How FLiDARs can enrich your Metocean datasets and reduce your project development costs

September 30th, 2019

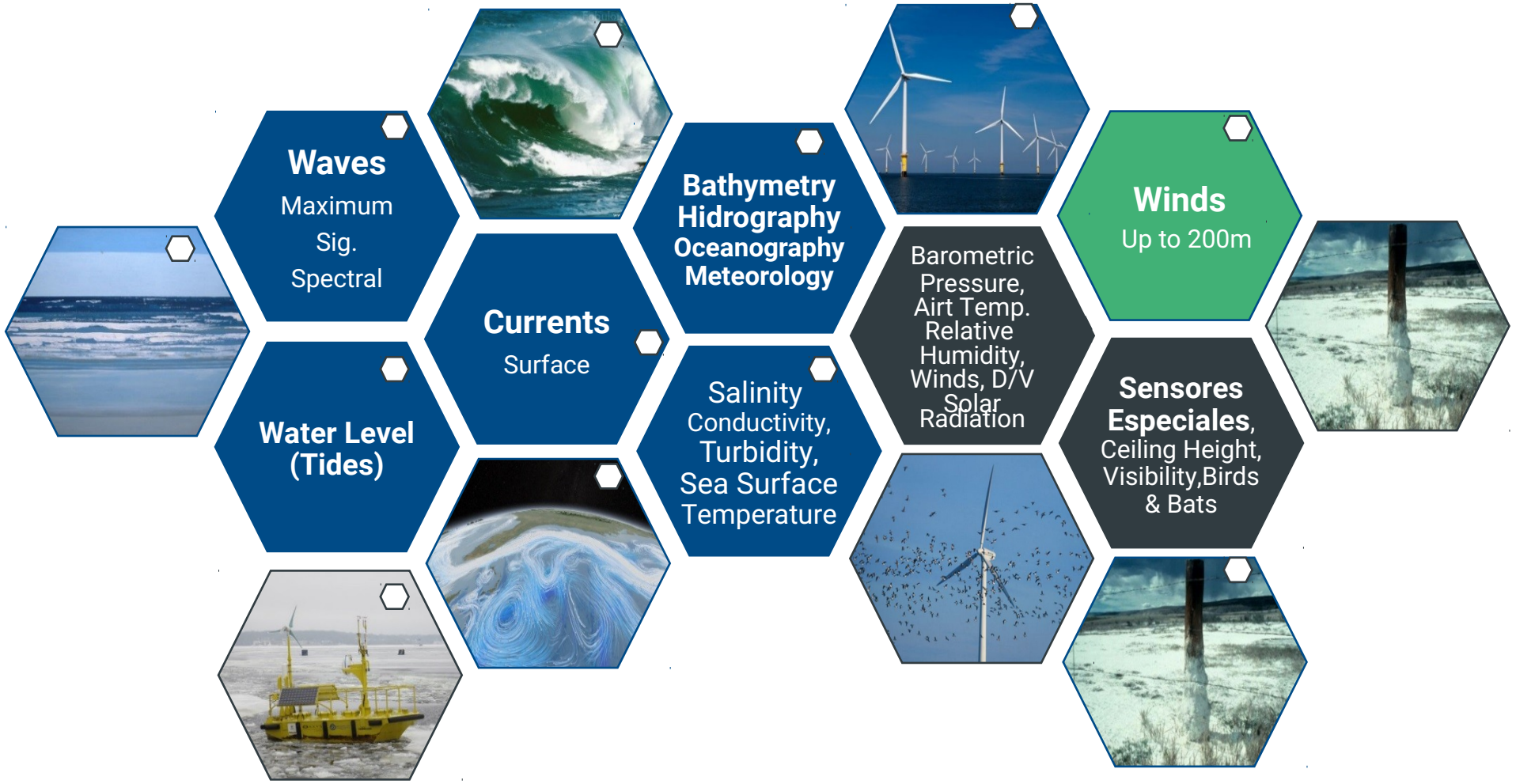
Agenda

1. Data
2. Purposes of a FLiDAR® campaign
3. Project timelines
4. FLiDAR® performance verification results
5. FLiDAR short video
6. Lessons learned
7. Introduction to AXYS

