yahsat الياه سات

YAHSAT KNOWLEDGE SERIES

Space Tech and the Internet of Things

March 2023

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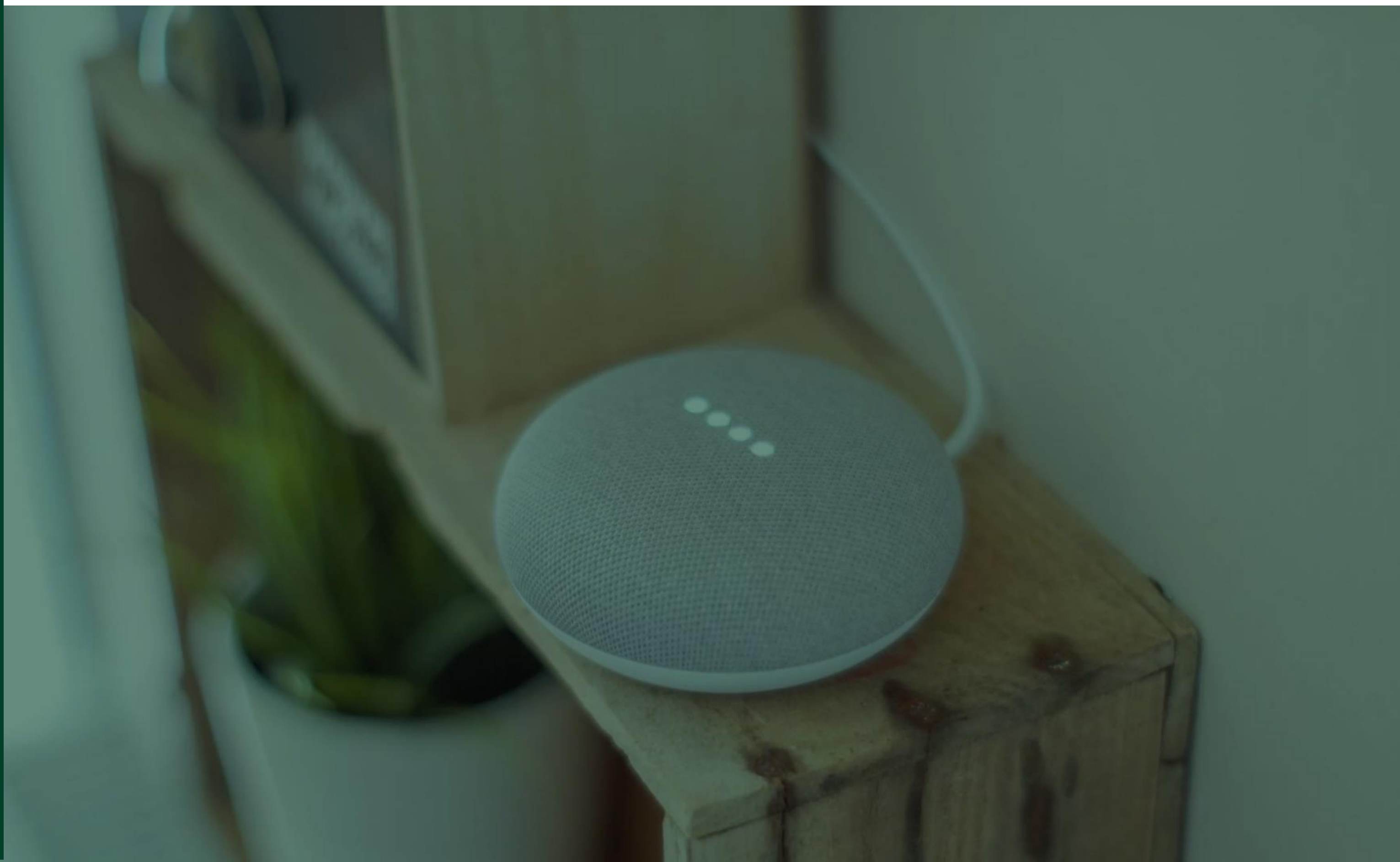

Foreword

“Yahsat is committed to providing its customers with the best satellite communications services through its pioneering spirit in adopting the latest satellite technologies for new markets. The Internet of Things (IoT) is the latest of these services provided by Yahsat and is central to our growth strategy over the coming years.

This *Yahsat Knowledge Series* White Paper, the second in the series, is not only an introduction to IoT, and satellite-enabled IoT in particular, but also showcases Yahsat's unique IoT offering and the commercial and socio-economic benefits it provides.

IoT allows users to operate and manage large and complex systems in an efficient and sustainable manner, and Yahsat is proud to be at the forefront of satellite communication providers in delivering this critically important service across its extensive area of coverage that encompasses 80% of the world's population.

I invite you to join Yahsat in bringing the benefits of IoT to the world.

Ali Al Hashemi
Group Chief Executive Officer

Introduction

The Internet of Things (IoT) emerged nearly two decades ago and has revolutionised the functioning our infrastructure and economic activities ever since. IoT comprises several individual technologies that, when combined, produce widespread effects that allow users to manage large and complex systems, such as transportation infrastructure, energy pipeline operations, and healthcare delivery in more efficient, timely, and manageable ways.

For most of the past two decades, IoT has been enabled by terrestrial telecommunication technologies such as 3G, 4G, and more recently 5G. In the past few years, however, the scope and reach of IoT has been extended by satellite communications and this *Yahsat Knowledge Series* White Paper describes how satellite-enabled IoT works, and specifically, how Yahsat plans to deliver IoT solutions using its satellite fleet.

As the leading satellite communications provider in the Middle East, and increasingly across Europe, Africa, Central and South Asia, and Southeast Asia, Yahsat is exceptionally well-placed to provide customers with satellite-enabled IoT services as it is the only organic provider in its area of coverage.

The economic and social impact of IoT cannot be overstated, especially in developing and emerging countries and in remote and even environmentally hard areas. As well as its obvious commercial benefits in, for example, the transportation and energy sectors, IoT plays an increasing role in bringing the digital revolution to underserved and unserved communities. Satellite-enabled IoT allows remote education, logistics, remote operations, transportation, healthcare delivery and the extension of financial networks to remote communities and aiding their socio-economic development.

Moreover, satellite-enabled IoT is playing a growing role in the sustainable management of scarce natural resources such as water and the protection of fragile ecosystems and endangered species.

