Full proposal oc-2013-1-15312 for a new COST action

EU-MORNET: *European Model Reduction Network*

Proponent
Wil Schilders

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Where innovation starts

COST Actions

- COST is an intergovernmental framework for European **CO**operation in **S**cience and **T**echnology, allowing the coordination of nationally-funded research on a European level.

- COST has a very specific mission and goal. It contributes to reducing the fragmentation in European research investments and opening the European Research Area to cooperation worldwide.

- It anticipates and complements the activities of the EU Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries.

- It also increases the mobility of researchers across Europe and fosters the establishment of scientific excellence in nine key domains, as well as for TransDomain proposals

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COST mission

- Building capacity by connecting high-quality scientific communities throughout Europe and worldwide;
- Providing networking opportunities for early career investigators;
- Increasing the impact of research on policy makers, regulatory bodies and national decision makers as well as the private sector.

breakthrough scientific development for Europe's innovation

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We submitted a proposal EU-MORNET

- **Aimed at coordinating all activities in MOR and related areas within Europe**
- **It can be a breeding place for consortia that can apply for other European projects in the new Horizon 2020 programme**
  - **First calls were issued yesterday**
  - **http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/index.html**
  - **Very interesting option is EID (European Industrial Doctorate), cooperation between 1 university and 1 industry located in different countries**

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Outline

- **What is Model Reduction**
- **Why COST? Why now?**
  - *Structure of the Action*
  - *Objectives and deliverables*
  - *Organization*
  - *Timetable and milestones*
  - *Dissemination plan*
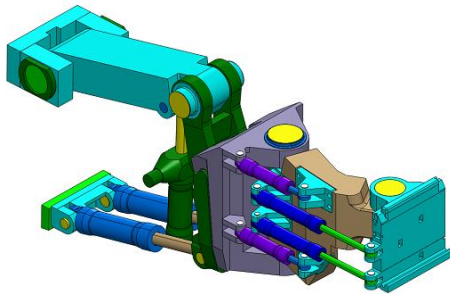 - *Long term impact*
  - *Global perspective*

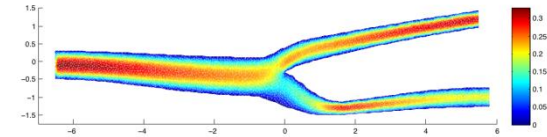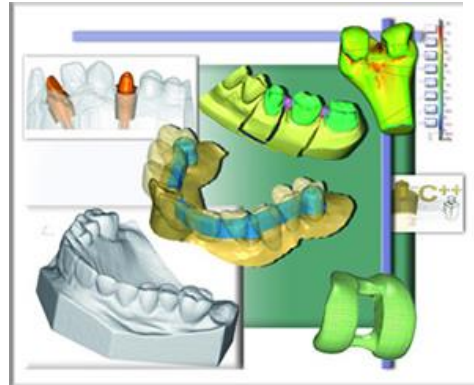# Countries participating in MoU preparation

