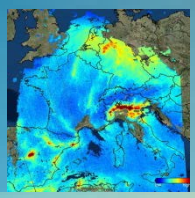
Top sector HTSM

Roadmap Space 2017-2021





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PREFACE

This roadmap gives the framework for development in the Netherlands of advanced space technologies and space applications and is an update of the Roadmap Space published in August 2015. In this field, companies, knowledge institutes and government closely cooperate, which is key to success. The commercial market for space technologies and space applications is growing at increasing rates, providing new opportunities for the Netherlands. At the same time, institutional space programmes – both through the optional ESA programmes and through the national programme - remain of vital importance for a level playing field in a dynamic international scene. Space is a critical enabler for innovation in many technical and societal fields of application and, as such, is a cross-sectorial activity in the 'Top sectors' of the Netherlands.

Given the long cycles required for the development, qualification and certification of new technologies for use in space, it is essential for the space sector to have the ability to invest in promising new initiatives. As such, a continued loyal Dutch participation in the European Space Agency (ESA) is a prerequisite for competitiveness as it ensures the qualification of new technologies and products for the international market. 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 a participation and accompanying policy will be continued and intensified independent of Top sector funding sources.

Top sector HTSM

Roadmap Space 2017 - 2021

SOCIETAL CHALLENGES AND ECONOMIC RELEVANCE

>> Societal challenges

Space infrastructure and space applications are critical enablers for many key societal challenges and economic activities. Space innovation therefore is the part of innovations needed in space across all sectors of society and economy.

New space-borne instruments provide invaluable data for the big questions regarding **climate change and air quality**, and feed applications for monitoring our efforts on these topics and allow for the global measurement of the effects of implemented mitigation measures. Building a strong national effort in the past, the Netherlands now have a world-class position.

Next generation space infrastructure will provide services essential to the security of our society, such as **secure broadband communication** using optical links and quantum key distribution with communication coverage in remote areas. These are domains where the Netherlands owns key technology in the global playing field. The European global navigation satellite system Galileo provides **secure and accurate navigation and time**. Satellites provide a broad range of **monitoring and observation** capabilities using different sensing technologies across the electromagnetic spectrum. Space infrastructure and space applications are essential for making today's data-driven society reliable and secure.

Food and food security are addressed through the Dutch participation in the Copernicus Programme and the EU and ESA's associated R&D programme. Dedicated developments lead to the provision of value-added services in selected domains, such as soil moisture mapping and land surface temperature mapping from space, building on data generated by the fleet of Copernicus satellites. Space infrastructure and space applications are indispensable for risk management in global food production and food security by providing independent monitoring available to all stakeholders in the food production chain.

Water and water quality is primarily addressed through participation in the EU's Copernicus programme for infrastructure through services on water quality. Space-borne sensors provide daily mapping of coastal structures, inundation and surface water quality assessment on a global scale.

Mobility and transport in the air, road and maritime domains are supported by a broad spectrum of space-based systems and services, including satellite navigation, satellite communication and satellite-based earth observation. Space infrastructure and space applications are fully embedded in virtually all forms of transportation and enable the use of systems all across the globe.

Last but not least, **scientific** instruments carried by satellites are fundamentally changing our knowledge of the Earth, our solar system and the universe. Space systems allow us to leave the Earth and explore the universe across the full electromagnetic spectrum, to accurately measure the gravity field and to detect gravitational waves. New technologies developed for science create a backbone for commercial success in the space arena and beyond, today and in the future.

An element not to be underestimated is the **technology drive and spin-off** from space-related activities, enabled by the Top Sectors. Many technologies originally developed for specific space missions have found their way into other application domains, such as the semiconductor equipment, security, industrial automation and medical technology. Many more space technologies offer similar potential. Furthermore, space is a huge source of inspiration for children and students to start a career in Science, Technology, Engineering and Mathematics. According to the recent projections made by the University of Maastricht, the Netherlands will continue to struggle filling the vacancies for engineers and technicians. For precisely this inspirational reason Dutch astronaut André Kuipers was chosen as the figurehead of the "Techniekpact".

