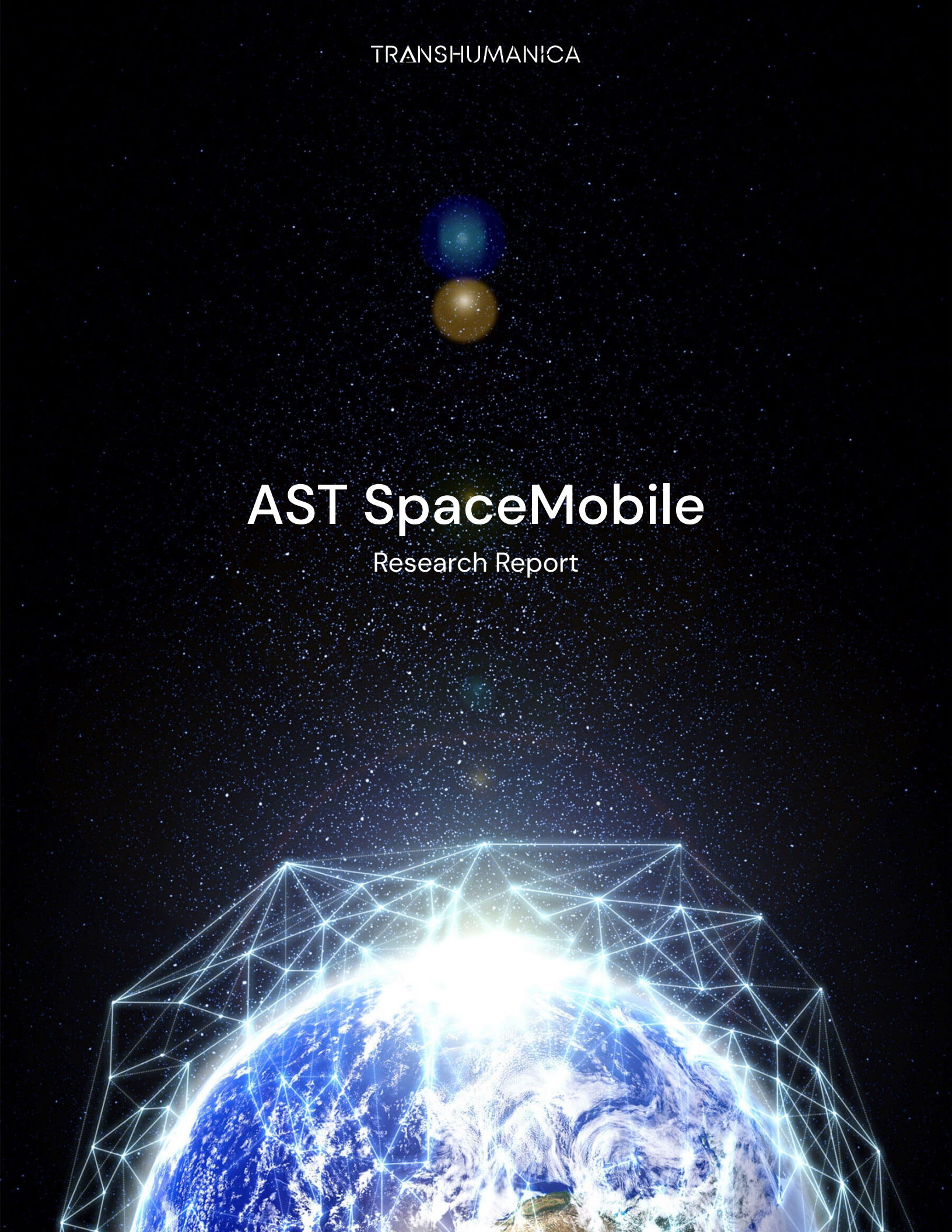
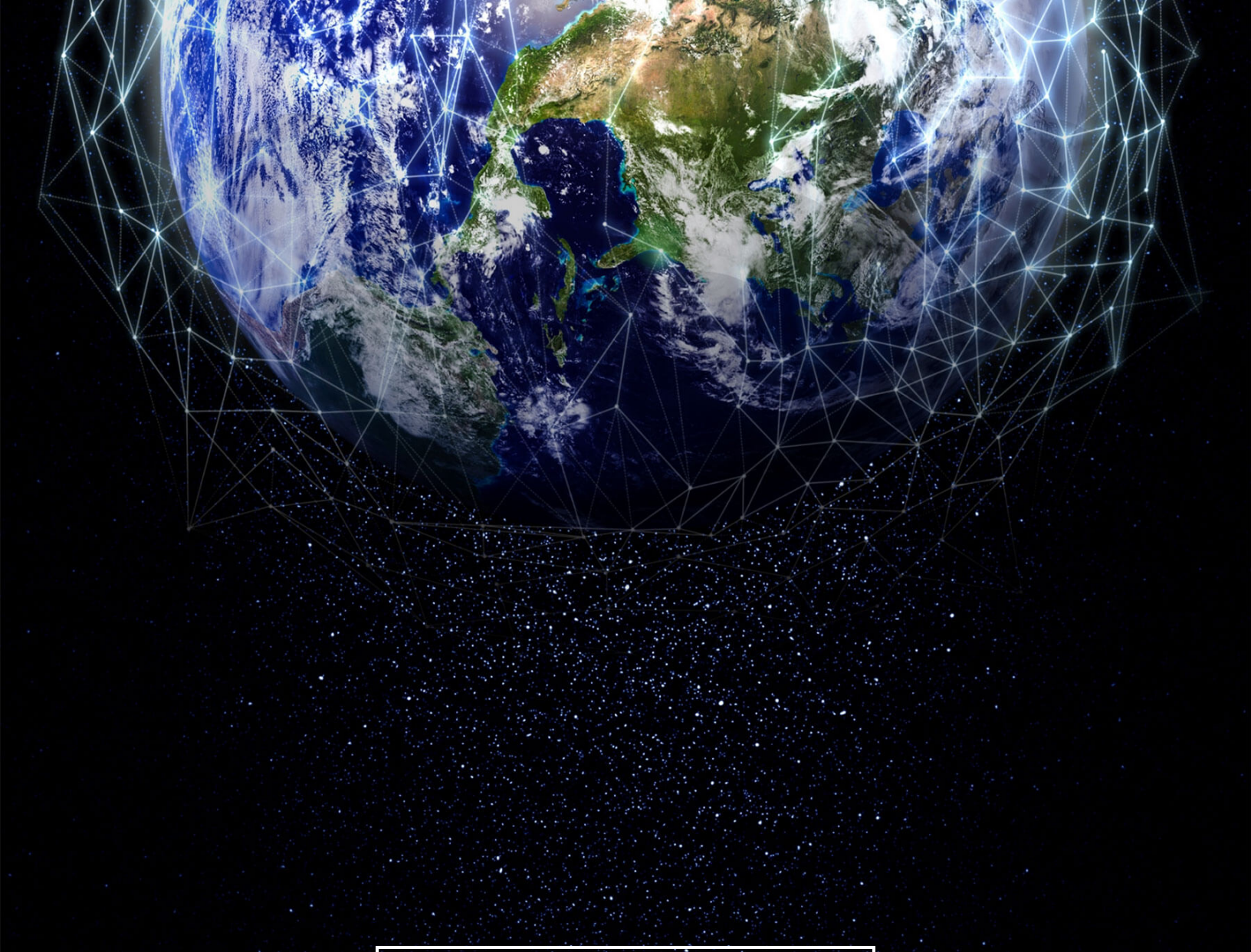
TRANSHUMANICA

AST SpaceMobile

Research Report





NOTE: If you are online, we recommend viewing the interactive version of this report instead. It has videos, dark mode, interactive valuation model and other extra features missing in the PDF version.

September 9, 2022

Transhumanica Research LLC

transhumanica.com/asts

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Disclosure: Individuals and entities related to Transhumanica hold a long position in AST SpaceMobile common stock, warrants, and/or call options at the time of this writing.

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Table of Contents

ASTS stock might go to $500: SpaceMobile plans to turn every phone into a satellite phone and bring up to 3.2 billion people online for the first time

Highlights

- AST SpaceMobile (ticker: ASTS) will turn every smartphone into a satellite phone with broadband internet access anywhere in the world
- It will achieve this by deploying and operating satellite "cell towers" in orbit that will cover the whole planet with LTE/4G/5G signal
- 3.2 billion people are currently offline with no internet access [1,2]. The pro-social and economic impact of bringing these people online can't be overstated
- 1 trillion USD addressable market undergoing rapid growth in the sectors targeted by SpaceMobile: There will be more than 400 million new mobile phone users by 2025. Four in five connections globally will be smartphones by 2025; smartphone connections in Sub-Saharan Africa will nearly double. Global mobile data usage will grow almost fourfold by 2025. [1]
- AST has a head start over competition. Other satellite internet providers usually require expensive satellite phones and offer very limited data - e.g. Iridium - or they require satellite dishes – e.g. SpaceX's Starlink broadband internet. The most viable competing service was announced only recently on August 25, 2022 - a partnership between T-Mobile and Starlink [3], which validates what AST is doing (more on this in the Competition chapter). The second closest competitor is a private company called Lynk, which is commercially behind SpaceMobile. Lynk's service will initially focus on low data rate services - text messaging only [4]).
- Patented (2,400+ patents & patent claims [5,6,7,8] and to an extent tested [9] technology (space to Earth communication)
- Funded for a commercial launch
- Partnered with Vodafone [10] for immediate access to 271 million unconnected people, as well as additional agreements with major mobile network operators who together have 1.8 billion mobile customers [11]
- 50/50 revenue sharing business model with mobile network operators leads to extremely attractive 90%+ profit margins, as AST will be selling its services wholesale only and most of the administrative, sales, advertising and related expenses will be on the side of operators
- Commercial viability validated by enterprise partners and investors, including Vodafone, Rakuten, American Tower [12], AT&T [13], Telefonica, Nokia [14], TSMC [15] and more
- Explosive stock price growth potential (>$500 share price 2030 target in case the company succeeds in its mission, a 50x return from $10 price)

⚠️ Keep in mind that in case the company *doesn't* succeed in its mission due to technological, regulatory, execution, financial, competition or other risks, the stock can go to $0 and become entirely worthless.

What follows is a 2-page summary, followed by the actual report. Enjoy!

Current ASTS price and chart courtesy of TradingView:

The problem: 41% of humanity is offline

Over a decade ago, internet access got established as a fundamental human right. However, 3.2 billion people remain offline. [1,2] Cellular dead zones plague the world, and 6% of global population doesn't even have cellular coverage.

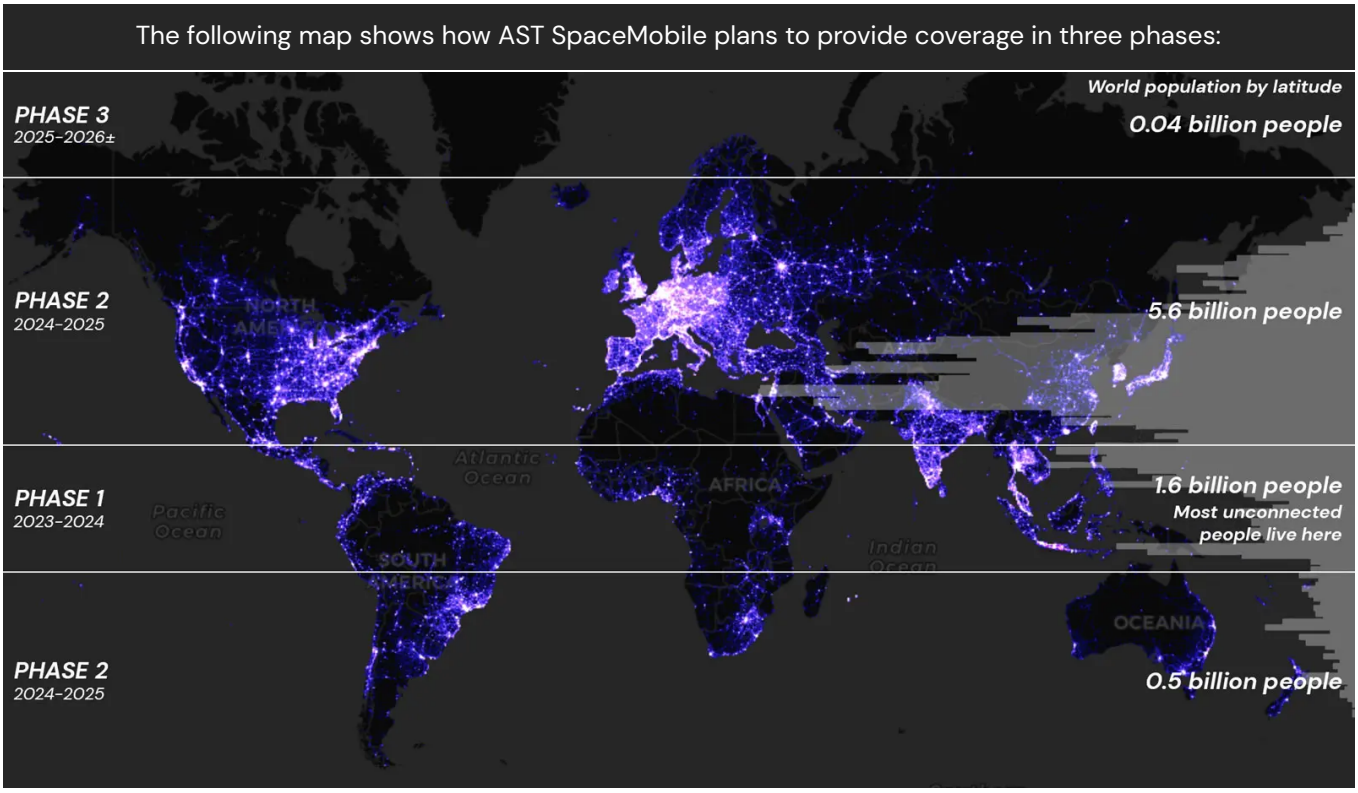
Imagine how your life would be different without internet: no email, no Google, no YouTube, no Wikipedia, no social media, no chat apps. That's the reality for billions. And 6% of people [1] have it even worse - not just no internet access, but also no cellular coverage. Even calls with family or to emergency services can't be taken for granted by everyone, or everywhere.

Based on the current rate of the internet coverage expansion projected by the United Nations, the goal of getting 90% of the world's population online won't be achieved before 2050. [16]

Without aggressive innovation, meeting this target will take even longer. High initial costs of cell towers dramatically slow down connectivity expansion in the developing world. In the poorest nations, an internet connection is unaffordable for most. This won't change as long as the necessary infrastructure remains expensive.

Countless people have died because they had no cellular connectivity to call for help.
Lack of connection with the outside world dramatically adds to the monetary misfortune of the world's poorest, closing doors to potential opportunities for lifting themselves out of poverty.

This is also bad for human civilization as a whole. Many geniuses came from impoverished backgrounds. There are currently hundreds of millions of children, many of them undoubtedly gifted - potential next Einsteins and Newtons and Elon Musks - with no internet access. Just imagine all their contributions if they were able to join the global academic and business community. There are historical cases of people with no formal training making substantial contributions to science, such as the fascinating story of Srinivasa Ramanujan [17].



For a visualization of cell tower coverage (and the dead zones), check out this website: https://alpercinar.com/open-cell-id/

The solution: turn all phones into satellite phones

Cellular coverage and internet access go hand in hand. 92.8% of internet users use mobile devices to go online most of the time. There are 5.27 billion unique mobile users, increasing each year rapidly. [18]

Today, only about 25 percent of the world's landmass is served by cell towers, the rest has no coverage [19]. Traditional terrestrial tower networks will never reach full global coverage, as there are no economic incentives to expand into low population density and low-income areas. For a solution, we must look to the sky.

Satellite constellations are magic made real. They provide robust wireless networks with global coverage at a fraction of the cost of traditional terrestrial towers. The satellites can easily cover the whole planet, including the most impoverished regions. The services can then be priced accordingly in each region to be affordable by locals.

Many understand the gravity of the global connectivity problem and the economic opportunity that it presents. Recent technology advancements and the rapid decrease of payload to orbit costs started a commercial space race. Starlink from Elon Musk's SpaceX and Project Kupier from Amazon are some of the most prominent players.

However, even the most advanced satellite constellations are of no benefit to those who can't afford their services. Nearly all existing services require customers to purchase expensive hardware such as satellite phones (>$1,000 for Iridium sat phone) or mounted terminals with powered antennas ($599 for a Starlink terminal [20]).

For this reason, a space-based cellular broadband network which works with regular phones that people already own is the holy grail.

The opportunity: it's still early for AST SpaceMobile stock

Until recently, the technology of direct satellite to unmodified mobile phone communication has been the stuff of imagination. AST SpaceMobile (ticker: ASTS) is now making it a reality.

AST SpaceMobile has the first-mover advantage, nearly $500M funding, unique product, over 2400 patent claims [5] and exclusive commercial agreements with Vodafone/Rakuten/AT&T [21] and other big players which allows it to target billions of customers almost instantly once their satellites get deployed.

It already proved their solution works by establishing space communication with their prototype satellite.

This in-depth report will analyze the AST SpaceMobile ($ASTS [22]) stock as an investment.

We believe that if the company succeeds in its mission, it could bring shareholders eye-popping returns by 2030, e.g. as much as 50x~ from a $10± entry price. This report explains how.

At Transhumanica Research, we focus precisely on opportunities like this: high pro-social returns for humanity and high potential financial rewards for visionary investors in our community.

We believe that ASTS has all the ingredients necessary to become a "cult stock".

See how AST SpaceMobile plans to connect the unconnected:

Source: Official AST SpaceMobile YouTube channel

Chapter One

SpaceMobile introduction

AST SpaceMobile is a company that plans to launch a constellation of satellites to space to provide global mobile phone signal coverage (LTE/4G and 5G) over the entire planet. The satellites will work with ordinary phones that everyone already has in their pockets, without any modifications necessary [23,24]. No external antennas are needed. AST satellites will operate on the LTE spectrum authorized to AST's partner carriers via a licensing lease.

Even a cheap $5 refurbished phone used in rural Africa will be able to connect without any modifications [25]. SpaceMobile will provide connectivity to billions of people, whom will move from having no connectivity to suddenly having Netflix streamed to their cellphones [25].

The satellites act as a relay (repeater) between the phones and existing antennas on the ground that are connected to the cellular network [26].

SpaceMobile will also support NB-IoT (Narrowband-Internet of Things) devices [27]. The global IoT market was worth $760 billion in 2020, and is expected to grow by 10.5% every year up to $1.39 trillion in 2026 [28]. This represents a huge opportunity, since the 50/50 revenue-sharing business model that SpaceMobile has with mobile network operators means SpaceMobile will profit from each IoT device connected to its network.

AST is a U.S.-based company with a manufacturing and operations facility in Midland, Texas, and R&D offices in Maryland, Spain, Space Park Leicester in United Kingdom and Israel [29,23,30]. AST has a growing team of 566 [31].

Photo source: https://ast-science.com/

51% AST-owned nanosatellite manufacturer NanoAvionics [32] has sites in Lithuania, UK and USA. NanoAvionics is currently pending sale [33] for $28M in net proceeds to AST.

On April 6, 2021, SpaceMobile merged with a SPAC named New Providence Acquisition Corp. (NASDAQ:NPA). After closing of the transaction, AST SpaceMobile became a publicly traded company. It's listed on the NASDAQ exchange under the symbol "ASTS". All AST SpaceMobile shareholders retained 100% of their equity in the combined company. [34]

To quote Adriana Cisneros [35], an investor in AST SpaceMobile:

"It's the coolest thing I've been ever involved with, and if we pull this off, it's not only going to be the most important thing that we do as a business group in the hundred years that we have been around, I also think it's going to be thought of as one the greatest innovations to happen in our generation." [25].

You can listen to Adriana's thoughts about her SpaceMobile investment in an investing podcast KindredCast starting at 6:30. [36]

💡 **Did you know?** In mid 90s, Adriana's father Gustavo Cisneros of Grupo Cisneros launched the first ever direct broadcast satellite and brought satellite television to Latin America. [37]

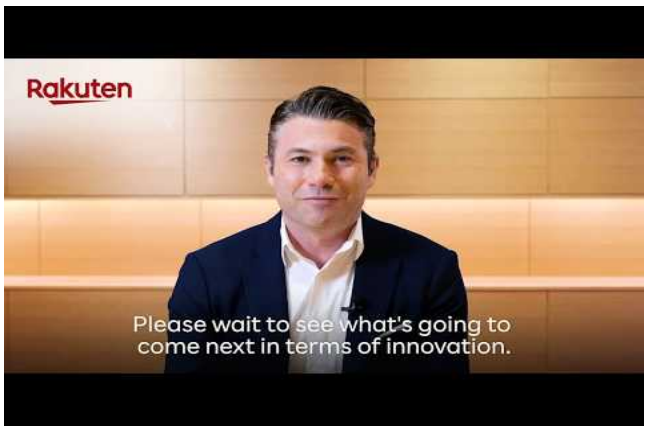
AST SpaceMobile CEO is Abel Avellan. Abel has a long history in the communications industry. After graduating college in his native Venezuela, he moved to Sweden and joined telecom giant Ericsson as an engineer. A few years later, in 1999, he founded satellite communications company Emerging Markets Communications, which provides high-bandwidth connections over satellite for video and other applications. He sold EMC in 2016 to telecom company Global Eagle for $550 million. Fresh off that sale, he founded AST. [38,25,39,40]

SpaceMobile will work for consumers as follows: When subscribers exit mobile coverage, they will receive a text message from their wireless provider that offers access to SpaceMobile connectivity. With a simple "yes" response via text, the user will receive a day pass. This pass will be an add-on charge to the subscriber's monthly bill. Subscribers will also have the option to add ongoing SpaceMobile connectivity as a monthly subscription, ensuring seamless, uninterrupted service. [41] A stand-alone plan will be available to use SpaceMobile as the primary network in areas without cellular coverage [29].

As of December 1, 2020, AST has entered into agreements and understandings with mobile network operators which collectively cover over 1.8 billion mobile subscribers of which at least 790 million mobile subscribers are covered by binding and mutually exclusive agreements that provide for revenue-sharing with AST. AST estimates that the global market opportunity for its services is $1.1 trillion, according to GSMA market data. [29]

SpaceMobile will be offered to mobile network operator's subscribers under 50/50 revenue share agreements [42].

Both Rakuten and Vodafone - investors in AST - publicly announced that SpaceMobile is coming and will dramatically improve geographic mobile coverage using satellites [43,44].

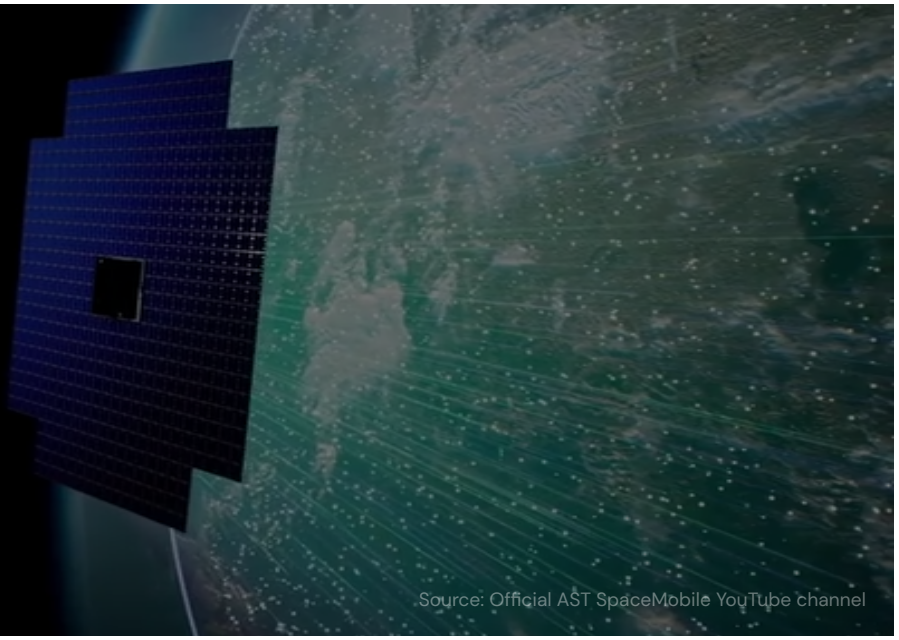


Recently, American Tower's CTO Ed Knapp highlighted some of their reasons for partnership with SpaceMobile in a YouTube video:

Vodafone, American Tower and Rakuten all publicly suggesting the technology is a done deal is a promising sign.

