Industrial expectations towards Exascale – ENI

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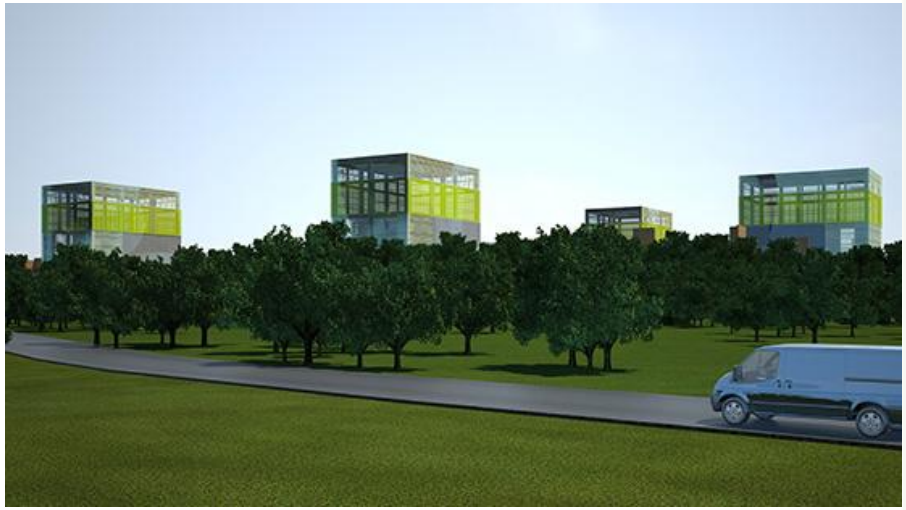
by K. L. Nielsen and N. Bienati

Computing

- Computing in Oil & Gas Industry

Actual status of HPC in eni: Green Data Center

- Characteristics
  - Nr 12 on top 500 (Nov.-2014)
  - 72000 cores (CPUs+GPUs)
  - 3188 TFLOP/S sustained



  - Please see:
    - http://www.eni.com/green-data-center/it_IT/pages/home.shtml

HPC and Oil & Gas Industry – evolution

- Traditional
  - Geoscience
  - Reservoir simulation
- Currently extended to
  - Multiphase flow
  - Flow assurance
- Coming
  - System Engineering
- Focus on solving:
  - HSEQ – Health, Safety, Environmental and Quality
  - Economics
  - Time, schedule and planning

related HPC and DATA aspects

- *Inverse problems*
- *Diffusive fluid transport*

- *Navier-Stokes*
- *Heat and mass transfer*
- *Stiff problems*
- *Multiscale physics*

- *Many Task Computing*
- *Multiphysics*
- *ODE's and DAE's*

- *Data processing*
- *Scenario analysis*
- *Extract data for decision making*

System engineering

- Example of system engineering in Oil & Gas Industry

Example of industry context: System-Engineering in oil and gas

- Steps:
  - Find the field
    - HPC in Geoscience
  - Model the reservoir
    - HPC in reservoir modelling
  - Design and build production facilities
    - HPC in multiphase flow and systems engineering
- An example of subsea layout:

- Let us focus on the system…

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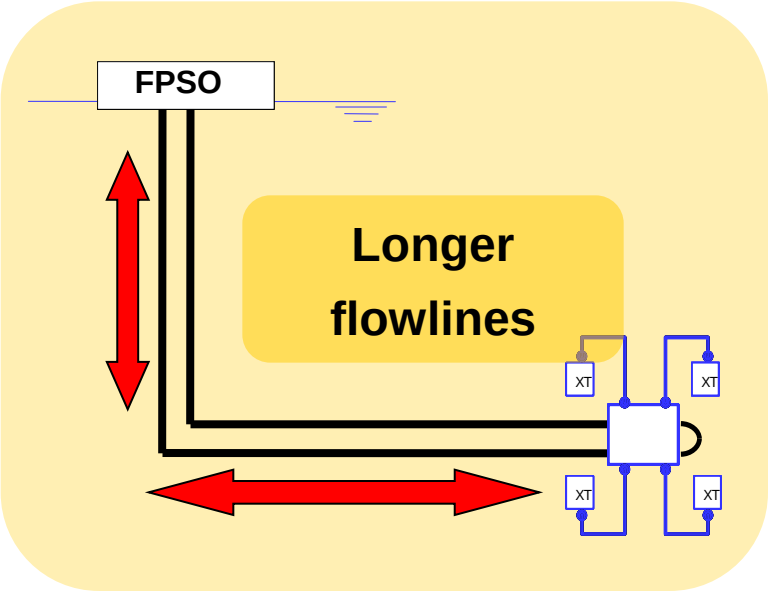
A FPSO (Floating Production Storage and Offloading unit)

