

A Modular Geodesy System for Subsea Monitoring: Update on the SOS Module

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Kongsberg: International high-tech solutions, from deep sea to outer space



Advanced solutions and applications for the maritime, oil & gas, defence and space industry.

- Extreme Performance for Extreme Conditions -

KM Subsea Division Companies & Locations



Subsea
Horten, Norway

- Underwater Mapping
- UNAV
- Fishery Naval
- AUV Systems
- Subsea Monitoring



Hydroid
Pocasset, MA, USA

- AUV systems



KUTI
Lynnwood, WA, USA

- Hydrography
- Seaglider
- Fishery



Mesotech
Port Coquitlam, Canada

- Hydroacoustics for ROVs, fishery, security, inspection and monitoring



Camera
Aberdeen, UK

- Underwater cameras
- Vessel camera systems



Underwater Mapping
Great Yarmouth, UK

- Swath bathymetry, SSS, SBP



Simrad Spain
Alicante, Spain

- Fishery, Subsea and Merchant



KM Embient
Halstenbek, Germany

- Subsea Monitoring
- Lander, Launcher
- Monitoring Systems



KM Contros
Kiel, Germany

- Subsea Monitoring
- Underwater gas sensors
- TA Systems

Sensors

KM CONTROS

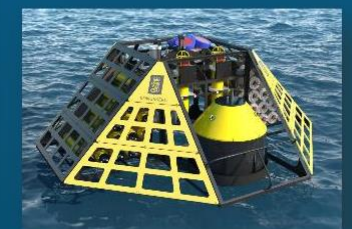


Platforms

AUVS



K-Lander



Versatile Lander Options

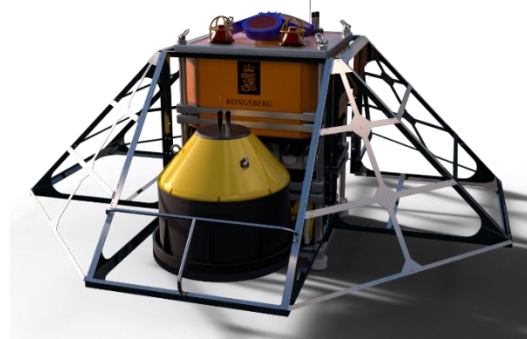
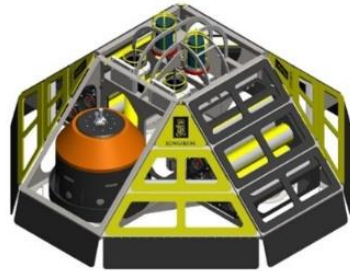
K-Lander μ

cNODE® IQAM



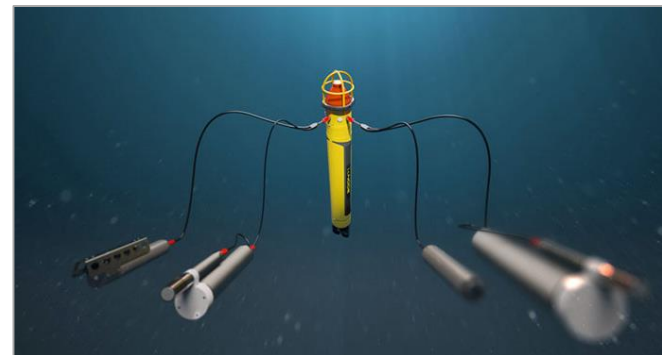
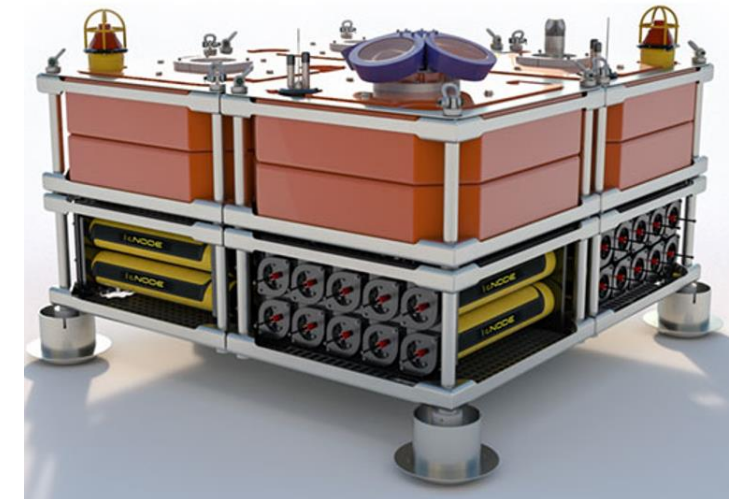
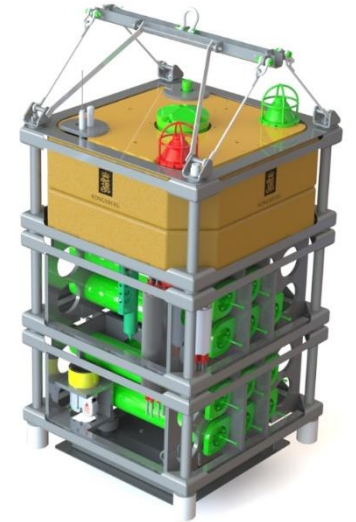
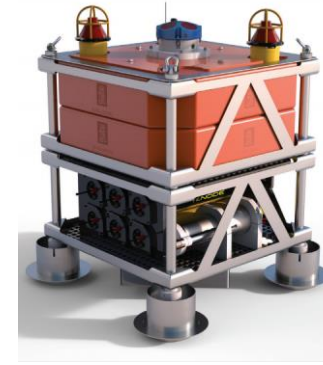
K-Lander 12 and 30

(with RRU; max depth 250m)



K-Lander

1s2h, 1s4h, 4s2h



K-Lander Floating Design - Benefits

Very low maintenance costs - No additional material, like ropes is required for the recovery procedure, only a new ground weight (made from standard steel) and standard system maintenance is required.

