

## **Astra Space, Inc (ASTR)** ***Headed for Dis-Astra***

We are short shares of Astra Space, a \$2.0bn space launch company formed at the peak of the 2021 SPAC bubble – with no revenue, no track record of reliability, and no established market for its undersized vehicle. A story stock that's yet another example of the questionable businesses going public via SPACs, Astra faces massive obstacles in its quest to develop a viable business model.

Astra is poorly positioned within an overcrowded market for small launch vehicles. Its main competitors will soon be launching larger 1,000kg+ payload rockets while Astra has yet to overcome developmental hurdles necessary to successfully launch even a single satellite into any of the emerging broadband mega-constellations. Shortly after Astra announced its SPAC merger, the company increased its payload capacity goal (not a trivial matter in rocket programs) and signed a “secret” [deal](#) with a competitor for access to some of the competitor's more powerful engine IP – both clear signs that Astra is struggling to keep pace with market leaders. Moreover, Astra shortsightedly relies on cheap, off-the-shelf commercial parts – a strategy that precludes it from exploiting the economic advantages that its more sophisticated competitors enjoy by developing reusable rockets that in the long run reduce expenses. Consequently, Astra remains strikingly vulnerable to the relentless price deflation that characterizes today's launch market.

Astra's investor pitch boils down to selling the pipedream of an unprecedented number of cheap rocket launches. Astra's forecast calls for *300 launches per year by 2025*, a whopping 10x more than SpaceX achieved in 2021. Management markets this exceptionally aspirational goal (which we view as pure fantasy) in a bid to spread its expensive Bay Area manufacturing costs over enough rockets in order to turn a profit. A reality check is in order: *To date, Astra has managed just one successful orbital test flight.* If Astra's five-year projection of almost daily successful launches of rockets made with non-aerospace grade parts does not sound improbable enough, it ignores an even graver problem with Astra's projection – not one expert whom we interviewed, nor any independent market study we reviewed, offered any reason to think that, industry-wide, sufficient market demand will exist for Astra to sustain approximately daily launches by 2035, let alone 2025.

From an execution standpoint, Astra is already exhibiting tell-tale signs of a company that'll never fulfill its cosmic promises. FY21 EBITDA guidance of negative \$(110)m is -35% lower than projected at the start of the year. Post-merger cash on hand – originally touted as sufficient to fully fund the company until daily launch in 2025 – is now only enough to cover monthly launches in 2023, meaning Astra will almost certainly need to tap the capital markets in the upcoming year. We're skeptical that public investors will stick around at the current valuation to underwrite Astra's tenuous business prospects, and the lock-up expiry of 91m shares tomorrow could result in near-term volatility. As Astra encounters inevitable setbacks, hemorrhaging cash in hopes of developing a rocket that is undersized and lacking demand, its shares valued at the height of the SPAC boom should tumble further to the ground.

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## Executive Summary

**Astra's rocket launch projections are nonsense.** No market analysis supports Astra's planned 300+ launches by 2025. Excluding satellites from SpaceX and China from industry-wide forecasts, there is insufficient demand to support even a fraction of Astra's aggressive forecast. Large launch vehicles are a more efficient and cost-effective solution to deploying whole orbital planes versus piecemealing coverage through a series of small launches and will dominate the market for mega-constellations (which are widely expected to comprise the bulk of all satellites deployed over the next decade). Only scraps will remain for Astra and all the other smaller launchers – far less than Astra needs to turn a profit.

**Astra is falling behind its competitors.** Multiple industry executives we interviewed, who routinely secure launch services for small satellite manufacturers on a global basis, agree that Astra's rocket dimensions and payload capacity are well below the "sweet spot" of customer needs. Rocket Lab, Relativity, ABL, and Firefly all have plausible plans to produce 1,000kg+ rockets that will be entering the market in the near term; by contrast, Astra aspires to produce a 500kg rocket *two years from now*. Astra's attempt to catch up is self-evident. Shortly after its SPAC announcement, Astra publicly disclosed (without any credible technological explanation) an increase in the targeted capacity of its rockets; shortly thereafter, and surely to Astra's embarrassment, the public learned that Astra had entered into an agreement allowing it limited access to study one of its competitor's rocket engine IP in exchange for \$30m.

**Expect many more failures as Astra ramps up its launch efforts.** Astra is playing a risky game. It needs to ramp production and prove reliability of a cheaply built rocket while maintaining access to public markets to fund cash burn. We believe Astra's reliability goal for its rockets is 80% (which itself is not exactly confidence inspiring). According to a well-informed source, however, at its *current* stage of development, the rate of Astra's rockets failing may be as high as 1 in 2. Should Astra encounter even one high-profile failure, considerable damage to Astra's reputation and development plans seems inevitable.

**Six months into public life and Astra has already missed expectations.** Like many other 2021 vintage SPACs, Astra has already badly missed its financial forecasts, and will likely continue to do so. 2021 EBITDA will come in -35% below original SPAC forecasts, and even with the benefit of delayed capex, Astra is burning cash at a rate of \$50-\$60m *per quarter*. Even only 5 months after closing a deal that placed nearly \$500m of cash on Astra's balance sheet, the company has already walked back "being fully funded to 2025" and instead indicated it will only have enough cash to get through sometime in 2023.

**Astra's strategic direction lacks differentiation and raises concerns.** Recent M&A and a broadband constellation announcement smack of trying to run SpaceX's playbook – but without any of SpaceX's resources and without having first established basic launch reliability. Apollo Fusion technology is too slow to be an attractive orbital transfer vehicle in LEO and ferrying small satellites to GEO and beyond is a nascent, niche market. If the objective is to use Apollo Fusion for Astra's own constellation, as contemplated by the company's recent V-band application, investors should be questioning the purpose of a costly mega-constellation that is years behind Starlink, Project Kuiper, OneWeb, and Telesat.

**The Space SPAC boom has bust.** Of the 8 new space SPAC mergers that have closed in the last 6 months, 7 are trading below the SPAC IPO price, with an average decline (excluding Astra) of -38%. Astra's market capitalization is still over \$2bn despite a business model more

unproven than many of its space SPAC peers. On December 30<sup>th</sup>, 91.2m shares unlock, twice the current float, posing additional downside risk in an unforgiving tape for pre-revenue speculative stocks.

## Company Overview

Astra's Market Capitalization and Summary Financial Forecast							
Capitalization (as of 9/30/21)		Financial Summary (\$ mm)					
Share price (\$)	\$8.00	Revenue	2021E	2022E	2023E	2024E	2025E
Diluted shares (mm) <sup>(1)</sup>	280		\$ 1	\$ 48	\$ 110	\$ 230	\$ 425
Fully diluted market cap (\$mm)	\$ 2,242	Adj. EBITDA (ex. SBC)	(110)	(139)	(107)	(32)	130
Total debt	-	Capex	(36)	(65)	(70)	(65)	(27)
Less: cash	(379)	Free cash flow	(146)	(204)	(177)	(97)	103
Enterprise value	\$ 1,864	Operating Base	\$ 111	\$ 187	\$ 217	\$ 262	\$ 295
EV / '22E Revenue	39.2x						
EV / '23E Revenue	16.9x						

*Source: Company filings, Kerrisdale estimates.*

1. Includes: 202m Class A common stock, 56m Class B common stock, 11m shares available under 2021 Omnibus Incentive Plan, 9m RSU under the 2021 Plan, and 2.2m dilutive effect of stock options under treasury stock method.

Founded in 2016 by Chairman and CEO Chris Kemp and CTO Adam London, Astra is a launch service provider that purports to provide small satellite (“smallsat”) manufacturers and operators with inexpensive, frequent, and precise deployment of satellites to required orbits. Astra operates a class of rockets with sub-2,000kg payload capacities known as small-lift launch vehicles (a.k.a. small launchers). Astra’s headquarters and primary manufacturing facility is in Alameda, California. Astra has never generated any revenue and has no track record of reliability – to date, just one of seven of Astra’s attempted rocket launches has reached orbit, and that was after a series of notable failures.

