Commercial LEO PNT On Orbit

WSTS 2023

Vancouver, BC

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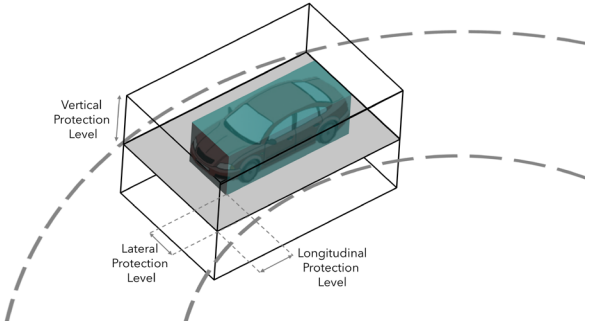
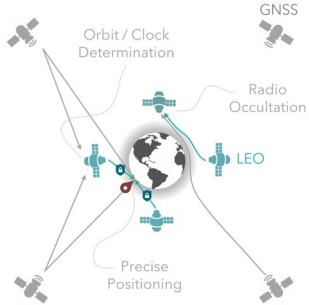
xona space systems

Outline

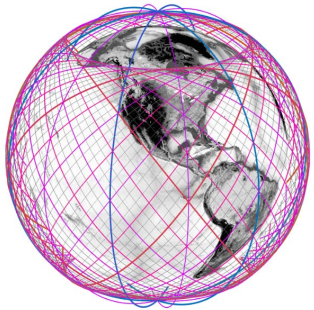
PNT Needs



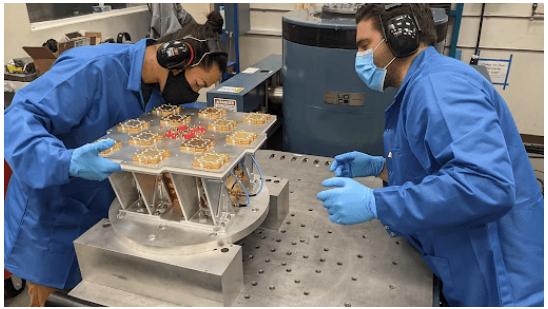
Commercial Sat Nav



Commercial Time Services

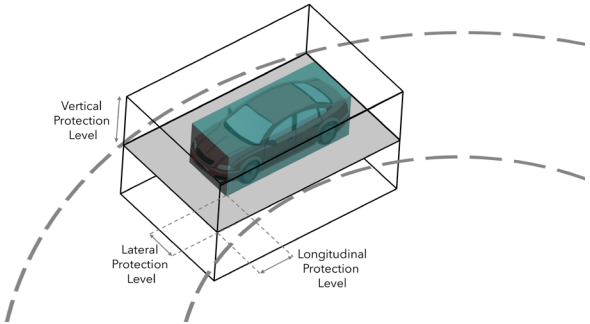


In Orbit Demonstration



Outline

PNT Needs



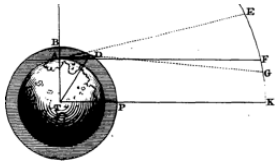
Commercial Sat Nav

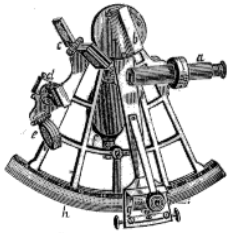
Commercial Time Services

In Orbit Demonstration

A Brief History of Navigation

Celestial/Chrono
1770-1920
3000 m
(5 sec)



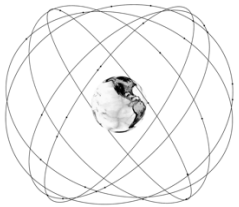


Sextant, p. 1932.

Loran
1940s-2010
460 m
(100 ns)

Transit
1964-1996
25 m
(10 µs)

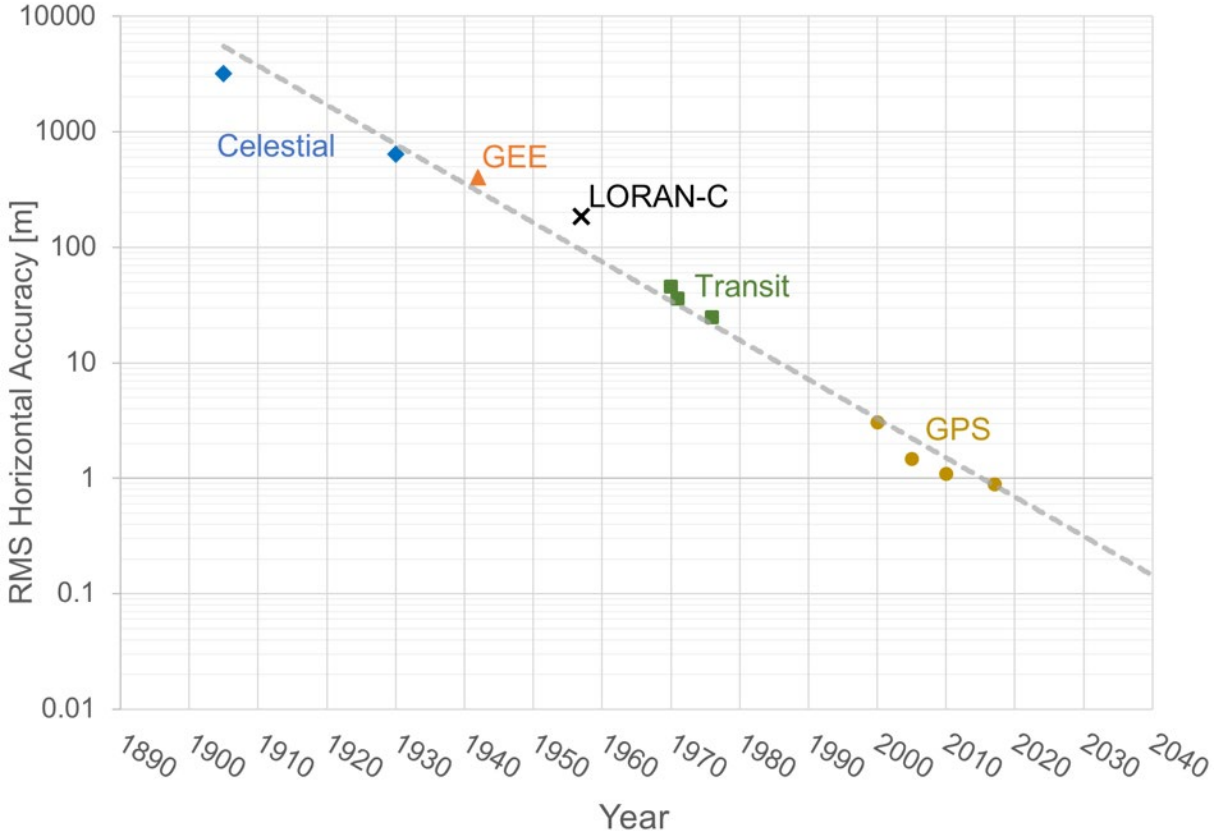
GPS
1996-Present
3 m
(10 ns)



?
2025+
<0.30 m
(< 1 ns)

