



Planetary Science and Exploration in the Netherlands: a vision for 2011-2016

Nationaal Platform Planeetonderzoek (NPP) strategy document

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Introduction

In 1655 Christiaan Huygens discovered Saturn's moon Titan. In January 2005 ESA's Huygens probe made a soft landing on Titan, one of the greatest technological and scientific success stories in modern planetology. In that same year, planetary science was not well-developed in The Netherlands, in sharp contrast to the mature fields of astronomy and the Earth sciences.

This situation has changed drastically over the past 6 years. A vibrant multidisciplinary planetary research community has been established in the Netherlands, making use of many recent technological advances to explore objects within our Solar System by orbiters and landers in addition to traditional Earth-based telescopes. Driving forces for the re-birth of a small but increasingly influential planetary science community include the establishment of a dedicated NWO Planetary Science User Support Programme (GO) as well as a Principal Investigator Preparatory Programme (PIPP), and the awarding of several prestigious national and European research grants to individual scientists. The DutchMars programme now funds national participation of planetary scientists in ESA's ExoMars mission. In parallel to these developments in planetary science research, several universities have developed BSc and MSc level courses specifically focussing on planetary science.

The Nationaal Platform Planeetonderzoek (NPP), founded in 2004, brings together Netherlands-based planetary scientists and engineers from universities and institutes including SRON, TNO, NLR, and JIVE, representatives from the Dutch space industry, and the Netherlands Space Office (NSO). The NPP has been highly instrumental in optimising communication and collaboration between these different stakeholders, and has helped in taking planetary science in the Netherlands to its current position.

As we approach the end of the first 5 years of the Planetary Science User Support Programme it is time to take stock of the Platform's current position, and set our goals for the future. This document provides a brief overview of the current status of planetary science activities in the Netherlands and sets out the NPP's vision for Dutch planetary research over the next five years. This vision focuses on further strengthening Dutch planetary science and its relation with planetary science missions, touches on improvements to be made to the internal organisation of the NPP, and includes plans to expand the platform's activities in the areas of education and outreach.

Current status of Planetary Science and Technology in the Netherlands

Planetary science and technology activities have grown rapidly over the past years. Dutch planetary scientists are now actively involved in ESA's flagship ExoMars mission (specifically the Life Marker Chip and Raman instruments), and are planning for direct involvement in future ESA missions to Mercury, Venus, Mars and Phobos, the moons of Jupiter, the Saturn system, and to Earth's Moon. Significantly improved funding opportunities through the Innovational Research Funding Scheme (Vernieuwingsimpuls), EC FP7 and ESF, DutchMars, Planetary Science User Support (GO) and Principal Investigator Preparatory (PIPP) programmes have led to a rapid growth of planetary science and technology activities over the past five years. Biologists, chemists, Earth scientists and astronomers have initiated interdisciplinary collaborations related to context-of-life studies; the Netherlands has become an affiliate member of NASA's lunar science institute, with a very broad team including members from the Dutch space industry, scientists from ESA, radio-astronomers, and particle physicists; and Netherlands-based planetary scientists and space industry are actively planning for direct involvement in instrumentation as well as data interpretation for future ESA missions including EJSM, ESA Lunar Lander, as well as missions planned by Russia, China, and the US.

The embedding of planetary science in universities and institutes has also improved markedly. (Honorary) professorships in planetary science are now filled at VU University Amsterdam and TU Delft, and Utrecht University Earth science staff now includes a UHD position focused on planetary science. The new SRON Earth and Planetary Science (EPS) division (recently renamed from 'Earth-oriented Science' to include its planetary activities) has developed a clear focus on (exo)planetary atmosphere research, collaborating actively with universities and financially supporting a 0.1 fte professorship at TU Delft. JIVE, located in Dwingeloo, spearheads radio astronomy applications for planetary science and exploration. Approximately 20 ALW-funded PhDs and postdocs are active in planetary science in the Netherlands. In the area of undergraduate teaching, UU, TUD and VUA now all offer planetary science courses for both BSc and MSc students, with staff from all universities and SRON collaborating by teaching parts of each others courses, and the ESTEC campus hosting an increasing number of work placements at both the BSc and MSc level.

Although planetary science in the Netherlands has grown significantly compared to 2004, the total number of scientists active in planetary science is still relatively small (approximately 40 including postdocs / PhDs). It is also clear that at the level of permanent staff, most university-based scientists do their planetary research 'part-time' – i.e., their job descriptions do not explicitly include developing and maintaining activities in planetary science. Furthermore, the range of topics covered by NL-based planetary science is extremely broad, from the detection, atmosphere characterisation and interior evolution of exoplanets, via the measurement of isotopic evidence for the activity of microbes on Mars, to the deformation of the crust of Europa and the composition of lava on the Moon, to constraining the diagnostics of planetary atmospheres and interiors by means of radio-astronomy tracking of planetary probes. This makes the research field vulnerable with respect to long-term viability on the one hand, but can equally be considered as a strong point: Due to the limited geographical distribution and manageable size of the community interactions are easy and communication lines (amongst scientists and between scientists and the Netherlands Space Office, for example) are very short. In addition, the breadth of Dutch planetary science research makes us extremely agile with respect to new developments in the field, especially where these new developments require an interdisciplinary approach.

