Crowdsourced starlink performance measurements from https://starlinkstatus.space

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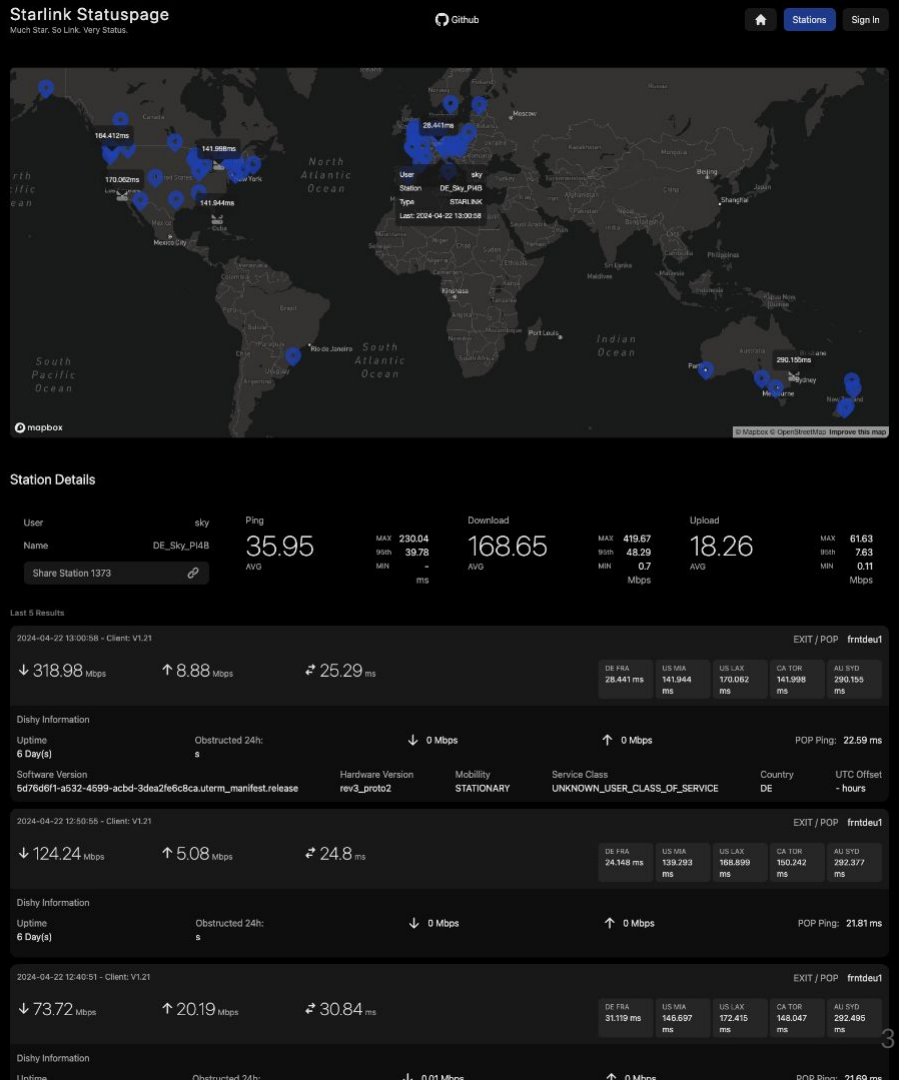
What is starlinkstatus.space ?

The project starlinkstatus.space

Project goal: collect detailed & independent performance statistics of Starlink around the world

- started in 2021
- crowdsourced data collection
- collects data from Ookla speed test, ICMP latency and starlink terminals RPC API
- public website to view data
- stations in over 20 countries
- currently over 50 active stations
- over 3 million measurements



Framework description

Client setup & data collection

The interval and what data get's collected can be adjusted by the User.

Because of this, many data points had to be filtered out that didn't include RPC data from the starlink terminal.

