



Internet Exchanges... in SPACE!

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**NLNOG Day
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ESA STARS project

- European Space Agency (ESA) commissioned: Space-based Topology and Autonomous Routing Study (STARS)
- The idea: figure out if internet exchanges in space can work
- Prime contractor: SINTEF, Norway
- Subcontractor: TTTECH Computertechnik AG, Austria
- Subcontractor: inet⁶ consult, Netherlands (me!)

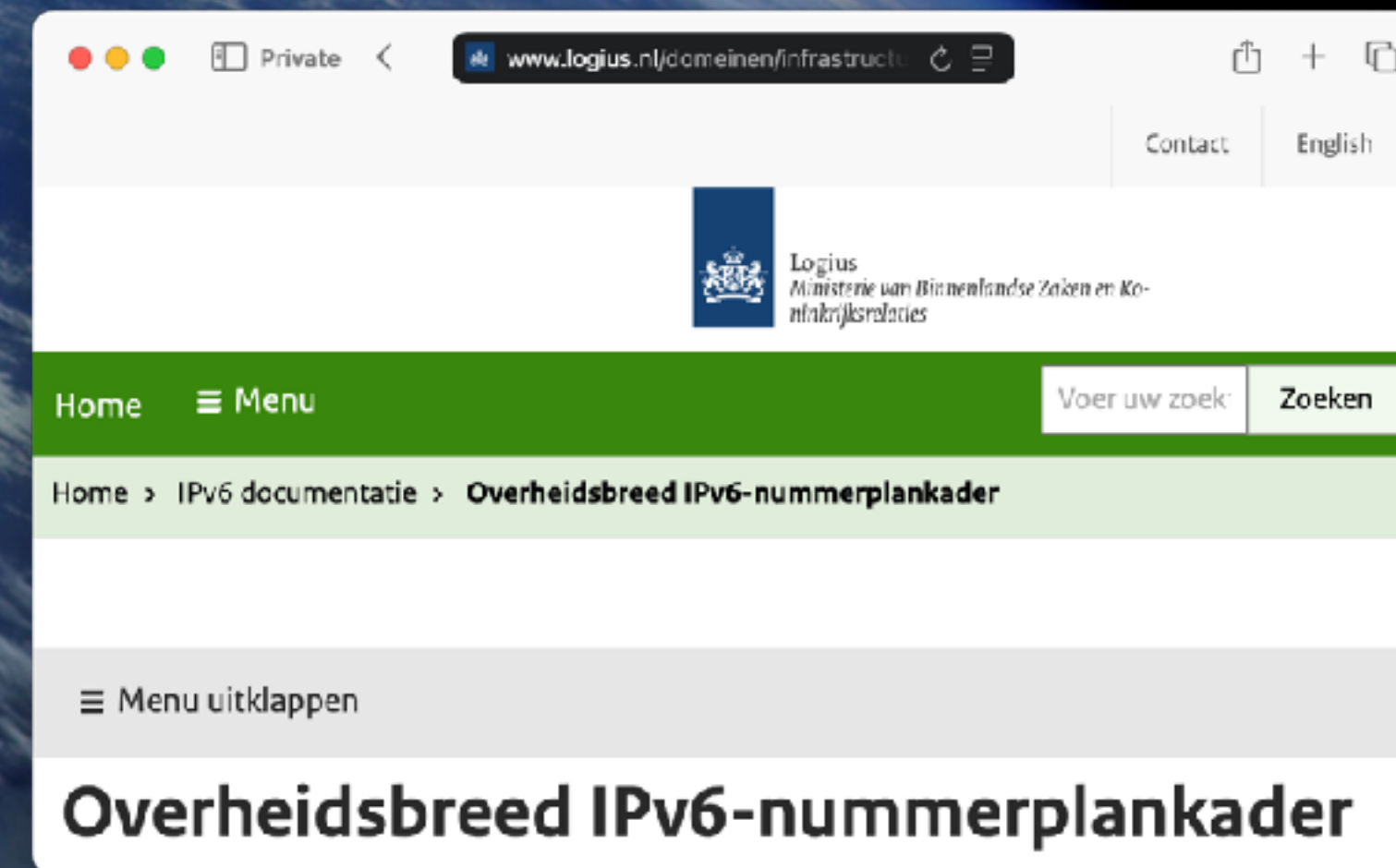
I've been doing BGP and IPv6 stuff for a while...



