



# PROJECT LOON

ICAO Drone Enable  
Chengdu, September 2018

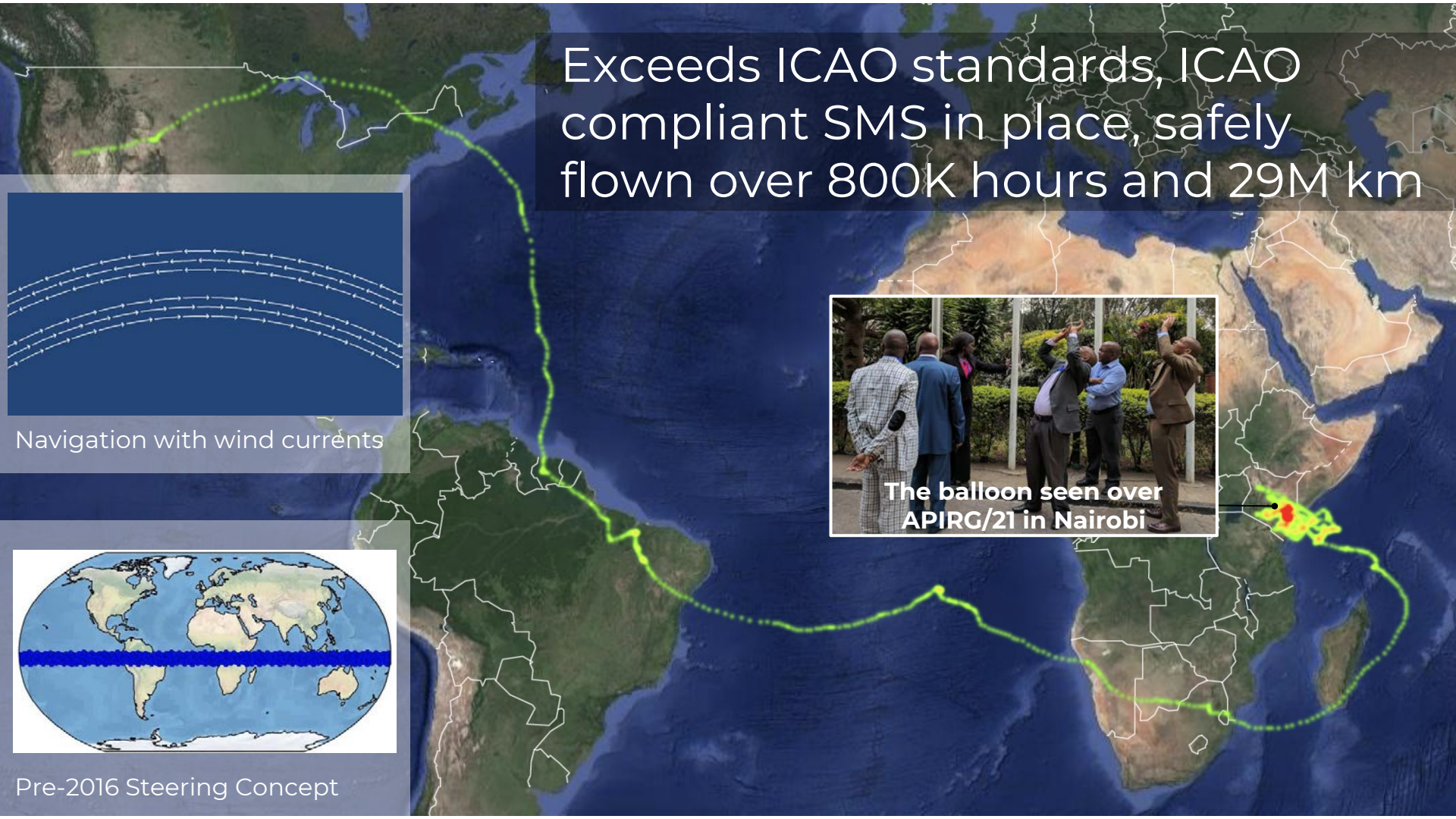
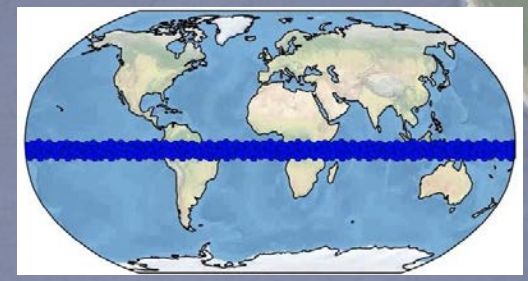
# Working with ICAO and industry, leading CONOPS for high altitude operations.