As this *Yahsat Knowledge Series* White Paper explains, Yahsat is pioneering new technologies and markets and its satellite-enabled IoT service is an important cornerstone of its growth strategy over the coming years and highlights the company’s wide-range of market leading satellite communications services.

Chapter One: An Introduction to the Internet of Things (IoT)

It is more than likely that, without knowing it, you use the Internet of Things (IoT) every day at home, in the city streets, and at work.

If you have a smart watch, or some other kind of wearable device, that monitors your vital signs you are using the IoT.

If you drive a car less than ten years old, you are using the IoT. When you drive to and from work in a modern city such as Los Angeles, London, Tokyo, or Abu Dhabi the traffic lights and other infrastructure and systems that makes everything work are part of the IoT.

If you have digital sensors at home monitoring the temperature in your house, or how much electricity you use, then you are also using the IoT.

And if you work in the energy, transportation, and agricultural sectors, the chances are that your business depends on the IoT in order to efficiently function.

The Internet of Things is everywhere, and it is projected that by 2030 there will be at least 500 billion devices and living beings connected to it all around the world.[1] But what is the Internet of Things?

The Internet of Things can be defined as follows:

Physical and virtual objects, as well as human beings and animals with wearable devices or implants that are connected by a network to the internet.

An Internet of Things system comprises the following features:

- **Embedded Computers:** Devices, wearables, and implants contain miniature computers such as chipsets that are programmed and controlled by an operating system with a specific function, such as detecting movement or motion, taking temperatures, and so on, within a network;
- **Sensing/Actuation:** These devices contain sensors that gather information and detect changes in the environment in which they are deployed. Devices with actuators can physically interact with the environment or activate/deactivate other devices;
- **Connectivity:** Devices are connected to the internet through various means such as Wi-Fi, Bluetooth, 5G cellular networks, and satellite communications;

[1] See "At-a-Glance: Internet of Things," Cisco, 2016 http://www.audentia-gestion.fr/cisco/pdf/at-a-glance-c45-731471.pdf

- **Programmability:** Devices can receive application or system updates that can modify, enhance, or alter their functionality;
- **Unique ID:** Devices must be uniquely identifiable, which means they can be distinguishable and authorized to communicate with a human or another device;
- **Autonomy:** Devices may need some decision-making capabilities even when disconnected from the network or other devices;
- **Ubiquity:** Devices are always operating and accessible.

Whether it is at home, large public infrastructure, or an activity that takes place over a large geographical area such as transportation, agriculture, and fishing, the Internet of Things is increasingly pervasive throughout our lives.

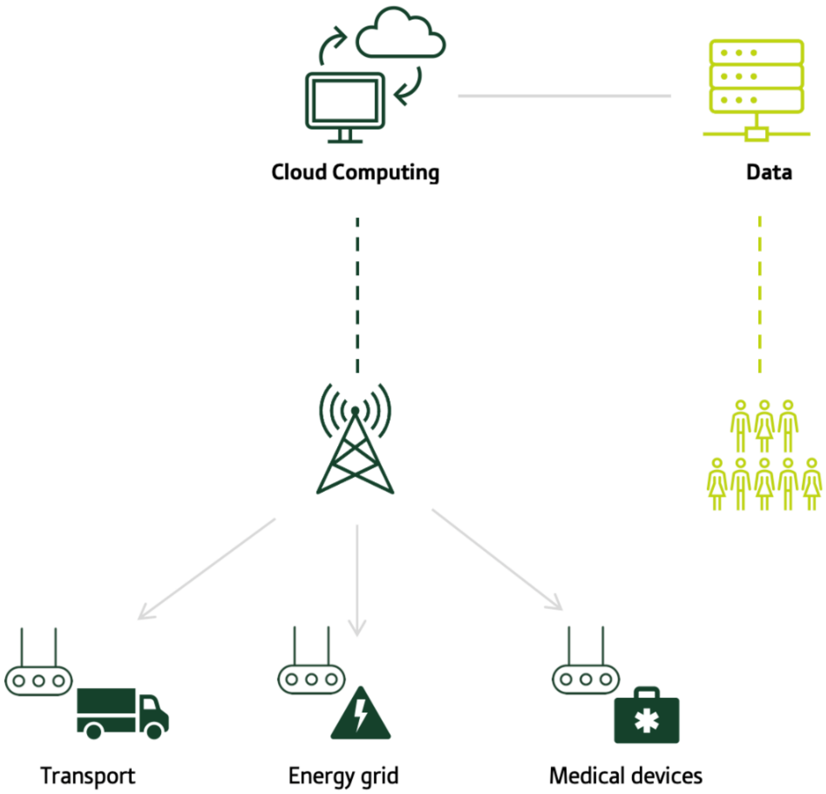

FIGURE 1: Graphical representation of a basic Internet of Things system.

The Internet of Things came about in the early 2000s, thanks to the convergence of several technologies that include:

- **Miniaturised and ubiquitous computing systems** such as chipsets and that can be fitted into small devices that are attached to larger objects such as shipping containers, pipelines, electrical grids, vehicles, ships, airplanes, satellites, and even people and animals with wearables such as smart watches or collars;

- **Miniaturised sensors** such as cameras, thermostats, and positioning, navigation, and timing (PNT) systems that are installed into small devices and controlled by miniature computing systems;

- **Network and communication technologies** such as 3G, 4G, and more recently 5G cellular networks, Wi-Fi, and advances in commercial satellite communications;

- **Automation of machines** ranging from industrial robots, driverless vehicles, unmanned aerial vehicles, and drones through to small devices such as motion-activated cameras, microphones, thermostats, and other sensors;

- **Machine Learning (ML)** that allows computerised devices to interact and even learn basic functions without human interaction or involvement;

- **Data Science** allows operators of IoT systems to collect, store, and derive insights from the large amounts of information collected and used by IoT systems;

- **Cloud Computing** enables the storage and distribution to users and operators of data and information collected by IoT devices and systems.

This convergence that enables the Internet of Things continues to this day as emerging technologies such as Artificial Intelligence (AI), quantum communications and encryption, blockchain, space technologies as well as advanced geospatial systems become more readily available and usable. [2]

With the Internet of Things defined, and its technological components are understood, the next chapter addresses another fundamental question: What is the purpose of the Internet of Things?

