The impact of GAFAM on the space sector

CASE STUDY OF SPECIALIZED TRACK FOR SPACE BUSINESS

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1 EXECUTIVE SUMMARY

The industrial structure of the space industry is changing dramatically with the entry of private companies into the industry called Newspace. Traditionally, this sector used to have a CAPEX-intensive industrial structure. However, with the miniaturization of satellites, the barriers to entry have become lower. In this context, gig Tech companies known as GAFAM (**G**oogle, **A**pple, **F**acebook, **A**mazon and **M**icrosoft) are leveraging their capital power and IT infrastructure to enter this new market potential aggressively.

GAFAM's position in the space industry varies from company to company; Amazon is the most aggressive example. Amazon intends to be fully vertically integrated into the value chain from rocket and satellite manufacturing, launch, satellite operations, ground segment operation and service delivery to end customers. What GAFAM have in common is that they have all invested in telecommunications satellite services. GAFAM, with its strength in IT infrastructures such as data centers and end-user services, have relied on local telecommunications services for its communications. Now, however, GAFAM can connect directly with users via satellite communications.

The impact of GAFAM's entry into the space industry, which affects everything upstream and downstream in the value chain, can be summarized in three aspects: 1) Ground Segment, 2) Satellite Communication Services, and 3) Investment. The space industry will further develop as an indispensable tool for the IoT industry. In the rapidly commercializing space industry, the impact of GAFAM's entry is significant. As Early Adopters, GAFAM are trying to become a driving force in the space industry's growth.

This scenario brings a certain level of instability to the traditional players of the space sector, who now try to understand the impact of the GAFAM arrival in their business. At the same time, they pursue strategies that can be adapted to the new context of the space industry.

2 INTRODUCTION

2.1 Context And Background

In the past decade, the space sector has become one of the hot topics of the technology industry. In this context, large corporations and risk-prone investors have approached the space industry aiming to profit from its high visibility and promising financial prospects. According to Space Capital[1], an early-stage venture capital firm specializing in the space industry, the total investment in space technologies in the second quarter of 2022 reaches $6.1B spread over more than 1,727 companies worldwide. These impressive numbers demonstrate the potential of a market that has continuously grown in recent years and is being boosted by the increasing trend of Newspace.

In addition to the recent boom in the sector as a whole, the use of space assets to provide worldwide connectivity has been of particular interest to tech giants. GAFAM is increasingly implicated in space-related projects. As an example, Amazon and Microsoft are continuously investing in providing satellite connectivity infrastructure through their network of Ground Station as a Service. The arrival of these behemoths in the industry brings exponential opportunities but also creates questions about their ultimate strategies in entering the sector.

With the potential to completely reshape and disrupt almost any industry in the world, these companies bring along their extensive resources and capabilities, and customer portfolios. In this context, incumbents of the space industry try to understand the real impacts of these strategic moves from the GAFAM companies. By understanding their motivations better, established players can elaborate their own business and development strategies to keep up with the more challenging competitive landscape.

2.2 Objectives

The goal of this study case is to investigate the real impact of the arrival of the GAFAM companies in the space industry. This includes:

- Understand their specific motivations when joining this industry;
- Understanding what possible roles these companies can play in the current space industry value chain;
- Evaluate their current products and offerings already in place;

[1] Space Investment Quaterly - Q2 2022 - Space Capital

3 SPACE SECTOR

3.1 Overview

The space industry is composed of all the elements required to build, launch, operate and monetize space assets in orbit. This includes, but is not limited to the development and manufacturing of satellites on one end, but it also includes the development of applications that leverage data collected from space. Because of its inherent technical and business complexity, the space sector market is concentrated over a limited number of key players worldwide. In addition, although the benefits generated by space assets spread to an ample number of industries and end customers, the main financing sources of these assets are still governments and a few major industry players.

The image below provides the main components of the space value chain. The chain can be divided into two main blocks:

- **Upstream:** The Upstream portion of the value chain focuses on all the aspects of satellite manufacturing, launching and operating. It also encompasses ground segment development and deployment. In a nutshell, this segment is dedicated to providing the space infrastructure required to acquire data in space and beam it down to earth.
- **Downstream:** The connection between customers and satellite data is done through companies operating in the downstream end of the value chain. In general, downstream-positioned companies are responsible for operating space assets (Satellite Operators) or making direct use of space data/applications in their business models (Satellite Service ProviderS). Because of the size and potential of the market, the majority of the companies in the space industry are operating at the Downstream end of the value chain. This is also due to lower technical and capital requirements when compared to the Upstream end of the chain.