- AN-Conf/13 - Paper to be presented by ICAO secretariat on operations above FL600
- At GANIS/2 the industry indicated that they were working as a community to consider and propose solutions to potential risks and other issues.
- FAA planning to use Industry based cooperative separation.
- Working with industry to plan Initial Cooperative Upper “UTM” Operational testing.





Exceeds ICAO standards, ICAO compliant SMS in place, safely flown over 800K hours and 29M km



# Command and control of Loon's balloons

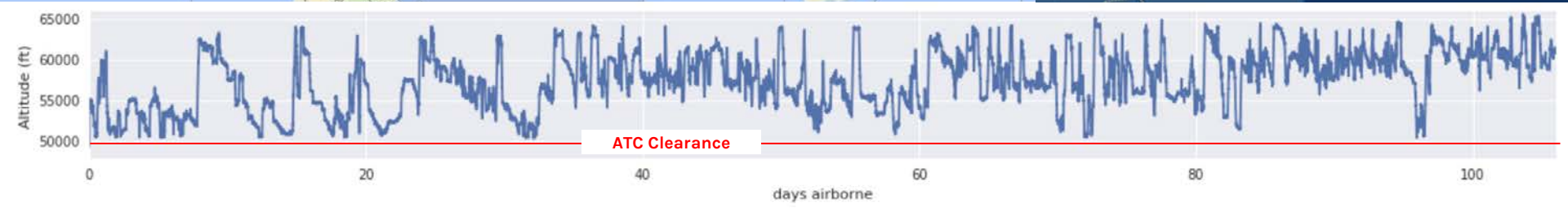
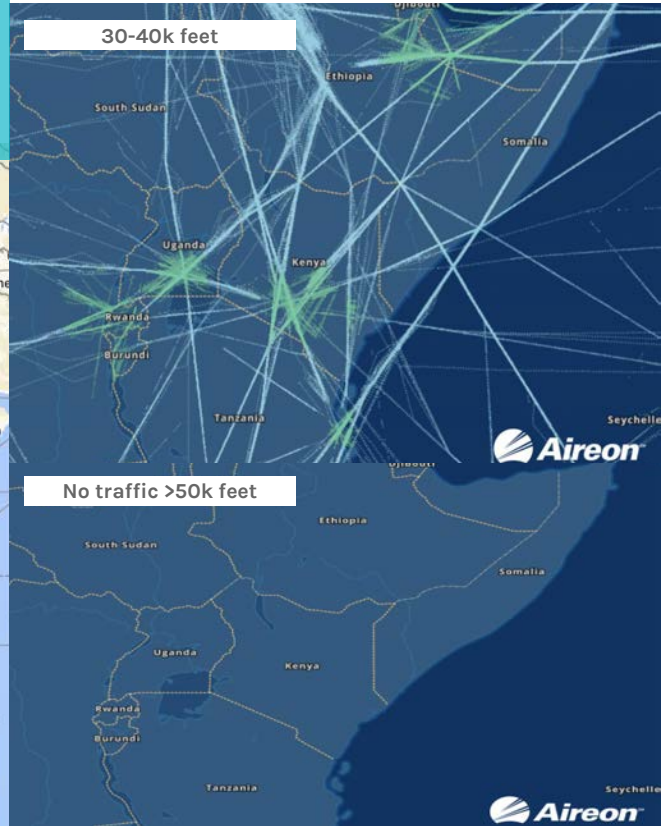
- **Redundant satellite communication** allow sending of commands / control of balloons
- **Automated** navigation algorithm
- **Full override / automation** constraint authority
- **Automated health monitoring and alerting system** to assist operators
- **Integrated NOTAM display and airspace activity** monitoring.
- **Trajectory simulation**

The screenshot displays the SmallWorld software interface, which is used for managing Loon balloons. The interface is divided into several sections:

