Navigating Space Technology

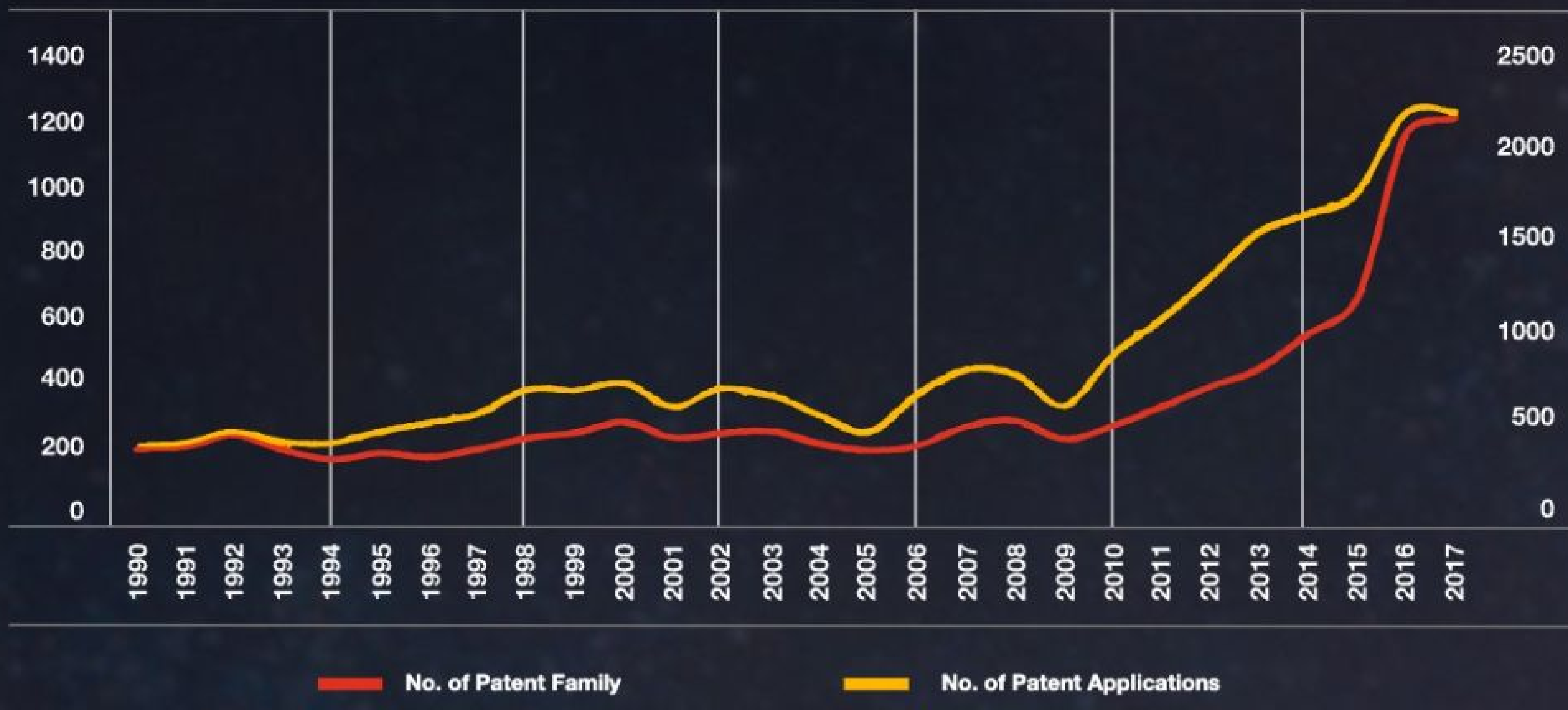
A booster for Saudi Arabia's digital economy

Introduction

There has been much discussion about recent developments in the space sector, the democratisation and consumerisation of space industries, and the decreasing cost of manufacturing. However, it is important to note that space and technologies, particularly those related to digital and communication, should not be considered separately. They have inspired each other since the second half of the 20th century. SpaceTech is already a reality and the potential for innovation and economic growth resulting from the space and technology sectors is enormous.

As an indicator for this potential, see Exhibit 1 for increase in space-related patent filings in the European Patent Office (EPO).

