



# Smart Transmission System Lab

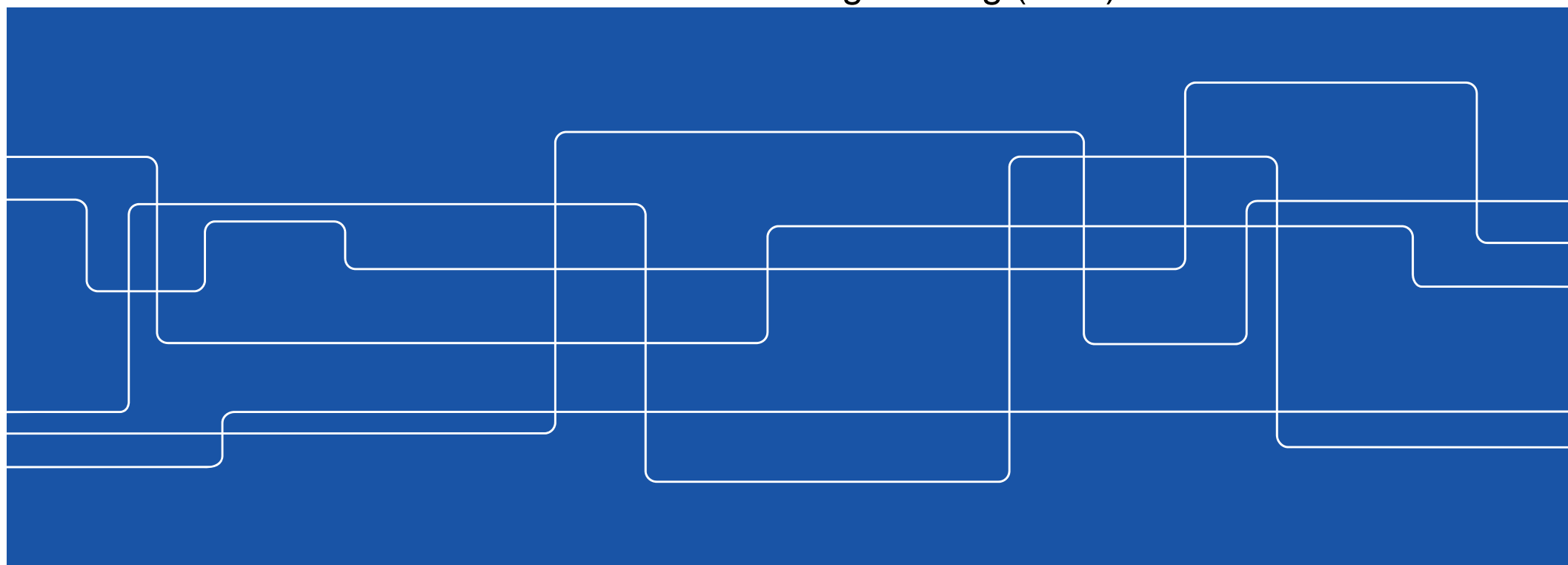
**SmartTS Lab**  
Smart Transmission Systems Laboratory

Muhammad Shoaib Almas

PhD. Candidate

Department of Electric Power and Energy (EPE)

School of Electrical Engineering (EES)





KTH Royal Institute of Technology  
Stockholm, Sweden

KTH

## Schools

- Architecture & Build Envir. (ABE)
- Biotechnology
- Chemical Science & Engineering
- Computer Science & Communication
- Electrical Engg (EES)**
- Education and Communication
- Engineering Sciences
- Industrial Engineering
- Information & Communication
- Technology & Health

## Departments

- Automatic Control
- Communication Networks
- Communication Theory
- Electromagnetic Engineering**
- Electric Power and Energy**
- Fusion Plasma
- Micro and NanoSystems
- Signal Processing
- Space and Plasma

## Groups

- Electric Machines
- Electricity Market
- Power Electronics**
- Renewable Energy
- SmarTS Lab**
- Management of Technology
- Power System Op. & Control**
- Power System Op. & Planning
- Software Systems Arch



# FACTS & FIGURES

University

**KTH**

- **311** professors, **258** Associate Professors **12000+** Full-time students
- QS World University Ranking **92**
- Ranked as **44<sup>th</sup>** best university in Europe

