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MAGIC Partners Meeting		
3.25.2019		Downing College, Cambridge

Paul Linden – Introduction
Please see presentation attached

Field Study Work:

- Field study work shows that things are complicated and predicting them accurately is a major challenge – e.g. the test room at Elephant and Castle in 2017 showed vertical stratification, CO_2 higher at the ceiling
- 2018 Cambridge Field study – looked at impacts of green and blue infrastructure
- We are currently planning a test site for this summer
- We are likely to go back to the previous London test site.
- We will be looking more closely at traffic issues

Models:

- Fluidity development has been a strong focus, we can now e.g. automatically generate buildings, topography etc.
- Open source code, and Laetitia and Carolanne have written a fantastic manual to get to know how it works.
- Also focused on modelling indoor as well as outdoor
- Increasing the amount of physics in the process, taking into account green and blue spaces and the effect of radiation from buildings.
- Also, dealing with the impact of trees
- In Energy Plus we can now make predictions of temperatures inside the room compared with the measurements. They are close together, it's doing a good predictive job
- From this we can get estimates of the energy changes

Experiments

- Work in Fluidity backed up by wind tunnel and water bath studies:
- In the wind tunnel, changed size of model to see if we see a difference between 1:500 and 1:200 scale, and performed comparisons if you take away a number of buildings
- Water bath experiments show that what goes on in a room can be complicated. We built a test room with windows on both sides. Small temp difference changes the flow completely. Coupling internal and external flow is critical.

Traffic

- Computer algorithm detecting and tracking vehicles, gives speed and acceleration estimates.

OPAL:

- Aim is to develop an integrated system for everything. This is being led by Imperial.

Future Work:

- More controlled tests with traffic monitoring
- Hoping to work with TfL to collect more information for traffic modelling,
- Janet Barlow and Hannah Gough collaboration on the Lidar
- Complete Fluidity and testing
- Link with ROM and DA
- Choose 2019 test–site(s) still trying to define a definitive case
- Conduct further room ventilation studies and controlled indoor/outdoor pollution tests
- Develop a Cost Benefit model

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Dan Clarke (Cambridge County Council), Anne-Marie Hindley (Cambridge City Council)
Addressing Urban Air Quality Issues – sensing and data

Smart Cambridge Programme:

- Look at how data and new technology can deliver the City Deal
- City Deal has identified transport, housing and skills barriers that need to be tackled.
- Greater Cambridge is one of the fastest growing cities in the UK. Roads are almost at capacity and there are issues with the electricity grid.
- Will need to triple capacity in energy infrastructure and build 33,000 new homes to meet demand.
- And there is huge pressure on the transport network, more cars will be coming in, knock-on impact on air quality.
- Aim is to get one in four people out of cars and onto public transport.

Air quality monitoring:

- 5 continuous monitors Nitrous Oxides and PM
- Another monitor at Station Road, where the developer put in a monitor
- 70 passive NO tubes
- Road traffic the biggest problem
- In the air quality map, the red areas are the problems – mostly main roads in the cities. High levels of N02, just at the AQO level.

Clean Air Feasibility study:

- Worried about growth, need x2 buses to manage growth.
- Expecting more people to bike/walk and need to make the environment better/cleaner for them
- 106 deaths p/a from air quality issues, more than road traffic accidents
- Likely to have a greater problem in next ten years, need an intervention
- So, the Clean Air Feasibility Study Looked at standard and non-standard clean air zones and different scenarios.
- For example, looked at making all buses electric, and then the same for different categories of vehicles
- Changing the bus fleet makes a huge difference
- The feasibility study can be viewed online and is currently out for consultation – looking at how people feel about congestion charging, closing roads etc.
- A model is being built for the Greater Cambridge Area

Mill Road Monitoring:

- Planned closure of Mill Road will happen over Summer 2019 for essential bridge maintenance works
- Will last for 8-weeks
- Team want to monitor to look at what happens to e.g. air quality, traffic and bike movements, when this happens, and this can inform future interventions
- There are cameras on Mill Road and surrounding roads, which can capture vehicle movement and classifications as well as cycle and pedestrian movements.
- That will be brought together with air quality data
- This analysis can hopefully inform future interventions.