>> Economic relevance

As of 2016, the **world space economy** totals around $339 billion for all countries and private enterprises combined. This number is expected to grow significantly over the coming decades; many economists and private experts put the size of the space economy at $2 to $3 trillion in the next three decades. Around 77% of the space economy consists of the so-called satellite industry. This comprises satellite manufacturing (around $14 billion), the launch industry (around $5.5 billion), satellite services which represent the largest part of the space economy totalling almost $128 billion in 2016, closely followed by ground equipment ($113 billion).[1]

One of the niche markets showing strong growth is the small satellite market (satellites in the range of 1 to 500 kg), which show increasing capabilities through advances in miniaturisation of components. In the Netherlands, a growing number of companies and institutes focuses on so-called CubeSats, very small satellites typically smaller than 10 kilograms. In 2016, 219 satellites were launched, 81 of which were CubeSats (about 37% of the total). Although the total market size for these spacecraft is still small (about 1% of the total value), it is the fastest-growing sub-segment. The global market for small satellites is expected to reach $10 billion by 2021[2] (of which around $600 million for the sub-market of CubeSats, growing from an estimated market size of $127million in 2016[3]).

In the global space market, institutional actors (state agencies) provide the majority of funding in important areas, such as defence, research and space exploration. They provide funding of critical new technologies as well. At the same time private companies play a significant role that grows fast. Especially in Europe and the US, state agencies partner with private industry to develop new technology, programmes and missions, a trend which is also being adopted in China and India. The private sector closely cooperates with state agencies, but also develops private (commercial) activities, such as private satellite manufacturing and ownership (telecom, earth observation and tracking), private rocket development and satellite launch capabilities. In the Netherlands, such private initiatives start to take hold, basing their commercial activities on the decades of expertise, experience and technology developed largely for the institutional programmes. New telecommunication companies

[1] All figures derived from State of the Satellite Industry Report, June 2017, by Bryce
[2] According to "Global Small Satellites Market, Analysis & Forecast, 2017-2021", by BIS Research
[3] Information derived from "Global Nano Satellite Market Research 2017-2021"by BIS Research

have recently been established in the Netherlands and various companies (established companies as well as start-ups) are beginning promising new remote sensing services. A number of companies is expanding their position in the commercial rocket segment with new technology investments. In the future, the space economy will further expand to new activities, such as in-orbit servicing, planet colonization, space tourism and asteroid mining (the orbital economy).

>> Competitive position of the NL space ecosystem

The space sector in the Netherlands generates a turnover of about €600 million and directly employs some 4000 – highly skilled – knowledge workers. ESTEC in Noordwijk is one of the largest R&D organizations in the Netherlands with more than 2500 personnel of which 50% permanent staff.[4]

The Dutch space ecosystem consists of a strong **interlinked network** of businesses (many of them SMEs and start-ups), knowledge institutes and universities and has achieved **scientific top positions** in domains such as astronomy and air quality & climate research, both in the field of instrument design and manufacturing and in applications and science. The resulting expertise is relevant to European developments, such as Copernicus. The network and the high quality of academia and education provide a solid **foundation for innovation.** This attracts foreign investments as well. The space programmes driven by ESTEC and the space institutes provide an excellent basis to monetize on the **available know-how** and grow the **commercial space activities**. The NL space sector aims at strong (double-digit) growth of the commercial part of the space activities.

In 2012, the HTSM Top Team published a **White Paper** recommending actions to better align ESA's European Space Research and Technology Centre (ESTEC) in Noordwijk with the space sector in the Netherlands. A number of these recommendations has led to the **Space Campus Initiative**, in which national and regional governments, ESA ESTEC and the space sector come together to work on a combined vision and plan for a Space Campus with a focal point in Noordwijk. Within these Campus initiative various elements are addressed, such as infrastructure sharing across the Netherlands, increased cooperation between ESTEC and space institutes and companies, as well as facilitating spin-in and spin-off opportunities. Better access to the research and innovation potential within ESTEC will help the HTSM Space Roadmap to achieve its ambitions, while creating a physical focal point (the campus) will stimulate cross-sectoral activities between space and its application in other Top sectors.

