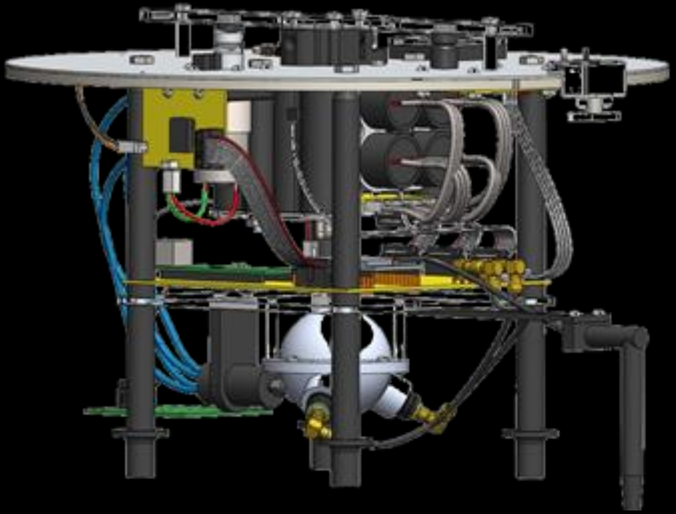
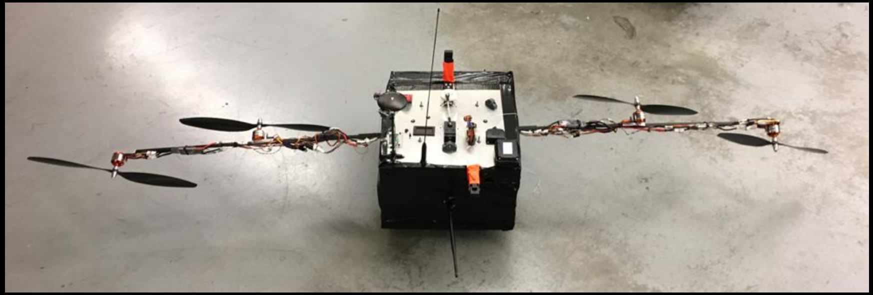
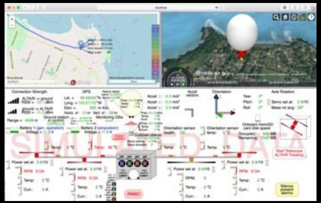
ALTAIR: High-Altitude, Low-Cost Micro-Airships

for "Workhorse" Precision Rubin Observatory Calibration & Beyond







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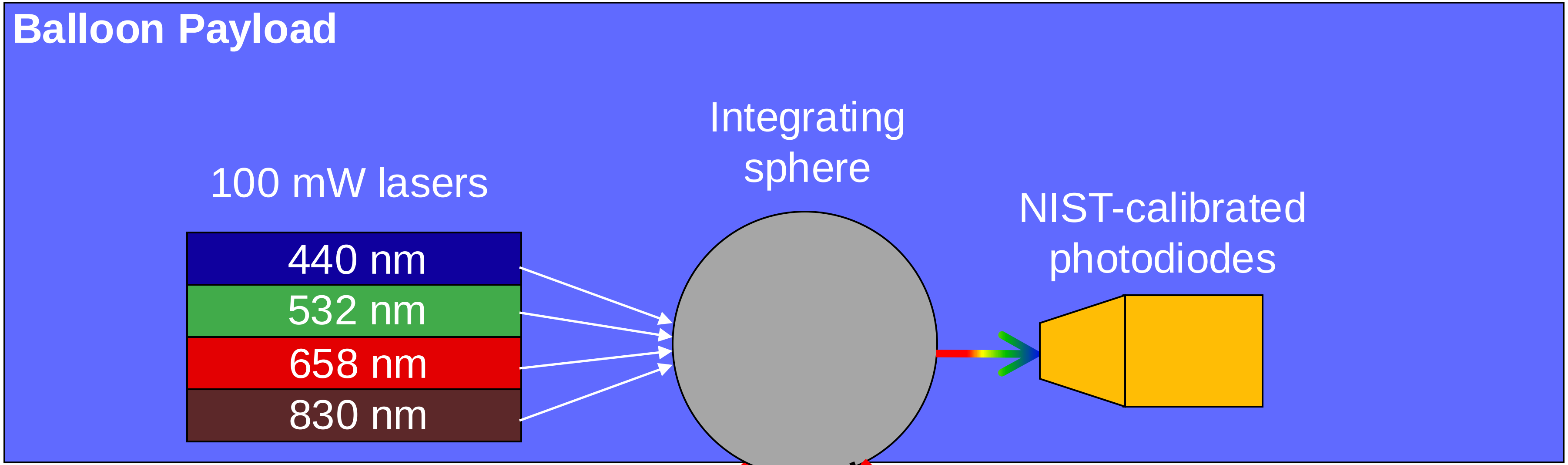
Airborne Laser for Telescopic Atmospheric Interference Reduction

