23rd Conference and 7th Meeting of the Region F ICCWG
Ljubljana, Slovenia – 29 March - 1 April 2022.

The Potential of Artificial Intelligence in Phase-Measuring Bathymetric Sonar Data Processing

GeoAcoustics

MBHSC23 (2022)
IHO International Hydrographic Organization

UKRI Innovate UK
UEA University of East Anglia

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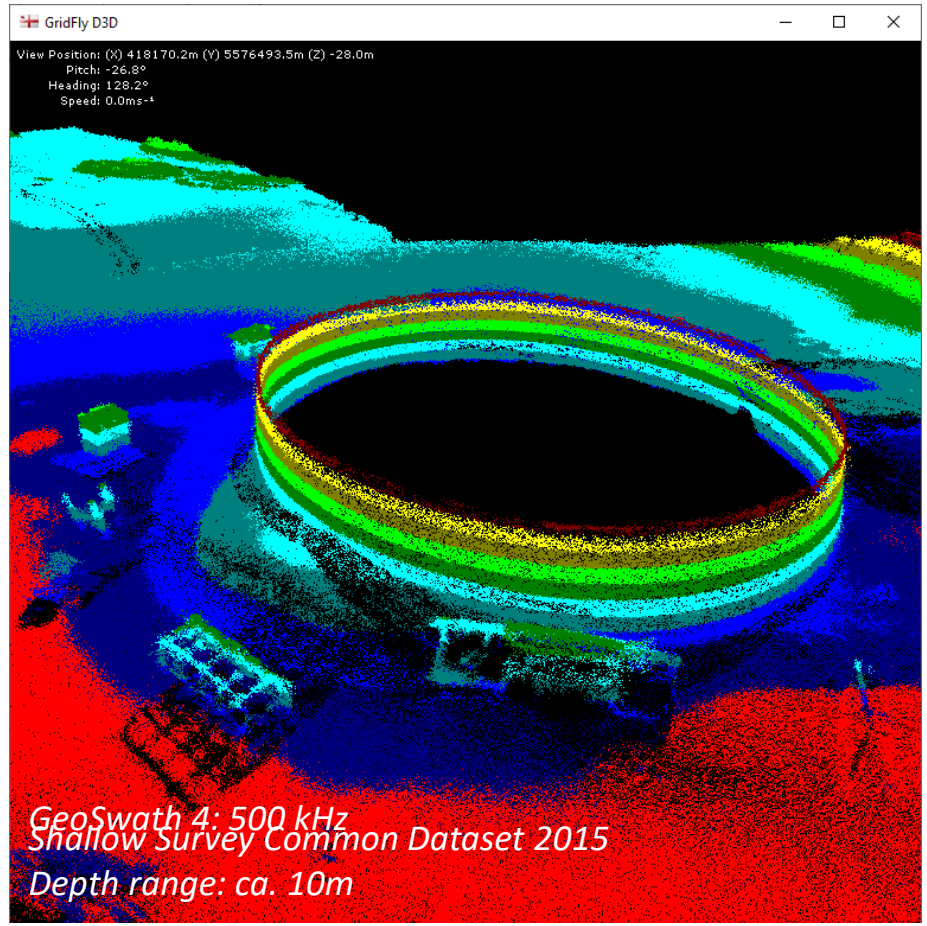


MBES vs PMBS

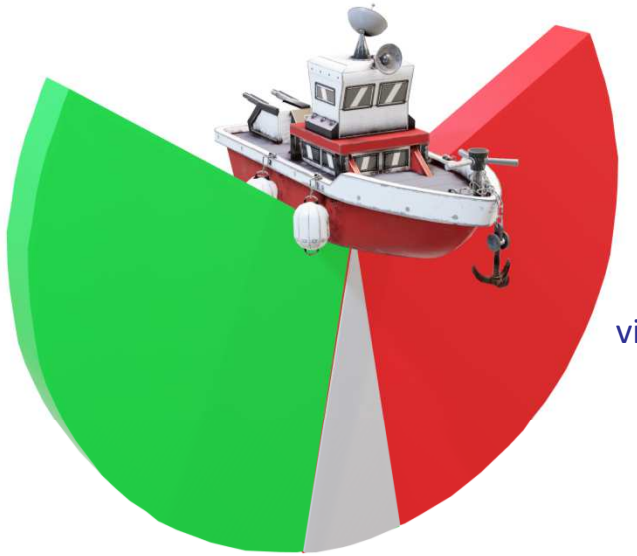
MBES

x 512 beams (pencil-like)

Narrow
view angle

PMBS

x 2 beams (fan-like)



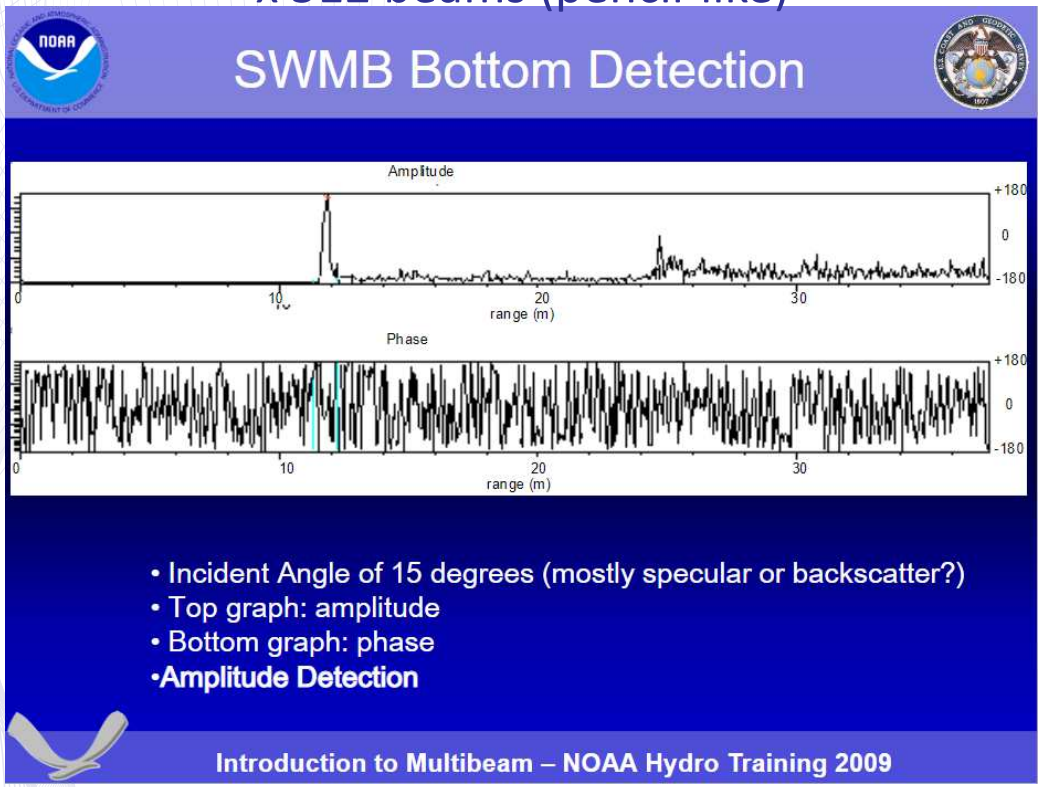
Wide
view angle

Nadir overlap

MBES vs PMBS

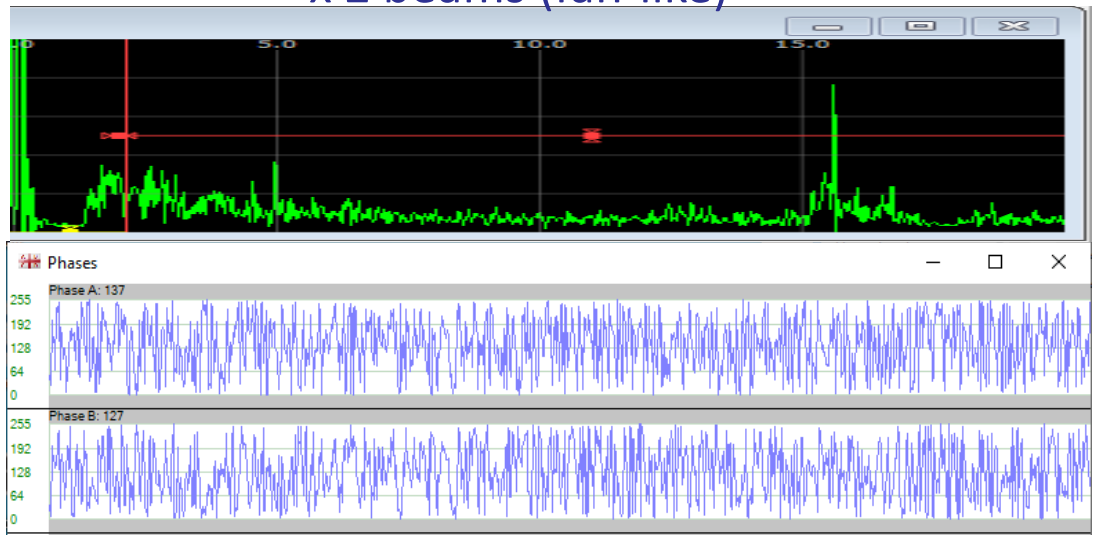
GeoAcoustics

MBES
x 512 beams (pencil-like)