School

**Electrical Engg (EES)**

- **441 Faculty & Staff**
- QS World University Ranking by subject: **17**

Department

**Electric Power and Energy**

- **22 Faculty, 60+ PhD Students (Largest group in Europe)**
- **600+ Applicants** for EPE Program (450 in 2015)

Group

**SmarTS Lab**

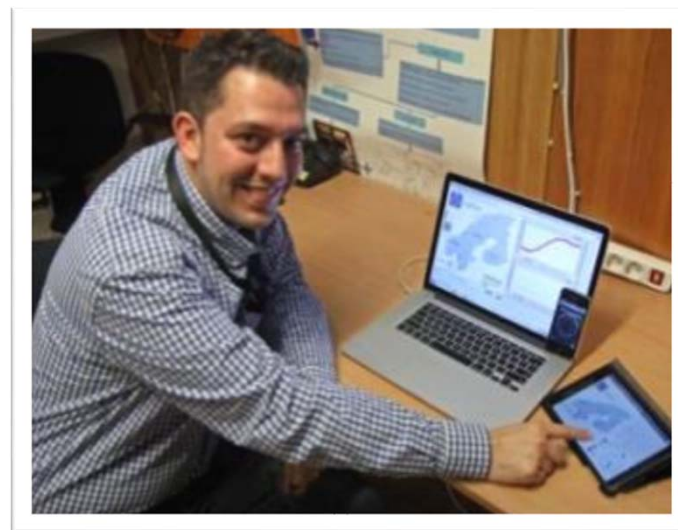


# Research Group Leader

Associate Professor: Dr. Luigi Vanfretti

Academic Appointments and Education:

- 2013 - Associate Professor (Tenured), KTH, Stockholm, Sweden
- 2012 - Docent, KTH
- 2010 - Assistant Professor, KTH
- 2010 - Post-Doc at RPI and KTH
- 2009 - Ph.D., Electric Power Engineering, RPI, Troy, NY, USA
- 2007 - M.Sc., Electric Power Engineering, RPI, Troy, NY, USA
- 2005 - Visiting Researcher, EEE Dept., The Univ. of Glasgow, UK
- 2005 - "Licenciatura" in Electrical Engineering, USAC, Guatemala.



# Statnett

• **Academic Activities:**

- Prof. Luigi Vanfretti the "Smart Transmission Systems Lab." or KTH SmarTS Lab at the Electric Power Systems Department at KTH carrying out research projects in the area of synchrophasor technology applications, and power system modeling, dynamics, simulation, protection and control.

• **Professional Activities:**

- Since 2011, Prof. Vanfretti serves as advisor to the Research and Development Division of Statnett SF. He is currently employed as Special Advisor in Strategy and International Work..
- Duties include R&D strategy development, and aiding in the execution of internal and external R&D projects.

# Research Group

12 persons: 2 staff, 1 post-doc, 7 PhD. students,  $\sim$ < [1 - 5] MSc students at a time

Research Group Leader: Associate Prof. Luigi Vanfretti

Lab coordinator: Viktor Appelgren

Post-docs (1):

