2x the payload for 2x the cost.

Rocket Lab has the massive advantage of high cadence and a proven track record, so in reality, the breakeven point from a constellation operator's perspective goes even higher. The massive first-mover advantage Rocket Lab has today translates to other aspects as well. In Peter Beck's recent interview with Eric Berger in reference to constellation customers he said: "They've designed their constellation or their spacecraft around Electron. It does things that you just can't get on other missions." Given the size of recent constellations in both individual satellite mass and the total number of satellites, it's clear that Electron is the best option and is being optimized for by the industry. It will take many years for the advantages of 1-ton class rockets to be fully realized by the industry.

iQPS's upcoming constellation may be the only one out of the 7 dedicated-launch-addressable constellations in the chart that could reasonably fly on a 1-ton class launch vehicle. According to Gunter's Space Page (Amazing source) they are planning a constellation of 36 100kg satellites. With 6 launches on a $15M 1-ton class rocket, this could be competitive with Electron. The other constellations either have satellites that are too light to warrant anything other than Electron or too few planned satellites. Too few satellites mean unoptimized coverage of the Earth if launching too many at once, ie. lower revisit rates.

Given the lack of constellations launching in the next few years that would see a large enough benefit from 1-ton class rockets, it's unlikely Alpha and RS1 will reap the benefits of their size & cost per kilogram advantages until the late 2020s. Assuming constellation design shifts to the 1-ton class instead of Electron due to cost, there is a world in which they get 50% or more of the market. However, at a certain size of constellation rideshare missions become competitive.

The Future of Launching Small Sat Constellations

There is zero chance Electron loses a significant number of launches to another rocket in the next ~3 years. As Peter Beck said, they are the industry standard in small satellite launch and the industry is building around the capability Electron provides. However, in 5+ years if the 1-ton class rockets succeed, there will be more room in the industry to design larger satellites that take advantage of the cost per kilogram advantage of these rockets. The lower cost of mass also allows for heavier (cheaper) materials to be used, lowering satellite costs even further. This is however not a paradigm shift as it is mainly a marginal improvement. There is enough space for Firefly or ABL to succeed in the market, but it's very unlikely they displace Electron. The market will grow to support more companies, market share may be lost, but there will be net growth. Rocket Lab enabled the small sat business while Firefly and ABL are merely improving it.

Rideshare missions will soon have the ability to eat even more of the dedicated small sat constellation launch market when kick stages come online and propulsion becomes cheaper. The two main advantages of dedicated launches are schedule and orbit precision, all other benefits stem from these points. Schedule will remain a benefit of dedicated launch but orbit precision can be addressed by kick stages or on-satellite propulsion.

Sun Synchronous Orbits precess around the Earth which is the mechanism that allows them to always stay in the sun, otherwise, there would only be a few days per year in which the polar orbit is 100% exposed to sunlight. This same principle makes it possible to shift the orbital plane of a satellite with minimal fuel expenditure through slightly increasing altitude and changing the inclination of the orbit. This process can take up to several months or if the launch is already near the desired orbital plane a few weeks is possible. Either way, revenue is delayed. However, for mature constellations, revenue delay is less of a concern and millions of dollars per satellite can potentially be saved.

Either space tugs like Impulse's Mira or ion thrusters on each satellite can accomplish the low-energy polar orbital plane change. Ion thrusters have the advantage of providing efficient propulsion that can extend the satellite's lifespan. Starlink satellites currently use Argon ion thrusters to boost themselves to their final orbit. With 2500 seconds of isp, they are far more efficient than chemical propulsion, meaning more mass can be delivered to the final orbit. As always, the limiting factor here is the cost. This is possibly offset by a longer satellite lifespan, but it remains to be seen how many constellations opt for this route. In the next 5-10 years we will see.

The advantage of ion propulsion is best seen on large constellations like Starlink, OneWeb, or Kuiper. This may have an impact on the industry as we see convergence to an end-to-end model. In the case of Rocket Lab, this could mean manufacturing their Lightning satellite bus with ion propulsion to host many different payloads. This allows for the benefits Starlink has seen with a common satellite bus and launch vehicle while serving multiple customers. While Rocket Lab sees competition from 1-ton class rockets and potentially Stoke's Nova, they will be transitioning to hosting payloads on a common satellite bus where Neutron and Space Systems take over from Electron on constellations.

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Christopher Kalitin Blog

On the Overallocation of Labour to Finance and Law

May 25, 2024 • Christopher Kalitin

Go to where the vibes are

Useless ambitious people are the most dangerous people in the world

The value of finance and law professionals is found in the facilitation of real useful work. The aim of increasing the efficiency of a productive society is to lower the percentage of accountants and lawyers to the minimum required amount. Increasing the number of these useless workers and increasing their power leads to negative outcomes. Many issues in modern society are attributable to this class in two ways: (1) inefficiency leads to suffering and (2) jobs that don't inherently produce value are susceptible to becoming part of the Professional Managerial Class.

Hospitals demonstrate the suffering of inefficiency. There are countless reasons government-sponsored institutions are inefficient, but in the case of hospitals finance people are doubly to blame through insurance. Increasing efficiency is the goal, **do not be complicit in these systems.**

The Professional Managerial Class is a part of the the deep state. A decentralized system of middle men and beauracrats that are not inherently useful themselves. Decentralization is a point of the deep state that must be highlighted (I am using the word deep state to mean groups or individuals with power over society that aren't obvious). Every group has ways of profiting off of events and movements around the world and this sets the incentive structure. Powerful groups (politicians, corporations, PMCs (both meanings)) are incentivized to support certain outcomes of movements. They piggy back on these movements to support their own goals - not quite hijacking but slightly nudging in their preferred direction. This means the teachers making your kids gay are not doing it because of a secret meeting they had with Big Gay. They are doing it because they think it is the right thing to do and this is supported by deep state groups, sometimes quite obviously.