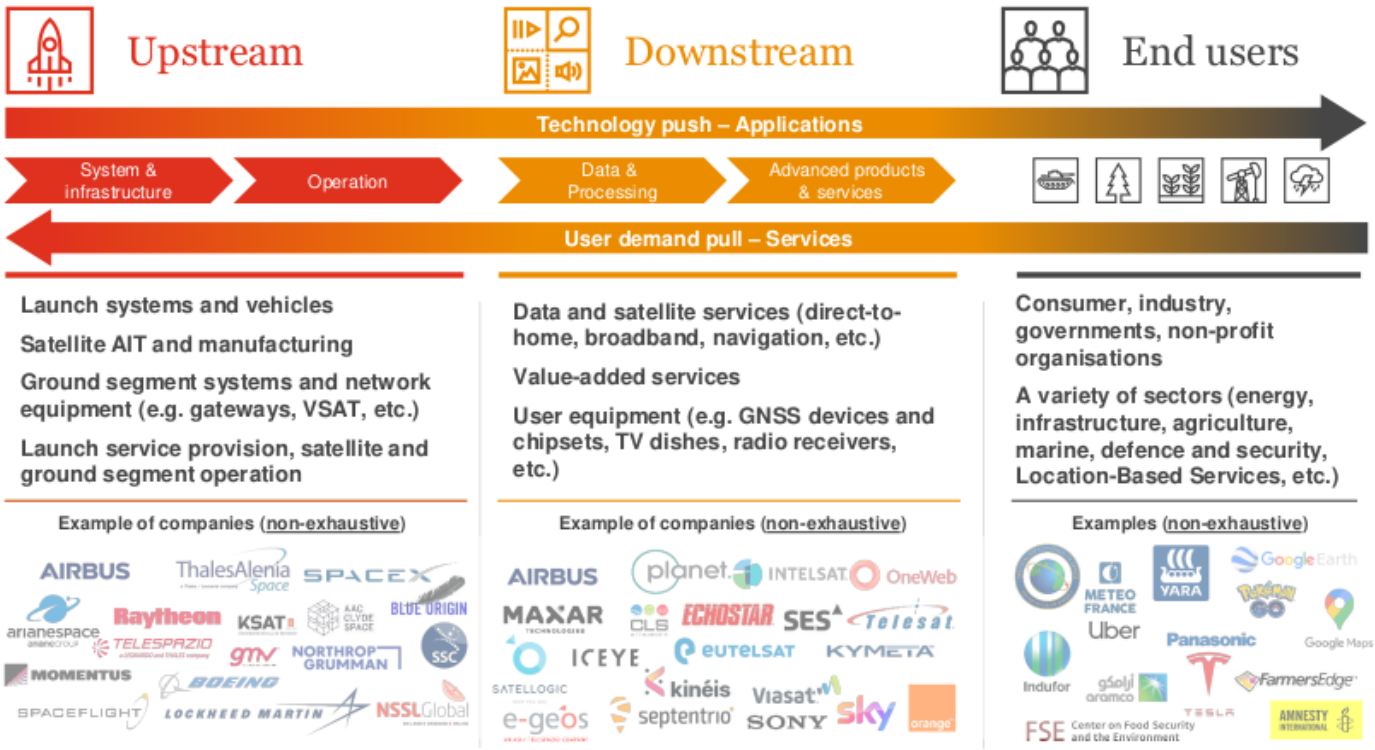

Figure 1 - Space Industry Value Chain[2]

In terms of market size and potential, the main part of the market is concentrated in the downstream part of the value chain, as shown on the right-hand side of the diagram below. In addition, satellite communications (SATCOM) and navigation services account for roughly 90% of the total space-related market.