Astra's Launch History				
Date	Rocket Version	Serial Number	Status	Comment
7/20/2018	Rocket 1	LV0001	Fail	Anomaly suffered after 27s, landed within spaceport
11/29/2018	Rocket 2	LV0002	Fail	Vehicle aborted after 30s, landed on spaceport property
3/23/2020	Rocket 3.0	LV0003	Fail	Destroyed by fire during launch preparation
9/12/2020	Rocket 3.1	LV0004	Fail	Flight terminated as rocket drifted off course, exploding inland
12/15/2020	Rocket 3.2	LV0005	Fail	Reached space but ran out of fuel before achieving orbit
8/28/2021	Rocket 3.3	LV0006	Fail	Engine failure led to horizontal drift, flight terminated T+02:28
11/22/2021	Rocket 3.3	LV0007	Success	First successful attempt at reaching orbit

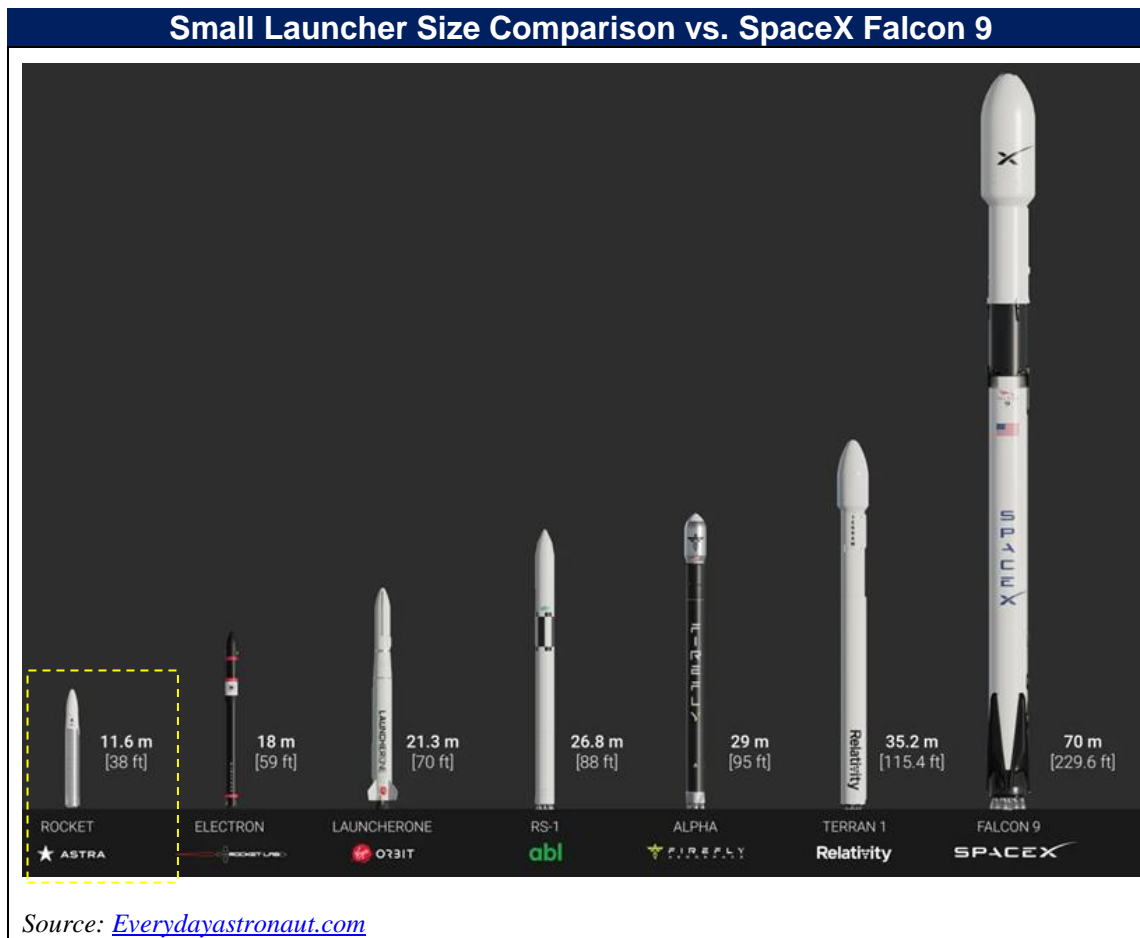
*Source: Kerrisdale research.*

Thanks both to reduced launch costs pioneered by SpaceX’s Falcon 9 program and advancements in smallsat manufacturing, the coming decade will witness the deployment of

thousands of new Low Earth Orbit (LEO) satellites into orbit per year, particularly as part of new broadband communications constellations like SpaceX’s Starlink and Amazon’s Project Kuiper.

Seeking to disrupt historical reliance on larger, more costly rockets, Astra is one of over [100](#) small launchers in various stages of development and funding that have sprouted up in recent years to better serve the perceived demand from smallsats for smaller, dedicated launch vehicles. While the number of smallsats in orbit over the coming years is sure to rise, Astra faces difficult and unresolved [questions](#) regarding the viability of small launch providers. Larger launch providers are responding to smallsat demand by offering increasingly [frequent rideshare](#) missions, where many satellites (the record is [134](#) held by SpaceX) from multiple operators are launched on a single rocket at a fraction of the price quoted by small launchers.

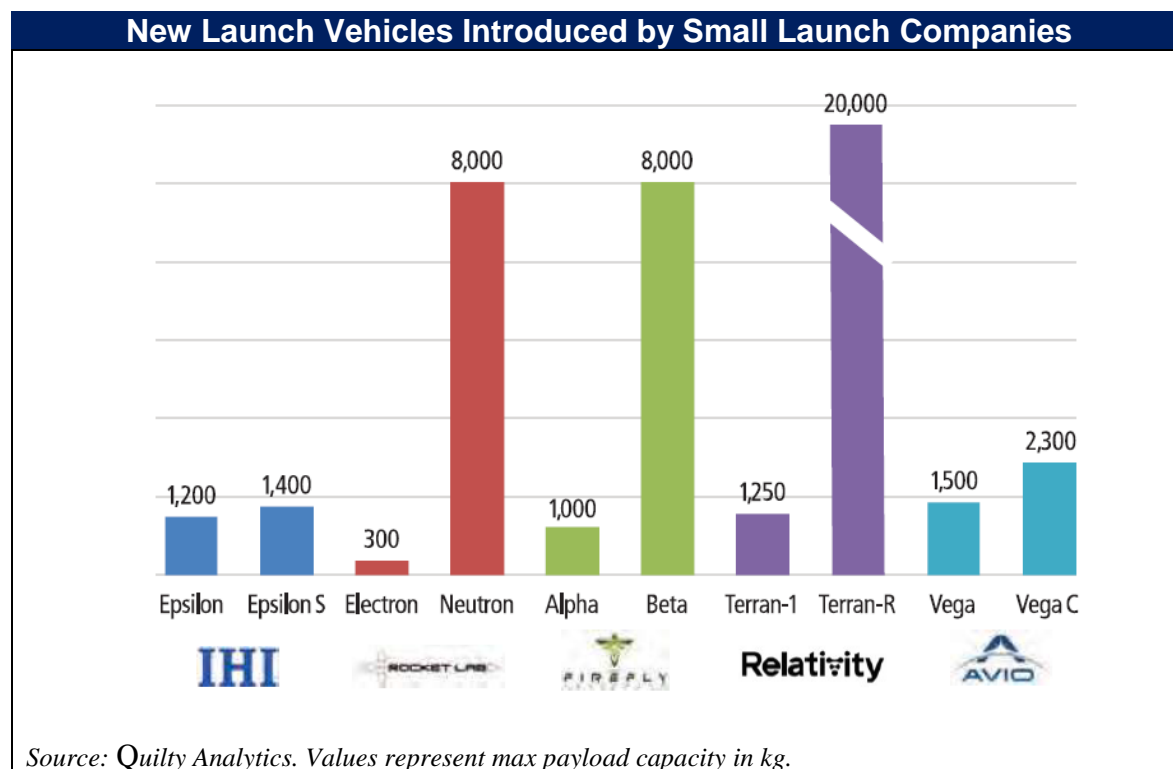
As we detail later in the report on page 9, only a small subset of the projected number of satellites launched through the end of the decade are not already accounted for as part of constellations with in-house launch capabilities. SpaceX’s 850+ Starlink satellites in 2020, for example, represented 70% of the market<sup>1</sup> and Chinese and Russian satellites are effectively un-launchable for US operators due to regulatory restrictions. The fact that an overwhelming number of the satellites to be launched are part of large constellations, with potentially hundreds of assets in a single orbital plane, limits the usefulness of vehicles that can only launch one or a small handful at a time.



<sup>1</sup> Source: Northern Sky Research, *Global Satellite Manufacturing and Launch Markets 11<sup>th</sup> Edition*, July 2021.

The significant and largely immutable limitations are especially pronounced for Astra, as its rockets are small even by small launcher standards – with a product development path that still places it significantly below the payload capacities of its competitors.

