Meeting the challenge of making use of advanced chemical engineering models in oil and gas production

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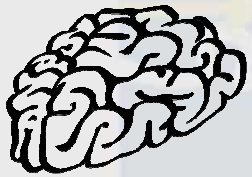
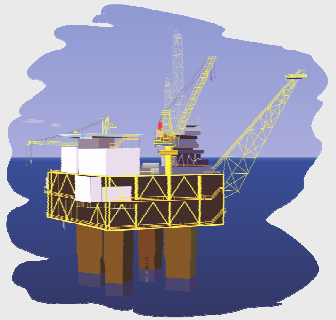
Where are ending R&D software deliverables?

JIP,
research consortium,
PhD, in-house





But often
after a while…

R&D software deliverables are faced with

- **Some negative constraints**
  - Software developed by non programmers
  - Software specific to a given simulation environment
  - Poor documentation
  - Incomplete requirements before development
  - Lack of resources
  - …
- **Changing environment**
  - Interfaces are evolving over time
  - Programming tools are deprecated over time
  - …

Needs and solutions

- **Interoperability is getting crucial**
  - Fewer and fewer solutions are relying on stand-alone tools
  - Shift from total integration to interoperation
- **Standardization**
  - Prevents duplication of effort
  - Prepares ground for better products
  - Ensures interoperability between technical solutions
  - Opens exchange of information
- **Open standards recommended for success**
  - Developed in a transparent and collaborative process

Outline

- What is CAPE-OPEN?
- Thermodynamic models as CAPE-OPEN compliant process modelling components (CO PMCs)
- Unit operation models as CAPE-OPEN compliant process modelling components (CO PMCs)
- Process simulators as CAPE-OPEN compliant process modelling environments (CO PMEs)
- Conclusion, perspectives, opportunities

What is CAPE-OPEN?

- **CAPE-OPEN**
  - defines rules and interfaces that allow CAPE (Computer-Aided Process Engineering) applications and/or software components to interoperate
  - is a freely available documentation set (www.colan.org)
- **CAPE-OPEN interfaces are implemented**
  - By process simulation software vendors:
    - Aspentech, Honeywell, HTRI, Infochem, Process Systems Enterprise, ProSim, SimSci-Esscor, SolidSim, TUV NEL …
  - By in-house developers
    - BASF, IFP New Energy, KBC Profimatics, SASOL, TOTAL, etc…
  - By academics
    - Ruhr Universität Bochum, University of Trieste, etc…