[2] Main Trends & Challenges in the Space Sector - pwc, Dec 2020

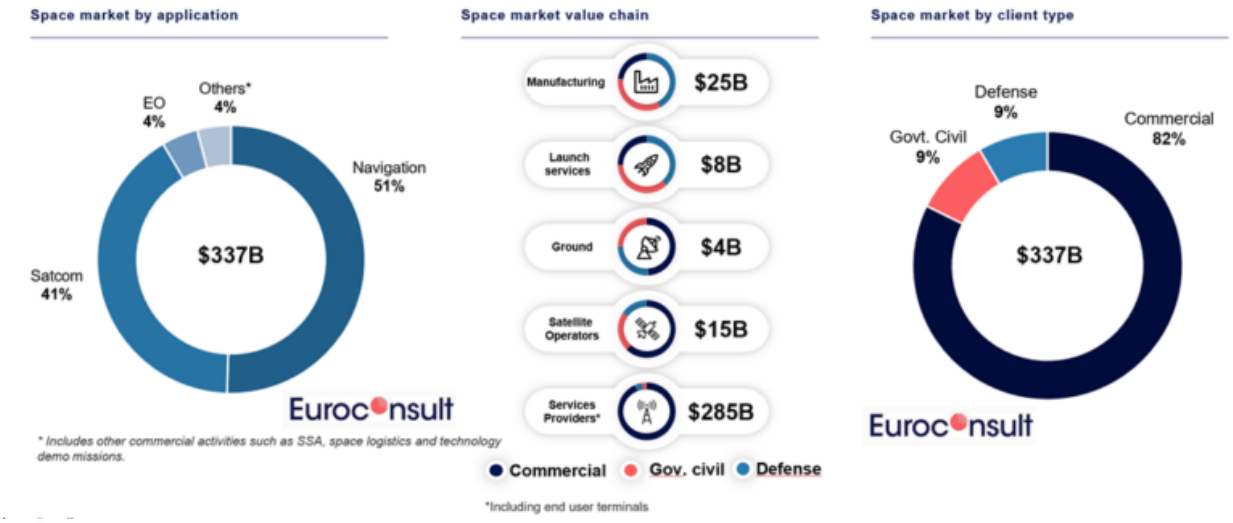

Figure 2 - The market size of the Space value chain[3]

3.2 Trends

As mentioned previously, the space sector is currently going through a series of changes in the context of Newspace. In this scenario, the arrival of new companies and startups which were not traditionally part of the space industry has brought considerable uncertainties to a sector that was habitually stable and highly inertial.

Also in the context of newspace, the arrival of small satellites has brought new possibilities and opportunities to the industry, mainly through the deployment of large constellations of satellites with limited CAPEX investment. This effect has been particularly boosted by the increasing availability of launchers in recent years. For instance, the graph below depicts the number of small satellites launched into orbit in the past decade.

[3] Space Economy Report - Euroconsult, 2021

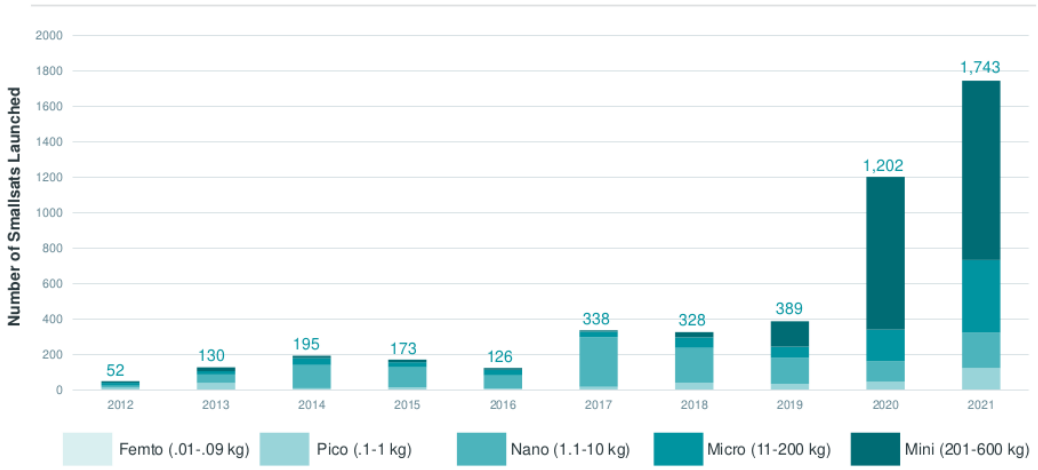

Figure 3 - Number of small satellite launches per year[4].

This space revolution is currently reshaping the space market and is especially impactful in large portions of the market like SATCOM, where these large constellations can offer significant technical benefits compared to traditional satellites. The graph below shows the main applications of the small satellites launched in the past decade, showing that SATCOM is clearly dominating, mainly due to large batches of launches from companies like SpaceX and OneWeb.

