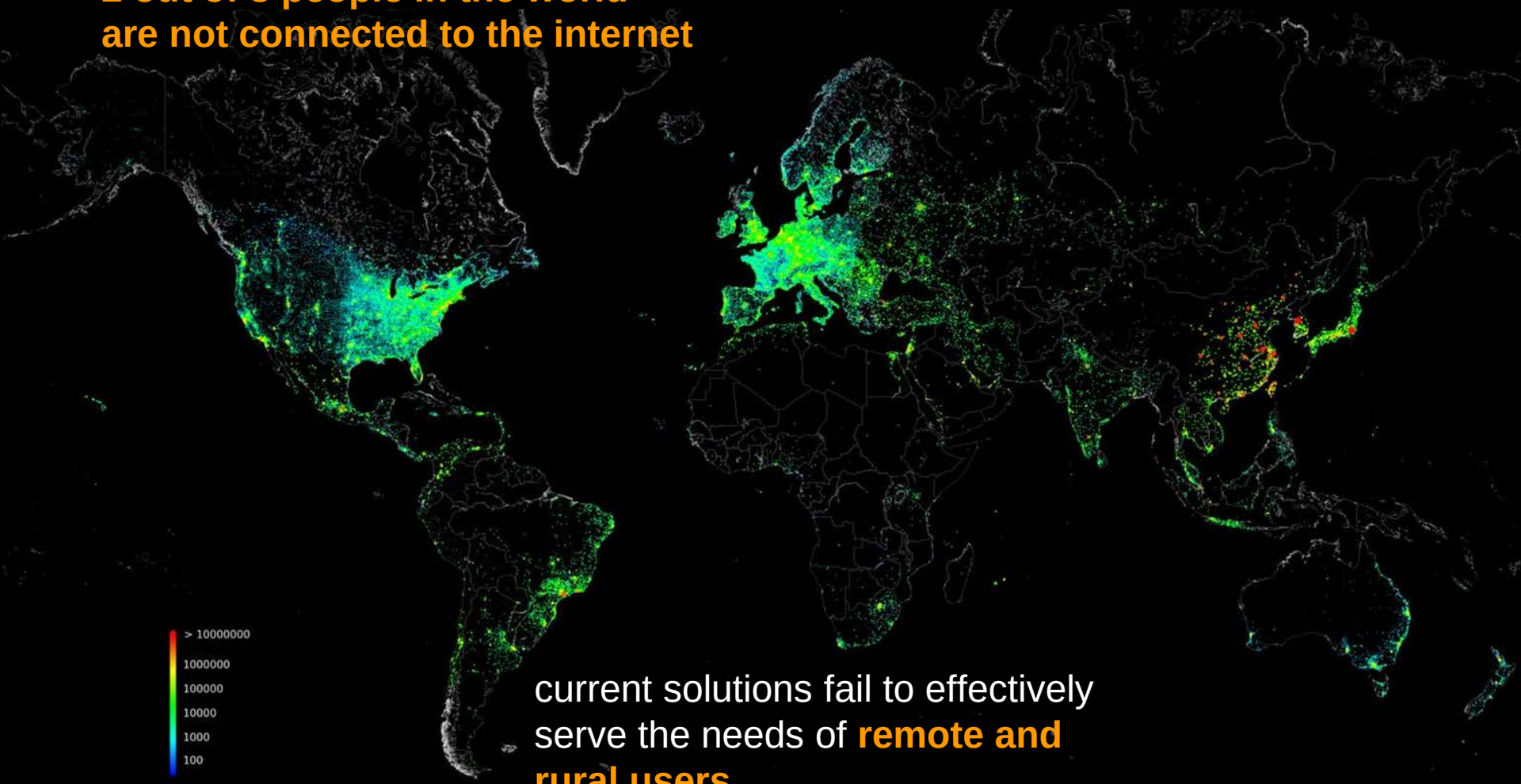
PROJECT LOON

FLIGHT OPERATIONS
INTRODUCTION
ICAO Air Navigation Commission

Access is a huge problem

2 out of 3 people in the world are not connected to the internet



current solutions fail to effectively serve the needs of **remote and rural users.**

Reachable IP addresses observed in 2012 using ICMP Ping requests and Port Scans (Carna Botnet)

Why does access matter ?