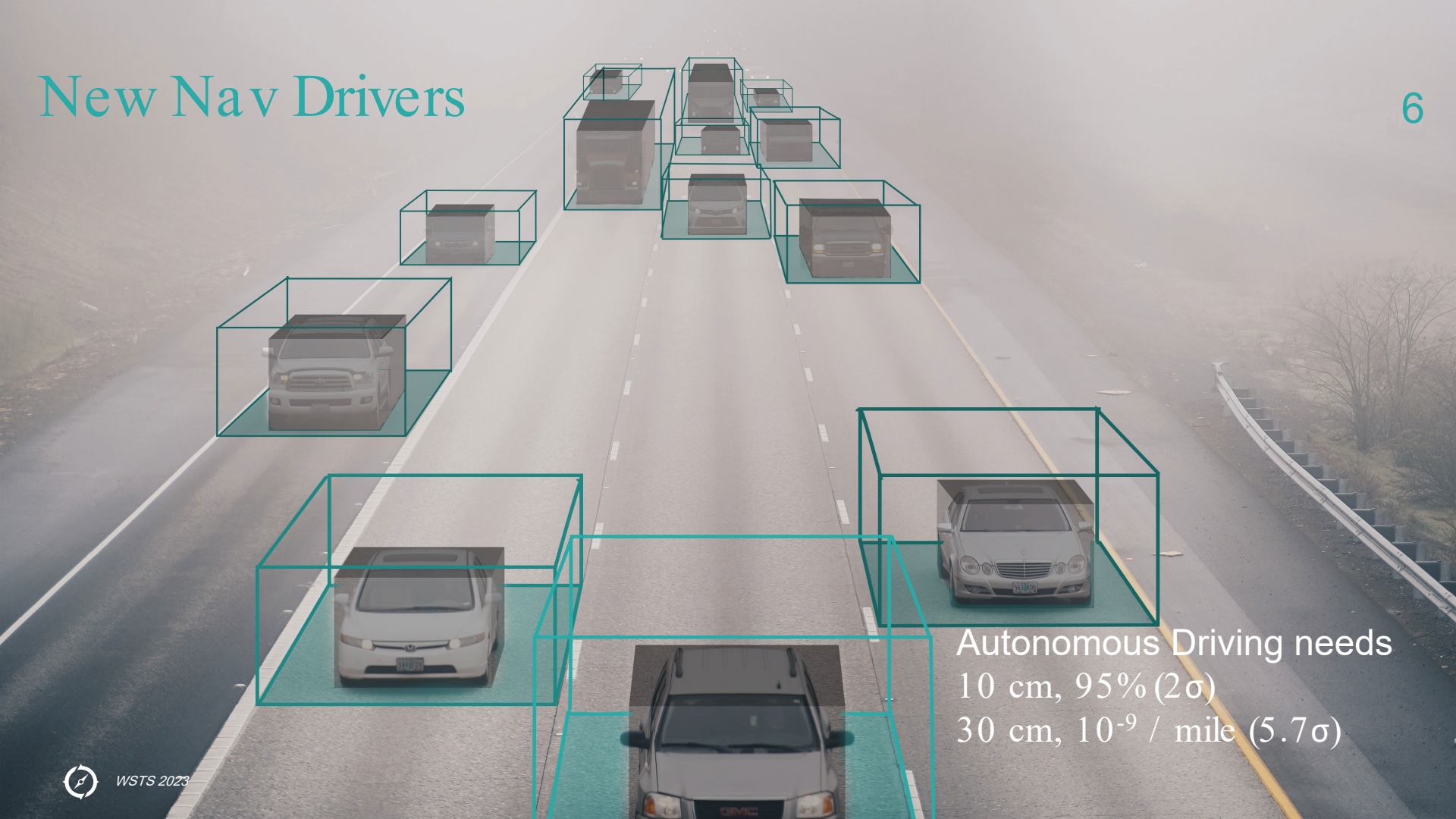
‘Moore’s’ Law of Navigation

Trend
10x better accuracy every 30 years



2020s:
Decade of the Decimeter

New Nav Drivers

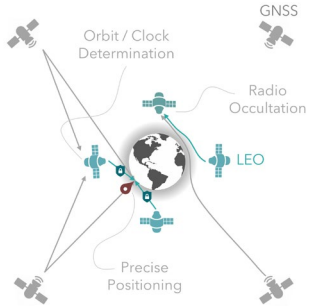


Autonomous Driving needs
10 cm, 95% (2σ)
30 cm, 10^{-9} / mile (5.7σ)

Outline

PNT Needs

Commercial Sat Nav



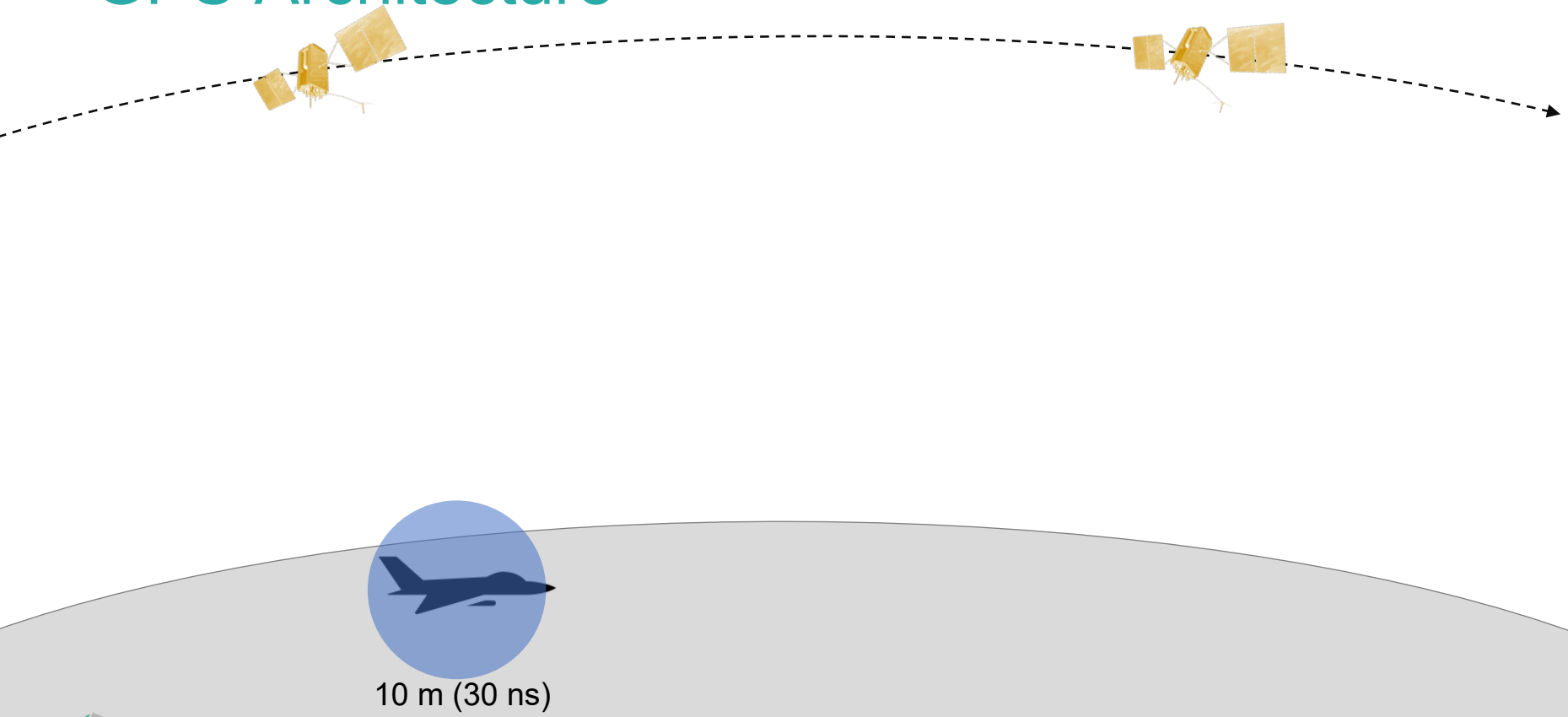
Xona Pulsar

In Orbit Demonstration

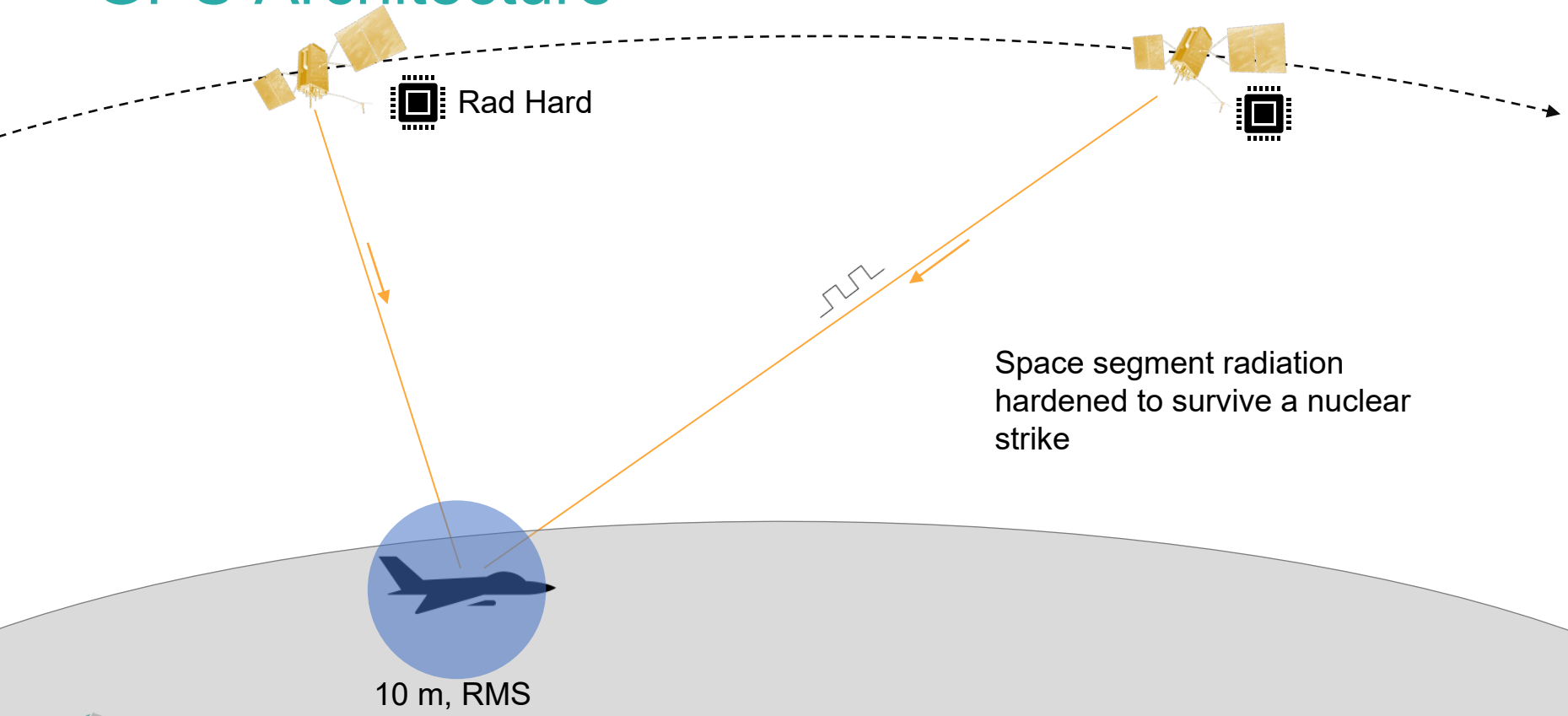
A Comparison of Requirements

	GPS	Sat Nav for Today
Focus User Group	Government	Commercial
Accuracy	5 bombs in the same hole	Keep self-driving cars in their lane
Availability	Global	Global, enhanced in population centers
Resistance to Interference	State-level actor	Unintentional & PPD's
Cost-Effective Space / Ground Segment	Government	Commercially viable
Affordable User Equipment	Portable	Mass market

