MAGIC CIRCULAR

Envisaging a world with greener cities

AN UPDATE ON THE MAGIC PROJECT

ISSUE NO. 02 | APRIL 2017

MEET THE RESEARCHERS

Who is working on MAGIC?

PROJECT UPDATE

Progress on the project

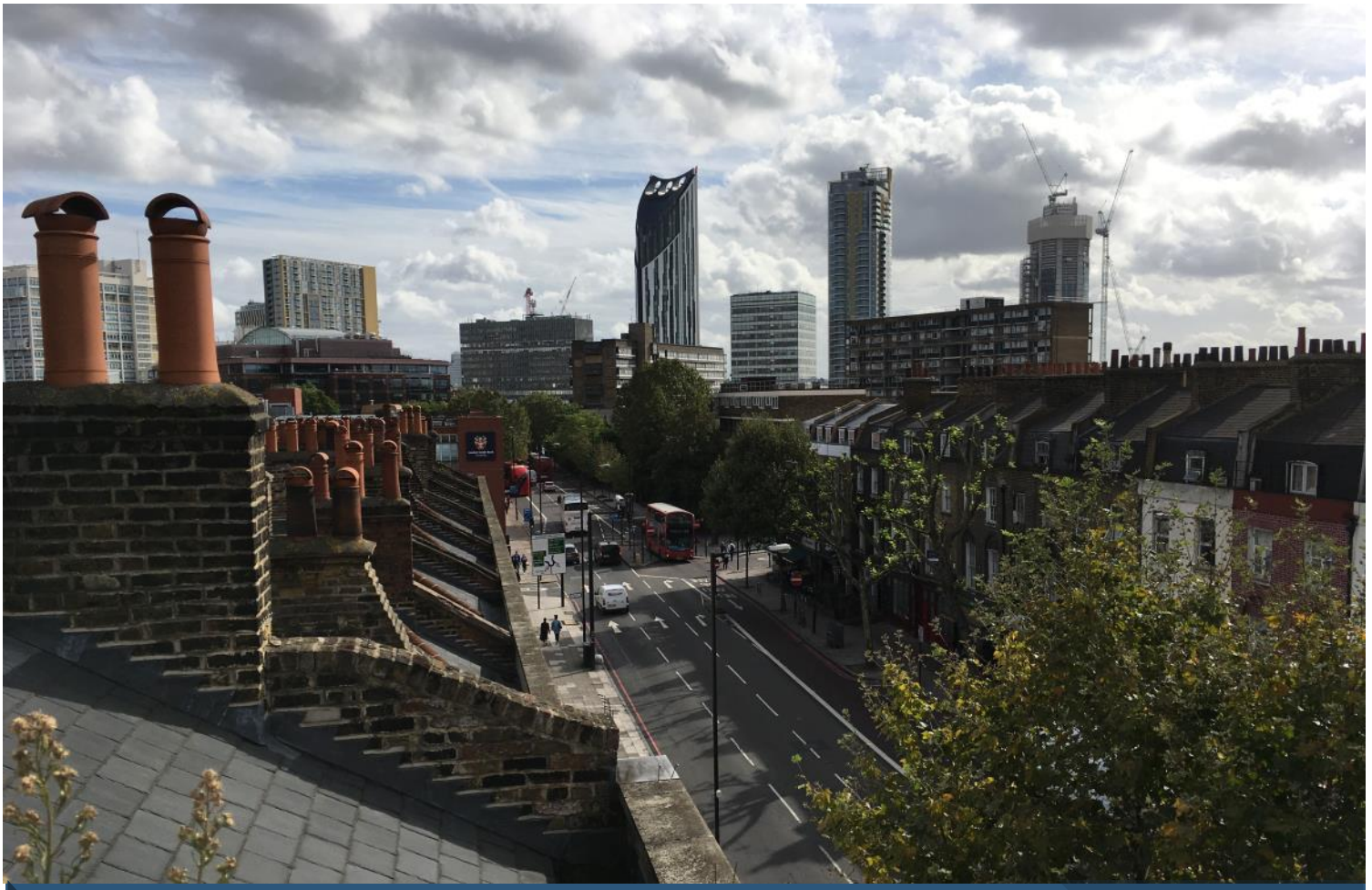
PARTNERS MEETING

Find out what happened at the last meeting

UNIVERSITY OF CAMBRIDGE

Imperial College London

UNIVERSITY OF SURREY



INTRODUCTION TO MAGIC

Welcome to the second MAGIC newsletter, which aims to provide you with an update on the progress of the project so far.