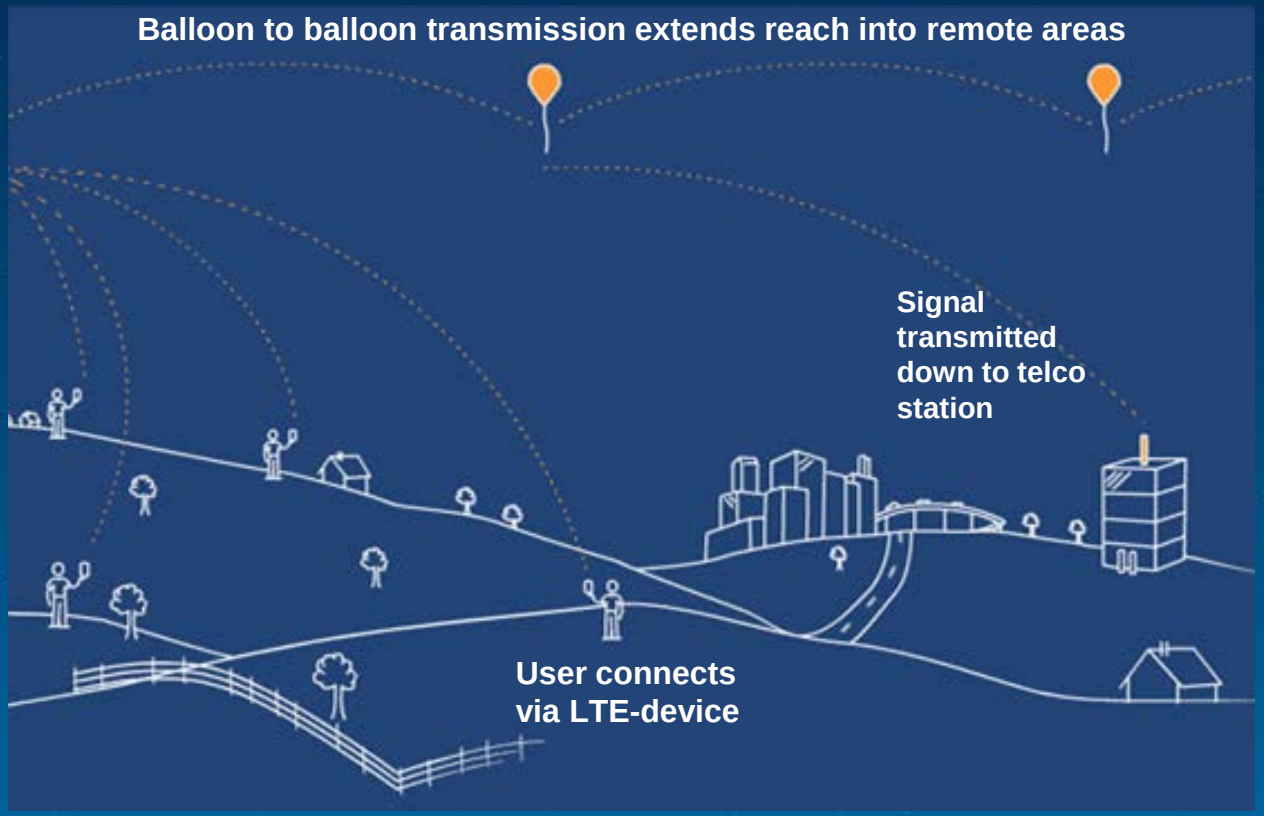
Access to information and resources afforded by the Internet has a demonstrably positive impact on people's lives:

- Increase **crop yields by 50%**
- Lift **160 million people** out of poverty
- Small and Medium-Sized businesses on the internet are **10% more productive** and grow up to twice as fast
- Access to relevant health information has the potential to save nearly **2.5 million lives**

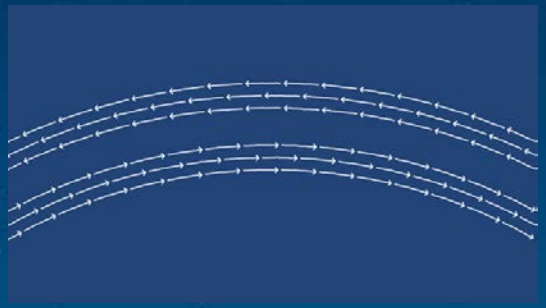
www.internet.org
www.mckinsey.com
www.deloitte.com

Our solution -- Project Loon

A network of stratospheric balloons that connect directly to user's mobile device via LTE

