

WAVE RIDING INTO THE STRATOSPHERE

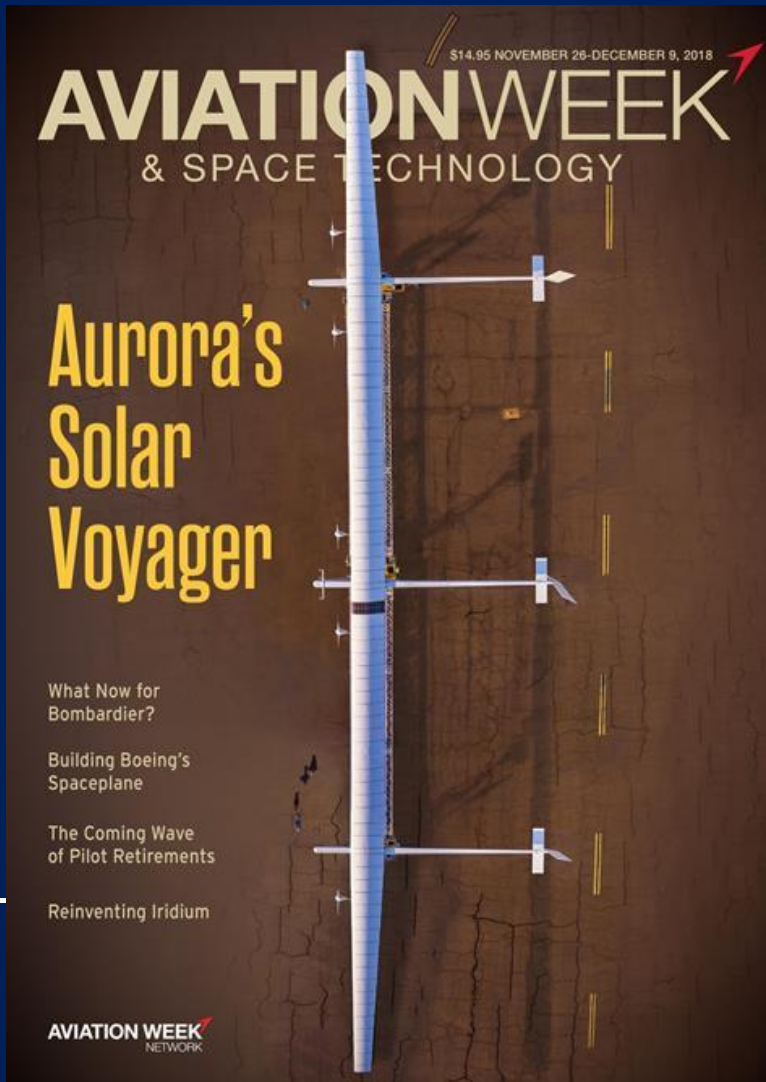
A high-altitude view from the cockpit of a solar-powered aircraft, showing the wings and the Earth's horizon under a bright sun.

Presented by:
Miguel Itumendi (Test Pilot)

November 2021

AIRBUS
PERLAN
MISSION II

Miguel Iturmendi – Experimental Test Pilot



PERLAN
MISSION II

EQUIPMENT, SERVICE AND INSTITUTIONAL SUPPORTERS





Content

- Project
- Theory
- Mission
- Vehicle
- Operation
- Summary

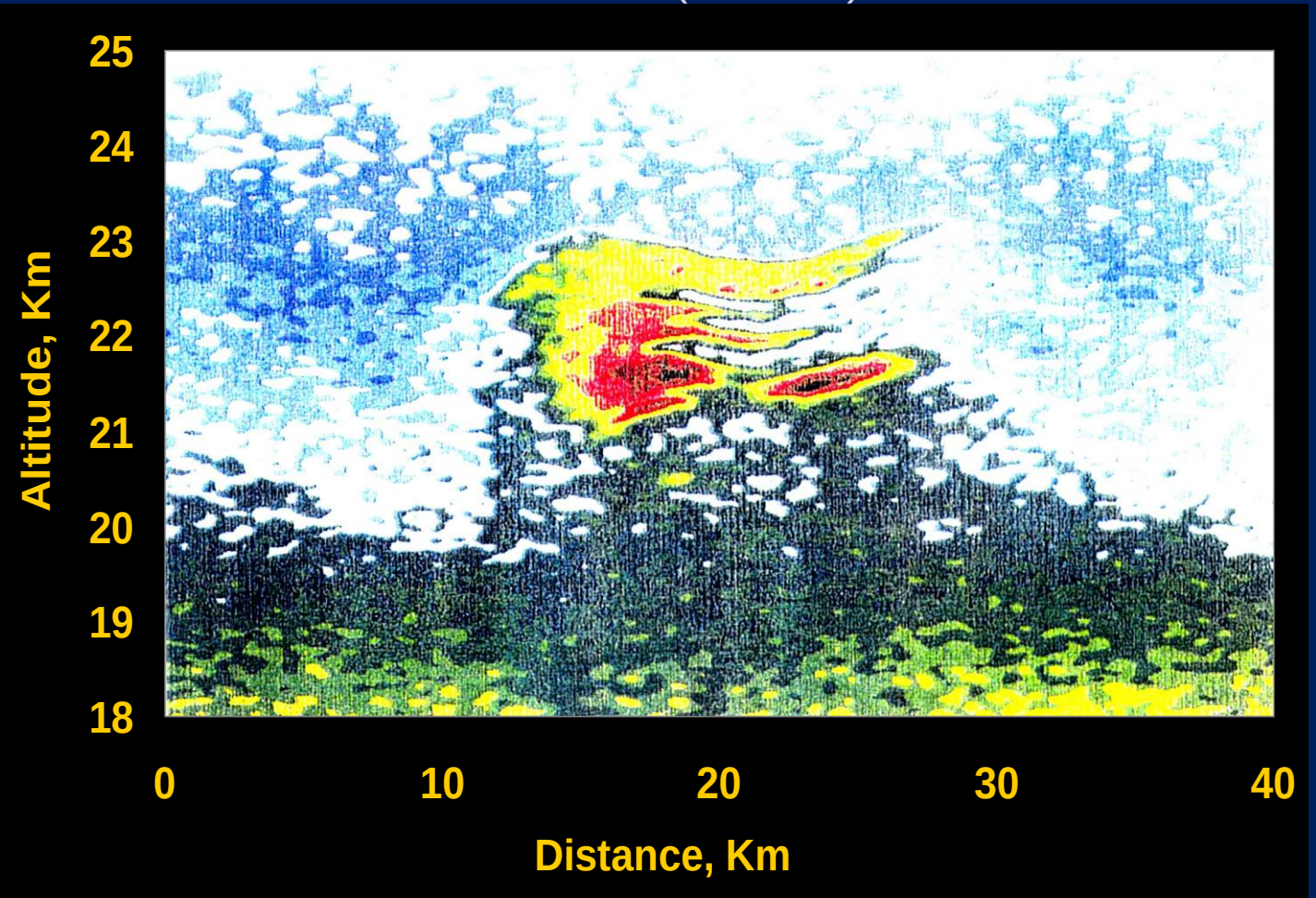


The Perlan Project

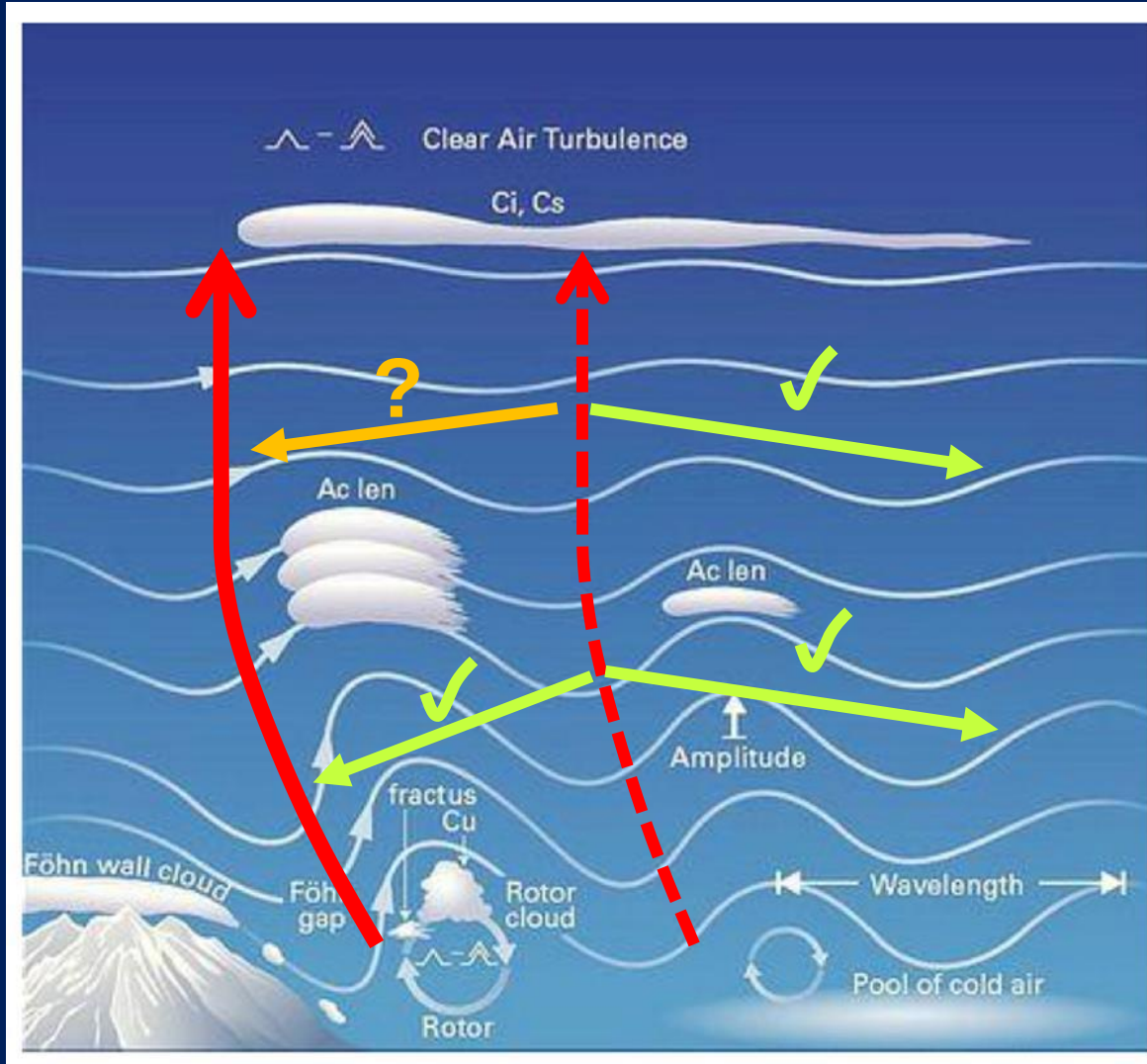
Founder: Einar Enevoldson



Lidar observations of Polar Stratospheric Cloud (PSC) over Mountain Kebnekaise (Sweden) 2095m