How many watts do you use?

We must to chose which metric to work on increasing to expand society. The economy or the S&P 500 aren't the correct metric because it is very scammable as we've seen in the last 5 years. On the other end of the scammable spectrum is total energy output and to a lesser extent gross domestic product.

The S&P 500 can't be the metric we use because it's scammable by the government. We must avoid scammable systems because they incentivize scammers. Lawyers convince you they are needed by supporting the creation of laws. A system of arbitrating disagreements is needed, but remember, efficiency is the goal. The Professional Managerial Class are scammers in that they do not provide value themselves but rather hijack systems that provide useful output. Energy output measures what we truly produce and is one of the least scammable metrics. This is why the Kardashev Scale is the ultimate measure of a society.

Increasing output increases human flourishing

I was careful when writing the title of this section to not say: "Increasing output increases human happiness."

However, increasing productive output does increasing the flourishing of humanity. We can explore the universe and connect people on opposite sides of the planet. Increasing the tech level of humanity leads to a higher potential for happiness, exploration, and everything else. One of the core outputs of humanity has been increasing the time and impact of leisure (Think heating, soft beds, TVs, TikTok, Starbucks). This will hopefully increase happiness.

If everyone followed Andrew Tate's teachings you would have no engineers. Tate is part of the group that harnesses technology to increase either their own economic worth and/or power. Someone has to harness technology and there are many more individuals that play this role rather than those who build technology. Building technology is more useful - and harder - than harnessing it.

Don't be a scammer

A scammer is an individual who does not provide value themselves but rather forcefully extracts value from productive systems. Think back to finance bros and lawyers.

One of the best outcomes of capitalism is giving the option to harness selfishness for the good of society. However, this only occurs when this fundamental rule of capitalism is followed: goods, services, and currency are exchanged *consensually*. Increasing the efficiency of society means decreasing the number of scammers - those who do not follow the above rule of capitalism, exchanges are consensual.

Every scammer is an individual that could be increasing total output instead of manipulating the systems built around real productivity to favour themselves. Atoms cannot be scammed. The closer you get to the base level of reality the less scamming is possible and the more impactful the work is.

Misallocating the time of scammers to scamming - which depending on their field requires immense intelligence - is a waste of human capital. Building the core productive systems that scammers exploit is far more useful than being one of the individuals that extracts value from these systems for their own benefit, you also get more rich. The inefficiency of scammers currently infects and will continue infect AI. Many H100s are wasted on activities that are not increasing productivity.

BUILD

The four principles laid out above:

1. Do not be complicit in increasing the inefficiency of the world
2. Do not create or work on scammable systems and minimize your participation in them
3. Increasing productive output increases human flourishing
4. Instead of scamming, BUILD!

Increasing the productive output of humanity by building useful things is one of the best uses of life. Your creations will directly impact the future flourishing of humanity, or, if you work on something farther from the base level of reality, you will at least be one of the real productive people - someone has to do the real work. A life well lived is one directly useful to the future of humanity.

Deep tech is the least scammable sector and the place where the most true impact and innovation occurs. This is why You Should Be Working On Hardware.