Exhibit 1: Worldwide Patent Filing in Space Sector



Source: Cosmonautics / Lexology / ESA
https://www.lexology.com/library/detail.aspx?g=aa4771e8-c44e-4858-91d9-72df87f71f9b

01

Examples from History

Examples from History

The history of space exploration is filled with examples of inventions that most people wouldn't associate with the space sector. However, these have now become an integral part of our daily lives. From LEDs to wireless headphones, infrared thermometers to memory foam, and portable cameras to mobile computers - our world today would look a lot different without these.

Here's a timeline of digital technologies used, enhanced or made possible by developments in the space sector.

A timeline of innovations related to the space sector

1960s

Video conferencing: NASA's need for remote communication during space missions led to the development of early video conferencing technology in the 1960s, enabling real-time collaboration across vast distances.

Wireless headset: NASA were looking for a lightweight and wireless communication system that would allow astronauts to communicate with their teams on earth which would not be damaged or lost on splashdown.

Digital Signal Processing: Used for processing the Apollo 11 video in real time, later used for audio compression and image/video processing.

1970s

Heart Echo Scans: NASA engineers developed an echo-cardioscope to monitor cardiac functions of astronauts in flight. It forms images of internal structures using high-frequency sound.

Electronic Health Record: A computer software that was developed at NASA to monitor the health status of astronauts was subsequently used by a commercial Hospital as a first electronic health record solution.

1980s

Infrared thermometers: Because normal thermometers can't measure the temperature of stars, NASA tried out infrared technology to assess the temperature of distant planets and stars. Exploiting this idea, a company invented a device that measures the thermal radiation emitted by a patient's eardrum.

Digital Imaging: The active pixel sensor in most digital image-capturing devices was invented when NASA needed to miniaturise cameras for interplanetary missions. It is also widely used in medical imaging and dental X-ray devices.

1990s

Weather Monitoring Systems: Weather/environment satellites that provide high resolution images of Earth's atmosphere for use in such applications as cloud top temperature monitoring, hazardous weather prediction and crop monitoring.

Examples from History

2000s

Countertop gardens: The space industry indirectly influenced the invention of countertop gardens through the development of LED Grow Lights and hydroponic and aeroponic systems.

2010s

Metal 3D Printers: A high-precision 3D printer capable of manufacturing items in microgravity out of resources mined in space to produce spacecraft components.

Virtual Reality Platform Helps Pilots Land in the Sky: it allows a pilot to practice landing on a virtual runway in the air By superimposing virtual elements over a view of the real world, it allows for safer, more accurate, and cheaper training.

Drone/Car Anti-collision Software: Neurala is working to house both processing and memory capabilities in one "brain" rather than relying on cloud computing. This uses less energy, speeds reaction time, and would be essential for a self-learning Mars rover.

RoboMantis: A robot which could take over dangerous jobs in disaster zones or hazardous areas. While originally designed for outer space missions, the robot can also carry out jobs like cleaning chemical containers or bomb disposal.

2020s

Improved Medical Device Design: NASA engineers relied on simulations when developing the James Webb Space Telescope. This helped push capabilities in integrated modeling software which are now used to design medical devices.

Medical-Grade Smartwatch: EmbracePlus is a smartwatch for astronaut monitoring and clinical research.

Case Studies

The Microchip:

The Apollo programme stands as a monumental achievement in human history, showcasing the power of science, engineering, and exploration with the historic 1969 Moon landing. Amidst numerous challenges, the success of Apollo hinged on pioneering technologies, notably the Apollo Guidance Computer (AGC), a digital computer that emerged as the unsung hero. The AGC computer was revolutionary since it leveraged integrated circuits or microchips, which allowed NASA engineers to maximize system performance while minimising size and weight to meet the various constraints posed by the mission. This breakthrough not only propelled humanity to the Moon but also accelerated the development and adoption of integrated circuits.

Satellite communication:

In the 1960s, the first commercial communication satellites became operational. In fact, the 1964 Olympic games in Tokyo, was the first mega global event with satellite-transmitted television coverage. SatComms is the use of artificial satellites to provide communication links between various points on earth. Today, the SatComms domain has expanded with governments and businesses growing keen on providing complete communications and internet coverage across the globe, especially in remote areas which do not benefit from fixed signal receptors. Today, more than 6,000 Low Earth Orbit satellites are orbiting earth and providing internet coverage worldwide.

