HALO

High Altitude Lensing Observatory

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The University of Edinburgh

Science & Technology Facilities Council
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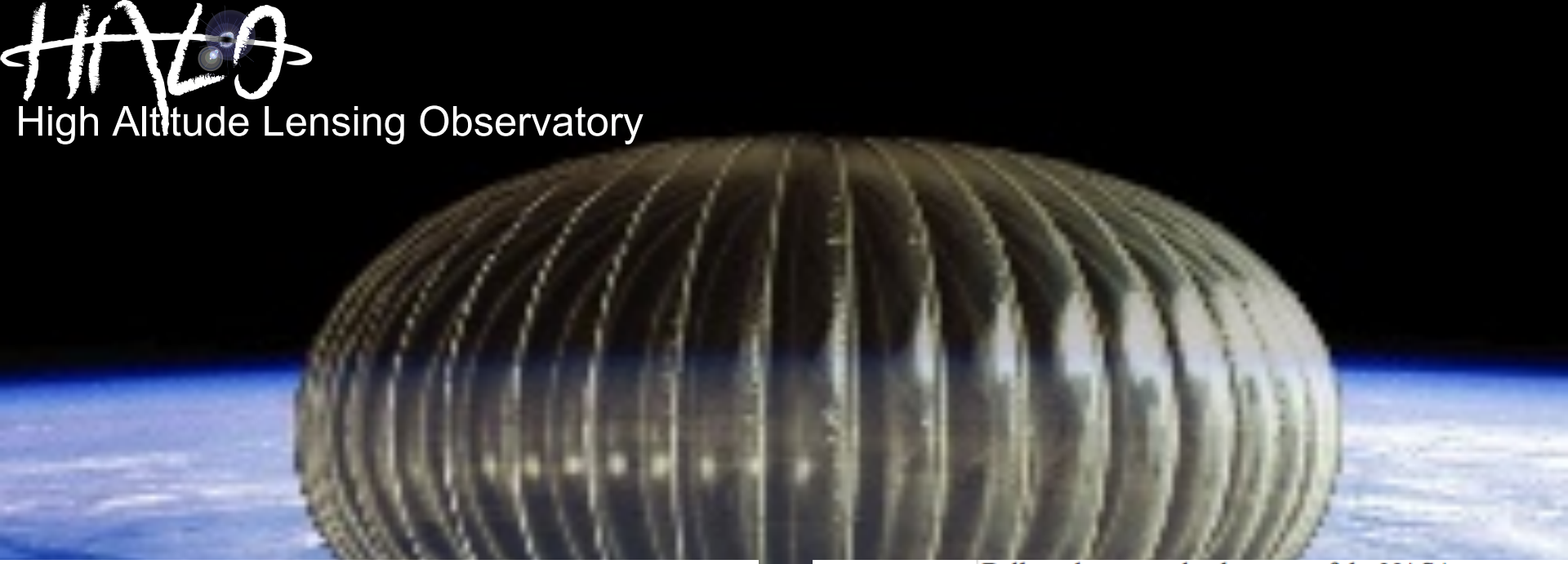

Extracts from the US decadal report

In the coming decade, when budgetary constraints will limit the number of much-more-expensive satellite programs, increasing support for the Suborbital program is a priority. By doubling the access to near space, multiple areas of study will remain vibrant at relatively low cost. This will naturally require a corresponding investment in the program offices. In addition to addressing many of the key science objectives of the current decadal survey, it will help to ensure that NASA will enter the following decade in a strong position in terms of technology and expertise.

Balloon-borne payloads—part of the NASA Suborbital program—are a key component in the invention of new detectors and methods, allowing low-cost development of components for future satellite missions. The EOS Panel recommends an *augmentation* of the Suborbital program, together with technology development to support CMB and other research programs that depend on invention, innovation, and experimentation. These activities deliver cutting-edge science while providing irreplaceable hands-on experience with technologies that are often destined for large space missions, training the next generation of instrument builders in the process. They are essential to the health of the NASA astrophysics program.

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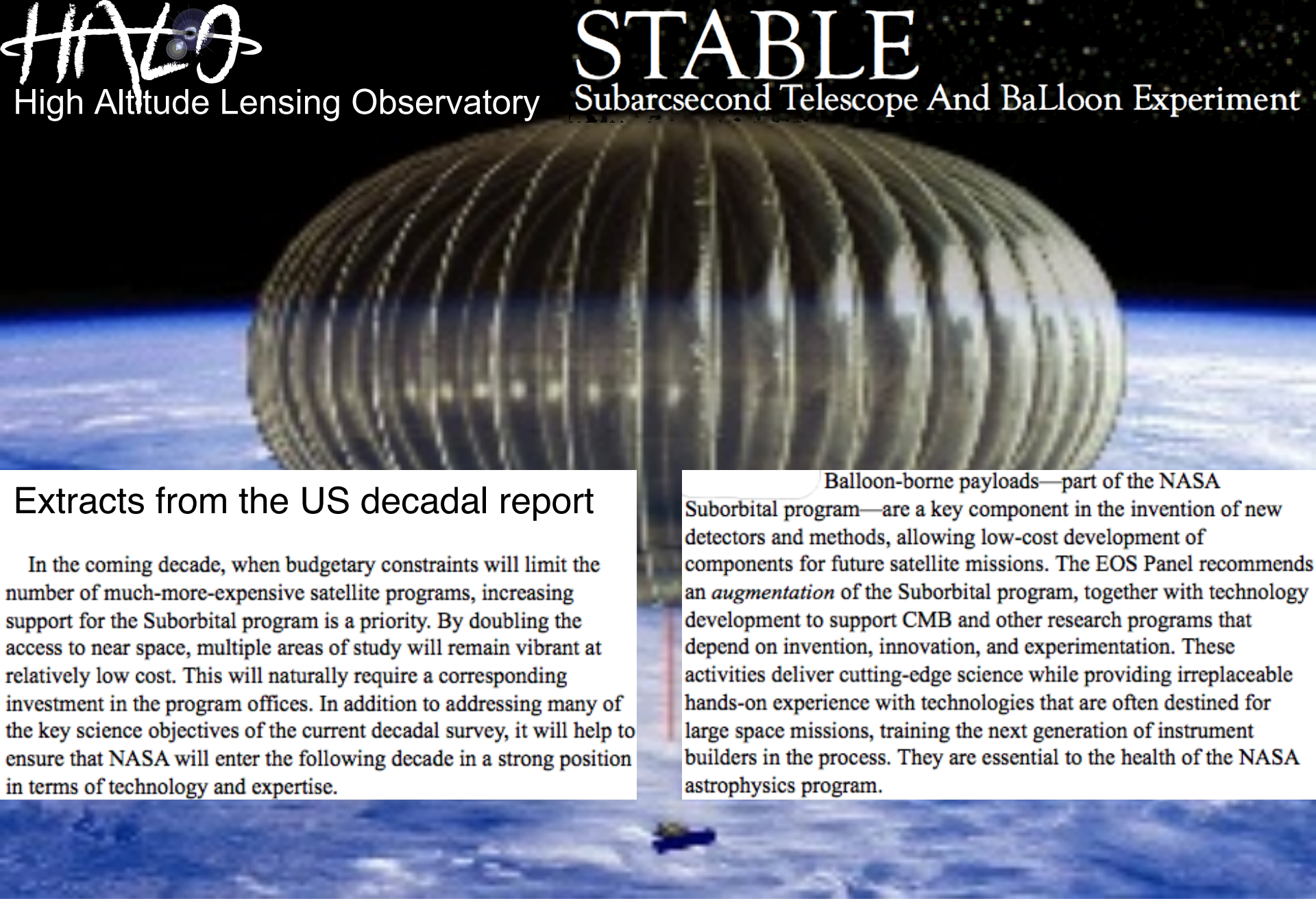
STABLE
Subarcsecond Telescope And BaLloon Experiment