Next steps:

- Developing a data platform - working with computer labs at the University taking real time and static data from around the city, feeding into a monitoring platform in real time, so they can begin to predict and act
- Trialling a new sensor, whose business model has reduced the cost, they are hoping to deploy a network across the whole city
- Bringing air quality, transport and energy modelling together.
- Planning transport interventions – e.g. mass rapid transit system and cycle and pedestrian routes.

	Q&A for Dan and Anne-Marie: • Cambridge council are working with Cambridge Uni for the Mill Road closure. The intended and unintended consequences could be hard to separate out. They are trying to take a data led, evidence-based approach. • They are trying to formally evaluate the impacts of the data platform, but they are in the process of figuring out how, at the moment. • Greater Cambridge Partnership is looking at traffic light phasing, as part of the bigger picture, as they are aware that avoidance of stop-start traffic is key to reducing pollution. Many traffic signals have Scoot on them, that can be optimised. • Data from the pollution monitoring stations is available to everyone on the city council website. • They are developing the infrastructure for electric mobility, for example, the operator is putting two electric buses on as a trial, project at the station – and an electric charging station for taxis is being put in at the station. By 2028 all taxis licensed by Council need to be zero emission hybrid. Every new taxi will need to be that from 2020. Then phased in. Check point 2025. Looking at smart grids and e.g. building solar canopies on the park and ride, but some constraints associated with this. • The reduction in traffic during school holiday periods is being assessed in terms of its impact on the models – the group working on it estimates a 10-15% reduction. • They are not currently doing any monitoring of air quality inside buildings.

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Sabine Banzhaf, Institute of Meteorology, Freie Universitat, Berlin
Development of an online chemistry module for the microscale urban climate model PALM-4U within the [UC]2 program

UC2 -Urban Climate Under Change:

- Consists of 3-modules
- Module A – Model Development
- Module B – Observational Data (in different cities)
- Module C – Practicability and Usability. Partners are mostly local authorities, not used to steering those kinds of models, they test the model in an iterative process together with the model developers.

Module A:

- Uses the existing Palm model core, building PALM-4U
- Parallelized LES model
- Has very high scalability, can run computationally expensive simulations on high resolutions
- Contains many embedded models – e.g. canopy models
- Sabine and team are putting in new modules and it will all be open source
- For example, online chemistry model has been implemented into PALM-4U
- The more complex the mechanism the grater the additional CPU, up to x15 if you use the very expensive mechanism.
- Berlin showcase ran for the model
- Regarding traffic emissions, they identified main and side roads and, using emissions factors, they used this for the model simulation
- First results for Berlin show good correlation
- There is an aerosol model, SALSA, which was developed in Cambridge, around Pembroke Street

Conclusions and outlook:

- PALM-4U is a future state of the art urban climate model.
- All the data will be open source.
- There are improvements the team would still like to make in the second phase, city scale applications with comparison to the measurements.

Q&A:

- PALM resolved clouds but not rain. The meteorology was initially missing, so in the first phase there was no need to include precipitation in the model. In the second phase, wet deposition was added, they had to wait for developments in the core of the model.
- There are 3D trees in the model. If you know the position of the tree, and the specific species, you can put this in the model
- Canopy model includes evaporation related to trees.
- Particle emissions are parameterised from the traffic. Team did traffic counts and put the emission factors to the cars. This was studied to evaluated the basic functioning of the SALSA model. More detailed evaluations will follow.

