Military payloads that are launched by SpaceX and ULA. It is unlikely that Stoke or Neutron will be competitive in NSSL Lane 2 without more changes to NSSL policy, but they will be compete in NSSL Lane 1.

Heavy-lift rockets such as New Glenn and Terran R are much harder to compete against with a vehicle on the scale of Nova. Larger rockets can pursue unique missions and are better suited for heavy GEO satellites and massive constellations. For example, Nova could not compete for HLS as a vehicle on the scale of New Glenn or larger is required. Furthermore, for extremely large constellations such as Starlink or Kuiper, a larger rocket is better suited due to the sheer amount of satellites needed. Nova will need to launch many times a day to compete with these rockets on Starlink-sized constellations.

Competing Against Fully-Reusable Launch Vehicles

Stoke's Nova is clearly an excellent architecture to compete against partially-reusable launch vehicles, but Nova's position against larger fully and rapidly reusable launch vehicles is far less clear. In the next 10-20 years we will enter the paradigm of fully and rapidly reusable launch vehicles. It will not be just Starship and Nova, but every new rocket will be fully and rapidly reusable. When every major rocket is fully and rapidly reusable, Nova will not have all the benefits it will enjoy against partially reusable launch vehicles over the next ten years.

Large constellations will most likely be launched on large rockets. The sheer number of launches required to put the same mass into orbit compared to a heavy-lift reusable rocket makes it unlikely that a Nova-sized vehicle will be able to compete. For example, Nova would have to be 30x cheaper than Starship to be competitive. When rockets enter an airline-like model, cost per kilogram will become a more important factor and the larger scale of Starship will become more of a competitive advantage.

While large constellations will not be addressable by Nova, smaller constellations will be. All constellations require satellites to be launched into unique orbital planes to achieve proper coverage of the Earth. This can not be done on a single launch because of the immense fuel requirements to change orbital planes. On the scale of Starship, this means each launch may not carry enough satellites to be economical. For example, each Falcon 9 Iridium launch carried 10 satellites which weighed ~6.6t. This scale of constellation or smaller (Eg. Blacksky, Synspective, etc.) are well suited for a Nova-sized vehicle.

Aside from constellations, Nova may become the most economical small sat launcher. Its small size and full reusability will allow it to launch small satellites at a lower cost than any other vehicle, including Electron. Furthermore, it may not be economical to develop a smaller fully reusable small sat launcher due to the upfront development costs. A rocket designed for only small satellites will not be able to launch constellations or 1-5 ton satellites, which comprise the

majority of the launch TAM. So, even if a smaller rocket is >50% cheaper per launch, it will take a very high number of flights to amortize the development cost. In 10-15 years Nova may begin launches more small satellites than any other vehicle.

In a world of fully and rapidly reusable rockets, Nova may be similar to Electron today. It will have a niche of payloads that are well suited for its size and cost. This includes small satellites, small constellations, and <5t satellites like those currently launching on Falcon 9.

Not Many Organizations Can Pursue Full Reusability

Current and upcoming rockets that are aiming to launch constellations are all partially reusable medium/heavy lift launch vehicles (excluding Starship, which is covered in the section above). A partially reusable rocket is the most reasonable thing for a slightly risk-averse company to do. For companies like Rocket Lab or ULA, it is very difficult to pursue a fully and rapidly reusable rocket because it is an unproven market and has never been done before which makes it a very hard sell to investors. This is especially true when you consider the development cost of such a program: ~$250M for Neutron vs. ~$5B for Starship.

It takes a level of audacity to push for such a program that will create its own market. SpaceX has done this again and again with Falcon 9, Starlink, and now with Starship & Mars. When existing stakeholders are not willing to take the risk, a more conservative approach must be taken that is less likely to succeed against a sufficiently capable competitor. We've seen this in the past with the SLS and other legacy launch companies like ULA.

A clear vision and path are required to pursue a fully and rapidly reusable rocket - along with immense amounts of capital. SpaceX achieved this under Elon Musk with his own fortune, NASA contracts, and venture capital. Stoke will follow a similar path, pursuing a goal that is decades away and beating the competition along the way because of this forward vision.

Conclusion & Predictions

A fully and rapidly reusable launch vehicle on the scale of Stoke's Nova is perfectly sized to compete against existing and under-development partially reusable launch vehicles. It is well suited to launch constellations, LEO satellites, small & medium GEO satellites, dedicated small satellites, and small sat constellations. If full reusability is achieved with Nova, it will take significant market share over the next 5-10 years.

Over the next decade, we will start to enter the paradigm of fully and rapidly reusable rockets. These rockets will be able to launch all payloads at a lower cost than all existing vehicles and alleviate the current mass and volume limitations. The lower cost will allow for new markets to emerge and for a new paradigm of satellite design. K2 Space is already preparing for this by

developing satellites that are very heavy and have a large volume. This increases launch costs but decreases the cost to build the satellite through using cheaper (but heavier) parts. There will come a point in the next 10-20 years when this becomes more economical than the current paradigm of satellite design, at which point a paradigm shift will occur.

Nova's market this decade will be very different than the following decades. Before we firmly enter the paradigm of fully and rapidly reusable rockets and have payloads well suited to it, Nova will be able to compete against partially reusable rockets. After we enter this new paradigm, Nova will go the way of Electron and become more of a niche vehicle.

It is possible that Stoke will die brutally like Astra before it achieves low cost and high cadence with Nova. This would be immensely unfortunate because Nova is the coolest rocket ever developed, tied with Starship. However, even in such a depressing scenerio, a vehicle of similar scale to Nova will be developed in the future to adequately serve the <5t satellite market.

Geohot made a blog too. You should be working on hardware

Comparing Demand for Firefly's Alpha vs. Electron

Feb 16, 2024 • Christopher Kalitin

Firefly's Alpha and Rocket Lab's Electron are both in a similar mass class of launch vehicles capable of catering to the small satellite launch market, but because of the differences in capability and price they are not in direct competition for most payloads.

