

# A Review of the Last Ten Years of Research Presented at the Annual International Concurrent Enterprising (ICE) Conference

Fiona Lettice<sup>1</sup>, Peter Thomond<sup>1</sup>, Kul Pawar<sup>2</sup>, Johann Riedel<sup>2</sup>, Kathryn Cormican<sup>3</sup>, Frithjof Weber<sup>4</sup>, Nel Wognum<sup>5</sup>

<sup>1</sup>*IERC, Building 37, Cranfield University, Cranfield, Beds, MK43 0AL, UK. {f.lettice, p.thomond}@cranfield.ac.uk*

<sup>2</sup>*Centre for Concurrent Enterprising, Business School, University of Nottingham, Nottingham, NG7 2RD, UK. {kul.pawar, johann.riedel}@nottingham.ac.uk*

<sup>3</sup>*Digital Enterprise Research Institute, National University of Ireland, Galway, kathryn.cormican@nuigalway.ie*

<sup>4</sup>*Airbus, Bremen, Germany, frithjof.weber@airbus.com*

<sup>5</sup>*Fac. of Bus., Publ. Adm. And Techn., University of Twente, The Netherlands, p.m.wognum@utwente.nl*

## Abstract

The 10<sup>th</sup> International Conference on Concurrent Enterprising (ICE) provides an excellent opportunity to reflect on the history of the conference and how it has developed and evolved over the last 10 years. The purpose of this paper is to present a detailed analysis of the papers that have been presented within this ICE community since it was established in 1994, to look at the trends across time and to look forward to future research directions and the continued growth of the ICE community.

## Keywords

ICE, History, Trends, Future

## 1 Introduction

The European Society of Concurrent Engineering (ESoCE) was founded in 1991, born as an aggregation of local initiatives in France, Italy, United Kingdom and Germany. Its aim was to bring together leading academics, researchers and practitioners in a common forum so as to stimulate the exchange of ideas, views and latest research and developments in the field of Concurrent Engineering ([www.esoce.net](http://www.esoce.net)). In 1994, ESoCE supported the launch of an annual International conference on Concurrent Engineering (ICE) to bring together the community in a formal setting. Before this conference was launched, its members were publishing in diverse conferences and journals in the fields of design, manufacturing/production engineering, operations management and marketing. Interestingly, in the same year, the IPSE Concurrent Engineering Conference (IPSE/CEConf) was launched in the US with similar aims, but with a predominantly American and Canadian membership.

Both communities have used the Winner et al (1988) definition of Concurrent Engineering: “Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule and user requirements”.

In 1995, ICE embraced the concept of Virtual Enterprises, defined as “a temporary alliance of independent companies, cooperating to a unique business goal. It is characterised by a complex

organisation that needs systematic approaches, methods and advanced technologies for increasing efficiency, and is enabled by the means offered by most recent ICT developments”.

In 1996, the two concepts of Concurrent Engineering and Virtual Enterprises were amalgamated into the concept of Concurrent Enterprising, which is “the co-operation among companies, possibly geographically dispersed, harmonising their processes and involving customers and suppliers for the design and manufacturing of products and services” (www.esoce.net).

Since its inception, the ICE Conference has developed and evolved. The aim of the study reported in this paper is to understand how the ICE community has changed over time, in its tenth anniversary year. The paper will act as a milestone of what has been achieved in the ten years and point the way forward for the future of the ICE community and conference.

## 2 Approach of the Study

The authors (seven researchers from five countries) have analysed the ICE conference proceedings from the outset of the conference in 1994 to the conference held last year in 2003. In total six proceedings were analysed: 1994, 1997, 1999, 2000, 2001, 2002 and 2003. No conference proceedings were available for the years 1995 and 1996. The conference was not held in 1998, so there are also no proceedings for that year. The previous nine conferences have been organised in different locations across Western Europe (see Table 1). The contents of the proceedings were systematically analysed, using a structured questionnaire to ensure consistency. In total, 361 papers have been analysed.

