



الهيئة الاتحادية
للتنافسية والإحصاء
FEDERAL COMPETITIVENESS
AND STATISTICS AUTHORITY



POLICY IN ACTION

MISSION TO MARS

The **Policy in Action Series** is published by the Federal Competitiveness and Statistics Authority (FCSA). The series is intended to raise public awareness and stimulate discussion on key areas of competitiveness and policy work in the United Arab Emirates (UAE).

FCSA is a UAE federal government entity created in 2015 by the Presidential Decree No.6. The authority's mission is to strengthen and enhance the UAE's national data and competitiveness capacities. FCSA is one of the official government sources for national statistics and is one of the government representatives on matters related to national competitiveness.

FCSA aims at improving the UAE's global competitiveness performance by working with stakeholders on defining and implementing reforms and policies across sectors.



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CONTENTS

Executive Summary	4
The International Space Race	6
- Top 10 Countries with Largest Space Budgets	8
- The UAE's Space Ambitions – A Competitive Edge	9
The UAE's Cosmos Story	11
- Sheikh Zayed and Space	11
- A Dream Come True	12
Timeline	18
The UAE Space Sector Policy	20
In Focus: The Red Planet	22
The UAE Mars 2117	24
The UAE Space Program's Benefits on Earth	26
Achieving the UN's Sustainable Development Goals	28
Conclusion	30

EXECUTIVE SUMMARY

Nations around the world have embarked on innovation strategies and frameworks as they have identified them as key to promote economic growth, increase competitiveness and provide new job opportunities by enhancing the knowledge economy and fostering entrepreneurship in all sectors.

As the Fourth Industrial Revolution disrupts traditional industries and economies, countries are seeking to invest in future technologies to boost their level of competitiveness and further improve the quality of life for their societies.

The renewed interest in space technologies can be attributed to its widespread applications across multiple sectors and challenges currently faced on Earth. Furthermore, the interest in colonization and exploring new viable sites that support human life is due to the tremendous advancements in technology as well as the strain on natural resources on Earth that are impacting food security, climate change and human displacement. The initial Space Race between two competing superpowers has matured over the decades into an international public/private collaborative competition that now includes more than 50 space agencies and 300 private companies.

Since its founding in 1971, the United Arab Emirates has transformed itself into a leading

destination for talent and business in record time, led by massive infrastructure investments and a business-friendly environment.

The late His Highness Sheikh Zayed bin Sultan Al Nahyan's interest in the world beyond ours, triggered the UAE's space odyssey that steadily evolved into the country establishing a National Space Policy. The policy aims to build a strong and sustainable UAE space sector that supports and protects national interests and vital industries; contributes to the diversification and growth of the economy; enhances the UAE's specialized competencies; develops scientific and technological capabilities; engrains the culture of innovation, boosts national pride, and strengthens the UAE's status and role in the region and around the world.

As part of its commitment to implementing an effective science, technology and innovation (STI) strategy, the UAE's space professionals are developing a national space agenda within the purview of a stable space regulatory framework.

The UAE government's competitive and confident direction towards capacity building of the country's future generations is evident through the 2021 Emirates Mars Mission and 2117 Mars Strategy, as their ultimate goals are to be inspiring science missions that benefit humankind, the Arab world and the UAE.



Through the UAE's competitive direction, the Federal Competitiveness and Statistics Authority (FCSA) examines how the UAE is already in an advantageous position to be a competitive player in the global space sector, as well as the positive impact and benefits it will bring to the country and the superiority of its competitiveness standing at the international level.

Space strategy has evolved from satellites and communication leading up to a future-focused agenda designed to enable innovation-led industries to improve the country's competitiveness, leveraging its existing expertise and leadership in aviation to expand into aerospace and commercial space activities in the very near future.

The competitive benefits for the nation are multiple. A robust space industry will further contribute to the UAE's soft power diplomacy, as it will demonstrate a commitment to advancements in science, technology and innovation (STI) and collaborations with other countries.

From an economic perspective, the pursuit of the Mars Mission will drive investments from

the international private sector and industry-specific startups, who will be able to partner with the UAE and thrive in a pro-business landscape. Moreover, a social impact of an ambitious space program will extend across the education sector, which will benefit from a renewed interest in STEM-inspired studies. It will lay the foundation for a generation of homegrown scientific and technical talent that can spearhead the nation's programs, thereby reducing the reliance on experts from overseas.

The UAE's space sector, which is working towards Emirati building capabilities and engaging the young scientists to manage the project by 100%, already has a strong gender balance ratio with an average of 40% of women working in the sector, which is more than double the average number of women working in NASA (14%) and as a result, UAE's space program will spearhead innovation in the industry that will have a multi-sector impact and have the potential to present unique solutions to address the existing challenges on Earth, beside work on collaborations with international partners to embark on a mission that will ultimately serve humankind.

THE INTERNATIONAL SPACE RACE

More than seven decades of progress in humankind's advancement and quest for space exploration and dominance have contributed greatly to enhanced security, economic growth, international cooperation, knowledge and human development. Initially limited to two superpowers competing at full speed to reach the Moon, the race then slowed down and has now become more cooperative between a growing number of participating nations. Their achievements have triggered renewed interest in the potential of the space exploration sector, which is now witnessing an unprecedented race to space that has engaged public-private partnerships.

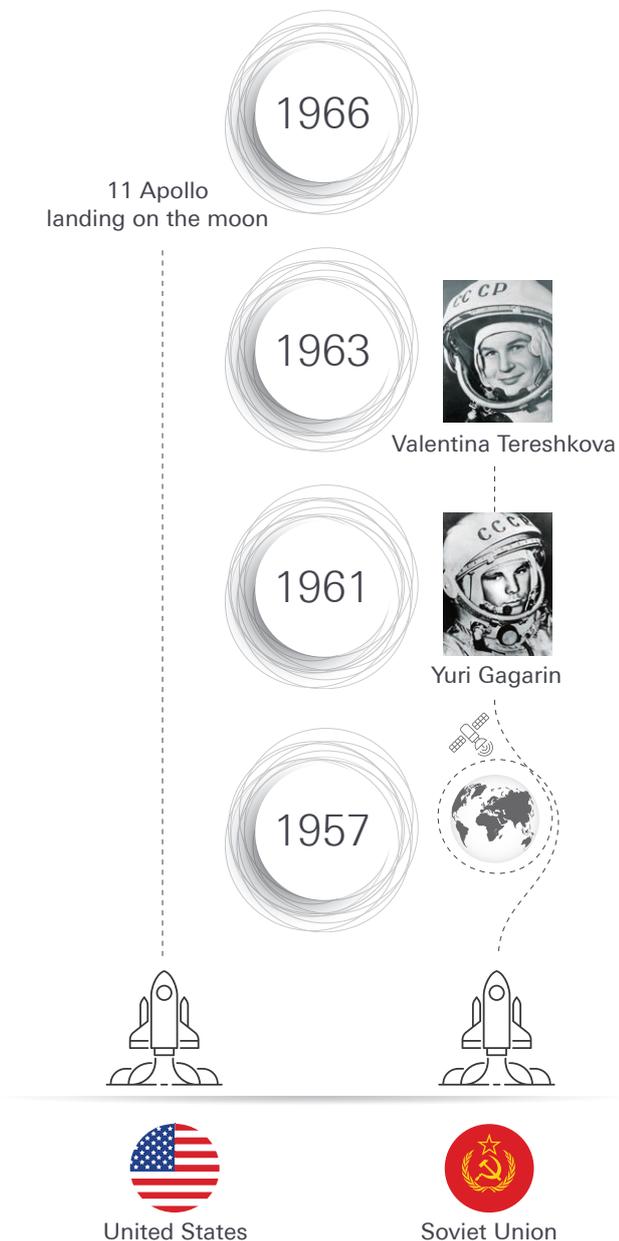
The US-USSR Rivalry

The International Space Race traces its origins to 1955 and refers to the rivalry between the two global superpowers, the Soviet Union and the United States, as they both sought political, technical and economic dominance. Pioneering in space innovation was perceived as a necessity for national security as well as a symbol of exceptionalism or national superiority over other nations. The race commenced when the Soviet Union stunned the world and launched Sputnik 1, the first artificial Earth satellite into orbit in 1957.