Yesterday I was interviewed by Dave G about the small satellite launch market and we discussed Firefly's Alpha briefly. I felt the need to write this blog post to effectively convey my thoughts and show the information that made me come to my conclusions.

Firefly Alpha Planned Launches

Firefly's Alpha rocket is capable of delivering 1,030 kg to LEO while Rocket Lab's Electron does 300 kg to LEO. Due to Alpha's larger size it is more expensive than Electron and the primary

feature of rockets in this class is launching payloads too massive for smaller rockets. This can be seen in Alpha's planned launches (from wikipedia).

1. NASA ELaNa Rideshare mission (11 satellites)
2. Commercial Rideshare mission (With orbital tug)
3. Satlantis Satellite (first launch, details unknown)
4. NRO Satellite (Classified US Military Payload)
5. ESO SAR 1 Satellite (~200kg+)

From this list of upcoming Alpha launches there appears to be several reasons for payloads to fly on Alpha instead of Electron with mass requirements being the most common. This presents few opportunities for competition.

First, the NASA VCLS (Venture Class Launch Services) rideshare mission contracts have been given to numerous launch providers as a way of supporting development of new launch vehicles. There isn't space for competition between Firefly and Rocket Lab here as the goal of the program is to give new launch vehicles extra funding. Electron is a mature vehicle and is not eligible for these launches anymore.

Second, the Commercial rideshare missions will use Firefly's Elytra orbital tug to deliver the payloads in an exact orbit. This is the first flight of Elytra and on it they will test all the systems. They are dispensing commercial small satellites and proving their capabilities for future NRO missions.

Thirdly, although there is little information available about it, judging from EOS Data Analytics' previous satellite and extrapolating forward, the EOS SAR 1 satellite may to be too heavy to launch on Electron. Furthermore, the CEO of EOS Data Analytics is Max Polyakov, a co-founder of Firefly.

Fourth, Satlantis is a young company so they may have not been able to get on Electron's manifest soon enough. All Electron launches in 2024 are booked and many are already scheduled in 2025. Furthermore, SpaceX Transporter missions have a 2 year wait. This shows merely having a functional launch vehicle - even one that costs 2x more than Electron - is enough to get awarded contracts when there are customers who can't afford to wait two years to launch their payload. Also, their satellite may be too massive to launch on Electron, we will know once it launches in 2024.

Finally, the NRO responsive space mission is part of a contract between the NRO and Firefly. The goal of this contract is to provide the capability to launch a payload for the NRO at a moment's notice. In 2023 Firefly demonstrated this capability when they launches the Vitcus Nox satellite within 27 hours of the launch order. Another requirement for this contract appears to be that it must take place in the US as it is a military payload that must launch on short notice. Rocket Lab

only has one Electron launch pad in the US, so staying ready for a launch at all times may interfere with commercial payloads.

Competition between Alpha and Electron

With the context of Firefly's planned launches we can consider the opportunities for competition between Firefly and Rocket Lab for these launches.

If the commercial rideshare mission is too massive to be launched on a single Electron, two launches could have been used. This would make the cost nearly equal between both launch providers and schedule becomes a larger concern. Because Electron is all booked for 2024 this gives Firefly and advantage until Rocket Lab increases cadence. Furthermore, with SpaceX transporter mission being booked for the next two years, Firefly was in a very good position to launch this mission.

If Electron was a larger vehicle it may have been able to launch the EOS SAR 1 satellite. However, the development costs associated with this make it not economical for Rocket Lab to pursue such a capability. Marginally increasing payload capacity is much less useful than increasing cadence or partial reusability.

With increased cadence and a smaller backlog for Electron, Rocket Lab may have gotten the opportunity to launch the Satlantis satellite. This is assuming it is not too heavy for Electron which is currently unknown. Rocket Lab has always been interested in increasing cadence and with current trends Electon may be demand limited within 2-3 years.

Schedule and payload requirements may have limited Rocket Lab's ability to compete for the NRO responsive space contract. Rocket Lab's first launch from the US was in early 2023 and the contract was awarded in August 2023. As mentioned above, Rocket Lab can get more use out of the pad when launching commercial payloads than keeping it primed for the NRO. So, for this contract to be a net gain to Rocket Lab they may have needed another launch pad in Virginia. Space is limited on Wallops Island and Rocket Lab had limited time which led to the company not being able to successfully compete for this contract. If another similar contract arises in the future it will be very interesting to follow and observe if Rocket Lab is in a better position to compete for it.

Overall, the only planned Alpha payload that reasonably could have flown on Electron is Satlantis' satellite and possibly the rideshare mission. This shows the different niches both rockets are optimized to compete for.

Firefly does not have a vehicle well-suited to compete for payloads currently launching on Electron. The cost to launch Firefly's Alpha is $15M while Electron costs ~$7M. With the 200% difference in cost, satellite operators are highly incentivized to launch on Electon. Furthermore,

the average mass of payloads launched on Electron is ~116kg. The primary reason for a satellite that can launch on Electron to use Alpha is likely schedule considerations and Firefly may have gotten the Satlantis launch because of this. This schedule constraint will likely alleviate in the future as cadence increases.

In conclusion, the larger size and higher cost of Firefly's Alpha rocket makes it well-suited for different payloads than Electron. This niche of payloads will likely increase in number as the commercialization of space continues and this growth will offset potential competition from smaller and cheaper rockets.

Edit July 4 2024: This analysis didn't include small sat constellations, I've written more on this here.

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Analysing the Dedicated Small Sat Launch Market

Feb 10, 2024 • Christopher Kalitin

In the last 6 years, Rocket Lab's Electron dedicated small satellite launches and SpaceX's Transporter rideshare missions have become regular occurrences. This has posed a problem many have struggled to answer by my standards: Why would any satellites be launched on a small rocket when rideshare missions are cheaper?