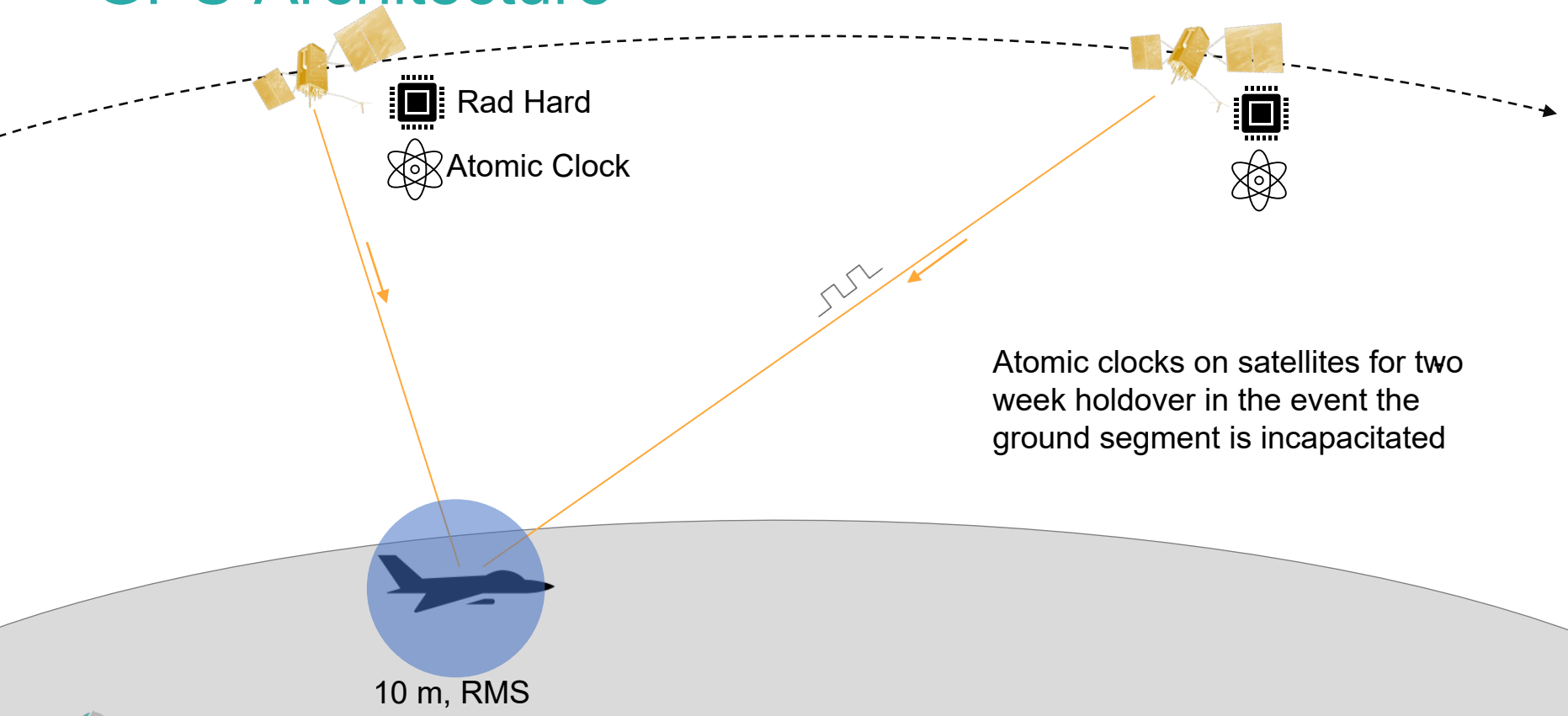
GPS Architecture



GPS Architecture

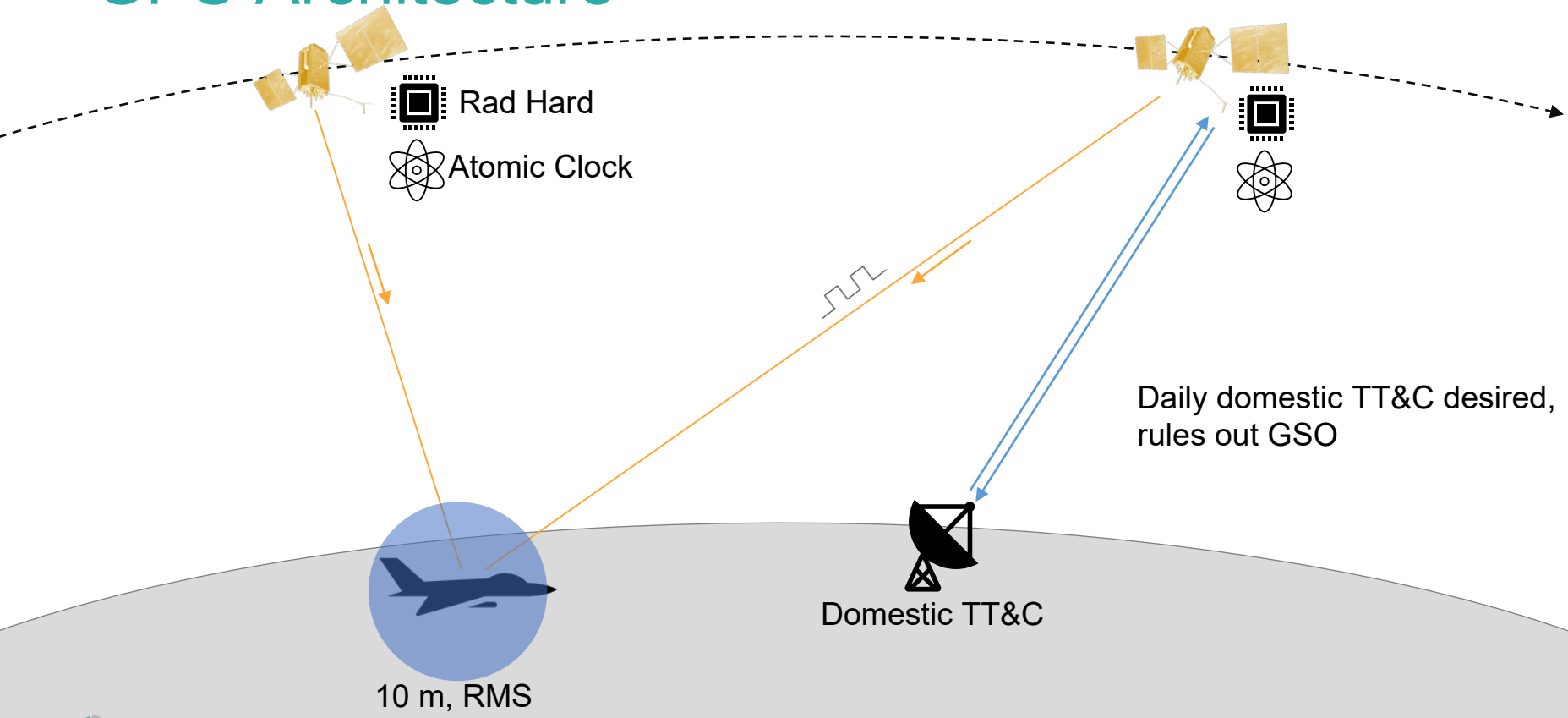


GPS Architecture

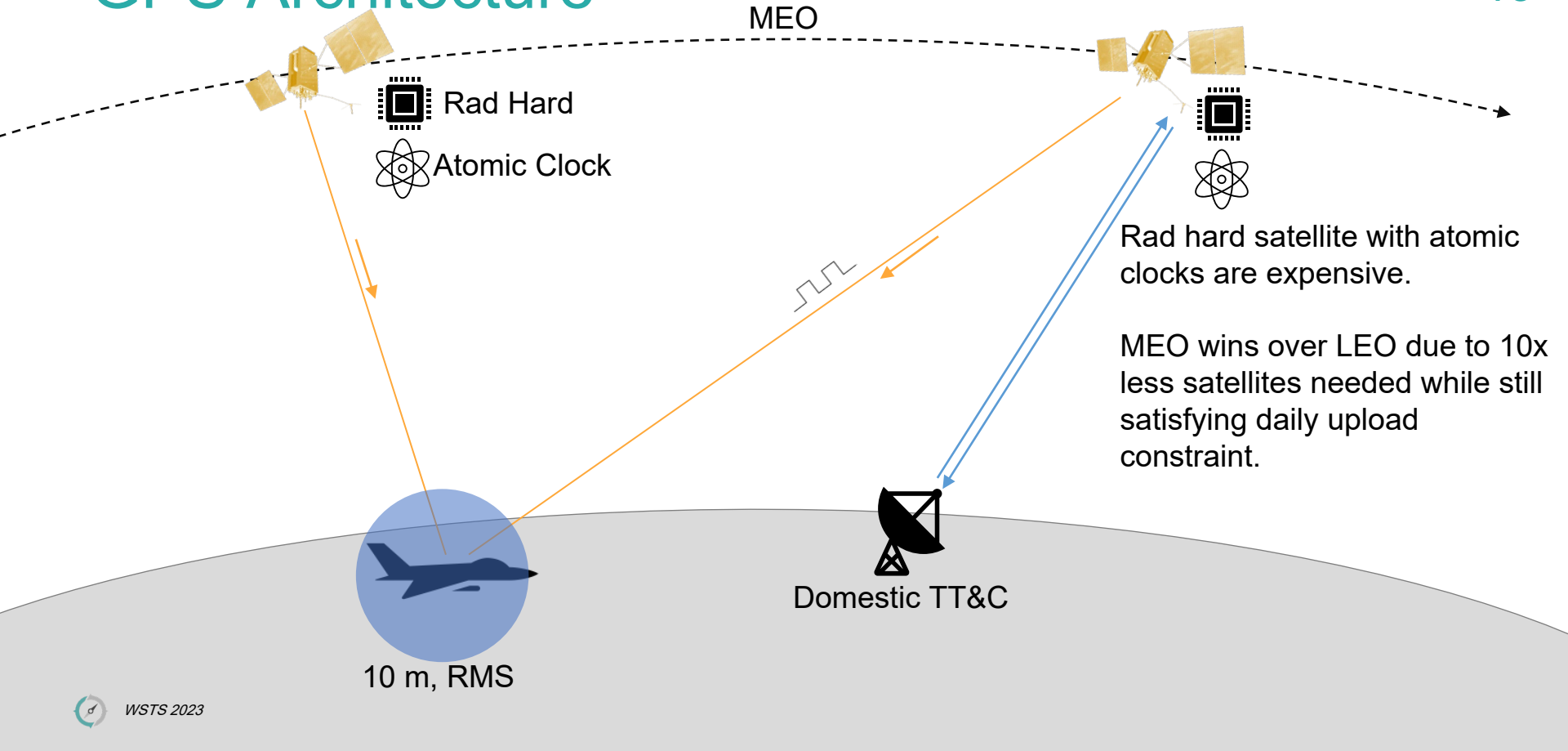


Atomic clocks on satellites for two week holdover in the event the ground segment is incapacitated