Positioning and navigation:

The US-owned Global Positioning System (GPS) uses satellite positioning and navigation systems and was developed primarily for military and national security purposes. But it was gradually opened up through the 1990s. In mid-2000, the GPS services opened up for civil and commercial use and was made available and free for use worldwide. Since then, we've seen an explosion of use-cases and it's not only our Uber or Zomato; applications span across many sectors including agriculture, mining, logistics (fleet, port, and airports operations) and many more.

02

Advancements in the Region

The region has witnessed, over the last few years, ambitious plans for the space and technology sectors. Significant advances have also been made by countries of the Gulf Cooperation Council (GCC), with many having their independent space programmes. National transformation agendas, efforts to localise manufacturing and services and the introduction of effective regulation and deregulation will continue to propel the transformation of the sectors.

Last year, KSA sent Rayyanah Barnawi – the first Arab woman in space – to the ISS. On the ground, the the Kingdom is establishing the foundations for the execution of its space strategy which is expected to be released soon. The former Saudi Space Commission has been transformed into the Saudi Space Agency which is already making global news through the inaugural Space Debris Conference in February 2024, expected to be established as a bi-annual event in the Kingdom.

From launching the Arab world's first Mission to Mars to signing the Artemis Accords, the UAE has also emerged as a leader in space exploration. Emirati astronauts, Hazzaa Al Mansorri and Sultan Al Neyadi flew on ISS missions in 2019 and 2023 respectively. The uncrewed Mars mission "Hope Probe" was launched in 2020 and is in Mars orbit since 2021.

In the space sector, Oman has published its 10-years "Policy and Executive Programme" (that includes plans to construct the first space port in the Middle East in 2023), promptly followed by hosting the first Middle East Space Conference in 2024 earlier this year.

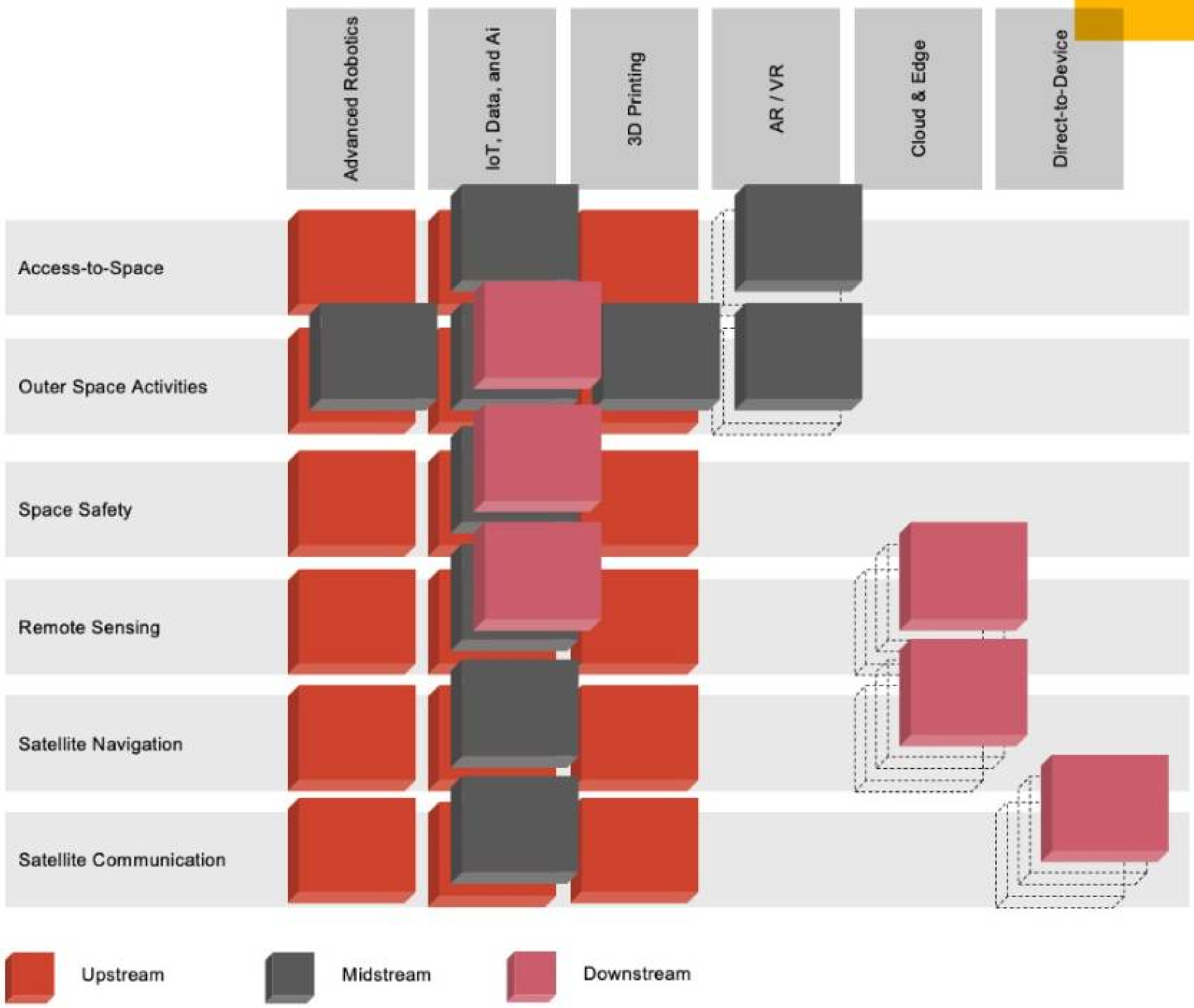
GCC governments are also already investing heavily in the technology sector. From early adoption of electronic government to the first minister of AI in the UAE, from the vision of NEOM as a cognitive city to strengthening cyber security in KSA, the government agendas in the GCC have been technology-driven for a long time.