Astra has said its next-generation Rocket 4.0 will have a payload capacity of [around 150kg](#) in 2022. By late 2023, Astra hopes to improve on this with a 500kg payload to 500km LEO. Astra has never met any of its own projections, so we are naturally skeptical that Astra will come close to achieving its stated goals for either 2022 or 2023. Even if Astra were to meet its targets, however, those goals leave us underwhelmed – they still represent only half of the targeted lift capabilities of Astra’s small launch competitors such as [ABL Space Systems](#), [Firefly Aerospace](#), [Rocket Lab](#), and [Relativity Space](#), all of which are developing rockets with payloads far in excess of 1,000kg.



The reality is that Astra operates in a highly competitive, global launch industry and the company’s capabilities and go-to market strategy are not unique. All small launchers market their services as affordable, flexible to customer schedules, tactically responsive and able to bring a customer’s satellite directly to a desired orbit. The ability to mobilize a launch quickly “from anywhere” using standard shipping containers and a minimum of personnel is also not unique to Astra, with [ABL](#) and Virgin Orbit’s [LauncherOne](#) emphasizing similar ease of deployment. Astra’s goal of moving beyond just launch to providing a “modular spacecraft platform” and turnkey space services are objectives shared by all small launchers who have studied SpaceX’s playbook (and Orbital Science’s from the 1990s), with Rocket Lab currently distancing itself from peers.

Astra’s core business model is predicated on an ambitious, unprecedented, and frankly unrealistic launch cadence – from monthly launches in 2022, to weekly launches in 2023, to daily launches in 2025. For context, consider that in 2021, [SpaceX](#) set a record with 31 orbital

launches. By using manufacturing processes which allow the production of hundreds of rockets per year (some of which Astra anticipates will explode or otherwise fail to perform as intended) and relying on commercial off-the-shelf components, Astra's business model is to drive economies of scale, lower production costs, and target customers at the lower end of the smallsat market who theoretically are willing to accept lower reliability for a lower price. The manufacturing infrastructure and skillset needed to pull off this incredible volume of rocket production is still in development and apparently encountering setbacks. The delayed start to building out its factory has shifted \$60m in capex originally slated for 2021 into 2022-2023. Of the roughly 125 [job openings](#) on the company's website, 87 are related to manufacturing, engineering, production management, etc.

Despite (or because of?) the lack of proven market demand, business model, launch reliability, production capability, and competitive differentiation, in February of this year Astra announced a plan to go public by merging with a SPAC, Holicity. Though Holicity originally pegged a reasonable valuation range for Astra at ~\$1.0bn in October 2020, by the time the deal was finalized a couple months later, the company's value had doubled to \$2.1bn.<sup>2</sup> Only in the frenzied excess of the 2021 SPAC boom could a pre-revenue launch company without any successful launches and, staring at the [possibility](#) of bankruptcy only 10 months earlier, be valued at such a ridiculous sum.

Key developments since the merger was announced include a surprise increase in targeted payload capacity, the concerning purchase of engine IP from a competitor shortly thereafter, and not-so-strategic M&A (Apollo Fusion) – all of which are classic signs of a company that is falling (further) behind the competition. In what should be a concerning sign for shareholders, Astra has provided no update to its contracted backlog figure since February (whereas Rocket Lab leads off its calls with the number).

Upcoming catalysts include the unlock of 91.2m shares of Class A common stock on December 30<sup>th</sup> (the 6-month anniversary of the merger close)<sup>3</sup>, an event that poses downside risk given the prevailing poor performance of nearly every space SPAC, followed by the launch of Rocket LV0008, scheduled for January out of Cape Canaveral (Astra's first attempt at that launch site).

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<sup>2</sup> [S-4/A](#) filed May 21, 2021, *Background of the Business Combination*, p.76.

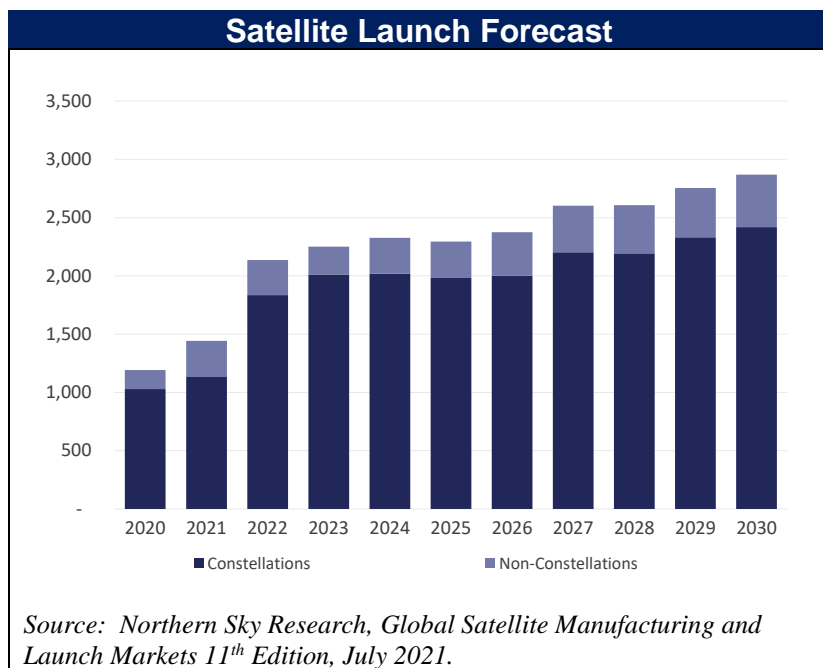
<sup>3</sup> [Prospectus](#) (424B3) filed August 13, 2021, p. 95.

## Financial Projections Rely on Absurd Market Assumptions

Astra’s financial forecasts rely on launching an astounding 165 rockets by 2024 and 300 rockets by 2025. To put these figures in context, 300 launches is 10x the total number of US commercial launches in 2022. 300 is nearly *triple* the total number of launches conducted *globally* in 2020. Incredibly, despite the obvious engineering, manufacturing, logistical, and regulatory challenges hitting such a cadence would represent, Astra felt it appropriate to issue this outlook before successfully reaching orbit even once.

### **Planned Daily Launch Cadence Far Exceeds Addressable Market**

In a sign of the remarkable exuberance of the space SPAC market in 2021, Astra went public without citing a single launch market study in its investor deck or in the “Launch Market” section of its S-1 filing. Instead, Astra touted big picture themes like “\$1 trillion+ Total Space Economy in 2040” (from Morgan Stanley), and a misleading slide that shows a large increase in the cumulative number of satellites to be launched in the coming years, but without specifying Astra’s niche role in this economy and the true addressability for a rocket with only a 500kg payload capability (eventually). It’s a significant red flag with a simple explanation: every legitimate market study that Astra could include would only show its projections to be laughably unrealistic – so Astra just left them out.



The above chart shows a global satellite launch market from industry research provider Northern Sky Research (NSR). Based on the firm’s tracking and risk-assessment of 143 non-GEO satellite constellations across key verticals – communications, earth observations, situational awareness, and several others – the number of satellites launched globally will approach 2,300 per year by 2025, growing to nearly 3,000 as the decade concludes, which



amounts to a CAGR of ~9%. 85% of satellites are to be deployed as part of constellations, not single assets.

How should one think about the TAM for a new entrant like Astra? The above is a global forecast that makes no adjustment for constellations that already have a committed launch provider (or a natural partner) and/or satellites that are not addressable for a US provider because of geopolitical and regulatory constraints. It also does not exclude satellite masses that Astra's still-in-development 500kg payload rocket cannot lift.

Below we walk through an analysis to determine a more refined view of the market opportunity for Astra as it strives to establish daily launch in 2025. We begin with NSR's estimate of the total number of non-GEO satellites to be launched in 2025 (2,255). We then apply two simple filters: 1) we exclude 90% or 851 of NSR's North American communications satellites forecast to account for Starlink (SpaceX launched 850 Starlink satellites in 2020), 2) we deduct 90% of satellites from Asia and 20% from Europe based on the contribution to these regions from Chinese and Russian satellites.

