GNSS-RO Observations at Scale

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Founder, Director, Chief Innovation Officer

IROWG-9, September 2022

SKYKRAFT
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Air Traffic Management Constellation

Skykraft is based in Canberra, Australia

Launching a constellation:

- 210 satellites
- for Air Traffic Management
- in first half 2024

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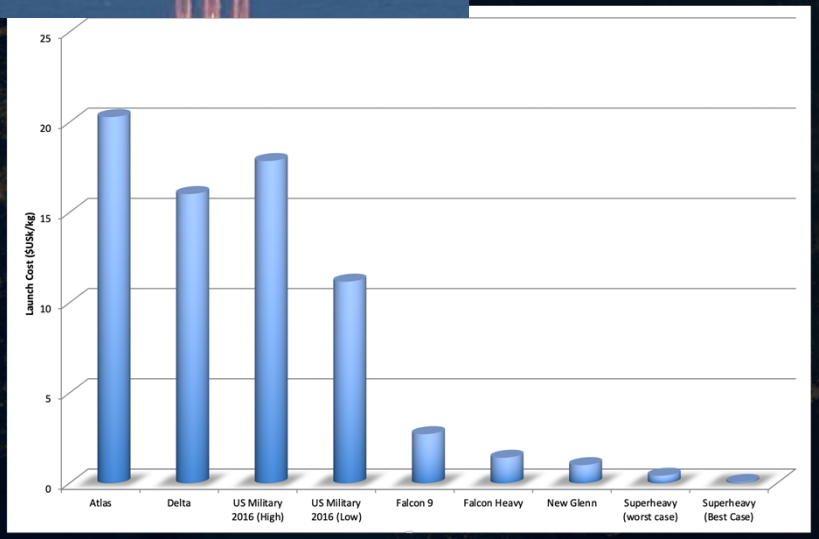
Modern Space Launch



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Images: Wikipedia, Skykraft, Blue Origin, SpaceX

New Space

Convergence of 2 Factors

Lower Launch Costs

- Higher Launch Cadence
- Less Exotic Designs
- Greater Risk Appetite

Electronics and Modern Manufacture

- Miniaturisation
- Global markets
- LEO is fairly benign

Falcon 9 Image: NASA

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New Space Mission Design and Implementation

- Move Rapidly
  - Back-up or Adjust when appropriate
  - Desire flexibility
- Design and Build for 80/20
  - Harvest the low-hanging fruit
  - Defer burdensome requirements to future work
- Simplify
  - Streamline engineering processes
  - Reduce supply-chain friction
- Launch is about 1/3 of mission cost
  - LtCol John London III (1994)

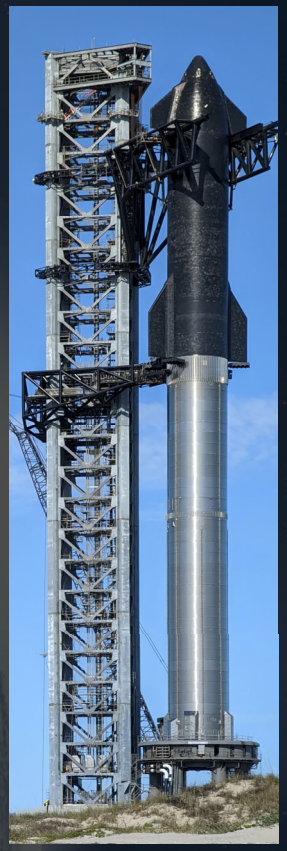

Image: Wikipedia

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Modern Air Traffic Management