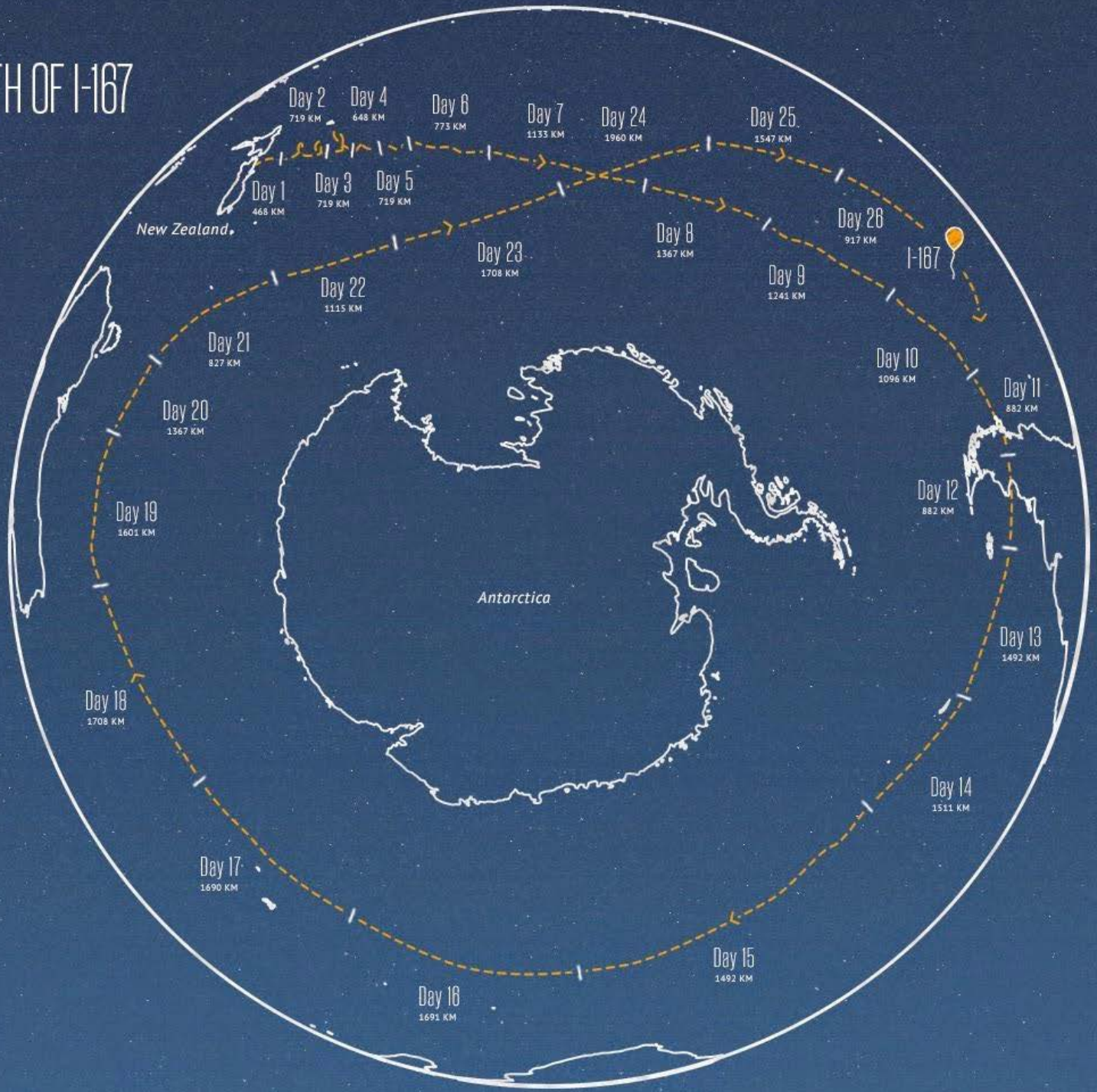


coordinated as a mesh to ensure continuous coverage



and navigates by catching currents at different altitudes

THE FLIGHT PATH OF I-167



Our goal is to build a fleet covering latitude bands

Balloons tend to circumnavigate, forming bands around the world.

