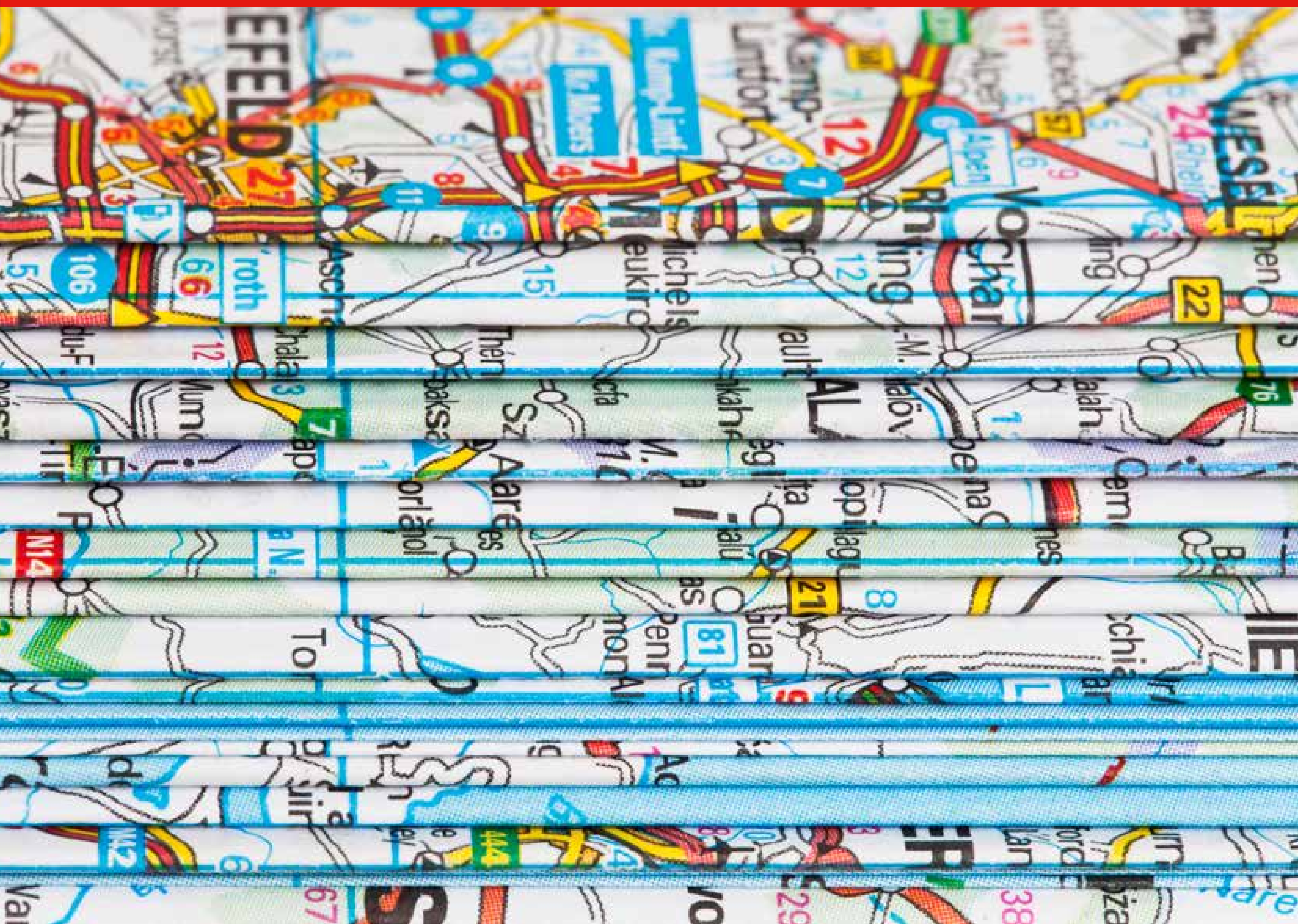
Ministry of Education, Culture and Science

Uncharted Frontiers:
the Netherlands' Roadmap for Large-Scale Research Facilities



Uncharted Frontiers:

the Netherlands' Roadmap for Large-Scale Research Facilities

Contents

Foreword

Science and research are essential for dealing with major societal challenges, now and in the future. Scientific developments contribute to our wellbeing, health, safety, and wealth. In the Netherlands, our endeavor is to be among the top performers in the world in terms of science. In this light we underline the significance of a top-quality research environment and international cooperation.

Large-scale research facilities contribute to this kind of research environment. It is widely acknowledged that facilities like these are extremely valuable for achieving scientific progress, since they enable the concentration of technology, people and capital, in this way creating an inspiring research environment. Large-scale research facilities, in particular, require cooperation.

The Netherlands developed a first national roadmap in 2008. Since then, many of the facilities included in the roadmap have evolved and the research environment has changed. Hence this updated national roadmap for large-scale research facilities contains 28 progressive projects which are nationally and internationally important for meeting future challenges.

Various research projects vied for a listing on this updated national roadmap, and we are justifiably proud of the excellent facilities which are included in this list. This roadmap can be seen as an invitation for international cooperation between scientists, institutions and countries. I hope that the different and varied projects will inspire you and that they will lead us to new, uncharted frontiers.

Sander Dekker
State Secretary of the Ministry of Education, Culture and Science

Introduction - The importance of large-scale research facilities

Large-scale research facilities are crucial to boost science in all scientific fields in the Netherlands. This is because of the multidisciplinary approach of these facilities. Research of the Technopolis Group[1] confirms that these facilities contribute to the creation of networks and the build-up of human capital. Concerning the economic value, there are long-term and temporary effects of the development of a research facility in terms of jobs, investments and economic innovation. Finally, it is recognised that research contributes to produce solutions to societal problems.

The Dutch government acknowledges the importance of large-scale research facilities. Therefore a Dutch roadmap was commissioned, a strategic advice that singles out the large-scale research facilities that are essential for the robustness and innovativeness of the Dutch science system. The first National roadmap (2008 – 2012) included 26 research facilities; a total budget of 63 million euro was available. Since 2008 the status of many of these facilities has changed and new large-scale projects have come up. A recent report of the Taskforce to Promote Large-Scale Research Facilities emphasized the importance of periodically updating the roadmap to keep track of developments in the field.

The roadmap that is presented here is an update of the first National Roadmap on Large-Scale Research Facilities. The new roadmap is based on the advice that the Netherlands Organisation for Scientific Research (NWO) asked from an independent advisory committee chaired by prof. dr. E.M. Meijer.[2]

The updated National roadmap includes 28 large-scale research facilities, which are listed in this publication. The Meijer committee was asked not only to update the 2008 roadmap but also to advise on the funding of some of the projects. For this funding a budget of 80 million euro has been made available. The available annual budget per year for the National roadmap is 40 million euro. In addition an annual budget of 15 million euro is available for e-Infrastructure facilities. In 2014, NWO will grant another 75 million euro to some projects of the roadmap.

The impact of large-scale research facilities extends into a number of domains, and they both have direct and indirect effects. By financing the facilities in this roadmap the Dutch government invests in top research to develop new therapies against cancer and age-related diseases, the functioning of proteins, new materials, magnetic fields and the structure and chemistry of the universe.

The National Roadmap for Large-Scale Research Facilities

Out of the 28 projects five projects were selected for funding, namely:

Domain Biological and Medical Sciences

1. Mouse Clinic for Cancer and Aging research (MCCA) (18.6 M €)
2. Proteins@Work: A large-scale proteomics research facility for the life sciences (13.5 M €)

Domain Physics, Astronomy, Astrophysics and Mathematics

3. The SAFARI Imaging Spectrometer on the SPICA space observatory; revealing the origins of the universe, from planets to galaxies and beyond. (18 M €)
4. High Field Magnet Laboratory; An international research facility for Science in High Magnetic Fields in the Netherlands (HFML) (11 M €)

Domain Chemistry and Material Sciences

5. An ultra-high field NMR facility for the Netherlands (uNMR-NL) (18.5 M €)

Another three projects received ‘seed capital’:

Domain Biological and Medical Sciences

1. Biobanking and Biomolecular Research Infrastructure, the Netherlands (1 M €)

Domain Social Sciences

2. The Generations and Gender Programme: A Large-Scale, Longitudinal, Comparative Database for Social Science Analysis (GGP) (0.5 M €)

Domain Humanities and Arts

3. Common Lab Research Infrastructure for the Arts and Humanities (CLARIAH) (1 M €)

[1] Technopolis Group (2011): The role and added value of large-scale research facilities http://www.technopolis-group.com/resources/downloads/reports/1379_Report_Large-scale_Research_Facilities_EN.pdf

[2] The Meijer committee assessed the proposals for each of the research facilities on eleven criteria (appendix II).

The European context

The first National roadmap has been developed as a response to the development of a European roadmap for research infrastructures by the European Strategy Forum on Research Infrastructures (ESFRI). ESFRI is established as an informal platform of scientists and ministerial representatives in 2002. The mission of ESFRI is to support a coherent and strategy-led approach to policy-making on new and existing pan-European and global research infrastructures. ESFRI facilitates multilateral initiatives leading to the better use and development of research infrastructures, acting as an incubator for decision-making processes. In 2004, the Competitiveness Council mandated ESFRI to develop a roadmap to describe the scientific needs for Research Infrastructures for the next 10 to 20 years and this mandate has recently been extended. This roadmap has been updated in 2008 and 2010. Currently, ESFRI focuses on supporting the implementation of the projects on the roadmap.

While setting up these research infrastructures between EU countries it became clear that an adequate legal framework allowing the creation of appropriate partnerships was missing. Existing legal forms under national, European or international law did not fulfil the needs of these new European infrastructures. To facilitate the joint establishment and operation of research infrastructures of pan-European interest, the European Commission designed a legal framework for a European Research Infrastructure Consortium (ERIC).

The Netherlands developed a simple procedure for the set up of an ERIC in July 2010. This procedure has made it possible to host the very first ERIC in 2011 (SHARE-ERIC) and the second ERIC (CLARIN-ERIC) in 2012. It is foreseen that in 2013 also EATRIS-ERIC and JIVE-ERIC will be established with their statutory seats in the Netherlands. Other countries are also in the process of setting up ERICs.

The strategic value and future of large-scale research facilities for the Netherlands

The Netherlands currently have a high participation rate in different ESFRI-projects. Three European facilities have their seat in the Netherlands: SHARE at Tilburg University, CLARIN at Utrecht University and EATRIS at the VU University Medical Centre. The Netherlands invest in these important projects, despite of the current limited financial means and limited alternative financing possibilities (e.g., structural funds). The contribution to the solutions to societal challenges is one of the guiding points in the Dutch research and science policy. There is a focus as well on nine so-called 'top sectors' in which the Dutch government, businesses and research institutes cooperate in the development of new knowledge and innovation. This matches in large part with the European focus on the Grand Challenges in the development of Horizon 2020, the European Framework Programme for Research and Innovation.

In spring 2013, the Dutch Advisory Council for Science and Technology Policy (AWT) will advise the Ministry of Education, Culture, and Science and the Ministry of Economic Affairs on the strategy to optimise the Dutch research facilities and the utilisation of international facilities by Dutch research and innovation. Continuity will be an important factor of the future vision on the large-scale research infrastructure of the Dutch government.

In this publication, the history, the European connections and the aim of the research of the research facilities of the roadmap are described. We also highlight three projects that are on the roadmap. Please note that all projects are under development, therefore this publication needs to be seen as a reference for the total roadmap of 28 projects.

Jos Engelen, chairman of the Netherlands Organisation of Scientific Research (NWO) and interviewed hereafter in this publication: "The large-scale facilities on the roadmap lead the way to the future. In time they will come up with scientific answers to issues that are also of social importance, such as ageing healthily. "And in the interview in this publication also Hans Clevers, president of the Royal Netherlands Academy of Arts and Sciences (KNAW), says to be positive on the roadmap. "It is a ray of hope in a time when there are increasingly fewer investments in science. Hopefully this roadmap helps to retain young talented scientists."