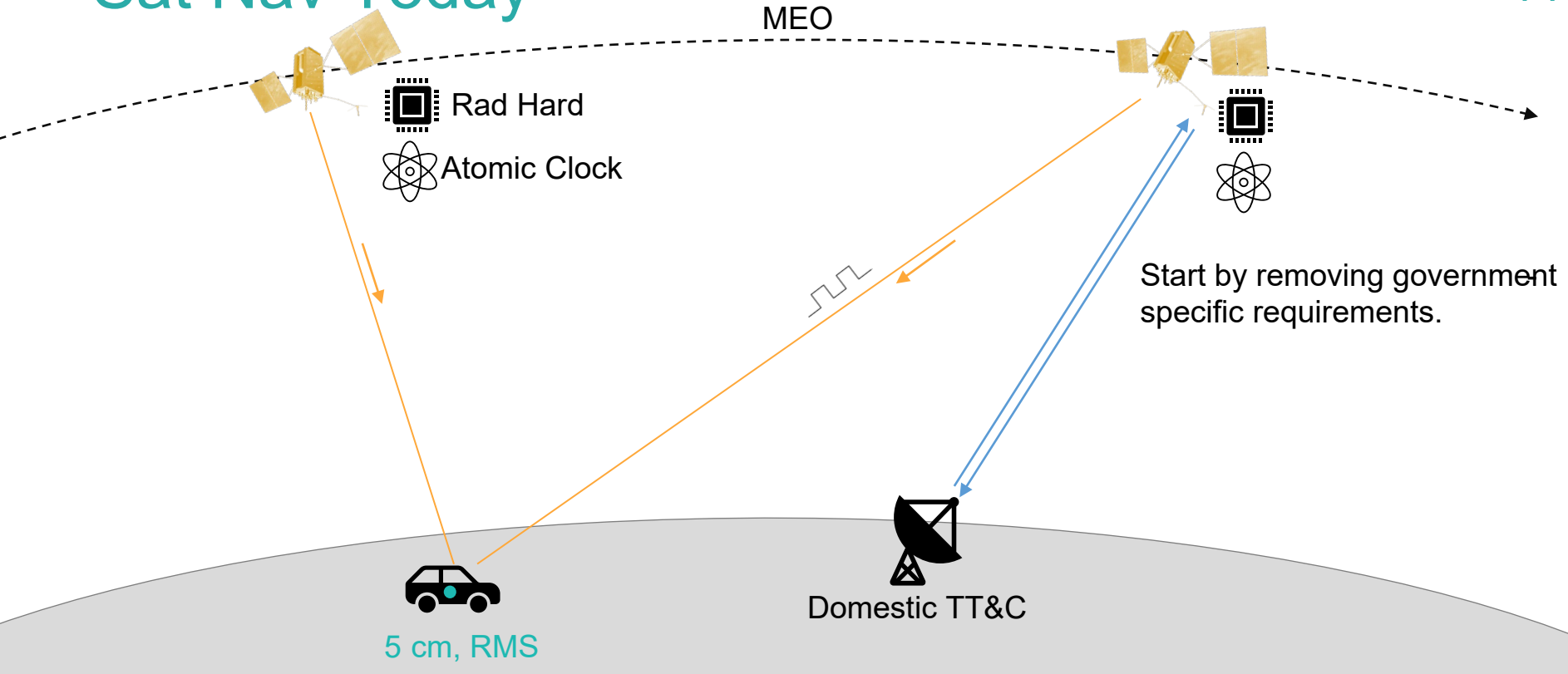
GPS Architecture



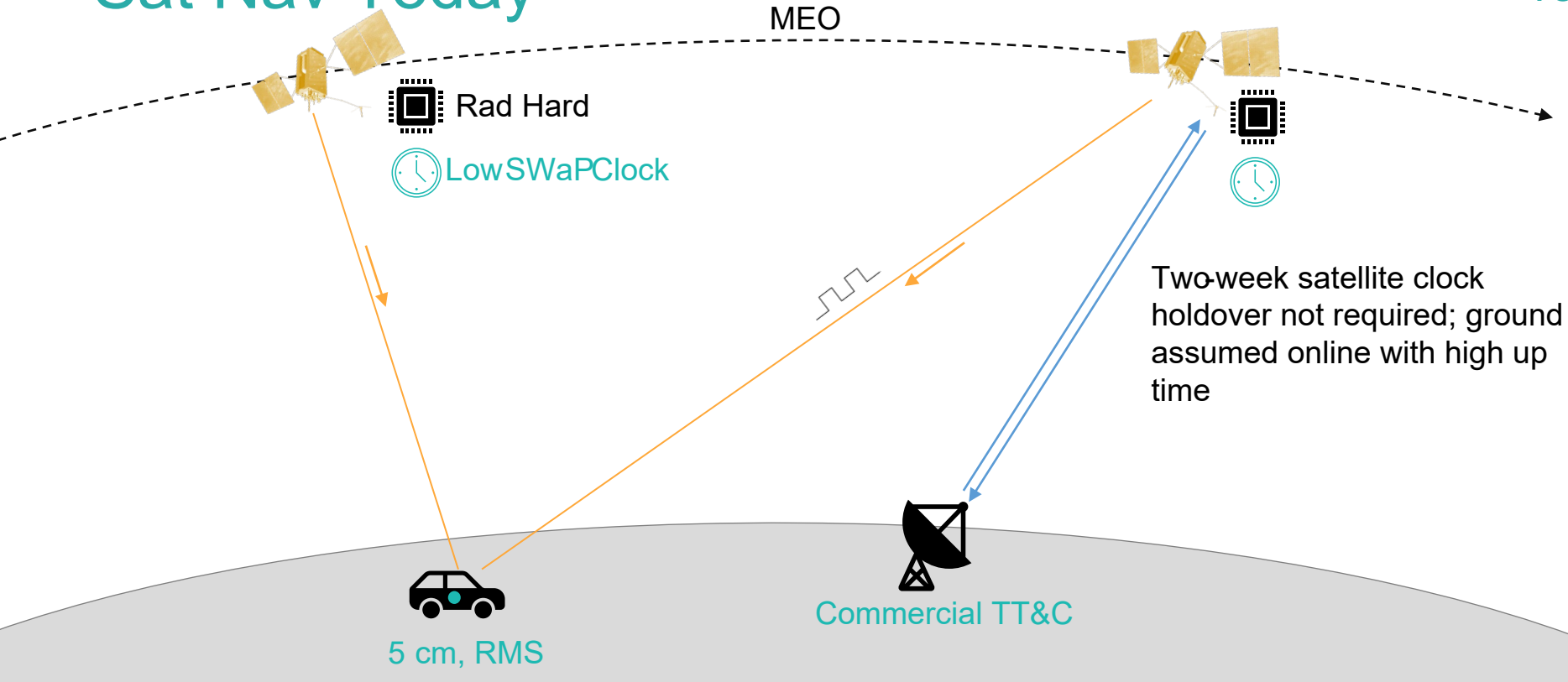
GPS Architecture



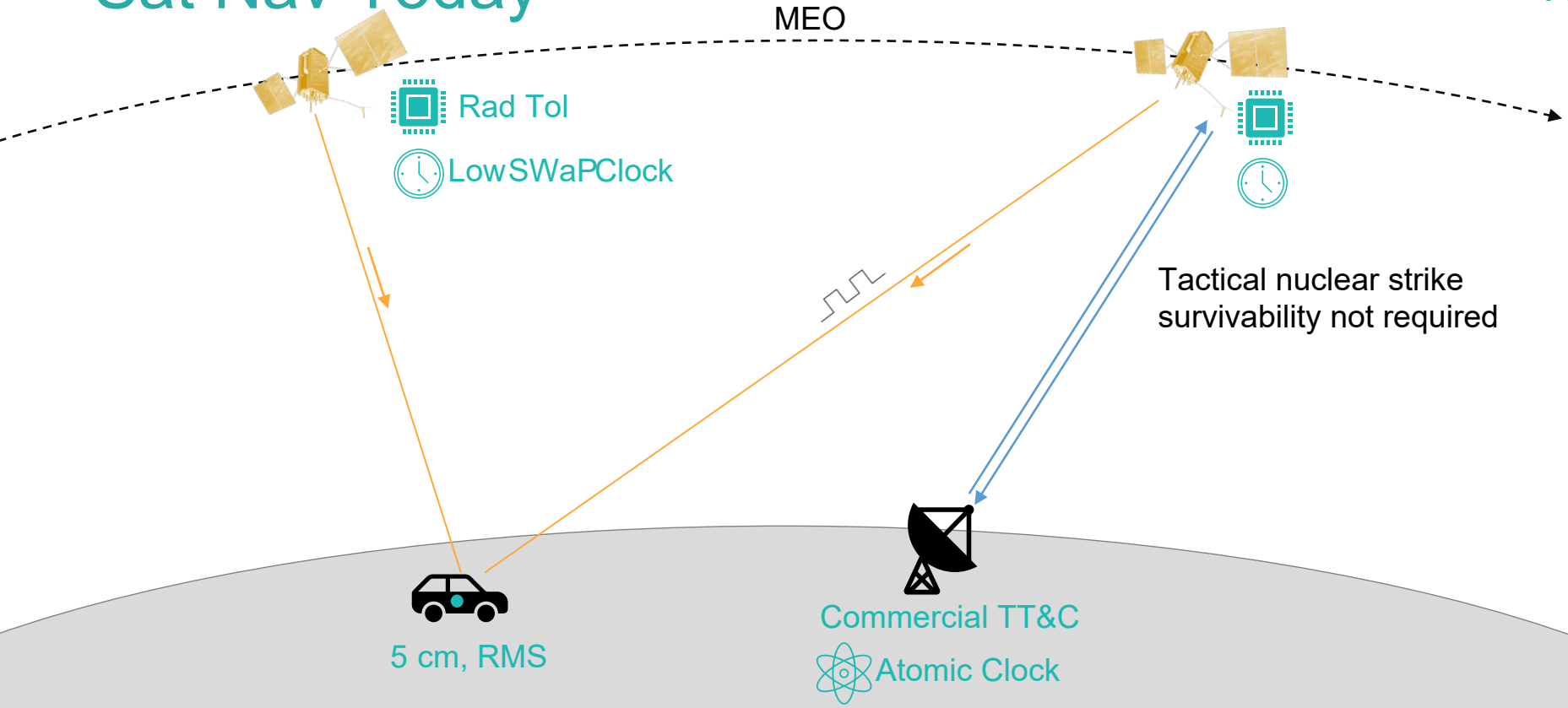
Sat Nav Today



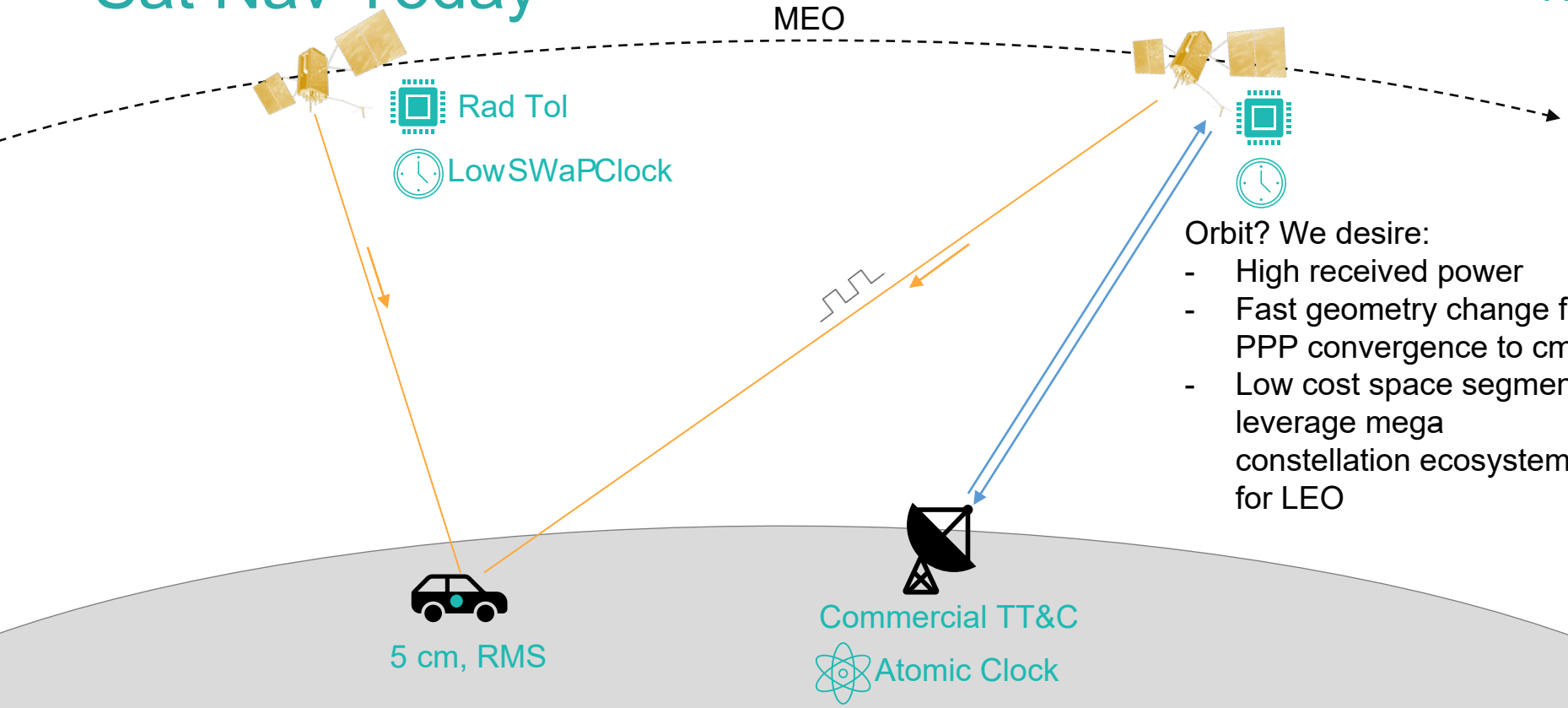
Sat Nav Today



Sat Nav Today

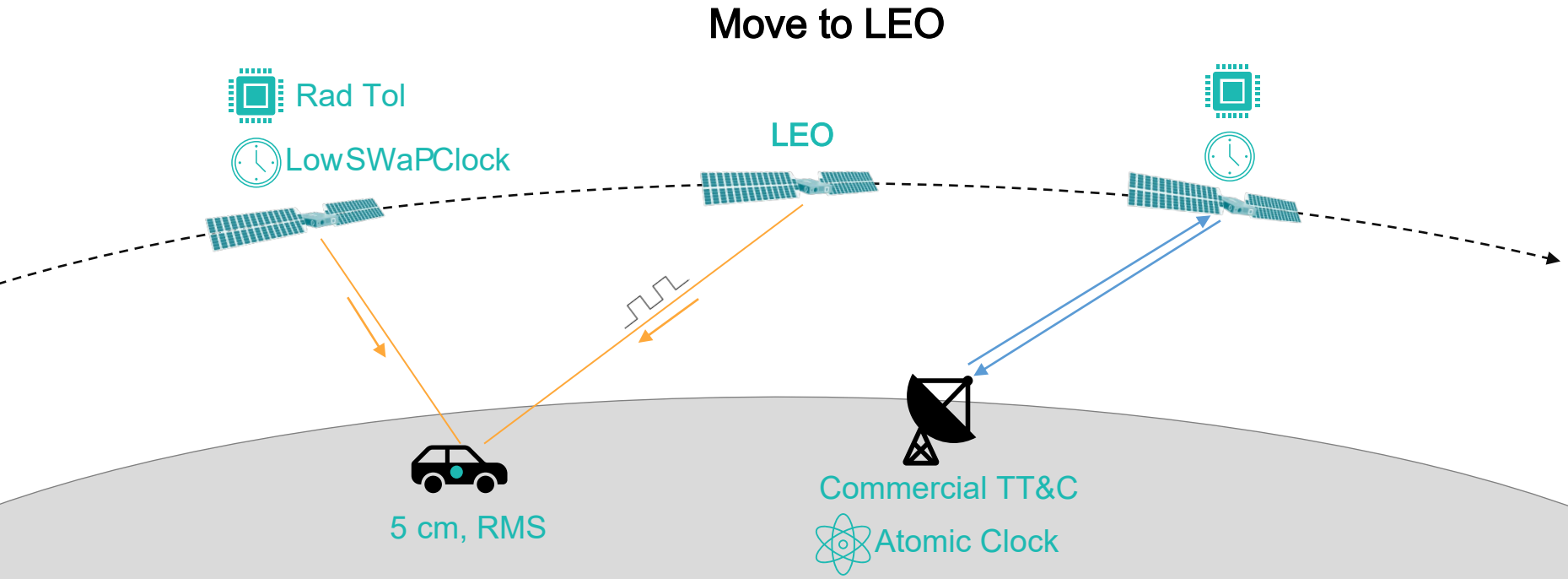


Sat Nav Today



Sat Nav Today

Novel signals can be introduced, unbounded by legacy GNSS

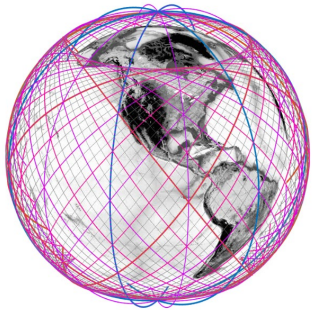