Communication
VHF, HF, Limited Satcom

Navigation
GPS, Inertial

Surveillance
ADS-B, Radar

Image: wikipedia

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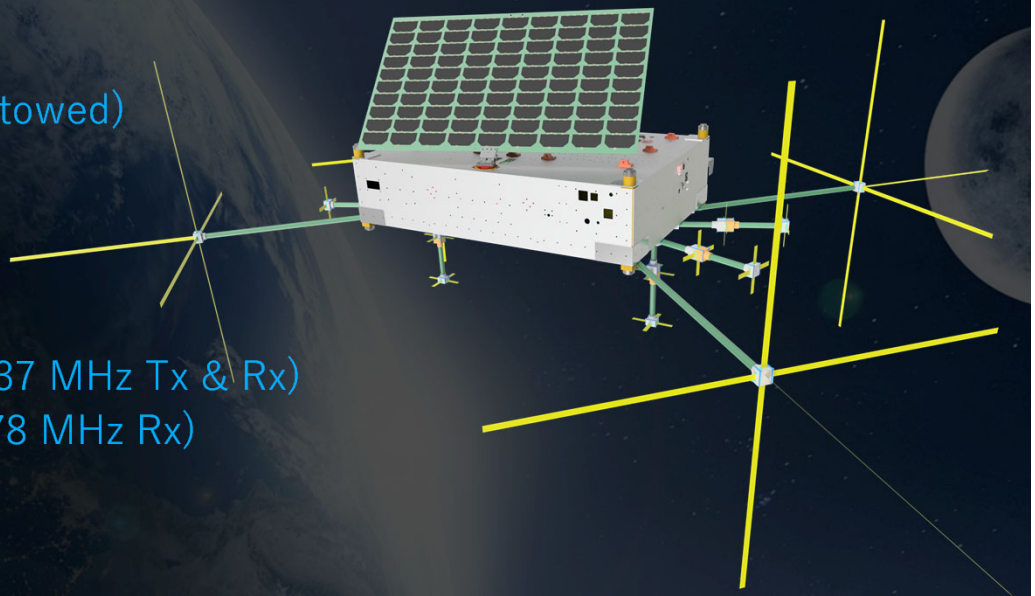
Skykraft Air Traffic Management Constellation

Spacecraft Features

900 x 600 x 200mm (108 liters when stowed)
30 kg Mass
7 orbital planes
  1 x SSO, 6 x 53 degree, 600 km
23GHz Inter-Satellite Link
Direct Pilot-Controller Comms (118-137 MHz Tx & Rx)
ADS-B Global Surveillance (1090 & 978 MHz Rx)
  Array of L-band receivers
Capacity for additional payloads



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Skykraft Air Traffic Management

Transporter-6 Launch

Florida, 7 Nov 22

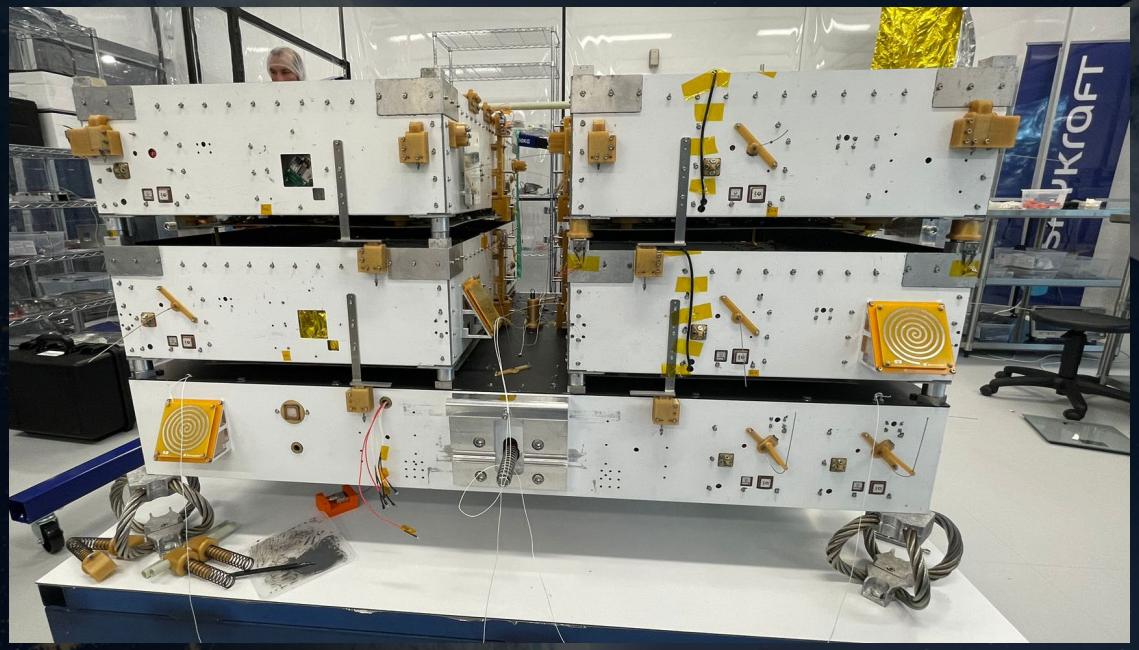
Orbital Transfer Vehicle (OTV)