Jonathan McDowell Data					Orbit			Small Sat Type		
Launch Type	#Launc	LV_Type	Flight	Mission	Apogee	Perigee	Inclincation	Is Small Sat	Type	Sat Type
Commercial	2018-010	Electron	Still Testing	Dove/Lemurs	500 km	300 km	83°	Yes	Rideshareable	Earth Imaging
Government	2018-016	SS-520	Tasuki	TRICOM-1R	1,500 km	180 km	30°	Yes	Government	Earth Imaging
Commercial	2018-088	Electron	It's Business T	CICERO 10/Le	420 km	210 km	85°	Yes	Rideshareable	Earth Imaging
Government	2019-015	Vega	PRISMA	PRISMA	625 km	625 km	98°	Yes	Government	Earth Observa
Government	2019-016	Electron	Two Thumbs U	R3D2	425 km	425 km	40°	Yes	Military	Military
Military	2019-026	Electron	T.A.Funny Loo	STP 27RD	500 km	500 km	40°	Yes	Military	Military
Commercial	2019-037	Electron	Make It Rain	BlackSky Glob	500 km	490 km	94°	Yes	Unique Plane	Earth Imaging
Commercial	2019-054	Electron	Look Ma No Ha	BlackSky Glob	500 km	490 km	94°	Yes	Unique Plane	Earth Imaging
Commercial	2019-069	Electron	As The Crow F	Palisade	1,230 km	1,220 km	88°	Yes	Kickstageable	Earth Imaging
Commercial	2019-084	Electron	Running out o	ALE-2	400 km	410 km	97°	Yes	Rideshareable	Tech Demo
Military	2020-007	Electron	Birds of a Feat	NROL-151	610 km	590 km	71°	Yes	Military	Military
Military	2020-037	Electron	Don't Stop Me	NRO/ANDESITE/I	590 km	570 km	98°	Yes	Military	Military
Military	2020-046	Minotaur IV	NROL-129	NROL-129	580 km	570 km	54°	Yes	Military	Military
Commercial	2020-060	Electron	I Can't Believe	Sequoia	525 km	525 km	45°	Yes	Unique Plane	SAR
Commercial	2020-061	Vega	SSMS	SSMS	460 km	460 km	94°	Yes	Government	Rideshare
Commercial	2020-077	Electron	In Focus	CESAT-IIB/Flo	350 km	340 km	97°	Yes	Unique Plane	Earth Imaging
Commercial	2020-085	Electron	Return To Sen	Dragracer/BRC	480 km	470 km	98°	Yes	Rideshareable	Tech Demo
Commercial	2020-098	Electron	The Owl's Nigh	Strix-Alpha	510 km	490 km	97°	Yes	Rideshareable	SAR
Government	2021-002	LauncherOne	Elana XX	-	400 km	400 km	61°	Yes	Rideshareable	Rideshare
Commercial	2021-004	Electron	Another One L	BIU GMS-T	1,200 km	1,200 km	90°	Yes	Kickstageable	Earth Observa
Commercial	2021-023	Electron	They Go Up Sc	Global-5/Paths	460 km	450 km	42°	Yes	Unique Plane	Earth Imaging
Military	2021-051	Pegasus XL	Odyssey	TacRL-2	500 km	500 km	50°	Yes	Military	Military
Military	2021-052	Minotaur I	USA 316/317/3	NROL-111	600 km	580 km	96°	Yes	Military	Military
Government	2021-058	LauncherOne	STP-27VPA	Tubular Bells I	480 km	480 km	61°	Yes	Military	Military
Military	2021-068	Electron	It's a Little Chi	Monolith	600 km	600 km	37°	Yes	Military	Military
Government	2021-102	Epsilon	RAISE-2	-	560 km	560 km	98°	Yes	Military	Tech Demo
Commercial	2021-106	Electron	Love at First Ir	Global-14/Glob	460 km	450 km	42°	Yes	Unique Plane	Earth Imaging
Military	2021-108	Astra Rocket 3.3	Rocket 3.3	STP-27AD2	440 km	510 km	86°	Yes	Military	Military
Commercial	2021-120	Electron	Data With Dest	Global-16/Glob	460 km	450 km	42°	Yes	Unique Plane	Earth Imaging
Government	2022-003	LauncherOne	STP-27VPB	Above The Clouds	510 km	500 km	45°	Yes	Rideshareable	Rideshare
Commercial	2022-020	Electron	The Owl'sNigh	Strix Beta	550 km	540 km	96°	Yes	Rideshareable	SAR
Commercial	2022-026	Astra Rocket 3.3	Rocket 3.3	Spaceflight Ast	525 km	525 km	98°	Yes	Rideshareable	Rideshare
Commercial	2022-034	Electron	Without Missic	Global-18/Glob	450 km	460 km	53°	Yes	Unique Plane	Earth Imaging
Commercial	2022-047	Electron	There and Bac	E-Space Demo	520 km	520 km	98°	Yes	Rideshareable	Tech Demo
Government	2022-070	Electron	CAPSTONE	CAPSTONE	300,000 km	200 km	28°	Yes	Unique Plane	Other
Government	2022-074	LauncherOne	STP-S28A	Straight Up	400 km	380 km	45°	Yes	Military	Military
Military	2022-079	Electron	Wise One Lool	NROL-162	620 km	620 km	40°	Yes	Military	Military
Military	2022-091	Electron	Antipodean Ac	NROL-199	620 km	620 km	70°	Yes	Military	Military
Commercial	2022-113	Electron	The Owl Sprea	Strix-1	560 km	550 km	98°	Yes	Unique Plane	SAR
Commercial	2022-122	Firefly Alpha	To The Black	-	300 km	300 km	137°	Yes	Rideshareable	Rideshare
Commercial	2022-127	Electron	It Argos From	GAzelle	767 km	750 km	98°	Yes	Kickstageable	Earth Observa
Government	2022-147	Electron	Catch Me If Yo	MATS	585 km	585 km	98°	Yes	Kickstageable	Earth Observa
Commercial	2023-011	Electron	VA is for Laun	Hawk 6	550 km	540 km	41°	Yes	Unique Plane	SAR
Government	2023-019	SSLV	EOS-07	EOS-07	440 km	430 km	93°	Yes	Government	Tech Demo
Commercial	2023-035	Electron	Stronger Toge	Capella 9/10	575 km	565 km	44°	Yes	Unique Plane	SAR
Commercial	2023-041	Electron	The Beat Goes	Global-19/Glob	464 km	451 km	42°	Yes	Unique Plane	Earth Imaging
Government	2023-044	Shavit 2	'Ofeq-13	'Ofeq-13	500 km	500 km	140°	Yes	Military	Military
Commercial	2023-062	Electron	Rocket Like A	Tropics SV05/S	550 km	550 km	32°	Yes	Unique Plane	Earth Observa
Government	2023-072	Nuri	NEXTSAT-2	-	540 km	550 km	98°	Yes	Government	Tech Demo
Commercial	2023-073	Electron	Coming To A S	Tropics SV03/S	550 km	550 km	32°	Yes	Unique Plane	Earth Observa
Commercial	2023-100	Electron	Baby Come Ba	Electron 39 Ric	1,000 km	1,000 km	99°	Yes	Kickstageable	Earth Observa
Commercial	2023-126	Electron	We Love The M	Capella 11 Acc	648 km	640 km	53°	Yes	Unique Plane	SAR
Government	2023-188	ADD TV2	S-STEP	-	650 km	650 km	50°	Yes	Government	SAR
Commercial	2023-196	Electron	The Moon God	QPS-SAR-5	587 km	577 km	42°	Yes	Unique Plane	SAR
Commercial	2023-202	Firefly Alpha	Fly the Lightni	Tantrum	Military			Yes	Military	Military

