

# **Global CAPE-OPEN (GCO) Project Results To Date: June 2001**

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## **Abstract**

Manufacturers in the process industries must use a collection of software (in-house, commercial, and/or academic) to perform Computer Aided Process Engineering (CAPE) because the market for process simulation has been so far one of incompatible proprietary products. More effective CAPE is required to be competitive in the process industries. The Global CAPE-OPEN (GCO) project is expanding and developing interface specification standards to insure interoperability of CAPE software components. This paper presents results of the GCO project to date.

## **Introduction**

Process industry manufacturers typically use a collection of software (in-house, commercial, and/or academic) instead of just one tool to perform Computer Aided Process Engineering (CAPE) because the market for process simulation has been so far one of incompatible proprietary products. This situation constitutes a barrier to increased competitiveness within the process industries.

The EU-funded CAPE-OPEN (CO) project (January 1997 to June 1999) established a set of standards to allow communication between software from different sources (software and equipment vendors, universities, and "home grown"). Global CAPE-OPEN (GCO, July 1999 to December 2001) is an EU-funded as well as an Intelligent Manufacturing Systems (IMS) project. GCO uses CO results and capitalises on further opportunities that can be gained from open standard interfaces for process simulation. The GCO consortium involves a wide range of leading process industry companies, researchers, and software vendors in Europe, Asia, and North America.

## **Global CAPE-OPEN general results**

GCO has made significant progress toward the global acceptance of CAPE-OPEN standards. CO compliant process simulators and software components are now available from software and equipment vendors, research organisations, and specialised suppliers that offer the process industries a way to reach new quality and productivity levels in designing and operating their plants. Approved interface specifications are publicly available and readily accessible to software component suppliers and developers [1].

A key accomplishment of GCO has been to put together an active international consortium focused on the completion of required standards, the updating of existing

standards, pursuing research for expanded areas of CAPE activities, and the full implementation of the CO standards in the marketplace. Another significant accomplishment is the launching of the CAPE-OPEN Laboratories Network (CO-LaN), an international non-profit organisation that will carry forward the work of CAPE-OPEN once GCO is completed. The CO-LaN co-ordinates the enhancement and expansion the CO standards, serves as a labelling organisation for CO compliant software components, encourages the delivery of CO standards training in the market place, and facilitates full implementation of CO standards for CAPE products.

### **Global CAPE-OPEN Work Package Deliverables**

#### *Work Package 2: Open Interface Standards for new Modules*

Work Package 2 is charged with adding new interface standards that were not in the scope of the CAPE-OPEN project. WP2 is developing interface specification standards for:

- complex mixtures: a general petroleum fraction, and a general electrolyte system (standards are in prototype stage)
- kinetic models in process simulation (prototype in development)
- advanced mathematical tools: Mixed Integer Linear Programming (interface specification standard available) and Non Linear Programming, Partial Differential Algebraic Equation solvers, and Parameter Estimation and Data Regression techniques (interface specification standards in development, with final standards to be published by the end of the GCO project)
- process flow diagrams and economic analysis (draft interface specification standards developed, a working prototype by the end of the project)

Complex mixtures are at the same time very important to the process industries and significantly more challenging to model than single component systems - a key opportunity for value delivery from GCO. Kinetic models are developed either by a company's own engineering organisation, a process technology licensor, a university or research institute, etc. Using these independently developed kinetic models in commercial process simulators represents a major opportunity to improve the quality of a process model, thereby allowing improved plant design and operation. Advanced mathematical tools offer the possibility for developing process models of improved accuracy and fealty to the real world.

#### *Work Package 3: Development of CO-compliant Software*

One of the absolutely necessary results of the GCO project is to deliver actual CO compliant software components. WP3 is charged with this task, and has already delivered CO compliant software "plugs" to be connected to the CO compliant software "sockets" in a Process Simulation Environment (PSE). A CAPE-OPEN PSE is known as a COSE (CAPE-OPEN Simulation Environment). To date, WP3 has delivered a Unit operation plug, Thermo plugs, a non-linear equation (NLEQ) solver, and commercial COSEs to work with these plugs from AEAT Hyprotech and AspenTech. At Hyprotech 2000 in November 2000 (Amsterdam) the interoperability of the Unit plug and Hysys.Process and AspenPlus was publicly demonstrated.