Thermodynamic models as CO PMCs

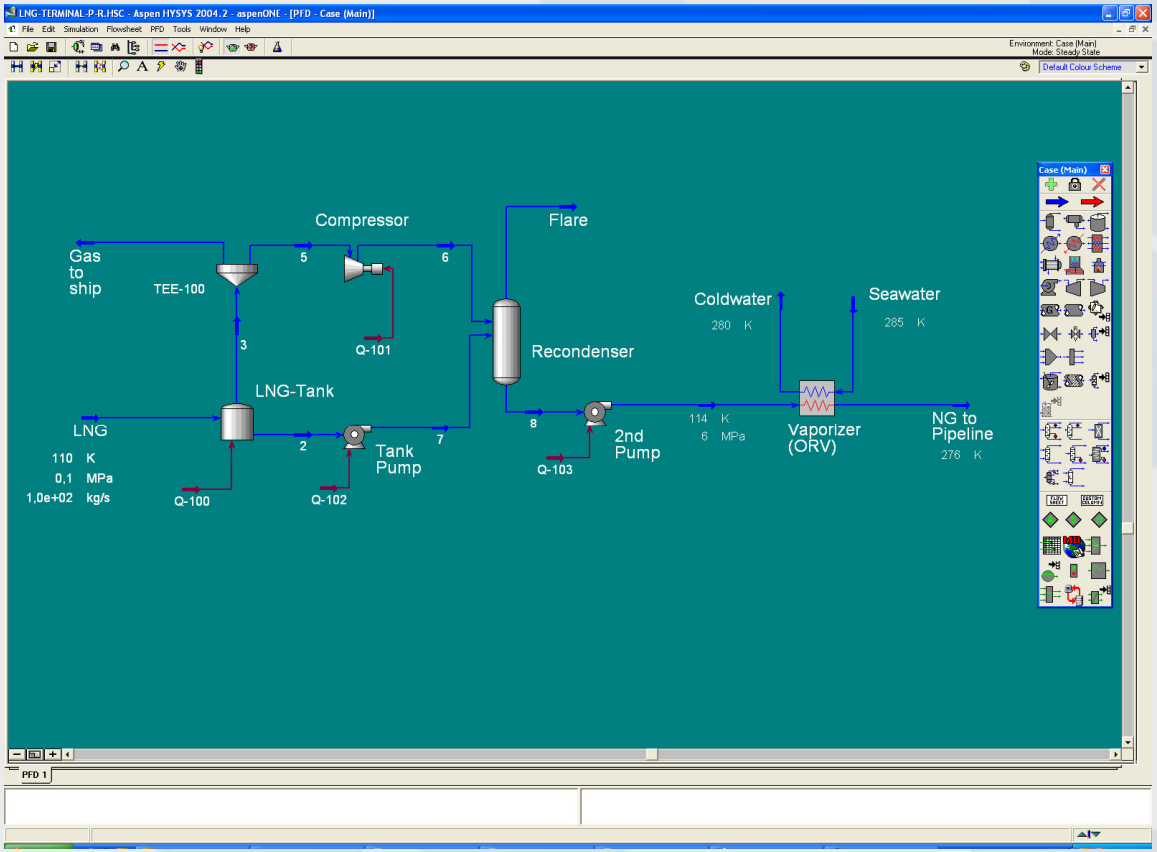
- Thermodynamic models are used by most if not all process simulation activities
- While many general purpose thermodynamic models (e.g. cubic equation of states) are widely available, there is room for specialized, dedicated models
- Challenge is to make use of such advanced thermodynamic models in all simulation tools available
- CAPE-OPEN allows that to happen
  - GERG 2004
  - IVC-SEP
  - MultiFlash

THERMODYNAMIK

Embedding the GERG-2004 in simulation tools using the CAPE-OPEN standard

- **Motivations**
  - Consistent and stable calculation of thermodynamic properties of natural gases
  - Allowing the use of the property package in several commercial simulation tools
  - Creating a product improving simulation software to achieve higher accuracy when modelling natural gas processes

Simulation of LNG processes



Successfully embedded the GERG-2004 in Aspen HYSYS

- **LNG - Evaporation terminal**
  - **Open Rack Vaporizer**
  - **LNG: 110 K; 0.1 MPa**
  - **$NG_{Pipeline}$: 6 MPa**

IVC-SEP Thermo System

- Now from CERE, still at Denmark Technical University
- Thermo System contains models such as:
  - Cubic Plus Association (CPA)
  - PC SAFT
  - SRK and PR
- Consortium members include many operating companies using different simulation tools
  - Need to provide IVC-SEP Thermo System as a software tool pluggable in Aspen Hysys as well as PRO/II as well as UniSim Design or INDISS Plus
  - IVC-SEP Thermo System made CO compliant

MultiFlash from Infochem

- MultiFlash has been interfaced with a number of simulation tools early on through proprietary interfaces
- MultiFlash has also been made CAPE-OPEN compliant early on to enhance usage of advanced models including:
  - Hydrate formation models
  - Paraffin formation models
- This has made MultiFlash a tool of choice for a number of model developments in these areas (see further)