The national space R&D and the ESA technology development instruments provide the framework to develop new applications. By alignment of development into integrated value chains, we maintain and develop specializations which give us world-class positions.

The NL public investment in space does not match the ambitions of the NL space sector however. Especially the investment in ESA's optional programmes lags behind and even shows a decreasing trend. This not only limits the opportunities for the NL space sector in ESA, but it hampers ambitions in the commercial space market as well since many technologies are developed within ESA and then used in the commercial market. Furthermore, ESA expects member states to contribute to the optional programmes in accordance with their relative economic strength. In this line of reasoning, the Netherlands is expected to contribute 4.6% of the budget for optional programmes. During the last Ministerial conference in 2016, the Netherlands subscribed around €100 million in these programmes, amounting to 1.74% of the total budget.

[4] (in Dutch) Verkenning naar maatschappelijke kosten en baten van Ruimtevaart en het ruimtevaartbeleid, Dialogic / Decisio i.o.v het ministerie van Economische Zaken, april 2016

Space is not a free and open market; despite many new private endeavors, public authorities still play a pivotal role, not only in Europe but worldwide. The Netherlands' government should acknowledge this reality and invest accordingly in order to create a level playing field for the high-tech NL space sector and fulfill its full potential for societal value and economic growth! Therefore, an additional investment of €27 million per year is needed, which is still modest compared to other economically-developed high-tech nations.

APPLICATIONS AND TECHNOLOGIES

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

Application areas

In the space economy we distinguish three application areas that are relevant for this roadmap as described below. These areas are closely related but each is characterized by its own programmes, market dynamics, funding structures, national heritage, market positions and ambitions.

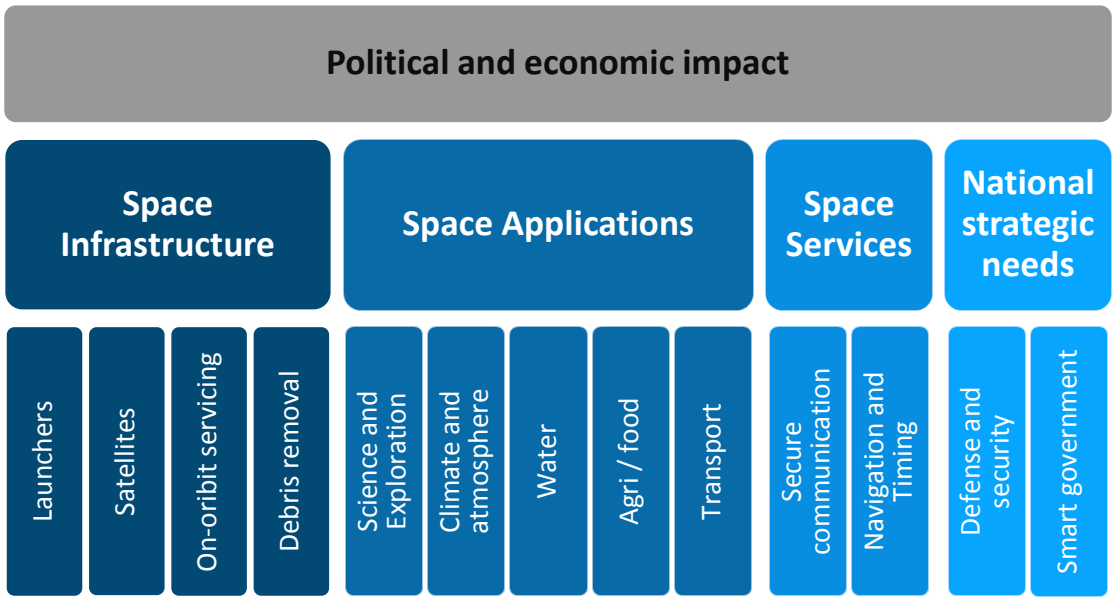
Space Infrastructure is a strategic asset and political need in the European context. It consists of launch vehicles, satellites and man-tended space infrastructure, as well as the systems to service this infrastructure. While traditionally this was the domain of cooperation through ESA, the economy of space is developing and private companies increasingly take on development of space infrastructure.