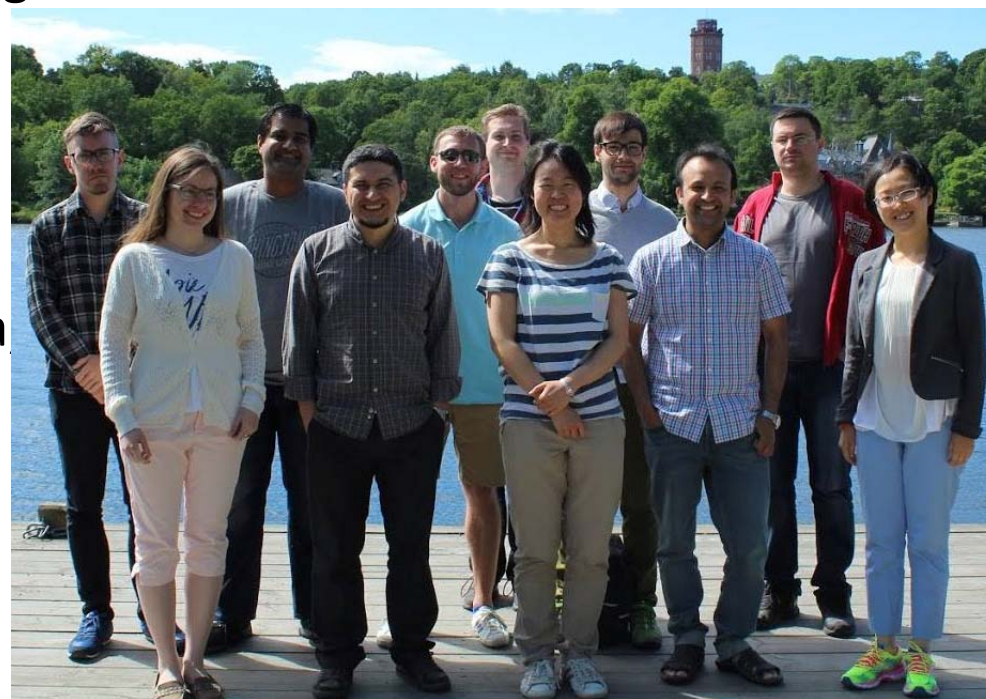
- Hossein Hosshyar

PhD Students (7):

- Wei Li, M.S. Almas, Tetiana Bogodorova
- Jan Lavenius, Farhan Mahmood,
- Maxime Baudette, Francisco Gomez

Researchers (2)