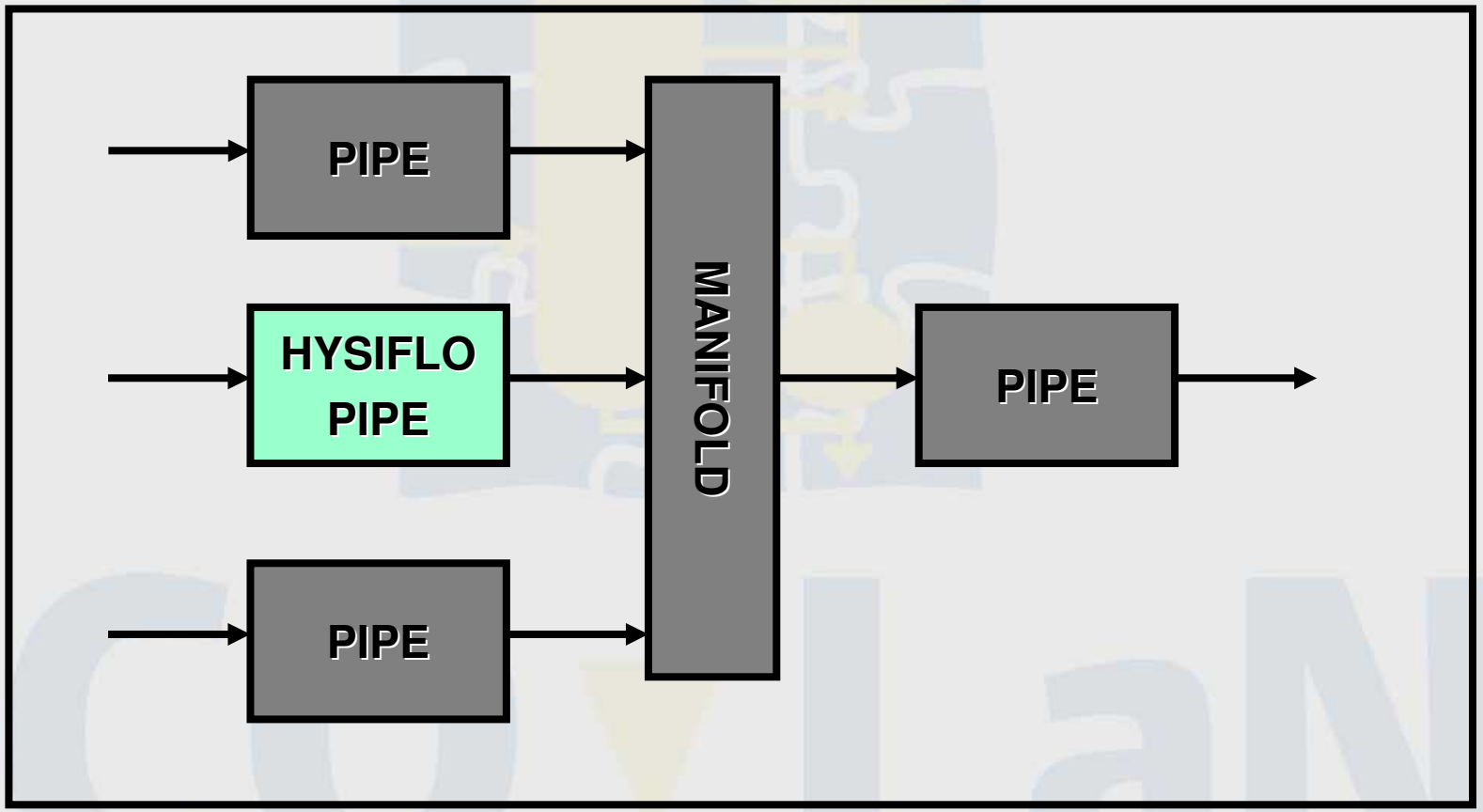
Unit operations

- Represent a piece of equipment, a part of a production network
  - Pipes, separators, compressors, valves, manifolds, wells
- A model of a production network is made of several unit operations
- Examples of CAPE-OPEN standardized Unit Operations
  - HYSIFLO
  - GLCC
  - TUWAX

HYSIFLO JIP

- **Context**
  - Hydrate related issues in deep-water fields
  - Long tie back
- **Objective**
  - Prediction of maximum pressure drop in hydrate slurry flow and evaluation of plugging risk
- **Deliverables**
  - Experimental results
  - Hydrate flow simulation module (pipe module)
    - To be plugged into simulation platforms such as Aspen Hysys, UniSim Design, PRO/II, etc…
    - Developed as a CAPE-OPEN Unit Operation