Chapter Two

Technology



Source: Official AST SpaceMobile YouTube channel

Timeline

Following the BW3 launch (exp. mid-Sep 2022), we can expect the phased array (satellite) unfolding in orbit in about 2 months [45]. This represents some technical risk, so a successful unfolding might be a positive stock catalyst. In the 4 months following successful unfolding, AST will be performing connectivity tests with regular phones in cooperation with mobile network operators on all 6 inhabited continents. In the meantime, AST will be ramping up manufacturing capacities.

ext, they will launch 5 first-generation "BlueBird" satellites (same size and technology as BW3 [46]) which should fit on a single Falcon 9 rocket in late 2023. With these satellites online, the company expects to start commercial service and to generate first revenue in early 2024.

Following that, AST launch additional 15 second-generation (2x bigger) satellites. These 20 total satellites will cover the equatorial region (49 countries, 1.6 billion people), which has a large portion of unconnected population - particularly in India and Africa.

The equatorial constellation will cost a total of about $300-340M. They chose to launch the equatorial network first because this network requires the fewest satellites for full coverage, and their partner Vodafone already has 500 million subscribers in the region [41], who can immediately use SpaceMobile's service.

AST will continue launching more satellites over the following years. A total of 110 satellites will provide full global mobile coverage. A total of 168 satellites will add 5G support afterwards. [27,47].

While the estimates above are up-to-date as of now, the actual timing of satellite deployments is a moving target and already delayed by at least a year as compared to original AST management estimates presented in 2020.

Manufacturing and supply chain resilience

"Abel Avellan said during the company's earnings call that AST SpaceMobile is on track to complete a second manufacturing facility in Texas by the end of 2022, which would enable the company to ramp up to producing six satellites a month the following year." [48]

"He said AST SpaceMobile is confident its expansion plans will not be caught up in supply chain issues that have delayed other satellite projects." [48]

The satellites will feature 900 square-meter large phased array antennas, with a hard-body radius of 30 meters, weighting well over 1.5 tons [49], and a peak gain of 47 dBi [50,51,52]. The way they can do this is by self-assembling the final structures in space [25]. Each SpaceMobile satellite will be composed of identical modules linked together, reducing manufacturing costs [53].

The following GIF illustrates how the satellites are designed to orbit Earth:

Source: AST SpaceMobile Twitter - [54]

The AST satellites are absolutely huge in comparison to other comparable satellites [51]. For example, Starlink satellites have a cross-section of 32 meters squared [55]. In fact, AST satellites are so large that the National Radio Astronomy Observatory is concerned the light-reflecting surface area of the satellites will have a significant effect on the appearance of the night sky [56].

As KookReport explains [57]:

ASTS' satellites are ~10x bigger than the norm because they are essentially cell-phone towers in space. With a 900-square meter array, it's a large "loud" system that can connect with a regular mobile phone. Traditional satellite phones "listen hard" whereas ASTS simply produces a loud signal to connect to regular mobile phones.

Note: The final satellite size is kept secret by the company. According to an analysis by ASTS investor community member CatSE, the final production BlueBird satellite size could be as small as 336 square meters thanks to ongoing engineering improvements. [58]

Contemporary mobile phones have enough power to reach a terrestrial cell tower up to 72 km away [59]. Thus, it makes sense AST needs huge satellites with powerful antennas in order to receive the faint mobile phone signal from a distance of 700 km [60]. No clear line of sight of the satellite is needed [61], and the service should work even indoors, on planes and at sea [26]. The communication delay (latency) will be about 20ms [62,63]. The SpaceMobile service will meet and exceed the download and upload speed of 35 Mbps / 3 Mbps [63].

A question remains over what network performance will look like once the user base widens meaningfully, as network congestion has historically been the largest issue with satellite internet [64]. However, AST constellation is designed in such a way that they can launch additional satellites to increase the capacity.

Expected satellite lifetime is 7-10 years [65,66].

AST has 2400+ patent claims and a team of over 200 space scientists and engineers inc. 24 PhDs [5,67]. Additionally, Vodafone has been working with AST developing and testing the technology since September 2019 [42,68].

Existing investors doubled down on AST in the NPA SPAC accompanying PIPE transaction. According to Abel Avellan (the CEO), Vodafone and American Tower were doing due diligence of AST and their technology for years [69,70].

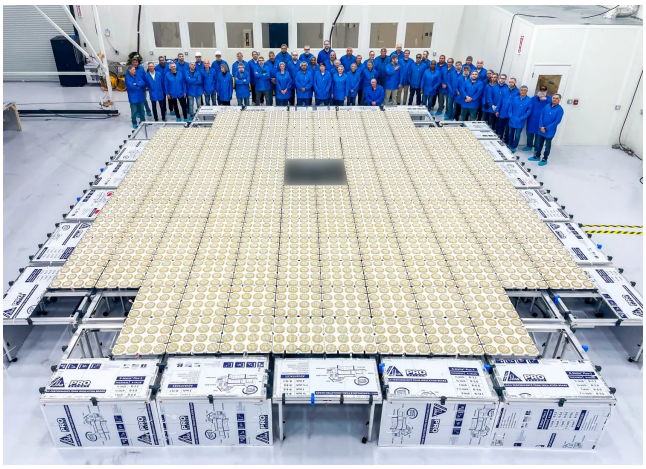
Lynk, a SpaceMobile competitor, was able to send a text message from LEO (low-Earth orbit) test nano-satellite to a common Android phone on the ground [71,72]. Since they managed to do this using a nano satellite, it gives us a signal to the validity of SpaceMobile technology and their several orders of magnitude bigger satellites.

Test satellites

AST launched a BlueWalker-1 satellite in April 2019 to test their technology, and proved it could establish a link directly to cellphones [73]. They launched a tiny satellite to space to act as a handset (mobile phone), while keeping the large satellite prototype on the ground (codenamed BlueWalker-2), which allowed fine-tuning the prototype [27,26]. BlueWalker-1 was a 6U cubesat built by NanoAvionics [73]. The test also

showed that AST's cellular architecture is capable of managing communications delays from LEO orbit and the effects of doppler in a satellite to ground cellular environment using the 4G-LTE protocol [27].

Additional 1.5 ton, 64~ square meter test satellite BlueWalker-3 (BW3) is scheduled to launch mid-September, 2022 [58]. In order to do so, AST has signed a multi-launch agreement with SpaceX, covering not only the launch of BW3, but also providing a framework for future launches, such as the BlueBird production satellite. [74]



BlueWalker-3 test satellite. Source: [75]

The BW3 test satellite is expected to enable live ground, sea, and airborne testing with unmodified LTE and 5G devices such as smartphones, tablets and internet of things ("IoT") equipment. The satellite is also expected to enable live testing for voice, video and data. [29]

💡 **Fun fact:** BlueWalker-1 is still orbiting the Earth and can be tracked online in real-time, e.g. on the n2yo.com website [76]. BlueWalker-3 will be also trackable after it's launched.

🏁 **September 2022 launch: Key event for investors**

Because BlueWalker-3 has the full technology stack implemented [77], we expect its successful launch to be a key "catalyst" and technological de-risking & validation event accelerating the growth of SpaceMobile investor base (and the stock price in tandem).

That said, we expect high stock volatility leading up to the launch and after it. If there's too rapid stock price increase leading up to the launch, the stock might possibly experience a typical "sell the news" event, temporarily falling on successful launch.

The following video by AST explains how the BW3 mission will work:

BlueWalker-3 Ground Test Successful. Source: Twitter

On June 11, 2022, AST CEO Abel Avellan announced "BlueWalker 3 end-to-end (ground) test conducted successfully this week. We also got the satellite fueled for our planned summer launch." on Twitter [78].

RKF Engineering's David Marshack's Technical Due Diligence

On virtual analyst day (Jan 22, 2021), David Marshack (COO of RKF Engineering [79]) shared his

thoughts on AST risks. Here are the key points:

- RKF Engineering got involved a few years ago already on behalf of AST investors, working closely with the AST team building the satellites
- BlueWalker-1 and BlueWalker-2 prototypes proved that the phone-satellite connection works. This greatly lowered the risk that the connection won't work.
- BlueWalker-3 will be smaller than a full satellite but it will use the exactly same components. It will de-risk the components and help with the final debugging.
- He doesn't see anything that would prevent BlueWalker-3 going up this year
- The satellite is nothing new, but a constellation like this was unaffordable before due to launch costs and component costs
- Most of the risks he sees are timing risks. Final tweaks of the technology, launch vehicle delay (e.g. weather), key components delays could delay the project by several months. He says satellite program delays are common.
- AST is assembling the satellites themselves in Midland, which removes some of the major delay risks
- There is redundancy built into the satellites. The satellites can handle damage as they are built form many identical components (mass produced "microns") that can re-route power and other capabilities around the satellite if it gets damaged.
- The magical thing is the patented (software) backend that makes it possible to connect to phones directly. The patents are insured with Lloyd's of London.
- Key takeaway: He doesn't see any major technical risk. In fact, what AST is doing was already possible before, but it was unaffordable and the magical backend processing wasn't invented yet.

Conclusion

All in all, the technology looks promising and is already partially validated. Vodafone and American Tower with their talented engineers have vetted the company and even increased their investment in the PIPE.

AST investors are eagerly awaiting successful BW3 test satellite launch in mid-September and the results from the following 6 month testing period. Once the technology is fully validated, the remaining key risks will remain in execution (mass manufacturing and at-scale deployment and operation of satellites) and regulatory approvals.

Source: Official AST SpaceMobile YouTube channel

Chapter Three
Funding

Funding history

Leading up to the "IPO" via NPA SPAC merger, the company received $588M~ total funding. Here's the breakdown:

In January 2017, the company was seeded with $6M by the company CEO, Abel Avellan [27].

In June 2018, Series A funding resulted in additional $10M funding by Cisneros [27,80].

In October 2019, Series B funding brought in $110M from Vodafone, Rakuten, American Tower and Samsung Next [27].

NPA SPAC trust contributed $232M in April 2021, and the NPA PIPE contributed additional $230M. It was led by AST SpaceMobile strategic partners, including Vodafone, Rakuten, American Tower, UBS O'-Connor (hedge fund) and other financial institutions [69,81].

Ownership and control

The table that follows sets forth estimated beneficial ownership of securities (< 5%) after the business combination [29]:

Abel Avellan (majority voting power)	47.5%
Rakuten	18.1%
NPA SPAC shareholders and sponsors	16.0%
Adriana Cisneros	6.3%
Vodafone	5.8%
American Tower	< 5%
Samsung NEXT	< 5%
Others	The remainder

As the company is now publicly traded, the current ownership percentages might differ. However, it currently seems that Mr. Avellan nor any of the early investors are divesting at these early stages of the company. [82]

Abel Avellan, CEO & founder has majority (88.3% [83]) voting power. This is a great sign, as founder-led companies tend to outperform and out-innovate companies with hired guns at the helm [84] (think Tesla, Netflix, Amazon).
The fact that Mr. Avellan was able to retain majority voting control through several funding rounds with top-tier investors is a positive signal.

Phase 1

After fees, the reverse merger injected around $423M cash to the company. All of the cash will be consumed for Phase 1. The cash will be used for the manufacture and deployment of the first 20 equatorial BlueBird satellites (Phase 1), along with $128M the company raised to date.

Phase 1 also includes buildup of manufacturing facility, BlueWalker-3 test satellite, ground infrastructure and others. Direct expenses projected for the manufacture and launch of the 20 satellites were projected to be $259M originally [27], but got revised to $300-$340M (16-31% higher) during the 2022 Q2 call. [85]

Phase 1 aims for full equatorial coverage with 20 satellites. It will cover 1.6B people across 49 equatorial countries, 700M of which are currently unconnected.

AST was fully funded for Phase 1 based on original cost projections, but due to increased costs on various fronts, it will need to raise a modest amount of additional capital in order to enter commercial service with the first 20 satellites in 2024. The first 5 out of these 20 satellites could enter intermittent commercial service as early as very late 2023. [85]

Phase 1 budget breakdown

For Phase 1, the budget per satellite was originally about $13M, now about $16M. [85]

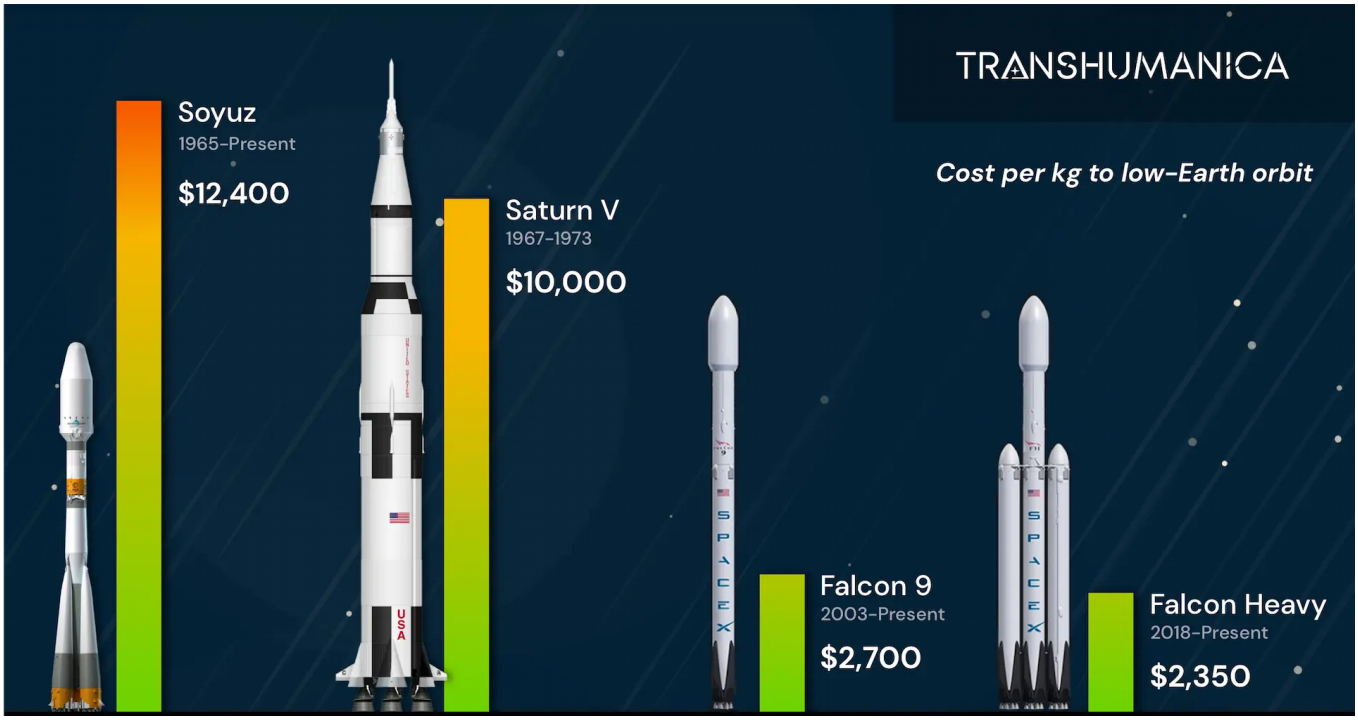
This seems to be realistic in comparison with other satellite projects. Deutsche Bank provides a comparison to Telesat [83]:

"Telesat's Lightspeed constellation is estimated to cost $5-6B for its 298 satellites ($18.5M per satellite). The Lightspeed satellites are more advanced than AST's, thus they should cost more than AST's, even though they are smaller."

Let's break the satellite cost further (manufacture + launch).

Each SpaceMobile satellite should weigh about 1.5 tons.

SpaceX's Falcon rockets can achieve prices as low as $1.4k - $2.7k / kg for low-earth orbit launch [86]. While busy with frequent Starlink deployment flights, SpaceX regularly flies primary missions for 3rd party customers as well [87].



On March 9, 2022, SpaceMobile secured SpaceX as their launch partner [88], which is tremendously positive news for shareholders, as SpaceX is the cheapest option by far. This news nearly doubled the stock price (and rightly so, as it dramatically increased the available manufacturing budget per satellite). However, in the following 4-5 months, the stock price fully returned to its previous levels due to macroeconomic factors.

Based on the launch costs listed at Wikipedia [86], the deployment of a 1.5 ton satellite will cost $2.1M to $4M each, thus $42M to $80M for 20 satellites.

This will leave AST SpaceMobile with a $220M to $298M (as the total budget is $300-$340M) budget for the manufacture of all Phase 1 satellites, or $11M to $14.9M per satellite. That's $7.3k to $10k per kg of satellite. Is this price achievable?

In comparison, NanoAvionics (until recently a 51% owned subsidiary of AST) 16U satellite bus has a max weight of around 15 kg [89], and costs hundreds of thousands of EURs [90].

AST SpaceMobile plans to build their huge satellites from lots of small modules, which makes comparing AST satellites with NanoAvionics nanosats not completely unreasonable. Assuming the 16U NanoAvionics bus costs $250k, that's $16.5k per kg.

So AST has to cut the costs of NanoAvionics satellites by about 50%. Subtracting NanoAvionics profit margins from that differential, accounting for fixed costs (which represent a much higher percentage of the total cost for small satellites) and also accounting for AST's mass production $30M 185,000 square foot satellite assembly plant in Texas, and the fact AST wants to build the satellites from relatively cheap identical modules, it seems economically feasible.

In conclusion, the budget for the first 20 satellites (Phase 1) seems realistic.

Phases 2, 3 and 4

Phase 2 will launch 45 satellites to cover North America, Europe and Asia. It was originally scheduled for 2023 - 2024, but we expect a postponement till 2024 - 2025.

Phase 3 will launch 45 more satellites for full global coverage. It was also originally scheduled for 2023 - 2024. Given the launch delays, we suspect it will get postponed to 2025.

Phase 4 will launch 58 satellites for 5G and MIMO - using multiple antennas to communicate with a single device for faster speeds; originally scheduled for the end of 2024.

Phases 2-4 will require $1.4B of additional capital expenditures. Per the investor presentation, the company plans to get them funded through a potential mix of debt / equity.

AST might also be able to get non-dilutive financing from their commercial partners [77] and subsidies from the US 5G Fund (see the next section). AST also expects to generate $28M net proceeds from its sale of NanoAvionics subsidiary [33].

Out of the additional $1.4B required, SpaceMobile already has $202M~ secured in the (possibly near) future from their warrants. They issued 17,600,000 warrants and can get $11.50 per warrant once they call them for redemption (1 warrant + $11.50 = 1 share of ASTS). The requirement is that the stock price "equals or exceeds $18.00 per share for any 20 trading days within a 30-trading day period". Once the requirement is met, the company can call the warrants for redemption and warrant holders will have 30 days to exercise their warrants [29].

The management originally expected to generate $181M in revenue in 2023 already, and over $1B in revenue in 2024. [27]. We expected these revenue streams will get delayed by 12-24 months, though.

It's fair to assume that SpaceMobile's goal is to roll out Phases 2, 3 and 4 as soon as possible, even at the cost of potential equity dilution (= issuing new shares to cover the cost). That said, we expect the company to do its best to keep the dilution as low as possible and to be opportunistic with getting non-dilutive financing (such as loans and subsidies), given the tremendous growth potential for shareholders. Striking a balance here is one of the key strategic challenges facing the management.

The company is already pursuing multiple non-dilutive financing options. If it manages to secure one or more of such funding sources, the market should interpret that favorably. Such an event would definitely be a potential stock price catalyst.

It's of interest that Deutsche Bank, a potential financing partner for ASTS, expected no dilution for ASTS in their initial research analyst's model [83].

On May 6, AST announced "the right, without obligation, to sell and issue up to $75 million of its Class A Common Stock over a period of 24 months to B. Riley at AST SpaceMobile's sole discretion" [91]. If AST takes advantage of this option, we assume it will around a key milestones (e.g. after a successful BW3 launch or test results).

If AST raises funding through equity and thus dilute existing shareholders, the market might interpret that negatively in the short-term. If that's what it takes to roll out the global coverage sooner, we are generally supportive of such a move. Insisting that the company intentionally slows the global coverage rollout just because it can't get non-dilutive funding would be the wrong strategic move.

Here's why -

The potential revenue from global coverage is tremendous, and will quickly pay for any financing costs incurred to generate it. The company originally projected over $1B EBITDA (gross profit) for 2024 already, and over $2.6B for 2025. [27]

For completeness sake, as a thought experiment, let's also consider the scenario where the company doesn't get any further financing at all, and instead fully boot-straps by re-investing the revenue it will generate from Phase 1. While theoretically possible, this would result in at least a several year delay of Phases 2 to 4 and would also possibly hinder the commercial agreements AST has in place and provide a window of opportunity for competitors to sweep in. This scenario is both extremely improbable and undesirable.

In any case, once the company starts generating revenue, we expect it will get a large portion (possibly most) of its financing through debt and other non-dilutive options. Share buy backs will be also on the table soon after the company has enough cash to finance all its satellites, effectively reversing any dilution incurred initially.

💡 **Some fun facts:** for each 100 ASTS shares you buy, you will own and operate 0.24 kg (0.54 lbs) of a satellite in space, 38 x 38 cm (= 14.96 x 14.96 inches) large. That's larger than an 12.9" iPad Pro, which costs $1,099.

If everything goes great, by 2030, your tiny piece of satellite could generate $2,694 in revenue per year. At 96%+ projected profit margins, most of it will be pure profit, too! This could be worth $51,400~ of market cap (or $514 per share).

Of course, you will also own a slice of all the patents, software, ground facilities, pay your slice of AST's employees' salaries, etc.

(Assumes 336 satellites deployed, each 900 sqm large and 1500 kg heavy, 210,800,000 ASTS shares outstanding, and other assumptions from our scenario in our valuation model [92]. It is possible that the final satellite size will be smaller due to engineering improvements [93]).

Satellite replacement costs

Given the expected satellite lifetime of 7 - 10 years, AST will have to start replacing satellites by as early as 2029. The estimated total cost to build and launch all of the satellites is $1.7B~. This estimate does not consider any cost savings from volume ramp up, falling launch prices, etc. The company originally expected 2029 EBITDA of $14B, so replacing the satellites should not be an issue.

5G Fund

In 2020, AST SpaceMobile participated in the public comment period regarding the FCC's 5G Fund for Rural America. Afterwards, FCC formally moved to allow mobile-satellite providers that meet specified performance standards and other requirements to apply to participate with its partners in the 5G Fund auction as a 5G broadband provider. The 5G Fund will distribute up to $9 billion for 5G wireless broadband connectivity in rural America to close the digital divide [94] - which also happens to be the major goal of AST SpaceMobile.

The U.S. Senate recently encouraged the FCC to address regulatory hurdles and promote innovative space-based cellular broadband communications to existing mobile devices [95].

AST is interested in the subsidies offered by 5G Fund and expects to be an active participant in the 5G Fund auctions [96,97]. Given the goals of the fund (getting a country-wide 5G coverage), SpaceMobile is well positioned and possibly the single "best shot" the fund has.

Abel Avellan is confident that SpaceMobile will get a portion of the fund. [77]

Any awards from the fund are a potential stock price catalyst, because they are essentially "free" cash to help the company grow, without any dilution of the shareholders.

Note: Non-dilutive government / subsidy financing is very common in the space industry, due to high upfront costs and national interests at play.

On August 10, 2022, the U.S. Federal Communications Commission rejected SpaceX's Starlink and LTD Broadband's applications for more than $2 billion in internet service subsidies [98]. It is notable that ASTS stock price reacted favourably to this news on large volume, suggesting that the market participants now expect ASTS to possibly receive more from the fund, or to have a higher chance of receiving a subsidy in the first place.

Conclusion

To conclude, based on the company estimates and plans, AST is fully funded for commercial launch with Phase 1 (equatorial coverage), and has several options to secure funding for Phases 2 to 4 (global coverage) to scale rapidly.

Chapter Four

Regulators

U.S. regulators

On April 13, 2020, AST&Science filed an application requesting access to the U.S. market for its constellation of low-Earth orbit satellites [99]. There is a wealth of information present within the application and subsequent comments from multiple parties.

First and foremost, it is against the Federal Communications Commission (FCC) regulation to transmit signal from space over terrestrial frequencies. In other words, given the contemporary regulation, no one can broadcast 3G, 4G or 5G signal from space.