Astra 2025E Launch TAM	
	<u>2025E</u>
Total Non-GEO Satellite Launches	2,255
Less: NA Communications	(851)
Less: 90% Asia (China)	(792)
Less: 20% of Europe (Russia)	(25)
Total Addressable Non-GEO Satellites	587

*Source: Kerrisdale analysis and Northern Sky Research, Global Satellite Manufacturing and Launch Markets 11<sup>th</sup> Edition, July 2021.*

At less than 600 satellites, the entire non-captive TAM for launch is easily supported by less than 100 total launches. SpaceX rideshare recently set a record for [134](#) satellites on a single mission. Juxtapose a potential addressable market of less than 100 launches *in aggregate*, with Astra's projection of conducting 300 launches *themselves* when there are dozens of competitors, and one can see why our conversations with a range of industry participants yielded the following comments regarding Astra's plans:

***"I laugh at that number... There's no way they are doing 300 launches by 2025; by 2035 it would still be a stretch."***

— Senior Engineer, launch broker

***"We are, all around in the industry, in the same spot. Even within Astra and at [our small launch company], I'm looking at [1/10<sup>th</sup> Astra's number] rockets, and we are freaking out – are we really going to have enough customers for this?"***

— Senior Engineer, small launch provider

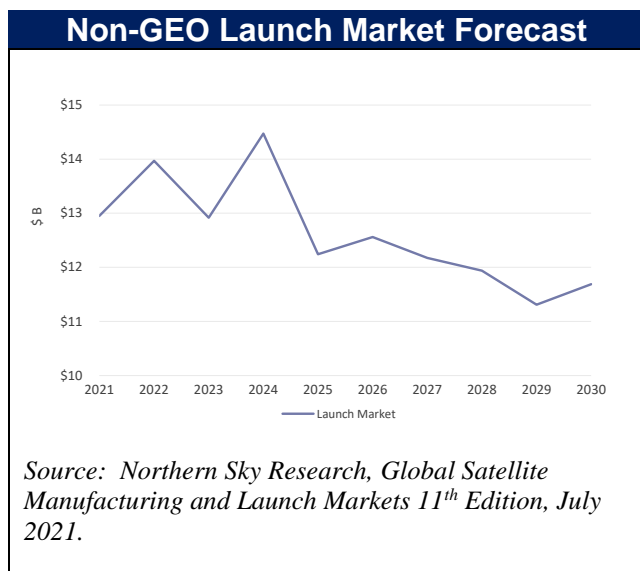
*“Happy they got to orbit on last launch a few weeks ago, that’s great, but **there’s just a lot of issues with their rocket and their business model...claims of launching every day?** It’s pretty exciting when a launch provider can launch once a month – and sure, everyone would love for rockets to be like airplanes – that’s not going to happen for at least another decade. So yes, **I have some serious concerns about Astra’s claims.**”*

— Mission Manager for a broadband mega-constellation

To be clear, our view is not that zero market exists for smaller launchers. We believe there will always be some level of interest in a service that can regularly/flexibly bring a handful of smallsats to a specific orbital location, even at a premium price to rideshares – but that is a niche offering in a highly competitive field. It is not an addressable market that comes anywhere near supporting 300 launches per year for a single company with Astra’s limited capabilities.

What about the dollar value of the non-GEO launch market? Perhaps the only thing more far-fetched than Astra’s launch rate is how it expects to hold price.

### Launch is Not an Attractive, High-Growth Market



Above is Northern Sky Research’s estimate of the value of the global non-GEO launch market – which, after spiking in the middle of the decade as constellations such as Project Kuiper get built out, is not a growth market. This is because while satellite volumes are increasing, launch pricing is under constant deflationary pressure (the latter is enabling the former).

Competition from new entrants and from larger rideshare players lowering price, cost efficiencies from reusable launchers, and improvements in technology and operations all conspire to exert downward pressure on price. Taken together, we estimate a total launch market value that averages ~\$13bn per year over the next several years, with a whopping 85% accounted for in constellations, where larger launch vehicles enjoy economies of scale, leaving an annual TAM for a small launcher like Astra in the \$~2 billion dollar range.

Astra’s 2025E launch revenue [forecast](#) of \$1.125bn assumes it can hold ASP constant at \$3.75m and rise in 4 years to become the dominant player in the small launch market. Either

NSR is too pessimistic (which anyone who has followed the industry knows is not usually how industry projections work) or, as we would contend, the projections of a new space SPAC, announced at the height of the bubble (two days before Virgin Galactic hit its all-time high of \$62) is complete fantasy.

### ***Without High Launch Cadence, Astra’s Business Model Falls Apart***

The failure to capture forecasted launch demand as outlined in Astra’s SPAC forecast has direct implications for Astra’s financial projections and valuation. Launch companies (and the space industry in general) have notoriously poor records when it comes to hitting projections for launch timing and rate. SpaceX initially projected a Falcon 9 launch tempo of 30-40 per year in 2018 but managed to hit that rate only this past year. In 2014, Rocket Lab projected 52 launches by 2016 but only achieved a quarter of that rate by 2020. Even if Astra were to achieve what we would characterize as a heroic, unprecedented launch cadence of one rocket per week in 2023E, the company’s own projections indicate this would result in deeply negative EBITDA and free cash flow (See: Appendix 1 - Astra Summary Financial Forecast).

The problem lies in the unit economics of launch. Starting a launch business requires massive investment in infrastructure, R&D, and engineering talent – none of which is cheap in the Bay Area where Astra is headquartered and has its main manufacturing facility.

Based on Astra’s 3Q 2021 overhead and R&D costs of \$39m (\$158m annualized), and assuming 10 launches in a year, Astra’s allocated fixed cost per launch, would be roughly \$16m. Add in \$2m for materials<sup>4</sup> and Astra’s total cost per rocket would be \$18m. Astra’s disclosed ASP is \$3.75m, meaning if launching just shy of a monthly cadence, Astra will lose a little over \$14m in EBITDA per rocket. The only way to improve on these economics and break even is to amortize high fixed costs by moving a massive number of rockets through the factory.

Only with over 100 launches, well above our estimate of the entire addressable market in 2024/25, and generously holding price constant at \$3.75m per launch and giving the company credit for lowering material costs to \$1m, does Astra begin to break even on a per rocket basis.

<b>Challenging Unit Economics</b>				
	<u>3Q21A</u>			
G&A	20			
Sales & Marketing	1			
R&D	22			
Less: Transaction Costs	-3			
Total Fixed Costs	39			
Annualized	\$158			
Assumed Launches per Year	10	24	52	100
Assumed ASP	\$3.75	\$3.75	\$3.75	\$3.75
Allocated Fixed Costs per Launch	\$16	\$7	\$3	\$2
BOM	2	1.75	1.5	1
Total Cost per Launch	\$18	\$8	\$5	\$3
EBITDA per Launch	(\$14)	(\$5)	(\$1)	\$1

<sup>4</sup> December 2021 [Investor Presentation](#), p.7.

Source: Astra SEC Form 10-Q, [Astra December 2021 Investor Presentation](#), and Kerrisdale Analysis

Investors should be asking whether Astra devised a launch cadence to meet market demand or to merely solve for the inherent weaknesses in its business model? Our research, supported by a range of interviews with key industry players, point strongly to the latter. Astra took full advantage of the lack of scrutiny SPACs enjoyed earlier this year relative to traditional IPOs, passed off a launch cadence without any supporting market demand, and sold equity in a bubble that has now burst. As a launch services broker with direct insight into market trends on a global basis described, “we get it, it was a cash grab...but how are you not going to squander all this money? Astra is all show and it’s not clear where they’re going to go aside from just building a bunch of stuff.”

## Undersized and Not Reusable: Astra is Falling Behind Industry Trends

*“When it comes to securing market share in launch services, time is of the essence, and Astra is falling behind.”*

— BofA Securities, *Initiating Coverage: Underperform*

*“Astra is undersized, it’s just too small. If they don’t announce something larger, I don’t know how they hang-on...**the market really wants a one-ton launcher, Astra is half that.**”*

— Senior Manager, *launch and mission management services firm*

Not only is the overall addressable market Astra has promoted vastly overstated – Astra’s development path is on the wrong side of key trends within the industry: larger payloads and reusability.

Most of the increase in mass-to-orbit in the coming decade will be as part of large broadband constellations. According to NSR, nearly 80% of all non-GEO satellites from now until the end of the decade will be part of constellations of communications smallsats. Smallsat manufacturers are taking advantage of declining launch costs to build larger, more sophisticated constellations of satellites which generally have more mass than previous iterations. Current Gen1 Starlink satellites weigh approximately [260kg](#). Starlink’s Gen2 satellites, however, call for more power, bandwidth capacity, and accordingly, mass – bringing its weight up nearly 5-fold to [~1,000kg per satellite](#) (which is partly why SpaceX is developing a much larger vehicle in Starship). Telesat’s global broadband network, Lightspeed, calls for 298 satellites weighing 700kg each.

With thousands of satellites to launch and ongoing [difficulties](#) with its natural partner, Blue Origin, Amazon’s Project Kuiper is the biggest wildcard for small launchers chasing well-funded mega-constellation volumes. Though the exact mass has not been disclosed, given Amazon chose two of ABL’s [RS1](#) rockets to launch two test satellites and each rocket has a mass limit of ~1,000kg to 500km SSO, it’s likely Project Kuiper satellites have a mass of ~500kg. Away from communications, earth observation providers like Planet are also moving up in weight class. In upgrading its fleet of SkySats, Planet recently announced a new class of Pelican satellites with a mass between 150-200kg each, up from current 110kg SkySats.

