

# « Introduction OF HIL'16 summer school »

**Prof. Betty LEMAIRE-SEMAIL**  
**Prof. Alain BOUSCAYROL**

L2EP, University Lille1

## - Outline -

*HIL'16, Lille, September 2016*

### 1. L2EP Lille

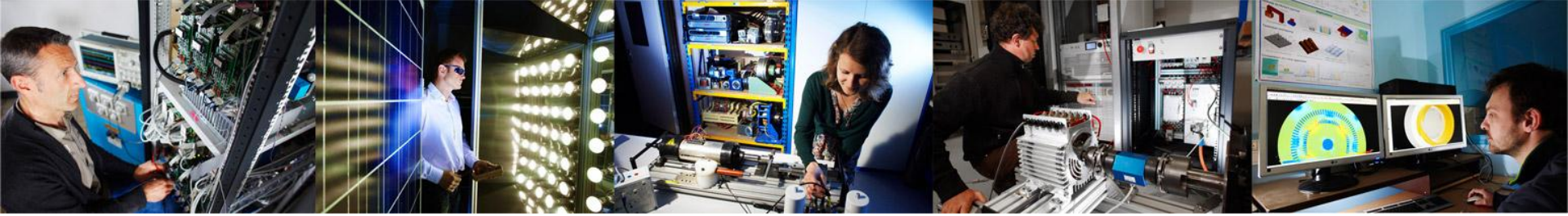
- University of Lille
- Research at L2EP
- HIL at L2EP



### 2. HIL'16 summer school

- global organization
- detailed information

**HIL'16**



HIL'16

# Lab of Electrical Engineering and Power electronics of Lille



Prof. Betty LEMAIRE-SEMAIL  
(L2EP, Université Lille1)



<http://l2ep.univ-lille1.fr/>

# at the crossroad of Paris, London and Brussels

Lille and suburbs more than 1.5 million inhabitants

4 universities

(120,000 students)

