

ESF Exploratory Workshop on
Natural Resources for Innovative Design

Eindhoven (the Netherlands), March 3-5, 2010

Convened by:
**Gerard Dijkema (stepping in for Paulien Herder),
Wybo Houkes and Pieter Vermaas**

SCIENTIFIC REPORT

1. Executive summary

Scientific objectives and agenda:

The workshop was designed as a meeting place for innovative approaches in engineering design that draw on similarities between technical systems and natural systems; the goal was to explore ways of developing these approaches more systematically, by employing their cross-connections, and connections with philosophical analysis. For this, it brought together design innovators from three engineering areas – biomimetic engineering, evolutionary design and complex systems design – with philosophers concerned with technical and biological functions and researchers in engineering ontologies. The leading idea was that collaboration between engineering and philosophy, using the precision and thoroughness of the formal tools of engineering ontologies, could make possible a systematic use of biological knowledge for innovation in engineering design. The primary aim of the workshop was to form a network of engineering designers, philosophers and engineering ontologists, which could explore and then define future collaborative projects on the three engineering areas already identified, and which could explore other approaches and interfaces between philosophical analysis, understanding of natural systems and innovative engineering design.

A non-standard approach was chosen in organizing the workshop to maximize exploratory scope and potential: researchers were invited from many disciplinary backgrounds and the core sessions of the workshop were devoted to exploration rather than formal presentations. In parallel sessions, suggestions for specific research topics and collaborative projects were to be developed. Participants rotate between sessions to make optimal use of the expertise of the participants and to introduce a constant generation of new ideas in the exploration. In plenary sessions after each session of parallel tracks, the results of the explorations in the tracks were reported and discussed. This should organize feedback by participants on the results, stimulate commitment to these results, and ultimately define specific projects for future activities.

In case commitments could be created in all three areas and a number of other areas and modes of collaboration can be identified, we envisaged developing a proposal for a EUROCORES theme, to be submitted later in 2010. This program should involve research on all three programs explored in this workshop, as well as several areas of innovative design identified as showing similar potential.

Organisation and atmosphere:

As could be expected on the basis of the disciplinary variety, the atmosphere at the workshop was initially probing. However, it evolved quickly into a productive one. The structure of the workshop was an important factor in this, since the brainstorming sessions invited participants to contribute and later present their ideas. This led to a spirit of friendly cooperation. Even doubts expressed about the value of engineering ontologies as a meeting place were taken in stride, and quickly led to the formulation of new ideas. Discussions continued during lunch and dinner, and once the open, lively atmosphere was established, it remained throughout the workshop : in terms of atmosphere, the second day started very much where the first day ended.

The workshop was held over two days at the School of Innovation Sciences of Eindhoven University of Technology. Participants stayed at the same hotel, most of them arriving on Wednesday 3 March and some staying until 6 March (this possibility was offered to all, but many chose or had to return on Friday). Most participants attended the entire workshop, with three people unable to attend on Thursday and one on Friday. There was one last-minute cancellation. Plenary sessions were held in the same room throughout the workshop ; two additional rooms were used for tracks in parallel sessions. Each of the three tracks in parallel sessions was moderated by one of the three convenors; each plenary discussion session was moderated by one of the convenors (see program). This arrangement provided continuity between parallel sessions and facilitated coherence with the workshop objectives. Dinners were arranged for all participants on Thursday and Friday, as well as taxis from and to the hotel, and if needed to the railway station or Eindhoven airport.

Immediate surroundings did not permit additional informal interaction. Lunches and dinners provided opportunities, but were also chosen to allow time to relax between intensive brainstorming sessions.

The workshop was indeed exhaustive in terms of the energy it demanded from its participants and in terms of the topics that were defined. Bridging the disciplinary backgrounds between engineering design, philosophy and ontology proved to be possible and worthwhile; the topics for future research that were identified turned out to be both visionary and practical (see section 3 below).

Participants

23 researchers with different disciplinary backgrounds (biomimetic design, evolutionary design, complex-systems design, philosophy, computer science) participated in the workshop, which was further enriched with two representatives of ESF. The participants represented 11 countries: nine European countries plus Canada and the United States of America.

The ESF representatives were, for the Standing Committee for the Humanities (SCH)

- Prof. Dr. Kosta Gouliamos, Vice Rector for Research, European University Cyprus

and for the Standing Committee for Life, Earth and Environmental Sciences (LESC)

- Dr. Aslihan Kerç, Marmara University, Istanbul, Turkey

The overall conclusions were

- That there is ample opportunity for a network of researchers interested in systematising the use of biological knowledge for innovative design practices. As a “seed event” with a lively and constructive atmosphere, the workshop was very successful.
- The network needs to be extended, also with other disciplines (especially the life sciences), to warrant the proposal for a EUROCORES theme. Johan Schot’s presentation made clear that such a theme is most successful if it builds upon a previously existing network, carried by several fully committed researchers.
- A variety of interesting, ambitious and multi-disciplinary topics were brought up by the participants.
- Several follow-up initiatives were proposed, including an ESF Research Networking Programme; an “Ontology week” connected to a major conference; a contribution to the FP7 consultation on the FET Flagship Initiative.