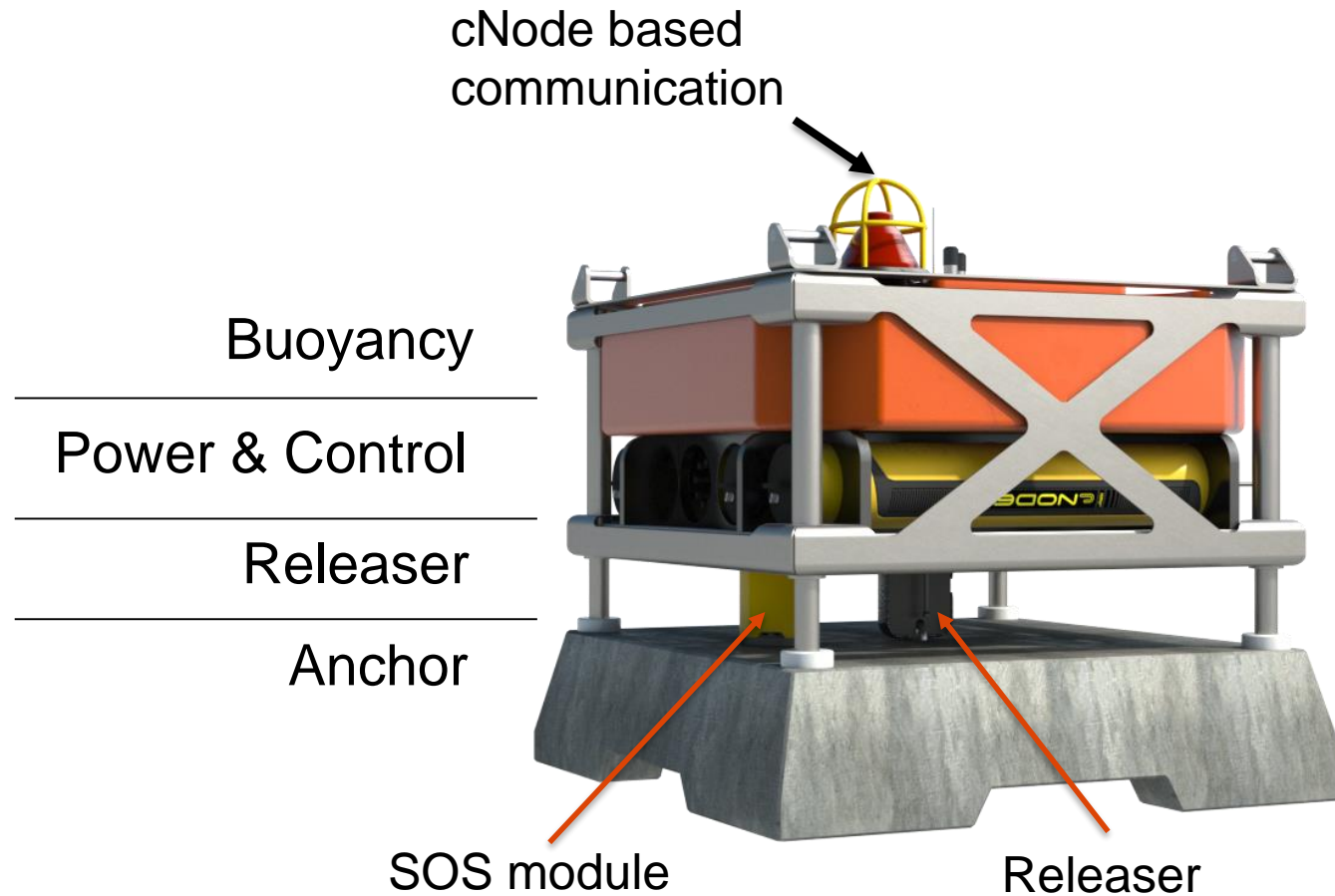
Durable Components - The Frame is build from Titanium (Grade 2) and therefore corrosion resistant with a very low maintenance on the frame itself.

Increased operational Envelope - The K-Lander floating Design allows a safe recovery from water depth down to 2.000m (limited by sensors specs) and is independent from recovery limitations induced by current speed.

Modular & Scalable - The design is modular down to the building bricks of the system. The same base frame is utilized for all modules. Content and function of each module is highly customizable.

Versatile - The Lander can be completely reconfigured and still tailored to the requirements from project to project.

K-Lander 1S1H - Geodesy Package (SOS Module)



Triaxial accelerometer is used to distinguish between **pressure events originating from sea level changes** (wave/stunami) **and seafloor movement** (subsidence/earthquake).

The integrated datalogger uses the accelerometer data to remove seafloor movement events from the pressure measurements.

The triaxial accelerometer can also be used as a **seismometer** to get more detailed information about the earthquake that caused the tsunami.

The module is calibration free and requires very low maintenance (→ A0A correction).

