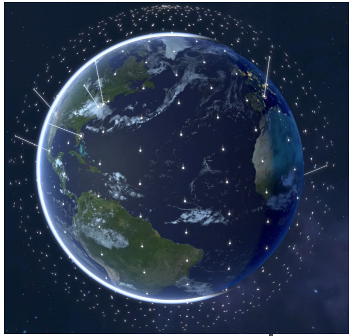
A code for satellite constellations

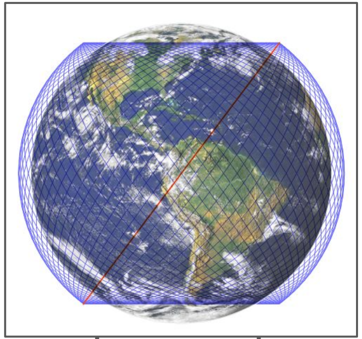
[draft-piraux-space-constellation-code]

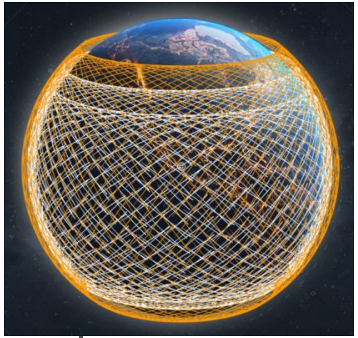
IETF 124 – SPACE RG

Maxime Piraux - Aerospacelab

Satellite constellations today & tomorrow







OneWeb
Deployed 2019-mid 2023
Walker Star shell
No inter-satellite links

Starlink v1.0 Group 1
Deployed 2019-mid 2021
Walker Delta shell
No inter-satellite links

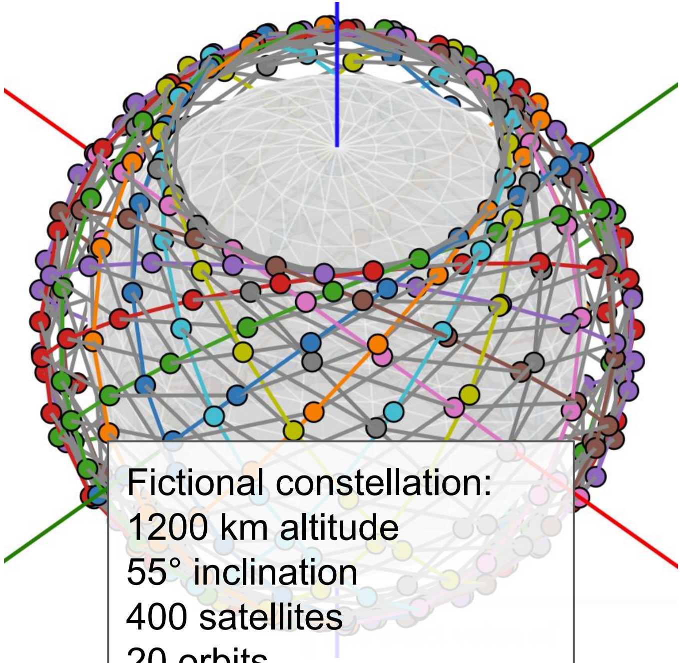
Starlink v1.5 Group 2+
Deployed mid 2021-2023
Walker Delta shell
Optical inter-satellite links

. . . . .