AST SpaceMobile does not intend to apply for and own a terrestrial frequency license, but they still intend to transmit on these frequencies based on a license leased from their partners. Thus, AST requested waivers in order to be in compliance, and awaits FCC decision. Either a waiver or FCC rule-making is required for AST to access the U.S. market. An experimental license was already granted for the BlueWalker-3 test satellite, paving the way for future grants [100].

A number of third-parties submitted comments to the AST application, both to support and to deny the application [101,102].

SUPPORTERS INCLUDE:

- **Samsung NEXT**
  - *Investor in AST*
  - Support is obvious and biased
- **Rakuten Mobile Americas**
  - *Investor in AST*
  - Support is obvious and biased
- **U.S. Senator Ted Cruz**
  - Praises connectivity for hard-to-reach areas
  - AST can serve as a backup communication during national emergencies and natural disasters
- **U.S. Senator Benjamin Cardin**
  - Connectivity for hard-to-reach areas
  - 5G for U.S. citizens
- **U.S. Senator Chris Van Hollen**
  - 5G for rural and hard-to-reach areas
- **U.S. Representative Michael Conaway**
  - 5G for hard-to-reach areas, and in emergency situations
- **Midland Development Corporation**
  - *A development company run by the city of Midland, Texas*
  - AST headquarters and satellite manufacturing plant will be in Midland

- **Commercial Spaceflight Federation**
  - U.S. to lead the world with 5G thanks to AST
  - U.S. to stay ahead of China
  - 5G for rural areas

OPPOSITION INCLUDE:

- **CTIA**
  - *A trade association representing wireless industry, used to represent mostly cellular carriers, who likely still play a lead role in the association*
  - Use of terrestrial mobile spectrum for satellites is not permitted
  - Fear of signal interference
- **Verizon**
  - *A cellular carrier*
  - *Vocally negative towards AST*
  - Signal interference
  - Mobile services from space is against FCC rules, terrestrial spectrum cannot be used by satellites
  - LTE protocol is designed with latency requirements consistent with small area coverage within each cell, and not designed to operate with a space-based network latency
  - AST interference is unavoidable, because any cellular network needs to actively advertise (broadcast) its service availability to devices
  - Other interference and frequency use issues
  - AST not entitled to waivers
- **T-Mobile**
  - *A cellular carrier*
  - *Vocally negative towards AST*
  - SpaceMobile is "inconsistent" with public interest, convenience, and necessity
  - Numerous procedural deficiencies should lead to dismissal
  - Terrestrial mobile spectrum cannot be used by satellites
  - Rule-making by the full Commission necessary for request approval
  - Complains that AST is competing with T-Mobile in bringing 5G to rural areas
  - Signal interference issues
- **EchoStar / Hughes**
  - *A satellite communication and internet provider*
  - *The most active participant in the hearings, sent a total of 4 letters to reject AST*
  - *Very negative towards AST*
  - Various spectrum usage and licensing issues
  - AST must not offer mobile services through their satellites
  - Debris mitigation issues
  - However - as of August 2, 2022, it seems that EchoStar is no longer asking FCC to deny AST [103]
- **TechFreedom**
  - *A technology think-tank*
  - Concerned about space debris
- **NASA**
  - Concerned about space debris and satellite collisions [51]
- **National Radio Astronomy Observatory**
  - Radio frequency issues
  - Signal interference
  - Satellite body light reflection issues at night

The loudest opposition to the AST application comes from companies that are competitively threatened by AST technology.

NASA raised some concerns about possible satellite collisions and debris management [51]. As a result, AST reached out to NASA and shared confidential technical information regarding the SpaceMobile system with the agency [104]. Since then, NASA started collaborating with AST to facilitate safe operations in space [105,95]. While NASA still keeps its technical concerns in order to protect its assets in orbit - as it should - the issues raised by NASA to FCC need not preclude the issuance of the requested license [105].

EchoStar - a satellite communications company [106] - is directly threatened by AST SpaceMobile. They offer rural broadband connectivity via Satellite Services [107]. Their HughesNet is a satellite internet with millions of subscribers across North and South America [108]. EchoStar Mobile is a mobile satellite service in Europe [109]. HughesNet is likely going to be rendered obsolete by Starlink. EchoStar Mobile will be rendered completely obsolete by AST technology. EchoStar's current enterprise value is $2.43B compared to AST SpaceMobile's $1.4B.

T-Mobile - a global wireless carrier - amusingly claims that AST application should be rejected because T-Mobile is in the process of deploying their own 5G solution to cover rural areas, and AST solution would interfere with T-Mobile's plans to cover the market [110, page 12] T-Mobile, in their letters, is extremely dismissive to AST SpaceMobile's application, and an astute reader can infer their intention of blocking a competing technology company from entering the market.

Even though competitors claim potential issues with signal interference, AST is determined to only operate within the licensed frequency bands with their partnered MNOs. Aside from the regulatory existence of so called "guard bands", that exist to protect distinct frequency ranges, AST uses different interference management systems to ensure coexistance with other systems and channels [111]. A detailed technical explanation on this was provided to the FCC [66].

As a side-note, AST SpaceMobile technology would help FCC reach one of its main goals - bridging the Digital Divide - by bringing high-speed broadband internet to all Americans [112]. This gives AST a chance to receive funds from the $9B 5G Fund as discussed above.

AST also will need to secure FCC authority in the future for the ground segment of the SpaceMobile Service, namely two or three fixed earth stations located in the United States. [29]

Because the SpaceMobile Service will be using satellites transmitting on spectrum traditionally licensed to mobile network operators, AST also will need the approval of the Wireless Telecommunications Bureau, which handles terrestrial wireless licensing. AST intends to seek this approval in connection with a spectrum lease agreement with a terrestrial wireless carrier which AST has a cooperative arrangement. Certain wireless carriers have indicated that they intend to oppose this approval on procedural and substantive grounds. [29]

We believe that AST SpaceMobile should be allowed to operate outside of U.S. markets even before receiving FCC and other required U.S. approvals, as the Phase 1 targets equatorial markets, not the U.S. That said, given the support AST has received up to date, we believe its lobbying power should be sufficient to get the necessary U.S. approvals.

International regulators

As we have seen with the U.S. FCC application, local competitors are very much interested in AST not being granted access to the market. Hence, it is not a stretch to expect similar obstructions happening when AST inevitably applies for market access in other countries.

AST SpaceMobile Phase 1 focuses on 49 equatorial countries, of which vast majority are emerging markets – unfortunately some with the possible corruption and clientelism that comes with it. There is the risk of local established players using their connections and bribery to deny AST market access.

One potential political bear argument is that communications are a critical national infrastructure, and to some regimes and military juntas also a potential existential threat. During civil unrests or coups, less democratic governments typically resort to communication blackouts - such as the 2021 Myanmar coup [113]. India, a country of prime interest to AST [27], restricted internet use more than any other nation in 2020 [114]. Turning off terrestrial cells and cables is straightforward for a local government. The government or the military in some countries might be worried that they cannot easily turn off AST network when they need to. However, this doesn't make sense from a technical standpoint, as AST satellites need to talk to regional ground stations to relay the signal.

All that said, Vodafone, AST key partner, already successfully operates in many of these markets, and can thus lobby on behalf of AST to get the necessary approvals. We believe they will be able to get the job done, as AST already received licenses in several equatorial countries [41].

> 💡 **Did you know?**
> The World Bank estimates that every 10 percent increase in broadband penetration in developing countries raises GDP by 1.4 percent [115]. That's huge, and it's the main reason why governments in emerging markets would want to approve AST.

Vodafone will integrate SpaceMobile technology into the services provided by its Vodacom, Safaricom and Vodafone brands. Subject to regulatory approval in each market, these will include Congo; Ghana; Mozambique; Kenya; and Tanzania. AST SpaceMobile will also apply for regulatory approval to launch the service in India. [34]

The already approved permits include Nigeria [116] for the equatorial constellation. Nigeria is the most populous African country with a population of 207M and is the 27th largest economy in the world.

Vodafone received a license in Ethiopia [117,118]. Ethiopia is the second largest country in Africa with a population of 115M.

AST also already received a license from Papua New Guinea to operate its constellation. [29]

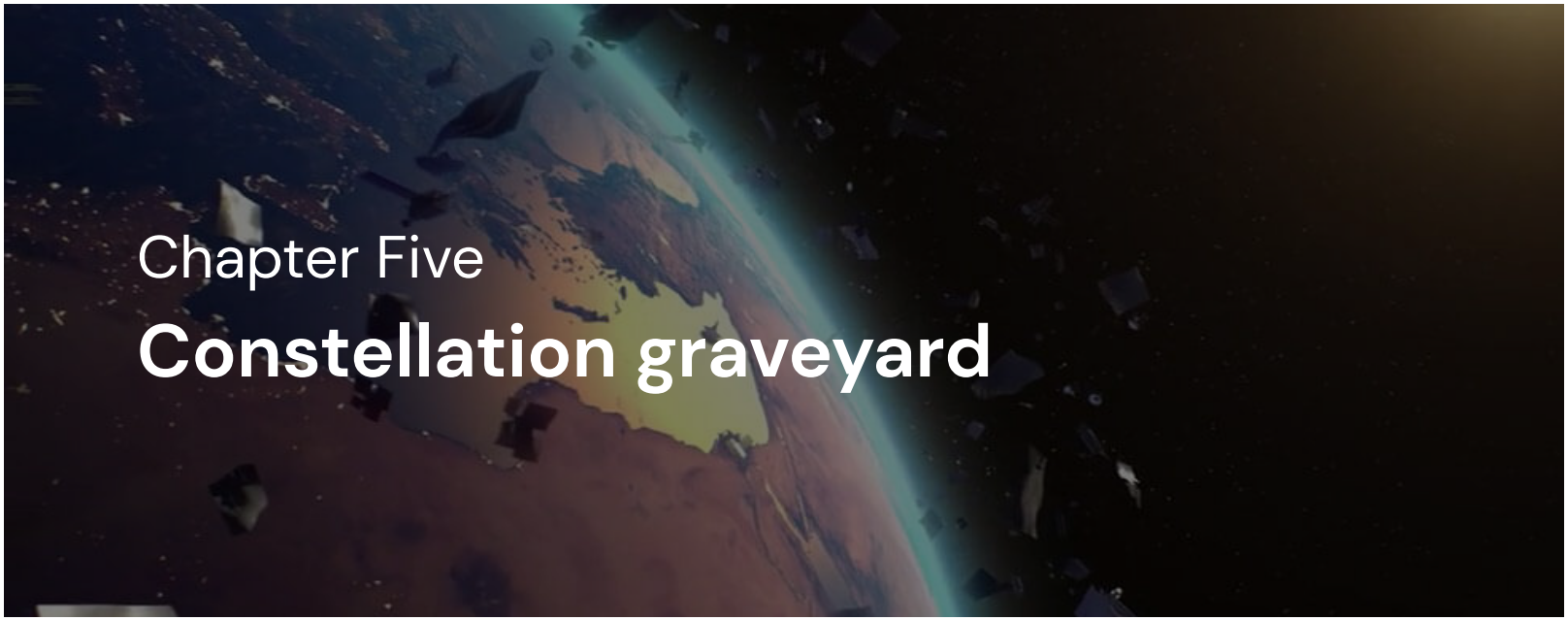
It is reassuring to see that AST keeps onboarding new commercial partners which can help with local licensing efforts. For instance, on July 6, 2021, AST signed a new Philippine partner (Smart Communications), to extend SpaceMobile cellular broadband connectivity to 70M~ subscribers in the Philippines mainland, islands and surrounding waters after the service is launched. [119]

What if AST is not allowed to operate in some countries?

It is possible that AST will not be allowed to operate in some countries. However, this shouldn't be a problem for AST commercially given its arguably conservative subscriber growth projection.

The equatorial region AST targets has a population of 1.6B [27]. AST partnered with Vodafone, and there are almost 271 million unconnected people in Vodafone's markets. This single partner can offer more unconnected people to AST in the region than AST expects to acquire until 2030 (180M equatorial subscribers).

Undoubtedly AST will need more partners to get to the 2030 numbers, but it looks like just Vodafone alone can carry AST - if need be - in the equatorial region for the critical years 2023 - 2024, as they launch their global satellite constellation. AST already has several other partners as well and keeps closing even more partners. In conclusion, international regulatory risks don't appear to be a major threat to AST growth.



Chapter Five

Constellation graveyard

Let's review certain failed constellation projects from the past and consider whether AST could face a similar fate.

LEO vs GEO satellites

Before we start, it's important to understand the difference between LEO (low-Earth orbit) and GEO (geostationary orbit) satellites, which differ significantly in their characteristics:

	LEO satellites	GEO satellites
Select projects	AST, StarLink, Iridium	GPS, LightSquared, TerreStar
Distance to Earth	Close (160 to 2,000 km)	Far (35,000 km)
Hardware cost	Low	High
Launch cost	Low	High
Size	Tiny to large	Medium to large
Constellation size	50 to 1000 or more	3 or more
Space debris risk	High	Low
Satellite movement	Orbits Earth every 90 minutes	Stationary against the Earth
Signal quality	High (close to Earth)	Low (potential persistent blockages)
Latency	20 - 40ms	500ms minimum [120]
Bandwidth	High throughput	Lower throughput
Ground antenna	Follows the closest satellite	Facing a fixed point in the sky
Satellite lifespan	5 to 10 years (atmospheric drag)	8 to 30 years

The key difference is latency. Even at the speed of light, GEO satellite can't perform better than 500ms due to laws of physics, which makes calls very impractical (people talking over each other due to a long delay), and most gaming downright impossible. However, it is good enough for broadcasting (TV, radio, etc.).

Source [121].

Costs now and decade ago

A decade ago, a lot of the technology required for satellites was more expensive [122].

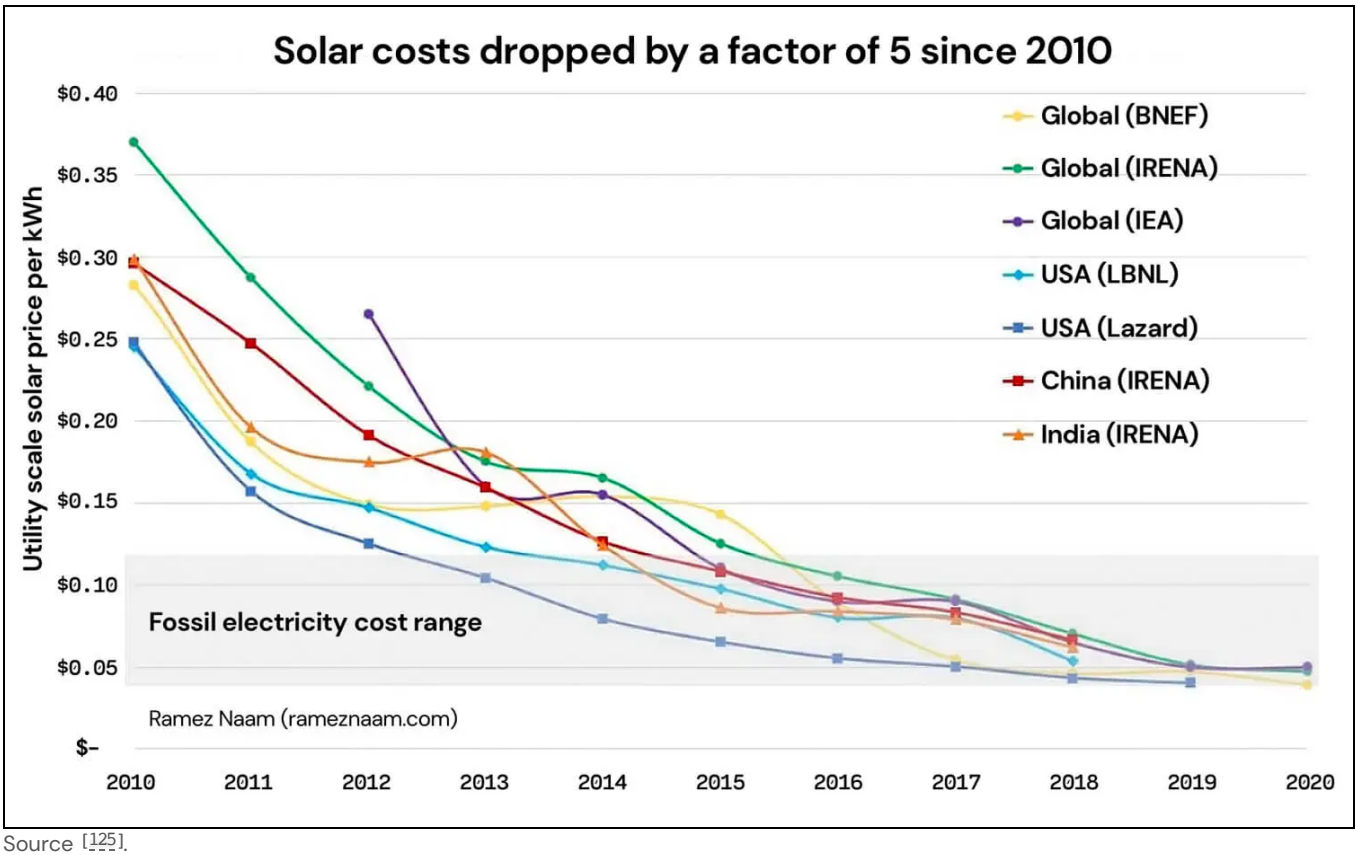
Technology is inherently deeply deflationary (Moore's law [123] and Wright's law - experience curve effects [124]).

For example, here's the cost of solar projects across the world. Photovoltaic panels are an important satellite component.

Launch costs have dropped by as much as 90% since 2008 [83].

Another challenge facing satellite companies are frequency use rights, which can cost billions in upfront costs. AST doesn't have to pay a single penny for the spectrum (frequencies) it will use, because it will lease them essentially for free from its partners under a revenue share model.

Let's take a short walk through a satellite projects graveyard!



Source [125].

R.I.P. LightSquared

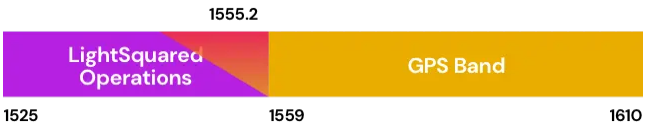
- *Time of death:* 2012
- *Cause of death:* GPS interference due poor choice of frequency spectrum

LightSquared was a company with the goal of building a wholesale nationwide LTE network that enterprise customers could then use to provide their own wireless services [126,127].

LightSquared's SkyTerra 1 geo-stationary satellite. Source [128], credit: Boeing photo

LightSquared's satellite was a geo-stationary (GEO) one, not low-earth orbit (LEO) like AST SpaceMobile.

LightSquared used frequency bands of 1525-1559 MHz and 1626.5-1660.5 MHz, which are close to the 1559-1610 MHz band that GPS operates in. [129] In particular, these frequencies are right next to the L1 primary GPS frequency that is the most important band for navigation purposes, such as in aviation. [130,127]



Frequency band graphics. Numbers are MHz. Source [131]

LightSquared's infrastructure was to contain a ground-based 4G-LTE network as well to provide connectivity more efficiently in population centres. And this network would use the same frequencies as the satellite.

The FCC initially approved LightSquared's usage of these frequencies even though they had originally been reserved for satellite services alone. However, testing showed that LightSquared's ground-based transmissions overpowered the faint GPS L1 signals from space [127]. This interference would have profound effects on aviation [132] and dramatically increase the risk of mid-air collisions and controlled flight into terrain.

As a result, there was a vocal opposition to the FCC approval, including from aviation associations, pilots, manufacturers, airlines and helicopter operators. Nine U.S. government agencies also went on record as opposed to the approval.

NTIA, the federal agency that coordinates spectrum uses for the military and other federal government entities, concluded that there is no practical way to mitigate potential interference [133]. As a result, the FCC indefinitely suspended LightSquared's terrestrial spectrum authorization, pushing it into bankruptcy in May 2012 [134].

LightSquared was doomed by its choice of frequency band. AST satellites, on the other hand, will not operate anywhere close to the exotic (for its purpose) spectrum chosen by LightSquared, therefore, there are no GPS interference concerns.

AST requires frequencies for two purposes: communication between satellites and customers' phones, on the one hand, and communication between satellites and its own ground stations (gateway links) on the other.

For gateway links, AST's amended application for frequencies to the FCC asks for so-called V-band frequencies. [135] Boeing, SpaceX, OneWeb, Telesat, O3b Networks and Theia Holdings have all told the FCC they have plans to launch constellations of V-band satellites too [136]. Furthermore, the FCC

has already approved SpaceX's Starlink to operate using V-band frequencies. [137] In light of this, we see no reason why AST should be denied permission to do the same.

Therefore, it is the communication between SpaceMobile satellites and user cellphones that poses a greater concern, as that is to happen on regular terrestrial mobile network frequencies. SpaceMobile will seek permission for this in a separate process, and this will be the key regulatory hurdle to overcome. However, SpaceMobile is well aware of the issue and if their technological claims hold true, the relevant regulatory approvals should be granted.

In LightSquared's case, the opposition to their frequency usage permissions came from an entirely different industry that found its operations interfered with, but had no interest in obstructing LightSquared as such. It is a good sign that in SpaceMobile's case, the situation is very different: the opposition to SpaceMobile's existing FCC application is composed almost entirely of commercial operators who are competitively challenged by SpaceMobile. It stands to reason that they may be motivated by other factors than genuine technical concerns.

Furthermore, among AST' commercial partners we find established companies with vast technical expertise and accumulated domain experience (incl. Vodafone, AT&T, and Samsung), many of whom are also investors in AST - not least among them American Tower, the largest cellphone tower company in the world. They have performed due diligence on SpaceMobile, and we can assume that they would not have partnered with or invested in the company if they did not believe that AST can successfully operate the satellites without interfering with ground frequencies.

They would know - they are the experts, and in this context, the smart money.

R.I.P. TerreStar

- *Time of death:* 2010
- *Cause of death:* bankruptcy
- *Contributing factors:* required special satellite phone which made distribution difficult

Note: TerreStar is commonly mis-spelled as TerraStar.

TerreStar was supposed to provide a fully integrated satellite and terrestrial mobile network. It used commercial chipset technologies from Qualcomm and Infineon to embed satellite communications capabilities into dedicated smartphones.

Their Genus phone resembled a Blackberry design with a keyboard below the screen and used an internal antenna for terrestrial communications, but required a rather large external antenna for satellite communications. [138]

Genus $1299 phone without the external antenna. Source: Amazon [139].

The external antenna; apparently sold separately for $265. Source: BarCodeGiant [140]

Needless to say, this does not make for an inherently attractive phone, especially considering that iPhone was introduced already 3 years before Genus!

In addition, it took the phone up to 5 minutes to connect to a satellite, and it did not always succeed as one reviewer points out:

The reviewer in the video concludes:

"I don't see this thing going mainstream anytime soon, and people are certainly not going to be updating their Facebook status on it."

TerreStar's satellites themselves were huge (6,900 kg; the world's largest at the time) and extremely expensive (upwards of $220M per satellite). [141] While no doubt an engineering marvel, they were designed for GEO with all its signal propagation disadvantages (worse latency, lower bandwidth, etc.).

The company accumulated over $1B in debt and was ultimately forced to file for Chapter 11 bankruptcy in 2010 [142].

💡 Did you know?

Former TerreStar veteran engineer David Marshack (now COO of RKF Engineering [79]) performed technological due diligence on AST technology on behalf of investors and while he prudently "hates to say it on a call with so many people", he "doesn't see any major technological risks" [143].

TerreStar-1 satellite. Source: ArianeSpace [144]

It is not difficult to see that AST and TerreStar are worlds apart:

- SpaceMobile will work with regular existing phones without special hardware; TerreStar failed to sell its special Genus satellite phones
- In fact, SpaceMobile already has global distribution secured through its mobile network operator partners such as Vodafone
- AST will operate a LEO constellation with better connectivity and latency than TerreStar's GEO satellites
- AST has $0 debt and some $420M in cash. It is fully funded for commercial launch. TerreStar was over $1B in debt.

R.I.P. Orbcomm

- *Time of death:* 2000
- *Cause of death:* Ran out of funding
- *Contributing factors:* high customer acquisition costs (CAC)

Orbcomm was a LEO operator that went bankrupt in 2000 [145]. It provided low data rate messaging services for industrial and government clients, who needed special hardware to use the service.