2002



2015: "20 years ago today, I got my first autonomous system (AS) number"



2016

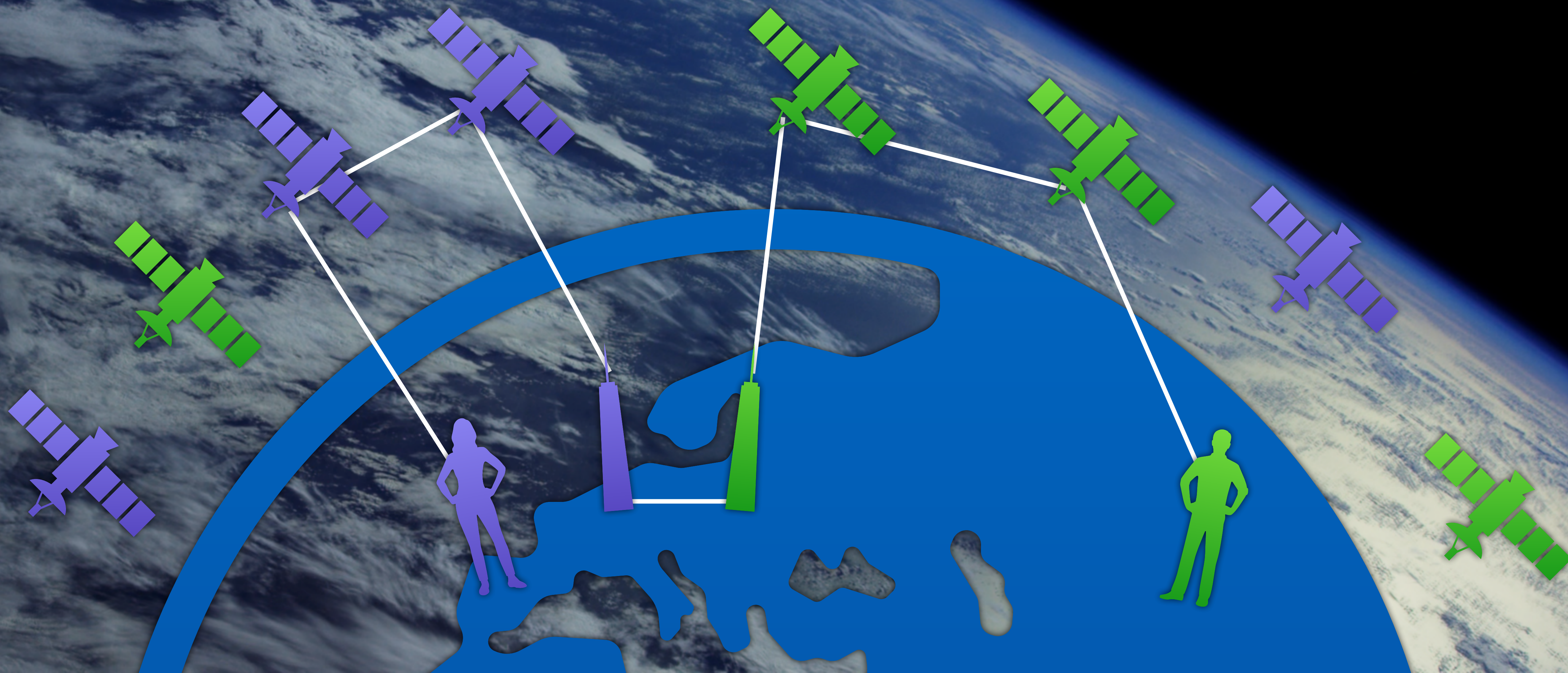


2022

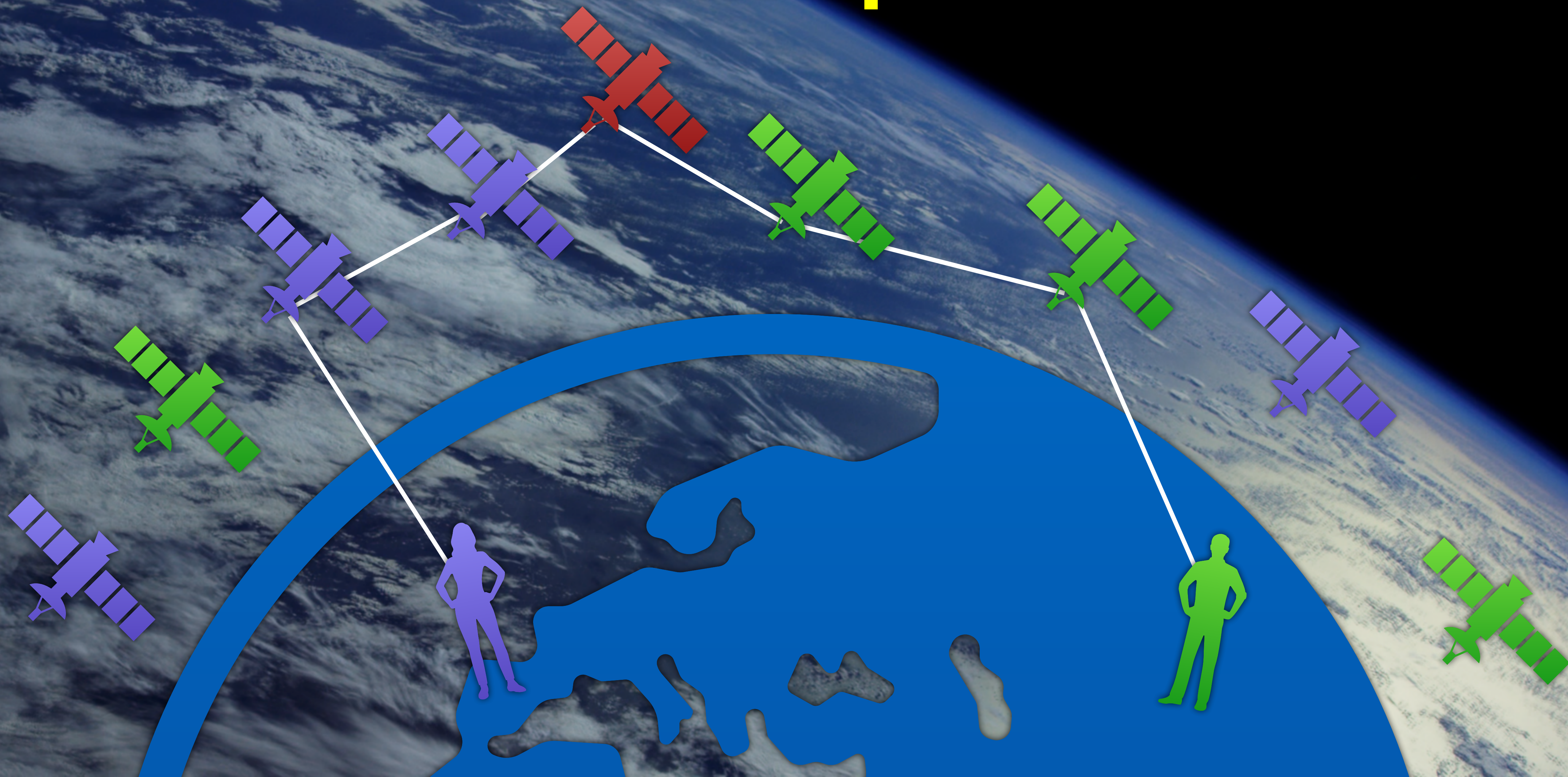
Why IXes in space?

- Broadband internet access through low earth orbit (LEO) satellite networks is booming:
 - Starlink
 - Eutelsat OneWeb
 - Amazon Leo
 - IRIS²
- But how do these networks interconnect?