Year	Location	Theme of Conference	No of papers
1994	Sophia Antipolis, France	“Building the Concurrent Engineering Community”	9
1995	Stockholm, Sweden	“Collaborative Working in the Virtual Enterprise – How to apply CE between trading partners”	-
1996	Milan, Italy	“A Guided Tour to the Concurrent Enterprise”	-
1997	Nottingham, UK	“Concurrency for Competitiveness: Towards the Concurrent Enterprise in the Age of Electronic Commerce”	42
1999	The Hague, The Netherlands	“The Concurrent Enterprise in Operation”	65
2000	Toulouse, France	“Enhancing Business Competitiveness through Sharing Experiences between Research and Industry”	48
2001	Bremen, Germany	“Engineering the Knowledge Economy through Cooperation”	59
2002	Rome, Italy	“Ubiquitous Engineering in the Collaborative Economy”	71
2003	Espoo, Finland	“Enterprise Engineering in the Networked Economy”	67
			<b>361</b>

Table 1: Location, Theme and Number of Papers for ICE by Year

A qualitative assessment report was also prepared for each individual proceedings. The results were then analysed and graphs produced to discuss and build a common interpretation of the findings. The main questions that the analysis followed, with the aim of understanding how the ICE community has developed and evolved over time, were:

- How has the composition of the ICE Community changed over time?

- What types of article have dominated over the 10 years?
- How has the research presented in the papers typically been funded?
- What topics have been popular over the last 10 years and what have the trends in topics been?

### 3 Community Composition

This section of the paper examines the geographic distribution of authors. The authors' affiliation has also been analysed to see whether they predominantly represent academia, industry or consultancies, and whether these characteristics have changed over time. The number of collaborative papers has also been calculated.

#### 3.1 Geographic Distribution of Authors

The number of countries represented at each conference, by authored papers, has increased from 6 at the first conference to 20 countries in 2003. In the intervening years the number of countries represented fluctuated around 15. Over the years, a total of 34 countries have been represented. Figure 1 shows that Germany is particularly well represented by paper contributions (with a total of 87), followed by the United Kingdom (57) and then France (36), Finland (32) and The Netherlands (26). Of countries in Western Europe, Belgium (2), Sweden (3) and Austria (3) are not well represented in this community. In Eastern Europe, some representation has been present from Russia (4), Slovenia (4), Poland (2), Macedonia (1), Croatia (1) and in particular Romania (11). Outside of Europe, representation within the community is low, with Japan (9), USA (6), Mexico (3), Brazil (2) and Singapore (2) best represented and single appearances from China, Chile, South Korea, Iran, Israel and India. Geographic distribution of authors does not seem to have been affected by conference location. In other words, larger numbers of authors from the host country have not been found in the data for that year.

