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Simulations in a Global Company: Possibilities and Challenges

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Power and productivity for a better world™

A global leader in power and automation technologies
Leading market positions in main businesses

- ABB has 120,000 employees in about 100 countries
- $32 billion in revenue (2010)
- Formed in 1988 merger of Swiss and Swedish engineering companies
- Predecessors founded in 1883 (ASEA) and 1891 (BBC Brown Boveri)
- Publicly owned company with head office in Switzerland

ABB at a glance
Divisional structure and product portfolios

	**Power Products**	**$11.2 billion 33,500 employees**	▪ Transformers, high- and medium-voltage switchgear, breakers, automation relays
	**Power Systems**	**$6.5 billion 16,000 employees**	▪ Substations, FACTS, HVDC, HVDC Light, power plant & network automation
	**Discrete automation and motion**	**$5.4 billion 18,000 employees**	▪ Robots, drives, motors, power electronics, and instrumentation
	**Process Automation**	**$7.8 billion 28,000 employees**	▪ Control systems and application-specific automation solutions for process industries
	**Low voltage products**	**$4.1 billion 19,000 employees**	▪ Low-voltage products, peripheral devices and modular manufacturing solutions for industry

2008 revenues (US$) and employees per division

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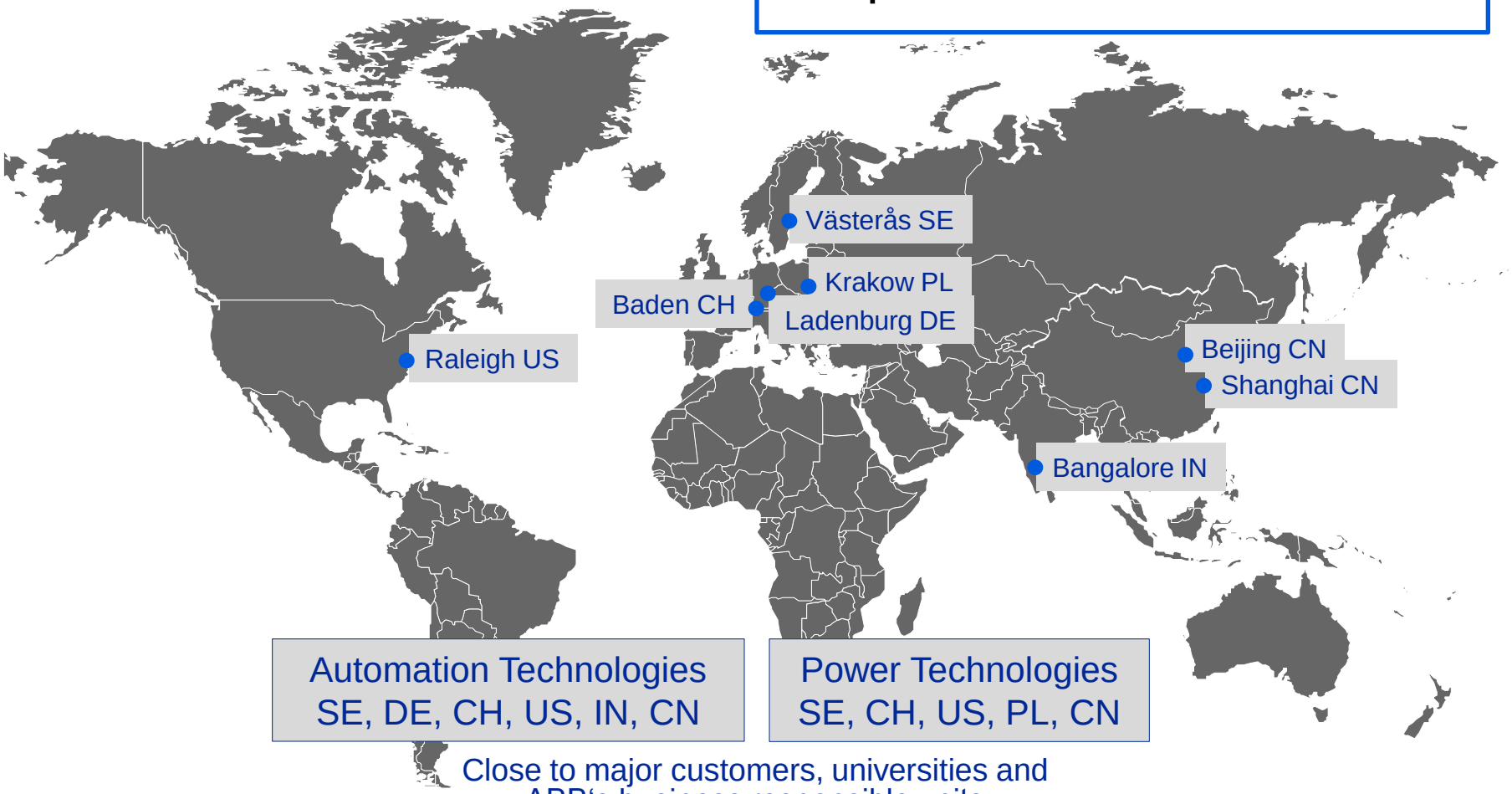
Outline

