Digital twins of flights – technological basis for SaaS products for operators of drones, air taxis and high-altitude platforms

UNISPHERE

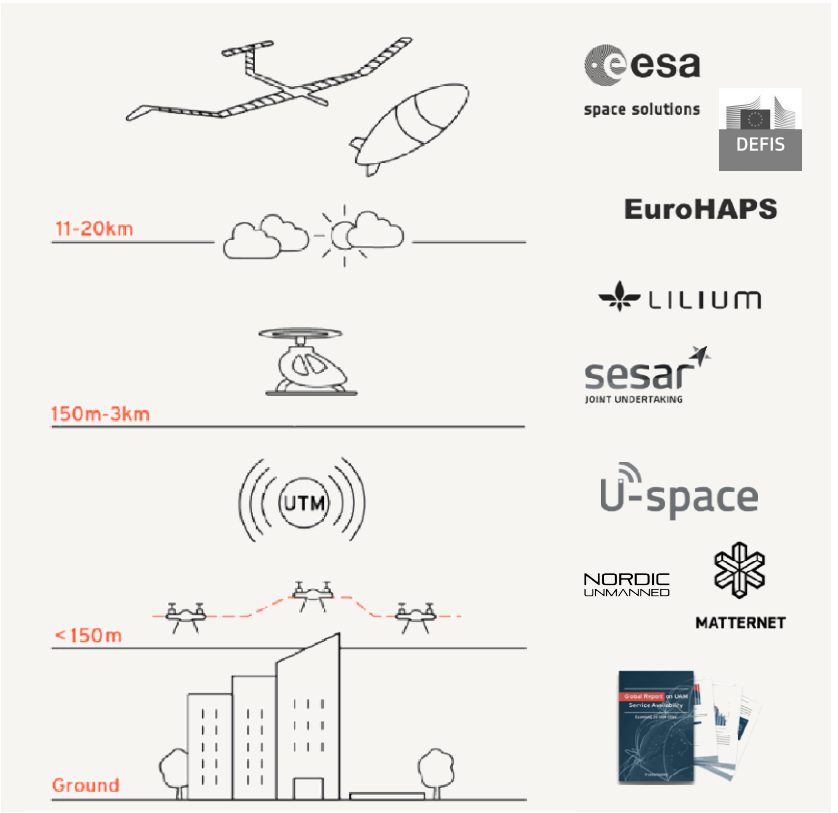
Unisphere in a nutshell – a team of aviation & innovation experts with a legacy in the pioneering Solar Impulse flight around the world

Christoph Schlettig - CEO

Dr. Christoph Selig - CCO

Michael Anger - CTO

- **Founded in 2017 in Konstanz**
- **Experts for automated and unmanned flight operations**
- **15 People, based in Konstanz, Munich and Paris**
- **Transferring pilot knowhow into reliable technologies**
- **Active in pioneering projects from ground to stratosphere**