Vision for the next five years

1. Planetary Science

Given the current national status of planetary science and technology sketched above, and international developments including the US Planetary Science Decadal Survey released in March 2011, we have identified the following aims for planetary science in the Netherlands:

Strive for continuation of the user support programme. The Dutch community firmly believes that the Planetary Science User Support Programme has revolutionised Dutch activities in the area of planetary science. Out of virtually nowhere, the national community has shown that it is capable of instigating novel planetary science research at the highest level – all the more remarkable since Dutch scientists do not have a long tradition in being actively involved in space mission instrumentation for planetary research. To guarantee that critical mass is retained in planetary science it is essential that the User Support Programme remains in place. The 'open competition'-type programme, which has clearly led to huge improvements in both the international status of Dutch planetary science and in the national infrastructure in the field over the past 5 years, is vital for the development of innovative ideas that have the potential to be world-leading in the next 5-10 years. All NPP planetary scientists stress the importance of the freedom this programme provides. The fact that the User Support Programme does not strongly limit the choice of planetary research topics enables innovative research directions, and provides optimal opportunities for young scientists, also when compared to programmes available for international colleagues. There is a strong feeling in the national community that without the freedom provided by this dedicated 'open competition'-type programme, and in light of the scarcity of alternative funding programmes, it is likely that university-based staff will refocus on Earth-science, biology or chemistry-related research that many used to pursue before expanding into planetary science.

Further strengthen collaboration between science and technology stakeholders. Planetary scientists in the Netherlands are very keen to collaborate more intensively with Dutch technological institutes and industry in the area of instrument development for planetary science missions. Scientific involvement in planetary science instrumentation (e.g. LMC, Raman-LIBS, SPEX) and method development (e.g. Very Long Baseline Interferometry, VLBI) have improved markedly over the past 5 years, but strengthening the interrelationship between national science and technology stakeholders remains one of the top priorities of the NPP and its members. The collaboration between science and industry is highly valuable (and an excellent example of the public-private partnerships that the current government is keen to promote). Finding the optimal balance between scientific arguments and industry stakes is crucial. One of the NPP's aims in the coming years is to position planetary science as the main driving force for future technology development and mission activity. Close collaboration with NSO will be required to achieve this goal.

Expand the research community. Planetary science activities in the Netherlands are currently predominantly undertaken by Earth-and-life scientists, embedded in the ALW area of NWO, with the exception of (exo)planetary atmosphere research, which has strong ties with astronomy and is predominantly financed through the NWO area EW. The NPP aims to actively engage chemists, astronomers, and physicists active in the EW and CW areas of NWO. Some steps in this area have been taken (e.g. the incorporation of radio-astronomers and astrophysicists into the Netherlands NASA Lunar Science Institute team), but more cooperation is required to advance Dutch planetary science. Our aim to broaden the science community is reflected in the contents of the thematic research theme introduced below.

Instigate a thematic NWO-funded research programme. Prior to elaborating on the focus of a thematic research programme, it is important to clarify that the planetary science community argues strongly against *replacing* the current User Support Programme (GO) by any thematic programme. As detailed above, the 'open competition' character of GO is invaluable for the national community. A February 2011 workshop at NWO showed broad and strong support from the Dutch planetary science community for the idea of setting up an interdisciplinary, thematic planetary science research programme *in addition*

to the GO programme. Below we sketch the contours of what the focus of such a broad programme could be. The planned activities complement and extend very nicely several current activities of the NWO areas ALW, EW and CW. Because of this we hope that NWO will support setting up a thematic programme. We note that instigating such thematic research would greatly increase the visibility of Dutch planetary science internationally, enabling more direct involvement of NL-based scientists in future planetary science missions and improving the possibilities of involvement in new space-related EU research programmes.