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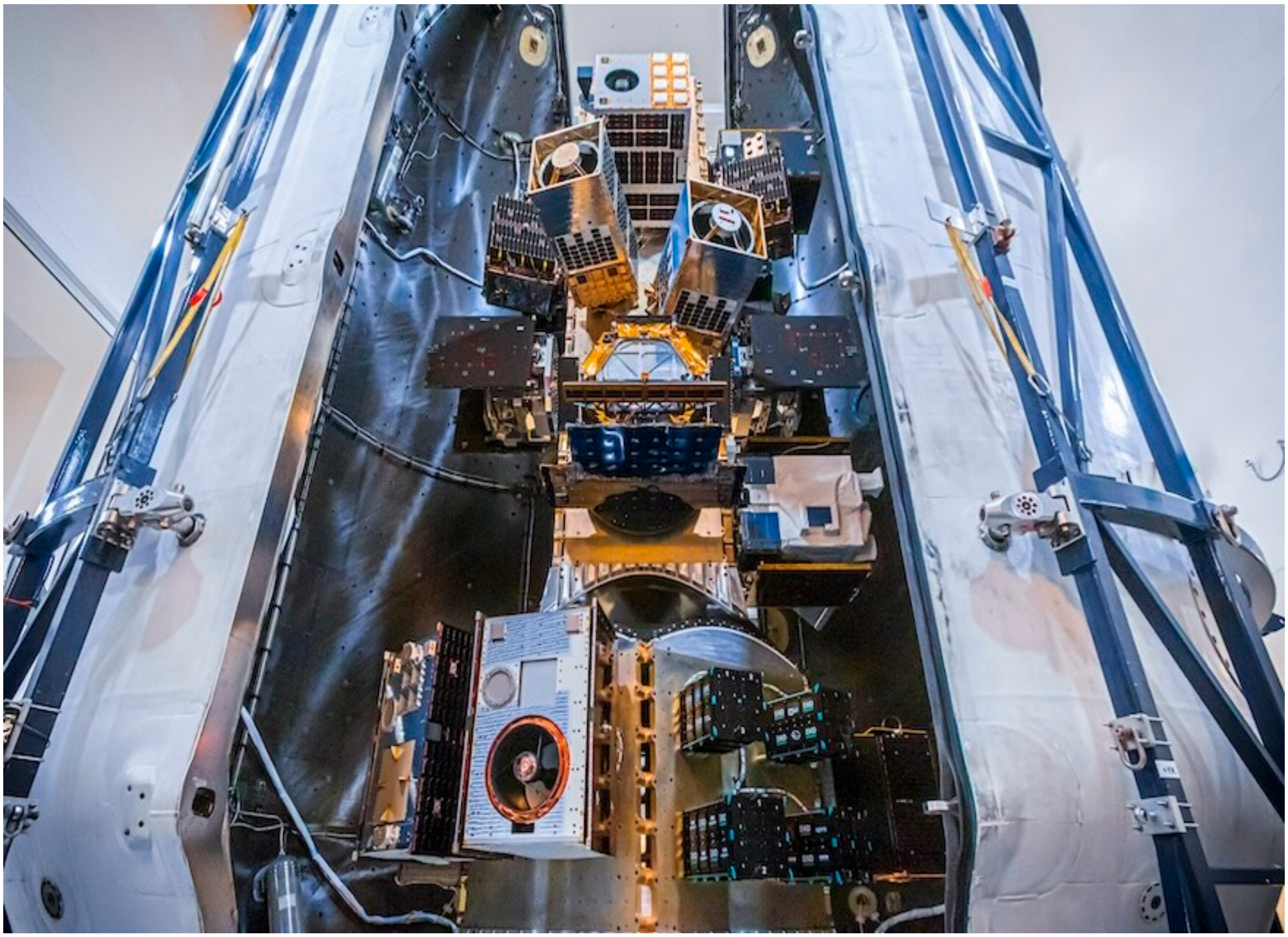
Christopher Kalitin Blog

What SpaceX's Bandwagon Missions Mean for Small Rockets

Apr 9, 2024 • Christopher Kalitin



SpaceX's Bandwagon-1 rideshare mission launched yesterday and I was busy speedrunning a unit of Chemistry 11 in 8 hours to write this blog post before the launch. Regardless, this is the first of SpaceX's rideshare missions to low inclination orbits. The Bandwagon-1 mission will expand the range of payloads that can be launched on a Falcon 9 rideshare mission and will continue the trend of making dedicated small satellite launch a smaller niche of the market. However, hile dedicated small satellite launch will lose market share, the overall market will increase and provide more satellites that must be launched.

Three months ago I wrote this blog post on the dedicated small sat launch market. The Bandwagon missions will have significant implications on the conclusions I came to. Specifically, many of the satellites I listed as requiring a dedicated small sat launch in fact do not.

Payloads Unsuited for Dedicated Launch

Bandwagon-1 launched 11 satellites, from SpaceX's website: "On board this mission are 11 spacecraft including KOREA's 425Sat, HawkEye 360's Clusters 8 & 9, Tyvak International's CENTAURI-6, iQPS's QPS-SAR-7 TSUKUYOMI-II, Capella Space's Capella-14, and Tata Advanced Systems Limited's TSAT-1A."

Two of the payloads are very well-suited to a rideshare mission:

1. CENTAURI-6 - Internet of Things connectivity satellite, 12kg
2. TSAT-1A - Tech demo for Earth Observation, 42kg

The CENTAURI-6 satellite is a 35kg, 6U cubesat that provides connectivity for relatively low-bandwidth applications. The maker of the satellite, Fleet Space Technologies, plans on launching a constellation of 140 satellites. Previous prototypes have flown on a PSLV, Electron rideshare, and three times on Falcon 9 rideshare missions. Because these are prototypes, they do not require exact orbits like a full constellation would. SpaceX Transporter missions are ~10x cheaper per kg than a dedicated launch, so it makes sense to launch these prototypes on a rideshare mission. In the future, when the constellation is ready to be deployed, they will likely use dedicated launches to get full coverage of the Earth.

The TSAT-1A satellite weighs 42kg and is a tech demo for Earth Observation from India. This is a demonstration satellite and does not require exact orbits. Given the fast that rideshare is 10x cheaper than a dedicated launch, it's clear why these didn't launch on an electron.

The default for small satellites is to use a rideshare mission, they only use dedicated launches if it is required for their mission or if they have schedule constraints.

Payloads That Could've Launched on a Small Launch Vehicle

1. Korea 425 - Korean Military SAR satellite, 800kg
2. HawkEye 360 Satellites - Space Situational Awareness Satellites, 25kg each
3. QPS-SAR-7 TSUKUYOMI-II - SAR satellite, 120kg
4. Cappela 14 - Earth Observation Satellite, ~100kg

The Korea 425 Satellite is the second in a line of Synthetic Aperature Radar (SAR) satellites for the Korean military. It's mass is 800kg which is outside the range of many small launch vehicles like

Electron, but Firefly's Alpha or ABL's RS1 could have launched it assuming the payload fairing are large enough. In the future, if the Korean military wants to position their satellites to optimize coverage of the Earth, they may need to launch on a dedicated mission.

