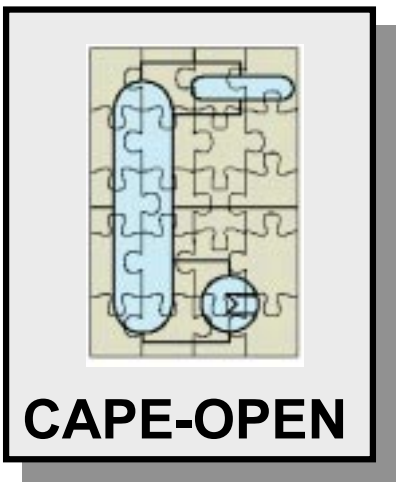
CAPE-OPEN RoadMap



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IMPORTANT NOTICES

Disclaimer of Warranty

This is a report of the CAPE-OPEN project and gives an overview of the project documents available to end users for applications and further developments. We make this document public in order to share it and the CAPE-OPEN project results with the wider process systems technical community and other interested parties as early as possible. While every effort has been made to make it internally consistent, it is recognised that some aspects will have to be further refined and modified. Also, while the guidance given here is for the benefit of the wider community and given in good faith, the CAPE-OPEN partners do not accept any liability in terms of any consequences of following this or any other CAPE-OPEN document. It is recognised that CAPE-OPEN has been a fast track project that has only taken the first step towards standardised interfaces for process systems toolkits by demonstrating their viability. Future projects and the experiences of the community will lead to revisions and improved precision of the standards.

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SUMMARY

CAPE-OPEN as a collaborative project between a group of operating companies, technology vendors and academic groups has in a fast-track project demonstrated the viability of standardised interfaces for process systems toolkits. This document is written for the benefit of the wider community who can benefit by using CAPE-OPEN results. It is a roadmap to the other documents and reports of the project that are available in the public domain. It also contains specific text for different categories of end users and draws their attention to the relevance of CAPE-OPEN to their fields.

FEEDBACK

In this document the end users have been frequently asked to provide feedback on their experiences of using open standards and following the results of CAPE-OPEN. This should be sent to one the following personnel:

Mr. Michel Pons, Elf – e-mail address: michel.pons@crde.elf-atochem.fr (Setting up the CAPE-OPEN laboratories network as part of Global CAPE-OPEN project)

Mr. Bertrand Braunschweig, IFP – e-mail address: bertrand.braunschweig@ifp.fr (Project Manager for CAPE-OPEN and Global CAPE-OPEN)

Mr. T.I. Malik – e-mail Tom_malik@ici.com (Conceptual Work Package leader for CAPE-OPEN)

1.0 Introduction

1.1 Purpose of RoadMap

This document is written for the benefit of those who are interested in using CAPE-OPEN results, or in knowing more about the project but who have not been involved in the project itself. It aims to guide different categories of users on the relevance of CAPE-OPEN to their activities, what ground the project has covered and what has not been addressed as yet. It aims to guide and lead to the public domain documents that the project has generated. It is thus a roadmap rather than a detailed description of the results themselves that are available in the other documents of the project.

As further activity in the field of standardised process systems interfaces will continue through the Global CAPE-OPEN project and the CAPE-OPEN laboratories network that is expected to be set up. This roadmap itself will continue as a living document, at any point in time, continuing to give guidance to end-users on the appropriate documentation available.

1.2 The CAPE-OPEN Project

CAPE-OPEN has been a collaborative project sponsored by the European Commission under the Industrial and Materials Technologies Program (BRITE-EuRam III, Project BE 3512) that has formally run from January 1997 to June 1999. The objective of the project was to develop open standard specifications for components of process simulators and to demonstrate the viability of the same through working prototypes. There have been a healthy number of partners in the project as the results are of much potential value to a large variety of end-users. The partners comprised chemical or petroleum operating companies (BASF, Bayer, BP, DuPont, Elf, ICI), a process licensor (IFP), major international vendors of process systems tools (AspenTech, Hyprotech and SimSci), European academic research groups in the process systems field (Imperial College, RWTH-Aachen, INPT-Toulouse) and a software consultancy (Quantisci). These partners have worked collaboratively to conceptualise and develop the specifications and build the prototypes. The project results were of direct interest to all the participants.

The term CAPE-OPEN is used synonymously by many to describe the more general area of open standards in the process systems field as a whole. This is partly because there has been considerable activity in this area before the formal start of this project and there is also a follow-up project, Global CAPE-OPEN, that aims to consolidate and extend further the work of CAPE-OPEN. The sum of this activity and the momentum developed has helped make the association between the term CAPE-OPEN and open process systems interface standards.

It is not the purpose here to give all the details of CAPE-OPEN objectives (for which references to other project reports are given), but for a quick appreciation, we give Fig.1-1 below, extracted from CDD2 (Conceptual Design Document 2), one of the released project documents. It shows pictorially

inter-operability between simulator software components from different sources. Please refer to CDD2 to find out more about the full objectives and priorities of the project.