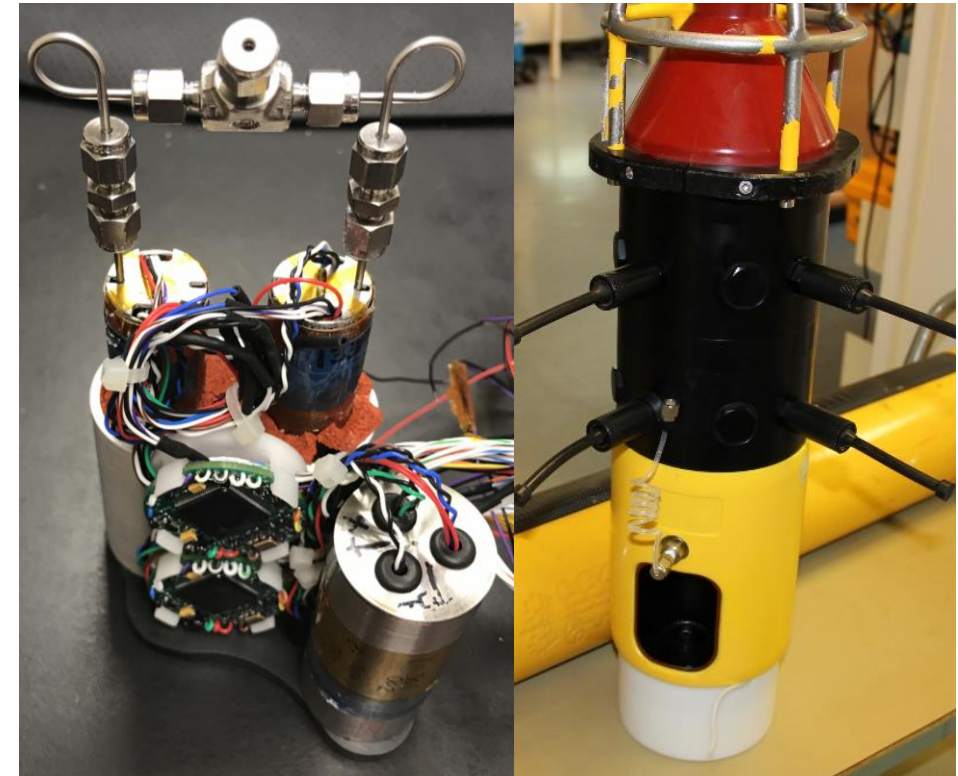
SOS Module

System components:

- 2 Digiquartz® Absolute Pressure Gauges (APG)
- 1 Triaxial Accelerometer
- 1 Digiquartz® Barometer
- 3 Nano-resolution Processing Electronics
- 1 Three-way Ball Valve for A-0-A Calibration

Benefits:

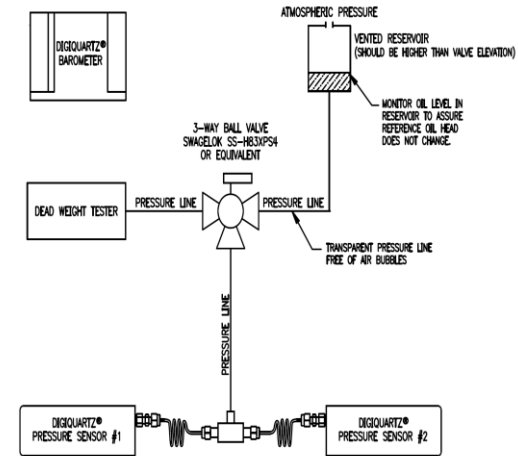
- Temperature-compensated & Linearized RS-232 Outputs
- Seawater Pressures (A) and Temperatures from each APG
- X-Y-Z plus total Vector Accelerations and Accelerometer Temperature
- Interior Housing Barometric Pressures (0) and Barometer Temperature
- All sensors can be synchronized and time-stamped using PPS inputs
- APG sensor drift < 1 cm/year (1ppm).
- Redundant depth measurements
- Tilt repeatability of 0.5cm on a 1 kilometer baseline



SOS Module - Capabilities

Digiquartz® Pressure Sensors can be recalibrated in-situ by periodically venting from ocean pressures (A) to the ambient pressure (0) within the system housing. Subtracting the drift at 0 from the measured ocean depth readings, A, **eliminated sensor drift to a few parts-permillion (ppm) of full scale with a standard deviation less than 1 ppm (< 1 cm/year).**

Triaxial Quartz Accelerometers can be recalibrated in-situ relative to Earth's 1 G gravity vector. Over 1045 test cycles using this Accelerometer Calibration Method resulted in an average cycle-to-cycle non-repeatability of 0.10 micro-g. **This is equivalent to a tilt of 0.010 cm at a span of 1 kilometer.** Longer-term fits to determine drift had a standard deviation less than 0.5 cm.



SOS Module – stand-alone - Geodesy

High resolution drift calibrated depth values and autonomous LBL to measure lateral movements between nodes

Depth accuracy: <0.01% (drift calibrated)

Depth sensor drift < 1 cm/year (1ppm).