The US accelerated its space program, but the Soviet Union maintained its lead through many early 'firsts' including sending Yuri Gagarin, the first human into outer space in 1961, and Valentina Tereshkova to be the first woman to fly in space in 1963.

During these years, under immense pressure from the public, the US had to dramatically increase its funding for research of new technologies, space exploration and education. The budget rose from 0.1% of its GDP in 1958, when the National Aeronautics and Space Administration (NASA) was created, to more than 4.4% of its GDP in 1966.

The US finally caught up with the Soviet Union by sending men to the Moon – a promise made by US President John F. Kennedy in 1961 – with the Apollo 11 mission that landed the first two humans on the Moon in 1969 and returned them safely to Earth. A further six Apollo missions followed until 1972, while the Soviets suffered four failed attempts to launch a lunar landing craft during the same period, thus concluding the space race with a US victory.



Increased International Cooperation

In 1972, the two countries began collaborating on a joint mission, the Apollo-Soyuz Test Project, which could arguably be the moment of reconciliation in the space race between the two countries. The project successfully docked two dissimilar spacecrafts to outer space by 1975, and the US and Russian crews shook hands in orbit and exchanged gifts in a historic moment of diplomatic détente between the two competing nations.



Growing international cooperation also became a necessity as the US spending on space exploration slipped back to less than 1% of its GDP after the Apollo-Soyuz Test Project, due to reprioritization of government spending.

For other countries that were not traditionally recognized as superpowers, participation in space exploration was an assertion of their capabilities and innovation, which in turn had an impact on their industries, economies and overall competitiveness. As the world became increasingly interconnected, new space agencies were established and contributed to the progress of human exploration in space.

The best example to date is the International Space Station, a joint project established in 1993 between five major space agencies – America’s NASA, Russia’s Roskosmos, Japan’s JAXA, the European Space Agency and the Canadian Space Agency. Together, they built a habitable microgravity and research laboratory in low Earth orbit from 1998 to 2011 that is likely to be used until 2028.

Although OECD countries account for the largest proportion of the global space budget, BRIC economies as well as other major emerging economies have been playing an increasing role in the last decades.

As of 2013, China was the second top spender after the US with US\$6.1b; Russia was the top spender in terms of share of its GDP with 0.25%, and India was in 6th position with 0.06% of its GDP. Notably, India caught the world’s attention when it successfully launched its Mars probe in its first attempt in 2013 and launched a record 104 satellites from a single rocket (including the UAE’s Nayif-1 nanosatellite) in 2017. Nigeria also has a robust space program aiming to send a Nigerian into space by 2030.

Private Interest

In the 20th century, space exploration relied on public funding. After the Space Race between the US and the Soviet Union wound down in the 1970s, the drastic reduction of government budgets towards the space sector resulted in a lack of long-term political vision and leadership, and eventually a significant slowdown. The additional participation of other countries was not enough to sustain the momentum witnessed in the first 20 years of the Space Race but the continuous achievements due to increased international cooperation reignited global interest.

Four companies have clearly emerged as leaders in terms of venture funding. The UK's OneWeb received the most funding with US\$1.7b and will start building in 2018 a satellite internet constellation of hundreds of small lightweight satellites that will connect the whole world to the internet and aims to fully bridge the digital divide by 2027.

A new movement in the 1990s gained momentum with private companies and entrepreneurs launching the next generation of space exploration and related technologies, mostly in collaboration with governmental institutions. Currently, more than 300 private companies work in space technologies, catalyzed by the prospect of using the advances achieved in space for applications on Earth.

Box 2: Four companies have clearly emerged as leaders in terms of venture funding. The UK's OneWeb received the most funding with US\$1.7b and will start building in 2018 a satellite internet constellation of hundreds of small lightweight satellites that will connect the whole world to the internet and aims to fully bridge the digital divide by 2027.

The Luxembourg-based O3b Networks received US\$1.2b and has been building a fiber-speed satellite network since 2013. The American SpaceX, founded by entrepreneur Elon Musk with the goal of reducing space transportation costs and enabling the colonization of Mars, has received US\$1.1b and

is already successfully competing with federal agencies with first-time achievements such as launching, orbiting and recovering a spacecraft, connecting it to the International Space Station, as well as reusing orbital rockets thanks to propulsive landing.

The UK's Virgin Galactic, founded in 2004 by entrepreneur Richard Branson to develop commercial orbital and suborbital spaceflights for space tourists, has already received US\$380m in funding from Abu Dhabi-based Aabar Investments in 2010 and 2011.

Top 10 countries with largest space budgets

- 1 United States**
National Aeronautics & Space Administration (NASA)
US\$20.7b (2018)
- 2 Europe**
European Space Agency (ESA)
US\$5.6b (2018)
- 3 Russian Federation**
Russian Federal Space Agency (Roskosmos)
US\$3.3b (2015)
- 4 France**
French Space Agency (CNES)
US\$2.6b (2017)
- 5 Germany**
German Aerospace Center (DLR)
US\$2.5b (2015)
- 6 Italy**
Italian Space Agency
US\$1.8b (2014)
- 7 India**
Indian Space Research Organization (ISRO)
US\$1.7b (2018)
- 8 Japan**
Japan Aerospace Exploration Agency (JAXA)
US\$1.5b (2015)
- 9 China**
Chinese National Space Administration (CNSA)
US\$1.3b
- 10 United Kingdom**
United Kingdom Space Agency (UKSA)
US\$0.5b

The UAE's Space Ambitions – A Competitive Edge

Today, the global space economy is estimated to be worth US\$323 billion, and it is widely expected to double by 2030 according to a 2015 report from the Space Foundation. Globally, the number of rocket options for sending commercial satellites into space is growing, and with the UAE's aspiration to diversifying its economy, the aerospace and commercial space industry stand to gain from its government's focus on the sector.

The UAE is steadily rising in the rankings of the most innovative and competitive nations in the world. As per the UAE Vision 2021 launched in 2010, the UAE aims to be among the top 10 countries in the WEF Global Competitiveness Index and INSEAD Global Innovation Index by 2021.

The UAE currently ranks 25th in the WEF Global Competitiveness Index (2019-2020), a composite indicator that measures the competitiveness of countries over 12 pillars: institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication and innovation.

In the 2019 IMD World Competitiveness Ranking, the UAE is 5th and is in the top 10 countries for business efficiency (ranked 1st), economic performance (ranked 7th) and government efficiency (ranked 2nd).

In the 2019 INSEAD Global Innovation Index, the UAE is ranked 36th and is in the top 30 countries when it comes to Institutions (ranked 28th), Human Capital & Research (ranked 18th), Infrastructure (ranked 21st) and Business Sophistication (ranked 30th).

More specifically, UAE is already an international leader in the aviation sector. Dubai-based Emirates Airline is the largest airline in the Middle East and one of the largest in the world. Dubai International Airport is the world's busiest by international passenger traffic (91 million passengers in 2017), while the recently operated Al Maktoum International, the city's second airport, will grow and be capable of handling 250 million passengers a year. The UAE has also established the Nibras Al Ain Aerospace Park to cater to major aerospace companies and is working towards becoming a global benchmark in aerospace.