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[2] For a general introduction to the Internet of Things and its component technologies see Nathaniel Kim, Insup Lee, and Javier Zazo, *Internet of Things*, Technology Factsheet Series, Belfer Center for Science and International Affairs, Harvard Kennedy School, 2019 https://www.belfercenter.org/sites/default/files/2019-06/TechFactSheet/iot%20-%205.pdf

Understanding the Purpose of the Internet of Things

The Internet of Things is comprised of a collection of different technologies – miniature computers and sensors, communication networks, and so on – that creates a larger technological effect.

It is this technological effect that makes the Internet of Things so useful to its users and why it is becoming more prevalent in new economic and government sectors with each passing year. By converging these disparate technologies into a larger whole, the Internet of Things creates a wider technological effect that leads us to understand its purpose and why it is becoming such a large part of our daily lives across the world.

The primary attributes of the Internet of Things help us understand its overall purpose and appeal. The Internet of Things provides its users with the following attributes:

Monitoring

Large infrastructure such as pipelines and electrical grids, as well as activities taking place over large geographical areas such as logistics, agriculture, fishing, and asset management all require constant monitoring to protect infrastructure from purposeful and environmental harm, provide safety of operations, and to detect malfunctions and other types of problems. IoT-enabled sensors automate this monitoring across large operations and geographical areas in near real-time.

Managing Complexity

Large infrastructure and activities in large geographical areas are complex and involve interactions not just with other devices within an IoT system, but with the surrounding environment such as weather, climate, animals, and human beings – with the latter two being largely unpredictable and difficult to control. The Internet of Things allows its users to understand the environment in which they operate and manage, or at least mitigate, the worst impacts of complexity and emergent behavior by conditions outside of their direct control. Similarly, large infrastructure and digitised manufacturing requires thousands of different components and processes to simply operate at optimum levels and these machine-to-machine interactions become very complex, very fast. IoT systems provide users with the means to manage this complexity and understand how smaller processes interact with the larger process of infrastructure management, manufacturing, or other similar activities.

Shrinking Geography and Time

The Internet of Things further manages complexity by shrinking geographical space and time. Large infrastructure such as the electrical grid and activities such as maritime logistics operate over geographical areas as large as thousands of kilometres are challenging to monitor, comprehend, control, and respond using pre-IoT technologies. The Internet of Things, however, shrinks geographical scale and time by providing continuous and near real-time data from thousands of devices over extremely large areas of operations.

Optimisation

Related to managing complexity and shrinking geography and time is optimisation. In large, complex systems where problems can suddenly arise or malfunctions routinely take place, the Internet of Things allows its users to optimise such system as required. This might involve rerouting electrical grids, increasing or decreasing electrical capacity in response to changes in weather or heavy usage, in real-time and without having to deploy hundreds or thousands of workers. In manufacturing it can involve reducing or increasing production using automated processes, or even updating product design and performance in real-time without having to stop the manufacturing process.

Efficiency

Similarly, by managing complexity, shrinking geography and time, and optimising complex processes, the IoT creates efficiencies in the use of resources and thus reduces costs and waste. While the Internet of Things will never replace human beings it does help us focus our time and efforts in a more targeted manner and so reduce the number of hours it takes people to do the tasks of an IoT system. In terms of reduced costs, the miniaturisation of computing and sensor technologies along with considerably cheaper communications means that IoT operators generate sizeable savings in financial outlays. For example, before the emergence of the Internet of Things, the management of pipelines was labour intensive and expensive. Maintenance crews had to be strategically stationed along the length of a pipeline and would have to constantly and physically monitor it for leaks and other problems. With the Internet of Things precise sensors designed to detect leaks, dangerous pressure levels, blockages, and other potential problems there is no longer the need for large numbers of maintenance crews. Instead, fewer maintenance crews can be deployed more efficiently to fix problems in a more timely and sustainable manner and ship heavy machinery and parts for preventative maintenance.

Managing Risk

Finally, these attributes mean that IoT users and operators can much better manage risks that can bring their complex operations to a halt and cause widespread disruption or worse. By allowing operators to efficiently monitor across large complex processes or geographical areas in near real-time they can benefit from early warning of potential problems, optimise the best timely response, and mitigate suboptimal effects.

These combined attributes of the Internet of Things all help explain its overall purpose and why so many operators across dozens of commercial and government sectors around the world have adopted IoT and will continue to do so well into the future.

With the purpose of the Internet of Things understood, the next question to address is what is the role of space technologies in enabling IoT operations?

Chapter Two: Understanding the Role of Space Technologies in IoT

The discussion so far has covered the more fundamental aspects of the Internet of Things, namely what it is and what is its purpose.

This chapter takes a more focused look at what role space technologies play in the Internet of Things. In particular, the roles of positioning, navigation, and timing (PNT), Earth Observation, and communication satellites are explained. Also relevant, especially in the coming few decades, is the role that the Internet of Things will play in the space environment itself. Lastly, the growing role of Yahsat in the Internet of Things is introduced with Chapters Three and Four providing greater details of Yahsat's activities and plans in IoT operations.

Space technologies have long played a role in the Internet of Things as they provide core enabling technologies and data that make IoT operations possible. Moreover, satellite operations in Earth's orbit provide unique attributes that enable the Internet of Things not just across large geographical areas, but across the planet, and eventually, the Moon and even other plants as humanity explores and seeks economic benefit from the Solar System.

Positioning, Navigation, and Timing (PNT) Satellites

Positioning, Navigation, and Timing (PNT) satellites, also known as Global Navigation Satellite Systems (GNSS) are a critically important technology for the Internet of Things. The most popularly known PNT satellites are those operated by the U.S. Global Positioning System (GPS), China's Beidou, and the European Union's Galileo system. Other PNT systems include Russia's GLONASS, India's NAVIC, and Japan's Quasi-Zenith Satellite System (QZSS).[3]

[3] For an introduction to Global Navigation Satellite Systems (GNSS) see the United Nations Office of Outer Space Affairs (UNOOSA), *Global Navigation Satellite Systems* (New York: United Nations, 2012) https://gssc.esa.int/navipedia/bookshelf/books/5.pdf

IMAGE 1: An artistic rendering of a U.S. Global Positioning System (GPS) III satellite. Image courtesy of the U.S. Air Force.