- Top Bar:** Shows the application name "SmallWorld", a "Dashboard" menu, and a user profile for "ngdon".
- Left Panel:** Contains flight data for a specific balloon (P-180) and a checklist. The flight data includes:
  - Time: 06-11 21:53:49 WET
  - Flight UID: 5a8e2995-0000-2200-806f-001a1139136a
  - Subnet IP: 2607:8780:1e8:c018::
  - Baro Pressure: 8369Pa
  - GPS Alt: 17665m (57956ft) [amsl]
  - Transp Alt: 17324m (56837ft) [amsl]
  - AGL Elevation: 17540m (57545ft) [agl]
  - Lat, Lon: -1.5958, -55.4782
  - DMS: 1° 35' 44.85" S, 55° 28' 41.56" W
  - DPS Pres.: 1273 Pa.
  - Heading: 245.45°
  - Ground Speed: 3.71m/s (7.22knots)
  - Ascent: 0.07m/s
  - OneConfig: link
  - Stats: link
  - Flight Controller: CartoSeeker
  - Map: catacaos\_osprey\_no\_fly\_no\_weath
  - Altitude Range: 6247 - 11297 Pa.The checklist includes a "Report new issue" button and a "Time" field.
- Center Panel:** A "Console P-180" window showing a list of commands and their responses. The commands are categorized by time and include status checks and configuration updates. For example:
  - 06-11 21:48:09 WET 4E loon-automation: ✓ acs configure 100 0.20 100 false 134674 136957
  - 06-11 21:40:01 WET 4D loon-automation: ✓ acs configure 100 0.20 100 false 133498 135781
  - 06-11 21:29:58 WET 4C loon-automation: ✓ acs configure 100 0.20 100 false 132022 134305
  - 06-11 21:28:57 WET 4B loon-automation: ✓ acs configure 100 0.20 100 false 131865 134148
  - 06-11 21:17:54 WET 4A loon-automation: ✓ acs configure 100 0.20 100 false 130226 132509
  - 06-11 21:06:49 WET 49 loon-automation: ✓ acs configure 100 0.20 100 false 128571 130854
  - 06-11 20:56:44 WET 48 loon-automation: ✓ acs configure 100 0.20 100 false 127068 129351
  - 06-11 20:46:44 WET 47 loon-automation: ✓ acs configure 100 0.20 100 false 125564 127847
  - 06-11 20:36:40 WET 46 loon-automation: ✓ acs configure 100 0.20 100 false 124055 126338
  - 06-11 20:34:53 WET 45 loon-automation: ✓ acs configure 100 0.20 100 false 122745 125025
- Right Panel:** A map of East Africa and the surrounding region, showing the flight paths of multiple balloons. A specific balloon, P-018, is highlighted with a blue circle and a label: "1 Balloon P-018 66450 ft 1076". The map includes labels for countries like Sudan, Ethiopia, Kenya, Tanzania, and Mozambique, as well as major cities like Khartoum, Juba, Kampala, Nairobi, and Harare.



# Always above traffic and clearance



# Precise altitude control and monitoring

- Adjustable ATC clearance entered by Mission control operators.
- **Mission Control sound alert** when balloon approaches 300ft of clearance
- **Reactive onboard altitude control system** corrects altitude deviation to maintain 100Pa tolerance (180ft at FL500)
- Balloons will not attempt to approach clearance by more than 500 ft
- Ballast system to maintain altitude

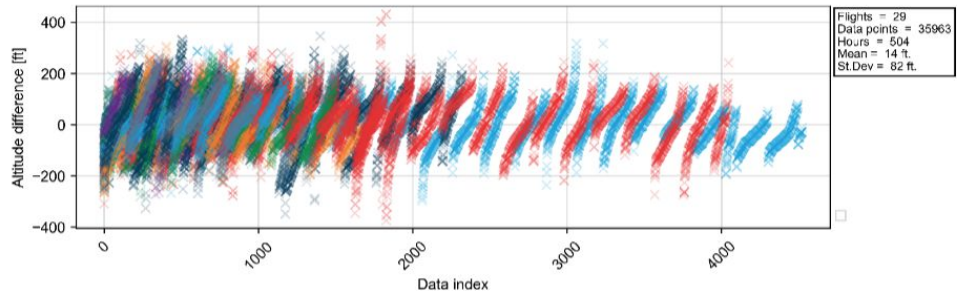


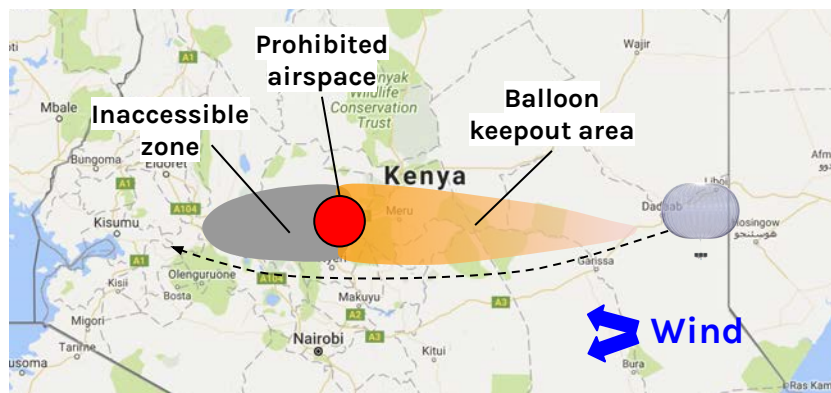
Figure 8: Example of altitudes and the difference between set and actual altitude for 29 flights and 504 hours of data. The mean variation from the set altitude was 14 ft, with a standard deviation of 82 ft. This figure demonstrates that a significant set of HABEOs were obtained where the balloon was attempting to maintain an altitude. It also demonstrates the height keeping ability of each flight to be within +/- 400 ft.