- Giuseppe Laera, Seyed Reza Firouzi





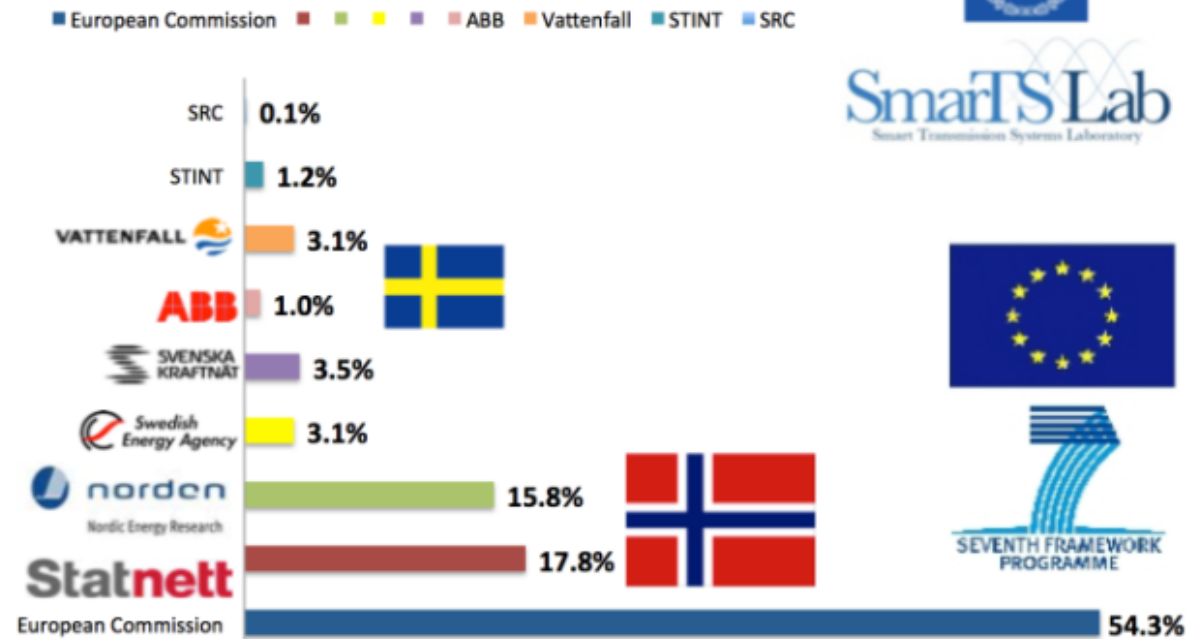
# International Projects and Funding

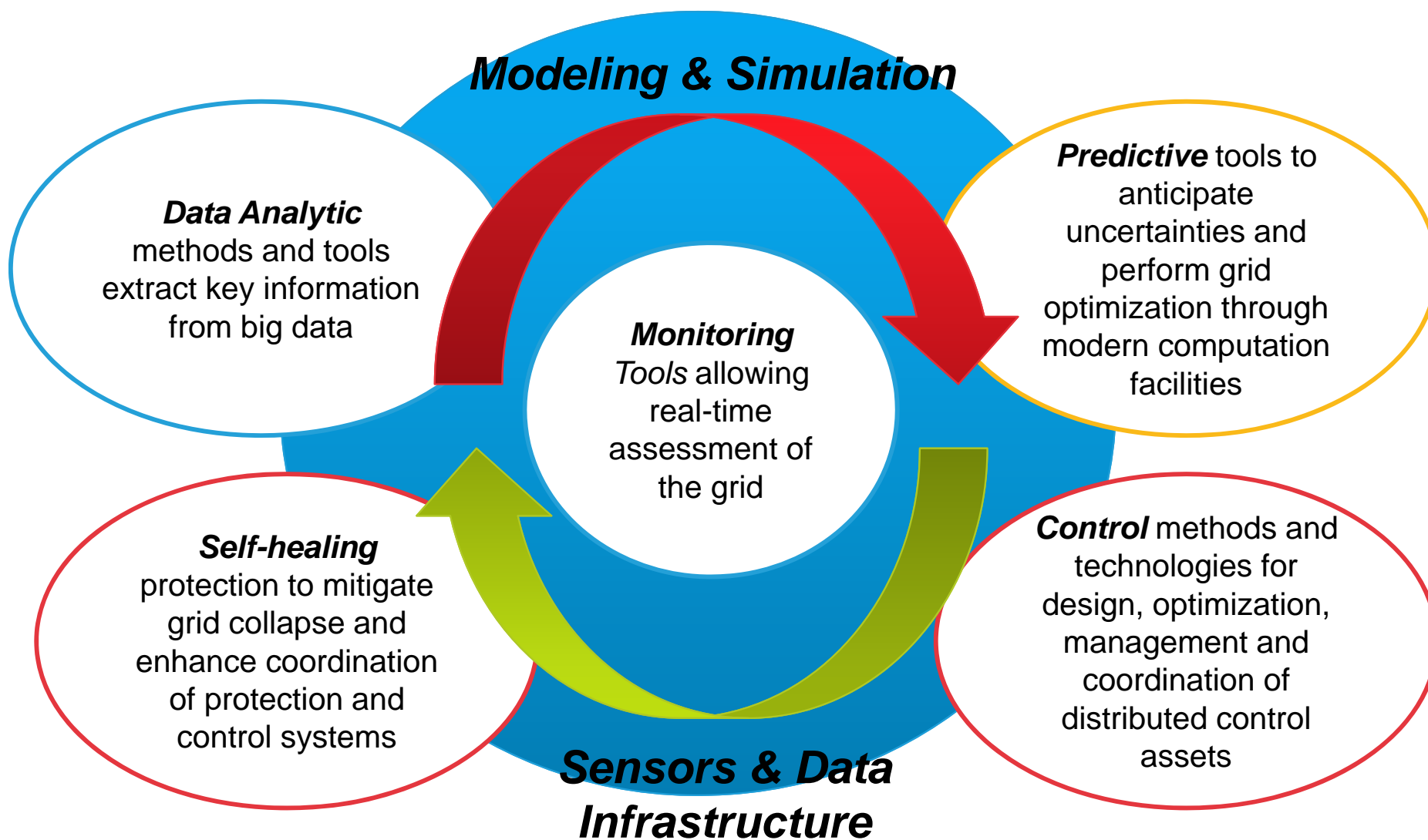
The research group participates in several international projects funded by the EC within the FP7 program and Nordic projects funded by NER, such as:



Smart Transmission Grids Operation and Control  
KTH - NTNU - AALTO - DTU - UI

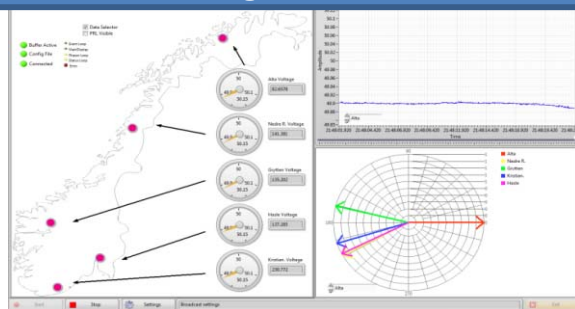
KTH SmarTS Lab. Research Funding Percentage by Funder  
Projects where Prof. Luigi Vanfretti acts as PI or CO-PI, 2010 - 2013  
(October)