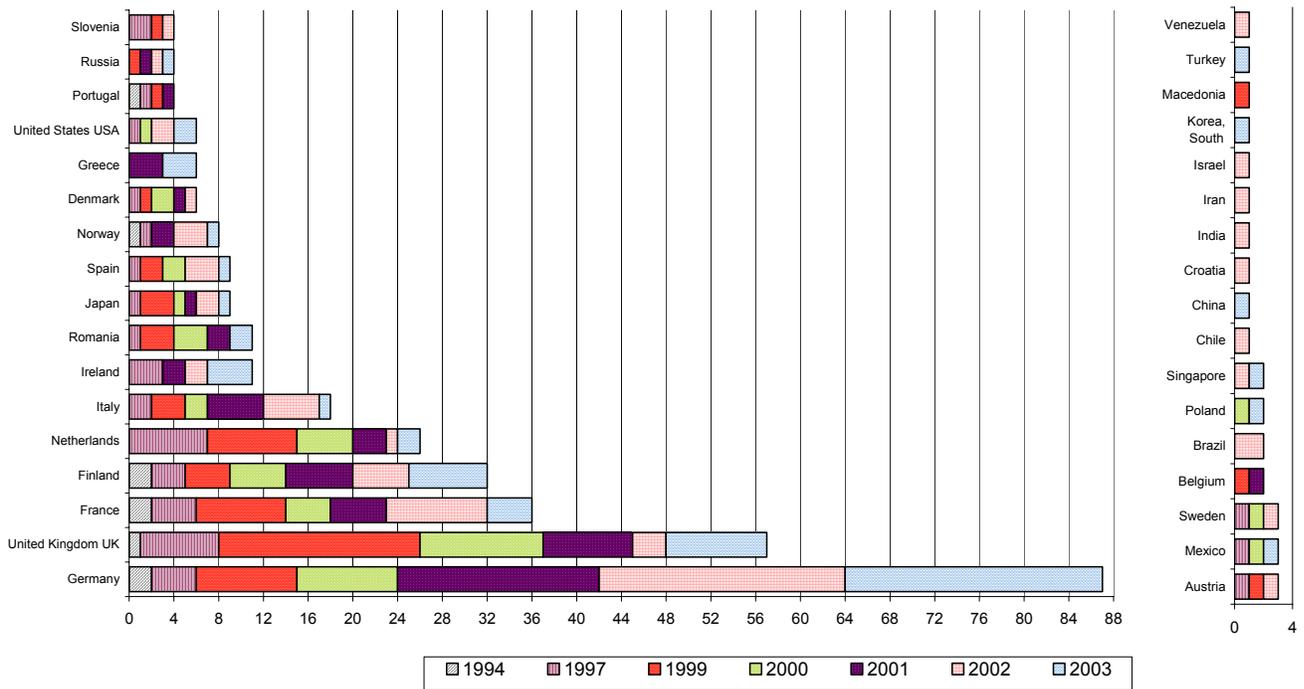


Figure 1: Geographic Distribution of Authors

### 3.2 Nature of the Community

Figure 2 shows the affiliations of the authors that have contributed to the conferences. This shows that the ICE Conference community is predominantly academic (ranging from 45% to 88% representation). Company representation has been relatively consistent, at around 20%, except in the first year when companies comprised approximately 40% of the ICE Conference community. The number of consultancies contributing to the conference has declined since 1994 and now fluctuates around 5%.

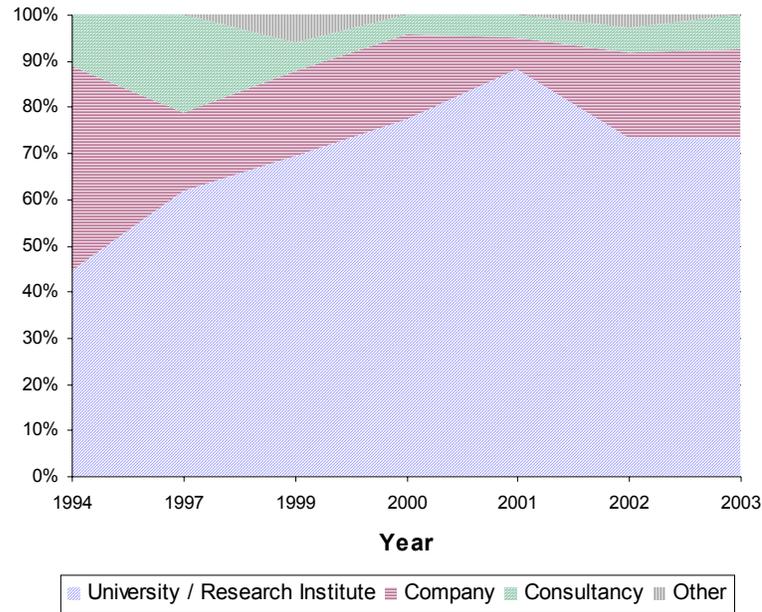


Figure 2: Affiliation of Authors

The author's affiliation has been taken by first author of the paper. However, between 30% and 50% of the papers at the conference are written with authors from more than one affiliation, suggesting a reasonably high rate of inter-organisational collaboration on papers, a trend which has been rising over the years.

## 4. Nature of Papers

This section examines the types of paper that are written for the conference, the primary topic areas of the paper, whether the papers have a predominantly hard/IT or soft/human factors focus, the industry sectors the research is targeted at, whether the focus of the papers is multiple or single enterprise and the source of funding for the research being reported.