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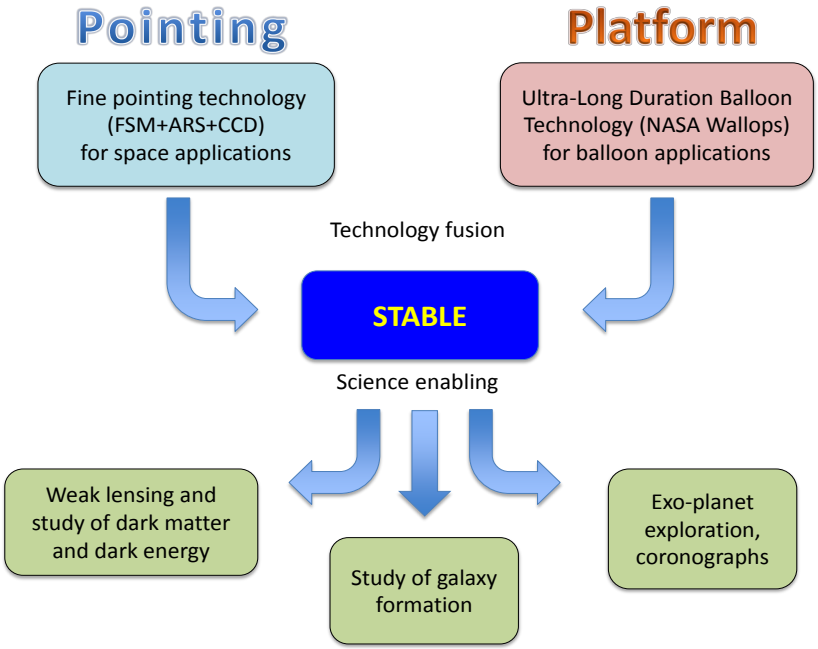
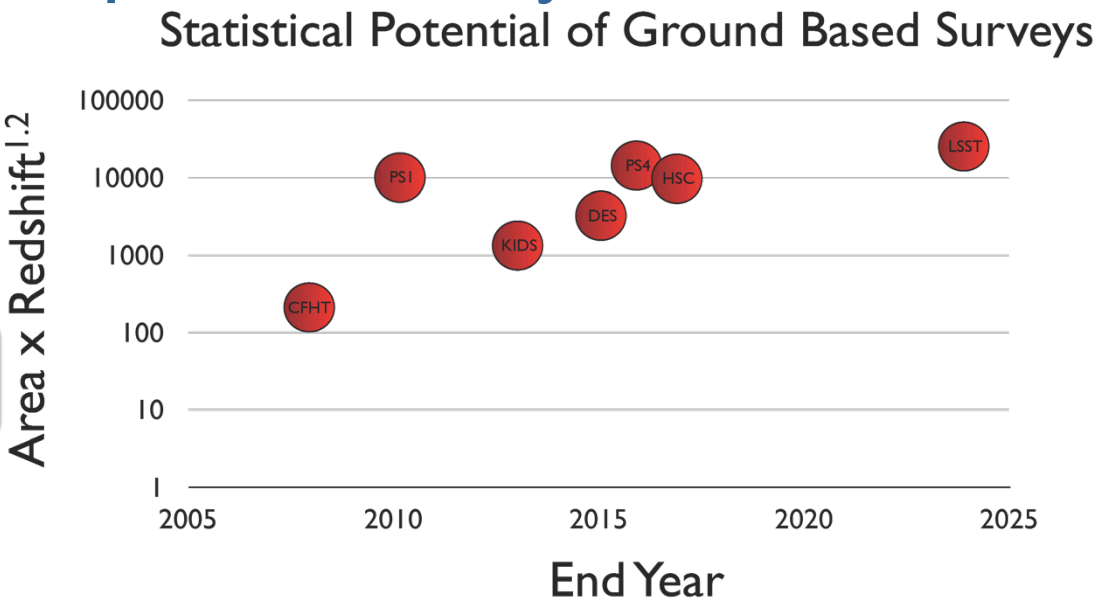
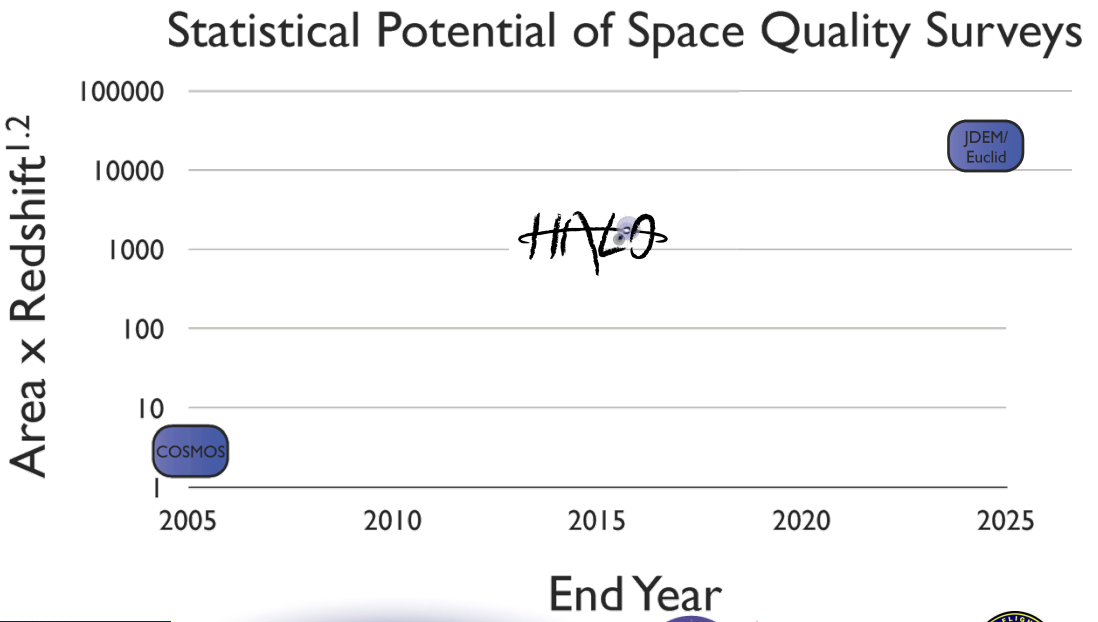
Filling a niche in large optical surveys