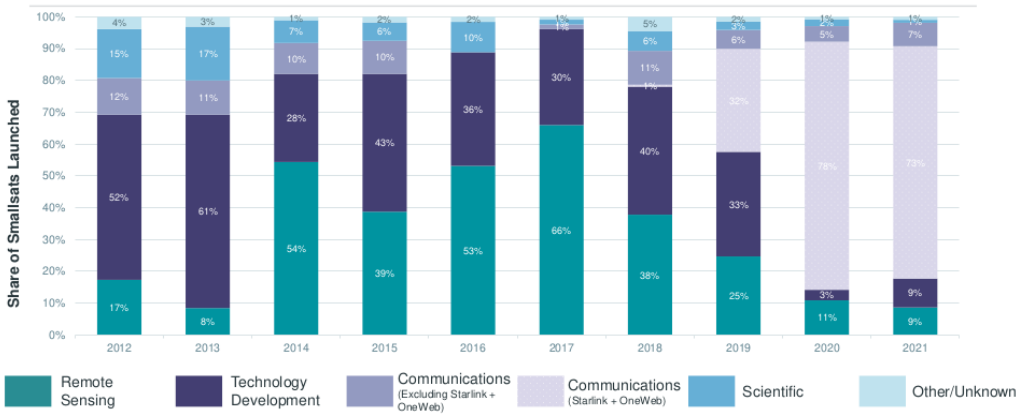

Figure 4 - Applications of previous small satellite launches[4].

[4] Smallsats by the Numbers 2022, Bryce Tech

Another important trend is at the ground level. With the increase in the number of satellites per year, the demand for ground infrastructure is inherently increasing. The plot below shows the expected revenue generated by ground-related infrastructure in the next few years.

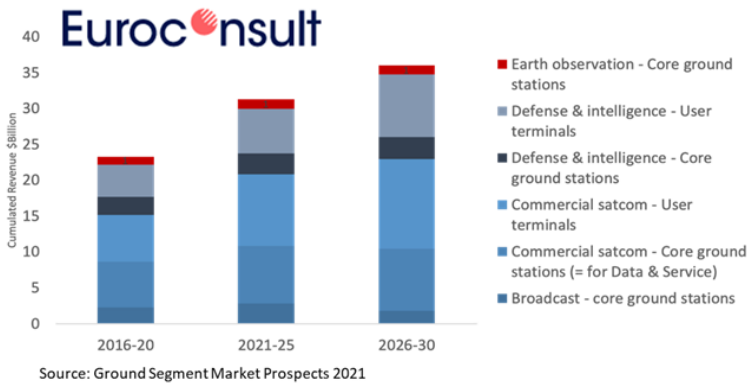

Figure 5 - Ground Segment market size in 2021[5]

The last important trend in the space market is the transition from Capital expenditures (CAPEX) financing models to Operating expenses (OPEX) models. CAPEX is a company's major, long-term expenses, while OPEX is a company's day-to-day expenses. The space industry has a CAPEX-intensive industrial structure. The value chain for space projects begins with the manufacturing of satellites and rockets, which require large-scale manufacturing facilities. They are operated using a global communications network. Therefore, satellite operators must be prepared to make a large capital investment at the beginning of the project. The CAPEX to be borne by the satellite operators includes the following costs;

- Satellite construction
- Office building construction
- Launch construction
- Launch insurance cost
- Construction of TT&expenseties
- Construction of gateway network

Not only the space industry but also the manufacturing industries tend to be CAPEX-intensive. They can ease the burden of CAPEX-intensive structure by a high volume of production to spread the burden per product. However, mass production has been almost impossible in the space industry because satellites and rockets are usually designed and manufactured for a single mission and then discarded, so they cannot be reused for other missions.

[5] Ground Segment Analysis 2021 Report - Euroconsult 2021

CAPEX-intensive industries are more vulnerable to economic slowdown because it takes away management flexibility. In addition, since space projects involve technical and political risks, insurance must be purchased to maintain the value of the invested assets. Furthermore, from the perspective of Net Present Value (NPV), high initial capital has a financial disadvantage. The CAPEX-intensive aspect is especially critical for Newspace satellite operators, which have a small economic base and rely on investor equity. They need to bear a bigger premium to investors to loan initial capital at the beginning of the business.

4 GAFAM

GAFAM are the 5 major giants of technology and the web. They have a combined market capitalization of $4.5 trillion[6] and are all founded and listed on the US, Nasdaq.

They dominate the digital market in America and Europe with products in mobile and desktop operating systems, cloud hosting, online social media and software products. Now, GAFAM's interest in the space industry takes the form of investments, satellite and rocket manufacturing, launch services, ground station service, cloud and end-user applications. We explore each of their initiatives and impacts below.

