

# Amazon Leo

## *Dark and Quiet Skies*



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Amazon Leo is Amazon's  
low Earth orbit satellite  
broadband network.



# Our guiding principles

## Customer-first

We start with the customer and work backwards. Our services are designed to delight customers, and to provide a simple, convenient experience every step of the way.

## Affordability

Amazon has a long-standing commitment to low prices. We are inventing new technologies so that Amazon Leo is accessible for more customers.

## Reliability

Customers around the world trust Amazon to provide reliable service that just works. Amazon Leo aims to deliver that same caliber of consistent, delightful service for our customers.

## Safety

We are committed to operating safely across every aspect of our business, from our satellites in space to our facilities here on Earth.

## Security

Our system is designed to protect the security and privacy of our customers, from individual households to large enterprise and government customers.

## Sustainability

Amazon is committed to building a sustainable business for our customers and the planet, and we're extending that commitment to help protect the space around Earth.

# Customer antennas

## Leo Nano

Ultra-small form factor

100 Mbps downlink

7" x 7"

18cm x 18cm



## Leo Pro

Built for performance

400 Mbps downlink

11" x 11"

28cm x 28cm

## Leo Ultra

Enterprise focused

1,000 Mbps downlink

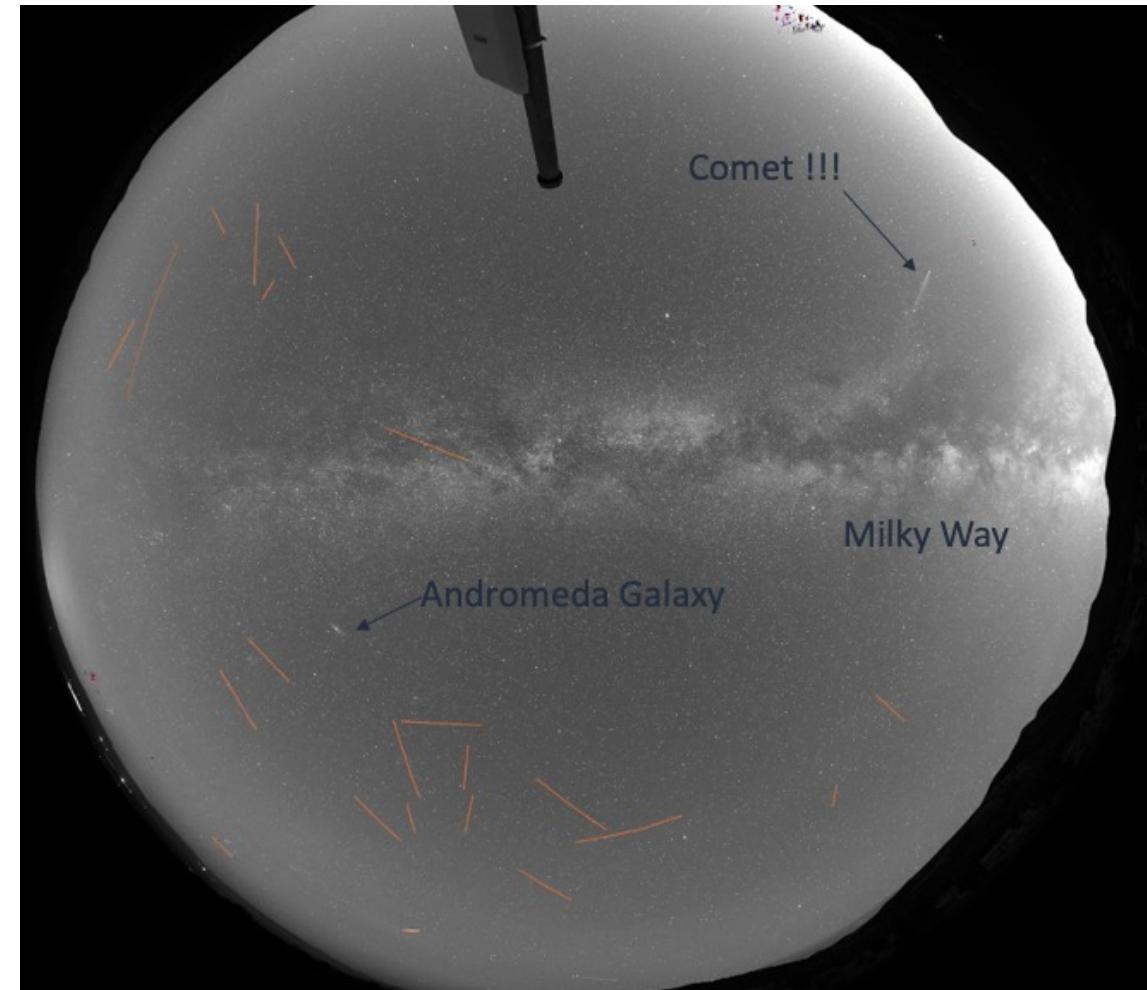
20" x 30"

51cm x 76cm

# Dark and Quiet Skies – Optical Astronomy

- Reflectivity: Light from satellites reflected by antennas can cause flares that affect telescopes.
- Mitigation investment by Amazon Leo
  - Dielectric films; non-reflective paints; attitude controls; sharing position data with observatories
  - Deployment of ground observatory for measurements
  - In-house modeling capabilities
- Shared burden of addressing Dark and Quiet Skies.
  - Better scheduling with real-time ephemeris; improved image processing; increased apertures; more robust receivers; enhanced detector technology (IAU Recommendation)

**Key takeaway:** Satellite constellations like Amazon Leo are implementing brightness mitigation solutions and continue to improve.