Now examine Astra's development path and some of the changes it has announced only months into being a public company. At the time of the SPAC [announcement](#) 10 months ago, Astra's stated goal was a 300kg payload to 500km Sun-Synchronous Orbit by 2023. By 2025, it hoped a vehicle that can "throw about 300 kilograms to a reference orbit" would be launched daily. Only 3 months later however, in conjunction with the [Planet](#) launch agreement, Astra announced a new goal: 500kg to 500km LEO. Why the sudden change? Because according to experts in the industry, management likely knew that to make good on claims that Astra could "meet the needs of all these mega-constellations like Kuiper", it needed a rocket with more than just a 300kg payload.

Announcing a 66% jump in payload capacity is not a trivial matter in rocket development. It involves meaningful redesign work with new components and a more powerful engine – one that apparently Astra did not have. As a sign of Astra's unpreparedness, four months after the new 500kg objective, Astra signed a "secret" [deal](#) to purchase the IP for an engine powerful enough to launch this new 500kg payload from its competitor, Firefly Aerospace (more on this later). Even with this shortcut, Astra will still only have a rocket two years from now that is able to launch 1 Project Kuiper satellite, barely 2 Project Pelican satellites from Planet, and zero Gen2 Starlink satellites.

Astra's strategy of applying Silicon Valley tech/software development to scaled rocket manufacturing has potential benefits – but how that should look in the launch industry today is a bigger, more reliable rocket with the advantage of full or partial reusability. A rocket should be large enough in terms of size and payload to recognize economies of scale, but not too large so as to leave the rocket unfilled. According to a wide range of experts we spoke with, that payload "sweet spot" is at least 1,000kg, a capacity many of Astra's small launcher peers will soon have.

Examine the actions of the leading small rocket launch company, Rocket Lab. After 20 successful Electron launches (300kg payload), Rocket Lab recently unveiled details of its [Neutron](#) rocket, a new medium-lift vehicle capable of delivering 8,000kg - 15,000kg payloads to LEO. With a launch date sometime in 2025, (right when Astra hopes to hit a cadence of 300 launches), Rocket Lab is building a rocket 26x larger than Electron to serve proposed mega-constellations and offer rideshares for heavier satellites because it understands that to be relevant for constellations, one needs far greater payload capacity than what it (and Astra) presently possesses. The targeted payloads of Astra's small launch peers tell the same story: Relativity Space [Terran 1](#) (900kg-1,250kg), [ABL Space Systems](#) RS1 (1,350kg), [Firefly Alpha](#) (630kg-1,000kg). All are twice Astra's capabilities, all are ramping production for multiple launches in the next couple years, and all represent better options for customers wishing to deploy multiple 100-200kg satellites into a particular plane.

In addition to higher payloads, rockets that are partially or fully reusable continue to lower the cost profile of the launch industry. In the conference call announcing Astra's SPAC merger, management claimed the unit economics of mass manufacturing small rockets could match that of a large rocket. Below we walk through how that falls apart once one factors in the marginal cost of SpaceX's reusable Falcon 9 and planned Starship.

Marginal Cost Benefit of Reusable Rockets				
	★ ASTRA		SPACEX	
	Rocket 5	Reusable Falcon 9	Marginal Cost Falcon 9	Starship
BOM + Labor Cost (\$ M)	\$1	\$28	\$15	\$2
Payload to LEO (kg)	500	13,680	13,680	100,000
\$/kg Production Cost	\$2,000	\$2,047	\$1,096	\$20
Timeframe	2025	Now	Now	2022/23

*Source: Astra investor presentations, public comments from [Elon Musk](#), Kerrisdale Analysis.*

Astra is hellbent on lowering costs to \$1m (\$500k each for materials and labor) per rocket by 2025 when it hopes to have 300+ rockets moving through the factory. At a production cost of \$2,000/kg this indeed would be competitive versus the all-in costs (\$28m) of a single Falcon 9. After the maiden voyage however, Musk has stated the marginal cost of refurbishing and launching a reusable Falcon 9 drops to only \$15m. Applied against a 13,680kg payload, (a reduction of 40%) to account for the reusability of the booster and fairing, and now the incremental cost of production is nearly half that of Astra’s target for 2025. The cost advantage for a re-used Starship is even more dramatic. Musk has outlined the possibility Starship may fly for a marginal cost of just \$2m, a staggering \$20/kg, orders of magnitude cheaper than anything Astra can hope to achieve (even if one discounts Musk’s hyperbolic tendencies).

Other small launchers in the industry are following SpaceX’s path to capture these economics. Rocket Lab’s Electron is being evolved to become partially reusable using parachutes and mid-air recapture, while its Neutron rocket will be partially reusable thanks to propulsive landing. Relativity Space aims to start flying a fully re-usable, 3D-printed Terran R rocket in 2024. VC start-ups like STOKE are developing reusable rockets. Astra on the other hand, a company with a corporate slogan of “Improve life on Earth from Space,” and a CEO with a “vision of a healthier” planet has no path to developing a reusable rocket, and apparently does not see a problem with having hundreds of rockets land in the ocean every year. We suspect management wishes reusability could be incorporated at some level into development plans; the problem is it would completely upend Astra’s business model. Astra’s manufacturing process eschews aerospace parts whenever possible in favor of cheaper, commercial off-the-shelf components that cannot be refurbished, and introducing reusability in a rocket of Astra’s size (whether for a parachute or additional fuel) would further constrain a payload that is too small to begin with.

Astra’s strategy has locked itself into pursuit of unproven demand for frequent launches of a rocket that is too small and incapable of competing with the improving economics of re-usability. As an engineer at a small launch company that is developing a reusable rocket put it, “If [Astra] hits its cadence and that’s a big if – then they have hit the ceiling, there’s nothing else they can do. If anyone else comes in and does something similar and can use a rocket just one time

more, they've undercut Astra by 2. If reused multiple times? Then Astra is blown out of the water."

It's a matter of time before Astra will have to pivot (again) to development of a larger rocket – a move that will impact cash flows which are already trending worse than first anticipated.

## Ignoring Reliability Issues is a Risky Game

"I'm personally worried about the reliability issues Astra will face...every single component on Astra's rocket is cheap. And they are rigorous about testing and they test really hard, and they do everything they can, but still, they don't have the redundancies that other rocket companies have...**I'm not sure customers will be happy with losing half of their payloads**...Kemp insists that because it's a cheap rocket, the customers will have cheap payloads...so the companies will be ok to make two, and launch one / lose one, because it's a lot cheaper than any other access to space...**honestly, not sure how the market will take it when rockets keep failing and I believe they will.**"

— *Industry professional with knowledge of Astra rocket development*

Conversations with an individual familiar with Astra's rocket design and manufacturing suggest investors may have to endure an uncomfortably high rate of failure as the company ramps to a targeted monthly launch cadence in 2022. Astra has previously stated "we're actually not shooting for 100 percent reliability" and is willing to trade a small amount of reliability for cost savings. Note that, despite "accepting less than 100%" reliability, Astra's financial projections as presented during the SPAC process assume zero failures (naturally).

CEO Chris Kemp has said an 80% success rate is a level Astra internally deems acceptable, substantially lower than the high 90s of far more sophisticated launch programs. This rate is an aspirational goal as the company continues to test and refine manufacturing, not the company's current level of anticipated quality. At the *current* stage of Astra's development, our source believes the risk of failure is as high as 1 in 2 launches.

It's also one thing for a private company to be launching test rockets in the dark wilderness of Kodiak, Alaska, suffering repeated failures in relative obscurity. Particularly early on in development, these failures can be reasonably justified as learning experiences. It's an entirely different situation now that Astra is public and launching out of Cape Canaveral – a change a former SpaceX logistics expert likened to "going from JV to Varsity."

The stakes are now substantially higher. Astra is trying to develop reliability of a cheap rocket, built without any redundancies, under the scrutiny of public markets to which it needs continued access. SpaceX President and COO, Gwynne Shotwell, has noted in the past that its development with private money was a key to its success since "you can tolerate failure." Public markets are rarely as forgiving. There is a reason that, prior to this most recent SPAC craze, few launch companies have dared to go public (the first and last was Orbital Sciences in 1990), let alone before the reliability of its core product is proven. Should Astra encounter even one high-profile failure during this coming year, the resulting delay to the launch cadence, potential technical changes to the rocket, and, critically – reputational damage – may be catastrophic.