Space Applications. With the deployment of Copernicus, the largest Earth Observation system in the world, the amount and variety of freely available Earth Observation data grows significantly. These data are generated from high-tech, innovative instruments that open new windows of observation on the globe. This includes the world-class Tropomi instrument on Sentinel 5 Precursor, launched on October 13th 2017. Tropomi is a major step forward for air quality & climate research using space data. Copernicus and its international counterparts in general enable a range of new applications, stimulated through the national satellite data portal as well.

Furthermore, various new private initiatives have started in the Netherlands, both in the area of instrumentation development (highly miniaturized sensors) and in the development of new services (e.g. air quality monitoring, water management, critical infrastructure monitoring and precision farming).

Scientific discovery remains an important focus with excellent Dutch positions in Astronomy as well as Earth Sciences. In this field ESA's science missions as well as national efforts and bilateral international cooperation are important.

Space Services enable terrestrial markets that obtain huge benefits from the use of space assets. Space assets are an integral part of communication and navigation services. Telecommunication is the largest commercial space market, with new players entering for MEO and LEO-based small satellite constellations and for the development of secure broadband optical communication solutions. The deployment of Galileo provides Europe with an independent, accurate and reliable space navigation infrastructure enabling a range of navigation, timing and location-based services. These space assets are increasingly important as critical infrastructure for society.



Finally, space assets and space applications are important for our **national strategic needs** within the context of national security. Firstly, it is important to protect our essential space assets, be aware of the space environment and safeguard them from (military) threats. Secondly, space applications and services for monitoring, communication and navigation support national security and international cooperation. With the increased geo-political instability and a growing need for self-reliance, attention is also drawn towards dedicated space systems for security and defence wherever national interests are not properly served by available systems (e.g. from allies or available on the market).

Technology position

Upstream Systems	Satellite systems	Solar arrays, Thermal systems, Small satellites, On-board processing, Attitude control systems, Test systems
	Launcher systems	Structures, Igniters, Avionics, Materials, Satellite Deployers
	Space infrastructure	Distributed space systems, Robotics servicing systems
Payload Systems	Instruments	Optical instruments, RF instruments
	Communication Systems	Beam forming RF antennas, Optical Communication, Narrowband communication payloads
	Navigation systems	Performance monitoring and test systems
Downstream Systems	Ground Segment infrastructure	Data Processing, Optical Ground stations, ground stations for small satellites
	Service development / data use	Soil motion, Air quality, Public security and defense, Precision agriculture, Food security, Land monitoring and use, Shipping and offshore, Aviation, Water Management and Quality

The Netherlands has a strong heritage, as well as active development in many segments of space technology indicated in the schematic above: Dutch companies serve the traditional satellite and launcher market with components, equipment and subsystems and develop the upcoming market of small satellites. A strong capability for developing Science and Earth Observation payloads exists, well-connected to the scientific and user communities for these payloads. In recent years, the development of ground segment, data processing and value adding has been intensified with amongst others the creation of a National Satellite Data Portal and the definition of downstream themes, with the purpose of growing the application of space and connecting to other Top sectors. The sector coordinates the development in all these areas via the roadmaps of the Netherlands Space Office (NSO) that address each of the topics mentioned in the figure above. The NSO roadmaps are updated regularly in synchronisation with the cycle of ESA Ministerial Conferences.