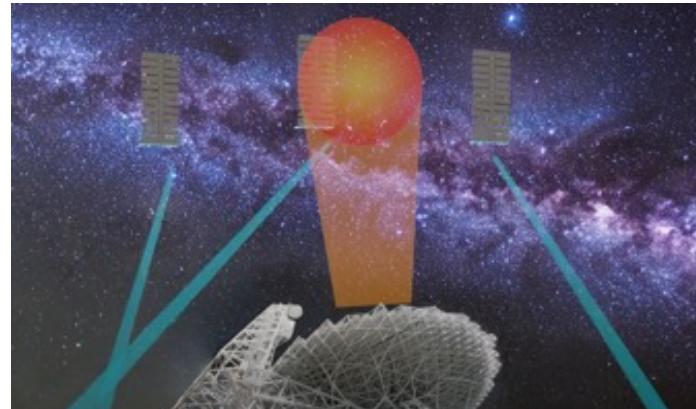
Long duration exposure of twilight sky with satellite streaks.  
Courtesy: Paul Gardner

# Dark and Quiet Skies – Radio Astronomy

- ITU Radio Regulations protect Radio Astronomy Service in several frequency bands.
  - No radio astronomy allocation in Ka Band (Amazon Leo).
- Amazon Leo implements mitigating measures as needed for national requirements.
  - Agreement between National Science Foundation and Amazon Leo



Source: ESO



Source: NRAO

**Key takeaway:** No general radio astronomy allocation in Ka-band.  
Amazon Leo mitigates as needed for national requirements.

Allocation to services		
Region 1	Region 2	Region 3
13 360–13 410 kHz	FIXED	
	RADIO ASTRONOMY	
25 550–25 650	RADIO ASTRONOMY	
37.5–38.25 MHz	FIXED	
	MOBILE	
	Radio astronomy	
322–328.6	FIXED	
	MOBILE	
	RADIO ASTRONOMY	
406.1–410	FIXED	
	MOBILE except aeronautical mobile	
	RADIO ASTRONOMY	
1 400–1 427	EARTH EXPLORATION-SATELLITE (passive)	
	RADIO ASTRONOMY	
	SPACE RESEARCH (passive)	
1 610.6–1 613.8	1 610.6–1 613.8	1 610.6–1 613.8
MOBILE-SATELLITE (Earth-to-space)	MOBILE-SATELLITE (Earth-to-space)	MOBILE-SATELLITE (Earth-to-space)
RADIO ASTRONOMY	RADIO ASTRONOMY	RADIO ASTRONOMY
AERONAUTICAL	AERONAUTICAL	AERONAUTICAL
RADIONAVIGATION	RADIONAVIGATION	RADIONAVIGATION
	RADIODETERMINATION-	Radiodetermination-
	SATELLITE (Earth-to-space)	satellite (Earth-to-space)
10.6–10.68 GHz	RADIO ASTRONOMY and other services	
10.68–10.7	RADIO ASTRONOMY and other services	
14.47–14.5	RADIO ASTRONOMY and other services	
15.35–15.4	RADIO ASTRONOMY and other services	
22.21–22.5	RADIO ASTRONOMY and other services	
23.6–24	RADIO ASTRONOMY and other services	
31.3–31.5	RADIO ASTRONOMY and other services	

Source: Wikipedia

# Amazon Leo Enabling Dark and Quiet Skies

We are taking steps to minimize the impact on astronomical observation.



## System design

- Project Kuiper operates at lower altitudes reducing duration of illumination compared to higher altitudes (consistent with IAU CPS recommendation).
- Prototype mission helped us evaluate reflectivity and test our mitigation measures including dielectric films, paint, and panel orientation.
- We have developed in-house modeling capabilities to predict brightness.



## Deployment & operations

- Maneuvering capabilities reduce earthward reflectivity during propulsive operations (orbit raise and lower).
- Steering capabilities minimize reflections during mission operations.
- Kuiper does not operate in any spectrum allocated for radio astronomy.
- We are currently deploying optical observatories for ground-based measurements.



## Collaboration

- Amazon is committed to working with the astronomical community to find shared solutions. We will share ephemeris data throughout operations to help protect and preserve scientific research.
- Kuiper has supported IAU's Centre since its inception and co-chaired the Industry & Technology Hub.
- We have a coordination agreement with the U.S. National Science Foundation (NSF).



# Thank you