# Research on Synchrophasor Technology Development in STRONG<sup>2</sup>rid (Software Apps)

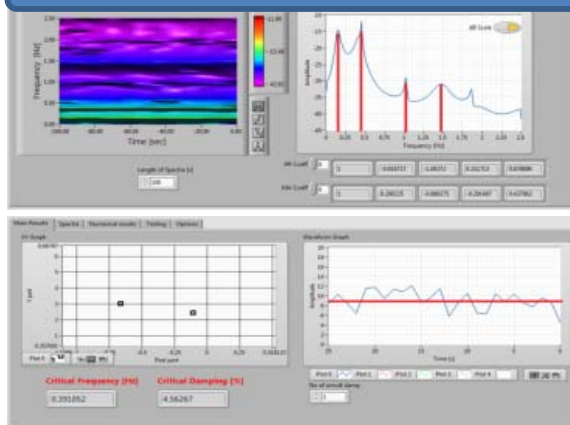
Monitoring & Visualization



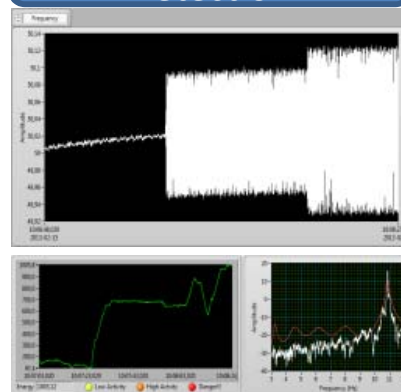
Mobile Apps



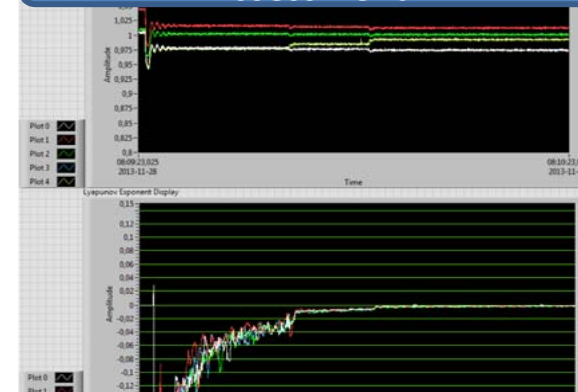
Inter-Area Oscillation Assessment



Forced Oscillation Detection



Real-Time Voltage Stability Assessment







# Lab. Implementation



# Thank you!

- Questions?
- <https://www.kth.se/en/ees/om/skolan/organisation/avdelningar/epe/research/smart-transmission-systems-laboratory-smarts-lab-1.627203>
- <http://www.vanfretti.com>
- [luigiv@kth.se](mailto:luigiv@kth.se)
- [msalmas@kth.se](mailto:msalmas@kth.se)



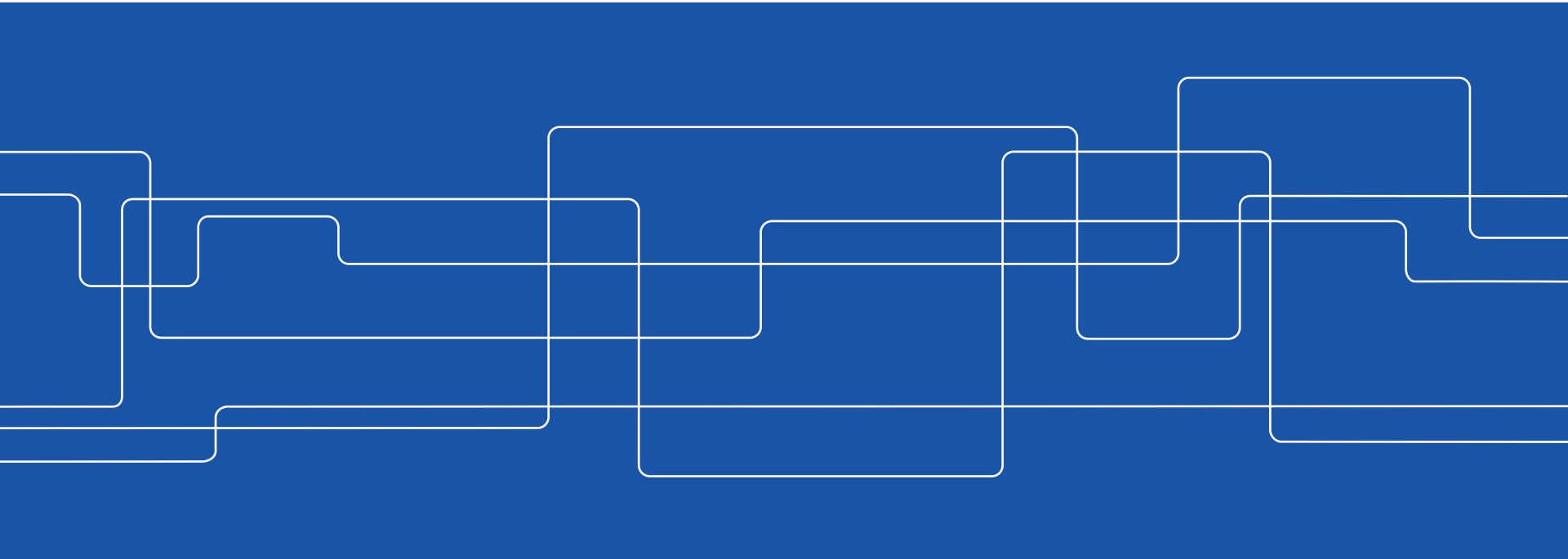
The scientific man does not aim at an immediate result. He does not expect that his advanced ideas will be readily taken up. His work is like that of the planter - for the future. His duty is to lay the foundation for those who are to come, and point the way. (*Nikola Tesla*)