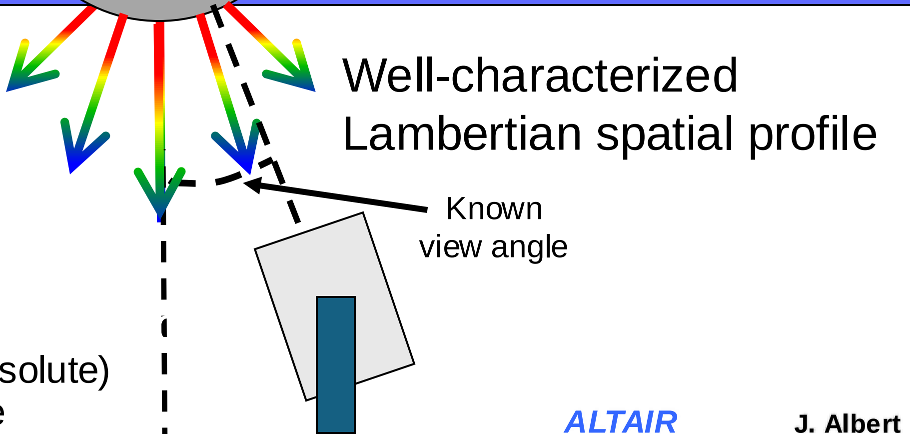
ACCURATE FLUX CALIBRATION in the Era of Space Astronomy and All-Sky Surveys