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Anna Schroeder, University of Cambridge
MAGIC Traffic modelling

How traffic modelling sits within MAGIC:

- Air pollution in Europe – premature deaths,16% of lung cancer cases, health related external costs are high
- Air pollution in air quality management areas (high air pollution areas) –vehicle emissions are the most significant source
- Modelling vehicles emissions – speed and acceleration important.
- MAGIC team use video footage and feed this into vehicle emissions model, vehicle information emissions model goes into Fluidity, which shows how the emissions spread in space. Out of Fluidity model you can see how the pollution disperses in space and get an estimate of what's happening at the building front, and from there indoor/outdoor exchange, estimate of what's happening inside the building.

Cambridge Field Study

- December 2018 –camera up and running for 3-weeks on Fen Causeway measuring PM emissions
- Team is now trying to correlate with traffic data.
- From the video footage, need to be able to detect vehicles, track them, count them and get positional information for speed and acceleration.
- Anna uses Yolo, which detects up to 80 different object types.
- Problems – congestion (vehicles close together can't distinguish) and also at night, unless the camera is good
- Generally, it works well, and post processing will improve the method.
- Each vehicle entering the study area gets box assigned and a number.
- It's not great at picking up HGVs, but some post-processing should improve this
- Biggest challenge is speed and acceleration, need good positional data for this, Anna has found an open source code to do this
- With the bounding boxes, while working well, the algorithm is struggling to decide does the wheel belong to the car, and to follow particular features. After post-processing it's more realistic. To check this, Anna has followed one feature of a car with mouse. That's the best estimate of the speed data at present. Feature is just above number plate, you get some shift, but it looks similar when compared to post-processed results.
- Speed comparison between 8 different vehicles is definitely looking promising, in terms of capturing the correct behaviour.

Summer 2019 Field Study

- Apply the above methodology to a larger area, add number plate recognition, validate vehicle emissions results of emissions model and Fluidity, Develop the Emissions model.

Q&A:

- Pedestrians were not considered in the trial study. Should be able to recognise cycles and pedestrians when camera not so high up. Need them on lampposts in London field study.
- Manual checks were only done as a validation, but the script itself is automated and is doing fine. With a fixed camera you only need to do it once, and then set it up and it's automated.
- It may help to add more cameras, but it depends how you link them, do you take the average, for example?
- This summer will take one car with GPS and drive it through the area several times for validation.
- Where possible, data will be published, but depends on the sort of data – can't publish the video footage, for example.

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- At the moment the methodology being used doesn't pick up loading, can infer gear from speed, and one model does use gear, but at the moment we can't do this. But it would be possible to look at it, and explore the use of e.g. acoustic sensors.
- Number plate recognition can go a long way towards identifying the most polluting vehicles
- Have not yet decided which emissions model to use, but someone has developed an emissions model in the research group. This has 80% cover, which would give good results. But not gear changes etc.
- Elephant and Castle test site, ANPR record for congestion charging could help a great deal, it's at the boundary for congestion charging as air pollution measurements were taken at the same time.

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Craig Robertson, Allford Hall Monoghan Morris
Natural Ventilation in Architecture

Please contact Sophy if you'd like Craig's contact details for more detail/ questions regarding the presentation, much of which is commercially sensitive, so not on our website or written up here in detail.

The Design Team

- As an architect you work with a wider design team.
- Building performance team is unusual in architects' practices. Not necessarily on the architect's agenda to look at building performance in such detail.
- Often set by very limited scopes of work and responsibility.
- Implementing natural ventilation strategies often fails because of the way teams are put together

Systems:

- Need an intelligent interrogation of a building, the building finish, how it relates to the external environment and how the humans operate inside. So, a much more systemic view of a building.
- A building is a filter between humans on the inside and environment on the outside. Humans interact with environment through filter of the building.
- A building is ultimately for people. How do people feel in the building? How are our decisions as designers impacting on all these people?