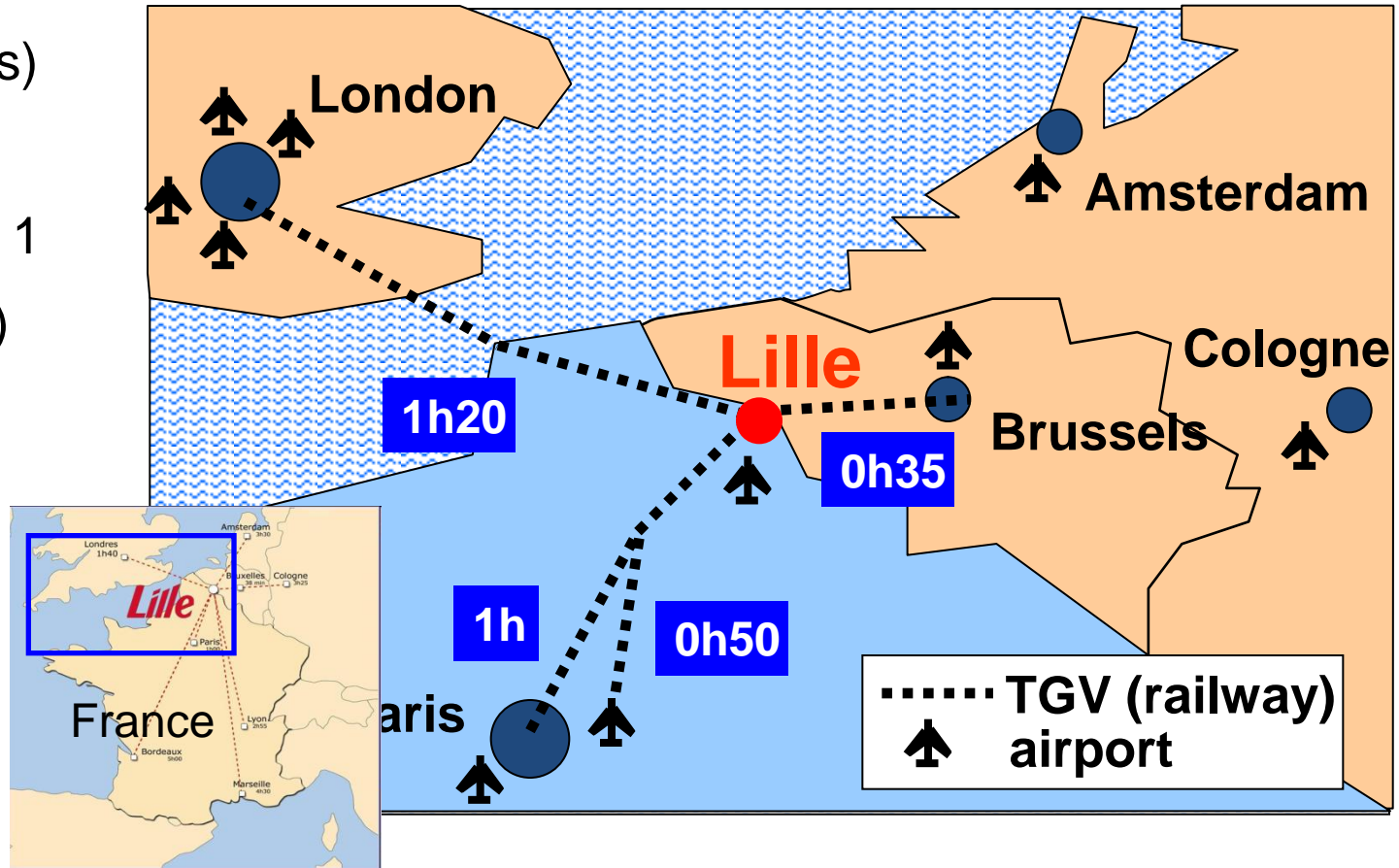
University of Lille 1

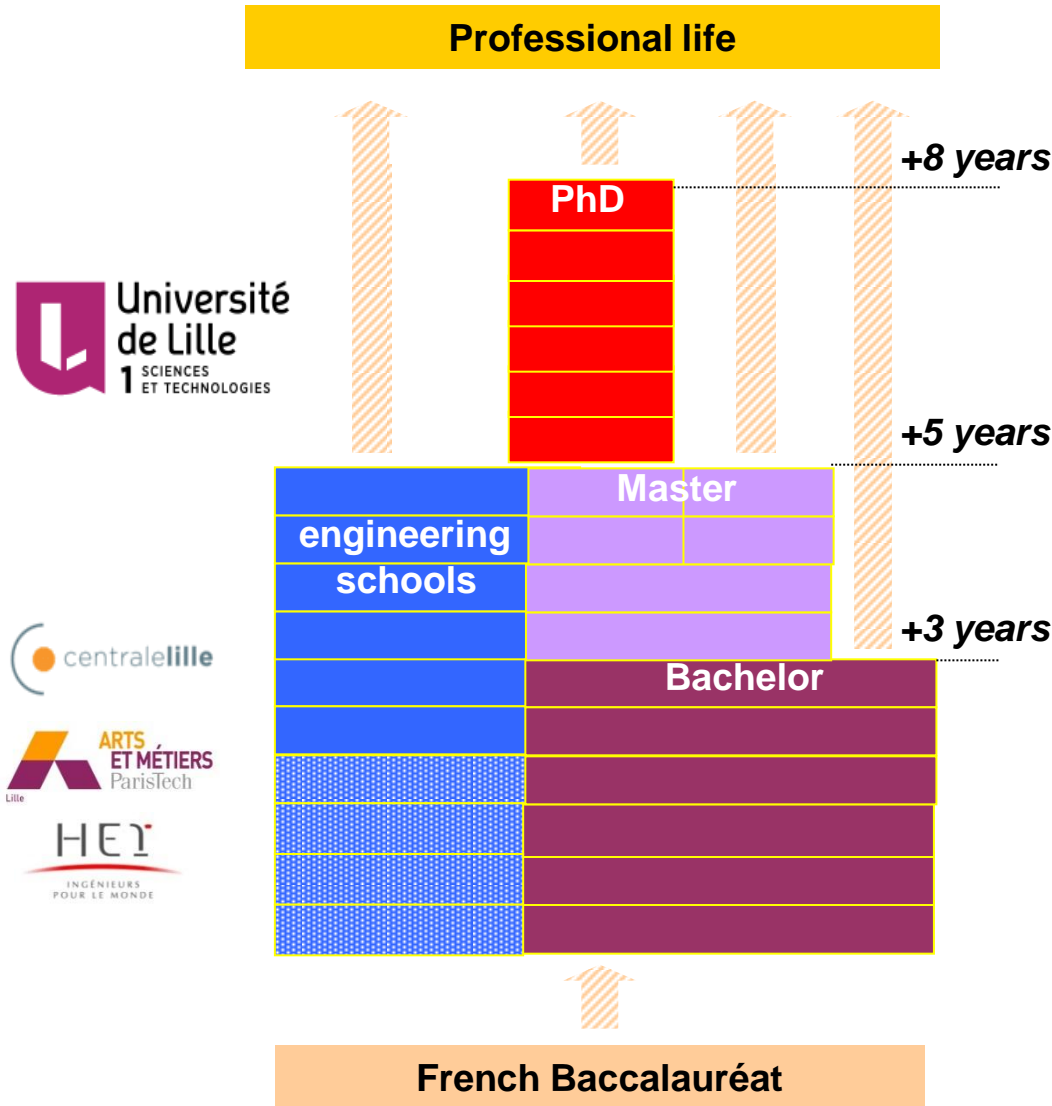
(30,000 students)

Univ Lille

(1+2+3)

70,000 students





## Fields of study at UL1:

- Social and human sciences
- Economy and management
- Sciences and technologies
  - ~ computer sciences
  - ~ control engineering
  - ~ **electrical engineering**
    - ~ mechanics engineering
    - ~ telecommunications...