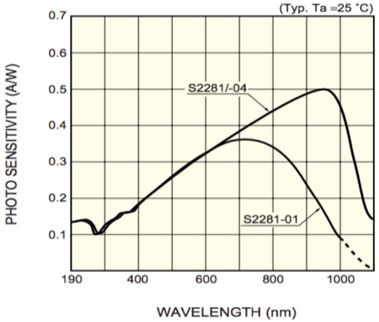
October 22-25, 2024

Airborne Laser for Telescopic Atmospheric Interference Reduction

Basic Technique & Goal: *A 0.1% Calibrated, Mobile Source Above the Atmosphere*

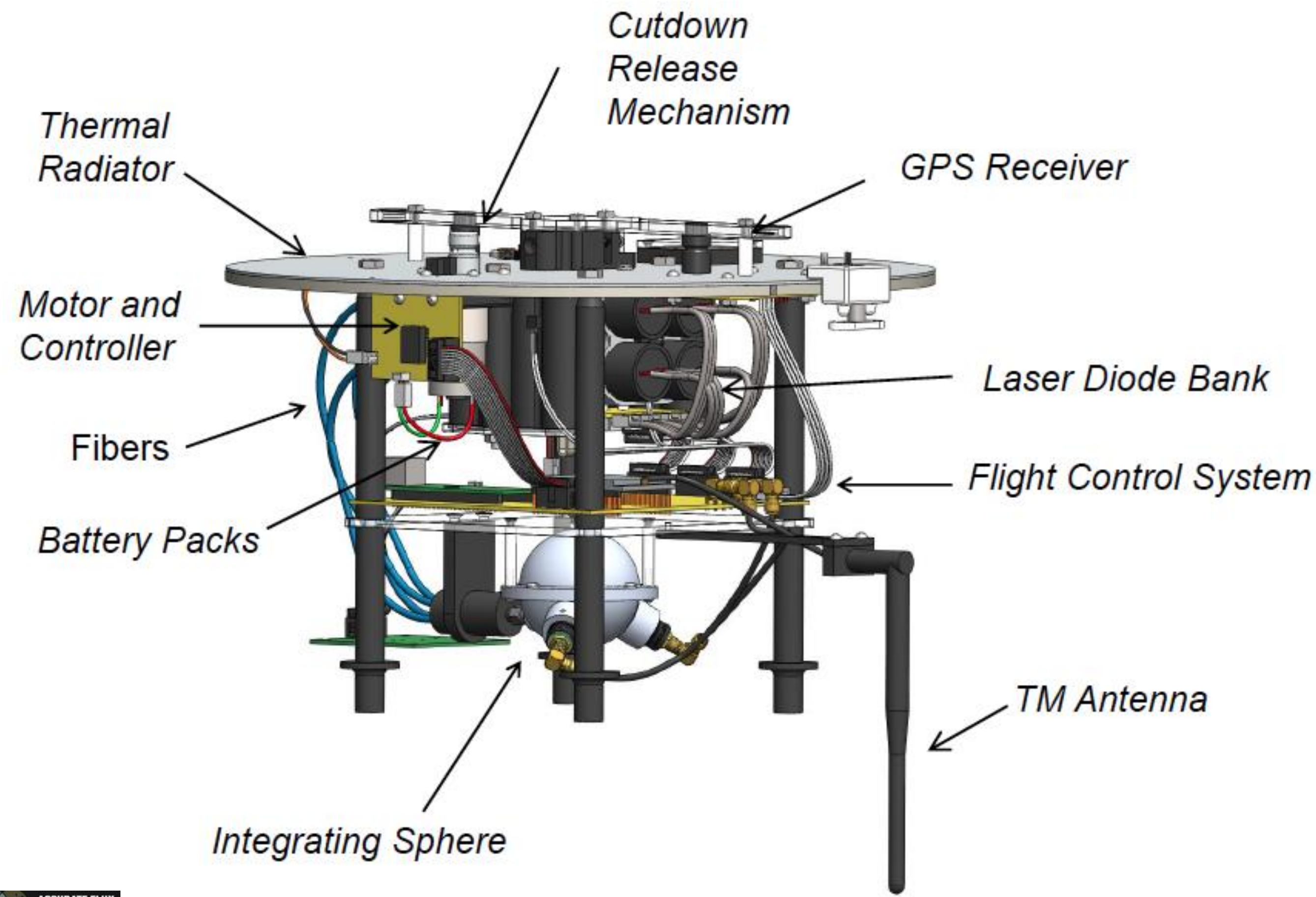


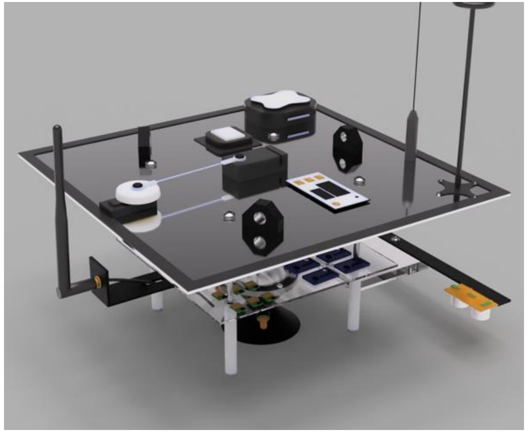


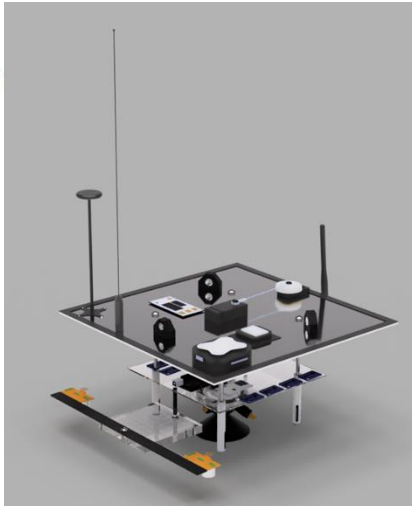


NIST- & NRC-calibrated (~ 0.1% absolute) photodiode spectral response

Basic Payload Design





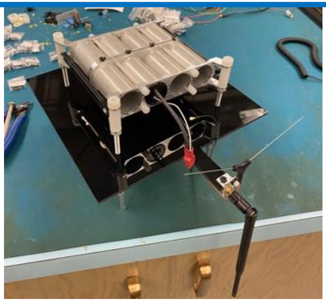


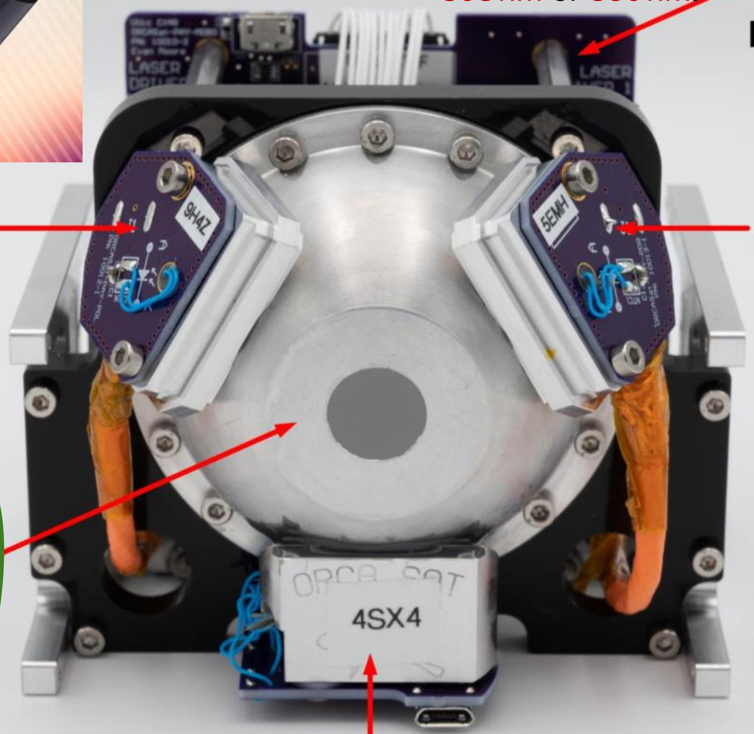
Light Sources & Calibrated Monitoring Photodiodes on 2" ID Integrating Sphere

Four WorldStarTech 100 mW laser diode modules, respectively **440** nm, **532** nm, **658** nm, & **830** nm, each fiber coupled into a fused-ends, "quadfurcated" MM optical fiber (custom fab'd by Ceramoptec).

Can be swapped out for **635** nm or **780** nm.

Can be swapped out for **808** nm or **850** nm.





Electronics MCU, TIA, Laser drivers

Photodiode 1

Photodiode 2

Integrating Sphere (coated with Avian B)

Laser Module

One photodiode is a **Hamamatsu S12698-01** (**Si**) and the other is a **Hamamatsu G10899-03K** (**InGaAs**).

