SESSION 3: What instrumentation is emerging/needed?

Report by Helmholtz, adapted from Deliverable 3.2 “Emerging RI needs”

Summary
To perform outstanding research in life sciences cutting edge, instrumentation is a prerequisite. One remarkable example of how the development of methods and instrumentation has significantly changed research is the field of “Next Generation Sequencing”. Developments in the area of micro systems, IT and eventually in the area of nanotechnology has enabled the development of better instrumentation. With the new instruments scientists were able to sequence the genome of an individual in few weeks at reasonable costs. Projects like “The 1000 Genome project” would not be possible without these developments. However, to maintain cutting-edge research, it is necessary to explore the future requirements in the different fields of life science research and to understand how development of cutting-edge instrumentation is influenced by the market, the companies and academia.

The challenges in the various areas of life sciences are heterogeneous and depend on the method and specific instrumentation in use. It is still expected that new ground-breaking insights will be achieved by integrating data sets derived by different methods. Overall there is a strong need to integrate equipment and to merge data in a sensible way. To do the latter one it is absolutely necessary to improve data storage, data analysis and data processing.

To address the needs of emerging research infrastructures, two workshops had been organised providing experts’ opinions and discussions serving as essential source of input for the first and the present report.

A focus of the second workshop held in Vienna was to discuss the issue of the provenance of new technologies and instrumentations and the role of different stakeholders such as academia and industry. Additionally, systematic approaches to help early identification of new developments in instrumentation were discussed.

In summary, incremental improvement of instrumentation could be foreseen from scientists and manufactures who are working in the respective field. Break-through innovations cannot be anticipated before they occur. A systematic process, e.g. Foresight, seems to be of no significant help to identify upcoming break-through innovations. Therefore, the best approach for funders is to stay in close contact to academia and industry in the respective area and to “react” as soon as a new instrument or instrumentation is surfacing.

Approach

During the workshop # 3 in Hinxton the needs of emerging research infrastructures were discussed focusing on Next Generation Sequencing, High Throughput Crystallisation, Biomolecular Characterisation, etc.. These topics were identified during a discussion with the Scientific Advisory Board (SAB). In preparation of workshop #5 no new areas of interest arose. Therefore we decided to discuss the issue of the provenance of new technologies and instrumentations and try to answer the following questions:

- Are there early indicators for emerging technologies and developments in instrumentation?
- What is the role of industry?
- What is the role of academia?
- Is a Foresight Process of help?
- Is there a systematic approach to support funding agencies to identify upcoming relevant developments?

In addition to these questions we addressed issues like quantum leap innovation in opposite to incremental innovation, the role of market pull and technology push.

Accordingly we invited a scientist, an expert from industry and an expert in methods relevant to Foresight Processes to give short introductory presentations followed by a discussion of the different issues with the plenum (s. appendix).

Results

From an academic point of view it is relatively easy to anticipate the incremental developments in a specific area. Looking at NMR for example it was very clear that higher magnetic fields were of great interest. De facto this kind of development took place. However, at a certain point of advance technological boundaries were met. The expenses for further improvements became very high and it was questionable whether the cost-value-ratio was acceptable.

New technologies like the development of the superconducting NMR-coils, which lie in-between incremental and break-through innovation, allow further improvements in the area of NMR.

It is believed that break-through innovation is unforeseeable. For example in the area of mass spectrometry FT-ICR-MS is a break-through innovation and this development was not anticipated before the instrumentation (Orbitrap) hit the market.

Orbitrap is based on a patent which was filed in 1996 and published in 1999. Luckily the patent was bought by a company which saw the potential of the technology. In 2005 the instrument was brought to the market. Due to the attractive price it was very soon accepted by the scientific community and a number of instruments were available in many places. Even in retrospective no indicators for such a development could be detected. It was assumed that the development was pushed forward due to the needs of the applicants. Finally the development of the Orbitrap forced somehow the improvements in the area of mass spectrometry in general (demand pull).

This general assessment of the situation is shared by industry. For manufacturers in the NMR field it was clear from the beginning which improvement was needed (enhancement of sensitivity) and in consequence the magnetic field, the dynamic magnetic field and the

detection was improved by industry. This type of development was clearly driven by the market (“market pull”).

In case new technologies emerged somewhere and were helpful for incremental innovation, the development was driven by “technology push”.