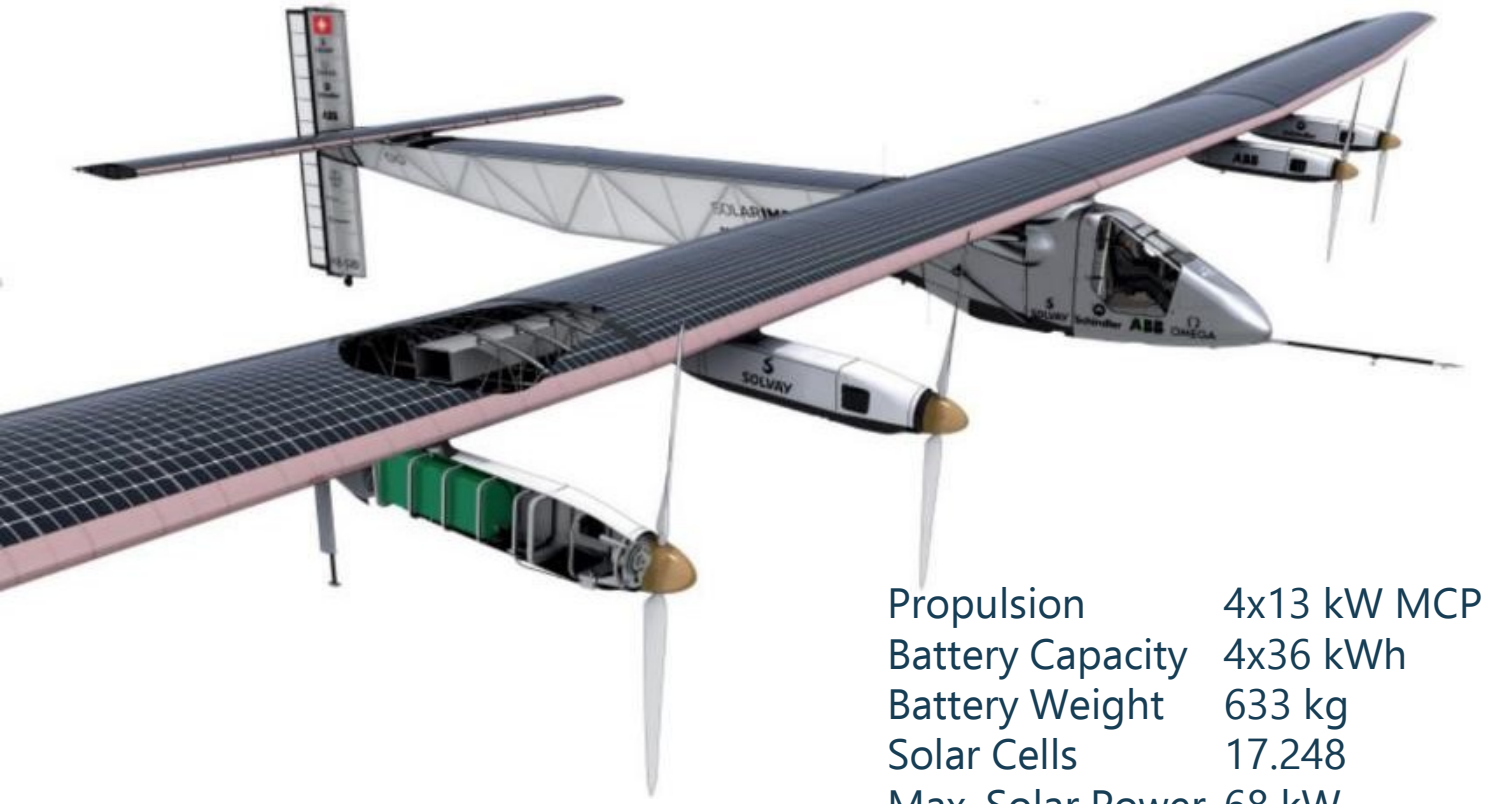


Solar Impulse – The Project

- Founded in 2003 by Bertrand Piccard and André Borschberg
- Based in Switzerland (Zurich, Lausanne, Payerne) with a core team of 90 people
- Funded by over 100 industry- and institutional partners

„...to demonstrate the potential of clean technologies by flying a solar-powered aircraft around the world without using fossil energy.“

