

A Call for Decentralized Satellite Networks

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Rural internet coverage



Critical connectivity in conflict



Maritime internet access



Post-disaster communication

Few Dominant Companies Control This Space

Current Number of active LEO Satellites: 7500



**6400 deployed
Planning for 42000**



648 deployed




Planning for 3000

Others Also Want to Have Their Own

Why Taiwan Is Building a Satellite Network Without Elon Musk

The island democracy urgently needs an internet backup. Mr. Musk's total control over his Starlink service, which dominates the market, left Taiwan wary.

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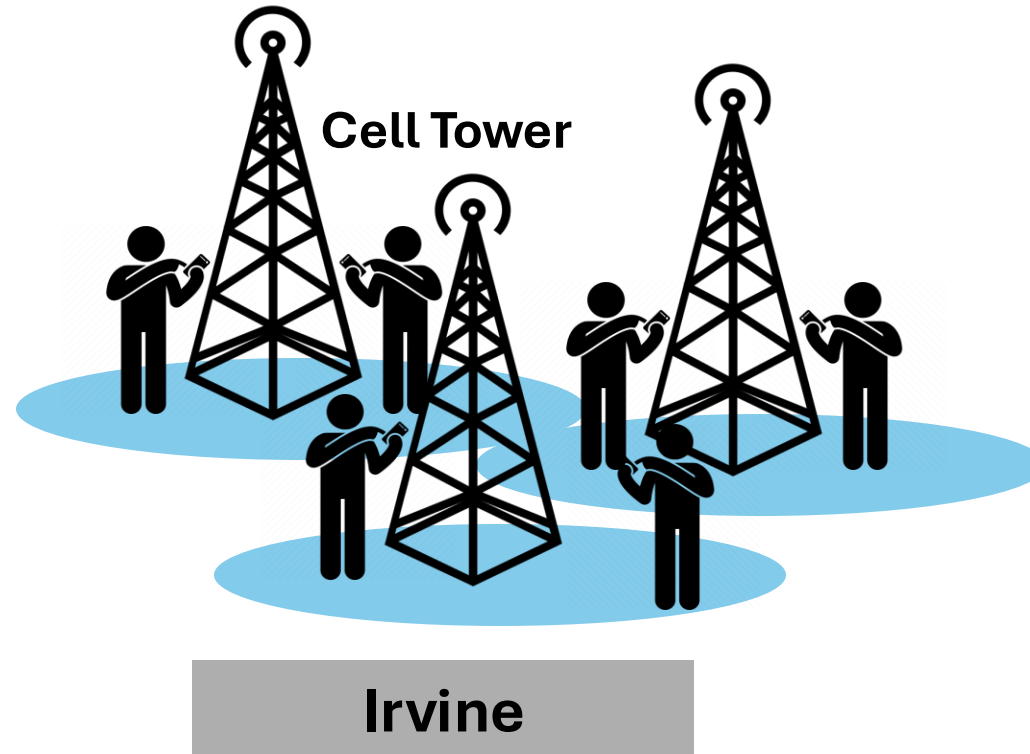
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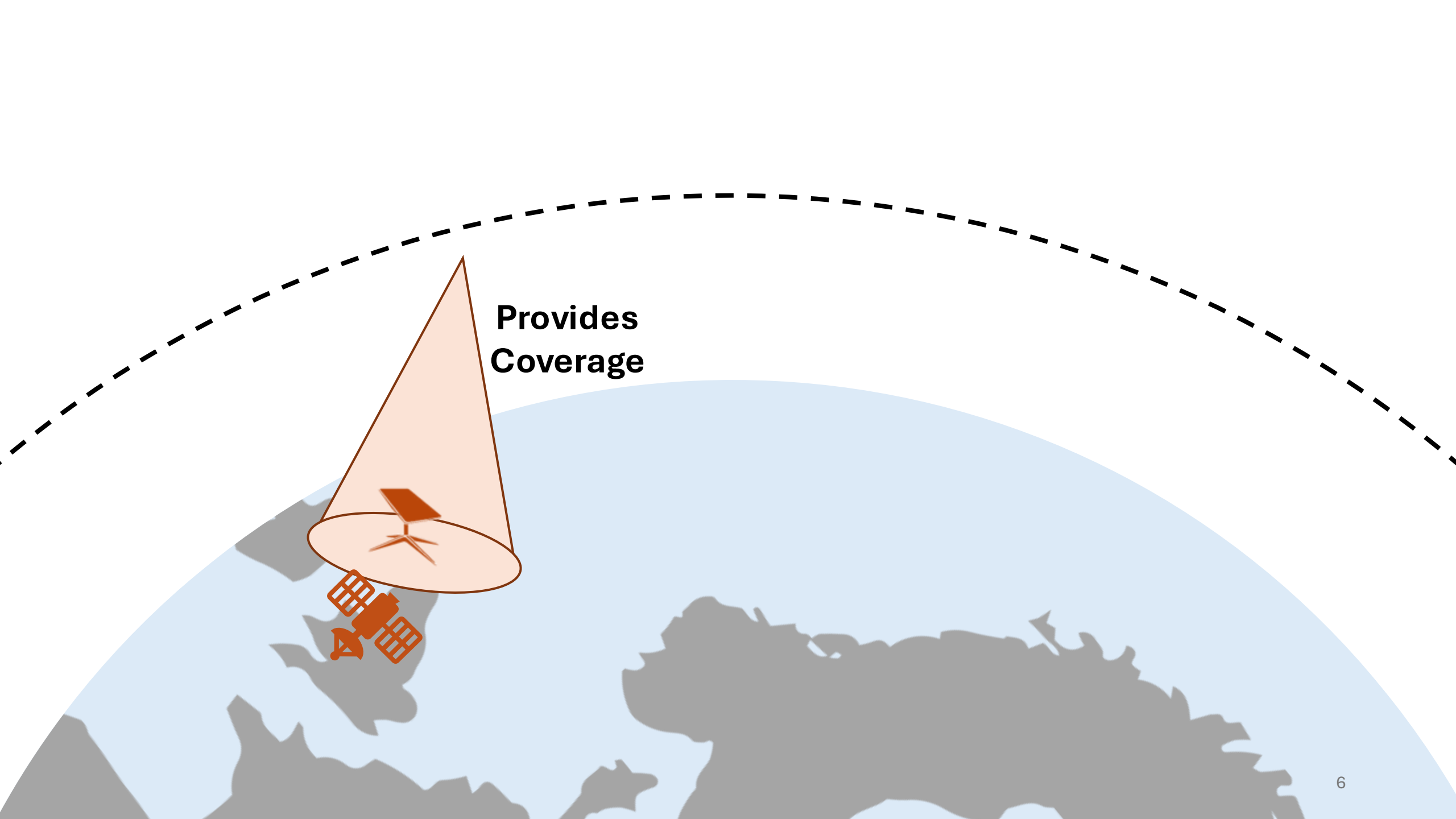
Also....