How the European and Dutch Roadmaps came into being

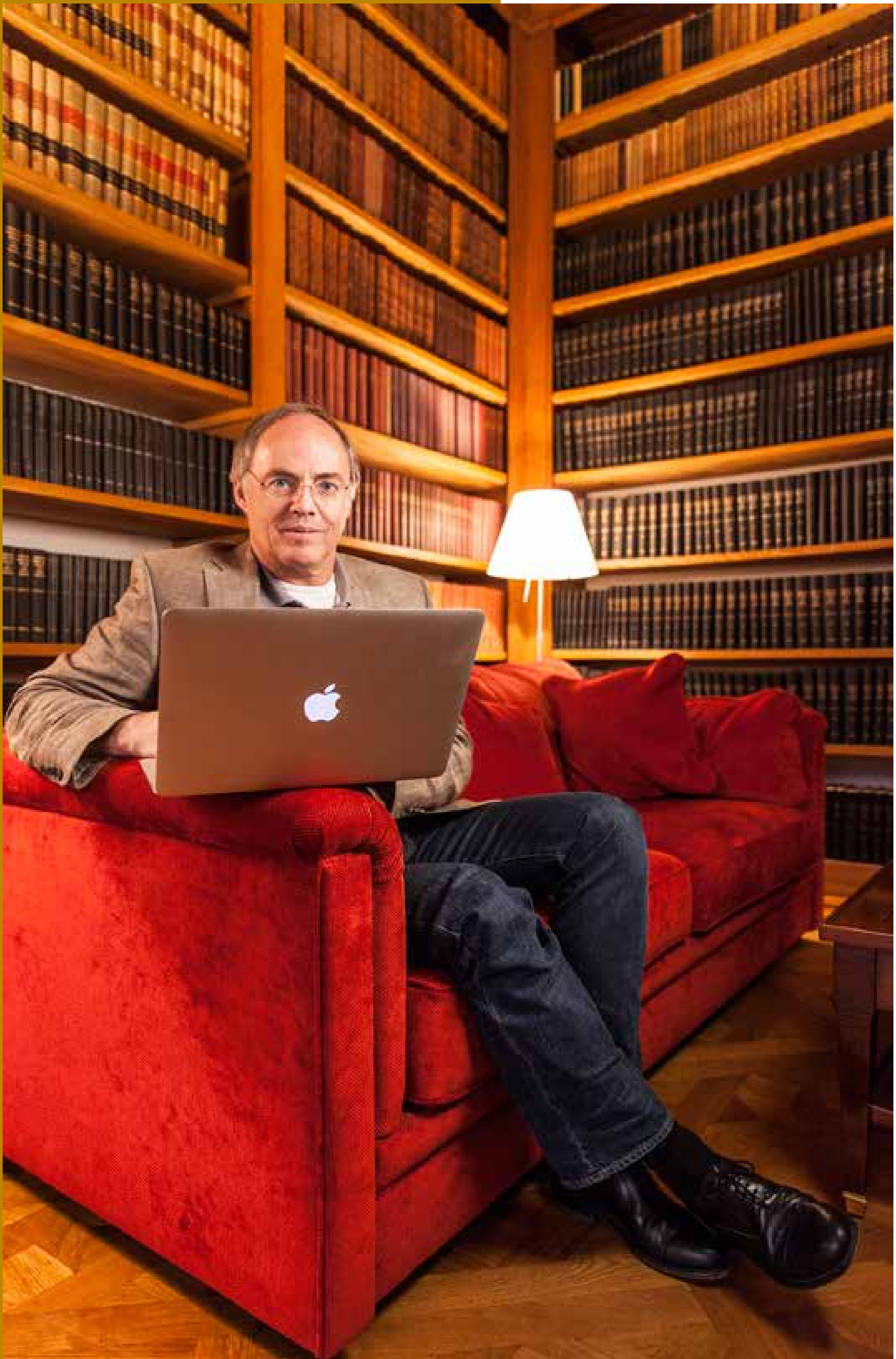
In 2005 the Innovation Platform released an advisory report. It stressed the need for state-of-the-art facilities for scientific research, for conducting the research and attracting top-flight researchers and innovative companies. At a European level, the European Strategy Forum on Research Infrastructures (ESFRI) drew up a roadmap enumerating European priorities for the development of large-scale research facilities. In response to this plan, the Dutch government commissioned a Dutch Roadmap, leading to the publication in October 2008 based on an advice of the Van Velzen committee.

Specific features of large-scale research facilities:

1. **Research facilities or infrastructure**
   Our national roadmap uses the term 'research facilities' whereas the European Commission uses the term 'research infrastructure'. These two terms coincide. According to the European Commission in Council regulation No 723/3009: 'Research infrastructure' means facilities, resources and related services that are used by the scientific community to conduct top-level research in their respective fields and covers major scientific equipment or sets of instruments; knowledge-based resources such as collections, archives or structures for scientific information; enabling Information and Communications Technology-based infrastructures such as Grid, computing, software and communication, or any other entity of a unique nature essential to achieve excellence in research. Such infrastructures may be 'single-sited' or 'distributed' (an organised network of resources)'.

2. **Best international researchers and multidisciplinary research**
   The key large-scale research facilities have not only been responsible for some of the greatest **scientific discoveries and technological developments**, but are also influential in attracting the best researchers from around the world and in building bridges between national communities, research communities and scientific disciplines (multidisciplinary research). The research facilities should be accessible to and attract foreign researchers and users from the commercial sector. In addition, research facilities have major potential learning -, networking -, and cluster effects.

3. **Focus on national or international research**
   The investments for implementing a research facility go beyond the capacity of an individual faculty, institution, or funding programme. The focus of a large-scale research facility is likewise national or international.



Hans Clevers

President of the Royal Netherlands Academy of Arts and Sciences (KNAW) and Professor of Molecular Genetics

"Only the best facilities deliver discoveries"

"Generating manpower and resources for something that transcends the local faculty appears to be difficult in practice. Therefore it is of great importance that there is a separate funding for large-scale projects that is divided objectively." Hans Clevers, president of the KNAW, is enthusiastic about the roadmap. "It is great that scientists can now utilise all kinds of research areas for the scientific work they have always wanted to do."

From an international point of view Dutch science is doing well. However, in order to stay ahead investments in new facilities are essential. "Science is making discoveries. Such discoveries you make only once. Those with the best facilities stand the best chance to make such discoveries. The chance that researchers with ten or twenty years old equipment discover something that people with state-of-the-art equipment have overlooked is very small." The best facilities do also attract the best people, says Clevers. "International top-scientists are not lured by salary or an additional analyst. They are attracted by an environment that enables them, both practically and financially, to do everything they want."

Ray of hope

"The roadmap is a ray of hope in a time when there is a tendency to invest less in science. Researchers plod away to raise money. For a large investment in equipment they have to argue with their university that has to weigh the pros and cons of such an investment versus the retention of personnel; locally they are communicating vessels. Therefore it is of extreme importance that large-scale facilities are managed and financed nationally. Also for the perspective of young scientists: when, scientifically, you cannot compete at an international level, then an alternative career, for example as a consultant, all of a sudden becomes very attractive. Hopefully with this roadmap we can retain such talent."

Complex world

The time that a scientific experiment consisted of three test tubes and a notebook for the results lies far behind us. "Modern-day science cannot be done without large-scale facilities. Science has deepened enormously, also in biology we are now able to discover patterns in loads of data. The larger the scale the more you discover. The world is complex and therefore science as well." For Clevers this is precisely the beauty of science. "In my own lab we have tested our theory on intestinal cancer with a mouse with special stem cells. If we would be right the stem cells in the test mouse would radiate. After years of labour and thanks to a high-level animal facility that mouse became reality. When you finally see a couple of radiating lines and you realize: this is a breakthrough... Such a eureka moment after years of hard work, that is what motivates us!"

Jos Engelen

Chairman of the Netherlands Organisation of Scientific Research (NWO)

"Large-scale facilities find answers to large questions"

"The large-scale facilities on the roadmap lead the way to the future," says NWO chairman Jos Engelen. "In time they will come up with scientific answers to issues that are also of social importance, such as ageing healthily." NWO evaluated the applications and provided, also on behalf of OCW, the funding. "The roadmap is a good initiative because from a scientific point-of-view you will gradually be pushed into the background if you do not make these investments."

For Engelen largeness of scale in itself is not an objective, but the investments are necessary to maintain a top position internationally. "For example, for the development of equipment such as the HFML magnets. Or for enabling advanced animal experiments and thus enabling cancer research, as at the Mouse Clinic (MCCA). In this way you enable researchers to do innovative research and to acquire new insights." According to the chairman the roadmap contributes to the structural support of scientists and for the government it is a good means for anticipation. "We also observe that internationally the Netherlands can take part at a very competing level. For example, Dutch researchers receive a contribution for the development of super-camera SAFARI that comes along on board the Japanese space telescope SPICA, as part of an international mission."

Enjoy practising science

From childhood Engelen was interested in science. He studied physics - "I was caught by the relativity theory" – took his PhD and among other things worked at CERN. "It is not true that in science you move from one eureka-moment to the other. First and foremost it is working hard. However, practising science is fun to do. As a young researcher I sometimes thought: 'Is it not weird that I get paid to do this?'" He also loves the large-scale infrastructures of the roadmap. "What really appeals to me is research in the field of the cell-sciences, Proteins@Work. There is so much to learn in the area of proteins. That is also something I would like to get down to one day."

Answers to large questions

The chairman of NWO finds it very important that the *science case* is leading with the assessment of the projects on this roadmap. "In our knowledge economy scientists are looking for answers to the large questions. Next you must also be receptive to the possible applications. We fund research with money granted by the government (and therefore society). Consequently, in our democratic system, it is self-evident that we cannot turn away from society. We fund excellent science and take into consideration the boundaries that are desired within society." Whether the roadmap will bring forth a Nobel Prize winner, Engelen finds hard to predict. "All of these facilities are active at the front of science. If they set foot on new territory anything is possible, so winning a Nobel Prize as well."

The Netherlands' Roadmap for Large-Scale Research Facilities

Domain Social Sciences

1. The Generations and Gender Programme (GGP)
2. Survey of Health, Ageing and Retirement in Europe (SHARE)
3. European Social Survey in the Netherlands (ESS-NL)

Domain Humanities and Arts

4. Common Lab Research Infrastructure for the Arts and Humanities (CLARIAH)

Domain Information Sciences and Technology

5. SURF, the National e-Infrastructure for Research

Domain Biological & Medical Sciences

6. Mouse Clinic for Cancer and Aging research (MCCA)
7. Proteins@Work; A large-scale proteomics research facility for the life sciences
8. Biobanking and Biomolecular Research Infrastructure, the Netherlands (BBMRI-NL)
9. Netherlands BioImaging Advanced Microscopy (NL-BioImaging AM)
10. Systems Biology Natural Technology Facility (SYMBIONT)
11. Population Imaging Infrastructure in the Netherlands (EPI^2)
12. Netherlands' Infrastructure for Translational Biomedical Research (EATRIS-NL)

Domain Earth and Environmental Sciences

13. Netherlands Solid Earth Observatory (NSEO)
14. Integrated Carbon Observation System Netherlands (ICOS-NL)
15. LifeWatch Infrastructure for Biodiversity and Ecosystem Research
16. Netherlands Centre for Biodiversity Naturalis (NCB)
17. The European Marine Biological Resource Centre Netherlands (EMBRC-NL)

Domain Physics, Astronomy, Astrophysics and Mathematics

18. The SAFARI Imaging Spectrometer on the SPICA space observatory; revealing the origins of the universe, from planets to galaxies and beyond.
19. High Field Magnet Laboratory (HFML)
20. Dutch contributions to the detector upgrades of the Large Hadron Collider experiments at CERN
21. NanoLabNL
22. Deep-sea facility in the Mediterranean for the Neutrino Astronomy and Earth and Sea Sciences (KM3NeT)
23. The Square Kilometre Array (SKA)
24. European Extremely Large Telescope (E-ELT)

Domain Chemistry and Material Sciences

25. An ultra-high field NMR facility for the Netherlands (uNMR-NL)
26. A Dutch small molecule screening and hit optimisation facility for the translation of biomedical research findings (NL-OPENSCREEN)
27. Netherlands Center for Nanoscopy (NeCEN)

Domain Engineering and Energy

28. Netherlands Silicon Solar Cell Laboratory (NLSiSCL)

1. The Generations and Gender Programme (GGP)

The GGP-programme is a pan-European research infrastructure that is led by a consortium of 12 institutions. The Netherlands Interdisciplinary Demographic Institute coordinates the programme.