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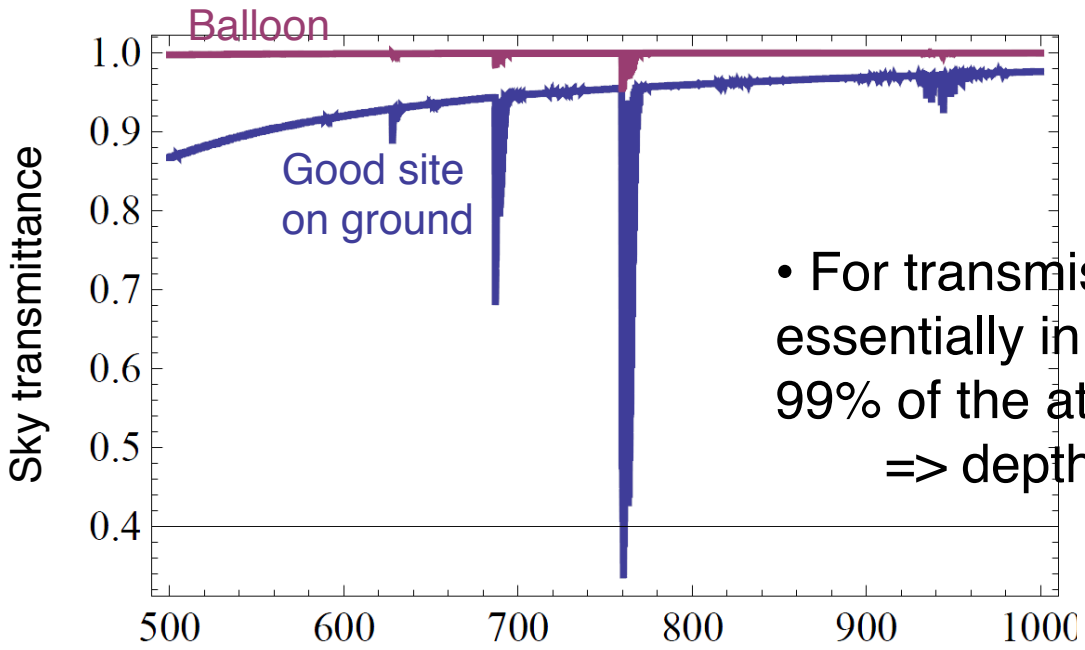
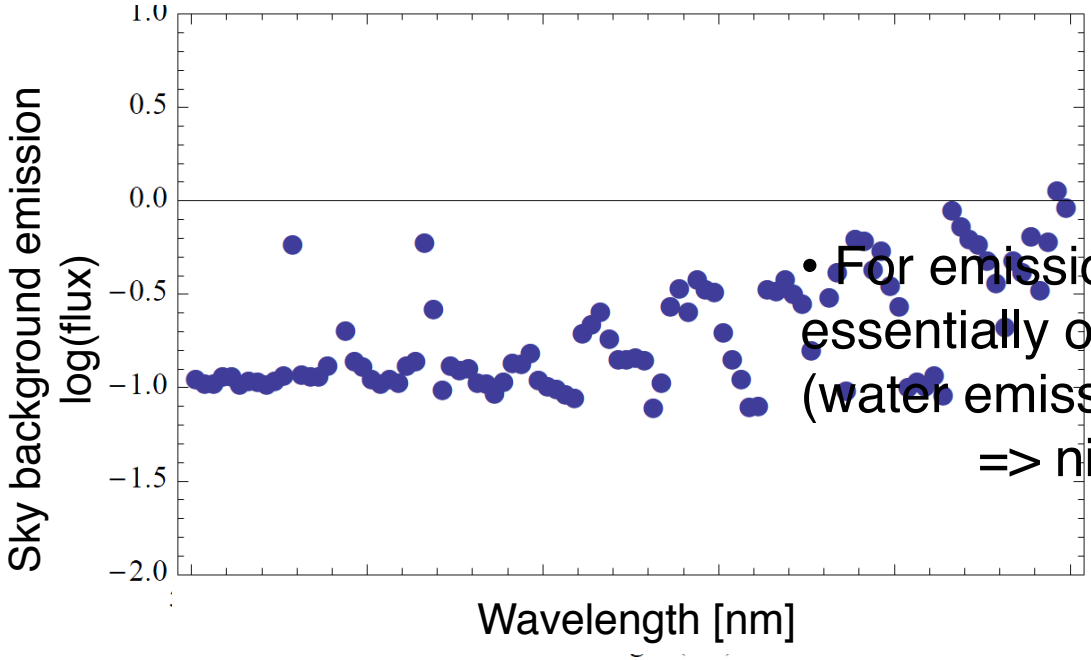
Other benefits of altitude





- For transmission, we are essentially in space (above 99% of the atmosphere)
  => depth and great seeing

- For emission we are essentially on the ground (water emission is at 90 km)
  => night time observing