>> Future outlook in present and emerging markets

Space Infrastructure

The **satellite infrastructure** is going through a fundamental change. Next to traditional large, powerful and ultra-reliable satellites, now constellations of small satellites and distributed systems emerge that together provide earth observation, communication and navigation services. These systems are based on a new approach with faster development cycles, lower required component reliability, lower cost, more spin-in of commercial-off-the-shelf technology, miniaturization of avionics and new system architectures like swarms and formations to bring new functionality and performance. Space is now moving towards "Space 4.0"[5].

In the **launcher market,** Europe feels the pressure of increased international competition from the US as well as China, India and Japan and drives to reduce cost (e.g. through continued innovation in materials and industrialization of the production process) and increase performance of future launchers. Also, the economic deployment of large quantities of small systems requires new, flexible launcher capabilities.

The use of servicing systems and robotics in space to manage **space infrastructure** will extend from Space Stations where these technologies have traditionally been developed and deployed to other space infrastructure. Also, solutions for the removal of systems after their useful life (space debris management) are part of this.

Space Applications

Observations of the Earth from space can be used for a wide range of societal and economic applications across different sectors, ranging from land use to water quality, from soil moisture measurement to crop monitoring, from detecting methane emissions to changes in underground and infrastructure. The possibilities are immense and the growth of this sector will accelerate with the implementation of Copernicus and with new privately-owned satellite-based sensing systems being

[5] A concept introduced in the ESA Long-Term Plan, ESA/C(2016)105 indicating the transformation of the sector from traditional spacecraft manufacturing and mission planning into an interconnected economic activity in the digital era that provides services and employs "industry 4.0" methods to optimize production.

deployed[6]. The "downstream" themes from NSO provide a good overview of the national ambitions with respect to the development of these opportunities. Private initiatives both in the form of start-ups and of foreign companies setting up local activities drive growth in this sector. The instrument technology development in the Netherlands aligns with the downstream service position and ambitions in order to strengthen national value chains in space applications wherever possible.

The Netherlands is a very successful contributor to **space science**. As the cost of new missions increase, amplifying the need for international cooperation, this imposes a need for focus and specialization on strong positions. At the same time the sector remains open to new promising topics, such as space-based radio astronomy. Wherever ambitions exist on both private developments and scientific research in a particular domain, this provides additional opportunities to benefit from a common technological base. This is particularly true for earth sciences, such as water, climate and environmental monitoring. Exploring the Solar System is a prominent topic in the international arena to be considered in the longer term.

Space Services

The telecommunications market is going through a transition. Large geostationary satellites get competition from constellations of (small) LEO satellites. The introduction of optical communication terminals and ground stations serves the growing demand for high-speed and **secure broadband communication**. These trends present an excellent opportunity to develop new positions, using our capabilities both in upstream systems and in (optical) payload systems.

Regarding **navigation,** the Netherlands are involved in the implementation of the Galileo Public Regulated Service and the recently opened Galileo Reference Centre near the ESTEC site in Noordwijk, which supports the development of receiver technology and GNSS-based applications. Navigation services become increasingly important e.g. as an enabler for autonomous transport.

National Strategic Needs

The Space Security Centre builds knowledge of space for the Ministry of Defence, recognizing the criticality and vulnerability of space assets, as well as needs for space applications for our **defence and security**. The Government plays an important role in the creation of new applications and value chains by developing and using space applications in government tasks and services ("**Smart Government**"). NSO's downstream roadmapping process targets to connect new users to space applications, while the National Satellite Data Portal lowers the barrier to access data.

>> Questions and milestones for this roadmap in 2025

The process preparing the ESA Ministerial Conference which will take place by the end of 2019 will largely define the Dutch priorities for the period until 2025. An expected assessment of national needs from a Smart Government perspective will be a driver for development of new applications. The introduction of the new Ariane 6 and Vega-C launchers by 2020 will give Europe a modern and competitive launch capability. The European civil navigation service Galileo will reach full deployment and service level by that same year. Copernicus will evolve, expand and improve its services, deploying a second generation of instruments and satellites. With the completion of EC's Horizon 2020

[6] The taskforce "Toepassingen Satellietdata (2014). De Ruimte voor het gebruik. 'Meer waarde voor onze Aarde' (in Dutch): concludes that the areas Agriculture and food security, Energy and Urban development of deltas present good opportunities for growth in the Netherlands, targeting a direct revenue of 105 M€ p.a. as of 2020 giving an overall economic impact of 1,5 to 2 B€.

programme the new Framework Programme 9 is under development and will provide new opportunities for space technology, infrastructure and applications research and development.