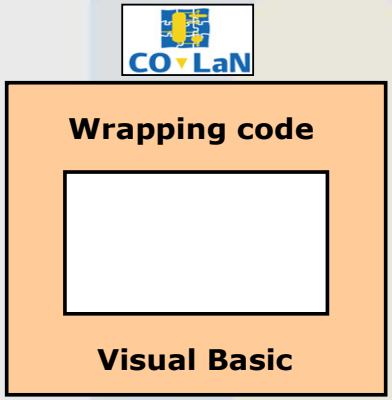
HYSIFLO JIP

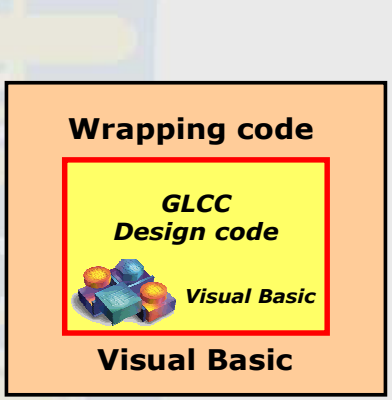

PIPE
HYSIFLO PIPE
PIPE
MANIFOLD
PIPE
Process simulator A, B or C

Gas-Liquid Cylindrical Cyclone (GLCC)

- **Context**
  - Alternative to conventional separators: simple, compact, less expensive, lower weight, less maintenance
  - Design and verification code available as stand-alone piece of software
  - Need to use the GLCC design and simulation code in process simulators
- **Constraint**
  - Resources: one interface to fit all simulators
- **Solution**
  - Wrap existing code as CAPE-OPEN Unit Operation

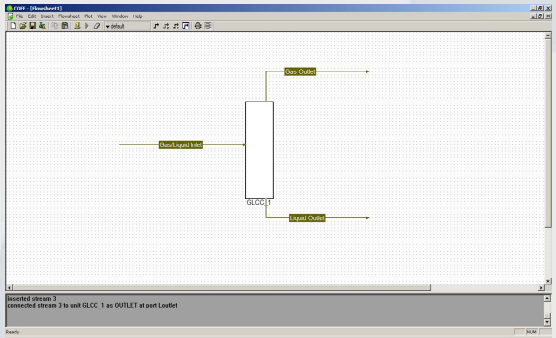
GLCC UO development





Compile into a DLL

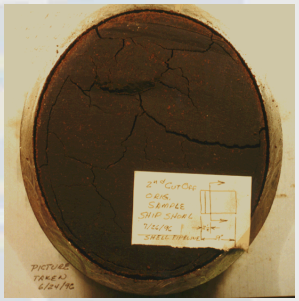
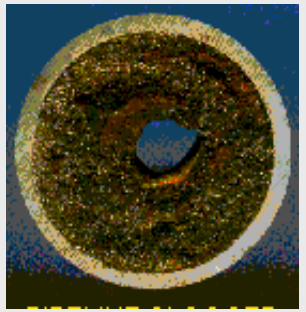
Install on user computer



Ready to use GLCC in a simulation environment

TUWAX



Inputs

Pipe configuration

(Length, Diameter…)

Operating conditions

(Pressure, Temperature, Flow rate…)

Fluid properties

(Density, Viscosity, Enthalpy…)