2. Scientific content of the event

4 March, morning

The morning of the first day was the only part of the workshop devoted entirely to plenary presentation. These provided the practical and theoretical frame of the workshop, marking the scope of our ambitions and the way we chose for exploring its realisation. Following the welcome by Anthonie Meijers (TU/e ; Philosophy & Ethics) and a round of introductions, the first presentation by ESF itself, represented by Kosta Gouliamos and Aslihan Kerç, who to our pleasure participated actively throughout the workshop. Second, Johan Schot (TU/e, history of technology) presented the perspectives a long term innovative collaboration, including a EUROCORES theme, can generate. Third, Wybo Houkes introduced the overall topic and aim of the workshop, and Stefano Borgo defined our chosen theoretical framework with a presentation of engineering ontologies.

The presentations by Kosta Gouliamos and Aslihan Kerç of the different programs for function running with ESF and by Johan Schot focussing on the EUROCORES programme, provided the practical context to the workshop. Both presentations produced the necessary clarity of the possibilities for funding of research and networking for research, and revealed the delicate relation between ESF and the national science foundations in Europe with regard to the financing of researchers within EUROCORES projects. Especially the possibility that contributions to an accepted EUROCORES theme that originated from individual countries could eventually not be financed if the relevant national science foundations decided not to support the theme, led to a feeling that collaboration within the EUROCORES programme should be embedded within a strong network of researchers willing to pursue a particular research agenda on a European scale, if needed without funding.

Stefano Borgo's presentation provided a welcome overview of the history of and different approaches in engineering ontologies, along with some of its institutional embedding. Questions showed overlap with efforts at conceptual clarification made in other domains, as well as curiosity about what could be gained by constructing ontologies.

4 March, afternoon

The core of the workshop was formed by parallel sessions. In the afternoon of the first day, the parallel sessions were devoted to identifying, through brainstorming, topics on which engineering design, philosophy and ontology can meaningfully collaborate. Participants formed three groups defined by the three areas of biomimetic engineering, evolutionary design and complex systems design. These groups devoted over two hours to discussing disciplinary backgrounds and future research agendas, to determining common ground and to formulate big challenges that face the research areas. All groups were asked in advance to define three ambitious research topics that could bring together and advance two or more of the disciplinary groups represented at the workshop. The formal program of the first day ended with a plenary session in which participants presented the nine ideas that were generated in this way. That was followed by an informal buffet dinner, at which discussions could continue.

Three research ideas were indeed identified and developed in each track. These ideas were:

For the **biomimetic-engineering area**, three particular design challenges were identified:

- Designing a capsule sustaining human life for a longer time as is needed in, say, a mission to the planet Mars.
- Creating wet engineering: designing technical systems in which water is a helpful component, like it is in biological systems, rather than a harmful material that is seen to corrode and deteriorate the systems.
- Developing an ontology that facilitates the exchange of knowledge about biological systems and knowledge about technical systems

For the **evolutionary-design area**, three projects were identified that develop the idea of systematising the use of biological knowledge for engineering design:

- Ontology of multi-level processes that would properly represent how higher-order objects emerge from processes in biological and engineering systems.
- Ontology of self-representing systems, which present an even larger challenge to traditional applied ontologies.
- The Killer-App Finder would bring together an ontology of applications with a representation of various kinds of systems (evolutionary, swarm, etc.) and of the mechanisms central to such systems.

For the **complex systems design area**, three ambitious ways were defined to bring together biological and engineering expertise:

- Human-natural systems interaction: how are these best described, and how can they be improved?
- “Stealing from Biology”: how can biological knowledge be used as a heuristics for solving design problems?
- Intentionality, inevitability and sustainability: towards understanding cognition and our place as humans in reality, for creating a more sustainable relation to that reality.

After presentations of these ideas at the plenary session at the end of the first day, several similarities were noted. The Killer-App Finder project was identified as developing the most detailed view of the application of engineering ontologies to innovative design, and of the challenges facing the construction of such ontologies. The concept of capsule designing was generalised to include the broader project of truly designing on the basis of biological knowledge, rather than merely introducing biological knowledge as yet another source for engineering inspiration, and of taking an ecological approach to the understanding of artefacts as objects that interact with humans creating a niche in which both influence and change one another.