- A few words about ABB
- When simulations became important in ABB
  - The ABB Simulation Network
  - Study on ABB simulation needs
- Trends and actions taken
- A couple of technical examples
- Summary

Global Labs…
… and Local Lab Locations

Corporate Research Centers



Automation Technologies
SE, DE, CH, US, IN, CN

Power Technologies
SE, CH, US, PL, CN

Close to major customers, universities and ABB‘s business responsible units

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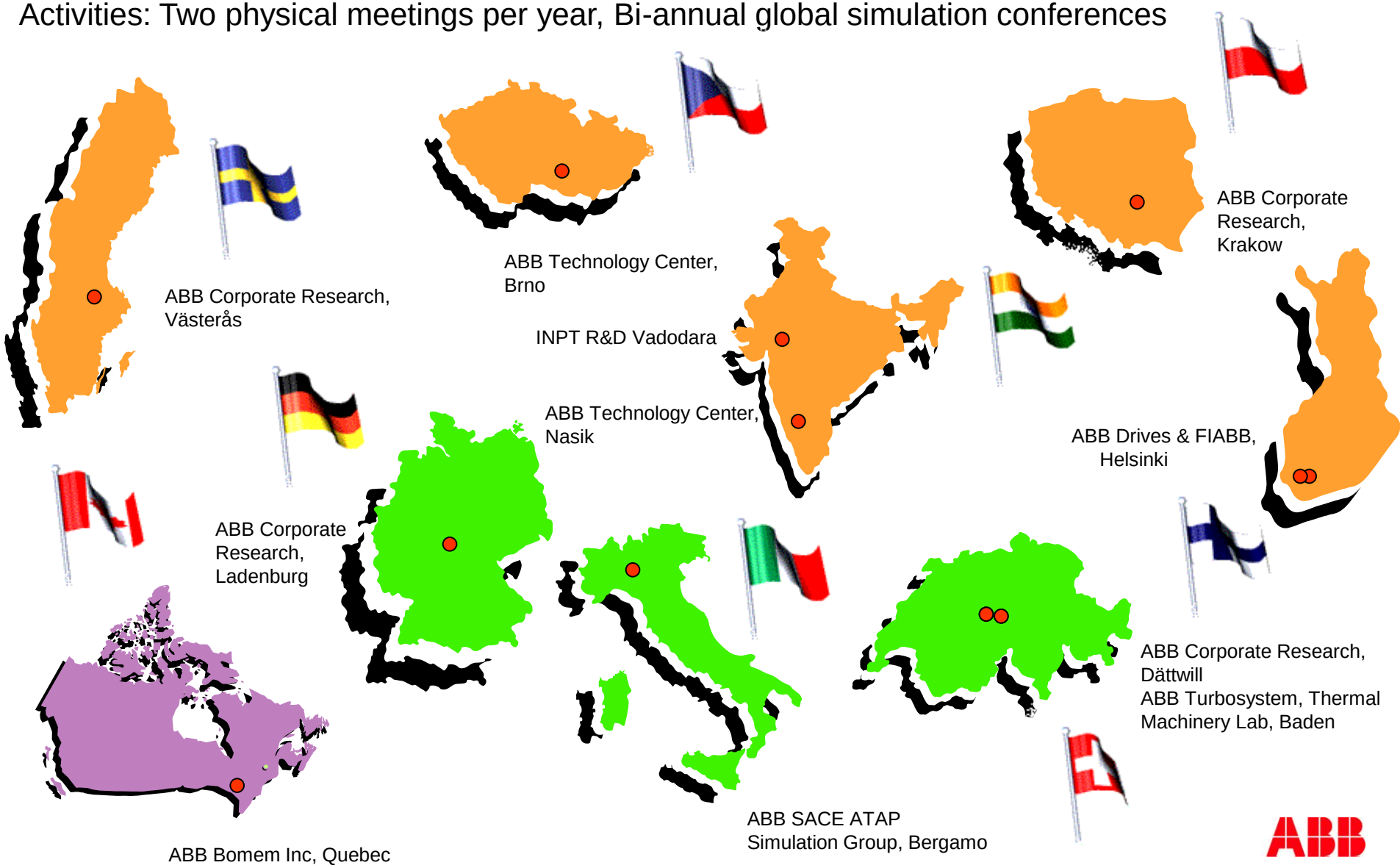
ABB Simulation Network, formed 2005