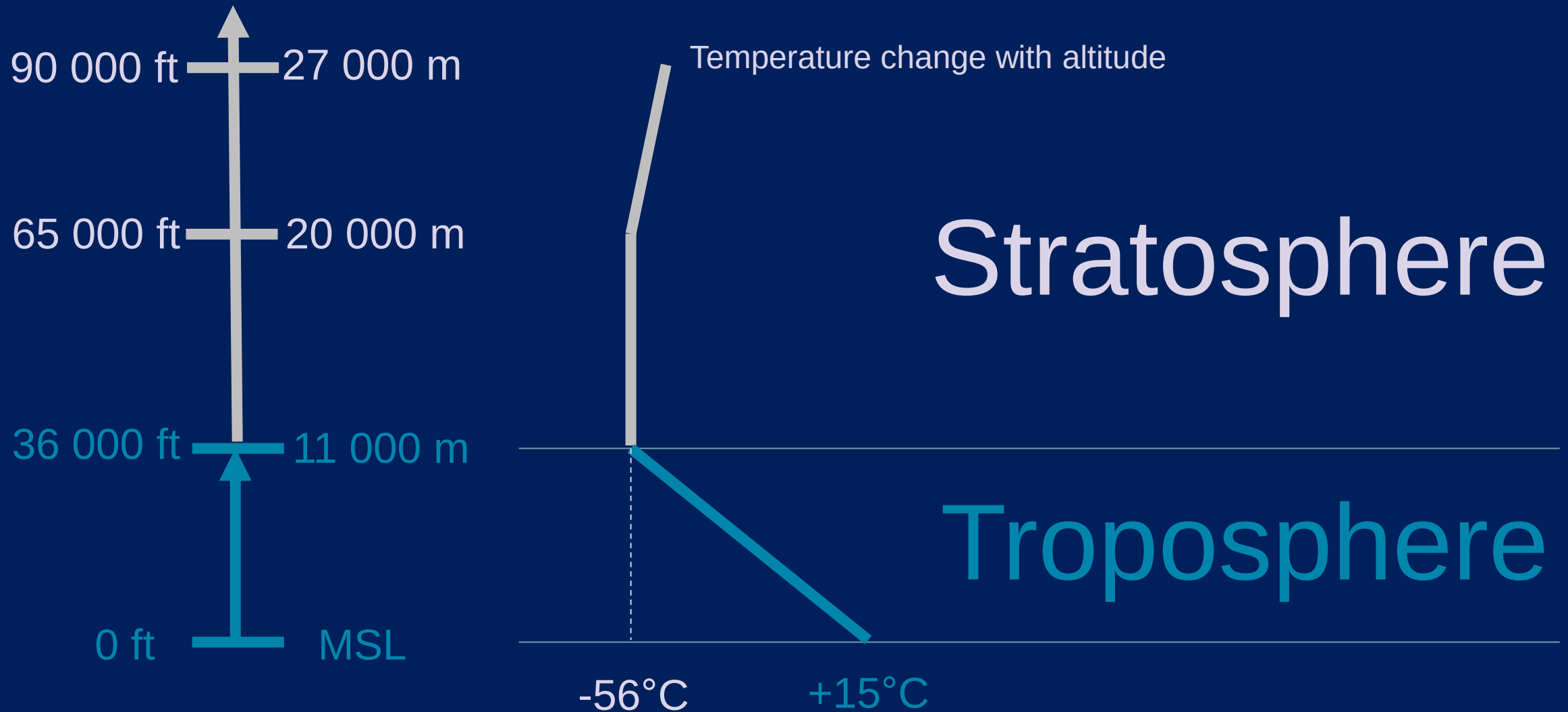
Fundamentals about wave riding



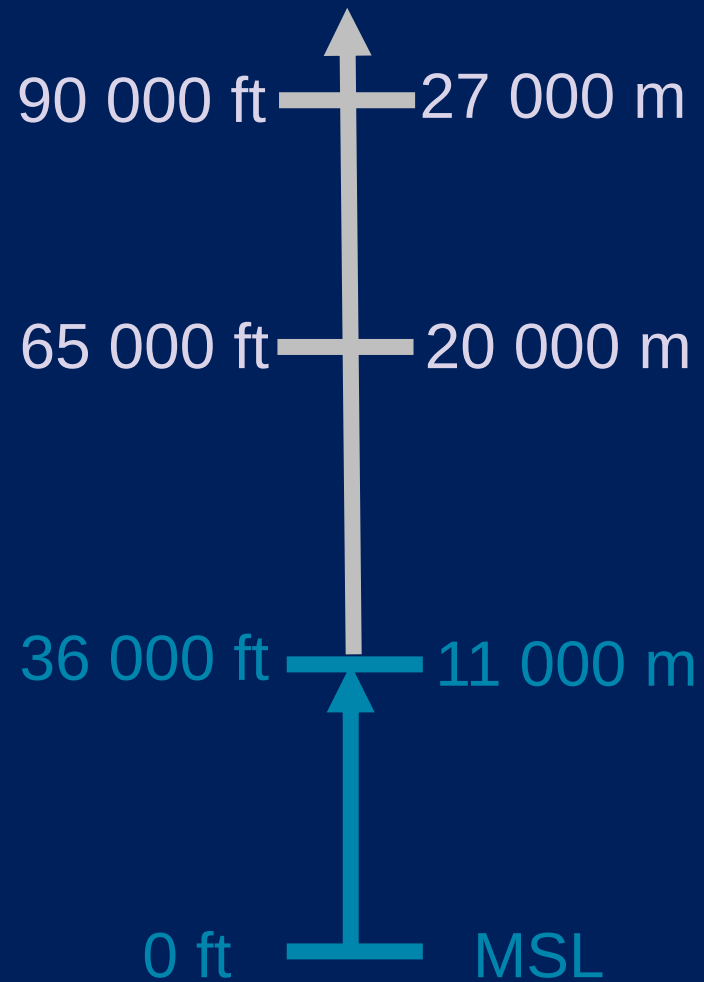


Where does the name „Perlan“ come from?