WP3 has also completed a major GCO deliverable: the Physical Property Data Base (PPDB) interface standard specification. Allowing process simulator users to chose from any CO compliant PPDB is a major milestone for GCO and for CAPE users. Independent PPDB suppliers can now make their information available to CAPE users in a plug and play environment, and companies can use their proprietary PPDB

in the same fashion. A process model result is only as good as the model itself and the data it uses, so having the PPDB CO standard is a critical step forward to the successful implementation of CO principles in the CAPE marketplace

#### *Work Package 4: Integration of Open Simulation in the Work Process*

The primary activity of WP4 is the Interoperability Task Force, which has taken the responsibility of directly addressing the practical ability of the CO standards to deliver true plug and play to CAPE users. It must be recognised that while CO standards describe the protocols for interaction between software components, they may be "necessary but not sufficient" for them to work in practical application. There may need to be modifications of the standards and there is a need for working rules of implementation of the standards to insure interoperability. The ITF addresses these issues by evaluating demonstrations and then recommending changes in standards (draft or final) and in developing work processes to insure that the standards are implemented properly. The work of the ITF was most dramatically displayed in the public CO interoperability demonstration at Hyprotech 2000 in Amsterdam, November 2001. The ITF continues to work with each CO interface specification standard as it is developed to insure that the potential of CO principles are fully realised.

#### *Work Package 5: Open Support Tools and Technologies*

Models of unit operations are currently represented by two components, the unit component itself as well as the physical property component. Model structuring must be generalised in order to allow a larger coverage of model detail and to support reuse of modelling knowledge on a finer granularity. In addition to the Unit component, which interfaces with the physical properties component, other components should be introduced. WP5 has developed a conceptual framework for the structuring of models beyond the unit level.

A central issue is the construction of models for non-standard pieces of process equipment with the ultimate goal to generate CAPE-OPEN compliant unit components from a declarative description for different model-based applications. Besides equation-oriented simulation systems, high-level specification systems are under development. The systems are based on an object model to support model structuring. Finally, a common object model has been provided. The object model is the basis to modify the presentation of structured models in the tools of the participating partners

Generation of CO compliant modules (e.g. Unit or Thermo) from declarative description runs through a common declarative model exchange format. The evolving standard modelling language MODELICA and the object model defined are reconciled to define a process engineering model exchange format that could become an extension of the draft pdXi object model.

#### *Work Package 6: Advancing Open Process engineering*

WP6 is focused on the general topic of CAPE activities in an open environment. WP6 is addressing enterprise integration, looking at case studies, component selection, and work processes. Additional research is being conducted on model structuring, modelling process, hybrid and discrete models, lifecycle interfaces, real-time and online interfaces, and web-based environments for collaborative process

engineering. This work is being leveraged through the use of CAPE-OPEN principles in education and training. To consider the full spectrum of CAPE and its integration with the wider enterprise, appropriate interface structures and model prototypes will be developed for Unit Operations, Scheduling and Planning, and Operation and Control. Several research papers have been and will be presented on these topics. The deliverables of WP6 are: 1) to develop a data (flow) model to support and enable the use of process models through the process lifecycle, 2) to develop a data (reference) model to support and enable the use of process models in distributed simulation environments, 3) to develop interface specification standards for batch and polymer systems, and 4) to develop the conceptual basis for integrating simulators and optimisers in a real-time environment for the support of process operations.

#### *Work Package 8: CAPE-OPEN Laboratories Network*

The work of CAPE-OPEN will be continued after the completion of GCO with the establishment of the CAPE-OPEN Laboratories Network (CO-LaN). The CO-LaN is a non-profit organisation officially established in January, 2001, and membership is open to any interested organisations or individuals. Support for the activities of the CO-LaN comes from membership dues and software component labelling fees. Membership dues are structured to reflect the size and nature of the member organisation (including memberships for interested individuals). Labelling fees reflect the size of the certification effort, the scope of the software component to be certified, and the size and nature of the organisation requesting certification.

The main activities of the CO-LaN are:

1. Support international CO information and technology distribution.
2. CO specifications life cycling management: organise the maintenance and evolution of the standards.
3. CO software labelling: manage the process as well as the steps for labelling of software components as being "CO compliant".
4. CO training: ensure that suitable training is available and provide technical information to support compliance efforts.

#### **Conclusion**

The Global CAPE-OPEN project has accomplished a great deal in the past two years, with many additional deliverables scheduled for completion in the final six months of the project. GCO project partners Air Products, AspenTech, BASF, BP, Carnegie-Mellon University, DECHEMA, Denmark Technical University, Dow, Honeywell Hi-Spec Solutions, AEAT Hyprotech, ICI, Institut Français du Pétrole, Imperial College, Institut National Polytechnique Toulouse, JGC (Japan), Kyoto University, Mitsubishi Chemical, Norsk Hydro, Norwegian University of Science and Technology, Protesoft Corporation, Rheinisch-Westfälische Technische Hochschule Aachen, SIMSCI, Tokyo Institute of Technology, TotalFinaElf, Universitat Politecnica Catalunya, University of Massachusetts, University of Virginia, and UOP are expending resources in excess of 5MM Euros to successfully deliver CO standards to the CAPE user.

#### **Literature**

- [1] GCO web site – <http://www.global-cape-open.org>