The key differences with AST are:

- It targeted a completely different market (industrial enterprise clients) from AST (smartphone users) with high customer acquisition cost
- It was more than two decades earlier, which means much higher launch and tech costs and significantly less advanced technologies in general. The communication and IoT market was radically smaller back then as well.
- It required special hardware - this is usually the killing blow from a distribution standpoint

As you can see, today's AST opportunity is not even remotely close to Orbcomm back in its day. Again, AST's mass distribution is solved and its marginal customer acquisition costs will be roughly $0 thanks to its partners.

R.I.P. Iridium, ICO Global, Globalstar and others

In August 1999, Iridium filed for bankruptcy. The event was dubbed as one of the "The 10 Biggest Tech Failures of the Decade" by the Time magazine [146]

Shortly after, another satellite operator, ICO Global Communications, went into bankruptcy [147].

And in 2003, Globalstar went bankrupt [148] as well.

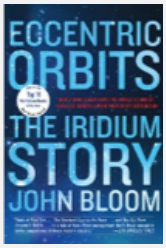
There was a wave of satellite operator bankruptcies in late 1999 and early 2000's. As none of these companies were profitable and investors saw one after the other of them fold, investors naturally became less and less willing to invest in the remaining ones, making capital more expensive for them, which in turn made it even more difficult for these companies to move towards profitability. Eventually, more and more of them would be caught in this death spiral.

All of these companies couldn't reach profitability due to high customer acquisition cost and small (niche) addressable markets. The subscriber growth was lower than the companies needed in order to survive. Customers were not keen to purchase expensive and unreliable hardware.

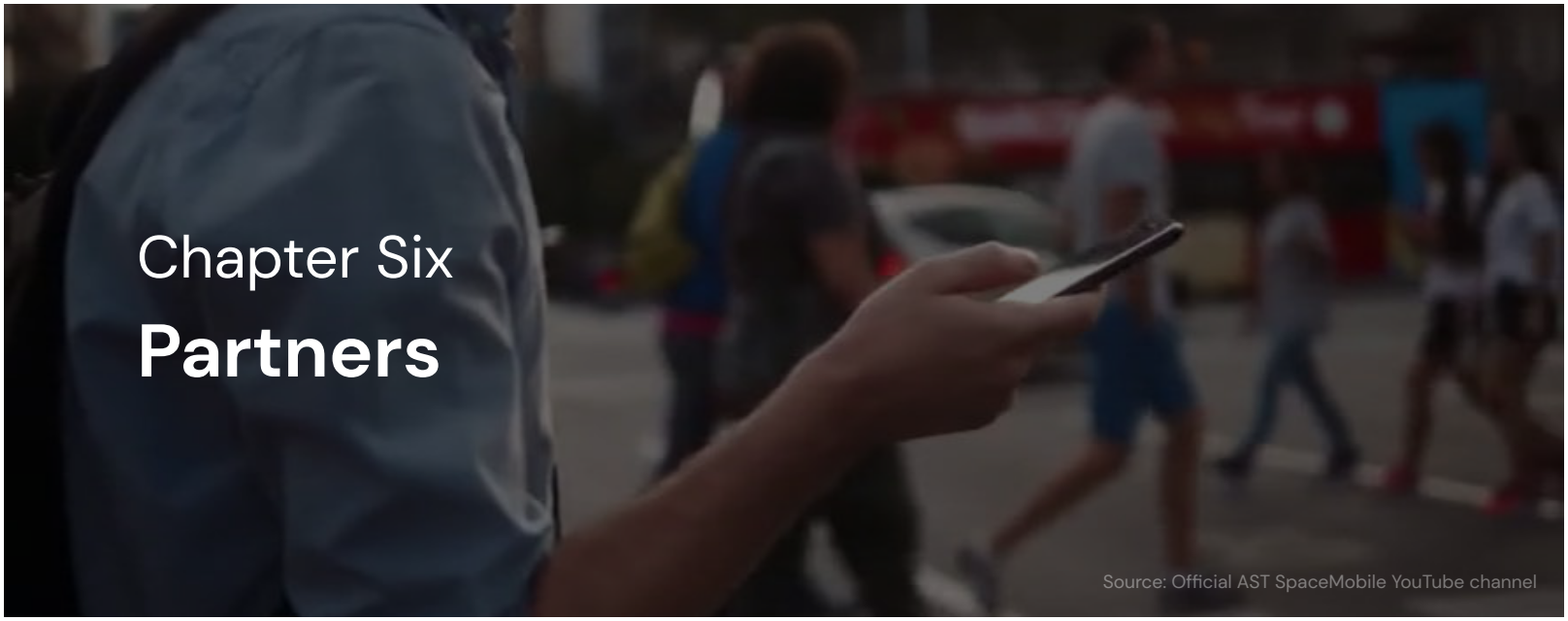
In most cases, they also had to pay up to a billion dollars or even more just for the right to use specific frequency spectrums.

Today, two decades later, AST gets to learn from their failures and make another attempt with zero user acquisition costs, zero spectrum license cost, 90% cheaper launches, cheaper and better hardware and more advanced software... all while targeting one of the largest markets on Earth – smartphone owners.

The Iridium story is full of drama and unexpected twists. You can learn more about it in the book the book "Eccentric Orbits" [149]. The book also tells the just as fascinating history of satellites in general.



⚠ Today, Iridium is a publicly traded company ($IRDM). It still requires special satellite phones. While it seems to be able to keep itself financially afloat, its mobile phone services are in prime danger of getting completely disrupted by AST.



Source: Official AST SpaceMobile YouTube channel

Chapter Six
Partners

Let's take a quick inventory of some of the commercial partnerships AST has established up to date.

Vodafone

Vodafone has agreed to a strategic partnership with AST & Science in addition to its investment in the company [150]. The global carrier will contribute technical, operational and regulatory expertise in support of SpaceMobile.

Vodafone has presence in 65 countries, 625 million+ mobile customers and 94 million+ business IoT connections [151].

"At Vodafone we want to ensure everyone benefits from a digital society – that no-one is left behind," Nick Read, CEO, Vodafone Group, said. "We believe SpaceMobile is uniquely placed to provide universal mobile coverage, further enhancing our leading network across Europe and Africa – especially in rural areas and during a natural or humanitarian disaster – for customers on their existing smartphones." [152]

AST and Vodafone signed an agreement with mutual exclusivity. Vodafone will make SpaceMobile Service available to all of its customers and promote the service for five years after the launch of commercial service based on SpaceMobile's Phase 3.

In return, SpaceMobile will provide for exclusivity, making its services available only through Vodafone and no other network operator in the relevant markets, and furthermore share 50% of its revenue with Vodafone. [29]

American Tower

AST will use American Tower facilities for AST's terrestrial gateways in certain markets. The term of the operational agreement between AST and American Tower is five years after the initial launch of commercial mobile services by AST [29].

In markets in which Vodafone operates, AST will work with Vodafone and American Tower to evaluate and plan deployments [29].

In markets where Vodafone does not operate, AST and American Tower may enter into an agreement for American Tower to manage the operation of the AST-deployed gateway [29].

Rakuten

AST entered into a commercial agreement with Rakuten, for AST's investments in building network capabilities in Japan compatible with the mobile network of Rakuten and its affiliates [29].

Rakuten will receive unlimited, exclusive rights and usage capacity in Japan in exchange for a $500,000 annual maintenance fee payable to AST [29].

We speculate the reason for the seemingly favorable terms with Rakuten is that Rakuten Mobile is providing AST with Altiostar software [153].

AT&T

AST and AT&T entered into a binding memorandum of understanding to collaborate on the design, implementation, and launch of a space-mobile communications ecosystem [29].

Under the agreement, AST will design, develop, manufacture, launch, manage, and maintain a constellation of 168 satellite to enable continuous satellite-based mobile wireless service across the AT&T coverage area comprised of the continental United States, Hawaii, Puerto Rico, Mexico, and adjacent international waters.

AT&T will provide technical and commercial resources to work with AST to develop service and commercial offerings for the coverage area. AT&T will also give permission to the FCC to authorize AST to test the BW3 satellite under an experimental license on certain mobile bands. [29]

Other partners: Telefonica, Safran, NEC, Samsung, Orange, Nokia, TSMC and more

AST has also entered into a memorandum of understanding with other mobile network operators (MNO), including Telefonica, Indosat Ooredoo, Millicom International Cellular, Telecom Argentina, Telstra, Liberty Latin America Ltd., Smart Communications [119], Orange [154] and others. These memorandums of understanding each generally provide for a non-exclusive arrangement whereby AST and the MNO collaborate on technology development and/or implementation with respect to the SpaceMobile Service. [29]

AST also has numerous equipment supplier partners: Nokia [14,155], TSMC [15], Safran, NEC, Dialog Semiconductors, the until recently 51%-owned subsidiary satellite maker NanoAvionics, and possibly others.

It's also worth mentioning that AST investors include Samsung's fund Samsung NEXT, who sent a letter to FCC in support of SpaceMobile [156].

Funds and indices

Technological advancements brought us on the brink of a new space race. Only this time, space is no longer an exclusive domain of national space agencies. The spotlight is on commercial applications coming from an ever-growing number of public and private companies, making "new space" one of the hottest investment sectors in 2020s'.

The space industry inflows are growing rapidly. Quilty Analytics recorded $5.7 billion in investments for the first quarter of 2021, a 356% increase from $1.2 billion in the same period last year [157].

A number of asset managers already jumped in, securing their place early-on.

ARK Invest is one of such firms, focusing on disruptive innovation. Lead by the now-superstar portfolio manager Catherine D. Wood, best known for being one of the earliest bulls on Tesla generating impressive returns for ARK's investors. In 2020 ARK Invest's flagship fund ARKK became the largest actively managed ETF after delivering a 170% return.

ARK defines disruptive innovation as "the introduction of a technologically enabled new product

or service that potentially changes the way the world works".

Based on this definition, SpaceMobile is a potentially a good match for ARKK [158].

In March 2021, ARK Invest launched a new Space exploration and innovation ETF (ARKX). The fund focuses on companies that are leading, enabling, or benefitting from technologically enabled products and/or services that occur beyond the surface of the Earth [159].

SpaceMobile fits into that description for ARKX. [160].

Launches of new space focused funds are becoming a common occurrence.

Some of the smaller, more agile funds already include AST SpaceMobile.

Seraphim Space fund planning their IPO on the London Stock Exchange lists AST SpaceMobile as part of their portfolio [161].

As of 8/4/2022 Procure Space ETF (UFO) held 109,165k ASTS shares worth $0.8M~, with a 1.10% weight in the fund. [162].

Increasing fund flows into the space sector and technological innovation / disruption themes can potentially provide a significant price boost to ASTS stock in the future.

As of 8/4/2022, ARK ETFs invested the following amounts into Iridium, an American hand-held satellite phone company [163,164]:

Fund	Investment
ARKK (Innovation)	$0M (down from $320M)
ARKQ (Tutonomous Tech & Robotics)	$72.5M
ARKX (Space Exploration)	$24.6M

(Side note: Iridium works only with special expensive satellite phones, unlike SpaceMobile, which will work with regular existing phones. You can learn more about Iridium in the Competitors section.)

ARK ETFs historical total investment of about $500M in 2021 to Iridium would represent a very large percentage of ASTS's current marketcap.

Given the current SpaceMobile market valuation, even a small allocation of ARK funds into AST SpaceMobile should have a substantial effect on the price.

Not to mention that ARK purchases are reported daily by the firm and, given its popularity, influence the markets, as they represent a stamp of approval by ARKs analyst. Numerous followers copy-trade ARK's moves.

We believe the reason ARK has not invested in AST SpaceMobile so far is because they do not enter positions with binary outcomes, as mentioned by Cathie B. Wood in a CBOE webcast when talking about investments into psychedelic therapeutics clinical-stage companies, which are also binary bets [165].

It is likely ARK Invest will re-consider buying ASTS after further tests are done following launch of the BlueWalker-3 satellite (expected mid-September 2022) or the company generates first revenue (expected 2023 or 2024), at the latest.

AST SpaceMobile can be considered a binary investment - if the constellation works as expected, AST is well positioned to be very successful. But if AST runs into unforeseen technological, regulatory or other issues, they could go bankrupt in the worst-case scenario.

There are also passive funds that might end up including ASTS.

nce ASTS gets added to an index, funds following the index will need to buy shares. These inclusions would further grow the stock price and help reduce volatility. .

Unfortunately, according to a SEC filing [166], AST SpaceMobile is currently not eligible for Russell 2000 [167] inclusion, due to its share composition.

Other larger indices, such as S&P 500, should include AST at various weightings after AST achieves reliable positive earnings following its Phase 1 (equatorial) constellation deployment.

NanoAvionics

AST SpaceMobile owned 51% of NanoAvionics since March 2018, purchased for $3.5 million [27,168]. It was a successful investment for AST, as its currently selling NanoAvionics for $28M in net proceeds to AST [33].

NanoAvionics is a satellite manufacturer with around 80 employees, founded in Lithuania in 2014. They have offices in Lithuania, UK, and USA.

NanoAvionics builds small (6-25 kg), robust, agile, and fast-to-build (~2 months) satellites. The satellites are around 100 times smaller than Airbus or Boeing satellites, but the usual idea is to launch hundreds of them - in order to cover the entire planet in a mega constellation. To be specific, they build satellite vehicles, while the payload (the function, such as telecommunication, observatory, scientific research, etc.) is supplied by the customer. They outsource some of the components, such as rocket boosters and solar cells, and then assemble and integrate the components into the satellite frame.

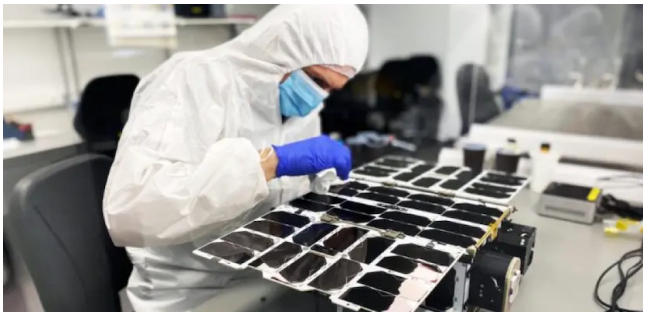


Image by NanoAvionics [169]

The satellites are made of modular units called cubes, which allows scaling the satellites to different sizes while using the same underlying technology. For example, NanoAvionics offers satellites made of 6, 12 or 16 units.

One 16-unit satellite bus (excluding the payload) costs several hundred thousand EUR. Currently advertised prices for payload delivery via SpaceX Falcon is $5k per kg, so launch of the satellite would cost around $100k.

70% of their customers are telecommunication-related, 20% Earth observation customers, and 10% are in-orbit demonstrations (technological or scientific missions). Most of their missions are for low-earth orbit up to 800km, although in the past they were in talks about lunar flyby and deep space missions.

The general contemporary trend with satellites is making them smaller while increasing their functionality - and NanoAvionics specializes in this approach. It takes around 12 months from signing the contract to having the NanoAvionics satellite in space (need to acquire communication frequency licenses, integrate and test the payload, set up ground stations, booking the launch, etc.), all of which they can help their customers to do. [90,170,171]

90 percent of their contracts are for full missions that include satellite bus manufacturing, payload integration, launch, operations (recurring revenue), and other services [172].

They also have a substantial backlog of satellite projects to work on [173]. Their existing paying customers include: NASA, Thales, The European Space Agency, The Royal Netherlands Aerospace Centre, Massachusetts Institute of Technology, SEN Space TV, Lacuna Space, HyperActive consortium [174].

NanoAvionics revenue in 2019 was $0.8M, and $3.3M in 2020 [29], a YoY increase of 300%.

NanoAvionics helped AST build its BlueWalker-1 and 2 satellites, but its future role in the manufacturing of further AST satellites is uncertain. AST is working with NEC and Safran to manufacture their satellites, and also does a lot of the manufacturing in-house.

While the NanoAvionics stake owned by AST might have some strategic benefits (it's helpful to have manufacturing expertise in-house and to keep tabs on the industry), AST was exploring the possibility of reducing its ownership interest in NanoAvionics already in January 2021 [29] and recently succeeded in the sale [33].

Chapter Seven

Competition

General comment on AST competitors

Telecommunications market is enormous ($1T) and AST plans to capture just 1%~ of it by 2027. [27]

There are currently no true direct competitors in commercial service at this time, and the market is large enough to support several competing companies even if that wasn't the case. However, AST is the clear leader today (inc. commercial partnerships, funding, technology and patents).

Lynk is possibly the most similar company to AST because it also targets the cellular market. It seems to be behind AST by several years in terms of development, though, and received much less funding to date.

The most recent (announced on August 25, 2022) new competitor is T-Mobile in Starlink partnership [3], which will initially target low-data services, such as emergency messaging and calls. They aim for commercial service by late 2023, same as AST.

One common misconception is thinking that Starlink's existing flagship internet broadband service is already directly competing with AST. However, Starlink currently doesn't provide mobile phone services – its customers need a satellite dish and other hardware in their homes.

It is true that Starlink's + T-Mobile's upcoming direct-to-mobile service will compete with AST. We will talk about this in detail later in the Starlink section.

Here's a useful comparison of some LEO mega constellation projects (showing only the existing Starlink's broadband offering and not yet reflecting the newly announced T-Mobile service) [175]:

	AST SpaceMobile ($ASTS)	Starlink by SpaceX (Private)	OneWeb (Private)	Kuiper by Amazon ($AMZN)	LightSpeed (Private)
Target Markets	**Cellular Broadband**	**Residential Broadband, Mobility**	**Residential Broadband, Mobility, IOT, Backhaul, PNT**	**Residential Broadband, Mobility, IOT, Backhaul**	**Mobility, IOT, Backhaul**
User Hardware	**Existing Cell Phone**	**Antenna Terminal**	**Antenna Terminal**	**Antenna Terminal**	**Antenna Terminal**
Hardware Cost to User	**$0**	**$599**	**$200-$300**	**No Estimates**	**No Estimates**
Speed / Latency	>35 Mbps / <30 ms	~100 Mbps / <30 ms (200 Mbps peak)	~200 Mbps / <32 ms (400 Mbps peak)	"up to 400 Mbps" / Likely ~30 ms	"up to 7.5 Gbps / Likely ~30 ms
Primary Go-to-Market Strategy	Super Wholesaler to Telcos	Direct to Consumer	Direct to Consumer	Direct to Consumer	Direct to Enterprise
Distribution Partners	Vodafone, AT&T, Rakuten, Telefonica, Telestra, Indosat, Telecom Argentina, Tigo, Liberty LatAm	NA	AST Group, Hughes, TrustComm, Pacific Dataport	NA	NA
Spectrum for User Communications Propagation = Lower is Better Throughput = Higher is Better	Wireless Carrier Low Band (700-950 MHz) Midband (1.7-2.2 GHz) C Band (3.7-4.2 GHz)	V and Ku Bands (10.7-12.7 GHz) (37.5-42.5 GHz)	Ku and Ka Bands (20-40 GHz)	Ka Band (17.7-18.6 Ghz) (18.8-20.2 Ghz) (27.5-30.0 Ghz)	Telesat "Priority" Ka Band (26-40 GHz)
Satellites Planned	340	12,000	648	3,236	298
Capex	$3.3B	>10B	<6B	$10B	$5B
Commercial Service (Est)	2023	2021	2022	Before 2025	2023
Complete Launch Date	2028	2029	2022	2029	2023
Main Investors	Rakuten, Vodafone, American Tower, Samsung, Cicernos	SpaceX	Eutelsat, Bharti, UK, Softbank, Hughes	Amazon	Telesat
Design / Manufacturing Partners	Nokia, TSMC, NEC, Safran, Dialog Semiconductor, NanoAvionics	Starlink	Airbus	NA	Thales Alenia

Note: AST Group, a distribution partner of OneWeb, is unrelated to AST Spacemobile

Let's take a look at some of the potential competitors, starting with Lynk.

Lynk

Lynk (previously known as UbiquitiLink) is a company based in Virginia, attempting to do a similar thing as AST SpaceMobile - deploy a constellation of low-Earth orbit satellite "cell towers" in space, and provide 100% broadband connectivity across the entire planet to unmodified standard cell phones everyone already has in their pockets [19,71].

Lynk's constellation is supposed to be made up of nano-satellites weighing 25 kg orbiting at about 500 km altitude with narrow high gain antennas [71,176,177]. This is a very different approach than AST has with its large satellites [178].

If you recall, Verizon critiqued AST SpaceMobile in the FCC comments that the cellular protocol is not designed to be broadcasted from space, and has latency constraints in line with typical distance of 35 km from the base station. Lynk claims they have solved this problem and patented the technology [176]. SpaceMobile have tested a similar technology via their BlueWalker-1 test satellite. Furthermore, Lynk also claims they found a way to broadcast mobile spectrum from the satellite to a phone without causing interference to phone users [176,179] - another common complaint against AST SpaceMobile from the FCC comments. This gives us additional confidence that there is a technological solution available to these FCC complaints.

On February 24, 2021, Lynk successfully tested their technology by sending a text message from a satellite to a standard Android-powered GSM mobile phone on the ground [71,72]. The transmission was done

from a nano satellite launched from the ISS [72]. This tested the downlink (satellite to phone) connection, and the company said they can achieve the uplink (phone to satellite) connection as well (which is the hardest part [180]), although they did not share how far they are with that [176]. The test used GSM (2G), and the company is already working on LTE, with plans for 5G in the future [176]. Their technology also requires the phone to be outdoors, but indoor functionality is in their plans for the future [176].

Lynk speed over LTE is currently 180 kbps [179]. But 10s of Mbps is supposedly achievable eventually in the future [181], although that will likely require a major technological redesign. As a result, Lynk's stated near-term goal is to provide text messaging services [182], and allow users to have an occasional call [183]. They consider text messaging the killer feature and something people are the most willing to pay for [184], and it's also the feature that's the easiest to achieve [181]. They will expand the features and performance as they launch more satellites [181]. Lynk plans to support GSM and LTE IoT protocols, including NB-IoT [152].

Lynk does not have any U.S. mobile network partner yet, although they are in talks with all of them [176]. They collaborate with 30 mobile network operators globally [182,185]. Some notable test partners are Vodafone and Telefonica [182,183,186]. Vodafone is also a key partner to AST SpaceMobile.

As of July 8, 2022, Lynk has launched 5 test satellites to date which have been de-orbited or shut down since then, and is operating a single commercial satellite "Lynk Tower 1". [187,188]

Lynk co-founder and CEO is Charles Miller, a former NASA senior advisor for commercial space and a co-founder of Nanoracks (in-space services company commercializing ISS) [182,181], said Lynk is working to deploy its first commercial product [71]. They apparently planned to bring their solution to the market by launching a few dozen satellites by the end of 2020 in order to begin providing basic emergency services (such as alerts displayed on people's phones in case of incoming hurricanes or tsunamis) [71,72], although there have not been any news on their progress since.

A functional satellite network is planned for as soon as 2022, but it won't provide a global 24h/day coverage - instead the network will provide text messaging coverage for around 5 minutes every hour or so [180,182]. This however will improve as they launch more satellites. Full global 24h/day coverage is planned for 2023 [189]. The company is capable of providing commercial services with just a few dozen satellites, but to provide 4G coverage, Lynk will need to launch thousands of its satellites [177].

Lynk needs to launch around 24 of their nanosatellites to start offering SMS text messaging and IoT. Realtime coverage for voice and data would require around 1000 satellites. The bandwidth available per satellite makes data rates of more than a few hundred kbps for more than a few users impractical. [152]

Lynk's business model is similar to that of AST SpaceMobile - act as a worldwide roaming operator that mobile network operators will pay to access (revenue share) [190,181]. The mobile network operators will then use the service and offer it to their customers for a price, or as part of existing packages [191,177]. However, emergency messaging services will be offered for free - they do not want to profit off saving people's lives [182,190].

Lynk raised seed and Series A funding. Lynk is backed by Revolution investment firm's Rise of the Rest Seed Fund, Blazar Ventures, RRE Ventures, Avonlea Capital, and One Way Ventures [71,182]. Steve Case, former CEO of AOL, also invested in Lynk [182]. They have raised about $20M so far in several funding rounds. The CEO Charles Miller said Lynk has a deep amount of interest among their existing investors if they need more funding (and even get approached by new investors) [181].

Eventually, Lynk plans to mass-produce their nano satellites in-house [181]. As they develop their service, the satellites will have bigger antennas and grow in size.

Given that SpaceMobile intends to enter into exclusive revenue sharing agreements with a mobile network operator in each market, Lynk will offer their services to another operator in that market. Most countries have more than a single operator, so this is not exactly a winner-take-all situation. According to Lynk's, there's about 800 mobile network operators globally [192].