Standard atmosphere



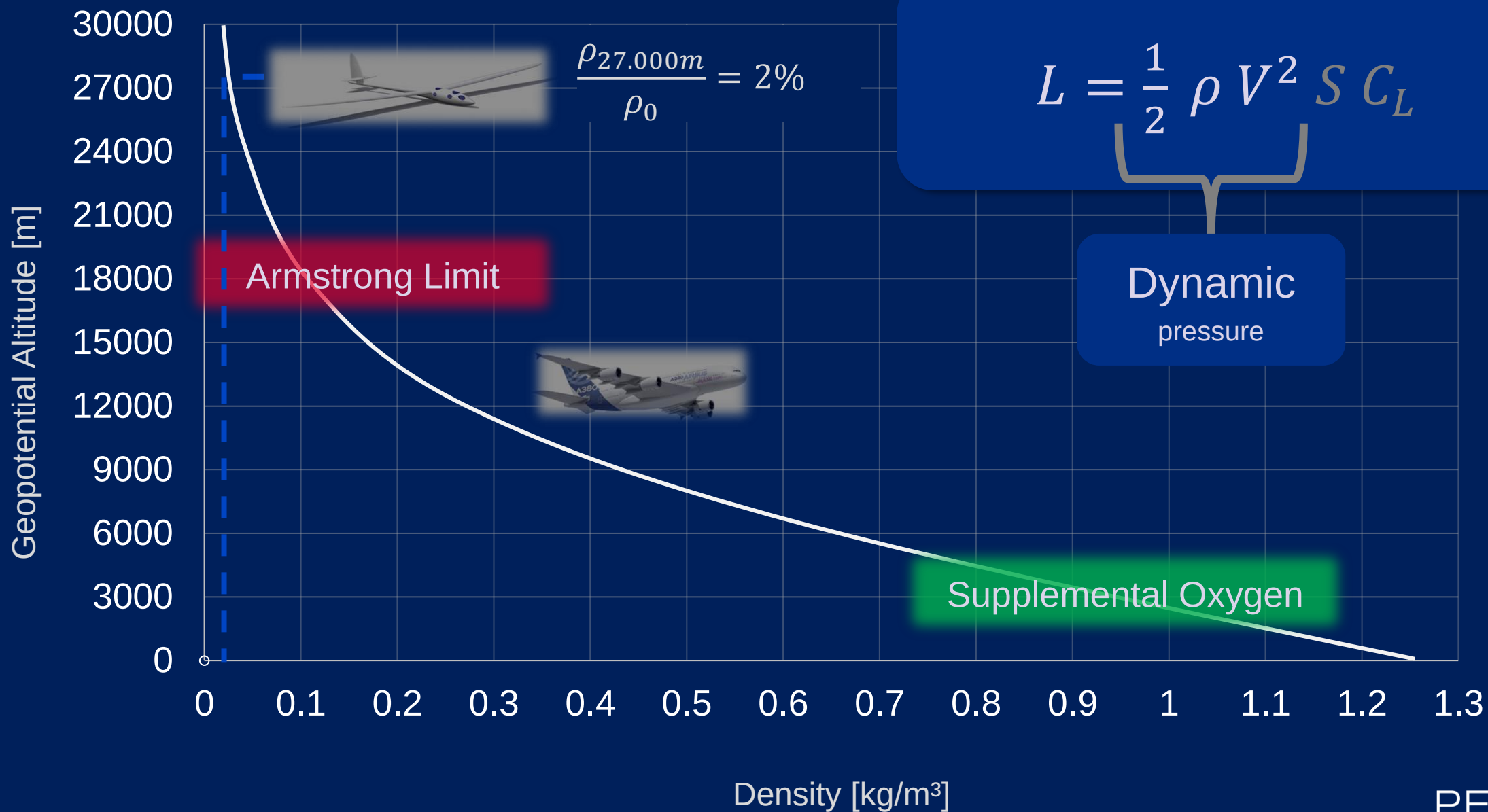
Standard atmosphere



Stratosphere



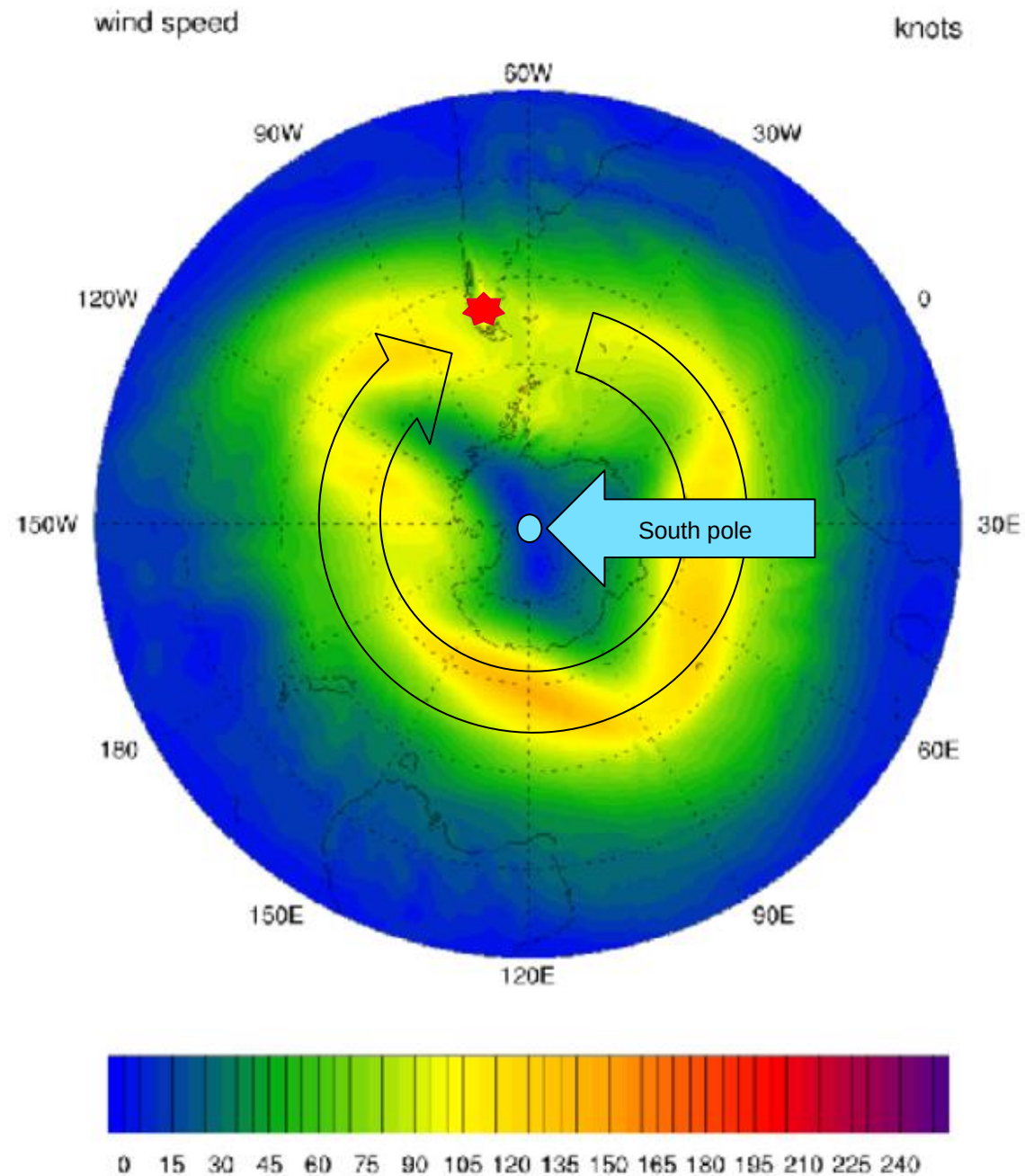
Troposphere



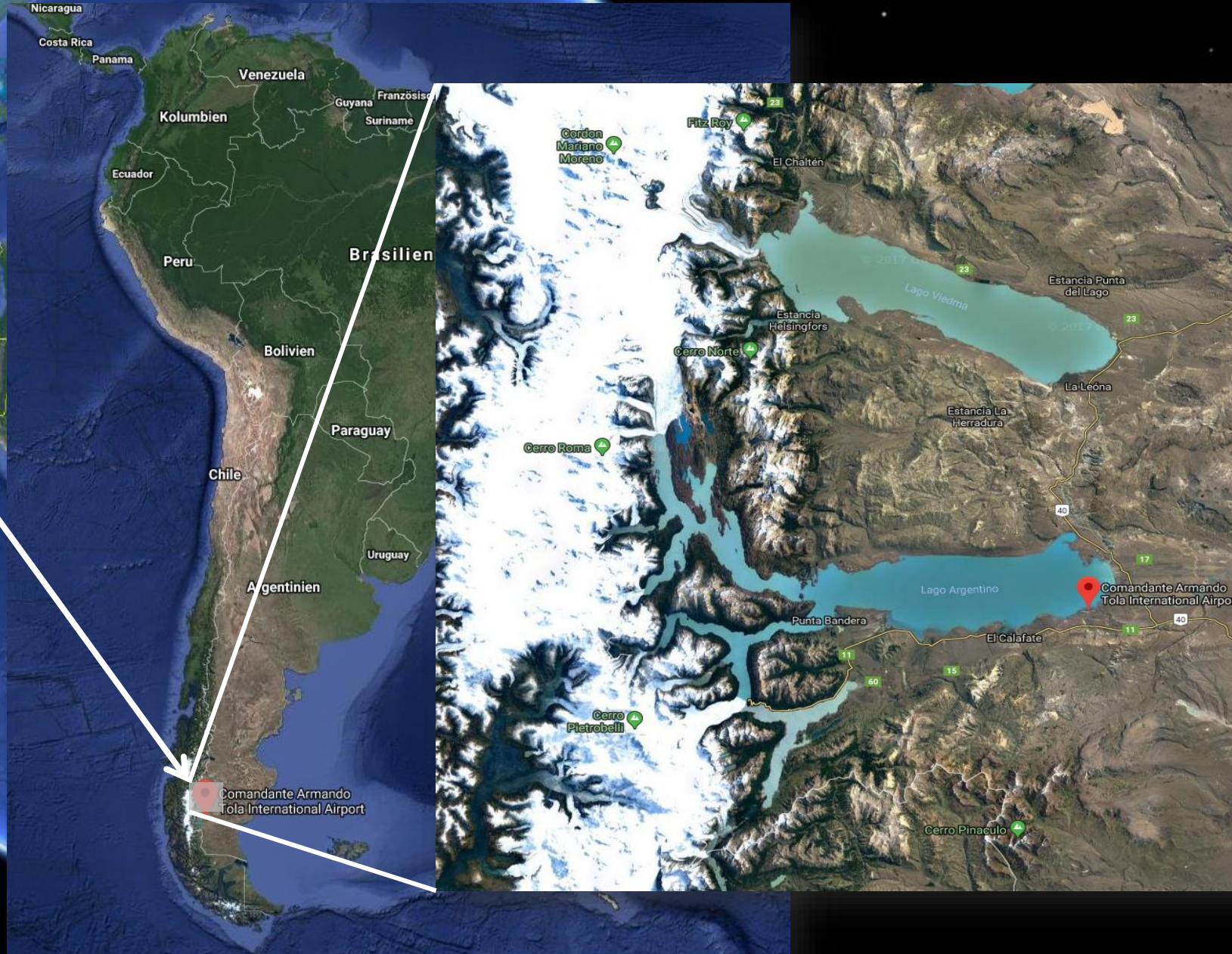
Polar Night Jet

70 hPA Wind speed (knots) for 0000 UTC 2 Sep 2018

0000 UTC 1 Sep 2018 initialization time



Launch site – El Calafate



Perlan I History: 30th Aug. 2006 - 50671 ft (15445 m)





Time for...

Perlan II



THE MISSION



AERONAUTICAL EXPLORATION

Push the frontiers of flight by soaring into near space



AERODYNAMIC ADVANCEMENT

Apply upper atmosphere understanding to improve high altitude and extra-planetary flight possibilities



METEOROLOGICAL RESEARCH

Investigate the impact of stratospheric waves on global weather patterns and atmospheric chemistry



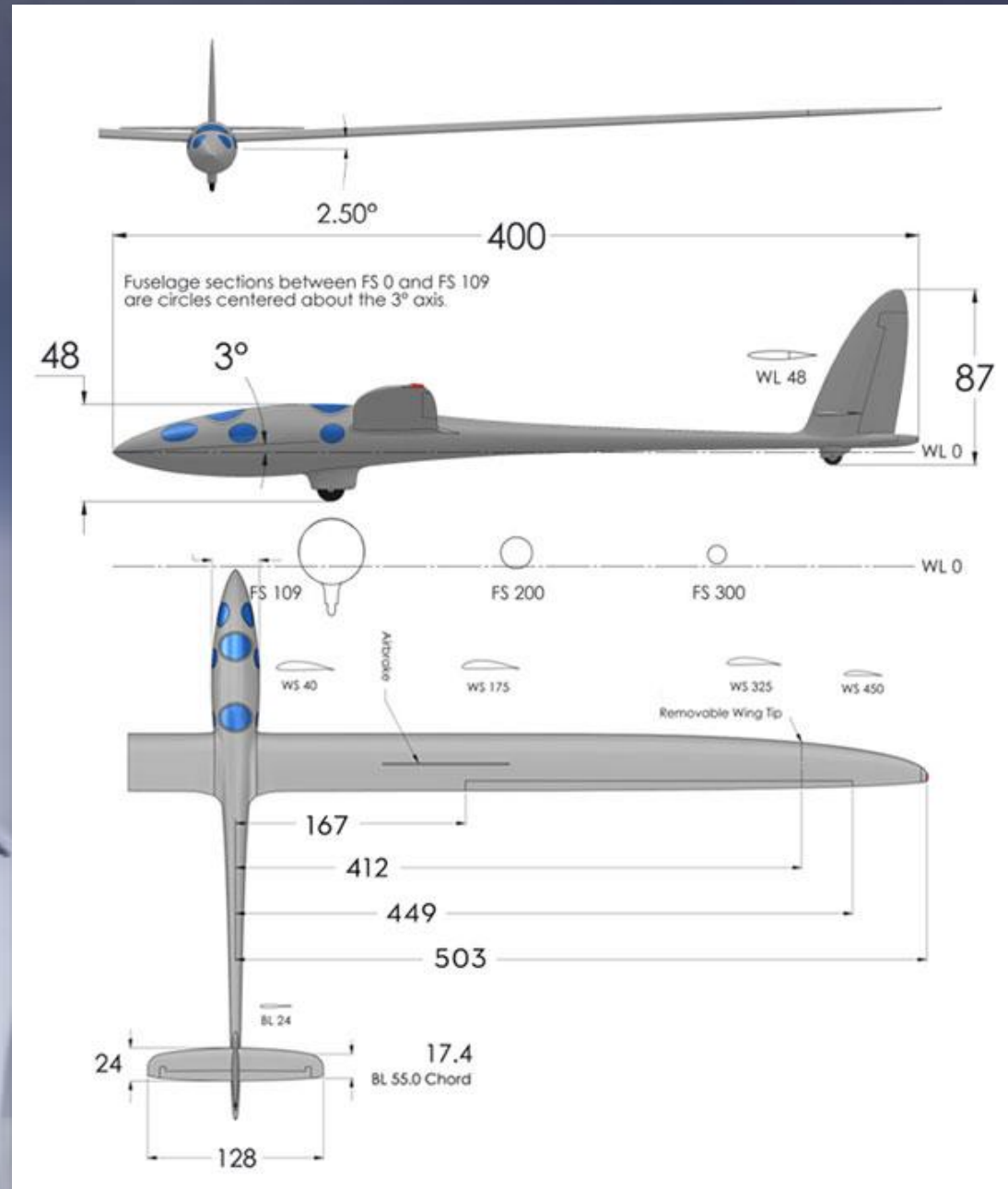
EDUCATION

Inspire future generations to pursue careers in math, science and research



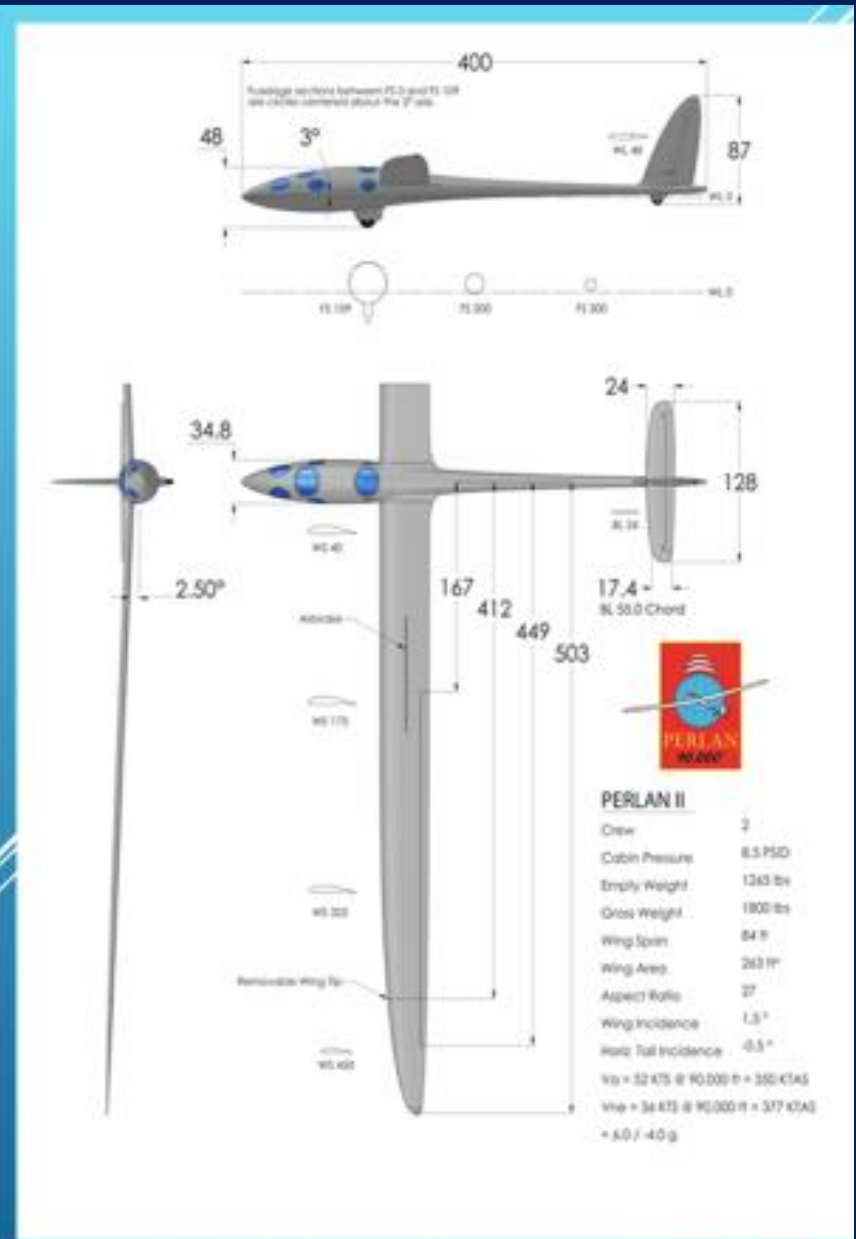
Perlan II design

Crew	2	
Cabin Pressure	8.5 PSID	590 mbar
Empty Weight	1400 lbs	635 kg
Gross Weight	1900 lbs	860 kg
Wing Span	84 ft	24,7 m
Wing Area	263 sq ft	24,4 m²
Aspect Ratio	27	
Wing Incidence	1.5 °	
Horiz. Tail Incidence	-0.5	
Max L/D	44/1	
Opt. design altitude	60.000 ft	