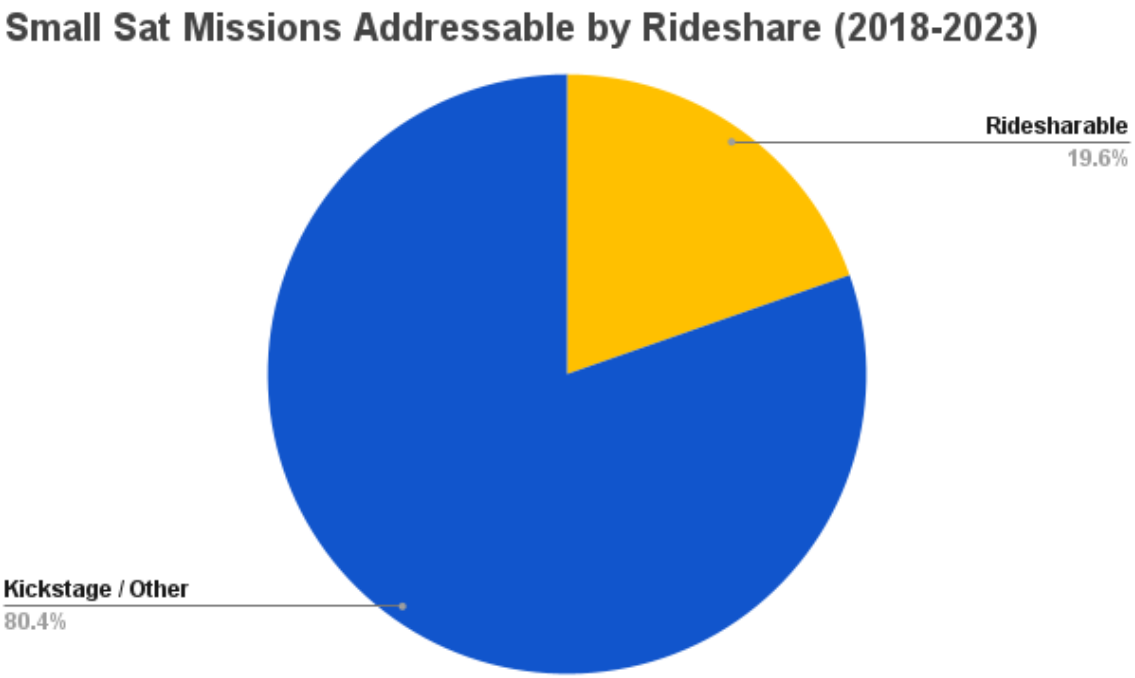
Expanded Source Data Image

To access the source data from the spreadsheet: copy the spreadsheet and in Cell BC2 filter to

only small sat launches.
https://docs.google.com/spreadsheets/d/1VOgRbnAsQZdGIPoemRj5ApSLk_jxGanNliWEPnBB3p4/edit?usp=sharing

More, better, and more accurate charts here: https://drive.google.com/drive/folders/1IAbB-Ydgv3udhIhvfdKp_dWnxUshMqmc?usp=drive_link

Rideshareable Satellites



In the past 6 years (2018-2023 inclusive), 55 dedicated small sat launches have occurred excluding Chinese rockets. By my criteria, 11 of these missions could have been completed by launching on a commercial rideshare mission. However, five of these appear to prefer a dedicated launch and the remaining six are more well-suited for a rideshare mission on a medium launch vehicle.

