Lucht- en Ruimtevaart Nederland

Topsector HTSM

Roadmap Space 2013 - 2020

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PREFACE

This roadmap concerns R&D in the Netherlands for advanced space technologies and is an update of the roadmap Space from October 2011. Strong cooperation between industry, knowledge institutes and government in the field of space is normal practice and is vital for success. Institutional space programmes will remain important and the commercial market will become more significant due to its expected growth. Space is a critical enabler for innovations in many technical and societal fields of application and, as such, is a cross-sectorial activity in the 'Top sectors'

A continued loyal Dutch participation in the European Space Agency (ESA) is a prerequisite, as it ensures the qualification of new technologies and products. Membership of ESA is a key element of European collaboration and crucial for the presence of ESA's largest site (ESTEC) in the Netherlands. Therefore in this document it is assumed that such participation will continue independent of Top sector funding sources.

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Roadmap Space 2013 - 2020

SOCIETAL AND ECONOMIC RELEVANCE

>> Connection with the key societal themes

Modern society has become critically dependant on space, enhancing our quality of life. Satellite-based services are critical enablers of many key economic activities. Mobility is supported by a global network of navigation, communication and information systems. GPS receivers and fast Internet access have an impact on our daily economic and social well-being. Observations from space are crucial to provide an urgent response to unprecedented environmental changes and are of key importance for monitoring climate change.

Space increasingly provides essential information for socioeconomic areas. Applications of satellite data will make key contributions to innovative services in the Top sectors Water, Agro & Food, Logistics, and Energy and thus significantly improve the international market position of these sectors. Now that the provision of data from space is guaranteed, many more smart applications are being developed.

Scientific satellites are fundamentally changing our knowledge of the universe. The associated technologies developed have created a backbone for commercial success in the space arena and beyond. Space activities inspire today's youth to choose careers in science and technical fields, as is illustrated by the continuous growth in the number of students at the Aerospace Engineering faculty of Delft University of Technology.

>> Global market size addressed (2013-2020)

Sputnik, the first artificial satellite, was launched in 1957. Since then the global space economy has rapidly grown to a total yearly revenue and budget stream of $ 276.5 billion. Despite the recent economic and financial turmoil a growth rate of 7.7% was recorded during 2010.

The value of global space activities in 2010 can be broken down into different segments as presented below:

Global Space Economy 2010		
Segment	**Revenue/ budgets ($ Billion)**	**Description**
• Commercial infrastructure and support industry	87.39	Satellite manufacturing, launch industry, ground control stations, terminals, etc.
o Satellite manufacturing	3.41	
o Launch industry	2.45	
• Commercial products and services	102.00	Satellite TV, satellite telecom, satellite radio, earth-observation data sales services and value adding, etc.
• Commercial space transportation systems	0.01	(Sub)Orbital flights, space tourism
• US Government space budgets	64.63	DoD, NASA, NRO, NOAA, etc.
• Non-US Government space budgets	22.49	ESA, EU, Japan, BRIC countries, France, Germany, Italy, etc.
ESA	*4.60*	*NL contribution 2.5%*
EU	*1.63*	*NL contribution 6.6 % (BNP level)*
Total	**276.52**	
• Number of launches	**74**	118 new satellites into orbit adding up to a total of 957 satellites

Source: Space Foundation 2011

Space companies in the Netherlands have a strong track record in this very demanding field of satellite and launcher manufacturing ("upstream") which is at the core of the space economy. This is a growing market, see table below.

Launch and satellites forecast			
	2001 - 2010	2011 - 2020	Value Growth rate
Number of satellites	756 ($131 B)	1145 ($ 196 B)	50%
Of which: Govnmt satellites	511 ($ 80 B)	777 (($137 B)	70%

The commercial satellite applications and services market ("downstream") consists largely of services from large telecommunication satellites for telecom traffic and direct-to-home TV, which accounts for 95% of the $ 102 billion in total for 2010. The predicted growth in capacity is 40% for the next decade. The demand for standard telecom services is largely driven by emerging regions and novel broadband and mobile services in traditional space economy countries.

