

# **ESGI 141**

**141<sup>th</sup> European Study Group with Industry**

**25<sup>th</sup>-29<sup>th</sup> June 2018**

**University College Dublin**



## Welcome to ESGI141!

The School of Mathematics and Statistics at University College Dublin are delighted to welcome you to the 141st European Study Group with Industry (ESGI141).

This delegate book contains descriptions of the companies and projects, the programme and the delegate list. We would like to welcome our Keynote speaker Prof. Simone Vantini (MOX - Department of Mathematics, Politecnico di Milano) and thank him for accepting our invitation. Prof. Vantini has been involved in numerous prestigious industrial collaborations: the AneuRisk project; Eni Exploration & Production project and the green move project. Prof. Vantini expertise in Functional Data Analysis for Business and Industry is unparalleled and his talk on this topic will be of great benefit to all our participants.

ESGI's are week long workshops that provide a forum for industrial scientists to work alongside academics on problems of direct industrial relevance. The scientific focus of the workshop is on the investigation and development of a suite of working solutions to complex challenging problems requiring mathematical/statistical/computational knowledge. Special emphasis is given to student contributions with awards for the best participating student.

We would like to thank the companies that submitted projects to this year's ESGI141: Prolego Scientific; ESB; Analog Devices and Captured Carbon.

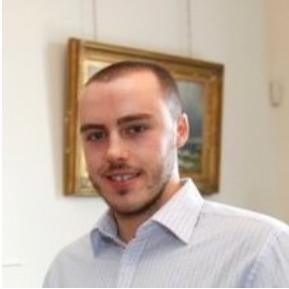
The workshop atmosphere is very informal and intellectually stimulating. The participants bring their own expertise, generate new ideas and get familiar with work done by their colleagues from other European institutions. We hope that you will have an enjoyable, productive and fruitful stay in Dublin.

## Thanks to Sponsors

The organising committee would like to gratefully thank the sponsors for generously supporting ESGI141:

- Science Foundation Ireland (SFI)
- MI-NET, Mathematics for Industry Network
- UCD research

## Organising committee

		
Michelle Carey	Andrew Parnell	Sinead Burke
		
Lennon O'Naraigh	Miguel Bustamante	Mel Devine
		
Andrew Smith	Kevin Burke	

## ***Keynote Speaker***



### ***Prof Simone Vantini***

**MOX - Department of Mathematics, Politecnico di Milano, Milan, Italy**

The continuous advances of measurement technologies has enabled the collection and storage of high-resolution data which can often be modeled as smooth functions (e.g., curves or surfaces). This kind of data are at the basis of functional data analysis (FDA) which is a well-known lively and expanding research area of modern statistics. In FDA, the classical concept for scalar or multivariate random variable is indeed replaced by the concept of functional random variable. Consequently, in FDA the typical data set is not made of numbers or Euclidean vectors, but a collection of functions embedded in a suitable functional Hilbert space meant to formalize application-specific relations between sample units. Recent applications of FDA techniques in different and many fields of science are countless. Nevertheless, very few business and industrial applications can be found, thus pointing out the existence of an unexploited potential of this type of techniques in these two fields. With respect to this discrepancy, after a gentle introduction to FDA, this talk will showcase some recent business and industrial applications in which state-of-the-art FDA techniques have been fruitfully used at MOX, the Modeling and Scientific Computing Lab of the Department of Mathematics of Politecnico di Milano.

## ***Companies and Projects***



### **Prolego Scientific**

Prolego Scientific are a UCD start-up company offering proprietary artificial intelligence solutions that are used to improve the accuracy of genetic tests in many areas such as improving animal health and performance metrics. These tests in turn improve the quality of the food chain and breeding values. Prolego Scientific's proprietary algorithms make use of genetic data and pedigree information to predict inherited physical traits of commercial value within the agri-food and biotech sectors. This information can be used in the poultry and aquaculture markets, for example, where it can predict metrics such as meat tenderness, resistance to antibiotics and protein yields.

**Title:** *Machine learning for the genetic testing of pedigree animals to improve animal health, performance metrics, the prediction of breeding values, and to hence improve the quality of the food chain.*

**Representatives:** Andrew Parnell

**The challenge:** There are several issues the ESGI group might be able to help Prolego with, including the ability to perform machine learning algorithms on encrypted data, and on exploring new tools (such as deep learning) for some of their existing data sets.



### **Electricity Supply Board (ESB)**

ESB was established in 1927 as a statutory corporation in the Republic of Ireland under the Electricity (Supply) Act 1927. With a holding of 95%, ESB is majority owned by the Irish

Government with the remaining 5% held by the trustees of an Employee Share Ownership Plan. As a strong, diversified, vertically integrated utility, ESB operates right across the electricity market: from generation, through transmission and distribution to supply. In addition, ESB extracts further value at certain points along this chain: supplying gas, using our networks to carry fibre for telecommunications, developing electric vehicle public charging infrastructure and more.