AXYS

FLiDAR®

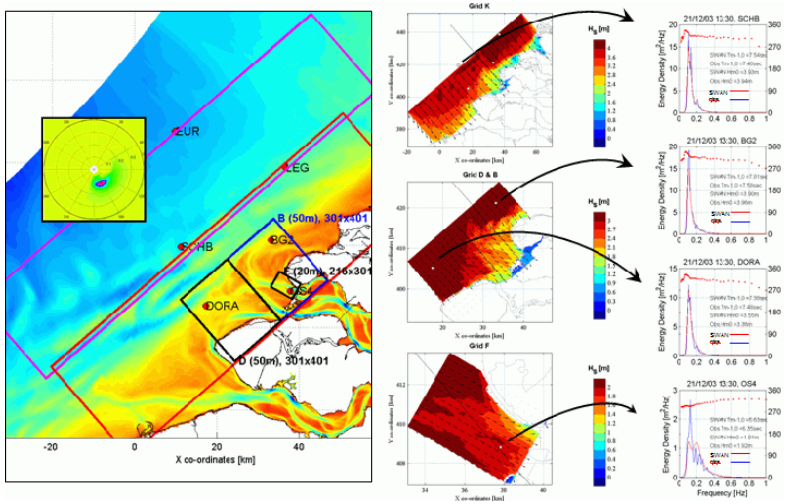
Met Ocean Data



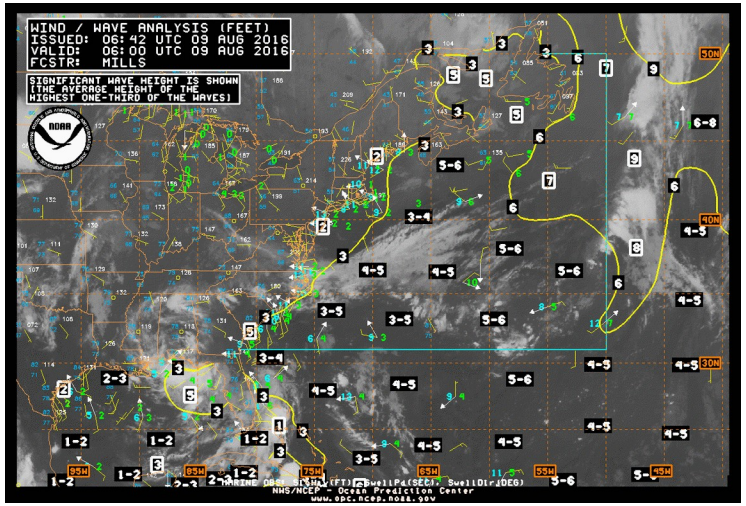
Modelos Durante el Ciclo de Vida de un Proyecto

Environmental Impact Analysis / Energy Yield Studies / **Shear Studies** / Turbulence Intensity Calculations / **Weather Hindcasting** / Sea-State Monitoring / **Pre-Construction Baselining** / Weather Forecasting **Physical Asset Design** / Power Curve Analysis / **Asset Condition Monitoring** / Bird/Bat Monitoring / **Scour Monitoring** / Fish and Flore Identification Studies / **End of Life Assessment**

Current High Level Data Tools



Satellite Data / Models



Hindcasting Data / Models

Purposes of a FLiDAR® campaign

Why do you need FLiDAR measurements?

1. For wind data which will be used in the annual energy yield predictions, for wind turbine selection and for operations planning (both installation and O&M)
2. For sea state data which depending on the site can be the more important design parameter for the tower and substructure as well as for operations planning
3. Other environmental monitoring e.g., birds, bats, sea mammals

Why choose a FLiDAR over a met mast?

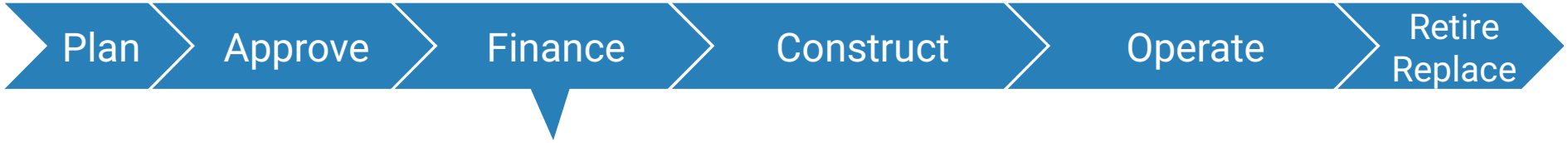
- FLiDAR® buoys can typically be deployed within a few months
- Permitting FLiDAR® buoys is typically more straightforward
- FLiDAR® buoys are typically 10x less expensive than a met mast option

Overall Eolic Project Timeline

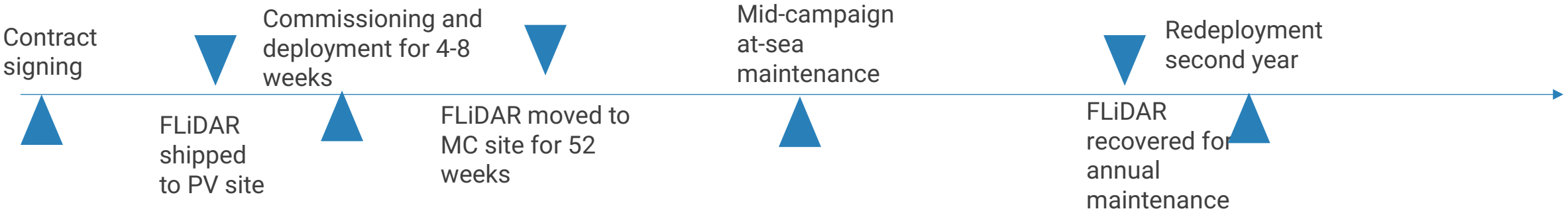
- Hind cast modeling
- Site characteristics
- Wind farm design

- Wind assessment
- Risk assessment
- Enviro assessment

- Real-time/forecast sea state during Construction/ O&M
- HSE/O&M contract compliance monitoring
- Turbine performance monitoring