Natural Ventilation:

- AHMM have integrated natural and hybrid ventilation systems into a number of buildings, from their own offices to a range of projects for clients. Different design approaches and varying levels of complexity of the set up.
- Part L of building regs can be obstructive in terms of natural ventilation as engineering colleagues in design teams are focused on simply meeting compliance in relation to this.
- AHMM try to look at how they can make Part L compliance better, and run parallel building performance model.
- They use IES in this context

Q&A:

- Team tries to do post-build evaluation on every building finished
- Hybrid buildings are often used, the aim being to extend the spring/autumn times when natural ventilation best, so you can open the windows over a longer period. In the coldest part of winter, however, you may still need a sealed building.
- They try to futureproof design based on CIBSE's future climate data. But predicting things like the future-use of adjacent buildings can be problematic.
- They use acoustic models to look at sound impacts
- In terms of internal pollution in buildings, they get a street level measurement, which determines if they are able to open the windows. But they would like to do more modeling of the exchange. This isn't currently addressed in building regs.

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Breakout Groups

Group 1:

- MAGIC should aim to provide greater understanding of the links between outside and inside.
- Need to make sure the traffic modelling is accurate, and validate how it fits together with the other modelling
- Need to understand the envelope of pollution outside the building. How does this impact how you use the building and open the windows? An intelligent building that opens the windows based on what's outside.
- Pollution is not just CO_2 inside the building, but NOx and fine particulates, how does that translate into this work?
- Find the story to tell to potential end-users. How do end-users use the various projects under-way, how do we bring them together? Small-scale traffic modelling, how does that feed into larger scale traffic models? How do you use that data? Do you make pavements wider, what kind of trees do you use?
- It would be good to have a guide or tool to be able to illustrate this to the public. Mill Road closure, something that can be done to get feedback to see how all the strands of work feed into that.
- Need to make links to active travel and exposure. How does the work link to how people travel around? Should you use a different street, for example?
- It is also important that all the work that's been done is validated, so it inspires confidence in the results.
- Think going forward of the user, how is this work going to benefit those who might need it in the future? Start to work with end-users more closely to develop the tools. Work with those we think would be able to apply it to refine our work.

Group 2:

- Would be good to develop an urban flow model that can plug into the models already used by designers.
- Could also look to provide best practice guidance and rules of thumb
- Design checklists – things to consider within a design process
- Urban heat island effect one of the key objectives in the programme, how are we dealing with that directly?
- Needs more quantification on e.g. green space on urban heat islands.
- Outstanding technical questions re. pressure coefficients and the impacts of those
- Can the output from the MAGIC project be used to say - if I had to drop a building into this development, what are the input parameters for the design in terms of the indoor air quality?
- Questions on complexity of the models. When you bring in chemistry it's heavy. When and how much is needed. How much can you use the reduced order models?
- Providing information on special and temporal variation of pollution. E.g. sixth floor and above open windows, below this closed, and show - where's the information and evidence driving that decision. Spatial horizontal and vertical, and also diurnal information would all be useful.

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Group 3

- How can we make sure that MAGIC is used? Beautiful model not used is no good.
- How could we make the package used as a decision support tool?
- Currently industry leader is IES. 90% market share (in the UK). If the physics isn't in IES it doesn't exist.
- IES is simple and you can show compliance with regs
- Assumed that if you comply with Regs you have efficiency and comfort taken care of.
- Part of the problem with IES – it's black box proprietary. Some information. But you can't go in the back and check they're doing it right. And you can't correct stuff.
- It's crude. They include a lot of things, but it's rules of thumb coded in and implemented in the building simulations.
- Limited environmental interaction. Build your building, and then it sits in a plane and the only interaction is a drop-down box where you say if it's a sheltered site. And that's about it.
- If what comes out of MAGIC is going to be used to improve buildings, then either the findings need to be put into these proprietary packages, or it needs to be capable of being a one-stop shop itself, so they can use MAGIC to comply with the building regulations. It needs to do everything. Or, it needs to be an add on. If that doesn't happen then what's discovered here won't feed in.
- Ultimately, construction is cut throat and money driven. And building something exceeding the building regs, unless client is not money driven, then that is the building they will build.
- Also, not really any validation required in IES. No one really verifies and checks that the post occupancy of the building is working as intended.
- Dream: MAGIC produces open source building simulation package, with information on air pollution and building regs, that can then be implemented as industry standard.

