



## CICERO Constellation Overview

PROPRIETARY

# FIRST OPERATIONAL LAUNCH

First launched January 12, 2018 on PSLV-C40

Also launched in November & December 2018 (PSLV and Rocket Lab)



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# SATELLITES

Two current operational satellites generating  
~1100 occultations

Tyvak Endeavor 6U platform

Reliable

Stable fine-pointing

Significant margin on X-band  
downlink

Power for 95% duty cycle



Aft-facing occultation antenna for setting occultations

Most upcoming satellites on new Tyvak Trestles platform

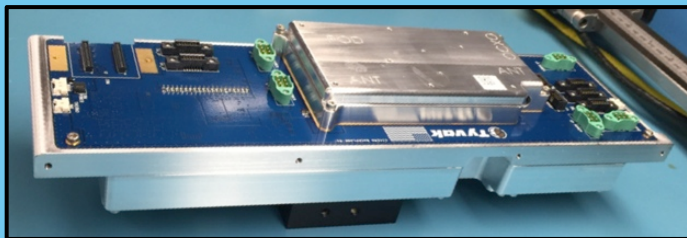
Will maximize duty cycle and enable new observations

# CION INSTRUMENT



Developed by JPL, based on TriG  
GeoOptics funded  
Available for use by both

Implemented by Tyvak and JPL  
System on Module (SoM) combining  
processor and FPGA