These missions are (Rocket, Payload):

1. Electron - Dove/Lemurs
2. Electron - CICERO 10/Lemurs
3. Electron - ALE-2
4. Electron - Dragracer/BRO/SpaceBEE
5. Electron - Strix-Alpha
6. LauncherOne - Rideshare
7. LauncherOne - Rideshare
8. Electron - Strix-Beta

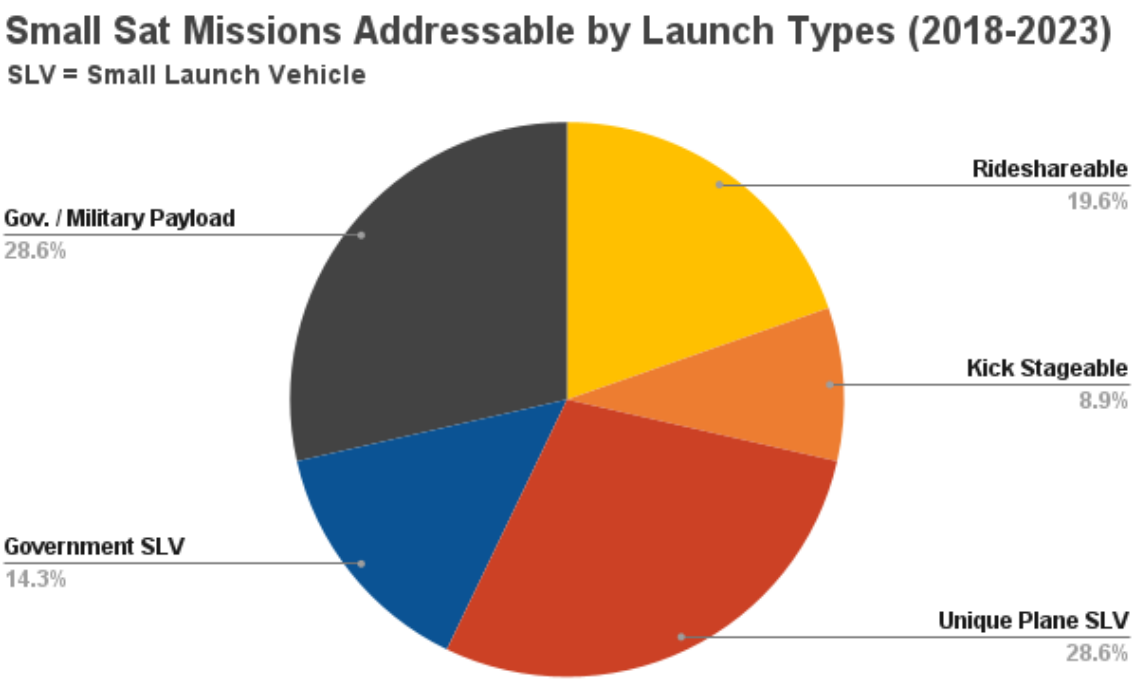
9. Rocket 3 - Rideshare
10. Electron - E-Space Demo
11. Alpha - Rideshare

The rideshare, Planet Labs Dove, and CICERO 10 launches are well suited for a rideshare mission on a medium launch vehicle (MLV). The rideshare missions are all risky flights on unproven launch vehicles (Astra Rocket 3, Firefly Alpha, Virgin Orbit LauncherOne). The reason these payloads flew on a small launch vehicle (SLV) is likely due to the lower cost of flying on a risky rocket. For example, many low-cost Government / Military rideshare payloads flew on Virgin Orbit's LauncherOne. The Dove and CICERO 10 launches are also well suited to rideshare missions because an exact orbit is not required. Planet Labs have been launching payloads on rideshare missions since the first flight of Antares.

The remaining five missions are all tech demonstration satellites and all require a commonly-used Sun Synchronous Orbit (SSO). This is a ~500km orbit at an inclination of 98 degrees that allows a satellite to pass over locations on Earth at regular intervals. This is the orbit every SpaceX Transporter rideshare mission has gone to, but there are more considerations than the end destination.

The reason for launching on a dedicated small rocket instead of a rideshare mission is likely schedule requirements. Rideshare missions only launch a couple of times per year and are scheduled by the launch provider. Small sat operators have much more control over launch date and orbital parameters when flying on a dedicated launch vehicle. This is often cited as the primary reason for companies choosing a dedicated launch over a rideshare mission. However, these five commercial schedule-constrained missions account for only 9% of the small sat launches in the last 6 years.

Kick Stageable Satellites



Only five of the previous 55 small sat launches are suitable for launching on a rideshare mission and using a kick stage. A Kick Stage is a small stage on top of the rocket that can change the orbit of the payload so it is delivered to the specific orbit that is required.

Missions (Rocket, Payload):

1. Electron - Palisade
2. Electron - GMS-T
3. Electron - GAzella
4. Electron - MATS
5. Electron - Rideshare

Each of these five launches have satellites that require unique orbits around the Earth and cannot use the default SSO orbit that many rideshare missions arrive at. The highest orbit is that of Paliside at 1,200km and an 88-degree inclination as of February 9 2024. The lowest orbit is MATS at 590km and a 98-degree inclination, this launch was also Rocket Lab's second attempt at catching a booster.

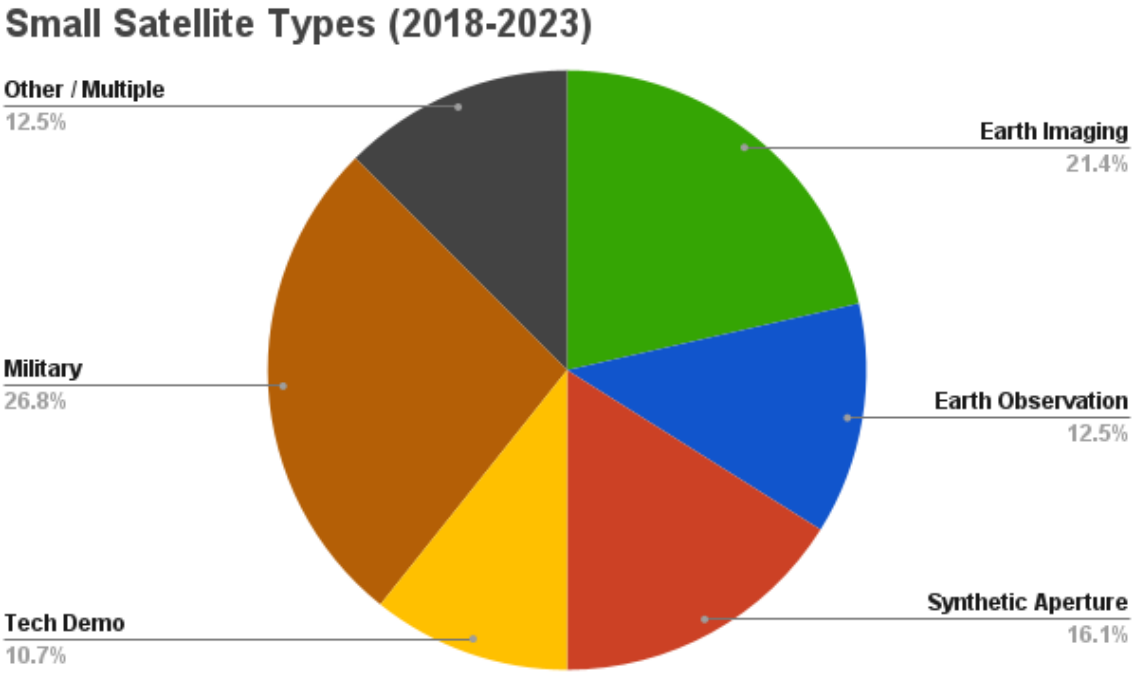
All the launches mentioned above have inclinations that are within several degrees of the 98 degrees that is common for rideshare missions. Major inclination changes require immense amounts of fuel to complete, so more than a couple of degrees of inclination change is not reasonable to be completed with a kick stage.