The nation has strategically established its favorable position to be a spacefaring nation through its successful foray into satellite technologies (Thuraya, DubaiSat, YahSat and KhalifaSat). Over the last two decades, the government encouraged and supported Emirati scientists to collaborate with international agencies to ultimately achieve self-sufficiency and be able to build satellites in the UAE with a 100% Emirati team, as was the case with KhalifaSat.

Being the only Arab nation with an established space agency – the UAE Space Agency (UAESA), today has US\$5.2 billion in government, private and semi-private support. The UAE is also leveraging its geographical location on the southeastern edge of the Arabian Gulf, which makes it a viable and attractive future spaceport to pursue further extraterrestrial ambitions.

With vast expanses of desert and miles of coastline at its disposal, the UAE can offer options for safe rocket launches, also its proximity to the Equator gives it an advantageous position as the spin of the Earth provides an extra push, which translates into less fuel required to get payloads into orbit. To this end, Aabar Investments' stake in Virgin Galactic has fueled the prospect of a spaceport being built in Abu Dhabi in the near future.

Furthermore, the long-term 2117 Mars strategy will provide the UAE with competitive advantages such as scientific credibility and increased soft power;

economic and social benefits; gender balance competitiveness and sustainability. In 2020, the UAE will be the sixth nation to send a probe to Mars.

Through the next phase of the strategy, human researchers and explorers will achieve scientific breakthroughs to facilitate the arrival of humans on the Red Planet by developing faster and more efficient means of space transportation. Currently, there is no known source of fuel on Mars, requiring

it to be transported and stored there. The strategy will also come up with an integrated scientific visualization of the settlement, as well as life on Mars with respect to food, transportation and energy amongst other factors. With the long-term plan to build a city on Mars, the UAE is now part of an even more exclusive group of pioneering nations, set to reap the benefits of their investments for future generations.



THE UAE'S COSMOS STORY

2nd December 1971, the day the UAE was formed, the world's space community celebrated the first successful soft-landing on the Red Planet, after receiving a radio-transmission from the Mars 3 Soviet probe. Since that fortuitous coincidence, the UAE's space odyssey has come a long way in a short span of time, with the country aiming in the short-term to land the country's and the Arab world's first probe on Mars in 2021 and pursuing a long-term strategy which envisions the construction of the first inhabitable human settlement on the Red Planet by 2117.

Sheikh Zayed and Space

The UAE's space ambitions can trace its origins back to the founding father of the UAE, the late His Highness Sheikh Zayed bin Sultan Al Nahyan. He was gifted a tiny fragment of Moon rock from US President Richard Nixon in 1972, a year after the official birth of the UAE, as a symbol of the unity of human endeavor. The rock is on display in the Al Ain Museum.

Sheikh Zayed always demonstrated tremendous curiosity towards space exploration and the impact of the scientific results on humanity, according to Egyptian-American space scientist Dr Farouk Al Baz, who worked with NASA to assist in the planning of scientific explorations of the Moon and has met Sheikh Zayed on three occasions.

The first meeting took place in June 1974, after the Apollo lunar exploration mission, when Dr Al Baz

presented him with a map of the surface of the Moon that detailed the six landing sites. The second meeting took place in January 1975 and was also attended by Apollo 15 astronaut James Arron. Sheikh Zayed inquired with keen interest about the atmosphere on the moon, breathing techniques, food and sleep. At the third meeting in February 1976, Sheikh Zayed welcomed Dr Al Baz and three American NASA astronauts from the historic US-Russia Apollo venture that linked-up in orbit with a Soviet Soyuz spacecraft. They presented him with a gift of a replica space shuttle.

Sheikh Zayed's meetings sparked a national focus by sending a prominent message to his people and the region that Emirati curiosity and ambitions knew no boundaries in space, and he set the foundations for the UAE to build a vibrant space sector.



A Dream Come True

After the success of the UAE astronaut Hazza Al Mansouri at the International Space Station (ISS), a new phase in the United Arab Emirate's mission towards space invasion and scientific exploration has begun. Hazza Al Mansouri spent eight days at the ISS which is over 3.4 million miles away from the Earth. The success of the mission is considered a turning point in UAE's Space Mission and marks a great achievement in the area of space exploration, which made Sheikh Zayed's dream a reality, and is an immense contribution to the UAE's space program and specifically in space and scientific research. Hazza's step is the beginning of a thousand-mile journey. His journey inspires Emirati youth to follow the path of space knowledge and aim to innovate to become the best in the field of space sciences; the field of which major countries in the world are competing to be listed in the top ranks. Hazza's achievement for the country symbolizes the leadership's vision and hope for the youth and hands the responsibility of the UAE's reputation to the youth who will carry the flag to beyond the space station and towards Mars and the moon. The establishment of the UAE Space Agency and the Mohammed bin Rashid Space Center signify the importance of achieving the aspirations and wisdom of the UAE leadership, to bring forth great opulence in the future to come.



Satellites

The first milestones in the UAE's space journey were in the satellite industry. In 1997, Thuraya Communications Company was established in Abu Dhabi. Its mobile satellite communication services enabled connectivity in remote regions beyond the range of terrestrial communication networks and gave subscribers the freedom to roam across countries with uninterrupted service. In 2000, they launched Thuraya-1, the Middle East's first mobile telecommunications satellite, as well as the first satellite phone.

The Thuraya-2 and Thuraya-3 satellites, launched in 2003 and 2008 respectively, expanded its geographical reach across Africa, Asia, Australia and Eastern Europe, while widening the range of its satellite services such as high-speed data and broadband modem. The award-winning company currently operates 2 geostationary satellites that provide telecommunications coverage in more than 161 countries.

In 2007, the UAE's status in the satellite sector was further cemented when Al Yahsat Satellite Communications (Yahsat) was established. Fully owned by Mubadala, the Abu Dhabi government's strategic

In 2006, the Emirates Institution for Advanced Science and Technology (EIAST) kicked off a 10-year knowledge and technology transfer program with a South Korean manufacturer to gain expertise at their facility to manufacture Earth Observation satellites. The Dubai-Sat-1 satellite, launched in 2009, was manufactured in South Korea by a 30% Emirati team; the DubaiSat-2 satellite, launched in 2013, was manufactured by a 70% Emirati team; the third and latest satellite, Khalifa-Sat, which is scheduled to be launched by the end of 2018, is the first satellite to be fully manufactured by an entirely Emirati team in the UAE.

investment company, it was the first company in the Middle East and Africa to offer multi-purpose satellite services, commercially for the private sector as well as strategically for the UAE government – providing secure satellite communications for the UAE Armed Forces.

Yahsat has launched three satellites – Al Yah 1 in 2011, Al Yah 2 in 2012 and Al Yah 3 in 2018 – manufactured by a European consortium and is now connecting more than 140 countries.

Global Space & Satellite Forum (GSSF) was launched by UAE in 2008 as a high-level gathering of the industry's stakeholders from around the world. The Congress supports the region's ongoing space projects and initiatives and establishes the region as a key contributor to the global industry of space exploration through its support for pioneering projects, space education and research, commercial space applications and scientific and commercial missions. It was re-launched as the Global Space Congress in 2017 in order to reflect its stature as the premier space event in the region.

On 15 February 2017, the UAE launched Nayif-1, its first ever nanosatellite designed and manufactured by Emirati engineering students. The mission was a partnership between American University in Sharjah, Innovative Solutions in Space – one of the world's leading companies in the development of space components and nanosatellite systems – and the Mohammed bin Rashid Space Centre (MBRSC), hosting the integration in its "Clean Rooms".

It was aimed at transferring knowledge to students and providing universities with an educational platform, offering Emirati students from various engineering disciplines hands-on experience at designing, testing and operating a communications satellite. Nayif-1, with a standardized and simplified cubic design (10 cm cube, 1.3 kg), produces a communication footprint ranging from 5,000 - 5,500 km and can orbit at an altitude between 450 km and 720 km for up to three years.