## Master « Electrical Systems & Automatic Control »

4 specialities including  
 “Electrical Engineering for Sustainable development”



## Laboratory of Electrical Engineering and Power electronics (L2EP)

<http://l2ep.univ-lille1.fr/>



100 members : 30 professors and associate professors,  
40 PhD students, 12 lab's staff, Post-doctoral positions, Master students, etc.





**Prof. Betty LEMAIRE-SEMAIL**

**control**

**power  
electronics**

**numerical tools  
& methods**

**electrical  
grids**

**Prof. Alain BOUSCAYROL**

**Prof. Philippe LE MOIGNE**

**Prof. Abdelmounaim TOUNZI**

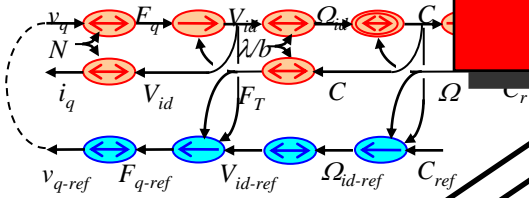
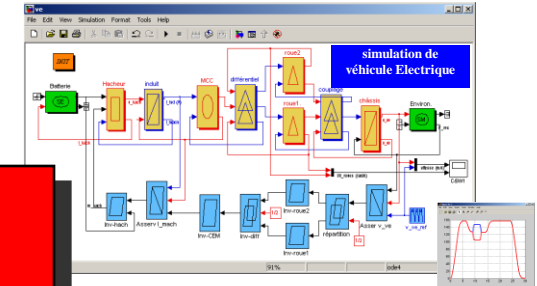
**Prof. Benoit ROBYNS**



4 Professors  
5 Associate Professors  
4 Engineers & Post-doc  
8 PhD students

« Control team »  
*Prof. A. Bouscayrol*

**Modelling and control formalisms**  
*(COG, EMR, MSV...)*

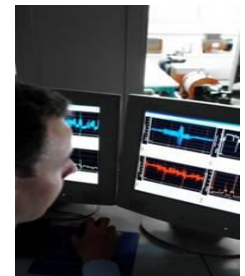


**B. Lemaire-Semail**  
« Electro-active actuators »

**A. Bouscayrol**  
« Electricity and Vehicle »

**E. Semail**  
« Multiphase drive »

**X. Kestelyn**  
« HVDC grids »  
*inter-team topic*



Formalisms bring solutions for new applications...  
... new applications lead to improve formalisms



## EMR Summer school

(Energetic Macroscopic Representation for modelling and control of energetic systems)

- Lille (France) 2006
- Harbin (China) 2008
- Trois-Rivières (Canada) 2009
- Lausanne (Switzerland) 2011
- Madrid (Spain) 2012
- Lille (France) 2013
- Coimbra (Portugal) 2014
- Lille (France) 2015
- Montreal (Canada) 2016
- **Lille (France) June 2017**



*EMR'15, Lille*

## PROTOTOUCH Summer school

(Human sensing and applications to robotics and haptic displays within ITN Marie-Curie Prototouch project of H2020)

- Lille (France) 2015

## Ecole d'été "Elément Finis"

(low frequencies Finite Element Methods for electromagnetic systems)

- St Nazaire (France) 2015

## First HIL application at L2EP Lille :

2002, HIL simulation of Wind Energy Conversion System

### “Control” team

Use of EMR to organize signal and power HIL simulation  
Application to wind conversion system, electric vehicles  
Human-In-the-Loop simulation for haptic devices



### “Electrical Grid” team

Use of real-time simulators of electrical grids for HIL simulation  
Applications to smart grids, renewable energy conversion systems



## International collaboration on HIL simulation (since 2005)

Aalborg university (Denmark), EPF Lausanne (Switzerland),  
Univ. Carlos III (Spain), Univ. Quebec Trois Rivières (Canada), etc.

## Industrial collaboration on HIL simulation (since 2006)

dSPACE France, Jeumont Industry, Nexter System,  
PSA Peugeot Citroën, Sherpa Engineering, Siemens  
Mobility, SNCF (French railway company) etc.