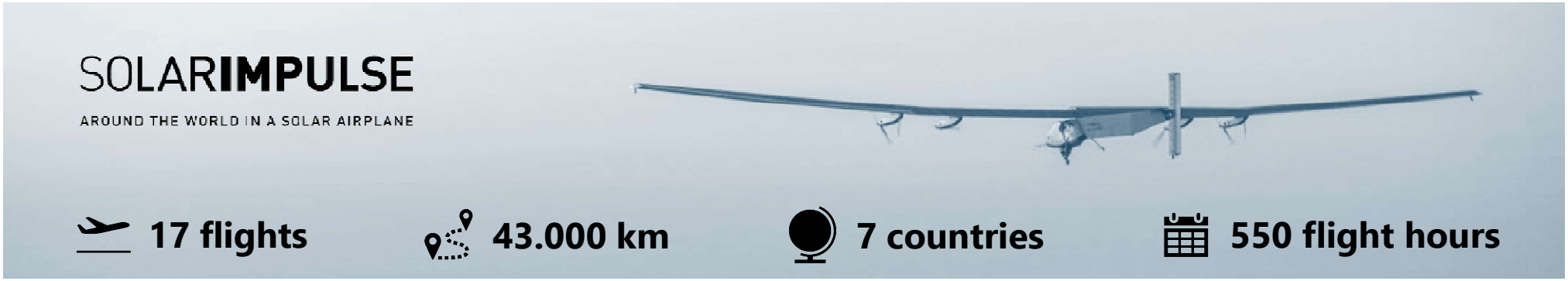
Solar Impulse 2 – The Aircraft

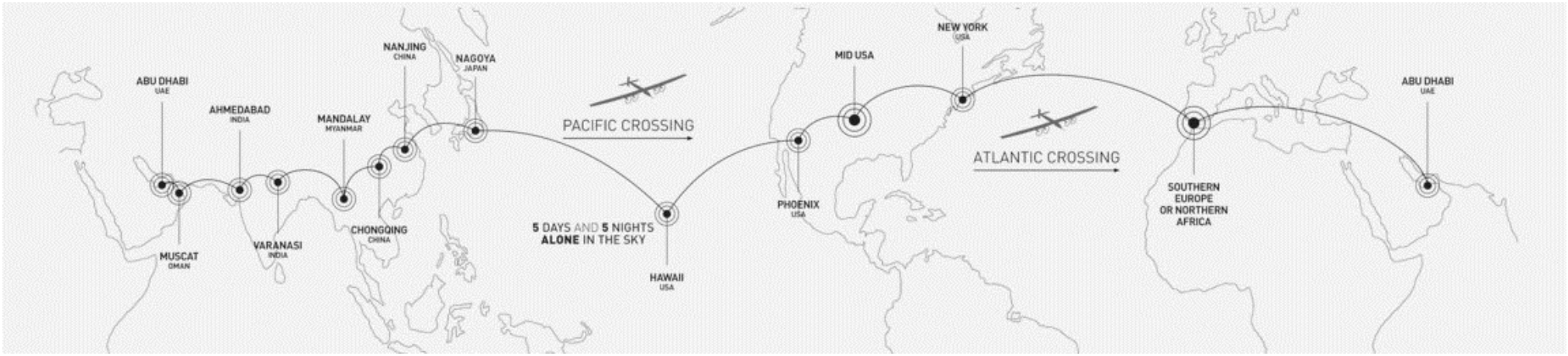


„Wingspan of an A340, weight of a mid-size car, power of a scooter“

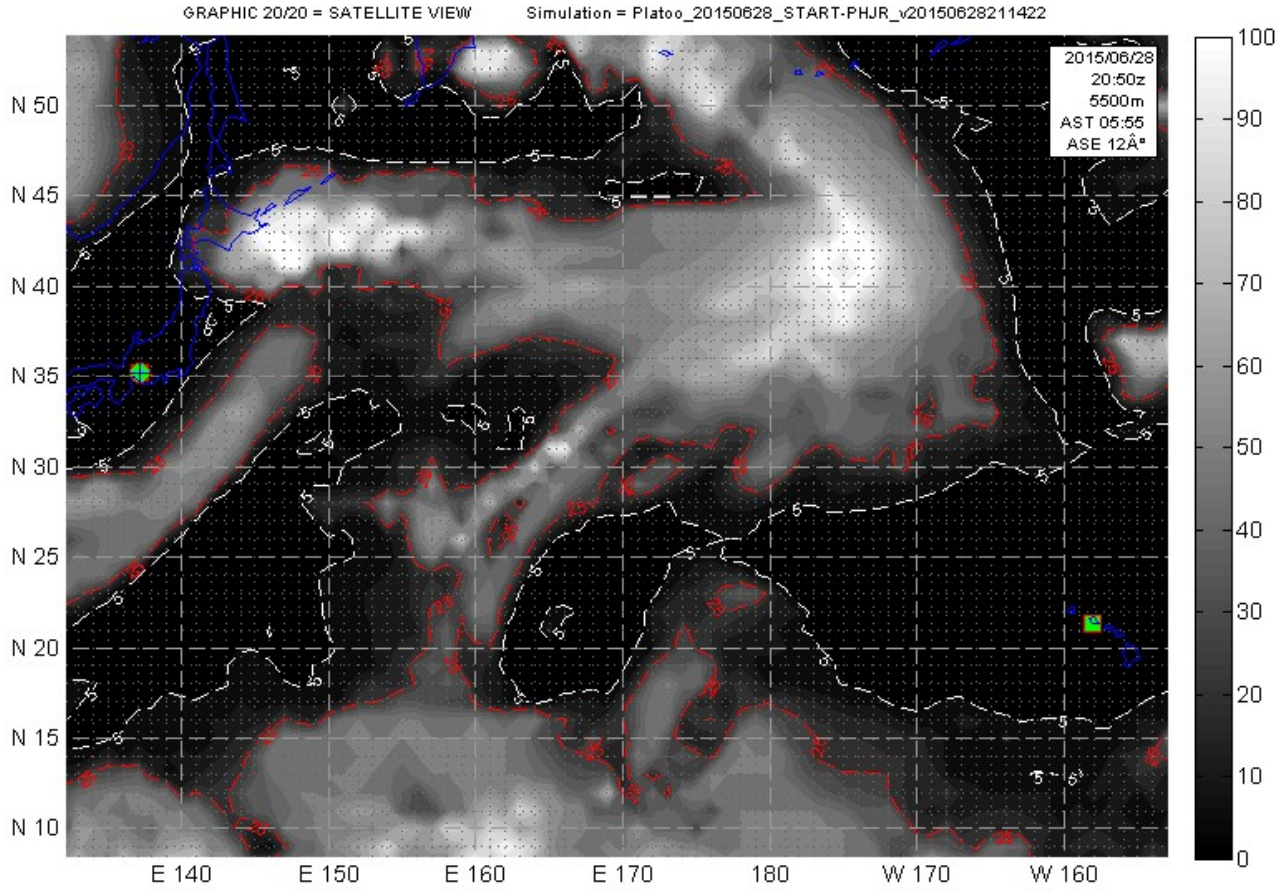
Propulsion	4x13 kW MCP	Wingspan	72.3m
Battery Capacity	4x36 kWh	Weight	2.500kg
Battery Weight	633 kg	Cruise Speed	24kts
Solar Cells	17.248	Max. Altitude	28.000ft
Max. Solar Power	68 kW		

Solar Impulse - the first **circumnavigation of the world** by an **electrically powered** and **partly-automated aircraft**





Rudimentary flight planning tool – **proven in planning multiple-day flights** considering weather conditions and battery capacity



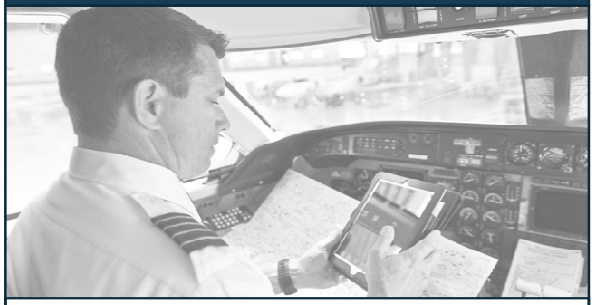
- Technology proved by successful flight around the world
- Simulation technology provided relevant data – planning was done by the flight ops team
- Mission control center consisted of around 20 people required for data interpretation & decision-making

The Paradigm Shift – entering the Era of Unmanned Aviation will lead to fully Automated flight operations in the future

Human-centered aviation
(before 1980)

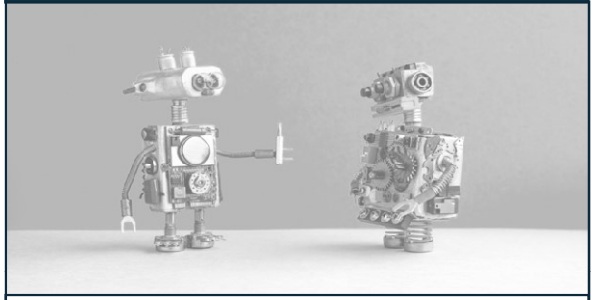
- Flight operations developed historically around humans
- Pilots is the center of the overall safety concept

Human-supported aviation
(1980 – today)



- Automated processes monitored by humans making decisions
- Pilots are an important element of the safety concept

Autonomous aviation
(>2025)