### 4.1 Types of Paper

In Figure 3, the different types of papers are shown, according to the predominant focus of the paper. A significant proportion of papers presented at the ICE Conference are tool design focused. Taken together with papers on tool application, this has remained fairly constant at between 40% and 55% of the papers, with the exception of the 2002 conference where only 25% were papers of this type. Most of these papers focus on descriptions of the tool and not on its validation in real contexts of use.

With the exception of 1997 and one paper in 2003, there have been no case study papers. 2001 and 2002 saw a large proportion of theoretical papers without validation, whereas in other years these have been balanced somewhat by papers on theory with validation. Empirical studies have

become more popular in recent years, peaking in 2002 with almost 20% of the papers being of this type.

An analysis of type of paper by author affiliation revealed no significant differences between the academic and practitioner communities.

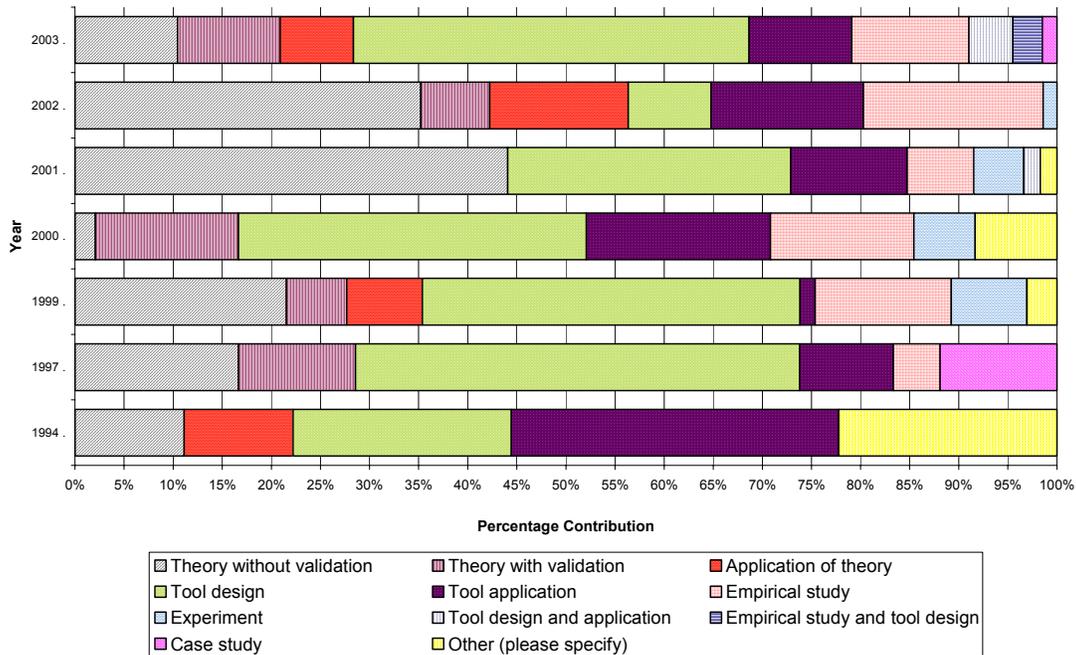


Figure 3: Types of Paper

## 4.2 Primary Topic Areas

Although many papers cover more than one topic, a dominant theme could be identified for each paper, and in many cases this process was facilitated by the authors' selection of keywords for their paper and the conference organisers' categorisation of papers by topic. Figure 4 shows how the topic area focus has changed over time.