- **South Korea**
- **China**
- **India**
- **France**
- **Germany**
- ...

Building a Local Network On the Ground

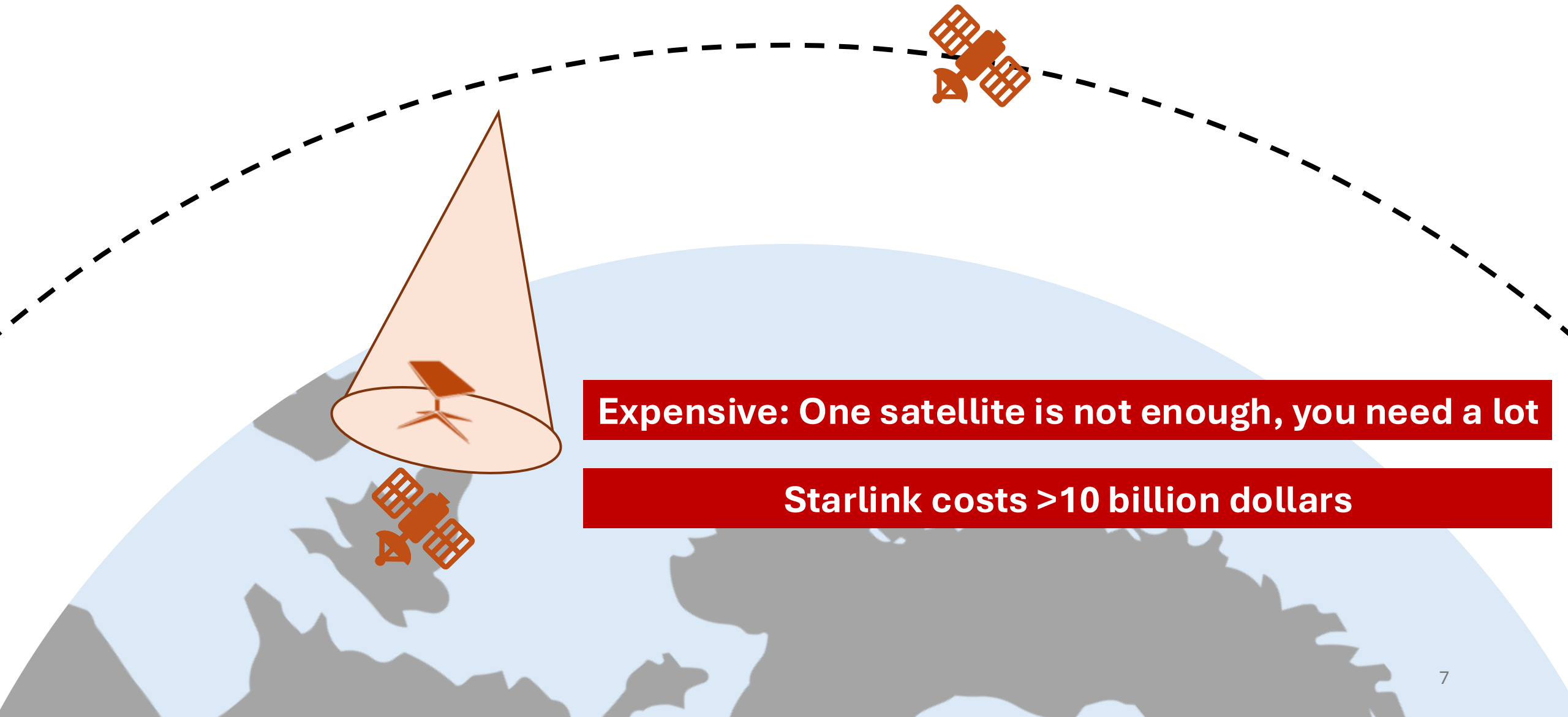


Deploy some base stations, and all done



**Provides
Coverage**

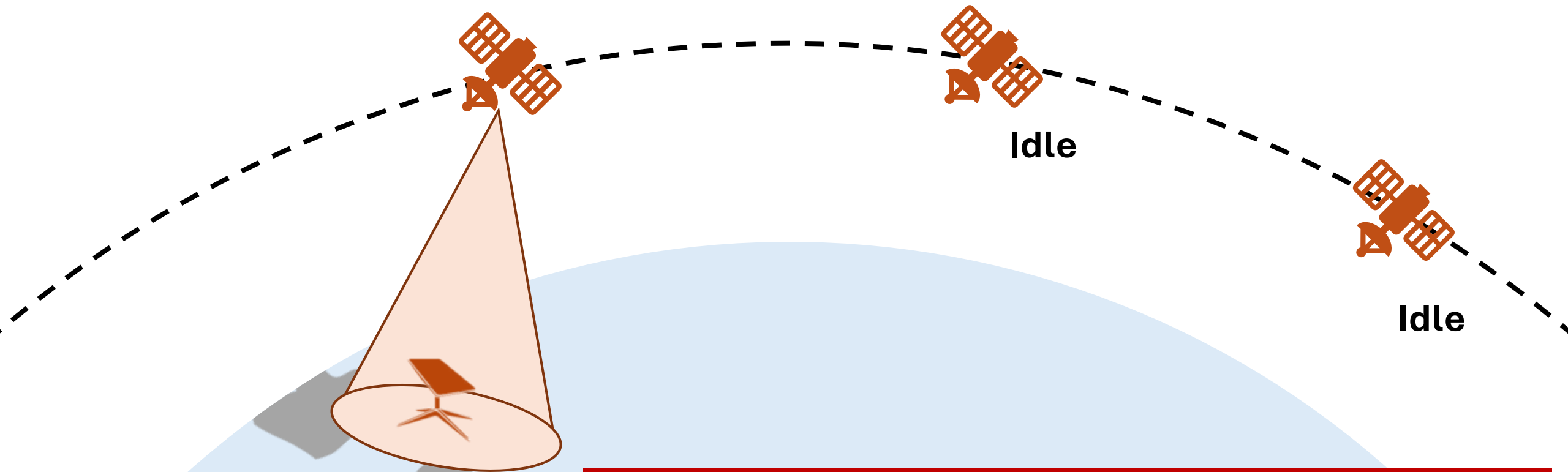
Challenge 1 : Need **1000** Satellites