1. Participants first register on https://starlinkstatus.space to obtain an API key for data collection

2. Second they install the required software and setup the shell script from Github: https://github.com/Tysonpower/starlinkstatus

3. The script runs every 15 minutes (default cronjob interval) and executes:
    - ICMP pings to different servers
    - RPC to the Starlink Terminal
    - Ookla Speedtest CLI
    - IP geolocation using ip-api.com

4. All collected data is sent to the starlinkstatus.space backend

Collected data

Each data point in the dataset has this data structure

ICMP ping measures round trip times (RTTs) to:

- Cloudflare (next Datacenter)
- Frankfurt - Germany
- Sydney - Australia
- Miami - USA
- Seattle - USA
- Los Angeles - USA
- Toronto - Canada

RPC to the Starlink Terminal collects data like: hardware & software version, latency to point of presence, alerts, service type etc.

Ookla Speedtest CLI collects:
up and download throughput, latency and latency during load

IP geolocation using ip-api.com:
collects the ISP, country, state, approx. lat/lon etc.

Dataset statistics

Dataset statistics

Initial & cross traffic filtering

Valid IP address
originating from Starlink ASN (14593)

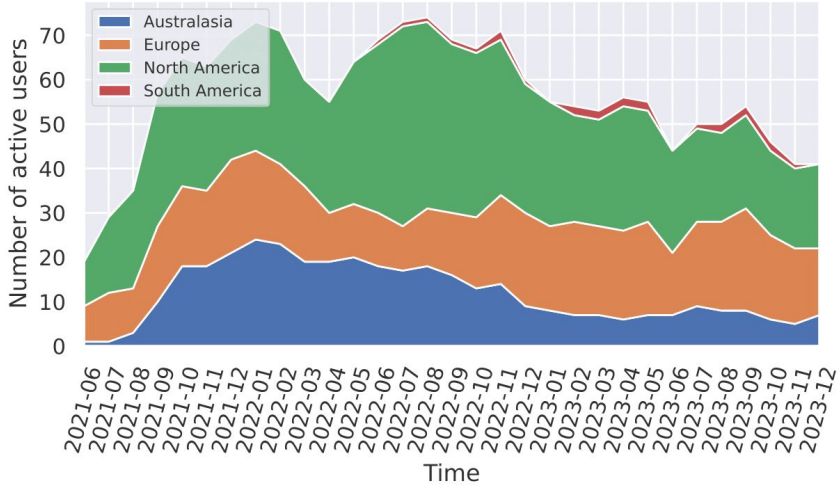
Valid RPC data
from the starlink terminals API. Without it we don't know how much the connection is in use while we collect the data

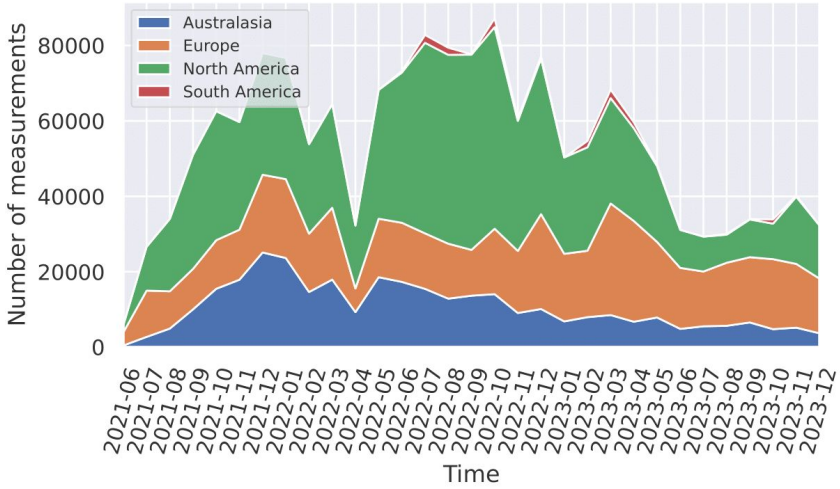
Low throughput usage
reported by the Starlink terminal before the Speedtest. Valid if below 5 Mbit/s in the forward link or 1 Mbit/s in the return link