**Title:** Short term wind portfolio output forecasting

**Representatives:** Ciaran Doran

**The challenge:** Deliver an enhancing wind output forecasting capability by analysing the correlation between weather data and wind generation output, with the goal of further integrating renewables into a diverse electricity generation portfolio.

**Details:** Quantify uncertainty and reduce systematic error in forecasting ESB's wind portfolio output over a 14 hour to 40-hour timeframe in order to support decision making in the ISEM Day Ahead Market.

In October 2018, the rules for buying and selling wholesale electricity in Ireland are changing. The new market will be known as the Integrated Single Electricity Market (ISEM). With the new rules, generators will be required to inform the Day Ahead Market (DAM), each day at 11:00, how much electricity they intend to generate from 23:00 of that day to 23:00 of the following day.

Under the old market rules, the transmission system operator was responsible for managing wind forecast errors. However, under the new rules, wind generators themselves will be responsible. This means that, if a generator underestimates its generation level forecast in the DAM, they must make up the shortfall via a balancing market, which could prove costly. Consequently, wind generators are seeking to reduce their wind forecast errors.

At 11:00, the most recent forecast available to generators is the 09:00 forecast, hence this problem will focus on a forecast range from 14 hour to 40 hour ahead.

Wind forecasts are produced by Numerical Weather Prediction (NWP) models. The current resolution of NWP models is around 3 km. At this resolution, the land around wind farms is often not well represented, and some wind behaviour is not captured by the model. Therefore forecast skill may change at different locations, and under different weather conditions.

The task is to produce accurate forecasts of the wind speed and direction at the locations of ESB's wind farms. The task will consider the following questions (amongst others):

- Which mathematical and statistical models should be used to reduce and quantify forecast error?
- Which atmospheric variables should be used to identify systematic errors in existing wind forecasts?
- How can a collection (ensemble) of NWP forecasts be combined with historical data at wind farms to best quantify the uncertainty of forecasts?
- How can large-scale (spatial) weather patterns be used in this analysis of forecast error?



AHEAD OF WHAT'S POSSIBLE™

## Analog Devices

Founded in 1965 Analog Devices Inc. are world leaders in high performance signal processing and are synonymous with high performance and innovation among electronics manufacturers. Their diverse product portfolio covers Entertainment and Media, Industry and Aerospace, Medical Technology, Wireless and Automobiles Applications. The focus of Analog's Irish operation is to produce quality precision products through precision manufacturing while exploiting cost-efficiencies.

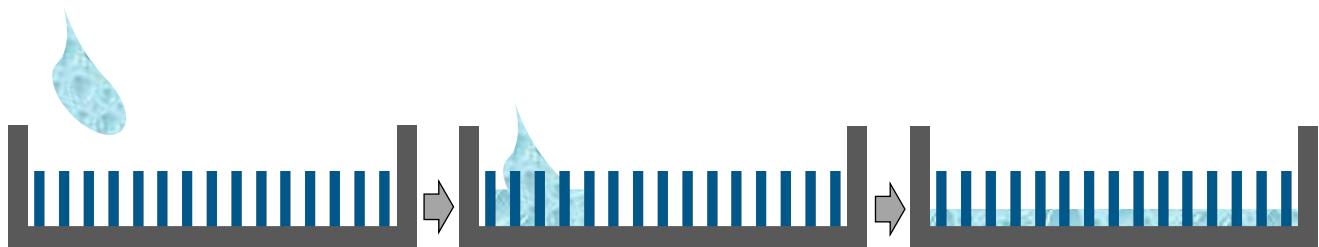
Analog Limerick has a great deal of local autonomy in product development. Access to R&D and highly skilled manufacturing and technological experts allows the Irish operation to develop and bring to market an average of 80 new products each year.

**Title:** Liquid Wicking in Hierarchical Microstructures

**Representatives:** Colm Glynn and Ricky Anthony

**The challenge:** What are the optimum structure morphology/size/porosity/materials for wicking/routing of liquid inside a cavity under various temperature and environment conditions?

**Details:** Determine an efficient wicking/routing of liquid inside a cavity using microstructured materials under various temperature and environment conditions.



Liquid dropped into cavity

Using silicon pillars as initial structure

Liquid initially spreads

Liquid routed/wicked throughout cavity

- Is there an optimum distribution for a large scale wicking structure (die size of 1 to 2 cm<sup>2</sup>)?

- What should be the pillars height, diameter and structure (cylindrical or hexagonal etc.) for most routing paths for water in a repetitive 3D pillar structure under vacuum to atmospheric pressure?