Expensive: One satellite is not enough, you need a lot

Starlink costs >10 billion dollars

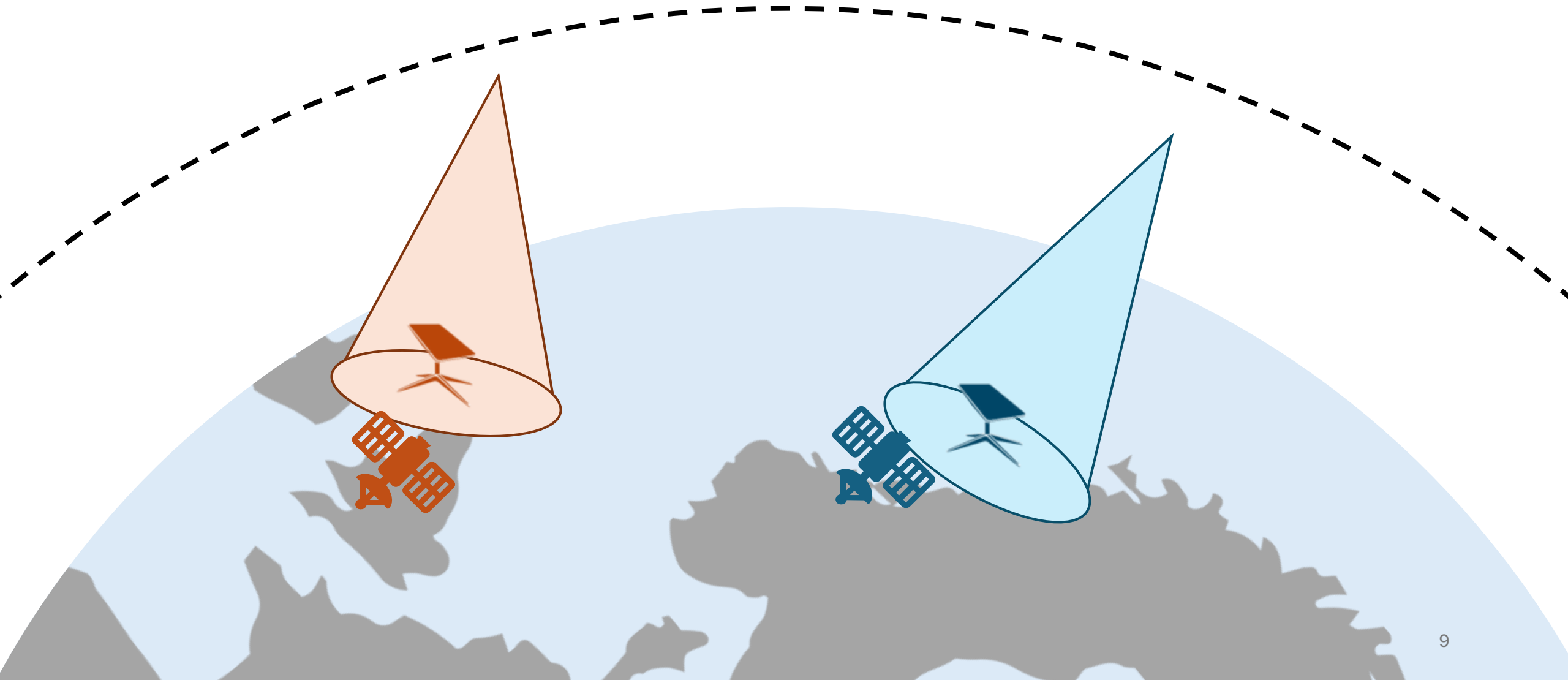
Challenge 2 : Less than **1%** Utilization



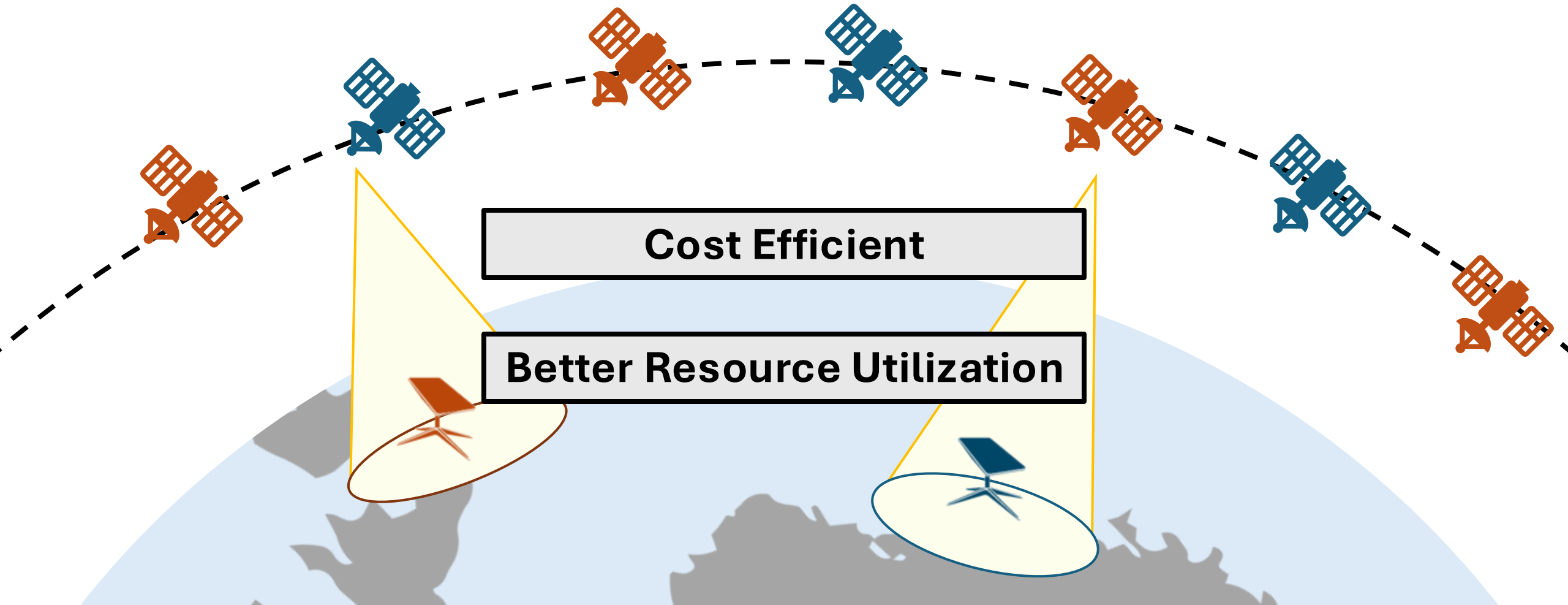
Wasteful: 99% of the time you do not even use them

Can we do something smarter?