The GGP consists of a system of cross-national comparative panel surveys and contextual databases. Its aim is to improve the knowledge base for social science research and social policy-making in Europe and other developed countries. Central topics are fertility, partnership, transition to adulthood, economic activity as well as the intergenerational and gender relations between people expressed in care-relations or the organisation of paid and unpaid work.

The panel surveys and contextual database can contribute significantly to policy goals such as securing social cohesion, modernising the social welfare system and improving life chances of future generations. From a science perspective it will give new insights in how major societal changes shape social and economic inequalities between genders and generations. To date at least one wave of a GGP Survey has been conducted in nineteen countries. The Netherlands have as yet conducted three waves.

Results of the GGP will be fed into European and national policies dealing with issues of population ageing, work-family balance and social inequality. In addition, tools will be developed that can be implemented by commercial fieldwork agencies. In the years to come the governance structure will be changed with the aim of establishing an ERIC by 2020.

After a decade of development and implementation, a blueprint is made for 2013-2022. New methodologies will be implemented and a further standardisation of data collection and processing will be one of the objectives. The GGP is set up as a long-term sustainable research infrastructure and as such has no pre-specified end.

2. Survey of Health, Ageing and Retirement in Europe (SHARE)

Netspar at Tilburg University is the Netherlands country team leader for this European infrastructure and the administrative chair of SHARE-ERIC

SHARE is a multidisciplinary and cross-national panel database of micro data on health, socio-economic status and social and family networks. The database includes data on more than 60,000 individuals aged 50 or over. Its longitudinal, multidisciplinary and cross-nationally comparative approach is essential for analysing the long-term efficacy of welfare state interventions, such as reform of labour markets, pension and health care systems.

The cross-national approach of SHARE is unique in that it uses comparable micro data (like pension entitlements, health condition and kinship) rather than macro-level indicators. The insights gained from analysing and comparing the diversity of experiences will help European countries to be prepared more effectively for the continuing challenges to their welfare systems in an ageing society.

The SHARE baseline study was executed for the first time in 2004 in eleven countries. Since then seven more countries started participating and three more waves have been completed. In 2011 SHARE was established as the first ERIC. SHARE is a crucial research tool for the Social Infrastructure Agenda of the Dutch top sector research programme and for the Grand Social Challenges of Europe 2020.

In order to create a solid research tool a longitudinal survey requires execution of ten waves at least. The fifth wave will start early in 2013, the tenth wave in 2023.

3. European Social Survey in the Netherlands (ESS-NL)

Universiteit Twente is the current coordinator for ESS-NL

The European Social Survey is a survey to map and explain the interaction between Europe's changing institutions and the attitudes, beliefs and behaviour patterns of different populations. Every two years data is gathered through questionnaires. The questionnaire includes a core module covering a wide range of social variables, such as the use of media, social and public trust, political interest and participation and national, ethnic and religious allegiances. In addition to the core module there are two or more rotating modules in every round.

The main innovative aspect in ESS is the comparability of social attitude data in European countries. In all participating countries the ESS has an identical setup, questionnaire and methods. The data includes important touchstones for the government such as trust in the government, social and political participation, social capital and evaluation of public-good provisions. The ESS enables a systematic comparison of the developments in the opinion climate in almost all European countries at regular time-intervals, e.g., on Europeans' attitudes towards minorities and migrants.

The European Social Survey started in 2001 and conducted a first round of data collection in 2002. Researchers from the Netherlands have been involved with the ESS from the very beginning. Until now there have been five rounds of data collection. The ESS has established itself as an indispensable infrastructure for social and political research. All data, without any restrictions, is freely available for non-profit purposes. ESS is to become an ERIC.

The data collection for the sixth round is currently running and two more rounds of data collection are expected, most probably in more countries than today. Funding is guaranteed up to 2017.

4. Common Lab Research Infrastructure for the Arts and Humanities (CLARIAH)

Core facility is Utrecht University, but more than twenty research institutes are involved

The facility is a distributed, virtual infrastructure that is hosted on (virtual) servers of the CLARIAH Centres. It will create a sustainable *eHumanities* research environment. This environment will provide researchers and research groups with integrated access to unprecedented collections of seamlessly interoperating digital research resources and innovative tools. CLARIAH enables *Data Intensive Science* in the humanities.

The CLARIAH facility does not exist yet, but will be built based on work already done in the CLARIN and DARIAH projects and on the infrastructure created by them. Rapid digitisation of massive quantities of formerly analogue sources (text, images and audio-visuals) for research is revolutionising the humanities. CLARIAH aims to offer a 'Common Lab' to humanities scholars, from literary researchers to historians and from archaeologists to linguists. This lab gives them access to large collections of digital resources and innovative user-friendly processing tools, thus enabling them to carry out ground-breaking scientific research.

This infrastructure directly contributes to important policy issues in society (top sectors 'High Tech' and 'Creative Industry') and to cross-sector ICT. Furthermore it can play an important role in tackling the problem of big data, not only for structured data but also for unstructured data hidden in textual and audio-visual resources. It may yield results that are relevant for the grand challenge ageing population.

The facility will be constructed and made fully operational in a period of 10 years. The facility will be made in an incremental way, so that parts of it can already be used after 2 years.

Dieter Van Uytvanck

Common Lab Research Infrastructure for the Arts and Humanities

ICT tools enable eHumanities top-research

“Half of all languages are threatened by extinction. It is a race against the clock to store information for future generations.” These are the words of Dieter Van Uytvanck, who works on the technical development of the online ‘laboratory’ CLARIAH. This facility enables the consultation of large collections of digital resources and the posing of new research questions. This causes a revolution in the area of eHumanities research.

CLARIAH (Common Lab Research Infrastructure for the Arts and Humanities) is the Dutch equivalent of the European facilities CLARIN and DARIAH. Humanities scholars – varying from literary researchers to historians and from archaeologists to linguists – can consult large collections of digital sources via the internet. A wealth of texts, images, sound – and video recordings are linked together. Talkative Van Uytvanck, a linguist and information scientist himself, emphasises that accessibility and openness are quintessential. “Through a current search-engine researchers get access to valuable linguistic information. Everybody has access and can share information. Here interoperability is key; at a technical level we must all speak the same language.”

Continuous battle against obsolescence of data

Van Uytvanck is proud that the infrastructure facilitates the daily work of scientists. In the Netherlands ten centres work on CLARIAH from their own field of expertise. “At the Max Planck Institute employees transcribe and digitise information like videotapes, sometimes brought to them by retired scientists. We fight a continuous battle against the obsolescence of information. In a digital form we can guarantee that data will be preserved for 50 years. Automated transcription can save the researchers hours of work. Furthermore ICT tools enable analyses, an enormous progress! Even as we speak we are saving time. For example, thanks to the roadmap, we link together more and more research islands in the current construction-phase.”

Practising interactive science every day

The digitisation changes the daily research practice. “Previously a scientist wrote a book on static research data. Nowadays colleagues can participate in analyses and new insights can be made accessible more easily. CLARIAH facilitates open and lively research, researchers can practise interactive science every day.” The results can also be replicated easily. “Especially after the Stapel-affair another advantage of digital archives is that you can follow the steps made during the initial research.” The material can also be queried in new ways. “A good example is a study on language sources from the Second World War that proved that the birth rate of new words showed an enormous peak at that time.”

Smartphones for recordings

Van Uytvanck expects that the use of new techniques will result in even more groundbreaking research. “Researchers can consult opinion-mining data, data on online sentiments. Or search in the SMS-database, in which you see language changes in *real-time*.” Moreover the technique is evolving continually. “We start using *smartphones* for recording purposes, of youth language or of usage in remote areas. This will find its way to the archive automatically, faster is almost impossible!”

5. SURF, the National e-Infrastructure for Research

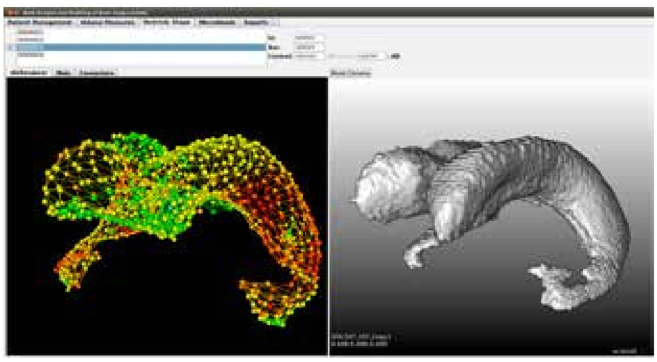
The SURF organisation is based in Utrecht and Amsterdam. Over 70 organisations participate in SURF.

SURF provides the ICT infrastructure for research, education and pre-competitive research. It is a complex ecosystem of highly diversified resources, services, algorithms and tools to support advanced research and ICT-intensive education. It comprises an integrated set of high-end networking, high performance computing, data storage, visualisation, big data and cloud services, expertise and support.

New scientific methods in all fields of research are demanding more computing, storage, networking and data resources. Scientific research creates Big Data and has 'big computing' needs. An example is the LHC (Large Hadron Collider), which generates so much data that it takes a large number of top computing centres around the world to process it. SURF supports and reinforces multidisciplinary and data-intensive research through creative and innovative use of ICT.

The national e-Infrastructure allows the organisations involved to provide knowledge for applications and innovations in both public institutes and private companies. It has strong European connections in every domain, for example with GEANT, GLIF, EGI and the European Partnership for Advanced Computing, PRACE RI.

The e-Infrastructure is already available for use but several upgrades are in progress. In 2013 the SURFnet7 Next Generation Ethernet roll-out will be completed and the new supercomputer will be installed. In the years to come various big data, HPC cloud and grid services will be installed and upgraded and the photonic layer of SURFnet7 will be replaced by a more flexible photonic substrate. The project has no fixed end-date.



6. Mouse Clinic for Cancer and Aging Research (MCCA)

A cooperation of the Netherlands Cancer Institute, the European Institute for the Biology of Ageing (ERIBA), and Brains On-Line.

The MCCA will establish an ultramodern research facility that consists of an animal-testing laboratory and a tissue culture laboratory and offers cutting edge expertise in mouse engineering technologies. The MCCA will accelerate the production of realistic mouse models for developing new therapies against cancer and aging-related diseases and at the same time this will reduce the number of mice required for breeding.

Studying complex processes such as cancer and ageing requires realistic in vivo models that realistically represent the human condition. For this purpose engineered mouse models with multiple genetic modifications are required. The MCCA will employ new methods for re-derivation of embryonic stem cell (ESC) lines from established mouse models in order to create an archive of single or compound mutant ESC lines. These can be further modified in vitro. The MCCA will also provide a state-of-the-art infrastructure for tumour intervention and imaging studies in mice. These studies will allow preclinical assessment of novel anti-cancer therapeutics and elucidation of mechanisms underlying therapy resistance.

The MCCA has excellent connections with the other European mouse clinics. It is the Dutch node in the European Mutant Mouse Archive (EMMA) network and also a full partner of Infrafrontier, the European Research Infrastructure for phenotyping and archiving of model mammalian genomes. The MCCA infrastructure is readily accessible to university centres and companies all over the world.

The MCCA will be fully operational by the end of 2013, the project will run through 2017.

7. Proteins@Work: a large-scale proteomics research facility for life sciences

Core facility: Utrecht University; smaller out-stations at the Netherlands Cancer Institute (NKI), the Erasmus Medical Centre Rotterdam and the University Medical Centre Utrecht.

Proteomics focuses on large scale analysis of proteins and their interactions in relation to their biological functions. For example, it allows studying the effect of protein modifications on cancer and autoimmune diseases. During the last few years, the realisation has emerged that successful proteomics requires an expensive and a constantly evolving infrastructure as well as a critical mass and high-level personnel. Proteins@Work will provide this by acquiring the latest generation mass spectrometry equipment and providing expert personnel to collaborate with scientists throughout the Netherlands.

The Proteins@Work proteomics facility will provide access to high-level proteomics technology, equipment and expertise for a very wide range of both academic and industrial partners. Thus it will contribute to the innovative climate in the Netherlands and it will help to address the societal challenges in health and food as defined in the EU Horizon 2020 programme. Proteomics has an almost limitless range of applications in fields as diverse as improving quality of life, health care and disease prevention as well as environmental monitoring and sustainability research. These fields have a broad societal and economical impact.

