

Tools and Infrastructures for LEO Measurement and Evaluation

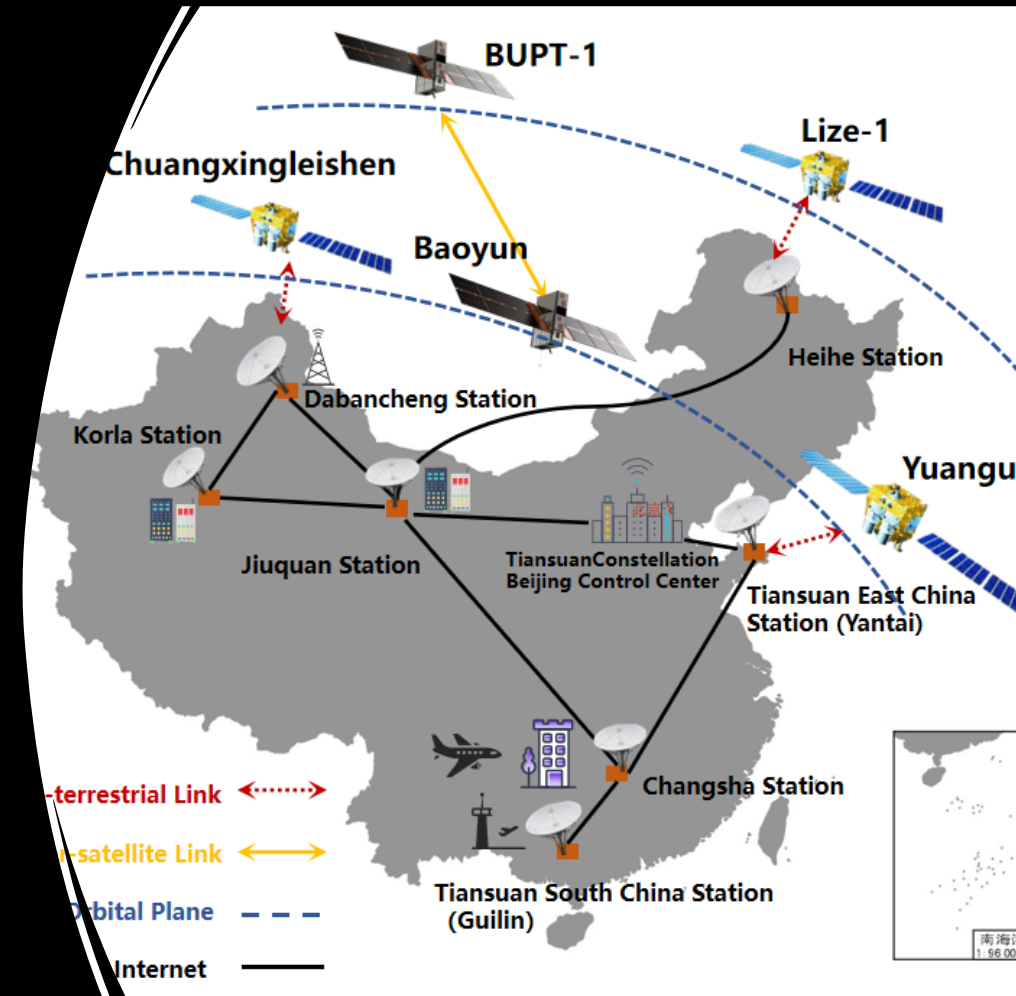
A call to arms

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HOW TO MEASURE & UNDERSTAND LEO NETWORKS?

- BYO Constellation?
- White box visibility which SpaceX won't grant!
- Complex and expensive endeavour!
 - Does not capture complexity of *megaconstellations*
 - Starlink has nearly 10K satellites **with ISLs**
 - May not replicate emergent behaviours
- Orbits \neq Starlink (or other constellations)
 - Cannot capture specificities of deployed or planned constellations



A TYPOLOGY FOR LEO EVALUATIONS



Volume




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MEASUREMENT USING PUBLIC DATASETS

CoNEXT'23
SIGMETRICS'26


Coverage



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MEASUREMENT USING BROWSER PLUGINS