Outline

PNT Needs

Commercial Sat Nav

Commercial Time Services



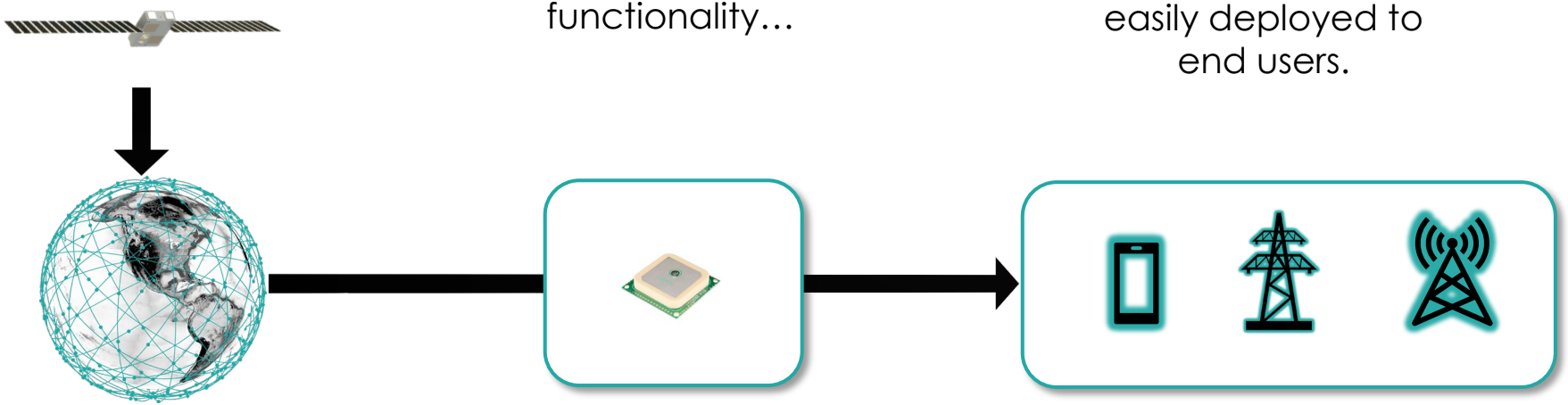
In Orbit Demonstration

Navigation & Timing as a Service

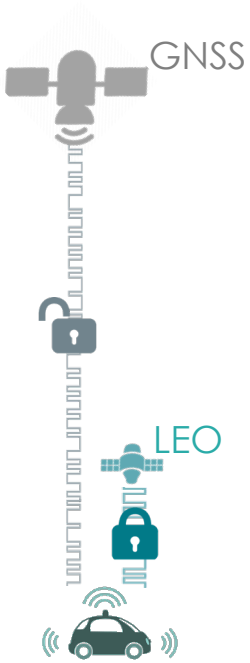
Commercial satellite infrastructure…

…work with receiver manufacturers to integrate functionality…

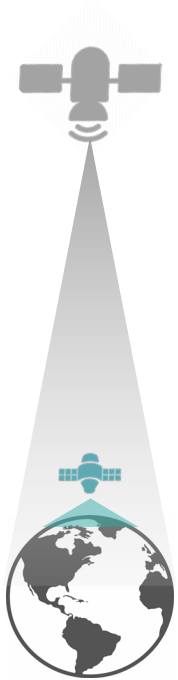
…to provide enhanced services that are easily deployed to end users.