Proteins@Work is essential for Life Sciences and Health research and will collaborate with other Dutch large-scale facilities. Internationally, it will associate with the European infrastructure project PRIME-XS and the ESFRI roadmap project Instruct for integrated structural biology.

The project is currently in a preparatory phase, it will start in the beginning of 2014 and will run for five years.

8. Biobanking and Biomolecular Research Infrastructure, the Netherlands (BBMRI-NL)

The project team is based at the LUMC Leiden and connects all major biobanks in the Netherlands.

BBMRI-NL is the Dutch national biobanking infrastructure for biomedical research. Its aim is to facilitate interaction with and between Dutch biobanks. Cooperation between these biobanks is essential in the research of common multifactorial diseases, which are caused by a combination of genetic, lifestyle and environmental factors. This research will facilitate the development of better strategies for diagnosis, prevention and therapy of those diseases.

BBMRI-NL has four focus areas: harmonisation of biobank procedures, enrichment of biobank materials and data, data management and Ethical Legal and Social Issues (ELSI). Together these areas will improve the quality and accessibility of Dutch biobanks, thus facilitating competitive scientific research without compromising the participants' privacy or rights.

BBMRI-NL is the Dutch node of the European initiative BBMRI, aimed at constructing a pan-European Biobanking infrastructure. BBMRI is to be established as an ERIC in the second half of 2013, involving at least 13 countries, including the Netherlands. The BBMRI-NL consortium consists of Dutch Universities and Research Institutes (all eight Dutch University Medical Centres in the Dutch Federation (NFU) as well as the Netherlands Cancer Institute (NKI), Utrecht Universiteit, University of Amsterdam, VU University Amsterdam, National Institute for Public Health and the Environment (RIVM), Parelsnoer Institute and Wageningen UR).

BBMRI-NL started in 2009 and is currently in a consolidation phase. Major focus areas are further harmonisation, making general tools available for all Dutch biobanks, strengthening of the ICT infrastructure, implementation of a general quality standard and stronger donor involvement on a national scale.

9. Netherlands BioImaging Advanced Microscopy

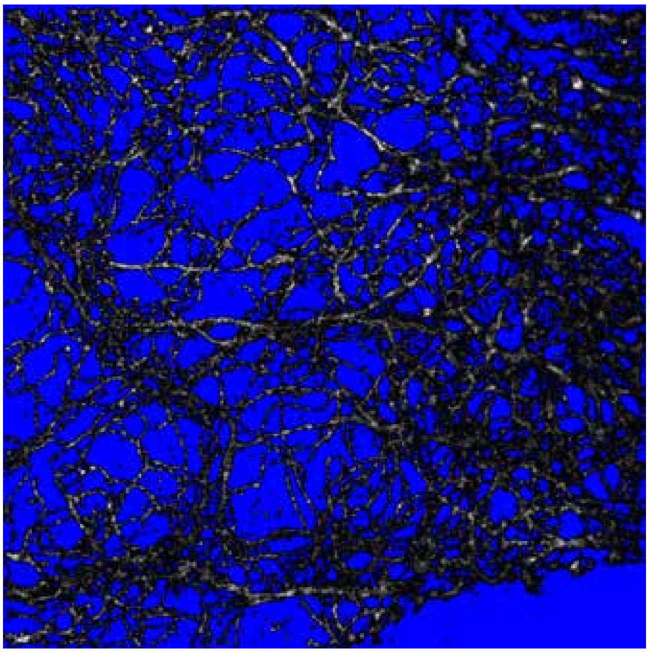
Coordinating facility: University of Amsterdam. All major life sciences institutions in the Netherlands are involved.

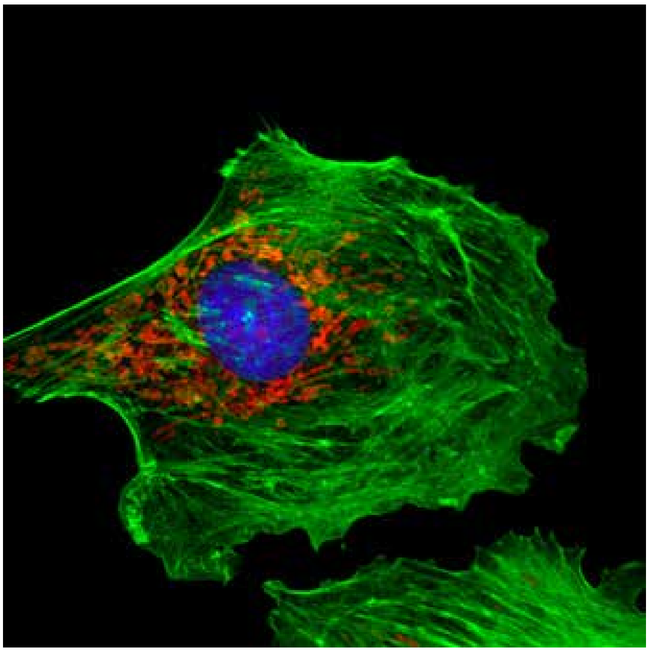
NL-BioImaging AM includes innovative bio-imaging microscopy nodes that are key to future developments in life sciences and healthcare. Recent developments in advanced microscopy have caused a paradigm shift in life sciences by enabling the direct visualisation of molecules and their interactions inside living cells and tissues. This information is crucial for understanding the biological mechanisms that underlie human development and diseases, plant growth and plant/pathogen interactions. Also it provides a strong basis for a wide variety of biotechnological advances.

NL-BioImaging AM is a distributed research infrastructure aimed at stimulating progress in the most cutting-edge microscopy technologies and at providing access to these technologies to a broad community of academic and industrial users. The infrastructure of NL-BioImaging AM provides open access for high-end microscopy applications in basic and translational biological research as well as biomedical and biotechnological topics of major societal impact.

NL-BioImagin AM was created to ascertain that the most advanced instrumentation and know-how are accessible to Dutch researchers in life sciences. Because NL-BioImaging AM is directly linked to and embedded within the European ESFRI program Euro-BioImaging. It will also facilitate transnational acces by leading European biomedical and biological scientists. NL-BioImaging AM will yield important breakthroughs in the elucidation of the mechanisms of tumorigenesis and invasive and metastatic behaviour of malignant cells. Breakthroughs are also expected in understanding the progression and molecular basis of neurodegenerative disorders, like Alzheimer's disease and in drug screening.

The project is in a preparatory phase in which the governance structure is partly implemented, two innovative nodes are being constructed and an updated national investment plan will be made in 2013. The total duration of the project will be at least 10 years.





Photomicrograph courtesy of dr K. Jalink, LCAM, The Netherlands Cancer Institute, Amsterdam

10. Systems Biology Natural Technology Facility (SYMBIONT)

Core facility: Wageningen University. The organisation of SYMBIONT is a close partnership between the WUR and other universities and researchers in this field.

SYMBIONT is a facility in which researchers design microbiological processes based on biomass such as plants, algae, micro-organisms and residual organics. We expect scientific breakthroughs in new process principles for food, chemical and environmental industries.

In the MODUTECH facility of Wageningen University researchers can use microbial reactors, online analytical tools, and dynamic modelling - and ICT services. With these tools new efficient microbial processes can be designed, in interaction with innovative start-ups, companies and industry, and in cooperation with other universities.

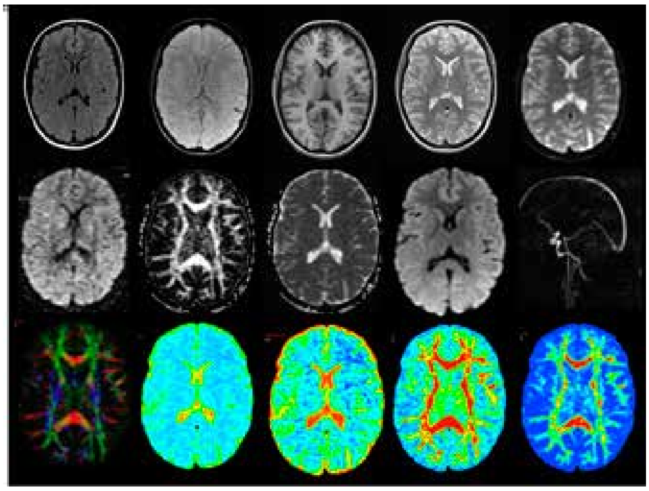
The change towards the renewable resource and bio-based economy is of paramount importance for the success of our society. Bulk environmental and industrial processes require high-throughput systems sustaining mild biologically mediated digestions, refineries and product syntheses. SYMBIONT will provide a modular high-throughput (HTP) platform for the research of the dynamics, regulations and networking in open and defined microbial biomass production and processing systems. One example is the microbial production of Volatile Fatty Acids, Energy Carriers, and nitrogen and phosphorous recovery products out of organic residuals from industrial and domestic waste waters.

SYMBIONT will be used by PhDs, Post-Docs, visiting and senior scientists of more than 10 research groups of the universities of Wageningen, Twente, Groningen and Delft. This facility is open to other leading research groups, including those from Technological Top Institutes and European institutions.

The project has a timeline of 10 years and is currently setting up an academic-industry network in the Netherlands and the MODUTECH facility (2011-2013).

11. Population Imaging Infrastructure in the Netherlands (EPI²)

Core facility: Erasmus MC: University Medical Centre, Rotterdam



The Population Imaging infrastructure (EPI²) consists of an integrated national network of dedicated, state-of-the-art imaging facilities embedded in population studies, together with a coordinating e-science infrastructure for data management and large-scale analysis. The infrastructure will help the development and implementation of strategies to prevent and treat diseases. It is related to the EU Grand Societal Challenge of 'active and healthy ageing' by its focus on early diagnosis and prevention of diseases. Main areas are neurodevelopment, neurodegeneration, cardiovascular and musculoskeletal diseases.

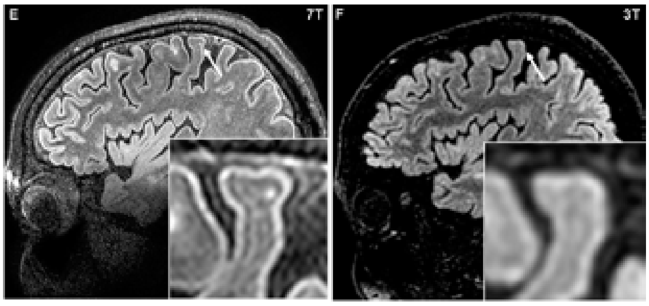
The EPI² will apply to become a node for the population imaging infrastructure within the EuroBio-Imaging research infrastructure initiative on the ESFRI roadmap. Image specific markers of pre-symptomatic diseases can be used to investigate causes of pathological alterations and for the early identification of people at risk. Imaging allows the assessment of structural and/or functional changes that may reflect specific pathology. The strength of population imaging lies in exploring new risk factors and determinants of disease.

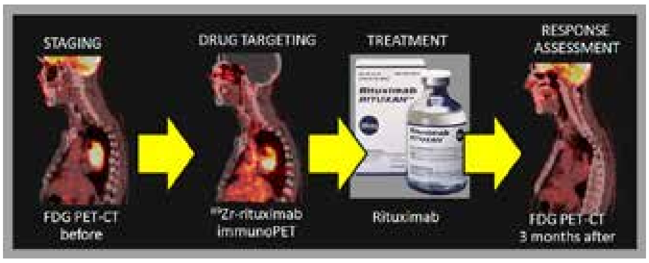
By shifting focus from curative to preventive medicine, people's quality of life will be improved in the short term and in the long term the costs for the healthcare sector will be reduced. To reach this goal EPI² must investigate the etiology of diseases and identify specific imaging markers of incipient diseases. Thus causes of pathologic alterations can be investigated and people at risk identified. EPI² will cooperate with Dutch and international medical, pharmaceutical and ICT-companies. The acquired data can be a source for industrial application in new products, processes and services.

In the next two years the e-science structure for data management and large-scale image data analysis will be created. The duration of the project is ten years.

12. Netherlands infrastructure for Translational Biomedical Research (EATRIS-NL)

Core facility: EATRIS-NL is closely connected with the ESFRI programme for translational research (EATRIS) with its headquarters in Amsterdam.