- 1400 x 900 x 200 mm
- 4 x Deployed Satellites

300 kg total mass

800 liter total volume

24” port on Falcon 9



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GNSS from Air Traffic Management Constellation

Block II Satellites – GNSS RO

Each face has 2 x GNSS Rx
- MAX2771 Chip L5 -> L1
- Current Antennas L1 & L1/L5
- Processing Smartfusion SoC

Downlink over S-band in 2022
- X-band from H1 2023

Can add additional channels
- MAX2771, 2121 or 2223

Phased Array for greater gain
- GNSS-RO, R and POD

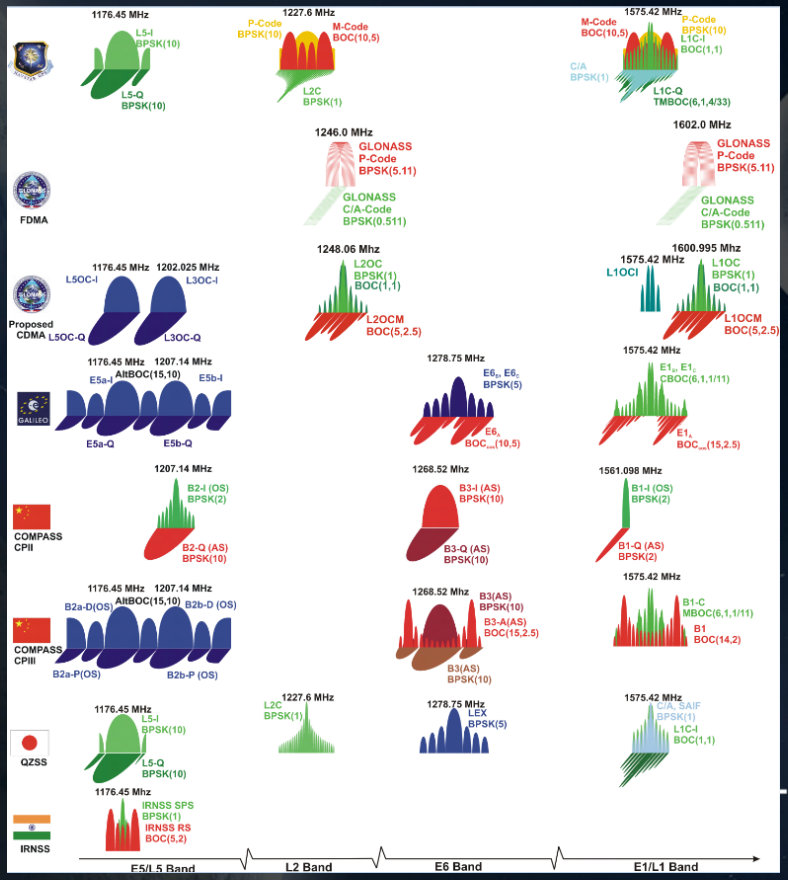
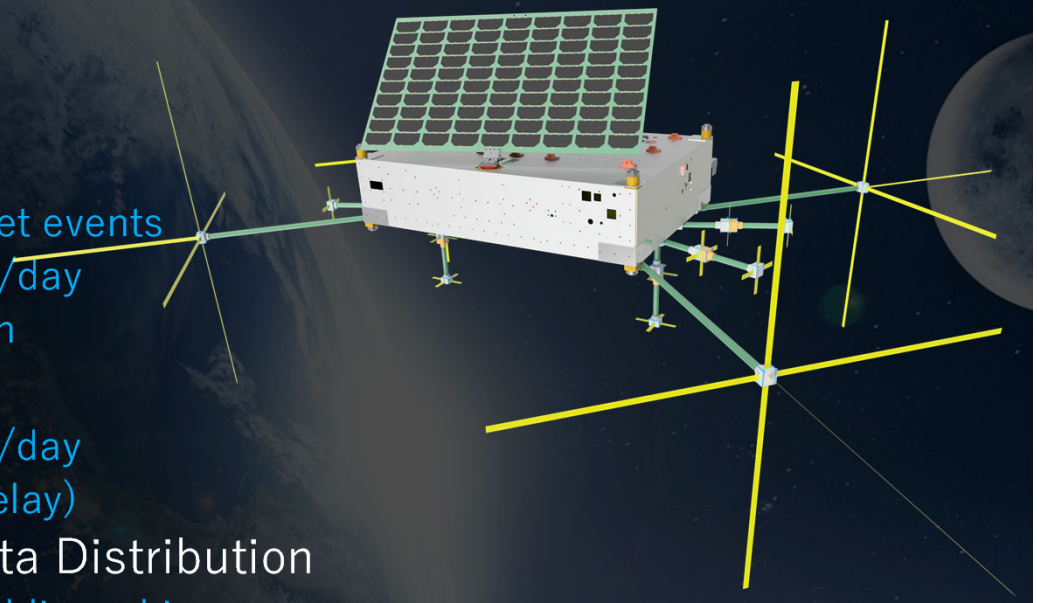