4.1 Google

4.1.1 Google Cloud

As a cloud provider Google Cloud has collaborated with NASA's Frontier Development Lab on 8 projects by 2020 to leverage its AI capabilities. For example on projects to create high-resolution images from low-resolution photographs and projects to enable navigation on the moon's surface without GPS, and using AI to compare an astronaut's surroundings[7].

4.1.2 Investments and acquisitions

Google took an early interest in space tech, focusing its investments in newspace, satellite connectivity and earth observation data. Starting in 2008 till 2016, Google invested $768M in O3b Networks to connect the unconnected through high-throughput internet via a satellite constellation in MEO. In 2014, Google employee Greg Wyler and other key O3B employees left Google and O3b to found OneWeb, the low-earth orbit operator now acquired by Eutelsat, to remain neutral Google has not invested in OneWeb. Google invested $500M in Terrabella a cube-sat constellation operator providing high-resolution earth observation, sensing data and image analytics, it eventually sold Terra Bella to Planet for an estimated $200M in 2017, less than what it was bought for. In 2015, Google invested $1B in SpaceX for Starlink, a satellite

[6] GAFAM Stocks, Investopedia, 2022
[7] Start-ups join Google, SpaceX and OneWeb to bring new technology to Space, CNBC, 2022

constellation for broadband. Also from 2015 to 2017, Google invested in $74M Orbital Insight, which works downstream as a data analytics and research firm using machine learning and image processing techniques to provide historical and predictive analytics based on satellite photography.[8]

Below is a visualization of the size and timeline of Google's investment ventures in Space technology.

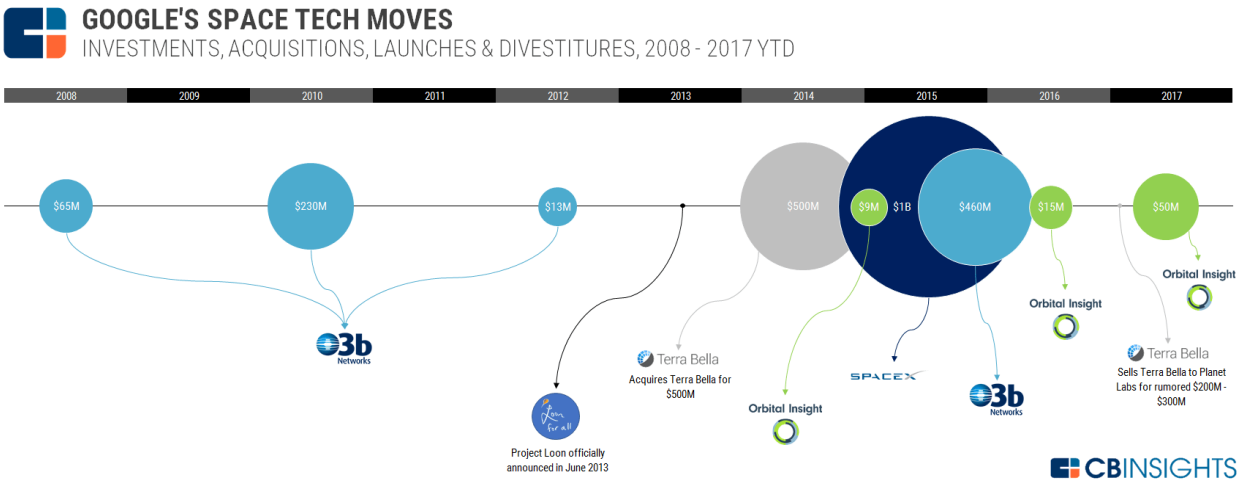

Figure 6 - Google's Space Investment strategy[9].

4.2 Apple

Apple partnered with Globalstar to release its iPhone 14 with an emergency feature that allows users to send compressed text messages from the phone via satellites[9]. In this context, the company announced an expected investment of $450m in expanding GlobalStar's constellation capability to reach the required demand for Apple's product. At first, the emergency service will be deployed and tested in US and Canadian territories, but the goal is to later expand it to other areas of the globe. In addition, according to Apple, the service will be free-of-charge during the first two years, no further pricing information was provided.