The mission of the Netherlands infrastructure for Translational Biomedical Research is to translate science into better healthcare. The facility supports translational imaging projects for early diagnosis, disease prognosis, treatment prediction and monitoring and image guided treatment (MR-HIFU, MR guided radiotherapy). The infrastructure will help to reduce the impact of diseases like cancer, cardio-vascular diseases and rheumatoid arthritis and improve the quality of life for those who must live with these diseases. The project will comprise implementation as well as fundamental research.

The aim of this facility is a fully operational and operating infrastructure with an optimal constellation of equipment and sufficient capacity for national translational needs. All University Medical Centres are involved and EATRIS is to be established as ERIC. The facility will set up a large distributed infrastructure of translational imaging facilities comprising state-of-the-art platforms for ultra high field MRI, PET-MRI, ultrasound and optical (fluorescence) imaging as well as image guided therapeutic platforms.

The infrastructure is indispensable for studies addressing major challenges in ageing populations, like degenerative diseases, cancer, cardio-vascular diseases and rheumatoid arthritis. There is also an urgent need for quality controlled imaging facilities to expedite drug development and the translation of ATMP’s (regenerative medicine, tissue engineering and stem cells). The Netherlands are coordinating one of the five product platforms within EATRIS, namely ‘imaging and tracing’. EATRIS facilitates academic imaging programs as well as an industrial leadership positions.

The completion of a fully functional distributed imaging infrastructure is foreseen in a period of five years. Parts of the infrastructure are already functional.

Jos Jonkers
Mouse Clinic for Cancer and Ageing research (MCCA)

New research on mice provides quicker answers to essential questions

"The mouse clinic will cause an enormous acceleration in the research on cancer, cancer therapies and ageing." Jos Jonkers, head of the department of molecular pathology at the Netherlands Cancer Institute, is eager to share the experiences of his lab. "The new technology that we have developed will bridge the gap between basic research and the clinical research in a hospital."

The Mouse Clinic for Cancer and Ageing research consists of an animal-testing laboratory and a tissue culture lab. The latter facility shows the biggest acceleration. Jonkers: "Cancer and ageing have multiple causes, an accumulation of genetic errors. For research, this complex interaction of mutations must be combined in *one* mouse. Our new technique enables us to very efficiently cultivate mouse stem cells from mouse stems that we have created in the past and which already contain a number of mutations that are important for tumour-growth. In these stem cells we can inject additional mutations; we want to study their effect on tumour-growth or therapy-response. Subsequently, we can transform the stem cells back into mice again by injecting them into a mouse embryo." In this way you immediately have the desired laboratory mouse instead of having to crossbreed mice endlessly. Thus far fewer mice are needed. "I am also very enthusiastic about the fact that young researchers can now work much faster. In the past they had to invest years in the creation of the appropriate mouse and still they had to hope for actual results. Now they can ask the essential questions *and* find the answers within their research period."

Mouse patient

The mice will be used in the animal-testing lab. "There we want to give them the exact same treatment methods as we do with patients in the hospital. So radiation, systemic intervention and imaging technology such as MRI and CT-scans. With the roadmap grant we can acquire all necessary equipment. For cancer research animal-testing is still necessary; 'in vivo' testing must be possible and not everything can be tested on humans. However, with the MCCA we also build a bridge to the work in practice. We perform research on the core mechanisms of cancer and therapy-resistance, but also on the clinical questions from the practice. Physicians who acquire experience with animal-testing in the MCCA will be better informed when performing experimental treatment on human patients."

Open to everyone

Jonkers has great ambitions. "Almost all our funding comes from charitable or public institutions. This can only be justified if you perform internationally competitive research. Research that really teaches you something about cancer. Our new technique in itself is wonderful, but what really makes me glad is that with this technique we can achieve things in a much shorter period of time. Patients who come to our hospital have no time. The clock is ticking. Therefore the MCCA is an open facility. Researchers from all over the world can use our stem cells or put a mouse in our animal-testing lab. This is the future of science: concentration of facilities in fewer sites that still maximally facilitate the Dutch and international research community. I am convinced that the MCCA will become a really strong hub!"

13. Netherlands Solid Earth Observatory (NSEO)

The NSEO focuses on the scientific base needed for a safe and sustainable global supply of geo-energy and indispensable geo-resources, and for improving public safety related to geo-disasters.

The NSEO comprises all Solid Earth scientists presently engaged at Dutch universities UU, TUD, VU, UT and RUG and at the research institutes of TNO, KNMI, NIOZ and NCB Naturalis. NSEO aims to establish the 'NSEO Facility'. NSEO combines the lead in observational, experimental and modelling capabilities which facilitate effective investigation of subsurface properties and processes with unprecedented detail and complexity. These capabilities are targeted at novel applications to geo-resources, -energy and –disaster research.

Integrating distributed facilities into the *NSEO Facility* boosts research innovation which will significantly improve the predictive power of experimental and modelling results for new energy- and resource exploration and exploitation. It will also provide a better understanding of the conditions and processes leading to (human-induced) geo-disasters, as for example in our country, where minor seismic, subsidence and other subsurface hazards are of an increasing importance with regard to natural gas extraction, underground CO_2 or gas storage, and the exploitation of geothermal energy.

NSEO is the Dutch contribution to EPOS (European Plate Observing System), which is on the ESFRI roadmap. NSEO research targets are also of strong relevance to research tasks and programmes of EuroGeosurvey. All observational, monitoring and experimental data of NSEO will be openly available through a national data infrastructure.
NSEO is intended as a structural and wide-based research infrastructure investment in Dutch and European Solid-Earth science with no specific end date.

Foto ondertekst: Some of the equipment used at the HPT Laboratory at Utrecht University for investigating the mechanical and transport properties of rocks and faults in the Earth's crust. Such technology is being applied to understand seismicity induced by production of natural gas and geothermal energy, and to understand natural seismicity, in collaboration with groups in the Netherlands and across Europe (EPOS).

14. Integrated Carbon Observing System - Netherlands (ICOS-nl)

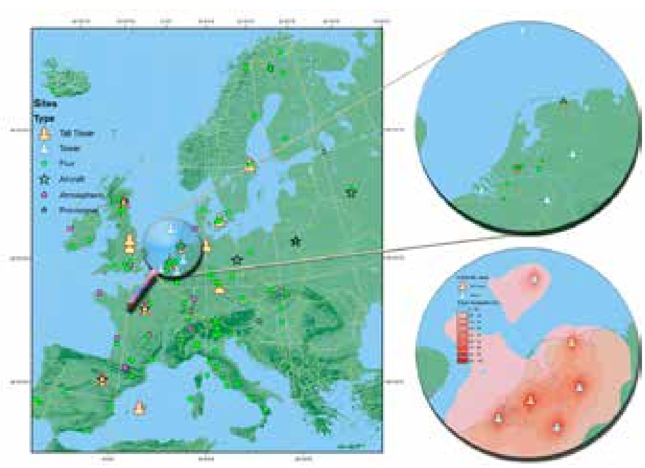
The ICOS-nl consortium consists of: VU, ECN, UU, SRON, WUR, RUG, KNMI, Alterra, EarthNetwoks and SensorSense.

ICOS is a distributed observation network to monitor the European carbon and net greenhouse gas balance. It consists of a large number of high precision observatories for greenhouse gas concentrations and exchange fluxes all over Europe and central facilities that process and integrate all data.

ICOS-nl will allow scientists to determine the development of CO2 sources and sink-strengths and atmospheric CO2 concentrations with unprecedented accuracy. Following the progress of emission reductions and changes in the (semi)natural fluxes of greenhouse gasses is essential to improve Earth System science and evaluate and develop climate-change abatement policies. The ICOS products will allow a better design of energy and agricultural systems to ensure availability of food, water and energy supplies. Clear visual products showing the development of carbon and greenhouse budgets of cities, regions, nations and Europe as a whole will raise public awareness to our responsibility towards a sustainable society.

A region like the Netherlands, being energy intensive and having high emissions, requires a dedicated and local network of observations and very high resolution modelling. ICOS-nl will provide exactly this. It will contribute directly to ICOS-EU that addresses the Climate Change societal Grand Challenge. An ICOS ERIC will be established in which 15 European nations participate.

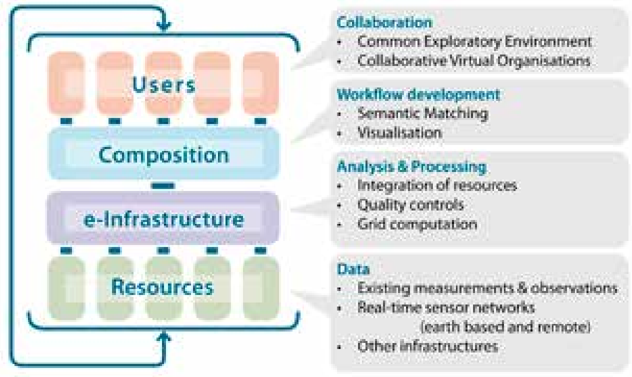
The ICOS ERIC will be setup in the middle of 2013. The ICOS Carbon Portal will then be defined and the construction of observatories will start. ICOS is planned to run for 25 years.



15. LifeWatch infrastructure for biodiversity and ecosystem research

23 Dutch partners from universities and research centres are involved in this European initiative. The Netherlands is hosting the LifeWatch IT Research and Innovation Centre.

LifeWatch is the European research infrastructure for analysing the dynamics of biodiversity and ecosystem functioning. It also contributes to innovative solutions for a sustainable use of our living environment. Modern technologies in remote sensing, genetic screening, GPS tagging and sensor networks make it possible to study the complexity and diversity of ecosystems in new ways. This allows us to research the stability and resilience of ecosystems in response to environmental change, to find new species in secluded forests or the deep oceans, to get a better understanding of the way in which migrating organisms travel across the globe and the ways in which organisms interact with their allies and enemies.



The facilities of LifeWatch and the exchange of data will support the creation of smart solutions to deal with urgent societal issues on food supply, land use planning, water availability and the impacts of global change. LifeWatch is developed as a part of ESFRI and to be established as ERIC. Currently, seven countries are participating and eleven more have expressed their interest in LifeWatch.

The LifeWatch Service Centre was inaugurated in June 2012. The Dutch projects for Virtual Laboratories are expected to start early 2013. The LifeWatch ERIC will be set up by the summer of 2013. After a construction phase of five years the research infrastructure is expected to be operational for an open-ended period.

16. Naturalis Biodiversity Center

Naturalis Biodiversity Center is a foundation established as a merger of the natural history institutes within Leiden University, University of Amsterdam, Wageningen University and the former National Natural History Museum, which closely collaborates with the Fungal Biodiversity Centre of the Royal Netherlands Academy of Arts and Sciences. Naturalis is based in Leiden.

Naturalis is a collection-based research infrastructure for systematic and biodiversity research, established in 2010. It has a top-class natural-history collection, considered to be the world's fifth largest. Naturalis is renowned for its research on the Tree of Life integrating the latest morphological and molecular knowledge. It is also a major natural history museum.

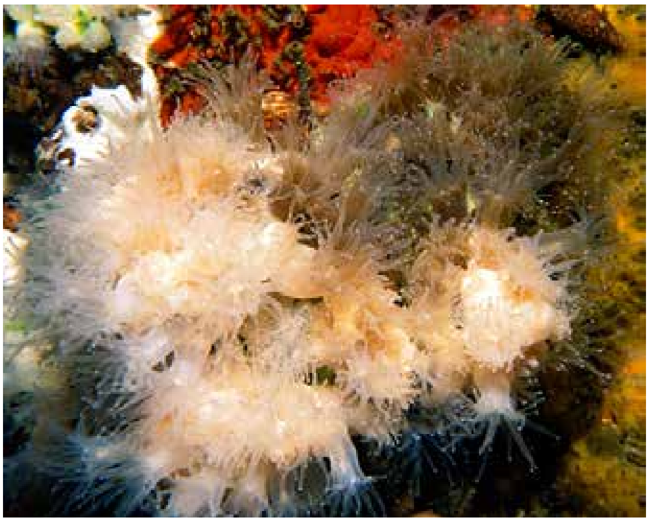
Naturalis aims to become an international centre of excellence for comparative morphological, taxonomic, phylogenetic, evo-devo and biogeographic research dedicated to reconstructing and understanding this Tree of Life. Naturalis is one of the founding members of the Consortium of European Taxonomic Facilities.