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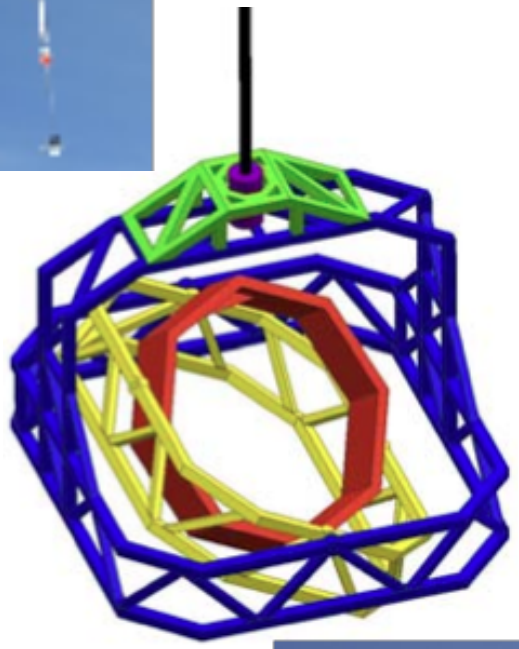
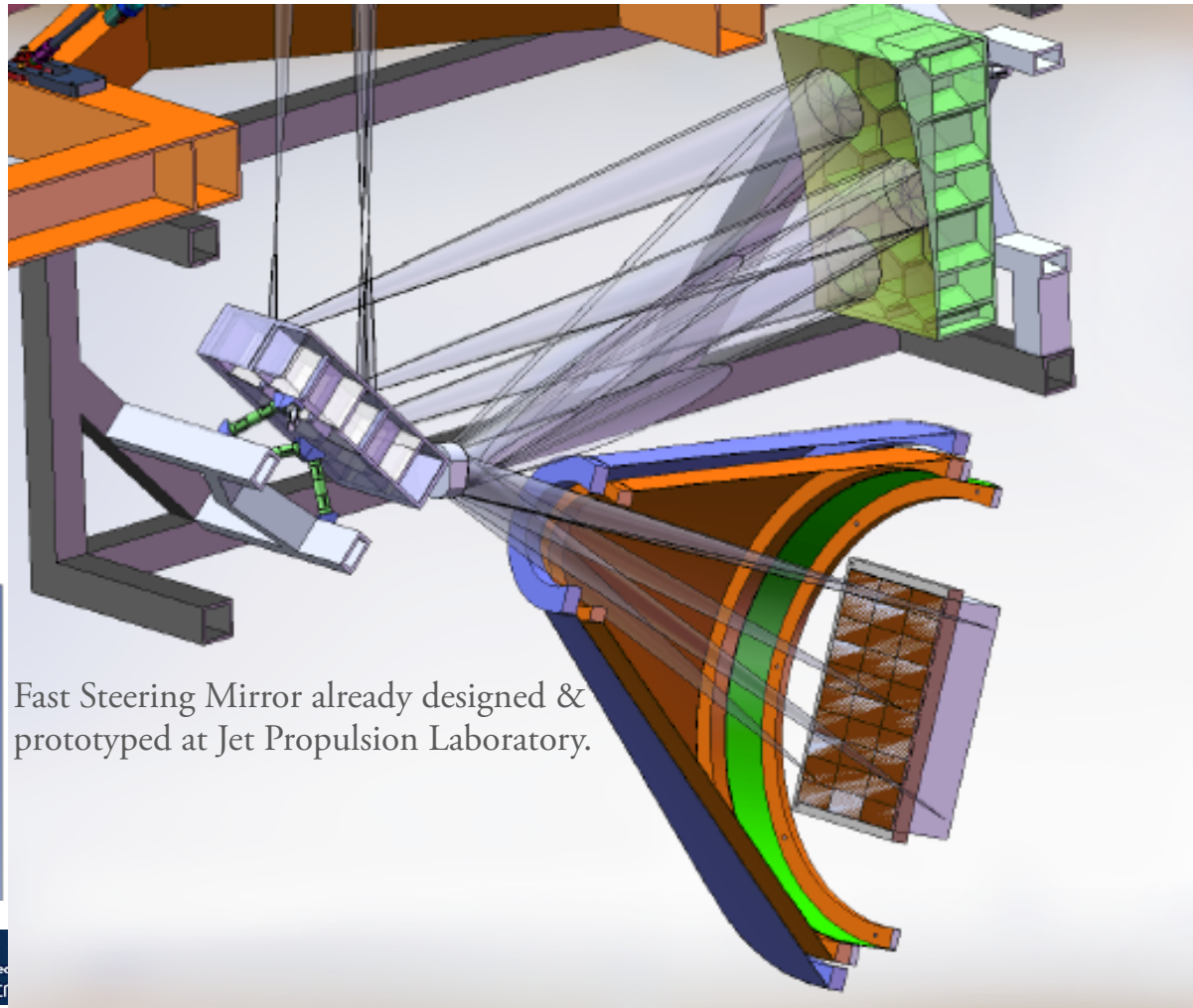
Pointing stability of 0.1” from a balloon?



Three-stage approach

- Passive damping of gondola ➔1’
- Nested telescope gimbals ➔ 1”
- Fast steering mirror in optics ➔ 0.1”



Fast Steering Mirror already designed & prototyped at Jet Propulsion Laboratory.

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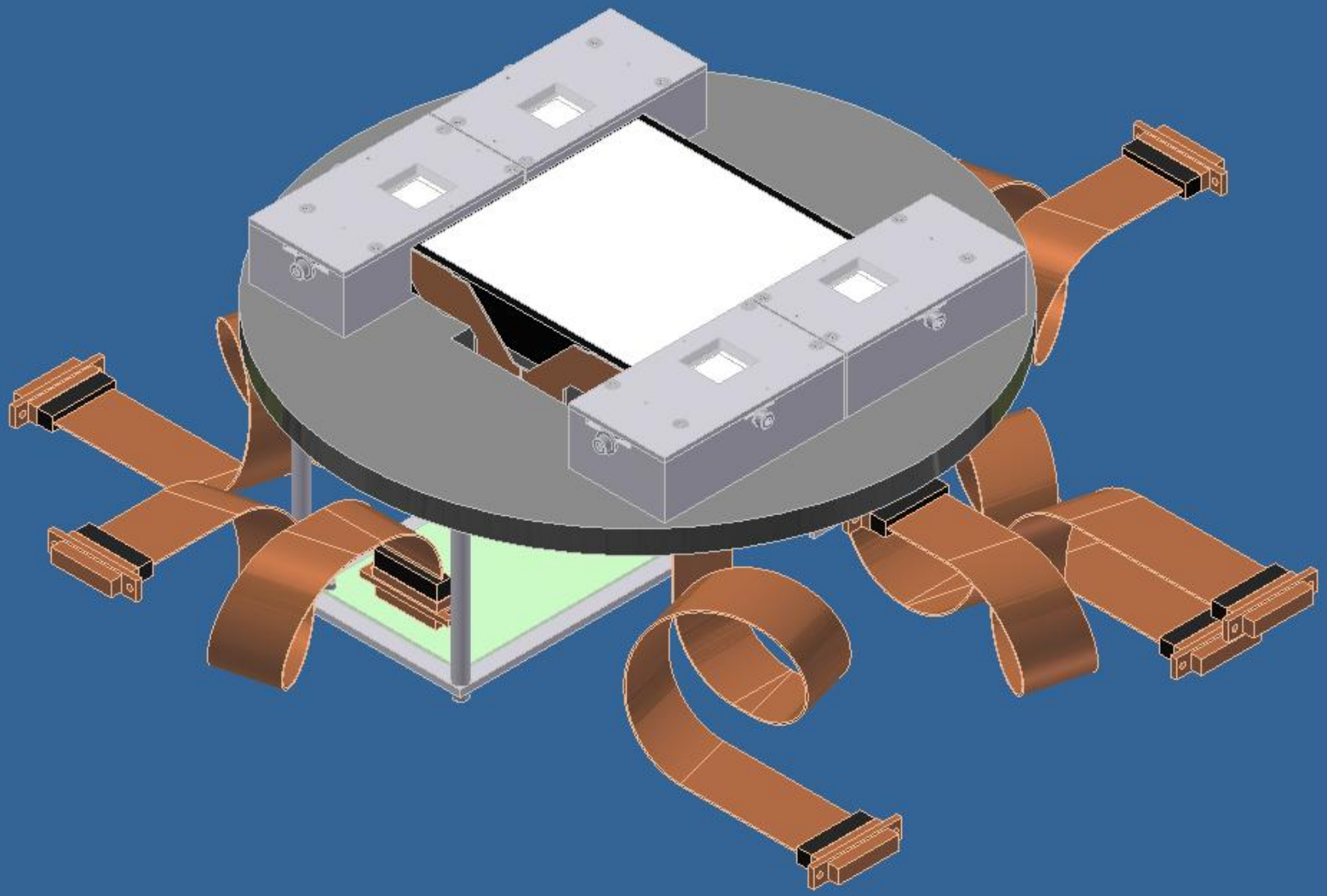
UK role: building optical camera (& DR pipeline)