Result
1 663 114 measurements from 309 users located in 29 countries

Dataset statistics

Multiple causes made the number of measurements fluctuate





Dataset statistics

Measurements by country and continent

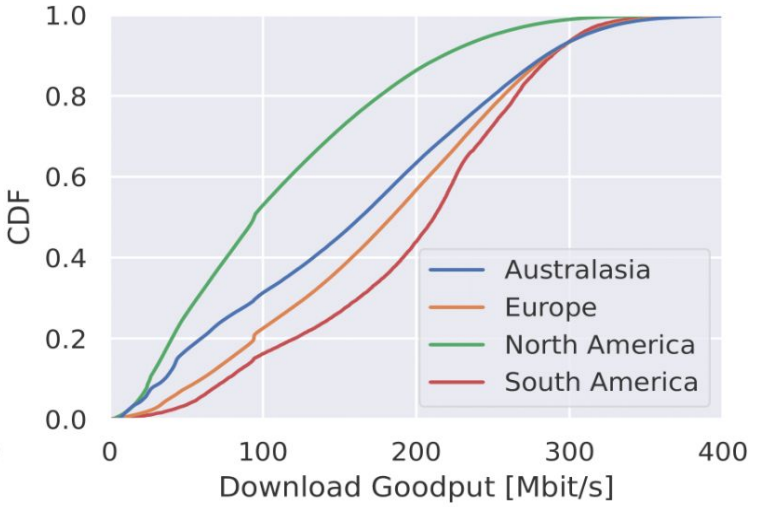
Country	Users	Measurements	Speedtest Download Mean	Speedtest Download Max	Speedtest Upload Mean	Speedtest Upload Max	ICMP Ping RTT Mean	ICMP Ping RTT Min
AU	30	146384	173.6	480.6	14.6	74.5	49.5	21.0
NZ	24	180622	150.0	439.3	18.6	74.5	47.6	17.0
AT	4	73331	188.1	437.0	18.3	73.0	41.0	17.0
BE	2	798	122.7	373.5	13.8	39.7	41.2	19.8
CH	2	200	200.5	357.0	19.0	66.7	40.5	19.7
CZ	1	3	217.3	262.0	22.7	32.6	40.4	32.8
DE	26	95281	161.5	419.7	19.7	76.5	39.3	17.7
EE	1	5147	182.7	409.7	17.2	65.7	46.3	23.7
ES	6	34313	195.5	425.8	21.4	68.9	50.2	17.7
FR	13	71937	208.8	443.6	18.7	76.2	45.2	18.0
GB	23	87611	164.9	429.6	13.7	65.7	41.4	13.5
HR	1	2	219.8	270.7	17.5	25.3	46.5	42.0
HU	1	44001	207.7	340.5	22.1	79.1	44.3	20.1
IT	5	10300	101.8	411.7	20.1	107.3	36.8	18.0
LT	1	5948	171.1	416.0	21.8	58.7	46.6	24.9
LV	1	2174	222.4	401.9	19.6	38.2	45.6	23.2
NL	8	14902	133.8	398.3	21.0	76.5	39.4	18.4
NO	1	33406	156.8	386.2	15.1	65.8	41.3	20.3
PL	3	16293	186.4	428.7	23.6	65.2	47.1	22.1
PT	3	5957	215.8	420.7	25.0	68.9	49.7	17.7
SE	1	1032	31.2	92.8	17.8	40.1	44.6	23.1
SK	4	248	148.1	290.6	20.1	38.2	46.8	22.0
JP	2	217	138.6	285.4	10.6	63.8	46.3	22.4
CA	28	123117	115.7	425.4	13.1	76.9	47.4	20.0
US	129	694362	109.0	431.8	10.7	74.6	50.3	17.9
BR	4	15485	196.6	417.5	23.2	73.6	45.1	20.2
CL	1	30	232.8	329.2	20.7	52.4	33.0	24.5
CO	1	3	91.1	127.4	23.7	30.5	91.3	88.0
TT	1	10	105.9	243.6	19.0	29.0	71.0	59.3
🐓	309	1663114	141.5	480.6	14.6	107.3	47.4	13.5