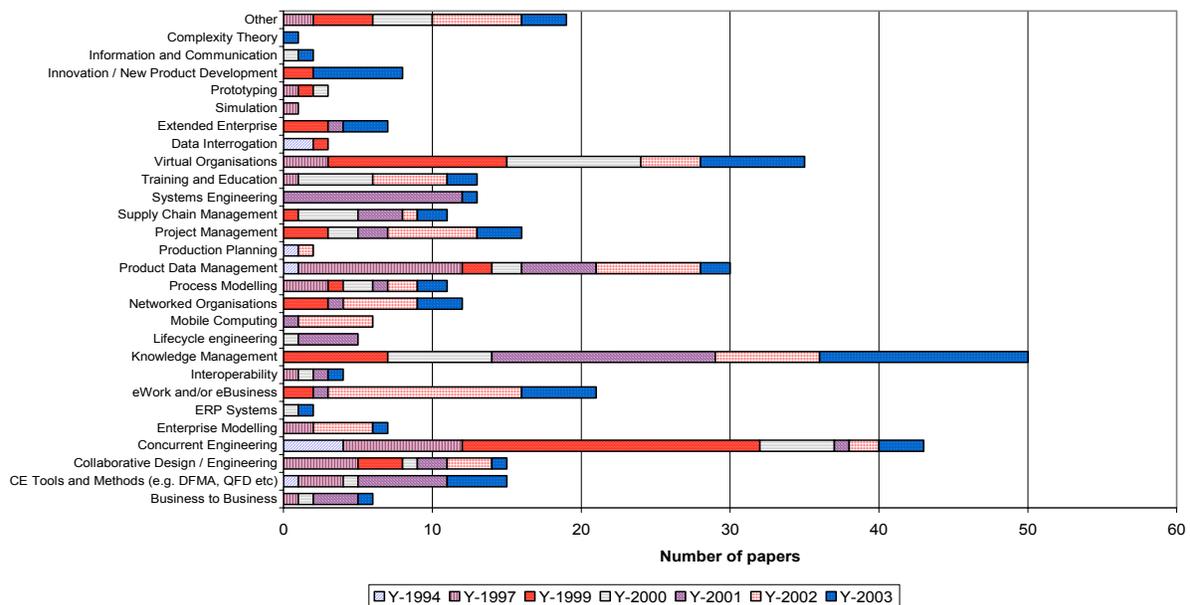


Figure 4: Primary Topic Areas by Year

Not surprisingly, the topics Concurrent Engineering (CE) and CE Tools and Methods have been consistently and well represented over all of the years of the conference (with a total of 58 papers

(16%) across the two categories), as have the topics of Virtual Organisations (35 papers/10%), Product Data Management (30 papers/8%), eWork and eBusiness (21 papers/6%), Project Management (16 papers/4%) and Collaborative Design/Engineering (15 papers/4%). The most remarkable increase in topic interest has been around Knowledge Management, which did not appear as a topic until 1999 and has since then been the predominant theme of papers presented each year (50 papers in total/14%). Other topics that have emerged since 2000 include Systems Engineering (13 papers/3%), Mobile Computing (6 papers/2%), Lifecycle Engineering (5 papers/2%), ERP Systems (2 papers) and Information and Communication (2 papers). The least popular topics over time have been Interoperability (4 papers), Prototyping (3 papers), Data Interrogation (3 papers), Production Planning (2 papers), and Simulation (1 paper). A new topic that emerged in 2003 was Complexity Theory (1 paper). The number of topics per year has steadily increased over time from 5 topics in 1994 to 23 topics in 2003 and over the ten years, the predominant conference topic focus has shifted from Concurrent Engineering and CE Tools and Methods to Knowledge Management.

### 4.3 Hard or Soft Focus

The papers were also classified as to whether they took a hard/IT focus or a soft/human factors focus or a combination of both. Hard papers have dominated each year of the conference, ranging between 49% and 72% of the papers, with a peak in 1997/1999. Soft papers have comprised between 12% and 33% of the papers, with a peak in 2002. Papers focusing on both hard and soft aspects have ranged between 7% and 34%, with a peak in 2000. So, although hard papers have dominated, there is a noticeable trend towards papers focusing on softer issues, or combining both hard and soft aspects. In Figure 5, papers with a purely hard focus are compared with papers which contain a soft focus (the bottom line in the graph is the combination of papers with purely a soft focus together with papers with both a soft and hard element).