Wind Assessment Timeline



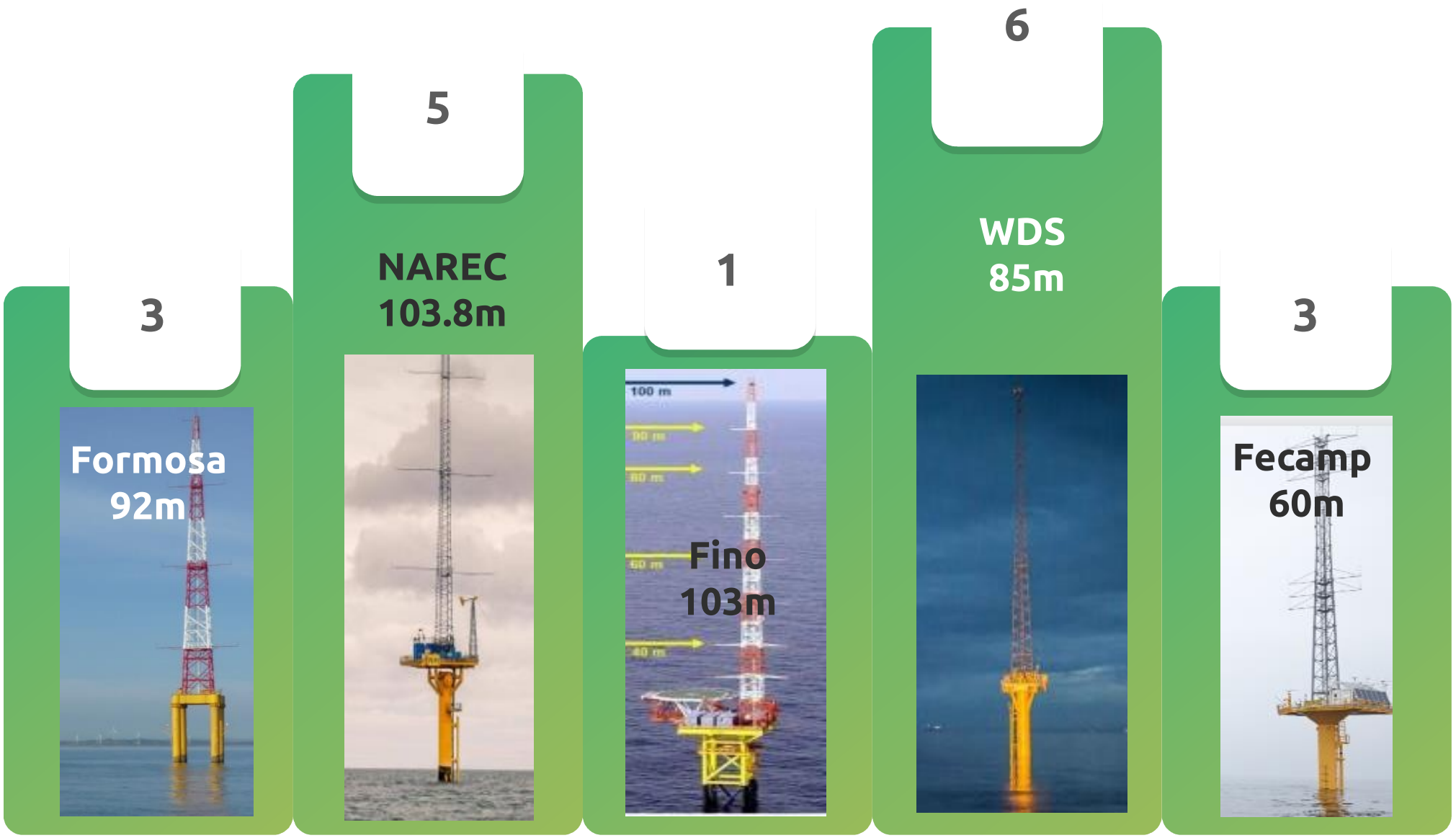
Schedule variations could be expected for -

- Time to fill wind speed bins during per campaign performance verification
- Weather delays
- Vessel availability
- Permitting delays

PV Pre Validation
MC Measurement Campaign

has 19 Met Mast Validations Complete or Underway

Proven accurate in a wide variety of sea states



Source: AXYS Technologies Campaign History Log June 2019

AXYS FLiDAR Solutions are Consistently Accurate to Industry Standards

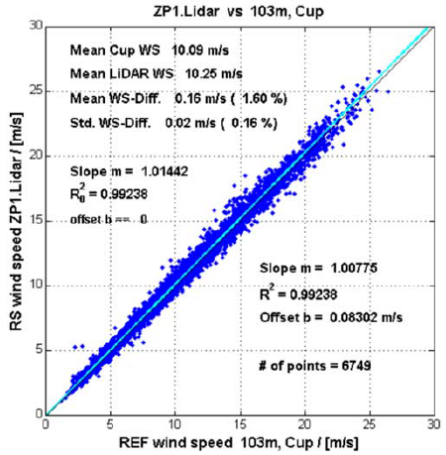
Table 2: Example of Recent AXYS FliDAR WindSentinel Validation Campaign Against Met Mast

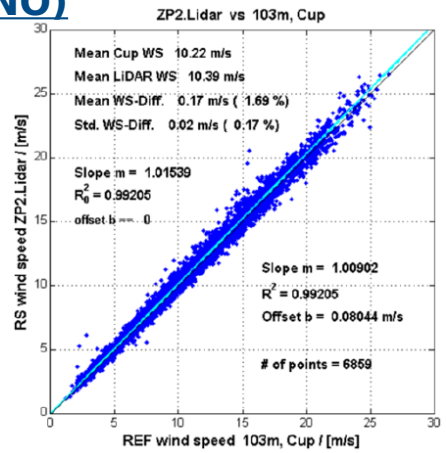
	88m			68m			48m		
	r2	slope	offset	r2	slope	offset	r2	slope	offset
Unit 1	0.9825	1.0047	4.0577	0.9895	1.0264	4.0577	0.9895	1.0271	2.4223
Unit 2	0.9846	1.0029	3.4251	0.9889	1.0267	4.4378	0.9924	1.0262	1.8153
Unit 3	0.9800	1.0032	5.2399	0.9838	1.0256	5.6647	0.9871	1.0281	3.6889
Unit 4	0.9777	1.0039	4.0265	0.9823	1.0288	5.0286	0.9827	1.0272	2.2357

KPI-AC passed best practice	KPI-AC passed minimum	KPI-AC failed

Accuracy - Results of Long-Term Validations

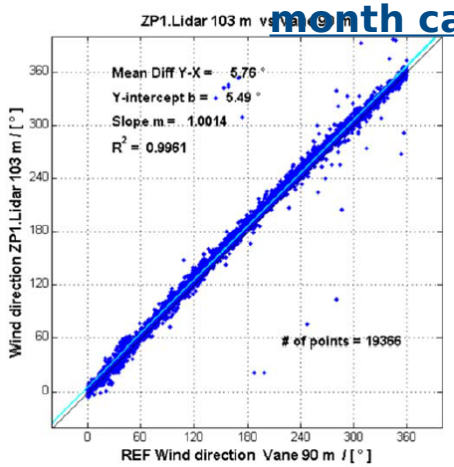
Top height wind speed correlation plots for five month campaign (FINO)