Active members, March 2011 Purpose: Maximize Benefit-Cost ratio of simulations

Activities: Two physical meetings per year, Bi-annual global simulation conferences



When simulation became **important** in ABB

- Official Benchmarks

Abeerden Simulation Benchmark Report Nov 2006
(200 enterprises world wide within manufacturing Industry)

Key Takeaways

- Best in class manufacturers their hit revenue, cost, launch date, and quality targets for 86% or more of their products.
- Best in class manufacturers average 1.6 fewer prototypes than other companies.
- Best in class manufacturers of the most complex products get to market 158 days earlier with $1,900,000 fewer product development costs.
- Best in class manufacturers of the simplest products get to market 21 days earlier with $21,000 fewer product development costs.

Figure 3: Best in Class Hit Targets on an 86% Average or Better

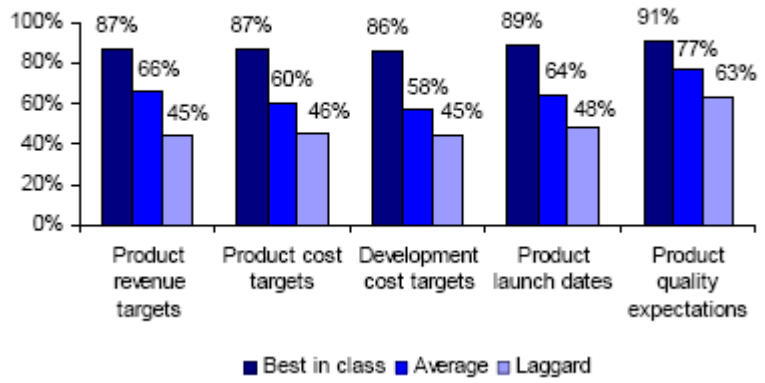
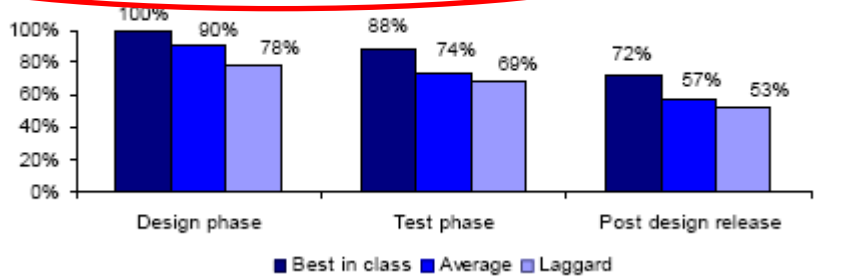


Figure 4: Best in Class Perform More Simulations Earlier



When simulation became **important** in ABB

- Nissan 2005

Toshikazu Kishimoto
General Manager, Engineering IS Department, Global IS Division
Nissan Motor Co., Ltd.

Mr. Toshikazu Kishimoto is the general manager of the engineering IS department in the global IS division of Nissan Motor Co. Ltd. Mr. Kishimoto joined Nissan in 1976 as part of the engineering IS department before moving on to the information systems department of the Nissan Research & Development Company from 1988 to 1992. Mr. Kishimoto then served at the Nissan Technical College to provide education and training to engineers and technicians from 1993 to 1996. Mr. Kishimoto attended the Rackham Graduate School at the University of Michigan where he received his degree in mechanical engineering and applied mechanics.

Abstract

SHIFT_Vehicle Development - Power of VPD

Nissan's mid-term business plan, NISSAN Value Up, calls for releasing as many as 28 new vehicles and providing customers with high-quality products incorporating the latest designs and technology. To successfully achieve the goal of this business plan, Nissan is now shifting from the conventional development based on physical confirmation to a new vehicle development process relying on a digital study, virtual product development (VPD). NOTE is the first VPD model and was released in January 2005. VPD helped Nissan significantly reduce the number of design changes, speed up development time, and improve the product quality of the NOTE model. The NOTE development clearly proved the power of VPD.