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ULDB balloon-only test flight, Winter 2009

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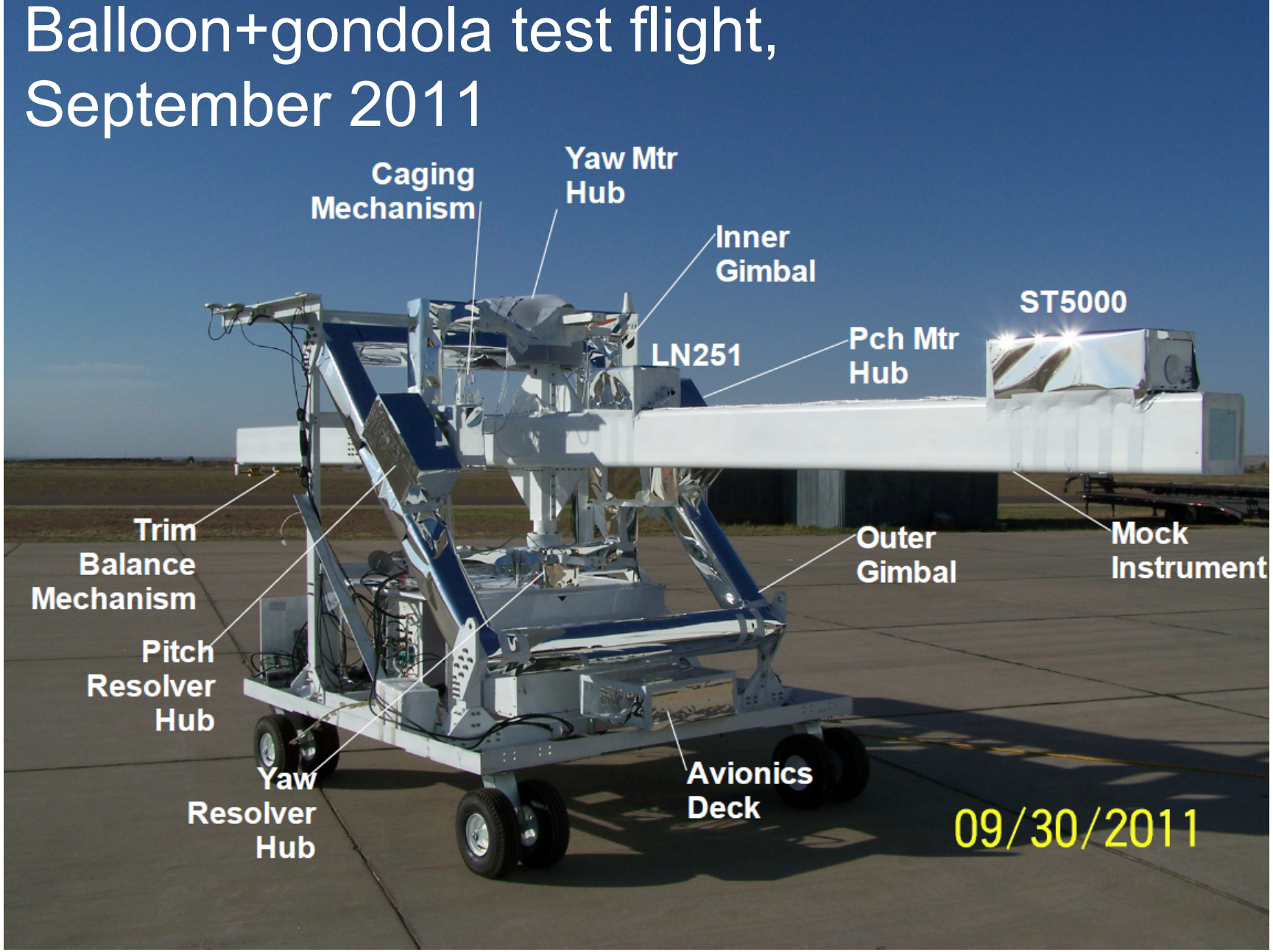
Balloon+gondola test flight, September 2011