Last year, on December 1st 2023, the first Korea 425 satellite was launched on a Falcon 9 mission along with 23 small satellites as rideshare payloads. Because it was the primary payload on the mission it was able to dictate the orbit and inclination of the mission. This may have occured on Bandwagon-1 as well because the Korea 425 satellite is the most massive payload on the mission and the first one listed by SpaceX.

When 1-ton class launch vehicles start launching regularly, it may be more cost-effective to launch these 1-ton class satellites on those vehicles. However, this time the Korean military chose to launch on a Falcon 9 rideshare mission likely because RS1 and Alpha were not an option at the time.

Six Hawk satellites were launched on this mission. In my previous blog post on the small satellite launch market I categorized these as Earth Observation when in fact they are Space Situational Awareness satellites. They collect RF signal data in space and sell this data to commercial customers. Previously they have flown on an Electron and on six Transporter missions. These satellites have been mostly indifferent to inclination and their exact orbit, but as they scale the constellation they may perfer dedicated launches to get better coverage of LEO. They have 2 launches coming up on Electron.

The trade-off between frequent coverage of the Earth and cost is clear in the case of iQPS. Electron has launched many Earth Observation satellites. This is their primary market because many constellations seek to image parts of the Earth as frequently as possible. SpaceX calls this a "high revisit rate". The QPS-SAR-7 TSUKUYOMI-II satellite is a Synthetic Aperature Radar satellite and iQPS has previously launched these satellites on a dedicated Electron mission as well as a rideshare missions on Epsilon and Falcon 9. Because of the relatively small size of the constellation - they're on their 7th satellite - they don't need dedicated launches to optimize their coverage of the Earth as opposed to a constellation like Starlink that must get very high coverage.

Capella has previously launched satellites on both Electron and Falcon 9. They currently have 7 satellites in orbit so they fall into the category of constellations small enough that they don't require dedicated launches to achieve optimal coverage of the Earth. The reason for Capella launching on both Electron and Falcon 9 is likely schedule. They may want to reasonably space out their satellites - hence launching one at a time - but also want to launch many. So, a few Transporter missions a year is not enough.

The advantage of Bandwagon missions over Transporter can be seen when comparing the inclinations of Capella's dedicated Electron missions vs. the Falcon 9 missions. The Capella Electron launches had an inclination of ~45 degrees while Transporter is around 95 degrees. The lower inclination means the satellites spend less time at the poles and more time over economially interesting areas of the Earth.

Analysing Electron's Manifest

There are a couple sources for Electron's 2024 manifest. Many of these are outdated as the manifest has changed since they were published. The most up-to-date source I've found is Scott O's list, even better than Next Space Flight's.

	Live and Let Fly	March 21, 2024	National Reconnaissance Office
NASA	NASA / KAIST Rideshare	April 24, 2024	NASA / KAIST
	HawkEye-2	June 2024	HawkEye 360
kinéis	Kinéis-1	June 2024	Kinéis
BLACK SKY	BlackSky-07	July 2024	BlackSky
NORTHSTAR	NorthStar-2	H2 2024	Spire & NorthStar
PREFIRE	PREFIRE-1	August 2024	NASA
PREFIRE	PREFIRE-2	August 2024	NASA
kinéis	Kinéis-2	September 2024	Kinéis
kinéis	Kinéis-3	November 2024	Kinéis
VARDA	Winnebago-2	Q3 2024	Varda Space

In the previous secitons I laid out the advantages of Transporter / Bandwagon missions. Both are lower cost and Bandwagon gives a more ideal orbit for many payloads because of the higher revisit rates. Now these advantages can be used as a framework for analysing which types of payloads on Electrons manifest may be at risk. Not the payloads themselves, but the general types of payloads.

The first launch on the list, NROL-199 (NROL-123?) "Live and Let Fly", was a US military launch. The military uses dedicated launch because of security reasons with payloads and this payload may need an exact orbit. From Jonathan McDowell's data it's not clear the final orbit the satellite was deployed into (COSPAR ID: 2024-053A). The estimated orbit is 500km at 48 degrees.

The NASA / KAIST (Korea Advanced Institute of Science and Technology) rideshare mission is going to a specific orbit. First, KAIST's NEONSAT-1 will be deployed in a 500km orbit and then the Photon Kick Stage will be used to deploy ACS3 - a solar sail tech demo satellite - to a 1000km orbit. From the mission profile, it seems the ACS3 satellite is the primary payload. The KAIST satellite may be launching as a rideshare payloads on an Electron due to schedule constraints, while the ACS3 satellite requires a dedicated launch for a specific orbit. Kick stages like Helios's Mira will made it possible to launch these payloads on Medium-lift rideshare missions like Transporter. In the cost estimates section of my previous blog post I point out how this can be much cheaper than a dedicated launch.

NASA's PREFIRE launches are an excellent example of the perfect payloads for Electron. The PREFIRE-1 and PREFIRE-2 satellites are Earth Observation satellites that will be deployed to a polar orbit to study the Earth's poles. Like NASA's earlier TROPICS launches, these satellites require specific orbital planes to optimally cover the Earth. This can't be done on a rideshare mission unless you are the primary payload, like the first launch of Korea 425. This is the type of launch that will continue to be done on dedicated small launch vehicles.

The remaining payloads on Electron's manifest can be put into two categories. First, payloads that are part of relatively small constellations that don't require perfect seperation of orbital planes. Second, payloads that much prefer unique orbital planes which can't be achieved on rideshare missions.