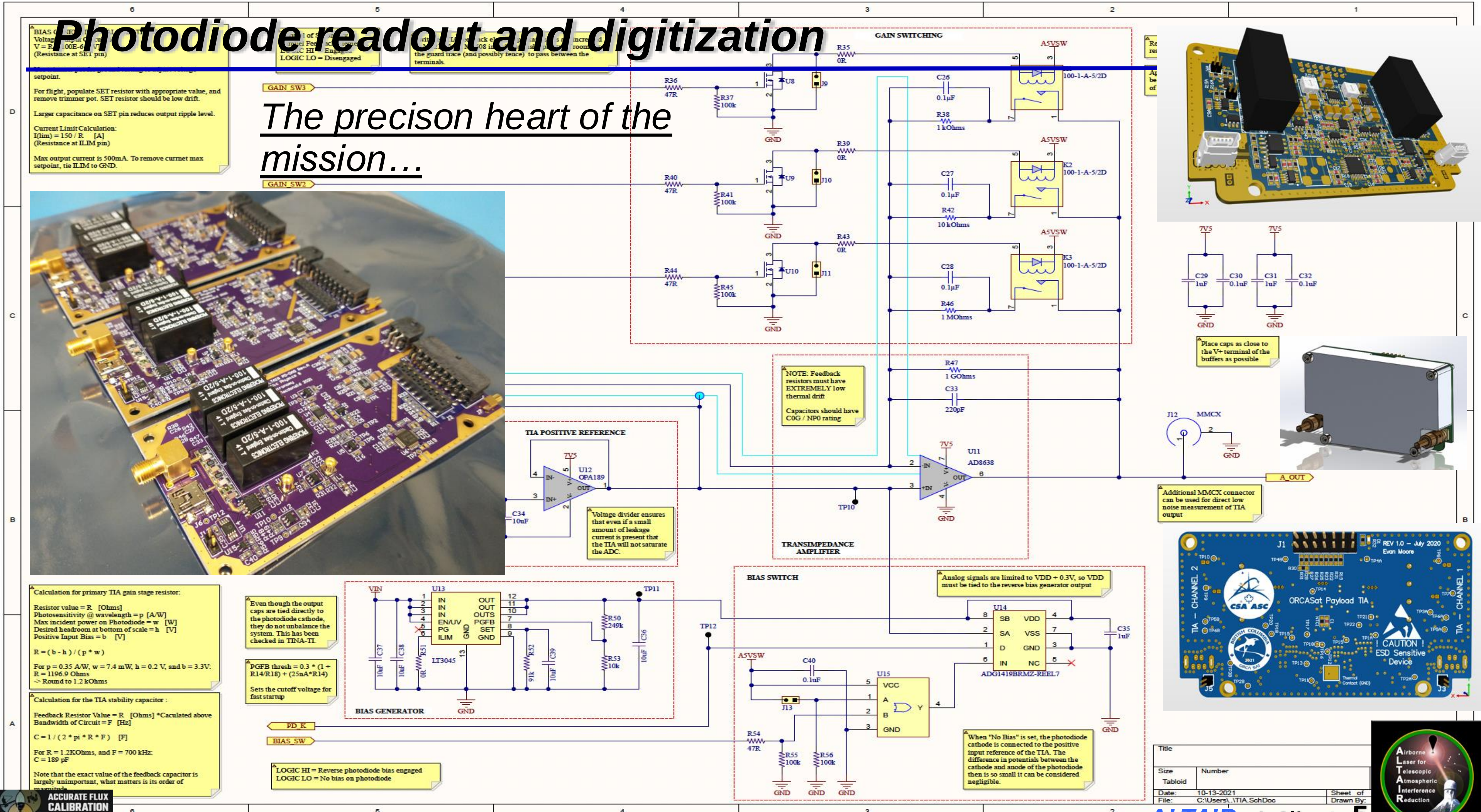
(Utilizing two different photosensor material technologies is a useful cross-check.)

Can be swapped out for **405** nm.

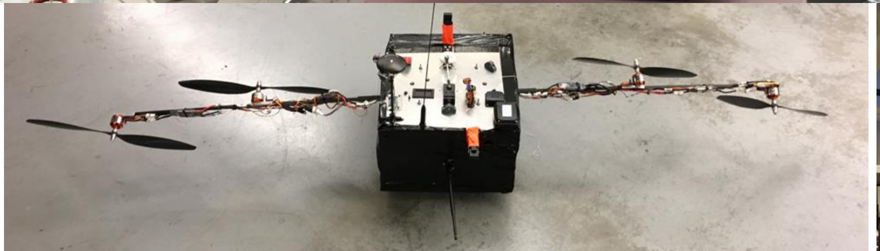
Can be swapped out for **520** nm.