A 3D view of the FPSO – a complex system

Subsea System Engineering and Field Architecture

Deeper water

Long distance



Low pressure reservoirs

Marginal ressources

HP/HT reservoirs

Viscous fluid

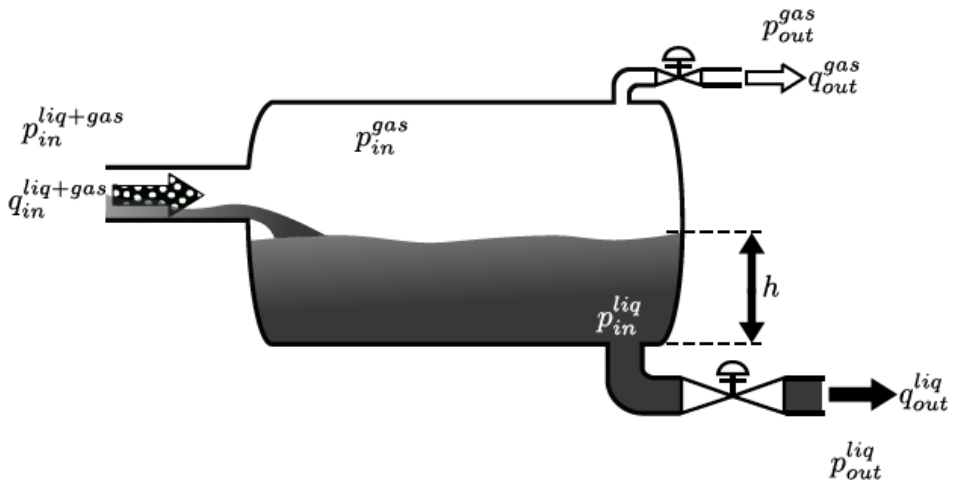
Acid gas

ENSURE MAXIMUM RECOVERY FROM THE RESERVOIR

Develop efficient, safe, reliable and cost effective solutions

Systems - Level of detail – example 1 with limited dataset

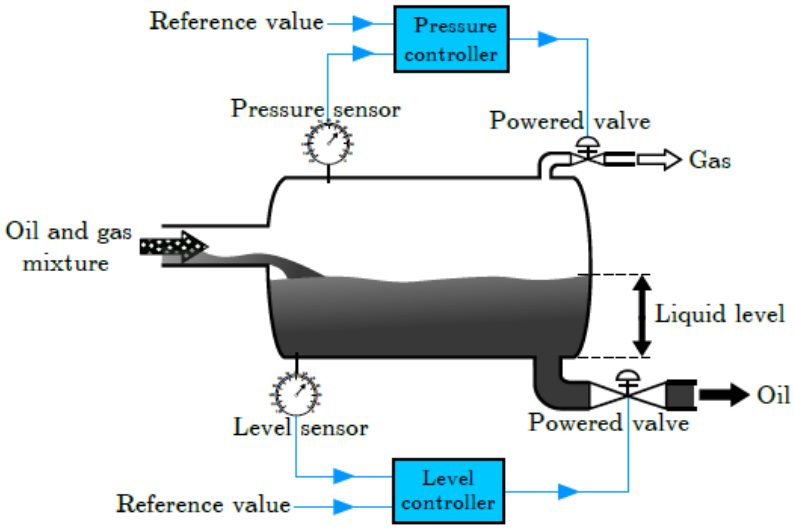
- A tank with inlet and outlet



- Assessment of liquid level
  - Level may be calculated from tank geometry and volume of liquid

Systems - Level of detail – example 2 with extended dataset

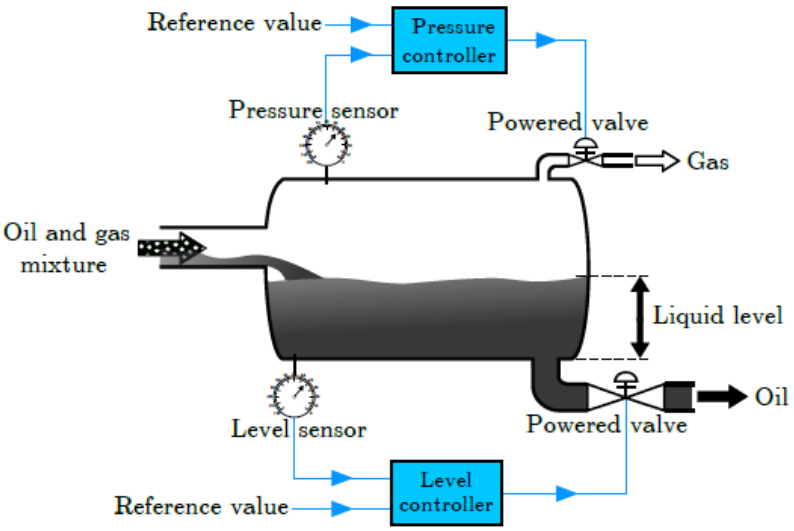
- A tank with inlet, outlet and level detection