< 1.5 U volume  
< 10 W power draw

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# CION INSTRUMENT

All open-loop tracking for occultations

GPS and Glonass tracking currently

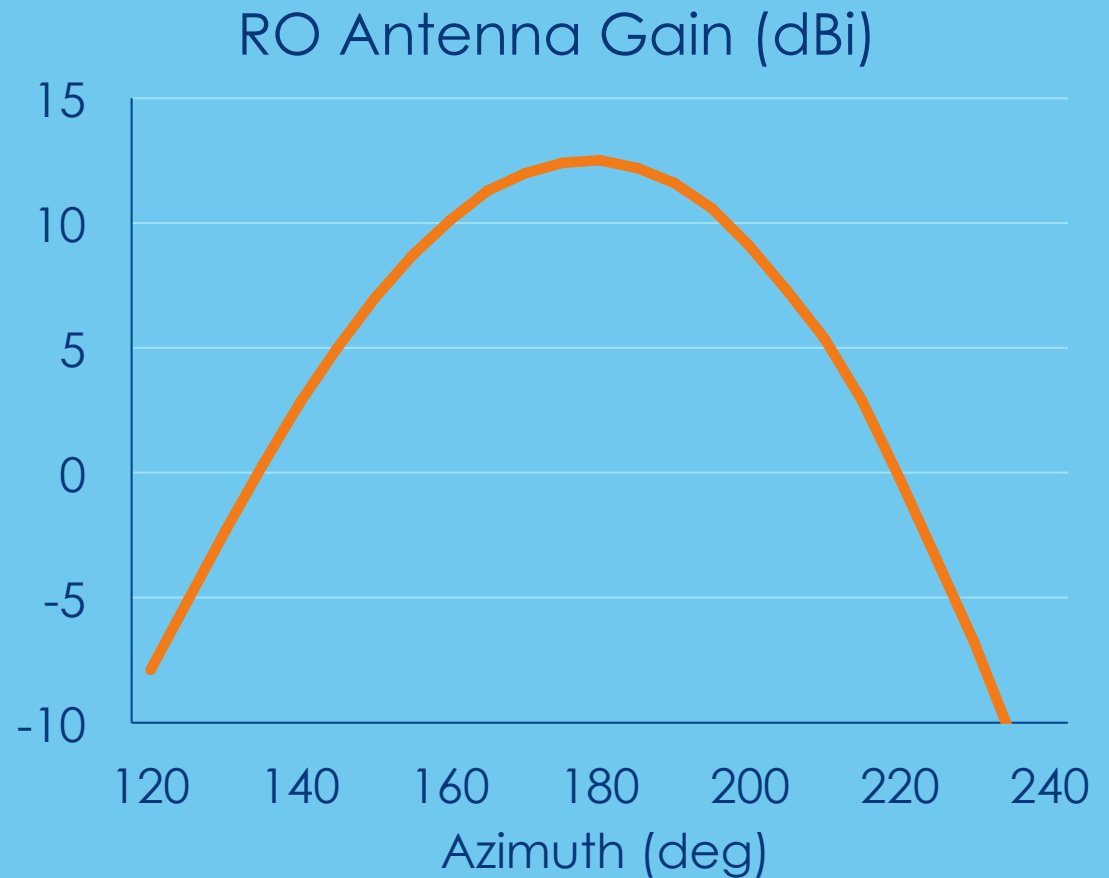
Galileo tracking planned for next month

Ultra-stable oscillator allows “zero-difference” processing without a reference GNSS satellite

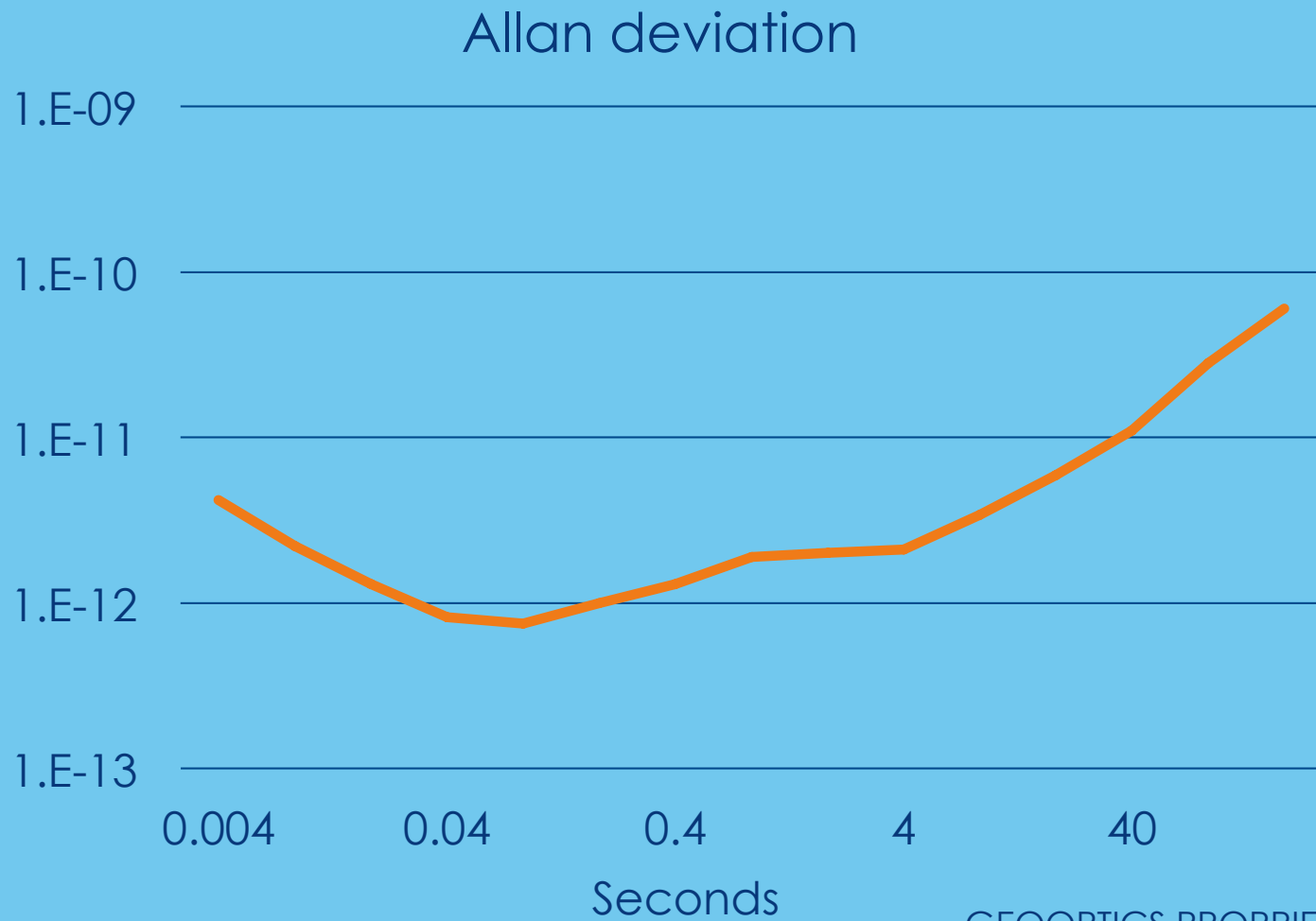
Closed loop tracking for overhead GNSS satellites