Kuiper
Deploying 2025-
Walker Delta shells
Optical inter-satellite links

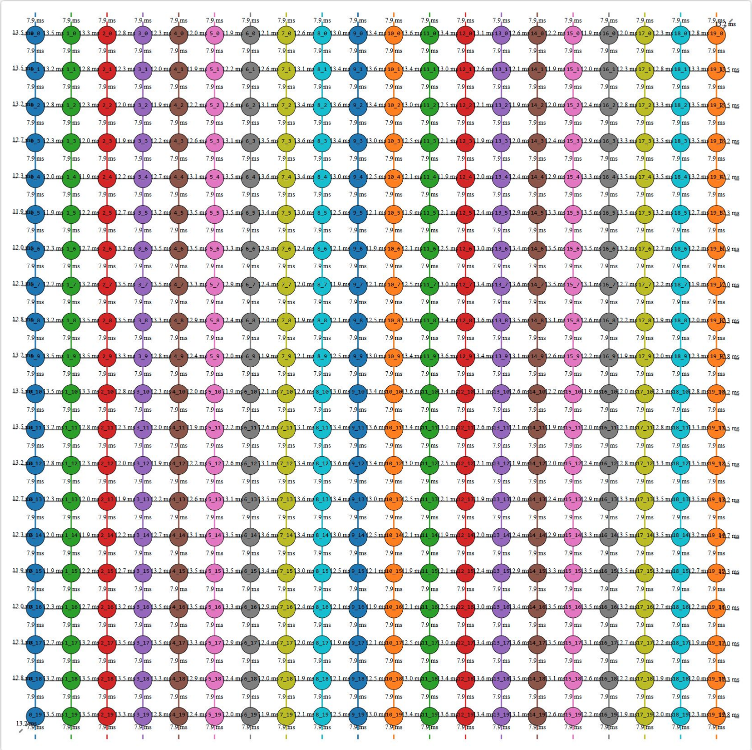
What network topology do they form ?

How to encode this problem?



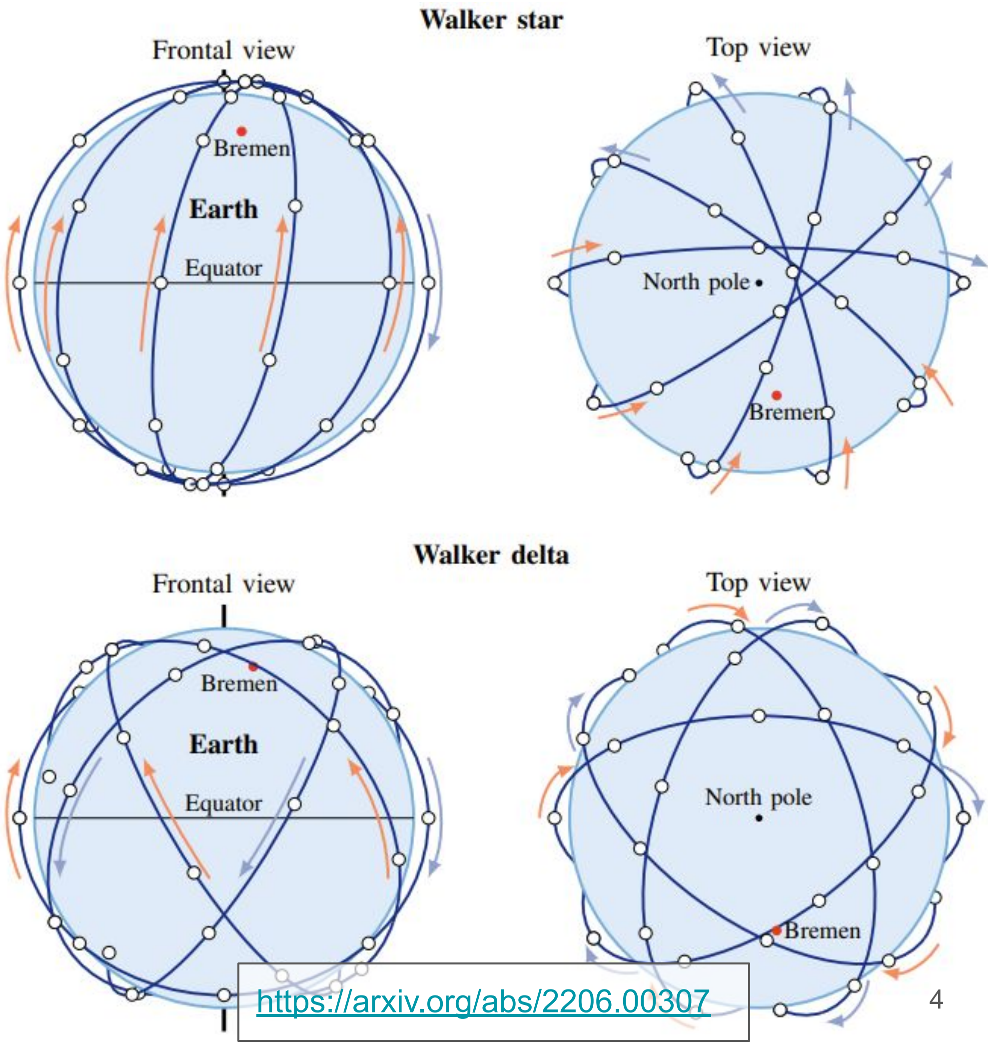
Fictional constellation:
1200 km altitude
55° inclination
400 satellites
20 orbits
4 OISLs per satellite