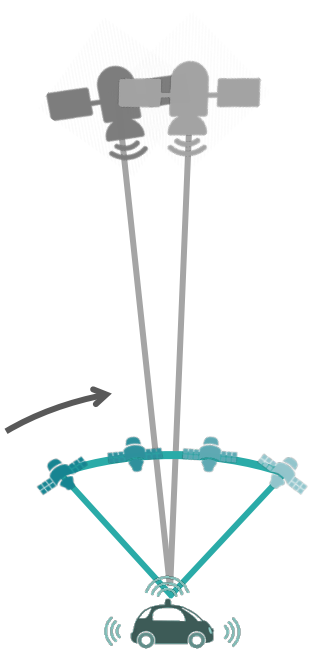
Commercial LEO PNT



Encryption & Authentication

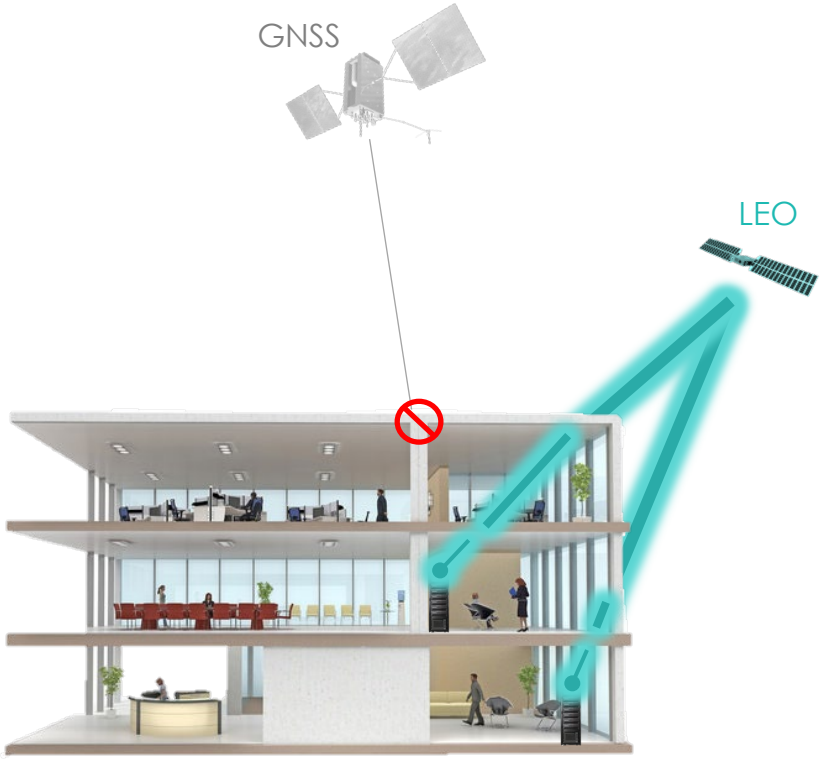


Stronger Signals



Geometry Change For Precision

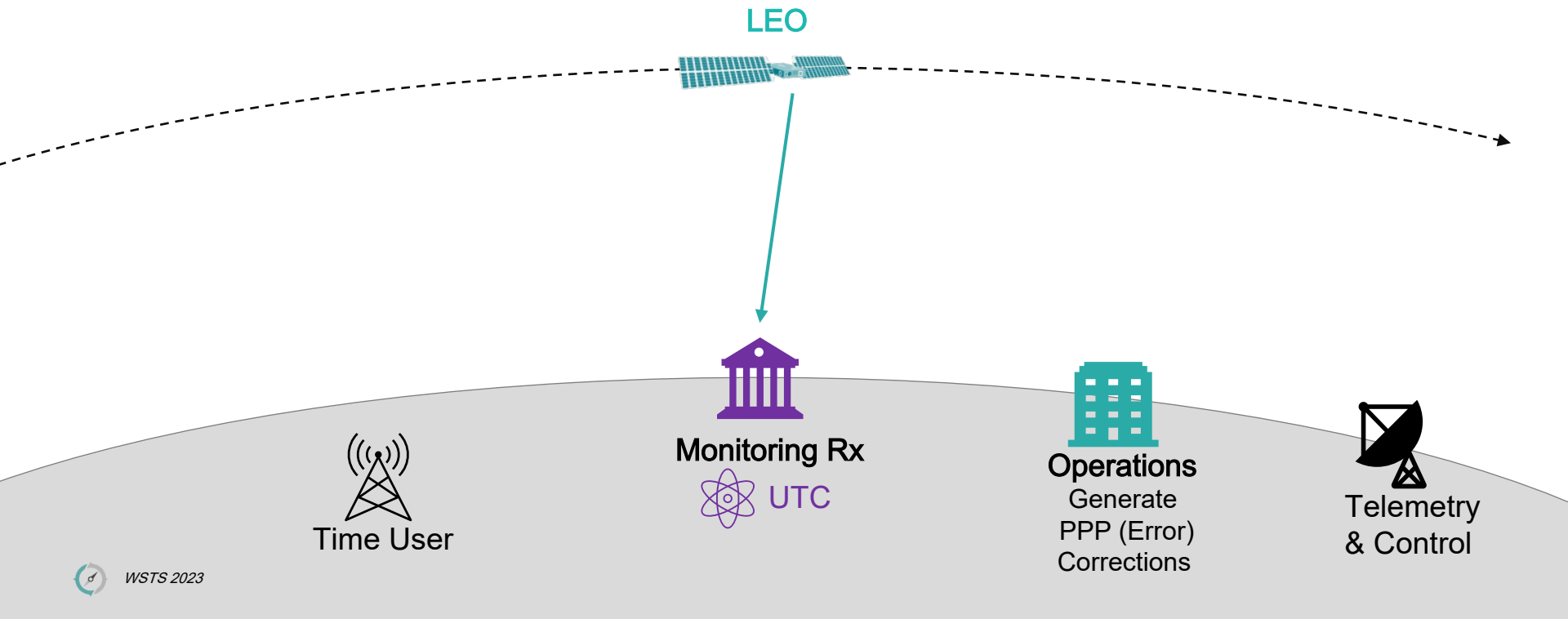
Indoors



- Powerful signal can penetrate several walls, enabling indoor antenna deployment
- Simplified installation
  - Remove need for roof access, rent, etc.