PSA PEUGEOT CITROËN

Valeo SIEMENS

nexter SNCF

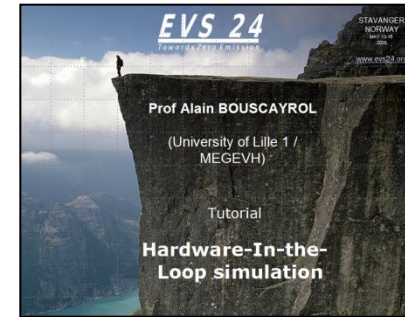
## Power HIL one of the main topics of L2EP for the 2010-2014 national evaluation

### Special sessions in conferences by L2EP (and MEGEVH)

IEEE-VPPC'07 (Dallas, USA), IEEE-VPPC'08 (Harbin, China),  
IEEE-ISIE'08 (Cambridge, UK), IEEE-VPPC'12 (Seoul, Korea)

### Tutorial in a conference by L2EP

EVS'2009 (Stavanger, Norway)

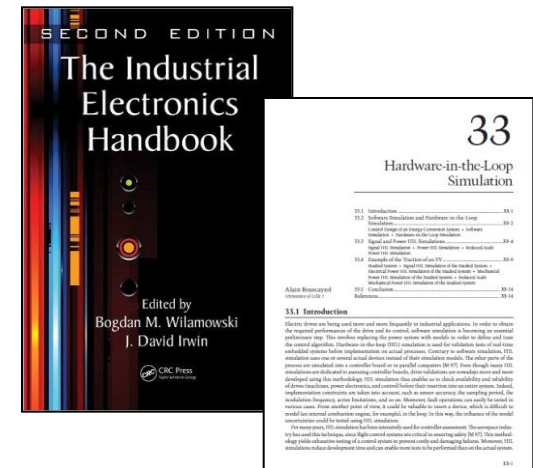


### Special section in international journal by L2EP

A. Bouscayrol, A. Monti, M. Steurer, "Hardware-In-the-Loop simulation",  
IEEE trans. on Industrial Electronics, vol. 57, no. 4, April 2010, (L2EP Lille,  
RTWH Aachen and Florida State University).

### Book chapter

A. Bouscayrol, "Hardware-In-the-Loop simulation",  
Industrial Electronics Handbook, second edition,  
tome "Control and mechatronics", Chapter 33,  
CRC Press, Taylor & Francis group, Chicago,  
March 2011, pp. 33-1/33-15, ISBN 978-1-4398-0287-8.





## “eV” (electricity & Vehicle) platform

focused on the study of innovative traction systems



## “EPMLab” (Electronic Power Management Lab)

focused on the study of future grids and related applications



# « HIL'16 organization »

**Prof. Alain BOUSCAYROL**

**Dr. Clément MAYET**

L2EP, University Lille1

## - HIL workshop -

HIL'16, Lille, September 2016

**First international workshop on HIL simulation**

L2EP Lille, July 2008 (1 day)

- Florida State University (USA)
- dSPACE (Germany)
- Opal-RT (Canada)
- LTE-INRETS (France, MEGEVH)
- L2EP Univ. Lille (France, MEGEVH)

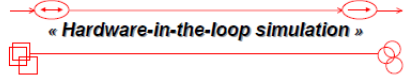
40 attendees, 5 lectures, 3 demos

outputs

- Special section “HIL” in IEEE trans. on Industrial Electronics



**INTERNATIONAL WORKSHOP**



« **Hardware-in-the-loop simulation** »

Lille, 3 July 2008  
 University of Sciences and Technologies of Lille  
 “Salle des thèses” (PhD room)

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*Preliminary program*

8h00 — *Welcome coffee*

8h30 — **Opening and introduction of the workshop**  
 (A. Bouscayrol, University of Lille, L2EP Lille)

8h45 — **Presentation of L2EP Lille and its control team**  
 (B. Lemaire-Semail, University of Lille, L2EP Lille)

9h00 — « **Hardware-in-the-loop simulation facility at Florida State University and applications** »  
 (M. Steurer, Center for Advanced Power Systems, Florida State University, USA)

9h30 — « **Hardware-in-the-loop simulation facility at dSPACE and automotive applications** »  
 (T. Schulz, dSPACE GmbH, Germany)

10h00 — « **Hardware-in-the-loop simulation methodology at University of Lille and applications** »  
 (A. Bouscayrol, University of Lille, L2EP Lille, France)

10h30 — *Coffee break* —

11h00 — « **Hardware-in-the-loop simulation at Opal RT and application using FPGA** »  
 (C. Dufour, Opal RT, Canada)