Vision of Multi-Party LEO (MP-LEO)



Vision of Multi-Party LEO (MP-LEO)



Cost Efficient

Better Resource Utilization

A decentralized network where participants share spare satellite capacity

Why is MP-LEO Possible Now?

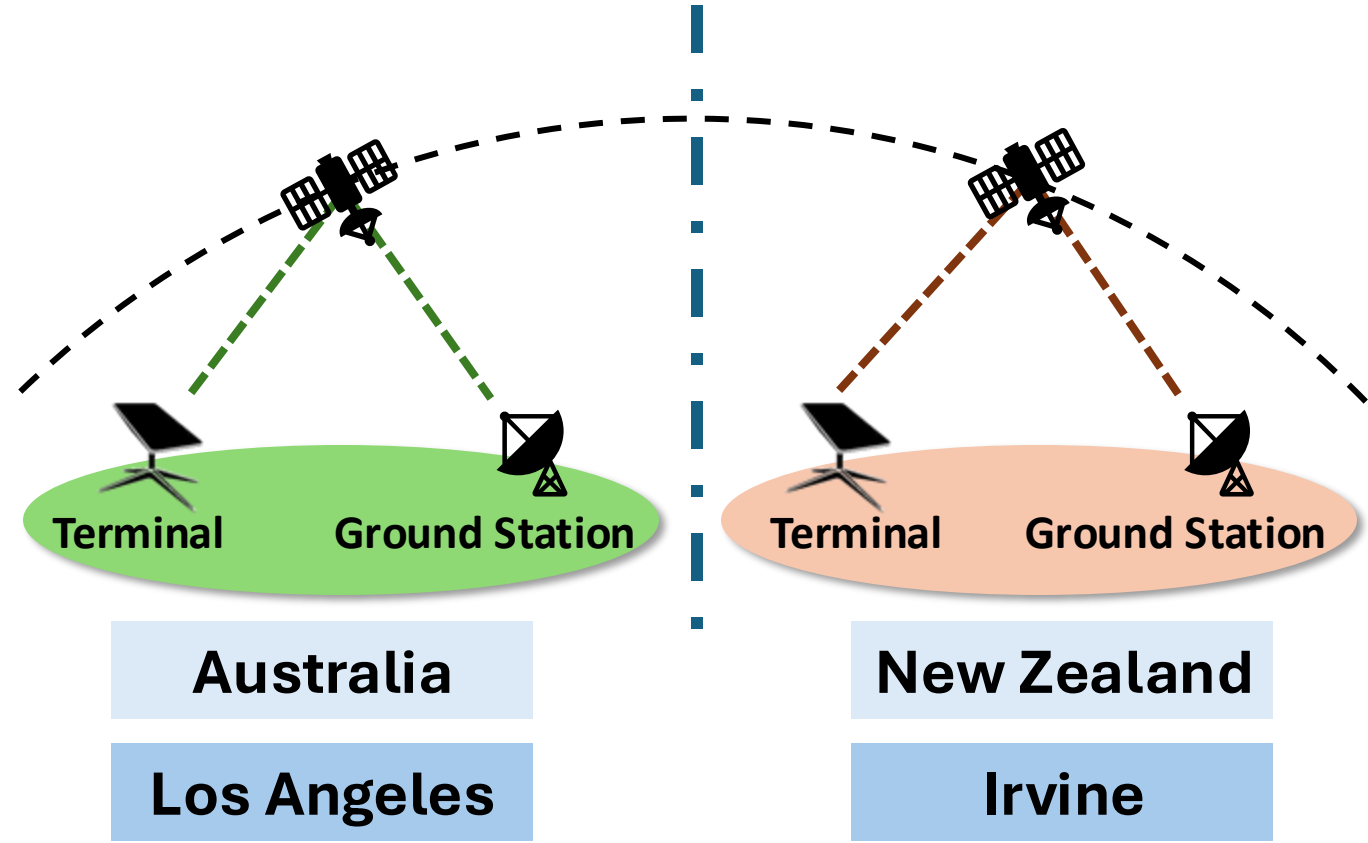
- **Decreasing Cost**
 - ✓ From \$20 million per satellite years ago to as low as **\$1 million** today

- **SaaS: Satellite-as-a-Service (SaaS)**
 - ✓ Cloud-based model that provides access to satellite services
 - ✓ Allows entities to **rent parts of a satellite** rather than deploying an entire satellite themselves