https://studylib.net/doc/5727336/multi-beam-sonar---noaa-teacher-at-sea-blog

PMBS
x 2 beams (fan-like)



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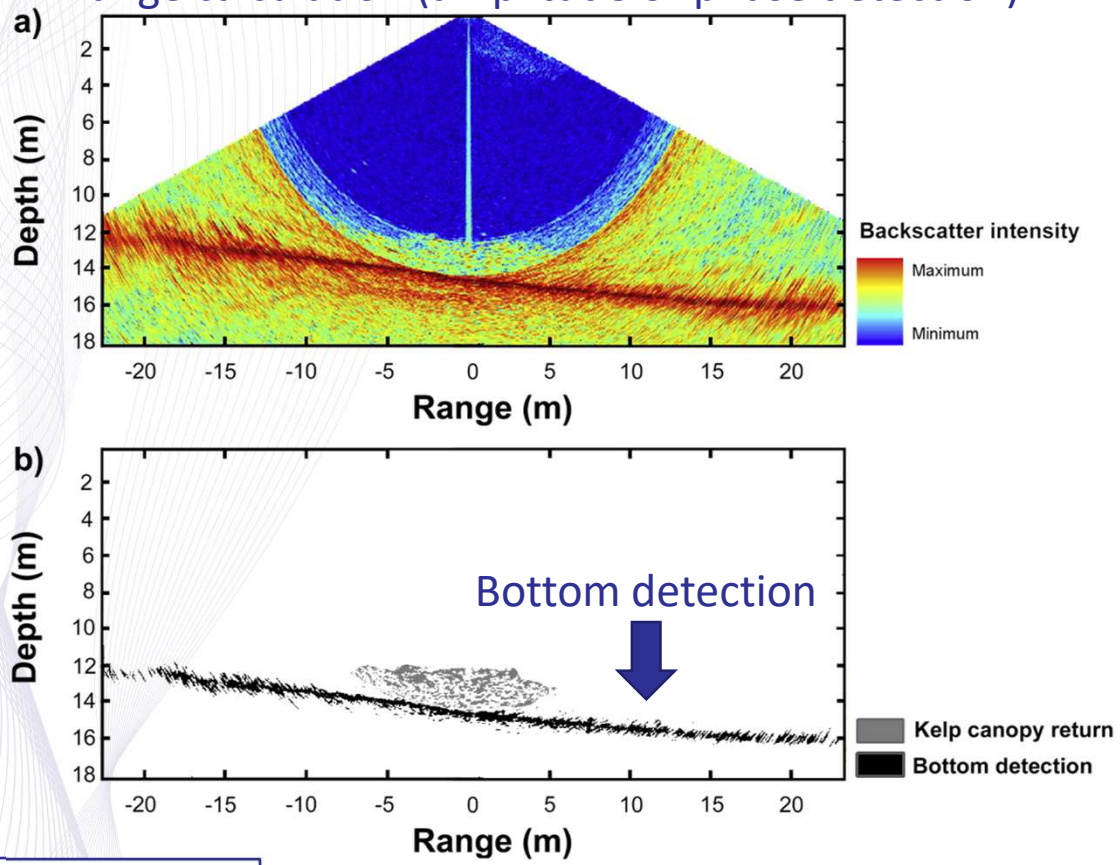
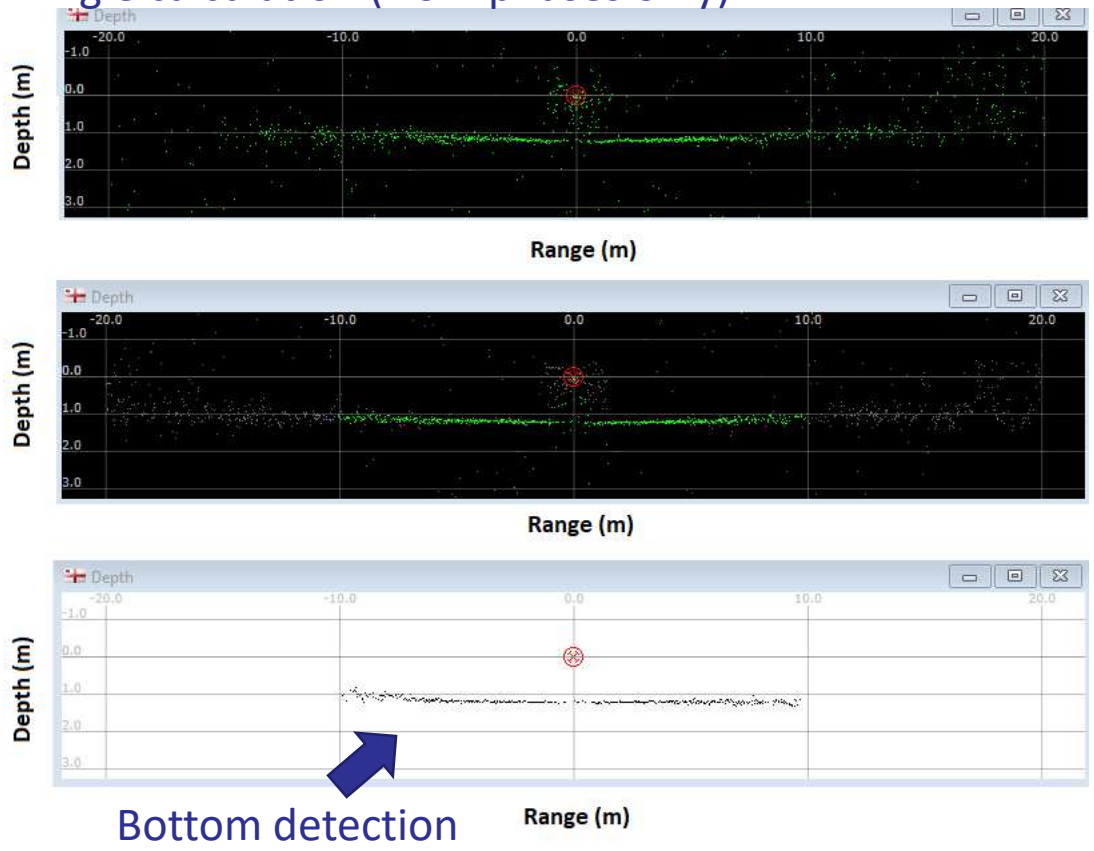
MBES vs PMBS

GeoAcoustics

Range calculation (amplitude or phase detection)



Angle calculation (from phases only)



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https://www.sciencedirect.com/science/article/abs/pii/S0272771414000900

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Problem outline

- **Wide swath bathymetry data can be collected using** either Phase-Measuring Bathymetric Sonars (PMBS) or a Multibeam Echosounders (MBES).
- Because PMBS is a high-resolution multi-stave side scan, **PMBS produces an order of magnitude more bathymetry data points than MBES for bathymetry** (*).
- This introduces **challenges for data processing**:
  - Typically this requires **manually configuring** a set of filters for outlier removal.
  - For best results this requires an **experienced trained user**.
  - **Highlighted further within real-time operation**.
  - The **quality of results produced is** therefore **very much correlated to the users experience**.