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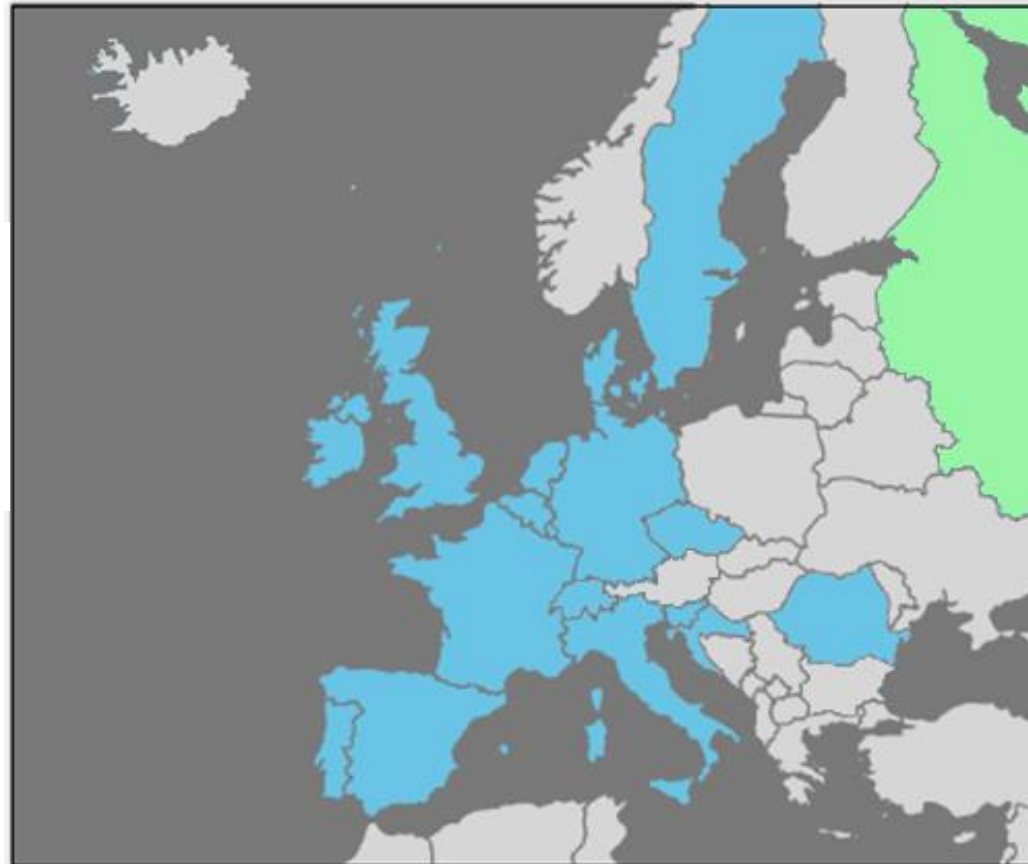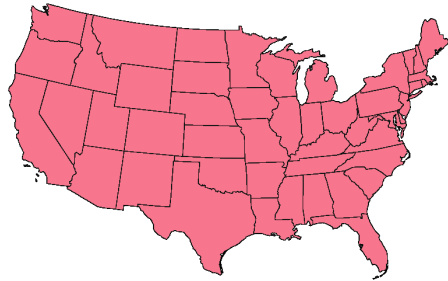
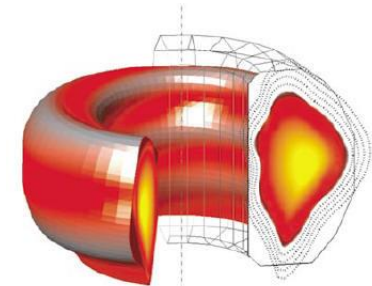# First stakeholders are already interested
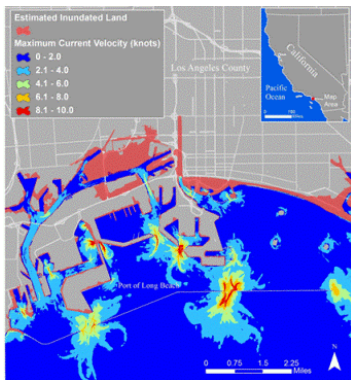
Applications of Model Reduction

Multibody systems
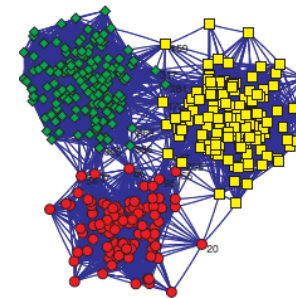
Medical and dental modeling

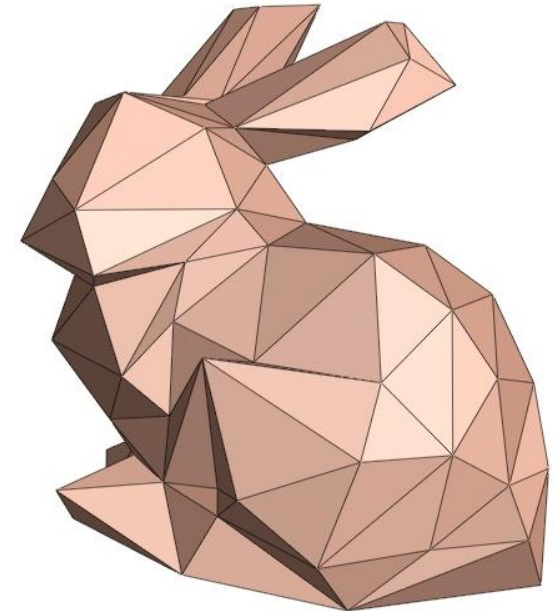Control and power

Tsunami risk analysis

Automotive

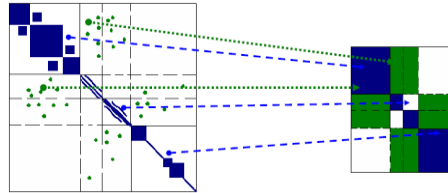Social networks

What is Model Reduction?