Overview Architecture of MP-LEO

- **Bent Pipe Architecture**

- ✓ Keeps data local, adhering to regional regulations



Each organization can define their own privacy protocols

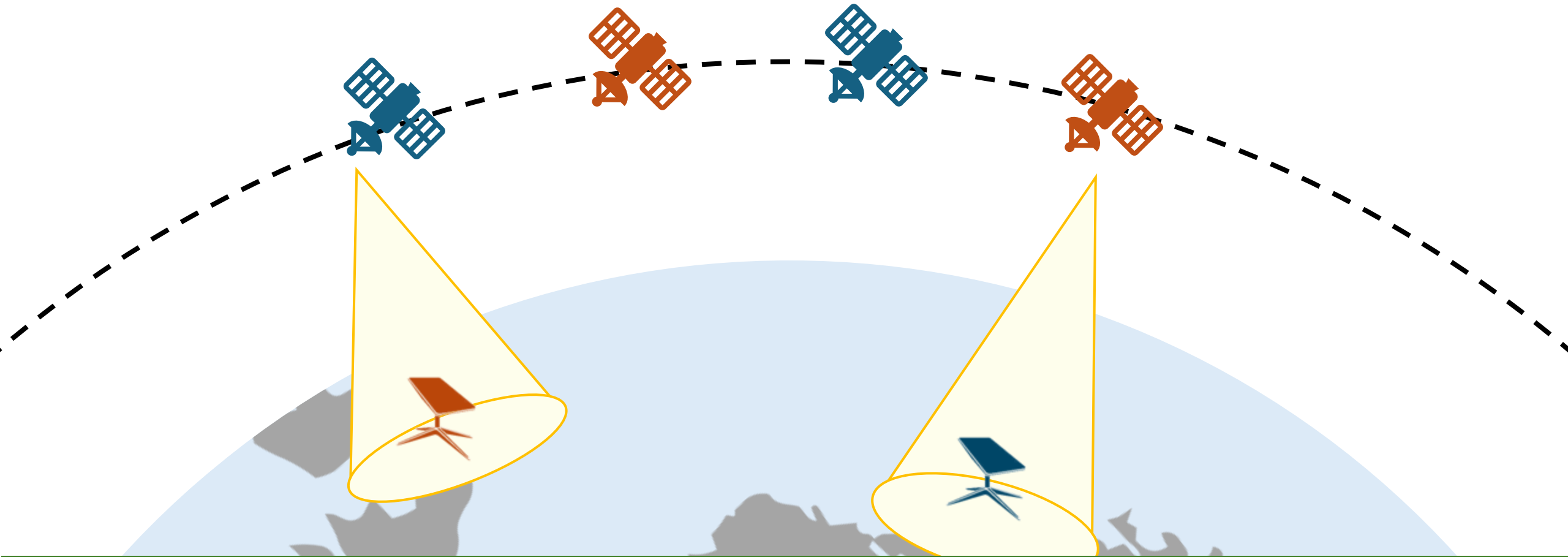
Research Questions

Design Choices for MP-LEO

- **Orbital Optimization**
 - ✓ What orbits **maximize coverage** while minimizing capacity waste?
 - ✓ How to enable **incremental deployment** for scalable growth?

- **Trust and Robustness**
 - ✓ How can the **network stay resilient** if a participant decides to exit or if satellite failures occur?

Research Question 1: Orbital Optimization



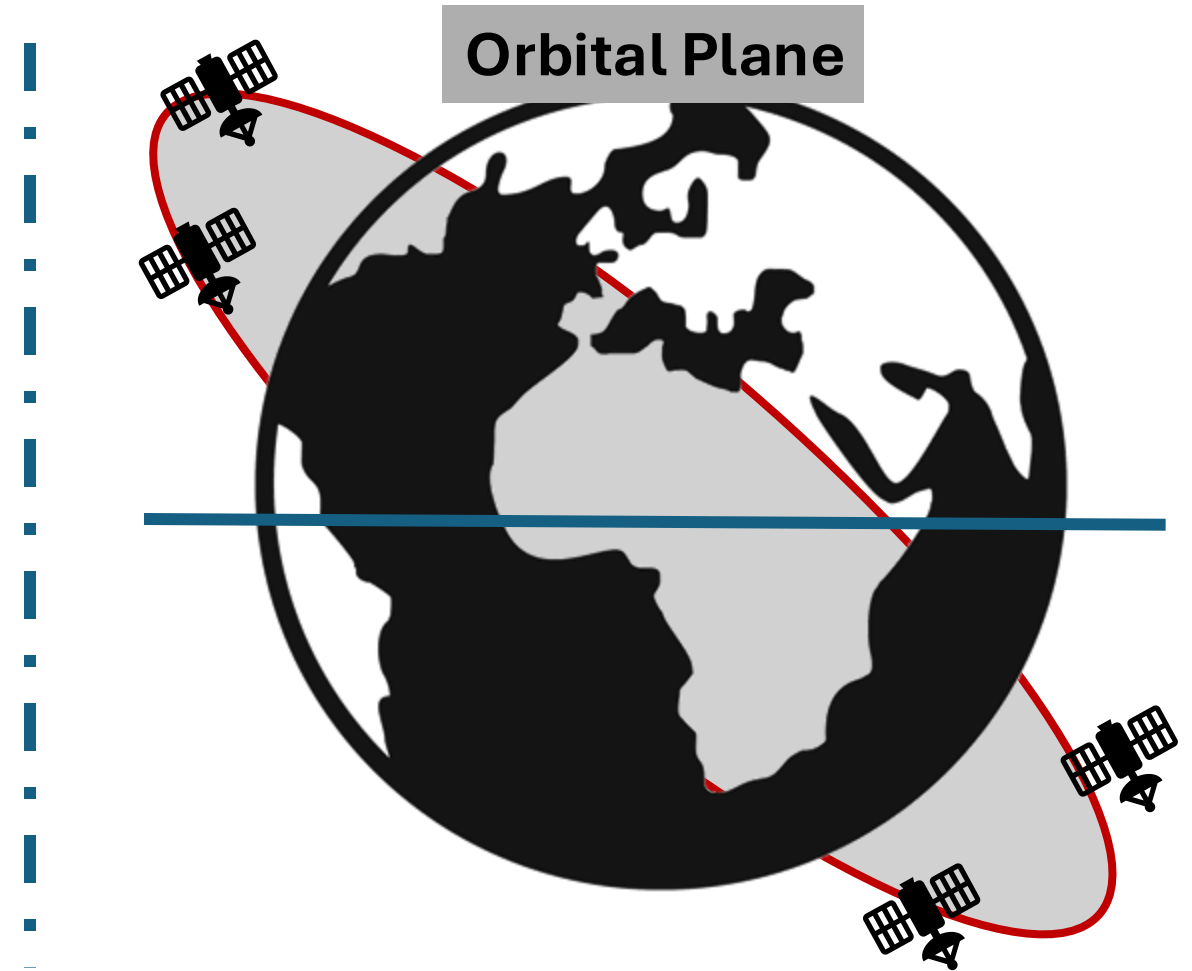
How can we optimally deploy satellites to maximize global coverage time?