NEXT PHASE OF OPERATIONS

Since 2013: New Zealand, Brazil

100+

1st user **WiFi connection** in New Zealand

First user **LTE connection** in rural Brazil

1 full day **continuous test coverage** in New Zealand

Maneuverability **accuracy** within 500m of targets

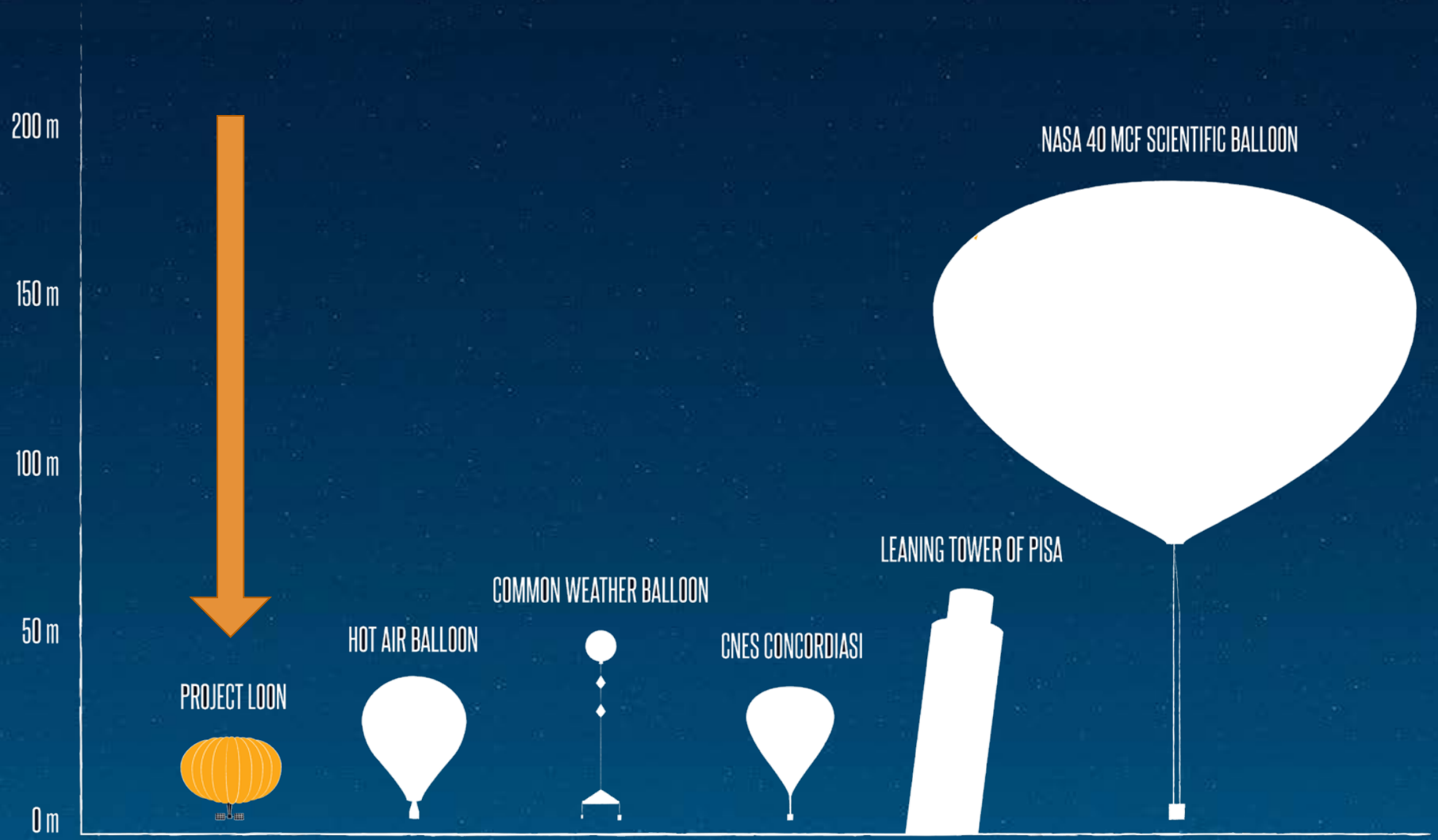
Switch to **700 MHz** which quadruples coverage area

JUN **2013** | MAY **2014** | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN **2015** | FEB | MAR

First successful **circumnavigation**

Launch operation capabilities scaled to 20 balloons/day

Loon balloon compared to other UFBs



Loon: general anatomy

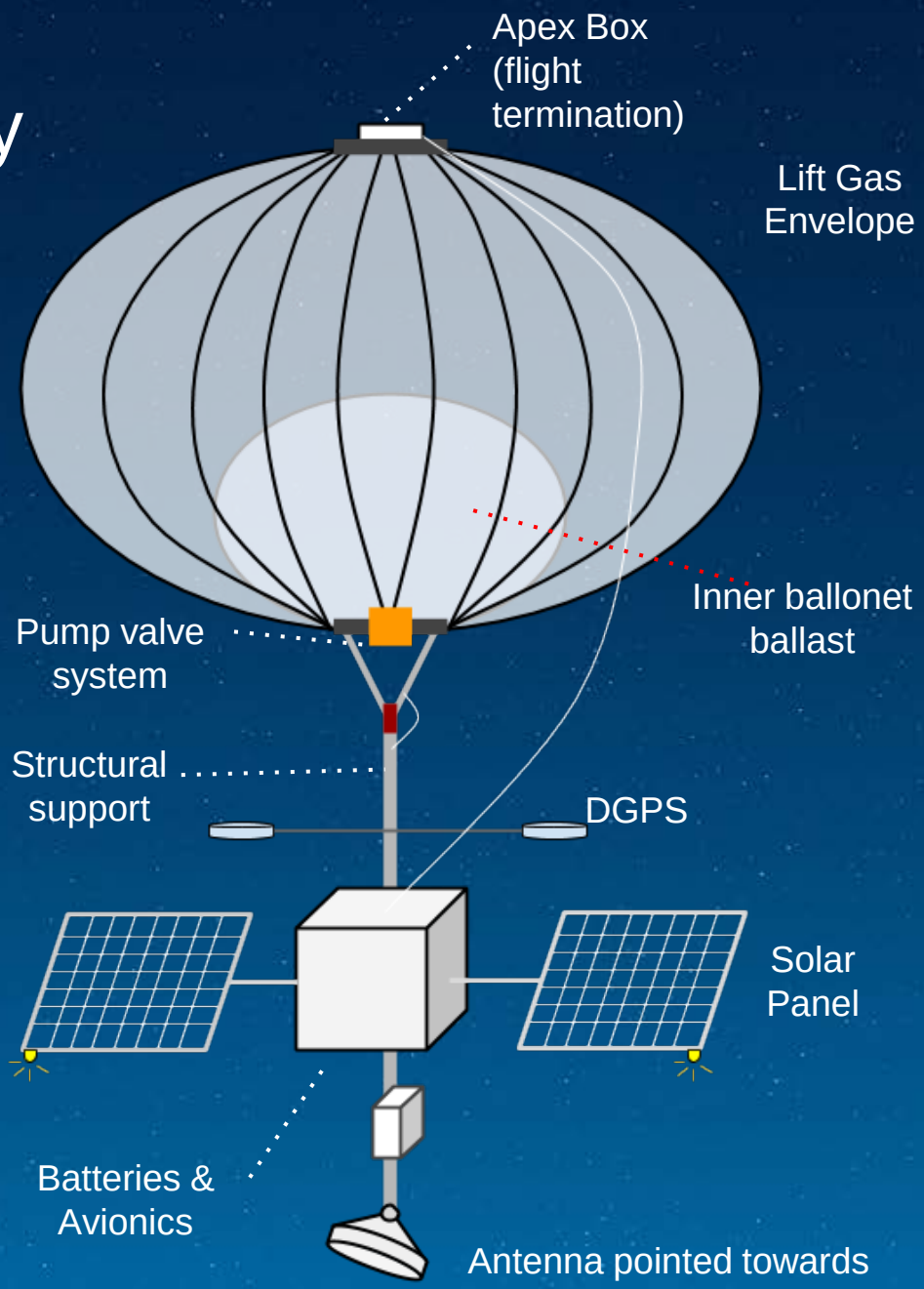
DIMENSIONS
Envelope - ~10m tall/15m wide at float
Flight System - ~45 kg carriage