PNT receivers are embedded in many IoT devices to provide the following data:

- **Positioning**: PNT services from GPS, Beidou, Galileo and others provide very precise positioning data that allows IoT operators to know the exact location of any one device at any time.
- **Navigation**: PNT services are also vital for IoT devices on vehicles, other modes of transportation, animals, and human beings using wearables. Because PNT services can provide precise positioning of anything on the planet they can also help to precisely and efficiently navigate to other locations.
- **Timing**: All PNT satellites, regardless of the national operator, have highly precise atomic clocks on board that provide IoT operators with split-second timing for the efficient management of large and complex networks that sustain communications, infrastructure, and real-time data management such as financial flows.

Without PNT services the Internet of Things would likely not exist, at least in its current form.

Earth Observation Satellites

Because Internet of Things devices exist on physical objects and living beings in various geographical locations around the world IoT systems need geographical data to understand the environments they operate in. The technical term for this is geospatial data, but more broadly and for the most part can be understood as aerial and satellite imagery. Earth Observation satellites provide a large part of this imagery that help users understand a location's topography, environment, and any activity taking place there.[4] Satellite imagery comes in several modes, each of which can image particular aspects of a location. These Earth Observation modes are:

Electro-Optical

Most Earth Observation satellites have a powerful digital camera on-board that collect black and white and colour imagery. These cameras vary in resolution (in other words, the size of objects that they can detect from several hundred kilometres altitude) and range from a couple of hundred or tens of meters resolution, good for wide-area monitoring and mapping, to less than one metre, and even up to 30 centimetres, resolution to accurately identify smaller objects.

Synthetic Aperture Radar (SAR)

While Electro-Optical observation satellites are very capable they cannot collect imagery at night or in cloudy or inclement weather conditions. Synthetic Aperture Radar satellites use a radar imager to image objects at night or through cloud cover, fog, and heavy precipitation and can have resolutions as powerful as one metre or less.

Infrared

IoT operators are often interested in temperatures at specific locations, in particular the temperature of their own assets. Infrared satellites have sensors that can detect the heat signatures of these objects.

Multi- and Hyperspectral

What can be seen by the human eye is only a small part of the spectrum. Multi- and hyperspectral imaging satellites image the unique chemical signatures of every object. Electro-Optical and SAR imagery may tell an analyst that there is a tree at a location. Multi- and hyperspectral imagery can tell an analyst what species of tree it is. This type of imagery data is of immense value to the energy, mining, and agricultural sectors and is instrumental in monitoring climate change and environmental conditions.

[4] For an introduction to Earth observation satellites see *Earth Observation Handbook*, by the Committee on Earth Observation Satellites (CEOS) published by the European Space Agency, 2005 https://eohandbook.com/eohb2005/CEOS_EOHB_2005.pdf

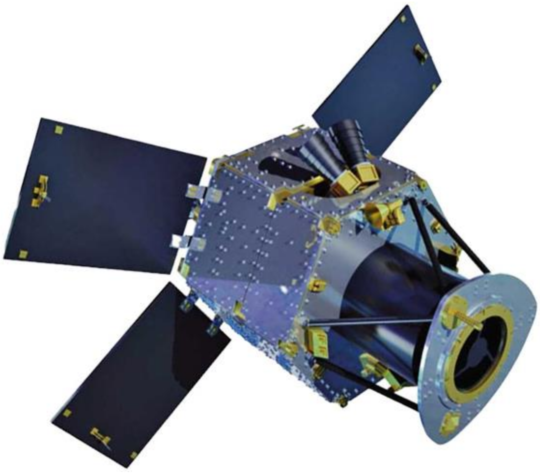

IMAGE 2: A digital rendering of the KhalifaSat Earth Observation satellite. Image credit: Mohammed Bin Rashid Space Centre (MBRSC), Dubai, UAE.

When fused with PNT data satellite imagery can generate powerful insights for IoT operators for comprehending the environmental and geographical conditions around their IoT system. Yahsat has partnerships in place with UAE Earth Observation operator, Mohammed Bin Rashid Space Centre (MBRSC) to sell and distribute satellite imagery to customers,[5] and with UAE geospatial company Bayanat to cooperate on developing Earth Observation satellites in the UAE.[6]

Satellite Communications

For IoT systems that operate large infrastructure such as pipelines or activities across large geographical areas such as maritime transport and agriculture, satellite communications provide the network backbone. These kinds of IoT systems often operate in remote and harsh environments that are either under- or unserved by terrestrial telecommunication networks. Additionally, for mobile IoT systems such as in the transportation and logistical sectors, satellite communications - due to their ubiquitous coverage - are ideal for providing connectivity on the move. Furthermore, operators of mobile IoT systems benefit from the convenience of having one connectivity provider rather than multiple contracts with numerous telecommunications companies. It is in these circumstances that satellite communications are the only and best option for providing Internet of Things services.

[5] See "Yahsat and MBRSC Partner on Remote Sensing and Earth Observation," 15 February 2023, https://www.yahsat.com/en/news-and-media/news/2023/yahsat-mbrsc-remote-sensing-earth-observation
The information provided at this link is accurate at the date of publication of this white paper.

[6] See "Bayanat and Yahsat sign MoU to develop in-country space program for earth observation capabilities," 23 February 2023, https://www.yahsat.com/en/news-and-media/news/2023/bayanat-and-yahsat-sign-mou-to-develop-in-country-space-programme The information provided at this link is accurate at the date of publication of this white paper.

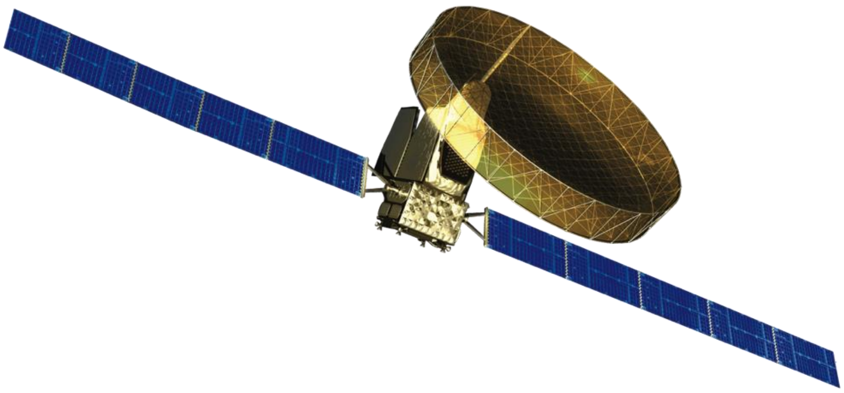

IMAGE 3: Digital rendering of the Thuraya-3 communications satellite operated by Yahsat. Image credit: Yahsat.