Group 4:

- Challenge – how do we go out to cities to deliver integrated energy-transport solutions?
- Need to know how to optimise electrification infrastructure, for example.
- The more nuanced understanding of MAGIC could help
- Tool – we can model this out for you. Then you can optimize your investment. If you're going to design a new environment, how can you make sure traffic flows through in the right way. Right now, when looking at optimization, it's just the same number of buildings evenly spready, not taking the surrounding building environment into account. More subtle understanding of interaction of building/environment, which could result in better conversation around cost/benefit analysis in terms of air pollution would be helpful
- Don't have the ability to model this at the moment when they go and talk to clients. How do they access better understanding of all the tools that may or may not be available?
- Also, when you speak to the rest of the business, it's hard to build understanding around what a model is and what it can do. Someone who could provide that visualization would help to have a better conversation.
- Adds more power to conversations – often say – we need a systems approach to working with systems, but the models are all done separately in silos, but having something that bought that together would be useful. How to bound that would be good to know.

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Group 5

- Need accurate measurement, reliable measurement
- Help planners and designers to make better decisions.
- Support so that these decisions are made on the basis of data
- Build confidence that data and model are reliable
- Plurality of models, different groups helps to build confidence. Here and also Berlin. Make sure model has some provenance, not black-box.
- Issues of machine learning come into that.
- Interested in using models to improve experimental design. Where you place sensors etc. Drive experimental design and save a lot of money.
- Integrate MAGIC into other national and international projects looking at air quality.
- Data Assimilation tools, how do you incorporate data to tune your models so they reflect what's going on in reality.

What has MAGIC done for us already

- The networking is very important
- Awareness raising. Many people know a lot about air quality, but not focused so much on inside. Issue around natural ventilation, new although 5000 years old
- Cross learning. Has delivered some of that already.

Group 6

- ROM is the big innovation
- This would allow planners etc. lots of variables, and normally very expensive to look at lots and lots and lots of variables. You won't look at them in an integrated way. Having a tool where you could easily punch out scenarios in 15-minutes would be useful. So ROM is critical.
- Infrastructure design, placing a bus stop somewhere, what type of design, that is not modelled, but those kinds of questions should be. It's intensive and time consuming, having easy answers to that would be useful.
- Indoor – if you start putting indoor air pollution monitors then you're just getting one point of data. This kind of contextual complex model might enable you to make those sensors more intelligent, in terms of where you put them etc.
- Also, this could be used for experiment design and optimizing sensor placement. And more context to analyse that data
- Started talking about real-time management, but not clear how MAGIC would be used for this, currently feels more like something for planning and scenarios, rather than something that would feed into smart cities systems and building systems.

What has MAGIC done for us already?

- It is informing air quality strategy and direction for some of the things that industrial partners have been developing.

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Jimmy Lirvat, Dyson **Notes from Steering Committee Meeting**
• In Jan s/c and management team met • Discussions focused on the impact of the tools and how to engage end-users. • Steering Committee plans to help by developing 'user profiles' and also some case-studies developing how/in what context the tools can be used. • They have a set of actions for how they will accompany the Communications Strategy to help the project to gain more impact.
Paul Linden **Wrap-Up**
• Thank you for coming • Partners meetings will be run every six months. • Any comments, please send them through directly to Paul • Message taken from this meeting is potential mismatch between the science, and elaborate numerical models, with the reality of trying to make decisions about planning aspects etc. and how do we bridge that gap. • The conversations and breakout groups have been useful. • We believe that the ROMs run very close to real time. So, we can do real time modelling. And with a fidelity that we will find acceptable. • Standard code is computationally very expensive, but in terms of the practical applications running the Reduced Order Models is the way we hope to take this forward.