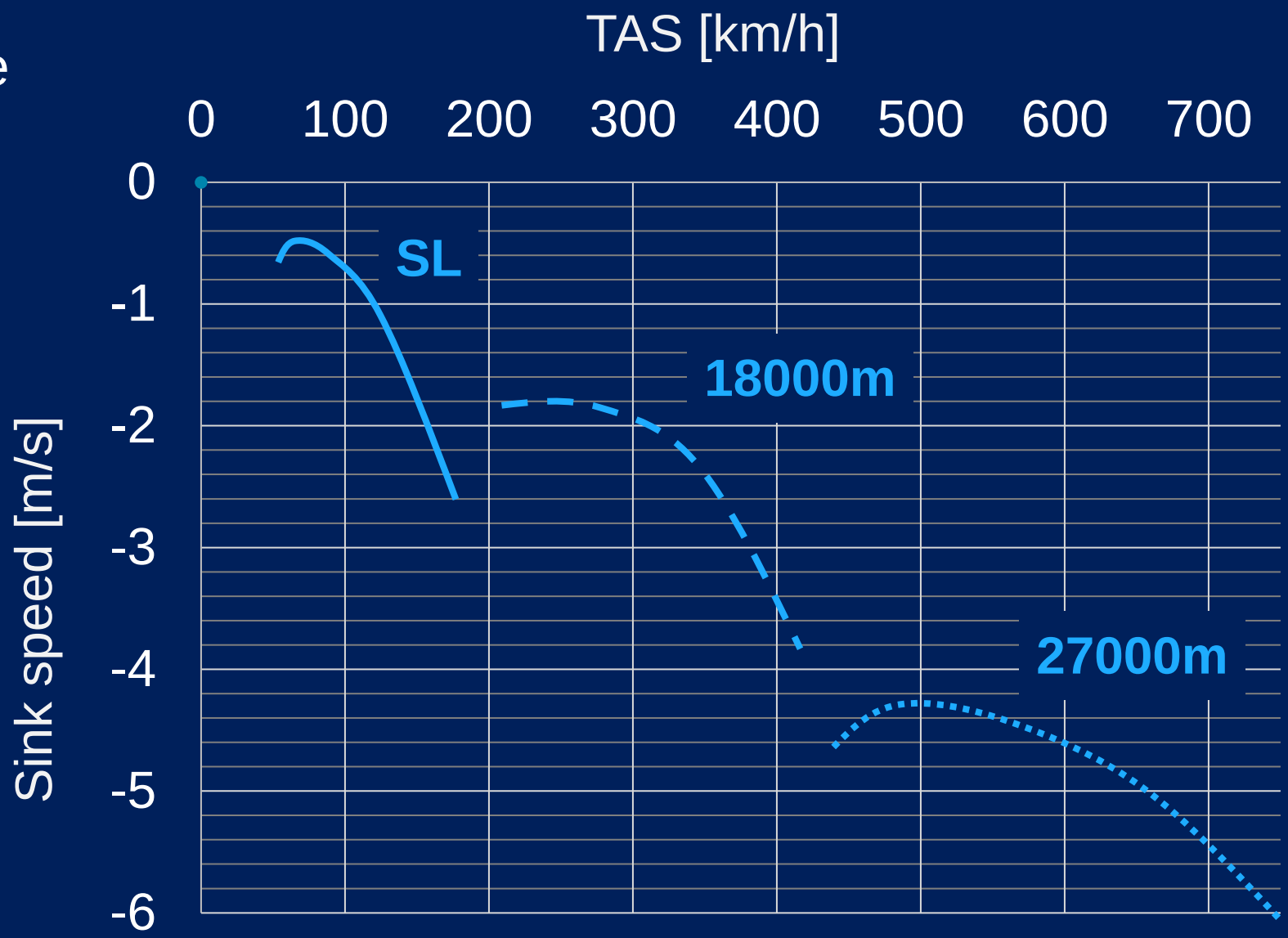
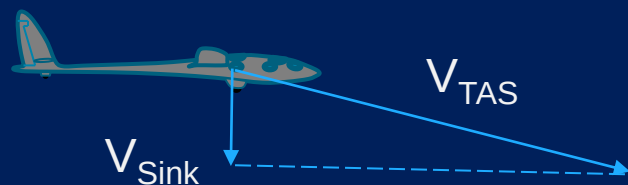


PERLAN'S INNOVATIVE DESIGN:

- ALL CARBON COMPOSITE CONSTRUCTION
- ELSS BASED ON RE-BREATHING SYSTEM
- CLOSED LOOP PRESSURIZATION
- ALL ELECTRONICS POWERED VIA BATTERY
- WING OPTIMIZED -HIGH ALTITUDE (FL600)

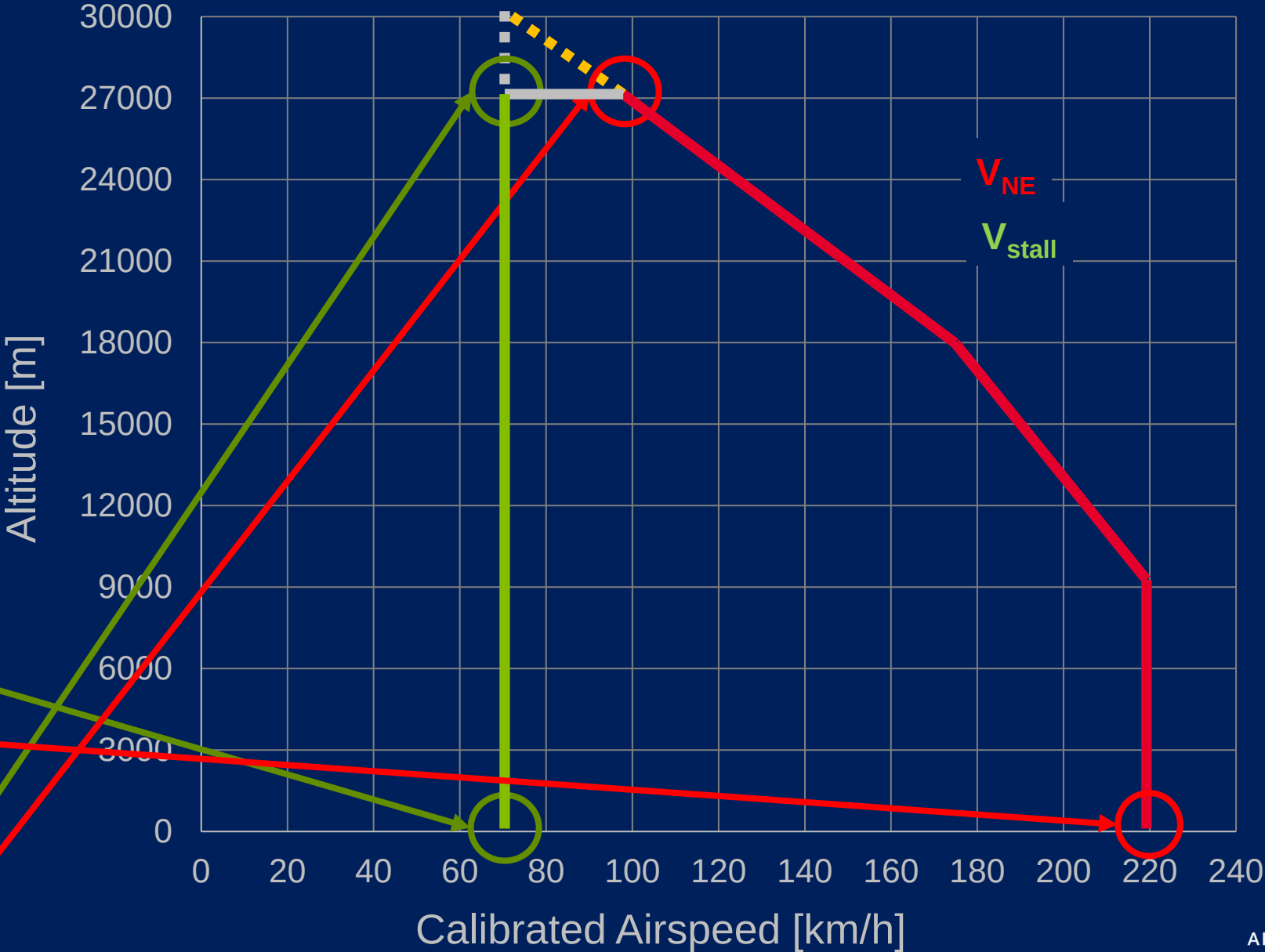


Glider Polar Example



Flight Envelope

Altitude [ft]	CAS [km/h]	TAS [km/h]	M [-]
SL	70	70	0.06
SL	220	220	0.18
90.000	70	430	0.43
90.000	100	640	0.61