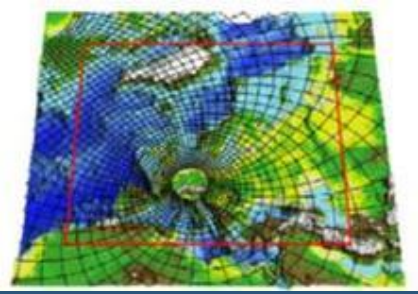
MAGIC is an EPSRC funded project which works towards answering The Grand Challenge question: Can we develop cities with no air pollution and no urban heat island effect by 2050?

The MAGIC project is a collaboration between the Universities of Cambridge, Surrey and Imperial College London, bringing together a multi-disciplinary research team to develop a decision support tool capable of taking a leap towards answering this Grand Challenge question.

Professor Paul Linden,
Lead Investigator
University of Cambridge

THE SCIENCE

Traditional approaches to urban environmental control rely on energy-consuming and carbon producing heating, cooling and ventilation (HVAC) systems, which produce an unsustainable cycle of increasing energy use. In order to break this cycle, a completely different engineering solution is necessary. The MAGIC project aims to provide an integrated suite of models and associated management and decision support tools that allow the city design to become its own HVAC system. The facility will be comprised of three components:

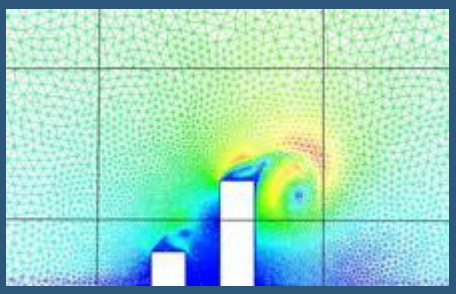


AIR QUALITY MODEL

The air quality model is a fully-resolved computational model that couples external flows with internal flows in buildings at the building, block and borough scales. The model will calculate the potential for the city air flow system to act as a natural HVAC system, examining pollutant and temperature distributions in complex city geometries, fully coupling with naturally ventilated buildings and green and blue spaces. Validation of the model will be provided through in-field, wind tunnel and laboratory studies.

REDUCED ORDER MODEL

By combining the computational model and laboratory process studies, it will be possible to develop reduced order models that allow for real time analysis and emergency response. The models will mainly consist of ordinary differential equations, solved in Matlab, and will be capable of producing gross features such as mean pollutant concentrations and temperatures in regions of a city. Reduced Order Models will also be used to provide scoping studies.



COST BENEFIT MODEL

The cost-benefit model will assess the economic, social and environmental viability of decision choices, linking the scientific and engineering models with implementation advice. The cost-benefit model will include modules for the built environment, public spaces and transportation, providing estimates of the life-cycle costs and benefits of scenarios at the building, block and borough scales. Although not in the current proposal, it is envisaged that the model will extend to include social and health effects.

RESEARCH PROGRESS

DR MEGAN DAVIES WYKES- UNIVERSITY OF CAMBRIDGE

Building Ventilation

Megan is investigating ventilation of a room, subject to wind and buoyancy forcing using water tunnel experiments. Megan is currently in the building stage of the water tunnel and will be supported in data collection over the Lent Term, by student intern, Jean-Etienne Debay, from INSA, Lyon- France.

DR SHIWEI FAN- UNIVERSITY OF CAMBRIDGE

Sensor Development

Shiwei is currently developing low-cost, lightweight battery powered sensors to be used on the MAGIC test site, to measure trace gases and take meteorological measurements, such as pressure, temperature and relative humidity. It is anticipated that the sensors will be ready for deployment by May 2017.

DR JAMES O'NEILL UNIVERSITY OF CAMBRIDGE

ATHAM Fluidity

James will be developing ATHAM Fluidity (a sister model of Fluidity) to run large-eddy simulations to capture turbulent structures based on the environmental data from the MAGIC test site. James' work will initially be carried out on the local scale, with the anticipation of expanding this work to borough and city scale over time.

DR JIYUN SONG- UNIVERSITY OF CAMBRIDGE

Building Energy Performance

Jiyun is investigating how to create a sustainable and comfortable working environment, using parameters from the chosen test-site, modelling using EnergyPlus. Jiyun spends 50% of her time on the MAGIC project and 50% of her time on a project entitled LoHCool, examining building ventilation in China.