Photodiode readout and digitization

The precison heart of the mission…



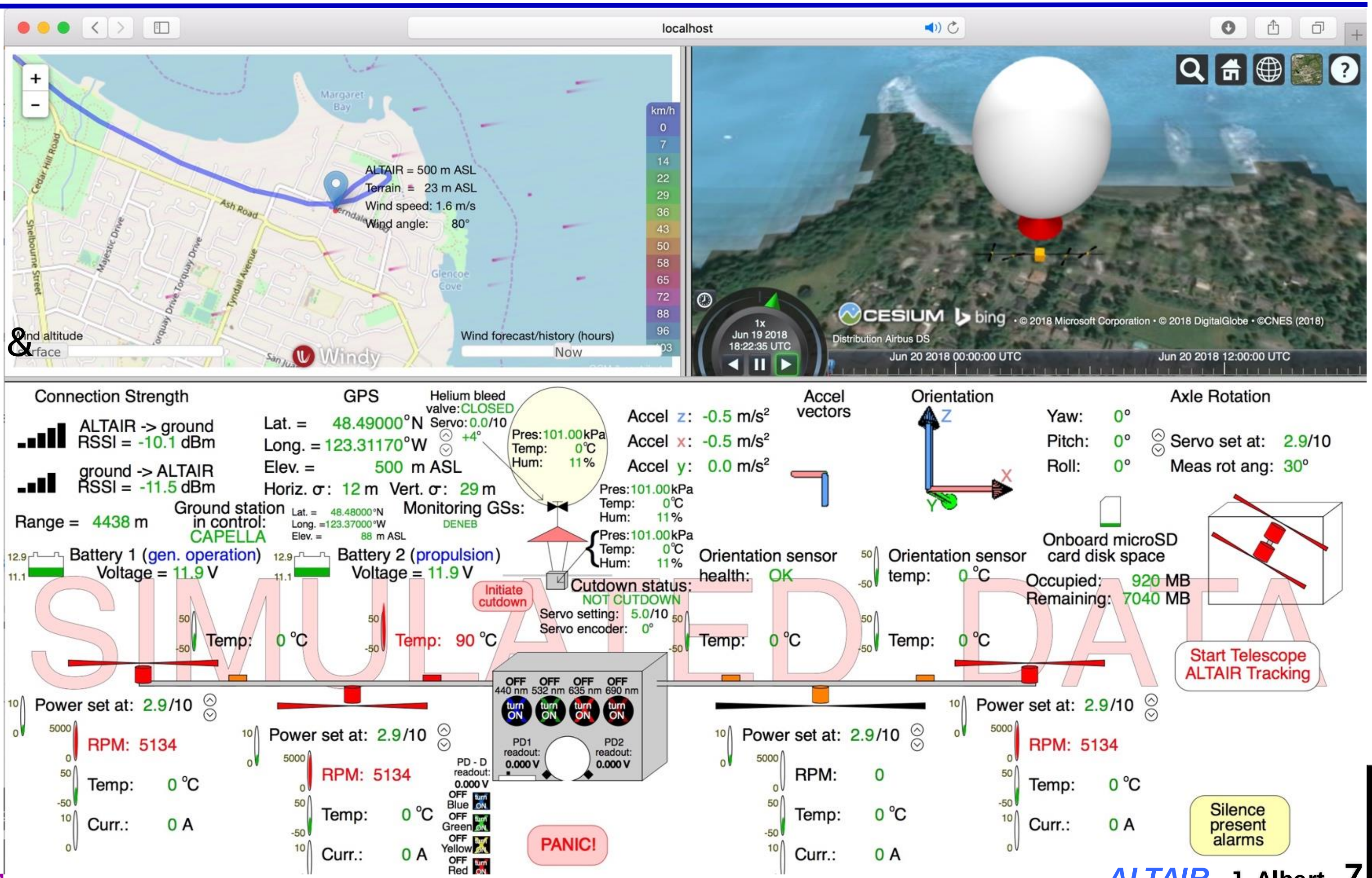
Payload



Flight control – AIFCOMSS

Code actively maintained / updated at:
https://github.com/ProjectALTAIR/AIFCOMSSwithCUPredictorTest