Measurement results

Forward link goodput

aka download

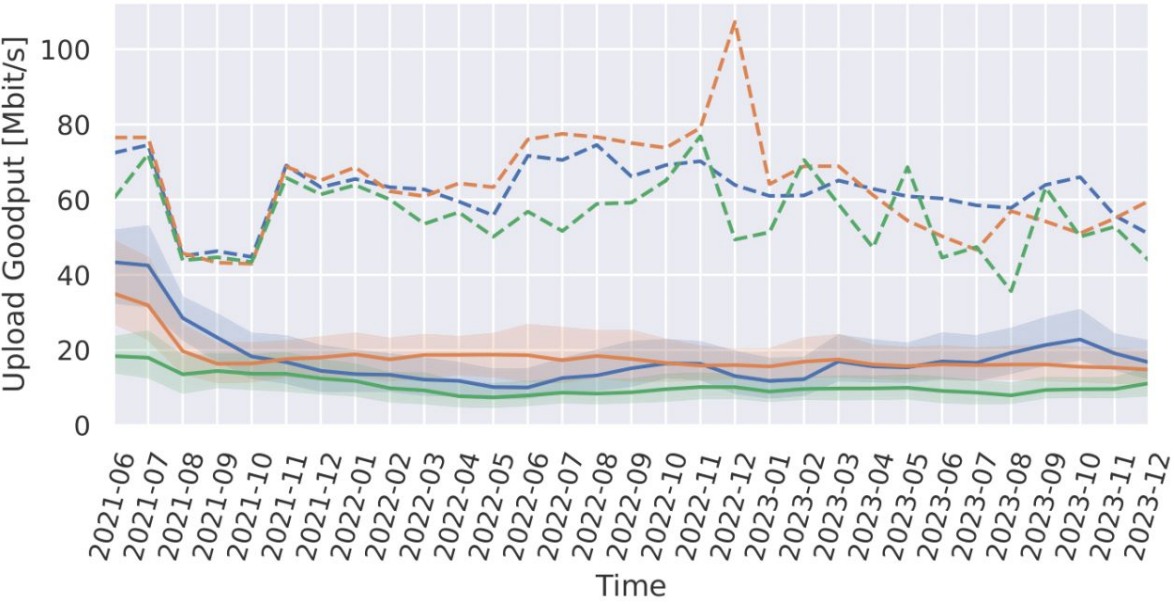
- Goodput is very variable in general.
- North America has lower goodputs than other countries, which is probably due to a higher subscription rate.
- Users from South America contributed only a few measurements

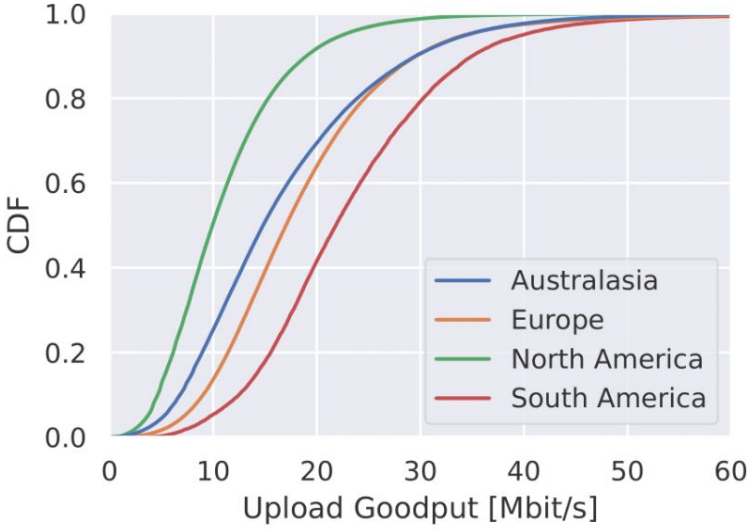


Return link goodput

aka upload

- Goodput is a bit variable and there are differences among continents.
- South America contributed only a few measurements