?



The code

- Represents the mission parameters of a constellation:
  - Altitude
  - Inclination
  - # of satellites
  - # of orbits
  - Phasing
- Can define several shells:
  - Currently, Walker shells are supported.



https://arxiv.org/abs/2206.00307

The code – ABNF definition

```
constellation = shell [ "+" constellation ]
shell = walker ":" altitude ":" inclination ":" plane-params [ ":" mean-anomaly ]
walker = "D" / "S"
altitude = float
inclination = float
plane-params = no-sats "/" no-planes "/" phasing-factor
no-sats = int
no-planes = int
phasing-factor = int
mean-anomaly = float
```

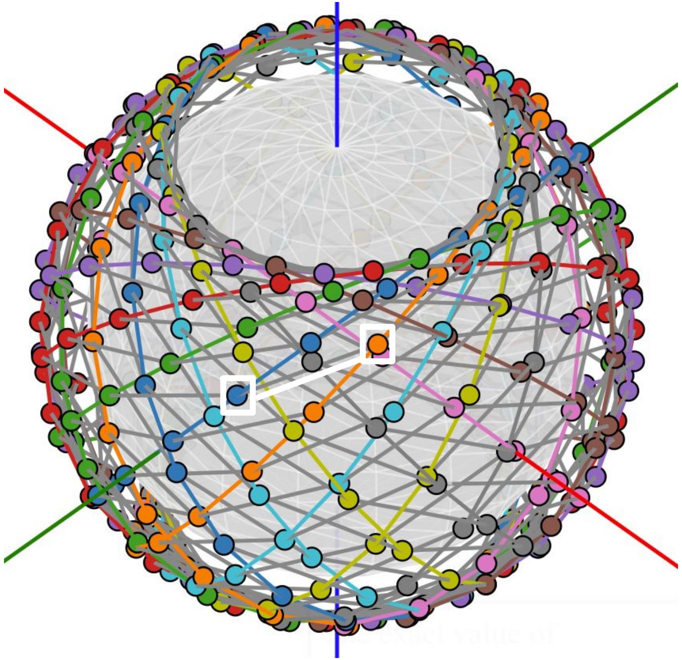
Based on the format of Tim van der Lee that served as the basis for this document.