At this emerging stage in the development of planetary science as an interdisciplinary research force in the Netherlands, it is essential to support a research theme that is focused enough to be able to make real scientific progress, while being broad enough to include as much of the Dutch scientific expertise as possible. A theme entitled 'Planetary evolution and habitability' seems to us to be a perfect theme to pursue, for four main reasons given below:

1. Virtually all (exo)planetary science missions that will be launched in the coming decade, whether by Europe, the US, Russia, China, India, or Japan, intend to deliver scientific data that will be key to answer some of the main questions related to the theme of habitability, and habitability's link with local and global-scale planetary evolution processes. Starting a research theme now could put the Netherlands in a prime position to interpret these data as they become available, in particular because the relatively new and close-knit Dutch community has a real opportunity to focus on tackling interdisciplinary scientific questions related to the theme.
2. The vast majority of NL-based scientists active in planetary science, ranging from astronomers to chemists to biologists to Earth scientists, are actively performing research related to this theme. Increased funding levels are needed to sustain this effort. Basing funding around this theme would therefore make full use of the breadth of the national scientific strengths, and vitally give added impetus to improving interdisciplinary research within the Netherlands.
3. Dutch scientists and Dutch industry will be actively participating in ESA's flagship ExoMars mission. There is a key Dutch contribution to the Life Marker Chip instrument, and there is Dutch scientific involvement in the Raman instrument. Both instruments will focus on measurements that are intended to improve our scientific knowledge in the area of the proposed theme. In addition to these scientific goals, there are clearly enormous opportunities for outreach and education activities at all levels related both to the specific Dutch contributions to this mission and to planetary science in general.
4. In addition to the instruments mentioned under (3), main planetary science instruments and methodologies being developed in the Netherlands at this moment in time are all ideally suited to deliver data that are directly related to this theme. For example, the SPEX instrument has been selected by CAST (Chinese Academy of Space Technology) as a candidate payload for a Chinese Mars mission in relation to this theme.

Even in the area of human space flight this theme would be of great importance, relating to habitability for humans during future prospective missions to the Moon, near-earth objects, Mars and its moons. In addition, the theme fits perfectly into both the aims of ESA's exploration programme and all three key research themes identified in the US Planetary Science Decadal Survey (i.e., understanding solar system beginnings, searching for the requirements for life, and revealing planetary processes through time). A strong interdisciplinary research effort related to this theme would lead to a significant strengthening of ties within the Dutch planetary science community, would significantly improve our visibility abroad, improve our chances of participating in future space-related EU research programmes, and by improving our scientific track record would lead to more opportunities for active participation in future planetary missions.

The workshop presentations and discussions lead to the identification of five subthemes within the general theme 'planetary evolution and habitability':

1. *Surface and interior evolution – providing global planetary context.* A wide range of internationally recognised expertise with long heritage is available in the Netherlands to cover this subtheme, mostly with an Earth science background

(geophysics and seismology at UU and TUD, petrology-geochemistry and tectonics at VU, geology at VU and UU, geography at UU, remote sensing at ITC and TUD), but also including radio astronomers (ASTRON, JIVE). Many planetary scientists in the Netherlands are currently active in this area, including 3 Vidi fellows and an ESF EURYI awardee. The Netherlands affiliate membership of NASA's Lunar Science Institute is based on recent activities by a section of this group of researchers. There is a natural interface with the activities of Top research school ISES which focuses on System Earth. Clear possibilities exist for interdisciplinary research involving NL-based radio-astronomy and astrophysics activities (e.g. an Ultra-Long-Wavelength (ULW) extension of LOFAR on the Moon; accurate tracking of spacecraft to derive gravity fields and crustal deformation evolution).

2. *Extreme and potential habitats – where can life thrive and survive?* This subtheme links together several areas of recently developed expertise at the interface between biology, geology, and chemistry (VU petrology, VU laser laboratory, theoretical chemistry at VU, UvA and RU, UU geology, Wageningen University, Leiden University). Together with subtheme 3 this theme covers the Dutch scientific involvement in the ExoMars mission, the EISM mission, and ExoMars follow-up missions.
3. *Signatures and chemistries of life – how to detect physical and chemical evidence for past or present life and anticipate (im)possibilities of alternative life chemistries?* The Netherlands has several world class paleoclimatology groups and has a long track record in the area of Early Earth habitability research, as well as expertise in organic material preservation (Leiden). In addition there is a long heritage and substantial and leading expertise in the area of theoretical chemistry. This subtheme complements the recently initiated astrochemistry programme sponsored by NWO. There is clear scope for interdisciplinary research with subtheme 2, for example in the area of extremophiles.
4. *Planetary atmospheres, rings and volatiles.* Atmospheres are essential for life, life in turn affects atmospheric composition, and planetary climate change is intimately linked to atmospheric change. There is a national centre of expertise in the area of atmospheres of solar system planets and exoplanets at the EPS division of SRON, with a Vidi fellow, a Veni fellow and a PhD-student working on the characterisation of (exo)planetary atmospheres. SRON expertise includes both expertise in science and instrument building excellence (for example the SPEX spectropolarimeter development together with the astronomical department of UU and the Dutch space industry). There are many opportunities to instigate collaborative work with experimental and computational Earth scientists to assess the role and timing of degassing during interior differentiation of (exo)planets, leading to initial atmosphere formation; the dynamics of planetary atmospheres could be investigated via advanced Earth-based tracking of planetary probes with balloons; and the link between the properties of atmospheres and those of the underlying surfaces and interiors could be explored. With the appointment of Prof. Imke de Pater, there is new expertise at TU Delft concerning ring systems in the outer solar system.
5. *Exoplanet habitability – in search of truly Earth-like planets.* There is a strong interest from highly active astronomers, in particular at UU and in Leiden, that includes world leading polarimetry and VLT-based work. With the assumed improvement in exoplanet detection and exoplanet atmosphere characterisation in the next decade, there will be a growing need for a better theoretical understanding of how "distant worlds" have formed and evolved and a remarkable opportunity to develop interdisciplinary research. This subtheme is complementary to efforts by the world-leading Dutch astronomy and astrophysics communities (e.g. NOVA top research school). The Netherlands excels in radio astronomy studies at the broadest range of frequencies, from decametre (LOFAR) to sub-millimetre (ALMA) wavelengths. There is abundant scope here for mutually beneficial collaborations between the national planetary science and astronomy communities. This is particularly important in this subtheme, as planetary studies within the Solar System can provide a "calibration benchmark" for exoplanet research.