## Small Launcher Price Comparison

When constructing mega-constellations of dozens, hundreds, or perhaps thousands of satellites in a single plane, it makes little sense for governments and commercial operators to use vehicles that can only haul 1 or 2 at a time. These customers will use larger rockets to deploy their assets more economically in bulk. Falcon 9 rideshares are priced as low as \$5,000/kg (a dedicated launch is closer to \$2,700/kg) while CEO Elon Musk has said [Starship](#), slated for launch early next year, could eventually lower costs to an astonishing \$20/kg, fractions of what an established small launch provider, Rocket Lab, charges for its Electron rocket (~\$23,000/kg). It's comfortably below what Astra claims is their cheapest-in-class \$7,500/kg pricing.

As ULA CEO Tory [Bruno](#) explained at last year's Euroconsult World Satellite Business Week conference, "the fundamental challenge is dollars per kilogram," and by that metric, it simply costs a lot more to launch a single small rocket with a single small satellite than it does to launch a single large rocket bundling many small satellites aboard it." Said Bruno, "While it is disheartening, a huge number of start-ups for micro launchers" are going to be "destroyed" and "that market [will not] recover."

Launch Price Comparison										
Vehicle	SPACEX			ROCKET LAB		Virgin ORBIT	Relativity	FIREFLY	abl space systems	★ ASTRA
	Falcon 9 Dedicated	Re-Used Falcon 9 Dedicated	Falcon 9 Transporter Rideshare	Electron	Neutron	LauncherOne	Terran 1	Alpha	RS1	Rocket 5
Est. Price (\$M) <sup>(1)</sup>	\$62	\$50	\$1	\$7	\$40	\$12	\$12	\$15	\$12	\$3.75
Payload to LEO (kg) <sup>(2)</sup>	22,800	22,800	200	300	8,000	500	1,250	1,000	1,350	500
Est. Price per kg to LEO	\$2,719	\$2,193	\$5,000	\$23,333	\$5,000	\$24,000	\$9,600	\$15,000	\$8,889	\$7,500
Initial Availability	Now	Now	Now	Now	2024/25	Now	2022	2022/23	2022	Late 2023

Source: Kerrisdale analysis.

- Falcon 9 dedicated list price per SpaceX [brochure](#), rideshare per [SpaceX](#) website. Rocket Lab Neutron pricing per CEO Peter Beck [comments](#) stating target pricing will be competitive with Falcon 9. Rocket Lab [Electron](#), [Virgin Orbit LauncherOne](#), [Relativity Terran 1](#), [Firefly Alpha](#), [ABLRS1](#) pricing per press reports. Astra pricing per public comments at DB Tech Conference, September 10, 2021 (which mirror implied pricing in Astra SPAC presentation (see Appendix: 1)).
- Payloads per respective company websites and payload user guides.

At a Deutsche Bank tech conference in September, Kemp stated Astra's average selling price was \$3.75m per launch while competitors are priced over \$10m for "similar capabilities." The comment suggests Astra is out in the market, undercutting competitors by 1/3<sup>rd</sup>. It's a misleading way to portray one of Astra's supposed points of differentiation. First, the competitors to whom Kemp is likely referring – Rocket Lab, Relativity Space, Firefly, ABL, etc. – do not have "similar" capabilities. Rather, they are all building larger, more highly engineered vehicles with greater payloads. In the case of Rocket Lab, its Electron vehicle also offers a level of flight heritage that none of the others are close to achieving. Second, comparing headline price for dedicated launch doesn't tell the whole story because it doesn't take into account payload capacity. It wasn't clear from the interview what payload \$3.75m buys at Astra, but assuming it's for the planned 500kg rocket (available late 2023, fingers crossed), the price works out to \$7,500/kg.



Relativity Space is advertising \$12m for a 1,250kg payload in 2022, or \$9,600/kg, a premium to Astra, but hardly the wide chasm Kemp portrayed. ABL is planning 8 launches in 2022 and at \$12m for 1,350kg to LEO, is priced at \$8,900/kg – a reasonable premium in our estimation for a more reliable rocket available well before Astra’s still non-existent 500kg rocket. What Astra does have is a relatively near-term path to a 150kg rocket with its Rocket 4, which, as recently as this past February, Kemp [stated](#) would cost \$2.5m or \$16,666/kg making it actually *more* expensive on a per kg basis compared to many of Astra’s competitors.

Now compare this \$2.5m price tag for 100-150kg to a Falcon 9 Rideshare, currently advertised on SpaceX’s website at [\\$1m for 200kg](#) – i.e., half the price for twice the payload. Sure, Astra will claim that a rideshare may not leave precisely when a customer wants or take them exactly to the orbit it needs, but that kind of discount compensates for these inconveniences. Our checks with launch brokers indicated many customers are happy to wait 4-6 months (as Falcon 9 rideshares are now regularly scheduled), settle for close-enough as far as orbit, or use increasingly available orbit transfer vehicles for last-mile transport.

## “Secret” Firefly Engine Deal is Sign of Weakness

On September 21, the tech blog [TheVerge.com](#), reported that Astra agreed to acquire the right to manufacture rocket engines in-house from launch competitor, Firefly Aerospace, for roughly \$30m. The article references internal Firefly documents viewed by the publication and includes specifics which suggest the agreement was leaked by Firefly. Though Astra’s CEO and VP of Communications declined to comment on certain specifics of the agreement, neither disputed its existence (there is no mention of this material agreement in Astra’s SEC filings and no press releases were ever issued by either company). When asked on the last quarterly call about the reported Firefly relationship, management once again did not disclaim the existence of the agreement, stating that anything the analyst had read online was “not inconsistent” with a strategy of all technology being “owned, licensed, or developed by Astra.”

So why the cloak and dagger? Perhaps Astra is aware that buying the IP for the most critical piece of hardware on a rocket from a direct competitor is not exactly a good look. Management can quibble about how the agreement is not a deviation from Astra’s vertical integration strategy because the deal is for IP and Astra is still building the rocket themselves, but we get the impression that in order for Astra to achieve its goal of “500kg to 500km” it needs to copy someone else’s homework.

Unsurprisingly, when doing a deal with a competitor, the agreement has some important restrictions. The IP agreement allegedly includes a clause that only allows Astra to use two Reaver engines per rocket – enough to hit Astra’s goal of 500kg to 500km – but no more. Recall that Firefly is developing a 630kg-1,000kg rocket, and therefore the agreement caps Astra’s use of the IP just below Firefly’s capability and the emerging sweet spot for smaller launchers. Firefly seems content to help Astra for a price – but it isn’t foolish enough to solve a direct competitor’s problem of being undersized. So what happens when Astra has to eventually move up in size like other well-funded players? Will they need to do *another* licensing agreement with a different competitor? It’s unclear, but if we were shareholders, we would be asking a lot more questions about the significance of this deal and what it means for Astra’s long-term development.

## Space Services Strategy Lacks Clarity and Credibility

In June, Astra announced the acquisition of Apollo Fusion, a manufacturer of electric propulsion engines for small satellites, in a transaction valued up to \$145m (\$30m in stock, \$20m in cash, and an additional \$95m in potential earn-outs). The acquisition is part of a broader trend within the industry to move beyond just launch services to higher margin, in-space sources of revenue. As Firefly CEO Tom Markusic [explained](#), “the rocket gives you the keys to space. It’s critically important, but the big revenue is doing things in space.”

The need for this diversification is driven by the fact that while launching rockets to the heavens can be an awe-inspiring event – as an actual business there’s not a lot to be excited about. At its core, building and launching rockets is a risky, capital intensive, non-recurring, low-margin hardware business. Greater profits (and valuations) lie in moving up the value chain to develop turnkey “space solutions”, orbital transport vehicles, and operating constellations. No better example of the benefits of the strategy exists than SpaceX.

11 years ago, after teetering on the verge of bankruptcy, SpaceX was bailed out by NASA with a \$1.6bn contract to develop a medium-lift vehicle (Falcon 9) to resupply the International Space Station. SpaceX took the opportunity to drive launch costs down through vertical integration, reusability, and high flight rates creating a cost advantage that accelerated deployment of the Starlink constellation of broadband satellites – a source of high-margin recurring revenue. The strategy has driven massive gains in SpaceX’s valuation. A recent Morgan Stanley note ascribed only 11% of SpaceX’s [estimated](#) \$100bn valuation to Launch. The vast majority (80%) was accounted for by Starlink.