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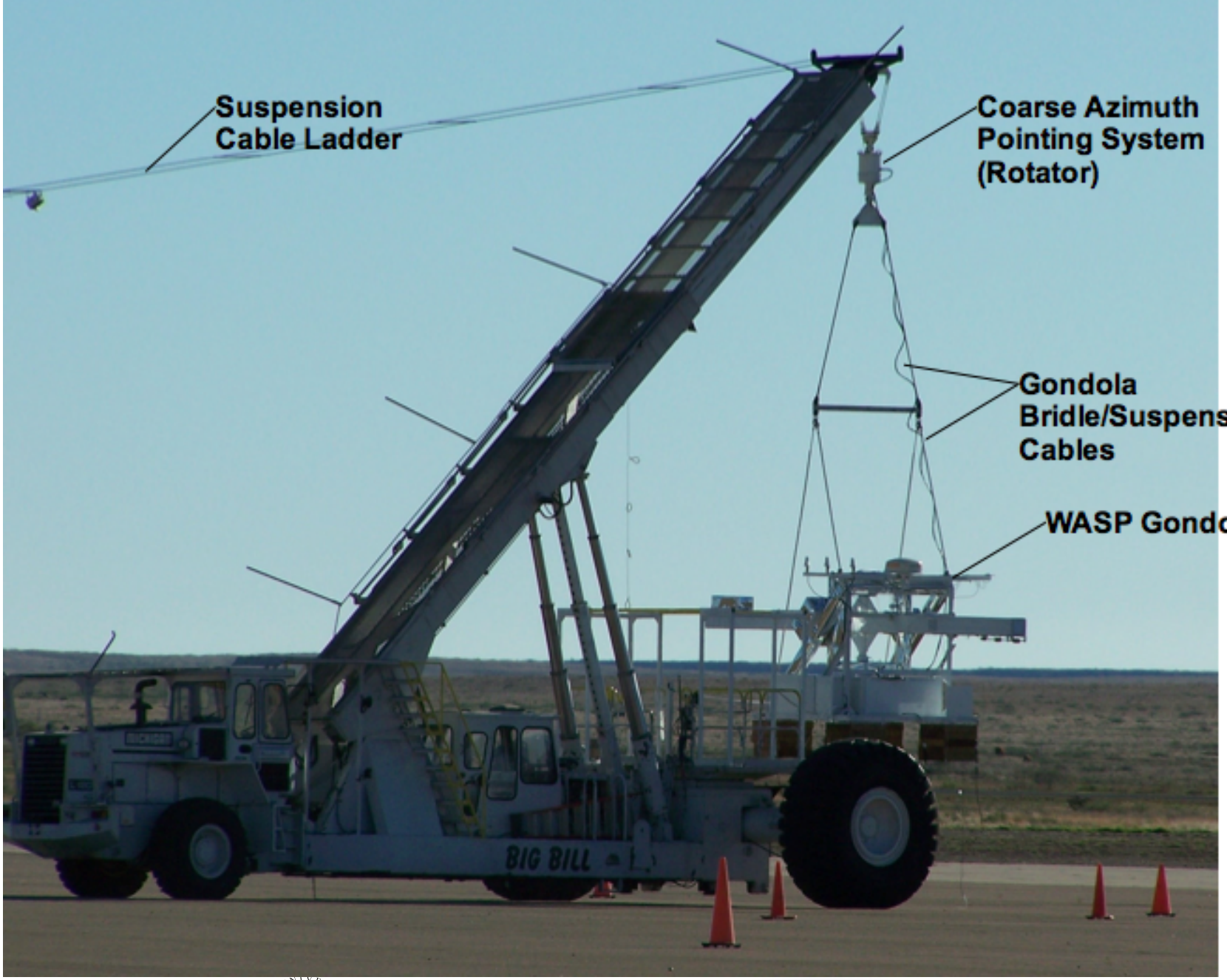