Background: Defining Coverage and Orbital Plane

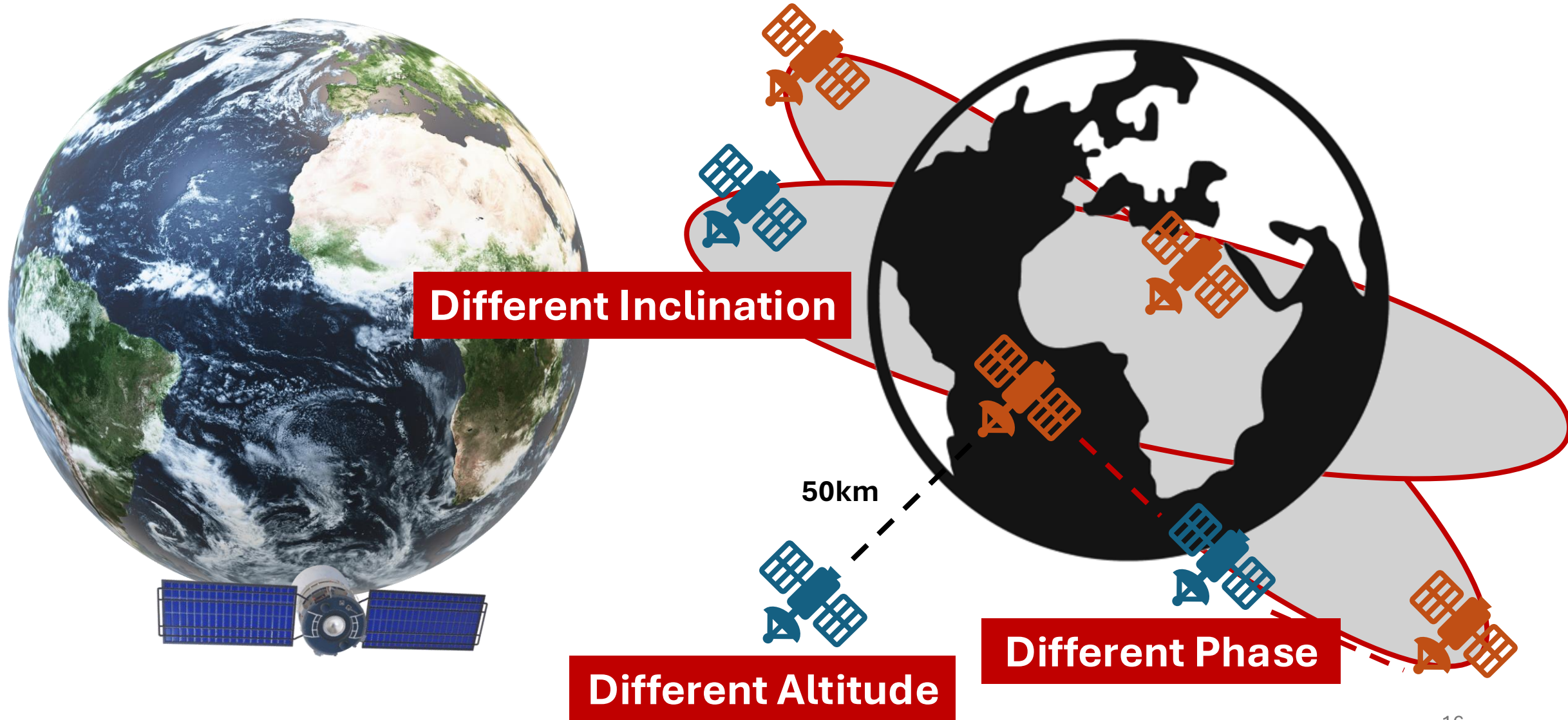


Population weighted coverage over
20 most populous cities in the world
+ addition of Melbourne