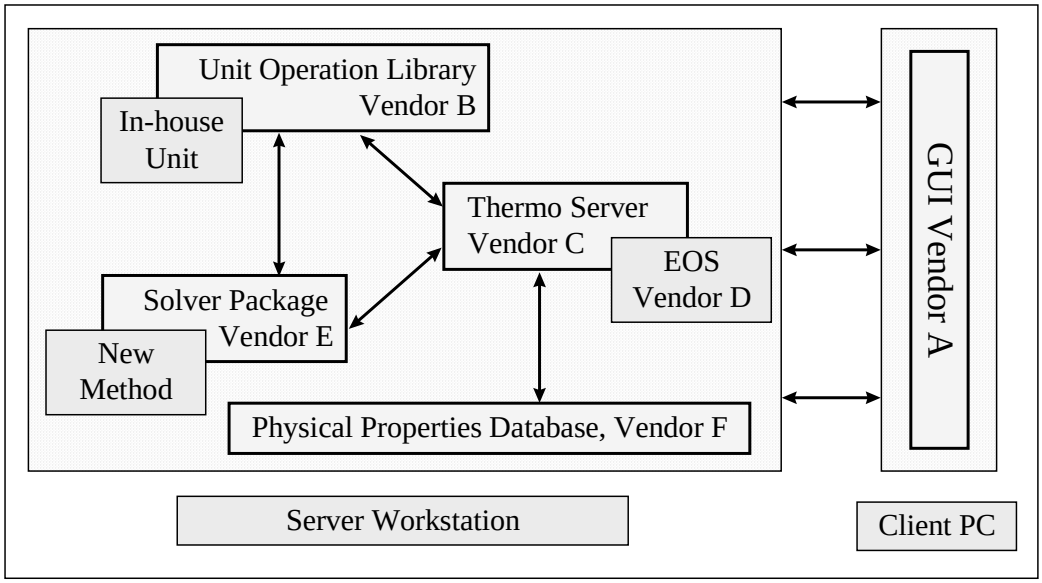

Figure 1-1: Simulator A Host Modified/Enhanced by CAPE-OPEN Compliant Components from In-house or Other Sources

1.3 CAPE-OPEN helps 'Kick-start' Process Systems Standards

By all measures, CAPE-OPEN has been a fast-track project particularly for standardisation work that requires consensus among many partners with different backgrounds and interests. CAPE-OPEN has helped to kick-start what is likely to be a long-term, ongoing activity. The use of process systems and modelling tools is expected to continue to grow and evolve, particularly since the benefit obtained from these systems will increase dramatically with increasing power and accuracy. CAPE-OPEN has addressed the question of standardisation of interfaces, initially for the most basic, coarse components of a process simulator (unit models, physical properties and numerical packages). Within the time available in the project, the basic conceptual foundations and consensus of the same have been obtained. Further, formal interface specifications have been developed for these components using UML notation and object oriented concepts. It has been possible to build a limited number of demonstrative prototypes to confirm the viability of the interfaces and collaborative operation of components from different sources.

However, it should be recognised that at the end of CAPE-OPEN project, there is not yet substantive experience gathered for using mixed component simulators and several aspects of operating/using the same have yet to be worked upon. It is expected a number of issues and problems will emerge that will require addressing both by the continuing initiatives in the field and individuals building and running such systems. Among the technical aspects is how to develop error handling and orderly shutdown following exceptions and to know unambiguously what component is at fault. There may be complications such as a given combination of components may lead to new types of error, not recognised or catered for by either component or the executive. There are managerial and administrative aspects too, how to cost a system where the individual components are licensed directly from different vendors, education of the process engineers and scientists on the use and power of mixed component systems.

The follow-up activities will lead to useful experience being gathered. The major vendors intend to make available commercial versions of CAPE-OPEN compliant simulators and guides will emerge through the testing and releases of these. The vendors will perform tests on foreign components embedded in their systems or vice-versa. Any end-users are encouraged to give their comments and feedback to the Global CAPE-OPEN team at present. In due course, the CAPE-OPEN laboratory network will be set up and this will become the focal point for feedback of users.

1.4 Who should use CAPE-OPEN results

Although the partnership has worked to establish the concept of open process systems standards and to develop the specifications within the project, it has always been the intention to make the results available generally to the community at large. Indeed the successful realisation of the objectives requires that the larger community adopts the standards and provides the feedback necessary to improve them in the future. The same benefits envisaged by the original partners will come to the wider community, through easier ability to interface third party components and applications. Through the CAPE-OPEN project, it has become recognised that widespread co-operation in this field of technology is highly beneficial for all concerned despite the competitive pressures. By concentrating solely on interface standards, CAPE-OPEN imposes no limits on functional diversity and stimulates the participation of specialist suppliers. There are many other such parallels where collaboration in technological fields has taken place for the benefit of all, for example in the fields of environment and control of emissions.

The results of CAPE-OPEN should be of interest to a wide group of personnel associated with researching, developing, supporting, maintaining or applying process systems or process modelling tools.

1.5 Types of Tools and applications covered by CAPE-OPEN

This section helps to get into perspective the kind of applications and tools that CAPE-OPEN interfaces will help enhance as compared to a paradigm with no effort for standardisation.

a) Complete environments that allow users to build models of processes by configuring existing library blocks in a flowsheet structure. In such environments, through CAPE-OPEN interfaces one could replace an indigenous component with a foreign one, e.g., a unit model from the host environment could be replaced by a foreign unit model.

b) Comprehensive physical properties systems that allow users to obtain any combination of a large set of thermodynamic and transport physical properties and phase equilibria for any combination out of a large databank of chemical species. Through CAPE-OPEN interfaces, the entire physical properties system of a host environment could be replaced by another one. Also, individual methods for given properties could be replaced by those contained in other complete systems or individual codes.

c) Specialised unit models that have been built to represent an unusual chemical engineering unit operation not commonly found in pre-built libraries or that contains different equations and methods. Such models could be integrated into complete environments or they could be run together with the bare minimum of other components (a simulator executive with the required numerical and thermodynamics routines).

d) Specialised Physical Properties routines and data for a given application. These could arise easily in given new projects. It is often necessary to develop these to adequately represent a new system despite the presence of so many databanks and existing environments. It would be very convenient to be able to directly port the specialised data and routines into the simulation environments that the project personnel normally utilise.

e) General equation based environments for making custom models applicable to both steady state and dynamic modelling. Equation based and custom modelling packages offer certain unique features in comparison to the pre-configured, block models. However, often a given application would involve developments in both the sequential modular and equation based systems to obtain the full benefits of the functionality on offer. It is particularly beneficial to be able to use the same Physical Properties package between the two types of packages. With CAPE-OPEN interfaces, ability to incorporate one type of unit model into the other environment also becomes possible and potentially very valuable.