Capture main features of the behavior, retaining the accuracy of the approximation

What is Model Reduction?

- Often, models to describe phenomena (physical, economical and other sciences) are available

- But: they lead to systems that are too large too handle, even with future generations of computers

- This holds even stronger if couplings, optimization, variability of parameters are included

- Model Reduction captures the main features, and thereby reduces the computational resources very significantly

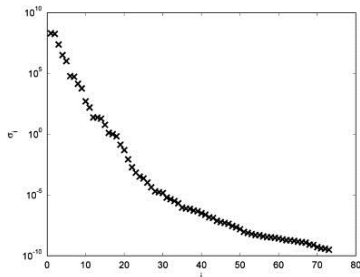- Model Reduction enables simulations that are not possible otherwise

NOTE: strong relation with the emerging topic of "Big Data"

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What is Model Reduction?

Scientific computing, numerical MOR, Krylov methods, linear algebra, tensors

- Pade-via-Lanczos and PRIMA
- Passivity preserving
- Structure preserving
- Linear and nonlinear problems
- Parameterized methods
- Tensor analysis

Systems and control, Lyapunov, Truncated Balanced Realization

- Large-scale Lyapunov systems
- Balanced realizations
- Observability and controllability Gramians
- Port-Hamiltonian systems
- Hankel singular values
- Projection methods

Mathematical modeling, behavioral modeling, models via data

- MOR at operator level
- Karhunen-Loeve expansions
- Neural networks
- Vector fitting
- Behavioral models

$O(t) = b + \sum_i w_i \tanh(c_i + \sum_j v_{ij} I_j(t))$

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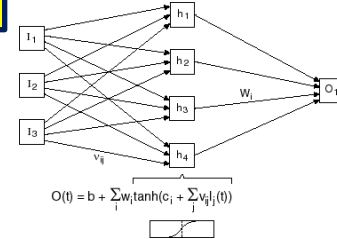
Why these topics together?

Scientific computing, numerical MOR, Krylov methods, linear algebra, tensors
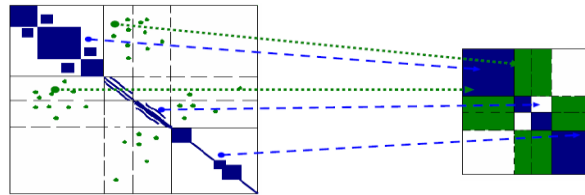
Systems and control, Lyapunov, Truncated Balanced Realization

Remarkably, they share the same common phenomenology!

Mathematical modeling, behavioral modeling, models via data

$$O(t) = b + \sum_i w_i \tanh(c_i + \sum_j v_{ij} I_j(t))$$

Why COST? Why now?

Scientific computing, numerical MOR, Krylov methods, linear algebra, tensors

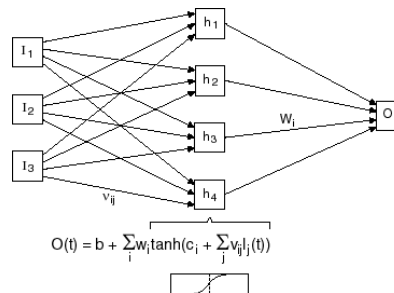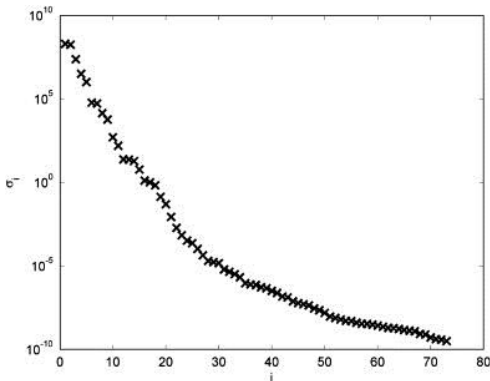Systems and control, Lyapunov, Truncated Balanced Realization