Earth-observation-based and location-based services and value adding is a new, and still relatively small, service that totalled $ 20 billion in 2010 but is predicted to grow by 80% per annum over the next decade with government demand accounting for 65% of this growth.

>> COMPETITIVE POSITION OF DUTCH INDUSTRY: TOTAL R&D INVESTMENTS

The Dutch space sector includes about 60 SMEs, knowledge institutes and universities, which together have an annual turnover of 140 million euros (unconsolidated, 2009 figures).
The volume of R&D amounts to approximately one third of the annual turnover, of which 5-8% is self-funded. 80% of the workforce has a higher vocational or university education

Space is an export market par excellence in view of its cross-border nature. The strong position in the institutional market is enabling Dutch companies to acquire a growing share on the commercial market. The economic return on the Dutch contribution to ESA is a factor of 5.3. The good score of the Dutch sector in winning contracts and the economic effects of ESTEC's presence in the Netherlands (2700 employees) both contribute to this excellent result.

The competitive position is focused in three areas: (1) High-Tech Space Instruments, (2) High-Tech Space Systems and Components, and (3) Downstream Space Applications and Services. These areas are further described below.

APPLICATION AND TECHNOLOGY CHALLENGES

>> State-of-the-art for industry and science

Space is high-tech and high risk. Multidisciplinary solutions are needed and development times are long. The harsh environment of space poses many technological challenges such as low mass, low-energy consumption, miniaturisation, robustness to harsh conditions and extreme reliability.

Only the most high-tech companies and organisations can remain competitive. An existing (market) position in the space sector can rapidly disappear when a more accurate, faster or cheaper solution is offered. The space sector is therefore characterised by a permanent effort in innovation and process improvement. Space hardware is always on the cutting edge of technological achievement.

- "High Tech Space Instrumentation" involves the development and use of space instruments for earth observation and astrophysics. The Netherlands have a strong heritage in designing, manufacturing, and use of (essential subsystems of) extremely robust and compact optomechanical instruments (see table below). SRON acts as a principal scientist in many programs. The combination of SRON, universities, TNO and the Dutch space industry is a world famous powerhouse in this field. Furthermore, there is a growing synergy between the developments in ground–based (NOVA, ASTRON) and space-based instrumentation. The technological knowledge accumulated is intensively applied outside the space sector, such as in the semiconductor manufacturing industry.

- "High Tech Space Systems and Components" focuses on technologies and products which can be applied on various types of satellites or launchers and delivered to the global market. A strong competitive position exists in delivering recurring products, for example solar arrays, sun sensors, reaction wheels, and structures. Dutch industrial parties, in close cooperation with knowledge institutes, have achieved important commercial successes on the global market.
- "Downstream Space Applications and Services" involves the application of space based information in applications with a strong Netherlands heritage like water, agriculture, logistics and energy. Based on newly developed 'smart satellite services', innovations in these sectors will be applied on the home market; products and services are exported. This will stimulate the demand for new upstream industrial activities as well.

The Netherlands holds a strong international position in these three areas. This has been achieved through cooperation between the government (via the Netherlands Space Office (NSO)), knowledge institutes (SRON, NLR, TNO, ASTRON, NOVA, technical universities) and companies, the so-called golden triangle, guided by an international space agenda formulated at ESA (and ESO) level. It should be noted that the Netherlands contributes to the development of critical technologies in the framework of European non-dependence.

>> Future outlook in present and emerging markets

Societal and economic developments will lead to an increasing demand for space infrastructure and data applications to monitor natural and man-made global change (generally initiated by institutional bodies) and to meet a growing commercial call for products in areas such as communication, observation and navigation. These demands will jointly shape the global space market of the future.