2.0 The CAPE-OPEN documents

In the progress of CAPE-OPEN, numerous documents have been released within the project to aid the development of the standards and demonstrative prototypes and on research aspects of component based process modelling. There have also been a number of progress reports for the benefit of the sponsoring organisation, European Union. The organisation of the documents released to the public at the end of the project is given in Fig.2-2, below:

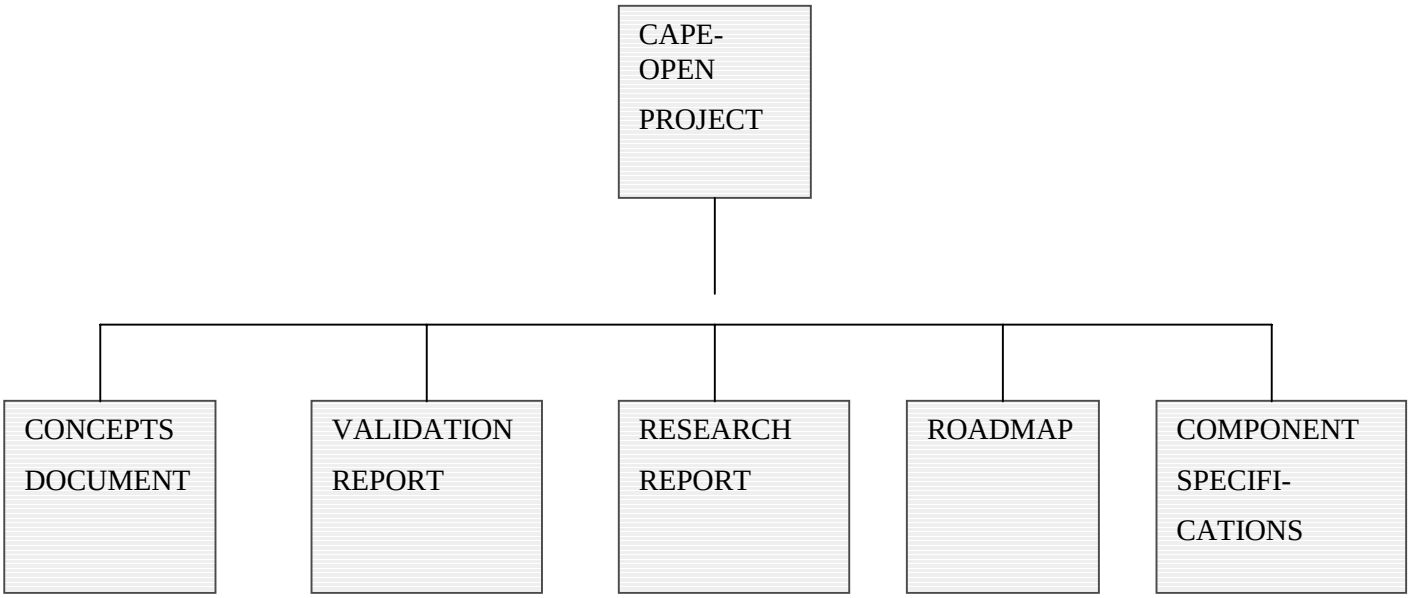

Fig. 2-2: CAPE-OPEN overall document road map

In general, the detailed specifications will be of use to the software developers rather than the process modellers but the latter would benefit by reading the conceptual documents. The research report will be of interest to anyone looking to the future of Process Systems technologies.

The user documents can be classified under five categories as shown in fig. 2-2 above. These are discussed in the sections below. The following embedded chart (fig. 2-3) shows the organisation of the documents with some more detail.

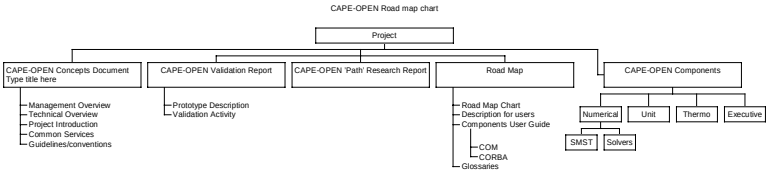

Fig. 2-3 Chart with details of Overall Documentation Road Map

The following embedded chart (fig. 2-4) gives an example of the documents within the component specification section:

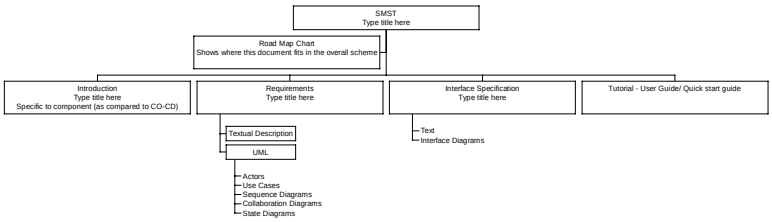

Fig. 2-4 Chart with an example of documents/sections within a component specification

2.1 The Concepts Documents

These include the conceptual design documents that were written earlier in the project following extensive technical discussions and consensus seeking. CDD1 was the first conceptual design document written about three months after the start of the project and contained the initial ideas without project wide resolution as yet. CDD1 is not a public domain document. CDD2 came out about a year after the project started and was the first document to be released to the wider community. It was based upon a wide consensus gained among the fifteen partners in the project and it was aimed to freeze as much of it as possible. It contained the priorities expressed by the partners and key conceptual decisions (including new innovative concepts) agreed through discussion but not yet fully tested through prototype development. Updates to CDD2 are given in the documents of the respective work-packages and other documents described below. An update to CDD2 called CO-CD (CAPE-OPEN Concepts Document) may also be written but is not available at this point in time.

