# The Concerted European Action On Magnets: A Model For Facing the Rare-Earths Challenge?

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*Gareth Hatch*

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## Introduction

In July 2009, the city of Calgary in Canada hosted CAETS 2009, a meeting of national engineering academies from around the world. At that meeting, Professor Masafumi Maeda of the Engineering Academy of Japan and Executive VP of the University of Tokyo, presented a paper on the actions taken by the Japanese government, in the face of perceived risks associated with being reliant on a handful of countries, for the importation of certain strategic metals not found in Japan [1]. In 2007, two programs were launched: the Rare Metals Substitution Development Project and the Elements Strategy Project.

The first of these projects included three broad categories of research, aimed at reducing and / or substituting indium in transparent conducting electrodes, technologies for reducing dysprosium in neodymium-based (Nd-Fe-B) permanent magnets, and the reduction or substitution of tungsten in carbide tools [2]. Running from FY2008-FY2011, this project received ¥ 1 billion (approximately US$ 10 million) in FY2008 alone, shared among several Japanese entities working in these three areas.

In an online article posted in late 2009, I discussed this provision of significant funds to researchers in these key areas of materials science and engineering. In that posting I said that "*this type of funding helps to create a whole new generation of materials scientists and related professionals, who 'get' the problems and challenges involved*" [3]. When I wrote this, I had in mind the results of a similar program that was initiated in Europe just over 25 years ago, as a response to the announcements in 1983 of the discovery of neodymium-based (Nd-Fe-B) permanent magnet materials.

The program was called the **Concerted European Action on Magnets** (CEAM) and was conceived in the wake of the "shock and awe" that the news of this new magnetic material family brought to the European magnetics research community. Researchers in the USA and Japan had effectively pulled ahead of the work then being undertaken in Europe, leaving a void in terms of the future direction of magnetics research there.

The CEAM story remains, in my mind, an interesting case study in successfully overcoming political, geographic, cultural and scientific challenges in order to achieve a significant set of goals of value to the participants involved. I believe that there are lessons here that can be applied not only to future permanent-magnet development, but also to the even larger challenge of helping the West to develop a rare-earth-metals supply chain that is independent of the People's Republic of China, which currently produces over 97% of the world's rare earths.

My hypothesis is that the successful application of the CEAM model could revive the development of rare-earths science and engineering outside of China, and ensure that there is a new generation of scientists and engineers in the West who understand these materials - their geology, extraction, processing & refining techniques, as well as the end uses of components and devices associated with these metals. Such a body of well-trained, seasoned scientists and engineers will be absolutely essential to the future success of any efforts to revive the rare-earth supply chain outside of China.

I am by no means the first to suggest revisiting CEAM as a model for research - for example, Dr. Stan Trout recently did so in the context of next-generation permanent magnets [4] - but to my knowledge it has not previously been suggested for application to the rare-earths sector.

## The Genesis of CEAM

The story begins in October 1984, when the Directorate for Science, Research and Development of the European Commission (DGXII) held a meeting on "Nd-Fe permanent magnets, their present and future applications". Casting our minds back, we have to remember just how things were at the time and place that was Western Europe in 1984. The European Community (the predecessor to the European Union or EU) had just 10 member countries, compared to the 27 members of today's EU. It was a full five years before the fall of the Berlin Wall, and three years prior to the implementation of the Single European Act in 1987, which created a common market within the European Community.

The meeting in 1984 therefore took place at a time when the bureaucrats of Europe were trying to find ways to help member countries work more closely together, as part of efforts to achieve the objective of a more integrated pan-European economic system. This is a system that today most Europeans simply take for granted, but at the time, it was far from clear as to whether it would, or could, be achieved.

At that DGXII meeting in Brussels, the idea was conceived to form a cooperative scientific and engineering network, to develop magnets based on iron and rare-earth elements. There were precedents for such networks, as they formed the basis of implementation by the European Commission (EC) of a variety of scientific programs and initiatives. Coordinated research on the development of new magnet materials was also not entirely new to the EC as, in the face of escalating cobalt prices in the late 1970s, beginning in 1980 the EC started to fund projects to reduce the amount of cobalt required in permanent magnets [5].