Combine the pillars with a connecting microstructure to improve wicking

- What form is most efficient for the microstructure for the movement of liquid?
- Is there an optimum porosity and pore size/shape? Circular, square etc?
- How much effect does the thickness of the microstructure affect the wicking?



## Captured Carbon

Captured Carbon have been providing energy services on the Island of Ireland for over eleven years. The company assists independent generators of all sizes, maximise revenues and protect their business model. CCL's expertise lies in the commercial side of energy production, the company offer all services required in the trading of the electricity produced by renewable generators.

The electricity market is an everchanging market place and independent generators benefit significantly from the experience, market and regulatory knowledge that CCL offers on behalf of their partners. CCL specialise in identifying revenue maximising avenues on behalf of their clients.

**Title:** Optimal Scheduling of Power Generation

**Representative:** Paddy Finn

**The challenge:** What is the optimal scheduling of a large number of power generators that operate at varying ramp rates and have different ramp durations?

**Details:** Captured Carbon control dozens of generators on industrial sites across the country on aggregate to achieve the same net effect as a large power station. For example, let's assume they have a sum total of 100 MW and this is spread across 100 sites. The volume on each site may vary. Some could be 0.1 MW, some could be 5 MW, and others could be

anything in between. Captured Carbon's fastest site may take 10 seconds to reach its maximum output but their slowest site may take 60 minutes.

It's not necessarily that the smaller ones are fastest .... essentially the slopes of these lines are fixed for each site but varying between the discrete sites. Ultimately, there is a straight line going from (0,0) to (100,60) their total volume at the time when their slowest site has ramped.

Captured Carbon would like to find a way to schedule each of the discrete sites so that the overall sum of the sites produce a slope that is as linear as possible and as close as possible to (0,0)->(100,60). For example, Site X may start at t+0, Site Y at t+4, Site Z at t+33 etc.

- Captured Carbon would also like to be able to cycle sites so the ones that are started first during one event, would be called last during the next.

## **141<sup>th</sup> European Study Group with Industry (UCD, Ireland)**

*25th to 29th June 2018*

### **Sunday 24<sup>th</sup> June**

Participants from outside Dublin arrive  
(There will be no special arrangements on Sunday)

### **Monday 25<sup>th</sup> June**

9.00am	Breakfast: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
9:15am	Registration <b>S1.67 Science Centre South, 1<sup>st</sup> floor.</b>
9:30am	Welcome: Dr Michelle Carey (Workshop Chair) <b>S1.67 Science Centre South, 1<sup>st</sup> floor.</b>
10.00am	<b>Opening Address:</b> Professor Orla Feely (Vice President for Research, Innovation and Impact, University College Dublin) <b>Keynote Speaker:</b> <i>Functional Data Analysis for Business and Industry</i> Prof Simone Vantini (Associate Professor in Statistics MOX - Dept. of Mathematics, Politecnico di Milano, Milan, Italy)
11 am	Coffee break
11.30 am	Industrial project 1: <b>Analog Devices</b>
12:00pm	Industrial project 2: <b>ESB</b>
12.30pm	Industrial project 3: <b>Prolego Scientific</b>
1:00pm	Lunch: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
1.30pm	Industrial project 4: <b>Captured Carbon</b>
2:00pm	Formation of Study Groups. Groups begin to work on Industrial Problems <i>Analog Devices</i> – <b>H2.40 (Science Hub, 2<sup>nd</sup> floor)</b> <i>ESB</i> – <b>H2.32 (Science Hub, 2<sup>nd</sup> floor)</b> <i>Prolego Scientific</i> – <b>H2.12 (Science Hub, 2<sup>nd</sup> floor)</b> <i>Captured Carbon</i> – <b>H2.20 (Science Hub, 2<sup>nd</sup> floor)</b>
3:30pm	Coffee break
4.00pm	Work on problems
5:00pm	Dinner: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
6:00pm	Welcome Reception: <b>Clubhouse, UCD.</b>

### **Tuesday 26<sup>th</sup> June**

9.00am	Breakfast: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
9.30am	Work on problems
11:30am	Coffee break
12.00am	Work on problems
1:00pm	Lunch: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
2.00pm	Work on problems
3.30pm	Coffee break
4:00pm	Work on problems
5:00pm	Dinner: <b>Pi Restaurant, Science Centre East, Ground floor.</b>

### **Wednesday 27<sup>th</sup> June**

9.00am	Breakfast: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
9.30am	Work on problems
11:30am	Coffee break
12.00am	Work on problems
1:00pm	Lunch: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
2.00pm	Work on problems
3.30pm	Coffee break
4:00pm	Work on problems
5:00pm	Workshop Dinner: <b>Exchequer Wine Bar Ranelagh</b>