Redundant depth measurements

Tilt repeatability of 0.5cm on a 1 kilometer baseline

Baseline accuracy: <1 cm

Position accuracy: < 10 cm*¹

Node distance: <100m*²

Nodes required: min. 3

1: position triangulation based on network with at least 5 nodes

2: line of sight 2-3m elevated above surrounding seafloor

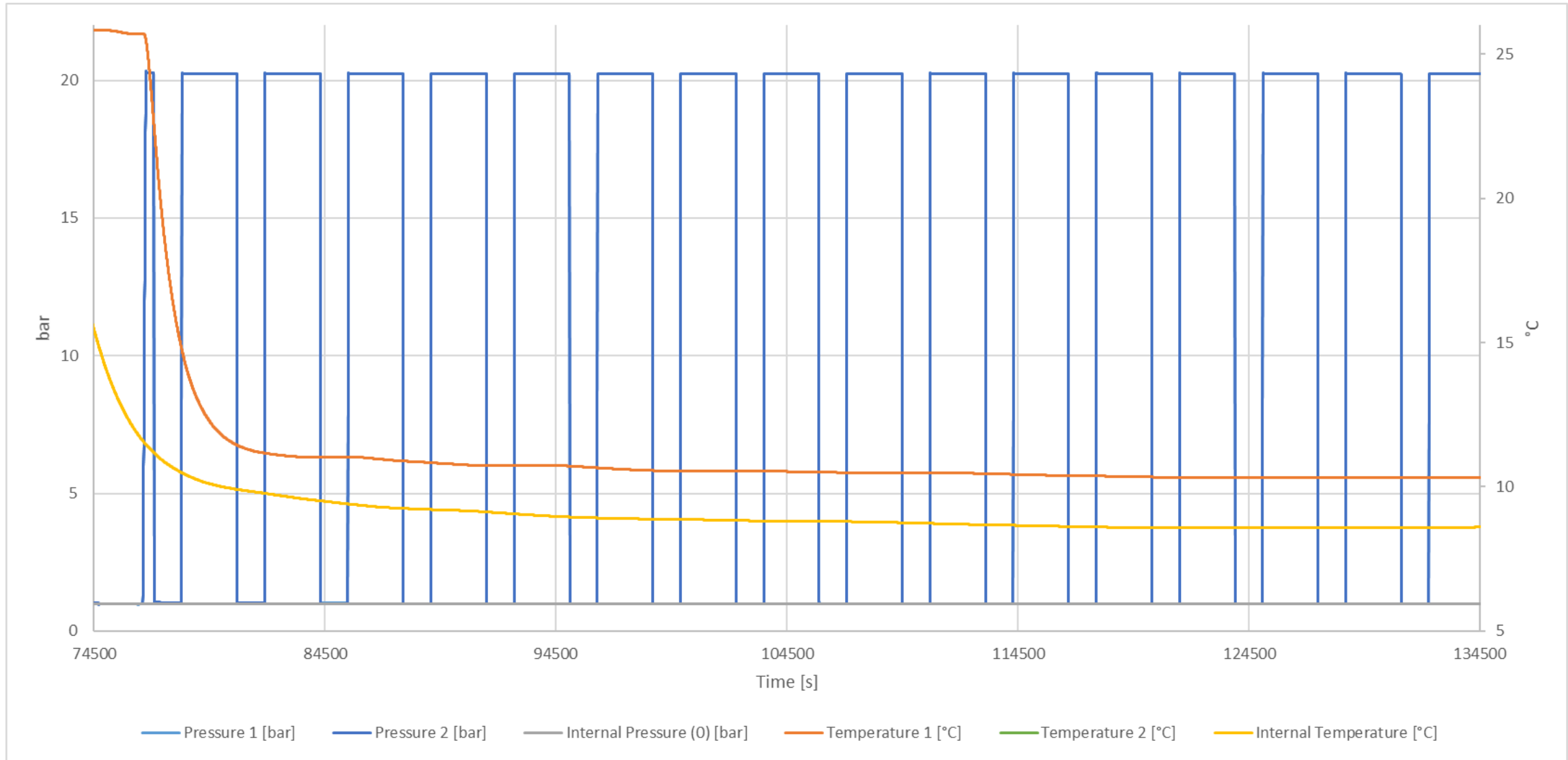


cNODE Midi/Maxi with MTS/SVP+

Sea Trial - Overview



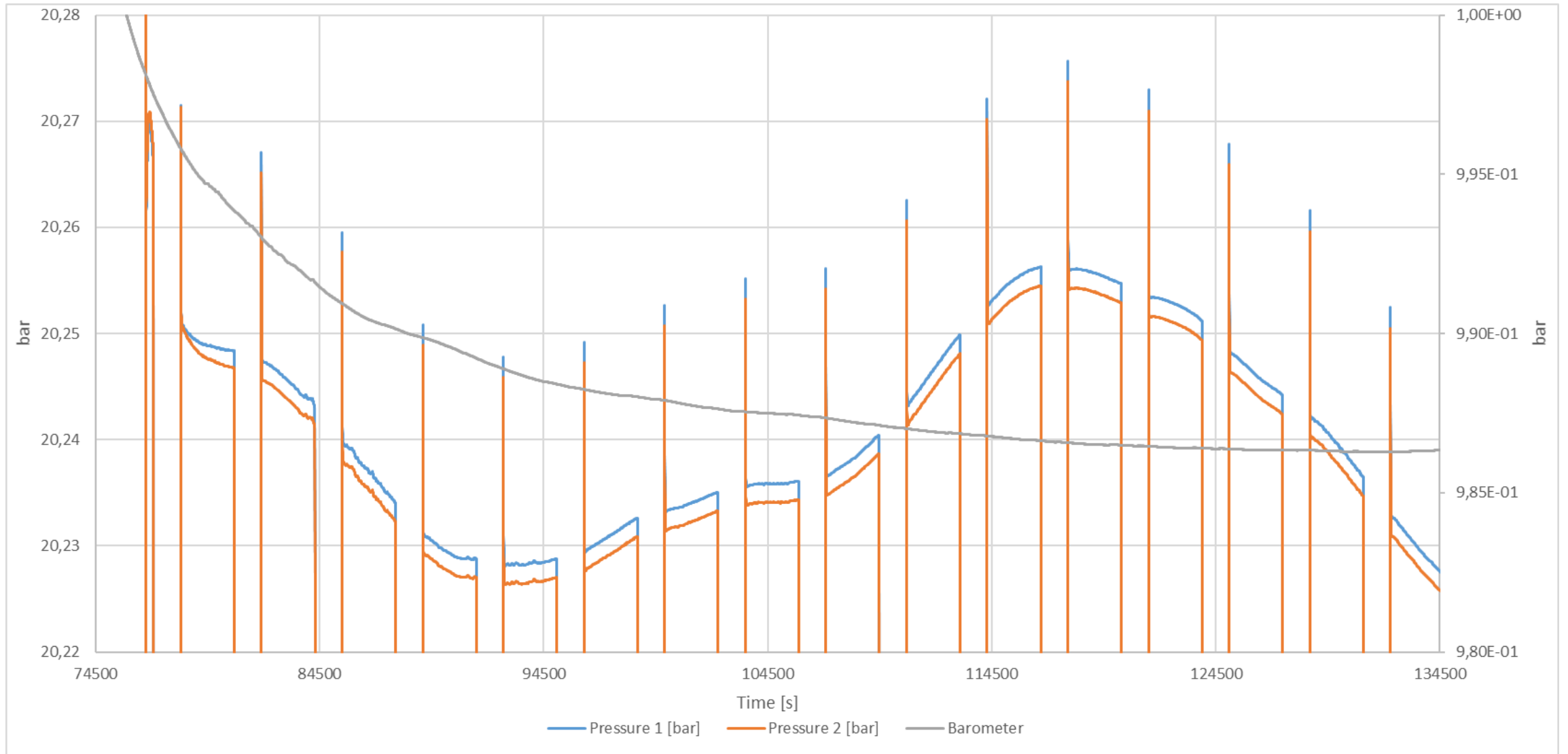