Thanks to the ongoing miniaturisation of satellite terminal antennas and competitively priced satellite communication services, satellites connect thousands of small, mobile, and geographically dispersed devices in real-time at increasingly competitively prices compared to terrestrial network providers.

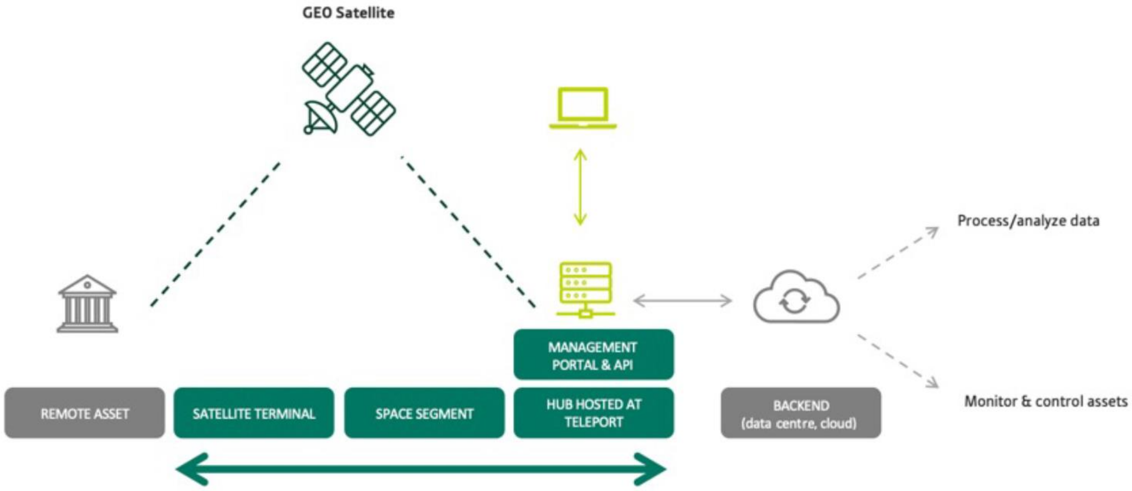

FIGURE 2: Graphical representation of a satellite-enabled Internet of Things system.

In fact, many IoT systems often use hybrid networks where the system requires terrestrial networks such as cellular 5G in urban areas and satellite communications in rural and remote areas. For some use cases (e.g. mission critical applications), both communication technologies (terrestrial and satellite) are used to ensure higher availability and better Service Level Agreements (SLA) for the end customers. Furthermore, satellite communications backhaul services that connect terrestrial networks are also important for IoT systems.

It is in satellite communications that Yahsat is playing an increasing role in the Internet of Things,[7] and is providing IoT solutions for a range of customers that operate in demanding conditions and which will be discussed in further detail later.

The Space Advantage

The technologies, capabilities, and data that satellites bring are very important for enabling the Internet of Things. Less well-known is that the space environment itself is important for the satellite component of IoT systems. Satellites operate in orbits at altitudes that range between several hundred kilometres to 36,000 kilometres. These altitudes provide satellites with large areas of coverage of the Earth's surface that allows for supporting IoT systems that cover large geographical areas, especially in remote and challenging areas such as large deserts or oceans. Additionally, with thousands of satellites in various orbits there is constant PNT, geospatial, and communications coverage.

A Space-Based Internet of Things Future?

Countries like China, the United States, and the United Arab Emirates are launching missions to the Moon. While exploration and science are prominent motivations for these missions, there is also a considerable economic component to these space activities as well. The Moon, for example, will be a hive of activity for many countries and companies over the next decade as probes, landers, and rovers are sent to the lunar surface. In the next few years, the United States and China will send astronauts to the Moon for the first time since the American Apollo 17 mission in 1972. Moreover, the Americans and the Chinese intend to build habitable bases on the Moon to ensure a permanent human presence there. Companies are planning missions to use the Moon's natural resources for the benefit of humankind.

[7] For an introduction to Yahsat's communication satellite fleet and business units see, *The Evolution of the MENA Space and Satellite Communications Sector*, Yahsat Knowledge Series, December 2022 https://www.yahsat.com The information provided at this link is accurate at the date of publication of this white paper.

IMAGE 4: An artistic depiction of future lunar infrastructure. Image credit: ICON/BIG-Bjarke Ingels Group/U.S. National Aeronautics and Space Administration (NASA).

All these activities require infrastructure on and around the Moon. The United States and the European Space Agency are building a communications and PNT satellite constellation to orbit the Moon by the end of this decade. The U.S. space agency NASA intends to build roads, pipelines, and utilities on the lunar surface to sustain a human presence there. As these developments take shape, we can also expect a lunar Internet of Things to emerge.[8]

As humanity eventually ventures beyond the Moon to Mars and the Asteroid Belt, the Internet of Things will expand also.

The role of space technologies in the Internet of Things is vital but has traditionally been less understood as it should be. Satellite communications in particular are the only viable network option for IoT systems that operate in remote areas unserved by terrestrial network providers. The next chapter examines several case studies for satellite-enabled Internet of Things services.

[8] See, for example, "European scientists bounced first ever LoRa message off the Moon," in *IoT Business News*, 24 November 2021 https://iotbusinessnews.com/2021/11/24/58577-european-scientists-bounced-first-ever-lora-message-off-the-moon/

Chapter Three: Use Cases for Satellite-Enabled IoT Services

Yahsat is initially providing satellite-enabled Internet of Things services to three sectors: maritime transport, agriculture, and environmental monitoring.

Satellite-enabled Internet of Things services not only provide users with greater operating efficiencies, optimisation, and risk management, they also help contribute to reducing the impact of climate change, greater sustainability, and contributing to the United Nations Sustainable Development Goals (SDG). For example, satellite-enabled IoT for the maritime sector leads to greater efficiencies in fuel consumption and the optimisation of cargo capacity on individual vessels, resulting in a net reduction in carbon emissions over time by the shipping industry. Satellite-enabled IoT for the agricultural sector enables more efficient farming techniques, greater crop yields, better pest control, and improved livestock stewardship that, in turn, ameliorates the challenge of food security in under-developed parts of the world. Lastly, satellite-enabled IoT services for environmental monitoring helps scientists and policy makers better understand climate change and its impacts in vulnerable ecosystems and on endangered species.