SpaceMobile seems to have a technological advantage and better approach, since they will offer much higher data speeds, bandwidth and even indoor coverage.

SpaceMobile also has much more funding than Lynk ($551M~ compared to $25M) – trying to achieve what AST is doing on 1/20 of the budget is difficult. Trying to catch up, on July 6, 2022, Lynk announced further capital raise of an undisclosed amount from Virginia Venture Partners [193].

While we wish Lynk every success, we do not see them as a threat to SpaceMobile.

Sateliot

The Spanish company Sateliot plans to launch a constellation of low-Earth orbit nano-satellites - acting as mobile cell towers - to provide global and continuous 5G (NB-IoT) connectivity to all elements that make up the universe of the Internet of Things (IoT) [194].

The company does not seem to plan on supporting mobile phones.

Similar to AST SpaceMobile and Lynk, Sateliot's "cell towers in space" will offer connectivity through a roaming service (wholesale agreement) to existing mobile network operators [195,196]. The company will invest 20 million euros in the coming years to develop the technology [195].

Sateliot plans to start deploying its constellation of up to 100 nano-satellites in 2021 [195]. The satellites will have the size of a microwave oven, weight around 12 kg, and will be located at low altitude - barely 500 km from Earth [197]. The Sateliot service is planned to be operational in 2022 [196,198].

Sateliot has the backing of the European Space Agency (ESA), with whom it has signed an MOU to advise on the development and implementation of the project. It is working with this agency on the demonstration of the service [197]. The company has also reached an agreement with the British operator Open Cosmos to build and operate this nanosat constellation. In fact, the firm is already working on the manufacturing, mission management and launch of the first three devices [196].

In addition, Alén Space, the Spanish manufacturer of aerospace projects, will be responsible for the design of the payload of at least the first nanosatellites that will be used for the development and research of new protocols and modulations that will make it possible to connect objects anywhere [196].

Because Sateliot is targeting a different market – IoT, it is not a direct competitor. However, we think it's interesting to track its progress.

HAPSMobile

HAPSMobile, a subsidiary of SoftBank Corp., is developing a high-altitude unmanned aircraft system that continuously flies in the stratosphere as a ground station, delivering connectivity directly to mobile devices [199,200]. This technology can be achieved by advances in the development of solar power generation and storage battery systems, as well through enhancements of telecommunications technology [200].

The planes have a futuristic design:

Source: https://en.wikipedia.org/wiki/HAPSMobile

HAPSMobile aims to launch commercial services by early 2024, with tests of its aircraft in SoftBank's home market, Japan, planned to be conducted by the end of 2021 as it moves to use the system as a substitute for ground-based systems during emergencies and natural disasters. The goal of commencing mass production is set in 2027. [199] Further tests of various aspects of their technology are ongoing [201].

The company targets pricing of $1 per month for users in unconnected areas [199].

AST SpaceMobile plans to have a full satellite constellation deployed by the end of 2024 (our estimate is 2025), providing not only global coverage, but faster 5G speeds as well.

Apple

Apple supposedly has a team of engineers working on satellite technology to beam data to devices, although not much is known as to what they are trying to achieve, as Apple is notoriously secretive.

Perhaps they could beam internet services directly to iPhones and bypass traditional wireless networks. Or it could be used to connect the devices, thus mitigating dependency on traditional carriers. Or, the project could be abandoned. They possibly plan to deploy the results within the next 4 years [202,203].

Starlink (broadband internet)

First, let's discuss Starlink's existing satellite internet offering, and in the next section, we will discuss their recently announced cellular offering in partnership T-Mobile.

SpaceX's Starlink is currently a satellite internet provider. The current end-user price is $599 to purchase a satellite dish, mounting tripod and router, all of which is required to access the internet service [20,204]. The service currently costs $99 per month. End-users need to install the satellite dish themselves, and position it to have a clear line-of-sight to the satellites orbiting Earth. In their October 2020 report, Morgan Stanley Research valued SpaceX at $52 billion to $200 billion [64]. Current actual SpaceX valuation is closer to $125-150B, and there are estimates that Starlink alone could be eventually worth trillions of dollars [205].

Starlink unboxing photo by Brian Westover, source: PCMag - How to Get Starlink Satellite Internet and Set It Up the Right Way [206], showing the dish, tripod and cables needed to connect to Starlink satellites.

SpaceX is currently selling their Starlink satellite bundles at a loss (which, given the monthly subscription costs, are a justified subsidy/investment by SpaceX). The manufacturing cost started at $3,000 and the company managed to lower it to $1,300 recently. That's still a $700~ loss per each dish sold to customers for $599. However, the company expects to be able to reduce the prices further in the following years, possibly even to profitability. [207]

In comparison, SpaceMobile will get subscribers for free from their mobile network operator partners and the end customers will be able to connect without any upfront costs: they won't require any additional hardware, external terminals or satellite dishes. Regular phones everyone already has in their pocket is all that is needed to connect via SpaceMobile. This is the key difference.

Elon Musk, SpaceX and Tesla CEO, commented on Twitter: "Not connecting Tesla cars to Starlink, as our terminal is much too big. This is for aircraft, ships, large trucks & RVs." [208]

Starlink is also preparing its own VoIP phone service [209,204]. However, access to the phone service will require an IP-enabled phone AND an internet connection from a third party, or customer premises equipment - the $599 satellite dish bundle mentioned above. It can be speculated that SpaceX is motivated for introducing this service in order to qualify for additional government subsidies [210].

What is the advantage of Starlink to customers over a mobile solution? Starlink's target internet speeds are 1 - 10 Gbps, with an average latency of 34ms [211]. The internet speeds are likely to be orders of magnitude faster than that of SpaceMobile, given that Starlink's whole purpose is providing internet services, and each user will have to install a satellite dish in their home - something that ordinary smartphones with their small antennas will have hard time matching.

SpaceMobile is targeting a different market - cellular services - and so a direct comparison to Starlink's broadband service is a stretch.

In developed countries, consumers have enough disposable income to easily afford SpaceMobile on top of their potential home Starlink service, for the added convenience of having phone and internet service everywhere they go. If they can afford only one service, SpaceMobile will be more affordable while offering lower internet speeds - a natural compromise.

However, the crucial fact for AST investors is the following:

Emerging markets represent the largest portion of the unconnected global population. Given that SpaceMobile can offer some of their services for as low as $1 per month [27], while Starlink currently costs $99 per month with a $599 initial investment required, most people in emerging markets will choose SpaceMobile as their primary home internet service, and use cheap LTE Wi–Fi routers or phone hotspot to connect their other devices.

Thus, unconnected consumers in undeveloped countries will likely use SpaceMobile for their phones and *also* as their primary home internet connection.

To be fair, in the very long-term, as emerging economies develop, some SpaceMobile subscribers using the service as their primary home connection might upgrade to Starlink or other more expensive solution with higher performance. However, these new middle-class entrants might also value having mobile connection on the go and being able to place calls in emergencies, so it's not a given they will cancel their existing SpaceMobile subscription. In fact, it will now become a luxury item for them that they might be willing and capable to pay more for.

💡 **Did you know?**
With some DIY hacking, it is possible to make Starlink terminals mostly mobile. This requires a large battery or other electricity source. Starlink also started offering special backpacks for transporting the dishes around - for operation, the dish needs to be first deployed though. [212,213,214,215]

💡 **Did you know?**
Shift4 Payments (ticker: FOUR) is processing subscription payments for Starlink in a 5 year partnership deal. [216]

To conclude: We are bullish on SpaceX and their Starlink project. However, we don't think that SpaceMobile is competitively threatened by existing Starlink's service, or vice versa, and consider the constellations complementary. Both are important for humanity and both can be commercially successful (possibly extremely so).

Starlink (direct-to-mobile)

Starlink and T-Mobile announced that they plan to offer low-data cellular satellite services, such as emergency messaging and calls, by late 2023 (same as AST).

From the T-Mobile press release (August 25, 2022) [3]:

With this technology, T-Mobile is planning to give customers text coverage practically everywhere in the continental US, Hawaii, parts of Alaska, Puerto Rico and territorial waters, even outside the signal of T-Mobile's network starting with a beta in select areas by the end of next year after SpaceX's planned satellite launches. Text messaging, including SMS, MMS and participating messaging apps, will empower customers to stay connected and share experiences nearly everywhere. Afterwards, the companies plan to pursue the addition of voice and data coverage.

Source: T-Mobile

To early AST investors, this announcement was somewhat of a bombshell, as T-Mobile and Starlink are the first serious competitor showing up. The implications of this new player require a careful analysis.

The announcement also created a lot of interest among the general public. As Verge wrote, "Elon musk let the satellite-to-phone cat out of the bag" [217]

Let's take a look at this from several angles.

Market opportunity validation

ASTS marketcap is $2B±, SpaceX's is $150B±. Them wanting to pursue this market validates the overall size of the market opportunity - if they thought the market is small related to their marketcap, they wouldn't bother.

It's possible that SpaceX has motivations for pursuing this market other than profit, e.g. appeasing regulators, which would also signal that a partnership with ASTS is critical for mobile network operators globally.

Performance

SpaceX talks about "clear view of the sky" requirement, but AST says their tech will work inside buildings.

Starlink will have many more satellites total than AST, but AST will have much more powerful satellites purpose-built for cellular services exclusively [218].

Starlink announced relatively small array for their satellites and talked only about emergency and low-data services, whereas AST is aiming for 5G broadband from the beginning.

However, this shouldn't give investors an illusion of complete safety. Starlink definitely thinks in "versions" of their satellites, and we can expect the far future versions to be vastly more advanced and powerful.

Tesla, according to Sandy Munro (an industry analyst), is oftentimes "sandbagging" when it comes to engineering: Tesla's fundamental tech is far more advanced than they say and the company is secretive about a lot of its nextgen improvements. (With the public-facing features, such as full self-driving or Teslabot, the company does the opposite of sandbagging in order to rally the troops and attract talent.)

Given that engineers in SpaceX and Tesla are allowed to switch between the companies, and both companies have Elon Musk at the helm, we can speculate that SpaceX might be possibly sandbagging the scope of its ambitions with direct-to-mobile connectivity.

Elon said they made the tech work in a lab, but we don't know what that means exactly.

The first gen satellite-cellular connectivity they described at the press event is unimpressive compared to AST's planned specs, but they are quite possibly working on the next gen already.

On the other hand, it's also possible that Starlink's core functionality - satellite broadband internet - will remain a priority to Starlink over cellular services. Only time will tell.

Tech architecture

Starlink's mobile service will have different backend architecture. Starlink's architecture includes satellite-to-satellite communication + SpaceX's own ground stations, whereas AST works with local ground stations (gateways), which is a solution presumably favoured by mobile network operators and local regulators as it allows them to retain more control.

Mobile apps ecosystem implications

SpaceX and T-Mobile are now actively encouraging popular app developers (e.g. WhatsApp) to add support for satellite messaging.

This is a boon for AST potentially too, as AST will also initially target intermittent texting service with the very first 5 BlueBird first-generation satellites.

Will SpaceX try to acquire AST?

It could make commercial sense for SpaceX to try and acquire AST, because AST has been already working on the technology for years, has a broad patent portfolio and commercial agreements covering up to 2 billion subscribers [219]. (However, the commercial agreements are less important than the technology in our opinion, as MNOs are highly motivated to increase their coverage and enter such agreements with any viable partner.)

SpaceX has a history of acquiring companies with complementary technology. For example, SpaceX acquired Swarm Technologies (IoT satellite technology startup, backed by Chamath Palihapitiya) for an undisclosed amount in August 2021 [220].

AST has likely much higher valuation than Swarm, but SpaceX can easily raise billions of dollars in equity (e.g. $2B in 2022 [221]), so we have no doubt that SpaceX could get the funding required for this deal - as long as it pulls the trigger fast enough.

All that said, Abel Avellan has majority control (>88% of voting rights [222]) of AST. While the rest of shareholders could potentially pressure him one way or another, the ultimate decision of accepting an acquisition offer would be up to him. Our best guess is that he would reject most such proposals, due to the tremendous intrinsic value of the company's yet to be realized vision.

Also, AST has mutually exclusive agreements in some markets (e.g. a 5-year agreement with Vodafone), which means AST can't freely work with T-Mobile. Therefore, SpaceX could possibly need to reduce the scope of its cooperation with T-Mobile if they decide to acquire AST.

For sake of completeness, we should also mention that it can't be ruled out that other large players, like Google, Blue Origin, or Microsoft are or will be interested in acquiring AST. Acquisition offers, if any, would possibly come after AST achieves some of the technological "de-risking" milestones we talked about earlier (e.g. proving the technology works at scale). Apple is possibly working on its own solution [223], so it's not likely to try to acquire AST.

AST's patents

Will SpaceX possibly need to license some of ASTS patents? This is an open question which requires further research.

AST is dependant on SpaceX launches

Starlink, now competing with AST, is fully owned subsidiary of SpaceX, so it's a natural concern that AST is dependant on SpaceX launches.

SpaceX is not the only launch services provider, but it is the best option. In case AST loses the ability to launch their constellation with SpaceX, we estimate it would substantially increase launch AST's costs and/or delay the project.

SpaceX has a history of launching competitor's product, e.g. OneWeb satellites, which are direct competitor to Starlink. SpaceX and OneWeb even wrote a joint letter to FCC, saying their satellite-internet constellations can co-exist [224,225].

SpaceX and Elon Musk have no history of unfair competition practices. In fact, Tesla famously open-sourced its patents [226].

Additionally, SpaceX is unlikely to risk anti-trust allegations, esp. considering it already operates most of Earth's satellites and moves most payloads to orbit [227].

Also, SpaceX's mission is to colonize Mars and make human civilization multi-planetary [228,229], not to monopolize various forms of satellite communications on Earth. Starlink is primarily a way to fund the mission. Elon Musk is dead serious about the Mars mission.

Elon Musk and his companies openly communicate the desire to do what's best for humanity, and it's clearly better for humanity to have two constellations providing direct-to-mobile connectivity than being dependant on just one.

For all these reasons, we are not concerned about AST using SpaceX as its launch service provider.

Shared goal: regulatory approvals

SpaceX and T-Mobile will now lobby with US regulators (FCC) for approvals of essentially the same cellular spectrum use case as AST, which could be of great benefit to AST, as their efforts could potentially accelerate the grant of approvals AST seeks.

SpaceX has orders of magnitude more resources to get regulatory approvals, and AST can piggyback on SpaceX's and T-Mobile's lobbying efforts.

T-Mobile will also inevitably have to stop objecting to AST's requests for regulatory approvals. These objections are completely without merit in our opinion, but it's still one less minor hurdle for AST to overcome.

Finally, SpaceX and AST have a new option of approaching FCC together in a joint effort, which might be a rational choice.

Ultimate impact of Starlink's new market entry on AST

We estimate that the market entry of Starlink into direct-to-mobile market will likely have the following impact on ASTS stock (as opposed to a hypothetical scenario where this announcement wouldn't happen at all):

Short term (next 2 years): positive

- Market opportunity validation. The market is clearly attractive enough to enter for SpaceX, a $150B± company. In comparison, ASTS is a $2B± pure-play company.
- Technology feasibility validation. SpaceX and T-Mobile announced to the world that the tech can and will be done, which should further erode concerns of those who still doubt the technology in general.
- Likely regulatory approval acceleration, as discussed earlier.
- Increased awareness of ASTS. SpaceX and T-Mobile's announcement attracted a lot of media attention [217,230], and as the current market leader, ASTS is mentioned often.
- T-Mobile is pushing mobile app developers to add extra support for low-data and intermittent services, which benefits AST too, as discussed earlier.
- Finally, AST has a new motivation to work hard to stay in the lead.

Medium term (2 to 4 years): neutral

- Starlink has a lot of catching up to do with AST.
- Both services will likely initially be supply constrained (the demand for the services will be higher than the capacity they can offer).
- The mutual competition will be limited, as AST will initially target the equator region whereas Starlink will target US region.

Long term (4 to 10 years): likely negative

- AST Management likely didn't account for new satellite-to-cellular market entrants like Starlink in their original 2020 NPA SPAC presentation [231, page 31], so the projected number of future subscribers should be revised down.

What remains an open question is how serious Starlink is about making direct-to-mobile its core offering and promoting it aggressively, as opposed to making it a secondary service (possibly to appease regulators or to primarily offer emergency communications). High-bandwidth mobile broadband could possibly even cannibalize its own core internet offering in some cases. Starlink might not be interested in that happening, as mobile internet is likely less profitable to Starlink due to having to use (and pay for) T-Mobile's spectrum, and Mr. Musk is famously a fan of vertical integration in business. (SpaceX is "vertically integrated": It has built its entire supply chain, from rocket engines to the electronics components used in its rockets, from scratch. [232]).

That said, if Starlink decides to pursue 5G broadband mobile internet, long-term AST investors should keep in mind that even though AST is currently in the lead both technologically and commercially, SpaceX is a Goliath with two orders of magnitude more resources than AST. Starlink already owns more than half of all active satellites of humanity [233], and expects to operate 2/3 of all satellites in existence in the near future [234]. Investors should thus account for Starlink being capable of capturing a substantial market share in all markets it enters and prioritizes.

The ultimate scarce resource limiting AST's competition in general is communication spectrum availability, especially when it comes to providing services to unmodified phones. (Some future phone models might have inbuilt specialized modems for communicating with satellites, which would make it possible to communicate using non-cellular spectrums as well. However, the number of these additional spectrums is ultimately limited as well.)

Ultimately, the satellite-to-phone market might end in a similar oligopoly situation as terrestrial mobile network operators, with AST firmly established as commanding a substantial market share, thanks to its early market entry.

Amazon Project Kuiper

Project Kuiper is a similar project to Starlink (broadband), except it is owned by Amazon instead of SpaceX. Starlink (broadband) analysis above thus roughly applies to Kuiper as well.

Kuiper didn't announce plans for mobile services yet, so it's not a direct competitor to SpaceMobile as of now.

The project is in earlier stage of development than Starlink and Amazon is still somewhat secretive about it.

"The Seattle tech giant has said it ultimately plans to launch 3,236 satellites, half of which must be in orbit by the end of July 2026, according to the terms of its Federal Communications Commission authorization." [235]

OneWeb

OneWeb, funded by the UK government and SoftBank, is also almost the same project as Starlink, without any plans for phone services. OneWeb takes a similar business model as SpaceMobile though, offering its services primarily through established partner telcos, while Starlink is selling its services directly to consumers [236]. OneWeb User Terminals (a satellite antenna, a receiver, a router) will be required to access the service [237].

The company faced recent setbacks. According to Bloomberg, "OneWeb Ltd. took a $229 million writedown after Russia scuppered its launch plans and took 36 of its spacecraft hostage indefinitely earlier this year." [238]

OneWeb's new launch provider is SpaceX. [224]

Telesat

Again, similar to Starlink or OneWeb, except those are direct-to-consumer, while Telesat targets enterprises customers. It provides fiber-like satellite internet to B2B customers, and requires specialized terminals to access the service. [239,240]

It was established in 1969 and thus has a long operating history. It's currently a private company, but has plan on going public on the NASDAQ exchange in 2021. [241]

Swarm

Swarm Technologies is a company building low-Earth orbit nano satellite constellation for Internet of Things (IoT) communications [242]. Chamath Palihapitiya's Social Capital invested in Swarm Technologies in Series A funding.

Swarm works as follows: IoT devices communicate with Swarm Tile (a small circuit board designed to be integrated within the IoT devices). Swarm Tile communicates with the Swarm satellites. The satellites forward the messages to Swarm ground stations. The ground stations forward messages to Swarm backend servers, available on the internet, and accessible to customers via API.

Clearly, Swarm cannot compete with SpaceMobile in cellular services. However, SpaceMobile plans to offer NB-IoT connectivity, with no modifications to existing IoT devices necessary [27]. SpaceMobile can thus compete with Swarm in the growing IoT market. It can, for example, get its slice in the booming AgTech IoT industry [243].

The IoT communications market is getting very crowded. In 2018 alone, 18 new IoT-only satellite startups launched [244]. Other newcomers include Sateliot OQ Technologies and Eutelsat [152].

SpaceX acquired Swarm in August 2021 for an undisclosed amount. [220]

Iridium

Iridium Communications (NASDAQ:IRDM) is an American company providing worldwide voice and data communication to hand-held satellite phones and other specialized transceiver units [245].

More specifically, Iridium provides satellite communications to businesses, ships, IoT, hand-held satellite phones, aircrafts, drones, governments and military [29,246]. There are lots of different products/devices that Iridium offers to connect to their satellite network.

Iridium 9555 Satellite Phone, available for purchase SatPhone UK. Source: [247]

Iridium satellite phone costs around $1000 USD [248].

The company also offers Iridium GO! portable satellite Wi-Fi hotspot, for $800 USD [249], which allows you to connect the smartphone you already have (iPhone or Android) to the network. A steep price to pay, and an extra battery-powered device to carry with you everywhere.

After purchasing Iridium devices, you also need to select either a prepaid or postpaid service plan.

The Iridium GO! data speed is 2.4 Kbps (yes, you read that right), usable for text messaging, emails, weather forecasts, and other minimal-bandwidth applications [250]. This is the same data speed as all other Iridium & Inmarsat Satellite phone services.

For comparison, MP3 music is typically encoded at 192 Kbps, and low quality 480p YouTube video consumes 500 to 2000 Kbps, 200 to 800 times more than is possible to achieve with Iridium network.

Iridium data plans are also expensive. The cheapest Iridium GO! plan sets you back $60 per month, for 40 on-call minutes (data usage is counted as calling too, with no data-cap) [250]. Iridium GO! Unlimited plan costs $150 per month, for 150 on-call minutes and unlimited data minutes.

We do not yet know the final pricing of SpaceMobile, but it will work with existing phones without having to pay additional $1000 for an extra device you now have to carry with you (and recharge) everywhere. AST mentioned they will be able to offer some service for as low as $1 per month in developing countries [27].

SpaceMobile can also provide more than 35 Mbps download speeds [63], enough to watch 4k Ultra HD YouTube on your existing phone in the middle of nowhere [251]. It does not look good for Iridium from the mass-market/consumer perspective.

On the other hand, governments and military are less likely to jump the ship and suddenly change their satellite communications provider just because SpaceMobile is available. Aircrafts, drones, and ship captains will also probably keep using a proven and (literally) battle-tested satellite communication system over a startup, at least until SpaceMobile is ubiquitous.

IoT business line of Iridium may experience some disruption, but given the number of IoT satellite communication startups, it's difficult to estimate the extent of SpaceMobile disruption specifically. Freight ships, aircrafts, drones, military and governments will likely exhibit much higher migration friction, and many of them might not migrate for a long time or at all.

All in all, SpaceMobile will completely disrupt one division of Iridium - namely satellite phones for civilians.

Source: Official AST SpaceMobile YouTube channel

Chapter Eight
Social impact

SpaceMobile's positive impact on society will be enormous.

The company's mission is to bring up to 3 billion people online for the first time, starting with those living in developing countries. This makes it one of the most pro-social companies in existence today, and it should receive maximum possible ESG ratings based on this alone.

Mobile phones are already the most popular device for accessing the internet, accounting for the majority of online time. [252] As a result, SpaceMobile is positioned to provide exactly what the world needs.

Megatrend: closing the "digital divide"

Solving the climate crisis became an urgent global priority, and we believe that closing the so called "digital divide" (or "connectivity gap") is one of the next megatrends that investors can profitably bet on.

The markets richly rewarded companies working on decarbonization, and they should eventually reward companies working on closing the global digital divide as well.

Due to globally increasing regulatory pressures on closing the connectivity gap and digital divide, now accelerated by the COVID-19 pandemic, mobile network operators are increasingly required to provide coverage in rural and underserved areas with low population density.

For instance, in June 2021, Elon Musk said he was talking to possible Starlink partners as a number of countries require operators to provide rural coverage as conditions of their 5G licenses! [253]

Operators will have the following choices: partner with a company like SpaceMobile to provide universal coverage at no extra cost to them, build expensive and unprofitable towers, or face huge regulatory fines and risk losing their license.

Scraps from decommissioned cell towers. Source: https://www.indiamart.com/tranz-logistics/mobile-tower-scrap.html

This could eventually lead to an interesting effect - decommissioning low-margin cell towers in areas where SpaceMobile is more cost-effective.

