

Rocket Payload Volumes (All US Vehicles)



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Summary

Payload volumes for every active or soon-to-be active orbital rocket produced by the United States as of January, 2024.

[Learning](#) > [Engineering](#)

Tags: [spacex](#) [rocket](#) [starship](#) [spaceship](#) [nasa](#) [alpha](#) [pegasus](#) [vulcan](#) [minotaur](#) [satellite](#) [sls](#) [firefly](#) [falcon9](#) [falconheavy](#) [electron](#) [rocketlab](#) [ula](#) [fairing](#) [atlasv](#) [northropgrumman](#) [deltaiv](#) [blueorigin](#) [newglenn](#)

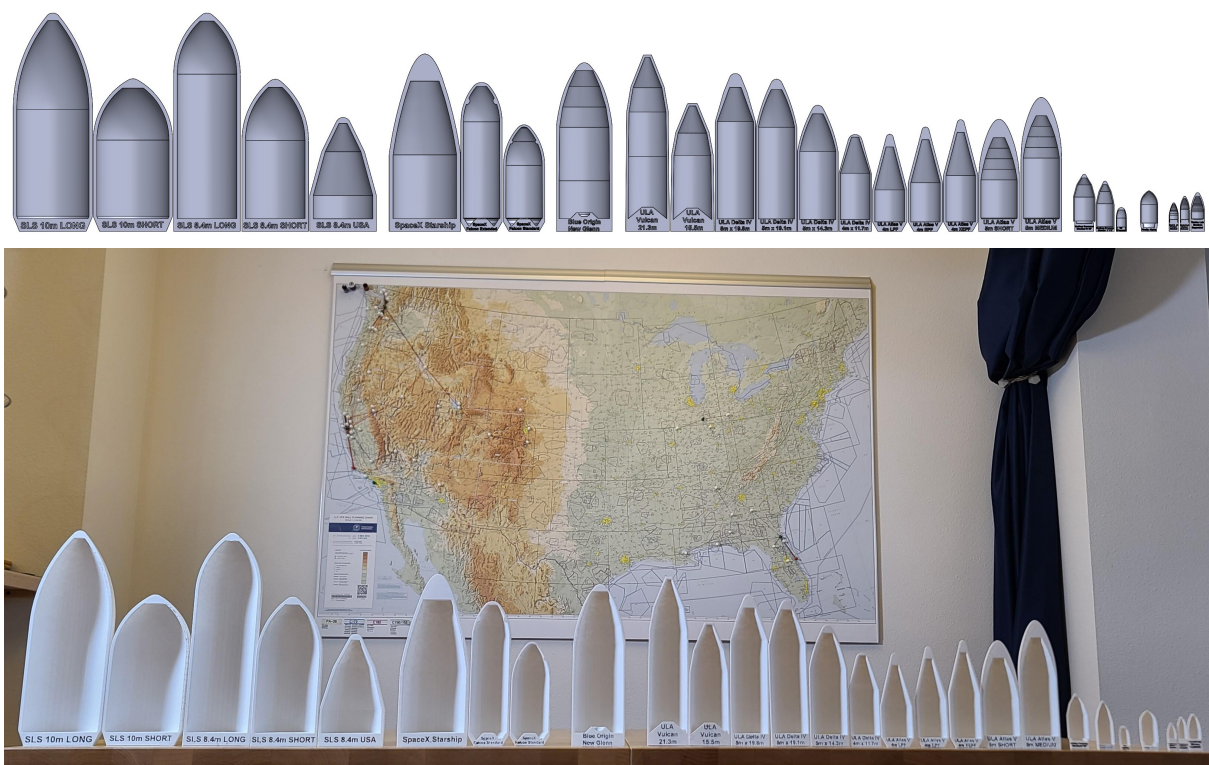
Introduction

Welcome! Here you will find STL files for all 27 of the officially published payload volumes available for all 11 active American orbital launch systems, based on the following published sources:

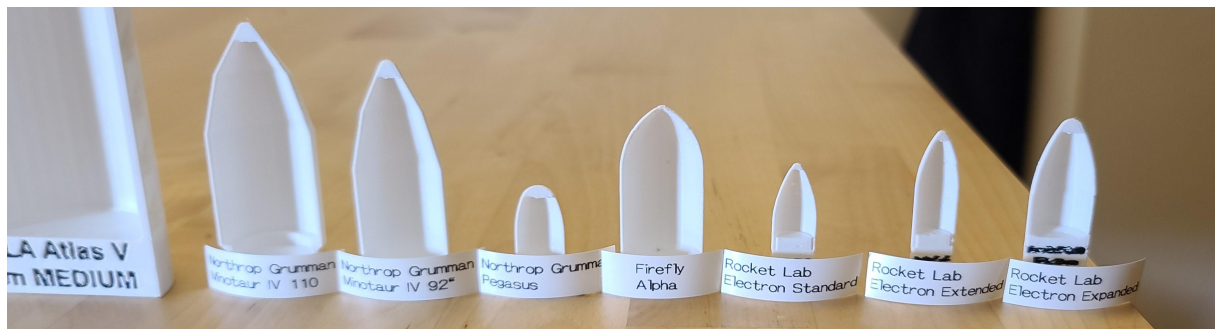
1. SLS: [Space Launch System Mission Planner's Guide, Rev A](#), 2018/12/19, pg. 59-70
2. SpaceX Starship: [Starship User's Guide Rev 1](#), 2020/03, pg. 2
3. SpaceX Falcon 9 and Falcon Heavy: [Falcon User's Guide](#), 2021/09 pg. 75-84