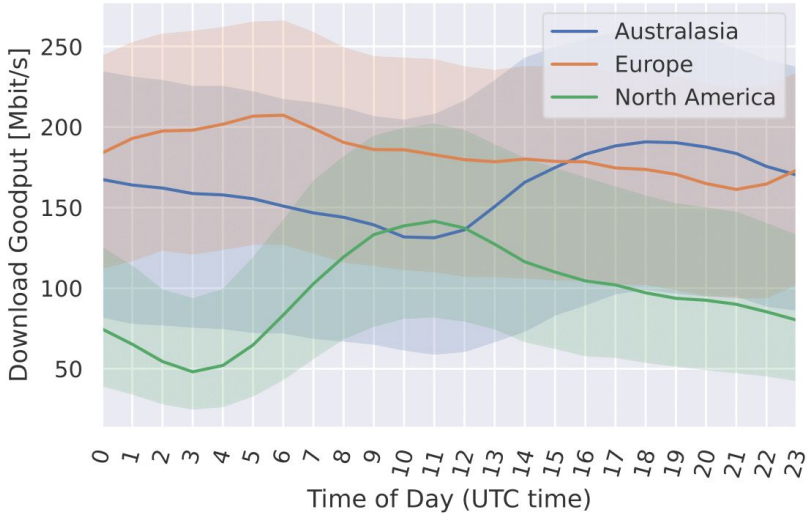


Goodput by time of day

forward link aka download

- North America has the lowest download goodputs around 03:00 UTC (18:00 PST and 21:00 EST) and highest goodputs around 12:00 UTC (03:00 PST and 06:00 EST).
- Australasia, download goodput increases around 14:00 UTC (22:00 AWST and 02:00 NZST) and decreases roughly 12 hours before/later
- In Europe goodput is stable around the clock

Solid lines are median values; shaded areas show first and third quartiles.