ALTAIR
Integrated
Flight
Control,
Operation,
Monitoring, &
Simulation
System

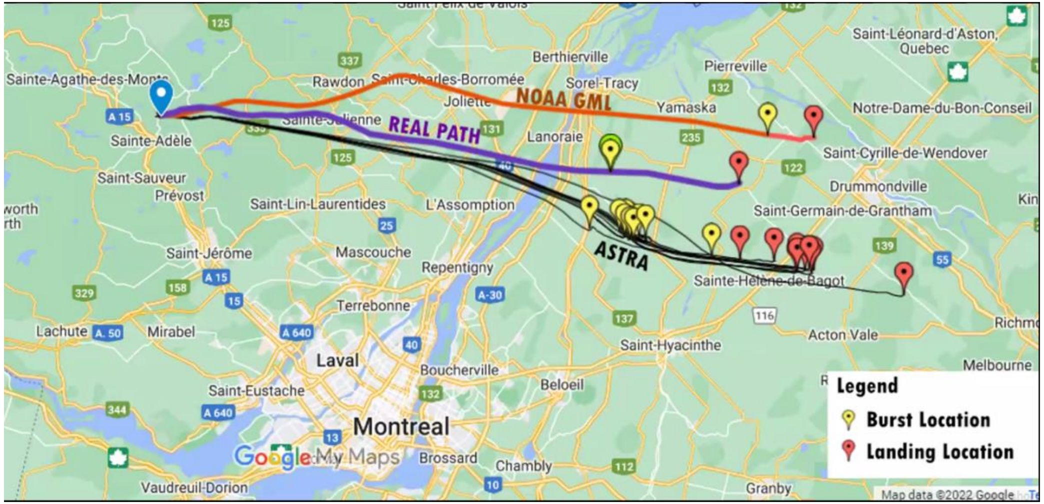


Onboard transponder (uAvionix ping900XR)

For <u>continuous real-time communication with and identification to air traffic control</u>.
(FAA & Transport Canada certified.)

So that we don't get shot down by NORAD!!! ;)
(Or by the Chilean air force!!!)

Operations & McGill / Montreal Test Flights



910 MHz portable directional ground antennas, range approx. 100 km.

Always ≥ 2 ground stations in contact.

Conclusions

➢ **Artificial sources can in principle provide up to two orders of magnitude better photometric calibration precision than any stellar, non-solar light sources can presently.**

1) Can ***study them right in the lab before and after use***, unlike stars.
2) Can ***monitor them in-situ***, in real time.
3) Can also be used to ***calibrate white dwarfs*** (and other stars, and the Moon) very precisely, and on a detector-based standards scale.
4) Small balloons are ***<u>inexpensive</u>!!!*** *E.g.:* Rubin could own 3 or so!!! – <u>launching them at dusk each night, flying to different areas of the sky, and having them ***return home*** at dawn ***each morning***</u>!
5) ***<u>Fully observer-controlled</u> choice of spectrum*** & color on demand, … and ***brightness***, …exact ***location*** in the sky as function of time of night (or day), …

➢ **Not restricted to optical/IR!:** *e.g.* a precisely-polarized Gunn diode-based precision microwave polarimetry calibration source could also be flown. (Radio, near-UV…)

➢ Balloons, of course, <u>do not</u> replace additionally having a satellite source to (at least occasionally!) determine effects from the very top of the atmosphere!!! But ALTAIR-style balloons can (and I posit will!) be the <u>low-cost, ground-based-observatory-owned, workhorses</u>.

Some separate & additional conclusions (backup slide)

- **A very interesting (& very useful) fact about Earth's atmosphere is that, at mid-latitudes, winds in the upper troposphere statistically tend to be in opposite direction to winds in the lower stratosphere.**
- **Thus, with just very small amounts of (weather-optimized) upward and downward propulsion (just above and below the tropopause), powered using very lightweight flexible solar panels on top of the balloon (+ onboard rechargeable LiPoly batteries for nighttime power), one could utilize the winds to circulate near the tropopause over a given region of Earth (*e.g.*, over a region the size of Illinois, or of Vancouver Island, etc).**
- **After a few weeks, a significant fraction of the helium would diffuse through the balloon latex, and the balloon would descend to base for (simple and low-cost!: latex balloons are about $150) balloon and helium replacement. Then, balloon and payload would be sent back up again.**
- **This opens up many additional, very different usage possibilities:**
  1) **Communication: replacing the need for cell-phone towers with very wide coverage balloons in remote (or not-so-remote) areas.**
  2) **Earth observation (for, *e.g.*, long-term studies of Arctic ice, etc.)**
  3) **…… !**