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Supplementary editorial material

Summary of discussion session on 'industry–academic interactions and open standards'☆

T.I. Malik [a], S. Skogestad [b,*]

[a] *ICI Technology, Runcorn, WA7 4QF, UK*

[b] *Chemical Engineering Department, Norwegian University of Science and Engineering, 7491 Trondheim, Norway*

1. Introduction

This is a summary of a plenary panel-based discussion session entitled, 'Industry–academic interactions and open standards' that took place on 29 May 1997 during the conference PSE'97/ESCAPE-7 in Trondheim, Norway. The discussion was part of a concerted effort to improve the level of participation from industry in these conferences, the relevance and benefits to industry and the interactions between industry and academia, and the panel was composed to provide a balance between academia, industry and vendor organisations.

The session was organised by Dr Tahir Malik following discussions between Professor Sigurd Skogestad and a group of industrialists at the ESCAPE-6 conference in May 1996 about improving the interaction with industry at these conferences. The session was chaired by:

1. **Professor Roger Sargent**, Imperial College (as a world authority in Process Systems Engineering)

2. **Malcolm Preston**, ICI Technology (as a foremost industrial consultant in Process Systems and Process Safety).

In addition to the two chairmen the panel consisted of

3. **Mr. Bertrand Braunschweig**, Institut Francais du Petrole (IFP), France (Artificial Intelligence and statistics group manager at IFP and co-ordinator of the EU funded CAPE-OPEN project that is defining open process systems standards with fourteen organisations participating).

4. **Dr Herbert Britt** from Aspen Technology, USA (as one of the foremost technical experts from a vendor organisation).

5. **Colin Gent**, ICI Katalco, UK (senior technical manager in industry who chaired ICI's Design and Modelling Interest Group for several years and has established innovative, collaborative ventures in catalyst technology).

6. **Professor Ignacio Grossmann**, Carnegie Mellon University, USA (renowned academic researcher in mixed integer programming and head of department of chemical engineering).

7. **Dr Siegfried Nagel**, Bayer, Germany (one of the most experienced and renowned industrial process systems engineers having led the activity in Bayer for a long period).

8. **Dr Yukikazu Natori**, Mitsubishi Chemicals, Japan (the leading manager from the far east responsible for rapidly introducing several process systems technologies in his company).

9. **Professor Rex Reklaitis**, Purdue University, USA (a well known academic with reputation for original work in scheduling systems and editor of Computers and Chemical Engineering).

10. **Dr David Smith**, DuPont, USA (leader of one of the most active industrial groups in Process Systems).

11. **Knut Harg**, Research Director, Norsk Hydro, Norway. (K. Harg was the plenary speaker of the day and joined the panel).

The panel discussion covered two distinct, although somewhat related topics:

- Industry–academic interactions
- Open standards

The session was well attended with about 200 persons present. A quick show of hands demonstrated that the ratio of industrialists to academics in the audience was

☆ The full version of this paper is available on the Internet. See the home page of Sigurd Skogestad or www.kkt.chembio.ntnu.no/research/PSE_ESCAPE.

* Corresponding author. Fax: +47-73-594-080.

E-mail address: skoge@chembio.ntnu.no (S. Skogestad)

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about 50:50, in itself quite an achievement (given the meagre industrial attendance in other recent ESCAPE meetings). The discussion was opened by Professor Sargent and M. Preston who introduced the subject by saying that *the challenge is to realise in industry the full potential of more than 20 years of Process Systems research*.

2. Comments on the pre-discussion paper

In preparation for the panel discussion, T. Malik had prepared a pre-discussion paper that had been circulated among the panel members. Professor Sargent had given written comments on the pre-discussion paper. In the pre-discussion paper it had been questioned why some technologies (developed originally in academia) have not flourished in industry whereas others have. Professor Sargent's responses were (the questions are also repeated here):

Q. Treatment of uncertainty in process modelling: despite this being the norm most industrial process design is still based upon steady state base case design. Why are we being so slow?
A. The problem is modelling the uncertainty.

Q. Why are process synthesis packages not used extensively?
A. Process synthesis packages are not currently powerful enough for realistic problems.

Q. Why is there very little integration between process systems software and some degree of intelligence?
A. There are two cultures, which do not mix easily.

Q. Why do the physical properties packages not give suggestions on the most appropriate data gathering experiments required in a given problem?
A. Physical properties is a Cinderella area—Government believes industry should fund it if it wants it, and industry does not see why it should.

