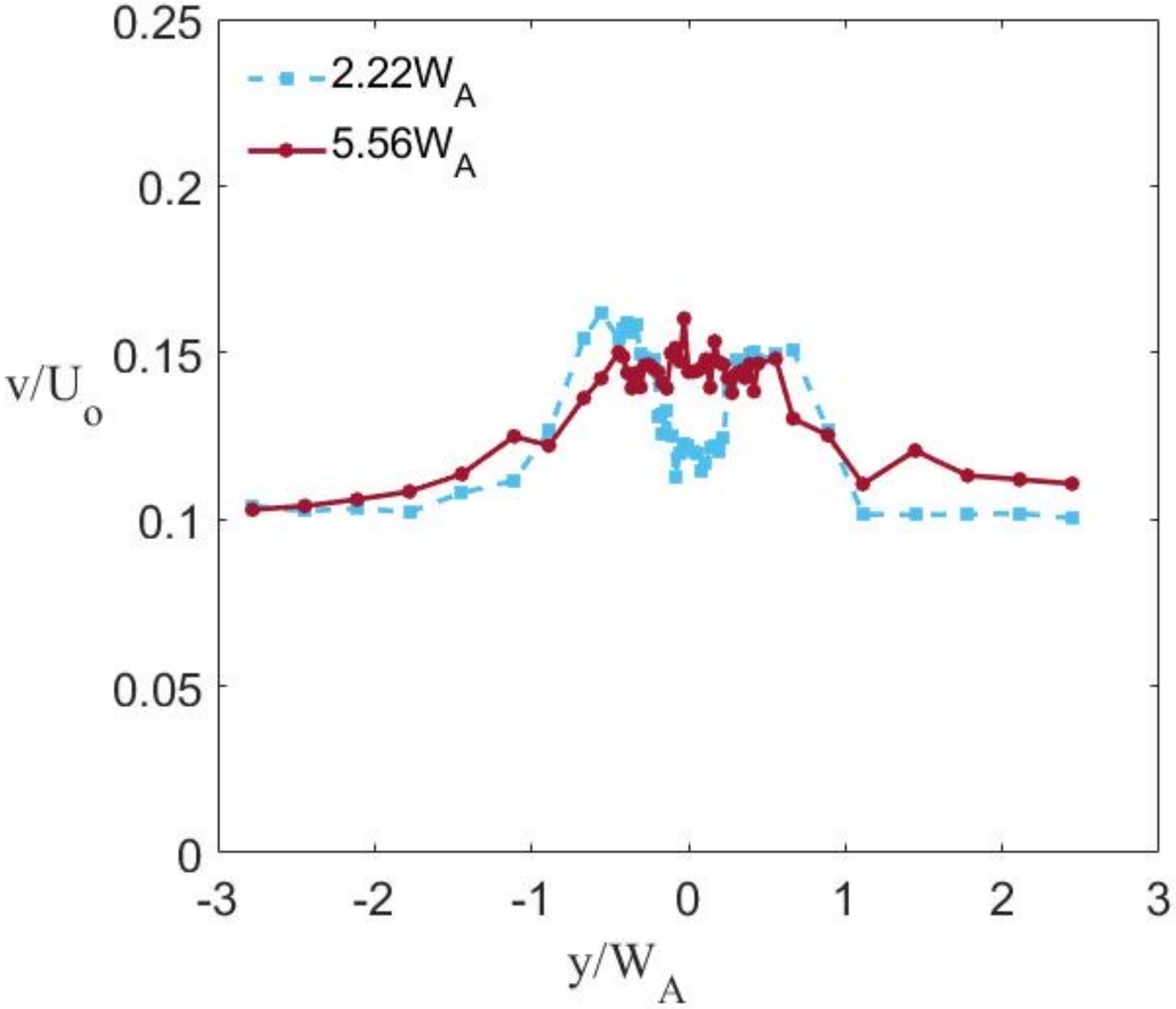
Example: $W \sim H/10 \rightarrow 9W_B \sim H \sim 150$ m

(a) Near-wake extends to ~ 100 m downwind

(b) Adjustment region ~ 200 m

(c) Far-wake – results at 330, 830 m

Turbulence



At 5.56 W_A, $U/U_0 \sim 0.7$

$v'/U \sim 0.21$

That is about twice the value outside of the wake.