Image: ESA

GNSS from Air Traffic Management Constellation



Skykraft Satellites – GNSS RO

210 satellites – All in View GNSS

- 100+ GNSS Satellites
- O(15) orbits per day = O(30) Rise/Set events
- 210 x 100 x 30 = O(600k) RO events/day
- Multi-Frequency, Multi-Constellation

Inter-Satellite Link

- 23GHz LEO-LEO occultation, O(40k)/day
- Real-time data (<1s typical global delay)

Data Collection Algorithm & Data Distribution

- Open source – community driven, public archive
- Real time processed data
- Full I/Q recording (LO) on next ground station pass (nominal <12h)

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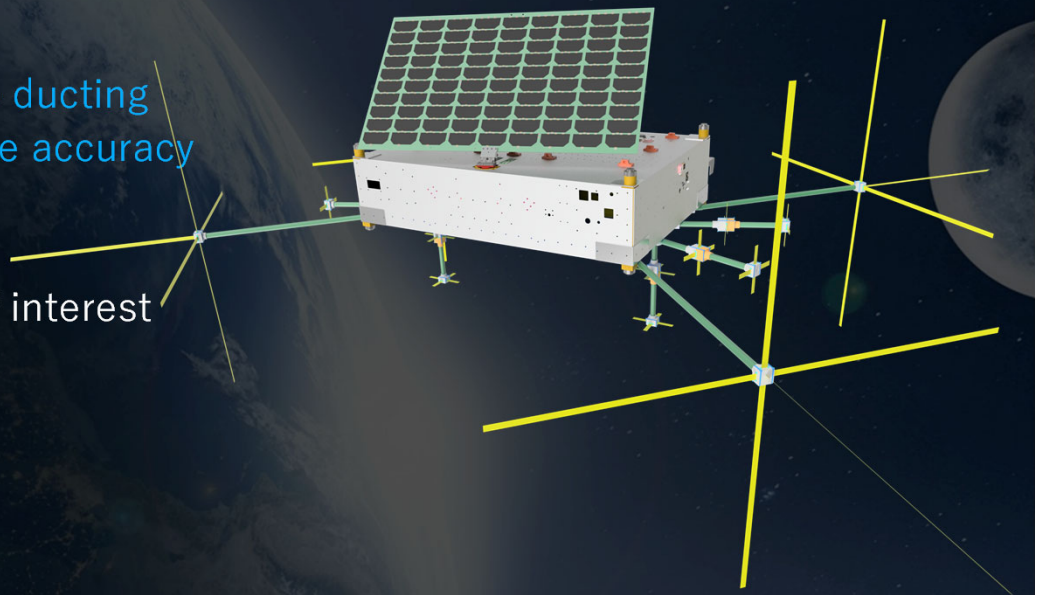
Insights from IROWG-9