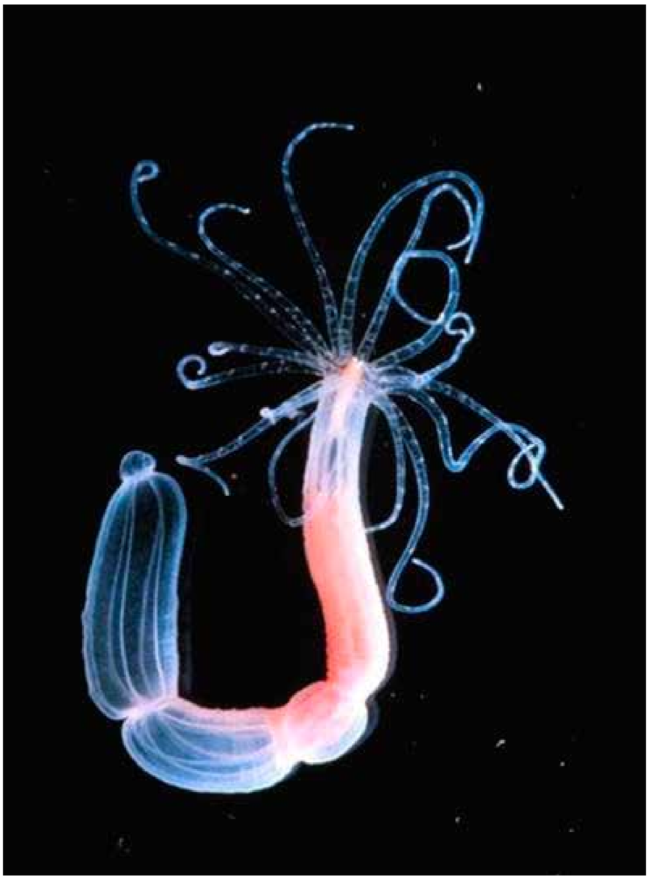
Naturalis preserves the largest Dutch natural-history collections of unique zoological, botanical, fungal and paleontological specimens. It will catalogue this by using state-of-the-art imaging and digital techniques and it will make its content accessible for researchers worldwide. It will attract top researchers to capitalize on its newly established high-quality laboratory-facilities (GIS, Biodiversity informatics, DNA barcoding). The knowledge of nature, taxonomy and biodiversity will help to utilize the power of Earth's natural resources for a sustainable, healthy society.

The scientific research within Naturalis has been reorganized with a major focus on an integrative approach, optimizing the utilisation of the scientific capacity. Naturalis plans to digitize 7 million of its specimens and to generate 60.000 DNA barcodes by the first half of 2015.

17. European Marine Biological Resource Centre - the Netherlands (EMBRC-NL)

EMBRC-NL is a cooperation of NIOZ, UvA, RUG and WUR.





Marine biological sciences are undergoing a major revolution with the consolidation of comparative, functional and ecological (gen) omics *sensu lato*, making marine models and ecosystems more attractive to the overall scientific community.

The EMBRC-NL will optimize opportunities for integrated excellent research and post-graduate education at the national and international levels as it prepares for integration into the EMBRC (to become ERIC in 2014-2024 and currently in the preparatory phase). EMBRC-NL will focus on a unique combination of marine (gen) omics data (transcripts, proteins, metabolites), bioinformatics capacity (including metagenomics and other derived approaches to reconstitute genomes, transcriptomes or proteomes of uncultivated organisms), access to selected marine model systems (prokaryotic culture collections, selected (macro)invertebrates, algae) and access to unique ecosystems (deep sea, Wadden Sea, tropics).

It will provide a unique infrastructural facility for studying species interactions at the "omics" level thereby enabling breakthroughs in global biogeochemical modelling (prokaryotic-eukaryotic) including community genomics and functional genomics of how organisms interact and affect (and are affected by) global change. EMBRC-NL will develop new knowledge and boost innovation in the areas of food, chemistry, health and natural products synthesis. Marine genomic knowledge has direct applications in the management of natural resources and protection of marine environment. Both on-site and remote access for collaborations and services are envisaged.

Becoming a member of EMBRC is essential to further competitiveness and opportunity within marine sciences Europe (e.g., ESFRI, EUROMARINE).

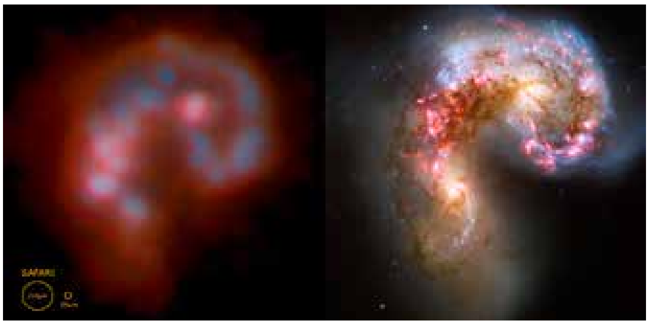
18. SAFARI Imaging Spectrometer on the SPICA space observatory

SRON Netherlands Institute for Space Research Groningen

SAFARI studies the basic process of the formation of celestial bodies, ranging from planets to stars and galaxies. This will result in a better understanding of the formation history of our own solar system and the universe. The far-infrared imaging spectrograph SAFARI on the Japanese space telescope SPICA will provide the most sensitive view ever of the cool, obscured universe. The faintest galaxies have a brightness of one ten-billionth of that what the human eye can see. Because of the extremely cooled mirror of SPICA and its ultra-sensitive detectors SAFARI can detect the very weak infrared emission from these galaxies.

SAFARI/SPICA is the next step after the Herschell mission. It will be able to look deeper into space than its predecessor. At the same time SPICA/SAFARI will complement the James Webb Space telescope and the ALMA radio observatory by closing the gap in the wavelength domain between these two. SRON scientists have developed the extremely sensitive Transition Edge Sensor (TES) detectors for SAFARI. These detectors, with their necessary support equipment, are too complex for commercial applications. However, the underlying technologies might well be applicable to, for example, medical applications or defence and security purposes. The SAFARI project is carried out by an international consortium led by SRON.

The project is entering its implementation phase that will result in the delivery of a fully tested instrument in 2019. The launch of the SPICA satellite with the SAFARI instrument is expected at the end of 2022.



Herschel-PACS (left) and Hubble images (right) of the colliding galaxy pair "the Antennae". Regions that are obscured in the Hubble image appear bright in the far-infrared. These are likely sites of massive star formation, triggered by the collision. SAFARI will provide a full 34-210 μm spectrum at every pixel (credit ESA / PACS / SHINING / U. Klaas & M. Nielbock, MPIA).

19. High Field Magnet Laboratory (HFML)

The HFML is jointly operated by the Radboud University Nijmegen and the Foundation for Fundamental Research on Matter (FOM). The HFLML is part of the Eureopean Magnetic Field Laboratory (EFML)

The highest magnetic fields are made with large installations of which there are only three in the world. The HFML magnets create extreme circumstances under which proteins, micro-electronics, new metals and synthetic fibres have to yield up their characteristics. Sometimes this leads to new physical phenomena. HFML can make fields up to 38T (45T in a few years' time). Furthermore, the HFML performs its own research and provides access to external guest researchers.

The HFML focus is fundamental research with an open eye for applications. Much of the HFML research in the last 20 years provided knowledge that is now used practically. At the highest fields often the latest discoveries are made in the earliest moments of material developments. Graphene research in the Netherlands started at the HFML of which previously Nobel prize winners Geim and Novoselov were staff members. Present research on topological insulator may be important for quantum computing.

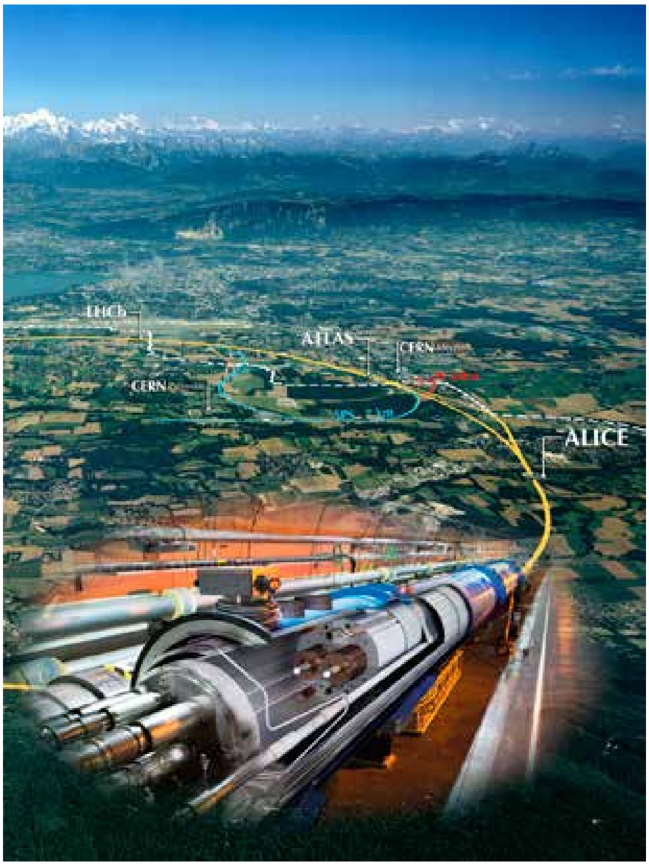
With the other European DC facility (Grenoble) and the pulsed field facilities in Dresden and Toulouse HFML is leading a project on the realisation of the European Magnetic Field Laboratory, based upon the collaboration of the four laboratories. Scientific excellence and attracting top researchers are the most important contributions to the formation of a European research area. The three partners have decided to found an International Foundation under Belgian Law (AISBL) in Brussels. EMFL can compete with the US based magnet laboratory and become a global player.

The official foundation of the EMFL AISBL is expected by the end of 2013.

20. Large Hadron Collider (LHC) detector upgrades

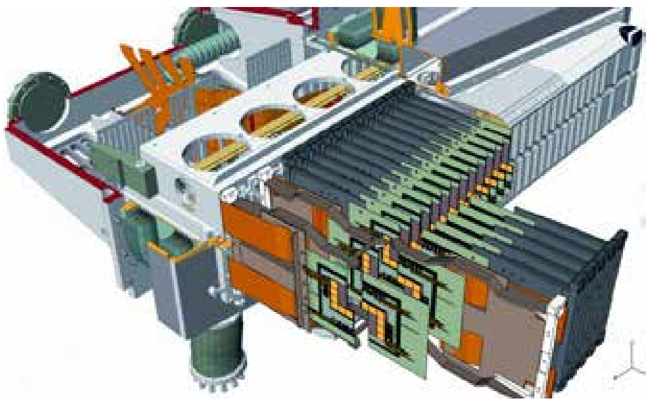
Coordinator of Dutch activities at CERN is Nikhef (National Institute for Subatomic Physics). Partner universities are UvA, RU, VU and UU.

The Large Hadron Collider (LHC) at CERN is installed in a 27 km circumference underground ring. Since 2009 two counter rotating beams of particles are being accelerated to world-record energies and subsequently they are made to collide. At four locations along the ring they are observed by huge particle detectors (ATLAS, ALICE, LHCb and CMS) to study elementary particles and their interactions. It already brought the exciting result of the first evidence of the elusive Higgs particle.



The roadmap project comprises the Dutch contributions to upgrades of the Large Hadron Collider experiments at CERN (involving ATLAS, ALICE and LHCb). The project aims at enabling LHC-detector upgrades (including the Dutch grid-compute centre NL/Tier-1). These upgrades heavily rely on state-of-the-art silicon-strip and -pixel technologies and fast electronics. The current valorisation comprises cooperation with Philips, technological start-ups and technology transfer to, for example, PANalytical, a supplier of analytical instrumentation.

Machine and detector upgrades in the second half of this decade should increase the discovery potential to investigate the features of the newly found Higgs particle. It can help to investigate the nature of the minute matter-antimatter differences, essential to explain the matter dominance in the universe. Furthermore it might contribute to the discovery of physics beyond the so-called Standard Model, the theoretical framework that describes observations but falls short in explaining the nature of the mysterious dark matter in the universe.



The duration of the roadmap project is: 2014-2021. The upgrades for LHCb and ALICE are expected to be installed in 2018, Those for ATLAS in 2020.