The problem with a small launcher that wants to provide greater service in space is everyone has the same idea. Making orbit transfer vehicles (OTVs) that facilitate “last mile” delivery of a satellite to a specific orbit or moving beyond LEO to MEO, GEO and lunar orbits is a crowded field. Our research yielded no fewer than 10 domestic launch providers, component suppliers, rideshare aggregators, and smallsat propulsion manufacturers that have OTVs in development with launch dates over the next 3 years, and another 8 internationally.<sup>5</sup> The prospects for developing a successful broadband constellation is even more challenging. Astra’s crazily ambitious V-band constellation is years behind Starlink, OneWeb, and Project Kuiper without any of the technical and financial resources, and without a business case that justifies the bootstrapping of yet another broadband mega-constellation. Taken together, Astra’s acquisition of Apollo Fusion and V-band spectrum application are uninspired attempts at mimicking the strategies of more advanced competitors which underscore the limitations of its undersized rocket in providing in-space solutions.

### ***Apollo Fusion as an OTV Does Little to Expand TAM***

Rocket Lab’s Kick Stage OTV and Photon satellite bus are examples of what a leading in-orbit space solution should look like for a small launch company. Rocket Lab has successfully deployed 18 Kick Stages, delivered multiple customer satellites, and demonstrated a range of in-space maneuvers. Photon was first announced two years ago and enables missions beyond

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<sup>5</sup> U.S. Companies: Atomos Space (2022), Bradford space (TBA), Firefly (2022), Launcher (2022), Momentus (2022), Moog (2022), Northrop Grumman (2020), Rocket Lab (2018), Spaceflight (Jan. 2021), and Starfish Space (2023/2024). Rest of World: ArianeGroup (2024), D-Orbit (Sep. 2020), Exolaunch (2023), Exotrail (2024), Lunasa Space (2023), Rocket Factory Augsburg (TBA), Skyrora (TBA), and Space Machines Company (2022).

LEO through to planetary science and exploration to the Moon, Mars, Venus and beyond. [Photon](#) is vertically integrated with in-house subsystems, as the upper stage of Electron it can “eliminate the parasitic mass of deploy spacecraft”, and it can fly on other larger launch vehicles.

Astra has described the benefits of Apollo Fusion in similar terms as Rocket Lab’s Photon and Kick Stage but their respective use cases and TAMs are different. Rocket Lab’s platforms use its Curie liquid-propellant based chemical propulsion engines, while Apollo Fusion is a manufacturer of electric engines. Electric propulsion (EP) has a crucial drawback that limits its use as an orbital transfer vehicle: it’s painfully slow. Experts we spoke with provided a range of colorful analogies to describe the limitations of EP for in-space transportation: “Like driving cross country in first gear,” “pushing a glider with mosquito wings, and “sending a carrier pigeon versus email.”

This lack of thrust is particularly concerning because it contradicts one of Astra’s key purported benefits: speed-to-orbit. For example, when asked on Astra’s 2Q call to articulate its competitive differentiation versus rideshare, Kemp sated, “A lot of our customers value how quickly they can deploy a particular satellite and also where they want to go...Astra is actually very affordable because you’re not waiting 6 months either for a launch or waiting 6 months once you’re already in space to get to the exact orbit.” According to the five propulsion experts we spoke with however, if Astra were to “vertically integrate” Apollo Fusion technology into its rocket system as Kemp has discussed, several months is precisely how long a customer may have to wait for a transfer vehicle to reach a desired orbit. So, what would be the point? Why would a customer select Astra for a timely and responsive launch only to crawl to its destination once in space? A long in-space voyage fails best practices from an engineering and financial standpoint. A satellite would be better off sitting on a shelf for months waiting for a cheaper rideshare than spending the same amount of time grinding along in the harsh environment of space, risking irrevocable failure.

On the 3<sup>rd</sup> quarter call, Kemp offered that development of a vehicle using Apollo Thrusters could be used with a larger rocket, like Falcon 9, but this too is hard to fathom. If customers were held “waiting for a year or waiting for many months” for a rideshare why would that customer wish to tack on even more months with a horribly slow ride in space? Answer: they wouldn’t. As a launch broker clearly explained, “You can’t get anywhere fast with electric propulsion...using [electric propulsion] as part of rideshare? **People talk about it, but no one uses it. You look at all the other orbital transfer vehicles out there, they all use chemical propulsion because [electric] just takes too long...unless there’s someone who is willing to wait like a government customer. But anyone in new space? There’s no way they’re going to want to wait.**”

The efficiency of EP thrusters lends itself to long, slow journeys and Astra can boast that Apollo Fusion accelerates plans to reach higher orbits such as GEO and beyond, but this is a niche opportunity relative to Astra’s supposed core servicing LEO constellation. According to NSR, less than 2% of all satellites in the next decade will be in GEO. Furthermore, the market for small satellites that operate in GEO barely exists; the vast majority of GEO satellites in key verticals like earth observation and communications have a mass greater than 1,000kg – which means Astra doesn’t have a rocket in-house that could launch such a satellite in the first place.

Our diligence into Apollo Fusion itself and the market for thrusters yielded further red flags regarding the strategic merits of the deal. According to a former SpaceX propulsion engineer, Apollo Fusion is just one of many commoditized, low-cost thruster providers whose ranks have

apparently grown so numerous that it once led a frustrated new space [CEO](#) to complain, “two companies a week were coming in with the same designs and talking to me about the same things.”

An engineer we spoke with who is familiar with Apollo Fusion’s history stated the company originally generated excitement within the propulsion community for a system using iodine as a propellant. The technology didn’t work as hoped and within a couple years Apollo transitioned to using [Mercury](#), a low pressure propellant used in thrusters since the 1960’s. Just like iodine, Mercury is toxic, and after the idea of working with a dangerous neurotoxin before showering into the atmosphere was (thankfully) reconsidered, it too was discontinued in favor of Apollo’s current propulsion system based on Xenon and Krypton – propellants that nearly everyone in the propulsion industry has been using for decades. As the expert explained, “[Apollo Fusion] is a company that has made claim 1 and failed, made claim 2 and failed, and is now building something that everyone else has been building forever.” Without any proven technological differentiation, the only way to win business is price, a market position which puts a dent in the strategy of “moving up the value chain.”

Astra’s acquisition of Apollo Fusion is an example of a company making decisions based on what it must do given the limitations of its rocket – not what the market wants, and not what a company without such limitations would ever devise. The right solution for an OTV would have been chemical propulsion but Astra couldn’t go that route because of the bulkier dimensions of the system’s propellant tanks. Under pressure to keep up with competitors, electric propulsion was simply the only option small and light enough to fit in Astra’s rocket. While others in the industry like Rocket Lab are developing well-suited, best-in-class technology, enabling a variety of TAM-expanding missions, Astra is settling for suboptimal acquired technology with only niche applications.

## Broadband Constellation Plan is a Pipedream

Though Astra has articulated plans to evolve into a space services platform, it is first and foremost a launch company. Astra co-founder and CTO, Dr. Adam London, spent 11 years developing technologies to “miniaturize high-performance rocket technologies” for DARPA and NASA at [Ventions LLC](#), a predecessor to Astra. Neither he nor Chris Kemp have a background in communications satellite design or network operations.

Holicity’s Chairman and CEO, Craig McCaw, however, has had a storied career in the cellular telecommunications world; buying the first cell-phone license rights in the 1980s, starting McCaw Cellular which was later sold to AT&T for \$12bn, and founding Clearwire Corporation (among many other entrepreneurial achievements). McCaw also has had a longstanding infatuation with space-based internet service, founding [Teledesic](#) in the early 1990s, a proposed constellation of hundreds of LEO satellites that encountered numerous execution issues before the [bankruptcies](#) of Iridium and ICO Global in 1999 cast a pall over the industry, and the project was abandoned. McCaw eventually led ICO Global out of bankruptcy, later [changing](#) its name to Pendrell Corporation, the entity that sponsored the Holicity SPAC.

McCaw’s lingering interest in communications satellites was evident on the conference call introducing the merger. Rather than lead off with a glowing description of Astra’s rocket or the market for small launchers, McCaw began his comments by saying, “I’ve long believed that there has been an amazing opportunity to provide communications satellites, essentially an internet in the sky, with the opportunity to provide internet anywhere and everywhere, fulfilling

one of humanity's great needs." But what is McCaw talking about? Astra is no closer to having a broadband constellation than a Nikola truck. Astra has enough on its plate just trying launch a basic rocket into orbit without it blowing up half the time. McCaw indicated Astra was well-positioned to take the next step in satellite launch, describing Astra's capabilities in providing a small, simple launch from "anywhere in the world" (which we debunk in the next section), but this too doesn't gel with launching a network of thousands of satellites. If the objective is to deploy a broadband mega-constellation, its far more cost-effective to use a larger vehicle.