# *Research Group* **Power System Operation and Control**

May 25<sup>th</sup> , 2016

KTH – Royal Institute of Technology





# Department of Electric Power & Energy Systems

Research Groups	Group Leader
Management of Technology	Joakim Lillesköld
Software Systems Architecture & Security	Pontus Johnson
Power System Operation & Control	Lars Nordström
High Power Electronics	Staffan Norrga
Electrical Machines & Drives Laboratory	Juliette Souldard
Integration of Renewable Energy Sources	Lennart Söder
Smart Transmission Systems Lab	Luigi Vanfretti
Electricity Markets Research Group	Mohammad Reza Hesamzadeh
Power System Operation & Planning	Mikael Amelin



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# PSOC - Research Area

## Power System Stability & Control

- Control of hybrid AC/DC transmission grids
- Realtime estimation of power system inertia
- Design & operation of low-inertia power systems

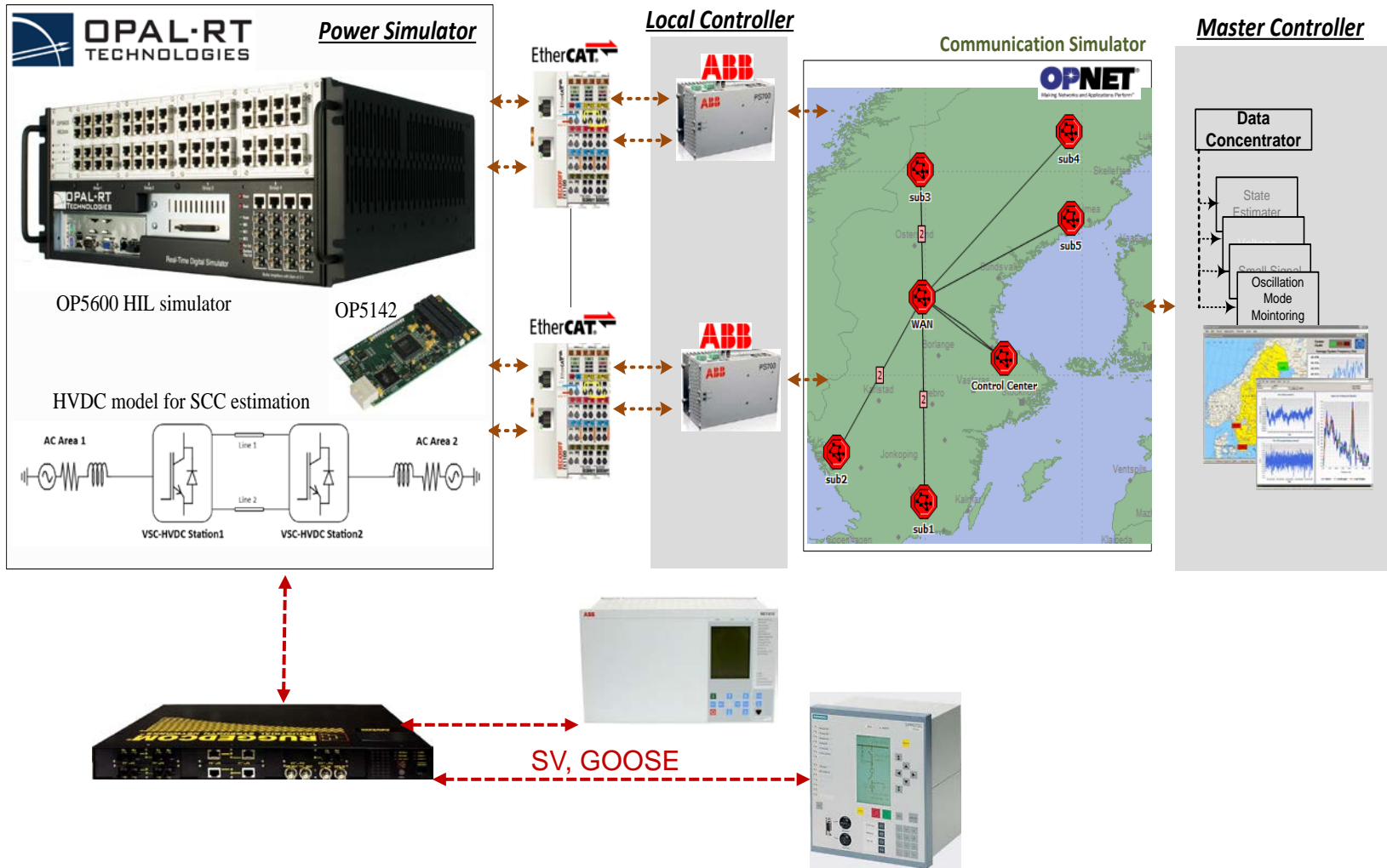
## Power System Communication & Substation Automation