POWER SYSTEM
Solar panels, batteries

AVIONICS SYSTEM
Transponder/ADS-B out, GPS + sensor state information, transmitted via Iridium

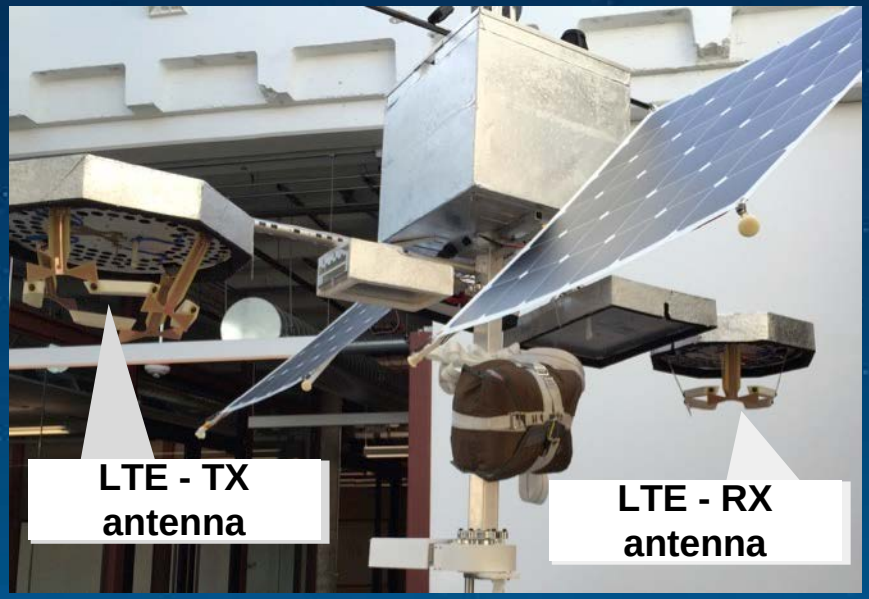
ALTITUDE CONTROL
Pumps and valves that enable the balloon to maneuver with the winds

DATA NETWORKING
Balloon-to-balloon and balloon-to-ground communications



NOT TO SCALE

Loon: Flight Systems



Safety features

WE COMPLY WITH OR EXCEED ALL HEAVY UFB REQUIREMENTS (ICAO Rules of the Air, Annex 2, Appendix 5)