Current situation



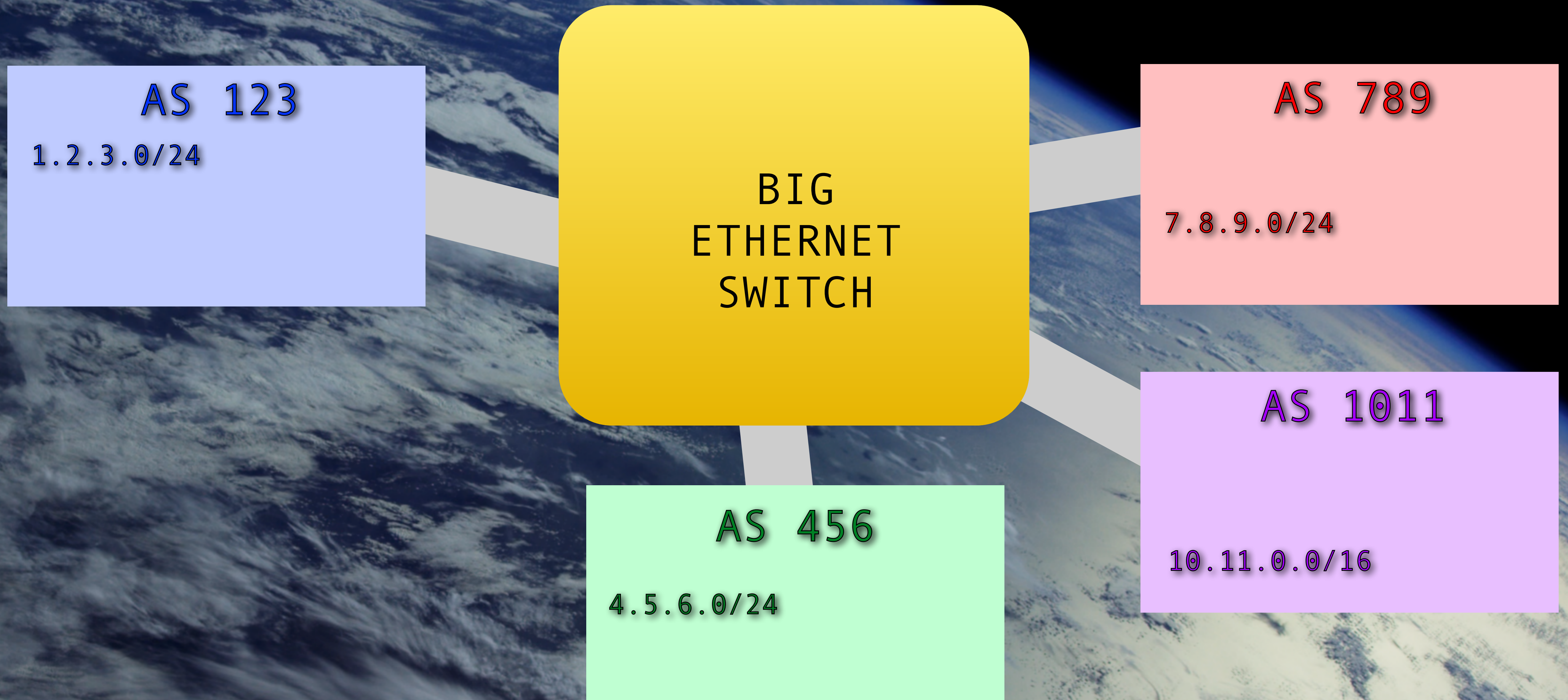
IXes in space



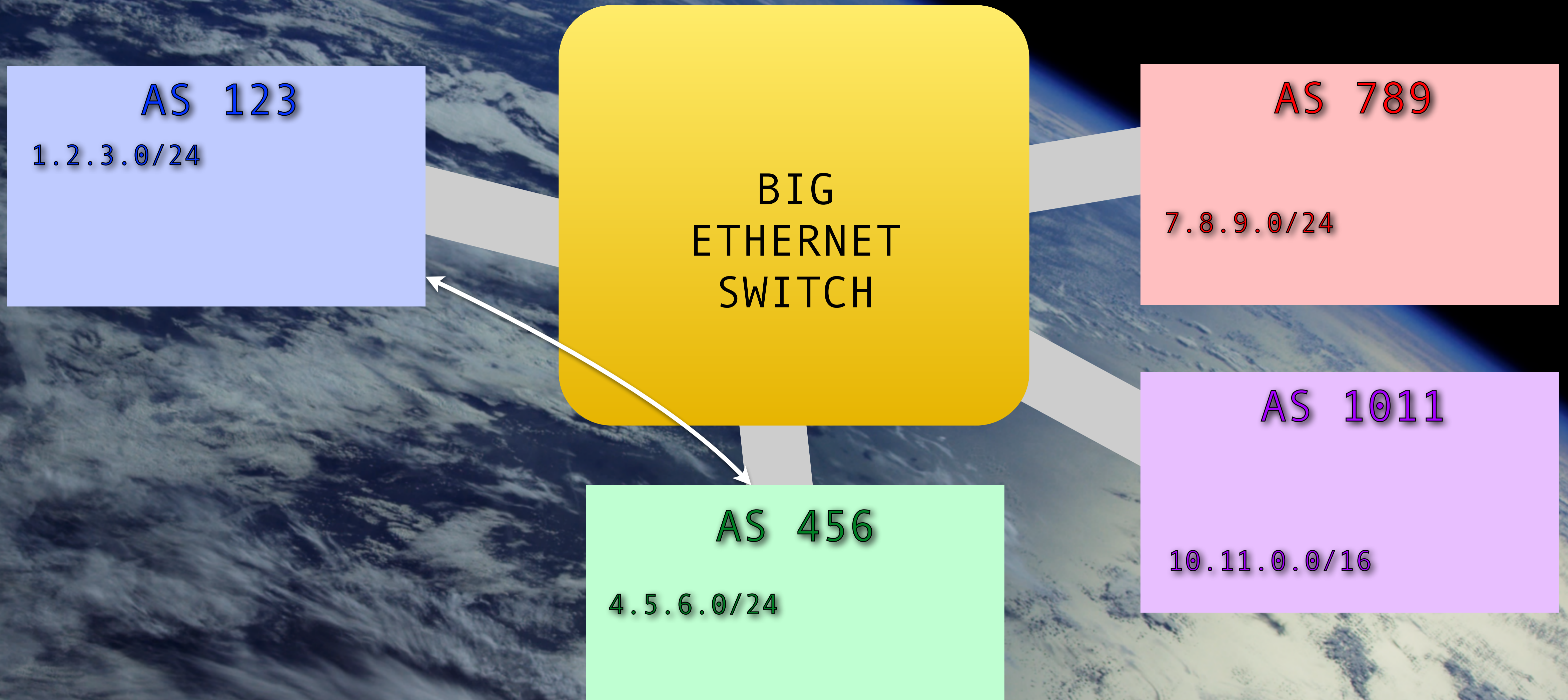
Why IXes in space? (2)

- Removes space ↔ ground ↔ space bottleneck
 - More efficient
 - Cheaper?
 - Faster?
- New use cases:
 - More robust emergency communication
 - Content delivery from space
 - Smaller country's military/diplomatic networks can peer and de-peer as alliances change