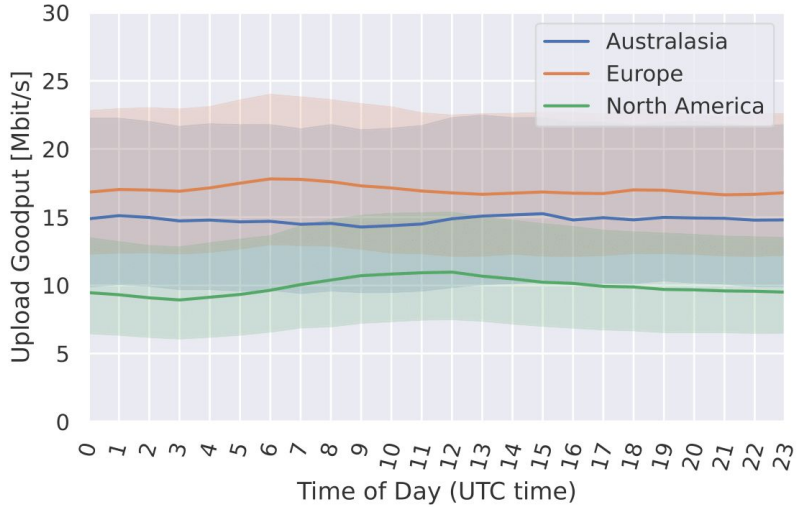


Goodput by time of day

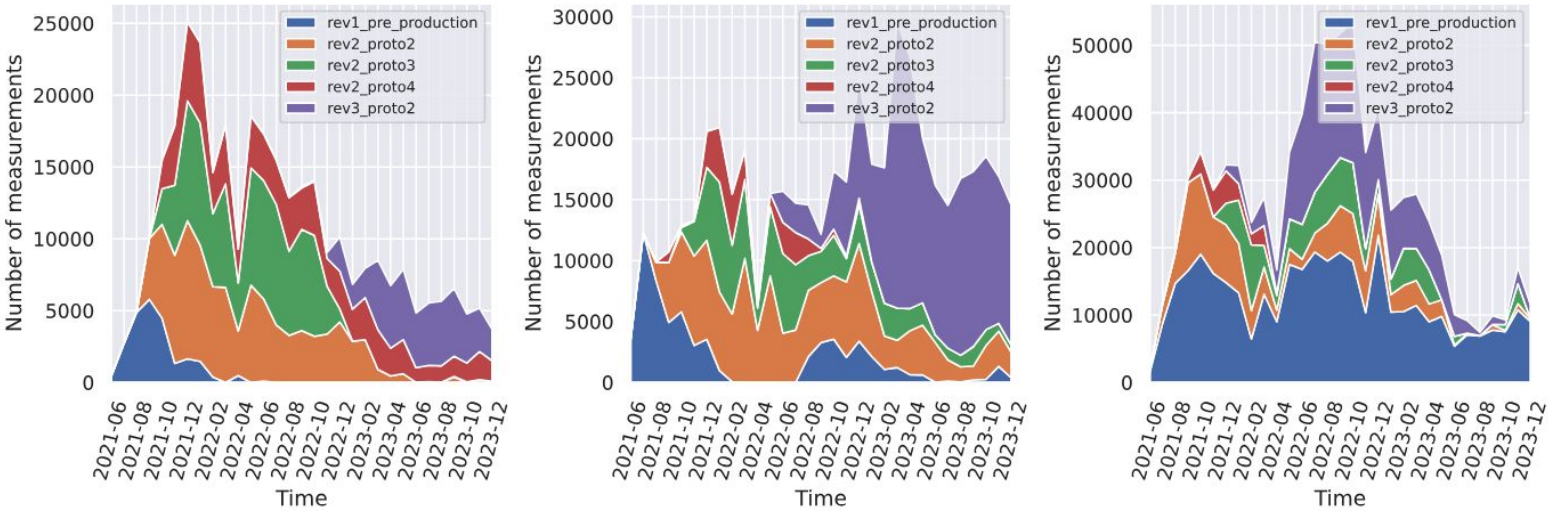
return link aka upload

- A temporal impact on the upload goodput is observable but less severe compared to the download goodput
- No significant temporal performance impacts are visible for Australasia and Europe

Solid lines are median values; shaded areas show first and third quartiles.