Kick stages are very useful for achieving a target orbital altitude. In the past, this has been a capability only achieved through dedicated launch or complex satellites that have propulsion built

in.

Only ~10% of small sat launches can be addressed by a kick stage. For all the news around them, this appears to be a fairly low number, but this is only small kick stages like Impulse's Mira. The larger market (especially economically) for kick stages may be as a GEO delivery mechanism.

Dedicated Launch Required Satellites



Sixteen small sat launches of the last 55 are in a category that is not addressable by rideshare or kick stages. These are satellites that require a unique orbital plane to take their place in a constellation. To properly cover the world with a satellite constellation the satellites must be placed into precise orbital planes so that there are no locations on the surface that lack coverage. For example, Starlink Shell 1 consists of 72 orbital planes with 22 satellites in each. Satellites cannot be moved between orbital planes due to a similar reason as inclination changes, it requires an immense amount of fuel.

The requirement for a unique orbital plane and the immense difficulty of addressing this market with a kick stage makes it the perfect market for small launch vehicles.

All of these launches carried satellites that conduct Earth observation:

1. 7x Blacksky (Imaging)
2. 3x Capella (Synthetic Aperture Radar)
3. 2x Tropics (Weather Observation)
4. 4x others (mostly Synthetic Aperture Radar)

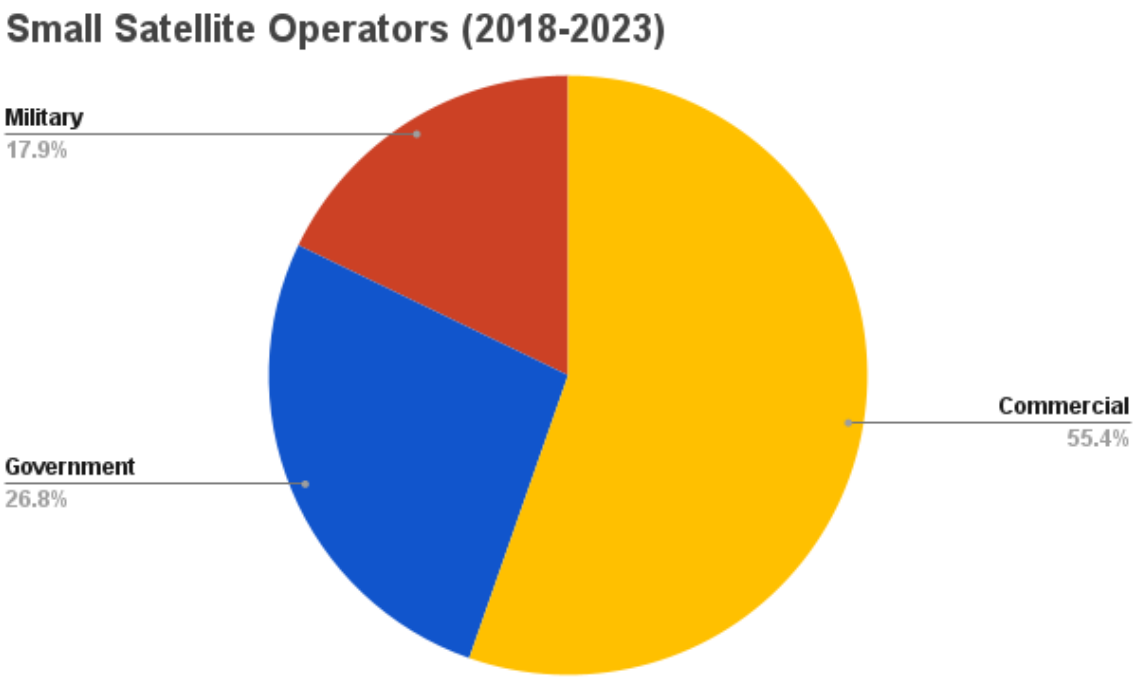
These Earth observation constellation satellites all require launching to a specific orbit on a small launch vehicle, but not all constellations do. The prime example is Planet Labs. Their constellation is used for Earth Imaging but they have flown many times more on rideshare missions than small sat launches. Planet Labs solved the dedicated launch problem through the sheer scale of their constellation. They currently operate 150 satellites and have launched 462 in total. Because of the size of this constellation, the number of launches required, and eased requirements on orbital planes, Planet Labs is able to forego the need for dedicated launches.

Rocket Lab is currently targetting 22 launches in 2024 and the majority of these are for Earth Observation satellites:

1. 3x Spire
2. 2x NASA Prefire
3. 5x Kinéis
4. 2x Capella
5. 3x Strix
6. 2x Hawk
7. 5x Blacksky
8. 2x Non-Earth Observation

All 16 of the launches that required a unique plane in the last 6 years were launched by Electron. Furthermore, 22 of the 24 currently planned Electron launches are for constellation satellites that require unique orbital planes. These are launches that can only be done with a small satellite launch vehicle and will be the primary business of small launch providers for the coming years.