The CDD2 document is available under the following URL:

http://sunsite.informatik.rwth-aachen.de/bscw/bscw.cgi/0/571261

2.2 The CAPE-OPEN Integration Report

This report describes the activities carried out in order to validate the standards. It describes the steps that were taken in order to test and validate the interfaces (preparation of a suite of test problems, testing of the same on existing simulators, testing them on CAPE-OPEN compliant interfaces, testing the ability of independent authors to link into the software system, preparation of test harnesses to validate basic interface components, testing the components against the harnesses, ability to interface components from independent authors, testing of scenarios based upon the use cases). This report is of interest to all software developers who will want to familiarise with the validation strategy used in CAPE-OPEN. The report also mentions essential conditions for example testing of an interface should not be done by original authors of the software that conforms to the standards. Different types of tests, function test, actual value test and performance test were carried out and described. The test harnesses focussed on the thermo and unit components and on a simple mixer-splitter example.

The UML methodology applied to the development of the test harnesses themselves is given including the test harness use case model and the test harness component diagram. The main thrust of the validation activity was to demonstrate the viability of standardised interfaces. A number of additional tests are suggested and listed in the appendix to make the standards closer to not requiring revisions. This list is of interest to all component developers who can use the additional tests suggested on their own systems. Feedback to the Global CAPE-OPEN team should be given on the results of this.

The appendices also contain the screenshot of the test harness user interface, an example report generated for the basic test and an example report generated for a function test.

The Validation Report describes activity that has taken place in the project to validate the specifications developed and the results of the same.

The report is named, ‘WP Validation Deliverable D521: Report on Integration’. The file is named Integration Report.pdf. It is available as an Adobe Acrobat document in the hypertext Transfer Protocol with the URL given below:

http://sunsite.informatik.rwth-aachen.de/bscw/bscw.cgi/d595943/CO%20Integration%20Report.pdf

2.3 The Research Report

The research report describes the work of the ‘PATH’ work-package that considered the conceptual and technical issues related to the use of component software in process systems for the environments of the future. A prototypical simulation environment called CHEOPS was developed those verified CAPE-OPEN compliant interfaces for numerical solvers and equation objects. CHEOPS is based upon CORBA middleware and reference to this document will be useful for those considering using CORBA. A chapter is dedicated to the use of CORBA including description of implementing interfaces in CORBA, the invocation mechanism and CORBA services etc.

The report also gives a description of a conceptual object model for process simulation with a view to the flexible environments of the future. Appendices give comments and an object oriented view of thermodynamics and streams, thermodynamics and unit operations.

The research report is of interest to all those concerned with providing future tools, software developers, simulator and systems architects etc.

The report is named, 'CAPE PATH recommendations A window to the future'. The file is named CO Path Recommendations.pdf. It is available as an Adobe Acrobat document in the hypertext Transfer Protocol with the URL given below:

http://sunsite.informatik.rwth-aachen.de/bscw/bscw.cgi/d595980/CO%20Path%20Recommendations.pdf

2.4 The RoadMap

The RoadMap is the present document. It is aimed at the end user of the CAPE-OPEN results and gives guidance on what other documents the user should consult. It draws the attention of different categories of end-users on how CAPE-OPEN results would be valuable for them and how they could set about to exploit them further.

2.5 The Components Specfications

Four detailed component interface specifications have been written. These are for the unit operations model component, thermodynamics and physical properties component, sequential modular specific tools component and the numerical solvers component. Within these overall headings, there are sub-divisions as needed. There is no separate specification for the simulator executive as it is assumed that if an executive can link into the unit, numerical and thermodynamic components with a CAPE-OPEN interface, then it will be a CAPE-OPEN compliant Simulator Executive (COSE). However, there is a discussion on the role of the CAPE-OPEN compliant simulator executive in CDD2.

The Component documents give all the details for the interface specifications for the component under consideration. The development of the specifications has followed the application of the UML methodology and the documents themselves follow the systematic application of the methodology. However, the component specifications have been developed by separate work-package teams and there are differences in some aspects of and extent of UML usage and to the style and format of the documents.

2.5.1 The Unit Operations Component Specification

The unit component specification is written with the guidance of UML methodology. It has addressed the steady state, sequential modular simulator most thoroughly with some outline treatment of equation based simulators in the appendix. First there is the textual description of the requirements for an open unit operation component. This is then expressed in UML through selected use cases and sequence diagrams, state diagrams, component diagrams and interface descriptions. Then interface specifications are given in both COM and CORBA. There are notes on analysis and interface specifications. A chapter describes the implementation of the prototype including the pseudo-code for the mixer-splitter example. There is a glossary specifically for this document; a bibliography and an appendix containing the considerations on equation oriented systems.

The software developers would be interested in using the whole document as reference whereas the requirement chapter will be of interest to all end users. Section 5.1 is a useful list for everyone to look at and lists the issues that have not been resolved within CAPE-OPEN, some of these would have to be resolved individually at implementation time while others would be resolved through standardisation in future.

The report is named, 'CAPE-OPEN interface specifications Unit Operations'. The file is named CO Unit Operations.pdf. It is available as an Adobe Acrobat document in the HyperText Transfer Protocol with the URL given below**:**

http://sunsite.informatik.rwth-aachen.de/bscw/bscw.cgi/d596351/CO%20Unit%20Operations.pdf

2.5.2 The Thermodynamic and Physical Properties Component Specification

The document is entitled, 'Open interface specification for Thermodynamic and Physical Properties'. It contains an overview of the process used to develop the interfaces in terms of component diagram, interface diagram, entity descriptions and interface glossary, IDL specification and code examples. The CAPE-OPEN properties list is also given in terms of constant properties and non-constant (model dependent) properties and a CAPE-OPEN list of phases and flash calculations allowed. One chapter gives the use cases that were developed with a number of different actors, e.g., material object, neutral file system, physical properties client, physical properties developer, physical properties system, simulation engineer, simulation end user, simulator executive, stream and unit model.

The details given in this document are of interest to all engaged in developing CAPE-OPEN compliant thermodynamic and physical properties systems or routines within these. The document will also be of interest to simulator system architects and designers.