SNR matters … in some ways
- Seems to improve ability to measure ducting
- Doesn't seem to affect bending angle accuracy

Polarimetry is useful
- Observe ice in atmosphere

Combined RO and Reflectometry is of interest
- Requires dual-polarization
- Flooding
- Soil Moisture
- Sea State
- Sea Ice



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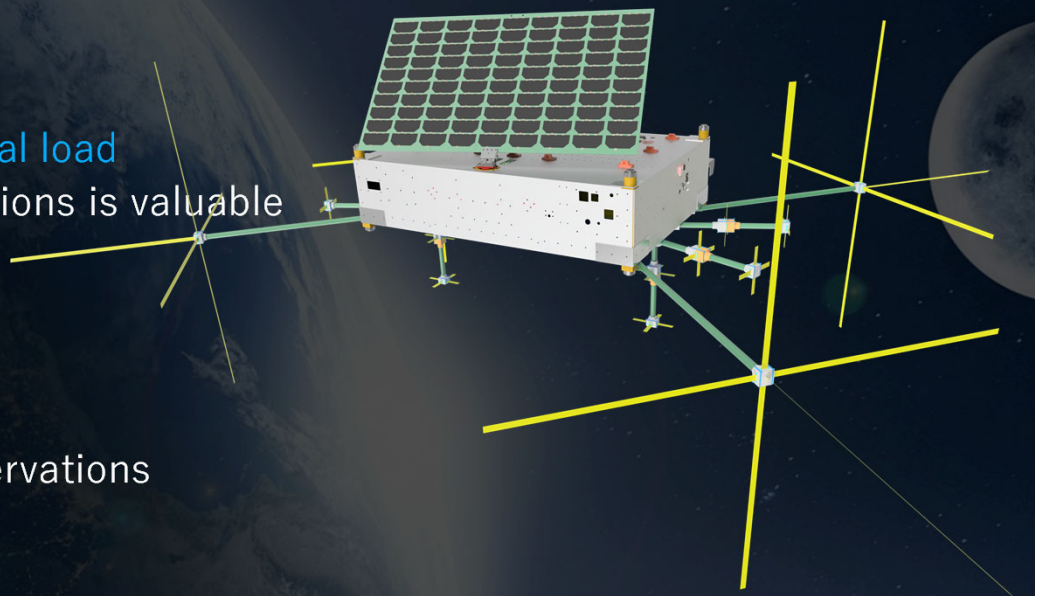
Insights from IROWG-9

- LEO-LEO occultations are of interest
  - In H_2O band (23GHz)
  - Measure attenuation to estimate total load
- Spatio-Temporal diversity of observations is valuable
  - Spread in latitude
  - Spread in longitude and time of day
- Low latency is valuable
  - Especially for space weather
- Impact on NWP grows with daily observations
  - no saturation observed in modelling