Institutions and Programs

As part of the vision to transform Dubai and the UAE into a knowledge-based economy, the Government of Dubai established the Emirates Institution for Advanced Science and Technology (EIAST) in 2006 as a future-focused entity that would inspire younger generations to explore the field of space research and promote a culture of advanced scientific research and technology innovation in the country.

Through a hands-on approach in the form of designing, manufacturing and operating Earth Observation satellites, EIAST acquired knowledge and technology through transfer programs with South Korea before building facilities in the UAE to manufacture satellites. EIAST also shared its own experience in establishing a space industry as a model to other developing countries and its vision has been recognized globally as a major contributor to the space industry.

In 2010, Sheikh Mohammed bin Rashid Al Maktoum, UAE Vice-President and Prime Minister and Ruler of Dubai, announced the UAE Vision 2021, an innovation policy and strategy to position the UAE among the best countries in the world by the Golden Jubilee of the Union. It emphasized the importance of innovation across all sectors, including the space sector: "Innovation, research, science and technology will form the pillars of a knowledge-based, highly productive and competitive economy, driven by entrepreneurs in a business-friendly environment, where public and private sectors form effective partnerships." To this end, the National Innovation Strategy was launched in 2014 with a four-fold goal of developing and stimulating innovation at an institutional, government, private sector and individual levels. It prioritizes seven sectors to drive future innovation. Space has an important role to play in the UAE's economic diversification strategy and transformation from a resource-based to a knowledge-based economy.



Our region is a region of civilization. Our destiny is, once again, to explore, to create, to build and to civilize.

Sheikh Mohammed bin Rashid Al Maktoum

UAE Vice-President and Prime Minister and Ruler of Dubai



In 2014, a major institutional milestone was reached when the UAE Space Agency (UAESA) was established to supervise and organize all space activities – especially the Emirates Mars Mission– to develop the sector, ensure knowledge transfer, enhance the UAE’s standing as a global player in aerospace and maximize the contribution of space industries to the national economy.



UAESA has entered into agreements with leading international space organizations allowing the UAE to become the first Arab state to join the International Space Exploration Committee and become a member of international organizations including the United Nations Committee of the Peaceful Uses of Outer Space, the International Astronautical Federation and the Group on Earth Observation. Its comprehensive strategy includes developing the space sector, preparing and regulating its policies and guiding national

space programs that will benefit the national economy. By focusing on industry and inspiration through its education outreach programs, the agency aims to encourage the UAE’s children to pursue STEM fields in a variety of new industries.

Highlighting the UAE’s Year of Innovation (2015) was the establishment of the Mohammed bin Rashid Space Centre (MBRSC), headquartered in Dubai and to which the EAIST is currently affiliated. The Centre contributes to the establishment of the National Space Sector in the UAE and oversees preparations and implementation of all phases of the UAE’s Mission to Mars. The Chairman and Crown Prince of Dubai, Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum launched a 15-year strategic plan to develop resources, knowledge and to expand its space exploration capabilities, reiterating the Centre’s strategic importance within the long-term vision of the leadership for Dubai and the UAE.

With the Mars Probe announcement, a seven-year agreement was signed between EIAST and UAESA to develop the knowledge, skills and infrastructure needed to build the first Arab Islamic probe and reach Mars. The building of the probe is fully financed and supervised by UAESA and undertaken by EIAST’s engineers.



This probe represents hope for millions of young Arabs looking for a better future. There is no future, no achievement, no life without hope. The Emirates Mars Mission will be a great contribution to human knowledge, a milestone for Arab civilization, and a real investment for future generations.

Sheikh Mohammed bin Rashid Al Maktoum

UAE Vice-President and Prime Minister and Ruler of Dubai



The 2021 Emirates Mars Mission was officially unveiled in 2015. Named "Hope", it ushered in a symbol of hope for a new era of peaceful human development. As a joint project between the UAESA and the MBRSC, the spacecraft is scheduled for its launch in July 2020, with the landing on Mars timed during the first quarter of 2021, to coincide with the UAE's 50th anniversary.

The UAE will be the sixth nation to launch Mars missions after the US, Russia, Europe, India and China. The spacecraft will start operations mid-2021 and last for two years, with the potential to extend for another two years. The mission's goal is to obtain the first truly global picture of the Martian atmosphere. Al-Amal will be Mars' first true weather satellite as previous probes only took snapshots of the climate at certain times of the day.

In 2016, a formal National Space Sector Policy was launched by the UAESA to underline the vital role of the space sector as a catalyst in the development process and its direct and indirect influence on strategic sectors of the economy and international cooperation. The policy's main principles are to enhance the lives of UAE citizens; support UAE national interests; support the growth and diversification of the UAE economy; promote collaboration and support the UAE's international status while respecting international laws and treaties.

At the 5th World Government Summit in 2017 held in Dubai, the UAE took a giant step further with the announcement of the Mars 2117 strategy, unveiled in the presence of representatives of 138 governments.

The strategy is a 100-year national agenda that envisions the construction of the first inhabitable human settlement on Mars, starting with Mars Sci-

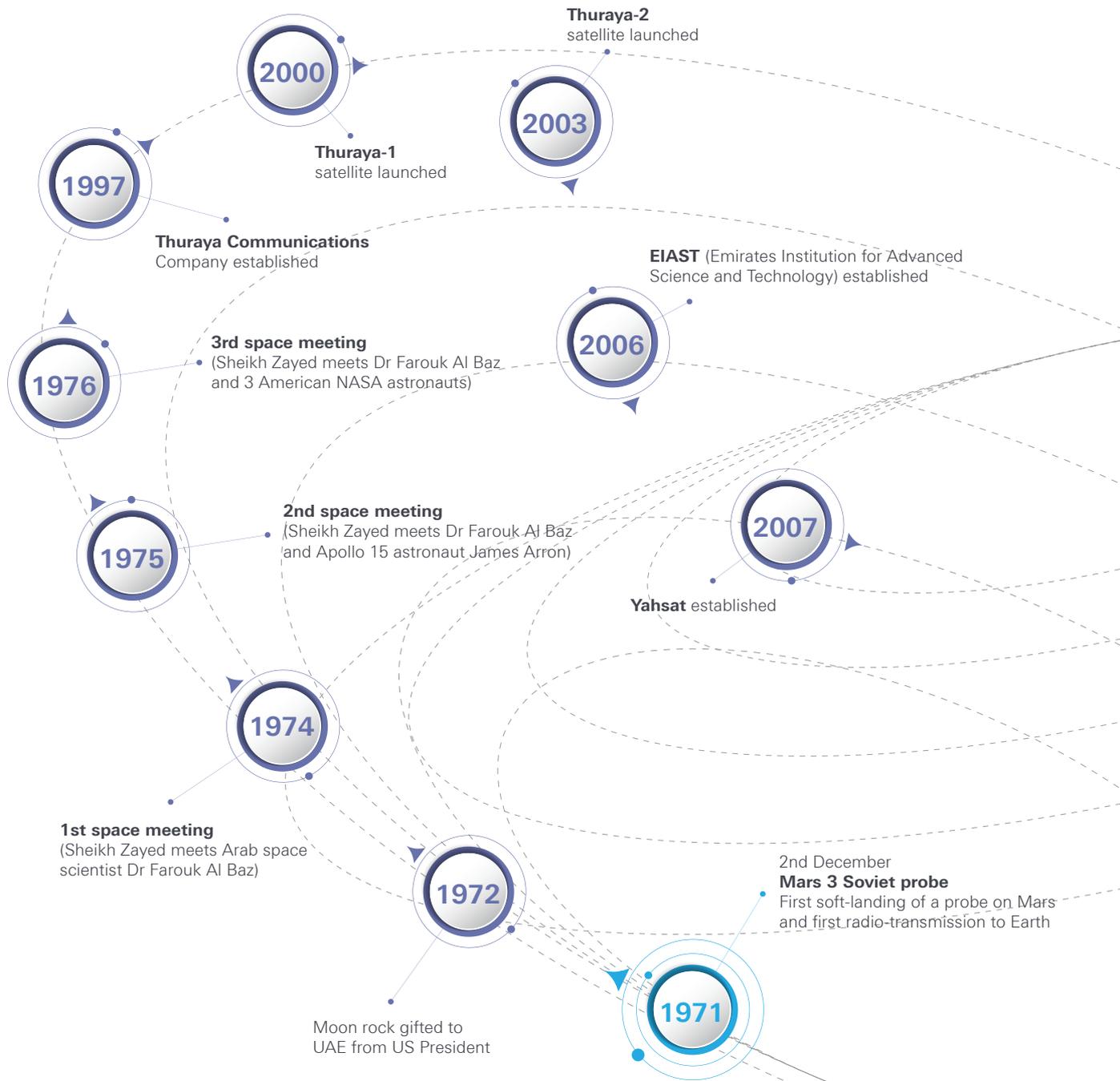
ence City, the largest space-simulation city to be built in the UAE to simulate the Red Planet's terrain and harsh environment.