The report is named Open Interface Specification Thermodynamic and Physical Properties. The file is named CO Thermodynamics & PhysProps.pdf. It is available as an Adobe Acrobat document in the HyperText Transfer Protocol with the URL given below**:**

http://sunsite.informatik.rwth-aachen.de/bscw/bscw.cgi/d595898/CO%20Thermodynamics%20%26%20PhysProps.pdf

2.5.3 The Solver Component Specification

The solver component specification describes the specifications developed for numerical solvers. The document follows the UML methodology, starting with introduction and user requirements, which include the use cases. These two chapters will be of general interest but the rest of the document is aimed more at the software and interface developer.

Chapter 3 gives the analysis in terms of UML models, the component diagrams, the sequence diagrams, the collaboration and interface diagrams before giving the interface descriptions. The interface specifications in CORBA IDL and COM IDL are described next in the document with a final chapter giving notes on the analysis and interface specifications.

The report is named, 'Open Interface Specification Numerical Solvers'. The file is named CO-solvers.pdf. It is available as an Adobe Acrobat document in the HyperText Transfer Protocol with the URL given below**:**

http://sunsite.informatik.rwth-aachen.de/bscw/bscw.cgi/d600441/CO-Solvers.pdf

2.5.4 The Sequential Modular Specific Tools Specification

This component has also been termed Graph-Analysis-Tool component in some places. The document is implemented in full HTML and the reader needs to download the required set of files to make the document operational together with a web browser for example Microsoft Internet Explorer.

The document is divided into four parts, Introduction, Analysis and Design, Interface specifications and tutorials. This component addresses the partitioning, ordering, tearing and sequencing functionality of sequential modular flowsheeting packages. Analysis and design contains both a textual description and a UML description. Interface specifications contains a full interface diagram and the interface specifications developed in CORBA.

The file is named, CO Sequential Modular Specific Tools.Zip. It is a set of files that allow the full .HTML version to be installed. It is available from the following URL:

http://sunsite.informatik.rwth-aachen.de/bscw/bscw.cgi/0/571261

2.6 Other documents

These documents are available from the following URL:

http://sunsite.informatik.rwth-aachen.de/bscw/bscw.cgi/0/571261

There are a number of other documents that are of interest to the wider community that have been generated in the course of the CAPE-OPEN project.

The **CAPE-OPEN migration report** that gives a strategy on migration of legacy systems and software towards CAPE-OPEN compliance and component based architecture. This report is of interest to anyone considering wrapping existing software to make it CAPE-OPEN compliant. This is of interest to vendor companies, academic groups as well as the operating companies.

The **CAPE-OPEN Methods and Tool Recommendations** give the results of the methods and tools task force that was initiated at the start of the project to select methods and tools both for the project work and documents and for the writing of the interface specifications. This document will be useful to those wanting to know more about the methods and tools selected for CAPE-OPEN and the rational used.

The **CAPE-OPEN Guide for Authors of CAPE-OPEN documents** has been a very useful document to give guidelines on the document writing itself and the revision, review and approval process. This guide will continue to be useful in Global CAPE-OPEN and the wider community may wish to use it for writing documents related to interfacing work they carry out.

3.0 Relevance for Different categories of end-users

The position of different categories of end users with respect to CAPE-OPEN and their potential to utilise the results generated is discussed here. Of course, many users will relate to more than one category, e.g., many process modellers may also carry out software development and some developers would also be modellers. The categories of process software developers and process modellers, being the key interested parties in these standards, are discussed in detail in terms of these personnel being present in different types of organisations and the relevance of CAPE-OPEN to each. Discussion on other categories of end users is more brief and grouped together in section 3.3.

3.1 Process Software Developers

Process software developers are primarily engaged in developing, testing, making robust, software systems, software system components and tools that allow other users to repeatedly use them on different applications.

3.1.1 Based in Vendor Companies

There are different types of vendors. Process Modelling tools vendors and engineering vendors. Many of the products of the former are heavily in the form of software systems whereas the latter provide design and consultancy services for engineering projects. Clearly, the process modelling tool vendors are the major developers of software whereas the engineering vendors will actually be customers. The discussion below is therefore based mainly on the former while the latter can be considered together with the industrial end users.

3.1.1.1 Nature of Activity

Clearly software development and testing is a major activity in the vendor companies. Software is developed both at the systems level and at the individual component level. Within the latter, there may be new numerical routines with improved convergence, new unit models, improvements to existing unit models, new thermodynamic methods, extensions to existing ones etc.

3.1.1.2 Recent Trends

Among the major process systems vendors, there has been a flurry of take-overs and mergers. Companies that started with process modelling and flowsheeting software as their main business has expanded into online application, advanced control software, data handling and management systems. Conversely DCS system vendors have expanded their operations to cover process modelling and operator training. This has resulted in a mix of software components coming together that started their lives in different companies under their own unique architectures. It is a challenge for these

companies to rationalise their software systems and to provide the appropriate interfaces between different components where beneficial.

3.1.1.3 Relevance of CAPE-OPEN

Clearly CAPE-OPEN is very relevant to all the process software developers in the vendor companies. It provides a standard through which they can provide interfaces between their systems and those from other sources as well as interfaces between components within their own companies. CAPE-OPEN interfaces will help in unifying the architectures of different groups of products. Software developers that are based in vendors that were part of CAPE-OPEN project (specifically Aspen Technology and Hyprotech) would already have in-house experience of adapting components to CAPE-OPEN standards. They have already declared their intentions to produce compliant commercial simulators as soon as possible.

The developers will find all the public domain documents are of interest. The concepts documents give the overall philosophy of CAPE-OPEN that the vendors can relate to their own architectures, whereas the detailed specifications on unit, thermo and numerical give the formal description of the standard interfaces. The role of a CAPE-OPEN compliant executive is described in the concepts documents.

It is requested that the vendors provide feedback to the Global CAPE-OPEN group on the experience of carrying out the various tasks. In particular feedback for third parties that want to link specialised components to their systems would be valuable.