(*) That is not true when MBES water column data is collected.

Problem outline

GeoAcoustics

Could an **automated approach using Artificial Intelligence (AI)** maintain or **improve outlier identification in real-time** over a more standard post-survey approach?

Could it **alleviate user-induced discrepancies and save time and money as well?**

Would it be accepted by the experts???

AI Model

GeoAcoustics

General requirements:

- Real-time, hands-free, & equivalent (or improved), outlier identification.

Proposed methodology:

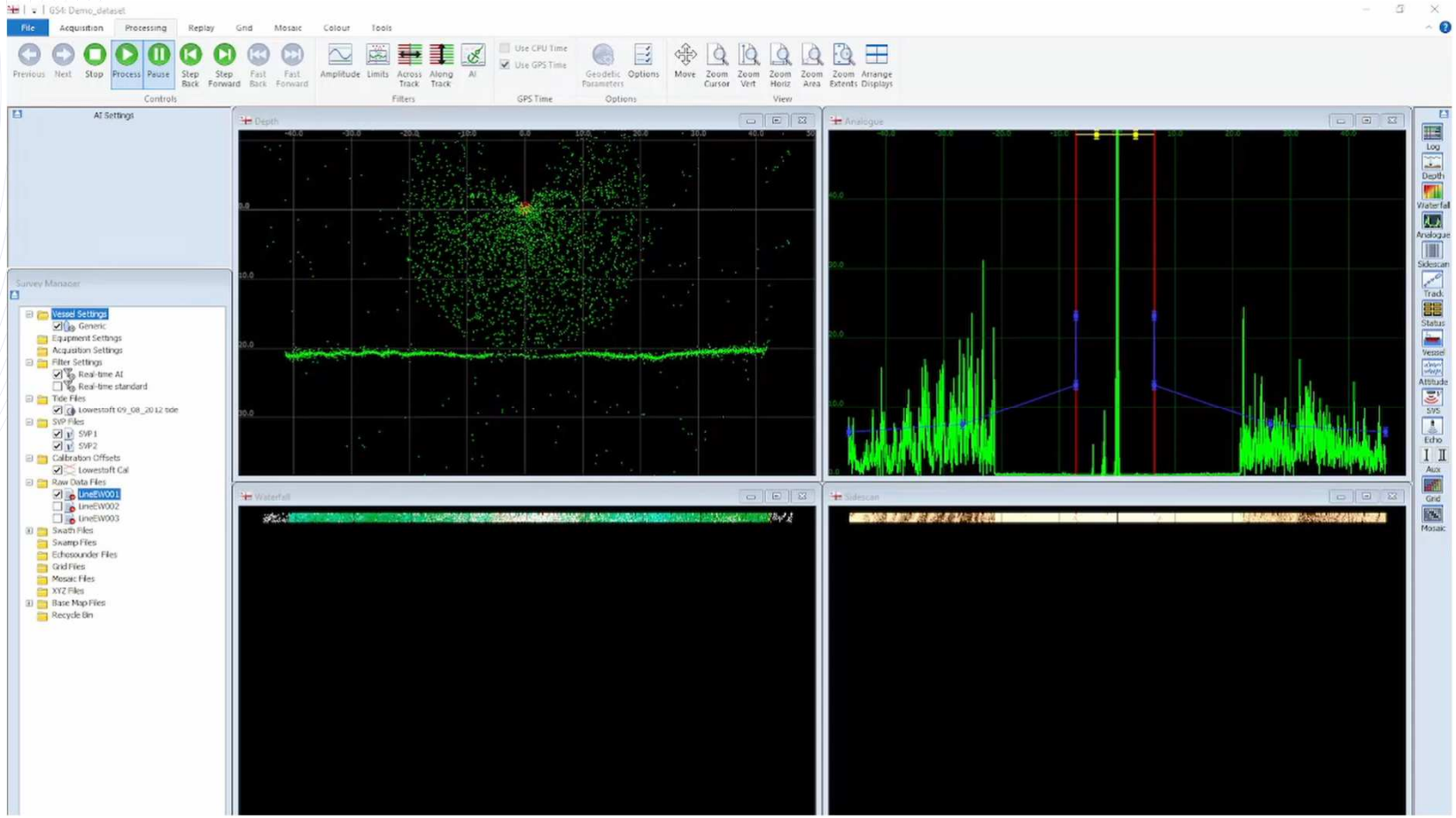
- Develop an **unsupervised AI outlier identificatory**
- In partnership with AI specialists (University of East Anglia)

Funding:

- via Innovate UK (two-year KTP project).

AI Filtering – Example

GeoAcoustics



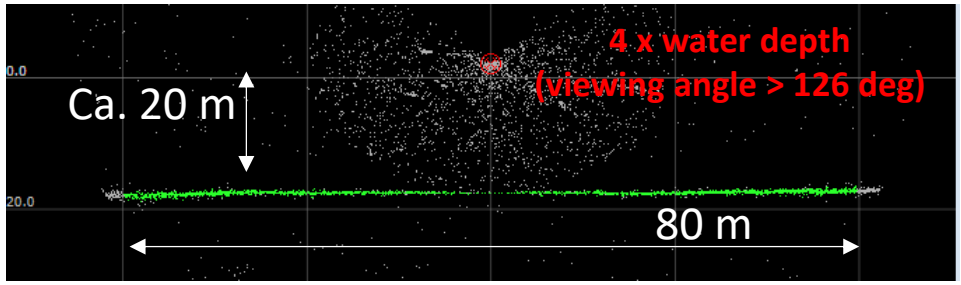
GeoSwath 4 500 kHz

AI Filtering – Results

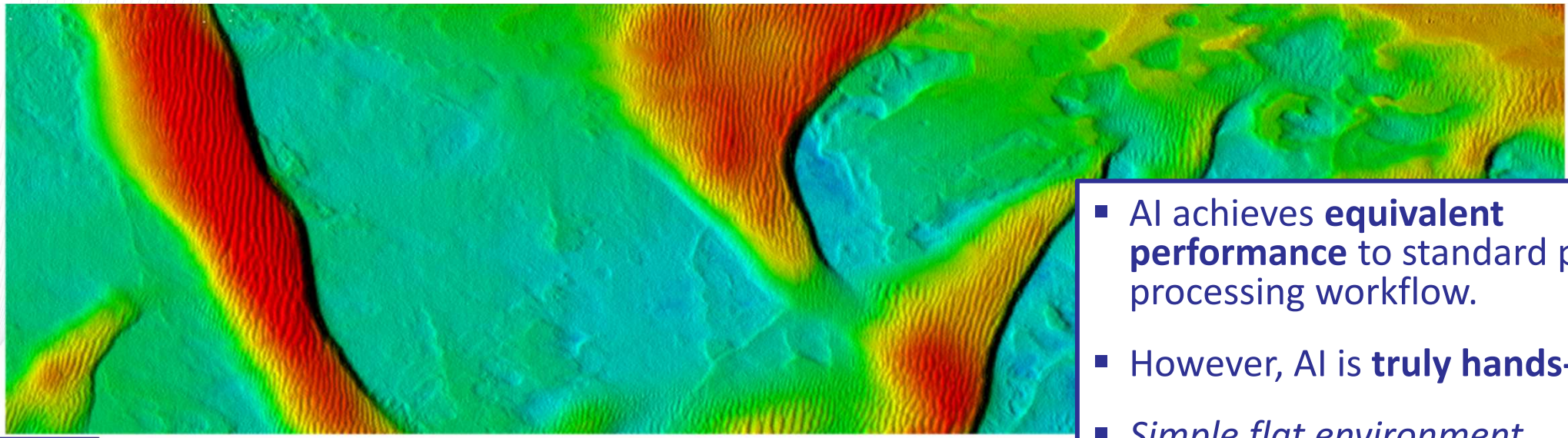
GeoAcoustics

GeoSwath 4: 500 kHz – Training Dataset

Depth range: ca. 20m
Survey line spacing 40m
Swath coverage set to 80m



Summary:
Survey Accuracy: **IHO Special Order** (Bc10,Bd8)
a = 0.250, b = 0.0075
Compliant Bins 98.74%



- AI achieves **equivalent performance** to standard post-processing workflow.
- However, AI is **truly hands-free**.
- *Simple flat environment.*