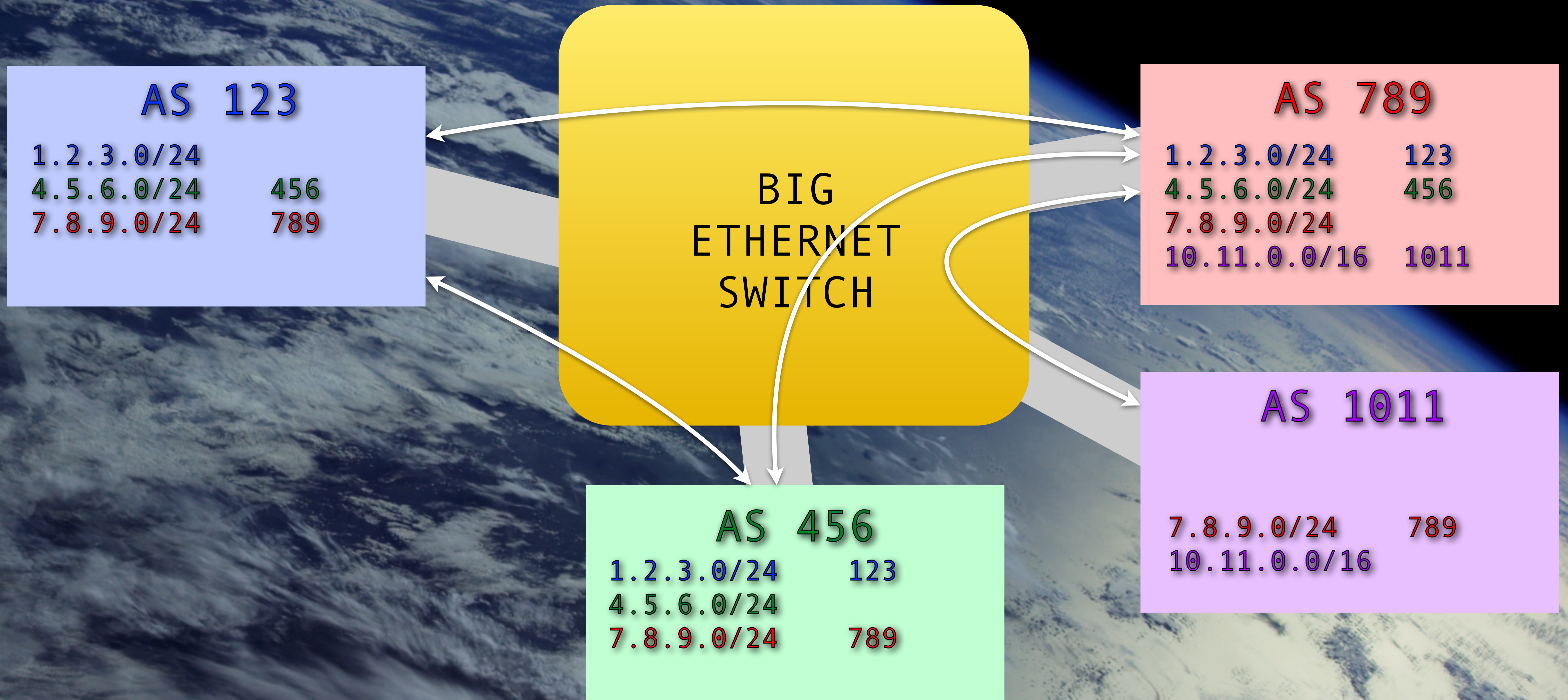
What is an internet exchange?