The goals of CEAM [6] were threefold:

- To develop high-performance, iron-based rare-earth permanent magnets and to design novel devices which exploit their exceptional properties;
- To generate European collaboration by the exchange of scientists, and to stimulate a new generation of researchers to undertake projects in applied magnetism of industrial relevance;
- To provide a skills and information base to permit European industry to exploit the advanced magnets effectively.

The original proposal to form CEAM was put together by five individuals who led laboratories in four different countries, and who went on to become the project coordinators. The project was approved and began in late 1985.

## Funding Mechanism

The CEAM initiative spanned the eight years from 1985 until 1993, and was divided into three phases. Phase 1, which lasted from 1985 until 1988, was funded by the DGXII's Stimulation program, to the tune of ECU 2.5 million ($3.1 million (US) at the exchange rate of that time). In this phase, the focus was on the partial funding of research costs, the exchange of researchers between participating laboratories, the creation and distribution of a newsletter and database, and a series of general and topical meetings. Over 50 laboratories and entities drawn from industry and academia were involved.

Phase 2 lasted from 1988 until 1991, and was funded by the DGXII's European Research on Advanced Materials (EURAM) program for the amount of ECU 0.25 million ($0.31 million) and involved over 70 participating entities. This money was used to fund additional meetings and the exchange of information, but did not include monies for research costs or for the exchange of scientists.

Phase 3 of CEAM went from 1991 until 1993, and was allocated ECU 0.5 million ($0.62 million) in funds from DGXII's Basic Research on Industrial Technology in Europe (BRITE) / EURAM initiative. In this final stage, meetings continued to be held, in addition to information sharing, and scientist exchanges were re-instituted between participating laboratories. Again, over 70 entities participated.

Total funding then, for the program, amounted to ECU 3.5 million ($4.0 million). These funds were not divided evenly between participating organizations. In Phase 1, each laboratory received an average of ECU 20,000 ($25,000) per year, with a range of ECU 5,000 - 80,000 ($6,250 - 100,000) for specific project-funding allocations. In today's US dollars, the total funding for this project is roughly equivalent to $8 million, or approximately $1 million per year.

Note the contrast here between the fairly modest per-laboratory funding levels given the number of entities involved, when compared to the funding for the Japanese program mentioned earlier.

## Areas of Research

Activities in the CEAM program were divided into three broad categories - Applications, Processing and Materials. Each category was placed under the administration of lead academic laboratories, which coordinated the activities of the other participants in that category (see Figure 1).

The specific areas of interest within each category were as follows:

**Materials:**
- New magnetic phases
- Crystal growth and structure
- Phase relations and microstructure
- Magnetic properties
- Atomic scale magnetism
- Coercivity

**Processing:**
- Primary materials
- Powder metallurgy & sintered magnets
- Bonded magnets
- Corrosion protection

**Applications**
- Design techniques
- Engineering techniques
- Small machines
- Industrial machines
- Static devices

In addition to these three categories of research, an Information Centre was created at CNRS Grenoble, to allow for the coordination and free flow of technical and scientific data between participants. The Centre published a bi-monthly newsletter and maintained a bibliography and database on permanent magnet materials.

| | |
|---|---|
| **Chief Coordinator** | |
| **1985-1987** | *R Pauthenet* |
| **1987-1993** | *J M D Coey* |
| **Materials** | |
| **J M D Coey** | *Trinity College Dublin* |
| **D Givord** | *CNRS Grenoble* |
| **Processing** | |
| **I R Harris** | *University of Birmingham* |
| **Applications** | |
| **R Hanitsch** | *Technical University of Berlin* |
| **Information Centre** | |
| **J Laforest** | *CNRS Grenoble* |

**Figure 1: CEAM Coordinators (after [3])**

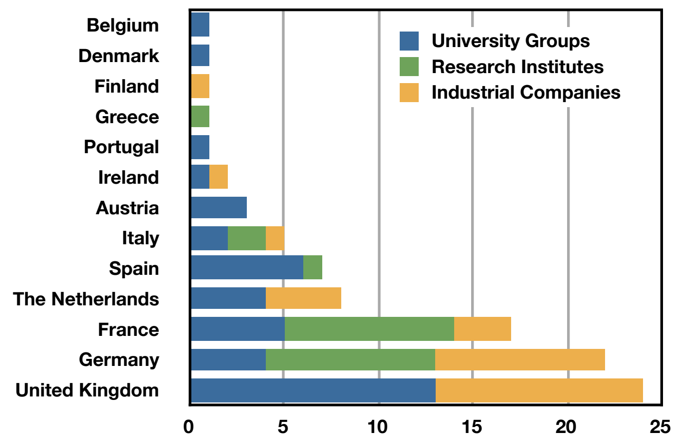


**Figure 2: CEAM Participants by Country (after [3])**

Created for the benefit of CEAM participants, the Information Center was not dissimilar to the now defunct Rare-Earth Information Center that Ames Lab, based at Iowa State University, used to run. I recently discussed elsewhere the possibility of using such a Center as a model for the creation of a modern-day equivalent for the rare-earths industry [7].