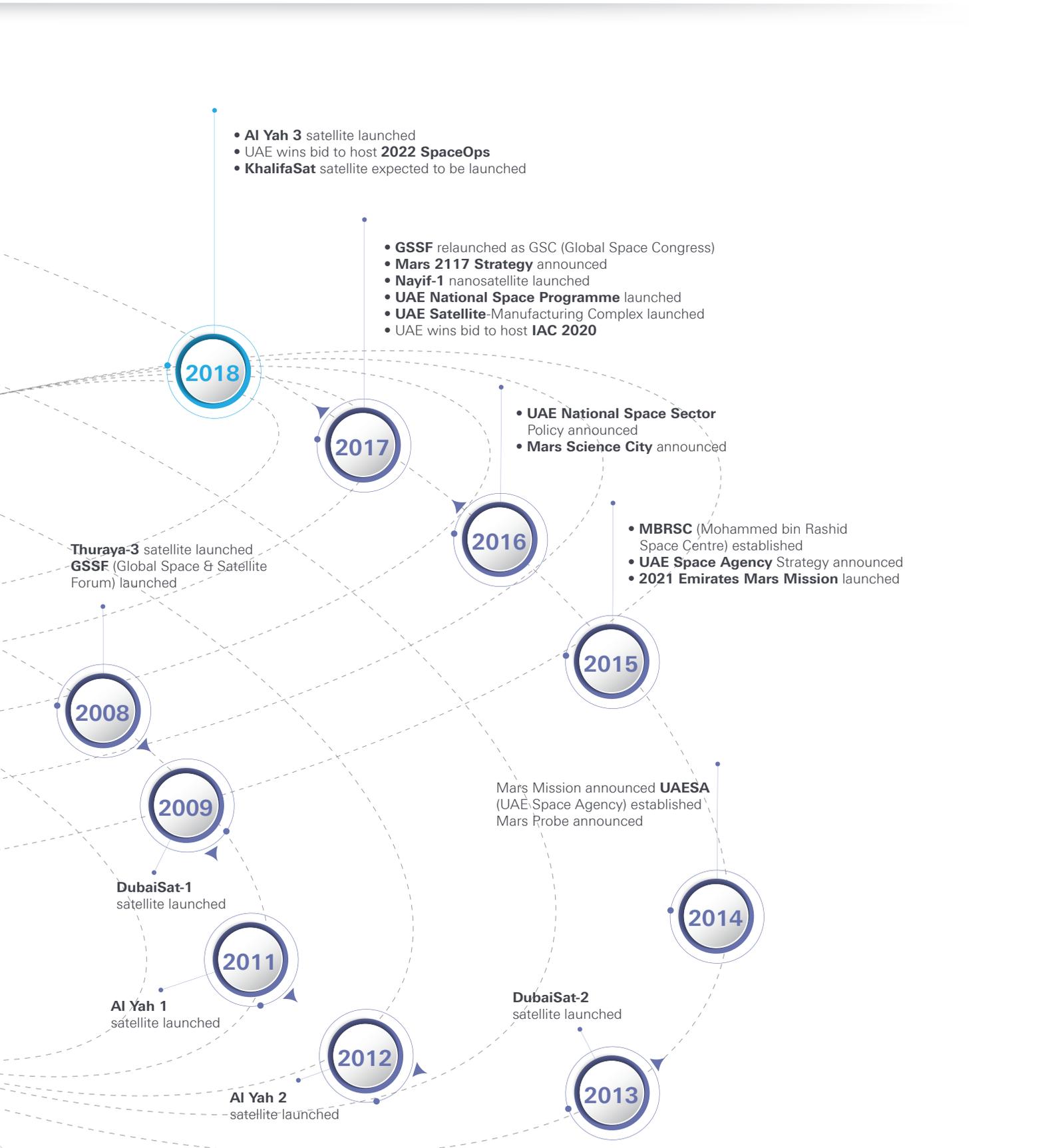
Later in 2017, the UAE also launched its National Space Program, which aims to prepare Emirati astronauts to join scientists at the International Space Station. The program includes setting up the Mars Science City and the Arab Space Discovery Program, a knowledge and expertise transfer program in space sciences in collaboration with Arab universities and institutions. The New York University in Abu Dhabi (NYUAD) will host the UAE's first space data center where critical scientific data will be collected by space observatories. The center will support a significant capacity for facilitating pre-launch studies accompanying the Emirati Mars Mission, Solar Orbiter and the Transiting Exoplanet Survey Satellite (TESS) mission.

The UAE's recognition as an important contributor to the international space sector and industry has led to the historic winning of the bid to host the 71st International Astronautical Congress (IAC), the world's largest specialized conference in the global space sector. Due to be held in Dubai in 2020, a few months after the launch of the Mars Probe and Mars Science City project and hosted by the MBRSC in coordination with the UAESA, the conference will attract over 5,000 scientists, astronauts and experts from around the world. The UAE has also won the bid to host the International Conference of Space Operations (SpaceOps) 2022. Bringing together major international institutions and space agencies to discuss the strategies of space operations.



TIMELINE





- **Al Yah 3** satellite launched
- UAE wins bid to host **2022 SpaceOps**
- **KhalifaSat** satellite expected to be launched

2018

- **GSSF** relaunched as **GSC** (Global Space Congress)
- **Mars 2117 Strategy** announced
- **Nayif-1** nanosatellite launched
- **UAE National Space Programme** launched
- **UAE Satellite-Manufacturing Complex** launched
- UAE wins bid to host **IAC 2020**

2017

- **UAE National Space Sector** Policy announced
- **Mars Science City** announced

2016

- **MBRSC** (Mohammed bin Rashid Space Centre) established
- **UAE Space Agency** Strategy announced
- **2021 Emirates Mars Mission** launched

2015

Thuraya-3 satellite launched
GSSF (Global Space & Satellite Forum) launched

2008

Mars Mission announced **UAESA** (UAE Space Agency) established
Mars Probe announced