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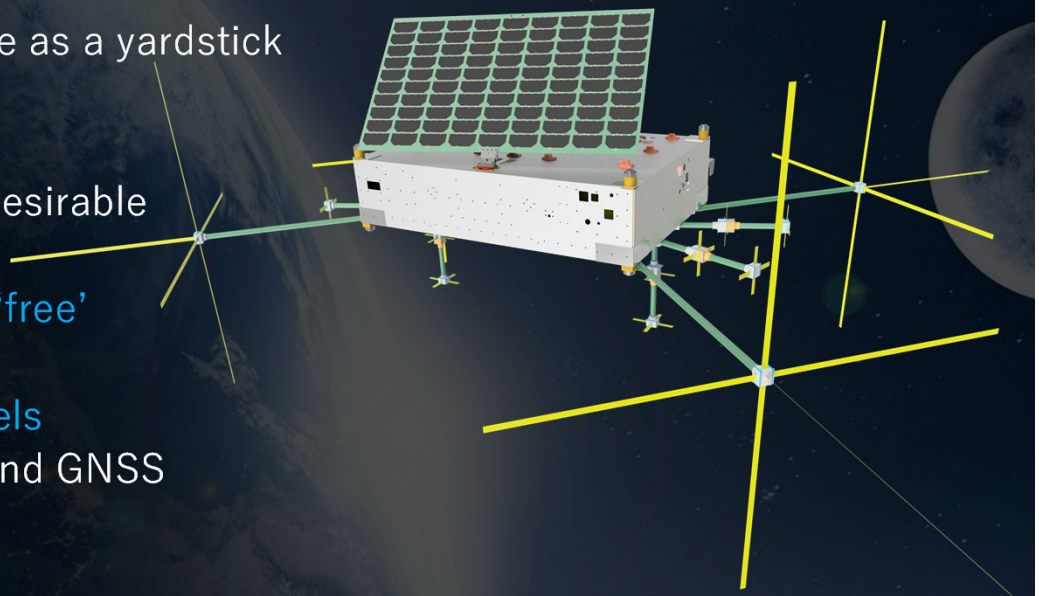
Insights from IROWG-9

Need for an enduring, trusted baseline as a yardstick
- long term truth
- calibration source for other data

Open data dissemination is strongly desirable
- real time use
- no limitations on use or distribution ‘free’

Need for processed (vs raw) data
- L2, L1, etc for assimilation into models

We should look for other signals beyond GNSS
- such as ILS, VOR, DME/TACAN



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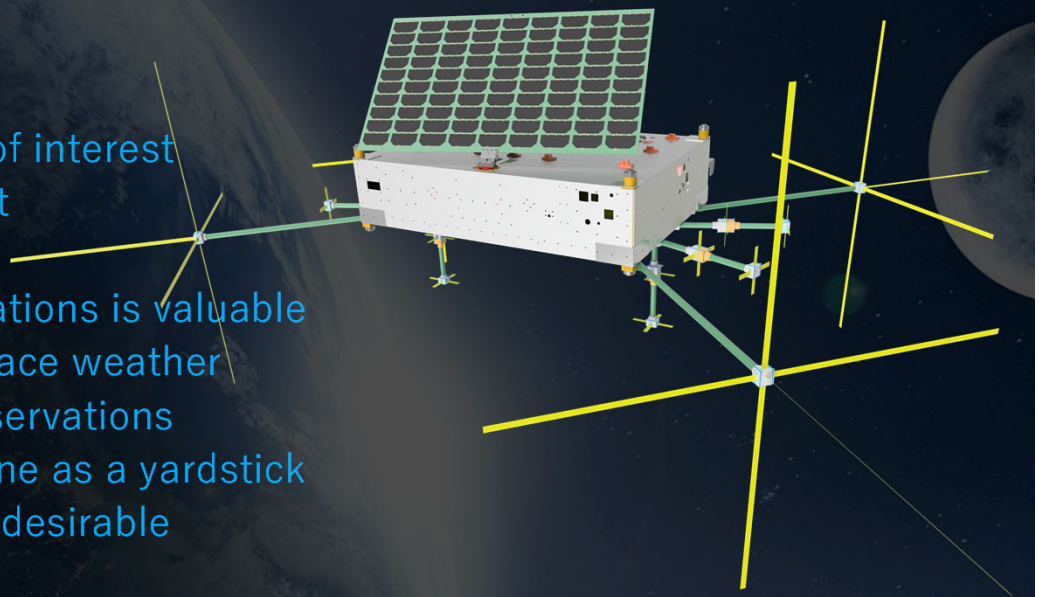

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