# ANTENNAS

POD antenna is a single patch with wideband gain



# OSCILLATOR



# DATA CHARACTERISTICS

Altitude minimum in QCed processed data:

~1.3km average

~750m median

Gain varies across the antenna pattern

SNRs, noise and inversion success rates do to

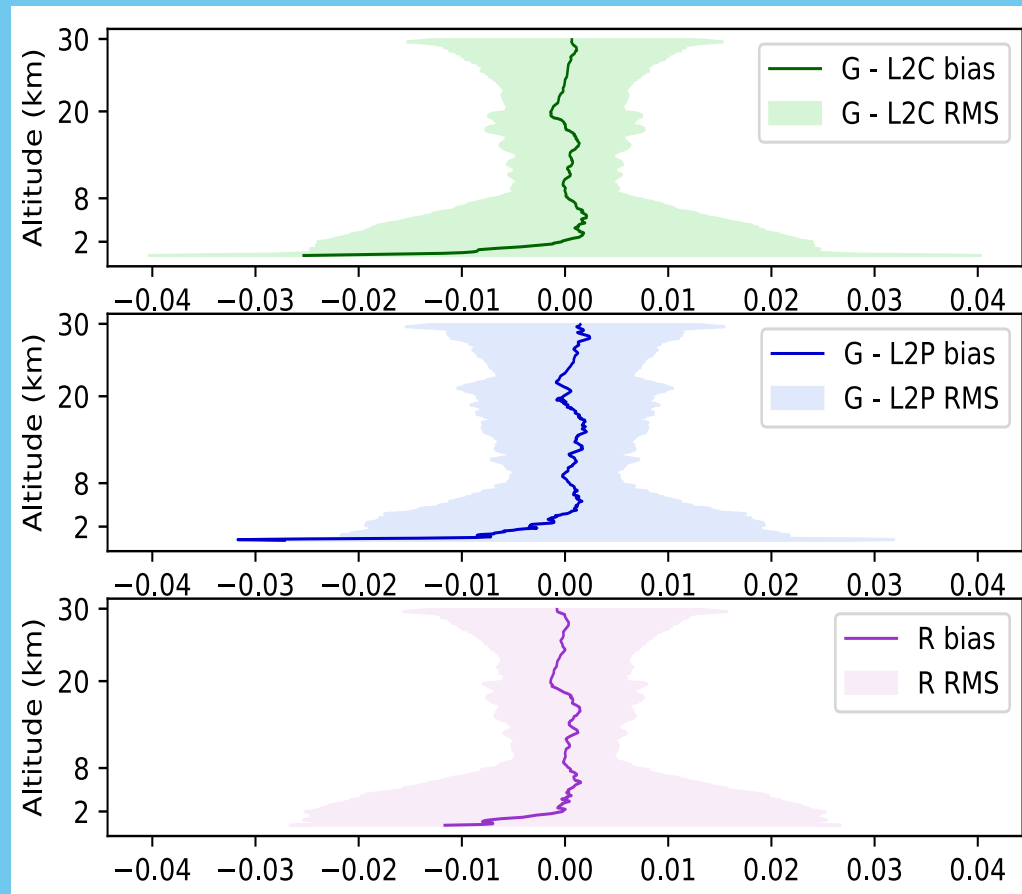
Many occultations above 1000 V/V

But some great occultations out to  $\pm 60$  deg.