21. NanoLabNL

NanoLabNL consists of four locations in the Netherlands: Delft, Eindhoven, Twente and Groningen.

NanoLabNL is the Dutch national facility for nanotechnological research. It has open access and can be used by scientists and industry. Each year, on average, 100 companies use the facilities. NanoLabNL creates, maintains and provides access to a coherent, high-level, state-of-the-art infrastructure for nanotechnological research and innovation in the Netherlands. NanoLabNL brings about coherence in the national infrastructure, access and a tariff structure.

Each of the NanoLabNL locations offers a range of basic and expert techniques. The cleanrooms are used by companies, start-ups and academic users such as PhD students and postdocs. Their research is very diverse: From groundbreaking excellent research to new applications for future products that contribute to the Dutch economy.

NanoLabNL creates, maintains and provides access for nanotechnology research and innovation in the Netherlands. This excellent infrastructure ensures rapid growth of the number of spin-off companies. NanoLab NL is and remains a crucial factor for attracting, educating and keeping excellent scientists for groundbreaking research. The organisation is an integral part of the High Tech Systems and Materials (HTSM) top sector's Nanotechnology roadmap. It is an active partner in the European nano and facilities research area.

In order to keep a competitive advantage and a worldwide leading position NanoLabNL realizes a state of the art research infrastructure for nanoscience and innovation wich enables the Dutch nano future vision.

22. KM3NeT, Deep-sea facility in the Mediterranean for Neutrino Astronomy and Earth and Sea sciences

Forty institutes and university groups worldwide constitute the KM3NeT consortium. Participating parties in The Netherlands are Nikhef, NIOZ, UvA and UL.

KM3NeT is a deep-sea research infrastructure hosting a neutrino telescope. The telescope has a volume of several cubic kilometres and is to be constructed in the Mediterranean Sea. An array of thousands of optical sensors will detect the faint light in the deep sea from charged particles originating from collisions of the neutrinos and the Earth. Unlike traditional telescopes, KM3NeT will detect neutrinos instead of light. In sky coverage the KM3NeT infrastructure complements the currently largest neutrino telescope, IceCube and surpasses it in sensitivity.

The detection of neutrinos from the cosmos will help with the study of the origin of cosmic rays, the mechanism of astrophysical particle acceleration and the birth of relativistic jets in the universe. The primary goal is the discovery of neutrino point sources in the Milky Way. KM3NeT will establish neutrino astronomy as a new, viable and exciting field of research.

The KM3NeT infrastructure will also be used by Earth and Sea scientists to perform long-term measurements in the deep sea. The wealth of data that will be collected offers a rich source for analyses that will lead to new insights in astro-particle physics, astronomy, oceanography, seismology and climate research.

KM3NeT is currently evolving from a consortium to an ERIC. The KM3NeT project has entered phase-1. The funding for the next phase(s) has not yet been secured. After the construction has been completed, it is intended to operate the infrastructure for a minimum of 10 years.

"The KM3NeT optical module.
The telescope will consist of more than 10,000 of such modules. Each module consists of a glass sphere with a diameter of 42 cm, housing 31 photo-multiplier tubes. The glass sphere can withstand a pressure of up to 600 bar and is transparent for the faint light that must be detected to see neutrinos from the cosmos. The umbrella at the top provides cooling for the electronics inside."

23. Square Kilometre Array (SKA)

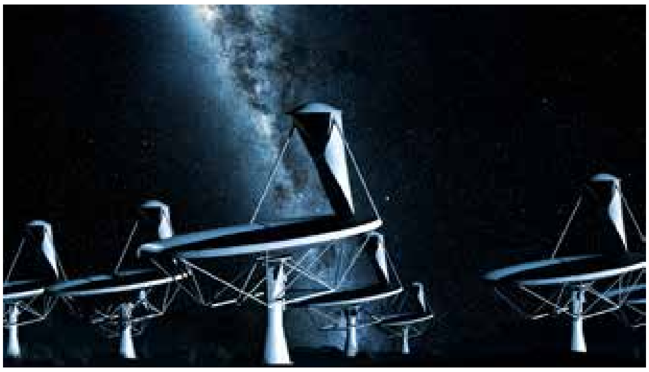
The SKA Organisation is based at Jodrell Bank Observatory, 30 km South of Manchester, UK. The project is an international partnership; 67 organisations from 20 countries including the Netherlands participated in the preparatory phase.

The Square Kilometre Array (SKA) will be the largest radio-telescope of the world, with antennas in Southern Africa and in Australia. The SKA uses new approaches in antenna technology, high-tech systems and information processing. The SKA extends European radio telescopes (WSRT, LOFAR, the European VLBI Network) and is complementary to large optical telescopes (VLT, ELT).

The SKA will be the first telescope to image the phase in the early Universe when stars and galaxies started to form. Furthermore, the SKA will trace such a large network of pulsars that gravitational waves can finally be detected. This research will have a huge impact on our understanding of the formation of the Universe and of the fundamental laws of physics. It will enable the study of how galaxies have evolved since the formation of the Universe, investigate the role of magnetism in the cosmos, the nature of gravity and search for life beyond Earth.

The technology for the SKA will realise further breakthroughs in the field of high-tech systems and ICT. For example in the Netherlands, ASTRON and IBM are using the SKA as a target to develop technologies for green supercomputers, new models of data-centric information processing and nano-photonics.

The SKA project is currently in the pre-construction phase. The start of construction of the first phase (SKA1) is planned for 2016. SKA1 should be operational in 2020 and full operation of the second phase is planned for 2024.



24. European Extremely Large Telescope (E-ELT)

Main partner for the Netherlands: NOVA, (Nederlandse Onderzoekschool Voor Astronomie), a collaboration of the astronomical institutes of the Universities of Amsterdam, Groningen, Leiden and Nijmegen

The European Extremely Large Telescope (E-ELT) is a 39.3 metre diameter telescope optimized for optical and near-infrared wavelengths. The E-ELT will be the world's biggest eye on the sky. It is a revolutionary new ground-based telescope concept and will be the largest optical/near-infrared telescope in the world.

Extremely Large Telescopes are considered worldwide as one of the highest priorities in ground-based astronomy. The E-ELT will allow astronomers to advance their knowledge via detailed studies of a wide range of objects. This includes planets around other stars, the first objects in the Universe, matter very close to super-massive black holes, and the nature and distribution of the dark matter and dark energy, which dominate the content of the Universe.

The E-ELT will tackle the biggest scientific challenges of our time and aim for a number of notable 'firsts', including characterizing and maybe imaging Earth-like planets around other stars in the 'habitable zone' where life could exist. In addition, astronomers will also be prepared for the unexpected — new questions will surely arise from many new discoveries to be made with the E-ELT.

Besides scientific discoveries, the advanced scientific instruments will allow the industrial partners who are involved in the design and construction of the instruments and parts of the telescope, to also enhance their expertise and capabilities in numerous state-of-the-art technologies. This provides the perfect ground for innovations. Furthermore, being the first ones to use the instruments will enable Dutch scientists to take a lead in exploiting the new discoveries.

Construction is likely to start in 2013, and regular astronomical observations will commence in 2022-2023.

Jan Kees Maan
High Field Magnet Laboratory (HFML)

The world's strongest magnets unravel surprising characteristics of matter

"The funding that we receive from the roadmap makes the difference between participating in the margin and being a genuine international player." These are the words from professor Jan Kees Maan, director of the High Field Magnet Laboratory (HFML) in Nijmegen. The lab is unique; nowhere in the world it is possible to generate continuous high magnetic fields for such a long period of time. Research resulted in pioneering innovations and produced Nobel Prize winners such as Andre Geim and Konstantin Novoselov. "I am proud that researchers are not only attracted by the availability of the magnets but also by the people who work here and the insights and techniques that we offer them."

The HFML magnets create extreme conditions under which proteins, micro-electronics, new metals and synthetic fibres have to yield up their characteristics. Most labs can measure up to 18 tesla, while in Nijmegen even measuring up to 38 and 45 tesla will soon be possible. "The higher the magnetic fields , the more visible the effects on the behaviour of matter. So, what we do is always at the beginning of the discovery of the latest materials such as graphene that was tested here by Geim and Novoselov." New applications often result from the expertise of the own employees. "For example we discovered how molecular systems with only one direction of rotation can be made, such as DNA or citric acid. This is important because in the other direction citric acid becomes toxic."

Doing research in the spur of the moment

While gesticulating enthusiastically Maan describes how real discoveries are made. For example during the research on graphene. "Normally we measure at extremely low temperatures. In a spur of the moment we decided to do quantum oscillations at room temperature and it was successful. Such an important discovery you only make by trying things and that is how we earned our reputation." The roadmap allows the HFML to further continue this research. "At present we can do fundamental research and withdraw from the issues of everyday life. The roadmap is of great importance for the scientific status of the Netherlands. The HFML is a good example; worldwide there are only three other places where comparable conditions can be created."

Magnets and cellular phones

The question, from a granting institution, of the practical applicability of the scientific research is one that Maan understands well. Every inch a scientist he once took up physics in order to understand the world. "Physics is universal, both on Jupiter and on Earth. This is really fascinating. However, practical applications are important, you also want to apply your knowledge." In later phases much research at the HFML often results in important practical applications. "For example, the electronics in our cellular phones finds its origin in research of high magnetic fields in the eighties. There can easily be a gap of ten years between such research and the application. We are an 'enabling platform', the industry uses our findings for further development."

25. An ultra-high field NMR facility for the Netherlands (uNMR-NL)

uNMR-NL is a collaboration between Utrecht University, the Radboud University Nijmegen, Leiden University, Wageningen University, the Eindhoven University of Technology and TI-COAST.

Nuclear Magnetic Resonance (NMR) spectroscopy and imaging (MRI) exploit the magnetic properties of atoms. NMR is used to understand diseases, to discover new medicines, to develop new materials, for example for batteries and solar cells, and to improve crop production and food quality. The uNMR-NL facility will be set up including new magnets that are stronger than were ever used before, opening entirely new avenues for research.

The enhanced sensitivity of these new magnets makes possible the analysis of smaller samples. It also improves the resolution of the NMR spectrum, enabling more complex samples to be analysed. By offering 'beyond-the-state-of-the-art' magnetic resonance spectroscopic and imaging capabilities, the facility will allow for ground-breaking cutting-edge basic research and applications. It addresses the societal challenges that are defined by the European Union as part of the Horizon 2020 programme, especially those that focus on health, food, energy and materials.

uNMR-NL forms a unified infrastructure for the Netherlands with a high flexibility to support the national and European science agenda. For example, international access to the facility will be offered through current and future EU funded infrastructure programmes and the ESFRI roadmap project, Instruct, for integrated structural biology.

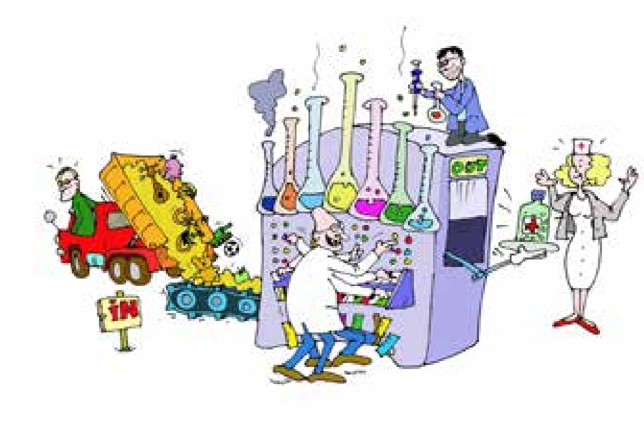
The first research is expected to start at the end of 2013 with a temporary NMR instrument. Between 2015 and 2017, the installation of the final 1.2 GHz NMR spectrometer is planned. Both systems will be installed at the NMR facility of Utrecht University that has already served as an NMR infrastructure on the national as well as EU level. The project will be completed in 2019, but the Dutch analytical sciences expect to benefit from the facility far beyond that time.

26. A Dutch small molecule screening and hit optimisation facility for the translation of biomedical research findings (NL-OPENSCREEN)

Core facility: Leiden University (representing parties from RUG, RU, UU, UvA, VUA, TUE, Pivot Park and NKI).

NL-OPENSCREEN is a facility for the translation of biomedical applications into research reagents and small molecules of therapeutic value. The intended facility will offer services for high throughput screening and medicinal chemistry to provide novel research reagents and to help tackle unmet medical challenges.