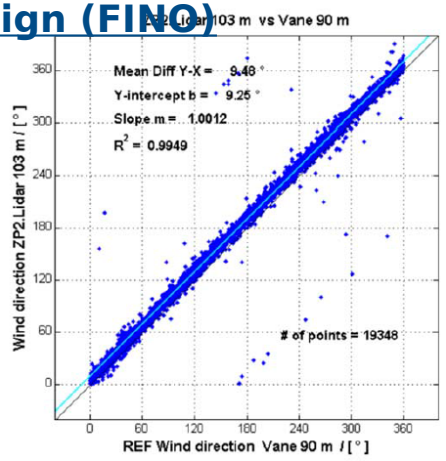




No Degradation in Measurement Accuracy Over Time

Top height wind direction correlation plots for five month campaign (FINO)





Source: DNVGL analysis

The FLIDAR WindSentinel performs in extreme weather conditions for extended periods

<u>West of Duddon Sands</u> 6-mo campaign

- Max 10-minute average wind speed measured by the top cup – **29.8 m/s**
- Significant wave heights as measured from the buoy were **H_s > 5 m** with a **max wave of 9.4 m**[1]
- Tidal difference **was 10.2 m**

WS Max	WRMM	FliDAR
Level / [m]	WS [m/s]	
55	28,05	28,10
70	28,85	28,99
85	29,78	30,02

<u>FINO 1 Validation</u> 5-mo campaign

- Max 10-minute average wind speed measured by the top cup – **26.4 m/s**
- Significant wave heights as measured from the buoy were **H_s > 5.9 m** with a **max wave of 10.7 m**[1]

WS Max	Cup	ZP1	ZP2
Level / [m]	WS [m/s]		
103	26,42	25,01	26,57
90	26,07	25,57	25,72
80	25,71	25,56	25,14
60	25,13	25,01	24,59
40	24,40	23,31	24,29

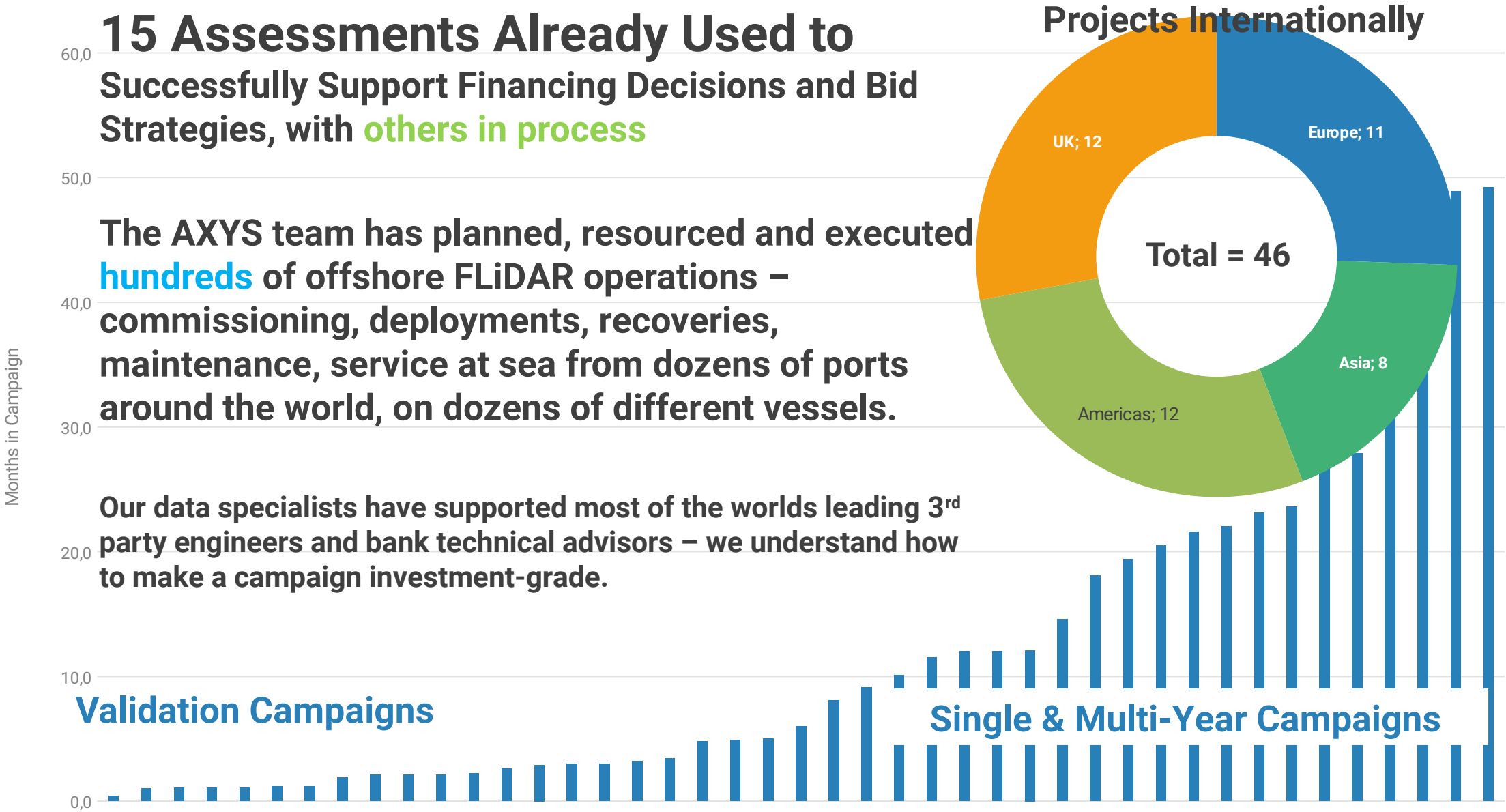
Source: DNVGL analysis
Note: AXYS measures waves using a 30-minute interval

AXYS Experience - 46 Campaigns and Counting

15 Assessments Already Used to Successfully Support Financing Decisions and Bid Strategies, with others in process

The AXYS team has planned, resourced and executed hundreds of offshore FLiDAR operations – commissioning, deployments, recoveries, maintenance, service at sea from dozens of ports around the world, on dozens of different vessels.