Procter & Gamble Dec 2004

Technology Leader Of The Year -- P&G's Secret: Innovating Innovation

http://www.industryweek.com/ReadArticle.aspx?ArticleID=9508

G. Gil Cloyd, chief technology officer of America's biggest consumer packaged goods company, is acknowledged by CEO A.G. Lafley as "the technical innovation leader" of Procter & Gamble. A 34-year veteran of the company, Cloyd became CTO

Cloyd sees computational modeling and simulation as the evolving solution for fast cycle learning. "Computational modeling once existed primarily in a computer-aided-engineering context to facilitate our manufacturing processes. Now we're using it to help with actual product design. A computational model helps us more quickly understand what's going on. The simulation capabilities are also allowing us to interact with consumers much more quickly on design options. For example, Internet panels can engage consumers in as little as 24 hours. Digital technology is very important in helping us to learn faster."

Eventually Cloyd predicts that as much as 90% of P&G's R&D will be done in a virtual world with the remainder being physical validation of results and options. "Not only will it accelerate innovation, but the approach will greatly enhance the creativity of our people."

In one example, Cloyd cites the significant time and cost savings made possible by using computer models in consumer testing. "In R&D, equally significant savings will be made by better understanding product performance via techniques such as computational fluid dynamics," he says. "It will work better than our visual or physical measurement systems and enable us to be more creative and design better products."

ABB Simulation Needs 2005/2006

- The need for computer simulations is growing in all simulation categories and for all ABB divisions.
- General trend: Focus towards simulation tools and CAE-embedded simulation, i.e. enabling simulation within the Business Units
- Hardware/Software
  - Large need for sharing licenses.
  - Clear need for cluster sharing mainly within R&D companies (CRCs) and some Business Units (BUs).