Universal affordable cellular coverage and broadband internet access for every human is simply the future. Sooner or later, savvy institutional investors will align with this global megatrend both due to financial incentives and their pro-social & ESG policies.

Tareq Amin, CTO of Rakuten Group, talks about their partnership and the aspirational goals of universal connectivity. Rakuten is an important AST investor and commercial partner.

Let's take a look at some of the implications of bringing this record amount of people online for the first time and providing coverage in areas without any connectivity before.

Climate impact

The positive climate impact of closing the connectivity gap is not obvious, but it might manifest indirectly.

According to IMF, only 28 percent of Africans use the internet. [254]

Currently, African citizens are disproportionally under-represented in social media and online in general. If you open a comment feed on YouTube, Facebook, Twitter, Instagram, or any other major news site or media platform, there are 3 billion unconnected people missing. Internet access will give them a voice in the global community for the first time.

This "voice for all" might have an impact on global climate awareness. Politics aside, here are the simple facts –

The majority of Africans live in countries that get disproportionately affected by climate change, because their countries are located in the tropical and subtropical climate that is already hot. With a warming of just a few degrees Celsius, many of these areas can become completely unhabitable and plagued by droughts and deadly heat waves, possibly causing global migration crisis of unprecedented proportions.

Yet, African countries produce far less carbon emissions than developed nations. For instance, in 2020, Africa produced 1,195 million metric tons of CO2. However, Europe produced 3,593 and North America 5,307, for a total of 8,900 metric tons. Africa has a population of 1.2B, and Europe + North America 1.3B. Europe and North America thus produce over 7 times more CO2 than Africa per capita. [255]

We don't want to imply that developed nations are ignorant or malevolent – but they do lack some direct salient feedback due to lack of connectivity in the poorest nations. Bluntly put, it's harder to "throw trash" (CO2) in your neighbor's backyard when you have to interact with them on a regular basis, as opposed to when they are invisible to you.

By giving African citizens a voice through universal internet connectivity, it will become increasingly difficult for developed nations to ignore the growing challenges they are facing due to climate change. This could further accelerate the decarbonization of developed economies.

Saving lives in emergencies and during disasters

The most direct effects of universal coverage can be literally measured in lives saved.

Most notably, there is 700M people in the world without *any* cellular coverage [27], who currently can't quickly call for help during medical and other emergencies at all.

Both SpaceMobile and Lynk say their service will save lives during disasters and states of emergency, even in developed nations. Terrestrial mobile network may be down due to a disaster, in which case satellite-based mobile signal can provide the connectivity needed to call for help, pinpoint location, or access life-saving news and directions.

Similarly, for reasons discussed earlier, very few people bring a satellite phone or terminal (dish) when they go hiking, or when they visit some remote

out-of-coverage area (such as a national park). However, people are likely to still bring their smartphones, at the very least to use them as portable cameras.

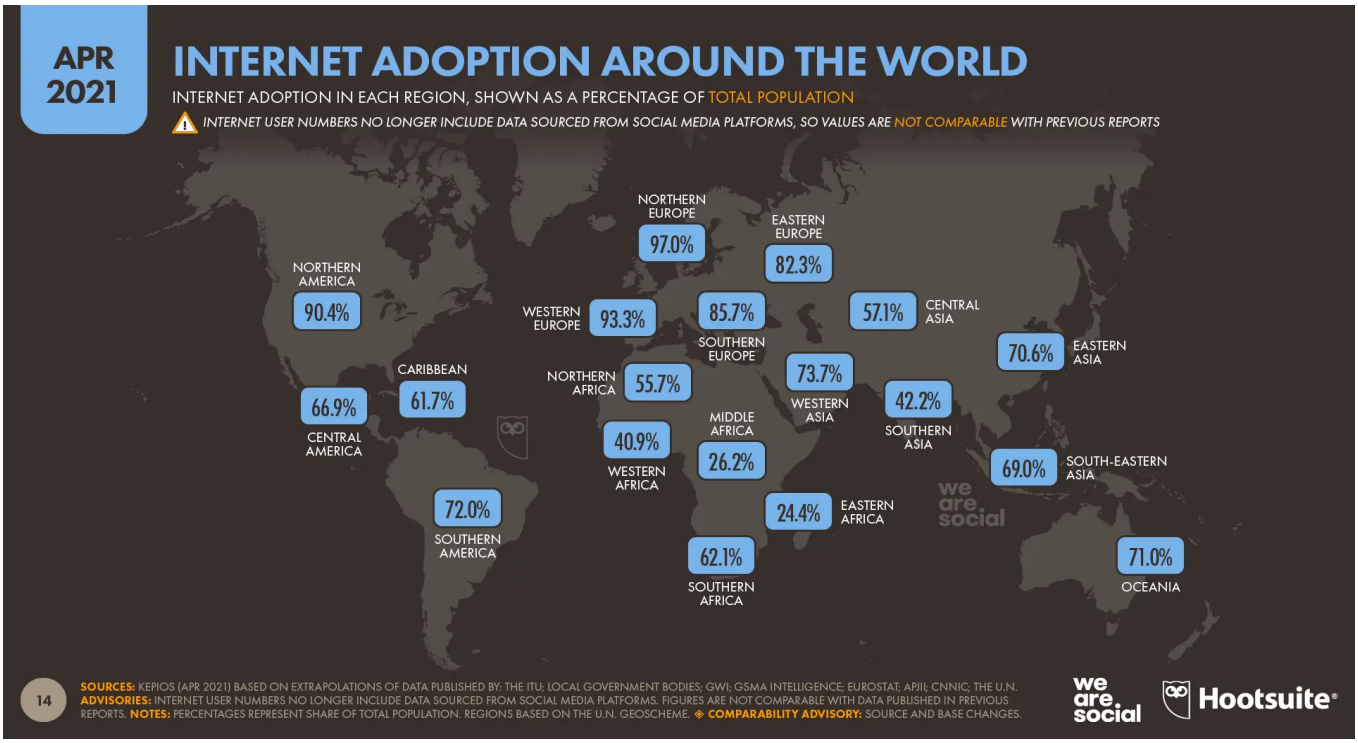
Accidents that happen in remote areas without the ability to call for help are the most dangerous. SpaceMobile will turn every mobile phone into a satellite phone, giving everybody access to help when needed anywhere in the world.

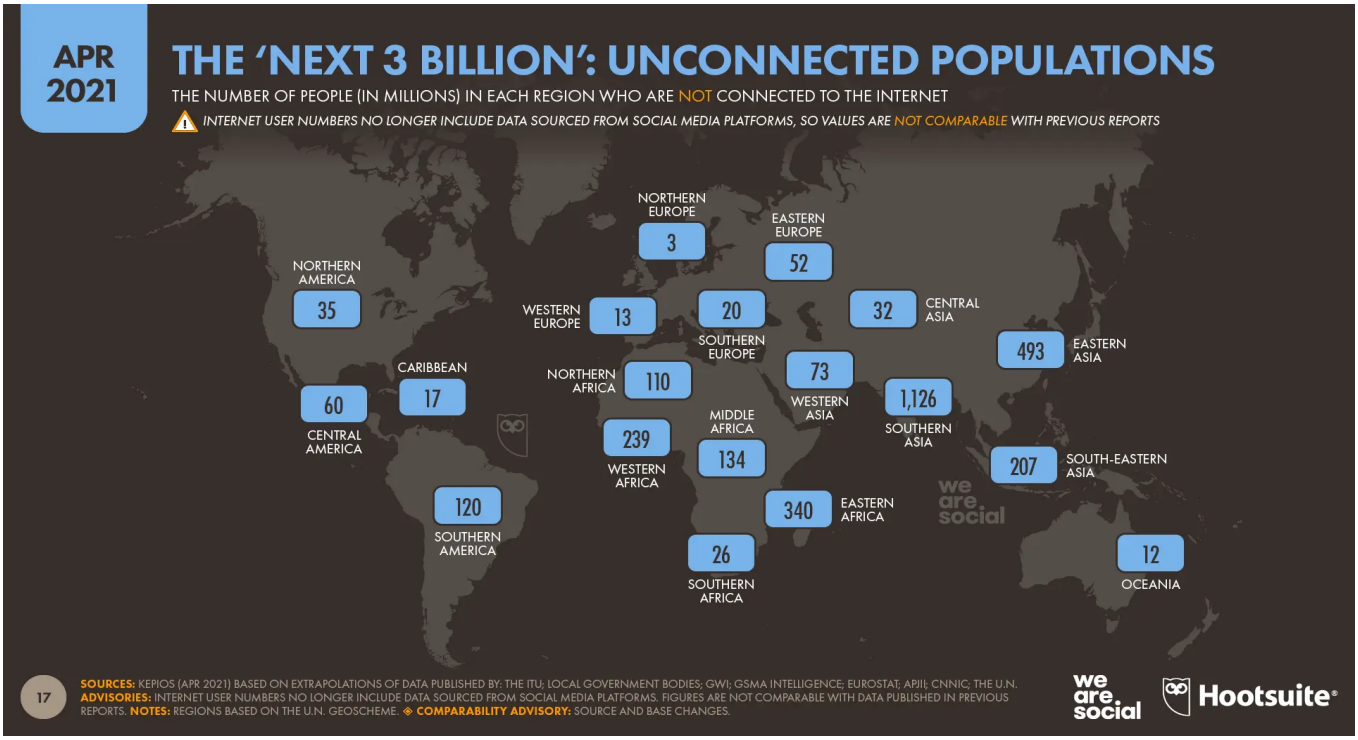
Connecting the unconnected

To recap –

- There are 700 million people in the world who are not connected and not even covered with any cellular signal. This means that SpaceMobile won't bring just Internet to them, but also voice and text messaging – for the first time! [27]
- There are 3B people with no Internet access [252]. SpaceMobile will bring many of them online for the first time.
- Finally, there are 5B mobile phones moving in and out of coverage. SpaceMobile will provide coverage to these phones at all times (with the exception of tunnels, caves, etc.).

Datareportal.com [252] has depicted global internet use and the size of the unconnected population:





Let's take a look at the first category of 700M underserved people who have no coverage at all:

700 million people is about the size of the population of Europe. With SpaceMobile, they get a chance to become connected, with huge socio-economic implications that come with it.

They will suddenly get the ability to call or send a text to get things done, instead of having to walk or drive and spending hours or even days just to deliver a message. That time can be instead used for improving people's living conditions - education, work, rest and family time.

Every time one of these 700M people places an emergency call thanks to SpaceMobile coverage, a life will be potentially saved.

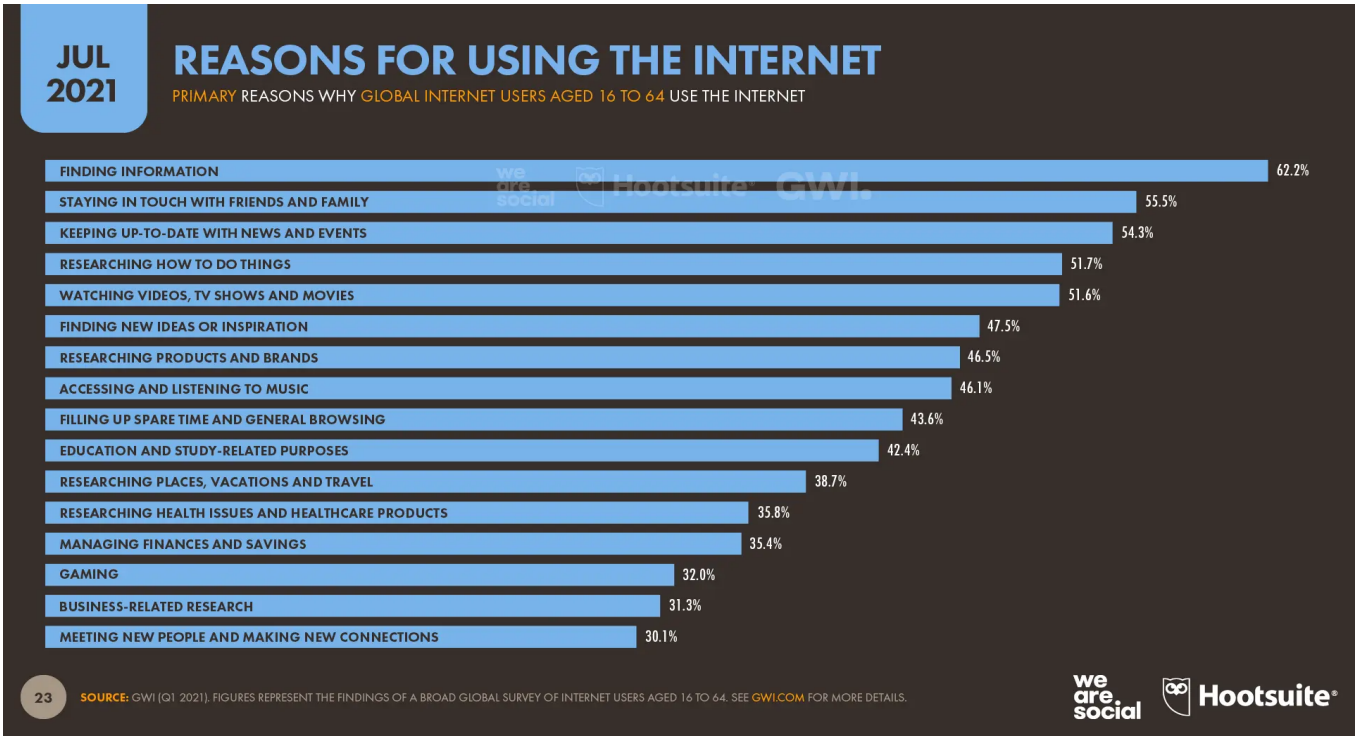
Then, add having Internet access on top of that. It is absolutely life-changing - communication, education, news, information, marketplaces, social networks, you name it.

For example, a farmer in Africa could find a thematic local Facebook group and access information that allows him to sell his products for a better price in another city. Alternatively, he will be able to get critical weather information which will allow him to protect and save his crops. All this will have immediate and tangible effect on his life.

Internet access will have a profound impact on education as well. For example, in sub-Saharan Africa, more than half of primary school-aged children do not attend school. [256] With universal internet access, modern distance learning apps will be able reach many of these children.

42% global population (3.3B people) are covered with a cellular signal but not connected to cellular internet [27]. The most probable reason is the prohibitive cost of mobile data. SpaceMobile will offer affordable mobile internet and thus give everyone the chance to finally enjoy the benefits of always-connected phones.

The most vulnerable people stand to benefit the most. Research shows that digital technologies are essential to addressing socioeconomic challenges. They are often described as the single ingredient Africa needs to leapfrog to sustainable and inclusive economic development.



Source: [257]

For example, a study by the International Telecommunication Union found that 10 percent greater mobile broadband penetration would generate a 2.5 percent rise in Africa's GDP. [254]

The relationship between internet access and household welfare in Africa is strong: One study from Senegal associated 3G internet coverage with a 14 percent increase in consumption and a 10 percent decline in poverty. [258]

The tree countries with the most expensive mobile data per 1GB are all in Africa. However, cost of data drops as the number of networks grows in a country. [259]

Today, Internet access is a luxury for many, just like electricity used to be. With SpaceMobile, it will become ubiquitous.

What about developed countries? There, SpaceMobile brings coverage for rural areas. It also brings added conveniences for everyone moving out of coverage. Having a vacation on a cruise ship? On a lonely island? Or in the mountains? Soon you will be able to watch Netflix in the middle of the Pacific Ocean. Or call your grandma from the peak of a mountain.

Globally, 5B mobile phones are moving in and out of coverage. SpaceMobile will fix that for all mobile network operators who decide to partner with them. Better coverage means people have more chances to spend their money – so it's not difficult to imagine the benefits of partnering with SpaceMobile, especially for regions where building cell towers is not profitable.

Impact on industries

Many of the digitization trends accelerated by COVID-19 will accelerate even more in the decade ahead.

Some of the industries and sectors that will benefit the most from the up to 3B new internet users include, but are not limited to:

- Cybersecurity
- E-Commerce
- FinTech & Cryptocurrency
- Social media
- Telemedicine
- Distance education
- Online job / freelancer / outsourcing marketplaces
- Streaming and subscription services
- Gaming
- Software
- Hardware

Hardware devices that will especially enjoy a popularity boost include:

- Affordable phones suitable for daily broadband internet use
- "SIM card enabled" Wi-Fi routers and hotspot devices
- Cheap external antennas for phones to improve their signal reception and connection speed (these are optional)

On the other hand, for the short-term and mid-term, we estimate only minimal impact on virtual reality (VR) adoption due to high costs of VR headsets. This might change in the future as the cost of VR hardware drops.

SpaceMobile will benefit not just Africa, but humanity as a whole:

"In the next 6 years, three billion minds will come online for the first time to join global conversation (via inexpensive smart phones in the developing world). This rapid influx of three billion people to the global economy is unprecedented in human history, and so to, will the pace of idea-pairings and progress."

- Steve Jurvetson from Future Ventures, source: [260]

Indeed, by bringing everyone online, we expect to see these positive **global** trends:

- Scientific and technological progress acceleration
- Lower mortality and increased longevity
- More art, culture and content of all kinds produced and shared
- Trade increase
- Literacy and attained education growth
- Wealth growth
- Life of quality increase

Source: Official AST SpaceMobile YouTube channel

Chapter Nine

Valuation and price target

Arguably, a similar company of this potential scale and profitability never existed before. This is why the market might be currently failing to properly value the stock. In this chapter, we aim to shine some light on the true long-term potential of AST.

To quickly recap -

SpaceMobile has an attractive business model. All they have to do is develop, launch and operate a satellite constellation. SpaceMobile will then offer the satellite connectivity to existing established mobile network operators - who will likely white-label the service as their own and offer it to their existing/prospective customers in the region.

SpaceMobile will not be responsible for marketing and customer acquisition - effectively outsourcing this to their already established partners with broad customer base and highly competitive customer acquisition channels.

It will not even have to acquire cellular frequency band licenses (which cost up to tens of billions of dollars [261]). Instead, they will borrow their partner's licenses. With 50/50 revenue share agreements (e.g. with Vodafone) in place, and with minimal capital expenses once the satellite constellation is deployed, SpaceMobile can achieve extremely high 90%+ profit margins (possibly up to 99%, as projected by the AST management for 2030).

If they can pull it off, the business model will be incredible.

The multibillion-dollar question is – how to value the company? What is the fair value for the stock price today and in the future?

Whether you are a financial professional or not, we got you covered. We will explain some key terms and concepts necessary for valuing a growth company, and will also show how these metrics work specifically for AST.

The anatomy of valuation step-by-step

EBITDA

- A fancy term for gross profit. It means "Earnings Before Interest, Taxes, Depreciation, and Amortization".
- In the case of SpaceMobile with incredibly high profit margins (90-99%), its EBITDA is projected to be only slightly lower than its Revenue.
- For example, in 2030, AST management projects $16.4B revenue and $16.3B EBITDA, which translates to 99% profit margin. [27] Such profit margins are almost unheard-of for a company of this size.

If AST hits the target revenue projected by its management for 2030 ($16B~), it will become one of the largest and most successful companies in the world.

What other companies generate revenue of that magnitude?

Here's one. MasterCard (NYSE:MA) generates $15.30B of revenue and is currently the world's 18th largest company with a market cap of $355B.

AST's business model is superior to Mastercard in several aspects. For example:

Mastercard has only 57%~ EBITDA margin [262] and thus generates only $12.4B~ EBITDA on $20.8B revenue. AST will be shooting for 99% EBITDA margins, which would translate to $20.6B EBITDA in Mastercard's case.

Mastercard has 11,300 employees. AST currently has 454 employees [263] and likely won't need many more than 1,000 even at peak scale.

Or, to really highlight the power of AST's ultra-high profit business model, consider The Walt Disney Company (NYSE:DIS).

While Disney generates $76.6B revenue, it has over 200,000 employees, and its EBITDA is only $10.6B. AST will need to generate less than $10.7B revenue to match Disney's EBITDA! The fact that it will need 200 times less employees and generate only 1/7 of the revenue to match Disney's EBITDA really showcases the strength of AST's simple business model.

Market Capitalization, or **Market Cap** or **Equity Value**

- It is the total number of shares multiplied by share price.
- AST has 210.8M shares outstanding total including employee incentive shares and shares exercisable for warrants [264], so if the share price is $10 for example, the market cap is $2.108B.
- In the future, AST might issue more shares to get more funding or to attract or retain talent. If this happens, market cap will go higher, but the share price won't. This is called dilution.
- Fortunately, once AST gets its first revenue, it should be able to raise capital in the form of debt instead of issuing new shares.
- Once AST grows to a sufficient scale, it should be able to repurchase shares on the open market to decrease the number of shares outstanding and to return capital to investors.

💡 In case you are a Gen-Z reader more familiar with the crypto world: share repurchases, or buybacks, are effectively the same thing as token burning.

Enterprise Value (also "EV")

- EV is a modified market cap. To calculate enterprise value of a company, you take its market cap (or equity value, same thing), then add to it all debt the company has and subtract the cash it has.
- So, for example, if the company has a $1B market cap, $0.5B debt and $0.1B cash on its balance sheet, its enterprise value will be $1.4B. Here's the calculation: $1B (market cap) plus $0.5B (debt) minus $0.1B (cash) equals $1.4B.
- Companies that have lots of debt and little cash will have higher EV than their market cap, and companies that have lots of cash and little debt will have lower enterprise value than their market cap.
- Why is EV widely used and considered useful? Because it gives a more accurate idea of what the company is worth "net".
  - Imagine you are an investment bank and want to buy a whole company that has a market cap of $1B, but also $0.3B cash in its bank account and no debt. You pay $1B, but you immediately get $0.3B back, because that's what the company has in the bank. So, you only pay $0.7B "net", which equals to company's EV.
  - Or, imagine the company has a market cap of $1B but also owes $0.5B in debt. In this situation, you will need to pay not only the $1B for the company but also have to take on its debt, so you will have to pay additional $0.5B. You will pay $1.5B total, which also equals to the company's EV.
- In case of SpaceMobile, we expect it to initially have lots of debt ($1.2B or more by end of 2023), but starting from 2024, if things work out, it will be fully self-funded and will be able to repay all the debt and start accumulating and distributing cash in the form of dividends or share buybacks, even in the face of additional spending for launching additional satellites to scale with customer demand (in 2026 and beyond).
- For simplicity's sake, we can assume that long-term (say, 2027 and beyond), AST's market cap (equity value) will be very close to its enterprise value.

Valuation Multiple

- This is the magic number which allows you to calculate market cap (or enterprise value) based on the company's revenue (or EBITDA).
- It's popular to calculate enterprise value (EV) by multiplying the company's EBITDA with a given multiple. It is called an "EV/EBITDA multiple".
- So, for example, if you think a company will have $1B revenue, and you think a fair multiple for such a company is 20 times its revenue, it means you think a fair market cap for such a company is $20B.
- For companies that already generate revenue, you can calculate their existing EV/EBITDA right now! For example, as of Aug 5 2022, Iridium's EV-to-EBITDA multiple is **19.39** [265], and American Tower's EV-to-EBITDA multiple is **25.58** [266].
- And in case you were wondering, Mastercard trades at **28.34** EV/EBITDA multiple and Disney at **22** EV/EBITDA multiple.
- When trying to determine a fair future value (market cap) of a company that does not yet generate revenue, you take its estimated (projected) future EBITDA and multiply it by a multiple of similar companies that already do generate EBITDA. That way, you can calculate its estimated future market cap. And if you divide that number by the number of outstanding shares the company has (or you expect it to have in the future) – *voilà* – you just calculated its future price!
- Of course, when you do that, you need to be careful in both estimating the future EBITDA correctly **and** choosing the right multiple by picking the most similar already revenue-generating companies as your guide.
- Now, future price calculated this way will always be higher than today's fair price. Why? Because the company needs to grow into this valuation. It does not *yet* have the revenues you estimate for the future.
- So how do you get today's "fair" price from the future price? Easy: you use the so called "discount rate".