## Outcomes of CEAM

So, after eight years of research and $4 million in funding, what did CEAM achieve in terms of output and deliverables?

In total, the program produced over 1,000 research papers and well over a dozen patents as a result of the research undertaken within CEAM. This ratio, by the way, underscores the primacy given to fundamental and applied scientific research, over and above commercial gains for individual entities. By the end of the program, over 150 scientists, engineers & product designers, from 93 participating laboratories in 13 different countries, had taken part in the program (see Figure 2).

A key positive benefit of CEAM was the success in getting groups from different working sectors to come together. Participants were drawn from university research groups, private research institutes and from industry (see Figure 3) and this provided a rich mix of the theoretical as well as the practical aspects of magnetics research.

In additional to all of the scientific research on rare-earth - iron permanent magnets, CEAM created

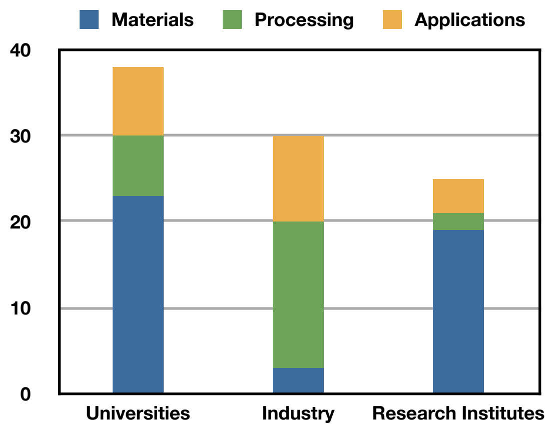


**Figure 3: CEAM Participants by Sector (after [3])**

enduring relationships and collaborative efforts among key research groups within Europe, who to this day continue to work together in areas of magnetics research. Just as important, CEAM enabled the creation of a new generation of research scientists, whose Ph.D. studentships and activities were made possible in whole or in part by CEAM.

In the immediate years after the conclusion of CEAM, the "halo effect" allowed many of the participating laboratories to continue to get strong funding for Ph.D. students to do related research. Many CEAM and post-CEAM Ph.D. students have gone on to become accomplished scientists and engineers in their own right, some now leading their own research groups in Europe, and taking the development of magnetic materials into the future.

## Applicability to the Rare Earths Sector

So why was CEAM successful? Coey and Mitchell argued that "*[p]articipation of the constituent laboratories was **not motivated by the prospect of substantial research funding** [...] **but by the desire to exchange good-quality scientific information**. The twin desires of scientists to collaborate and compete for the estimation of their peers [was] harnessed in a way that is different from that in a vertically-integrated research institute or invisible college*" (my emphasis) [6].

To the non-academic outsider, such an outcome may seem inevitable, given the dominance of academics and their institutions in the program, and generally assumed preconceptions of the "free flow" of information within such environments. However, there was substantial industry participation in CEAM, and Coey and Mitchell acknowledged the initial challenges faced by for-profit participants as they looked to participate, it being necessary "*first to establish confidence and common ground among participants so that the discussions could proceed as openly as possible, while respecting proprietary information*." [6]

So, how might the CEAM approach be used as a model for the successful creation of a framework for reviving rare-earths research and development and the subsequent "incubation" of new technical talent for this sector?

First and foremost, I believe that the rare-earth sector must look to work within an international framework of collaboration between scientists and laboratories from a number of different countries, which I'll call a Framework for Rare Earths Research and Development (FRERAD). To be most effective, we need for the talents and expertise of the few remaining historically-strong research groups in the rare earths arena to be brought together. This would include academic and government laboratories in the USA, Canada, Europe, Australia & Japan - and beyond. It could even include collaboration with Chinese groups too. This might initially seem to be rather ambitious, but when one considers the geopolitical climate that existed at the inception of the original CEAM, one can see that such inherent challenges can be overcome.