Q. Why are we still waiting for real model based predictive control (instead of simple linearised model based predictive control)?
A. Some companies are implementing schemes using non-linear mechanistic models. This is leading edge technology requiring special skills and companies have to see real economic incentive.

Q. Why on the other hand have some academic developments such as Aspen Plus, Speedup and Pinch Technology been more successful?
A. Vendors have seen a commercial interest in exploiting these developments.

3. Individual views from the panel discussion

Professor Sargent commented that industry needs to know what to expect from the graduates. It cannot benefit from academic research if it does not employ people who can communicate with academics. The recent downsizing of research activity in industry has made it more important than ever for both sides to work together.

Concerning the discussion on open standards, Professor Sargent's initial views on the subject were that software is a commodity, and subject to all the resulting commercial pressures. Each organisation (academic or industrial) must decide for itself on the appropriate mix of in-house, standard or customised software and the appropriate support organisation. In general, standardised interfaces are a good thing, but there may be a price to pay in loss of efficiency compared with specifically tailored integration, so each case must be judged on its merits.

M. Preston considered there was a lot of opportunity, but warned that we should not confuse activity with progress. Goal directed initiatives should always be preferred to introspective, self-fulfilling ones. M. Preston also raised the subject of flexibility particularly in relation to the standards discussion. He discussed whether standards would be constraining and interfaces inflexible. He compared these with computer languages such as Fortran, C, C++, and Visual Basic as being flexible but at times quite ambiguous. Today we have objects, agents, componentware and 'plug and play'.

K. Harg stated that the key challenge in the chemical industry is people rather than technology. This is an important statement, well worth reminding all, particularly at a scientific meeting. He raised the question if there was a lack of awareness of real world problems in academia. This question arose out of his view that the academics were often expanding their energies on outdated processes. He would like to see a shift in emphasis to new types of unit operations that will increasingly be used in the future. Given the rapid change in technology and tools, K. Harg considered education in basics to be of paramount importance. He would rather see a strong grounding in fundamental disciplines, e.g. thermodynamics, transport phenomena, reaction kinetics, mathematics and statistics rather than spending the limited campus time on learning many different computer languages. He concluded by quoting from Johan Wolfgang von Goethe, "Knowledge is not sufficient, Application is needed—Desire is not sufficient, Action is required".

B. Braunschweig explained the close relationship between Institut Francais du Petrole (IFP) and a neighbouring university (ENPSM). Some 30 PhD thesis students are linked each year and these students do some training at IFP. On the other hand, IFP re-

searchers give lectures and cutting edge examples to the students. Similarly there is a beneficial relationship between the licensor and the research institute, data going to the institute on real problems and new know-how coming back for applications. He demonstrated that process models, being the core tools, need to be easily transferred. His conclusion was that the arrangement at IFP comprised a unique set of highly interactive resources and that process models are among the core tools used there.

In relation to open standards, B. Braunschweig described the European Union sponsored CAPE-OPEN project. The objectives of the project are to assemble process simulators from software components and to be able to recycle legacy code. This implies that a definition of the components is required (in terms of thermodynamic package, EOS etc.). Also, a communication standard is required between the defined components and to check that the components are fully operational in terms of reliability, performance, etc. During 1997, the conceptual design will be completed and the conceptual framework developed. Also, interface specification drafts for thermodynamics component, main unit operation models and numerical solvers will be written. In 1998, the interface draft specifications for physical properties databank, other unit operation models, further numerical components and prototypes will be developed. In 1999, validated prototypes will be delivered as well as the final interface specifications. Looking ahead, further into the future, standard interfaces for other types of components may be added to the basic suite.

Dr Herb Britt view was that the distinctive role of academia is generation of new ideas, new technology and innovation. They should not be too concerned or dependent upon the immediate application of their results. He thinks that new technology and ideas may not have immediate general acceptance but may subsequently prove to be good. He gave the example of DMC technology that originally took time for acceptance but has since had widespread applications. New technologies take time to mature. They may also require a change in the engineering work processes and development of new infrastructures. He thinks that academia is doing a good job at its traditional areas of innovation and pioneering new technology. More collaboration is required however to demonstrate business benefits and to consider impact on work process and infrastructure.

Open standards can help increase the overall size of the simulation and process modelling market. There will be increased business for those vendors who add true technology based value to business operations. He thought that it is important that open standards should not be overly restrictive but help towards flexibility. For example, a desirable unit operations model would be usable in any one of a number of contexts (steady state, dynamic, from sequential modular simulators, from equation based simulators, etc.). At present there are at least three standardisation activities of CAPE-OPEN, ISO/STEP AP23 1 (PDXI) and ISO/STEP AP221 (PI-STEP). Dr Britt considers it important that these need to be consistent and complementary in order to achieve the true potential of open standards. Therefore if there are any ambiguities as to their respective roles they should be removed as soon as possible. Dr Britt considered that it is 'plug and play' capability between the software components that is being sought.