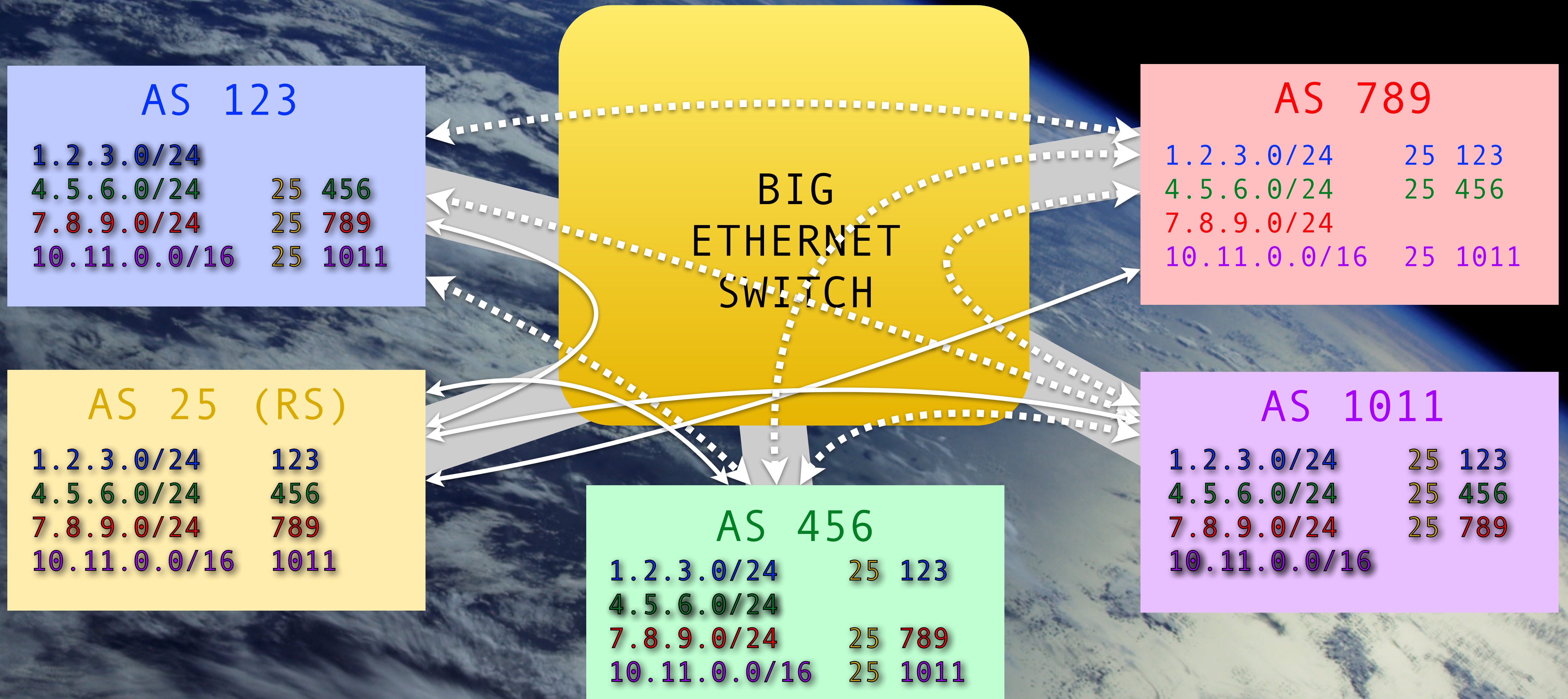
IX peering



IX peering (2)



Route servers



So launch this into space?

- The hardware seems doable:
 - Tbps class 32-port router/switch can be had for ~ € 6000 at 11 kilos, requiring 1500 W of power
 - Route server functionality can be provided by an ARM CPU with routine amounts of memory
 - (Of course space hardening required!)
- But:
 - On the ground your routers and switches don't move
 - In space they fly around at ~ 7 km/s

Optical inter-satellite links

- On the ground we have fiber
- Good news: in space you don't need fiber!
- Just point the laser from one satellite to another and you can have ~ 100 Gbps bandwidth between them
 - (Optical ISL)
- Bandwidth to the ground is more difficult
 - Clouds, rain etc. get in the way of optical communication (but otherwise not impossible)
 - Ground stations are a limited resource

Can BGP handle it?

- Researchers at SINTEF set up a simulation of separate satellite constellations talking BGP to each other. Results:
 - Performance was horrible as it takes BGP up to 180 seconds to detect that a link has gone down
 - I set up something similar with Free Range Routing software running in Docker containers
 - Results were immediately much better

Can BGP handle it? (2)