Both the HawkEye 360 and BlackSky have launched on both rideshare and dedicated launches in the past. Because of the significant cost savings over dedicated launches, they may choose to launch on Transporter or Bandwagon missions in the future, as they have in the past. Particularly Bandwagon in the cases of these two companies as they both benefit from lower inclinations. However, as they scale their constellations the benefit of unique orbital planes for each group of constellation satellites starts to outweigh the cost savings of rideshare.

Kineis and NorthStar are planning to start with large constellations. They aren't quite following the exact same path of previous satellite constellation companies like Capella which began with many test satellites. Right off the bat they've booked 8 Electron launches between them and may continue to book more dedicated launches as they scale their constellations. This approach allows a faster ramp to profitability. For some, this approach was not as possible in the past because of the youth of the small launch market. For example, when Capella was launching their first few satellites Electron only had a couple of launches and the industry had much less experience in manufacturing reliable small satellites. Like PREFIRE, these small satellite consetllations are the type of payloads that are very well-suited to dedicated small launch vehicles.

Just yesterday Rocket Lab signed a contract to launch a US Space Force payload to a very low Earth Orbit. "DiskSat will demonstrate sustained VLEO (very low earth orbit) flight and test a unique, 40-inch diameter, disk-shaped satellite bus that is designed to increase on-orbit persistence," the Space Systems Command said. This is a unique payload that requires a dedicated launch and it's where Electron shines. In the future this may be addressable by a kick stage like Mira on a rideshare mission, but for now it requires a dedicated launch.

Outlook on the Small Satellite Launch Market

In my Analysing the Dedicated Small Sat Launch Market blog post I came to a slightly incorrect conclusion. This error came from looking too closely at Rocket Lab and not the market as a whole as I did not look closely enough at the rideshare market to see how many small constellation satellites don't need exact orbits. My conclusion was that almost all small satellite constellations would require dedicated launches. This is slightly incorrect as we can see from the HawkEye, BlackSky, etc. launches on rideshare missions. There is an advantage from launching on dedicated missions - as is seen in Kineis and NorthStar's approaches - and with the growth of constellations like BlackSky there is a push for more dedicated launches. I came to the right conclusion, but with incorrect reasoning.

Rideshare inevitably would take significant market share from dedicated launch vehicles. The cost savings are too significant to ignore. Some think that SpaceX is maliciously trying to take market share from Rocket Lab and other small launch providers. This is not the case as rideshare is a commercial inevitability. SpaceX is simply providing a service that is cheaper and more convenient for many small satellite operators.

Rocket Lab does not compete with SpaceX on small satellites. In a conversation with Anthony Colangelo on the MECO podcast (check it out!) several years ago Peter Beck said, "[Dedicated Launch is] never going to be as cheap as rideshare" and "Our vehicle is more expensive and we don't try to compete with rideshare" (47:50).

From looking at Electron manifest we've seen that around 10-20% of payloads will be addressable by rideshare missions in the future. This is offset by the growing small satellite constellations. Rideshare allows for a lower barrier to entry for satellite constellations, which often evolve and expand to needing dedicated launches. There is a significant market for dedicated small launch vehicles even while competition from MLV rideshare grows. Over the next decade, rideshare will not be the largest threat to small launch vehicles. Vehicles like Nova will be the largest threat in my opinion as they will be able to have high cadence because many different segments are available to them which allows lower costs. Just like Falcon 9, it will be a side effect that they destroy the partially reusable small launch market.

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Christopher Kalitin Blog

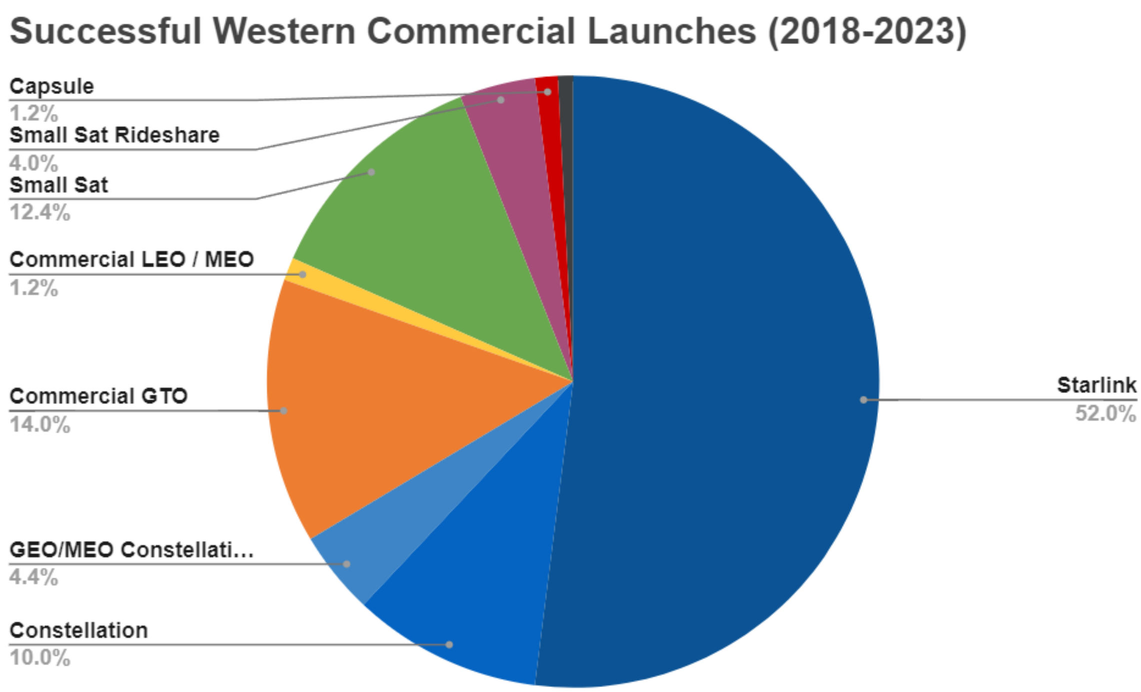
Stoke's Nova is a Perfectly Sized Rocket