3.1.2 Based in Process Operating Companies

3.1.2.1 Nature of Activity

Software developers in operating companies can develop both components and systems according to the specific needs of an operating company particularly when the needs are not satisfied by the commercially available systems. There are many reasons why such developments are needed, the unit operations may be new or the chemical process may be quite new and the existing methods and data may be inadequate. Also, many operating companies still harbour complete legacy simulators.

3.1.2.2 Recent trends

The trend is away from in-house software wherever possible but it will take some time (years) for the inertia in the legacy systems to be exhausted. Even if new simulators are available that may be of higher specifications, it takes quite a long time before the old systems will entirely disappear. The most important reason is that if a customer is satisfied with the performance of a model, then he will

be reluctant to change anything (even though developers may promise everything will work as before). Thus software developers in operating companies will have the challenge in supporting some of the legacy systems as well as externally licensed systems and occasionally providing some links between them, e.g. in interfacing physical properties systems from one side to the simulator executives of the other. Some large operating companies have also deliberately decided to maintain in-house simulators or simulation environments.

3.1.2.3 Relevance of CAPE-OPEN

CAPE-OPEN is very relevant to all the process software developers in the operating companies. It provides a standard through which they can provide interfaces between their systems and those from other sources. They need only wrap the legacy systems once and it will be possible to link them to all CAPE-OPEN compliant systems. It is recommended that all new developments by the operating companies should conform to the standards.

The developers will find all the public domain documents are of interest. The concepts documents give the overall philosophy of CAPE-OPEN that the developers in operating companies can relate to their own architectures, whereas the detailed specifications on unit, thermo and numerical give the formal description of the standard interfaces. The role of a CAPE-OPEN compliant executive is described in the concepts documents.

It is requested that the operating company developers provide feedback to the Global CAPE-OPEN group on the experience of carrying out the various tasks. In particular feedback that could help the vendors to provide better, more easily linked systems in the future would be very valuable.

Some component types that are popular for in-house developments these days such as implementation of a data warehouse, links between CFD and process models, business-led solutions, presentation of commercial information linked to process information, supply chain modelling etc. may not have been addressed in CAPE-OPEN. Many of these areas will be in the scope of the follow-up projects. In any case, feedback from developers who implement these systems, on desirable features of the interfaces and naming conventions would be valuable and please pass such feedback to the Global CAPE-OPEN team.

3.1.3 Based in Independent suppliers of Equipment

3.1.3.1 Nature of Activity

There are a large number of specialised vendors of equipment in the process industry; examples are suppliers of different types of pumps, valves, packing for columns, plate heat exchangers etc. Often, the characteristic of their equipment is quite specific and different from those from another supplier. For example, each type of packing will have its own characteristic that will not be known to vendors of process simulators. Similar specific considerations may apply to ion exchange resins and the supplier would usually have his own performance data and curves. Sometimes the suppliers will provide a stand-alone computer program that contains the characteristic of the equipment. The end-

users such as process engineers in industry then have to manually transfer data from a flowsheet simulation to the specific equipment and back. This can be quite time consuming.

3.1.3.2 Recent trends

Customers of equipment manufacturers are becoming more demanding in terms of performance of equipment for a given cost. It is increasingly required that the correlation's for the characteristic is made available. Customers certainly expect the equipment vendor to have carried out the full range of experiments to characterise their systems fully. Vendors that do not wish to reveal their methods or correlation's may still find it possible to provide the behaviour of their system to their customers in terms of a linkable model.

3.1.3.3 Relevance of CAPE-OPEN

The opportunity is now there for equipment vendors to provide software components that model the unique characteristic of their equipment without having to write a complete modelling system. The utilities from the established process systems vendors can be used by the model provided by the equipment vendor, e.g. for input-output of the data. Here, we see, open standards will help to reduce the time spent by the engineer but also improve the quality of engineering that may be carried out.

3.1.4 Based in Academia

3.1.4.1 Nature of Activity

There are many academic centres around the world researching in the field of process systems as well as conventional chemical engineering operations. These centres often develop new software and models to represent the results of their research or to provide better calculation methods for future. There are a number of well-known problems related to developments carried out in academia. Often the term 'academic standard' is used in relation to code that is not fully reliable despite having new innovative features in it. It is very difficult for the academics to maintain their systems and provide a full service to the end-users, an aspect that the vendors are good at. It is well known that some very good academic developments just take too long to reach the end-user, others may never do so.

3.1.4.2 Recent trends

There is a trend towards the use of C+ and C++ languages by the developers in academia. More and more academics are working on collaborative projects, quite often across borders particularly in Europe. This creates the need for a common interface denominator through which they can exchange and integrate their collaborative developments.

3.1.4.3 Relevance of CAPE-OPEN

CAPE-OPEN interface standards should enable the academics to be able to link their specialised components to existing systems that provide the infrastructure and the support environment. Thus the

academics will no longer need to develop a complete system in order to demonstrate the new components and they can focus their energies on perfecting that. They will be able to use the CAPE-OPEN standards to interface to the vendor environments that also conform to the standard or any public domain environments that may exist at a given time. In both cases the time taken to reach the end-user will be significantly reduced.

A new field of research is opened for the academics to investigate in terms of the performance and behaviour of mixed component process systems.

Academic developers will find all the public domain documents are of interest. The concepts documents give the overall philosophy of CAPE-OPEN that the vendors can relate to their own architectures, whereas the detailed specifications on unit, thermo and numerical give the formal description of the standard interfaces. The role of a CAPE-OPEN compliant executive is described in the concepts documents.

It is requested that the academic developers provide feedback to the Global CAPE-OPEN group on the experience of carrying out the various tasks. In particular feedback for third parties that want to link specialised components to their systems would be valuable.