NL-OPENSCREEN aims to develop a shared infrastructure in which materials (compound collections, screening robotics) are available to any interested party. The facility will also capitalize on the knowledge and expertise from initial findings for drug development programmes. The altered drug development landscape induced NL-OPENSCREEN to a different approach of this area of research. The activities of NL-OPENSCREEN are aimed at bridging the gap between chemistry and life sciences with novel research reagents. Therefore NL-OPENSCREEN connects to the Dutch top sector Chemistry and the top sector Life Sciences and Health.



Made by Eric Reits

NL-OPENSCREEN will facilitate the translation of basic life science findings into research reagents and future therapies. Future innovations in drug discovery and development will require close collaboration between different disciplines, from different institutes, both public and private. Similar developments are in progress in other countries. EU-OPENSCREEN aspires to become a compound screening and lead optimisation centre by bringing together national centres, including NL-OPENSCREEN.

Like the larger EU-OPENSCREEN consortium the Dutch facility is in a preparatory phase. EU-OPENSCREEN is preparing for the establishment of an ERIC governance structure.

27. Netherlands Centre for Electron Nanoscopy (NeCEN)

Core facility: Research facility of Leiden University. Eleven academic institutions in the Netherlands are involved in NeCEN.

NeCEN offers all research institutes and companies access to two advanced cryo-transmission electron microscopes. The NeCEN microscopes have been specifically designed to explore complex structures inside cells with great detail. The centre is specialized in biological research.

NeCEN offers two main aspects of cryo-transmission electron microscopy. One of the microscopes has been optimised for visualizing cellular structures in 3D with nanometre precision (tomography). The other microscope has been equipped for analysing single particles with even more detail (near-atomic resolution has been reached). Cryo-transmission electron microscopy (cryo-TEM) allows scientists to observe proteins and organelles in a near-native state. The microscopes are 4 metres tall and are remote-controlled.

Electron microscopes can generate much more detail than light microscopes, because an electron beam has a much shorter wavelength than light. The resulting images give new detailed information on cellular and molecular structures. The results of this research can thus have a large impact on humanity. With this technology individual atoms have already been distinguished in a virus. Visualizing these details is the first step towards understanding how diseases work and hence its potential cures. Examples are tuberculosis, malaria and cancer. The centre is expected to lead to many different applications, including faster and better developing of methods to diagnose, cure and prevent diseases.

The Titan Krios transmission electron microscope (TEM) is tailored for use in protein and cellular imaging. Cryo techniques preserve sample integrity by maintaining the sample in its natural condition and state. The Titan Krios is the most powerful and flexible high resolution electron microscope for 3D characterisation of biologicals samples. The new digital user interface gives the freedom to operate the Titan Krios remotely in ambient, normal light conditions, or even from a different city.

NeCEN has been fully operational since the summer of 2012.

28. Netherlands Silicon Solar Cell Laboratory

NLSiSCL is a cooperation of ECN, FOM-AMOLF and TUD-DIMES

The Netherlands has a globally leading position in silicon photovoltaic technology. Over 50% of all solar cells produced worldwide have Dutch technology inside. To maintain this position, new investments in research infrastructure are essential. NLSiSCL will therefore establish a new national solar energy research laboratory for the development of new device and fabrication concepts for wafer-based silicon solar cells and modules.

The facility brings together laboratories for advanced silicon photovoltaics (PV) at ECN, FOM-AMOLF and TUD-DIMES. Photovoltaics based on silicon wafers is the dominant technology in the global market. However, for silicon PV to serve the world at a terawatt scale, key improvements in efficiency and a further reduction in fabrication costs are necessary. This is possible by introducing new designs, processes and materials, especially based on nanotechnology.

NLSiSCL combines new insights in nanophotonics and nanoelectronics gained by FOM-AMOLF and TUD-DIMES with ECN's expertise in device integration and industrial process technology. This can lead to breakthroughs in high-efficiency, low-cost silicon solar cells and modules, with efficiencies above 25% and costs well below € 0,5 per watt-peak. The latter is a reduction by 30-50% compared to state-of-the-art.

NLSiSCL has been integrated in the Innovation Contract Solar Energy, but still lacks most of the funding required. It fits in with the Solar Europe Industry Initiative, which is part of the EU Strategic Energy Technology Plan. Establishment and initial phases of operation are expected to run until 2018.

Appendix I:
References

For more information on the current status of large-scale research facilities:

- http://www.nwo.nl/en/research-and-results/programmes/National+Road+Map+Large-scale+Research+Infrastructure

For more information on European Strategy Forum on Research Infrastructures (ESFRI) and the European roadmap

- http://ec.europa.eu/research/infrastructures/

Reports:

Rathenau Instituut (2008) 'Groot in 2008 – Momentopname van Grootschalige Onderzoeksfaciliteiten' (in Dutch)

- http://www.rathenau.nl/publicaties/publicatie/groot-in-2008-momentopname-van-grootschalige-onderzoeksfaciliteiten.html

Rathenau Instituut (2009) 'Investeren in onderzoeksfaciliteiten – prioritering, financiering, consequenties (in Dutch)

- http://www.rathenau.nl/publicaties/publicatie/investeren-in-onderzoeksfaciliteiten-prioritering-financiering-consequenties.html

Technopolis Group (2011) 'The role and added value of large-scale research facilities'

- http://www.technopolis-group.com/resources/downloads/reports/1379_Report_Large-scale_Research_Facilities_EN.pdf

Advice from the Governing Board of NWO on the Netherlands' Roadmap for Research Infrastructure (2012)

- http://www.rijksoverheid.nl/documenten-en-publicaties/rappoten/2012/03/02/advies-van-de-nederlandse-organisatie-voor-wetenschappelijk-onderzoek-over-de-nederlandse-roadmap-grootschalige-onderzoeksfaciliteiten.html

Appendix II:
Assessment Criteria

The proposals were assessed on the basis of the following eleven criteria:

1. *The likelihood of scientific breakthroughs (science case)*
   Innovation is dependent on scientific breakthroughs. If major investments are to be made in research facilities, those facilities should produce a greater likelihood of scientific breakthroughs in the research field concerned, or at least aid in that process.

2. *The potential for 'brain gain' (talent case)*
   Top research talent is essential to any knowledge-driven economy. Highly talented researchers will only come to the Netherlands – or remain here – if they are offered an attractive and challenging working environment. Advanced research facilities are vital in this respect.

3. *Social and commercial relevance (innovation case)*
   Research facilities are necessary for business and industry and for innovative public bodies. Large-scale research facilities act as a magnet for new knowledge and expertise, creating an excellent climate for companies both large and small. To maintain broad public support in the Netherlands and the wider European Union, especially as regards additional funding, it is important that such facilities should, wherever possible, reflect the *top sectors* designated by the present Dutch government and current hot *social issues* in the Netherlands and Europe at large.

4. *Collaboration and competition (partnership case)*
   Large-scale research facilities are embedded in wide-ranging networks. Research at such facilities is conducted via national and international networks. Moreover, facilities with a large critical mass ensure synergy between knowledge workers. The establishment of a large-scale facility calls for effective agreements between the partners (in the Netherlands and elsewhere), reached via a governance and management model.

5. *Financial aspects (business case)*
   Innovation costs money. The cost of bringing a facility of international importance to the Netherlands and operating it here, or of participating in an international research facility outside the Netherlands, will exceed the available budgets. Careful budgetary analysis is, therefore, essential.

6. *Technical feasibility/technical challenges (technical case)*
   Since new facilities inevitably involve risks, it is important to know whether it is technically possible to construct the proposed facility. It is also a good idea to estimate the technical challenges because these may constitute additional reasons for or against embarking on the establishment of the facility.

7. *Possible focus for the Netherlands*
   The following questions will be asked:
   a. Is the Netherlands an international leader in the field concerned?
   b. Can the Netherlands achieve a unique position in this field or part of it?
   c. Even if foreign research groups are the international leaders in the field, are there reasons to invest in the proposed facility and so to enter into competition with them?

8. *Critical mass*
   Large-scale research facilities exist mainly to serve the needs of researchers. This means that investment needs to be focused on facilities in those fields where the Netherlands has a good supply of top researchers, both as regards quality and numbers. It also means that there must be guaranteed access to the facility for external researchers. The results of recent external assessments should also show that Dutch research groups are international leaders in their fields.

9. *Embedding*
   Large-scale international research facilities need to be financially and institutionally embedded within the Dutch knowledge infrastructure. This also applies to large-scale international research facilities in which the Netherlands does not play the leading role. Such institutional and financial embedding can be demonstrated by, for example, the concentration of research groups within the Netherlands, the presence of Dutch research groups within European networks, and the investment made by Dutch government authorities in the relevant research field, for example through the Economic Structure Enhancement Fund (FES).

10. *Proven willingness to collaborate*
   The large-scale research facility must strengthen collaboration between the Dutch research groups concerned in the relevant field of research. To achieve this, it is essential that the facility is properly managed and cooperation well-organized. The research groups concerned can confirm their will to collaborate financially as well as otherwise by earmarking a certain percentage of their research budget for the operation of the large-scale research facility concerned.

11. Reflection of social trends

It is important to pay attention not only to scientific and economic aspects but also to national social developments and trends. This can be done by, so far as possible, reflecting present/future policy frameworks and scientific priorities in the Netherlands and the European Union.

Appendix III:
Roadmap projects and their European counterpart

Roadmap Project	European counterpart
Next steps for the National e-Infrastructure for Research	-
Mouse Clinic for Cancer and Aging research (MCCA)	INFRAFRONTIER (and EMMA)
Proteins@Work; A large-scale proteomics research facility for the life sciences	INSTRUCT
Towards a consolidated Dutch Biobanking Hub, integrating the Dutch Biobanking Infrastructure in the European ESFRI Roadmap	BBMRI
NL-BioImaging Advanced Microscopy	EuroBioImaging
Systems Biology Natural Technology Facility	ISBE
Population Imaging Infrastructure in the Netherlands (EP12): A node of EuroBioImaging	EuroBioImaging
EATRIS-NL: Shaping the Netherlands' Infrastructure for Translational Biomedical Research	EATRIS
Netherlands Solid Earth Observatory (NSEO)	EPOS
Integrated Carbon Observation System Netherlands (ICOS-NL)	ICOS
LifeWatch	LIFEWATCH
Netherlands Center for Biodiversity Naturalis (NCB)	-
The European Marine Biological Resource Centre Netherlands (EMBRC-NL)	EMBRC
The SAFARI Imaging Spectrometer on the SPICA space observatory; revealing the origins of the universe, from planets to galaxies and beyond.	ESA
High Field Magnet Laboratory An international research facility for Science in High Magnetic Fields in the Netherlands	EFML
Dutch contributions to the detector upgrades of the Large Hadron Collider experiments at CERN	CERN
NanoLabNL	-
KM3Net: The next generation neutrino telescope	KM3Net
The Square Kilometre Array (SKA)	SKA
Instrumentation for the E-ELT	E-ELT
An ultra-high field NMR facility for the Netherlands (uNMR-NL)	INSTRUCT
NL-OPENSCREEN	EU-OPENSCREEN
Netherlands Center for Nanoscopy (NeCEN)	INSTRUCT
Netherlands Silicon Solar Cell Laboratory; Exploring the Frontiers of Silicon Photovoltaics	-
The Generations and Gender Programme: A Large-Scale, Longitudinal, Comparative Database for Social Science Analysis	The Generations and Gender Programme (design study under FP7)
SHARE – Survey of Health, Ageing and Retirement in Europe	SHARE
European Social Survey in the Netherlands (ESS-NL)	ESSurvey
CLARIAH - Common Lab Research Infrastructure for the Arts and Humanities	CLARIN and DARIAH

Colophon

This is a publication of the Department for Research and Science Policy (OWB) of the Dutch Ministry of Education, Culture and Science.

Coordination OWB: Iris Binken, Richard Derksen and Jeannette Ridder-Numan
Edited by: Tekstkeuken, Delft
Designed by: VijfKeerBlauw
Photography (interviewees): Martien de Man Photography
Printed by: VijfKeerBlauw

Edition: February 2013

E-mail: e.m.vanderwenden@minocw.nl
j.w.a.ridder@minocw.nl

February 2013 | Publicatie-nr. O24-614818