PRIORITIES AND IMPLEMENTATION

>> Implementation of this roadmap in PPPs and ecosystems

In the Netherlands space priorities and programmes are based on co-operation in the triple helix: companies, knowledge institutes and government working closely together to build up, maintain and extend the Dutch space ecosystem. National space policy is implemented through investments in the European Space Agency aOnd a national programme. At government level the ministries of EZK, OC&W and I&W contribute financially, while also ministries such as MOD, J&V and BuZa are interested in space capabilities. Cooperation is stimulated by organizing networks of companies, institutes and universities, such as the so-called PIPP networks: Public Private Partnerships for Space Instruments & Applications Preparatory Programme.

In the roadmap process coordinated by the NSO, companies, universities and institutes outline the necessary development of individual key technologies. These roadmaps are updated every 2-3 years. The next update is planned in 2018/2019 in preparation for the ESA Ministerial Conference in 2019. The roadmaps also describe the public and private budget sources that fund the necessary developments. Specific programmes and projects implement these roadmaps aiming at the development of products that serve the science community, commercial customers in the space market (the “upstream” market) and users of services derived from satellite data (the ”downstream” market). The TO2 institutes TNO, NLR, the NWO institute SRON and TU Delft have established space R&D programmes. The Top sector’s PPS instrument facilitates the application of this R&D in new products and positioning in conjunction with ESA programmes for technology, product development or missions.

Specific environments, such as the Dutch Optics Centre (DOC) and the recently started Smart Advanced Manufacturing XL (SAM-XL) centre on the TU Delft campus, further stimulate public private co-operation. TNO, NLR and SRON make their production, test and qualification facilities available to companies in support of technology and product development. The initiative to realize a Space Campus in Noordwijk is planned to be a next step to build another focal point for space companies, while enabling a closer link to European Space Research and Technology Centre (ESTEC).

The space market is in transition from an institutional market with primary focus on science towards a more commercial environment. Satellite communication has been the first commercially successful application, now followed by Earth observation. A paradigm shift was initiated over the last decade in the US, with venture capitalists and internet billionaires (e.g. Richard Branson/Virgin Galactic, Elon Musk/Space-X and Jeff Bezos/Blue Origin) joining forces with a different space and contracting policy by NASA, changing the global landscape of the use of space. This shift takes place also in Europe e.g. with the foundation of ArianeGroup and the governance of the development of the new European launchers. In the European context, the implementation depends on cooperation between many different countries, while private risk investments by venture capitalists are still at a relatively low level.

A number of new players have emerged in Europe in certain niche markets. Particularly the small satellite sub-domain has seen a surge in entrepreneurship with a number of successes in the Netherlands, leading to strong growth in Dutch commercial space activities.

With this transition, the balance between institutional programmes (national, ESA and EU) and private initiatives gradually shifts. The challenge for the sector is to maintain a strong and internationally competitive basis for R&D and growth using Public Private Partnerships between companies and knowledge institutes at low TRL level, national innovation instruments, such as space SBIR and Instrument Cluster funding and effective cooperation and technology development through ESA programmes.