03

Proposed SpaceTech Framework

Various advanced and emerging technologies play a key role across space sector activities. In PwC Middle East, we have established a framework (see Exhibit 2) mapping these technologies against a taxonomy of business, research and exploration activities in the space sector.

Exhibit 2: PwC SpaceTech Framework



The framework reveals the relationship between Space and Technology, it helps us to identify application areas, clusters of entrepreneurial activities and description, profiling and measurement of economic activities across the Space upstream, midstream, downstream value chain.

Technology is pervasive across the six space sector domains highlighted in the framework: Access to Space, Remote Sensing, Satellite Communications and Satellite Navigation, Space Safety and Outer Space Activities.

Upstream

Development and manufacturing of components is employing technologies such as Digital Twins, Robotics, 3D-Printing and industry-scale usage of IoT connectivity and sensing.

Midstream

Operational activities are driving the progress in human-machine integration (e.g., tracking health data for crewed missions), advanced communications technologies and augmented and virtual realities for training, automation and execution of research and exploration missions.

Downstream

Processing of satellite-based data (remote sensing), before - on the spacecraft - or after sending it back to Earth is key to unlock value from remote sensing data and imagery. Another breakthrough technology will be the large-scale availability of direct-to-device communication and broadcasting from LEO constellations.

Space and technology are diverse and wide sectors. This report cannot do justice and cover all opportunities and intersections there are. As an invitation for further exploration, we included three-deep dives illustrating how the framework helps to understand the intersection.

AI in Remote sensing is a space domain that uses machine learning and analytics to make sense of earth observation imagery and other data. Direct-to-device communication and broadcasting is the ability to connect an end-user device directly to a satellite constellation and Robotics play a key role in in-orbit manufacturing, mining and servicing.