VISIBILITY ELEMENTS

Triple Redundant Position Tracking

1. Transponder (ADS-B out with Mode A/C)
2. Web based GPS
3 Iridium triangulation

Radar Reflective Materials

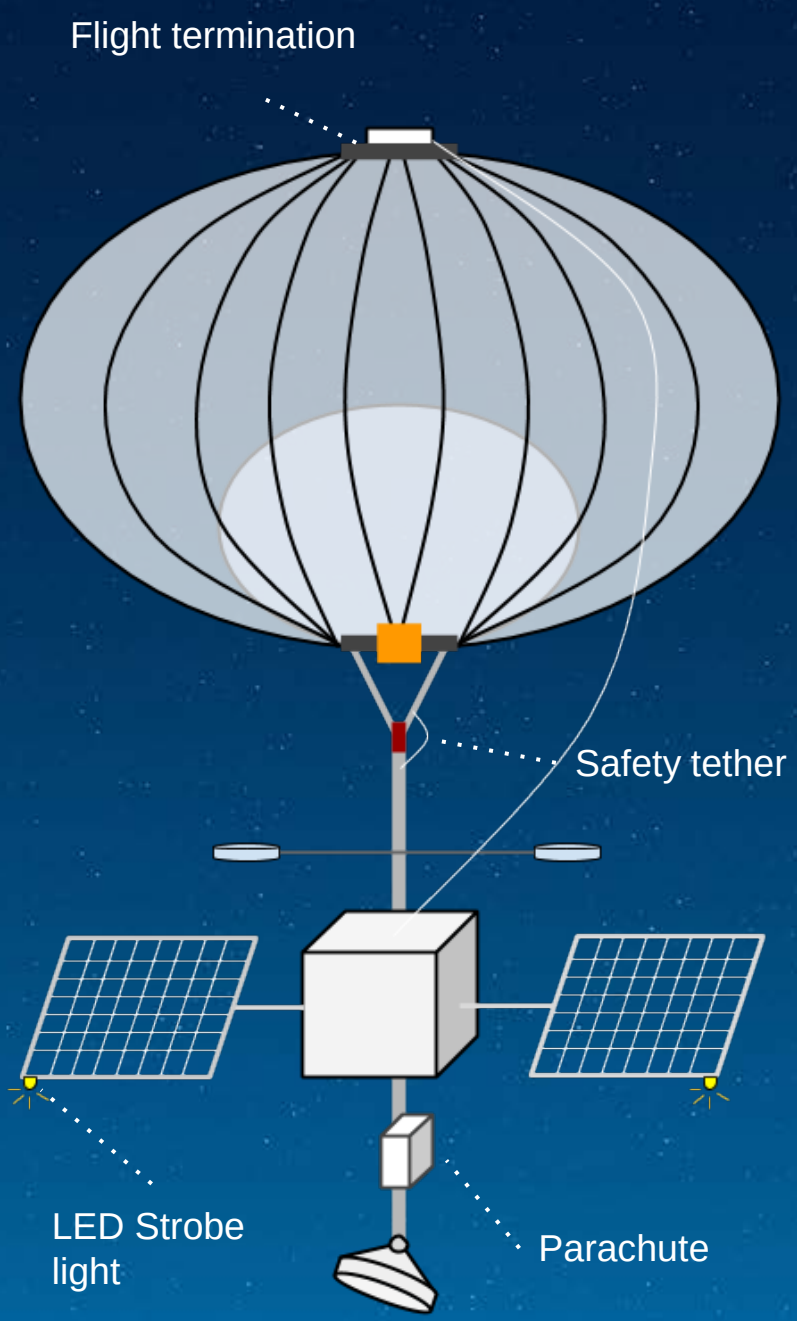
Omnidirectional light beacon (> 5NM vis.)