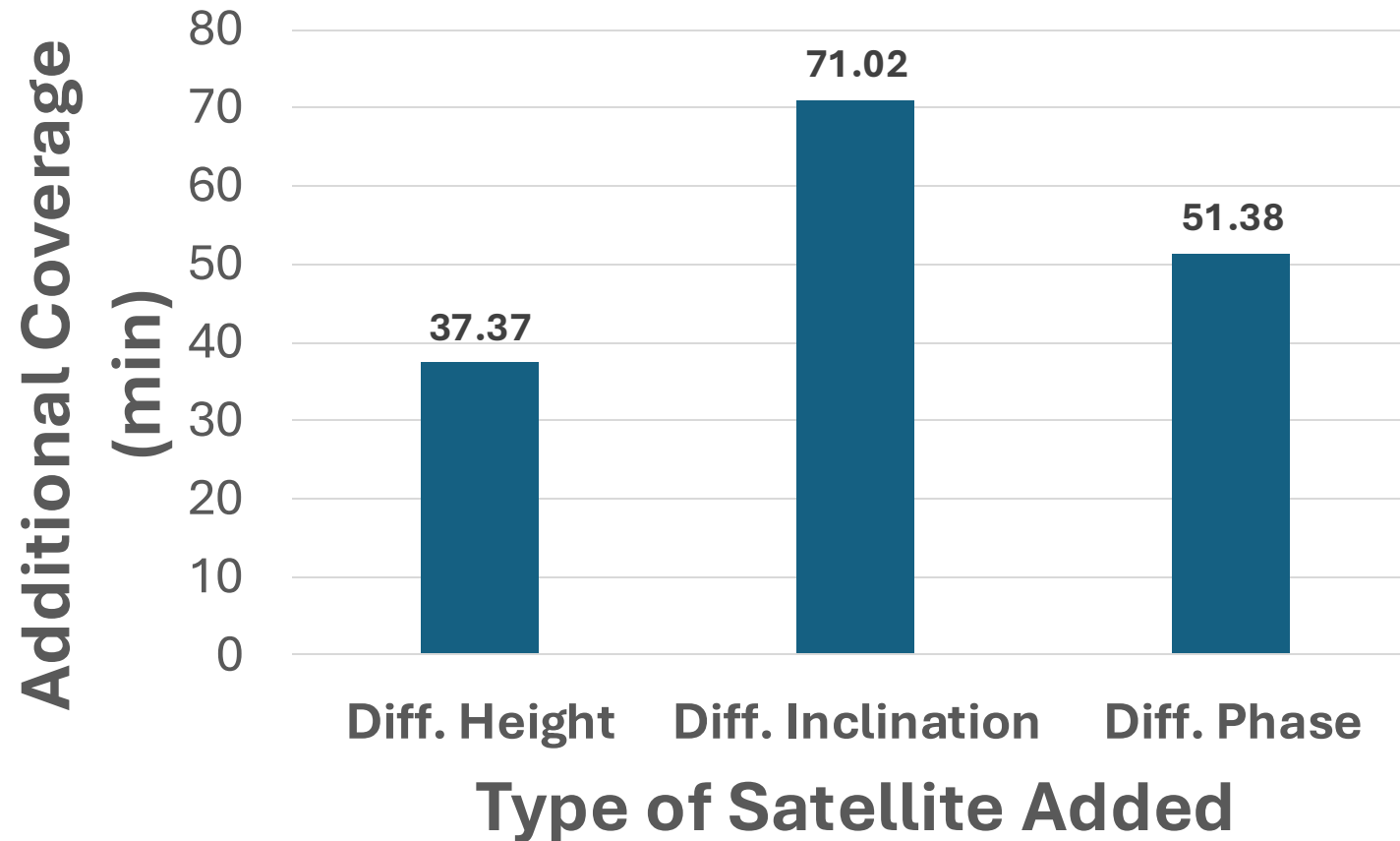


Inclination: Tilt of the plane relative to Earth's equator
Phase: Relative position of a satellite along its plane
Altitude: Distance from Earth's surface