All gathered at 100 Hz open loop

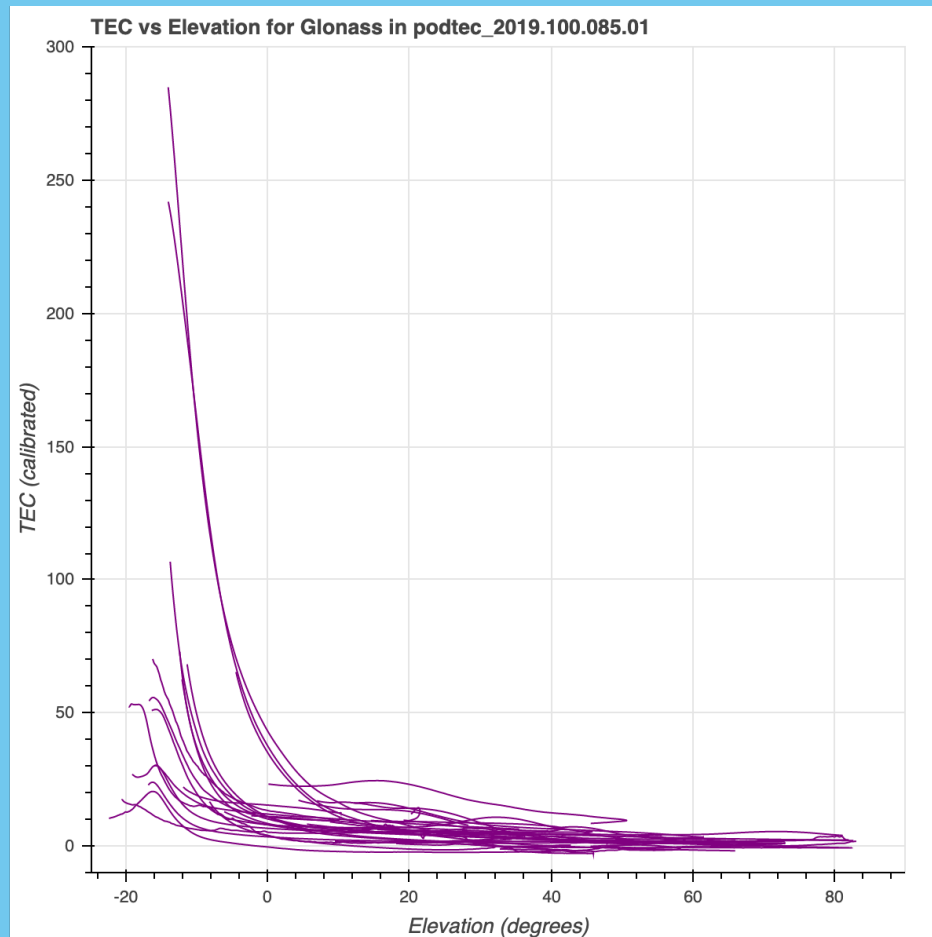


# REFRACTIVITY STATISTICS



July 1-7 profiles that pass QC  
(NCEP model comparison) GEOOPTICS PROPRIETARY

# EXAMPLE TEC DATA



# CURRENT DATA STREAM

## Level 1a data:

- Occultations in opnGns format
- POD data in Rinex format
- Attitude data in several formats

## Level 1b data:

- POD solution in netCDF4 format
- Excess phase in netCDF4 format
- TEC in netCDF4 formats

## Level 2 data:

- Profiles in netCDF4 and BUFR formats

# CURRENT DATA STREAM

More than 1100 total occs per day from 2 operational satellites

POD from 20-24 GNSS satellites each second (per RO satellite)

Currently 80% of Level 1a data delivered in 3-4 hours

Continuous latency improvements underway through additional ground stations and operations tuning

We expect to reach 80% within ~2 hours soon

# ALL SCIENCE DATA AVAILABLE

Accessible through an AWS S3 bucket

Requires a (short) scientific license that basically requires:

- Don't redistribute the raw data in volume
- Don't use it for commercial purposes

Currently two months of data, shortly all data available up to two weeks before present