11h30 — « **Hardware-in-the-loop simulation facility at INRETS and HEV applications** »  
 (R. Tringui, LTE-INRETS, MEGEVH network, France)

12h00 — *Lunch* —

14h00 — **Experimental demonstration of HIL simulation of an Electrical Vehicle**  
 (K. Chen & A.L. Allègre, University of Lille, L2EP & MEGEVH network, France)


14h30 — *Subway to ENSAM Lille (downtown)*


15h00 — **Experimental demonstration of fault tolerant operation of polyphase machine**  
 (E. Semail, University of Lille, L2EP-ENSAM, France)


16h00 — **Experimental demonstration of HIL of an electrical grid**  
 (X. Guillaud, University of Lille, L2EP-EC Lille, France)


16h — *End of the workshop* —


*Scientific support*

  
Université des Sciences et Technologies de Lille

  
IEEE Section France

  
French network on Hybrid Electric Vehicle

  
TC1

  
Laboratoire d'Electrotechnique et d'Electronique de Puissance



- HIL'16 global organization -

HIL'16, Lille, September 2016

**Generalities and HIL concepts**

**HIL advanced applications**

**Experimental demos**

From the concepts to advanced applications  
And tools

	Day 1	Day3
08:00		
08:30		
09:00		
09:30		
10:00		
10:30		
11:00		
11:30		
12:00		
12:30		
13:00	<i>Lunch</i>	<i>Lunch</i>
13:30		
14:00		
14:30		
15:00		
15:30		
16:00		
16:30		
17:00		
17:30		
18:00		
18:30	<b>Coktail Dinner A&amp;MPT</b>	



- HIL'16 program -

HIL'16, Lille, September 2016



HIL main concepts,  
systematic organization,  
basic example

	Day 1	Day3
08:00		ESPESA session on HIL applications
08:30		
09:00	Introduction	
09:30	Generalities on HILs	Coffee break
10:00		
10:30	Coffee break	MEGEVH special session
11:00	EMR and basic example	
11:30		
12:00		
12:30		
13:00	Lunch	Lunch
13:30		
14:00		Demo Typhoon OPAL-RT
14:30	Demos Univ. Lille1	
15:00		
15:30		
16:00		Coffee break
16:30	transfer	open dicussion
17:00	Demo A&MPT	
17:30		



From the models for HIL  
to industrial applications

- HIL'16 Demos -

HIL'16, Lille, September 2016

	Day 1	Day3
08:00		ESPESA
08:30		session
09:00	Introduction	on HIL
09:30	Generalities	applications
10:00	on HILs	Coffee break
10:30	Coffee break	MEGEVH
11:00	EMR and	special
11:30	basic example	session
12:00		
12:30		
13:00	Lunch	Lunch
13:30		
14:00	Demos	Demo
14:30	Univ. Lille1	Typhoon
15:00		OPAL-RT
15:30		
16:00		Coffee break
16:30	transfer	open
17:00	Demo	dicussion
17:30	A&MPT	

3 groups, 2 demos  
45mn/demo  
and rotation



1 group, 1 demo  
A&MPT Lille downtown



2 groups, 2 demos  
1h/demo and rotation



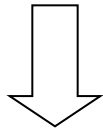
Typhoon HIL

plus free time  
for discussion

## - HIL'16 and credits -

HIL'16, Lille, September 2016

registered  
French Master  
and Phd students

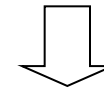


attendance  
Certificate  
for doctoral  
schools

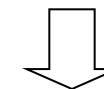


	Day 1	Day3
08:00		ESPESA
08:30		session
09:00	Introduction	on HIL
09:30	Generalities	applications
10:00	on HILs	Coffee break
10:30	Coffee break	MEGEVH
11:00	EMR and	special
11:30	basic example	session
12:00		
12:30		
13:00	Lunch	Lunch
13:30		
14:00		Demo
14:30	Demos	Typhoon
15:00	Univ. Lille1	OPAL-RT
15:30		
16:00		Coffee break
16:30	transfer	open
17:00	Demo	dicussion
17:30	A&MPT	

registered  
foreign Master  
and Phd students



4 pages report  
on HIL'16  
(deadline Sept.15)



2 ECTS from  
Univ. Lille1



## - HIL'16 &amp; partnership -

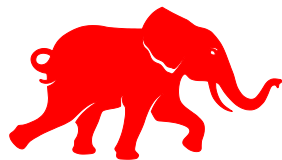
HIL'16, Lille, September 2016



## Scientific networks/organisations



French  
clusters



Typhoon HIL

Industrial partners



## - HIL'16 Venue -

**Demos:**

Building P2

**Lunches:**

restaurant "Ascotel"