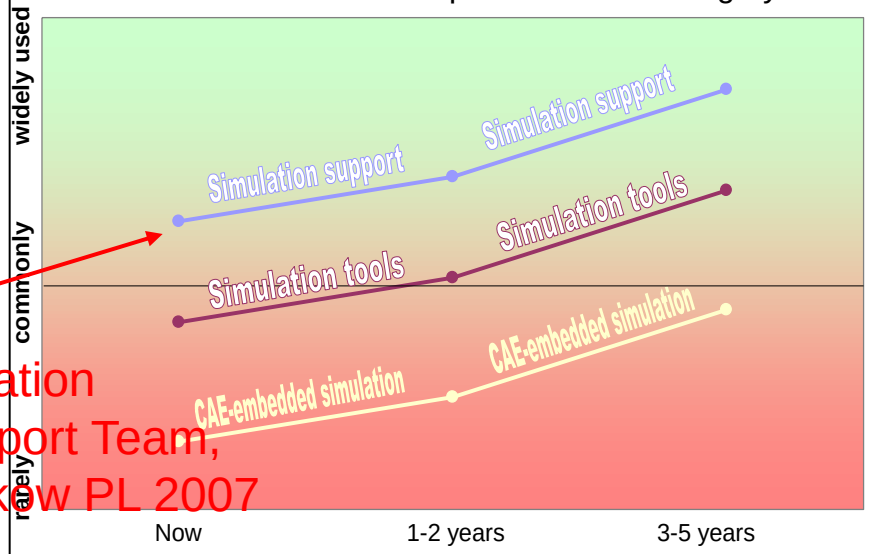
Actions taken

Shared licenses
ANSYS 2008
Mathworks 2009

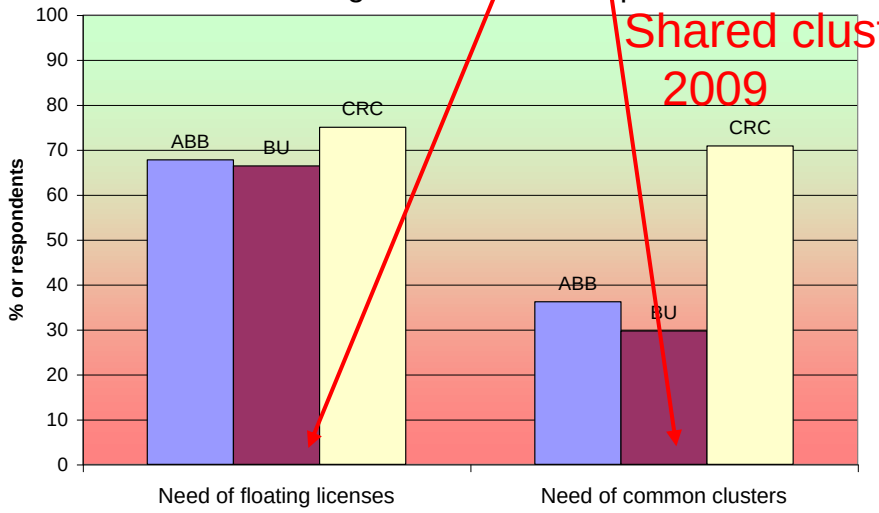
Simulation Support Team, Krakow PL 2007

Shared cluster(s) 2009

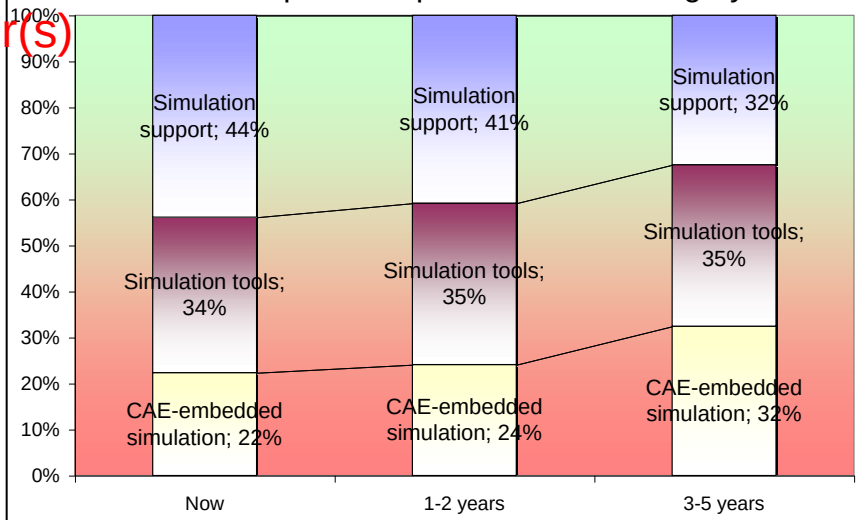
Predicted evolution per simulation category



Need of sharing licenses and computer clusters



Relative importance per simulation category



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Coordination of simulation software licenses

Global contracts with key ISVs

- Big customers get more attention…
- Global IS/IT and Supply Chain Management involved