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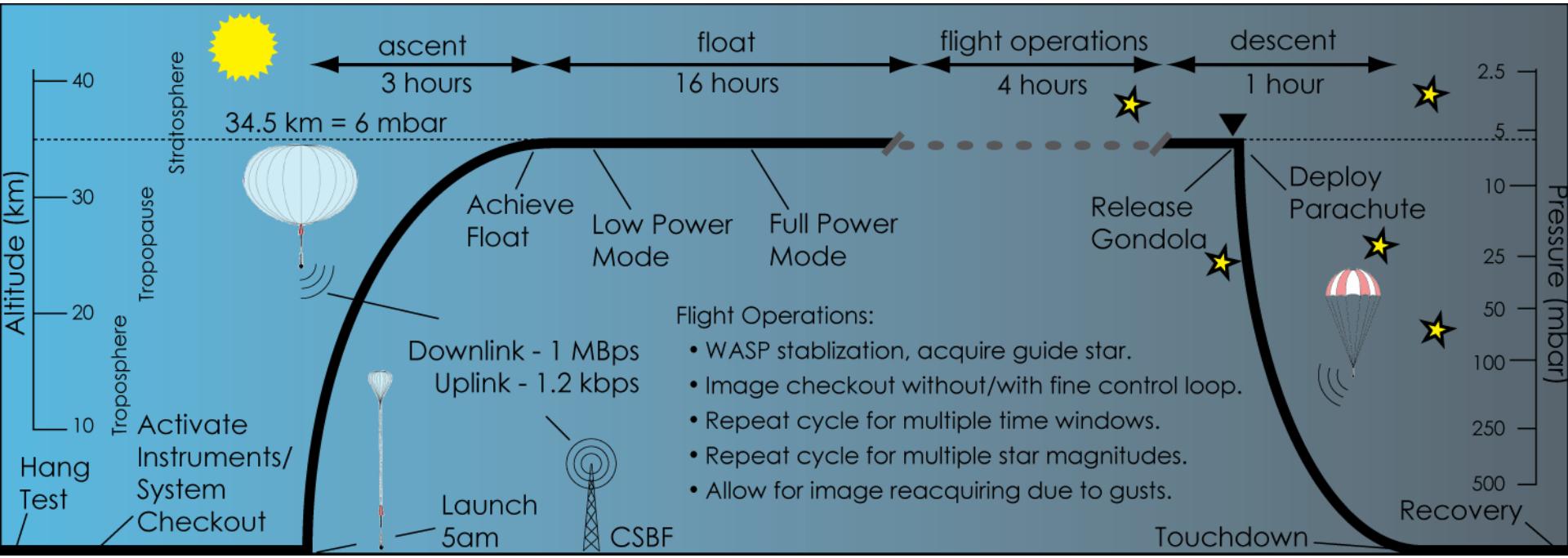
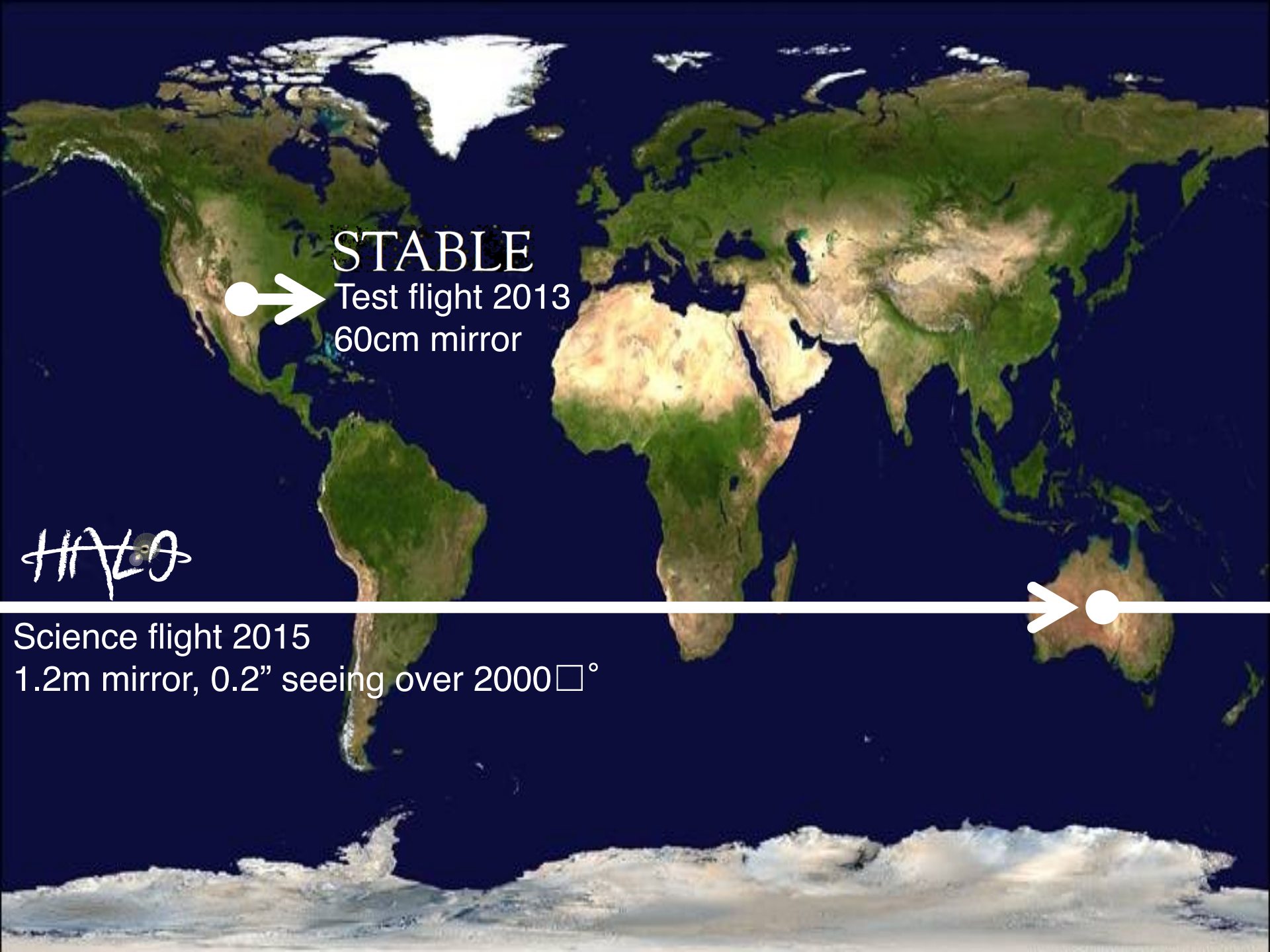
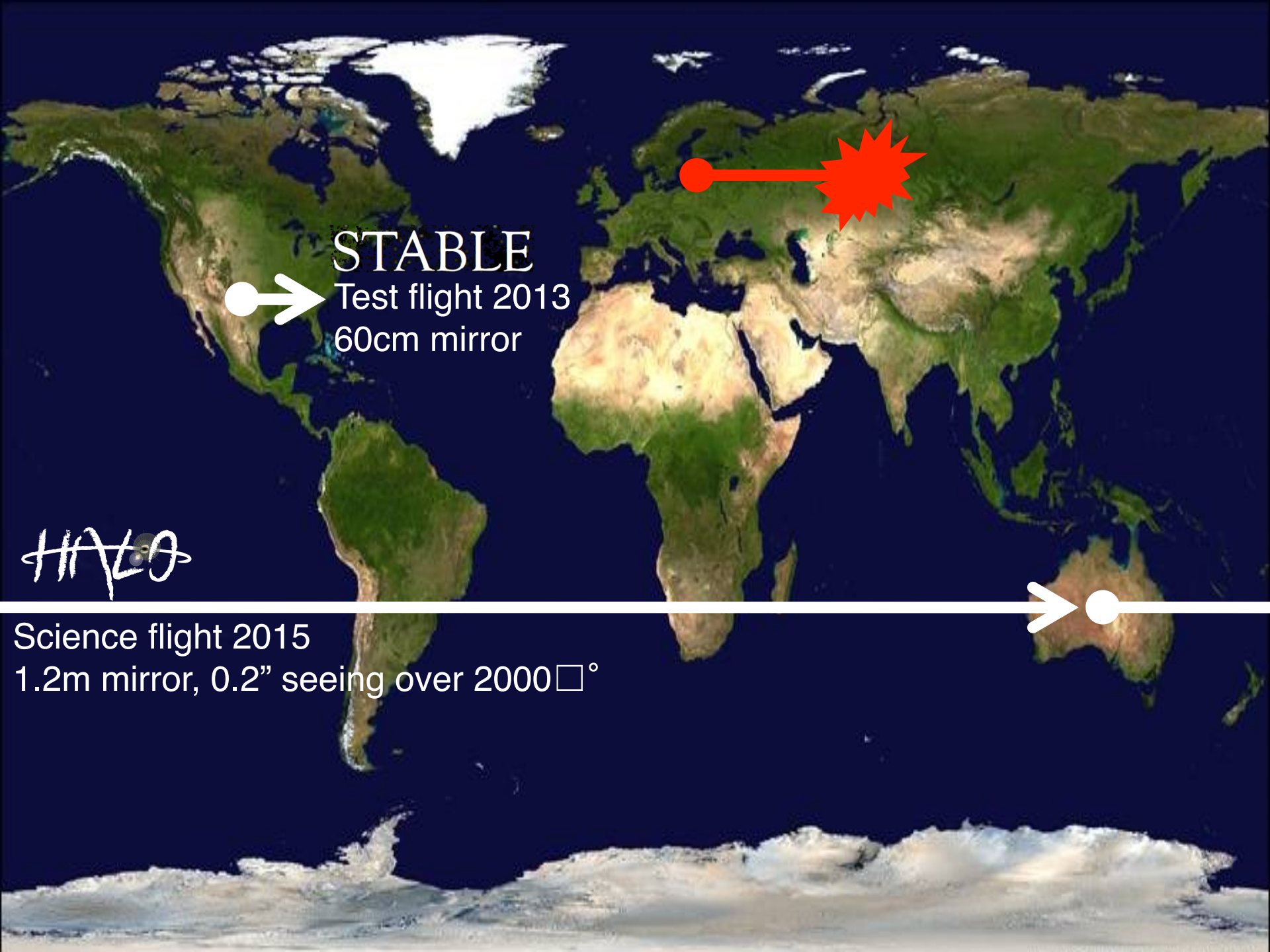
First full test flight plan, Scheduled for Autumn 2013

(if we hear positive news about funding in March)



60cm mirror, 0.1” stability, 0.4” seeing, nearby galaxy


STABLE
Test flight 2013
60cm mirror
HALO
Science flight 2015
1.2m mirror, 0.2” seeing over 2000□°


STABLE
Test flight 2013
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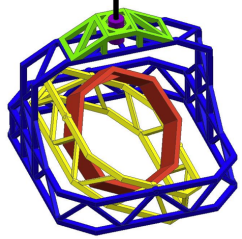
Control loop architechture

Disturbances

Gondola coarse pointing (<1 arcsec r.m.s.)