**Lectures:**

Polytech'Lille

**WIFI:***Service Set Identifier*

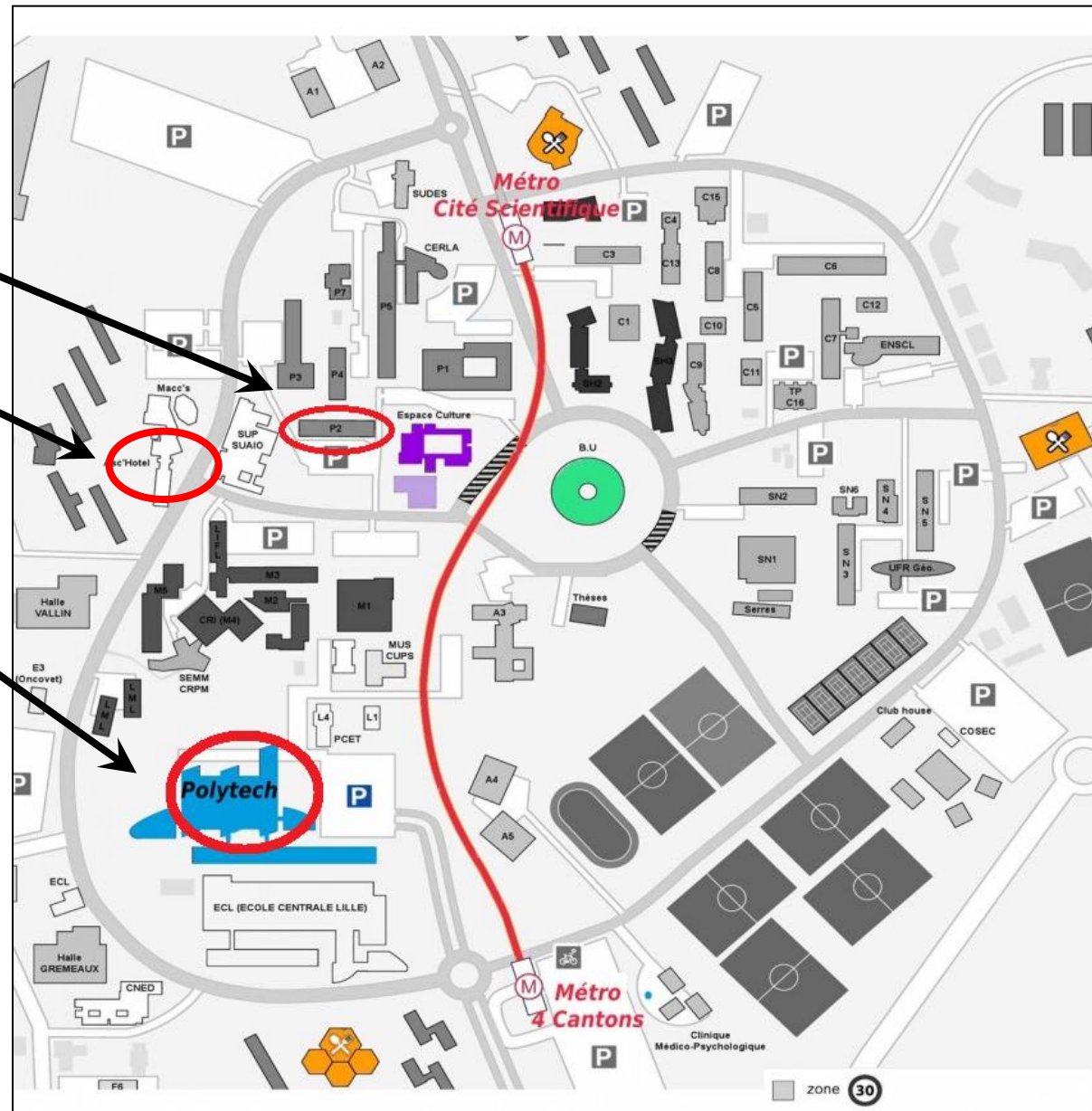
Polytech Guest

*Password*

tAs6teco (Day1)

zeNode5a (Day 2)