4. Blue Origin New Glenn: [New Glenn Payload User's Guide Rev C](#), 2018/10, pg. 59-63
5. ULA Vulcan: [Vulcan Launch Systems User's Guide](#), 2023/10, pg. 4-8 and 4-9
6. ULA Delta IV: [Delta IV Launch Services User's Guide](#), 2013/06, pg. 6-1 through 6-8
7. ULA Atlas V: [Atlas V Launch Services User's Guide Rev 11](#), pg. 6-3 and 6-4
8. Northrop Grumman Minotaur: [Minotaur IV/V/VI User's Guide Rev. E](#), 2020/09 pg. 47-48
9. Northrop Grumman Pegasus: [Pegasus User's Guide Release 8.2](#), 2020/09, pg. 40-43
10. Firefly Alpha: [Alpha Payload User's Guide v4.0](#), 2023/07, pg. 8
11. Rocket Lab Electron: [Rocket Lab User's Guide v7.0](#), 2022/11, Pg. 26-28

The STL files are generated at full scale. I recommend printing them at 1% (1:100) if you want to visualize them all at one common scale.



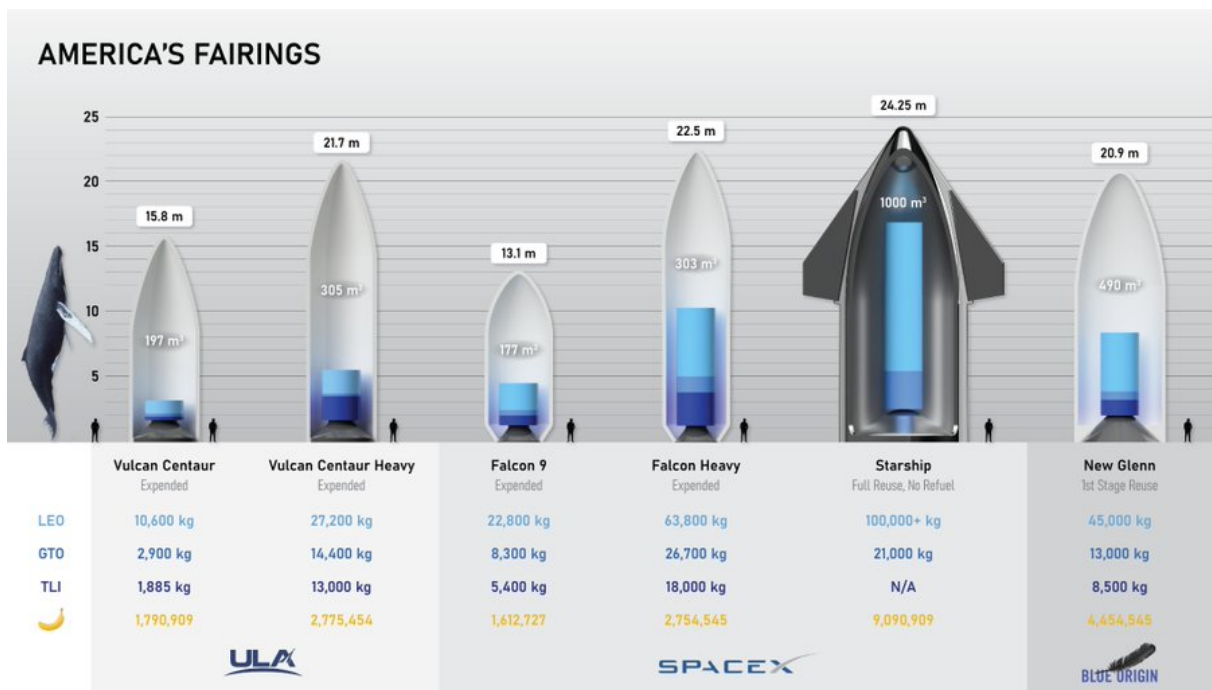
The files have the name of each rocket configuration embossed on the base, which won't be printable/legible at 1% scale for the smaller launchers; in that case, I recommend just using a label maker.



Payloads are not included, but I've collected some prints [here](#) of space-related objects that would print well at a 1:100 scale.