Our data specialists have supported most of the worlds leading 3rd party engineers and bank technical advisors – we understand how to make a campaign investment-grade.



Dual LiDAR Benefits

AXYS FLiDAR WindSentinel™ supports single, dual ZX Lidar or Windcube LiDARs (or mixed)

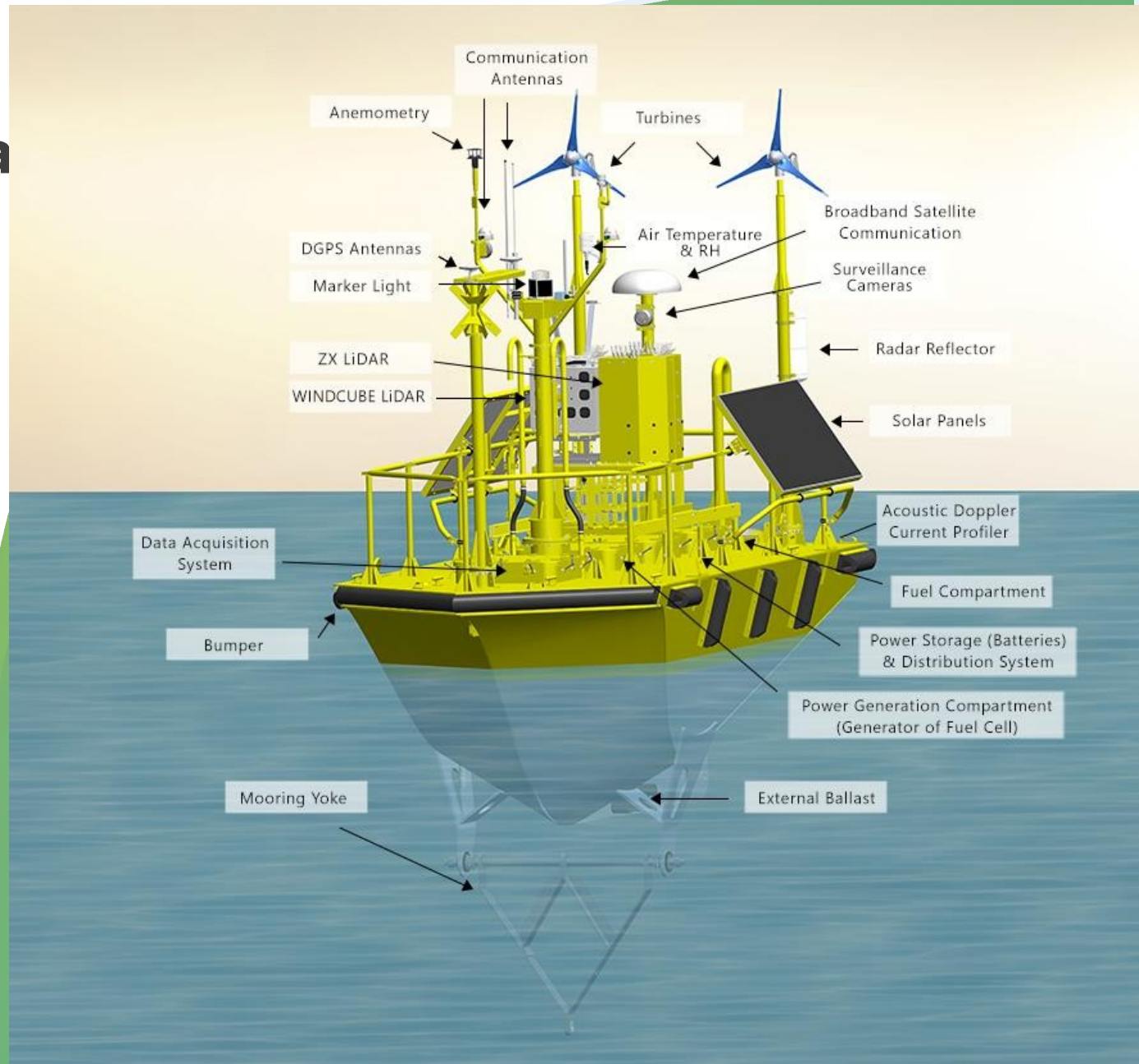
1. Improved data availability – Eliminate interruptions and extra costs in the case of LIDAR failure at-sea
2. Confidence in data accuracy– constant correlation of data to confirm data quality
3. Optimized maintenance cycles by using mixed life units
4. Higher data certainty – consistent link to original reference as well as potential reduction of systemic uncertainty