Feb 26, 2024 • Christopher Kalitin

At first glance, Stoke’s Nova appears to be an immensely exciting R&D project without much commercial appeal. In a world where the most successful rocket is a 20-ton class partially reusable launch vehicle, it is difficult to see exactly how such a comparatively small rocket will compete. Data is the answer to all your problems, so I’ve answered all my questions with my dataset (Based on Jonathan Mcdowell’s public data, Gunter’s Space Page, and others) on successful western orbital launches from 2018-2023 inclusive and will convey all insights in this blog post. My primary goal is to examine Nova from a demand perspective.

Stoke’s Nova rocket is perfectly sized to compete for existing satellite launches and future constellations. It can compete for LEO satellite launches as the average mass of customer payloads on Falcon 9 is 3.7 tons (ex. Dragon). Full reusability will allow it to compete against Electon and launch constellations even with its 3t-7t LEO capacity. The launch cost must be several times lower than competitors and reusability allows for this. Finally, the fully reusable architecture lends itself to becoming a cargo/crew capsule while refilling in orbit to address high energy orbits and potentially Moon/Mars landings.

Full Reusability Makes Constellations Addressable



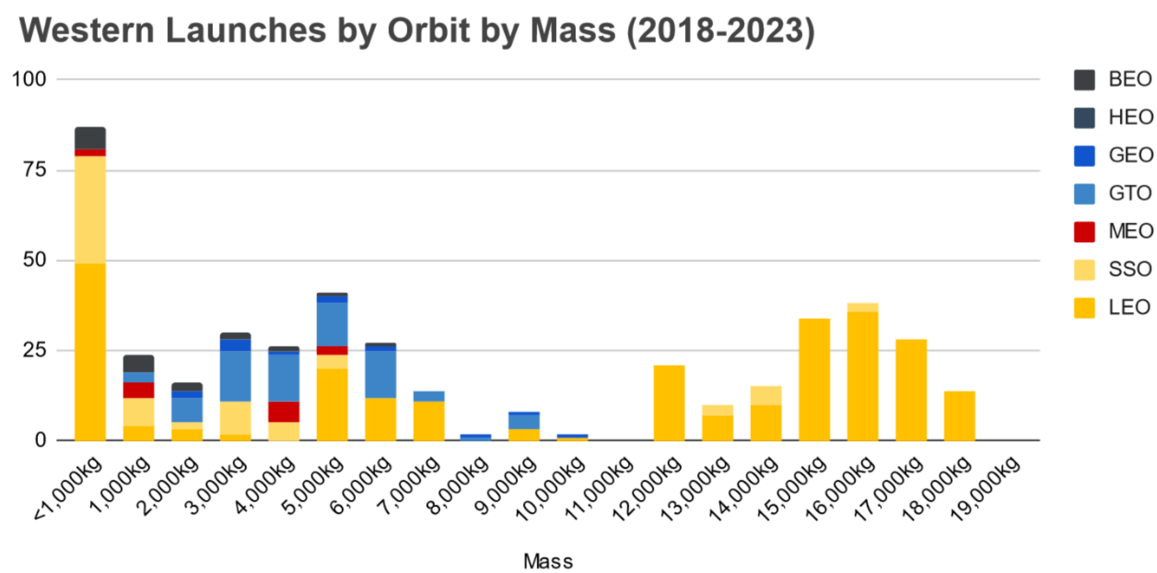
Through following current trends in the launch market it is clear that launching constellations is the market that almost all new rockets should be optimized for. 67% of commercial launches in the last 6 years were for constellations. 80% of these launches were Starlink while the remaining is comprised mainly of Iridium and OneWeb. With numerous upcoming constellations - mainly Kuiper - it is clear this market will experience much more rapid growth than other payload types.

Excluding Starlink, the market for commercial launches is shared in equal thirds between Constellations, GEO Communications Satellites, and Small Satellite launches. Legacy GEO Communications satellites are a fairly static market and have been for ~20 years at around 10 launches per year. Small satellites are experiencing exponential growth, but the TAM for rideshare missions is relatively low. This leaves constellations as the massive market that is exponentially growing.

The primary considerations behind launching constellations are responsiveness and cost per launch per satellite. Constellations can be launched on rockets of almost any size because they are made up of a large number of relatively small satellites. To illustrate this, a 20-ton class medium-lift launch vehicle is not the only vehicle type capable of launching constellations because a 5-ton class rocket can be competitive if the cost is 4x less and has 4x higher cadence. Furthermore, the requirement for an increased number of launches potentially gives advantages in responsiveness.