5 March, morning

Wybo Houkes presented the results of the previous day and the goals for the second day. After this, Peter Bentley gave a presentation that (1) provided a fascinating review of various projects in which biological knowledge was used to create design insights (e.g., on protein folding), and in which computer simulations were designed to generate biological insights (e.g., on tumour growth); and (2) outlined a general language for representing knowledge about biological and engineering systems. Discussion then focussed, among other things, on how this language related to engineering ontologies.

The second part of the morning session was devoted again to discussions in parallel groups, now to explore ideas for future collaboration that cut across and connect the three areas. Participants were redistributed over the groups to encourage new interactions and ideas. Each group was handed three of the nine posters describing the research projects created

by the earlier discussion groups, with the task of fitting the projects together, identifying “missing links” (i.e., additional questions that would need answering to relate the projects to each other) and determining the time frame and scope of the encompassing project. The results of these cross-connection sessions were, again, briefly presented in a plenary session right before lunch. One possibility that was brought up was to use the life-capsule project as a basis for constructing an engineering ontology; in this way, the construction would be driven by a large-scale engineering project, rather than proceed in a top-down fashion.

5 March, afternoon

The final afternoon of the workshop was dedicated to a more practical exploration aimed at defining the academic and practical conditions for indeed establishing collaborations on the basis of the ideas collected.

After lunch, the parallel groups formed in the morning continued their work. Pieter Vermaas, in his brief introduction set them the task to develop, in one hour, as many suggestions as possible for practically enabling and facilitating research on the individual and cross-connected research projects.

The results were reported in the final plenary session of the workshop, chaired by Gerard Dijkema. Brainstorming in the parallel sessions about cross area ideas led to the following suggestions:

- Organising a second event dubbed an ontology week, in which we would reconvene and actively share our different disciplinary backgrounds by developing an ontology.
- Continuing the creation of a network of researchers from engineering design, computer science and philosophy. The ESF Research Networking programme was recommended as a tool for doing this by the ESF representatives.
- Drawing in a more active participation of the biologists in our collaboration; here two scenarios were contrasted: starting the collaboration with the current group, and inviting the biologists with preliminary results, or immediately aiming at having an active contribution from biology.
- Starting a wiki as soon as further activities are planned.
- Writing a contribution to the FP7 Consultation on the FET (Future and Emergent Technology) Flagship Initiative, about constructing an engineering ontology that could facilitate life-capsule design.

3. Assessment of the results, contribution to the future direction of the field, outcome

The overall conclusions were

- That there is ample opportunity for a network of researchers interested in systematising the use of biological knowledge for innovative design practices. As a “seed event” with a lively and constructive atmosphere, the workshop was very successful by showing that researchers from the areas of biomimetic engineering, evolutionary design, complex systems design, philosophy and engineering ontology can cross their different disciplinary backgrounds and arrive constructively at innovative research questions and projects.
- The network needs to be extended, also with other disciplines (especially the life sciences), to warrant the proposal for a EUROCORES theme. Johan Schot’s presentation made clear that such a theme is most successful if it builds upon a

previously existing network, carried by several fully committed researchers. Follow-up projects should be instrumental to this development. One project that has been identified is an “Ontology week” meeting in which engineering ontologists introduce the results of their field and demonstrate how it can be a means for the transfer of knowledge from the biological to the engineering domain. Another project is having a wiki as soon as the network becomes more active.

- A variety of interesting, ambitious and multi-disciplinary topics were brought up by the participants. In addition to building ontologies that will facilitate the transfer of knowledge from the biological to the engineering domain, the Killer-App/life-capsule project is the most telling example, since it would bring about both what technical innovations biology can provide and how engineering itself can be innovated by biology.
- Several follow-up initiatives were proposed, including an ESF Research Networking Programme, the just mentioned “Ontology week” and wiki, and a contribution to the FP7 consultation on the FET Flagship Initiative (the latter initiative has already been realized).

The ideas and initiatives proposed have the potential to further the field of engineering. Initiatives that immediately aim at finding large-scale funding would, when funded, certainly bring us beyond this promissory note. For improving the chances for such funding, the founding ideas underlying projects such as the Killer-App and life-capsule projects, have to be developed, made precise and brought to full. For this we will also initiate smaller meetings with a limited number of committed researchers, aiming at focussed developments of innovations of engineering on the crossroads of biomimetic engineering, evolutionary design, complex systems design, philosophy and engineering ontology.