The goal is to deliver lighter, better and cheaper products, high-tech instruments and enhanced services based on satellite data. This will require robust solutions, miniaturisation and standardisation, state-of-the-art technology and fusion with other knowledge domains. The Netherlands now faces a set of engineering challenges, and it can use the expertise and experience it has gained from its role in current programmes to contribute to the development of a new generation of launchers and satellites. This will require a further intensification of the existing strong collaboration between industry, knowledge institutes, technical universities and government to foster the development of new technologies.

To enhance competitiveness and sustain the growth ambition in the commercial space market, the focus will be on developing products with a recurring character.

Private investments in space developments will lead to the growth of new commercial markets. This will require new ways of doing business and inventive collaborations and approaches. An example in the field of space tourism and transport is the Dutch company Space Expedition Corporation (SXC).

What does this mean for the Dutch space sector?
> High-Tech Space Instrumentation
The Netherlands holds a prominent position in space research – as represented by SRON, ASTRON, and NOVA – through its development of high-tech, world-class instruments. The ambition is to maintain this position and build on our track record. The next-generation instruments for atmospheric research, currently under development (TROPOMI, ESA's Sentinel-5 successors and SPEX2EARTH), benefits from

innovative optics, providing more compact, efficient and accurate instruments. There are good global commercial opportunities in the field of earth-observation instruments outside Europe.
To remain at the forefront of space science, future high-tech instruments for space research require detectors and components that are not commercially available and must therefore be specially developed. Such instruments are realised in large international consortia, consisting of institutes, academia and industry in missions in European Programmes.
The Netherlands will also exploit its strong position in naval radar by applying this technology in potential new space missions and applications.

> High-Tech Space Systems and Components
Our current position in the institutional market is based on the high-quality Dutch contribution to ESA. At the same time, the Dutch space sector has achieved a significant position in the growing international, commercial space market. Space companies such as Dutch Space, Moog/Bradford, APP, together with a broad supply chain of companies including many SME's and supported by TNO and NLR already deliver 'world-class' products and form the backbone of the Dutch space sector. The ability to rapidly apply new technology in systems and components is essential if we are to comply with the increasing demand for space infrastructure and maintain our competitive advantage. The space sector would therefore benefit from synergy with other high-tech sectors and from generic technological developments in the field of materials, miniaturisation and integration.

> Downstream Space Applications and Services
The worldwide availability of satellite data as 'raw material' for innovative environmental products and services is a growing market. Environmental information based on satellite data is a commercial asset of increasing economic and strategic potential. For example, in the field of water there are (export) opportunities in the context of the "Water & Climate Covenant", a consortium of more than 30 Dutch knowledge institutes and companies in the areas of water, space and geomatics . The ambition is to further strengthen the international market position by combination of application knowledge with data from space based and ground based sensor networks to develop new smart services.

PRIORITIES AND PROGRAMMES

The future space priorities and programmes are based on the NSO roadmap process initiated at the end of 2010 in preparation for ESA's ministers conference in November 2012, and are supported by the entire space sector in the Netherlands. The challenges facing the space sector combined with the technological expertise present in the Netherlands have resulted in the topics/programmes itemised below.