Stoke’s Nova is rumored to have a 3-ton LEO capacity when reused, 5-tons when the booster is reused, and 7-tons when fully expended. At this scale, to be competitive with Falcon 9 it must be ~6x cheaper per launch which would cost $10M for the customer or ~$2.5M internal marginal launch cost. As we’ve seen with Falcon 9, reusability has dramatically decreased launch costs to the point where the majority of the cost of a rocket is no longer in the first stage. Second-stage reusability will drive down costs even further and a small launch on the scale of Stoke’s Nova is well suited to achieving a high launch cadence which will accelerate the process of decreasing costs.

Nova can Launch Most Payloads



Launching legacy geostationary communications satellites has very different considerations from launching constellations. These launches require immense mass to GTO capability and prefer high-energy optimized architectures like Ariane 5 or Vulcan. However, ~60% of the commercial GEO satellites launched in the last 6 years were under 5 tons. Because refilling in orbit is planned for Nova, it will be able to put its entire LEO capacity directly in a geostationary orbit and potentially return the second stage (Assuming 6000m/s+ delta-v in the upper stage similar to Starship & <3-ton payload). Because the vehicle is fully reusable - at <3-ton payloads - this may cost less than a dedicated Falcon 9 launch.

The average mass of Falcon 9 customer LEO launches excluding Dragon is 3.7 tons. Between 2018 and 2023 inclusive, 32 of these launches occurred and only 4 of them were over 5 tons. This means Nova could have launched 28 of the previous 32 Falcon 9 customer launches while reusing the booster and slightly less if reusing the upper stage as well. This assumes there were no further considerations such as payload volume. Because Falcon 9 is oversized for the majority of LEO customer payloads, Nova is well-positioned to compete in this market.

Small satellite rideshare missions are well suited for Nova given their low mass requirements and flexibility. For example, SpaceX Transporter missions are often below 5 tons, another example of Falcon 9 being oversized for customer payloads. The limiting factor in Nova being able to launch these missions may be payload volume because Nova's payload fairing is smaller than Falcon 9's. Regardless, this is solved by launching fewer satellites at once. Rideshare missions are flexible enough that they can launch on nearly any vehicle and the potential for extremely low cost with Nova makes it well-suited for these launches.

It's not just rideshare missions that Nova can address, but given potentially extremely low costs, it could be economical to conduct dedicated launches for small satellites. Stoke will have to decrease costs below where Electron is today - ~$8M - and increase cadence. If second-stage reuse is achieved, Electron-level costs are possible and because Nova has many more market segments available than Electron, a higher cadence can be achieved.

All 4 of the Falcon 9 LEO customer launches that exceeded Nova's 5-ton booster-reuse payload capacity were for the US Military. There were two NROL launches and two SDA launches. Because of the classified nature of these payloads, their exact mass is unknown, so some of them may be within Nova's 5-ton payload capacity. Even so, to launch these payloads Nova would have to be certified by the US Military to launch classified payloads under NSSL Lane 2 which is unlikely given competition from SpaceX and ULA. NSSL Lane 1 payload are of lower mass and lower energy orbits which Nova will be able to compete for.

NSSL's phase 2 target orbits can illustrate the advantage of orbital refilling. Nova may be able to achieve all but one of the NSSL Phase 2 target orbits if the vehicle used the 7-ton fully expendable LEO capacity. These orbits are mainly high-energy and require 4-7 tons of payload capacity. For example, the GEO 2 target orbit requires 6.6 tons direct to GEO and MEO Direct 1 requires 5.3 tons direct to an 18,200km orbit of Earth. The only required orbit Nova can't achieve is Polar 2 which requires 17 tons to a 830 km polar orbit of Earth. This shows that in-space refilling is a feature that opens up a lot of capability and how Nova will be competitive for NSSL Phase 3 Lane 1 payloads.

Crew / Cargo Capsule and Lunar Landing

Nova's upper stage is a fully reusable orbital reentry vehicle capable of propulsive landing. Previous vehicles capable of orbital reentry have all carried crew or cargo and orbital vehicles capable of propulsive landing have all been Moon/Mars landers.

In Stoke Space's promotional video 4 months ago they teased in-orbit refilling and Moon landings. As mentioned above, in-orbit refilling allows them to increase payload capacity beyond low-earth orbit which also makes it possible to achieve a lunar landing. Using low earth orbit as a starting point, a lunar landing requires ~5,700 m/s of delta-v. If Nova's upper stage has a similar delta-v to Starship (6000m/s), this is possible with a full 5-ton payload. Even if delta-v is lower than 6000m/s or significant extra mass is required to achieve a lunar landing, the payload capacity to the lunar surface will be greater than a ton. This is a higher payload capacity than the largest Commercial Lunar Payload Services lander - Astrobotic's Griffin - which is capable of delivering 625kg to the lunar surface. A Nova-based lunar lander could deliver more payload to the Lunar surface for a lower overall cost than the existing CLPS landers.

Lunar landings of lower cost and higher reliability are made possible by testing the landing system on Earth dozens or hundreds of times before attempting a Lunar landing. Engines and maneuvering systems will be tested many times before a lunar landing which makes a failure during landing far less likely. For example, failures like Peregrine, Luna 25, or Beresheet would not have occurred on a sufficiently tested vehicle. Lunar-specific features cannot be tested on Earth such as communications or landing software and these are among the greatest causes for failure. A lunar landing with Nova remains a significant technological challenge, but a vehicle tested on Earth or in Earth orbit hundreds of times has a far higher chance of success and can be cheaper.