Government and Military Satellites



The Government and Military are not rational consumers. In the commercial world, everything makes sense because economics drives it all, this is not true of the government.

24 of the previous 55 small sat launches were paid for by National Space Agencies or Militaries. 11 of these launches used a government-developed launch vehicle (Rocket, Customer):

1. SS-520 - Japan
2. Vega - Europe
3. Minotaur IV - USSF
4. Vega - Europe
5. Pegasus - USSF
6. Minotaur I - USSF
7. Epsilon - Japan
8. SSLV - India
9. Shavit 2 - Isreal
10. Nuri - South Korea
11. GYUB-TV2 - South Korea

Many countries are interested in developing their own launch capability and do so with a government-led program. This often leads to achieving the goal of developing a rocket, but not often an economical one. Because the goals of these programs are more aimed toward increasing the technological sophistication of a country and not solely to create a cheaper and reliable rocket, these programs often struggle against privately developed rockets and require government subsidy to stay afloat.

This is all to say the above 11 launches do not compete in the same arena as the rest of the commercial small satellite launches. For example, the Vega rideshare mission is part of an ESA program to launch small satellites. The ESA perfers launching payloads on their own rockets due to the geographical return policy, and appear to only launch on non-european rockets begrudingly. With the commercialization of spaceflight, this paradigm - that has been present since the V2 - will go away in favour of cheaper and more reliable commercial rockets.

The remaining 13 government/military launches were all done for US customers by purchasing a launch on a commercial provider's rocket. This method opens competition among launch providers to provide the best service.

Launches (Rocket, Customer):

1. Electron - NASA
2. Electron - USSF
3. Electron - USSF
4. Electron - USSF
5. Electron - USSF
6. LauncherOne - USSF
7. Electron - USSF
8. Rocket 3 - USSF
9. Electron - NASA Capstone
10. LauncherOne - USSF
11. Electron - USSF
12. Electron - USSF
13. Alpha - Lockheed Martin

The US Military almost exclusively launches its satellites on dedicated launches. This is to maintain national security by having tight control over who has access to the satellite. The requirement for dedicated launch means these satellites cannot be launched on rideshare missions and will continue to be a large part of the small satellite launch market even when ridesharing & kick stages offer significant cost savings.

The NASA Capstone mission is not beholden to the same anti-espionage requirements. The reason it had a dedicated launch was Electron's ability to provide the Photon satellite bus / kick stage to reach a trajectory that passes the Moon. Even though a kick stage was used, this mission is not addressable by a rideshare mission because launching to the Moon requires the satellite to be in the same orbital plane as the moon and no rideshare missions have ever gone to this orbit.

Cost Estimates

Determining the price of a dedicated small satellite launch is straightforward as we can use the cost of an Electron launch, ~$7M.

The cost of a rideshare mission can be derived from what SpaceX charges for Transporter missions. They currently charge ~$5,500 / kg for a satellite on a transporter mission. The average mass of the payloads launched on Electron is 116kg. Multiplying these two numbers gives $638,000 as the cost of launching on a rideshare mission. This is 11x cheaper than a dedicated launch.

Determining the price of using a kick stage on a rideshare mission is more difficult because there are no publicly available prices for this service. We can estimate the price of launch by using Impulse Space's Mira kick stage. Mira weighs 250kg and can carry up to 300kg of payload while having 500m/s of delta-v. Using the average electron payload mass, the total mass of the kick stage and satellite is 366kg. This costs $2M to launch on a SpaceX Transporter mission, I will assume $2.5M because this is one of the larger payloads on a Transporter mission and there may be extra considerations around payload volume.

The cost of manufacturing the kick stage itself is unknown, but we can use Rocket Lab's Photon as an analogue. The Electron and Photon for NASA's Capstone mission cost $10M in total. We already know the cost of an Electron launch is ~$7m, so Rocket Lab appears to have charged an extra $3M for Photon.

This gives a total of $5.5M for a rideshare + kickstage launch vs. $7M for a dedicated launch.

Furthermore, there is more room for cost declines in using rideshare + kick stages compared to dedicated launches. SpaceX's margins on Falcon 9 are >50% as launch costs are ~$20M and they make ~$45M from Transporter missions. Rocket Lab's margins are ~22% on Electron. There is room for improvement in Rocket Lab's margins as they reuse boosters and increase scale, however, they are currently planning to reuse only ~50% of boosters and only increase scale ~2x.

This shows that the gap in cost between rideshare + kick stages mission and dedicated launches will stay at around $1M - $2M for the foreseeable future. The incentive for a payload to use a dedicated launch when a rideshare mission is possible appears to only be schedule considerations.

Summary

Around 20% of the existing dedicated small satellite launch market will go away with the increased cadence of rideshare missions and kick stages becoming a viable option. The market for dedicated launch has already been distilled through SpaceX transporter missions, with an increase in cadence and kick stages further distillation will occur. If rideshare missions and kick stages were ubiquitous in the past, I estimate ~50% of the small satellites launched in the

previous 6 years that had the choice between rideshare/kick stage vs. dedicated launch would have flown on rideshare missions.

The 30% of satellites that require unique orbital planes will remain part of the dedicated launch market forever. It is too difficult to significantly change the orbital plane of a satellite even with a large kick stage, so, this market is only addressable by dedicated launch. This can already be shown through Rocket Labs' launch manifest. >90% of their planned launches for 2024 and 2025 fall into this category.

Military launches make up another 30% of the dedicated small satellite launch market. National security requirements preclude these launches from occuring on rideshare missions so this segment will not be threatened.

Government-funded launch vehicles make up the remaining 20%. These programs exist because of political incentives so it is difficult to determine if they will continue into the future or not. However, with the push for commercialization in space flight, it is possible this market will slowly evaporate as privately funded alternatives arise in their respective countries. This segment is not addressable by commercial providers, so it is not of major interest.