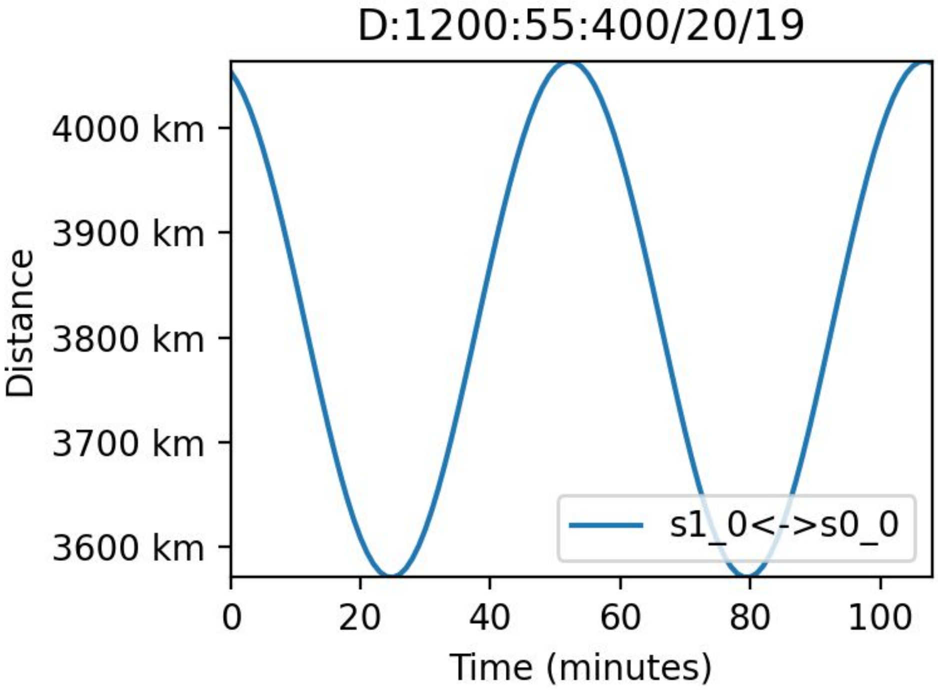
Example of uses of the code

Name	Description	Constellation code
Iridium	Walker Star, 780 km altitude, 86.4° inclination, 66 satellites, 6 planes	S:780:86.4:66/6/1
OneWeb	Walker Star, 1 200 km altitude, 87.9° inclination, 672 satellites, 12 planes	S:1200:87.9:672/12/11
GPS	Walker Delta, 20 180 km, 55° inclination, 24 satellites, 6 planes	D:20180:55:24/6/1
Starlink (Phase 1 Version 3)	Walker Delta, 550 km altitude, 53° inclination, 1584 satellites, 22 planes	D:550:53.0:1584/22/17

Example of uses of the code – Satellites distance

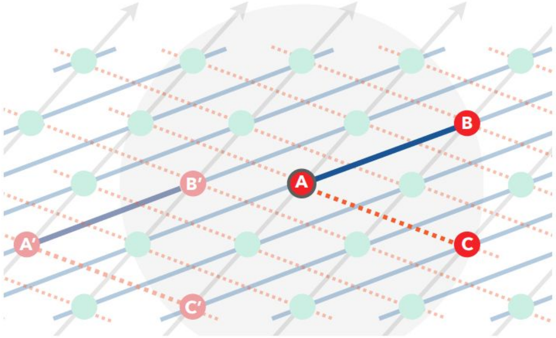
D:1200:55:400/20/19





Limitations & future versions of the document

- Link configuration is implicit:
  - “Four fixed links” for Walker Delta (two in-plane, two cross-plane to immediate neighbours of the same rank)
  - Fine for small-to-medium constellations, but mega-constellations may be more advanced.
- Only aspects of the *network graph* are considered so far. What about:
  - Link quality ? Link priority ? Link constraints ?
- Should there be a SPACE RG toolbox based on the code ?



Network topology design at 27,000 km/hour
D. Bhattacherjee and A. Singla — CoNEXT’19
https://doi.org/10.1145/3359989.3365407

The link topic

- Next to the definition of the network topology, a model of links between satellites is useful to fully capture the dynamics of satellite constellations.
- It sparked some interest in the group.
- Optical Inter-Satellite Links (OISLs)
  - Kevin Shortt
- Radio-Frequency Inter-Satellite Links (RF ISLs)
  - Juan A. Fraire

Conclusion

- Thanks for the comments & feedback on the list so far.
- I-D repository is at https://github.com/mpiraux/draft-piraux-space-constellation-code
- Discuss on the list & propose your ideas as PR.
- Use the code in your tools and give feedback.
- We thank Tim van der Lee for his open-source contribution.