Focus area: High-Tech Space Instrumentation	
Programs and activities	**Partners**
1. Optical Instrumentation Optical elements; Integrated optics; Opto-mechatronics; Detector technology and ROICs	TNO, cosine, Dutch Space, LioniX, Mecon, s[&]t , VSL, KNMI, NOVA/ASTRON, SRON, Delft University of Technology
2. Radio Frequency (RF) Technology Small satellite radar & platform; Active electronically scanned array radar; Antennae	ISIS, SSBV, NLR, Delft University of Technology, Eindhoven University of Technology, LioniX, TNO, ASTRON
3. On- board software/data systems General purpose (co-) processor; Integrated on-board controller; algorithms	SSBV, NLR, Neways, SRON
4. Ground segment data processing Data processing, data archiving, data archiving toolboxes	KNMI, NLR, Dutch Space, University of Groningen, SRON, SSBV, s[&]t, TNO, Vortech
5. In situ bioanalysis Life detection; Planetary protection instruments; Pathogen detection in manned space; Water quality preservation; Cell biology instrumentation; Single molecule detection	LioniX, Dutch Space, Bioclear, Culgi, CapiliX, Aqua Explorer, s[&]t, Vitens, TNO, Leiden University, Wageningen University, University of Twente, VU University Amsterdam, University of Groningen/University of Groningen Medical Center
6. Thermal management& cooling systems Payload thermal control (sorption cooler, stirling & pulse tube cooler	NLR Dutch Space, Cryoz, Thales Cryogenics, University of Twente

Note: Partners active in ground based astronomy (supplying to ASTRON and NOVA) are not mentioned in the table above.

The actions in "Optical instrumentation" are aimed at strengthening the Dutch position in astronomy and atmospheric measurements. The development of related instrumentation is characterised by long lead times, typically 10-20 years. Innovations therefore need an early start. Current ongoing projects are on-chip spectrometers, integrated optics and integrated electronics (aimed at more compact and lighter systems), smart processing, calibration and metrology.

Focus area: High-Tech Space Systems and Components	
Programmes (bold) and activities	Partners
7. Attitude and Orbit Control systems Reaction Control Wheels, (mini digital) sun sensor systems	Moog/Bradford, TNO, ISIS
8. Satellite Propulsion Latch valve, flow valve, pressure components, cold gas generators	Moog/Bradford, APP, Airborne Composites, CGG Technologies, Dutch Space, NLR, TNO, Delft University of Technology
9. Structures Carbon fibre and metal technology for launchers, radiators, (mini) satellite structures and substrates for solar arrays	Dutch Space, Airborne Composites, Bayards, Breman, Chromalloy, DTC, Fokker Aerostructures, Futura, ISIS, JPC, NORMA, Tecnovia, GTM, Delft University of Technology, NLR, TNO
10. Solar arrays Short term: CFRP technology, insulation foil, panel hinges, Double linkage yoke, NELS Hold-Down and Release System, wiring, thermal knife heater Medium term: Thin film GaAs, interconnection, transparent foil, solar panel frames, unfolding system)	Dutch Space, Airborne Composites, Tecnovia, Neways, Brandt FMI, UMI, TU Delft, TNO, NLR, University of Twente, Radboud University Nijmegen, Solliance
11. Thermal management & cooling systems (small systems & components); deployable radiators; high-conductive CFRP	NLR, Airborne Composites, AOES, Moog/Bradford Engineering, Dutch Space, University of Twente,
12. EGSE/Simulation Front-ends & SCOE, Real-time simulation & modelling; Integrated EGSE, CCS / Core EGSE	SSBV, Dutch Space, NLR, Nspyre, Terma, ISIS
13. Ignitors Ignitors for: Vinci, Vega Evolution, NGL, space tourism and thruster ambition	APP, Moog/Bradford, Airborne Composites, NLR, TNO
14. Satellite cluster technology Assessment of clusters /constellations of satellites	ISIS, NLR, SSBV, TU Delft, TNO, University of Twente
15. Miniaturised accelerometers High-resolution MEMS accelerometers, capacitive and optical read-out	University of Twente, Axiom IC, Bruco, Shell, Fugro, Delft University of Technology, TNO

Examples in this line are:

- "Solar Arrays" for energy supply of space systems that have the robustness of the current design and in the mid-term incorporate ultra-high efficiency thin film solar cell blankets to meet the requirements for a better power/weight ratio at lower costs.
- New lighter materials for launcher and satellite structures based on composites.
- Smart heat management of space systems such as thermal conductive structures, deployable radiators and advanced components/(sub-) systems for the positioning/control of satellites will be developed in this line as well.
- Advanced components for positioning and guiding satellites.