The wake of a clusters of tall buildings

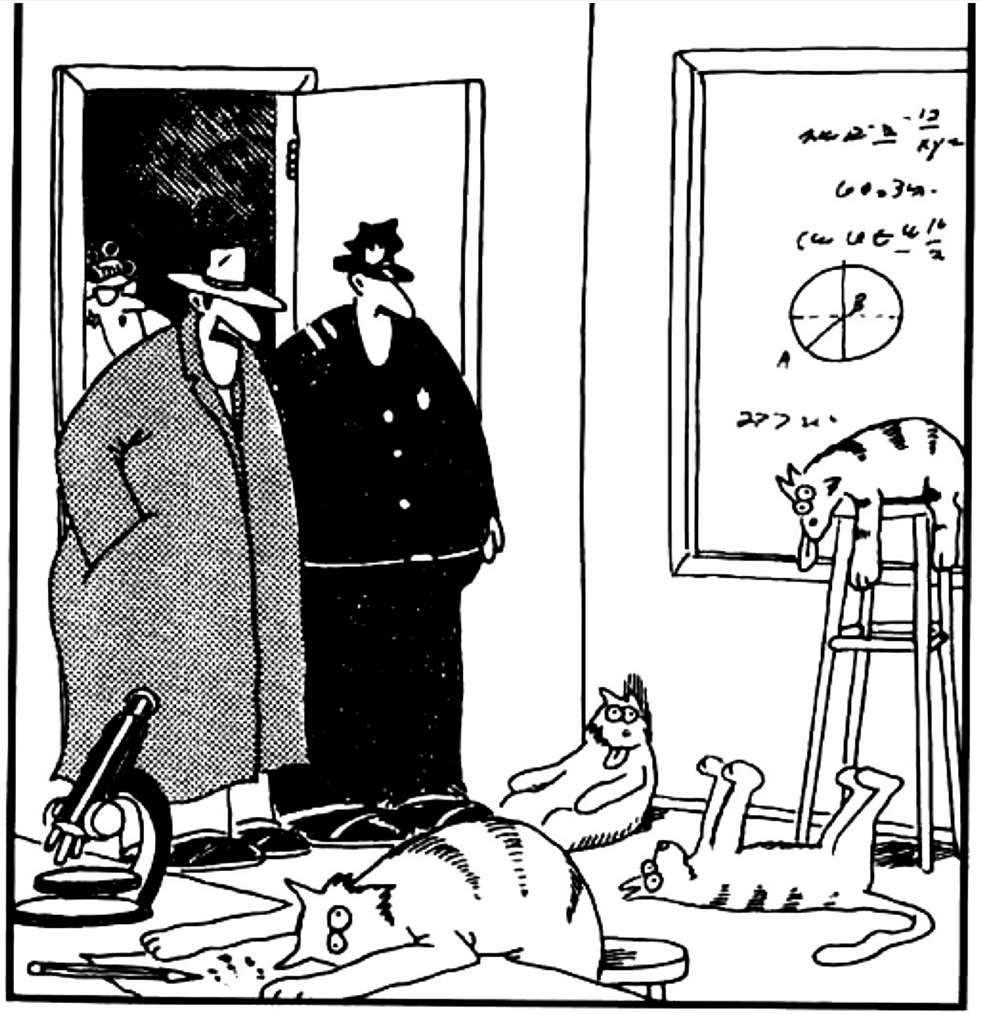
- Boundary layer structure strongly perturbed over a large region downwind.
  - → local flow conditions become highly heterogeneous;
  - → turbulence perturbations longest lasting.
- Impacts wind characteristics, heat and pollutant exchanges, and wind loads.
  - → important consequences at a range of scales (from micro to macro).
- … and atmospheric stratification may exacerbate effects.

Objectives

1. Understand magnitude and scale of effects, and impact on wind, dispersion, and temperatures;
2. Identify main parameters that govern extent and character of wake regions;
3. Assess what can be said generically and what remains site-specific;
4. Develop fast analytical models that describe wake behaviour;
5. Collate information in set of guidelines and tools that are publicly available.

FUTURE, a three year project, commenced mid-2021.

Strategy



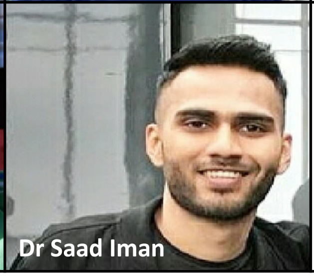
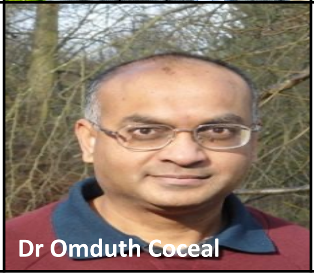
"Notice all the computations, theoretical scribblings, and lab equipment, Norm. ... Yes, curiosity killed these cats."

Larsen

The problem needs to be tackled by a combination of techniques:

- analytical modelling (Reading).
- field work (Reading)
- high-fidelity numerical simulation (Southampton)
- wind tunnel testing (Surrey)

Meet the team

Wind Tunnel (Surrey)	 Alan Robins	 Dr Marco Placidi	 Dr M. Carpentieri	 Dr Paul Hayden	 Dr Abhishek Mishra
Field Work (Reading)	 Prof Janet Barlow	 Prof Sue Grimmond	 Dr Matt Clements	Apologies for the distortions.	
LES (Southamp-ton)	 Prof ZT Xie	 Dr Davide Lasagna	 Dr Saad Iman		
Canopy Model (Reading)	 Dr Omduth Coceal	A 1-3-3-5 system = 12!			

… and the partners

City of London

DSTL

Met Office

RWDI

University of Cambridge

… and the work packages

Work Package	Topic	LES	Wind tunnel	Field	Modelling
WP1	Idealised clusters, neutral ABL	X	X		
WP2	Idealised clusters, non-neutral ABL	X	X		
WP3	Field work – real clusters, general ABL	X	X	X	
WP4	Modelling, parameterisations, application guidelines				X

Communication/management

Team meetings: Monthly

Team seminars: Bimonthly

Workshops: Year 1 & project End

Partners meetings: to be decided

Networks: UFM, LEVN, NWTF, NCAS

Collaborations: MAGIC, ASSURE, IfS, MODISAFE, URBISPHERE

Website:

https://www.surrey.ac.uk/research-projects/future

Thank you.
Questions?

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