3.2 Process Modellers

Process modellers are primarily interested in representing the behaviour of the physical world in a reproducible, mathematical form. They may mimic the behaviour of their chosen process by configuring pre-built blocks, as is done when building a model in a block structured, sequential modular simulator. They can also provide their own understanding of the real world in terms of equations through an equation-oriented package. There are two levels of process modellers, those who have the capability and understanding of being able to configure the models themselves for their own use and that of their colleagues and those who primarily only use, i.e., run the models. The primary interest of the process modeller is in the application rather than the tool but of course aspects of the tool will greatly affect the efficiency with which the modeller can work. Some process modellers will also be software developers and may write specialised extensions to suit their applications. However, in this section we address the relevance of CAPE-OPEN results to the modelling part of their work rather than the software development part that has been addressed above.

3.2.1 Based in Vendor Companies

We consider both the process modelling tool vendors and the engineering vendors. We classify the engineering vendors here as service and technology providers rather than equipment manufacturers but we have also mentioned the latter in the discussion.

3.2.1.1 Nature of Activity

Increasingly the process modelling tool vendors also provide a service for modelling. They use personnel competent in process modelling also to provide support services (often available via dedicated telephone lines called hotline) to customers who face problems with the use of the software tools. In order to provide state of the art unit models and other software components, the vendors also require the ability to understand and develop process models. They also provide examples and training material for their customers and the development of these requires the development of significantly complete and realistic models of different processes.

The engineering vendors mainly will use the tools provided by the process modelling tool vendors or sometimes those provided or specified by the operating companies that they are serving.

The equipment manufacturers such as heat exchanger fabricators and pump manufacturers usually carry out relatively little process modelling. They may provide programs that can give the characteristic of their equipment to their customers and these are likely to be stand-alone programs.

3.2.1.2 Recent Trends

There has been significant re-structuring of the process tool vendors who have ambitions to provide integrated solutions and services rather than just tools. The engineering vendors operate in an industry characterised by stiff competition and tight margins with customers demanding the best, energy and resource conserving solutions. Therefore, the vendors have started to take a deeper interest in process modelling and develop longer-term solutions. Some of the larger engineering vendors have a reputation for being strong in having models of a particular type e.g. Kellogg's made a number of presentations on dynamic modelling applied to relief calculations.

3.2.1.3 Relevance of CAPE-OPEN

The main thrust of applications for the Process Tools vendors is within their own set of tools but occasionally there is need to build models that use external software in addition to the system provided by the vendor. For example, the electrolytes modelling software from OLI systems Inc. has been interfaced to the process modelling tools of both the major vendors, Aspen Technology and SimSci. Also, due to re-structuring within the vendor companies, there has been a need within the vendor companies to build examples across systems that arose from different original sources. The CAPE-OPEN standards provide the interface protocol for all these above needs.

The engineering vendors often specialise in types of process technology. An example of a type of process technology is ammonia technology. A number of engineering vendors as well as catalyst manufacturers and process technology vendors specialise in serving this industry. They may primarily use the modelling tools from one particular process modelling tools vendor but are likely to have a mix of tools depending on the process they are focussing on as well as the customer they are working with. Once they have developed the data, methods and models in one particular tool, it is very useful to be able to port these across to other tools as the demands change from the customers. Some of the engineering vendors have their own in-house tools and they can also interface these to the mainstream simulators by converting them to CAPE-OPEN compliance first.

It should be pointed out that the CAPE-OPEN results have only demonstrated the viability of the interface standards and proposed the first set of standards. There will inevitably be adjustments and revisions. There are also several issues connected with the use of mixed component simulators that need to be investigated and experience gained, for example in the domain of error handling. Please feedback the experiences that you develop to the Global CAPE-OPEN team. The Global CAPE-OPEN project has a work-package dedicated to the practical aspects of bringing the open standards into the industrial work place and some of these additional issues are being addressed there. Any suggestions, ideas or feedback related to the use of mixed component simulators in the industrial work place should also be given to the Global CAPE-OPEN team.

The equipment manufacturers now have the opportunity to be able to link their unit models through to process modelling systems. In this manner, they can provide a more useful form of their model to

their customers. They can also conduct studies of the behaviour of their equipment within the overall plants and as a result improve the design and characteristic of their equipment.

3.2.2 Based in Process Operating Companies

The process modellers in the process operating companies are major users of process modelling tools.

3.2.2.1 Nature of Activity

Depending on the size of the operating company in question and the nature of its organisation, the process modelling activity may be carried out in centralised corporate groups or directly in the business units. In most companies, there will be a mix of both. Traditionally the large chemical companies had significant corporate groups in the process systems field that covered both the development of the tools and their applications. The number of persons engaged in process modelling varies greatly. One view is that each chemical engineer that runs a process modelling or a physical properties program is a process modeller. On this basis, companies such as ICI and Bayer traditionally had hundreds, possibly exceeding one thousand persons engaged in the process modelling activity to some extent. With the change in some companies towards specialty products, as in ICI, the focus has shifted somewhat from the chemical engineers towards the chemists. It can be argued that chemists who need to find out physical properties of their new materials and run process systems programs for some of their work are also process modellers as are other types of engineers who run process modelling programs.

3.2.2.2 Recent Trends

Traditionally the large chemical companies did most of their process modelling work on their own in-house simulators. As these were developed within the companies, they tended to be well integrated with each other through dedicated interfaces put in place by the tool producers. However, with the advent of the external vendors and the relative decline, even demise in some cases of internal process systems developments, many operating companies are today left with a large mixture of programs, both externally licensed and internal ones. The internal programs have a large number of legacy data and models that is not easy to discard but often the continued development and to some extent support for the internal programs has stopped. Thus the process modellers are left with a situation that is not as neat as the time when they mainly used their well integrated in-house tools. Process modellers are having to spend a significant amount of their time in systems related activities, keeping up with the new versions of the many programs from different vendors that they do run and converting old models to the new versions. The conversion of old models to new versions is not always as automatic and painless as is sometimes suggested.