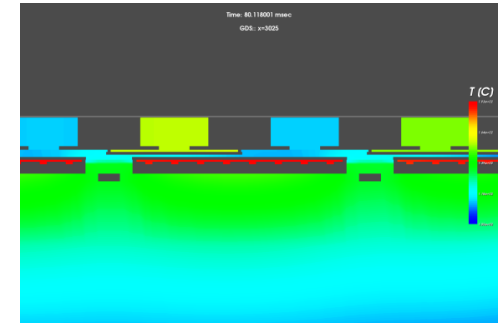**Many urgent and challenging problems need a unified approach!**

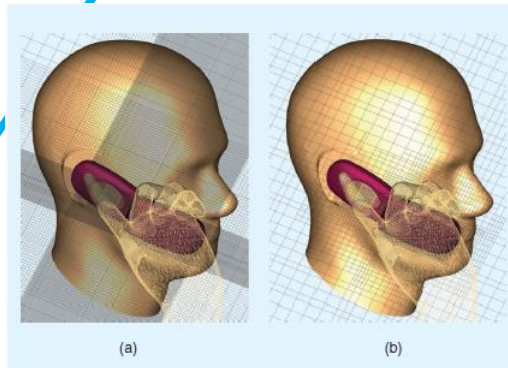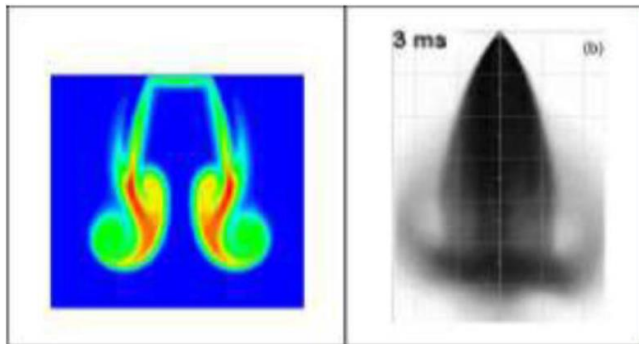Mathematical modeling, behavioral modeling, models via data
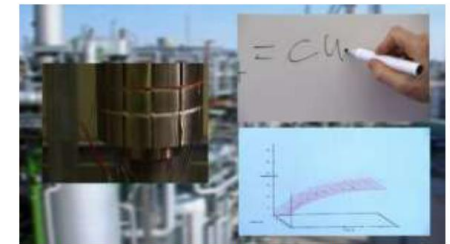
Experiment, modeling and simulation of heat transport.

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Trans Domain character

- ## ESSEM

  - Synthesis between a dynamical model of the atmosphere/ocean and noisy, incomplete and heterogeneous observations of the real atmosphere/ocean. The computational costs for this optimization problem increase considerably within the trend towards high-resolution simulation. To reduce these costs nonlinear model reduction techniques must be developed.

- ## BMBS

  - Data from EEG, MRI, or PET scans amounts to multiple mega-, giga-, or potentially even terabytes, with an associated increase in the time required to execute an individual step in NLME model fitting. Parameterised and nonlinear model reduction being one of the best candidates to resolve this challenge.

- ## MPNS

  - A systematic comparison between numerical simulations and experiments in order to validate new experimental techniques, mathematical modeling and to uncover a cleaner and more complete picture of the physics of air pollution is highly needed. Model reduction plays an important role in reducing the computation times for the complex turbulent flow simulations.

+ more to come

ICT outstanding application:
Electronics industry and fundamental science hand in hand

- Electronics is all around us, we are fully dependent on it
- The design of modern electronics is made possible by advances in mathematics
- Model reduction plays an essential role in satisfying the needs of designers:
  - Reliable and accurate simulation of huge interconnect structures
  - Reduction of substrate networks to describe signal propagation
  - Fast and accurate design of power transistors by using parameterized model reduction
- Results can be transferred immediately to applications in other COST domains
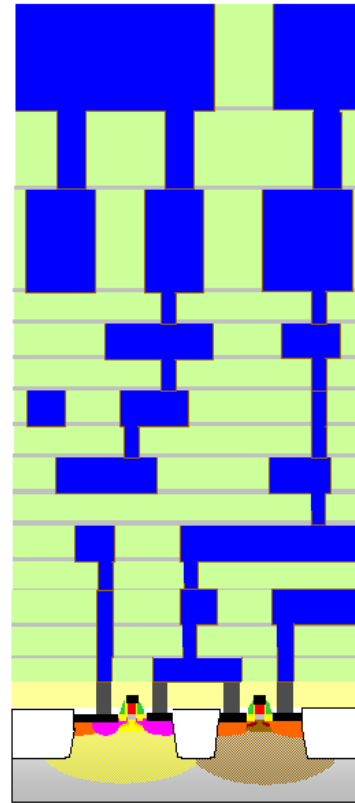
(Courtesy of NXP Semiconductors)