Elements of “Downstream Space Applications and Services” are detailed in the table. A roadmap process will be initiated by NSO during 2013 leading to cross sectorial business groups.

National Satellite Database: provides GMES-compatible satellite data for satellite application development, knowledge creation and support to market development	geo-ICT companies, satellite value adding companies, service companies, knowledge institutes, universities, institutional service providers, government geo-ICT organisations, ..
Agro & food: Precision agriculture, yield mapping & prediction, moisture assessment, food security	e-Leaf, SARVision, EARS, Geomatics Business Park, Wageningen University, Alterra, ITC/University of Twente, Geoserve, Delft University of Technology , TNO, ..
Water: flood prediction & management, delta life, maritime services, automatic identification for shipping, oil slick monitoring, dredging support, eco engineering, water quality, dike monitoring	Arcadis, BMT ARGOSS, Fugro, Deltares, INFRAM, Wageningen University, Hansje Brinker, TNO, van Oord, Boskalis, Hydrologic, NEO, Grontmij, Water & Climate Covenant partners, Delft University of Technology , Havenbedrijf, Waterschappen, ..
Logistics: navigation, routing, transport safety, AIS, tracking & tracing	BMT ARGOSS, Arcadis, Logica, NLR, TNO, Ursa Minor, Havenbedrijf, ..
Energy: monitoring climate change/treaties, supporting on-/off-shore drilling activities, land subsidence, environmental conditions for deep-sea mining, ice monitoring, monitoring pipeline safety, wind energy yield prediction	BMT ARGOSS, Wageningen University, ITC/University of Twente, Hansje Brinker, s[&]t/Orbital Eye, Fugro, Shell, NAM, Gasunie, NL Contractors, Delft University of Technology , ECN, TNO, ..

The National Satellite Database was made available in 2012, offering data to SME’s that is used to initiate the development and introduction of ‘smart’ services for innovations in agro/food, water, energy and logistics on the home market.

A start has been made in the downstream roadmap process and several programmes will run in 2013:

Satnav & Earth Observation to reduce risk at sea

To reduce risk at sea detailed information on the ocean environment as well as the behaviour of its users are of vital importance. Objective is to improve Metocean hind cast and forecasting services using earth observation satellite observations and integrate these with navigational data of the vessels using (satellite) AIS and EGNOS data.

Earth Observation to reduce emissions at sea and to support maritime logistics

Optimization of routes at sea to realize low fuel consumption and less emissions and avoid risk due to weather conditions by optimizing the selected routes and speed. This is realized by combining data from sensors on board ships with environmental information obtained from satellite data.

Earth Observation to support efficiency of (off shore) wind parks

For energy providers there is a high demand for accurate yield forecast requiring accurate wind predictions on specific locations at specific heights. Objective is to develop services delivering these predictions.

Earth Observation to monitor critical infrastructures

Owners of critical infrastructures such as dikes, roads, bridges and oil and gas installations need regular quality inspection. Objective is to increase safety and the efficiency of inspection by including information based on satellite optical and radar data.

(Satellite)-sensor-based optimization of potato farming
Bringing together the relevant market and technology players in the field of potato farming and sensor networks to examine innovative management practices in potato farming using advanced sensor techniques.

For these roadmaps specific projects are identified for 2013.

PROPOSED IMPLEMENTATION

To execute this roadmap a loyal Dutch participation in the European Space Agency Programs is a prerequisite not only for the societal benefits for the Netherlands but also because it ensures the qualification and in orbit validation of new technologies and products.

The proposed implementation of the Space roadmap will be realised by a combination of different regional, national and international partnerships.

Netherlands space ambitions and programs are firmly embedded in the international strategic research agendas of the space agencies (ESA, NASA, JAXA, KARI etc.), in many cases covered by MOU's. The TWA network and the technology ambassador role in trade missions plays an important role in these international contracts. Activities are developed in large international consortia consisting of research institutes and industry.