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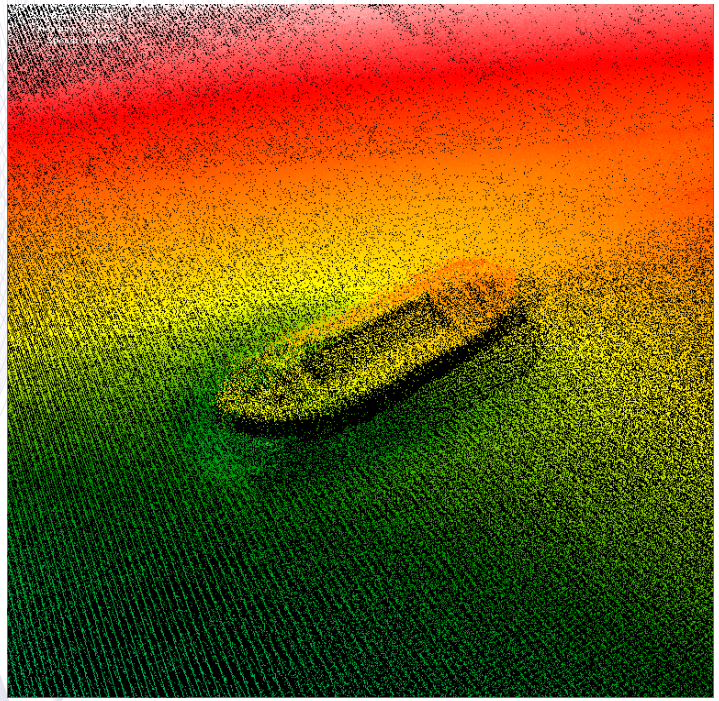
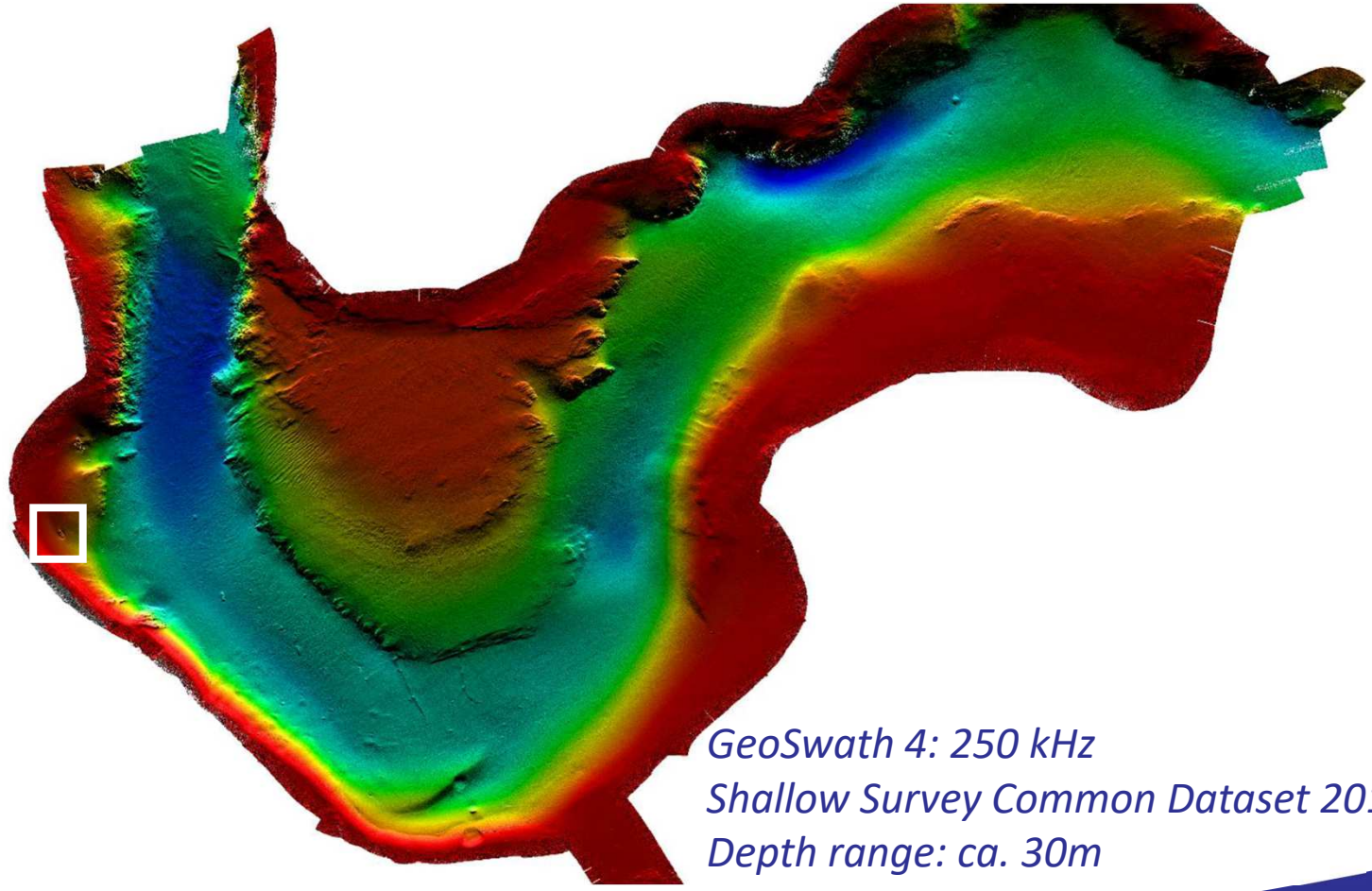
Results – Target detection (real-time)



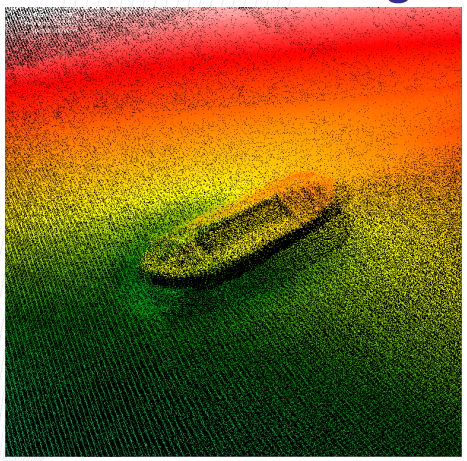


GeoSwath 4: 250 kHz
Shallow Survey Common Dataset 2015
Depth range: ca. 30m

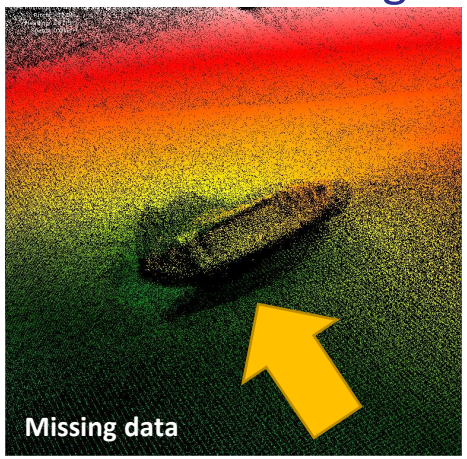
Results – Target detection (real-time)