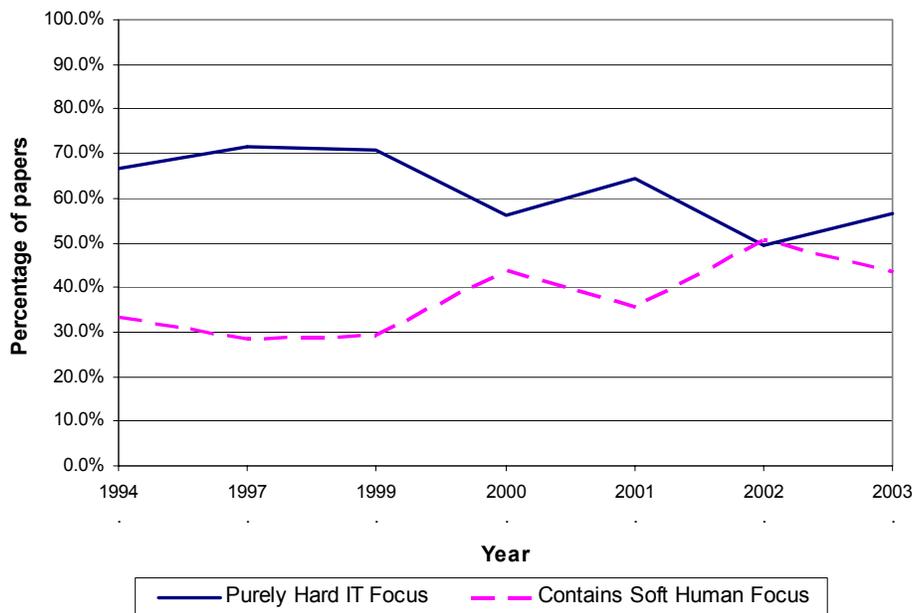


Figure 5: Balance of Purely Hard vs Contains Soft Human Focus

#### 4.4 Industry Focus

The papers were also analysed by industrial sector that the paper focused on, and the results can be seen in Table 2. Aerospace and Defence was the most popular single industry sector (10% of papers) in this community, although multiple sector papers are also popular (8%). In many papers, the industry sector is not stated (21%).

Industry Sector	Total number of papers across all years	Percentage of Papers
Diversified Industrial	82	23%
Aerospace and Defence	37	10%
Multiple Sector	31	8%
Automobile and Parts	24	7%
Engineering and Machinery	23	6%
Construction and Building	18	5%
Software and IT Services	14	4%
Electronic and Electrical	12	3%
Telecommunications	6	2%
Utilities	5	1%
Not stated	75	21%

Table 2: Industry Sector Represented in Papers 1994-2003

#### 4.5 Single or Multiple Enterprise Focus

In addition to the topic areas, we considered whether the papers had generally taken a single or multiple enterprise perspective. As can be seen in Figure 6, the study of multiple enterprises has increased since 1999 and is between 52% and 72%, with a particularly high peak in 2003.