  - Eliminates outdoor antenna installation & maintenance costs
- Large constellation = high probability of at least intermittent reception

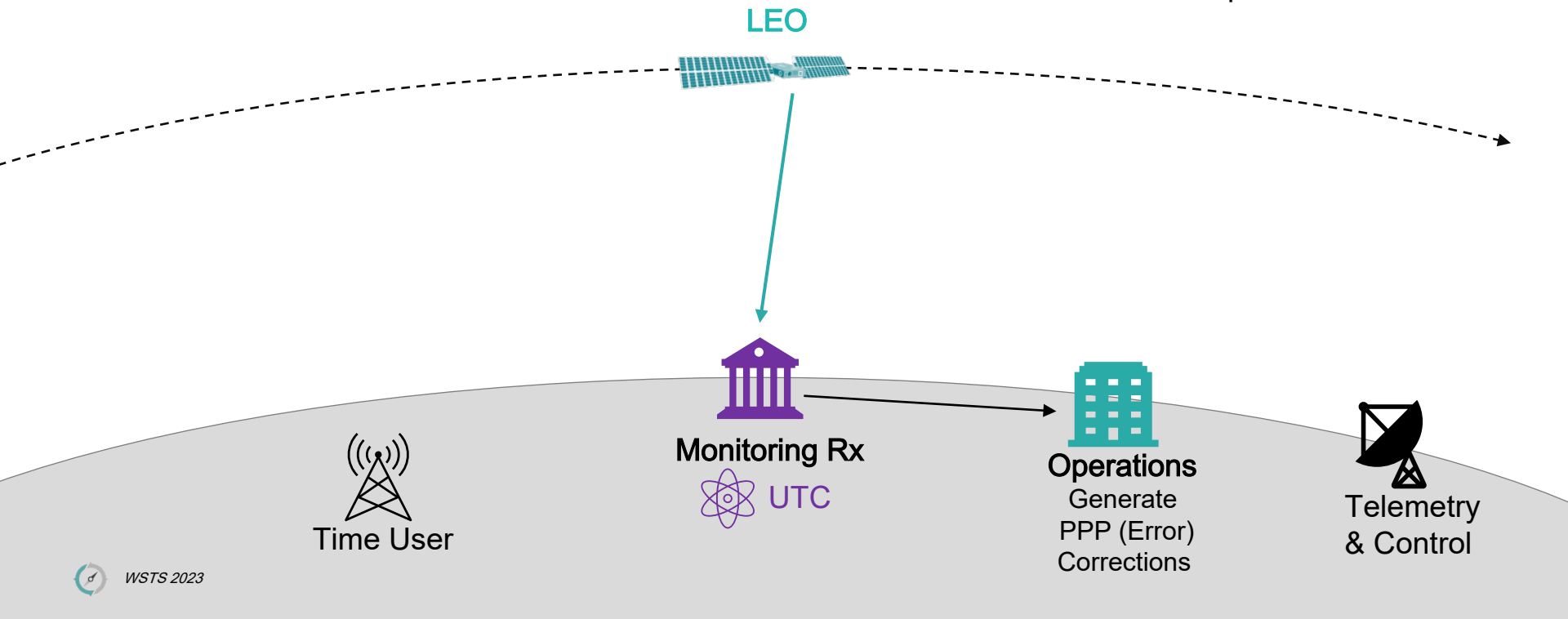
Accuracy

Monitoring LEO PNT signal receiver colocated at UTC timescale.



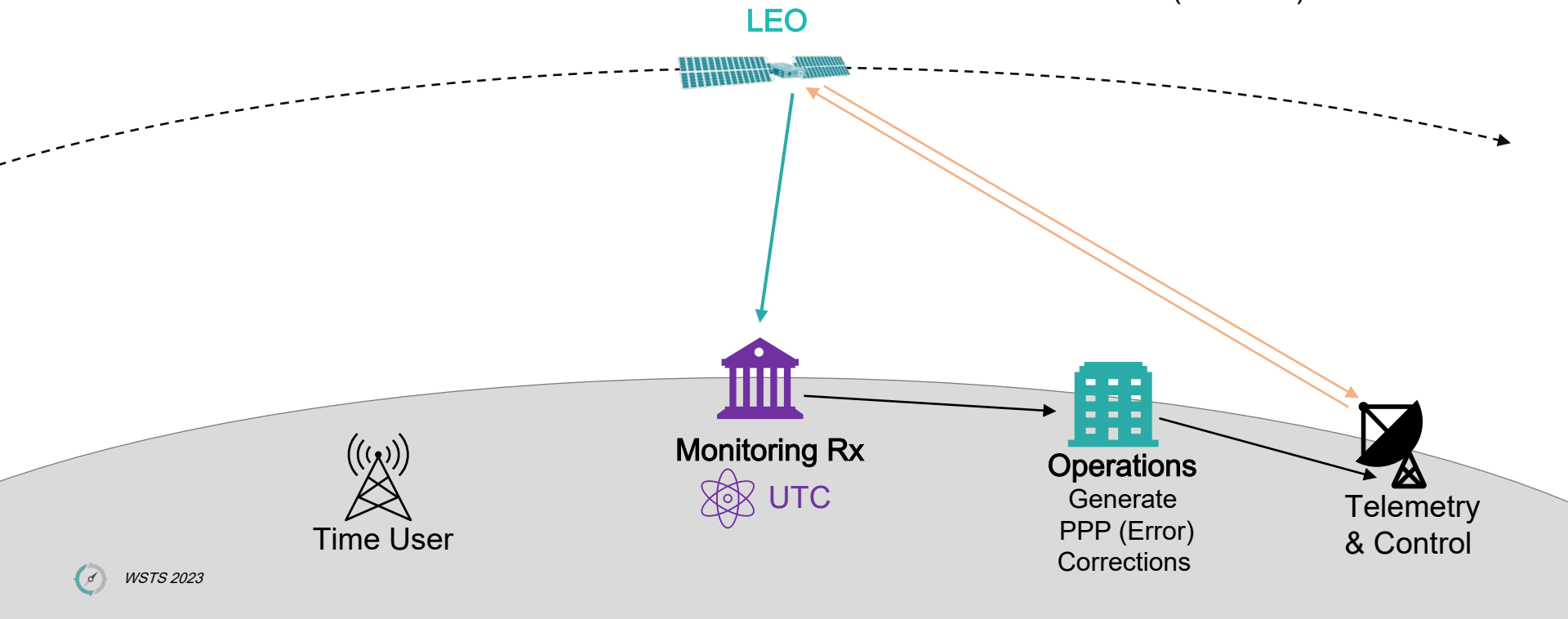
Accuracy

LEO-based UTC compared with UTC timescale and calibration is shared with operations.