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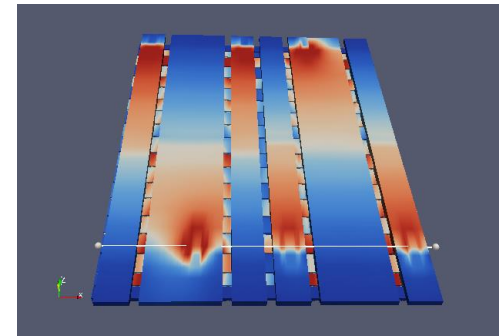
Advances in computer power AND mathematical algorithms

Improvements in Algorithms Relative to Moore's Law
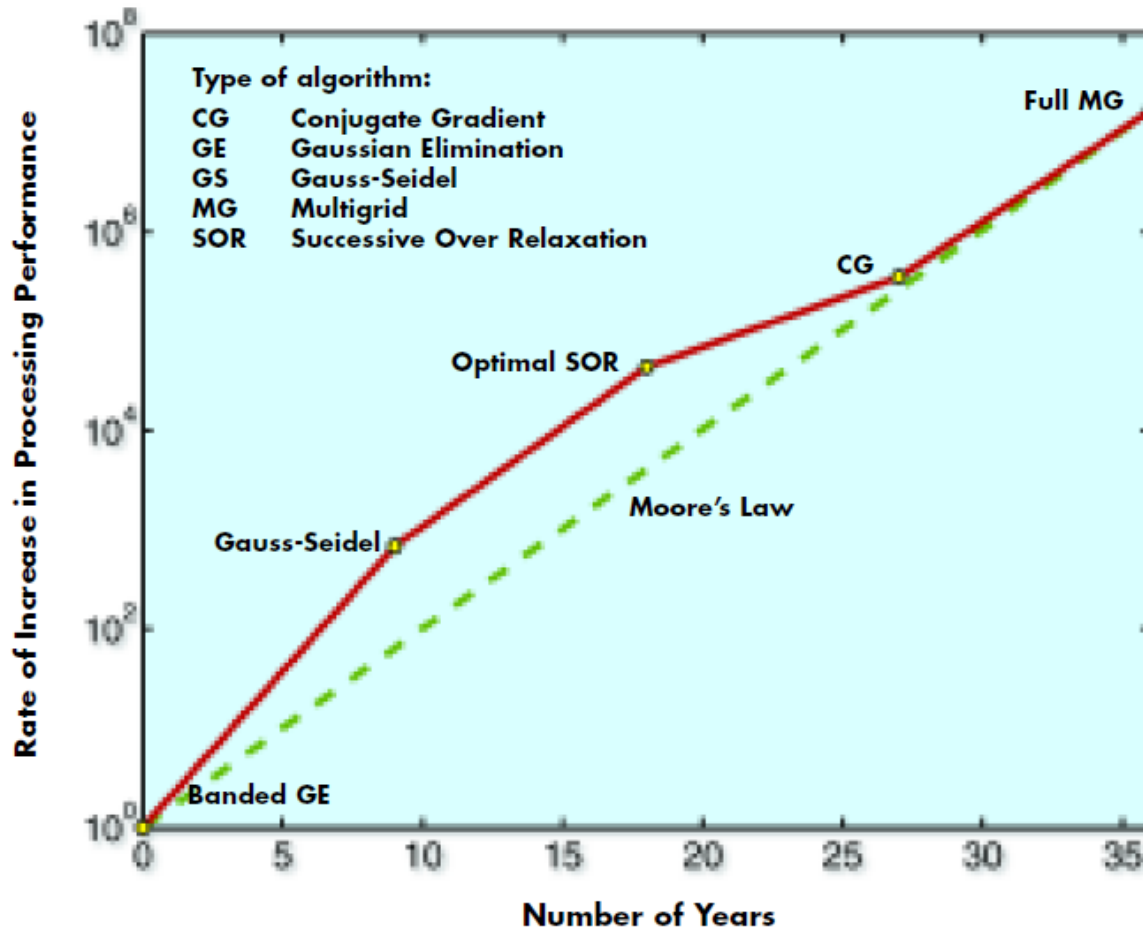
Model Reduction

Why COST? Why now?