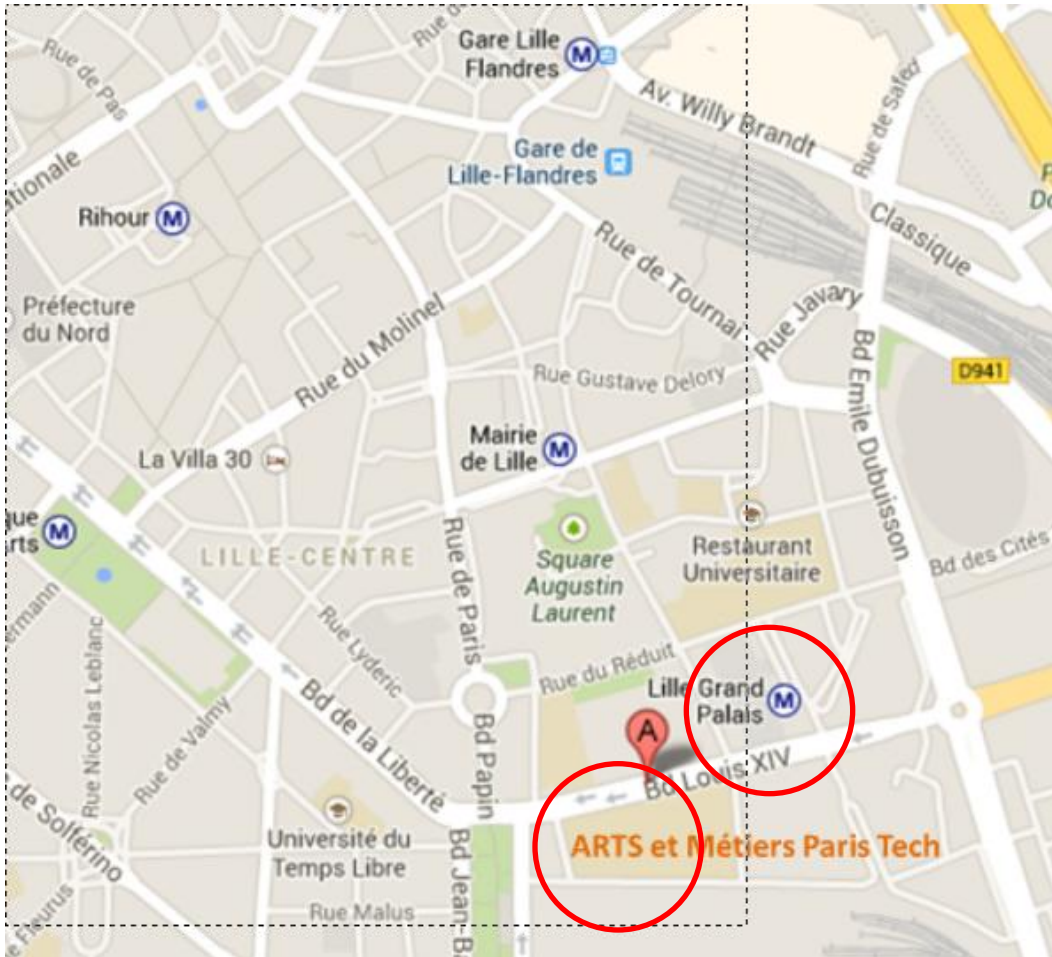
or EDUROAM





## - A&M Paris Tech -

HIL'16, Lille, September 2016



**Demo, today, 17h30**

A&M ParisTech

ENSAM

8 Bd Louis XIV

Lille downtown

(5 min walking from subway)

**Cocktail Dinner, 18h30**

A&MPT,

« Central Gallery »

**Subway station:**

Line 2,

« Lille Grand Palais »