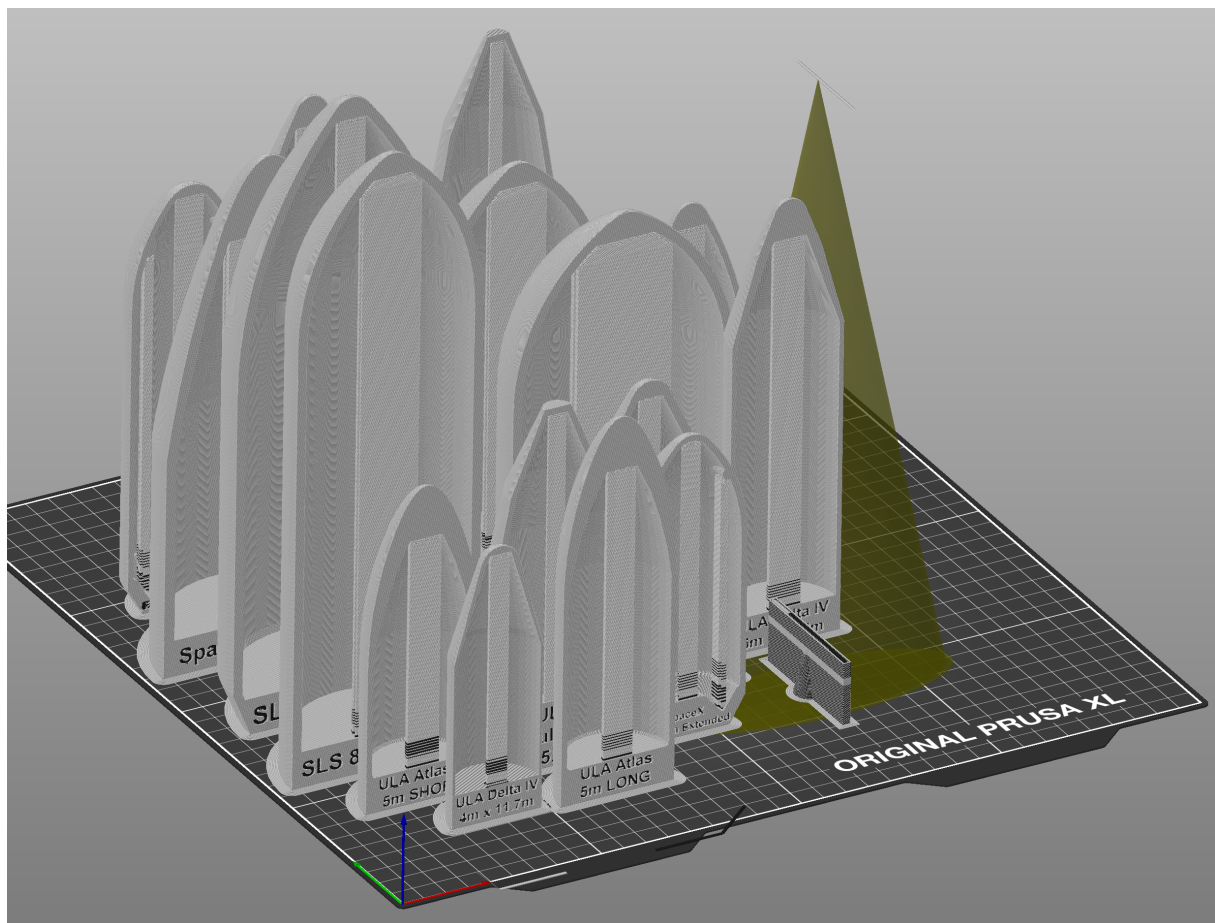
The information in these files was made from publicly available sources and is ITAR/Export compliant.

Thanks to Ken Kirtland IV (@KenKirtland17) for making the [original data visualization](#) that inspired this project!



Recommend Print Settings

Material	PLA
Perimeter Count	1
Infill	10-20%
Supports	Yes
Layer Thickness	Detail, 0.15mm (for text legibility)
Print Time (Prusa XL)	3 days 9 hrs
Print Material	1019 g



FAQ:

Q: Why do these prints look different than the actual fairings?



A: Because these prints aren't representations of the actual fairings. The actual fairings would be unprintable at 1:100 scale since the fairing walls would be $<1\text{mm}$ thick. These prints are representations of what we call the fairing's payload **Keep In Volume (KIV)**.

Q: What is a payload Keep In Volume, and why does it have a different shape than the fairing?

Rockets are a rough ride, and fairings are flexible structures. Here is an example of an ejection test of the New Glenn fairing, showing just how much a fairing can flex under dynamic loading:

Any part of a payload that is too close to the fairing walls will risk hitting the fairing. To avoid collisions, we define a volume that the fairing is guaranteed to keep out of during all dynamic events. Everything inside of that fairing dynamic volume defines the volume that the payload must keep inside. This volume is the KIV.

Q: Where does the KIV information come from?