Where Should We Put an Additional Satellite

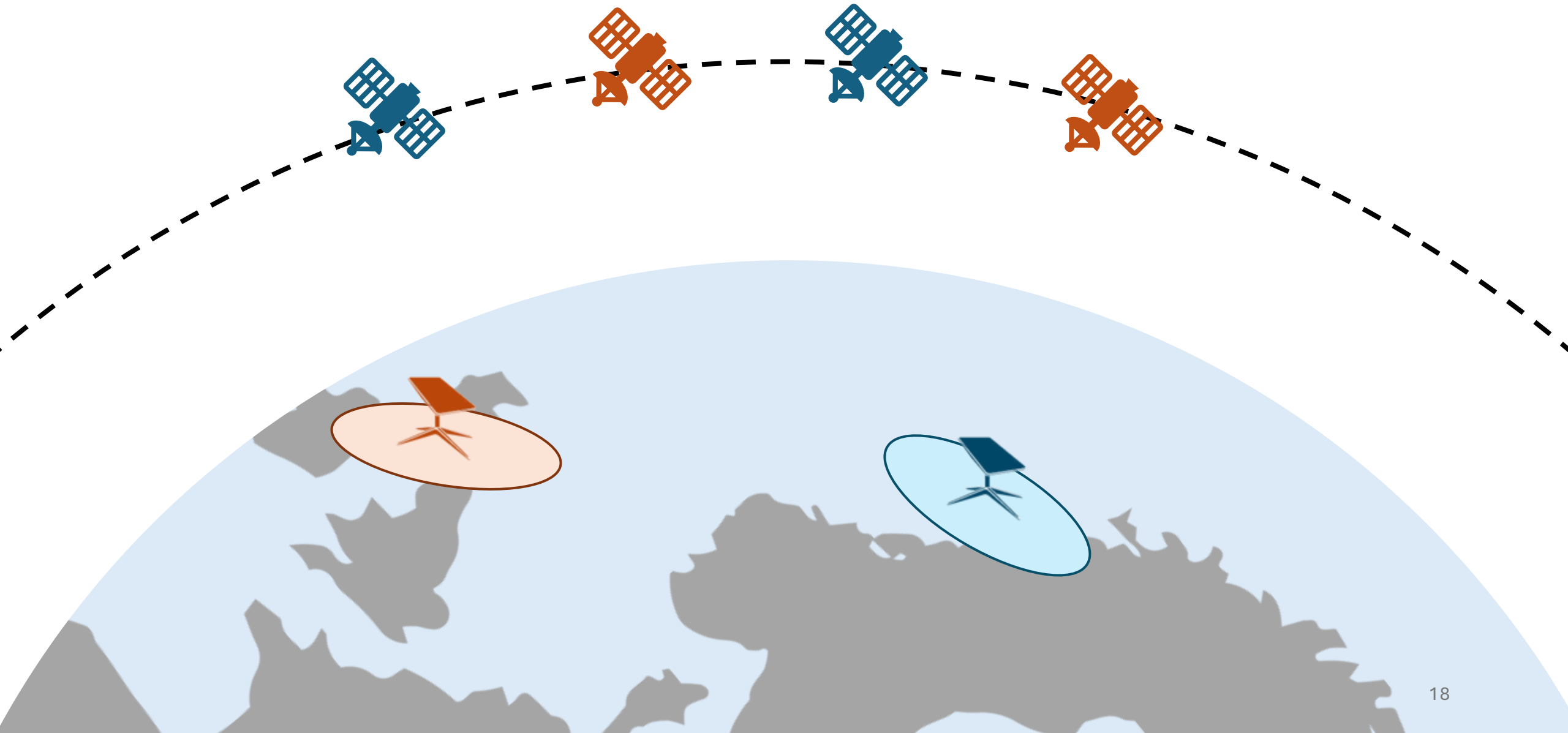


Results: Height, Inclination, and Phase

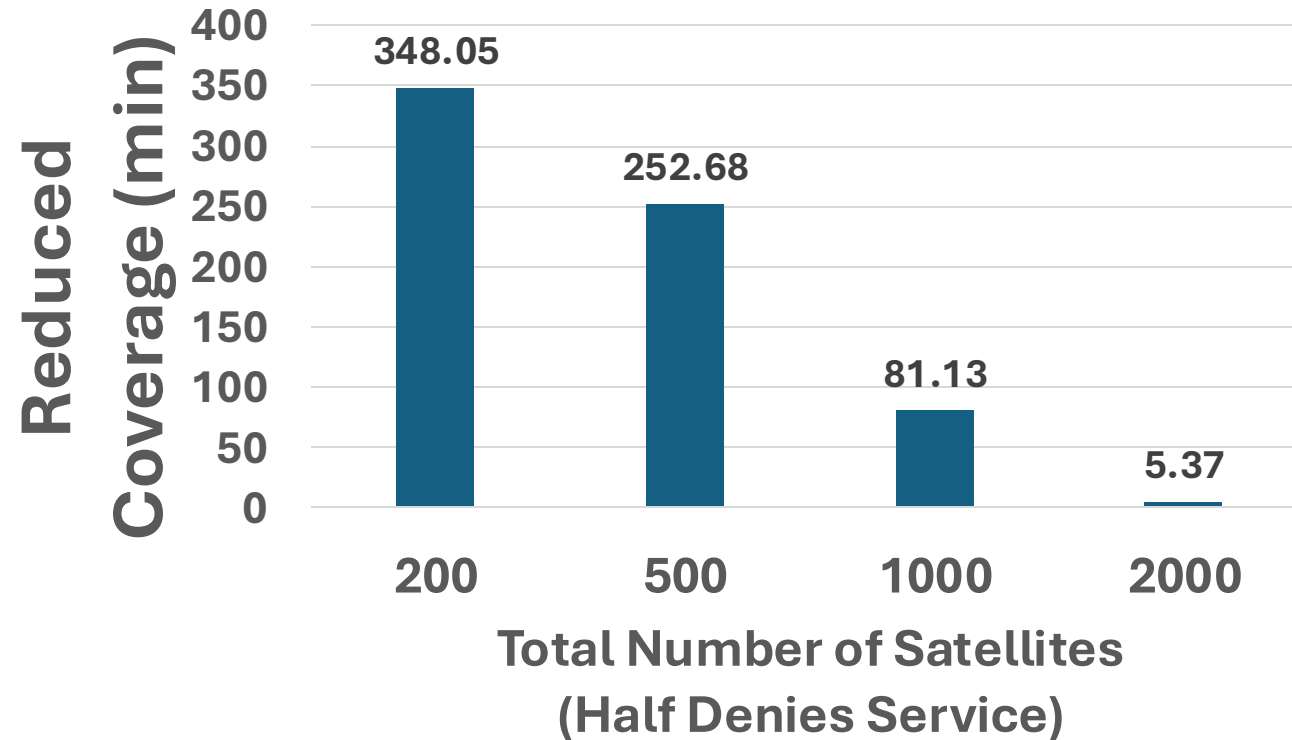


Varying inclination yields the highest coverage improvement

Research Question 2: Robustness



Results: Coverage Loss when Half Withdraws



As the number of satellites in the constellation grows, the network becomes more resilient to withdrawal

Open Questions

- **Bootstrapping Decentralized Networks**

- ✓ How can **early adopters** be incentivized, given limited initial coverage?

- **Market Design**

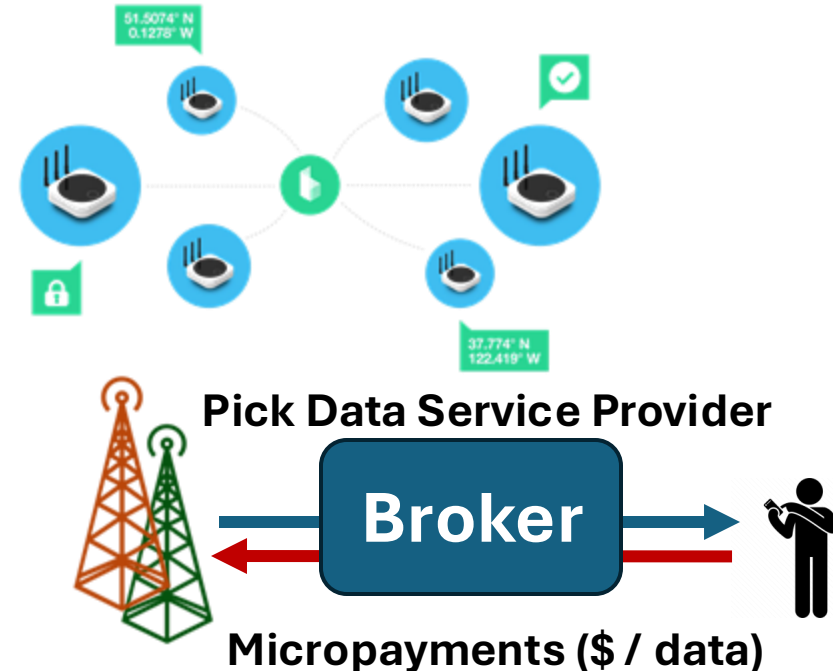
- ✓ What **pricing models** and quality-of-service guarantees will attract participants?



Helium Networks

Offers cryptocurrency rewards

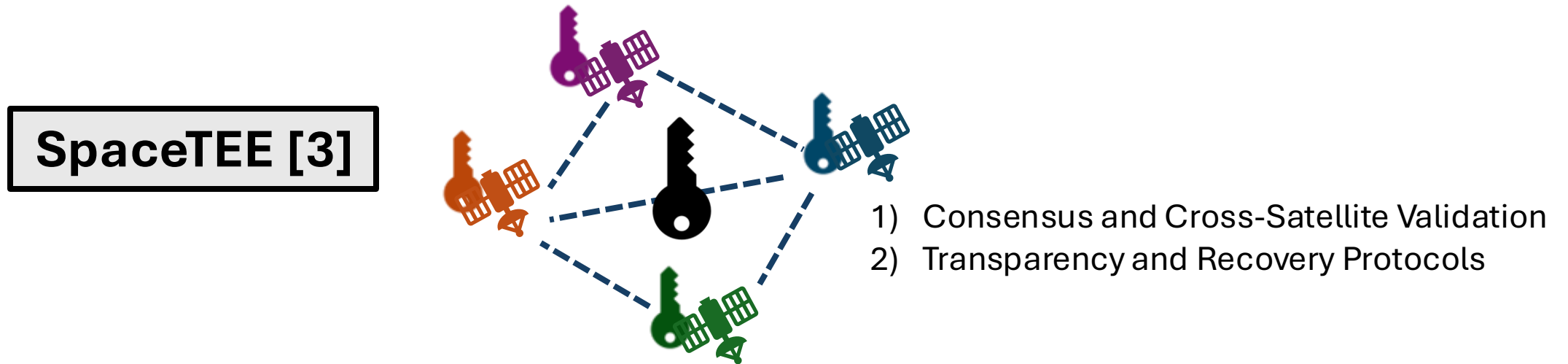
Cellbricks [1], dCellular [2]



Open Questions

- **Multi-Party Control**

- ✓ How can **distributed control** be managed securely, preventing service denial?



- **Spectrum Management**

- ✓ What strategies are needed for **efficient and fair spectrum allocation**?

- **Open-Source Designs**

- ✓ How can **open-source designs** be developed to encourage widespread adoption?

Conclusion

- Independent LEO constellations are wasteful and expensive
- We propose **MP-LEO**, a decentralized network where participants share spare satellite capacity