# Automated airspace avoidance

## Vertical Avoidance

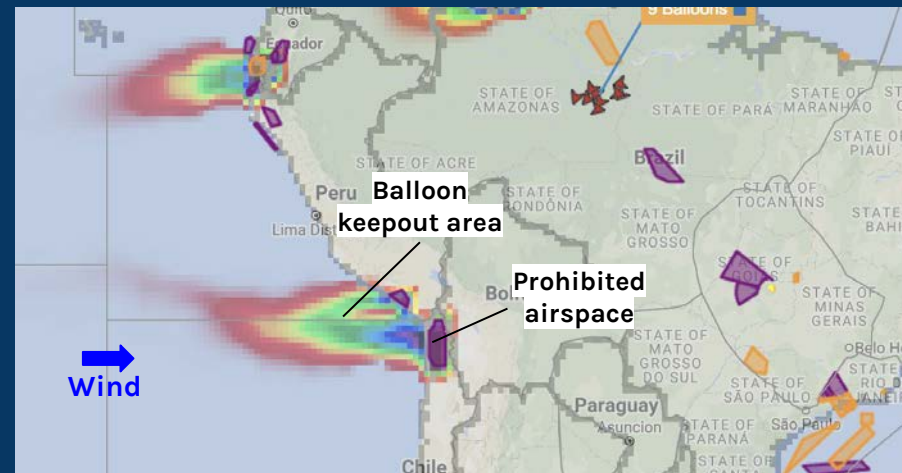


## Horizontal Avoidance



Certain wind conditions, may create extremely large keepout areas that prevent reliable internet service, when certain zones cannot be overflown.

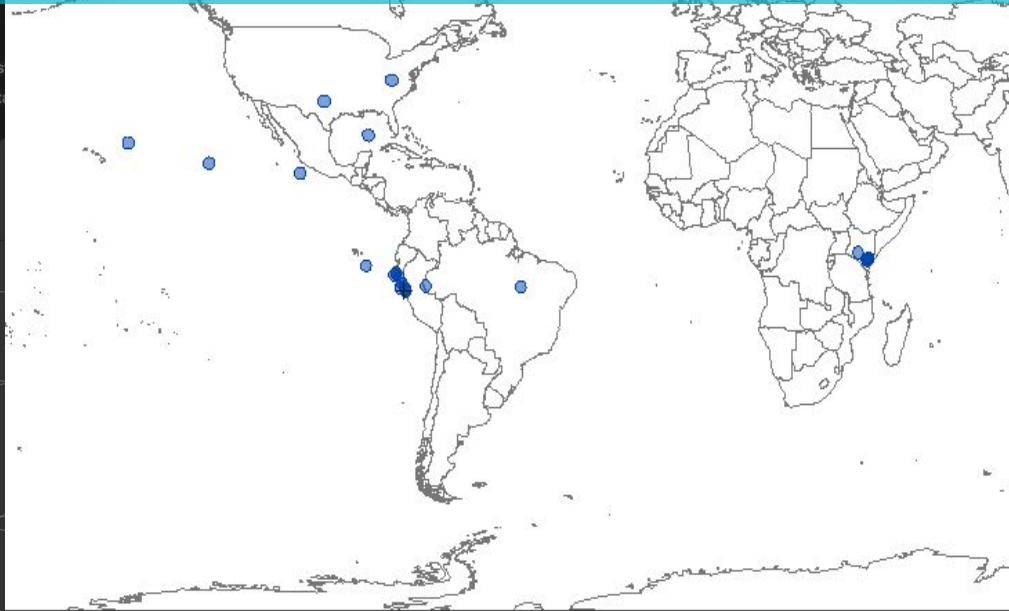
Vertical avoidance is always preferred if possible.



In many countries, Loon Mission Control coordinates directly with Military authorities and POC for efficient operations



# Minimal to no additional workload for ATC



Actual trajectories since Sept 2017

2017-08-25 19:35

- Loon manages balloon to balloon separation (balloons can be close to each other due to 0 true air speed)
- Always above traffic and will not interfere with it.
- Radar clutter and noisy proximity alert can be prevented by **filtering high altitude traffic (or balloon transponders)**
- Single transponder code usually preferred by ANSPs for easy management, identification and filtering.