GeoAcoustics

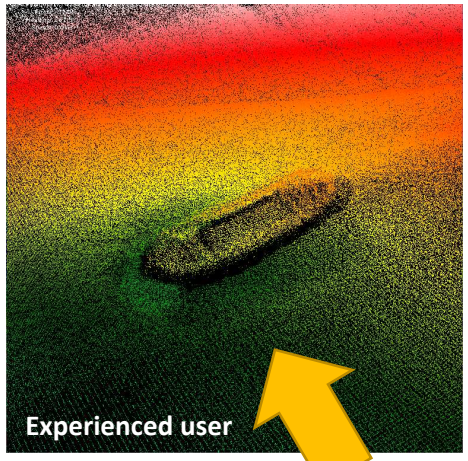
Manual cleaning



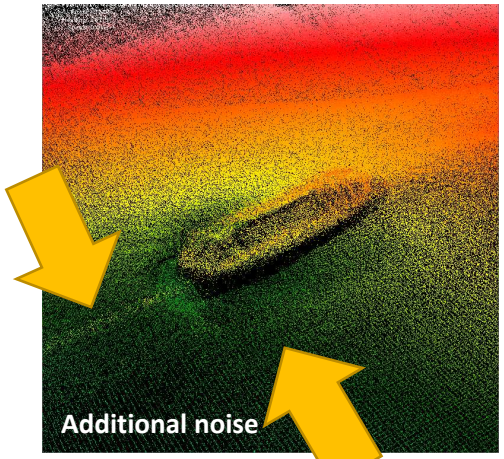
Standard – too tight



Standard



Standard – too loose



GeoSwath 4: 250 kHz
Shallow Survey Common Dataset 2015
Depth range: ca. 30m

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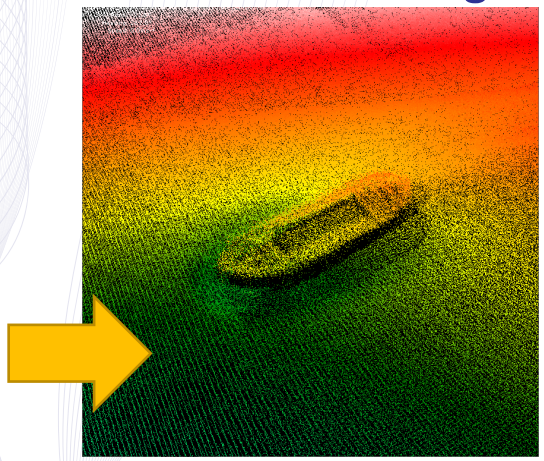
Results – Target detection (real-time)

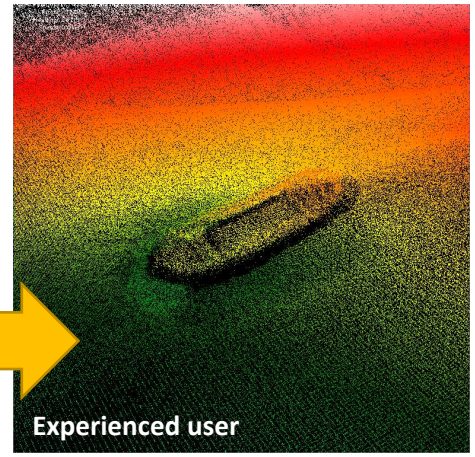
GeoAcoustics

Manual cleaning

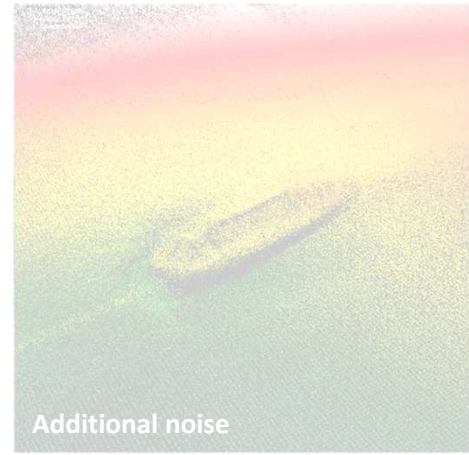


Standard – too tight

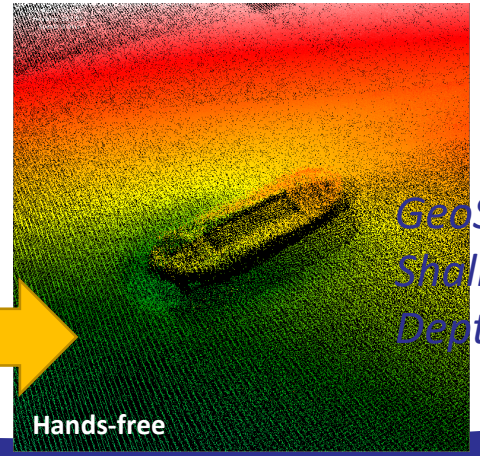
Standard



Standard – too loose



AI

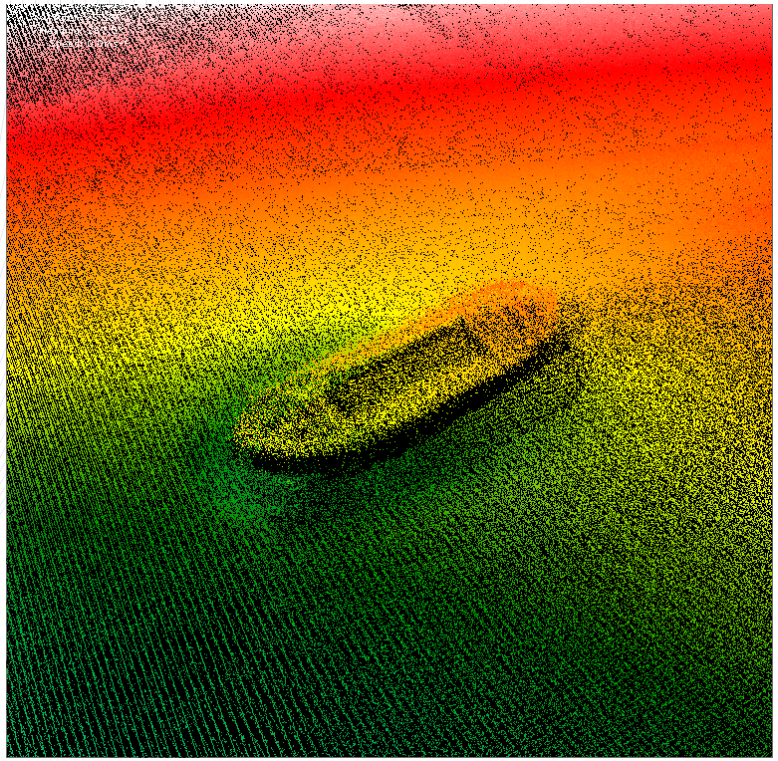


GeoSwath 4: 250 kHz
Shallow Survey Common Dataset 2015
Depth range: ca. 30m

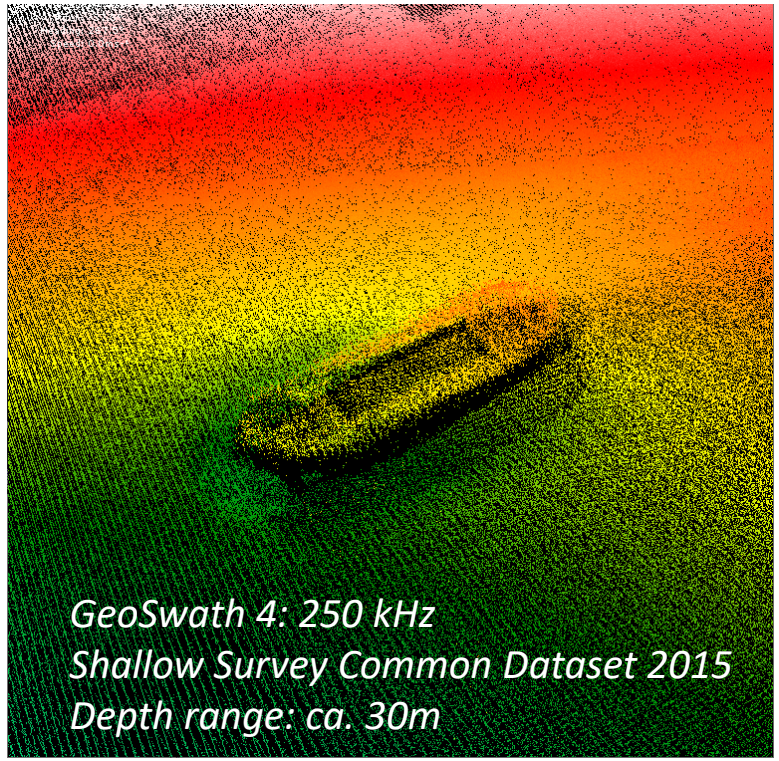
Results – Target detection (real-time)

GeoAcoustics

Manual cleaning

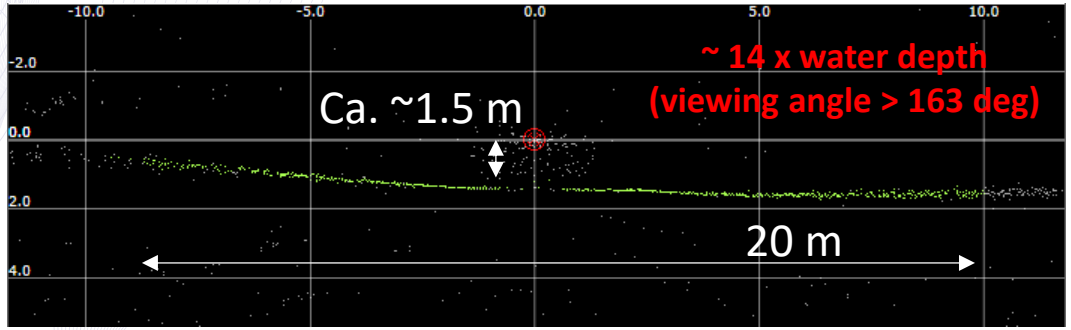


AI



AI Filtering – Real-time performance

- With improved real-time outlier identification, sonar-dependent IHO conformance can also be displayed in real-time.
- Allows users to check data collection likely meets the required spec and adjust survey accordingly.
- Saves time and costs.