### **Thursday 28<sup>th</sup> June**

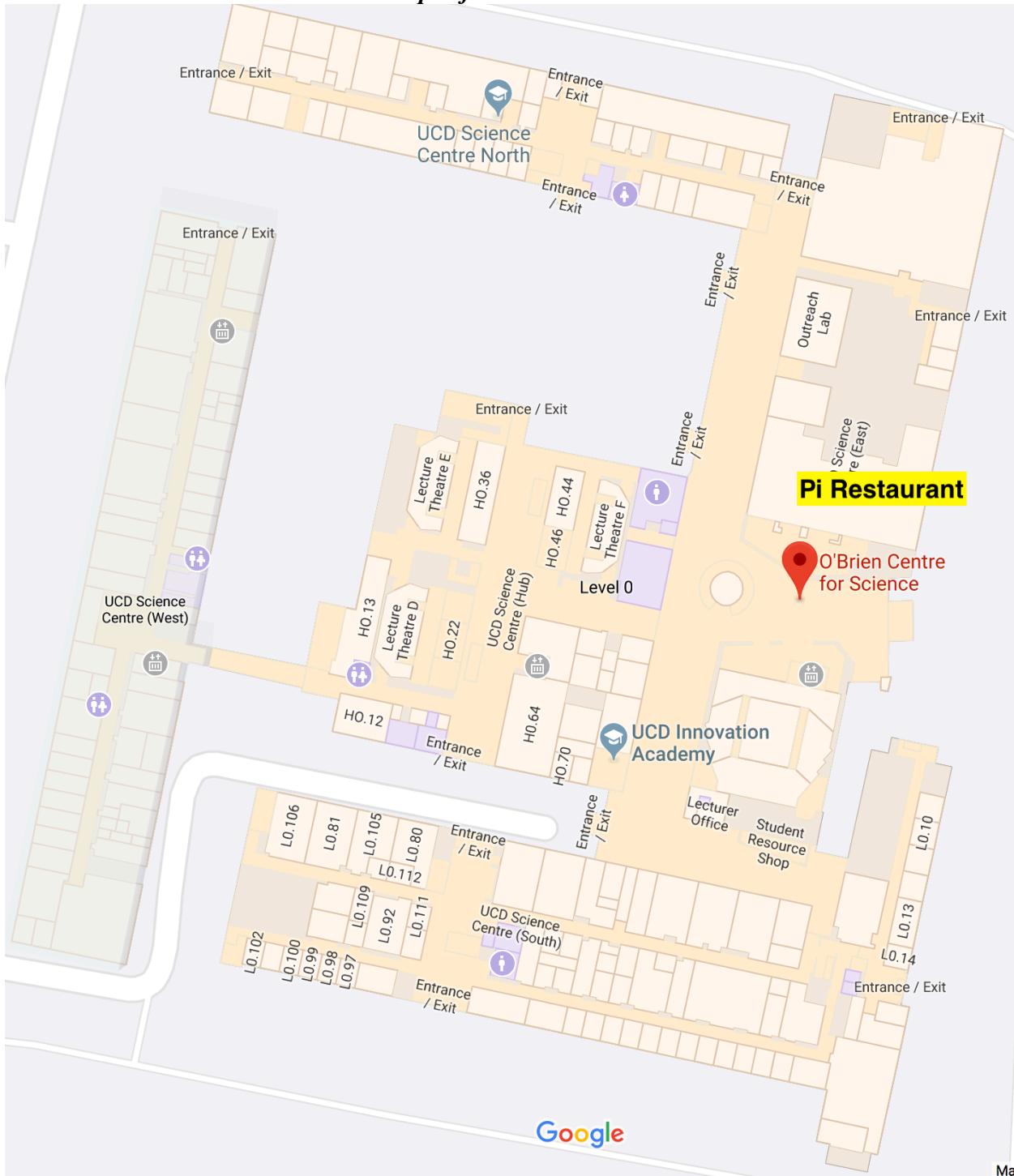
9.00am	Breakfast: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
9.30am	Work on problems
11:30am	Coffee break
12.00am	Work on problems
1:00pm	Lunch: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
2.00pm	Work on problems
3.30pm	Coffee break
4:00pm	Work on problems
5:00pm	Dinner: <b>Pi Restaurant, Science Centre East, Ground floor.</b>