Email [research-data@geooptics.com](mailto:research-data@geooptics.com)

# FUTURE PLANS

## 2020

4-6 additional spacecraft

First with dual RO antennas

Galileo and Beidou

Polarimetric RO  
GNSS reflection tests

Data volume by Q3 2020:  
5000 per day

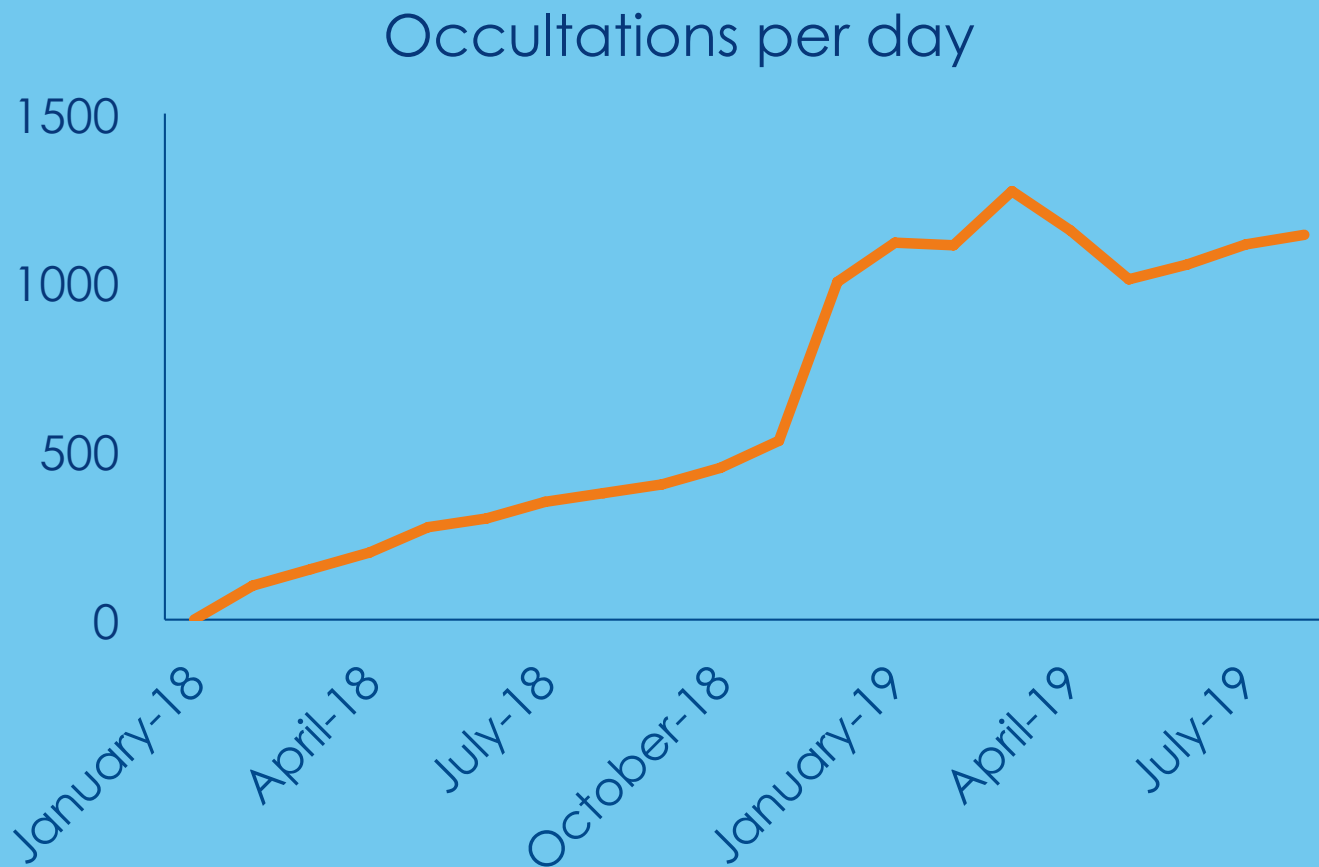