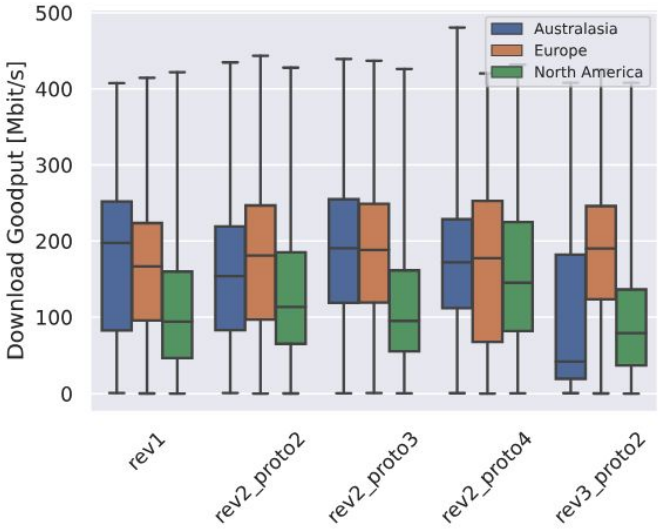


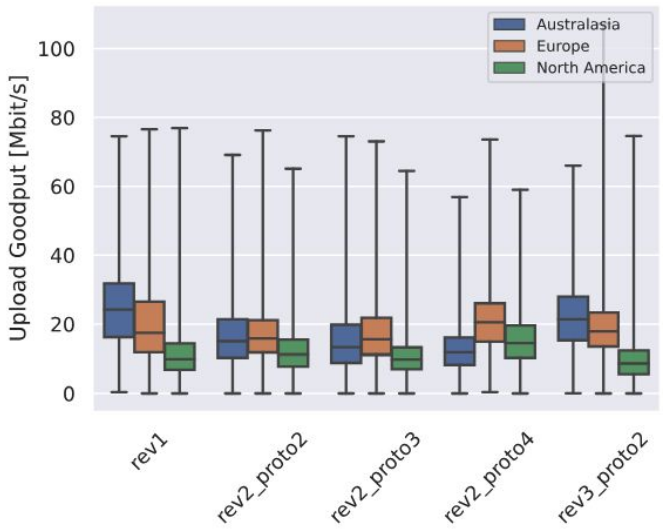
Hardware versions over time



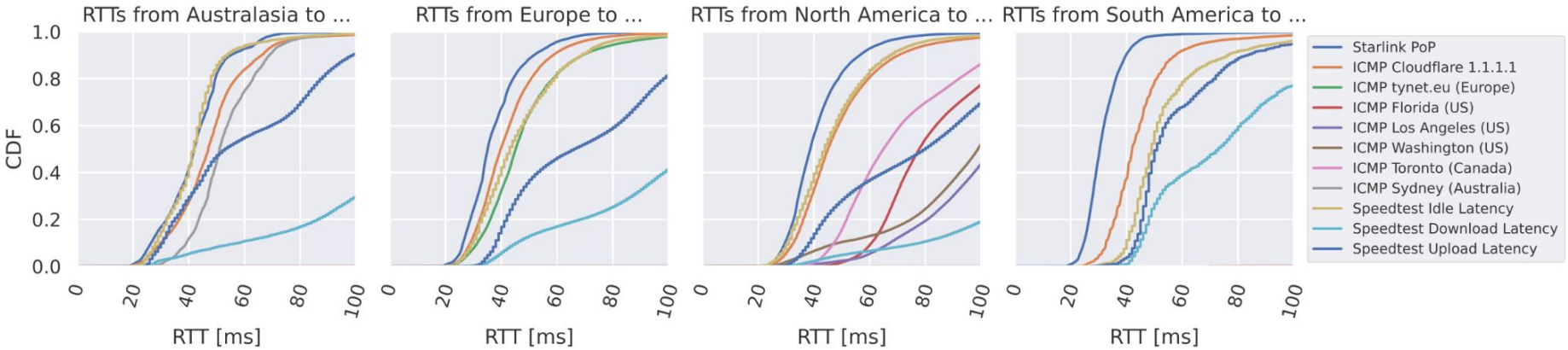
(a) Australasia (b) Europe (c) North America

Download and upload goodput



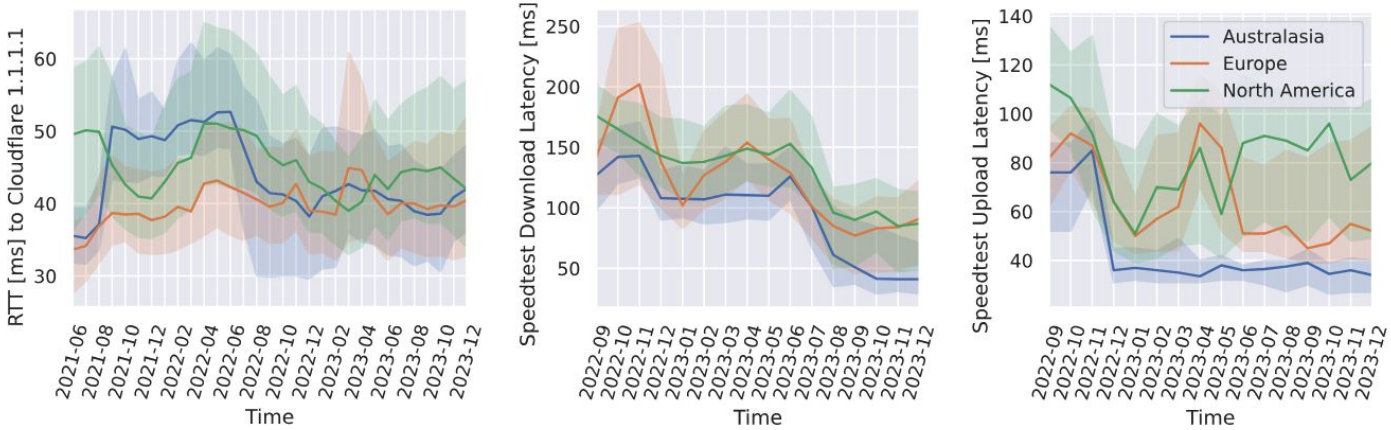


Latency around the world (RTT)



RTTs to the Starlink point of presence were obtained via RPCs to the Starlink terminal. Results from the Ookla Speedtest are rounded to full decimals, therefore the lines appear slightly ragged. ICMP packets were sent to manually selected servers across Europe, United States, Canada, and Australia.