TUWAX

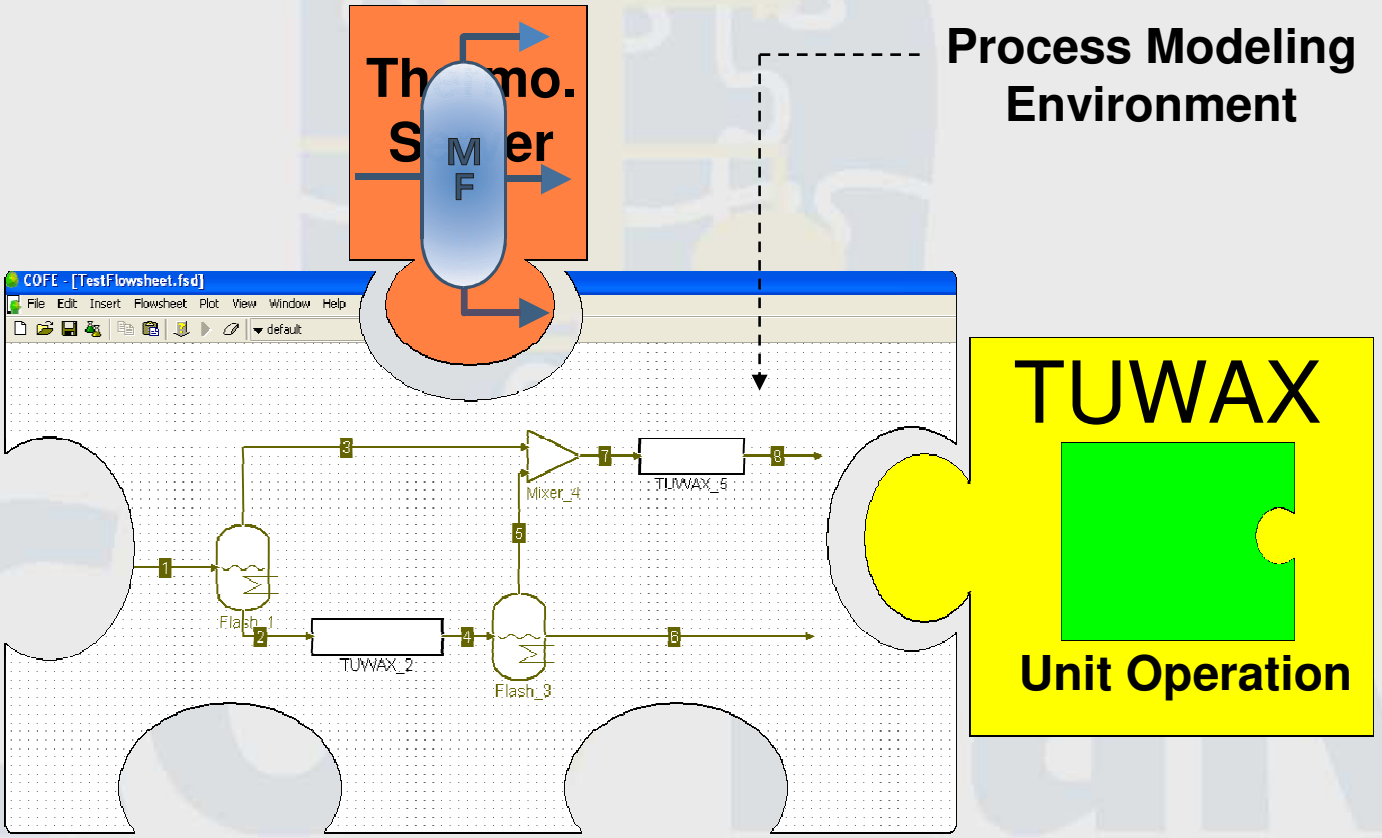
Outputs

Pressure profile

Temperature profile

Wax thickness profile

TUWAX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S er
M
F
Process Modeling Environment
COFE - [TestFlowsheet.fsd]
File Edit Insert Flowsheet Plot View Window Help
default
Mixer_4
TUWAX_5
Flash_1
TUWAX_2
Flash_3
TUWAX
Unit Operation

Process simulators as CO PMEs

- Development of new process simulators is not happening so often
- Still the most recent process simulators have adopted CAPE-OPEN as their basic architecture
  - SolidSim from SolidSim Engineering
  - COFE from AmsterCHEM
  - MFFPT from US EPA
- And almost all commercial simulators have implemented CAPE-OPEN interfaces: Aspen Hysys, Aspen Plus, UniSim Design, INDISS Plus, ProSim Plus, gPROMS, ChemCad, VALI, etc…

Conclusions, perspectives, opportunities

- CAPE-OPEN compliance of R&D software deliverables ensures interoperability with many applications
- CAPE-OPEN technology proved applicable to thermodynamic models as well as to unit operations models suitable for oil and gas production processes
- *What CAPE-OPEN may bring to my R&D effort?*
  - *Ease of deployment, increased usage, etc…*
- Many different ways to reach CAPE-OPEN compliance
  - Visit www.colan.org for more info or see paper 588a in session on Computer-Aided Process Modeling for Design

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Thank you for your attention!