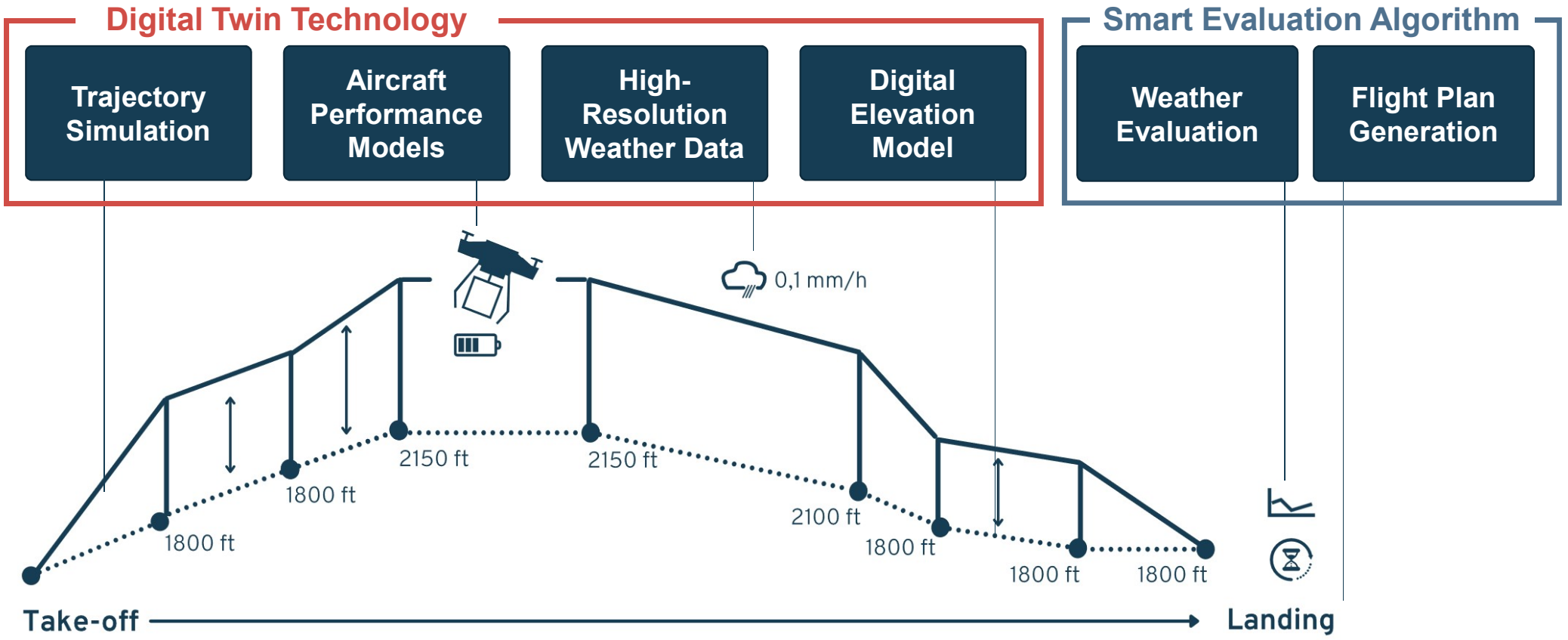


- Automated processes monitored by computers
- Autonomous decision-making enabled unmanned flight operations

decreasing human involvement

increasing automation 1010 1010

Smart 4D Trajectory – combines digital twinning technologies with pilot know-how & decision-making-mechanism transferred into technology

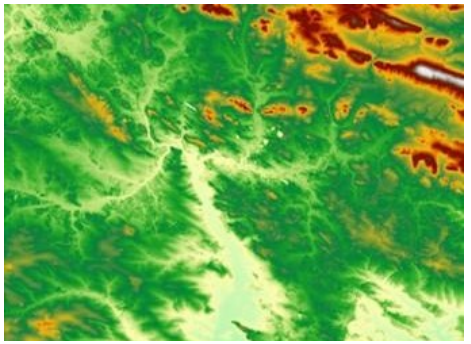


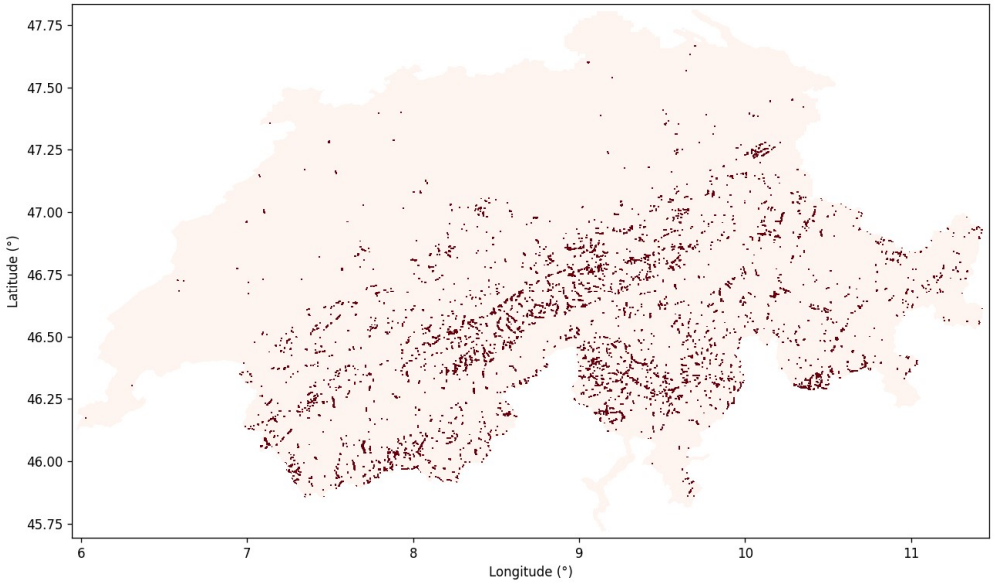
Weather Model Integration

- Best available weather model – the mixed model approach select the best available model for your mission
- Global availability of the weather data, single source for planning all flight operations
- High spatial and temporal resolution
  - Temporal resolution: up to 5 min (model dependent), 20 min (72hours), 60 min (5 days), 180 min (>5 days)
  - Up to 90m - depending on weather model
- Historic weather data of past 5 years with more than 1000 parameters available for analysis
- Open to integrate custom weather models

Examples of weather models integrated today	
European Center	ECMWF
Finish Met Institute	FMI
Dutch Weather Service	KNMI
Meteo France	MF
Meteomatics	swiss1k
National Weather Center	NCEP
UK Met Office	UKMO
German Weather Service	ICON/EU