KONGSBERG



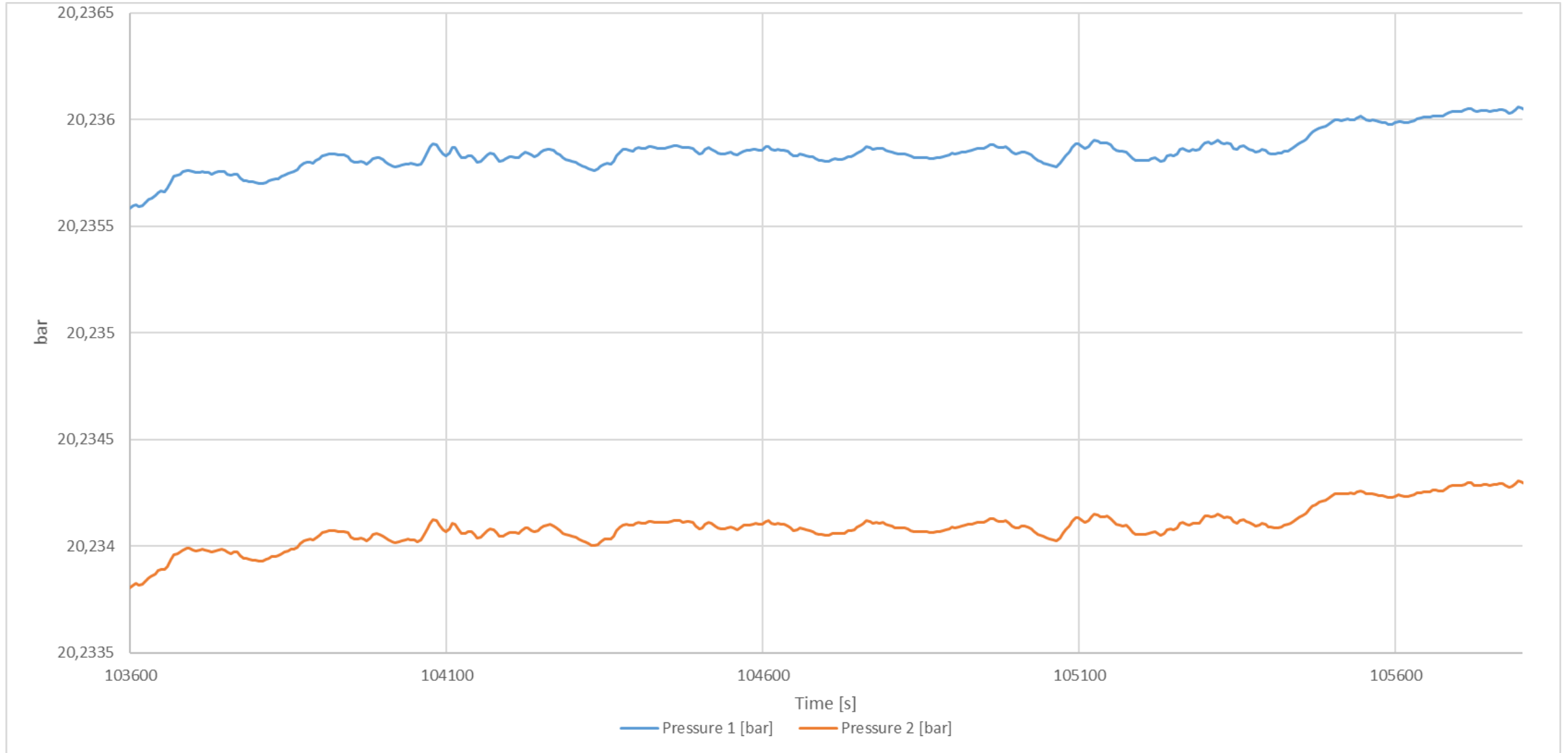
Sea Trial – A Pressure



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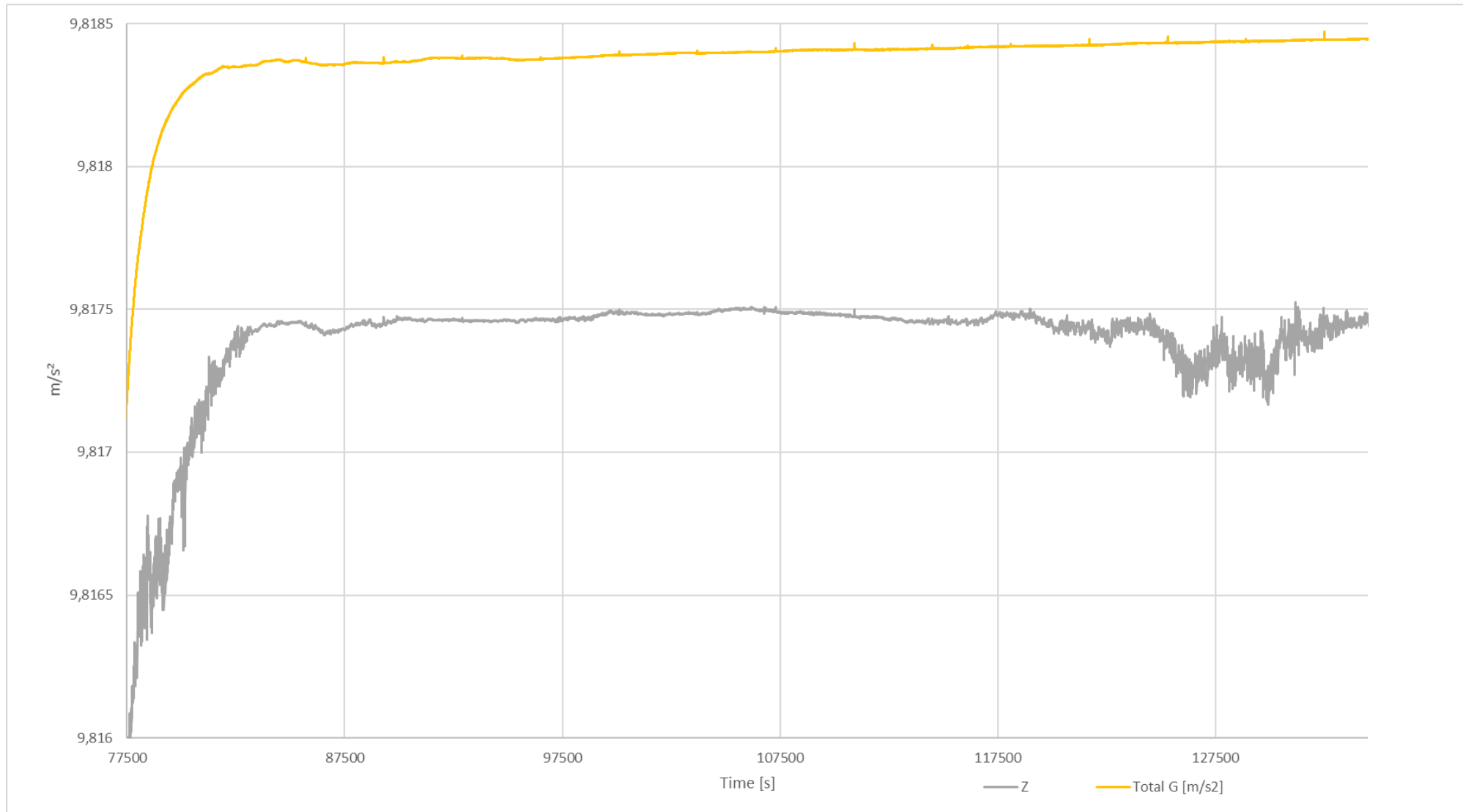
Sea Trial – 2-1 Pressure