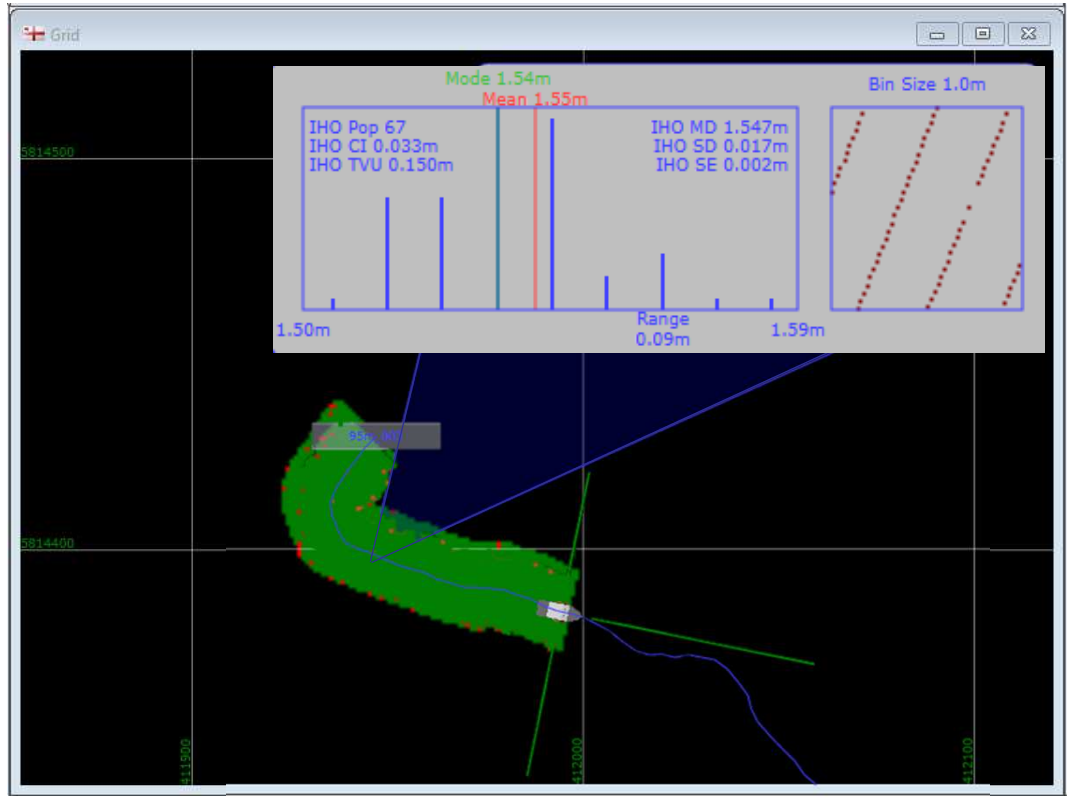
Summary:

Survey Accuracy: **IHO Exclusive Order** (Bc10,Bd8)

a = 0.150, b = 0.0075

Compliant Bins 98.28%

Real-time IHO conformance



GeoSwath 4 USV: 500 kHz

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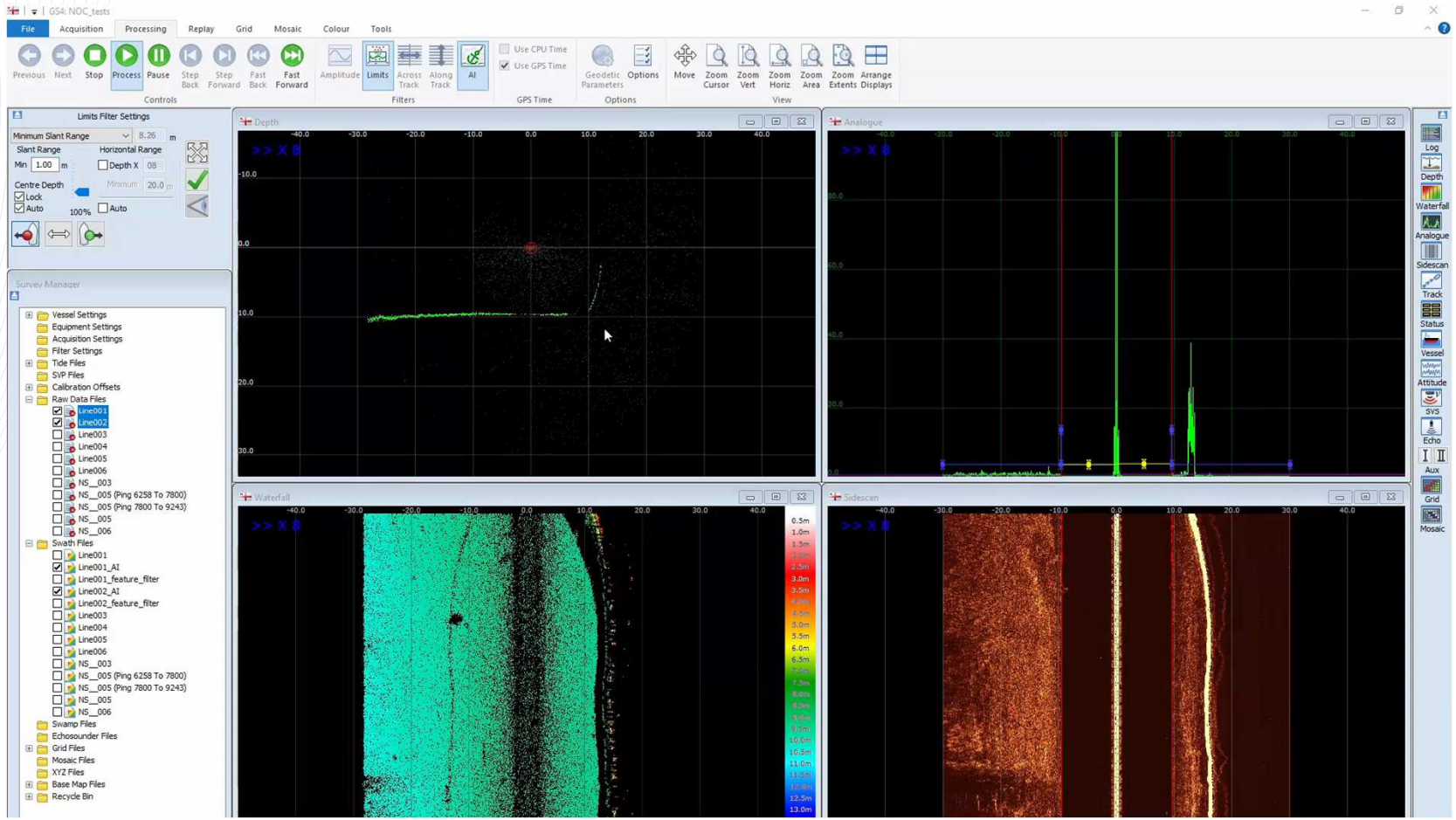
Examples – NOC OB 2021