2. Instrumentation for planetary missions

For the Netherlands to be able to play the prominent international role in instrument development for planetary missions that the NPP aims for, it would be beneficial to develop a programme that ensures continuous funding for planetary instrument development, thereby securing Dutch (co-)PI roles. At the moment, significant government investment in mission instrumentation is provided largely on an ad-hoc basis. Although the NSO PEP and PIPP programmes provide highly valuable funding related to instrument development, overall the current situation is that many Dutch-led planetary instruments are at a relatively low TRL level at the time that mission opportunities come along. This requires large investments on very short timescales – not the perfect combination, especially in economically hard times. In addition, Dutch involvement in multiple instruments on a single planetary mission (a realistic prospect on the basis of current planetary instrumentation developments in the Netherlands, as seen during the early stages of ExoMars payload developments) becomes extremely hard to achieve. This situation can lead to missing opportunities in the coming decade. The NPP calls for a comprehensive funding programme to bring planetary mission instrumentation to a sufficiently high TRL level so that Dutch instruments (or instruments with a significant Dutch contribution) become more viable payloads for both ESA-funded and other international planetary missions.

Related to this, we stress that if we want to establish permanent links between planetary scientists and instrumentation on planetary science missions leading to PI and co-PI positions, a clear indication of sustained and sustainable investment is required from the scientist's point of view. This argument was one of the pillars of the application that led to the formation of the NOVA astronomical Top Research school: active involvement by NL-based scientists in PI and co-PI roles in astronomical/astrophysical missions requires funding instrument-related scientific research at research institutes for time durations that exceed the typical time horizon of almost all governmental funding schemes. This is equally true for planetary missions.

3. NPP Internal organisation

The overall organisational structure of the NPP with a 'kerngroep' (core group) representing the main stakeholders works very well. The NPP working groups (WG) Life detection and Comparative planetology will be merged to form a WG Science. We feel it is important to strengthen the position of the science members within the NPP, given our aim to strengthen the role of science in the direction of instrument development in the Netherlands.

We plan to add core group members with a chemistry and astronomy background to strengthen their involvement in planetary science and exploration. The NPP working group 'infrastructure' does not seem to function very well, with little input given to NPP meetings. This situation must be improved. Infrastructural contributions to planetary science missions are important in their own right, but also provide leverage to include scientific payload on these missions.

4. Education and outreach

Explore possibilities to start a national virtual institute. As is the case with planetary science research, planetary science teaching activities are becoming increasingly integrated across universities. As a result an increasing number of students are being exposed throughout their academic careers to aspects of planetary science and exploration. Linking teaching to research is crucial for the future of Dutch planetary science, and NPP members are interested in exploring possibilities to start a virtual planetary science institute. At this moment in time it is not realistic to strive for a 'Onderzoeksschool' status for planetary science. This is something that should be explored in the next strategy document (2016). Starting a virtual institute could be a stepping stone towards such a more formal school in the future. Advantages are that no investment in infrastructure would be required, that exchange of students could be facilitated, and that the visibility of planetary science activities (both in teaching and research) will be improved for both students and university boards.

Improve outreach activities. The NPP website www.planeetonderzoek.nl suffers from an absence of day-to-day site management. We will explore hiring one of the User Support Programme PhD students to take over day-to-day management. In general, outreach activities of the NPP should get more professional. Links with organisations that do have

dedicated outreach and PR representatives (e.g. SRON, NSO, NVR, JIVE and universities) should be strengthened.