- Flexible & interoperable ICT architectures
- Protocols – IEC 60870-5-101/104, IEEE C37.118, MMS, GOOSE, SV

## Information Models & Modeling

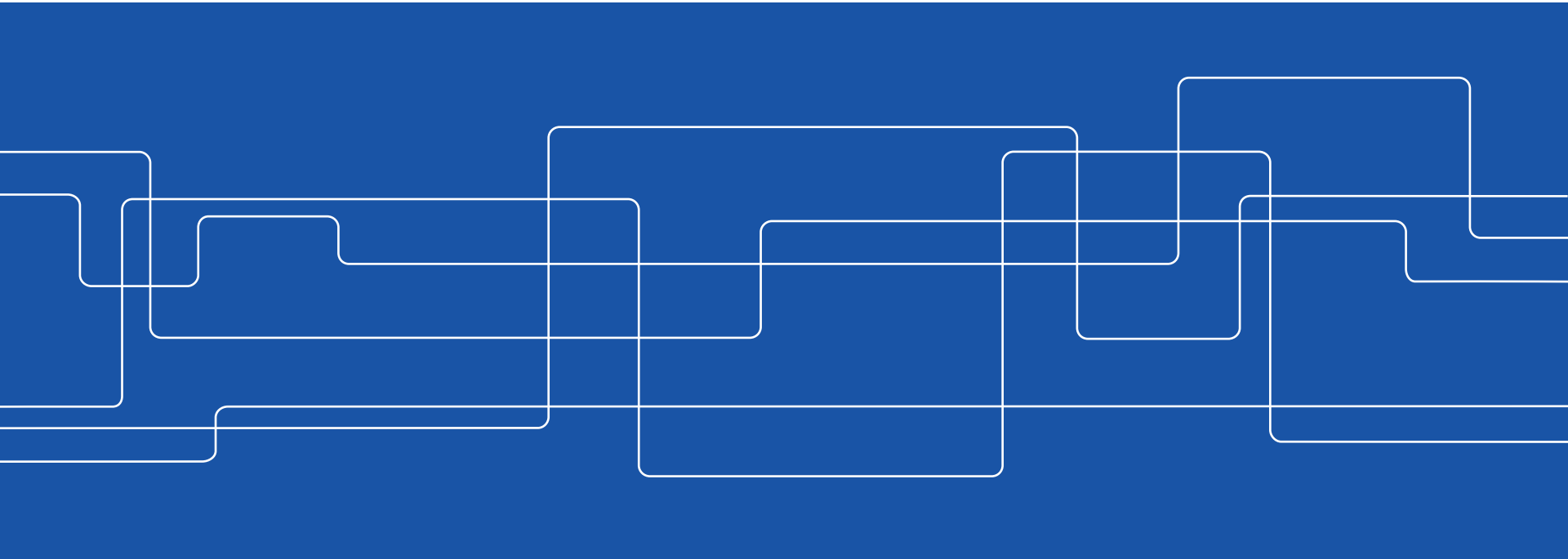
- IEC 61970 – Common Information Model
- IEC 61850 – SCL & Logical Nodes modeling