4. Final programme

Wednesday 3 March 2010

Afternoon Arrival

Thursday 4 March 2010

09.30-09.40	Welcome Anthonie Meijers (Philosophy & Ethics, Eindhoven University of Technology)
09.40-09.55	Round of introductions
09.55-10.15	Presentation of the European Science Foundation (ESF) Kostas Gouliamos, Standing Committee for the Humanities (SCH) Aslihan Kerç, Standing Committee for Life, Earth and Environmental Sciences (LESC)
10.15-10.45	Eurocores “How To” Johan Schot (Technology, Innovation & Society, Eindhoven University of Technology)
10.45-11.00	<i>Coffee / Tea Break</i>
11.00-12.30	Morning Session: Engineering Ontologies as a Meeting Place
11.00-11.15	Objectives and plan of the workshop Wybo Houkes (Philosophy & Ethics, Eindhoven University of Technology)
11.15-12.00	“The design and use of engineering ontologies” Stefano Borgo (Laboratory of Applied Ontology, Trento, Italy)
12.00-12.30	Discussion “Engineering Ontologies as a Meeting Place”
12.30-13.45	<i>Lunch</i>
13.45-18.00	Afternoon Session: Meeting within the Three Areas
13.45-14.00	Plan for the Afternoon Session Pieter Vermaas (Philosophy, Delft University of Technology)
14.00-16.45	Common ground and projects within the Areas [parallel] <i>with and followed by short Coffee / tea breaks</i>
17.00-18.00	Plenary: reports, discussion and round-up Wybo Houkes (Philosophy & Ethics, Eindhoven University of Technology)
19.00	<i>Dinner</i>

Friday 5 March 2010

09.00-12.00	Morning Session: Synergies between the Areas
09.00-09.30	Plan for the second day Wybo Houkes (Philosophy & Ethics, Eindhoven University of Technology)
09.30-10.15	“Natural Resources for Innovative Design” Peter Bentley (Computer Science, University College London)
10.15-10.45	Discussion
10.45-11.00	<i>Coffee / Tea Break</i>
11.00-12.00	Common ground and projects between Areas [parallel]
12.00-12.30	Plenary: reports and discussion Pieter Vermaas (Philosophy, Delft University of Technology)
12.30-13.30	<i>Lunch</i>
13.30-16.30	Afternoon Session: Practicalities and decisions
13.30-14.00	Preparing work on practicalities
14.00-15.00	Practicalities sessions [parallel]
15.00-15.30	<i>Coffee / Tea Break</i>
15.30-16.30	Deciding on Eurocores and Other Follow-Up Projects Gerard Dijkema (Energy and Industry, Delft University of Technology)
16.30	<i>Farewell and drinks at “De Zwarte Doos”</i>

Saturday 6 March 2010

Morning Departure

5. Final list of participants

Weslyne Ashton, Yale University, USA
Peter J Bentley, University College London, UK
Andrea Bonaccorsi, University of Pisa, Italy
Stefano Borgo, Laboratory for Applied Ontology, ISTC National Research Council, Italy
Ivey Chiu, University of Toronto, Canada
Gerard Dijkema, Delft University of Technology, the Netherlands
Dario Floreano, École Polytechnique Fédérale de Lausanne, Switzerland
Koen Frenken, Eindhoven University of Technology, the Netherlands
Paweł Garbacz, Catholic University of Lublin, Poland
Pierre Grenon, The Open University, UK
Pauline C. Haddow, The Norwegian University of Science and Technology (NTNU), Norway
Cecilia Hertz, Founder and Managing Director Umbilical Design AB, Stockholm, Sweden
Wybo Houkes, Eindhoven University of Technology, the Netherlands
Gilles Kassel, University of Picardie Jules Verne, France
Ulrich Krohs, University of Bielefeld, Germany
Sabina Leonelli, University of Exeter, UK
Françoise Longy, IHPST (Paris) & University of Strasbourg, France
Igor Nikolic, Delft University of Technology, the Netherlands
Thomas Reydon, Leibniz Universität Hannover, Germany
Susan Stepney, University of York, UK
Pieter Vermaas, Delft University of Technology, the Netherlands
Laure Vieu, Institute de Recherche en Informatique de Toulouse (CNRS), France
Julian Vincent, University of Bath, UK

The ESF representatives were for the Standing Committee for the Humanities (SCH)
- Kosta Gouliamos, European University Cyprus, Cyprus
and for the Standing Committee for Life, Earth and Environmental Sciences (LESC)
- Aslihan Kerç, Marmara University, Turkey

6. Statistical information on participants

The 23 invited participants who attended the workshop had affiliation in 11 countries:

Canada	1 participant
France	3 participants
Germany	2 participants
Italy	2 participants
Netherlands	5 participants
Norway	1 participant
Poland	1 participant
Sweden	1 participant
Switzerland	1 participant
UK	5 participants
USA	1 participant

(the 24th invited participant, from Estonia, had to cancel her attendance one day before the workshop)

Of the 23 participants, 8 were female and 15 male.

Disciplinary backgrounds / areas represented by participants:

Applied ontology	5 participants
Biomimetic design	4 participants
Complex-system design	4 participants
Evolutionary design	4 participants
Philosophy (biology, technology)	6 participants

Age bracket

40- years	12 participants
40 – 50 years	6 participants
50+ years	5 participants