GeoAcoustics



GeoSwath 4 USV 500 kHz

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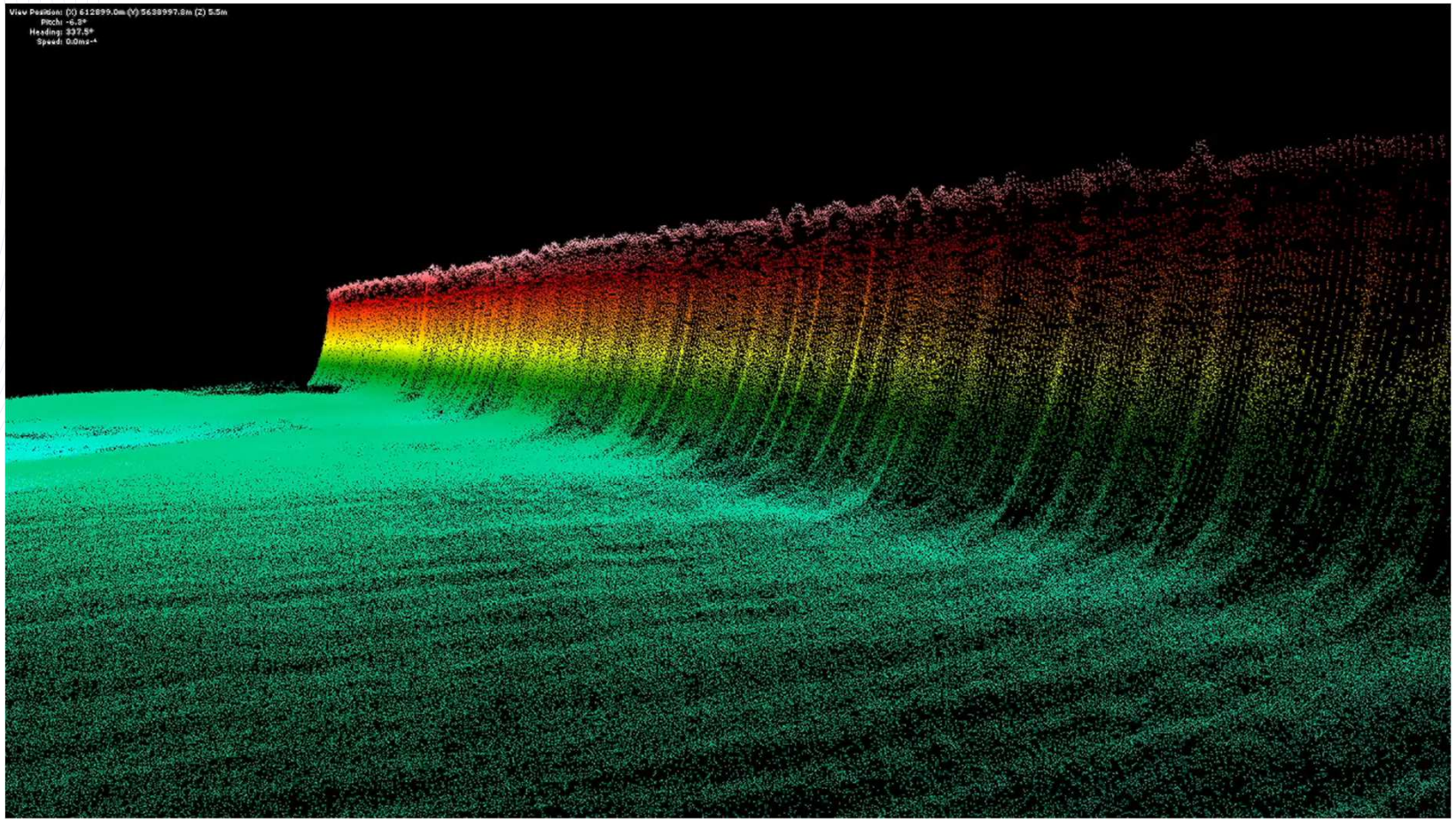
Examples – NOC OB 2021

GeoAcoustics



GeoSwath 4 USV 500 kHz

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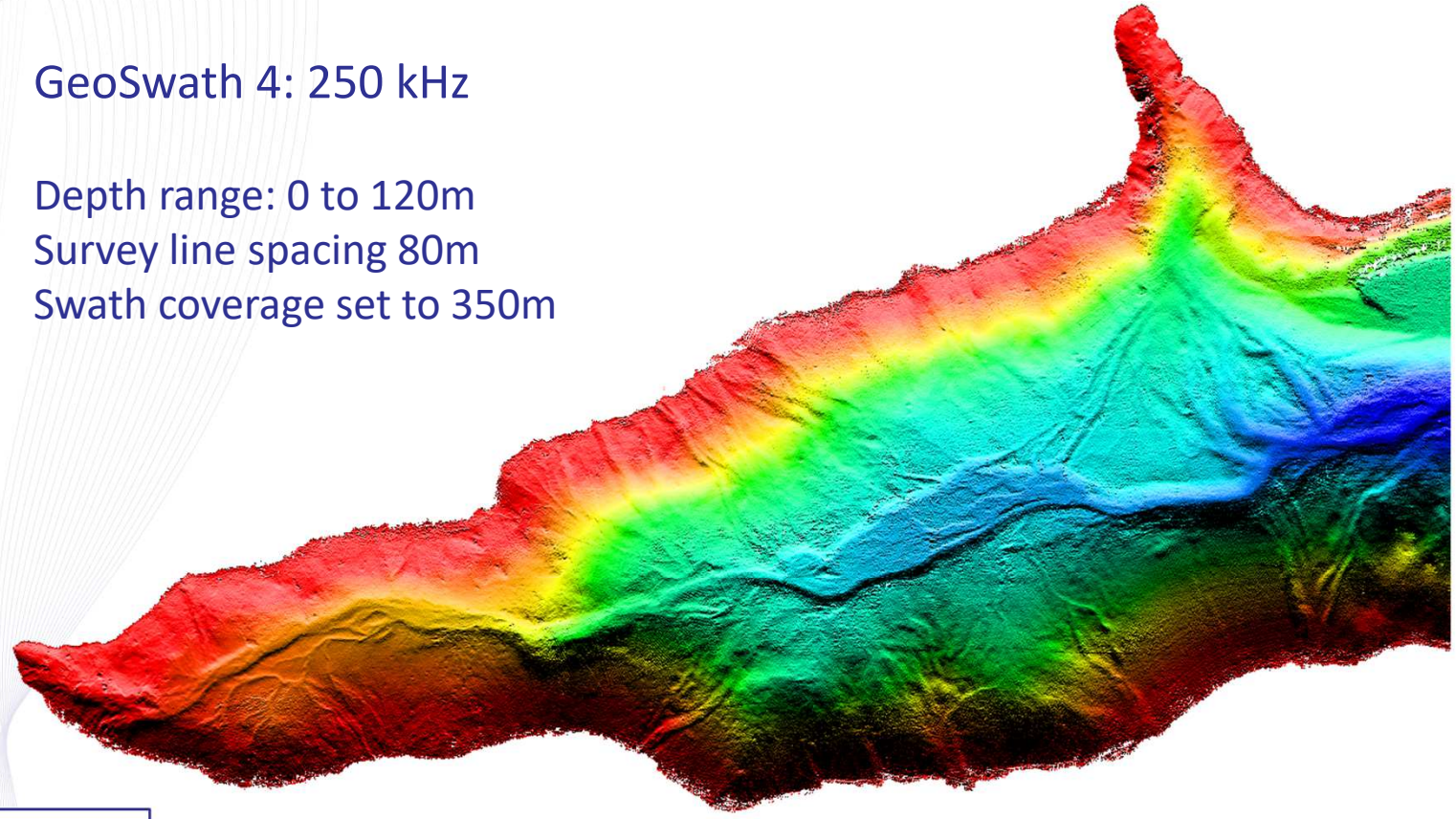
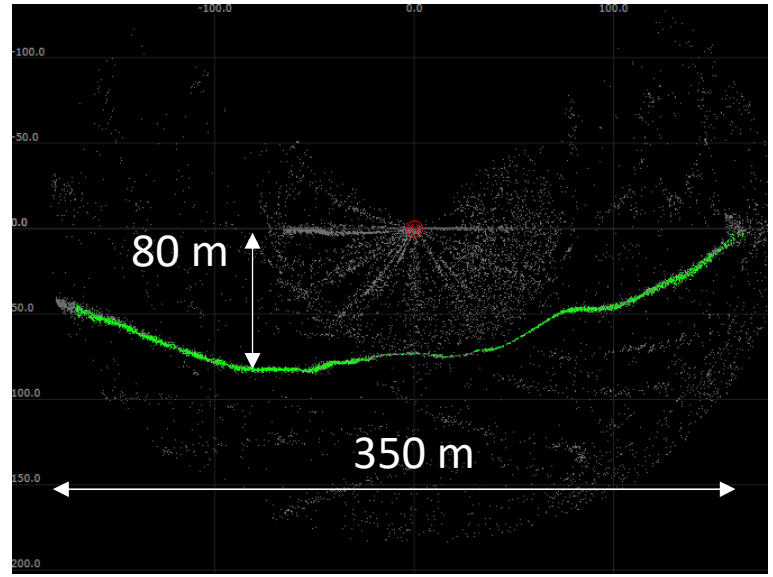
Examples – Alpine lake