Discount Rate or **Hurdle Rate**

- Hurdle rate is minimum annual return an investor requires when making an investment. Investors need to get paid for all the risks (e.g., the company could fail, economy could crash) and opportunity costs (they could just invest into Apple or S&P500 index fund instead) they take on.
- For risky high-growth companies, investors will demand higher hurdle rates (typically 15 to 20%).
- Here's an example.
  - If you think that a fair stock price of a company in 10 years is $100, but you require a 20% annual return, you won't be willing to pay $100 for it today, because then your return would be 0% for 10 years - you would just sit on it for 10 years until it grows into its valuation, and then and *only* then it might start growing further and you would start making a return.
  - Instead, you will whip out Excel and do some discounting. Discounting is basically the opposite of compounding: you start with an already compounded number ($100) and calculate the current fair price that will compound based on your hurdle rate (20%) each year.
  - Excel has a handy function called PV (Present Value) which allows you to calculate just this - today's value from future value [267].
  - If you input =PV(20%,10,0,-100) into a cell, the output will be $16. That's the today's fair value in our example! (The entered inputs specify: you have a 20% hurdle rate, there are 10 compounding periods, you will receive no dividend each year and the future stock price after the 10 years will be $100).
- So even though you think the stock price will be worth $100 in the future, because you want to make at least 20% per year, you shouldn't pay more than $16 for it today. If it seems low, consider the power of compounding: If a $16 stock compounds by 20% for 10 years, it will cost $100 on year 10. It will go like this each year: $16 (today; year zero), $19 (year 1), $23 (year 2...), $28, $33, $40, $48, $58, $69, $83, $100 (year 10).

Putting it all together: Naive ASTS valuation example

We will get to explaining our own more advanced model soon, but we know you can't wait, so let's try the valuation exercise above with some extremely optimistic AST numbers and a 20% discount rate.

Assuming AST will hit the 2030 $16.3B EBITDA as projected by its management [27] (which is unlikely), won't dilute its shares beyond 210.8M, will trade at a 22x multiple, then: its 2030 share price will be $1740 and today's fair price is $387. This means that if the assumptions come true, the stock should be trading about 170 times higher in 2030 from an $10± entry price.

The calculation is straightforward: $16.3B EBITDA times 22 (valuation multiple) equals $358.6B market cap. Divided by 210.8M (0.2108B) shares equals $1,701 future share price.

This is the most naive and most aggressive bull case that can be possibly made today.

However, this scenario is both too simple and unrealistic. For example, it's already almost certain that AST's revenue will be delayed by at least a year compared to original management's projections. Also, in 2020, AST management couldn't have possibly accounted for Starlink and T-Mobile's market entry, so its projections need to be revised for this reason as well.

So let's now think about how we can make our valuation model better: more conservative, realistic, comprehensive and also account for unforeseen circumstances (regulatory blockages, risk of total failure, new unexpected competitors, etc.)

How do others value AST?

Let's take a look at how the company was already valued by: AST management in the original presentation for SPAC investors [27], Deutsche bank [83], and Barclays [268]. We will consider some of the shortcomings of these three models and ultimately present our own more comprehensive model.

Valuation models	AST Management	Deutsche Bank	Barclays
Date released	December 2020	June 2021	July 2021
Rating	N/A	Buy	Overweight
12-month price target	N/A	$35	$29
12-month upside target	N/A	$86	$37.50
EV valuation multiple	14x	15-25x for 2024; 10x for 2030 (conservative; "illustrative" purposes)	21x (EV/net profit)
Shares outstanding estimate	181.55M	210.8M	181.53M
Valuation based on	2024E EBITDA	2024E EBITDA	2024 net profit + 2031 cashflow model (50/50)
Subscriber estimate	620M by 2030	27% lower for 2026	55% lower for 2030
Revenue per subscriber estimate	$2.21 by 2030	9% lower	25% lower
CAPEX estimate	$1.7B by 2023 $3.32B total by 2028	$2.2B by 2026 No estimate for 2028	$3.7B total by 2028
Discount rate used	20%	15%	20%

Deutsche Bank's model is based on 2024 estimates and on 4 different scenarios: "management" (optimistic), conservative ("Deutsche bank"), even more conservative, and total failure. They give 25% probability to each one. In our opinion, the 25% probability of a total failure is too pessimistic.

Barclays are actually using two different models – one based on discounted cashflow (2031) and another based on net profit multiple (2024). They give 50% weight to each of these models to calculate their final target.

The key limitation of all of the three valuation models is working with 2024 numbers only. AST expects explosive growth in 2025 (160%), 2026 (120%) and 2027 (66%) [27] – this should be taken into consideration! (To give credit where credit is due, Barclays are actually working with 2031 estimates in their cashflow model.)

None of these analyses give predictions for future (2027-2031) stock price. Wall Street analysts typically focuses only on the next 12 months. For a hypergrowth company with a tremendous long-term potential like AST, this short-term perspective is myopic and insufficient, especially for long-term investors.

Determining the valuation multiple

No company like AST SpaceMobile is currently publicly traded, so we need to be a bit creative when determining the most comparable companies to figure out the right EV/EBITDA valuation multiple for AST.

In the investor presentation [27], AST management team draws comparison to Satellite, Space Tourism, Telecom, Cable, Cell Tower, Electric Vehicle, 3D Printing and LiDAR companies to determine the multiple.

We don't agree with this approach.

AST is a company that intends to launch satellites to orbit to function as cell towers, while offering its services to network operators (not directly to consumers). Only the segments of "Satellite" and "Towers" are relevant, since that's what SpaceMobile is - a satellite cell tower operator. Not a mobile operator. Not a cable company. Not a space tourism company, and definitely not an electric vehicle manufacturer.

Deutsche Bank and Barclays don't repeat this mistake, and consider only satellite companies.

We think that's an improvement. However, cell tower companies should be included in the comparison as well.

Now let's take a look at some publicly traded satellite operators and how they differ from AST. We consider most of these to be "legacy" players.

Iridium Communications (IRDM)

- Iridium, which we already talked about in the Competition section of this report, is the most obvious comparison choice, because it provides voice and data services to hand-held satellite phones. (Key distinction: satellite phones, which are expensive and clunky. They are nothing like the phone you already have in your pocket.)
- Iridium's growth is projected to be less than 10% annually, whereas AST management expects 17% growth even in 2030.
- Iridium has $1.6B debt (this will be comparable to AST) and $5.77B market cap. Its EBITDA margin is 56.88% - in comparison, AST projects 95-99%.
- Notably, due to high depreciation & amortisation, Iridium is currently not profitable at all.
- Equipment sales and engineering services are about 20% of Iridium's revenue, which is another difference with AST.
- Iridium operates a LEO constellation, which makes it more similar to AST than GEO satellite companies.
- ARK Invest, an innovation-focused asset manager, owns 1.72% of all outstanding Iridium stock (down from 10%). ARK Invest requires minimum 15% hurdle rate for its positions, so we can surmise that ARK still considers Iridium sufficiently innovative and expects 15% or higher growth from it. AST is also a highly innovative, high-growth company.

Viasat (VSAT)

- Viasat operates GEO satellites providing high-speed broadband services. Its customers require expensive satellite dishes.
- It is currently not profitable.
- It has $2.87B debt, $2.5B market cap. ($5B enterprise value)
- The biggest positive of the company is that a revenue growth of over 10% is estimated.

ViaSat dish mounted on a rooftop [269]

Eutelsat (ETL.PA)

- Eutelsat is primarily in the television and radio broadcasting business.
- It has declining revenue.
- One redeeming aspect of the company is that it owns 19.3% stake in OneWeb [270], one of the main Starlink competitors we discussed earlier, currently deploying its satellites (with over 250 already deployed) in preparation of commercial service.

SES S.A. (SESG)

- SES is a Luxembourg-based satellite operator. It derives 60% of its revenue from video distribution and services – a very different business than AST.
- 40% of its revenue is connectivity from MEO satellites.
- It's barely growing with 3.7% revenue growth, but it is currently profitable.

Orbcomm (ORBC)

- Orbcomm is not a pure-play satellite operator. It provides industrial IoT hardware, software, connectivity and other services.
- Satellite connectivity is likely only about half or less of its revenue [271].
- During its 2021 stock price peak, it had the highest EV/EBITDA multiple among satellite companies, 24.30x.
- However, it got acquired in September 2021 and went private, so we have no visibility into its current financial numbers.

Intelsat (INTEQ)

- Intelsat went recently bankrupt [272] with over $15B in debt, so we won't be using it in our comparisons.

There is currently no directly comparable satellite business. Although still notably different than AST, we think that Iridium (handheld satellite phones) and Viasat (fixed broadband internet) are the most comparable ones, so we will use them.

We will also include the three largest cell tower operators.

Below are our choices of companies to use, with current EV/EBITDA multiples taken from GuruFocus.com on Aug 5, 2022 [265]:

COMMUNICATION / BROADBAND SATELLITES

Iridium	IRDM	19.39x
Viasat	VSAT	10.05x

CELL TOWERS

American Tower International, Inc.	AMT	25.48x
Crown Castle International	CCI	27.03x
SBA Communications Corporation	SBAC	35.67x

The average multiple for the two chosen satellite companies is 14.72x, while the average tower company multiple is 29.39x. Averaging these two already combined multiples gives us **22x**. This is also slightly higher than IRDM, which seems reasonable to us.

Based on the above, the 14x (2024) multiple chosen by the AST management team seems too low. That said, market valuations were lower across the board when they were preparing the presentation, which explains most of this discrepancy.

The 15x (conservative) and 25x (upside scenario) multiples chosen by Deutsche Bank seem reasonable to us. It's worth noting that Deutsche Bank is estimating the multiples for 2024 only. For 2030, it mentions a possible 10x "conservative" multiple for illustrative purposes. The main reason an investor might believe 2030 multiple should be lower than a 2024 multiple is slower growth of the company. However, we believe that AST should be able to sustain a 10%+ growth even beyond 2030, which is in line with cell tower companies and most existing satellite operators. This should support a 22x multiple.

Projected EBITDA

Projected EBITDA is arguably the most important component of the valuation model.

In the case of AST, its projected revenue is:

Number of Subscribers times **Average Monthly Revenue Per Subscriber** times **12**.

SpaceMobile expects the following average *monthly* revenue per customer [27]:

US & Europe	Equatorial	Global
$7.62	$1.03	$1.99

The table above represents SpaceMobile share of the revenue under 50/50 revenue share agreements, so from that we can imply the average monthly cost of the service to end-users (which will be purchasing the service from their local mobile network operators):

US & Europe	Equatorial	Global
$15.24	$2.06	$3.98

Note: It's possible that AST will get higher than 50% revenue share in same markets, but this is currently not disclosed and speculative, so we will not be including that possibility in our model.

The numbers above are averages, and SpaceMobile plans to offer various packages (daily pass, monthly pass, etc.), so some packages will be priced below the average and some will be priced above the average. The prices do look quite affordable though, and even the lowest income equatorial households can probably afford the service for at least one device.

SpaceMobile expects to have the following number of subscribers (in millions) [27]:

	Equatorial	Rest of the world	Total
2023	5	4	**9**
2024	17	27	**44**
2025	41	67	**108**
2026	81	153	**234**
2027	115	258	**373**
2028	136	332	**467**
2029	156	375	**531**
2030	180	440	**620**

This is a very rapid initial growth when expressed in YoY rates:

	Equatorial	Rest of the world	Total
2024	240 %	575 %	**389 %**
2025	141 %	148 %	**145 %**
2026	98 %	128 %	**117 %**
2027	42 %	67 %	**59 %**
2028	18 %	30 %	**25 %**
2029	15 %	13 %	**14 %**
2030	15 %	17 %	**17 %**

While such growth rates might seem high at first, it's important to keep in mind how SpaceMobile plans to acquire the subscribers. For the equatorial region (Phase 1), multiple mobile network operators in 49 countries will be simultaneously advertising the service to 730M unconnected people and up to 1.6B people in total [273,27].

United Nations project 8.5B world population by 2030 [274]. 620M subscribers represent 7.3% or world population then, and would position AST as company with a truly civilisational scale and importance. While this number might seem mind-boggling, it's still only a single digit market penetration!

AST aims for rapid growth. Given the sheer number of people living in the equatorial region and the chosen strategy that allows to enter the markets rapidly and without friction, it seems achievable. Most of the equatorial market is already accessible to SpaceMobile thanks to Vodafone and other signed partners.

The global subscriber growth rate correlates with equatorial growth rate. One notable exception is the 2024 YoY growth rate of almost 600%. This is caused by Phase 2 and Phase 3 launch of 90 satellites, scheduled for 2023-2024, increasing the coverage for rest of the world substantially.

From the average revenue per user and the number of expected users, what follows is AST's management original forward-looking income statement (in millions of USD) [27]:

AST's high EBITDA profit margin of up to 99% is realistic given the business model. Owning and operating a satellite communications company, and selling services that people want and need, is where the real money is in space. [275]

While we think that the revenue numbers projected by AST management are possible, our own projections are more conservative (see below).

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Revenue	0	0	181	1 070	2 625	5 812	9 655	12 391	14 086	16 445
Revenue growth	-	-	-	491 %	145 %	121 %	66 %	28 %	14 %	17 %
OpEx	-36	-47	-51	-56	-65	-81	-102	-116	-125	-138
EBITDA	-36	-47	130	**1 014**	2 560	5 731	9 554	12 275	13 960	16 307
CapEx	-123	-650	-928	0	0	-80	-632	-908	0	0
Free Cash Flow	-159	-697	-797	1 014	2 560	5 651	8 922	11 367	13 960	16 307

The green-highlighted CapEx represents the cost for buildup and launch of the Phase 1-4 of equatorial and global satellite constellation ($1.7B~).

The blue-highlighted CapEx represents construction and launch of additional "MIMO" satellites to grow with demand ($1.6B~).

The yellow-highlighted cell is the basis of valuation chosen by the NPA SPAC team before the reverse merger. (As you can see, if they selected a cell more to the right, the SPAC merger valuation would've been much higher. This is good for investors.)

For valuation purposes, the 2030 EBITDA ($16.3B) is the most important metric from above.

Transhumanica interactive AST valuation model

We created an interactive ASTS stock valuation model. It's embedded into this report (see below) and also hosted on our website.

We open-sourced it via GitHub, for the benefit of global investor community.

The model allows you to configure the following parameters based on your own views:

- EV/EBITDA multiple
- Number of projected subscribers
- Competitive pressure (what % of the projected subscribers will be lost to competition?)
- Regulatory hurdles (what % of the projected subscribers won't be reachable due to regulatory bottlenecks?)
- Revenue per subscriber
- Operational expenses
- Net debt or cash by 2030
- Shares outstanding (will the company have to dilute shares - OR - will they already start buying them back?)
- Risk of total failure
- Discount rate (also known as Hurdle Rate. What % return do you require from your investment? This determines today's fair value of the stock.)
- Initial stock price (to calculate CAGR upside; by default, it's the current market price)

We allow you to choose from a list of possible scenarios for each parameter based on your optimism or pessimism, and provide an explanation of what each scenario means. When changing the individual parameters, you can see how this affect the 2030 target price in real-time.

We recommend that you go through all options on every parameter to develop your understanding.

For each parameter, we suggest Transhumanica scenario, which is more conservative than AST management's scenario. When available, we also provide Deutsche Bank and Barclays scenarios as an option.

Finally, you can also set an entirely custom value for every parameter.

We plan to keep updating the model based on Transhumanica community feedback and new data as it emerges.

If you have suggestions for improvements of our model, please contact us at feedback@transhumanica.com

Transhumanica 2030 ASTS price target

Our 2030 ASTS price target is **$514**. At 20% discount rate, today's fair stock value is **$114**.

With an entry point at $12.00, the 2030 price target represents a 58% CAGR opportunity and 4,283% (42.8x) total return opportunity.

As of today, the market is significantly undervaluing and underestimating the company. Two large catalysts on the horizon, which could materially move the stock price, are successful BlueWalker-3 launch (est. mid-September 2022 [58]) and subsequent validation of the technology (which will be a multi-month process following the launch), and potentially a grant of subsidy from US 5G Fund (which could come unexpectedly).

⚠ We want to re-iterate that there is a non-zero risk of total failure of the company and thus a total loss of investor capital. For this reason, you should never allocate your whole portfolio to ASTS. In fact, never invest into "binary bets" like ASTS more than you can comfortably fully lose without it affecting your lifestyle. Finally, as a repeated friendly reminder, none of this is financial advice.

How we arrived at our price target is explained here and partially also in the interactive model.

Our ASTS stock valuation model: (Beta)

EV/EBITDA Multiple	22×	Neutral
OPEX (Operating Expenses)	$207M	Conservative
Projected Subscribers	476M	Conservative
Net Cash (Debt) by 2030	$0M	Neutral
Competitive Pressure	50%	Conservative
Shares Outstanding	210.867	Neutral
Regulatory Blockage	10%	Conservative
Risk of Total Failure	10%	Conservative
Revenue Per Subscriber	$2.21	Optimistic

Entry Stock Price

$ 10.01

Last closing market price from: Thu, 9/8/2022

$ASTS SpaceMobile stock predictions for 2030 based on your parameters:

Revenue	**$5.68B**
Operating costs	**$207M**
EBITDA profit margin	**96.4%**
EBITDA	**$5.47B**
EBITDA multiple	**22×**
Market Cap	**$120.42B**
Entry Stock Price	**$10.01**

Target Stock Price	**$514**
Upside until 2030	**5,034%**

💡 This is a simplified version of our ASTS stock valuation model. Open the full version.

Transhumanica scenario reasoning

Our EV/EBITDA is 22x, the methodology for deriving this value is explained above, in the "Determining the valuation multiple" section.

Our OpEx multiplier is 1.5x to account for future "talent wars". The space and satellite industry will get very competitive and grow much bigger in the future in our opinion. We also think that AST might have other strategic areas of focus than austerity in its OpEx, which represents only 1% of its projected revenue. While we believe the AST management to be competent, when institutions of any kind get vast profits rapidly, expenses tend to go up.

Our projected revenue per subscriber is in line with AST management. We don't see strong reasons to adjust the number up or down, and we believe the value of the service justifies the projected prices.

For our 2030 projected number of subscribers, we use the 2028 projection of AST management - thus a 24-month slowdown compared to the original AST management plan. The AST satellite network is currently delayed by about a year. Delays are to be expected in the space industry (and in deep tech / hardware and software engineering in general), so our 2 year delay estimate provides an additional buffer of security.

For the competitive pressure parameter, we conservatively use 50%, due to the newly expected competition from T-Mobile and Starlink and possibly new large players entering the market, which were presumably not accounted for by AST management in their original 2020 NPA SPAC presentation (p. 31) [231]. Depending on market developments, we think further revisions might be warranted, and reserve the right to update the model accordingly. Because our valuation model is fully interactive, you can easily adjust competitive pressure as you personally see fit to instantly calculate your own target price.

For regulatory hurdles, to get a safety margin, we conservatively project 10% overall roll-out slowdown to account for lower predictability of regulators in developing countries and the growing influence of China, which could possibly attempt to slow down AST in some jurisdictions in order to promote its own communication services instead.

For a risk of total failure, we estimate 10% to account primarily for risks of massively scaling up the technology, which we consider mostly proven on a small scale, and also unexpected (black swan) events.

We use a 20% discount rate. Given that AST is doing something that no one else did before, we think a high rate is fully justified. (The market currently offers a much deeper discount rate. Given our analysis, we believe the stock is undervalued and the discount offered is far too great.)

We estimate AST outstanding shares won't change on net by 2030. While we conservatively expect ASTs to issue new shares in the next couple of years to meet their funding and employee incentive needs, we also expect the company to initiate share buybacks later for a net zero change in shares outstanding by 2030 as compared to today.

About this report

This report was written by Futurician (Twitter: @futurician) et al. and published by Transhumanica Research LLC (Transhumanica.com, Twitter: @transhumanica) making it freely available online for everyone. (See the full disclaimer here: Disclaimer.)

Special thanks to Heahmund for writing the initial analysis draft and everyone on the Transhumanica team and the community (see Transhumanica Discord) for their invaluable contributions.

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This report is presented online using our own engine. The web version of the report supports dark mode and is compatible with various screen sizes, mobile devices and all major web browsers. Free PDF version is available for download as well.

The contents of the report is available for download on GitHub in plain-text Obsidian .md (markdown) format. You are welcome to submit content updates and edits - our team will review all submissions and do its best to incorporate all suitable submissions into future versions of this report.

Our accompanying ASTS interactive valuation model, which is a simplification of a complex future prediction, allows you to configure its various parameters according to your personal future scenario estimates. The ASTS interactive valuation model is also freely available on our GitHub and we welcome community contributions to it.

About Transhumanica

Transhumanica Research is an independent research firm and a community focused on highlighting select few companies with civilization-level impact which we feel are neglected by Wall Street relative to their potential.

Our long-term vision is to promote existential security and help team humanity thrive on its way towards the stars. To everyone working on that dream - THANK YOU!

This report is our first contribution to the global investment community.

We are currently working on a new research report for a company in an entirely different industry and are looking for enthusiastic independent analysts and researchers to collaborate with.

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Our Transhumanica Discord is currently open to new members. You can join for free.

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Contact us

You can contact us at feedback@transhumanica.com.

💡 If you just jumped at the end of this report to see a summary, go to the Highlights Section instead.