The dedicated small satellite launch market has already faced tremendous competition from rideshare missions. Since its inception, SpaceX's Transporter program has launched about 785 satellites. Electron has launched about 180 satellites. Rideshare missions already have 80% of the total small satellite launch market. Dedicated launch is a somewhat niche service for unique satellite constellations and government customers.

Around 30% of the market for dedicated small satellite launches addressable by commercial providers will disappear with better alternatives arising. However, this does not translate into a fall in the quantitative demand. Rocket Lab's launch cadence is planned to increase from 9 to 20 this year. This 200% growth in a single year will offset the decline from rideshare missions. The rise of small satellite constellations and economically productive uses of space will drive substantial growth in the dedicated small satellite launch market even taking into account the decline from rideshare missions kick stages.

Geohot made a blog too. <a href="https://caseyhandmer.wordpress.com/2023/08/25/you-should-be-

working-on-hardware/">You should be working on hardware

Analysing Neutron in the Commerical Satellite Launch Market

Jan 7, 2024 • Christopher Kalitin

Neutron is Rocket Lab's next-generation medium-lift rocket. In many ways, it looks and functions like Falcon 9 version 2 as it is designed from the ground up for reusability. This is most obvious with the booster. The fairings are built into the structure of the booster, the landing legs are built into strakes, and the Archimedes engine is designed to operate below maximum performance to optimize for reusability.

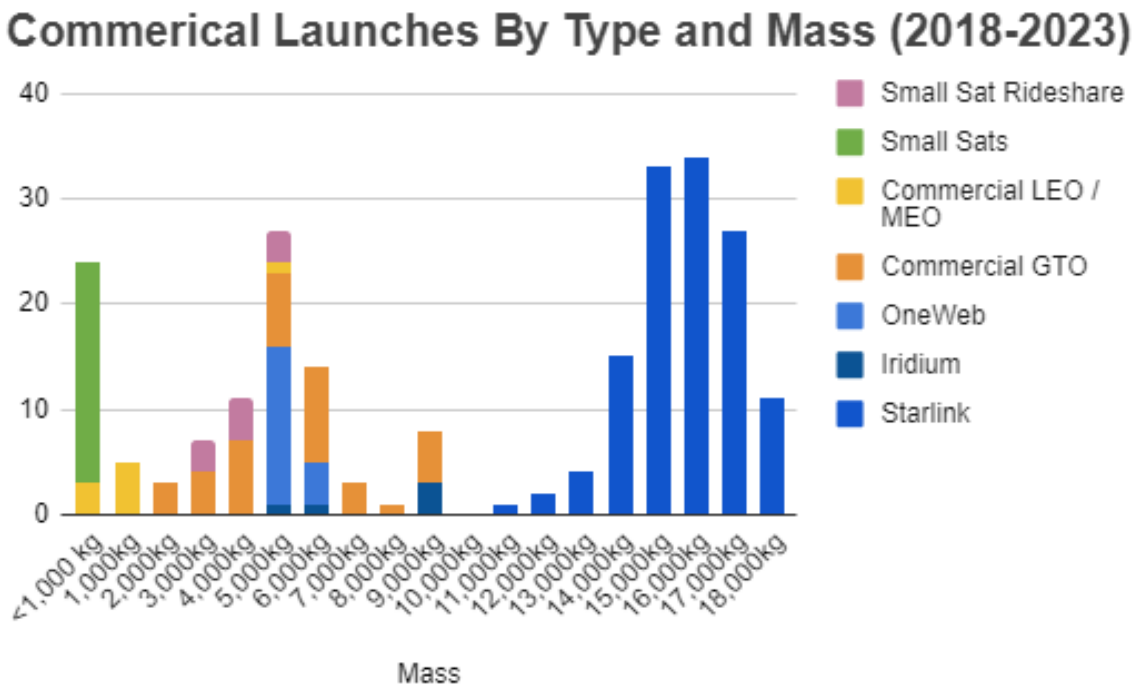
During the early development of Falcon 9, SpaceX was optimizing for the lowest probability of bankruptcy. With Neutron, Rocket Lab can optimize for the most competitive and efficient rocket.

However, Neutron is not a perfectly optimized rocket compared to its competition. In many ways the Falcon 9 and other future medium/heavy lift rockets out perform Neutron in its primary market of launching constellations. The volume of the fairing and payload mass are both lower than comparable rockets such as the Falcon 9, Terran R, and New Glenn and it is not optimized for high-energy orbits meaning it can't launch most GTO satellites.

Model this analysis is based on: https://docs.google.com/spreadsheets/d/1VOgRbnAsQZdGIPoemRj5ApSLk_jxGanNliWEPnBB3p4/edit?usp=sharing

More, better, and more accurate charts here: https://drive.google.com/drive/folders/1IAbB-Ydgv3udhIhvfdKp_dWnxUshMqmc?usp=drive_link

Legacy Commerical Communication Satellite Market



Updated Chart (Important! Click Me!)

The legacy commercial communication satellite market is dominated by GEO satellites. Between 2018 and 2023, 48 commercial satellites were successfully launched. 39 of these satellites were launched to GTO/GEO while only 9 were launched to LEO/MEO/SSO.

Neutron can only launch ~50% of these satellites and most require expending the booster. This was the primary commercial market for the Falcon 9 after the original CRS test launches. Before 2018, Falcon 9 conducted 6 LEO commerical satellite launches and 17 to GEO/GTO.

In the early days of Falcon 9 commerical launches it took market share from the Ariane 5. The Ariane 5 was optimized for high-energy orbits which was the majority of the market at the time.

Ariane 5 peaked at 7 launches per year. Compared to the 96 Falcon 9 launches in 2023 this is a relatively small market and shows that the new paradigm of constellations is far more important than the legacy market of commercial communication satellites. Clearly new rockets should be optimized for launching LEO constellations and not GEO satellites. This point is more of an indictment of Vulcan than Neutron. Even the majority of Vulcan's booked launches are for a LEO