Perlan II - construction

Carbon structure



F/CTL pass-through

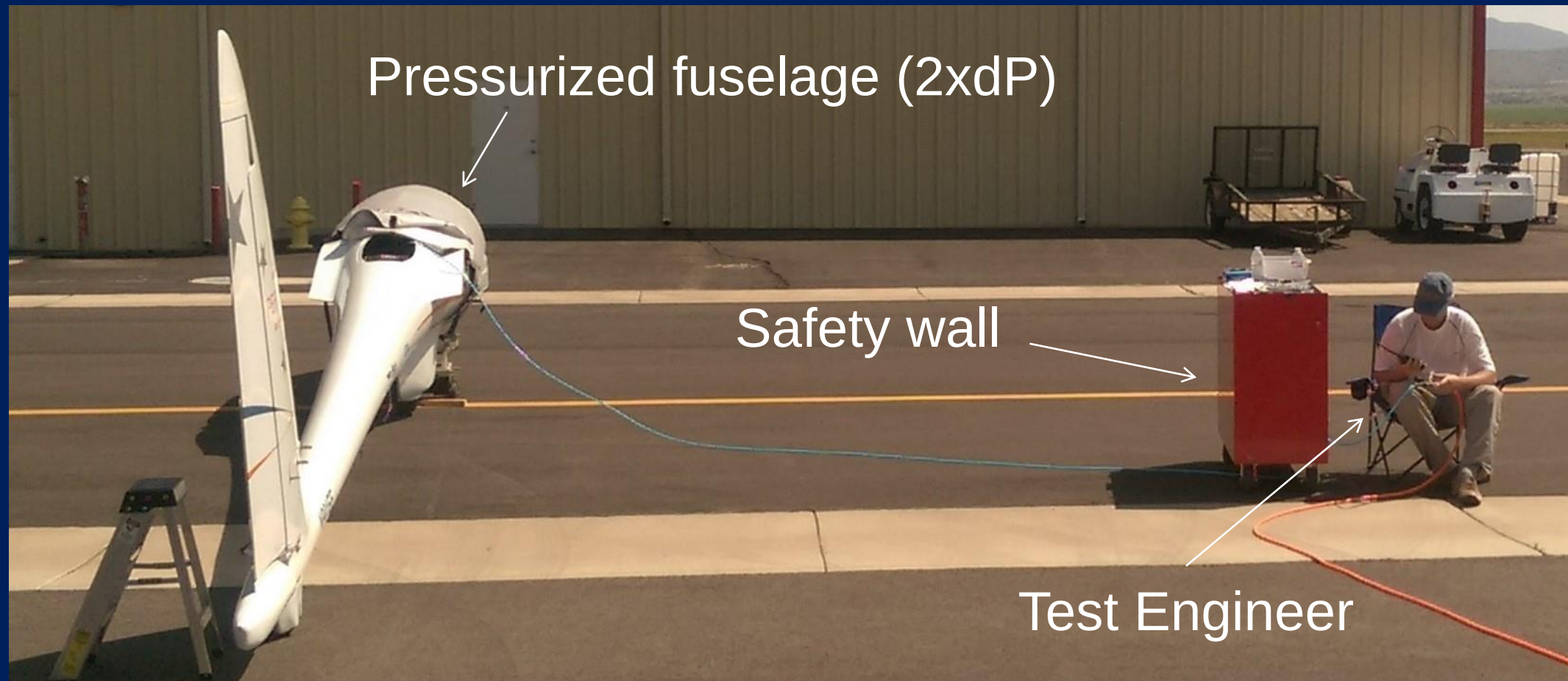


Hatch





Pressure testing



ELSS : TWO SYSTEMS – two environments

CABIN AIR

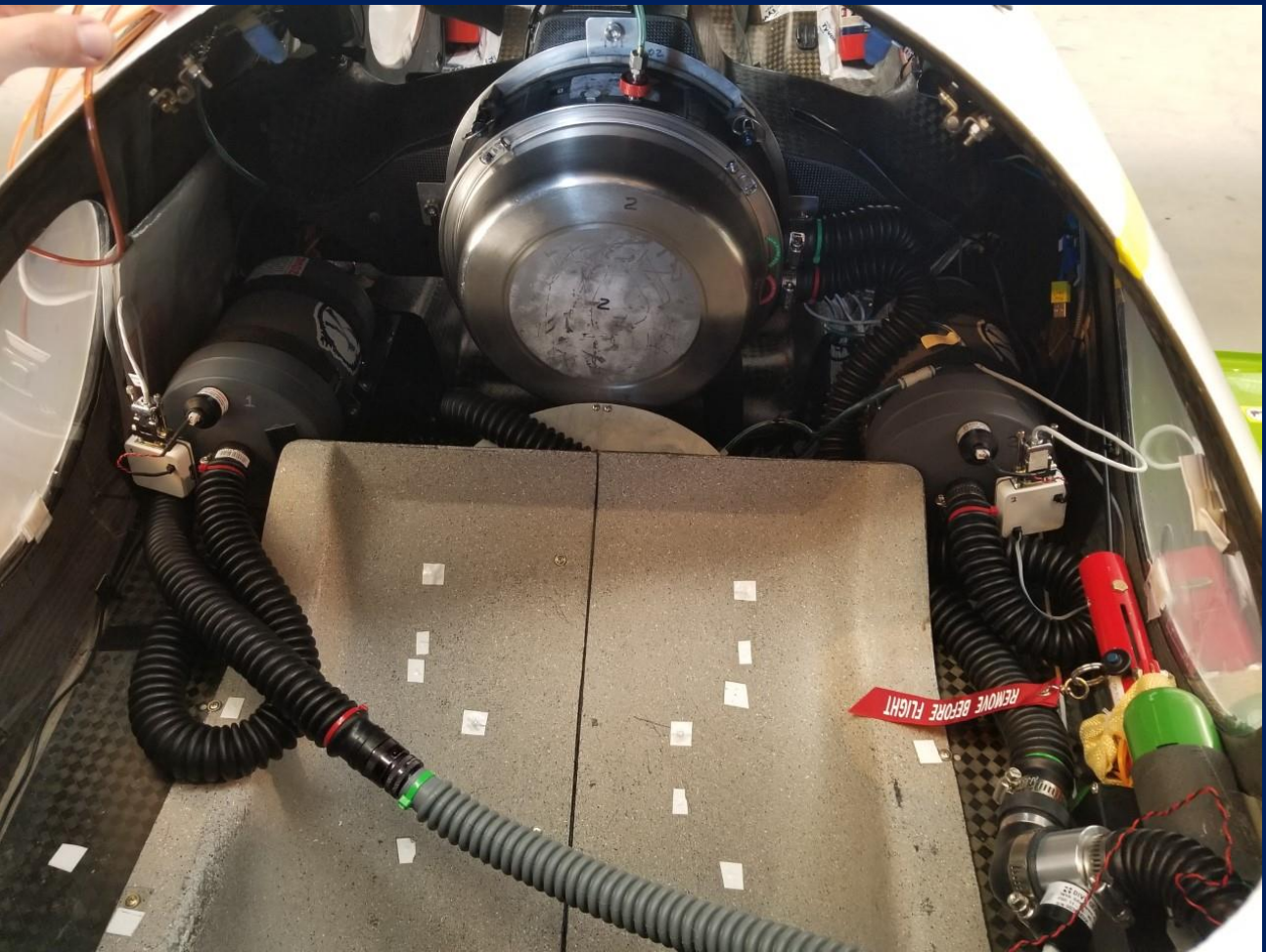


Cabin Air: 21% O₂ - Scuba Tank
De-Humidified Air

PILOT OXYGEN



Pilot-Mask: 90-99% O₂ -Circulated
Humid Air

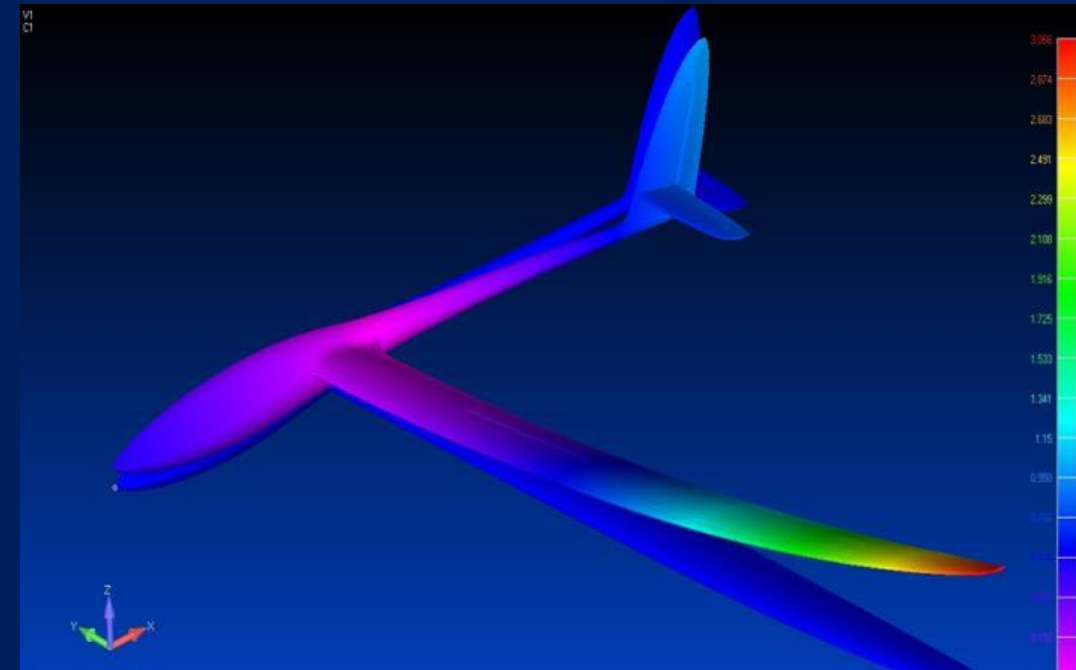


REBREATHER SYSTEM



EMERGENCY OXYGEN

GVT, Flutter analysis, etc.



Drogue chute and BRS (Ballistic recovery system)

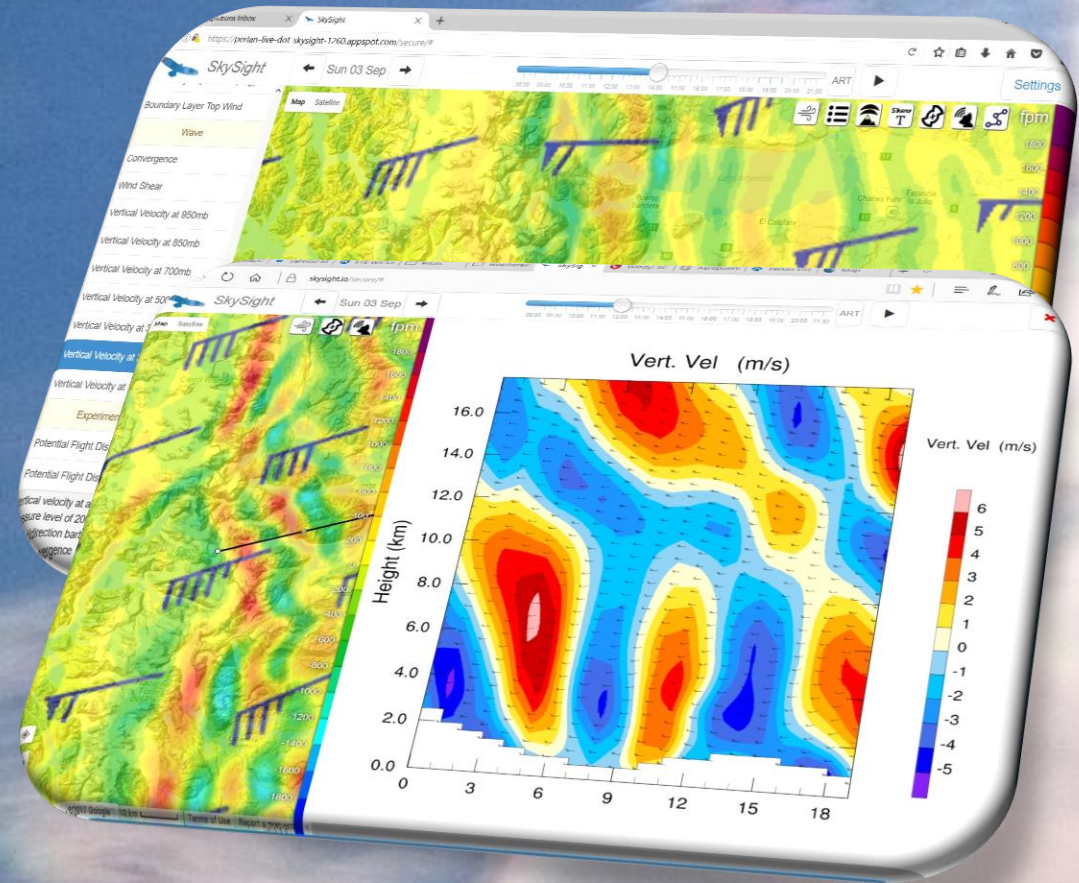
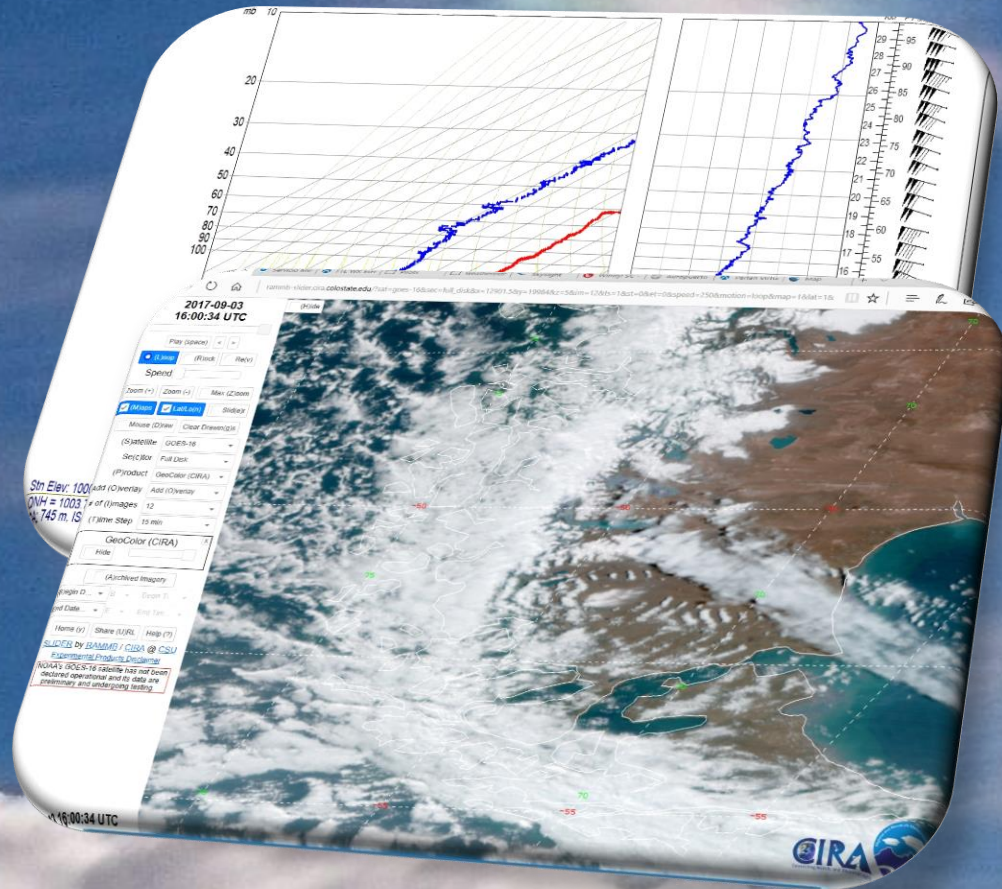