C. Gent looked back a few years when the corporate laboratories provided a bridge between the work carried out in the universities (typically with a 10 year application horizon) and application trials carried out within industry (typically 0–3 years from application itself). The work at universities was typically 100% curiosity driven, whereas on the other extreme the application trials were almost 0% curiosity driven and 100% application driven. In between these two extremes, existed corporate laboratories (5–7 years from application) and exploratory groups (2–5 years from application). Through the disappearance of the corporate laboratories and the exploratory groups (at least in the UK) there had emerged a large gap between academia and industry. As expressed by the other panellists, there have been different attempts to bridge this gap, e.g. through industrial consortia and indeed there are several examples of excellent collaborations. Nevertheless the major momentum for bridging the gap between academia and industry was due to corporate research departments and has disappeared with the same. Mr Gent thought that there is scope for a new collaborative body to be set up that could replace the role previously performed by the research departments.

In discussing open standards, Mr Gent raised the important subject of design pedigree. This is related to the collective experience of using a method or tool over a period of time. Engineers and technologists responsible for design would rarely give full reliance to new tools, code or methods. It takes a large number of applications, program runs in order to develop confidence. He said that every design program comes with a history of successful use. Major re-writes of programmes can destroy this pedigree.

Professor Ignacio Grossman mentioned the tensions in industry–academic research at the present time. There is a downsizing of industrial R&D activities, the companies are not necessarily staying with their traditional product lines, there is globalisation in terms of operations and marketing, and the funding offered to universities is much more targeted. At the same time, from the US universities point of view, there is decreased amount of federal funding available, the new members of faculty tend to have little or no industrial

experience, and there is pressure for a greater emphasis on teaching. On the other hand, he gave statistics that showed that the proportion of industry funding of academic research spending had actually gone up from 23% in 1981 to 38% in 1996. He was citing C&EN from August 26, 1996. The spending in 1996 was composed of 58% directly on research projects, 22% through consortia and 14% unrestricted funds.

He considered the interactions from the perspective of an individual professor in academia. One mode of interaction that was particularly prevalent in the 70s and early 80s was as a consultant to industry for targeted applications. This had the benefit of preserving confidentiality for industry while also provided benefits to the university, e.g. through exposing the faculty to industrial problems and also indirectly benefiting the students. One of the more popular modes of interactions at present is via centres and consortia. From the industrial point of view this provides a mechanism for leveraging resources and for networking, industry can access information and students. For the universities, the consortia provide a general communication with industry as well can be a desirable funding source. Another mode of interaction for an individual professor is via research projects that often originate from centres and consortia. For industry this provides a focused project. For the university this gives exposure to industry while retaining scope for fundamental work.

Professor Grossman gave examples of a dozen or so consortia in Process Systems Engineering in the US and UK. Among those listed, the consortium at Carnegie Mellon University had the largest number of members with 25. The consortium comprises five professors, 25 graduate students and four postdoctoral fellows. The objective of the consortia is to carry out concerted research effort with industrial collaboration in process synthesis, optimisation, control, planning and scheduling. The membership fee of the consortium is US$12 000 per year. The services to consortium members include a quarterly newsletter and research reports, a two day annual review meeting, free access to the computer software (SQP, DICOPT++, ASCEND and MINLP). Other benefits for industry include the possibility of contract research and 25% discount to members on 1-week short courses. Among the companies that are members are operating process companies, oil companies, process systems vendors, process engineering contractors, consultants and others. Both US and overseas companies are represented.

Centres are large university based operations, they tend to be multi-disciplinary, and funded by federal funding agencies such as National Science Foundation. From the industrial point of view, these help to gain access to new breed of students help in scoping large projects and enable testing of new technology. From the university's point of view, the centres help create high visibility, provide a large funding source and enable inter-disciplinary research to be carried out. The Engineering Design Research Centre at Carnegie Mellon University is an example of such a centre.

Both the consortia and the centres offer a relatively healthy co-operation between industry and universities. The major bottlenecks are technology transfer from one to the other, the fact that increasingly there is targeted funding and the issue intellectual property rights. Key factors for success are flexibility and the right people.