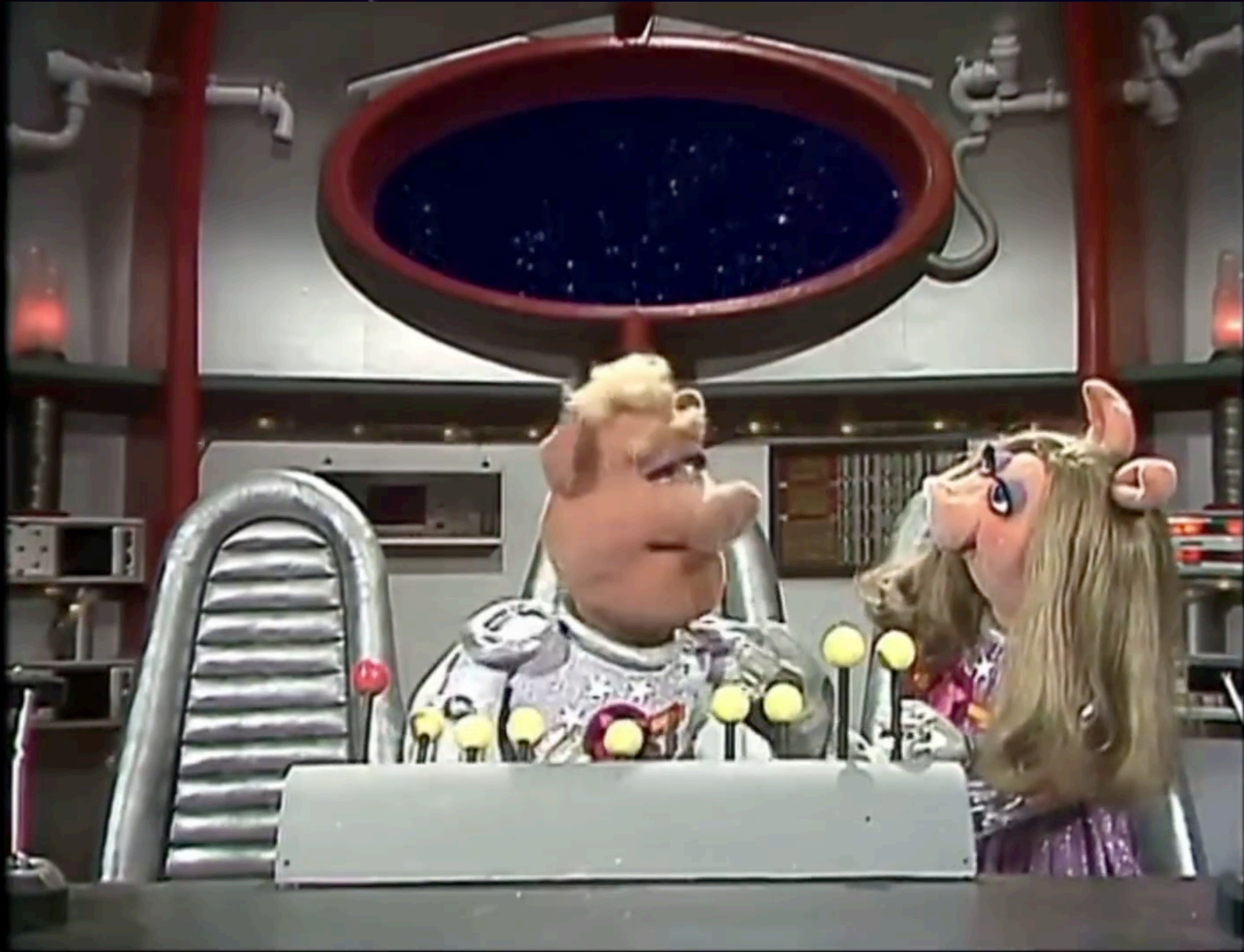
- Notable: although the satellites fly very fast relative to the ground, they move much slower relative to each other
- So handovers can be hours apart
- Tweak BGP timers
- Add Bidirectional Forwarding Detection (BFD) for sub-second link down detection
- Take BGP sessions down and reroute shortly before leaving communication range

Can BGP handle it? (3)

- An extra challenge: IP addressing
 - There will probably at least a dozen IX satellites in a mature system, possibly several times that
 - "Peering satellites" from different networks must *all* talk to all, or at least many, of the IX satellites
- That takes a lot of address space!
- This almost certainly means space IXes must operate on layer 3 rather than layer 2

Follow-up

- SINTEF has proposed four follow-up projects to ESA
- One of these is rather than having separate satellites that perform the IX function, have small modules that can be incorporated into other satellites
- NASA had a "Space BACN" program for creating modular, standardized ISL hardware
- So we suggest "Programmable Internet Gateway Subsystems" (PIGS)



Demo...

- If you want to see / interact with the demo on your own computer, go to:
- live.inet6consult.com

Questions?

- Come find me if you want to talk about:
 - 😊 Exciting BGP in space!
 - 😴 Boring BGP on the ground...
 - 😈 The awesome game Blood on the Clocktower