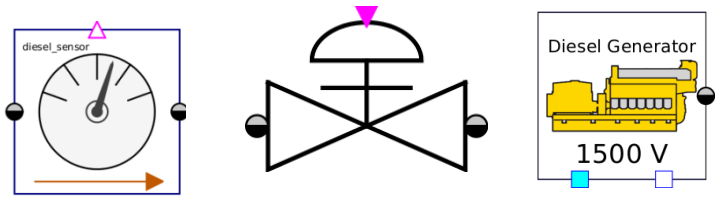


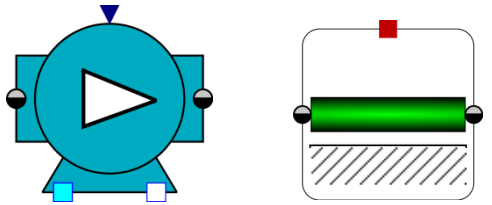
- Model assessment…
  - Level measurement depend on sensor, electricity, connectors and cables etc…

Systems - Level of detail – example 3 with extensive dataset

- A tank with…
- Depends on other components
  - Electrical system
  - Diesel power generator
  - Control system
  - Hydraulics
  - Compressed air actuators
  - Fire fighting equipment
  - …
- Constraints are
  - Weight limits on structure
  - Space limits
  - …



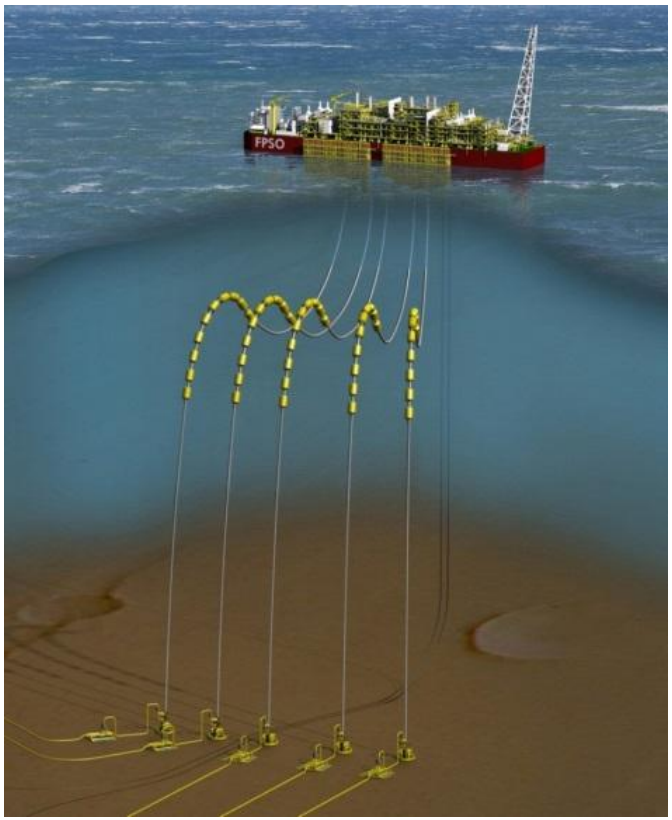




Bifurcations, constraints and multi-physics

The problem is to remain within boundaries of given constraints

- Relevant for control systems design
  - Sensor ranges
  - Feedback loops and control parameters



Example

- Multiphase pipe-flow in pipeline/riser
  - For particular valve settings…
  - …outflow unstable at FPSO (the ship)

Other challenges

- Sampling of scenarios
  - Monte-Carlo techniques
  - Uncertainty and resilience
  - Planning assessment

Systems and exascale

- In conclusion: Map from system engineering to exascale computing

From systems-engineering to exascale computing

Systems engineering is a design process which mathematically is:

- Linking of components => Graph theory
  - Normally it is a NP-complete graph problem; implications?
- There is only one way to know if a design is valid:
  - 1) Assemble the graph
  - 2) Run the calculus
  - 3) Check all constraints (the devil-in-the-detail hides in this step)

Challenges will become larger and more complex…

- Numerical methods:
  - Parallel-in-time, ODE's & DAE's – bifurcation assessment, constraint and answer set programming
  - Sparse systems, inverse systems, meshing, statistical methods, etc.
- Data:
  - Handling of datasets evolving and growing in-time
  - Data-system resilience and consistency
- Development of multi–physics or multi-domain simulations

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Oil & Gas Industry – vision on EESI and Exascale Applications

Actions must be taken in order to…

- Develop Programming Capabilities
  - A challenge to legacy-SW when moving towards Exascale HW
  - New software developments are necessary for Exascale HW

- Scalable & verifiable & maintenable Software, Algorithms and Data Handling
  - R&D in software design – distributed and asynchronous module interaction, debugging & profiling are NOT trivial tasks
  - R&D in numerical methods, e.g. for parallel time integration
  - R&D in analysis of distributed data-sets

Actions must be coordinated, henceforth:

Recommendations from EESI2 are exactly expressing industry needs.

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QUESTIONS?