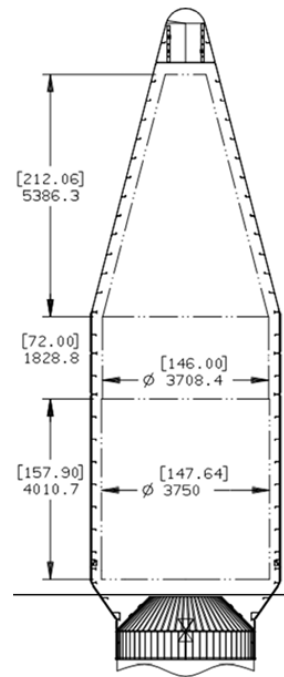
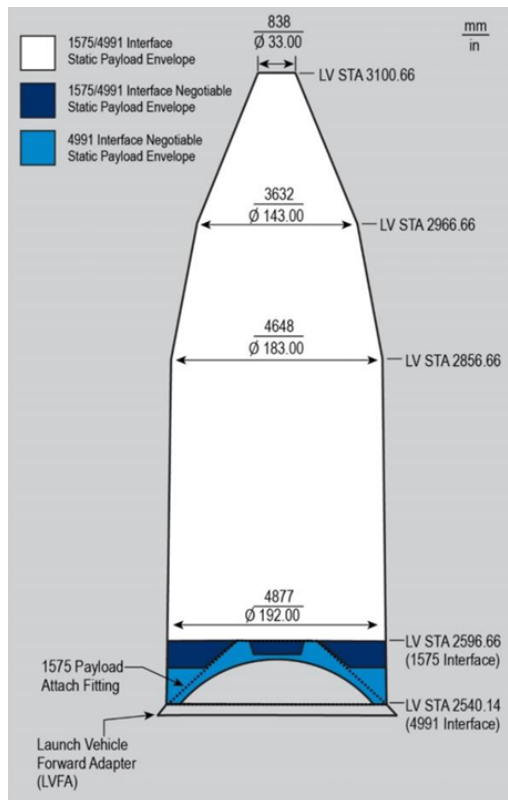
A: Launch providers publish a Payload User's Guides (PUG) for their vehicles, and that PUG contains drawings that define the KIV. A list of each PUG that defined these volumes for each rocket is in the introduction. The only modification I have made to the KIVs as published is to make sure

there is a 1500mm extension to the base so there is room to print text identifying what rocket/fairing the volume belongs to.



Q: Why do some prints have visible conical payload adapters, and others don't?

A: Some launch providers choose not to include the volumes aft of the payload adapter plane in their KIV, usually because that volume is protected for support equipment for the upper stage, access panels, or venting. In some cases, the PUGs will provide optional volumes in the KIVs that can be made available with extra negotiation or fees. For example, on the left is the Vulcan-Centaur 15.5m volume, which does allow for usage of the space aft of the adapter interface (shown in blue). On the right is the Atlas IV 4m XEPF volume, which does not.





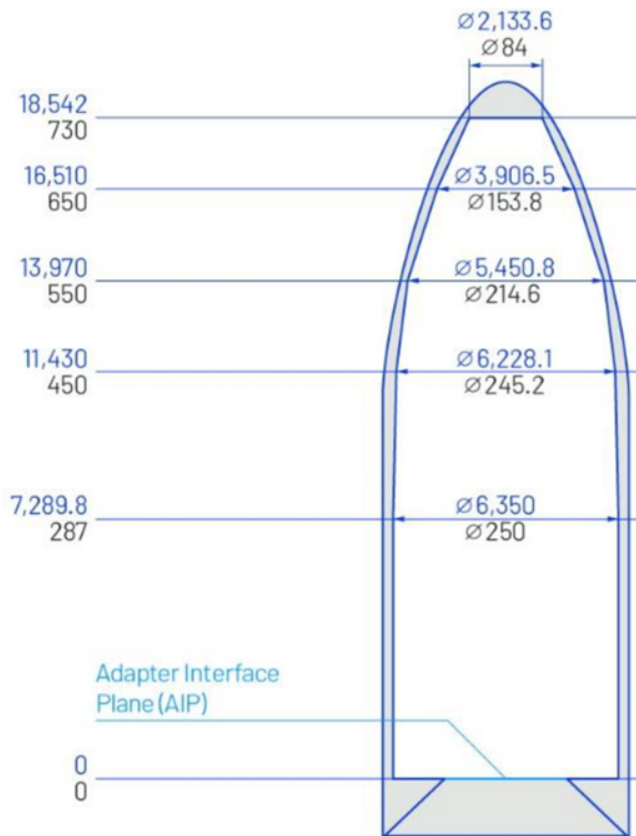
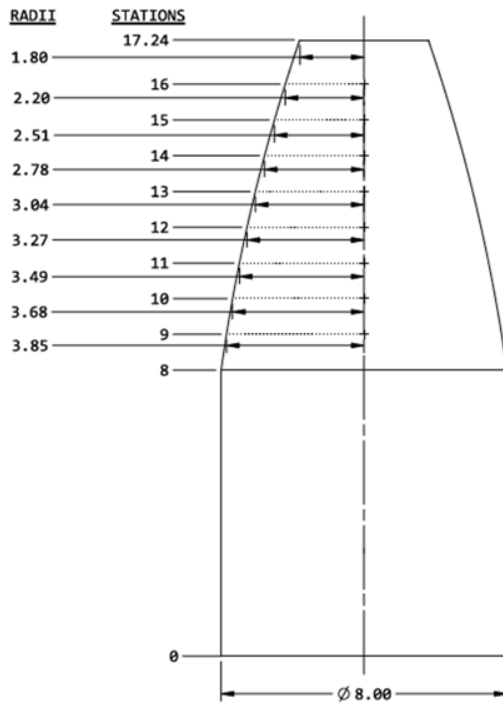
In situations like Vulcan-Centaur (left), the KIV will show a visible launch adapter. In situations like the Atlas IV (right), the KIV is going to look like a flat floor terminating at the adapter interface plane. When a vehicle's KIV specifies multiple launch adapters of a negotiable volume, I have tried to include the one that provides the largest possible payload volume.

Q: I heard from (PERSON) on (PLATFORM) that (ROCKET) would actually have a different fairing developed for it. Is that included?