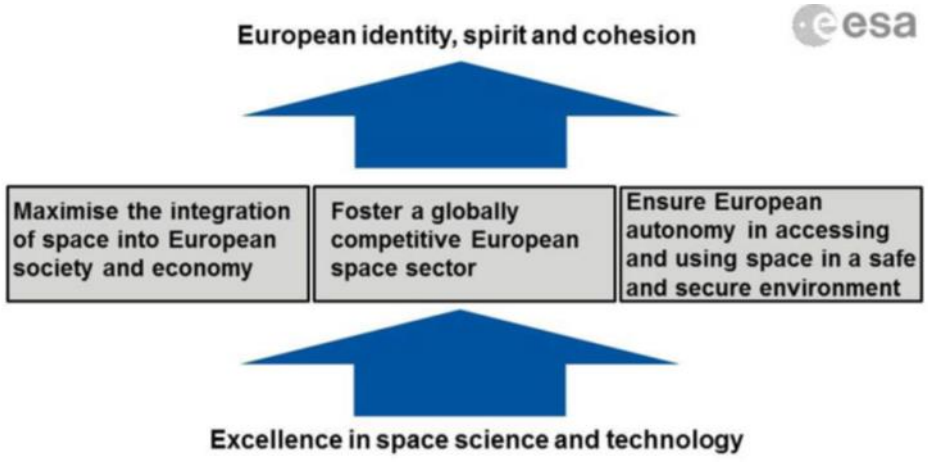
>> Linkage with other innovation instruments

Recent technology developments in space instruments and miniaturization of technology, as well as the ever-increasing availability of high volumes, high-quality, affordable satellite date has recently led to an increasing role of government as launching customer through public purchasing (e.g. SBIR programme). The need for increased security and autonomy in intelligence has raised the awareness of the Dutch MOD (e.g. CLSK) for the possibility to develop its own space assets in co-operation with Dutch companies and institutes, for which a pilot programme (BRIK-II) is currently running. When this direct procurement has proven to be successful, this could lead to an increased role for the government as a direct (smart-)buyer of space solutions.

>> Collaboration in and leverage with international policies and programmes

International cooperation has been key in space activities from the start of the Space Age some 50 years ago, with the International Space Station and many science missions as examples. In Europe there is a strong co-ordination of space technology development through the European Space Agency (ESA), next to ESA's Science oriented activities. ESA plays a key role in developing EU flagship space systems Galileo for satellite navigation and Copernicus for Earth observation. The European Commission has stimulated R&D in space through its Framework Programmes, now Horizon 2020, and to be continued after 2020, possibly by setting up a Joint Technology Initiative (JTI) in co-operation with industry and R&D organizations.

With the growing worldwide competition in space from countries such as US, China and India, the European Commission and ESA, by the end of 2016, formulated a joint Space Strategy with the objectives depicted in the figure below. In addition, the European Defence Agency has announced a growing interest in space activities, where – as an example – a list of Critical Technologies for Europe was compiled by ESA, EU and EDA.



The Netherlands plays a significant role in research and technology development in the European environment. This is realized both through involvement in ESA's mandatory and – to a limited extent – optional programmes, and participation in EU Framework Programmes – now Horizon 2020 - leveraging the knowledge and technology-based running projects in co-operation with European partners to the benefit of the space sector. EU and several ESA programmes require public and private funding and investments in addition to the European budgets provided.

PARTNERS AND PROCESSES

>> Partners in this roadmap from industry, science, departments, regions and cities

The implementation of the space roadmap will be realized by a combination of different regional, national and international partnerships. To execute the roadmap a loyal Dutch participation in the European Space Agency Programs remains a prerequisite for competitiveness, ensuring the qualification and in-orbit validation of new technologies and products.

The ambitions and programmes of the Netherlands are firmly connected to 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 play important roles in these international contacts.

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. This is only feasible with support of an adequate and focussed national R&D programme. The EU Framework Programme 9, as the successor of Horizon 2020, will include space as a programmatic topic to execute the research and innovation elements of the European Space Policy of the EU and may include a Joint Technology Initiative (JTI) driven by industrial needs and support from European R&D organizations.

The scientific activities will be realized in accordance with the NWO scientific ambitions and programmes. In the national context they are in agreement with the strategic plans of the astronomy (NCA on behalf of NOVA, SRON, ASTRON and NWO-EW) and earth and planetary research communities (SRON, KNMI, TNO, universities).