I would propose that key "themes" within the broad scope of rare-earths R & D be formally designated. The original CEAM categories of Materials, Processes and Applications might be a good start. To pick just one of these, Processes - sub-categories might include rare-earths geology, mining science & engineering, extractive metallurgy, chemical processing, environmental impact minimization, concentration chemistry, refining, finished metals handling, storage and recycling  What are the key areas of critical need for specific research programs? For developing new talent? Who is already doing work in these areas and how might it be augmented and strengthened? The groups in FRERAD would be encouraged to develop proposals for projects that meet very specific needs, involving more than one laboratory or entity.

Next we would need to think about coordinating the activities of FRERAD. Again, looking to the CEAM model, the first approach would be to have each theme within FRERAD led by an experienced academic, with a strong reputation for quality research. These volunteer coordinators would form a "Lead Team" to help guide the programs and to move it forward. Another approach would be to have national coordinators, depending on the numbers of countries involved, but again drawn from the international academic community.

While the themes were being fleshed out, and the coordinators being selected, commercial and industrial organizations would be invited to join FRERAD. These would include end users and producers of rare-earth components and devices; they would also include mining and exploration companies, processors and refiners of rare earths and other entities. Such organizations might provide access to physical rare-earth deposits, access to concentration or processing facilities, or provide financial support to fund studentships, without taking overall control of the work being undertaken. The key benefit of participation for such organizations, just as it was for CEAM, is potential access to the future scientists and engineers that these companies will need in order to successfully revive the rare-earths supply chain outside of China.

Of course, none of this is going to be possible without funding. While individual academic laboratories may be able to fund relevant projects of their choosing, potential FRERAD coordinators would need to work together on joint proposals to their respective national research-grant-issuing bodies, to encourage these bodies to fund programs within FRERAD for laboratories in their respective countries. Any existing collaborative framework programs could be tapped to provide funding for specific projects. In addition, there are often funds available from public and private organizations to help facilitate international collaboration and understanding between people and groups in different countries.

Finally, the progress and output of the various laboratories and organizations would need to be monitored and shared with participants. This is perhaps easier in the present day than it was during the days of CEAM, but in addition to publication in peer-reviewed journals, it would be important to have regular meetings within each theme, for participating researchers to present their work - and to provide a more significant forum for discussion and exchange than the typical conference. In addition, a FRERAD Web site and associated coordinator could provide information and online community spaces for all participants to share real-time information as appropriate.

## Final Thoughts

It is imperative that the rare-earths supply chain outside of China (such as it exists today), realizes that its constituent members are part of a single, international "ecosystem", and that the most effective way to challenge the dominance of China (which according to one industry insider, has over 6,000 PhDs and graduate students working in this area!) is to work together within a framework NOT motivated strictly by profit or limited by national borders. The greater good of the sector requires that future scientists and technicians be developed NOW, to take on the responsibilities that will come from bringing on-stream new rare-earth resources.

An initiative such as FRERAD, based on the CEAM model for research frameworks, is one possible approach to tackling the scientific and technical challenges associated with reviving the rare earths supply chain outside of China.

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## About the Author

Gareth Hatch is a Founding Principal of Technology Metals Research, LLC. He is interested in helping people to understand the challenges associated with the growing demand for rare-earth elements [REEs] and other critical and strategic materials, and how those challenges affect market sectors throughout the entire technology supply chain. He is based in the suburbs of Chicago, Illinois, USA.

For several years Gareth was Director of Technology at Dexter Magnetic Technologies, where he focused on the design & application of innovative magnetic materials, devices and systems, in order to solve real engineering problems. He led a stellar team of engineers who helped customers and clients in the aerospace, defense, medical, data storage, oil & gas, renewables and industrial sectors. He holds five US patents on a variety of magnetic devices.

A two-time graduate of the University of Birmingham in the UK, Gareth has a B.Eng. (Hons) in Materials Science & Technology and a Ph.D. in Metallurgy & Materials, focused on rare-earth permanent-magnet materials. He is a Fellow of the Institute of Materials, Minerals & Mining, a Fellow of the Institution of engineering & Technology, a Chartered Engineer and a Senior Member of the IEEE. Gareth is also a Chartered Scientist and a Chartered Physicist through the Institute of Physics.

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