McCaw's bankrolling of Astra has seemingly bought him strategic influence. A few months after acquiring Apollo Fusion, Astra filed an application with the FCC to use V-band spectrum for a constellation of up to [13,620 satellites](#). V-band is high frequency spectrum that sits above Ka-band, from 40GHz-75GHz, and is sensitive to rain fade and physical interference. No ecosystem currently exists to support the use of V-band for space-based telecommunications. As [described](#) by satellite communications expert, Chris Quilty of Quilty Analytics, "It's expensive, it's early stage, and there are limited sources of supply. I would argue that companies that are trying to build these components on their own are going to run into significant engineering challenges."

It's worth pausing to note the absurdity of the FCC filing: Astra has never built a single satellite; it has not yet proven it can reliably execute on its core business of launching small rockets – and yet, it filed an application for a constellation 2x larger than the next largest proposal from Amazon. While the application technically amounts to little more than a procedural "land grab" for spectrum rights, investors should be concerned about how and why a launch company still working out the kinks of rocket development would even contemplate the endeavor. Unsurprisingly, Kemp seems to want to avoid talking about the entire project.

On the 3Q21 call, Kemp ducked discussing relevant financial and technical details and imprecisely downplayed the three phases of Astra's plan, stating Phase 1 constitutes 20-40 satellites (the application says 40), Phase 2 involves 500-1,000 (application says 2,296), and Phase 3 "where we get up to the 5,000 to 6,000" (application says 11,284). Kemp also claimed that Phase 1 would require "only a couple" of launches on Astra's own rockets but with Rocket 4 capable of only a 150kg payload and Kemp nebulously stating it will fly "the 1.0 spacecraft, maybe 2, maybe it will fly 3", the initial buildout of the proposed constellation could easily require well over a dozen money losing launches. Kemp also stated Phase 1 would "provide a service that we believe has real value to customers," but this is a stretch as the application flatly states the phase is to serve as a minimum viable product for limited equatorial latitudes.

What new service would Astra provide using V-band in a satellite that Kemp has suggested will have 1/5<sup>th</sup> the mass of Starlink Gen2? Why does it make sense to enter an already crowded field of mega-constellations: Starlink, Project Kuiper, OneWeb, and Telesat – all of whom are much further along than Astra? Starlink is already serving 140k customers across 20 countries with an additional 750k preorders. It's one thing to act like the next SpaceX by announcing a lofty number of communications satellites, but SpaceX has the in-house ability to launch dozens of Starlink satellites with Falcon 9 and potentially hundreds at a clip with Starship. Both of those vehicles are also reusable which vastly lowers the marginal cost of launch. Astra has no such ability; it can't even commit to lifting 2 satellites and it has no path to a reusable rocket. The FCC application mentions the possibility of using third party launch providers to address this problem. Buy why would a 3<sup>rd</sup> party launch company help Astra, a launch competitor? If Astra ever develops proprietary communications satellite technology, would it be wise to have that IP in the hands of SpaceX engineers? Others in the industry certainly don't think so. Despite likely

being at a higher cost than Falcon 9, OneWeb is using Soyuz rockets to launch its constellation while Project Kuiper will start deploying satellites using ULA.

And where would the money for any of this come from? Astra only has enough cash on hand to get through 2023 (maybe). Satellite manufacturing, terminal development, gateways, regulatory approval, landing rights...the list goes on and the costs are staggering. [Musk](#) has pegged Starlink total investment costs at between \$20 and \$30 billion, OneWeb went bankrupt, and Project Kuiper and Telesat are years behind schedule. We believe Kemp does not wish to discuss Apollo Fusion technology being used for an internal satellite bus or the development of an Astra constellation, because the enormity of the costs and equity dilution involved would send investors running for the hills.

Attempts to “expand TAM” through M&A and develop higher margin service revenue are a distraction when Astra hasn’t even executed on its supposed core competency: launching rockets. As a rightly concerned sell-side analyst asked Kemp on the most recent earnings call, “So with this satellite thing and then the electric engine thing and the launch business, when do you worry about spreading yourself too thin, right?” We’d say investors should be worried now.

## Spaceport Availability is Key Logistical Hurdle

Management [habitually describes Astra](#) as having the [flexibility](#) to launch from “anywhere in the world,” which is simply not true. Just because a rocket can be transported in a shipping container – doesn’t mean one can lift off from any Walmart parking lot. In the US, Astra can only launch from an FAA-licensed commercial spaceport approved for vertical launch. There are only 5 such sites (plus SpaceX’s private Boca Chica spaceport) located in the U.S. 97% of launches over the last 40 years have been from only 2 launch sites: Cape Canaveral spaceport (30 launches in 2020) and Vandenberg Space Force Base (1 launch in 2020). For a company aiming to launch hundreds of rockets per year, the reliance on a small handful of key spaceports is a bottleneck that threatens its whole business model. While there are ongoing modernization efforts at Cape Canaveral and the FAA is streamlining launch licensing requirements, these efforts can get bogged down in bureaucratic quagmires.

Due to the fact vertical launch vehicles drop one or more stages downrange, creating a hazard to life and property in the drop zones, vertical launches must take place near bodies of water (like Cape Canaveral) or in remote locations (Spaceport America, adjacent to White Sands Missile range in New Mexico). Unsurprisingly, establishing a new vertical launch site has historically encountered significant resistance from environmentalists and locals. SpaceX’s Boca Chica launch [site](#) took 8 years from initial plans to first experimental launch. A new launch site in Camden, GA, was granted an FAA site operator license last week, 9 years after first exploring development in the [hopes](#) of attracting a SpaceX launch facility, but it still [faces](#) political and legal challenges.<sup>6</sup>

Perhaps in recognition of the challenge in finding sufficient domestic spaceport access, the company has described working hard to secure launch sites internationally. International space agencies, [trade groups](#), and regulatory bodies are working on various fronts to improve spaceport availability, but these efforts generally lag that of the US and have encountered their own challenges from local politicians and [environmentalists](#). How and if a US company with a

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<sup>6</sup> *Quality Analytics white paper, “Leveraging the Emerging Space Economy to Meet Critical Government Needs,” July 2021.*

US rocket would be granted approval – when many countries typically assign preference to supporting their own member nation launch programs – is also uncertain. With so much focus on scaling manufacturing processes and launch cadence, the seemingly mundane issue of finding somewhere to launch is a risk to Astra’s long-term vision because contrary to management’s oft repeated claim – Astra *can’t* launch from anywhere.

## Conclusion

The next several months are critical for Astra. Already falling behind with an undersized rocket, Astra has no room for setbacks – which is a problem. Silicon Valley’s “move fast and break things” innovation approach may work when it comes to software development, but for a rocket company whose rockets are prone to unexpected explosions, it has serious consequences. The only way to improve reliability is to continue testing and failing, with each successive failure – soon to be conducted under the spotlight of Cape Canaveral rather than the backwoods of Alaska – proving harder to spin as positive. If Astra were private like most of its peers, this wouldn’t be such a challenge – having an uncomfortable conversation about delays or needing a pivot with a small group of long-standing investors may not be easy, but it beats having to answer to new fickle public ones. The froth has come off the new space market. As investors watch yet another SPAC fail to deliver on lofty projections and with its cash balance burning away like a rocket with a fuel leak (which Astra has experienced), Astra shares will be left smoldering on the launchpad.

## Appendix I: Astra Summary Financial Projections

Astra Projections					
(\$ in Millions)	2021E	2022E	2023E	2024E	2025E
# of Launches	3	15	55	165	300
Total Launch Revenue	\$4	\$47	\$206	\$619	\$1,125
# of Satellites Launched	--	10	60	250	660
Modular Spacecraft Platform Revenue	--	\$6	\$31	\$123	\$314
# of Spaceports Deployed	--	1	1	2	3
Spaceport Services Revenue	--	\$15	\$18	\$38	\$62
Total Revenue	\$4	\$67	\$256	\$780	\$1,501
% Revenue Growth		1,687%	280%	205%	92%
Gross Profit <sup>(1)</sup>	(\$6)	\$14	\$119	\$477	\$1,045
% Gross Margin <sup>(1)</sup>	NM	20%	46%	61%	70%
Adj. EBITDA <sup>(1)</sup>	(\$81)	(\$130)	(\$53)	\$238	\$694
% Adj. EBITDA Margin	NM	NM	NM	31%	46%
(-)Δ Working Capital	\$3	\$1	(\$1)	(\$2)	\$5
(-) CapEx	(\$96)	(\$25)	(\$61)	(\$60)	(\$24)
Unlevered Free Cash Flow	(\$175)	(\$154)	(\$116)	\$177	\$676

Source: Management estimates.  
(1) Before stock-based compensation.

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Source: Astra [investor presentation](#) dated February 2, 2001



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