By announcing this major investment, Apple positioned itself as the market leader in satellite smartphone communications. As a result, the company can be identified as a major potential customer of the space sector as a whole. To put it in perspective, the announced emergency service is expected to utilize roughly

[8] Google's Space Wager: Mapping Investments, Acquisitions and Launches, CBInsights, 2017
[9] Apple to be largest user of Globalstar's satellite network for iPhone messaging, SpaceNews, Sept 2022

85% of GlobalStar constellation capacity, clearly showing the impact potential of Apple joining the space industry.

Finally, this strategic move from Apple seems to be the first step to a much larger strategy based on satellite connectivity. By investing in phone-to-satellite technology, and enabling at first simple messages to be exchanged between IPhones and satellites, Apple is clearly setting the stones to enable more complex communications between their customers through satellites in the future. This might be a potential for an industry that is currently almost entirely dependent on terrestrial infrastructure. New Street Research analyst Jonathan Chaplin highlighted this fact in his article[10]:

> "Satellite-enabled text is a small step toward a much bigger opportunity. The killer application will be ubiquitous global voice and data connectivity enabled via satellites that work seamlessly with terrestrial cellular networks. This could be a $20 Billion+ annual opportunity in the U.S."

4.3 Facebook (Meta)

Facebook's strategy in the space market seems to be fully focused on expanding internet connectivity. In this sense, the company invested in the development of its own small satellite project in AMOS-6, in 2015. The project aimed to provide internet connectivity to remote areas in Sub-Saharan but failed to be put in orbit due to the launch failure of Falcon rocket in 2016. Since then, the company has made investments in another constellation of satellites, called Athena, which also focuses on providing internet connectivity to remote areas[11].

Apart from the direct investments in space constellations and technology, the company seems to be also focusing on establishing a strong partnership with established members of the space industry. Recently, Facebook has announced[12] a partnership with major satellite operator Eutelsat to expand internet connectivity offerings in African regions. The goal is to leverage Eutelsat Konnect capabilities to demonstrate the potential of new technologies in connecting unserved areas of the globe.

Overall, although Facebook has not yet massively focused on directly joining the space industry as a main player, it seems that the company is well on track to become a major customer of space services and infrastructure. This interest seems to be mainly related to expanding the range of connected areas around the globe so that indirectly, the potential market of Facebook and Meta's products is increased. There have also been significant rumors of Meta investing in their own satellite constellations, but no official announcement has been released yet.

[10] Bloomberg - Apple and Satellite Connectivity
[11] Facebook - Athena constellation
[12] Facebook - Eutelsat partnership

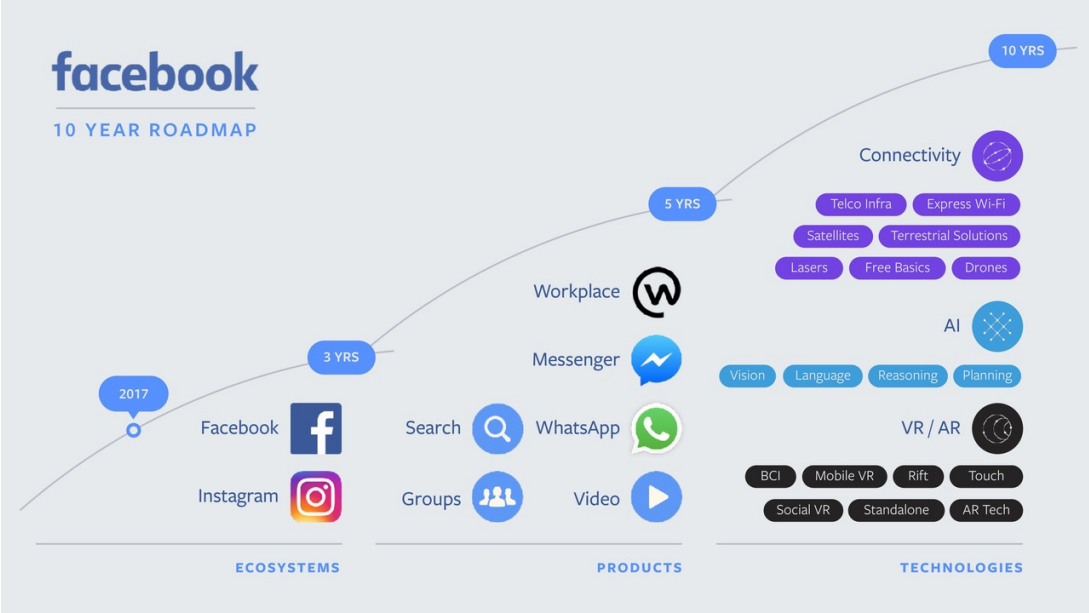

Figure 7 - Facebook's connectivity strategy and roadmap[13]

4.4 Amazon

4.4.1 Amazon Web Services, Cloud and Ground Segment

Amazon Web Services serves the downstream with its cloud services and new AWS Ground Station service. AWS's position as the cloud leader as ranked by Gartner for its completeness in services and execution has allowed it to attract governments, enterprises and start-ups. NASA's Mars Perseverance rover's mission-critical communication and telemetry data transfer is processed and hosted on AWS. Maxar uses AWS for high-power computing and high throughput processing, 58% faster and 45% lower computing costs. Axelspace satellite solution is globally available due to the cloud.