3.2.2.3 Relevance of CAPE-OPEN

The availability of CAPE-OPEN compliant software will make a very large difference to the efficiency of the process modeller. There will be a reduction in the time needed for systems related trouble shooting and porting of data from one tool to another. This will free up the time of the process modeller to engage in the creative engineering activity thus improving the quality of the solutions he

provides. Further, the use of more integrated tools directly will give him greater power and ability to give more optimal solutions.

The company legacy systems can be wrapped to make them CAPE-OPEN compliant and then they can be used together with the new external software. Consider, for example, a case where a business has invested a lot of resource in developing physical property data and models for a particular set of chemicals and processes. This is implemented in the legacy physical properties package. As it takes a lot of time and resource to develop confidence in these working models and systems, it is not easy to quickly discard the legacy systems and transfer everything to the external software. Some of the legacy systems will be in use for many years to come in part due to the conservative nature of the operating managers and staff. Here, through the wrapping and interfacing to external software, one could continue to use the legacy physical properties models and data together with the latest modelling software and techniques obtained from the outside world.

3.2.3 Based in academia

The academics are seeking to extend the limits of our know-how and they seek this both in terms of systems technology and modelling. There are many different reasons why process systems researchers want to carry out process modelling in academia and there are several persons working in academia building both simple and sophisticated process models.

3.2.3.1 Nature of Activity

The main activities in academia are teaching and research. Process Systems is usually an activity linked to chemical engineering departments although multi-disciplinary centres have been established in many leading universities. There are examples also of separate departments from chemical engineering that are involved in process systems or process integration activity. Process modelling is carried out both by students and faculty. The undergraduate students use it for learning about engineering principles. The postgraduates use it to solve the problems they are researching in which can cover a very broad range of subjects such as process control, heat transfer, mass transfer, combustion science and technology, physical properties and thermodynamics etc. The postgraduates may also be researching in the area of modelling itself and developing more accurate and powerful models for given phenomenon. The academic staff who practise process modelling may do it for exactly the same reasons as the research students or they may use it for teaching and developing examples for their students.

3.2.3.2 Recent Trends

All the major vendors have been providing their process modelling tools to academia at very favourable terms and conditions. This has enabled academia to teach process modelling applied on these tools to large contingents of undergraduate students for example in terms of applications on a design project. Postgraduates and research students have also benefited by similarly good terms and conditions. Some of the new generation process modelling packages have arisen out of academia themselves, for example, gPROMS from Imperial College. Such packages have often established a prominent position in academia around the world at first before entering the commercial market. Thus academia are by now quite used to having access to a broad range of process modelling tools.

3.2.3.3 Relevance of CAPE-OPEN

CAPE-OPEN standards will enable academic modelling studies based upon mixed component systems to be carried out. The opportunities for these are already there through the availability of a wide range of software systems and the benefits will be similar to those gained by process modellers in industry and the vendors.

3.3 Other end-users

There are other categories of end users that will find CAPE-OPEN results interesting and want to know more about the project, its results and documents. These are given below with a brief explanation in each case.

3.3.1 The European Commission

The European Commission sponsored the CAPE-OPEN project and continues to sponsor the European part of the Global CAPE-OPEN project. A number of reports have been written specifically for the benefit of the European Commission as required. The commission will also be interested in the public domain documents and the manner in which the CAPE-OPEN standards are adopted throughout the process systems community. The commission would also be interested to follow-up publications from operating companies in due course on how the standards are helping to improve productivity and quality of design thus also helping the environment and energy consumption levels.

3.3.2 Supply Chain and Production Managers

Supply chain managers are interested in the performance and characteristic of the entire supply chain of which production is one part. They have an interest in integrating process models with the wider supply chain models, accounting systems and SAP systems. While CAPE-OPEN has not directly addressed the standardisation of these additional interfaces, it provides a good model for future initiatives.

3.3.3 Simulator Architects and Simulation Systems Designers

They are not developing the software themselves but devising the overall architectures and design. For example, those within vendor companies have been concerned with integrating, bringing together into a common architectural framework, tools that started their lives in separate companies with their own peculiar technologies. They will have concerns on the integrity of applications with options for components mixed from different sources, robustness, reliability, and safety. CAPE-OPEN and its follow-up project results are of fundamental interest to these personnel.

3.3.4 I.T. Managers and Systems Administrators

These personnel are based in all types of organisations, in operating companies, vendor organisations and academic institutes. CAPE-OPEN inherently allows more possibilities in terms of use of process systems software components. These additional possibilities will have an impact on the I.T. resources required in terms of type, capacity and performance. In some respects, the greater possibilities lead to the need for more powerful and flexible resources. In other ways, the more efficient use of modelling tools actually implies less resource needed. The actual case will depend upon the nature of the applications and the propensity of the personnel involved in the modelling work. The I.T. managers will benefit by familiarising themselves with the concepts of CAPE-OPEN and its results and map this across to the I.T. needs for their organisations.

3.3.5 Process Systems Engineering Managers in Industry

These personnel may be professional managers of such groups and departments who do not work with the tools themselves. Familiarising themselves with the CAPE-OPEN results will alert them to the possibilities for the future as well as help in their management tasks.

3.3.6 Concurrent and Future Standards and Technology Developers

There are activities taking place concurrently with CAPE-OPEN and Global CAPE-OPEN projects both in the field of standardisation and general technological developments. Examples are pdXi (standardisation of representation of process data), OLE for process control (microsoft standards applied to DCS systems) and OPERA (a European Commission sponsored project on new generation operator training simulator technology). These projects in some cases have already considered the applicability of CAPE-OPEN results to their projects.

3.3.7 Standards Organisations

These are engaged in developing verified and agreed standards in different domains. An example of an international organisation is the ISO (International Standards Organisation). CAPE-OPEN is intended to be a defacto standard but its results and methods will be of interest to more formal. Ongoing, organisations for standards.