- ANSYS, ABAQUS, MathWorks, COMSOL, …

Pools of shared licenses

- Efficient use of licenses, easy scale-up
- Easy entry for new users
- Access to low-volume SW products

License monitoring and coordinated acquisitions

- Web-based tool accessible for all
- Centralized acquisitions
- Cost distributed on “teams”

Sharing of hardware resources

Considerations

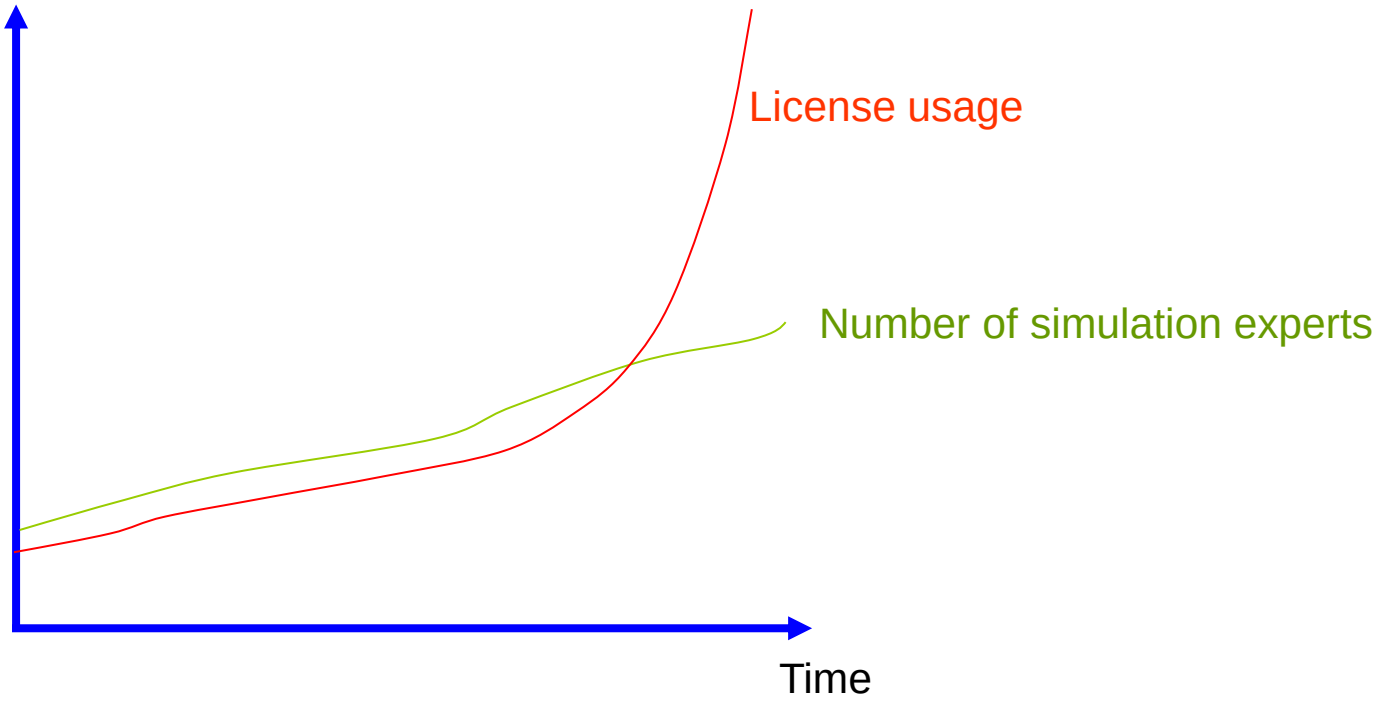
- No obvious single location in ABB for central resources…
- Limited possibilities to transfer large data sets
  - Remote pre- and post-processing
- Remote users bring their own licenses