Maritime Transport

Around 90% of the global trade of goods and commodities is carried by maritime transport.[9] From computers and cars through to wheat and oil are all transported by ships across the Atlantic, Indian, and Pacific Oceans. The thousands of ships that ply the world's oceans carry over two trillion dollars-worth of goods and commodities while accounting for three percent[10] of global carbon emissions every year.

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[9] See Ocean and shipbuilding by Organisation for Economic Co-operation and Development (https://www.oecd.org/ocean/topics/ocean-shipping)

[10] Carbon Revenues From International Shipping : Enabling an Effective and Equitable Energy Transition, World Bank (https://www.worldbank.org/en/topic/transport/publication/carbon-revenues-from-international-shipping)

IMAGE 5: Chinese ship. Image credit: Keith Skipper, Creative Commons.

Satellite-enabled Internet of Things devices monitor everything from a ship's position and voyage through to its fuel consumption. The data collected helps ship operators calculate the most efficient route from port to port, taking account of weather conditions along the route based on meteorological data and other conditions. By optimizing the most efficient route using IoT data ship operators can maximise cargo capacity on vessels while generating savings in fuel consumption and time at sea.[11]

For ships carrying containers, satellite-enabled IoT also plays a critical role. Each container is fitted with an IoT device that identifies its owner, the type and quantity of goods in the container, as well as detailed information on its origin and ultimate destination. This means that maritime operators, insurers, the manufacturer of the goods being transported, and the recipient of the goods can track each container in near real-time. With thousands of container ships traversing the oceans in varying weather conditions and sea states there are at least 1,000 containers lost at sea each year. On top of this, organised criminal gangs and some states seeking to circumvent sanctions steal containers in ports or on the road, or use them to smuggle contraband (and even for human trafficking) or sanctioned goods. Satellite-enabled IoT makes it much more difficult for criminal and other illegal activity to take place, while accurately accounting for accidental loss.[12]

[11] See https://www.thuraya.com/en/services/m2m-iot/m2m-iot-maritime The information provided at this link is accurate at the date of publication of this white paper.
[12] For an introduction to the Internet of Things in the maritime environment, see Matthew Lacey, Helena Lisachuk, Andreas Giannopoulos, and Alberto Ogura, *Shipping smarter: IoT opportunities in transport and logistics* (Deloitte University Press, 2015) https://www2.deloitte.com/content/dam/insights/us/articles/iot-in-shipping-industry/DUP1271_IoT_Transportation-and-Logistics_MASTER.pdf

Agriculture

In the developing world food insecurity is on the rise due to environmental degradation, climate change, conflict, and inefficient farming practices. Profit margins are tight and precarious due to factors such as famine, blights, and infestation of pests that ravage crops. Similarly, livestock are a valuable commodity and their unintentional loss or theft can change livelihoods for the worse overnight.

Combined with geospatial data IoT systems enable more efficient and precise farming techniques that maximise crop yield even from relatively small plots of land. IoT devices placed strategically on farmland can detect pests and crop diseases early before they blight the entire yield, and similarly, these same IoT devices can help farmers and commodity markets better understand future yields and to more accurately price harvests and plan for the following season.[13]

IMAGE 6: A cow wearing a collar with an IoT device attached. Image credit: internetofbusiness.com.

Yahsat subsidiary Thuraya provides IoT solutions for utility operators and farmers to monitor, conserve, and manage scarce water resources for agriculture, other public uses, as well as for the benefit of the environment. Thuraya's FT2225 Machine-to-Machine device connects with

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[13] See Momenta Partners, *Introduction to IoT in Agriculture*, 2019
https://www.momenta.one/hubfs/Resources/Whitepapers/Downloads/WP-Intro-to-IoT-in-Agriculture-PDF-LIVE.pdf

water sensors to provide remote monitoring and management capabilities via Thuraya's L-band satellite communications.[14]

For livestock farmers IoT devices installed in collars or even implanted under an animal's skin can track individual animals (and mitigate the impact of livestock theft and unintended loss) as well as entire herds. IoT can monitor herd movements to identify, optimise, and sustain grazing and watering areas.

Whether for crop or livestock farming, the Internet of Things is revolutionising agricultural practices in the most vulnerable and underdeveloped parts of the world and allowing farmers to maximise income, better and more sustainably manage resources, and provide greater food security for local populations. Since most farms and agricultural land are in rural and remote areas, satellite-enabled Internet of Things provides an essential and game-changing service.

IMAGE 7: Thuraya FT2225 and Thuraya IP M2M devices. Image credits: Thuraya/Yahsat.

Environmental Monitoring

Protecting the environment and our natural resources has become a priority for all countries and societies as climate change looms large in all our lives. Satellite-enabled Internet of Things plays a big role in environmental monitoring and tracking endangered species. IoT devices in natural aquifers and wells can monitor natural water resources where water security has become acute, such as in the Middle East and parts of Asia and Africa. Measuring natural water resources using IoT devices helps specialists and policy makers make informed decisions regarding water conservation, distribution, and alternative water sources.

[14] See *Thuraya M2M terminal keeps water resources data flowing in real-time for remote installations* https://www.thuraya.com/en/services/m2m-iot/m2m-iot-land The information provided at this link is accurate at the date of publication of this white paper.

IMAGE 8: The 25-megawatt Kabeli B1 hydropower station in eastern Nepal. Image credit: Marc Boettcher /Alamy.

In Nepal, for example, Yahsat's mobility arm, Thuraya provides the IoT devices and connectivity for securing the United Nations' Sustainable Development Goals (SDG) in remote parts of the country. Thuraya's IoT solutions provides data to monitor and manage air pollution levels due to the incomplete burning of fossil fuels. Thuraya's IoT services also monitor the performance of Nepal's hydraulic turbines to optimise power generation and consumption.[15]

Satellite-enabled Internet of Things also play an interesting role in conserving endangered animal and other species in fragile ecosystems. IoT devices attached to collars or implanted beneath the skin track endangered animal populations to conserve numbers, track their movements, feeding habits, and the environment, which they inhabit. [16] Similarly, other types of endangered species and natural resources such as trees (the Internet of Trees), other fauna such as mangroves and grasslands, and valuable natural and environmental resources.[17] These use cases represent only three applications amongst several verticals for Yahsat's satellite-enabled Internet of Things services. The next and final chapter explains how Yahsat will provide the service.