Digital Elevation Model

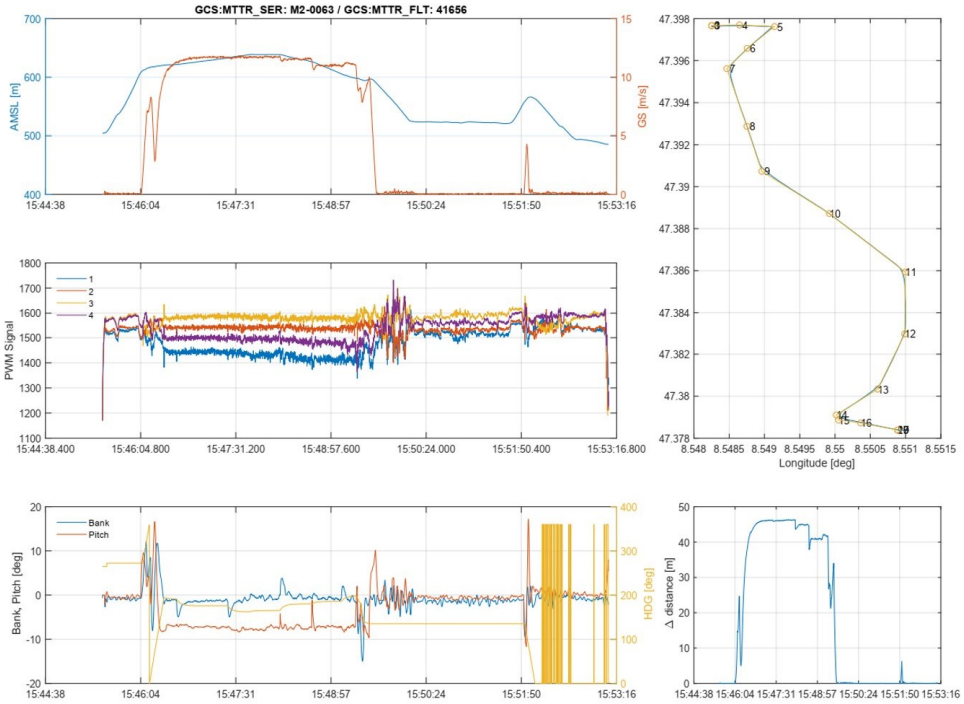




- Copernicus DEM GLO 30 as global baseline
- (In)validated with SwissTopo terrain data for full Switzerland (0,1% of Switzerland are not with in 99,9% prediction interval)
- Available as API service (for ANSP) and as internal “elevation service” for terrain and any AGL altitude inputs

Performance Model
Modelling & Integration Types

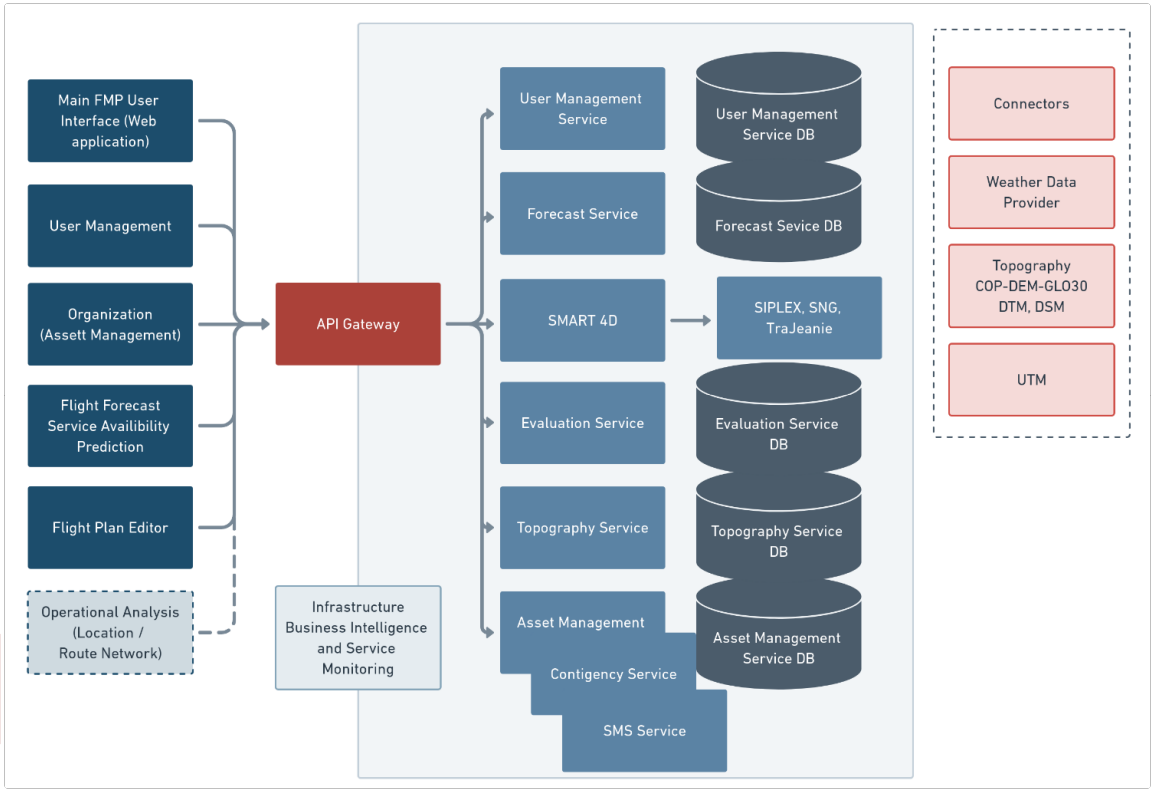
Type of Performance Model	Fidelity	
Simplistic model	Level 1	Point mass, fixed speed, ignoring EAS, TAS
Manufacturer-provided Lookup Tables	Level 2	Point mass, Lookup tables
Statistical Measurements (hundreds of flights)	Level 3	Point mass, lookup tables from statistical analysis & equation
Explicit Engineering Model validated with test flights	Level 4	Dynamic model, 6 DoF, explicit modelling
Black box provided by manufacturer	Level 2-4	Black box, fidelity depeding on customer input