$q^{cmd}_{Gondola}$ → (−) → Gondola controller → Gondola gimbals → Balloon and gondola dynamics → $q^{actual}_{Gondola}$

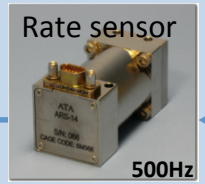


Balloon and gondola dynamics → Star tracker → Gondola Kalman filter

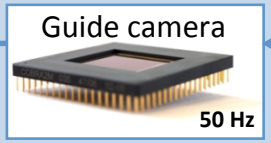
Balloon and gondola dynamics → Inertial Reference Unit → Gondola Kalman filter

Fine guidance signal 50 Hz

Telescope fine pointing (~0.065 arcsec r.m.s.)



Rate sensor → Telescope Kalman filter (500 Hz) → 50 Hz Low pass / Complementary filter / High pass 500 Hz



Guide camera → Telescope Kalman filter (500 Hz)

$q^{cmd}_{Telescope}$ → (−) → Fine Steering Mirror controller 500 Hz → Fine Steering Mirror

Fine Steering Mirror → $q^{actual}_{Telescope}$

$q^{actual}_{Telescope}$

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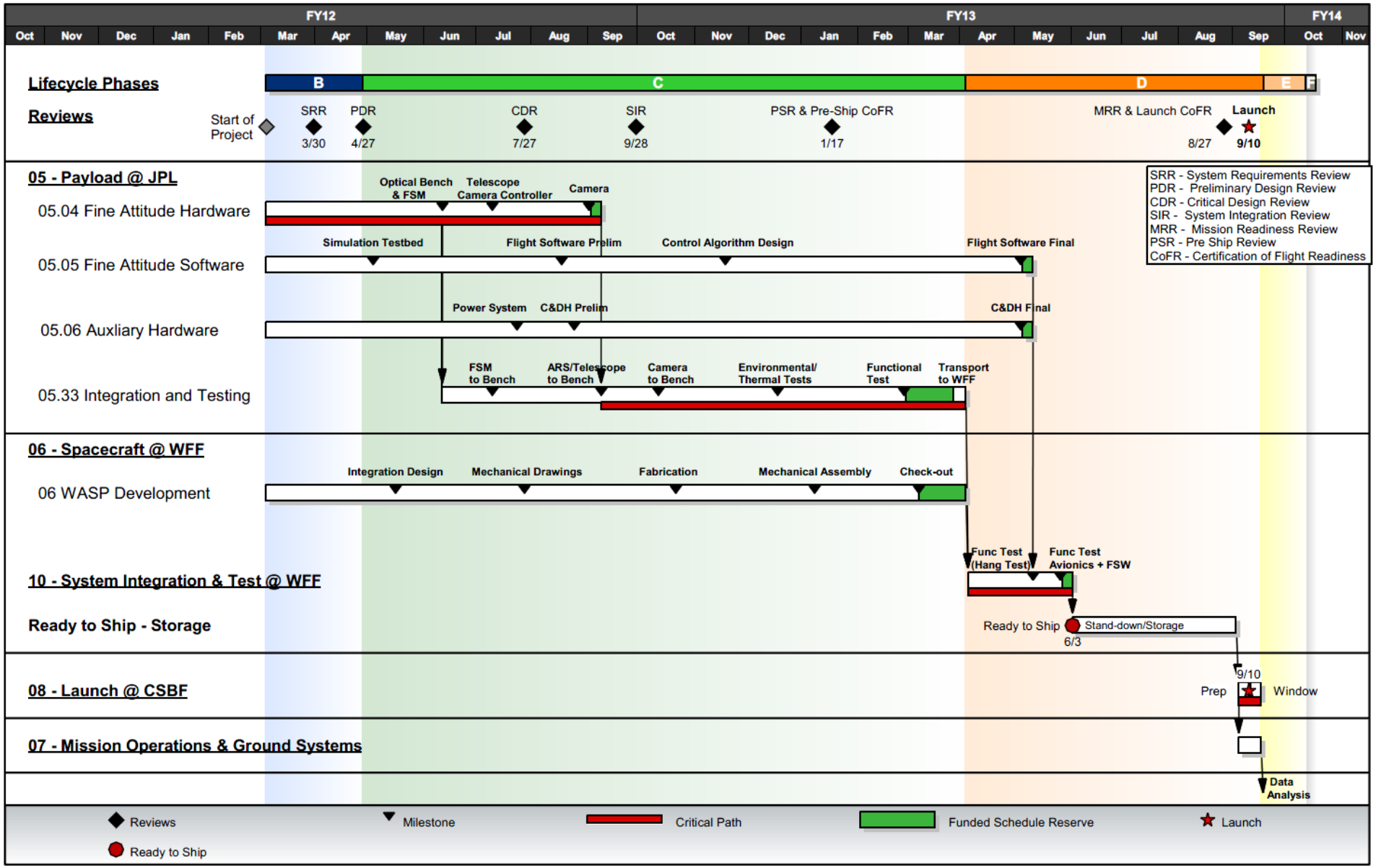
STABLE Top Level



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Filling a niche in large optical surveys

Telescope characteristics

- 1.2m primary mirror
- 48 2kx4k Hamamatsu CCDs (400 Mpix)
- 0.17” seeing (equal parts diffraction, jitter & charge diffusion)
- 0.11”/pixel (c.f. WFPC2 used 0.1”/pixel)
- Total payload mass 1000 kg
- Solar panel to recharge batteries during day
- Data stored on solid state hard drives, recovered at end of flight

Survey characteristics (for first flight)

- Fixed 500-720nm F606W filter
- Target DES fields for multicolour photometry
- Mag 24-24.5 (5 sigma point source) in stacked 1500s exposures
- 10 square degrees per night -> 1000 square degrees per flight
- We want to recover everything and fly again!

Timeline

- May 2009 – NASA/JPL funding acquired for stabilisation prototyping
- Mar 2010 – UK & European funding acquired
- Oct 2010 – NASA selected as “fundable” but congress delays US budget
- Feb 2011 – Construction of camera begins in UK
- Mar 2011 – Reproposal to NASA for US funding
- 2013 – System integration
- Early 2014 – Overnight Test Flight at Ft. Sumner, Texas
- 2015 – Science flight from Alice Springs, Australia

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