REDUNDANT FLIGHT TERMINATION

Soft Terminate (~90 minute descent time)
Slowly vents gas for gradual descent

Hard Terminate (~60 minute descent time)
Quickly vents gas for fast descent

THE PAYLOAD AND BALLOON STAY AS ONE



Managing the fleet : Mission Control

Actively monitoring and controlling a dynamic system

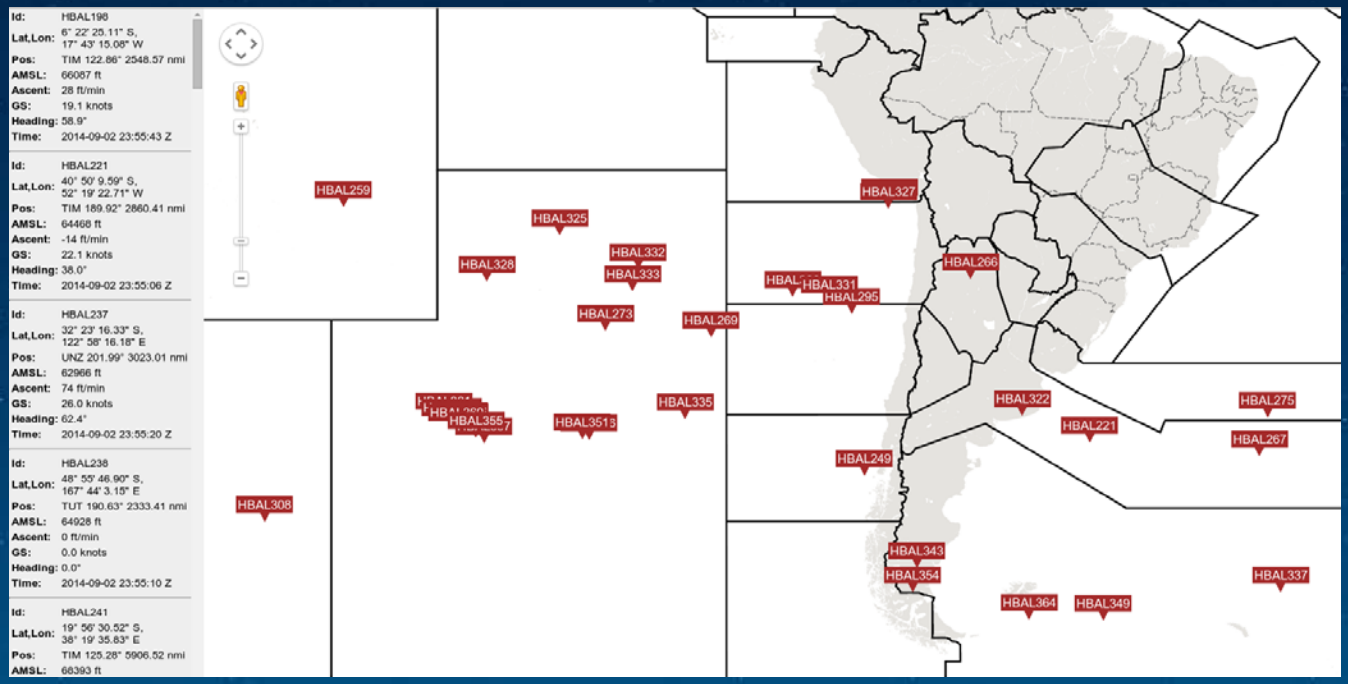
Flight operations team : Highly trained flight engineers on duty 24/7.

Command and control : For all flights possible with high frequency telemetry and system data.

Estimated Life Expectancy : Through multiple sensors, our flight systems constantly check indicators of balloon life (e.g., temperature and pressure).

Mission Control : In-flight tracking

We partner closely with Civil Aviation / Air Traffic Services globally



MISSION CONTROL TRACKING

Flight Engineers monitor flights at all times.

TRANSPONDERS: ADS-B Out with Mode C

WEB BASED TRACKING

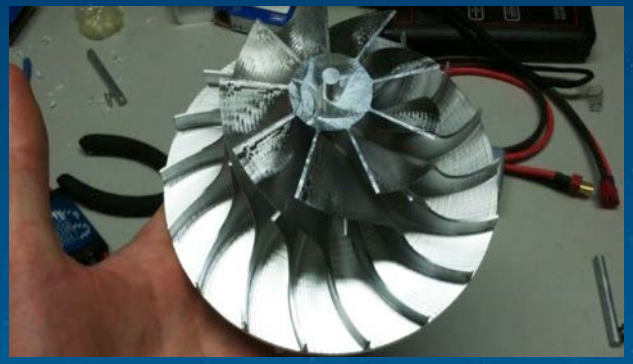
Basic flight information is shared with aviation agencies worldwide through aerostar-faa.com website.

MANEUVERING THE WINDS

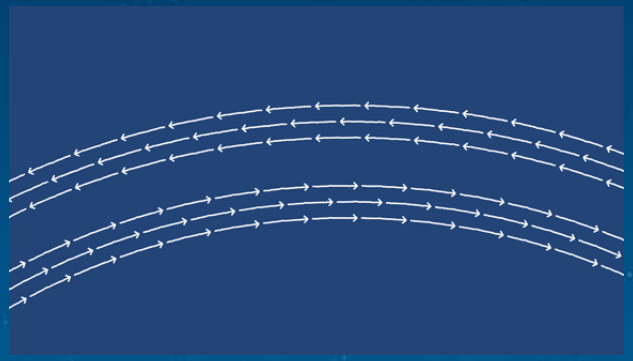
We use highly sophisticated data models and control algorithms to accurately steer Loon Balloons with the wind

We predict balloon trajectories with wind data + altitude models

We plan different trajectories based on our control capacity



Pumps and valves enable the balloon to change altitudes



We catch currents at different altitudes in real-time to navigate

Constant improvements to launch procedures

Transiting FIRs

Example operating procedure for coordination with ATCs

72 HOURS PRIOR

Flight plan to ATC in agreed upon format e.g. phone / email and then updated every 12 hours

1. Flight Identifier
2. Current Position
3. Approximate Entry Time
4. Approximate Entry Position
5. Balloon / payload description