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[15] See Thuraya, *Case Study: Securing sustainable development goals in Nepal with real-time remote data* https://www.thuraya.com/en/services/m2m-iot/m2m-iot-land The information provided at this link is accurate at the date of publication of this white paper.

[16] See Nadia Jamrozik, "3 Innovative IoT Solutions that Protect Endangered Species," *Medium*, 4 April 2019 https://medium.com/iotforall/3-innovative-iot-solutions-that-protect-endangered-species-ae90e8b2002f

[17] See Jennifer Gabrys, "Smart forests and data practices: From the Internet of Trees to planetary governance," in *Big Data & Society*, Vol. 7, Issue 1, January-June 2020 https://journals.sagepub.com/doi/epub/10.1177/2053951720904871

Chapter Four: Yahsat and IoT

Yahsat is the UAE's only commercial satellite communications company and the leading satellite communications company throughout the Middle East and Southeast Asia in terms of range of services and the use of the most advanced technologies in the industry.

COMPANY	COUNTRY	SATELLITE IoT SERVICES
Yahsat	UAE	Yes
Es'hailsat	Qatar	No
AMOS Spacecom	Israel	No
Arabsat	Saudi Arabia	No
Nilesat	Egypt	No
Space Communications Company	Oman	No
Azercosmos	Azerbaijan	No
Türksat	Türkiye	No
MEASAT	Malaysia	No
Kacific	Singapore	No
ThaiCom	Thailand	No
AsiaSat	Hong Kong	No

TABLE 1: List of Satellite Communication Companies Providing Organic Satellite-Enabled IoT Services in Middle East, Africa, South Asia, and Southeast Asia. Source: AzurX

Yahsat's subsidiary, Thuraya, is the provider for its satellite-enabled Internet of Things services using its two current satellites in Geostationary orbit: Thuraya-2 and Thuraya-3. In 2024, Thuraya 4-NGS (see below) will be launched to expand services and capacity. Thuraya's heritage includes being the first and only mobile satellite services (MSS) provider in the region for voice and data messaging and its coverage stretches from Western Europe all the way to Australia. Thuraya's MSS services, as well as its satellite-enabled Internet of Things services, can be accessed in over 150 countries.

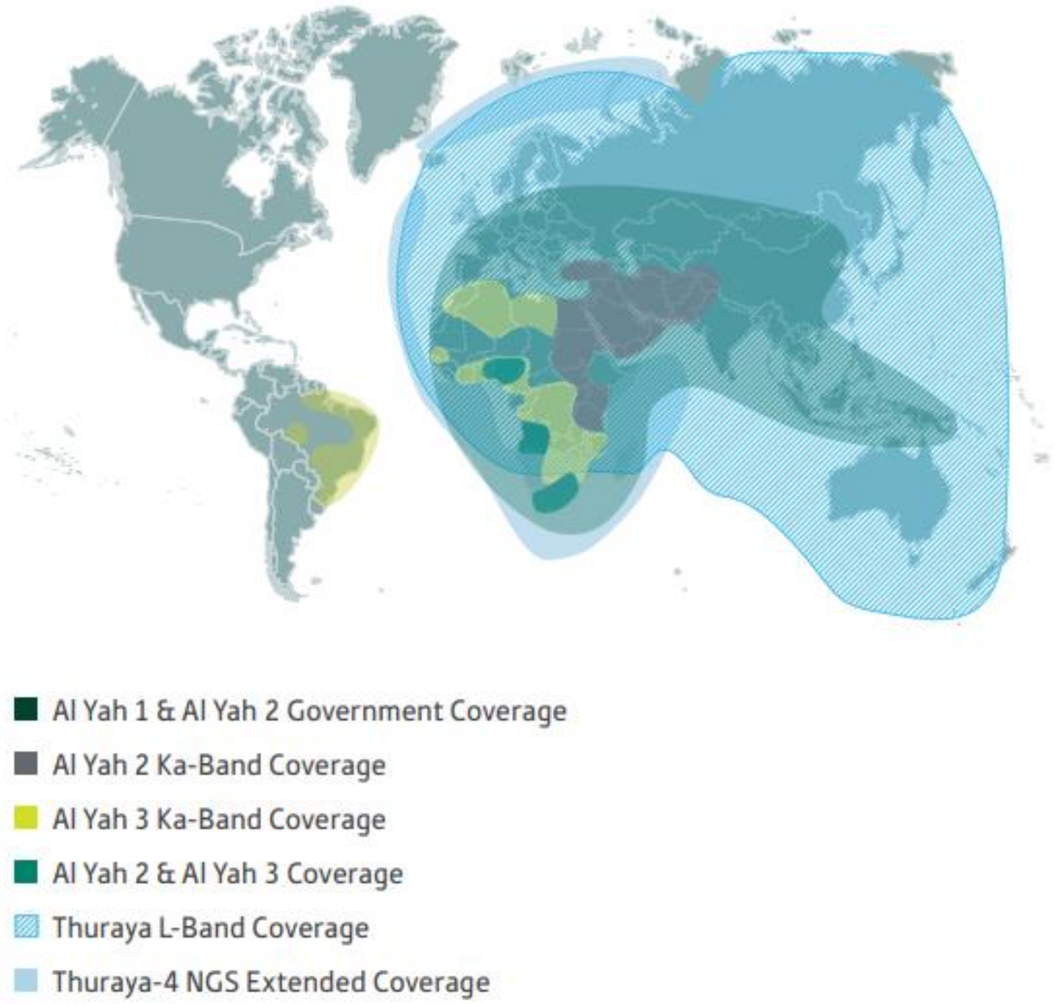

IMAGE 9: Yahsat areas of coverage

Thuraya satellites use the L-Band frequency, and along with Thuraya's own IoT device and services, provides customers with turnkey satellite-enabled Internet of Things services. Thuraya's IoT portfolio includes its land terminal (Thuraya T2M) as well as its maritime terminal (Thuraya MarineStar). Both products are enabled with the SatTrack application providing web-based monitoring and tracking services.