## Beyond

24 total RO spacecraft

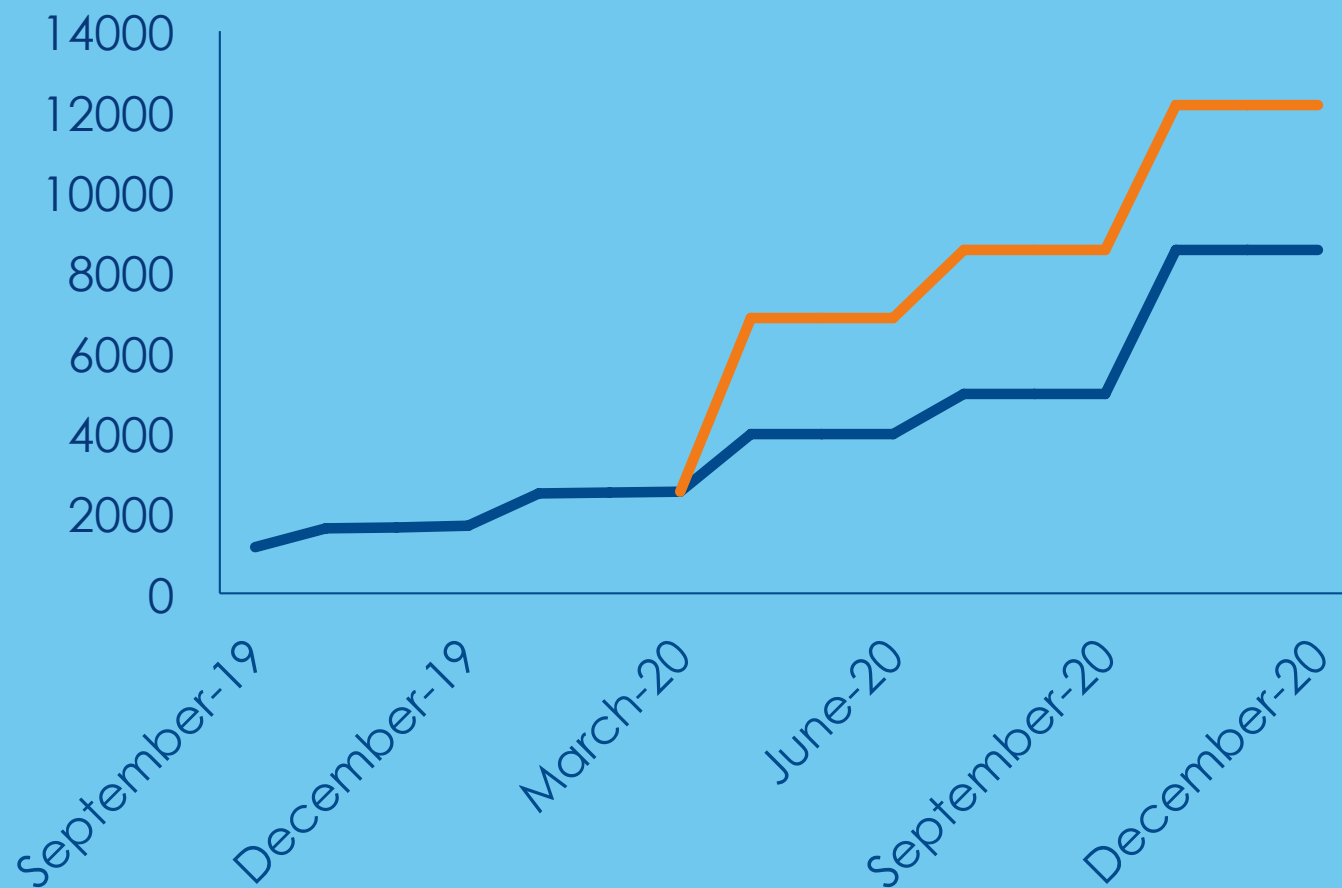
Polarimetric RO  
GNSS reflections  
Complementary instruments

Data volume:  
50,000 per day

# HISTORY OF DATA VOLUME



# HISTORY OF DATA VOLUME





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