30 min from Univ. Lille1

## - post-HIL information -

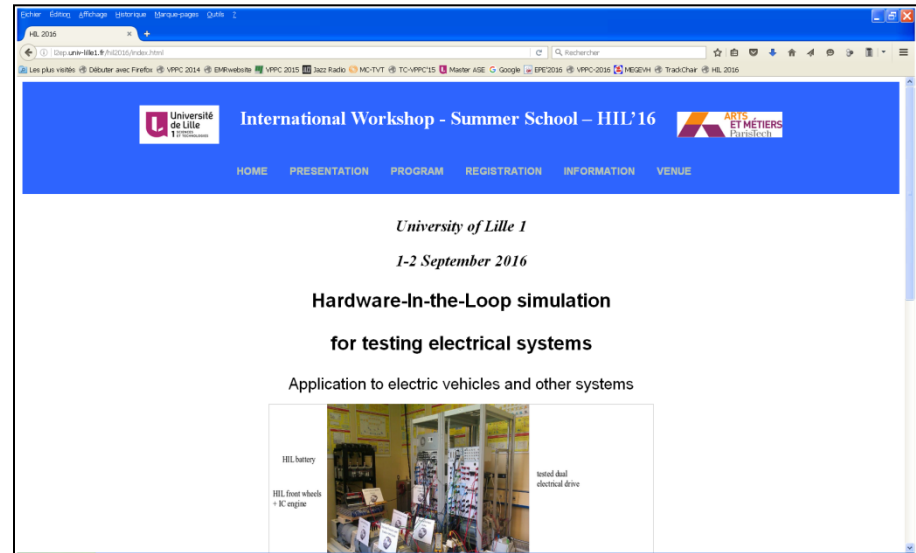
HIL'16, Lille, September 2016

pdf of lectures and photos

available in 2 weeks

on the HIL'16 web site

<http://l2ep.univ-lille1.fr/hil2016/>



**Thanks to all student volunteers!**  
**Thanks to all lecturers and demo presenters!**  
**Enjoy HIL'16 ! Enjoy Lille!**

# « BIOGRAPHIES AND REFERENCES »

## - Authors -

HIL'16, Lille, September 2016



### **Prof. Betty LEMAIRE-SEMAIL**

University Lille 1, L2EP, France  
Head of L2EP Lille

PhD in Electrical Engineering at Univ. Paris XI (1990)

Research topics: modeling and control of piezoelectric actuators

[Betty.Semail@polytech-lille.fr](mailto:Betty.Semail@polytech-lille.fr)



### **Prof. Alain BOUSCAYROL**

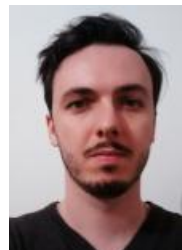
University Lille 1, L2EP, MEGEVH, France

Coordinator of MEGEVH, French network on HEVs

PhD in Electrical Engineering at University of Toulouse (1995)

Research topics: EMR, HIL simulation, tractions systems, EVs and HEVs

[Alain.Bouscayrol@univ-lille1.fr](mailto:Alain.Bouscayrol@univ-lille1.fr)



### **Dr. Clement MAYET**

University Lille 1, L2EP, France

PhD in Electrical Engineering at Univ.Lille1 (2016)

Research topics: Automatic subways, EVs and HEVs

[Clement.Mayet@univ-lille1.fr](mailto:Clement.Mayet@univ-lille1.fr)



## - References -

HIL'16, Lille, September 2016

- [Allègre 10] A. L. Allègre, A. Bouscayrol, J. N. Verhille, P. Delarue, E. Chattot, S. El Fassi, "Reduced-scale power Hardware-In-the-Loop simulation of an innovative subway", *IEEE transactions on Industrial Electronics*, vol. 57, no. 4, pp. 1175-1185, April 2010 (common paper of L2EP Lille and Siemens Transportation Systems).
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- [Bouscayrol 09] A. Bouscayrol, X. Guillaud, P. Delarue, B. Lemaire-Semail, "Energetic Macroscopic Representation and inversion-based control illustrated on a wind energy conversion systems using Hardware-in-the-loop simulation", *IEEE transactions on Industrial Electronics*, vol. 56, no. 12, pp. 4826-4835, December 2009
- [Bouscayrol 11] A. Bouscayrol, "Hardware-In-the-Loop simulation", **Industrial Electronics Handbook**, second edition, tome "Control and mechatronics", Chapter 33, CRC Press, Taylor & Francis group, Chicago, March 2011, pp. 33-1/33-15, ISBN 978-1-4398-0287-8.
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- [Letrouvé 13] T. Letrouvé, W. Lhomme, A. Bouscayrol, N. Dollinger, "Control validation of Peugeot 3008 Hybrid4 vehicle using a reduced-scale power HIL simulation", *Journal of Electrical Engineering and Technology*, Vol. 8, no. 5, September 2013, pp. 1227-1233 (common paper of L2EP Lille, and PSA Peugeot Citroën within MEGEVH, French network on HEVs).
- [Letrouvé 15] T. Letrouvé, A. Bouscayrol, W. Lhomme, J. Pouget, "Signal HIL Simulation of a Hybrid locomotive using Energetic Macroscopic Representation", *IEEE-VPPC'15*, Montreal (Canada), October 2015 (common paper L2EP Lille and SNCF, within MEGEVH, French network on HEVs).
- [Mayet 15] C. Mayet, A. Bouscayrol, P. Delarue, E. Chattot, J. N. Verhille, "Reduced-Scale-Power Hardware-In-the-Loop Simulation of a Subway Line", *IEEE-VPPC'15*, Montreal (Canada), October 2015 (common paper L2EP Lille and Siemens Mobility).
- [Verhille 07] J. N. Verhille, A. Bouscayrol, P. J. Barre, J. P. Hautier "Hardware-in-the-loop simulation of the traction system of an automatic subway", *EPE'07*, Aalborg (Denmark), September 2007 (common paper L2EP Lille and Siemens TS)