AWS's ground station service gives satellite operators access to an expanded network of ground stations and the ground stations are connected to the cloud. Satellogic uses AWS for their EO, LEO, and constellations that will grow from 17 to 200 by 2025[14] the service will help them scale quickly with lower costs.

[13] Facebook's 10-year road map, Paul Dughi, Medium, 2017
[14] Satellogic uses AWS Ground Station to Scale Services and Deliver Insights to Customers Faster, Satellogic, 2021

4.4.2 Kuiper Project

Amazon announced its plan for the 3,236 LEO satellite broadband constellation in 2019. Its estimated deployment is from 2022 to 2026. The satellites are designed to be manufactured in its in-house facility in Washington and launched by Arianespace and BlueOrigin[15] The project directly competes with SpaceX's Starlink and Eutelsat's OneWeb, though may pursue different business models and market fit; SpaceX for broadband access, cellular, maritime, aero in-flight connectivity, milsatcom and enterprise; Amazon for broadband access, cellular and enterprise and OneWeb for maritime and milsatcom.

4.4.3 Blue Origin

Blue Origin, LLC, not directly related to Amazon but was founded in 2000 by Jeff Bezos, founder and executive chairman of Amazon is an aerospace manufacturer and suborbital spaceflight company. Its New Shepard suborbital spaceflight system offers to take payloads and tourists to space, completing 6 crewed missions since Aug 2022. New Glenn, 7-meter diameter 2-stage orbital launch vehicle is expected to launch in 2023. Blue Moon is a crew-carrying lunar lander with the intent to transport cargo to the moon. Its range of engines are manufactured in America, namely, B3-3(liquid hydrogen-fueled), BE-4 (ox-rich stage combustion) and BE-7 (high-performance, dual-expander, cycle engine, 40kN thrust). In October 2022 Blue Origin completed delivery of a BE-4 engine to United Launch Alliance's (ULA) factory in Decatur, AL for Vulcan's initial launch, ending reliance on Russian engines.

4.5 Microsoft

Azure Space[16] is Microsoft's new initiative to serve the mission needs of the space industry. It aims to bring together Azure technology and a network of expert partners offering solutions for the industry.

4.5.1 Azure cloud.

Azure is Microsoft's cloud providing computing, storage and data processing of images and data downloads from satellites. Azure targets governments, space enterprises and operators.

To serve customers' operations in remote locations, there's Azure's Modular Datacenter (MDC)[17] for edge computing. MDC is a self-contained data center unit with a field transportable solution, and is resilient in temperate, humid and harsh surfaces. MDCs are capable of 1Gbps throughput and take short 30 days to deploy.

[15] Amazon plans a new Project Kuiper factory to build as many as four internet satellites a day
[16] Azure Space
[17] Introducing the Microsoft Azure Modular Datacenter, Azure 2020

4.5.2 Azure Orbital

Azure built its own ground station network to schedule contacts with NGSO which include LEO and MEO satellites, providing 99.99% SLA. The ground stations allow their customers to bring satellite data into their cloud environment via their virtual network.

SpaceX uses Azure cloud, MDC and Azure Orbital's ground station network on a monthly subscription fee (OPEX) that includes the price of the antenna and an on-demand, pay-as-you-go model for the usage of satellite capacity. There is no other equipment or rental costs[18]. They piloted the system with customer FireNet, a cloud-based application for wildfire management.

Satellite operator SES leverages Azure, MDC and Azure Orbital[19]. The figure below shows how they connect the SES network with MS Network. Extending their capabilities at lower CAPEX, moving to OPEX, and now able to operate in remote locations as scale.