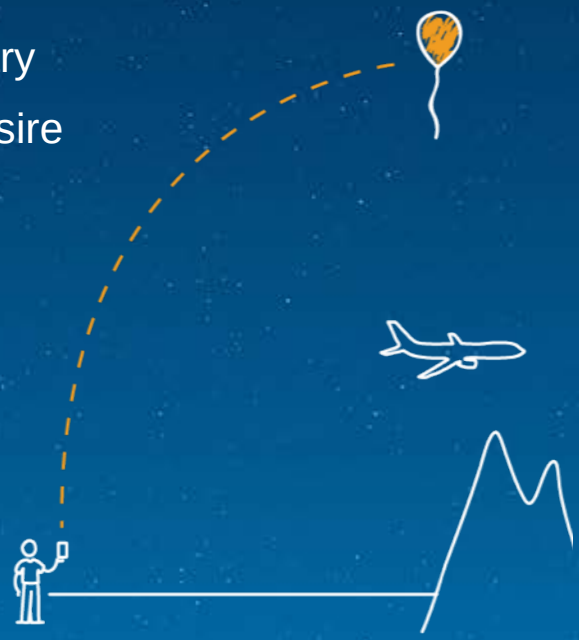
60 MINUTES PRIOR

50 km (approximately 60 minutes) prior to entry

1. Call affected FIR / ARTCC if they desire
2. Notify of any changes in flight plan
3. Provide additional info upon request

Transit occurs above 60,000 ft. In cases that we do transit below FL600, we coordinate with ATC.

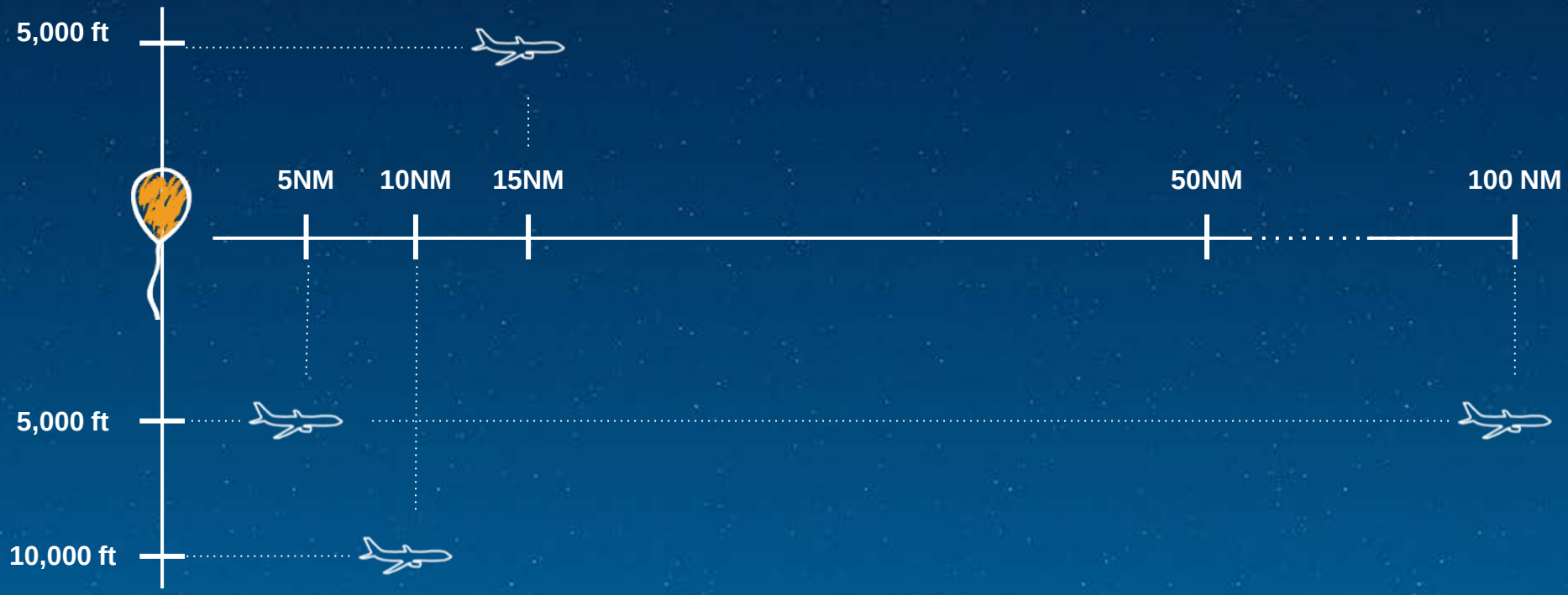
Able to tailor communications to ATC's requirements



Separation standards used currently

Often no lateral separation standards for flights above 60,000 ft

Below 60,000 ft : varies by country and airspace



Wide Spectrum of Separation Requirements Used Today

The journey moving forward

	FOCUS	LOCALE
NEXT THREE MONTHS	• Refining balloon / payload. • Continued improvement to automated steering of balloons.	• Continental US • Some international
THREE TO SIX MONTHS	• Mass production of balloons. • Polish operational procedures. • Telecommunications tests with local partners.	• Equatorial • Launched from US
SIX TO NINE+ MONTHS	• Refine automated controls. • Scaled operations.	• Equatorial • 20º N / S

Formalizing relationships with a focus on safe operations

BALLOON-POWERED INTERNET

Google