A: When new information shows up in an officially released PUG, I will update the files. But this project already required me to CAD up 26 files, tracking a total of 382 dimensions from 11 different documents. Version control for every speculated future change would just not be practical.

Q: Why are Starship and New Glenn included if they aren't launching payloads yet?

Starship and New Glenn will be launching payloads soon, and their providers have released official PUGs for both.





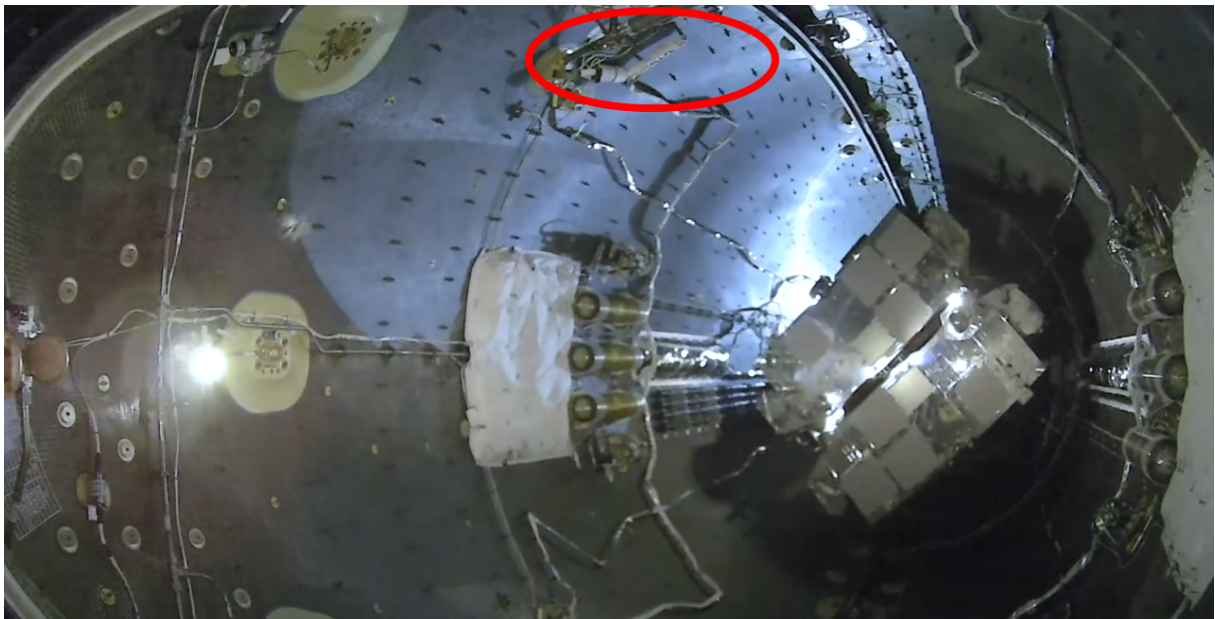
Q: Why is Delta IV included if? Isn't Vulcan-Centaur replacing it?

Yes, but Delta IV isn't retired yet (its last launch is scheduled for March, 2024), and ULA still maintains an official PUG for it. Plus, it makes a great family photo with the rest of the ULA fairings.



Q: What are the cylindrical exclusion zones near the top of the Falcon fairings?