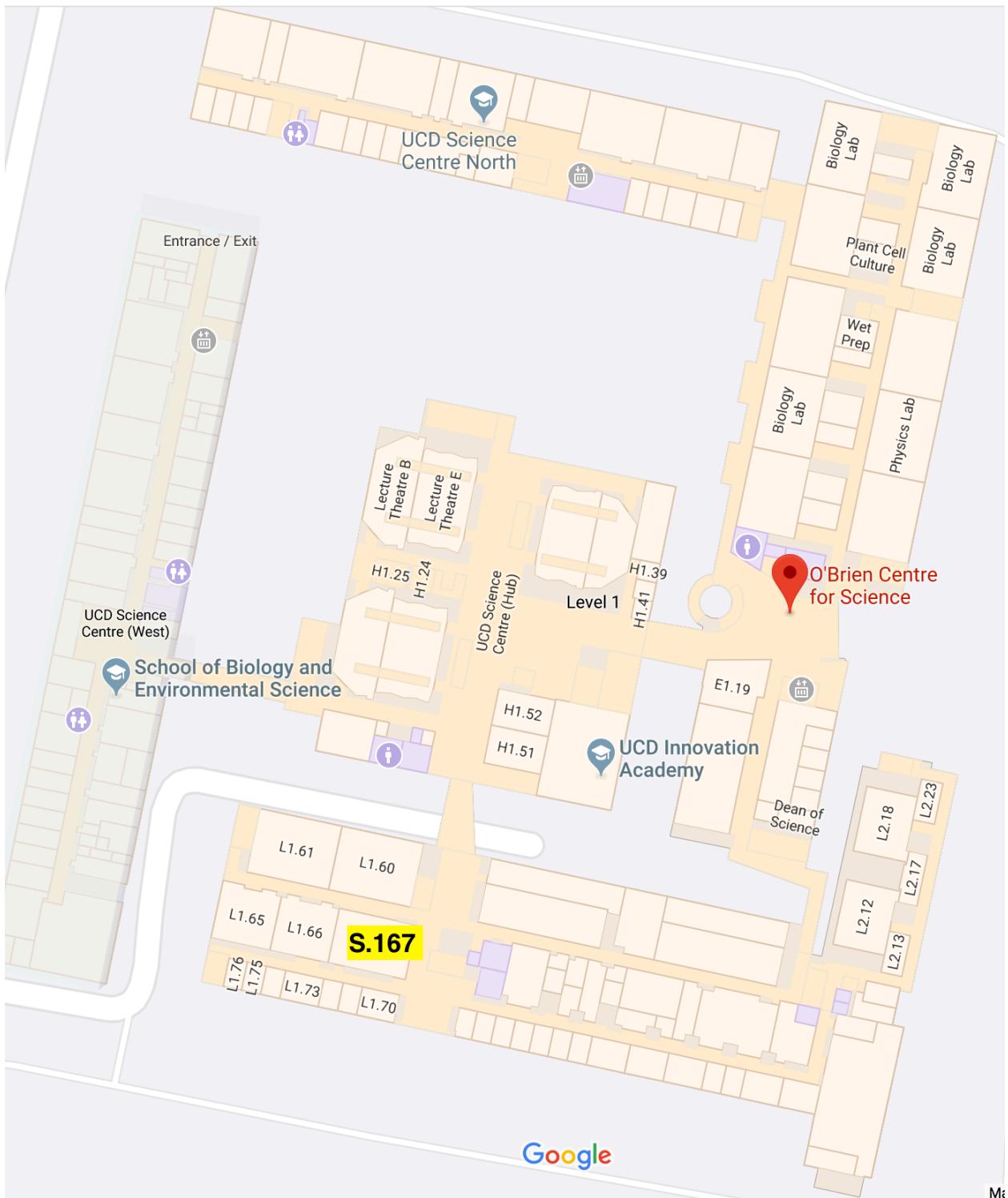
### **Friday 29<sup>th</sup> June**

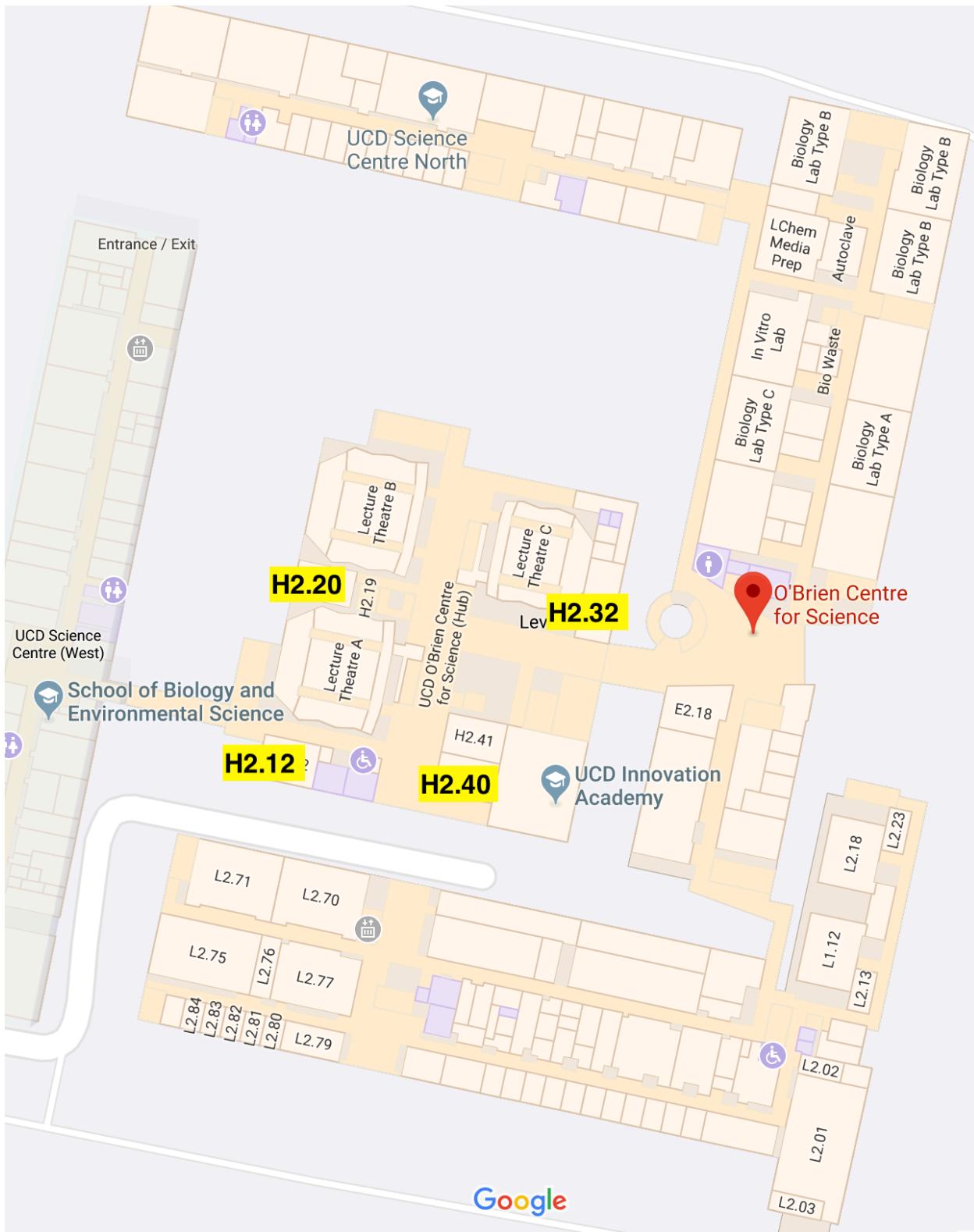
#### **Final presentations S1.67 Science Centre South, 1<sup>st</sup> floor**

9.00am	Breakfast: <b>Pi Restaurant, Science Centre East, Ground floor.</b>
9.30am	Industrial project 1: <b>Analog Devices</b>
10.15am	Industrial project 2: <b>ESB</b>
11:00am	Coffee break
11.30am	Industrial project 3: <b>Prolego Scientific</b>
12.15am	Industrial project 3: <b>Captured Carbon</b>
1:00pm	Student awards ceremony
1:10pm	Lunch: <b>Pi Restaurant, Science Centre East, Ground floor.</b>