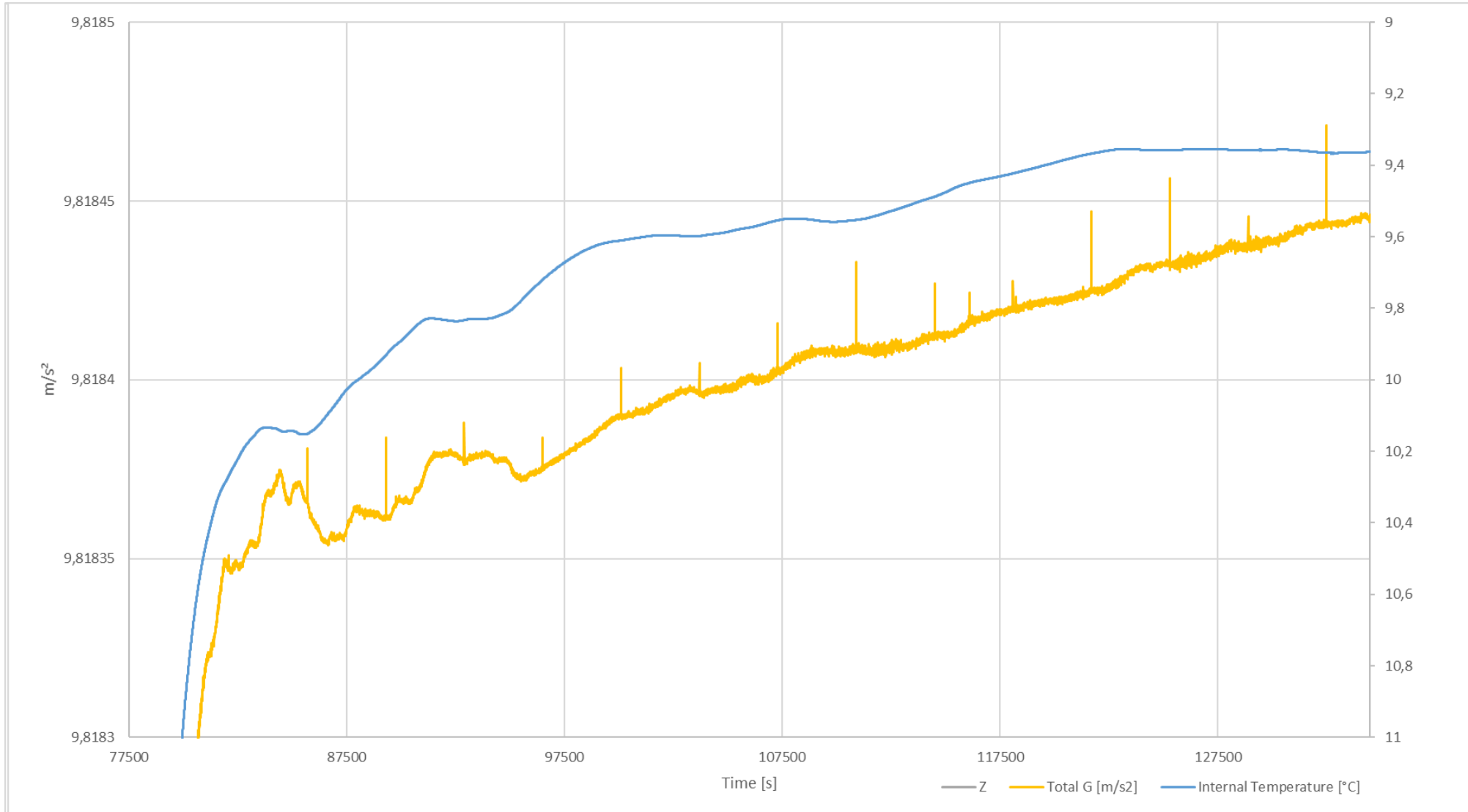


Sea Trial – 2-1 TriAx



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Geodesy Monitoring – Tsunami Early Warning



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Transmission buoy



Lander with SOS module



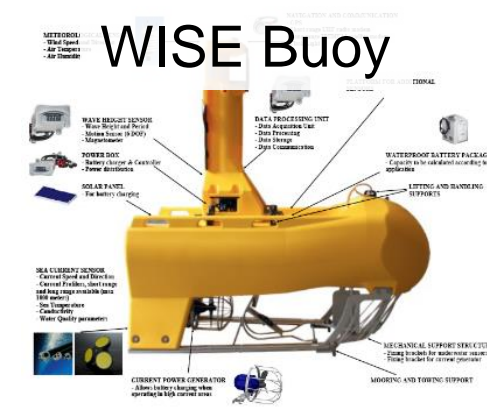
Geodesy Monitoring – Seafloor Movement (Hang Slides, Slumps)