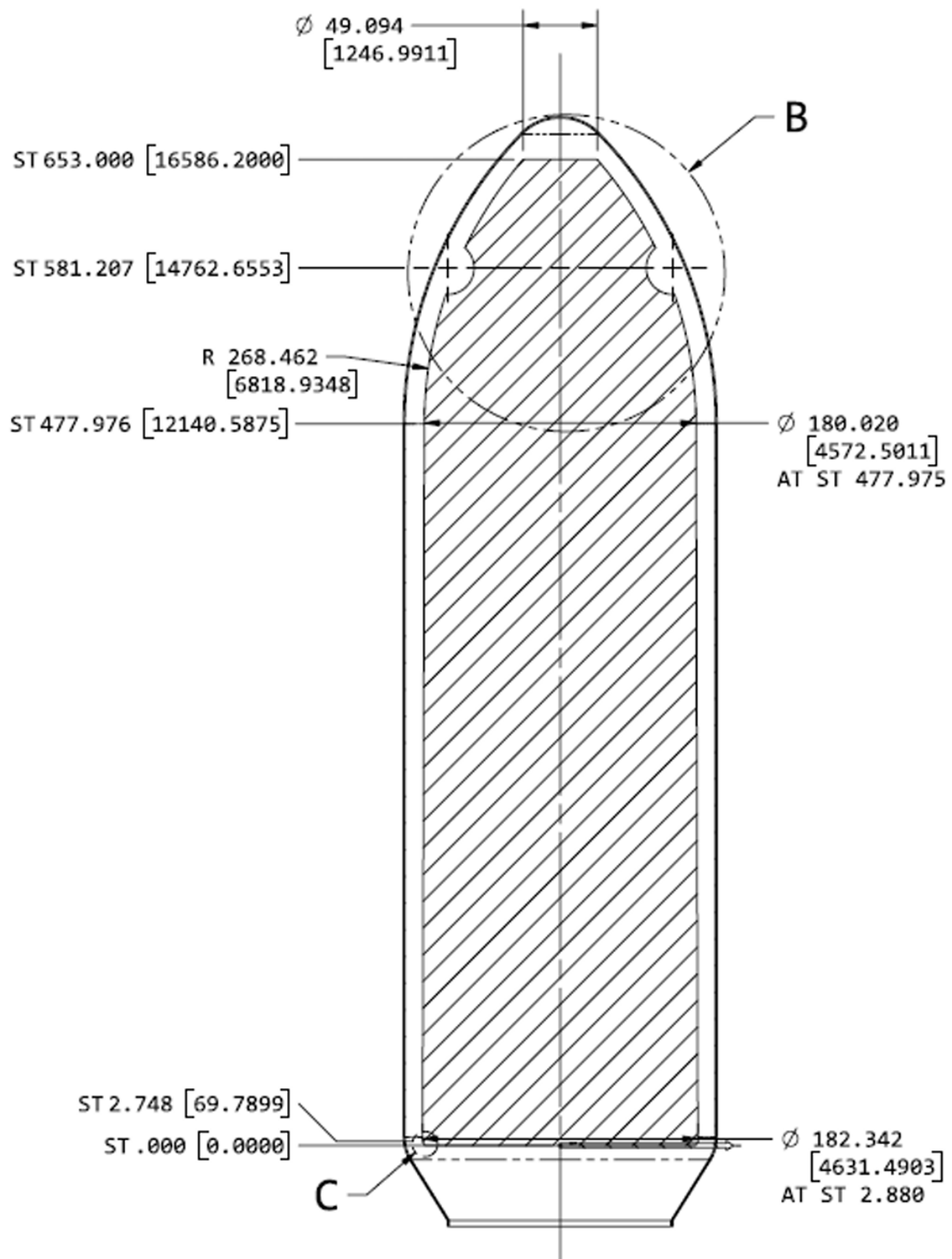
A: The PUG doesn't say what those are, but I think they are to protect an exclusion zone around the mechanisms that push the fairings apart. You can see them in some of the Starlink videos (even though Starlink isn't a tall enough payload for that volume to matter)





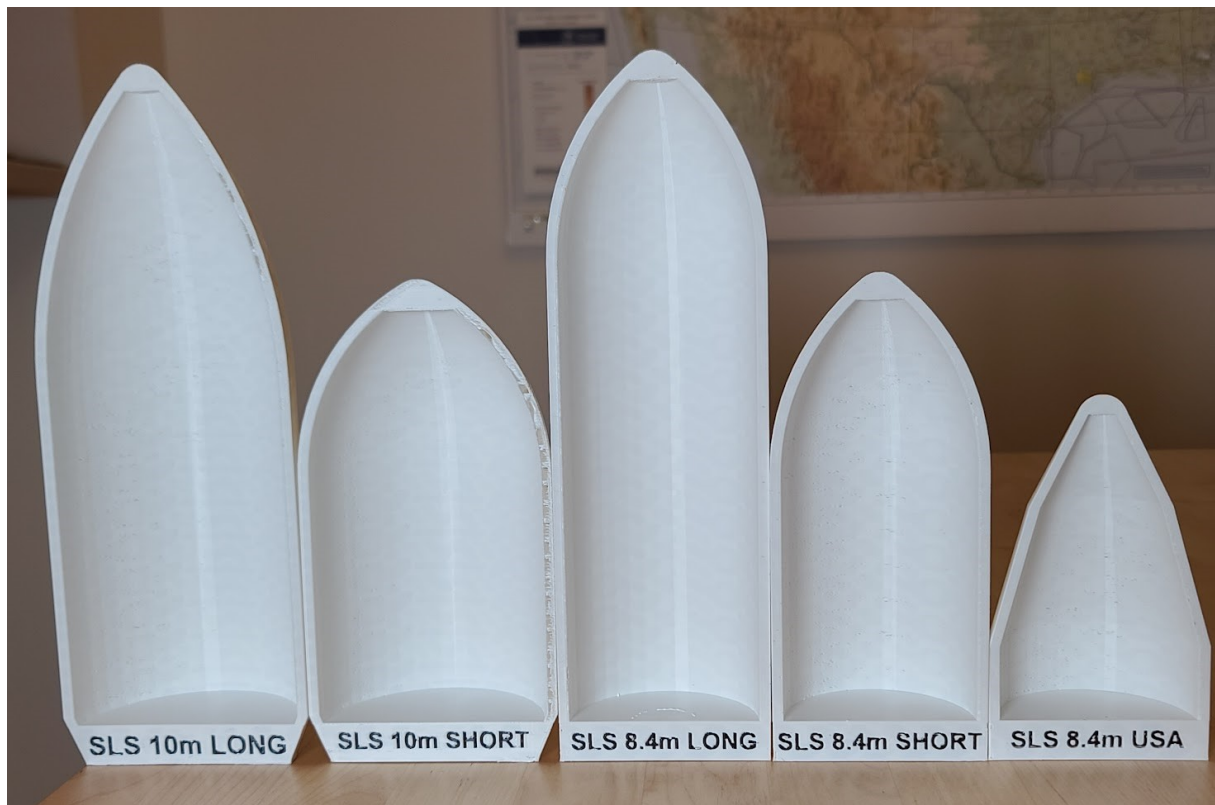
Q; Why does Falcon have an extended fairing?