Tow Planes

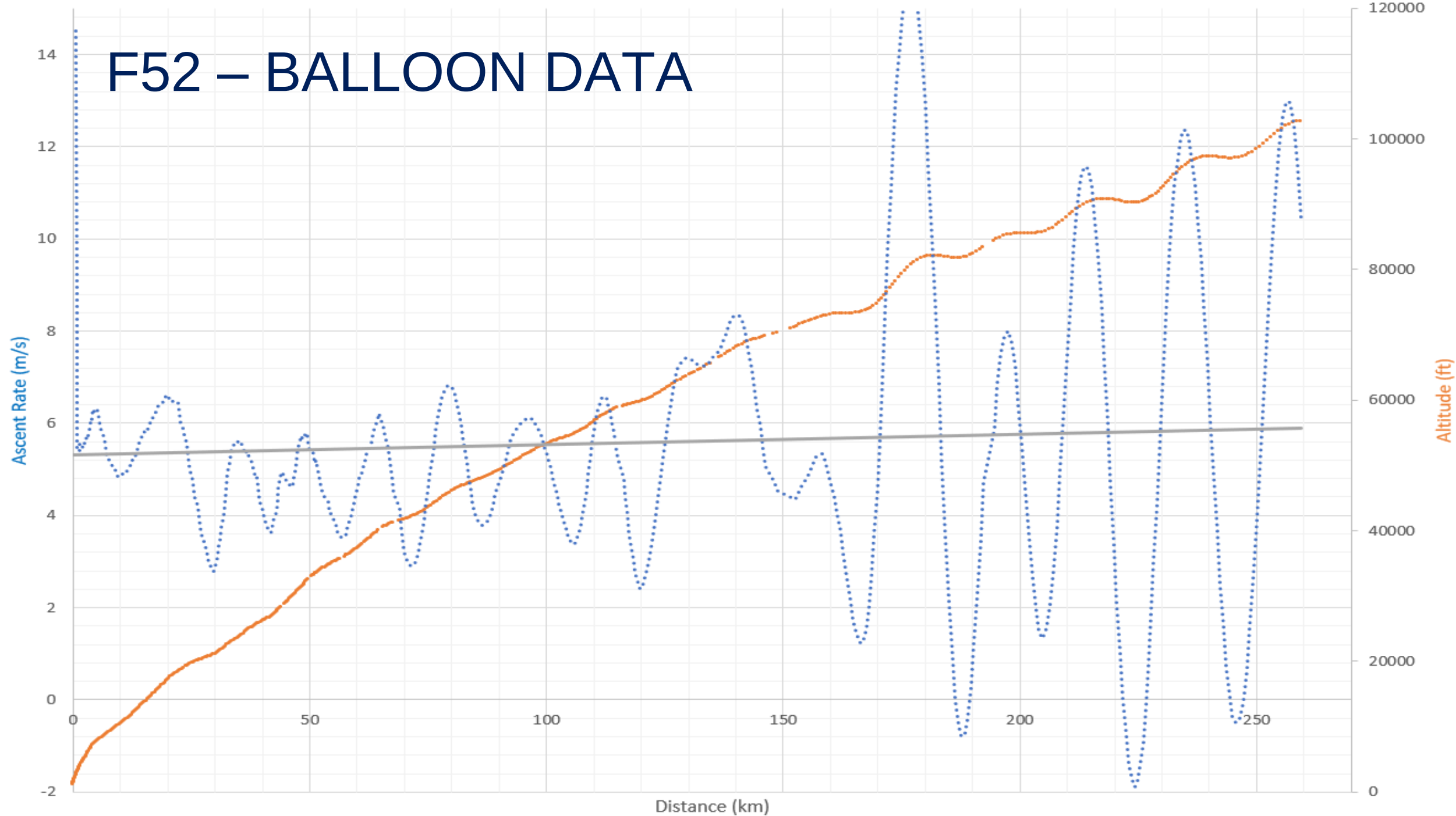




Meteorological Information Resources



F52 – BALLOON DATA



F52

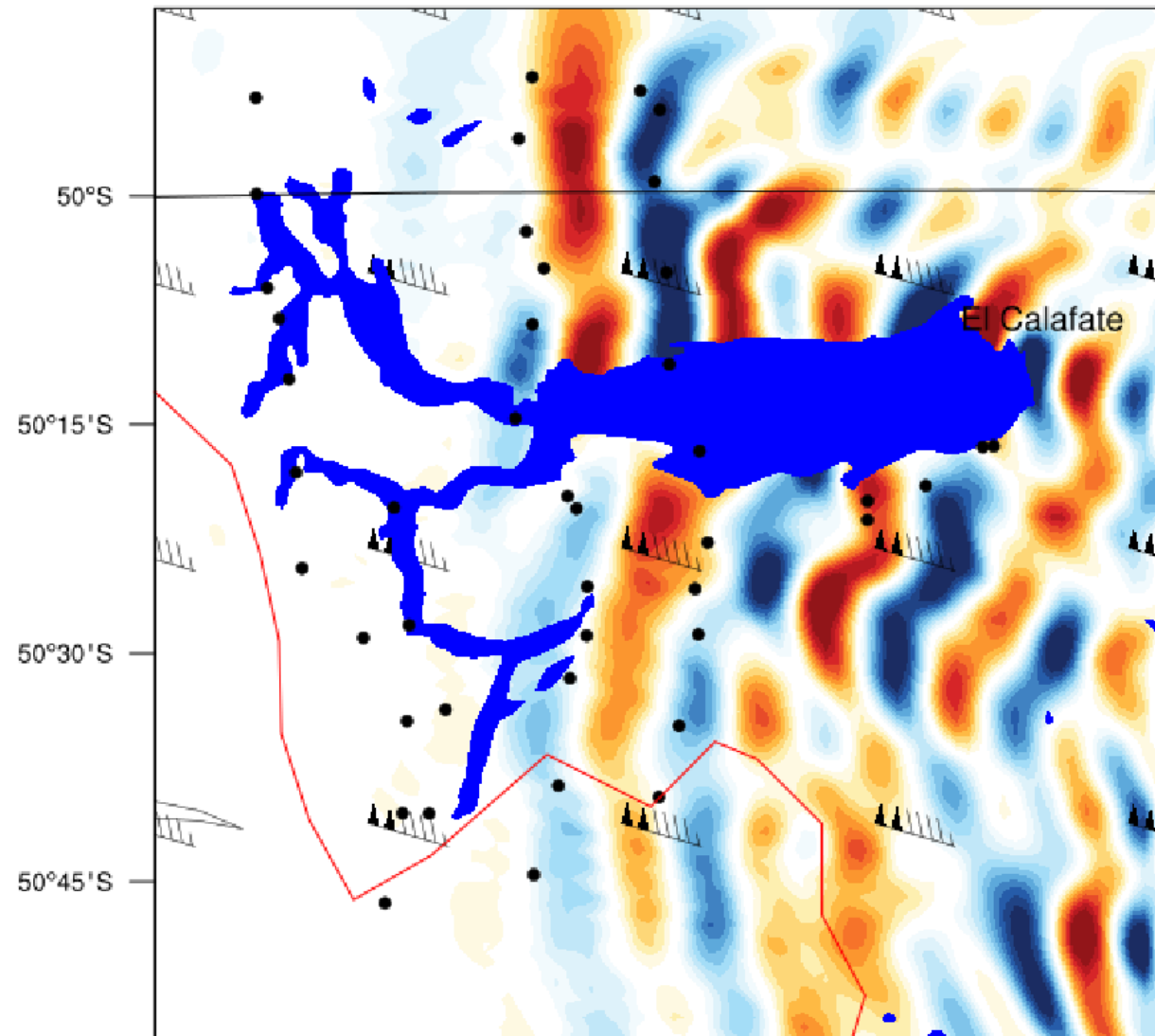
WeatherExtreme

50 mb Height

Init: 2018-09-02_06:00:00

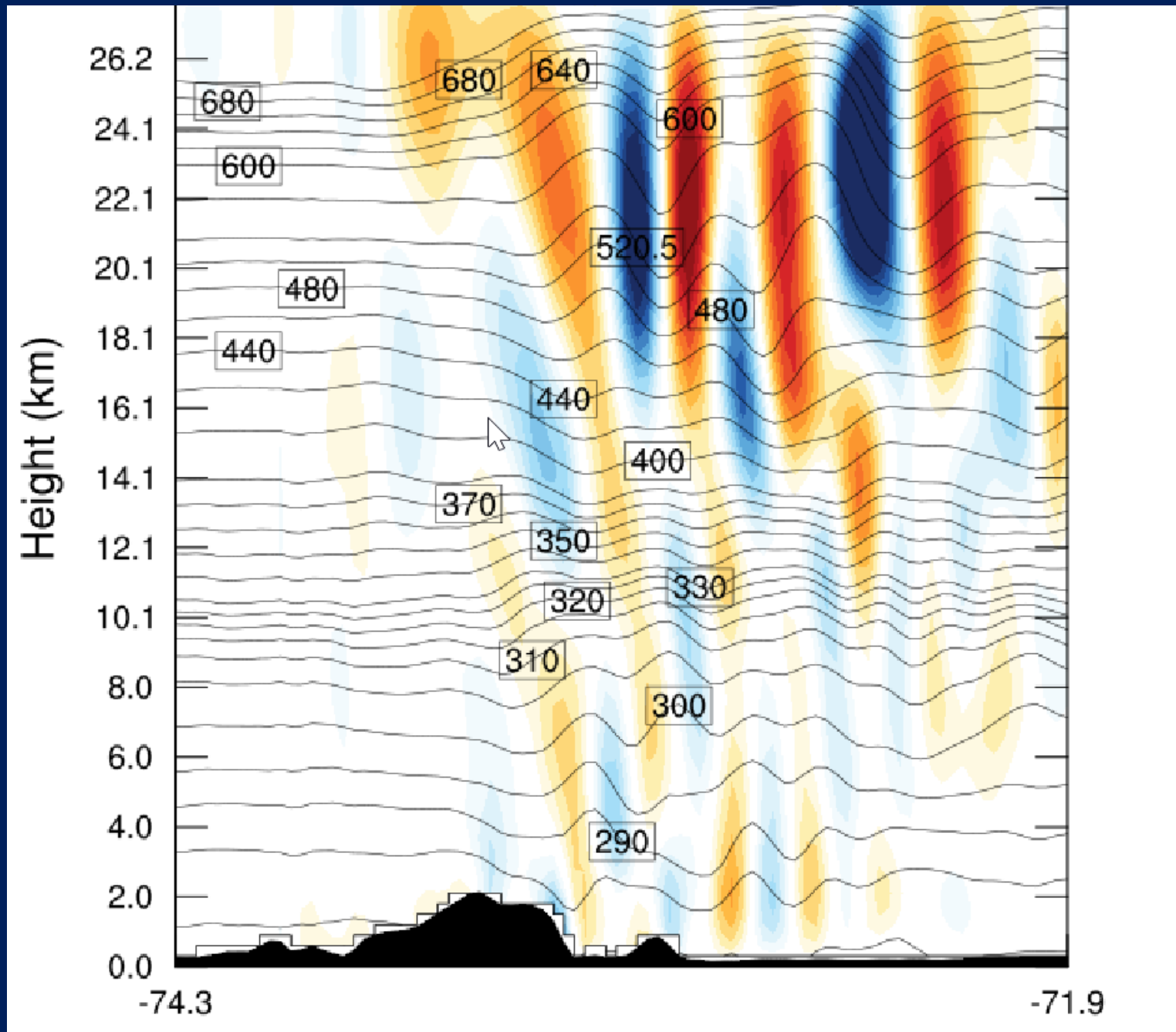
Valid: 2018-09-02_18:00:00

Vertical Velocity (feet/min) at 50 hPa
Wind (kts) at 50 hPa

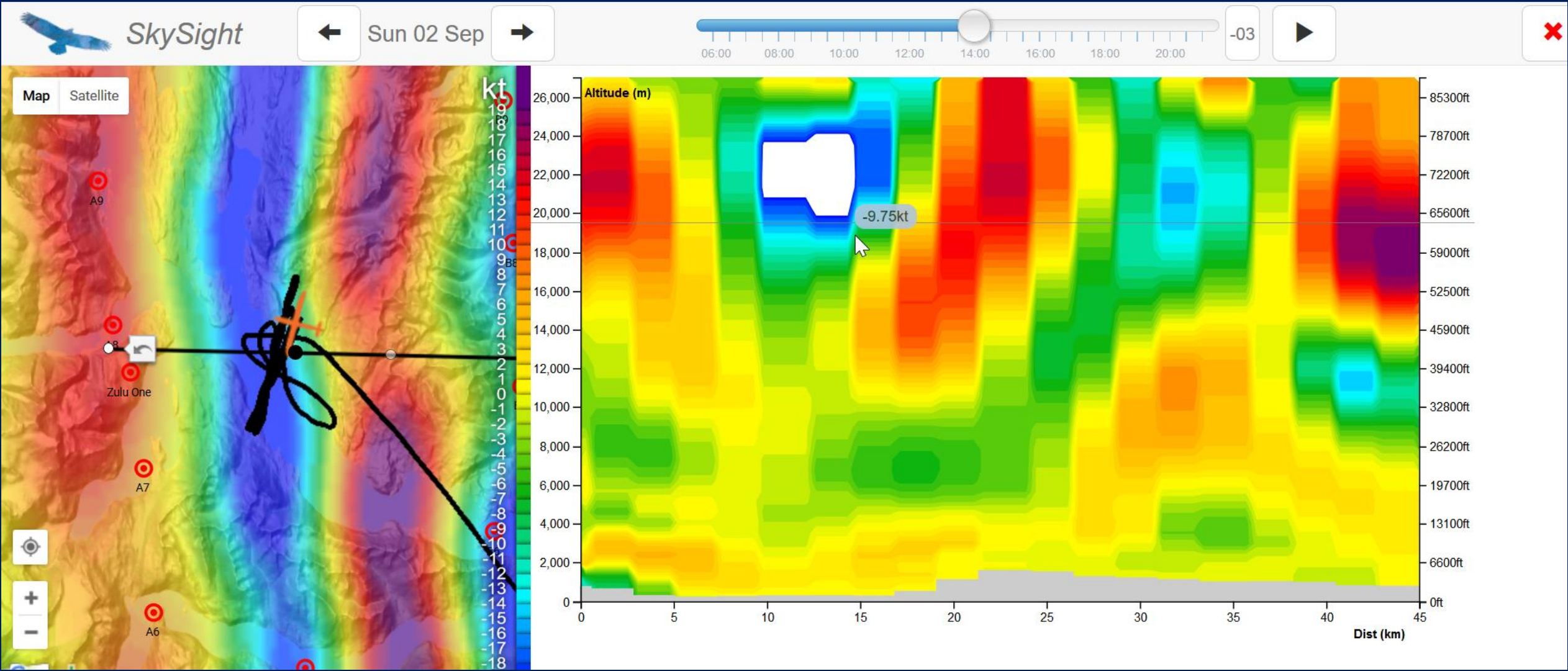


F52

WeatherExtreme Cross Section

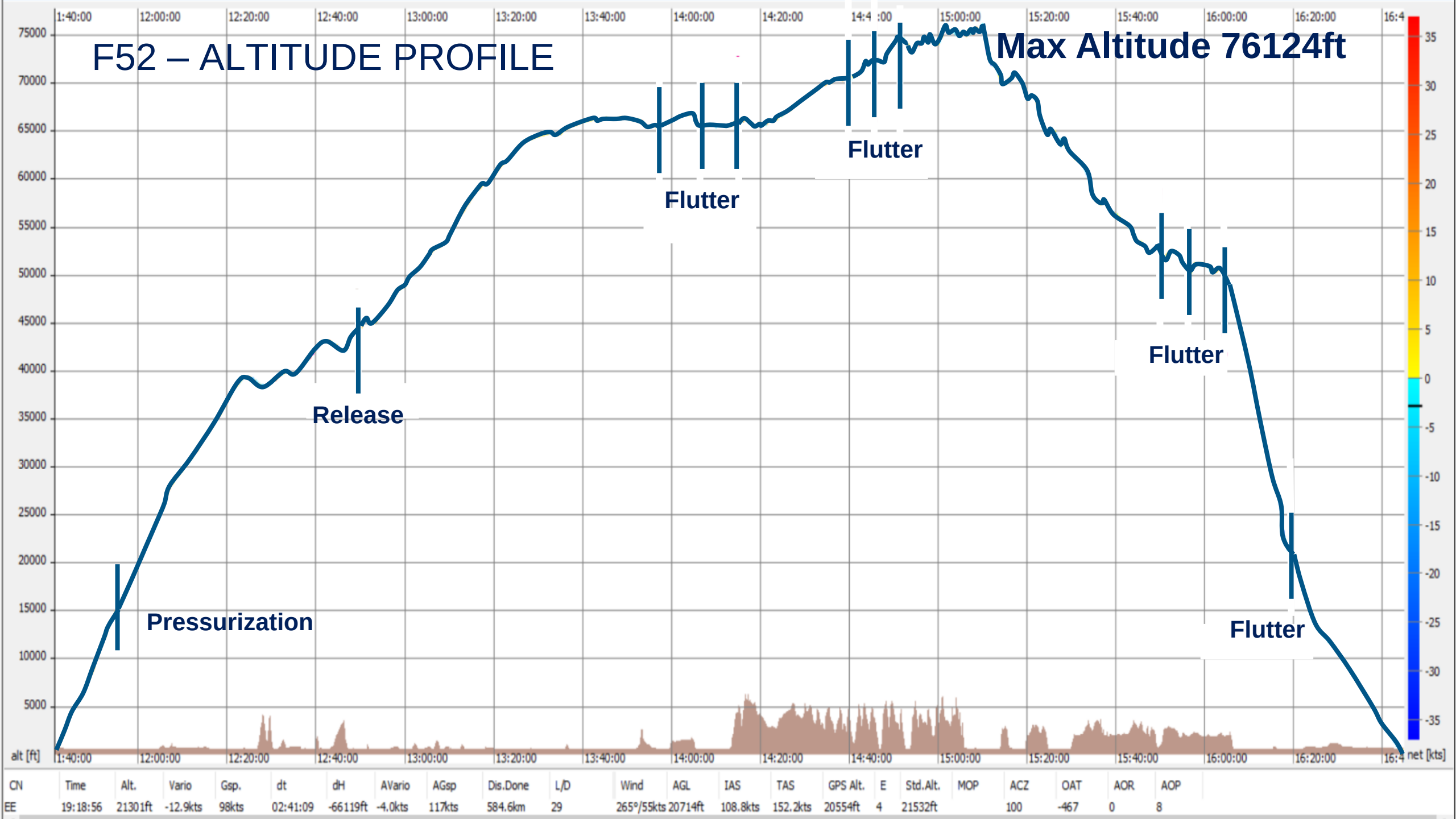


F52

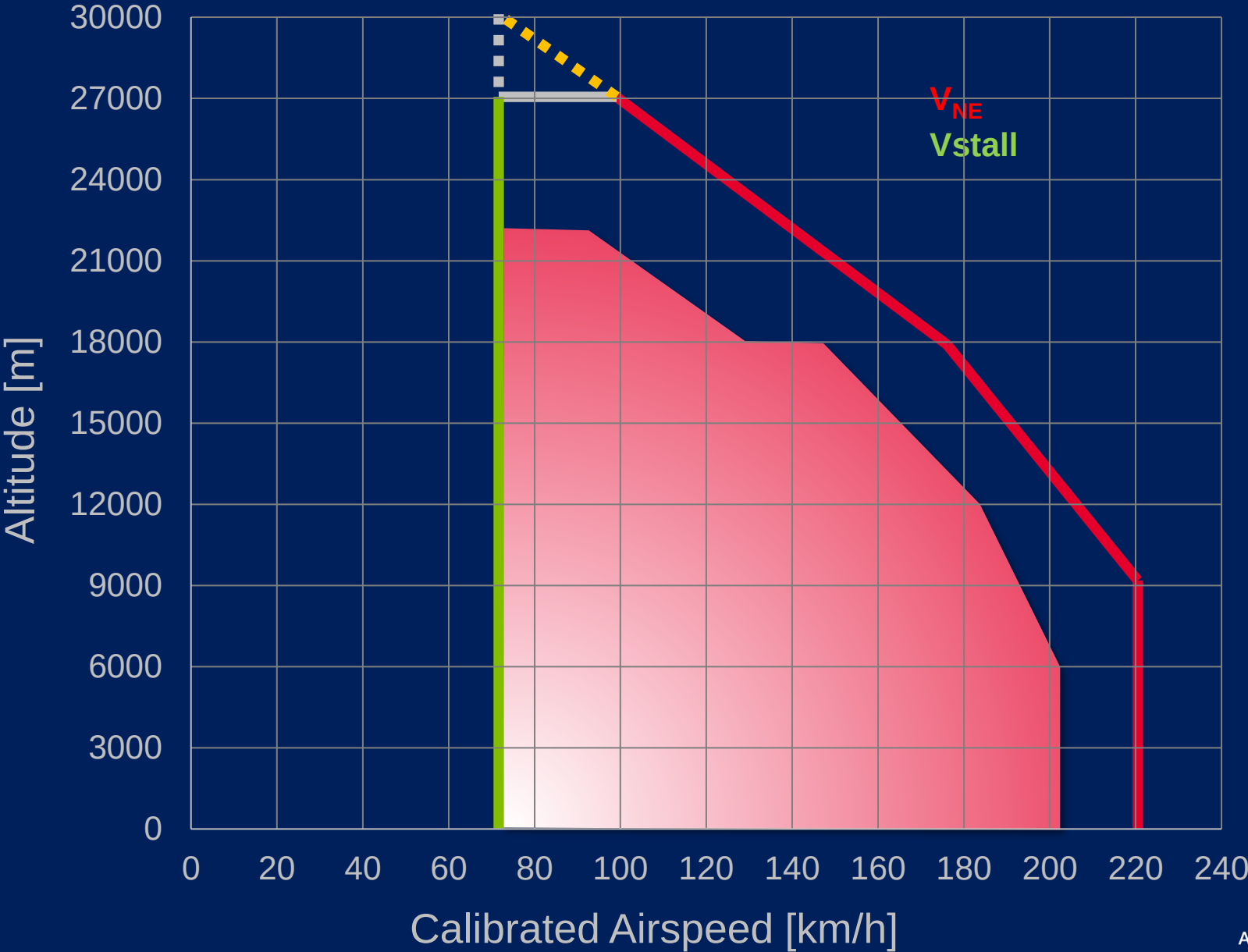


COCKPIT VIEW



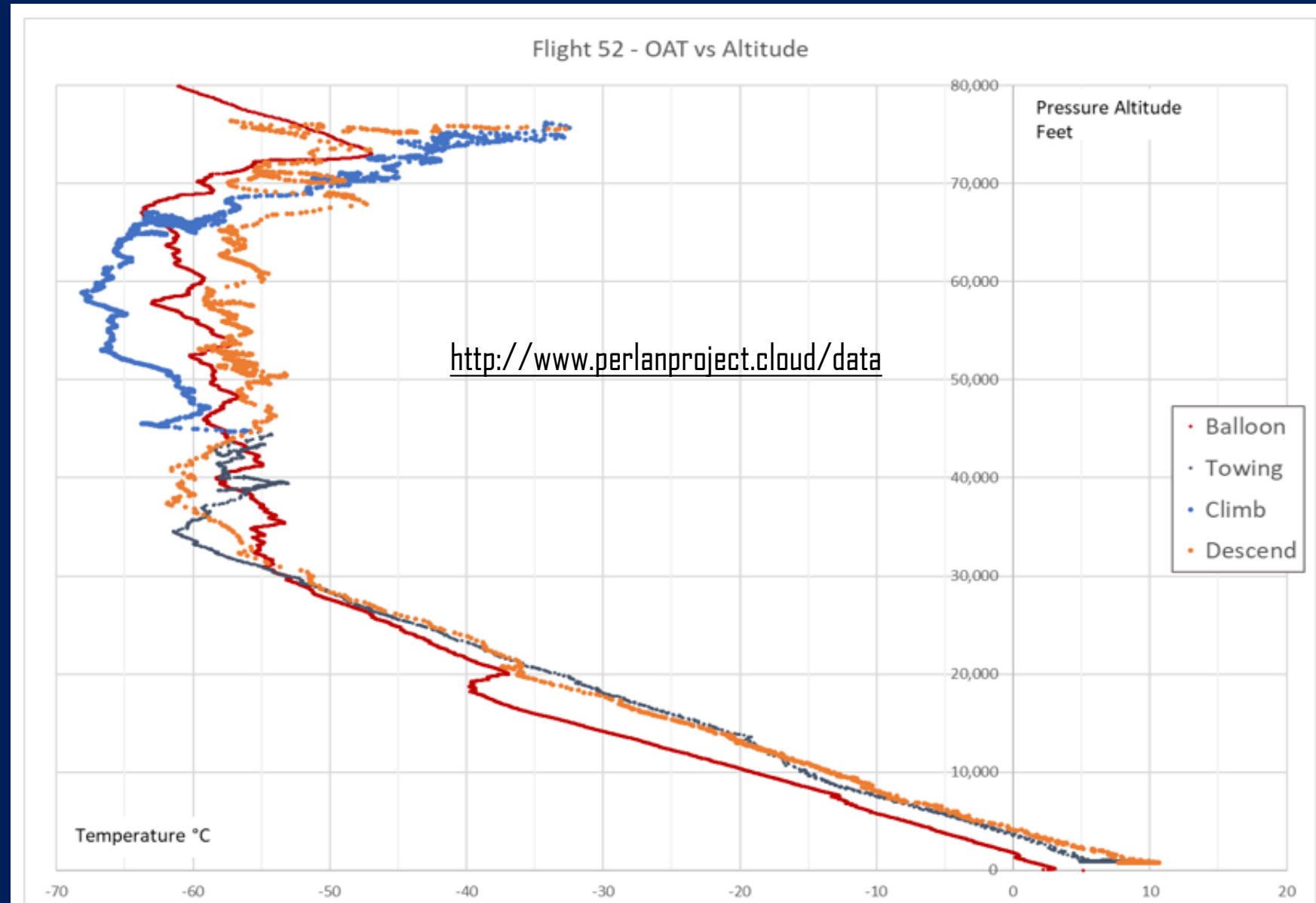


Flight Envelope



Science data

- Temperature deviations in the stratosphere
- Wave location and strength
- Radiation
- Ozone
- UV sensor
- Particle/ dust collection
- "CubeSat"



Perlan II Records

Rank	Date	Height
1	02.09.2018	FL760