2009

DubaiSat-1 satellite launched

2014

2011

Al Yah 1 satellite launched

DubaiSat-2 satellite launched

2012

Al Yah 2 satellite launched

2013



THE UAE SPACE SECTOR POLICY

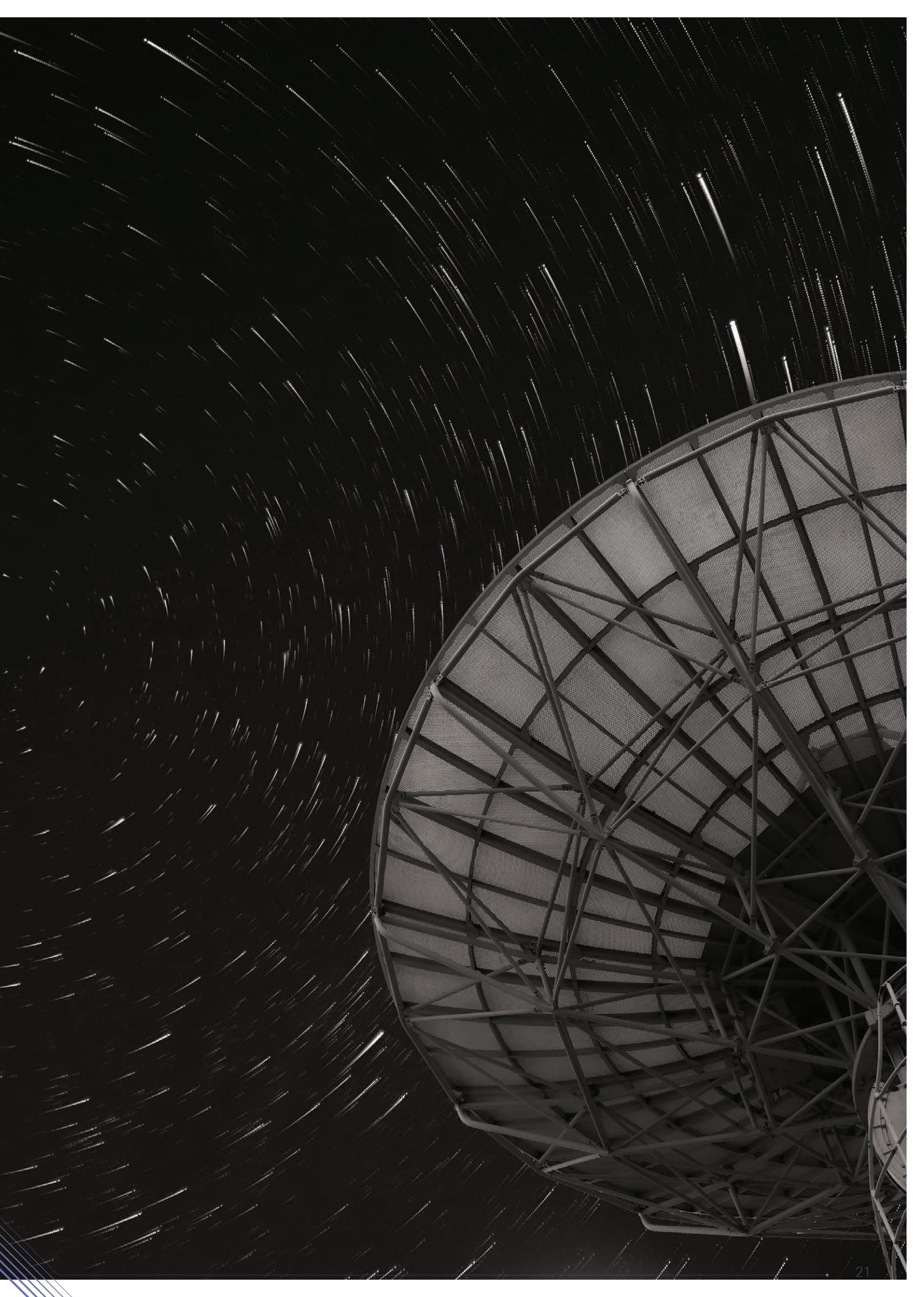
In light of the establishment of the UAE Space Agency (UAESA) and the announcement of the Mars Probe in 2014, the UAESA developed the National Space Sector Policy to achieve the following objectives:

- Convey the government's approach, priorities and ambitions in space;
- Coordinate national efforts and focus on the state's priorities in the space sector;
- Regulate the space sector, strengthen its role and ensure its sustainability;
- Stress the importance of international cooperation in the domain of outer space.

To achieve the National Space Policy Goals, the UAE stakeholders have developed guidelines that fall into three interdependent areas of space activities: national functions, science and exploration and commercial activities.

- The National Functions guidelines include: support to national security; enhancement of disaster monitoring and response; support to humanitarian aid; support to key UAE industries; utilizing space technology to improve the quality of the UAE's people; support to natural resources management; support to smart cities and e-government; and support to international efforts for the promotion of sustainable space activities.
- The Science, Technology and Exploration guidelines, include: develop and encourage UAE scientific and aerospace engineering professionals; enhance land and climate observation and support environment protection; support national space technology development; create programs to support space exploration efforts; and embark on space programs that increase the UAE's status in the field.
- The Commercial Sector guidelines, include: promote UAE products and services; support economic diversification and develop new markets; create a competitive and sustainable commercial space industry; promote and sustain innovation; promote creative entrepreneurship and commercial space projects; and support the development of space industry standards.

¹ Booklet "National Space Policy of the United Arab Emirates", September 2016



IN FOCUS: THE RED PLANET

The pursuit of the colonization of Mars is accelerated by the growing perception that Earth is becoming over-populated at an unprecedented rate, leading to a fast depletion of natural resources and wide extinction of entire animal species, potentially threatening the human race itself. The search for an alternate planet to settle on is now considered a priority by governments and entrepreneurs who are determined to contribute to saving humanity.

Mars is the fourth planet from the Sun and the second-smallest planet in the Solar system, with a diameter half of the Earth's and two moons (Phobos and Deimos). It is a rocky planet of terrestrial type, with a solid surface that has been altered by volcanoes, impacts, winds, crustal movements and chemical reactions; the average temperature is -63 degrees Celsius.

Mars has a thin atmosphere that offers protection from cosmic and solar radiations, made up mostly of carbon dioxide, argon, nitrogen and a small amount of oxygen and water vapor; it is known as the Red Planet because iron minerals in the Martian soil oxidize (rust), causing the soil and atmosphere to look red. The gravity on Mars is about a third of the gravity on Earth, believed to be sufficient for the human body to adapt to. A Martian day takes a little over 24 hours and a Martian year is equivalent to 687 Earth days.

Mars' surface cannot currently support life, but the average temperature is not too extreme for human protective solutions, the soil contains water to

Mars' similarities with Earth and its relative proximity, with an average distance of 225 million kilometers, made it a prime candidate for exploration and object of study as a potential inhabitable planet in the future.

extract and there is enough sunlight to consider the use of solar panels as a local source of energy.

In comparison, the Moon offers far fewer vital resources and no protective atmosphere against solar radiations; and Venus, the second closest celestial body to Earth, offers far more extreme conditions.

Many spacecrafts have visited the Red Planet, from flybys and orbiters to probes and rovers on the surface, in order to gather more information about the planet and prepare future missions. However, Earth and Mars are on two distinct orbits around the Sun. As a result, the distance between the two planets vary greatly and the launch window for the optimum missions happens only every 26 months, drastically limiting the opportunities to launch spacecraft.

The first Mars mission success was NASA's Mariner 4 flyby in 1965, which sent back 21 close-up photos. Several subsequent missions successfully orbited the Red Planet and returned high-quality images that allowed scientists to start mapping out its story. In 1976, NASA's Viking 1 and Viking 2 spacecraft made history when they landed on the surface and remained fully operational, igniting years of high-resolution imaging of the surface, measuring the composition of the surface and atmosphere, and conducting scientific experiments to search for life. NASA's Mars Pathfinder landed successfully in 1997 by testing a giant system of airbags to cushion the impact, and dispatched Sojourner, the first wheeled robotic rover; over almost 3 months, the mission returned over 17,000 images, 15 chemical analyses of rocks and soil and extensive weather data.