References

[1] https://www.gsma.com/mobileeconomy/wp-content/uploads/2022/02/280222-The-Mobile-Economy-2022.pdf

[2] https://www.weforum.org/agenda/2020/04/coronavirus-covid-19-pandemic-digital-divide-internet-data-broadband-mobbile/

[3] https://www.t-mobile.com/news/un-carrier/t-mobile-takes-coverage-above-and-beyond-with-spacex

[4] https://www.spaceitbridge.com/lynk-files-for-fcc-license-to-operate-cell-towers-in-space-next-year.htm

[5] https://www.sec.gov/Archives/edgar/data/1780312/000095017022010109/asts-ex99_1.htm

[6] https://uspto.report/patent/app/20220240151

[7] https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2022159894&_cid=P12-L6AM3F-57831-1

[8] https://twitter.com/AbelAvellan/status/1565113307954089985?s=20

[9] https://ast-science.com/2019/04/23/successful-launch-of-first-satellite/

[10] https://www.vodafone.com/news/technology/vodafone-ast-space-mobile-collaboration

[11] https://twitter.com/AST_SpaceMobile/status/1513589194903494659

[12] https://www.youtube.com/watch?v=GRvLA4YMhL8

[13] https://www.lightreading.com/satellite/ast-spacemobile-to-test-satellite-based-services-on-atandts-spectrum/d/d-id/777239

[14] https://www.fiercewireless.com/tech/nokia-inks-5-year-deal-ast-spacemobile

[15] https://www.youtube.com/watch?v=8Jt0EUxAy5E

[16] https://www.theguardian.com/technology/2019/jan/10/universal-internet-access-unlikely-until-2050-experts-say-lack-skills-investment-slow-growth

[17] https://en.wikipedia.org/wiki/Srinivasa_Ramanujan

[18] https://datareportal.com/global-digital-overview

[19] https://lynk.world/our-technology

[20] https://www.theverge.com/2022/3/22/22991841/spacex-starlink-price-hike-inflation-user-terminal

[21] https://www.satellitetoday.com/telecom/2022/04/10/ast-spacemobile-cso-details-companys-challenge-to-the-satellite-to-cell-paradigm/

[22] https://twitter.com/search?q=%24asts

[23] https://fcc.report/IBFS/SAT-LOI-20200413-00034/2257215

[24] https://www.youtube.com/watch?v=c4MQxMQuy-c

[25] https://podcasts.apple.com/us/podcast/kindredcast-insights-from-dealmakers-thought-leaders/id1223813619?i=1000457204297

[26] https://www.economist.com/science-and-technology/2020/03/07/a-new-firm-says-it-can-link-satellites-to-ordinary-smartphones

[27] https://npa-corp.com/wp-content/uploads/AST_SpaceMobile_Investor_Presentation_Public_12-15-20.pdf

[28] https://www.mordorintelligence.com/industry-reports/internet-of-things-moving-towards-a-smarter-tomorrow-market-industry

[29] https://www.sec.gov/Archives/edgar/data/1780312/000121390021004628/prer14a0121a1_newprovidence.htm

[30] https://www.business-live.co.uk/technology/500m-plan-satellite-calls-todays-20702481

[31] https://investors.ast-science.com/news-releases/news-release-details/ast-spacemobile-provides-fourth-quarter-and-full-year-2021

[32] https://nanoavionics.com/

[33] https://investors.ast-science.com/news-releases/news-release-details/ast-spacemobile-announces-agreement-sell-its-investment

[34] https://ast-science.com/2020/12/16/vodafone-and-ast-spacemobile-unveil-launch-plans/

[35] https://en.wikipedia.org/wiki/Adriana_Cisneros

[36] https://podcasts.apple.com/us/podcast/kindredcast-insights-from-dealmakers-thought-leaders/id1223813619?i=1000457204297

[37] https://www.adrianacisneros.com/back-to-space/

[38] https://www.forbes.com/sites/alexknapp/2020/03/03/this-satellite-startup-raised-110-million-to-make-your-cell-phone-work-everywhere/?sh=3981a5441e7f

[39] https://ast-science.com/2018/07/05/cisneros-investment/

[40] https://www.satellitetoday.com/telecom/2016/05/09/global-eagle-makes-550-acquisition-of-emc/

[41] https://finance.yahoo.com/amphtml/news/ast-ceo-avellan-wants-where-133119144.html

[42] https://twitter.com/VodafoneGroup/status/1234856557567004673

[43] https://rakuten.today/blog/rakuten-mobile-zero-yen-light-users.html

[44] https://www.vodacom.com/news-article.php?cid=SM_vdcm_9_crbr_2432&articleID=7592

[45] https://twitter.com/spacanpanman/status/1559389281701040128?s=20

[46] https://twitter.com/spacanpanman/status/1559389268614717442?s=20

[47] https://web.archive.org/web/20210511110353/https://ast-science.com/spacemobile/faqs/

[48] https://spacenews.com/operational-ast-spacemobile-satellites-could-proceed-without-prototype/

[49] https://spacenews.com/ast-spacemobile-books-more-spacex-rides-months-after-canceling-soyuz-reservation/

[50] https://arstechnica.com/science/2020/11/nasa-objects-to-new-megaconstellation-citing-risk-of-catastrophic-collison/

[51] NASA FCC comment - https://licensing.fcc.gov/myibfs/download.do?attachment_key=2765834https://licensing.fcc.gov/myibfs/download.do?attachment_key=2765834

[52] https://fcc.report/IBFS/SAT-PDR-20200413-00034/2266398

[53] https://spacenews.com/megaconstellation-startup-raises-110-million-to-connect-smartphones-via-satellite/

[54] https://twitter.com/AbelAvellan/status/1384336422765744129

[55] TechFreedom FCC comment - https://licensing.fcc.gov/myibfs/download.do?attachment_key=2770321https://licensing.fcc.gov/myibfs/download.do?attachment_key=2770321

[56] NRAO FCC comment - https://licensing.fcc.gov/myibfs/download.do?attachment_key=2862535https://licensing.fcc.gov/myibfs/download.do?attachment_key=2862535

[57] https://www.kookreport.com/post/spac-investing-npa-follow-up-how-to-frame-risks-industry-narrative-and-pro-forma-projections

[58] https://ast-science.com/2022/06/29/updated-bluewalker-3-launch-timing-september/

[59] https://smallbusiness.chron.com/far-can-cell-tower-cellphone-pick-up-signal-32124.html

[60] https://seekingalpha.com/article/4405139-npa-and-spacemobile-exciting-space-company-on-market

[61] https://ast-science.com/spacemobile/faqs/

[62] https://www.connectivity.technology/2020/04/ast-sciences-spacemobile-to-beam-4g-5g.html

[63] https://ecfsapi.fcc.gov/file/10061972201614/AST%205G%20Fund%20Ex%20Parte%2010-06-20%20(00168439xC33F1).pdf

[64] https://beta.documentcloud.org/documents/20418001-spacex-raising-valuation-scenarios-following-key-developments-october-22-2020-morgan-stanley-research

[65] https://fcc.report/IBFS/SAT-LOI-20200413-00034/2266398

[66] https://licensing.fcc.gov/myibfs/download.do?attachment_key=2511994

[67] https://ast-science.com/2021/05/04/ast-spacemobile-expands-management-with-new-hires/

[68] https://twitter.com/VodafoneEmpresa/status/1234910036645818368

[69] https://www.sec.gov/Archives/edgar/data/1780312/000121390020042898/ea131629ex99-1_newprovidence.htm

[70] https://icrinc.zoom.us/webinar/register/WN_M22qOp8sSVSjxDldT4gQ-w

[71] https://www.satellitetoday.com/broadband/2020/03/18/startup-lynk-claims-first-ever-leo-to-cell-message/

[72] https://www.lightreading.com/test-and-measurement/lynk-scores-big-win-in-global-space-race/d/d-id/758312

[73] https://space.skyrocket.de/doc_sdat/bluewalker-1.htm

[74] https://www.businesswire.com/news/home/20220309005369/en/AST-SpaceMobile-Announces-Multi-Launch-Agreement-With-SpaceX-for-Planned-Direct-to-Cell-Phone-Connectivity

[75] https://twitter.com/AbelAvellan/status/1504920229868101639

[76] https://www.n2yo.com/?s=44105

[77] https://www.reddit.com/r/SPACs/comments/mkbgi9/asts_npa_notes_from_meeting_with_abel_avellan_ceo/

[78] https://twitter.com/AbelAvellan/status/1535364704264241155

[79] https://rkf-eng.com/leadership/

[80] https://www.adrianacisneros.com/ast-spacemobile/

[81] https://www.cnbc.com/2020/12/16/ast-science-going-public-through-spac-at-1point8-billion-valuation.html

[82] https://twitter.com/nomadbets/status/1565556835196829696

[83] https://www.kookreport.com/post/spac-investing-ast-science-asts-deutsche-bank-initiation

[84] https://www.reuters.com/article/global-companies-founders-idUSKBN2741U5

[85] https://seekingalpha.com/article/4534655-ast-spacemobile-inc-asts-ceo-abel-avellan-on-q2-2022-results-earnings-call-transcript

[86] https://en.wikipedia.org/wiki/Space_launch_market_competition#2010s:_Competition_and_pricing_pressure

[87] https://www.spacex.com/launches/

[88] https://investors.ast-science.com/news-releases/news-release-details/ast-spacemobile-announces-multi-launch-agreement-spacex-planned

[89] https://nanoavionics.com/nanosatellite-buses/16u-nanosatellite-bus-m16p-m16p-r/

[90] https://spacebusiness.podbean.com/e/vytenis-buzas-nanoavionics-satellites/

[91] https://www.businesswire.com/news/home/20220506005266/en/AST-SpaceMobile-Announces-75-Million-Committed-Equity-Facility

[92] https://transhumanica.com/asts/model

[93] https://www.reddit.com/r/ASTSpaceMobile/comments/owc4v9/size_and_proportions_of_ast_space_mobile_bluebird/

[94] https://www.mondaq.com/unitedstates/telecoms-mobile-cable-communications/1000454/fcc-establishes-9-billion-fund-to-support-5g-services-in-rural-america

[95] https://ast-science.com/2020/11/19/senate-supports-next-gen-satcom/

[96] https://ecfsapi.fcc.gov/file/10625281047702/Comments%20of%20AST%20%20%20Science%20on%20the%205G%20Fund%20NPRM%20(00163715xC33F1).pdf

[97] https://licensing.fcc.gov/myibfs/download.do?attachment_key=2994406

[98] https://www.reuters.com/world/us/us-rejects-broadband-subsidies-spacexs-starlink-ltd-2022-08-10/

[99] https://licensing.fcc.gov/cgi-bin/ws.exe/prod/ib/forms/reports/related_filing.hts?f_key=-441408&f_number=SATPDR2020041300034

[100] https://investors.ast-science.com/node/7716/pdf

[101] FCC comments - http://licensing.fcc.gov/cgi-bin/ws.exe/prod/ib/forms/reports/related_filing.hts?f_key=-441408&f_number=SATPDR2020041300034http://licensing.fcc.gov/cgi-bin/ws.exe/prod/ib/forms/reports/related_filing.hts?f_key=-441408&f_number=SATPDR2020041300034

[102] https://fcc.report/company/AST-Science

[103] https://twitter.com/CatSE___ApeX___/status/1555139326631190529

[104] AST FCC consolidated response - https://licensing.fcc.gov/myibfs/download.do?attachment_key=2791876https://licensing.fcc.gov/myibfs/download.do?attachment_key=2791876

[105] NASA FCC second comment - https://licensing.fcc.gov/myibfs/download.do?attachment_key=2858625https://licensing.fcc.gov/myibfs/download.do?attachment_key=2858625

[106] https://www.echostar.com/en.aspx

[107] https://www.echostar.com/solutions/satelliteservices.aspx

[108] https://www.echostar.com/solutions/hughes.aspx

[109] https://echostarmobile.com/

[110] T-Mobile FCC comment - https://licensing.fcc.gov/myibfs/download.do?attachment_key=2770347https://licensing.fcc.gov/myibfs/download.do?attachment_key=2770347

[111] https://licensing.fcc.gov/myibfs/download.do?attachment_key=2882132

[112] https://www.fcc.gov/about-fcc/fcc-initiatives/bridging-digital-divide-all-americans

[113] Myanmar Internet Blackout - https://www.bbc.com/news/world-asia-55960284https://www.bbc.com/news/world-asia-55960284

[114] India Internet Blackout - https://fortune.com/2021/02/05/india-internet-shutdown-protests-backlash/https://fortune.com/2021/02/05/india-internet-shutdown-protests-backlash/

[115] http://www.satmagazine.com/story.php?number=1191104417

[116] https://www.reddit.com/r/ASTSpaceMobile/comments/o3b0xv/permits_for_equatorial_constellation_a_catalyst/

[117] https://www.operatorwatch.com/2021/05/ethiopia-to-get-new-mobile-network.html

[118] https://eca.et/wp-content/uploads/2021/05/Press-Release-New-Telecom-License.pdf

[119] https://www.businesswire.com/news/home/20210706005405/en/AST-SpaceMobile-Announces-Collaboration-with-Smart-Communications/

[120] Internet From Space – DW Documentary, 11:00 - https://youtu.be/IsqSwMsI_mc?t=660https://youtu.be/IsqSwMsI_mc?t=660

[121] https://www.avantiplc.com/wp-content/uploads/2020/09/GEO-vs-LEO_Quick-Facts_Avanti-Communications.pdf

[122] https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/large-leo-satellite-constellations-will-it-be-different-this-time

[123] https://en.wikipedia.org/wiki/Moore%27s_law

[124] https://en.wikipedia.org/wiki/Experience_curve_effects

[125] https://rameznaam.com/2020/05/14/solars-future-is-insanely-cheap-2020/

[126] https://www.fiercewireless.com/wireless/lightsquared-rebrands-as-ligado-networks-but-spectrum-plans-remain-cloudy

[127] https://www.gps.gov/spectrum/lightsquared/

[128] https://spacenews.com/inmarsat-expects-tidy-profit-lightsquared-spectrum-deal/

[129] https://spectrum.ieee.org/riskfactor/telecom/internet/lightsquared-network-faces-interference-of-its-own-making

[130] https://spectrum.ieee.org/tech-talk/telecom/wireless/final-blow-for-lightsquared

[131] https://insidegnss.com/lightsquared-gets-two-week-extension-on-gps-interference-report-congressman-calls-on-fcc-to-rescind-waiver/

[132] https://aviationweek.com/aerospace/opinion-ligado-lightsquared-fiasco-20

[133] https://www.fcc.gov/document/spokesperson-statement-ntia-letter-lightsquared-and-gps

[134] https://www.reuters.com/article/us-lightsquared-bankruptcy-idUSKBN0TR2QL20151209

[135] https://licensing.fcc.gov/myibfs/download.do?attachment_key=3874004

[136] https://spacenews.com/fcc-gets-five-new-applications-for-non-geostationary-satellite-constellations/

[137] https://eandt.theiet.org/content/articles/2020/11/starlink-launches-60-more-satellites-but-commercial-service-faces-delays/

[138] https://en.wikipedia.org/wiki/TerreStar_Networks

[139] https://www.amazon.com/TerreStar-GENUS-Windows-Satellite-Phone/dp/B004U280BK

[140] https://www.barcodegiant.com/terrestar/part-tsnaccext.htm

[141] https://www.sec.gov/Archives/edgar/data/913665/000119312509052330/d10k.htm

[142] https://www.fiercewireless.com/wireless/terrestar-files-for-bankruptcy

[143] https://www.youtube.com/watch?v=zUm3PyiLU0E

[144] https://www.arianespace.com/mission-update/terrestar-1-is-fueled-for-arianespaces-upcoming-heavy-lift-ariane-5-flight/

[145] https://www.spacedaily.com/news/orbcomm-01a.html

[146] http://content.time.com/time/specials/packages/article/0,28804,1898610_1898625_1898640,00.html

[147] https://www.nytimes.com/1999/08/28/business/two-weeks-later-ico-follows-iridium-into-bankruptcy-court.html

[148] https://www.nytimes.com/2003/01/16/business/globalstar-bankrupt-satellite-company-to-be-sold-for-55-million.html

[149] https://www.amazon.com/Eccentric-Orbits-Iridium-John-Bloom/dp/0802126782/

[150] https://www.vodafone.com/news/press-release/vodafone-and-ast-spacemobile-unveil-launch-plans-space-based-mobile-network-initially-reaching-16

[151] https://www.vodafone.co.uk/help-and-information/about-us

[152] https://www.spaceitbridge.com/ast-science-lands-100m-round-for-satellite-cell-towers.htm

[153] https://www.telcotitans.com/vodafonewatch/altiostar-flagged-as-supplier-for-vodafone-partner-ast-spacemobile/2686.article

[154] https://www.businesswire.com/news/home/20220331005952/en/AST-SpaceMobile-Provides-Fourth-Quarter-and-Full-Year-2021-Business-Update

[155] https://twitter.com/CatSE___ApeX___/status/1553681233724555265?s=20

[156] https://twitter.com/satorimind/status/1345484826766438405?s=20

[157] https://spacenews.com/space-industry-in-midst-of-transformation-following-record-private-and-public-investments/

[158] https://www.cnbc.com/2021/01/13/cathie-woods-ark-invest-plans-space-exploration-etf-arkx.html

[159] https://ark-invest.com/strategy/space-exploration/

[160] https://finance.yahoo.com/news/7-stocks-fit-cathie-woods-173506543.html

[161] https://seraphim.vc/portfolio/

[162] https://procureetfs.com/ufo/

[163] https://www.arktrack.com/

[164] https://cathiesark.com/

[165] https://www.youtube.com/watch?v=tOpPd1JWcpA&t=1875s&ab_channel=CboeGlobalMarkets

[166] https://investors.ast-science.com/node/7806/html

[167] https://research.ftserussell.com/products/downloads/Russell-US-indexes.pdf

[168] https://ast-science.com/2018/03/06/nanoavionics-investment/

[169] https://www.aerospacetestinginternational.com/news/space/nanosatellite-maker-nanoavionics-to-open-new-factory-in-the-uk.html

[170] https://www.linkedin.com/company/nanoavionika-uab/

[171] https://www.youtube.com/watch?v=7E8zibL__zc&feature=emb_logo

[172] https://www.geospatialworld.net/news/nanoavionics-built-satellite-for-aurora-insight-to-fly-on-spacexs-transporter-1-mission/

[173] https://www.nanosats.eu/org/nanoavionics

[174] https://stocktwits.com/SPACtori/message/270846740

[175] https://twitter.com/spacanpanman/status/1405014779228532736?s=20

[176] https://urgentcomm.com/2020/03/19/lynk-claims-successful-test-of-satellite-to-cell-phone-communications-cites-potential-public-safety-value/

[177] https://www.theverge.com/2020/3/18/21184126/lynk-mega-constellation-text-message-android-smartphone-cell-towers-space

[178] https://www.theverge.com/2019/8/2/20746947/ubiquitilink-satellite-cell-tower-space-mega-constellation

[179] http://www.satmagazine.com/story.php?number=1127710956

[180] https://www.wired.com/story/your-phone-may-soon-receive-4g-service-from-space/

[181] https://open.spotify.com/episode/32FzFAqH10P3CScCdXkuqC

[182] https://www.satellitetoday.com/innovation/2020/03/30/lynk-co-founder-says-satellite-to-cell-tech-will-be-bigger-than-5g/

[183] https://www.lightreading.com/mobile/4g-lte/this-tiny-startup-could-connect-your-smartphone-directly-to-a-satellite/d/d-id/750074?f_src=lightreading_editorspicks_rss_latest

[184] https://spacenews.com/ubiquitilink-has-raised-12-million-for-communications-constellation/

[185] https://lynk.world/lynk-signs-contract-with-mongolias-largest-mobile-network-operator

[186] https://www.geekwire.com/2019/ubiquitilink-wins-5-2m-boost-satellite-service-works-standard-phones/

[187] https://spacenews.com/second-commercial-lynk-global-satellite-still-looking-for-launch/

[188] https://www.newspace.im/constellations/lynk

[189] https://www.mobileworldlive.com/latest-stories/interview-ubiquitilink/

[190] https://techcrunch.com/2019/02/25/ubiquitilink-advance-means-every-phone-is-now-a-satellite-phone/

[191] https://mobileinsights.mobileworldlive.com/mwc19-dailies/ubiquitilink-sends-cell-tower-to-space/

[192] https://lynk.world/our-partners

[193] https://www.citybiz.co/article/288831/lynk-global-raises-undisclosed-amount-from-virginia-venture-partners/

[194] https://sateliot.space/sateliot-will-connect-with-5g-iot-secure-information-exchange-devices-for-banks-governments-and-security-agencies/

[195] https://sateliot.space/spanish-sateliot-to-connect-nanosats-and-iot-with-5g/

[196] https://sateliot.space/the-smallsat-space-race/

[197] https://sateliot.space/sateliot-joins-the-gsma-in-promoting-the-democratization-of-the-iot-through-satellite-technology/

[198] https://www.newspace.im/constellations/sateliot

[199] https://www.mobileworldlive.com/featured-content/top-three/softbank-targets-low-cost-hapsmobile-services

[200] https://www.hapsmobile.com/en/

[201] https://www.hapsmobile.com/en/news/press/2022/20220622_01/

[202] https://www.bloomberg.com/news/articles/2019-12-20/apple-has-top-secret-team-working-on-internet-satellites

[203] https://www.newspace.im/

[204] https://arstechnica.com/information-technology/2021/02/spacex-plans-starlink-phone-service-emergency-backup-and-low-income-access/

[205] https://www.youtube.com/watch?v=qU3klIvy0CU

[206] https://www.pcmag.com/how-to/starlink-starter-kit-how-to-get-it-and-set-it-up

[207] https://www.pcmag.com/news/spacex-has-been-selling-starlink-dishes-at-a-huge-loss-despite-499-price

[208] https://twitter.com/elonmusk/status/1369051431903268865

[209] https://www.teslarati.com/elon-musk-starlink-internet-phone-service-confirmed/

[210] https://twitter.com/satorimind/status/1413130515864031232?s=20

[211] https://www.tomsguide.com/news/starlink-internet-speed-cost-coverage-map-and-everything-you-need-to-know

[212] https://sundries.com.ua/en/spacex-unveiled-a-250-backpack-for-transporting-starlink-saucers/

[213] https://www.youtube.com/watch?v=yOFm79rXKGM

[214] https://www.youtube.com/watch?v=lEUmgoTTupQ

[215] https://twitter.com/1stMarsColonist/status/1552544777077268485?s=20

[216] https://www.cnbc.com/2021/11/10/shift4-stock-surges-after-spacex-starlink-payments-deal.html

[217] https://www.theverge.com/2022/8/27/23324128/t-mobile-spacex-satellite-to-phone-technology-ast-lynk-industry-reactions-apple

[218] https://twitter.com/spacecasetayl0r/status/1563153083542016000

[219] https://twitter.com/nomadbets/status/1565556254428241920

[220] https://www.cnbc.com/2021/08/09/spacex-acquiring-satellite-data-start-up-swarm-technologies.html

[221] https://www.cnbc.com/2022/08/05/elon-musks-spacex-raises-250-million-in-equity.html

[222] https://sec.report/Document/0000950170-22-005980/

[223] https://www.macrumors.com/2022/08/26/apple-globalstar-iphone-14-satellite-rumor/

[224] https://oneweb.net/resources/oneweb-resume-satellite-launches-through-agreement-spacex

[225] https://www.space.com/spacex-oneweb-satellite-internet-constellation-coexistence

[226] https://www.tesla.com/blog/all-our-patent-are-belong-you

[227] https://aerospace.csis.org/data/space-environment-total-payloads-launched-by-country/

[228] https://www.spacex.com/human-spaceflight/mars/

[229] https://www.spacex.com/mission/

[230] https://www.forbes.com/sites/moorinsights/2022/09/02/t-mobile-and-spacexs-satellite-partnership-paves-the-way-for-real-use-of-satellite-in-5g/

[231] http://npa-corp.com/wp-content/uploads/AST_SpaceMobile_Investor_Presentation_Public_12-15-20.pdf

[232] https://www.investopedia.com/news/how-spacex-reinvented-rocket-launch-industry/

[233] https://astronomy.com/news/2021/06/how-do-starlink-satellites-actually-work

[234] https://interestingengineering.com/innovation/starlink-to-double-satellites

[235] https://www.govtech.com/news/amazon-internet-program-project-kuiper-to-launch-satellite.html

[236] https://www.bbc.com/news/science-environment-55016402

[237] https://www.oneweb.world/technology

[238] https://uk.news.yahoo.com/oneweb-takes-230-million-hit-150710293.html

[239] https://www.cnbc.com/2021/02/09/telesat-building-5-billion-lightspeed-global-satellite-internet.html

[240] https://www.telesat.com/leo-satellites/

[241] https://en.wikipedia.org/wiki/Telesat

[242] https://swarm.space/our-technology/

[243] https://swarm.space/3-ways-low-cost-satellite-data-is-supercharging-agtech-iot-companies/

[244] https://www.spaceitbridge.com/the-2018-summer-of-satellite-iot-18-startups-over-1600-satellites.htm

[245] https://en.wikipedia.org/wiki/Iridium_Communications

[246] https://www.iridium.com/

[247] https://www.satphone.co.uk/product/iridium-9555-satellite-phone-handset/

[248] https://en.globalsat.us/collections/satellite-mobile-phone/products/iridium-9555-1

[249] https://en.globalsat.us/collections/satellite-mobile-phone/products/iridium-go

[250] https://satellitephonestore.com/service-iridium-go

[251] https://support.google.com/youtube/answer/78358?hl=en

[252] https://datareportal.com/reports/6-in-10-people-around-the-world-now-use-the-internet

[253] https://www.reuters.com/article/telecoms-mobileworld-starlink-idCNL2N2OB1OE

[254] https://www.imf.org/external/pubs/ft/fandd/2021/03/africas-digital-future-after-COVID19-duarte.htm

[255] https://www.statista.com/statistics/205966/world-carbon-dioxide-emissions-by-region/

[256] https://profuturo.education/en/topics/digital-education-to-change-the-future-of-africa/

[257] https://datareportal.com/reports/digital-2021-july-global-statshot

[258] https://www.brookings.edu/techstream/the-promises-and-perils-of-africas-digital-revolution/

[259] https://www.visualcapitalist.com/cost-of-mobile-data-worldwide/

[260] https://www.flickr.com/photos/jurvetson/51391518506

[261] https://www.cnbc.com/2021/01/31/5g-spectrum-auction-bids-total-80point9-billion-winners-revealed-soon.html

[262] https://finance.yahoo.com/quote/MA/key-statistics?p=MA

[263] https://investors.ast-science.com/static-files/69a8ada5-411a-4d89-af88-8ecab6dd808b

[264] https://www.sec.gov/Archives/edgar/data/1780312/000149315221016095/form424b3.htm

[265] https://www.gurufocus.com/term/ev2ebitda/irdm/EV-to-EBITDA

[266] https://www.gurufocus.com/term/ev2ebitda/amt/EV-to-EBITDA

[267] https://www.vertex42.com/ExcelArticles/discount-factors.html

[268] https://www.youtube.com/watch?v=z3D2gh_IyXg

[269] https://www.viasat.com/home-internet/faq/satellite-installation/

[270] https://www.eutelsat.com/files/PDF/investors/2020-21/FY%202020-21_Presentation_vfinal_web.pdf

[271] https://investors.orbcomm.com/news/news-details/2021/ORBCOMM-Announces-First-Quarter-2021-Results/

[272] https://advanced-television.com/2021/07/12/intelsat-bankruptcy-exit-plan-adjourned/

[273] https://investors.ast-science.com/news-releases/news-release-details/ast-spacemobile-provides-second-quarter-2021-business-update

[274] https://www.un.org/sustainabledevelopment/blog/2015/07/un-projects-world-population-to-reach-8-5-billion-by-2030-driven-by-growth-in-developing-countries/

[275] https://spacenews.com/op-ed-the-revolution-that-is-commercial-space-is-just-beginning/