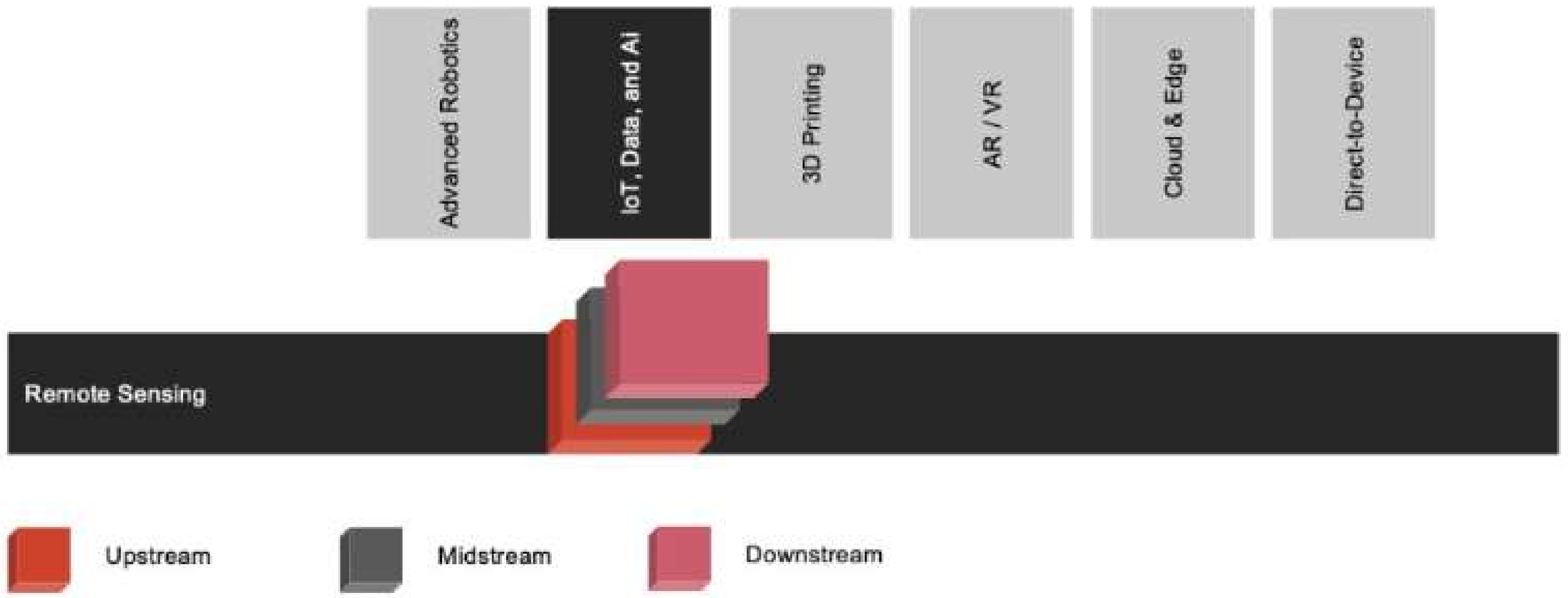
Of course, given the breadth and dynamism of the space sector, we are merely scratching the surface in this report.

SpaceTech Deep Dives

01

Artificial intelligence (AI) in remote sensing: This is an emerging space domain that is witnessing a high rate of commercialisation and growth within the private sector due to its countless industry applications. Remote sensing is the capture, processing, and analysis of data and imagery of the surface, atmosphere, and oceans of earth, moon, and other planetary bodies from space. Remote sensing satellites are equipped with specialized sensors capable of capturing information in the form of images, spectra, radar, and lidar (light detection and ranging). The captured data is then processed and used for monitoring, analysis, and decision making across a wide range of applications. Image processing and Artificial Intelligence (AI) are prevalent technologies in remote sensing as they are used to overlay and make sense of the data captured using different techniques.

AI algorithms, such as convolutional neural networks (CNNs), are trained to automatically identify and extract specific features or objects of interest from satellite imagery, such as buildings, roads, vegetation, and water bodies. Other AI algorithms are then used to detect changes or anomalies in land use, city infrastructure, and environmental conditions overtime. The resulting data and imagery are used for monitoring, analysis, and decision making across a wide range of applications including deforestation monitoring, natural disaster management, climate change studies, urban planning, agriculture and more.