At European level the implementation will be realized through collective R&D within European programmes like the ESA technology programmes covering R&D from TRL level 1 to 7/8.
Another example is the FP-7 programme and its successor Horizon 2020 which both include Space as a programmatic topic to execute the research and innovation elements of the European Space Policy of the EU.

The scientific activities will be realised in accordance with the NWO scientific ambitions and programmes. In the national context they are in agreement with the strategic plans of the astronomy (NOVA) and earth and planetary research communities.

National R&D activities will be realised in collaboration with TNO/NLR and will include projects with SMEs and links with the NSO roadmaps.

National downstream space applications and services activities will be realised in collaboration with amongst others the Geomatics Business Park (a fast growing, leading European business and science park that evolved into a 'hot spot' for earth observation based geo-information), the Water & Climate Convenant leading to business groups formed together with partners in the Topsectors Water, Agro, Logistics and Energy.

TKI PROGRAM

The TKI program in this roadmap will focus on the 2013 activities. For the 2014-2016 period the main line as expressed in the roadmap description of 2011 is still valid. For 2013 more than 60 projects are identified within the priorities described in the NSO roadmaps. An overview of the investments for the different roadmaps is given below.

TKI Program 2013 (M€)

Focus area	Private cash contribution in 2013	Total contract value in kind en in cash	Total value company contribution cash	Total value company contribution in kind	Total value knowledge institute in kind
Instrumentation	€ 0.35	€ 1.49	€ 0.23	€ 0.57	€ 0.70
System & Components	€ 0.33	€ 18.95	€ 0.37	€ 3.83	€ 1.24
Downstream	€ 0.15	€ 1.30	€ 0.65	€ 0.90	€ 0.26
Totaal	**€ 0.83**	**€ 21.73**	**€ 1.25**	**€ 5.30**	**€ 2.20**

EUROPEAN PROGRAM

Space is an international activity and the European programs deliver an essential contribution to the global challenges. The activities in the space roadmap are harmonized with the European developments as well in ESA as in the EU. With respect to ESA, the roadmap activities are strongly connected to the ESA technology programs.
Space is a programmatic topic in the EC FP-7 and its successor Horizon 2020,. to execute the research and innovation elements of the EU's European Space Policy. The Space Roadmap is in line with the formulated European Space Policy.

ENGAGED PARTNERS FROM INDUSTRY AND SCIENCE

More than 60 industrial and scientific partners are currently active in the field of space and space-based applications and services. This number is set to grow, as evidenced by the budget tables in the next section. For the implementation process of this roadmap, the NSO roadmaps are used as a basis for the definition of the activities for 2013. Partners collaborating in these roadmaps delivered their input to the roadmap coordinator.

INVESTMENTS

Public-private partnership R&D (budget tables 2013, 2014-2016)

Roadmap program	**2013**	**2014**	**2015**	**2016**
Industry	6.75	7.4	7.4	7.4
TNO	4	4	4	4
NLR	1.0	0.9	0.9	0.9
NWO Incl STW, FOM, ZonMW, etc	4	4	4	4
Universities	1.65	1.7	1.7	1.7
ESA	7.7	8	8	8
EC	8	9	9	9
EL&I	4.5	4.5	4.5	4.5
Other institutes Incl imec, non-NL universities, etc				
Other government Incl regional, etc				
Grand total	37.4	39.5	39.5	39.5

Year 2013

TKI program	**2013**
Industry, cash	0.83
Industry, in-kind	5.4
TNO	0.27
NLR	1.0
NWO Incl STW, FOM, ZonMW, etc	
Universities	0.76
Other institutes Incl imec, non-NL universities, etc	
Other government Incl regional, etc	
TKI grant	0.20
TKI total	8.46

Other innovation instruments

Opportunities for valorisation can be supported by funding schemes like SBIR with a space paragraph.