Digital twin technology stack - running today, scaling with demand

- Platform-agnostic through micro-service architecture
- Currently hosted at AWS, accessible as SaaS or API
- Discrete-Event-Simulation / variable increment time progression

4D Trajectories simulated: 5,600,000 + 30,000 more per day



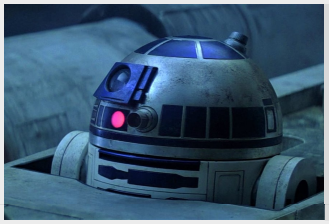
The Smart 4D Trajectory can be used to automatically analyze and evaluate **weather forecast** or **historic weather** data

Operational Analytics for UAM

Historic Weather Data

- Data-driven analytics of past operational conditions evaluating weather impact on future flight operations
- Supporting vertiport planning, eVTOL design verification, and evaluation of air taxi service viability
- Detailed understanding of future operating conditions

Digital Co-Pilot for drone flight operations



High-resolution weather forecast & observations

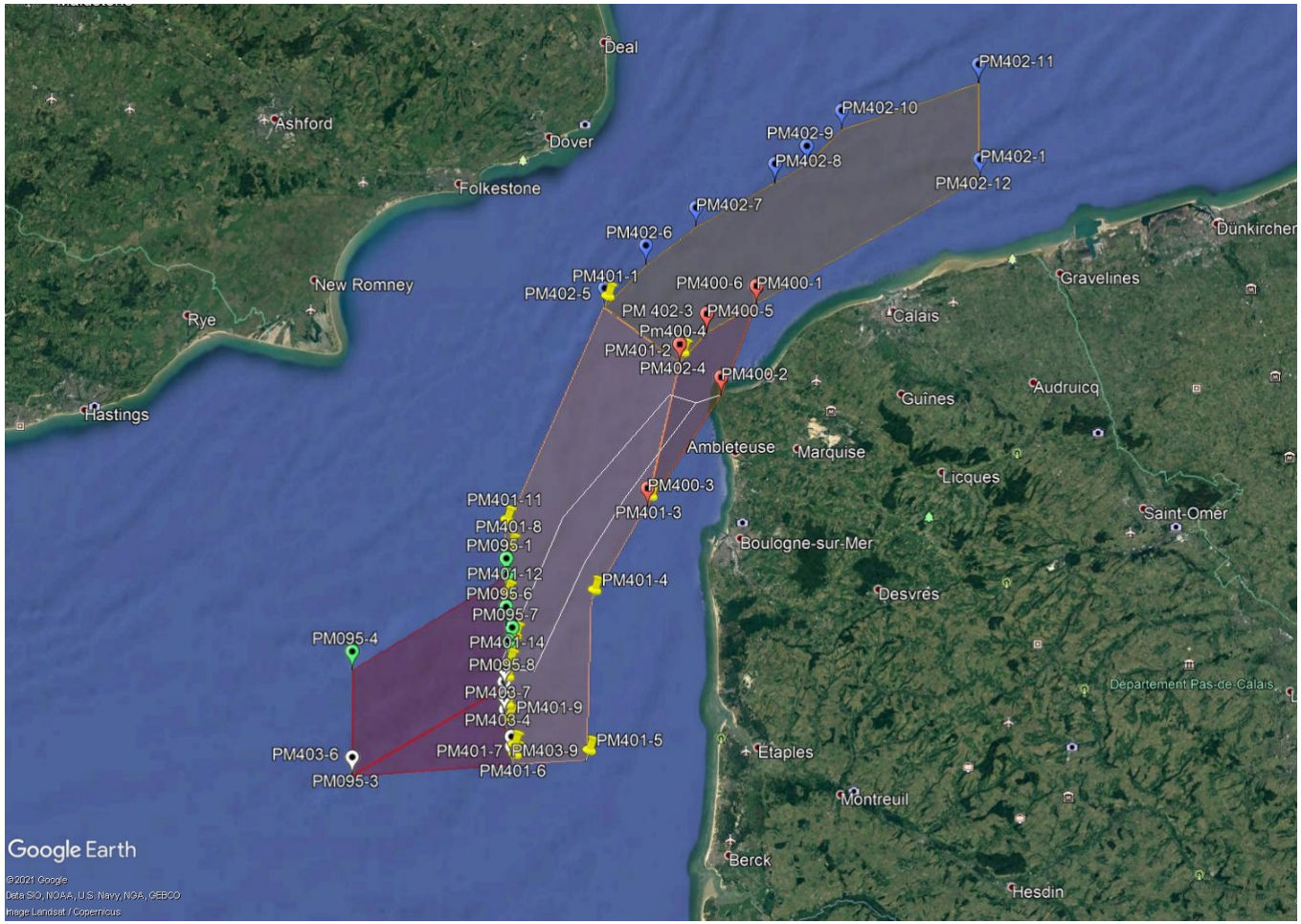
- Operations Management platform for drone and air taxi operations
- Pilot know-how and decision-making mechanism transferred to technology
- Underlying simulation technology designed to support piloted and fully autonomous drone operations

Smart 4D Trajectory Technology

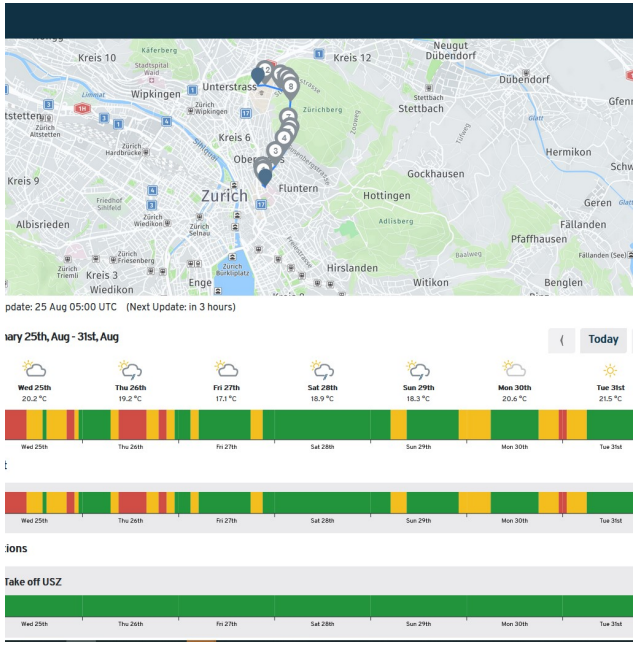
Maritime Drone Flight Operations - 1

- Commercial flight operations with significant coordination efforts between multiple stakeholders
- Operators are “paid by hour on station”, therefor strong interest to maximize flight times
- Unisphere SaaS used to identify suitable weather windows up to 7 days into the future
- Aircraft limits, payloads limits and operational constrains are taken into account