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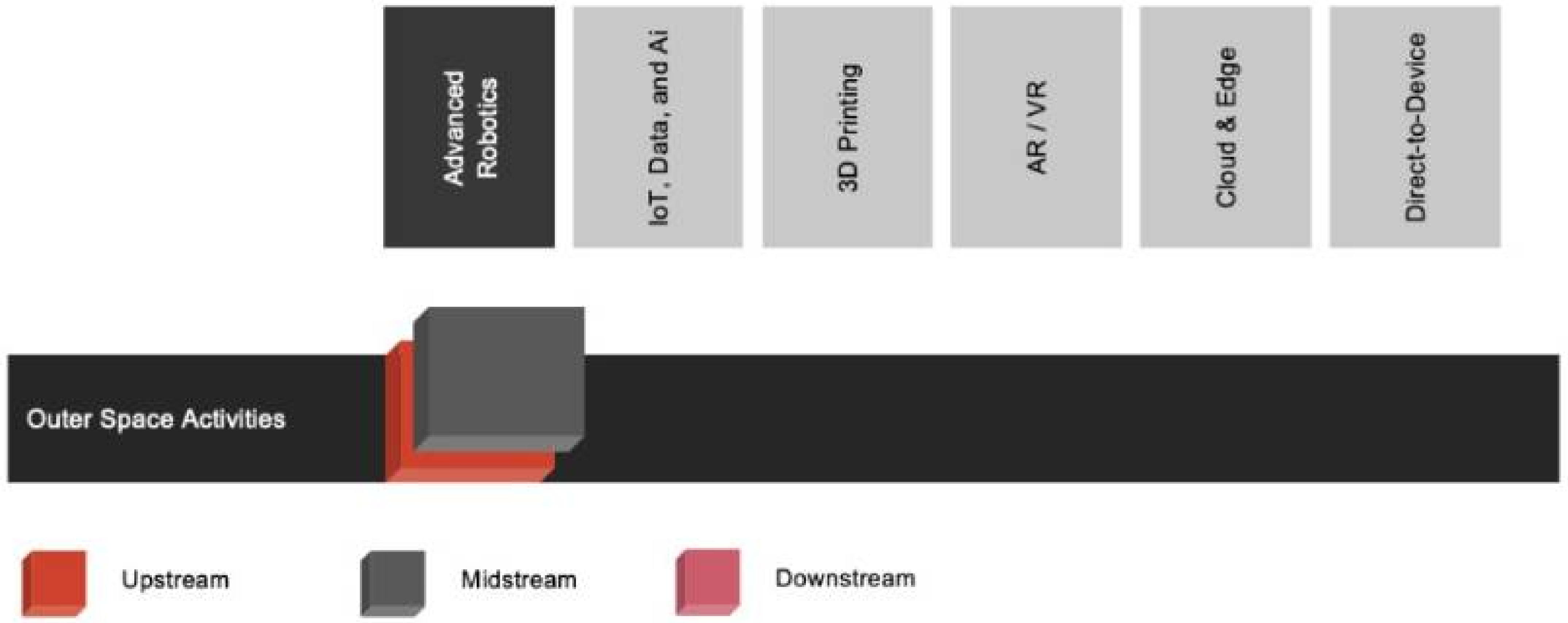
Direct-to-device in satellite communications: Direct-to-Device (D2D) technology, such as Starlink's, addresses the challenge of providing high-speed internet access to underserved and remote areas around the world. Traditional internet infrastructure, such as fiber-optic cables and terrestrial networks, often struggles to reach rural and isolated communities due to geographical barriers and high deployment costs. Modern D2D solutions leverage a constellation of Low Earth Orbit (LEO) satellites orbiting closer to earth than traditional satellites, reducing latency and enabling faster data transmission. These satellites form a network that communicates directly with ground terminals equipped with specialized antennas. Unlike traditional satellite dishes, terminals automatically track, adjust the orientation, and communicate with passing satellites, providing seamless internet connectivity to users without the need for complex or manual alignment procedures. The advantages of LEO satellites for D2D connectivity include low latency, high throughput, global coverage, resilience, flexibility, and scalability. By leveraging these advantages, LET satellite D2D technology aims to bring affordable, high-speed internet access to remote and underserved communities worldwide.

03

Advanced robotics in outer space activities: The space industry is one with a distinctively high barrier-to-entry for new operators due not only to the technical complexity of the field but also to the significant financial investment that is required. Operators have to shell-out hundreds of millions of dollars to design, manufacture, launch, and operate their satellites as well as acquire liability insurance against damages. Satellites also have a short lifespan relative to the investment required to place them in orbit due to their high energy demands and the rising threat of damage due to the increasing amount of space debris.

To mitigate this problem, several innovative technologies are being developed to provide in-orbit servicing and maintenance to active satellites. Service satellites with robotic arms are being produced which can dock onto existing satellites and refuel those satellites through a specialized interface to increase their time in-orbit. Other service satellites can perform maintenance, in-orbit manufacturing of components using 3D-printing, and relocate satellites to different orbits.



Our framework suggests a view of space and technology as essentially one single innovation engine for countries and economies. Policymakers and regulators must work together across sector boundaries to leverage this economic and innovation potential. Only through the juxtaposition of space activities and related digital technologies will we be able to discover all investment and innovation opportunities, clusters of entrepreneurship, skills gaps, and required improvements to legislative and regulatory frameworks, just to name a few opportunities,

As the socio-economic transformations across the region continue to be daring, aspirational and powered by strong commitment from regional leaders, the economic spillover from space, tech and indeed, "SpaceTech" will drive the digital economy for a while.
With a focus on the connection between "space" and "tech", the GCC countries are on their way to become a global hub of SpaceTech innovation with a significant impact on the local economies, non-oil GDP and job creation.