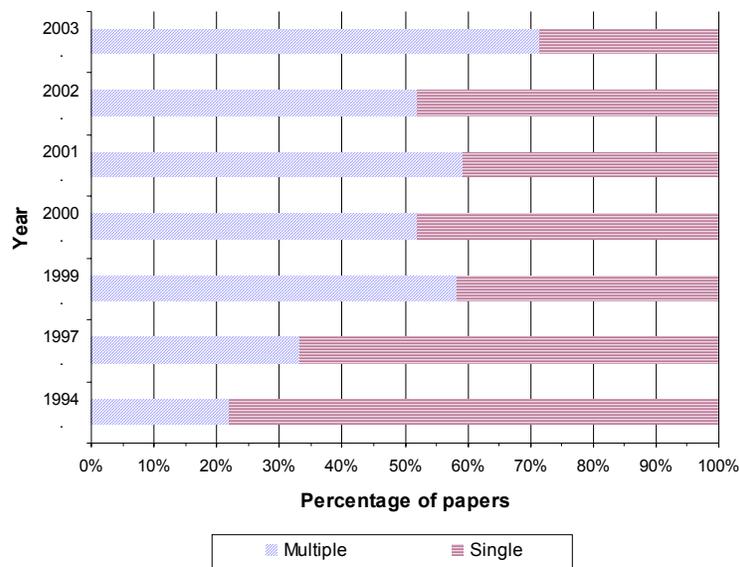


Figure 6: Single vs Multiple Enterprise Focus

#### 4.6 Source of Funding

The number of papers reporting EC funded research rose after the first year of the conference from 23% to between 45% and 55% in 1997, 2000 and 2001. In the last two years (2002 and 2003), it has been steady at approximately 30% of the papers presented. Apart from 1994, when

no nationally funded research was reported, this has remained relatively stable, fluctuating between 12 and 23% of papers presented. Industrially funded work was dominant in 1994, but since then has declined rapidly and represents between 5 and 18% of the papers presented at the ICE Conference. Interestingly, there has been a rising trend in not specifying how the research has been funded. For 2001, 2002 and 2003, between 34% and 45% do not specify a funding source. These percentages are illustrated in Figure 7.

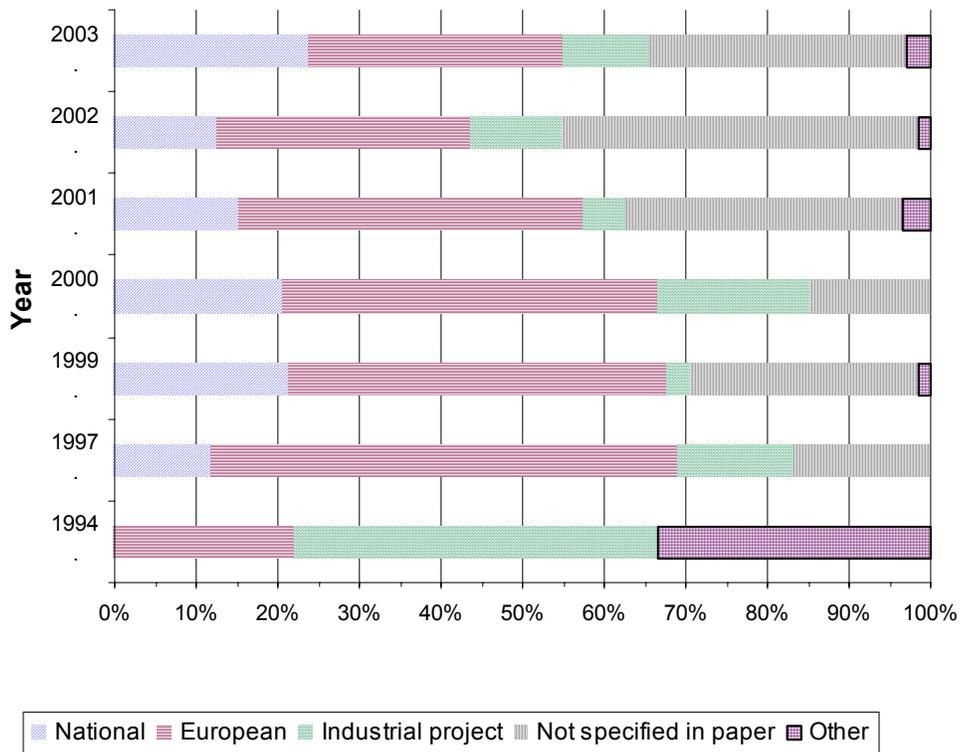


Figure 7: Source of Funding

#### 4 DISCUSSION AND FUTURE VISION

Although the geographic distribution of authors within ICE has been broad, five countries (Germany, United Kingdom, France, Finland and The Netherlands) have contributed 67% of the papers. Three countries have been responsible for just over 50% of the contributions. To make the research presented more representative of Europe, and indeed the rest of the world, more active contribution could be encouraged from other countries who now only participate occasionally in the community.