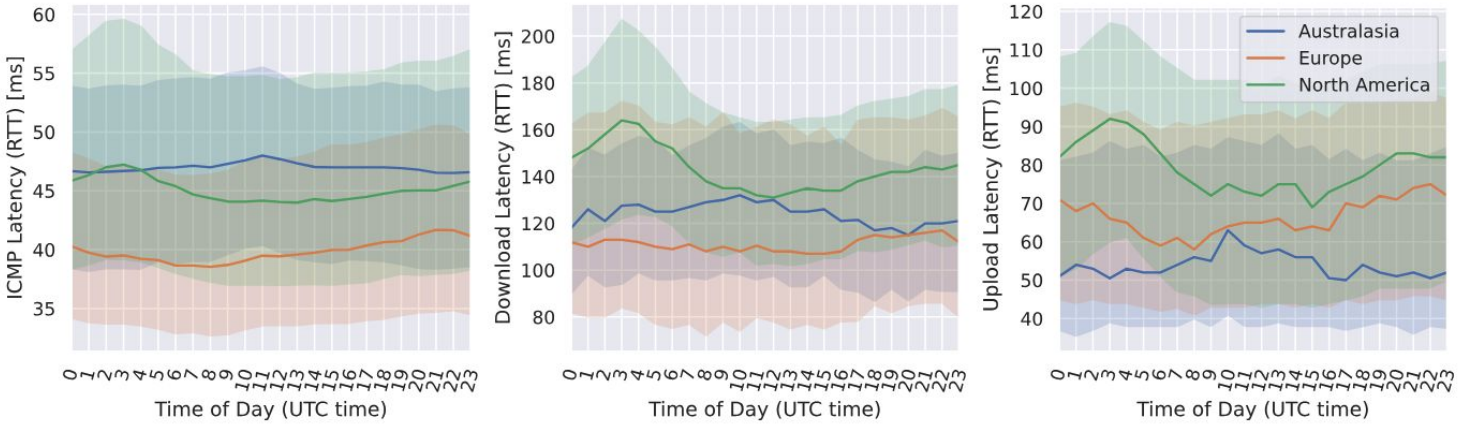
Latency by time (RTT)



(a) ICMP to Cloudflare's `1.1.1.1` (b) Speedtest Download Latency (c) Speedtest Upload Latency

RTT measurements over time. Solid lines are median values; shaded areas show first and third quartiles. Please note the different scales on the vertical axis.

Latency by time of day (RTT)



(a) ICMP to Cloudflare's `1.1.1.1`

(b) Speedtest Download Latency

(c) Speedtest Upload Latency

RTT measurements depending on time of day. Solid lines are median values; shaded areas show first and third quartiles. Please note the different scales on the vertical axis.

Conclusion and future work

Conclusion

Starlinkstatus.space provides crowdsourced performance measurements of the Starlink system and allows valuable insights into the overall system performance.

The software is a combination of readily available tools.

Goodput and latencies are comparable with terrestrial Internet access.

North America showing signs of a higher subscription rate and lower performance during busy hours.

RTTs are comparable with terrestrial cellular networks and show significant variance.

Latencies due to buffering were very high but also seem to have improved over the recent months.

Future work

UDP instead of ICMP packets could be used for RTT measurements.

Continued long-term measurements are planned. This is required because the number of satellites and the number of subscribers are subject to continuous change.

At the same time, both the satellites and the network is likely to be further optimized.

Adding other satellite megaconstellation systems once they become available would allow for a comparison of different systems.

Thank you!

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