National R&D activities will be realized in collaboration with SRON, TNO, NLR and universities and will include projects with SMEs linked with the specific technology roadmaps co-ordinated by NSO. Activities for the development of applications and services using satellite data will be realized in collaboration with the Dutch Value Adding Industry, including NEVASCO members along with the NL knowledge institutes (amongst others TO2 partners, ITC, universities).

Private investments are done by the companies directly and increasingly in public private partnerships in ESA and the EU technology programmes.

>> Process followed in creating and maintaining this roadmap

The roadmap has been created and reviewed by a team of authors that is representative for the space sector in the Netherlands. The roadmap is published on websites of Holland High Tech and SpaceNed, while stakeholders are informed about the roadmap and its objectives. In those cases where the national or European Space Strategy is changed, or NSO's roadmapping process leads to new insights, impact of these changes will be implemented in the roadmap, typically with a frequency of 3 to 4 years. The updated roadmap is published by Holland High Tech.

INVESTMENTS[7]

Roadmap	**2017**	**2018**	**2019**	**2020**	**2021**
Industry	6	6	7	8	9
TNO	4	4.5	4.5	5	6
NLR	1	1.1	1.1	1.2	1.2
NWO-SRON PPS/PPP*1)	3.5	3.5	3.5	3.5	3.5
Universities *2)	10	12	12	12	12
Government support space programmes *3)	80	90	90	100	100
Departments and regions	4	4	4	4	4
Grand total	108,5	121,1	122,1	133,7	135,7
European agenda within roadmap	**2017**	**2018**	**2019**	**2020**	**2021**
Industry	2	2	2	3	3
TNO	0.5	0.5	0.5	0.5	0.5
NLR	0.5	0.5	0.6	0.6	0.7
NWO-SRON	0.1	0.1	0.1	0.1	0.1
Universities	4	5	5	5	5
Regions	0.5	0.5	0.5	0.5	0.5
EZ co-financing of European programmes	0.5	0.5	0.5	0.5	0.5
European Commission *4)	8	8	10	12	12
Grand total	16,1	17,1	19,2	22,2	22,3

All figures in million Euro per year

1) The total funding of NWO for SRON is 14 M€ annually
2) estimate, based on the number of FTE involved in space research
3) estimate, based on anticipated contracts to be allocated by ESA and NWO
4) estimate, based on anticipated contracts to be allocated in Horizon2020 framework; EC programmes Galileo and Copernicus concern operational systems rather than R&D and are therefore not included in this table

[7] Investments listed do not include service development and data use (development of value-adding "downstream" applications)

ANNEX I List of SpaceNed members (status March 2018):

1	Aerospace Propulsion Products
2	Airborne
3	Airbus Defence and Space Nederland
4	ATG Europe
5	Braakhuis
6	Bradford Engineering BV
7	Capable B.V.
8	CGI
9	Cosine BV
10	Dawn Aerospace
11	Dutch Aerospace Group
12	De Roovers Vacuum & Precision Technology BV
13	ESA BIC
14	European Test Services (ETS) B.V.
15	HEAD Aerospace NL
16	Hyperion Technologies B.V.
17	ISIS Space
18	JAQAR Concurrent Design Services B.V.
19	KNMI
20	LioniX International BV
21	Leidse Instrumentenmakers School
22	Lens R&D
23	MECON Engineering B.V.
24	Nederlands Lucht- en Ruimtevaartcentrum (NLR)
25	NOVA
26	NWO-I/ SRON
27	Pentacon
28	Radboud Radio Lab
29	S&T
30	Stellar Space Industries
31	SystematIC
32	Terma Nederland B.V.
33	Thales Cryogenics
34	TMC
35	T-Minus
36	TNO
37	Topic Embedded Products B.V.
38	TU Eindhoven
39	TU Delft
40	Verhaert Netherlands B.V.
41	WEST END