The number of delegates from industry for ICE2003 was high at 40% ([www.ice-conference.org](http://www.ice-conference.org)). This is not fully reflected in the papers presented, where around 70% are now from academia. However, this is not surprising as publishing is typically the task of academics and not of practitioners, who suffer from other time pressures or from commercial sensitivity around the types of topics that are the focus of the conference. Addressing this situation, ICE 2002 had offered a practitioner stream with an extra call for industrial presentations where the submission of a paper was optional. The slight increase in industrial submissions in the last two years (cf. figure 2) may be attributed to this and might be encouraged in future calls. Nonetheless, many of the academic papers are focused on industry issues, so the conference continuously has a remarkable attraction for a practitioner audience.

A high proportion of the papers are theory without validation or tool design without application or validation. Although it seems that the overall quality of papers has improved and the reviews are more selective due to higher submissions, a lot of the research is not being validated, which

leads to questions about how well these tools and theories work in practice. This is consistent with the findings from the analysis of the last ten years of papers from the IPSE/CEConf, which also reported low application of tools and theories (Wognum et al, 2003). Being active in European research for many years ourselves, it is our observation that this methodical weakness seems to infect too large a percentage of the European research community. Especially in research which is carried out at the intersection of engineering, information sciences, management, and social sciences, a high proportion of the “findings” remain merely claims. Reasons for this may be manifold, ranging from limited awareness about theories of science and research methodologies, the transfer of inappropriate research approaches to new problem domains, or even the elementary lack of an appropriate theory of science in the domain. A call for more validation and empirical papers could improve this aspect, and on a broader level, encouragement for researchers to test and implement their tools and theories by EC and national funding bodies. Finally, a critical rethinking of the research community’s approach to research and research quality management should be encouraged.

The aim of the conference is to embrace more than just a single enterprise, as demonstrated by the combination of Concurrent Engineering and Virtual Enterprises to give the new concept of Concurrent Enterprising. This has encouraged a strong emphasis on Virtual and Networked Organisations (13% of papers) and the increasing trend to study multiple rather than single enterprises. The breadth of issues raised by concurrent working across multiple organisations has also been well represented, with 27 topics being discussed at the conference, a sign that the ICE community embraces diversity of subject matter. A regular analysis of emerging topic areas could ensure that new and emerging themes are encouraged in subsequent years, if they are felt to be appropriate and fit with the vision of the ICE community. The annual call for papers could be monitored against an analysis of the primary topics for that year to see if the call does strongly influence authors’ submissions. The increased diversity in topic areas has also been matched by an increasing trend to include more soft or human factors in the research and papers, leading to a more holistic view of the problems facing organisations and a more holistic approach to solutions for these problems, which should be maintained and encouraged in future.

Virtual and Networked Organisations are central and growing issues for companies, as are the expectations of a continued growth in Knowledge Communities and knowledge sharing and transfer within and between organisations. This is also reflected in the responses to the Concurrent Enterprising 2010 Vision “Skydome into the Future of Concurrent Enterprising” questionnaire, on the ESoCE website. These are likely to remain key topics in future years, but the ICE Community should remain open to new and emerging topics and encourage these to flourish in future conferences, just as the Knowledge Management area has been allowed to grow. In this way, ICE will continue to remain highly relevant to academics and practitioners alike.

### **Acknowledgements**

Barry O’Sullivan of DERI, National University of Ireland for support in analysing the 2002 conference proceedings.

### **References**

- ESoCE-NET Web Portal: The Concurrent Enterprising Knowledge Community. WWW page. <http://www.esoce.net/> accessed 9/3/04.
- International Conference on Concurrent Enterprising. WWW page. <http://www.ice-conference.org/> accessed 9/3/04
- Winner RJ, Pennell JP, Bertrand HE and Slusarczyk MM. 1988. The role of concurrent engineering in weapons system acquisition, IDA R-338. Institute for Defense Analysis
- Wognum PM, Jardim-Goncalves R, de Graaf R, Lettice F and Roy R. 2003. Analysis on 10 years of the CEConf/IPSE Community, Proceedings of 10<sup>th</sup> ISPE International Conference on Concurrent Engineering: Research and Applications: Advances in Concurrent Engineering, Madeira, 28-31 July