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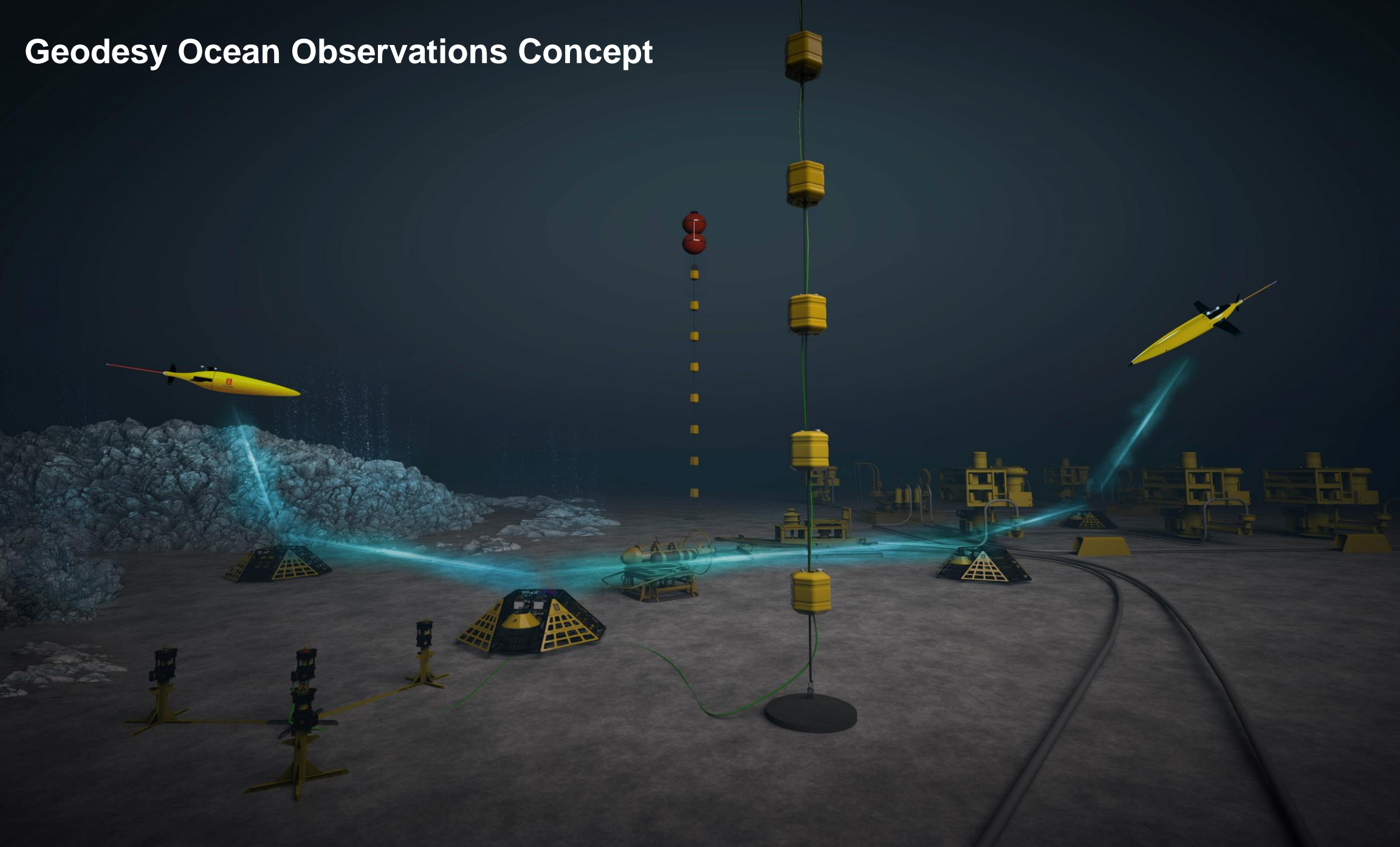
Monitoring - Autonomous surface vehicles



Geodesy Ocean Observations Concept



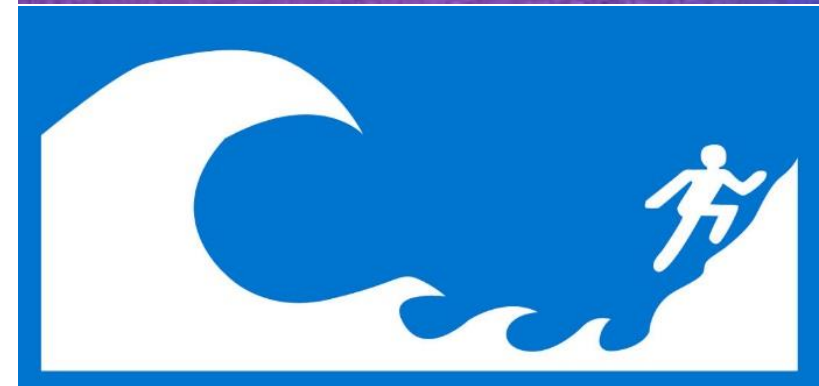
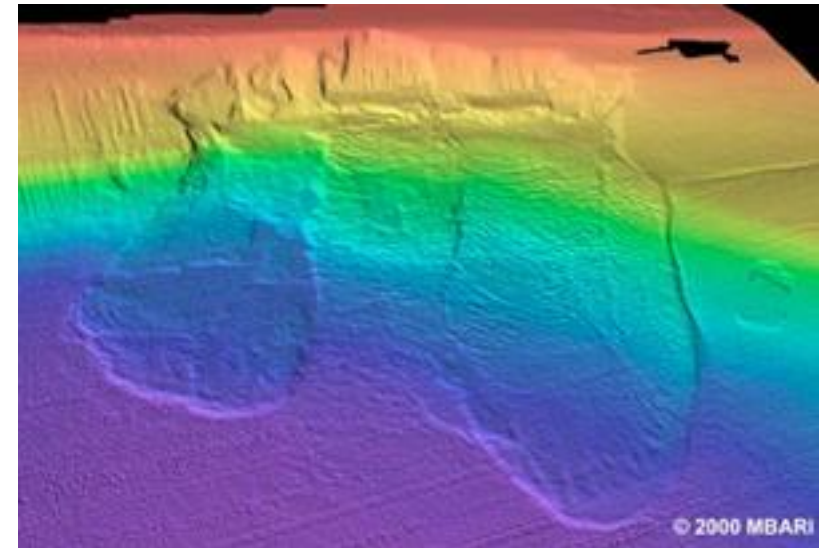
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Geodesy SMART Cabled Concept

Conclusion

Markets	Applications
Subsea Geodesy	Submarine landslide monitoring Borehole subsidence monitoring Structure monitoring
Tsunami Warning	Sea level monitoring Seismic monitoring
Abandoning Wells	Pressure Monitoring





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WORLD CLASS

THROUGH PEOPLE, TECHNOLOGY AND DEDICATION

Thank you for your attention!

Any questions?