Multiple Layers of Redunda

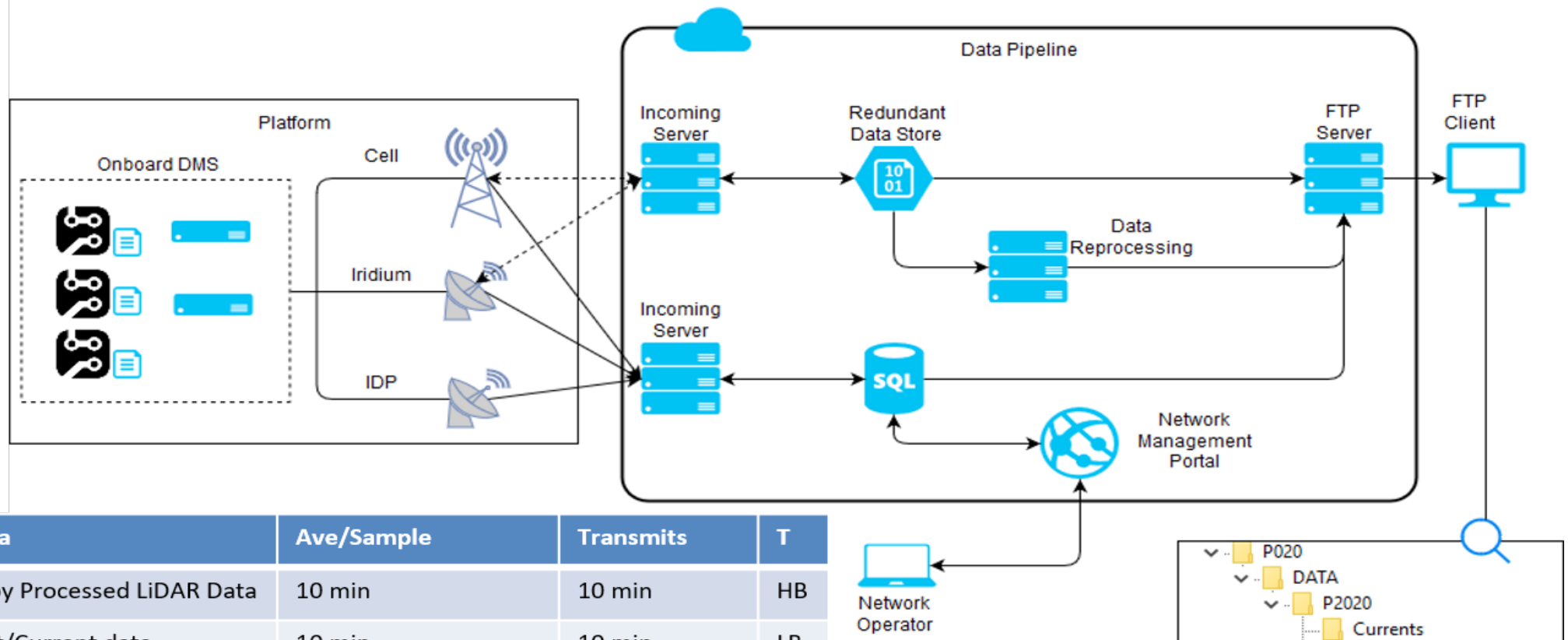
LiDARs, orientation sensors, data storage, power systems and more

Reduce the chance that typical issues in these regions impact our ability to collect your valuable measurement campaign data

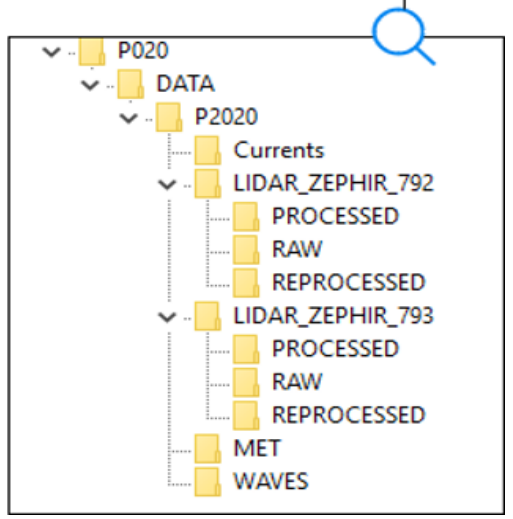
- Sensor OEM failure
- Weather damage
- Interference