Dr Nagel said that academic research clearly advances the state of art but fails to deliver reliable tools for an industrial environment. A lot has been done in academia that has never been used m industry. The reasons are well understood: In his view these are the rapid turnover of manpower in academia, inability to provide the necessary hotline support and inability to afford to develop an entire CAPE system. Traditionally, everybody has accepted that this does not belong to his or her scientific mission and consequently the gap keeps on growing. He thinks that there is hope to cure this situation, once the academic researchers have the means to implement their innovative components into industrial CAPE environments by plug and play. This will help them to verify the supposed capabilities of their work and to gain back the status of a direct partner with industry, and thus improve both the industrial understanding of academic research results as well as academic understanding of industrial business needs.

Dr Nagel considered some issues that need to be discussed to facilitate acceptance of open standards. Do standards inevitably impede scientific progress? What is the right level of granularity (e.g. coarse—co-operation of distinct simulators; middle—components such as thermo, solvers, unit operations, etc., or fine—where components are constructed from elementary functionalities, e.g. thermo from activities, fugacities, equations of state, etc.)? What happens to the legacy code in the new paradigm? Are market forces sufficient to enforce convergence to a standard?

Dr Yukikazu Natori said that there were some seven persons attending the PSE'97 conference from Mitsubishi and there were some five to six presentations from them. He considered this to be a good way to bridge the gap with academia as well as to improve the relations. It is important to foster long-term relations with academia. There should be effective R&D&E (where the E stands for engineering) and not just R&D; we need to go from modelling at a conceptual level right down to products and processes. He thinks that academia have a strong role to play in the innovation cycle. He thinks that without knowledge we cannot do anything. He has a vision of a 21st century plant where the innovation, production and business cycles interact with each other in harmony. He hopes for de facto standards to come through and is convinced that these ideas can even be applied to business systems.

Professor Reklaitis of Purdue University mentioned the US Council for Chemical Research that promotes research collaboration in chemical sciences and engineering. Its membership is composed of senior research managers from some 40 major chemical process industry companies, about 140 universities represented by chemistry and chemical engineering departmental chairmen and deans, some 12 national laboratories represented by area and laboratory directors. Its activities include networking, learning and benchmarking, sharing best practices, lobbying for government research support and building a road map for the future—'vision 2020'. There is a prominent role for process systems engineering in the promoted activities.

Professor Reklaitis described the attributes of an effective research partnership between academia and industry. This includes recognition of long-term needs rather than emphasis on short-term results, a broad perspective of technology, the understanding of the partner's strengths as well as limitations, mutual trust and respect, flexibility and openness to change, willingness to take risks, commitment of quality time and a multi-faceted interaction. Professor Reklaitis used the catch phrase, 'quality time with quality people' to sum up these attributes.

Dr Smith reflected on the earlier presentation by K. Harg of Norsk Hydro saying that industry has old equipment. He said that the original autoclave for nylon production built near the experimental research station at DuPont Wilmington is still there after decades of existence. By all means, new areas should be looked into, but remember that we still have distillation columns too.

He thought that industry needs to do a better job to help young faculty numbers. DuPont has introduced a successful program of a 1–2 year 'industrial post-doc' for PhD candidates who plan to pursue an academic career. He thinks that personnel relations are very important in determining the effective interactions between an industrial company and a university. He mentioned that DuPont are looking to re-arrange their commitments to universities. He said Dupont used to be like a white horse giving $10 000 here and there where they saw good work being carried out in academia. Now they were looking for fewer relationships but bigger commitments.

In relation to open standards, Dr. Smith mentioned a recent example of work carried out with University of Massachusetts and Hyprotech on reactive distillation whereby it took two people only 2 weeks to add a new method on azeotropic distillation. What would typically take 1 year in the past to complete was accomplished within 2 weeks. This example demonstrated the value of open standards to DuPont and this is why they were very committed to CAPE-OPEN and its objectives. He thought that standardisation is important also when bringing advanced control into industry so that it can be maintained by regular engineers. He said, ''We do not want to replace PID control with PhD. control''. He said that this is a fascinating point in history, we have object oriented technologies available, we have bigger and bigger computers and all the software companies want to take advantage of these. Should all of these go in different directions? We must take this opportunity to get our acts together.

4. Concluding remarks

Professor Sargent said that it was virtually impossible to summarise the entire discussion. He thought there was a lot to be gained by improving relations between industry and academia and that there is goodwill around to want to do this, he was optimistic. On the standards discussion, he reflected on his original scepticism but said that the consensus of the conference seemed to be for these standards. He thought the best type of standards is de-facto standards, and wished the CAPE-OPEN team well in promulgating such standards and hence in accelerating their acceptance.