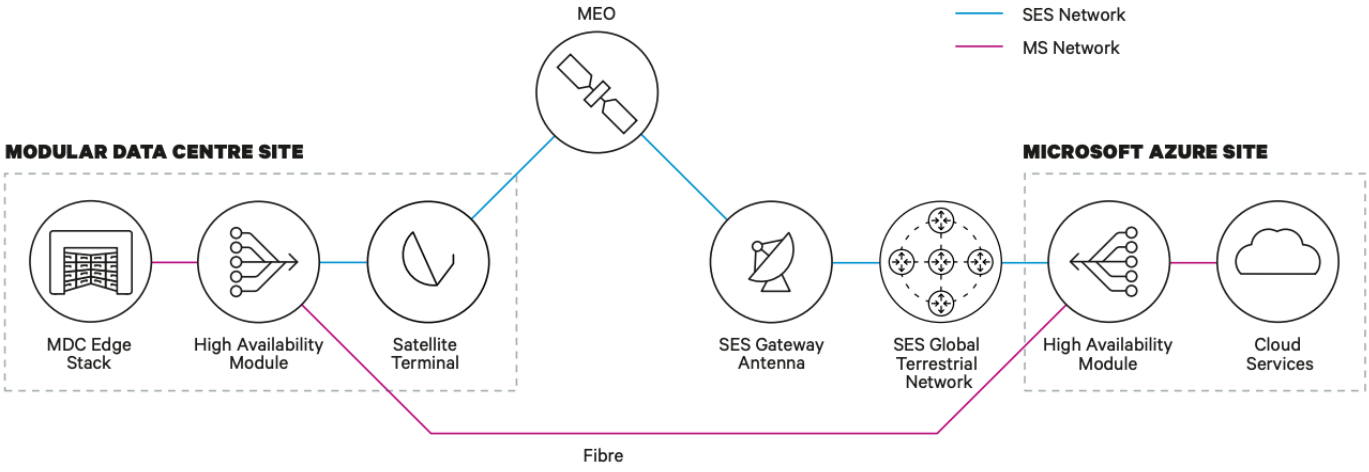

Figure 8 - Main blocks of Microsoft Azure Orbital.

Ground station operator KSAT,

[18] Microsoft Azure ramps up access to cloud computing via SpaceX Starlink satellites, Geekwire, 2022
[19] Connecting the edge, Microsoft Azure and SES Networks, 2021

5 CONCLUSIONS

As we have seen in the above section, GAFAM's position in the space industry varies and it is difficult to find a common motivation for their arrival in the space industry. However, we can identify some common trends, such as:

1. They are mostly interested in connectivity via satellite communication.
2. Based on their large financial resources, they are going to transform all the value chains in the space industry.

The impact of GAFAM on the value chain can be summarized as follows;

As ground segment service providers:
Google, Amazon and Microsoft are applying the infrastructure they have developed in their core data center business to the GroundSegment of the space industry and are promoting the cloudification of the Midstream of the space industry. Upstream of the space industry is a hardware-driven industry, while downstream is a data-driven industry. Therefore, the IoT industry and the space industry can form an extremely compatible partnership.

As satellite communication service providers and/or users:
Since all GAFAM have web-related services as their core business, ensuring connectivity with users is essential. They have been relying on the services of terrestrial telecommunication companies, but the satellite constellation has given them the means to ensure direct connectivity with their users.
Apple's decision to bring satellite communications capabilities to the iphone14 is a revolutionary effort to expand the end-user base for mobile satellite communications in one fell swoop.

As investors:
GAFAM companies have invested in various fields based on their abundant financial resources, and space is one of the major areas in which it has invested. Their investments have encouraged the entry of an emerging space industry player called NewSpace.

From the perspective of industrial innovation theory, the space industry is transitioning from the Emerging phase to the Growth phase where Early Adopters will play a leading role[20]. As Early Adopers, GAFAM are trying to become a driving force in the growth of the space industry.

[20] Innovation Trends in the Space Industry, *Victor Dos Santos Paulino,October 2019*

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[16] Azure Space

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[24] Axelspace scales data pipeline from one to five satellites seamlessly on AWS, Amazon Web Services, 2022

[25] Satellogic uses AWS Ground Station to Scale Services and Deliver Insights to Customers Faster, Satellogic, 2021

[26] Blue Origin Completes the delivery of flight engines to ULA for Vulcan's initial launch, Blue Origin, 2022

[27] AWS announces 2022 AWS Space Accelerator for startups in space technology

[28] ジェフ・ベソス氏も宇宙ビジネスに本気！　GAFAMとBATXの宇宙ビジネス参入事情　|　宙畑 (sorabatake.jp)