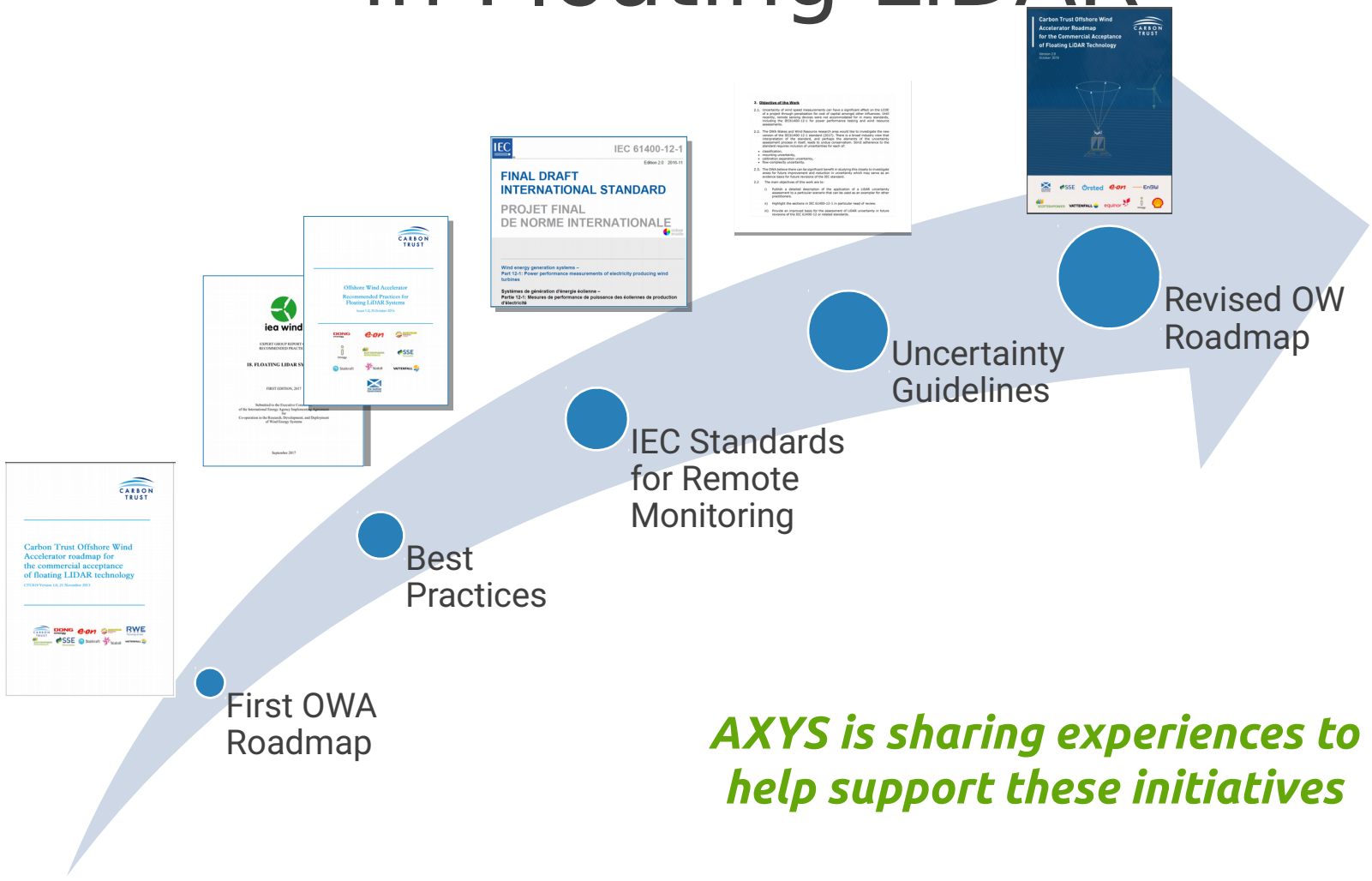
Sophisticated Data Network and 24/7 Quality Monitoring



Data	Ave/Sample	Transmits	T
Buoy Processed LiDAR Data	10 min	10 min	HB
Met/Current data	10 min	10 min	LB
Wave Data	20 min	20 min	LB
Heading Data	100msec	10min	HB
Rinex (Water Elevation)	1sec	60 min	HB
LiDAR Raw Unadjusted	1sec, 10 unadjusted	Zip file 1/day	HB
Camera Images	5-10 min	3-4/day	HB



The Evolution of Standards in Floating LiDAR



AXYS is sharing experiences to help support these initiatives

AXYS FLiDAR WindSentinel in the North Sea at FINO 1 Met Mast

https://youtu.be/5V8I0wPCq-M

Lessons learned

1. Try to plan deployment in the moderate weather seasons
2. Give as much notice as possible to the contractor
3. Start permitting as quickly as possible
4. Ensure your FLiDAR supplier has a reputable mooring engineering design team

OUR COMPANY

AXYS

Founded 1974

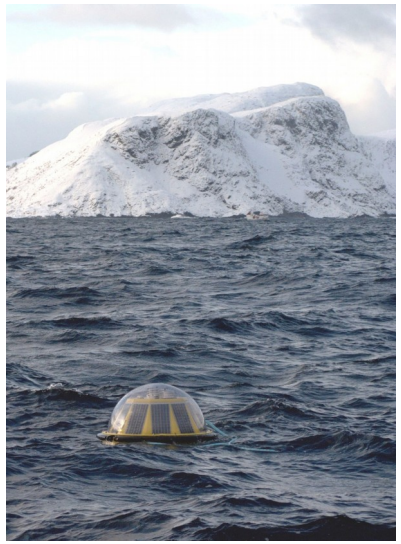
Headquartered in Sidney, British Columbia on Vancouver Island, Started to support environmental consulting for the artic.

1987 First Met Ocean buy NOMAD

2009 AXYS WindSentinel Floating LiDAR System Launch

AXYS integrates LiDAR into its Nomad floating platform.

.



2011 AXYS Builds 200th TRIAXYS

In 1999 AXYS completes the development of the proprietary wave technology and in 2011 launches the only Wave Buoy that measures waves and currents

2015 AXYS Acquires FLiDAR NV

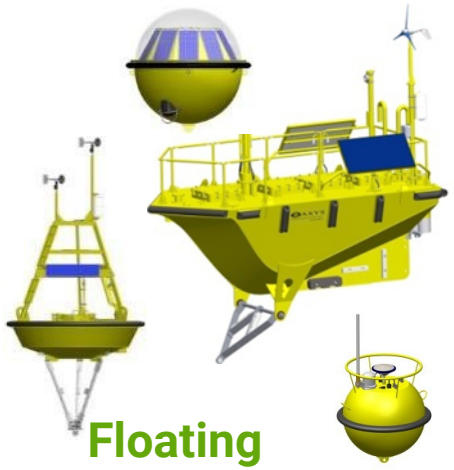
AXYS acquires lead competitor FLiDAR NV and their floating LiDAR device with a four-meter hull

2019 AXYS WindSentinel to Reach Stage 3

AXYS embarks on project to be the first floating LiDAR device to reach Carbon Trust Roadmap Stage 3 classification