2	28.08.2018	FL656
3	17.09.2019	FL650
4	12.09.2018	FL629
5	26.08.2018	FL620
6	31.08.2019	FL563
7	03.09.2017	FL540
8	28.08.2006	FL507
9	11.09.2019	FL506
10	14.09.2019	FL492







View from FL760

Next stop ...FL900

Questions?



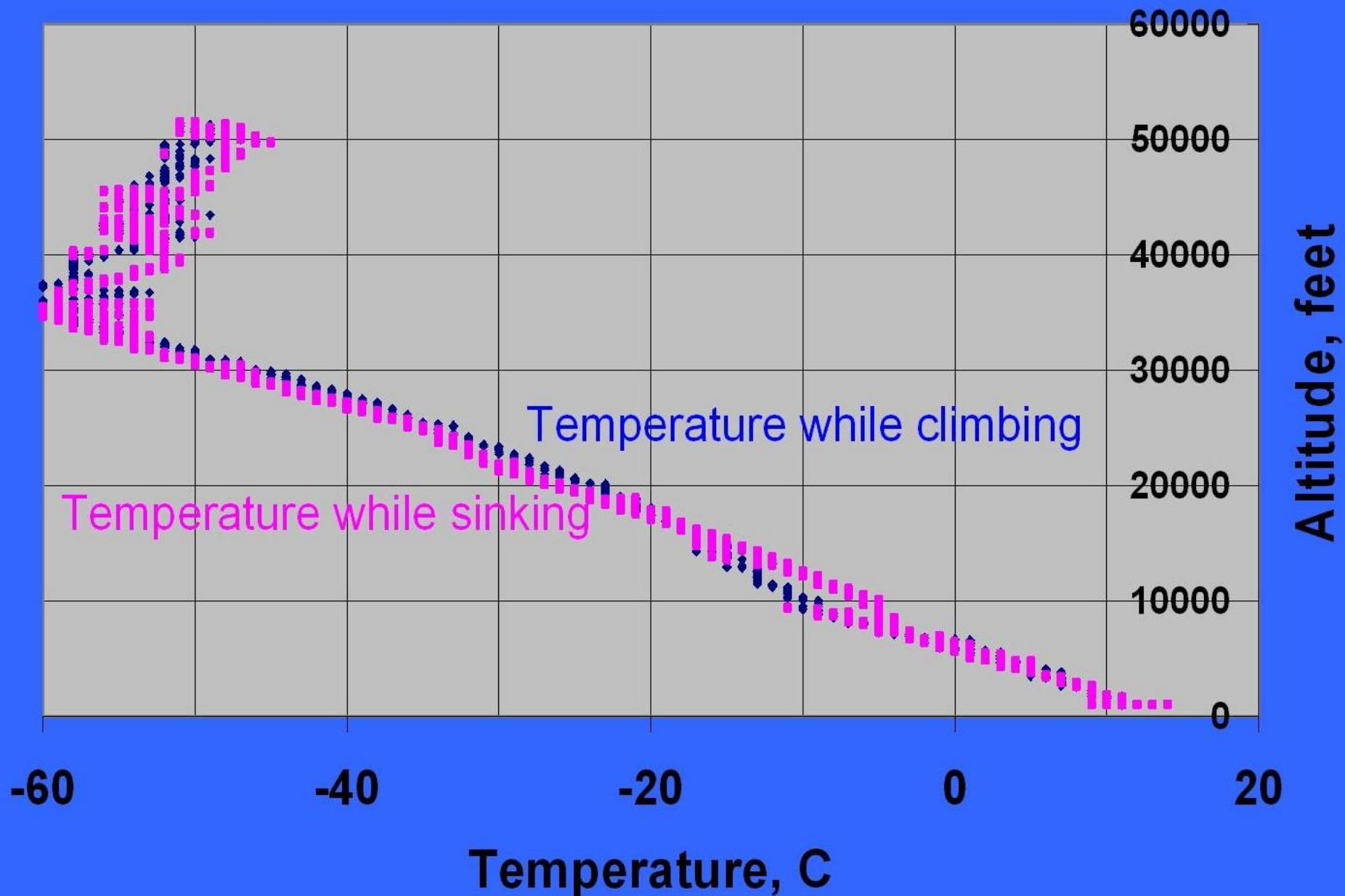


Daily work ...

- Maintenance
- Balloon launch
- Pre/post-flight
- Inspection
- Testing
- Analysis
- Flutter clearance
- Wing runner
- Derive Operational Procedures
- ...



Flight 066 Outside Air Temperature



TESTING RESULTS

- Handling Qualities Similar to an Open Class Glider
 - High inertia and heavy controls
 - Well damped dynamic modes < FL500, lightly damped DR > FL600
- Benign stall characteristics
- Flight Performance as predicted:
Stall Speed : 37 KIAS L/D: 44/1 Min Sink: Approx. 110 Ft/Min near S.L.