Maritime Drone Flight Operations - 2



Drone Logistics



- Managing customer expectations through service availability predictions
- Automated flight planning at takeoff, enroute and landing
- Shore to ship use cases

Availability Heatmap – implications for **business case of air taxi services**, supporting sales and business development activities

Airport	LTBA
Variable	All
Sub_period	Total
Severity	(Mehrere Elemer)

LTBA

	Total	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Jan	86%	85%	88%	86%	85%	86%	87%	86%	85%	86%	82%	85%	85%	85%	90%	89%	89%	85%	86%	86%	84%	85%	85%	83%	84%
Feb	83%	82%	83%	83%	83%	83%	81%	81%	81%	81%	83%	85%	87%	86%	88%	84%	82%	81%	80%	81%	83%	85%	85%	83%	81%
Mar	92%	92%	94%	94%	90%	90%	89%	89%	89%	90%	89%	93%	92%	95%	92%	92%	91%	92%	91%	94%	94%	94%	97%	94%	95%
Apr	96%	96%	95%	96%	96%	96%	97%	96%	95%	95%	94%	97%	97%	97%	97%	97%	97%	97%	97%	96%	98%	97%	97%	97%	97%
May	99%	99%	98%	98%	98%	98%	97%	97%	97%	98%	98%	98%	99%	99%	100%	99%	99%	99%	99%	100%	99%	100%	98%	99%	99%
Jun	98%	99%	97%	93%	91%	96%	100%	99%	100%	100%	99%	99%	100%	97%	99%	99%	98%	98%	99%	98%	99%	99%	98%	100%	99%
Jul	99%	99%	99%	99%	99%	98%	98%	98%	98%	99%	98%	99%	100%	100%	100%	100%	99%	98%	100%	100%	100%	100%	100%	100%	100%
Aug	99%	100%	100%	100%	98%	98%	98%	99%	100%	100%	99%	99%	99%	98%	98%	97%	97%	98%	98%	98%	99%	99%	99%	100%	100%
Sep	96%	98%	97%	97%	95%	95%	96%	96%	98%	97%	97%	97%	96%	96%	97%	95%	95%	95%	97%	97%	98%	97%	97%	97%	98%
Oct	98%	98%	96%	96%	96%	94%	96%	97%	97%	100%	99%	99%	98%	100%	99%	98%	99%	99%	99%	100%	100%	100%	100%	98%	97%
Nov	91%	89%	88%	89%	89%	90%	90%	89%	89%	91%	92%	92%	91%	93%	94%	93%	92%	93%	94%	92%	92%	92%	90%	89%	88%
Dec	88%	87%	87%	87%	87%	86%	84%	86%	86%	89%	89%	89%	89%	90%	94%	93%	90%	87%	88%	88%	85%	86%	87%	87%	87%
Year	94%																								

Operational Analytics – **tailored analysis** of a large amount of historic **weather data** and the **impact on future eVTOL flight operations**

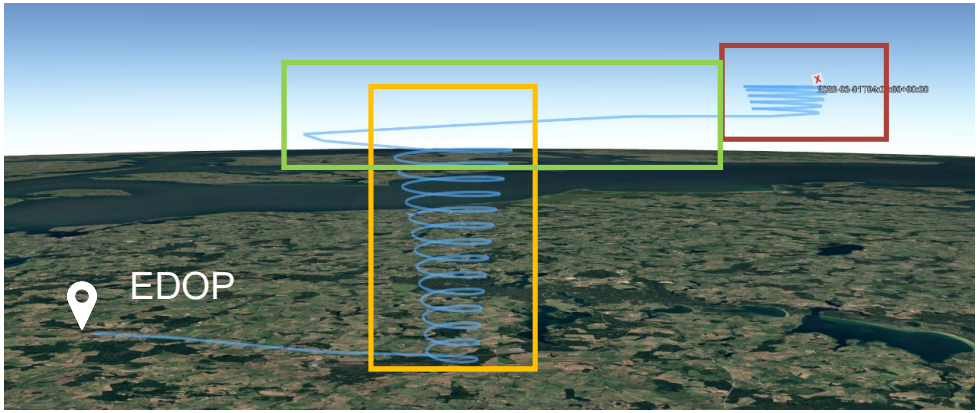
- The weather data is evaluated on an hourly basis, i.e., for the years 2018 - 2022.
- Given the timeframe and number of parameters around 600.000 data points are analyzed per location.
- If in a given hour one of the parameters e.g., gust factor, was beyond the limit of *nominal* it was considered m*oderate* or s*evere*.
- Providing a service availability prediction