Buried water ice was discovered in 2002, followed by twin rovers landing in two different regions of Mars and finding strong evidence that the Red Planet once had long-term liquid water on the surface. Missions have also dug up and analyzed icy soil in the polar region and found signs of possible habitability, including the presence of liquid water

and potentially favorable soil chemistry, as well as have landed in Gale Crater and found conditions once suited for ancient microbial life on Mars and gathered radiation data to help protect future astronauts.

Mars is currently host to eight spacecraft: six in orbit and two on its surface. NASA's future Mars 2020 Rover will study the availability of resources like oxygen and conduct unprecedented science and exploration technology investigations. Future Mars missions include the UAE's Al-Amal; ESA's

and Russian Federal Space Agency's ExoMars rover in 2020, to search for past and present microscopic life; the 2020 Chinese Mars mission; ISRO's Mars Orbiter Mission 2 in 2021-2022, to follow-up on its first mission in 2014; and SpaceX's planned launch of its Big Falcon Rocket to Mars with passengers scheduled for 2024. Despite this long list of missions to Mars, it must be remembered that Mars still has a reputation of being a difficult space exploration target, with roughly two-thirds of all spacecraft destined to Mars having failed before completing their missions.



THE UAE'S MARS 2117 STRATEGY

In spite of the first Mars probe reaching the planet in 1971, the race to its colonization has only gained tremendous traction in recent years, due to the remarkable advancements in science and technology. Consider this: the computing power of a present-day smartphone is equivalent to the computing power of the supercomputers that sent men to the moon in 1969.

The moment for a serious human endeavor to reach and settle in Mars has gained further urgency by the enormous strain on Earth's natural resources placed by over-population. Spacefaring is no longer science fiction, but an actual reality, with innovation across several sectors such as manufacturing, technology, communications, food and medicine, driving countries, institutions and individuals to truly explore beyond our planet for the survival of humankind.

UAE government's competitive and confident direction in building the capacity of its nation's generations is translated clearly in its ambition towards Mars, as its ultimate goal for the mission to be a novel science endeavor that gives back benefits to humanity and the UAE. The UAE believes that the Mars 2117 strategy and the 2021 Emirates Mars Mission (EMM) will have the same impact on the country's students as the Apollo mission had on generations of science and engineering graduates around the world.

Understanding Mars

The mission's goal is to obtain the first truly complete picture of the Martian atmosphere, by mapping its weather at a global level, understanding its climate dynamics, observing the interactions between the various layers of the atmosphere, as well as studying the loss of planetary atmospheric gases to outer space, known as atmosphere escape, that makes Mars uninhabitable.

The team has identified gaps in human knowledge that no other Mars missions have studied, in order

to provide answers to the international scientific community. As most knowledge about climate is based on Earth, studying the different atmosphere on Mars will help scientists further evaluate distant worlds for conditions that might support life. The Mission, which has established prestigious academic knowledge transfer partnerships, is expected to receive over 1,000 gigabytes of new Mars data that will be shared freely with the international Mars science community.

Building for Mars

Based on the findings of the EMM, the UAE will actively study ways to address the atmospheric challenges of Mars and create an inhabitable and sustainable environment for future settlements. Mars Science City in Dubai will be the largest space-simulation city ever built. It will comprise several domes covering 1.9 million sqft and serve as a "viable and realistic model" to simulate Mars' terrain and harsh environment. Laboratory spaces will be outfitted with advanced technologies allowing replicating Martian heat and radiation levels. Mars Science City will also include laboratories for food, energy and water, agricultural testing and studies about food security, to address the challenges that are mutual to Earth and Mars.

In the short term, the 2021 Emirates Mars Mission (EMM) will allow the UAE to understand the Martian atmosphere beyond the current available knowledge. Al-Amal is scheduled for blast off during a brief launch window in July 2020, for a 200-day journey across 60+ million kilometers, with landing on Mars timed during the first quarter of 2021. The 1,500 kg spacecraft will be equipped with star tracker sensors to determine its position in space by studying the position of the constellations in relation to the sun, in the same way Bedouin travelers and seafarers in ancient times would use the stars to find their way.

Experiments can lead to practices that can be perfected on Earth before being implemented on Mars:



The challenge of scarce water could be addressed if we invent a technology that can extract water from the soil and wet sand in large quantities.



Studying and growing plants that produce the most oxygen to make the atmosphere breathable could address the challenge of scarce oxygen. Technologies could also break down the components of carbon dioxide largely present in the atmosphere, extract the oxygen and combine it with hydrogen to produce water, while the surplus carbon could become part of another building material.



The challenge of food supply is that it would be too expensive to take livestock to Mars and much cheaper to grow it there. Experiments could be conducted on types of crops that don't need as much water and grow at the most effective rate.



The challenge of habitat construction could be addressed with technology using sand from the surface of Mars as a building material to 3D-print entire structures. This technique will be used to construct a museum displaying humanity's greatest space achievements, with 3D printed walls using sand from the UAE desert.

The project will be carried out by an Emirati team of scientists, engineers and designers, led by the MBRSC and Dubai Municipality, in cooperation with internationally renowned Danish architects from Bjarke Ingels Group (BIG)-the architects behind the designs for Two World Trade Center in Manhattan- and the Hyperloop One.

Speaking at the 2018 World Government Summit in Dubai, Bjarke Ingels said: "There are all of the ingredients to sustain life on Mars using exactly what is already there" and machines would use Mars' natural resources to create everything from Martian concrete and glass to electronics, plastic and steel.

The plan's experiential component will involve a team living in the simulated Red Planet city for an entire year. It is hoped the experience will form an important reference model for future innovation around sustaining life in a hostile planetary environment. A range of experiments is to be devised, which will lead to innovations around self-sufficiency in energy, water and food, that would have important applications on Earth itself, as climate change is redefining the natural resources of Earth.

THE UAE SPACE PROGRAM'S BENEFITS ON EARTH

Beyond Earth and beyond Mars, space exploration is about inspiring the explorer that lies in every human being and serving as a means to challenge the frontiers that are known while discovering the unknown. The ultimate goal is the rewards to humanity, the Arab world and the UAE: knowledge about the world beyond ours, scientific progress to achieve this exploration and new opportunities and hopes.

Pioneering in space – exploration and the industry – greatly benefits a country's competitiveness in innovation and scientific research, as the spin-off technologies from the space sector can be extended and applied to various industries. The UAE's leadership is aware that the scientific and technological achievements that go towards space exploration and research have a direct and indirect impact through their wide-ranging array of applications in several fields that are key to achieving high rankings in the world's competitiveness indices. As the UAE is focused on diversifying towards a knowledge-based and innovation-led economy, the country's extensive investment in a sustainable space program is a long-term investment in the future.

Domestic Benefits

The UAE's initial space journey has been dominated by satellite-related activities that have contributed towards its expertise in Earth observation, communication and navigation leading up to its space science aspirations.

The establishment of various UAE owned satellites enabled uninterrupted satellite communication connectivity in remote regions connecting many countries, making UAE self-sufficient and independent in addressing observation needs that are instrumental to the anticipation of natural hazards, the urban and infrastructure development of the nation, while also supporting the nation's security and scientific disciplines in national, private and academic sectors.

High quality imagery at the lowest cost among a vast array of facilities comes as a huge assistance in the development and planning of strategic sectors, and continuously contributing to success in other areas of competitiveness such as technology, innovation, industry, infrastructure and higher education, all while acquiring outstanding skills and expertise.

As a result, the UAE is competitive, confident and well positioned to launch an ambitious space program. Mars is both a short-term and long-term goal for the UAE and the trickle-down effect of the technologies during the pursuit of the Mars projects will have implications across industries and challenges relevant to Earth that will support the UAE's achievement towards the 2030 worldwide Sustainable Development Goals (SDGs).