IMC'22,
CoNEXT'23,
HotNets'24



Flexibility



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XEOVERSE "DIGITAL TWIN" (SIMULATOR)

IFIP Networking'24

- Scalable,
- Responsive,
- High fidelity,
- Low-footprint

Simulation of LEO/MEO/GEO (mega)constellations

Control

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LEOSCOPE: MEASUREMENT USING VOLUNTEER NODES

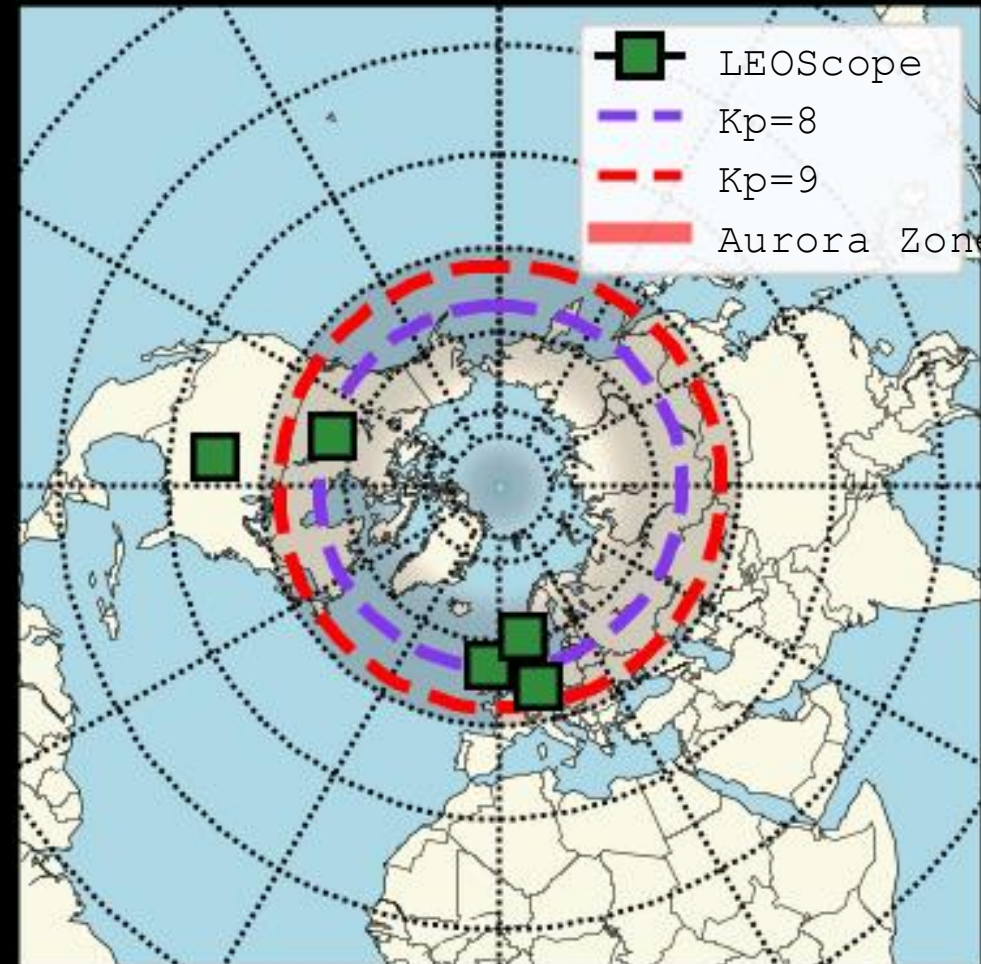
AKA "PLANETLAB FOR STARLINK"