Benefits for ABB

- Easy HPC entry for small units
- Facilitates technology transfer
- Access to HPC special competences
- “Rolling investments”, short-terms decisions

Trends driving license costs

- Moore’s law still holds, but relying on multiple cores
- Automatic simulations with parameterized models
- Multi-criteria optimization; parameter studies
- Integration in design processes (non-expert users)



What about open-source software?

Strategic direction to use commercial software

- "Guaranteed" to stay state-of-the-art over time
- No need to keep own competence for maintenance of in-house codes
- Superior documentation and support

Use-cases for open-source software (e.g. OpenFOAM)

- Special physics
  - No commercial alternatives
  - Numerical algorithms part of core technology
- Large-volume use of parameterized models
  - Low cost for use pays for more expensive model development
  - More simulations! Parameter optimization…

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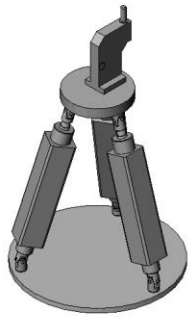
Prediction of Mechanical Instability of the 3-UPU Kinematic Mechanism (”Tripod”)
Using Elastic Multibody Model

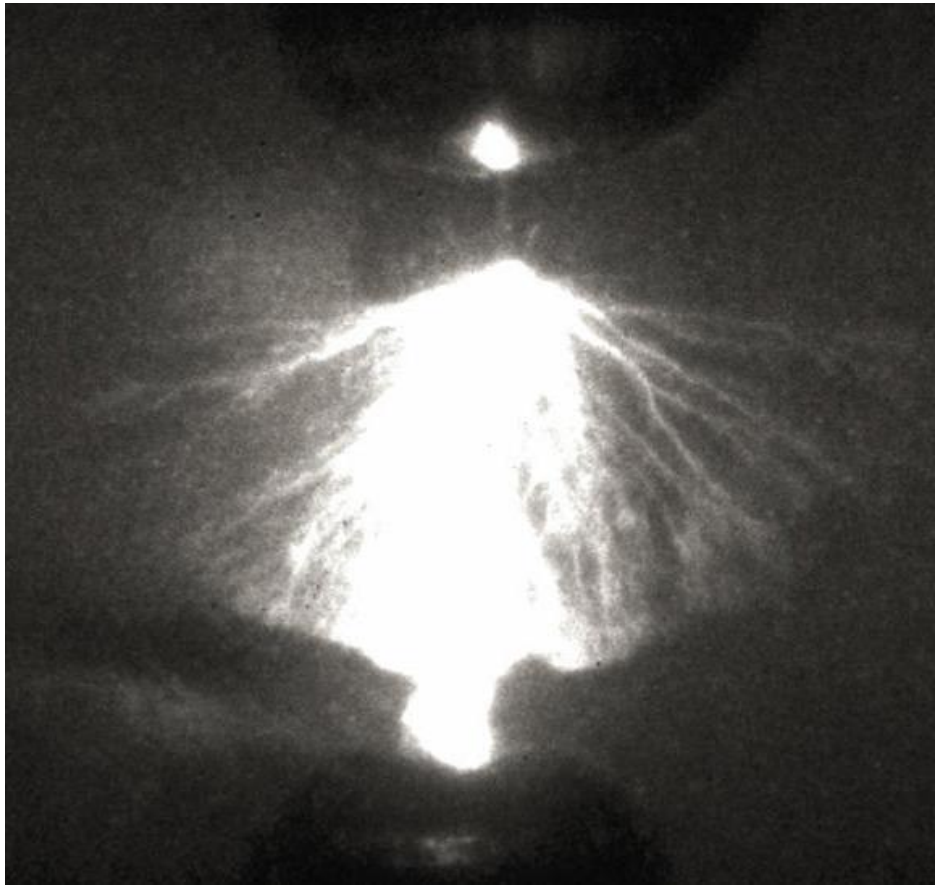


- 3-UPU mechanism is often found in scientific literature
- It was a candidate for an ABB 3-axis positioning device
- Simulations showed unexpected rotational weakness
- Simulation results were initially not trusted
- A mechanical mockup proved simulation result
- A 6-legged structure was chosen instead

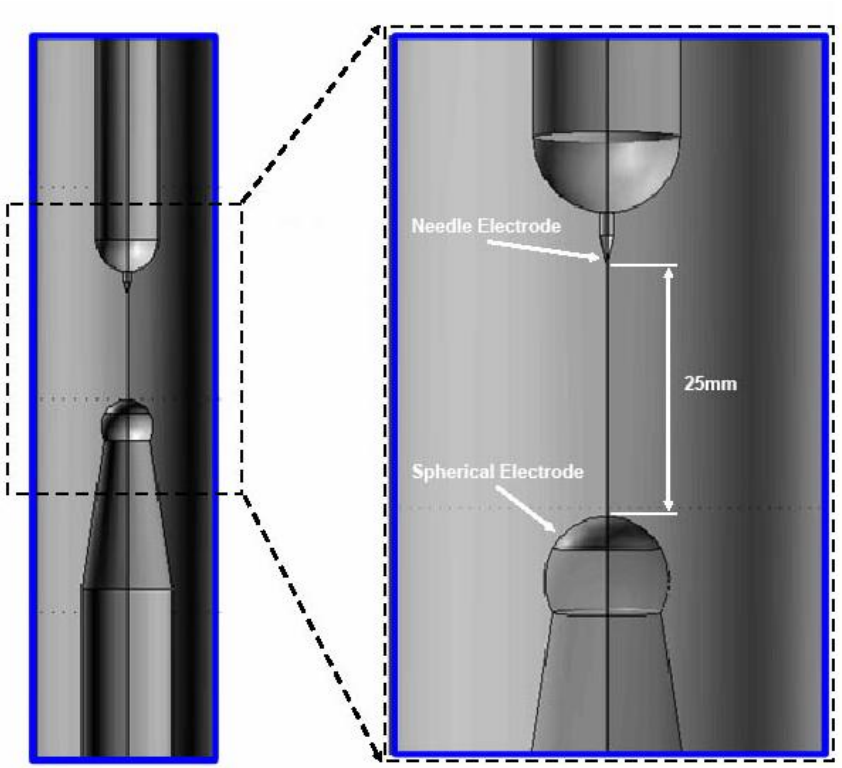
HVDC transformer (800 kV)

The insulation system of a high-voltage transformer
Windings, compressed cellulose and oil

Numerical modeling of streamer physics (Project with MIT)