Nova is an undersized rocket for launching crew. For example, Soyuz is one of the small crew capsules currently flying and it weighs 7 tons. This is beyond Nova's 5-ton partially-reusable LEO capacity and makes it very difficult to create a crew capsule even if it is integrated into an existing spacecraft with maneuvering capabilities. A Cargo Capsule is more reasonable, but it may be unlikely that there will be sufficient demand for Stoke Space to pursue this. In his interview with NASASpaceflight, Andy Lapsa - Stoke Space CEO and cofounder - was asked about crew rating Nova and said this: "I actually expect that we'll see a bimodal distribution in the optimal size of the vehicles. One of them is designed for satellites and one of them is probably bigger designed for humans with life [support] systems."

Small Size if a Feature

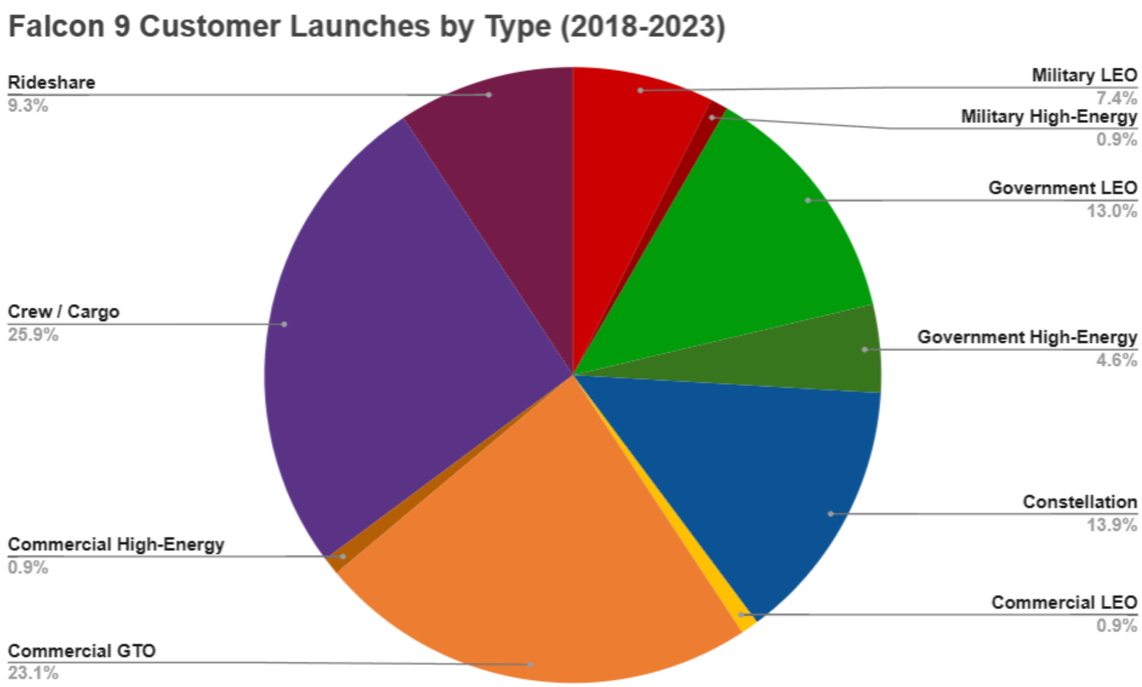
The fully reusable architecture allows for a high flight rate which can bring down the cost per launch and allows for rapid iteration.

Flight rate is one of the primary factors behind falling launch costs apart from vehicle architecture. Launching many multiples more than your competitors with a smaller fully-reusable vehicle allows for an accelerated process of lowering costs. Contrast this with Neutron, which will likely launch less than Falcon 9 with a second stage of similar complexity. This suggests it will be much harder for Rocket Lab than Stoke to compete with the Falcon 9.

Launching constellations would provide an excellent opportunity for Stoke as they could substantially increase launch cadence as Starlink did for Falcon 9. Constellation satellites are payloads that can accept more risk than other more expensive, one-off payloads. This means they can be launched on riskier life-leading boosters and upper stages. For several years, the life-leading Falcon 9 boosters only launched Starlink satellites. After years of testing and iteration SpaceX's customers became comfortable with launching on these boosters. SpaceX's current life-leading booster, B1060, recently launched the Odysseus IM-1 lunar landing mission on its 18th flight.

SpaceX iterated on Falcon 9's design for years and refined it through the process of launching Starlink satellites on life-leading boosters. Thus far, Stoke has embraced iteration and hardware-rich development through the development of Nova's upper stage and the first stage engine. Launching constellations will allow Stoke to used the same spirit of iteration, hardware-rich development, and pushing hardware to its limits to refine the vehicle.

Competing Against Partially-Reusable Launch Vehicles



Vehicles like Nova are the perfect competition against partially reusable medium launch vehicles. This can be illustrated by seeing where Nova and Neutron will compete. First, the average mass of customer payloads on Falcon 9 is 3.7t (excluding Dragon). This is addressable both by Nova and Neutron. Second, the next largest market for Falcon 9 is GEO communications satellites. Neutron GTO capacity is supposedly to be 3-5 tons and because Nova is planned to be refilled in orbit, it will have a comparable GTO capacity to Neutron. Finally, both rockets will compete for launching constellations and because Nova is designed for full reusability, it can achieve an overall lower cost than Neutron.

Almost every payload that can be launched on Neutron can be launched on Nova. The major exception is LEO satellites that are >5 tons. This is a relatively small market as it is mostly US