SIGCOMM
CCR

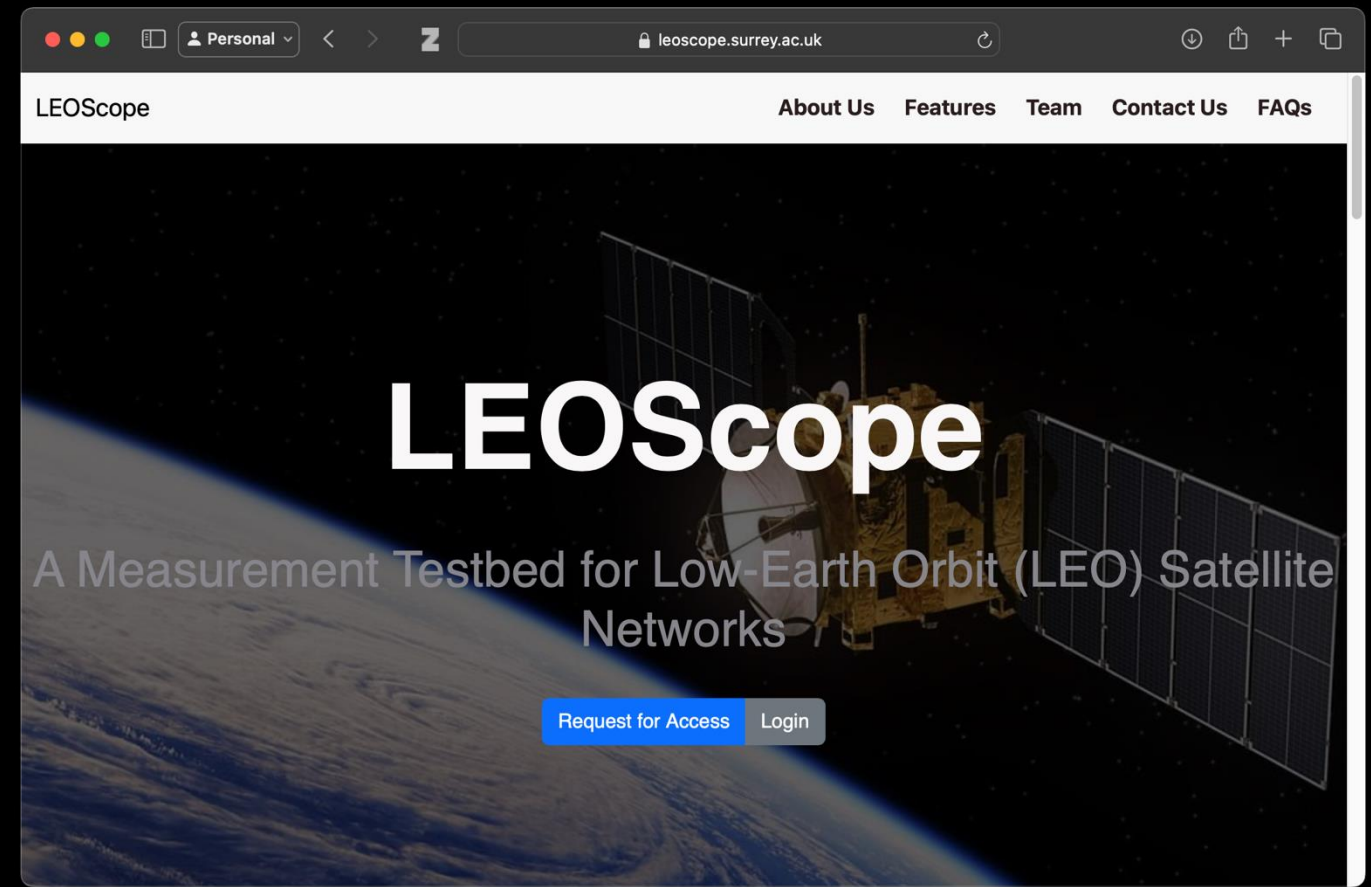



CALL TO ARMS: EARTH-BASED RESEARCH INFRA

1. **Measurement** of *deployed* constellations (**LEOScope**)
2. **Simulation** of *deployed, planned or imagined* constellations (**xEOVerse, Hypatia, CosmicBeats**)
3. User participation via Browser plugins (**NetMet**)
4. Public data/devices (**RIPE, MLab**)