Lyapunov equations

High performance computing

Eigenvalues

Scientific computing

Tensor methods

Singular values

Iterative methods

Systems & Control

Academia

Numerical linear algebra

Error estimates

Analytical techniques

Industry

Experimental techniques

Behavioral modeling

Extreme variety of approaches and views on the problem

Massive data

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Objectives

- **Main Action objective:** "significantly bringing down computation times for realistic simulations and co-simulations of industrial, scientific, economic and societal models by developing appropriate **model reduction methods**"

- **Secondary objectives:**
  - A **unified framework** of **model reduction** techniques
  - Support **fundamental research in MOR** in all areas
  - Stimulate development of **novel methods and models**
  - **Disseminate the results** towards other communities
  - Foster the multidisciplinary/multisectorial **training of ESRs**
  - Promote ESRs commitment towards **outreach activities**

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Deliverables

- **State-of-the-art research** covering a broad scientific ambit
- **Scientific publications** in high impact journals
- **Model order reduction techniques** for challenging problems of relevance for industries
- **A centralized database of resources** open to the full scientific community (including experimental and numerical data, numerical codes, manuals, scientific articles and presentations)
- **An online collection of seminars** and web-based dissemination material (such as e-books)
- **Final activity report** including self-evaluation
- **Annual prizes** for ESRs

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Organization
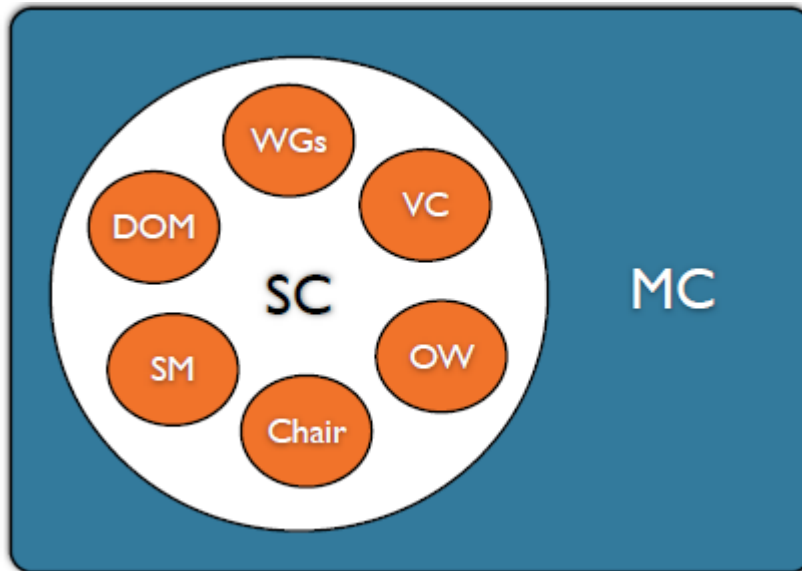
Chair - Chair of the Action

VC - Vice Chair

DOM - Dissemination and Outreach Manager

SM - STSM Manager

OW - Ombudswoman

WGs - WG coordinators

SC - Steering Committee

MC - Managing Committee

Within each of the WG,
all scientific topics are represented

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Time table and milestones

	WG1	WG2	WG3	WG4	
Year 1	Kick-off meeting & set up of Working Groups				M
	WG meetings				
	Dissemination and outreach (lead by WG4)				
	Training school, STSMs				
	Annual workshop (including MC and WGs meetings)				
	Annual ESR research and outreach prizes				D
	Progress and achievements report				M
Year 2	WG meetings				M
	Dissemination and outreach (lead by WG4)				
	Training school, STSMs				
	Annual workshop (including MC and WGs meetings)				
	Annual ESR research and outreach prizes				D
	Progress and achievements report				M
Year 3	WG meetings				M
	Dissemination and outreach (lead by WG4)				
	Training school, STSMs				
	Annual workshop (including MC and WGs meetings)				
	Annual ESR research and outreach prizes				D
	Progress and achievements report				M
Year 4	WG meetings				M
	Dissemination and outreach (lead by WG4)				
	Training school, STSMs				
	Final conference (including MC and review meeting)				
	Annual ESR research and outreach prizes				D
	Other Action deliverables (see section C.2)				M
	Final report including self-evaluation				