A: It hasn't flown yet, and I don't know when/if SpaceX is planning to fly it. But the extended fairing is specified as an option in the PUG, so it belongs on this list.



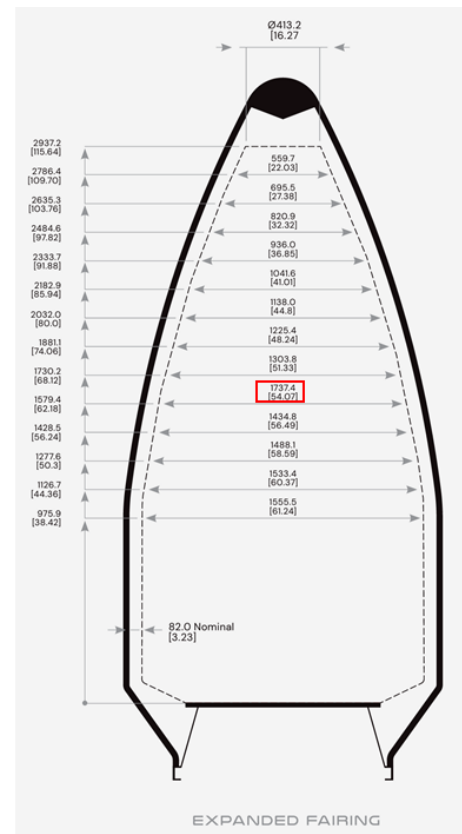
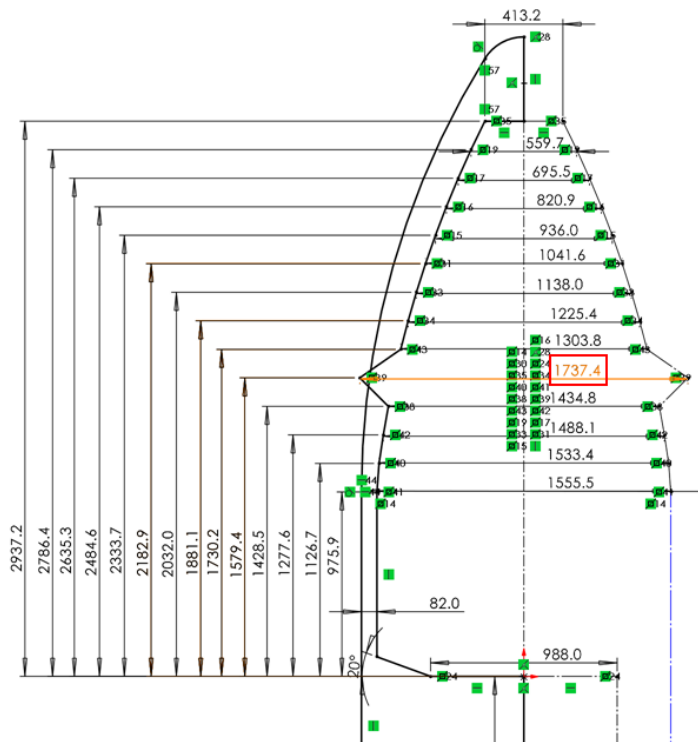
Q: Why does SLS have so many fairing prints?

A: Same reason as ULA: Because it is specified that way in the PUG, and it makes a great family portrait.



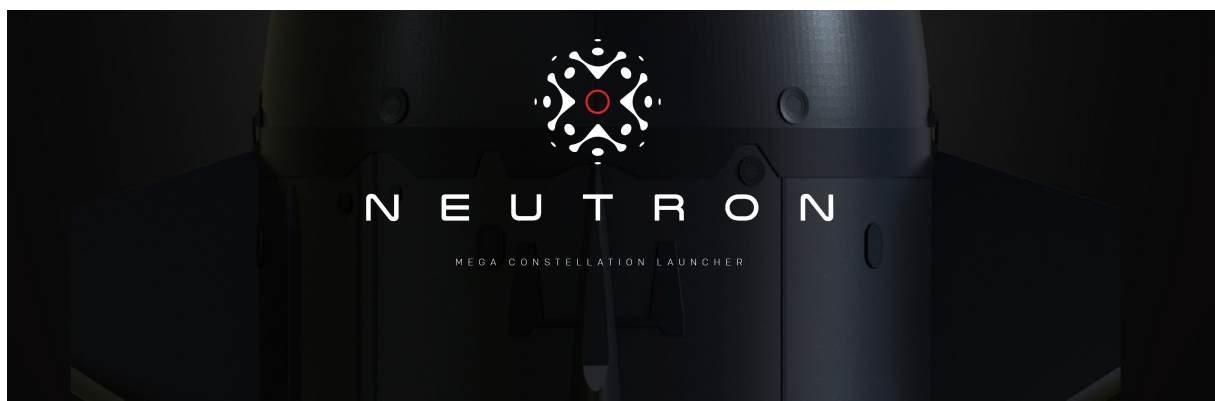
Q: The fairing KIV for Electron's Expanded fairing doesn't match the KIV specified in the PUG.