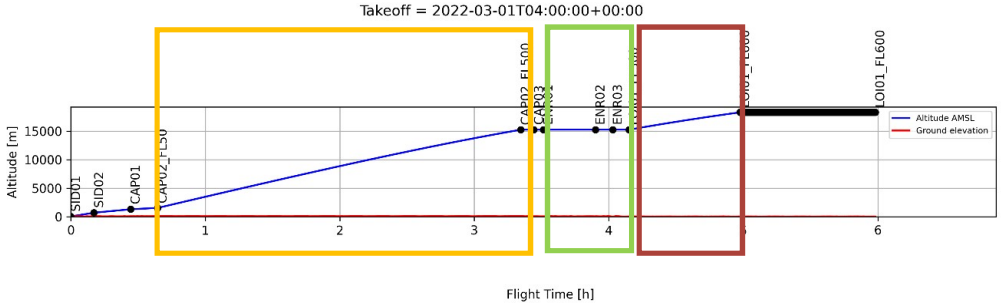
- Tailored to eVTOL capabilities & specific weather limits
- Scenario planning, i.e. comparing IMC vs. VMC or impact of de-icing system

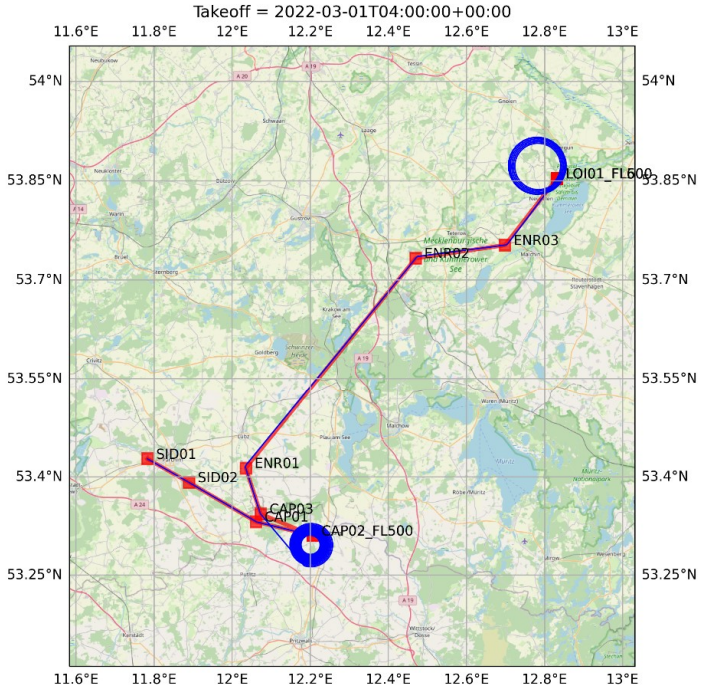
WX Group	Parameter	Nominal	Moderate	Severe
Visibility	Visibility	> 5000 m	5000-1500 m	< 1500 m
	Ceiling	> 500 m	500-150 m	< 150 m
Wind	Mean Wind speed	< 15 kn	15-20 kn	> 20 kn
	Gust Factor	< 10 kn	10-15 kn	> 15 kn
Temperature	OAT range	-20 to +40 °C	-30 to -20 / +40 to +50 °C	<-30/>+50 °C
Precipitation	Rain amount	< 2.5 mm/h	2.5-7.6 mm/h	>7.6 mm/h
Icing[1] (new)	General Icing	Always classified as severe		
Dangerous Phenomena	Thunderstorm	Always classified as severe		
	Sand- or dust storm			
	Funnel clouds			
	Freezing rain			
	Squall			
	Ice pellets			
	Hail			
	Fog			
	Smoke/volcano ash			

LUFO Obelisk – operationelles Betriebskonzept zur Luftraumintegration von HAPS

- **Initial Climb Area :** Steigen von 5000 ft auf FL500
- **Transition Route**: konstant FL500
- **Climb Area 2 :** Steigen von FL500 auf FL600

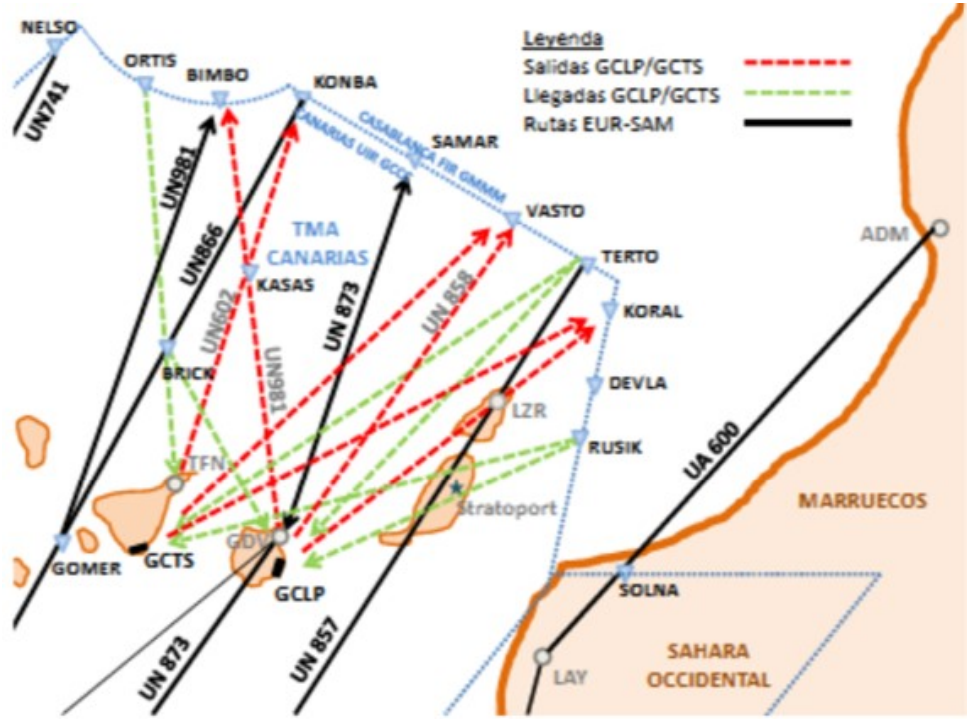






No wind

HAPS customers – Sceye and Thales



Thank you!

UNISPHERE

Christoph Schlettig
Founder & CEO

+49 178 3308093

christoph.schlettig@unisphere.de

www.unisphere.de