M: milestone
D: deliverable

Dissemination plan (WG4)

- **Target of dissemination activities**
  - **Researchers** in the scientific fields related to the Action
  - **Researchers** in scientific fields close to the topics of the Action that may find the research activities conducted within the Action of interest for their work
  - **Industries** and researchers at industries
  - **Universities** and **research institutions** working in topics related to the Action
  - Other **European projects and networks** (COST Actions, Horizon 2020, …)
  - **Research agencies** and **funding bodies** at national and international level
- **Target of outreach activities**
  - **Media**: journals, digital media and TV
  - **Early Stage Researchers**
  - **General public**
  - **Students** at high schools
- **Planned dissemination activities**
  - Start a series of **European conferences** on Model Order Reduction
  - European repository of **benchmark problems** including results
 - Series of **industrial workshops** with job openings for ESRs

Dissemination plan (WG4)

- **The Action website will contain:**
  - Description of the scientific scope and objectives of the Action
  - Information on how to join the Action, the WGs and how to apply for STSMs
  - Updated information on all forthcoming and past events organized by the Action
  - Collection of scientific presentations given at past Action events
  - Lost of all Action members with full contact information, field of expertise, years since PhD, participation in WGs
  - List of recent publications from each Action participant
  - Dissemination and outreach material such as posters and leaflets
  - Media releases
  - Information on how to apply for ESRs science and outreach prizes
  - Dedicated page on awarded ESRs with respective motivations
  - List of forthcoming and past outreach events
  - Announcement of career opportunities and openings within the Action groups
  - Availability of technical and soft skill training courses at participating institutions

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Long term impact

- **The Action will**
  - **Publish a handbook on "Model Order Reduction"** covering from the fundamental didactical aspects to the most recent interdisciplinary research. The preparation of the volumes will start during year 1 (plan discussed during KO) and will proceed till the end of the Action. These volumes will constitute the final Action publication.

  - **Foster the training of a new class of ESR with interdisciplinary background.** These ESR will be the warranty that "Model Order Reduction" will continue as a supra- disciplinary field in the longer period, well after the end of the Action.

  - **Set up a series of conferences.** These will be of a highly interdisciplinary nature.
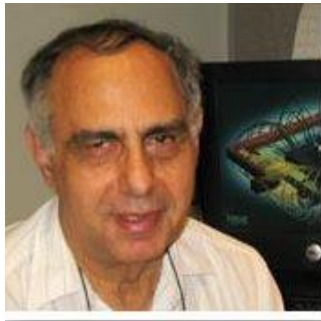
Global perspective
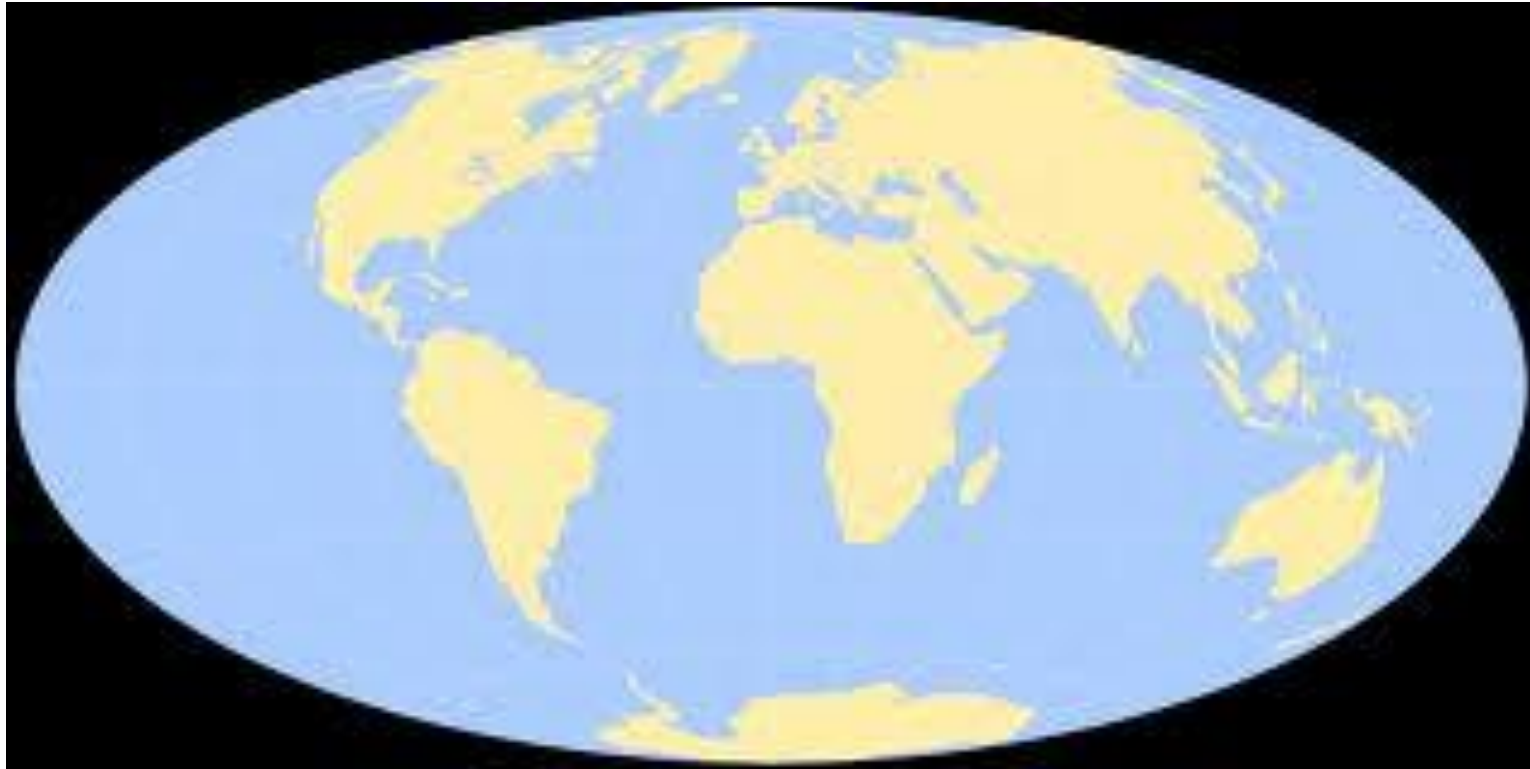
Some non-COST countries already in MoU
Request s for non-COST will be formulated during KO