DR LAETITIA MOTTET- IMPERIAL COLLEGE LONDON

Building Modelling

Laetitia has been generating the geometries for the test site using Fluidity software. Laetitia will continue to develop the Fluidity models, increasing geometry complexity (i.e. adding pitched roofs) to account for traffic, thermal effects, indoor models and coupled outdoor-indoor models. Like Jiyun, Laetitia spends 50% of her time working on the LoHCool project.

DR DAVID FAIRBAIRN- IMPERIAL COLLEGE LONDON

Data Assimilation and Sensor Development

David has started work using data assimilation to combine observed data from the test site and wind tunnels, with Fluidity models to better estimate air pollution over the London test site. David's work will advise on the best placement of sensors to gather the test data.

DR DUNHUI XIAO- IMPERIAL COLLEGE LONDON

Reduced Order Modelling

Dunhui is developing rapid reduced order models of a given neighbourhood and working to link these models together to produce a larger, city scale model. Dunhui has already begun work applying non-intrusive reduced order modelling to the MAGIC test site.

DR HUW WOODWARD- IMPERIAL COLLEGE LONDON

Atmospheric Modelling

As the most newly appointed member of the MAGIC Team, Huw began his post at ICL on the 1st May 2017. Huw will be focusing on applying ADMS and Fluidity modelling to the results of the wind tunnel and MAGIC test site, particularly understanding the movement of traffic pollutants at the test site.

DR WILLIAM LIN- UNIVERSITY OF SURREY

Wind Tunnel and Numerical Modelling

Will is modelling the MAGIC test site in the wind tunnel using flow visualisation to measure velocity and pollutant emissions and tracer concentrations. The output will provide further test cases for Fluidity modelling and guide future, more complex modelling. Will has already begun recreating the test site area for use in the wind tunnel.

LATEST PUBLICATIONS:

D Xiao, F Fang, CC Pain, IM Navon, A parameterized non-intrusive reduced order model and error analysis for general time-dependent nonlinear partial differential equations and its applications, *Computer Methods in Applied Mechanics and Engineering*, 317, 868-889, 2017.

F. Fang, C. C. Pain, I.M. Navon, D. Xiao, An efficient goal based reduced order model approach for targeted adaptive observations, *International Journal for Numerical Methods in Fluids*, 83(3), 263-275, 2017.

D. Xiao, Y. Pan, F. Fang*, J. Xiang, C.C. Pain, I.M. Navon, M. Chen, A non-intrusive reduced-order model for compressible fluid and fractured solid coupling and its application to blasting, *Journal of Computational Physics*, 330, 221-244, 2017

PARTNERSHIPS

Outstanding research is the foundation for the development of world-changing ideas and products; however academic knowledge cannot make these changes alone. Excellent partnerships, providing meaningful collaborations, are the key to making any project a success. We have big visions for the outcome of the MAGIC project and are excited to hear from others that can ensure our plans are realised.

As such, we are looking to hear from anybody who feels that they or their organisation has the key skills, interests and capabilities required to ensure MAGIC is a success. To get in touch with MAGIC, please email admin@magic-air.uk or ep526@cam.ac.uk.

Our offer to you:

- Collaborative effort to ensure the success of MAGIC.
- Full transparency of the project at each stage of development.
- Regular communications updates about the project.
- Networking opportunities with other project partners.
- Reference of your involvement, where appropriate.

What can you offer MAGIC:

- Willingness to share ideas and openly communicate about MAGIC in our partner forums.
- Drive to push MAGIC forward to ensure successful global project growth and implementation.
- Ideally a commitment in-kind or financially to support the MAGIC project.

Breathing Buildings

"Managing Air for Green Inner Cities (MAGIC) is an important initiative for Breathing Buildings because the holistic approach to improving thermal comfort and air quality, and reducing energy consumption, are core to the values of our company."