Core Technologies

CLIENT NEEDS	Infrastructure Design ● Site Yield Assessment ● Seastate/Seabed Monitoring ● Climate/Ecology Research ● Public Safety/Security ● Asset Mgt ● Insurance Verification ● Product Testing
APPLICATIONS	Data Validation · GIS · Weather · Analytics · O&M&AM
DATA INFRASTRUCTURE	AXYS Cloud Solution · Client On-Presence Networks
TELEMETRY	Satellite · Cellular · Radio · Wi-Fi · Others
SENSORS & ACTUATORS	LiDAR · Meteorological · Oceanographic · Environmental
PLATFORMS	



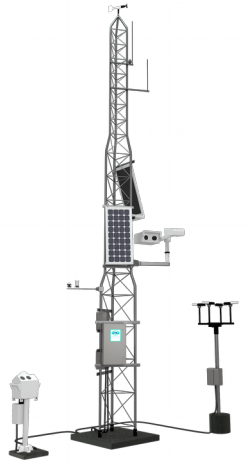
Floating

Moored

Seabed

Moving Stations

Fixed Stations



AXYS

ACCURATE, RELIABLE, COMPLETE WIND AND METOCEAN DATASETS

95%+
or more annual data availability

ROBUST REDUNTANT SYSTEM

600+
Commercial Campaign Months
*As of August 2019

CERTIFIED TO CARBON TRUST STANDARDS
against multiple Met Masts

Verified Uncertainty Rates
BELOW 4%

Proven rugged buoy design performs even in the harshest marine environments

ENEFITS OF AXYS METOCEAN CAMPAIGNS

High Data Availability Track Record

Multiple Data Quality Controls

Proven Rugged Solutions
Marinized for harsh conditions

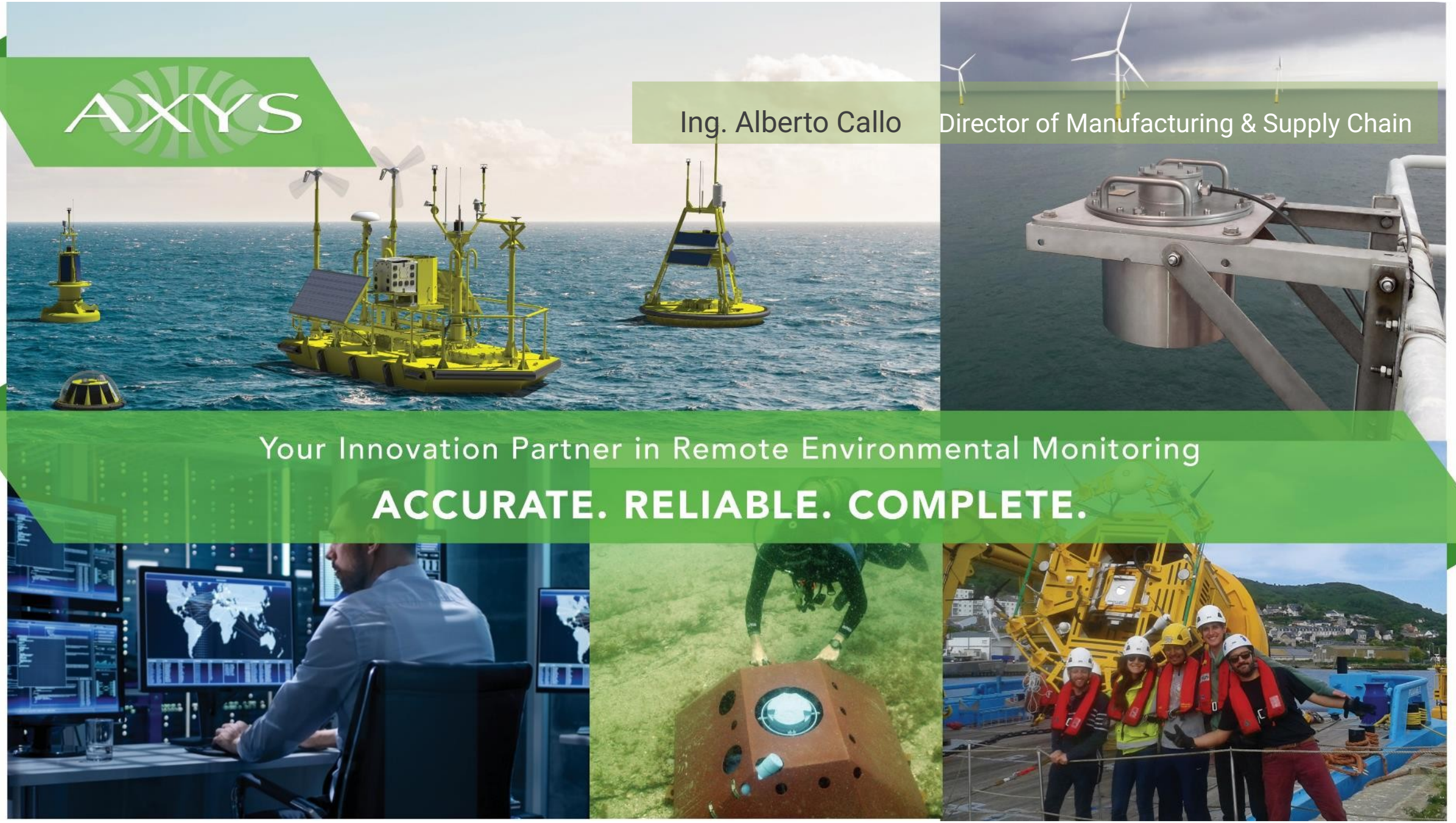
AXYS

Full Offshore Operations
Deployment/Recovery
Support and Maintenance

Experienced Field Teams
North America, Europe, Asia

ISO 9001, 45001, 14001

AXYS FLiDAR WINDSENTINEL™


AXYS
Ing. Alberto Callo
Director of Manufacturing & Supply Chain
Your Innovation Partner in Remote Environmental Monitoring
ACCURATE. RELIABLE. COMPLETE.