Effects of 1.5 years of Geomagnetic Storms
SIGMETRICS'26



<https://leoscope.surrey.ac.uk>

OPERATIONAL ISSUES

- Do we need a PlanetLab like testbed with full flexibility or a locked-down set of nodes like RIPE Atlas?
- Maintaining testbed involves LOTS of engineering
 - Volunteer nodes → need to protect their network access
 - Nodes can go down easily (Nigeria, W. Virginia)
 - Fights with university firewalls (Biggest change since Planetlab days)
 - **Engineering like this not easily fundable by research grants!**
- How to incentivize node contribution?
 - PlanetLab: “contribute your own node if you want to participate”
 - **Would exclude researchers from countries which do not yet have Starlink!**



A CALL TO ARMS



	A1	A	B	C	D
1	Resources Name		Resource Type	URL	Publication
25	FOCUS		Simulator		SPIE
26	Roman-HitchHiking		Data Collection	https://github.com/UCLA-SCaN/roman_hitchhiking	https://dl.acm.org/doi/10.1145/3748749.3749
27	LEO-HitchHiking		Data Collection	https://github.com/stanford-esrg/LEO_HitchHiking	https://izizhikevich.github.io/assets/papers/LI
28	WetLinks		Dataset	https://github.com/sys-uos/WetLinks	https://ieeexplore.ieee.org/abstract/document/
29	Starlink on the Autobahn		Dataset	https://github.com/sys-uos/Starlink-on-the-Autobahn	https://ieeexplore.ieee.org/abstract/document/
30	Starlink on the road		Dataset	https://github.com/sys-uos/Starlink-on-the-Road	https://ieeexplore.ieee.org/abstract/document/
31	phantomlink		Emulator	https://github.com/robinohs/phantomlink	https://doi.org/10.1145/3744200.3744758
32	FLoRaSat		Simulator	https://gitlab.inria.fr/jfraire/florasat	https://hal.science/hal-05424077v1
33	IPN-v		Visualizer	https://gitlab.inria.fr/jfraire/ipn-v	https://hal.science/hal-04996148v1
34	DtnSim		Simulator	https://gitlab.inria.fr/jfraire/dtnsim	https://ieeexplore.ieee.org/document/822755
35	Satellite Applications Lab Testbed		Testbed	https://abdn.elsevierpure.com/en/equipments/satellite-ap	https://doi.org/10.1016/j.comnet.2025.111950
36	Deepspace IP Toolkit - QUIC		Simulator	https://github.com/deepspaceip/dipt-quic-workbench	
37	Deepspace IP Toolkit - HTTP		Simulator	https://github.com/deepspaceip/dipt-http	
38	Deepspace IP Toolkit - Network scenarios		Dataset	https://github.com/deepspaceip/dipt-space-network-scenarios	
39	Deepspace IP Toolkit - Header Compression		Implementation	https://github.com/deepspaceip/dipt-schc-tap	
40	Deepspace IP Toolkit - Network management		Implementation	https://github.com/deepspaceip/dipt-netconf-over-quic-proxy	
41	Deepspace IP Toolkit - IP store and forward		Implementation	https://github.com/deepspaceip/dipt-ip-store-forward	
42	Meteornet		Simulator	https://gitlab.com/camilo.rojas/meteornet	
43	cote		Simulator	https://github.com/cmuaabstract/cote	https://dl.acm.org/doi/pdf/10.1145/3373376.3
44	Argus 1 constellation (Brandon Lucia)		Satellites		
45	EPASat		Satellites		
46	OPSSat		Satellites		
47	Polarlink		Satellites		https://www.uvic.ca/ecs/news/cfar-spaceleo.p
48	Tartan Artibeus		Satellites		https://par.nsf.gov/servlets/purl/10424448

<http://tiny.cc/space-networking-tools>

INITIAL TAXONOMY (FROM 60 TOOLS)

- Browser Plugins (2)
- Data
 - Datasets (9)
 - Data collection scripts and methods (2)
- Emulators and simulators (distinction not always clear)
 - Emulators (4)
 - Simulators (24)
- Reference implementations (3)
 - All related to DEEPSPACE (Marc Blanchet, Viagenie)
- Research Satellites & Constellations (6)
- Testbeds (4)
- Visualizer (3)



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FEEDBACK ON TAXONOMY

1. What categories are missing?
2. Would a “living” tools doc/I-D be useful to SPACE RG?
 - Please contribute 😊
3. Going beyond tools, pl. share tips and tricks for tools culture and community cohesion!