- No flutter encountered

Challenges ...

Cabin leak

Free play in control system

High friction forces in the control

Limited outside view

Leakage of the rebreather system

Hatch frame buckle

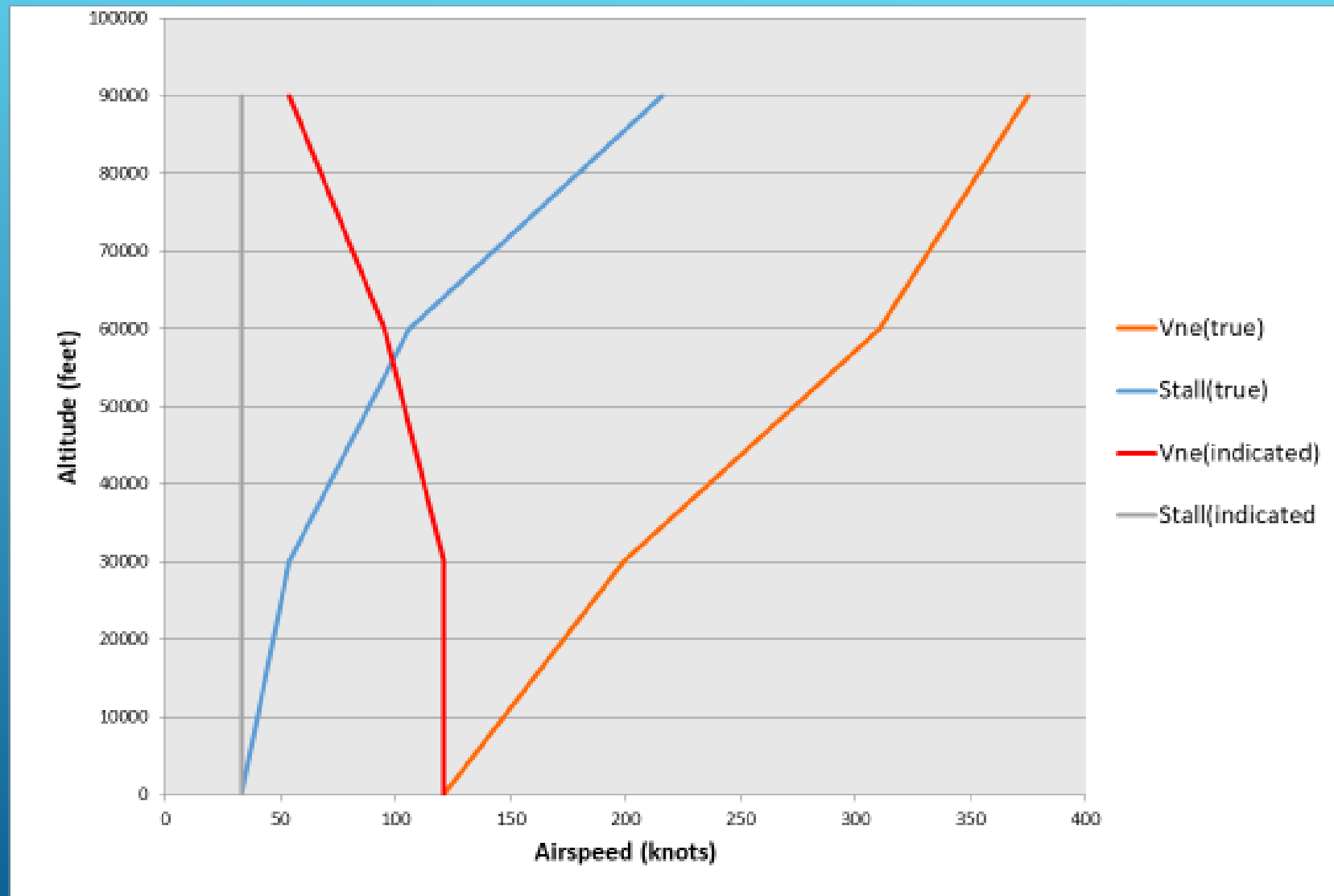
Logistics (shipping, ATC, bureaucracy, etc.)

PERLAN'S SPEEDS

At FL900

$V_{\text{stall}} = 37 \text{ KIAS}$

$V_{\text{ne}} = 54 \text{ KIAS}$



TESTING RESULTS

- Similar Flight Handling Characteristics for an Open class glider
- Heavily damped flight controls bellow FL500, Lightly damped above FL600
- High inertia and heavy controls
- Stable behavior in all three axes (Lat, Dir, Long.)
- Benin Stall characteristics
- No Flutter encountered
- No Dutch Roll up to FL760
- Flight Performance as predicted:

Stall Speed: 37 KTS L/D: 44/1 Min Sink: Approx. 110 Ft/Min near S.L.