IMAGE 10: Thuraya MarineStar (left) and Thuraya T2M-DUAL (right) terminals. Image credits: Thuraya/Yahsat.

In October 2022, Yahsat invested in U.S. company eSAT Global as part of its long-term strategy to develop a lower power wide area network (LPWAN) IoT portfolio.[18] eSAT chipsets and modules will allow Thuraya to roll out new devices that will expand its satellite-enabled Internet of Things services to new sectors and use cases. Yahsat is actively planning further investments in other IoT companies and is also considering expanding its Thuraya satellite fleet beyond Thuraya 4-NGS. Additionally, Yahsat is also considering partnerships or investment in low-Earth orbit satellite communications providers so that it can increase connectivity and expand into new markets for its satellite-enabled Internet of Things services.

IMAGE 11: Artist's rendering of the Thuraya 4-NGS. Image courtesy of Thuraya.

Manufacturer: Airbus Defence and Space
Spectrum Band: L-band
Geographical Coverage: Middle East, Africa, Europe, and Central Asia as well as large parts of the Atlantic and Indian Oceans
Services: Internet of Things, voice communications, messaging, data and streaming
Capabilities: Ability to surge in hotspots, over one megabit per second data rate, supports three times the number of users compared to older satellites
Expected Launch Date: H1 2024
Expected Operations Date: H1 2025

[18] See "Yahsat Acquires a Minority Stake in eSat Global," 11 October 2022, https://www.yahsat.com/en/news-and-media/news/2022/yahsat-acquires-a-minority-stake-in-esat-global The information provided at this link is accurate at the date of publication of this white paper.

The satellite-enabled Internet of Things market is ripe for expansion and growth in Yahsat's area of coverage and beyond. Yahsat is a market leader in satellite communications and through its satellite-enabled Internet of Things services and products it aims to lead, drive, and shape this important sector for years to come.

Yahsat is building the future of the Internet of Things in space. Join us on our mission.

Glossary

3G	Third generation of wireless mobile telecommunications technology.
4G	Fourth generation of wireless mobile telecommunications technology.
5G	Fifth generation of wireless mobile telecommunications technology.
Artificial Intelligence (AI)	Intelligence, such as perception, synthesis, and inference, as demonstrated by computers and machines rather than by animals and human beings.
Backhaul	The ability to extend a cellular network using other communication technologies such as satellite communications.
Bluetooth	A short-range wireless communications technology used for exchanging data over very short distances.
Cellular Networks	Also known as Mobile Networks, are networks where the links between nodes are wireless. Examples include 3G, 4G, and 5G cellular networks for mobile telephones.
Cloud Computing	The on-demand availability of computer resources, in particular data storage and computing power, over the internet.
Data Science	An interdisciplinary field that uses statistics, computing, scientific methods and processes, algorithms, and other systems to extract or extrapolate knowledge from vast amounts of messy, structured, and unstructured data.
Earth Observation	The use of satellites with cameras and other sensors to observe activities on the Earth's surface.
Electromagnetic Spectrum	The naturally-occurring range of frequencies that are exploited by technology to either communicate or observe.
Electro-Optical	Electronic sensors that convert light, or a change in light, into an electronic signal that can, among other things, be converted into an image.

Geospatial Data	Data that represents objects on the Earth’s surface and their precise location.
Geostationary Orbit (GEO)	An orbit above the Earth’s equator used by satellites, in particular communication satellites, at 35,786 kilometres altitude.
Global Navigation Satellite Services	A constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. The receivers then use this data to determine location.
Hyperspectral Imaging	The collection and processing of information from across the electromagnetic spectrum to find objects, identify materials, and detect processes.
Infrared Sensor	A sensor that can detect infrared radiation, invisible to the naked eye that is generated by heat.
Internet	A vast network that connects computers all over the world. Through the Internet, people can share information and communicate from anywhere with an Internet connection.
Internet of Things (IoT)	Physical and virtual objects, as well as human beings and animals with wearable devices or implants that are connected by a network to the internet.
L-Band	A range of frequencies within the radio spectrum used for voice and text communications by a communications satellite.
Low-Earth Orbit (LEO)	An orbit that ranges from 160 kilometres to 2,000 kilometres altitude above the Earth’s surface.
Low-Power Wide Area Networks	A group of wireless technologies used to efficiently deliver IoT connectivity at low cost over wide geographic areas.
Machine Learning (ML)	A branch of Artificial Intelligence (AI) and computer science that uses data and algorithms to imitate the way human beings learn.
Mobile Satellite Services (MSS)	The provision of satellite communications for users who are on the go on land, at sea, or in the air, or who are located in very remote areas.
Multispectral Imagery	The collection and processing of information from select parts of the electromagnetic spectrum to find objects, identify materials, and detect processes.

Positioning, Navigation, and Timing	A description of the functions and services provided by Global Navigation Satellite Services. GNSS signals can tell a user their exact position, how to get to another position, and due to the highly accurate atomic clocks on board GNSS satellites, the exact time.
Satellite Communications	The use of satellites in various orbits above the Earth for communications.
Satellite-Enabled IoT	Physical and virtual objects, as well as human beings and animals with wearable devices or implants that are connected by satellite communications to the internet.
Service Level Agreement (SLA)	A contract between a service provider and its customers that documents what services the provider will furnish and defines the service standards the provider is obligated to meet.
Synthetic Aperture Radar (SAR)	A radar sensor that creates two-dimensional images or three-dimensional reconstructions or objects or landscapes. SAR sensors can image objects and landscapes at night and in cloudy or foggy weather conditions.
Wi-Fi	A wireless technology used to connect devices such as computers, televisions, tablets, and mobile telephones to the internet.

Want to know more? Please visit www.yahsat.com

Contact Us

Telephone	Address	Email
+971 2 510 0000	Al Falah City, Abu Dhabi, UAE	info@yahsat.ae
+971 6 882 8888	Tawi Al Saman, Sharjah, UAE	info@yahsat.ae
+971 4 448 8888	Barsha Heights, Dubai, UAE	info@yahsat.ae
+65 6622 0600	991 Alexandra Road, Singapore	info@yahsat.ae
+278 2 536 6923	Victory Park, Randburg, South Africa	info@yahsat.ae