International Cooperation

Space exploration and Earth observation are collaborative in nature and reveal opportunities for extensive international cooperation. With challenges on Earth such as climate change, food security and rising sea levels, the need for closely coordinated efforts has never been greater. During humanitarian crises and natural disasters, space agencies can prioritize sharing satellite data to facilitate more efficient aid rescue and recovery efforts.

Over the years, the UAE has become a significant partner and contributor through its reliable satellites, having a longstanding relationship with the International Telecommunications Union (ITU) and working closely with governments in countries afflicted by natural disasters, through local service partners to provide free or subsidized communication services.

The UAE formally signaled its intentions of becoming a leading and active spacefaring nation when it became a party to the principal international space conventions by acceding to the Outer Space Treaty in 1967, the Space Liability Convention in 1972 and

The UAE has provided immediate emergency communications in Japan after the earthquake and tsunami in 2011; supported the setup of disaster surveillance centers in Uganda, Philippines and Turkey; contributed in helping to save lives in Samoa, China, Malawi, Pakistan, and Indonesia when they were hit by terrible natural disasters, and were first responders in Nepal following the devastating earthquake in 2015. High quality images provided by UAE satellites were instrumental in several humanitarian actions such as formulating a disaster recovery mission for the 2010 floods in Pakistan or monitoring relief efforts for United Nations after the 2011 Tohoku earthquake and tsunami in Japan.

the Registration Convention in 1972 which form the basic legal framework of international space law. The nation is aware of its responsibility towards developing the organizational infrastructure to handle the various international collaborations required to build its space policy, strategy and program. It has been a member of the UN's Committee on the Peaceful Uses of Outer Space since 2015.

The UAE signed MoUs with prestigious space programs to establish official partnerships for knowledge-transfer and resource sharing, and it has signed an agreement with the US Strategic Command to share data and services related to space situational awareness. The UAESA has also signed an Implementing Agreement with NASA that outlines Mars exploration as the first field of cooperation between the two nations' agencies and further space-oriented collaborations. Recently* (2017), the UAESA and the United Nations Office for Outer Space Affairs (UNOOSA) signed a MoU to increase cooperation in the peaceful uses of outer space exploration and to commence joint research projects on the use of space technology and its claims for economic and social benefits under the resulting Space agenda 2030.

Other UAE space related achievements commenced in 2017 involve becoming an official member of the International Charter on Space and Major Disasters and establishing the Emirati Youth Council to motivate young Emiratis with an interest in space, empowering the next generation of space leaders.

The UAE's space program is a matter of pride for the nation and Arabs in general, while also expanding the nation's existing international partnerships and growing the diplomatic goodwill through knowledge sharing of Earth and beyond.

² https://www.un.int/uae/statements_speeches/uae-statement-fourth-committee-%E2%80%9Cinternational-cooperation-peaceful-uses-outer

* Presentation "MBRSC contribution to the SDGs", 15 November 2017

ACHIEVING THE UN'S SDGs

In 2015, the United Nations approved the “2030 Agenda for Sustainable Development”, which provided a new development framework that required countries to achieve 17 SDGs that are inclusive, socially responsible and environmentally sustainable and shift the focus from GDP and economic growth as determinants of success and prosperity. The UAE’s commitment to the 2030 SDGs will positively affect its global competitiveness rankings and through the research and technology from the space program.

Some examples of the UAE’s space program’s impact on the SDGs³

4 QUALITY EDUCATION



- Nanosatellite Outreach Program
- Research Experience for Undergraduate Program, which provides students with an international internship opportunity in EMM’s academic partners.
- Entaliq Scholarships provided by MBRSC to undergraduates, who will later join the workforce.

5 GENDER EQUALITY



- MBRSC: male to female ratio is 60:40; at the assistant director general level it is 50:50.
- EMM: male to female ratio is 65:35; at the deputy project manager level it is 62.5:37.5.

6 CLEAN WATER AND SANITATION



- Using DubaiSat-1, DubaiSat-2, and KhalifaSat satellites’ images to monitor the levels of reservoirs, which can help define how people can access clean water
- Generating water area maps such as seawater, lakes and pools, in addition, studied the water surface area of dams with time to see the amount of surface water that changed

7 AFFORDABLE AND CLEAN ENERGY



- MBRSC built region’s first self-cooling eco-home completely independent from power grid
- Feasibility study done for urban heat islands
- Feasibility study done for solar panels detection from satellite imagery

³Presentation “MBRSC contribution to the SDGs”, 15 November 2017

9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



- Participation in Innovation week for two years consecutively
- Development of MBRSC's SME program for technology and science sectors
- Several new and innovative programs such as Nayif-1, NSOP, REU, etc.
- Classification maps of urban areas, roads, vegetation, water, and undeveloped areas, which help in infrastructure mapping and monitoring the area growth
- Coastline detection to monitor the changes and the causes for the changes
- Providing governmental entities with satellite data to support innovation, infrastructure and industrial projects

13 CLIMATE
ACTION



- Partnership with UNSPIDER for disaster management
- DubaiSat-1, DubaiSat-2, KhalifaSat satellites' images can be used to monitor deforestation, pollution levels, ice caps and desertification and enable preventative actions
- Manufacturing an environmental nanosatellite, DMSat-1, with instruments and tools specifically for environmental studies such as aerosol optical depth, aerosol effective radius, and greenhouse gases concentrations will contribute to the studies of Earth's atmosphere and greenhouse gas effect on the climate.

14 LIFE
BELOW WATER



- Using DubaiSat-1 and DubaiSat-2 satellites' images to monitor the levels of red tides and fish stock
- Monitoring maritime using satellite imagery (red tide detection)
- Desalination plant studies
- Studies conducted about the effect on fishes in certain areas
- Study conducted on coral reefs

15 LIFE
ON LAND



- Using DubaiSat-1 and DubaiSat-2 satellites' images to monitor deforestation and land changes
- Monitoring natural disasters worldwide using space-based data
- Vegetation mapping and health
- Mangrove forestry detection
- Palm trees detection and counting
- Supporting entities dedicated to conserving natural resources by signing MoUs and providing them with space-based data such as Dubai Desert Conservation Reserve and Emirates Wildlife Society – World Wildlife Fund

17 PARTNERSHIPS
FOR THE GOALS



- Numerous MBRSC partnerships, both nationally and internationally
- Establishing collaborative projects for remote sensing earth observation applications field with international partners such as Deimos UK and OSI



CONCLUSION

In a remarkably short span of time, the UAE has established itself as a serious contender and player in the international space programs of the 21st century. The nation's ambitious space policy and strategy is aligned with UAE Centennial 2071 goals that include best education, which dedicates improvements to the education system by focusing on technology and AI, in order to provide future generations with the tools to contribute to serving the nation and building its future, economic leadership, which positions the UAE as a major economic powerhouse by adopting advanced science and technology solutions through consistent innovation and investing in entrepreneurship and environmental sustainability, happiness, which invests in community wellbeing through cohesive families, tolerance and a solid national identity, and led by a sound government, which plays a vital role in empowering people, ensuring security and stability by harnessing the potential of advanced science and technology to improve the quality of life, provide social services and legislation to position the UAE as the leading country in the world.

The UAE has already demonstrated it boasts several competitive advantages in the space sector, including a robust and internationally renowned aviation sector; a government-led future focused innovation strategy supporting research, development and excellence in science, technology and engineering; a government committed to building on international diplomacy through greater global collaborations and partnerships; an existing geographical edge for the establishment and growth of a dynamic aerospace sector; and an economy with high competitiveness rankings in several crucial areas paving the way for a space program that will drive innovation and have direct and indirect economic and social impacts across industries and communities. It will support research and development (R&D) to address the existing challenges on Earth, inspiring future generations to pursue STEM-led education, with the end goal of achieving prosperity led by knowledge, innovation and technology.

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