A: Yes. That's because Rocket Lab had a small units conversion error in their PUG. Understandable that it hadn't been caught before since I don't think Electron has flown a customer with this expanded fairing yet. What appears to have happened is the dimension specified as 54.07" was mistakenly converted to 1737.4mm, when it should have been 1373.4mm. I already reached out to Rocket Lab and expect it will be corrected in the next release of the PUG.



Q: Is Rocket Lab's Neutron included?

A: Not yet. At the time of posting, Rocket Lab hasn't released a draft PUG for Neutron. But I hope they do soon, it's a fairing volume that belongs on this list.



Q: What about Relativity Space's Terran 1 and Terran R?

Relativity has indicated that **Terran 1 is retired**, and while Relativity has published **estimates** of the upcoming Terran R payload envelope, they haven't released an official draft PUG yet. But I do plan to include the Terran 1 payload envelope in a set of historical KIVs in the future, **here** is the link to the PUG I'll be using. Until then, the only two rockets on this list

that are actually 3D-printed unfortunately cannot be included in this set of actually 3D-printed parts.



Q: Where is the Atlas V Long fairing?

A: The Atlas V long fairing has an identical payload KIV to the Delta IV 5m x 19.8m fairing, so it would have been redundant to print it twice. I don't know if these are actually identical fairings, but for the purposes of these models, what matters is that they do have identical payload KIVs.

Q: What about retired launch vehicles like the Titan or the Space Shuttle?

A: I'm planning to do another set for the retired American launch vehicles. Stand by for updates.

Q: What about non-American launch vehicles like PSLV, Ariane or Long March?

A: I'm planning to do another set for active non-American launch vehicles, at least the ones I can find PUGs for. Stand by for future updates.

Q: I found an error. What should I do?

A: Thank you for taking the time and interest to check my work! Please either message me on Twitter @maxfagin, or post what you think is wrong

as a comment here. I'll take a look, and if the error checks out, I'll correct the files and send you a free print of one of the volumes as a bug bounty.

Suggested uses:

Some serious and some non-serious suggested things to do with these prints.

1. Payload Fit Checks: If you want to design a spacecraft to launch on one of these rockets, print your payload at the same scale and see if it is compliant. Remember though that these are the dynamic KIVs. It's not enough for your spacecraft to just fit in this volume, your spacecraft has to stay in this volume when your payload is subjected to the shake/rattle/roll of launch. Hopefully, your payload isn't too flexible, and you know how to do a Coupled Loads Analysis.



2. Gifts: Print two halves of each volume and make a fairing matryoshka doll. Makes a great(?) gift for the Russian aerospace engineer in your life, and is ITAR/Export compliant.

Bonus: Fairinception



3. Revenge: Let the dinosaurs finally have the space program they deserved.



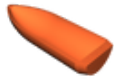
4. Payload Mass Representations: Comparing payload volumes between launch vehicles is pretty straightforward and simple, but comparing payload masses between launch vehicles can get complicated and controversial. Comparing payload masses between rockets depends on how you pick the target orbit, the launch site, the vehicle's configuration, and whether or not the rocket is being reused. Just like in Ken's original data visualization, I did print representations of the equivalent mass of water that each vehicle could launch to LEO (blue), GTO (grey) and TLO+ (black), but I decided not to include these files since it would have required too many caveats and asterisks to be accurate. But if you love rockets as much as I do and want to print your own representations of payload masses for your own kits, please do so, and enjoy!



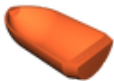
Model files



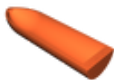
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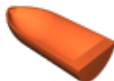
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payload-kiv-nasa-sls-10m-short.stl



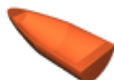
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payload-kiv-nasa-sls-84m-short.stl



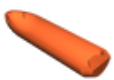
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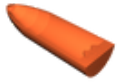
payload-kiv-spacex-starship.stl



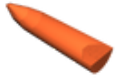
payload-kiv-spacex-falcon-9-h-standard.stl



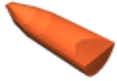
payload-kiv-spacex-falcon-9-h-extended.stl



payload-kiv-blue-origin-new-glenn.stl



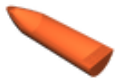
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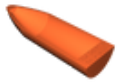
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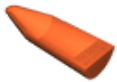
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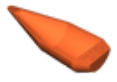
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payload-kiv-ula-delta-iv-143m-x-5m.stl



payload-kiv-ula-delta-iv-117m-x-4m.stl



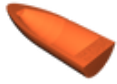
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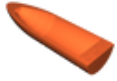
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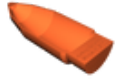
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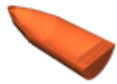
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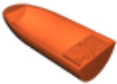
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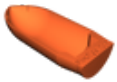
payload-kiv-northrop-grumman-minotaur-110in.stl



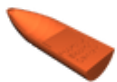
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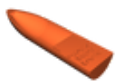
payload-kiv-northrop-grumman-pegasus.stl



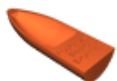
payload-kiv-firefly-alpha.stl



payload-kiv-rocket-lab-electron.stl



payload-kiv-rocket-lab-electron-extended.stl



payload-kiv-rocket-lab-electron-expanded.stl

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