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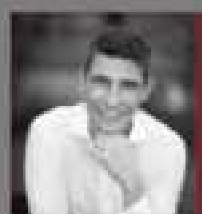

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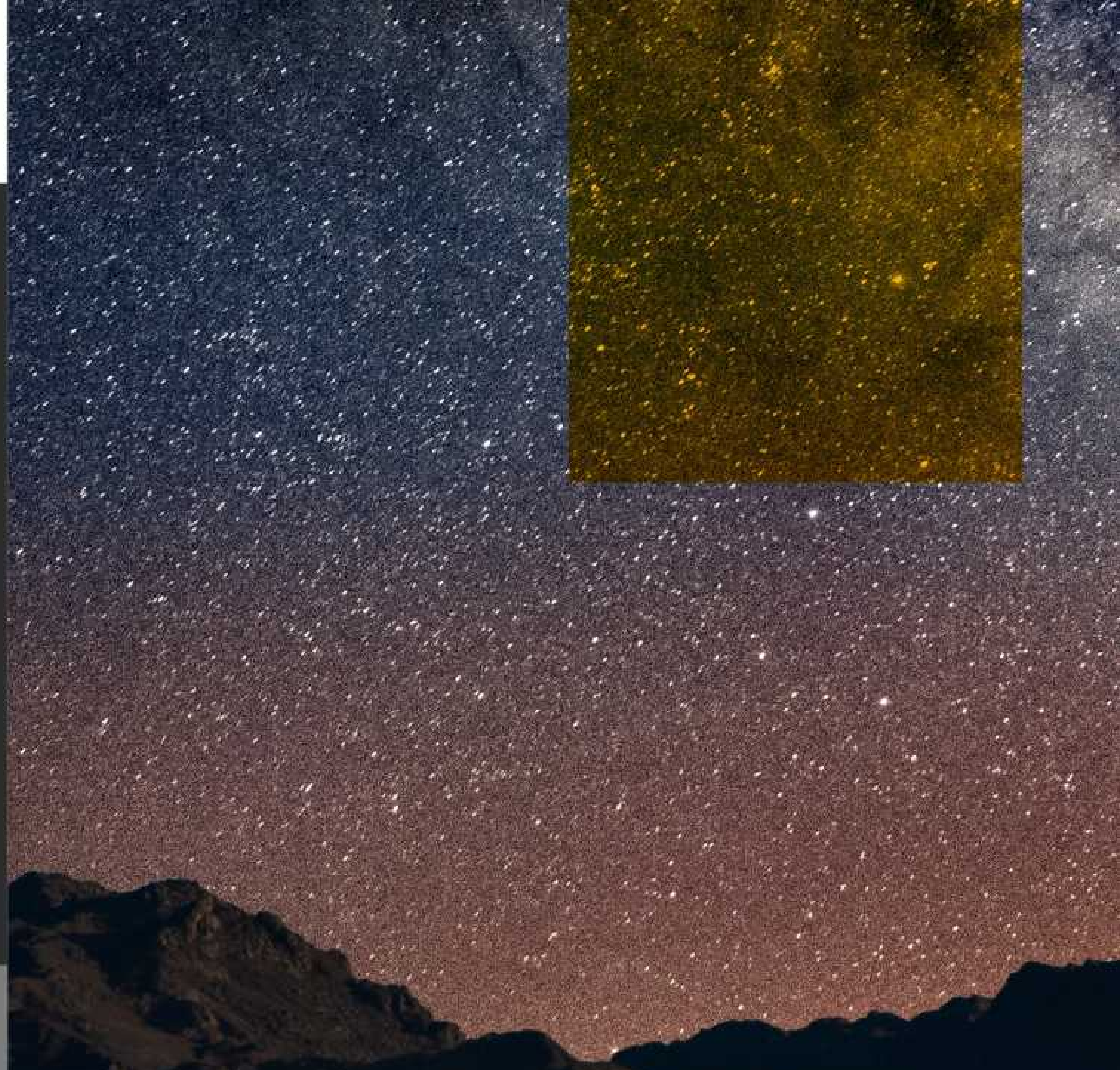

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