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Tentative list of first non-COST institutions

- **Luca Daniel (MIT, USA)** MOR for applications in health (MRI)

Ionel Michael Navon (Florida State University, USA) Hyper-efficient Operational Data Assimilation Using Reduced Order Models

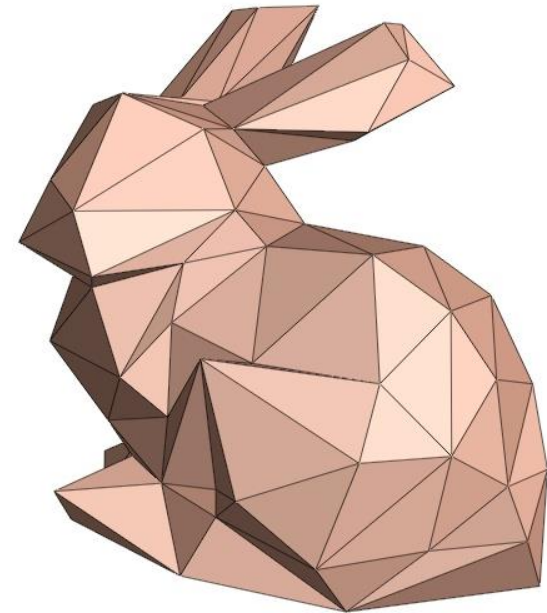- **Juan Carlos Afonso (Sydney University, Australia)** MOR for geodynamics

- **Michel Nakhla (Carleton University, Canada)** MOR for design of electronic systems

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What's next

- A web page has been created:
  - http://www.cost.eu/TD1307
  - Here you can download the Memorandum of Understanding, containing the original description of this COST Action
- Every country that was in the original list of proposers needs to nominate candidates for the MC
  - On the web page, you can keep track of the status
- Once this has been finalized, a kick-off meeting will be planned where the MC will meet, and first activities discussed
  - This includes setting up the structure for applying for short term scientific missions, proposals for workshops, etc.
  - We aim at a meeting early in 2014 to get things started quickly
  - After kick-off, additional members can join
  - From industry and Eastern Europe!

A logo would be nice…….

- **Ideas are welcome**
- **A good bottle of wine (or a few beers) will be the reward!**

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