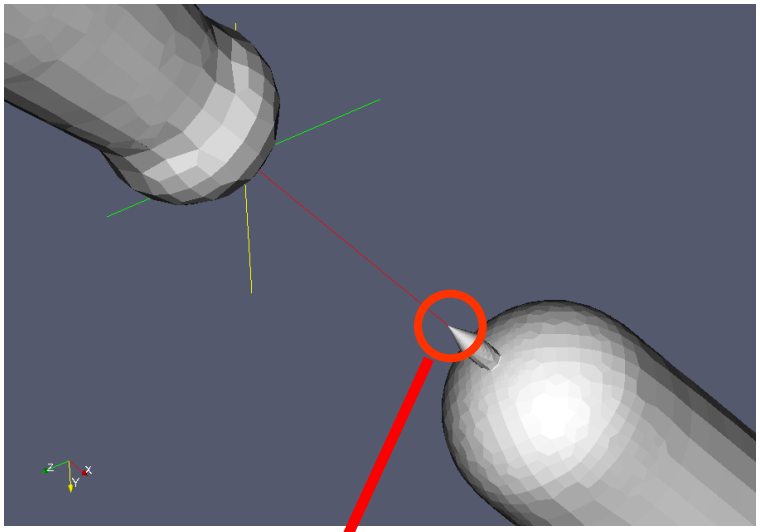


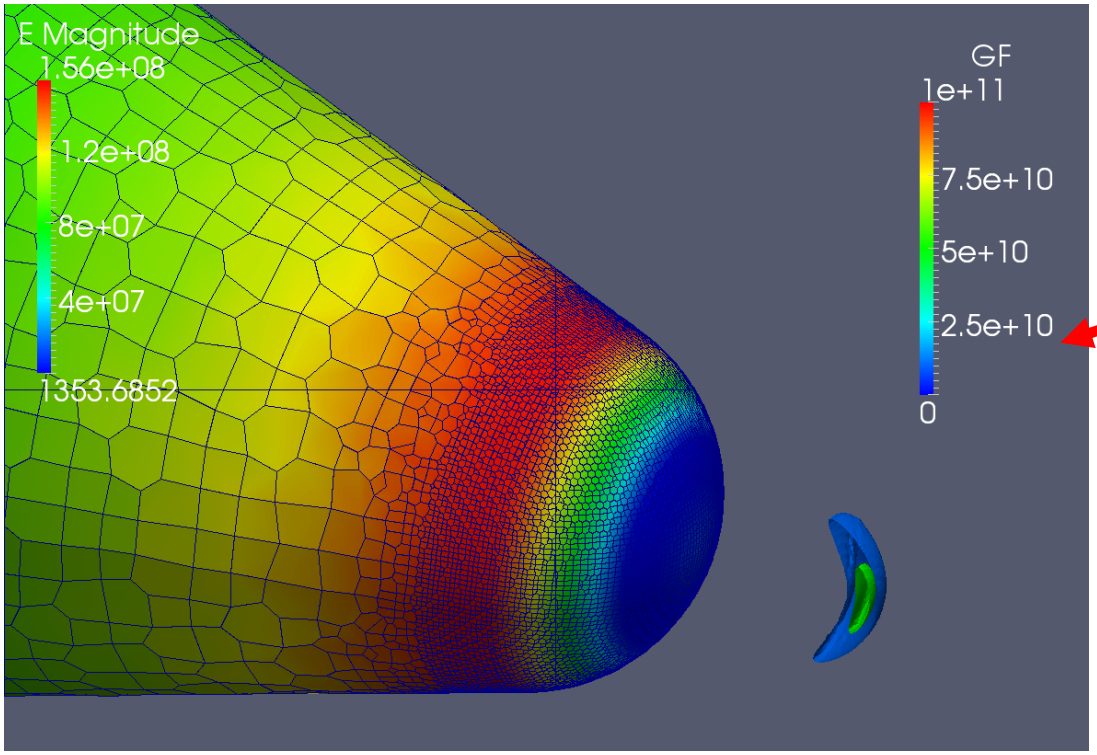
Test geometry for streamer propagation

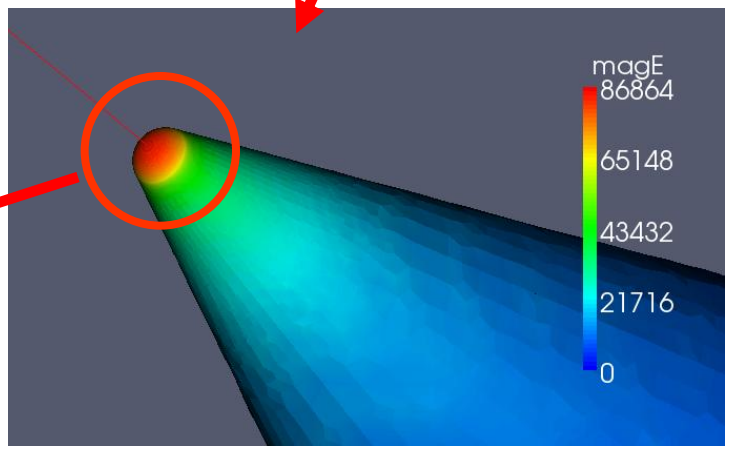


Example of 3-D calculation in streamer test geometry
Electric field and streamer propagation (OpenFOAM)

- Required mesh resolution for streamers: 0.5 um
  - ~10 billion cells/mm³ …
- OpenFOAM functionality to work on:
  - Adaptivity of octree/cutcell meshes
  - Load balancing as mesh changes







Summary

- The “ABB Simulation Network” of specialist plays important role in defining and driving company HPC strategy
- For a real impact on business: Simulations must be integrated into the design process
- Experimental validation still important
- Continued focus:
  - Optimized use of software licenses (global coordination)
  - Sharing of hardware resources
- Interest in PRACE effort
  - Potential partner for special projects
  - Sources of special competence
  - Benchmarking with other industries

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