## Maps of Science Centre





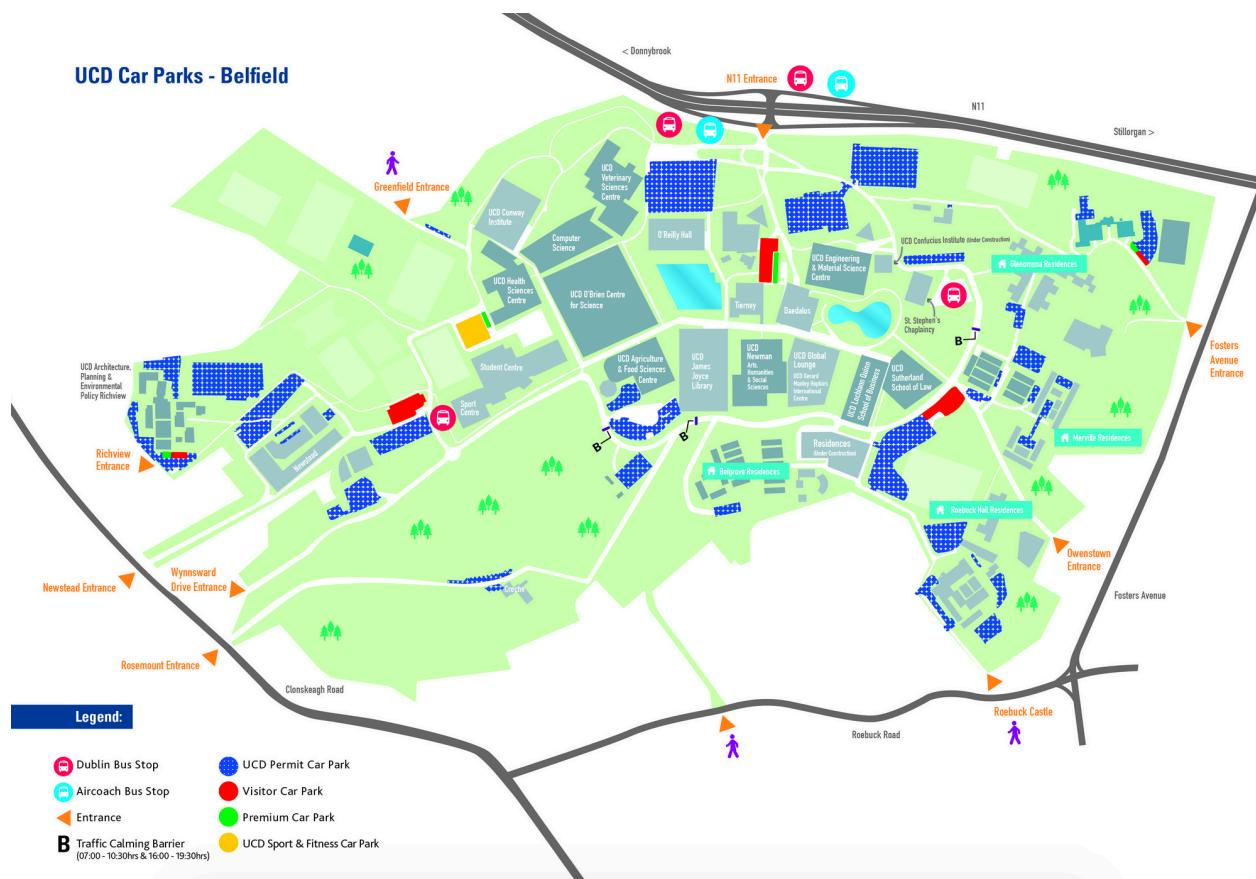


## Directions to UCD

<https://hitheroad.ie/#from=53.313232,-6.251808> shows you how to get to or from UCD Campus using a combination of Dublin Bus, Luas and DART links. You can also change searching options and search how to get from point A to B anywhere in Dublin.

## Parking at UCD

UCD permit parking is free during the summer. Park in any of the dark blue areas.



# UCD Campus Map

Building Index		No.	Grid	Building Index (cont)		No.	Grid	UCD College of Science		No.
Agnes McGuire Social Work Building (Arts Annex)	1	E9		Richview Buildings Labatory	52	E1		UCD School of Biological & Environmental Science	13,18,22,11	
UCD Agriculture and Food Science Centre	2	D7		Richview Lecture Building	53	F1		UCD School of Biomolecular & Biomedical Science	13,18,22,11	
Ardmore Annex	3	C8		Richview Library	54	E1		UCD School of Chemistry & Chemical Biology	13,18,22,11	
Ardmore House	4	C8		Richview Memorial Hall	55	F1		UCD School of Computer Science and Informatics	6,17,65	
Bank, AIB	5	C8		Richview Newstead Block A	56	F2		UCD School of Geological Sciences	6,22,65	
Belfield Office Park	6	D2		Richview Newstead Block B (Main Bld)	57	F2		UCD School of Mathematical Sciences	6,34,64	
Bicycle Shop	8	B10		Richview Newstead Block C	58	E3		UCD School of Physics	6,22,65	
UCD Boat	9	C4		Richview School of Architecture	59	E1				
Call Services	10	D7		Roebrick Castle	60	G11				
UCD Centre for Molecular Innovation and Drug Discovery	11	D6		Roebrick Newstead Residence	61	F11				
Centre for Research in Infectious Diseases (CRID)	12	B8		Roebrick Offices	62	G11				
Centre for Synthesis and Chemical Biology (CSCB)	13	D7		UCD Rosemount Environmental Research Station	63	H4				
Charles Institute	14	C5		UCD Science Centre (Hub)	64	D6				
UCD Clinton Centre for American Studies (Arts Annex)	15	B10		UCD Science Centre (North)	65	C6				
UCD Computer Centre	16	C5		UCD Science Centre (West)	66	D6				
UCD Computer Science and Informatics Centre	17	C6		UCD Science Centre (East)	67	C6				
UCD Conway Institute	18	B5		UCD Sports Centre	68	E5				
Cranmòg House	19	G12		St. Stephens	69	C10				
Daedalus Building	20	C9		UCD Student Learning Leisure and Recreation Facility	72	E5				
Energy Centre	21	F3		UCD Sutherland School of Law	73	D10				
UCD Engineering & Materials Science Centre	22	C9		Tierney Building (Administration Building)	74	C8				
Environmental Protection Agency	23	E1		UCD Urban Institute of Ireland (Ul) Veterinary Hospital	75	F1				
UCD Gary Institute (Arts Annex)	24	F9		UCD Veterinary Sciences Centre	77	B6				
Gerard Manley Hopkins Centre (UCD International Office)	25	D9		Woodview House	78	B5				
Glebe House	26	G11								
Glenomena Student Residences	27	C11								
Hanna Sheehy-Skeffington Building (Arts Annex)	28	E9								
Health Sciences Centre	29	C5								
UCD Humanities Institute Ireland	30	F9								
Information Point	31	B8								
UCD Institute of Sport & Health / Leinster Rugby	32	F2								
Irish Institute for Chinese Studies (UCD Confucius Institute)	33	G11								
UCD James Joyce Library	34	D7								
UCD John Hume Institute for Global Irish Studies (William Jefferson Clinton Auditorium)	35	B9								
Medical Bureau of Road Safety (MBRS)	36	D5								
Merton Street Residences	37	D11								
National Hockey Stadium	38	D4								
National Institute for Bioprocessing Research and Training (NIBRT)	39	C12								
National Virus Reference Laboratory (NVRL)	40	C8								
Newman Building	41	D8								
NovaUCD	42	B12								
Oakmount Crèche	43	G6								
UCD O'Kane Centre for Film Studies (Observatory)	44	F7								
O'Reilly Hall	45	C7								
Our Lady Seat of Wisdom Church Pavilion	46	E6								
Planning and Environmental Policy	47	D4								
UCD Quinn School of Business	48	E1								
UCD Research	49	D9								
Restaurant	51	D9								