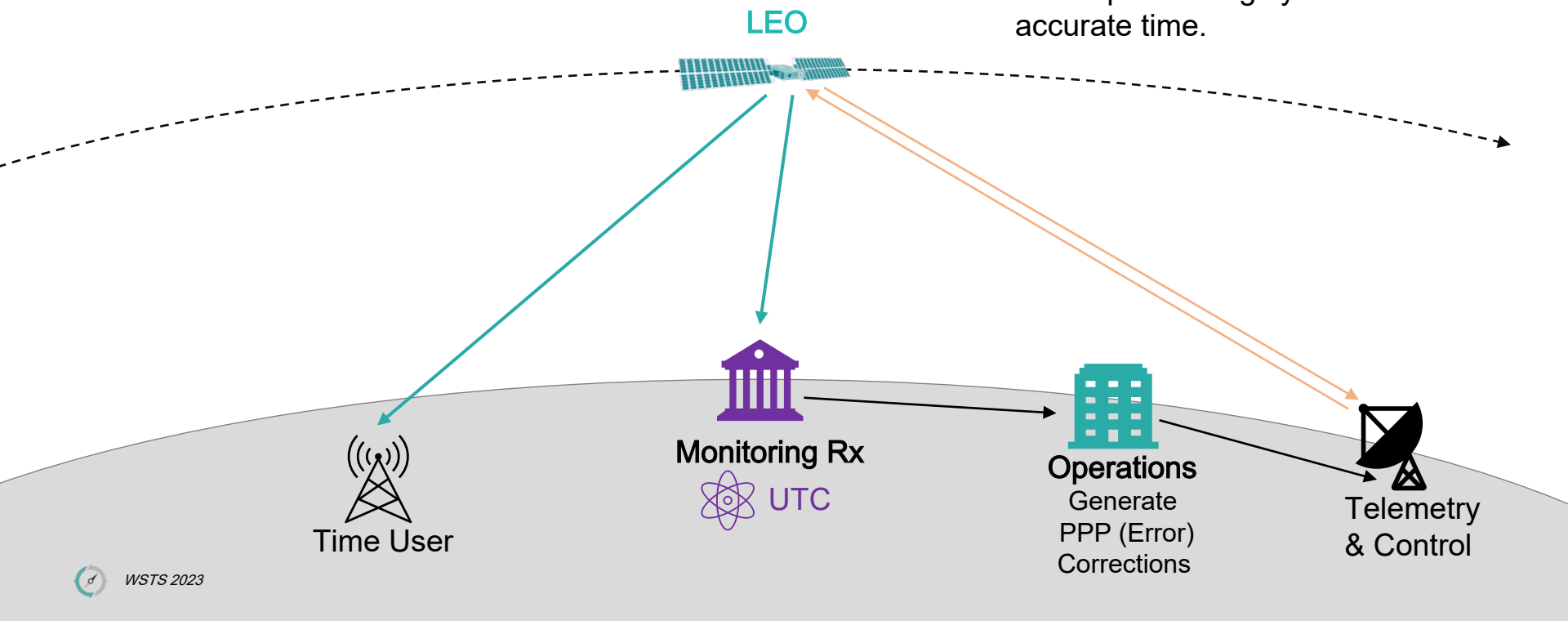
Accuracy

Orbit, clock, phase & code biases, and UTC corrections computed and uploaded to the satellite in short order (seconds)

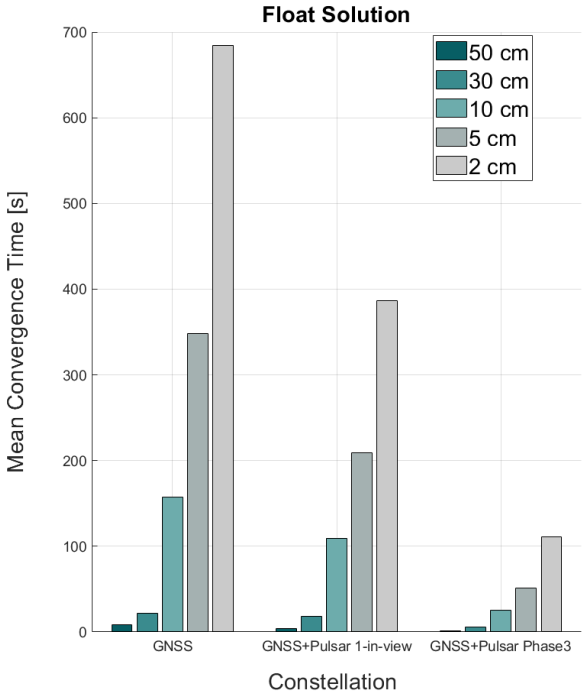


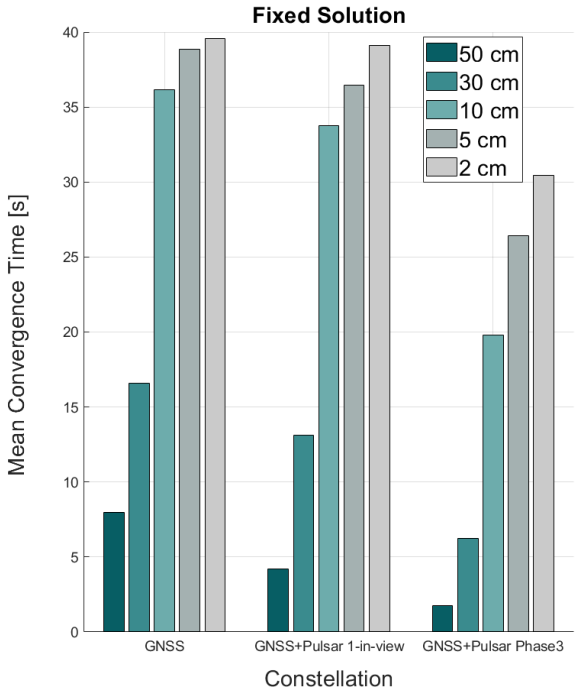
Accuracy

Time users leverage near real-time correction parameters along with Precise Point Positioning techniques for highly accurate time.



PPP Convergence





GNSS PPP techniques and services already used in high precision time today claiming < 1 ns ability.

LEO signals accelerate convergence time and bring shorter multipath decorrelation time for higher precision faster.

In-band data bring correction information directly.

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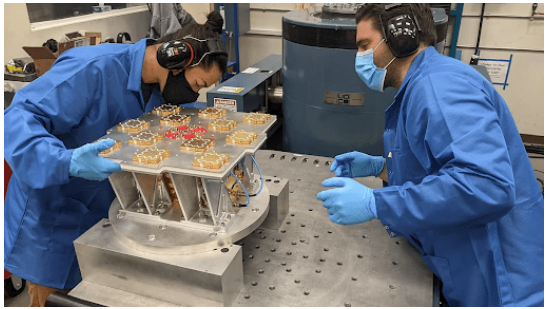
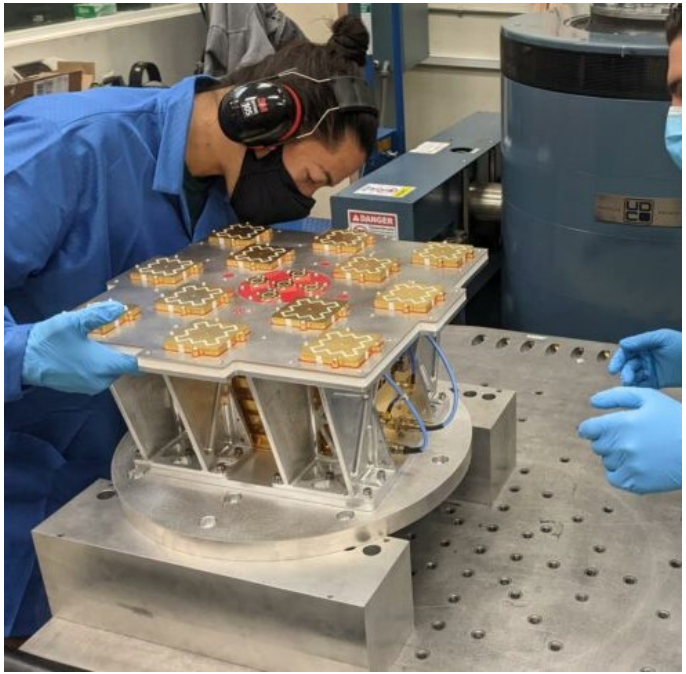
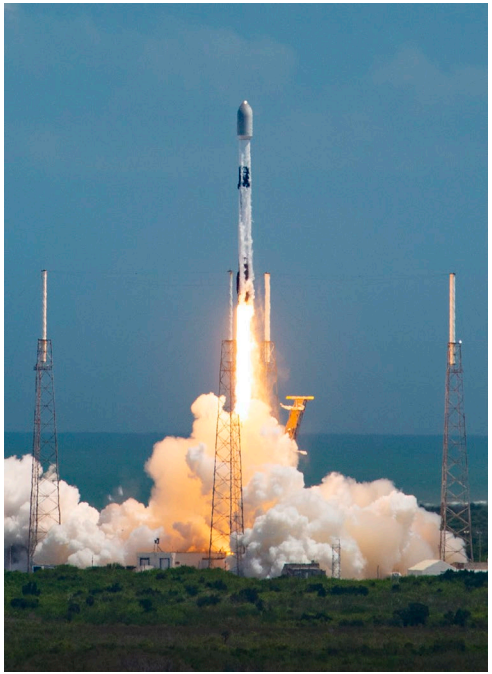
In Orbit Demonstration

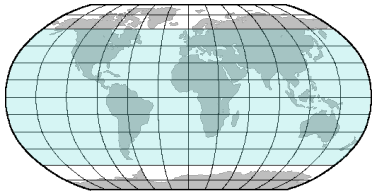
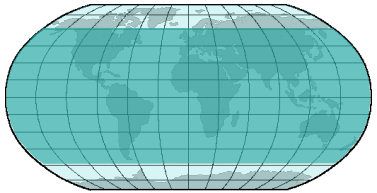
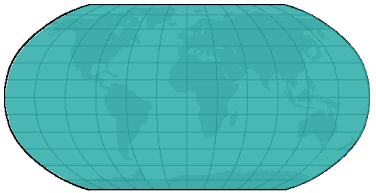


Demo Satellite Mission Huginn





Phased Roll Out

	Phase 1 ~ 40 Satellites	Phase 2 ~ 70 Satellites	Phase 3 ~ 300 Satellites
			
• Pulsar™ for Stationary Users • Corrections for Mobile Users	>99% Availability Mid-Latitudes	>99% Global 100% Mid Lat	100% Global Coverage
• Pulsar™ for Mobile Users	-	>50% Global Coverage	100% Global Coverage

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