Dr Shaun Fitzgerald, CEO

Breathing Buildings

OUR PARTNERS

Name	Company
NPL	Dr Alistair Forbes
Arup	Dr Jake Hacker
Breathing Buildings	Dr Shaun Fitzgerald
CERC	Dr David Carruthers
DUVAS Technologies	Dr Julian Iredale
Dyson	Dr Jimmy Lirvat
FFI	Espen Akervik
Fosters and Partners	Dr Chris Trott
IAP, China	Professor Jiang Zhu
Laing O'Rourke	Adam Locke
LSBU	Professor Patrick Bailey
Zhejiang University, China	Professor Gang Bao
University of Reading	Professor Janet Barlow

OUR AFFILIATES

Name	Company
Nottingham University	Ben Jones
Foster and Partners	Andy Acred
Dyson Technology Ltd	Frederic Nicolas
LBNL	Phil Haves
LSBU	Andy Ford
University of Southampton	Z Tong Xie
NPL	Nick Martin
Committee on Climate Change	Stephen Smith
UKCIP	Roger Street

View from the test site. Credit E. Aristodemou, LSBU (2016)

Satellite view of the test site. Credit Google Maps, (2016)

PARTNERS MEETING

24th March 2017

The MAGIC project held the second MAGIC Partners Meeting, in Cambridge, on the 24th March, with great success. The meeting was attended by representatives from UKCIP, Foster and Partners, Breathing Buildings, Dyson, CERC, LSBU, EPSRC and NPL.

The structure of the day saw meeting updates from the Research Assistants, with discussions after each presentation. There was then presentations from Ying Jin (Department of Architecture, Cambridge University) on modelling traffic; David Carruthers (Cambridge Environmental Research Consultants) on the latest developments in ADMS technology and Z. Tong Xie (University of Southampton) on the challenges of modelling wind engineering problems.

The meeting was rounded off with an open panel discussion between Partners and Researchers about developing the collaborations between MAGIC and the wider organisations involved with the project. At this stage of the project, the discussions included sharing access to models and data, hosting MSc and PhD students in industry and invitations to networking events. Presentations from the meeting and the full meeting minutes can be found on the MAGIC website (www.magic-air.uk). We hope to hold the next MAGIC Partners Meeting in October 2017.

WHAT'S NEXT FOR MAGIC?

The LSBU test site (highlighted in red box)

Credit: E. Aristodemou, LSBU (2016)

LABORATORY WORK

The next few months for the MAGIC project will be focused on research and results. The laboratory work at Cambridge will inform the computerised models of the fluid dynamics of the building, focusing on the effects of wind and buoyancy on ventilation rates.

The work in the laboratory involves constructing a water flume with a boxed room (containing heated floor and 'ventilation') inside, which represents the test site at LSBU. The flume allows the bidirectional movement of water through the tank, where measurements of the movement of the water around the room space will be taken by using dyes in the water. The data can then be cross -calibrated with the data from the sensors in the test site and used to try and help support patterns of movement or explain discrepancies between anticipated and actual results in the field.

TEST SITE

Over the summer, work will commence on the MAGIC test site, a naturally ventilated building owned by London South Bank University, in the Elephant and Castle area of London (left hand image). Monitoring of the test site will involve placing sensors both inside and outside of the test building to capture data on trace gases ($CO/CO_2/NO_2$) and meteorological data such as pressure, temperature and relative humidity. The strategy plan for placement of the sensors is currently being finalised.

WIND TUNNEL

At The University of Surrey, the MAGIC researchers will be modelling an initially low resolution (increasing in quality as the project develops) replica area of 200m diameter surrounding the test site in the wind tunnel. The Researchers will then be investigating:

- Flow: using smoke-air tracers and laser light sheets.
- Velocity: using laser droplet anemometry, particle image velocimetry and pressure-based velocity probes
- Pollutant emissions and tracer concentration measurements: using propane in-air point sources and fast-response flame ionisation detection.

The results of the wind tunnel experiments will help inform the future sensor deployment strategy for the test site and provide important information for computerised modelling of the test area.

Modelling the test site for the wind tunnel.

Credit: W. Lin, University of Surrey (2017)

THE LEAD INVESTIGATORS

Professor Paul Linden

University of Cambridge

p.f.linden@damtp.cam.ac.uk

Professor Chris Pain

Imperial College London

c.pain@imperial.ac.uk

Professor Alan Robins

University of Surrey

a.robins@surrey.ac.uk

Contact Us:

Managing Air for Green Inner Cities (MAGIC)

DAMTP, Centre for Mathematical Studies

Wilberforce Road,

Cambridge, CB3 0WA

Web: www.magic-air.uk

Tel: 01223 336494 (9am-1pm -Mon-Fri)

Email: admin@magic-air.uk

Funded by:

EPSRC

Engineering and Physical Sciences Research Council