Academic Index		No.	Grid	UCD College of Arts & Celtic Studies		No.	Grid	UCD College of Engineering and Architecture		No.
UCD College of Human Sciences				UCD School of Archaeology	19	A1, 60		UCD School of Art History and Cultural Policy	41	
UCD School of Applied Social Sciences	28			UCD School of Art History and Cultural Policy	41			UCD School of Classics	41	
UCD School of Economics	41			UCD School of English, Drama and Film	28	A1, 44		UCD School of History and Archives	30, 34, 41	
UCD School of Education	62			UCD School of English, Drama and Film	28	A1, 44		UCD School of Irish, Celtic Studies, Irish Folklore and Linguistics	41	
UCD School of Geography Planning and Environmental Policy	41, 48, 59			UCD School of History and Archives	30, 34, 41			UCD School of Languages & Literatures	41, 44	
UCD School of Information and Library Studies	34			UCD School of Irish, Celtic Studies, Irish Folklore and Linguistics	41			UCD School of Music	41	
UCD School of International Politics	41			UCD School of Languages & Literatures	41, 44					
UCD School of Politics and International Relations	41			UCD School of Mechanical & Materials Engineering	6, 21					
UCD School of Psychology	41									
UCD School of Social Justice	41									
UCD School of Sociology	34, 41									

Campus Information		Services		Traffic Calming Programme		Gates Opening Times	
		Bank	5	C8		N11 Entrance	24 hours
		Bicycle Shop	8	B10		Clonskeagh Entrance, (Mon-Sun)	07.00-20.00
		Campus Bookshop	34	D7		Owstenown Entrance, (Mon-Sat)	07.00-09.00
		Centra Supermarket	37	D11		Fosters Avenue Entrance	07.00-00.00
		CopiPrint	34,41,49	D7,D8,D9		Richview Entrance (Mon-Fri)	07.00-00.00
		Laundry	27, 61	C11, F11		(Sat)	07.00-18.00
		Pharmacy	70	D5		Richview Newstead Gate (Mon-Sun)	24 hours
		Post Office	51	D9		Roebrick Castle, Pedestrian Route	24 hours
		Sports Centre Barber	68	E5		Greenfield Park, Pedestrian Route	24 hours
		Student Desk	74	C8		Roebrick Road Gate Pedestrian Route (Mon-Fri)	07.00-18.00
		Student Health Service	70	D5			
		Students' Union	70	D5			
		Students' Union Shop	22,34,64	C9,D7,D6			
		UCD HIT	62	G11			

Traffic Calming Programme		Mon-Fri Barriers closed from:		16.00-19.30	

	<b>UCD Unicare:</b> our campus, our care...
	<b>Emergency Line:</b> <b>(01 716) 7999</b>

Buildings under construction or in the planning stage are shown in Italics





## Belfield Campus Map, July 2011



## **Delegate List**

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