# Real-Time Co-Simulation Test-bed





**Thank you**







# KTH / EES / ETK / ..

## *A quick introduction:*

Where the KTH protection-related groups come within the KTH structure

An introduction of one group:

( Nathaniel Taylor, in the Dept. of Electromagnetic Engineering )

## *Main aims of this presentation:*

Let everyone get a better idea of how we relate to each other at KTH!

Make connection if anyone here has similar / complementary interests.

Nordic Workshop in Relay Protection, Trondheim 25<sup>th</sup> May 2016

NT: KTH / EES / ETK



# KTH Schools

School of Architecture and the Built Environment

School of Biotechnology

School of Computer Science and Communication

School of **Electrical Engineering**

School of Industrial Engineering and Management

School of Information and Communication Technology

School of Chemical Science and Engineering

School of Engineering Sciences

School of Technology and Health

Scientific Information and Learning

KTH Business Liaison



# KTH Electrical Engineering in numbers

**440 Employees (~2015) including:**

- ~30 Professors
- ~30 Assistant/Associate Prof.
- ~240 PhD students

**Strategic areas:**

- **Energy and electrical power**
- **Information and Communication Technology**
- Intelligent transport systems
- Micro and nanosystems
- Space, plasma and fusion



# KTH School of Electrical Engineering – now 9 departments

- Fusion Plasma Physics
- Space and Plasma Physics
- Signal Processing
- Communication Theory
- Communication Networks
- Automatic control
- Micro and nano systems
  
- **Electric Power and Energy Systems [EPE: merger of three, Jan 2016]**
  - Industrial Information and Control Systems (Control and communication) inc. Lars Nordström
  - Electric Power Systems (System aspects) inc. Luigi Vanfretti
  - Electrical Energy Conversion (Machines, power electronics)
  
- **Electromagnetic Engineering (“ETK”)**
  - (HV, insulation, switches, components, electromagnetics) inc. Nathaniel Taylor

*Now I consider just ETK : others are here to represent EPE*



# Electromagnetic Engineering: research groups and some sponsors

Electromagnetic theory - *Vinnova, VR*

Antennas - *Vinnova, VR, Ericsson*

Electromagnetic compatibility – *Banverket, SvK*

Modelling and measurement of magnetic materials – *SweGRIDS, Elektra*

**Diagnostics for electrical apparatus** – *SweGRIDS, Elektra, VR, InnoEnergy, AB*

High performance switches – *ABB, EnergyAgency, InnoEnergy*

Reliability Centred Asset Management – *SweGRIDS, Elforsk*

## Lab facilities:

**High Voltage   EMC   Antenna   Magnetics lab   Switching lab**



## My main previous/current work-areas:

Measurements: particularly Partial Discharge and Dielectric Response

Generator/motor stator insulation diagnostics  
Transformer insulation diagnostics

Characterise new materials: e.g. XLPE, nano-filled insulators  
Assessment of loss in road-materials for inductive powering of cars

Measurement of dielectric response to transient voltages

LV-net studies: loading, voltage-control protection, safety.



# Present & Near-future work relevant to protection

## [MSc, running]

Out-of-synch detection of generator, using rotor current measurement

Line-protection for UHV (i.e. unusually long, and high corona)

## [PhD, starting or applying]

Fault location accuracy in resonant-earthed systems

Distribution protection taking advantage of communications

The long-(UHV)-line protection issues

## [Course]

**Power System Protection** (6p, i.e. 4 weeks fulltime study)

Started 2014: a subject previously felt to be lacking

Fits with Computer Applications course (Lars Nordström)



## So, in terms of the 6 themes in our invitation:

Not my area – and very well covered by colleagues:

- Relay laboratory developments
- Wide area protection and control
- Communication and IEC61850

All of direct interest to me:

- Protection in distributed generation and micro-grids
- Distributed sensors for protection purposes
- New protection algorithms and concepts

**Discussion and future work are welcome, with industry or university**