GeoAcoustics

GeoSwath 4: 250 kHz

Depth range: 0 to 120m
Survey line spacing 80m
Swath coverage set to 350m





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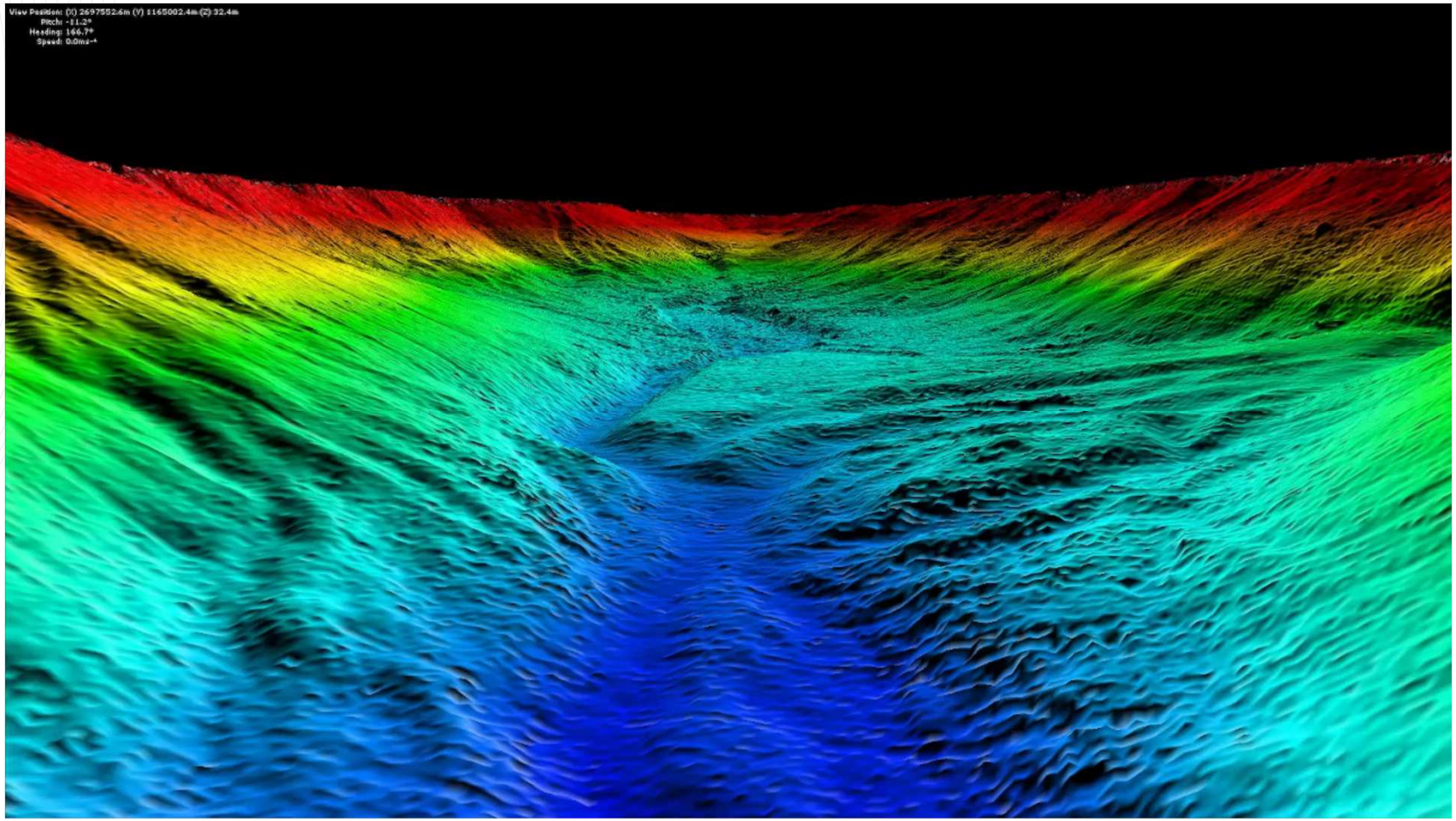
Examples – Alpine lake



GeoSwath 4R 250 kHz

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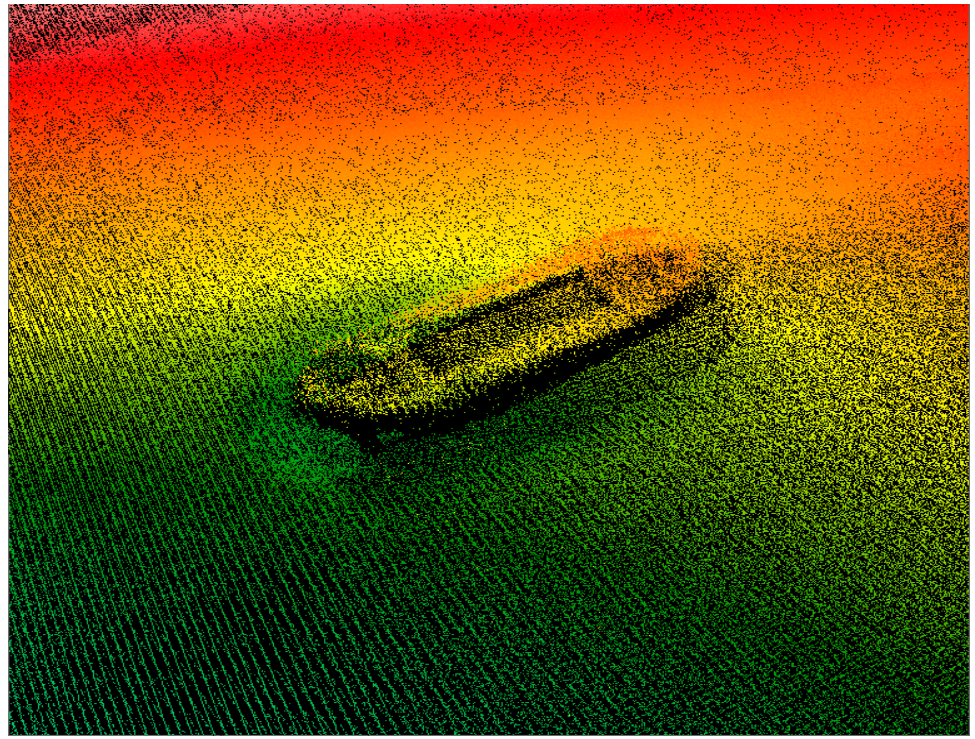
Conclusions

- **Developed an unsupervised AI solution.**
- **Provides equivalent performance to the standard filters in real-time.**
- **No user input required.**
- **General requirements met:**

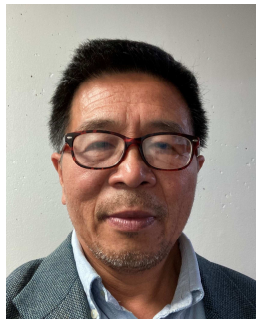
Real-time ✓,

hands-free ✓,

human expert-equivalent ✓



Acknowledgements



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Further work

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The results prove that this real-time cleaning approach can meet IHO standards and produce virtually clean data in real-time, but…

would PMBS data processed in this way be widely accepted by the experts???

under which circumstances???

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