The expert from Bruker confirmed that at some point incremental innovation hit the limit of a technology and further developments depend on new break-through technologies. If this kind of technology is not available further development of the instrumentation stopped until alternatives occur. Sometimes new technology does not fulfil the expectation and again the improvement of instrumentation will be stopped. For example HTS (high temperature superconductors) were demonstrated in 1986 and until now it is not possible to overcome the technical problems in using HTS for NMR magnets. Very often a decision to use one technology leads to a neglect of another technology. Years later the “old” technology gets a new chance because one hit the technological boundaries and a new approach is needed (e.g. Dynamic nuclear polarisation is more than 50 years old by now and but new approaches allowed its development to be re-invigorated in 2003).

Usually industry is very well informed about academic research in their field. Companies look on a regular basis for early signs for new technologies in literature, conferences and meetings or in patents. A systematic approach like Foresight is not needed although (huge) companies use related methods for expanding their portfolio or develop visions for the future development of the company.

From Brukers point of view funders may have an influence on developments. Companies are usually motivated by the potential of a technology, the demand of the market/ applicant and the rate of progress for a given technology as well as by the cost of developments and whether they can be supported by R&D grants. Especially in the case of Bruker, developments were driven by science. This is due to the fact that the owner of the company was a scientist himself.

However, cutting edge technologies are often emerging in an academic surrounding. To apply the new technologies or to get a translation into the market an interaction of academia and industry is needed. Very often the transfer from academia to industry is related to personal contacts between companies and scientists. For a successful interaction some prerequisites like trust etc. are needed.

The implementation of cutting edge technologies can be sabotaged or in worst case killed when one of the two partners is taking an extreme position concerning royalties or rights on exploitation. eg. a claim by a company to have the unique and sole right to make use of a technology will kill the application of that technology.

From the funders point of view it is very important to find out in due time what cutting edge instrumentation is emerging and what’s needed for performing outstanding research. Therefore they are interested to learn about early indicators or methods which may support them. One process which was taken into consideration was Foresight.

Foresight is a systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process. Scientific and technological developments are assessed. Before starting it is absolutely necessary to have a clear understanding of the aim/ question or target. Several methods can be used within a Foresight process but not every method (Delphi, Technology roadmapping etc.) is suitable for every question. Time and effort (costs) which are invested in the process should be adequate to the aim. Foresight is not a forecast of the future and time when developments will occur. It is not for short term decision making.

Conclusion

Incremental innovation can be anticipated by scientists or companies working in the area. Break-through innovation is not predictable. Developments in-between depend strongly on the development of enabling technologies which can be applied to existing instrumentation.
A systematic approach like Foresight seems to be not helpful for supporting funders to identify upcoming developments in instrumentation. Foresight might help when addressing very specific questions which are relevant for mid- or long-term decisions. It can be used to analyse technological developments which are relevant for the future.

Overall a close contact between funding agencies/ funders and scientists as well as with manufacturers is necessary to anticipate developments in instrumentation very early. A regular exchange between these groups should be established to create an atmosphere of trust for an open discussion.

Appendix:

Agenda:

SESSION 3: What instrumentation is emerging/needed?

Task Leader Helmholtz

Objectives *What is the origin of new technologies & instruments? How to sense emerging developments? This part intends to identify the latest cutting edge technology to provide information to funding agencies and allow for coordinated measures such as joint reviews.*

During the workshop # 3 the needs of emerging research infrastructures were discussed focusing on Next Generation Sequencing, High Throughput Crystallisation, Biomolecular Characterisation etc. In workshop #5 we’d like to discuss the issue of the provenance of new technologies and instrumentations. Issues that we intend to address include:

- *Are there early indicators for emerging technologies and developments in instrumentation?*
- *What is the role of industry?*
- *What is the role of academia?*
- *Is a Foresight Process of help?*
- *Is there a systematic approach to support funding agencies to identify upcoming relevant developments?*

Participants: *ERA-Instruments SAB members and partners, guests*

Chair: *Michael Sattler (SAB)*

16:30 – 16:35	Introduction, session Chair, Helmholtz
16:35 – 16:45	Emerging and required instrumentation – the academic viewpoint, (Julia Chamot-Rooke, SAB)
16:45 – 16:55	Emerging and required instrumentation – the industry viewpoint (Tonio Gianotti, Bruker BioSpin)
16:55 – 17:05	Foresight Process, (Kerstin Cuhls, Frauenhofer ISI tbc)
17:05 – 17:45	Discussion