

Expanding MCM Capabilities Using Commercial Sensors and Solutions

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Underwater Defence & Security 2023

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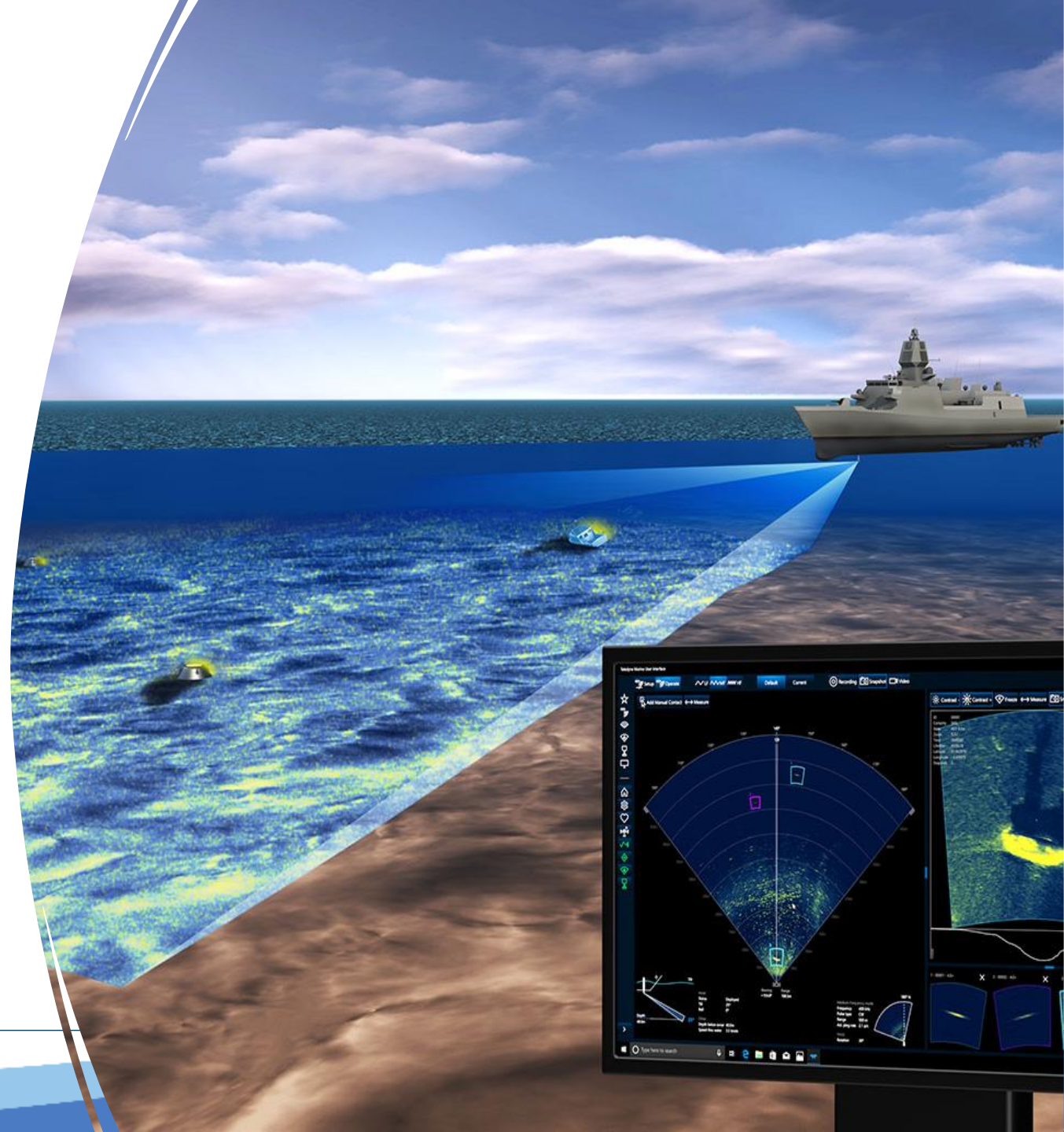


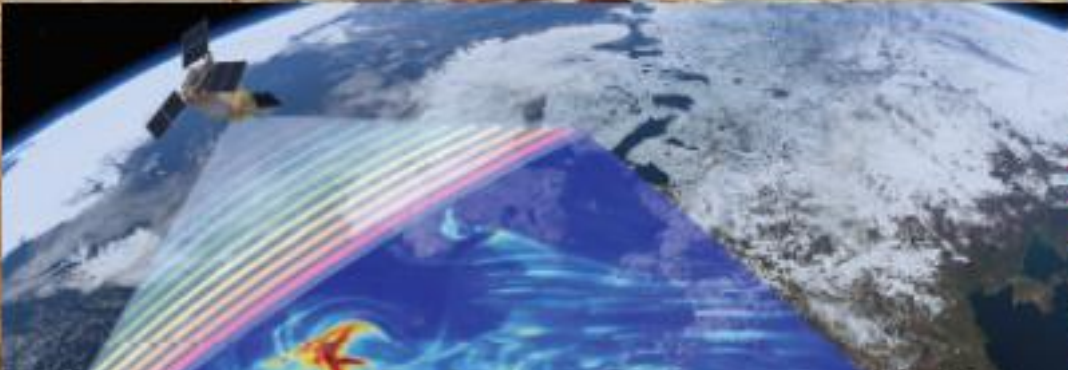
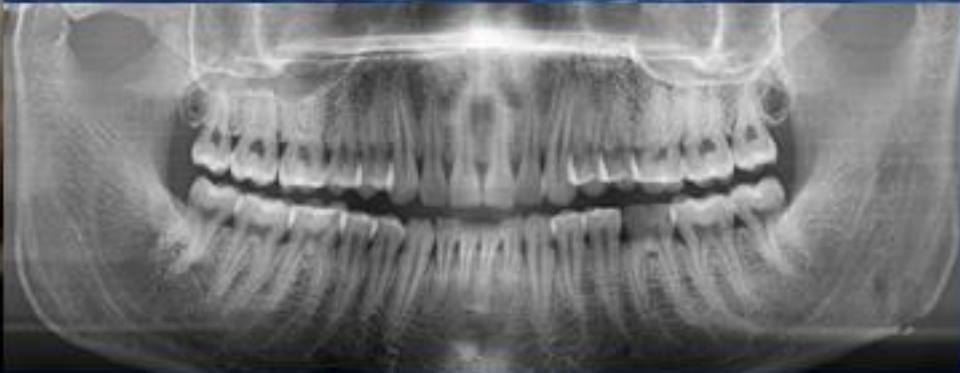
Introduction

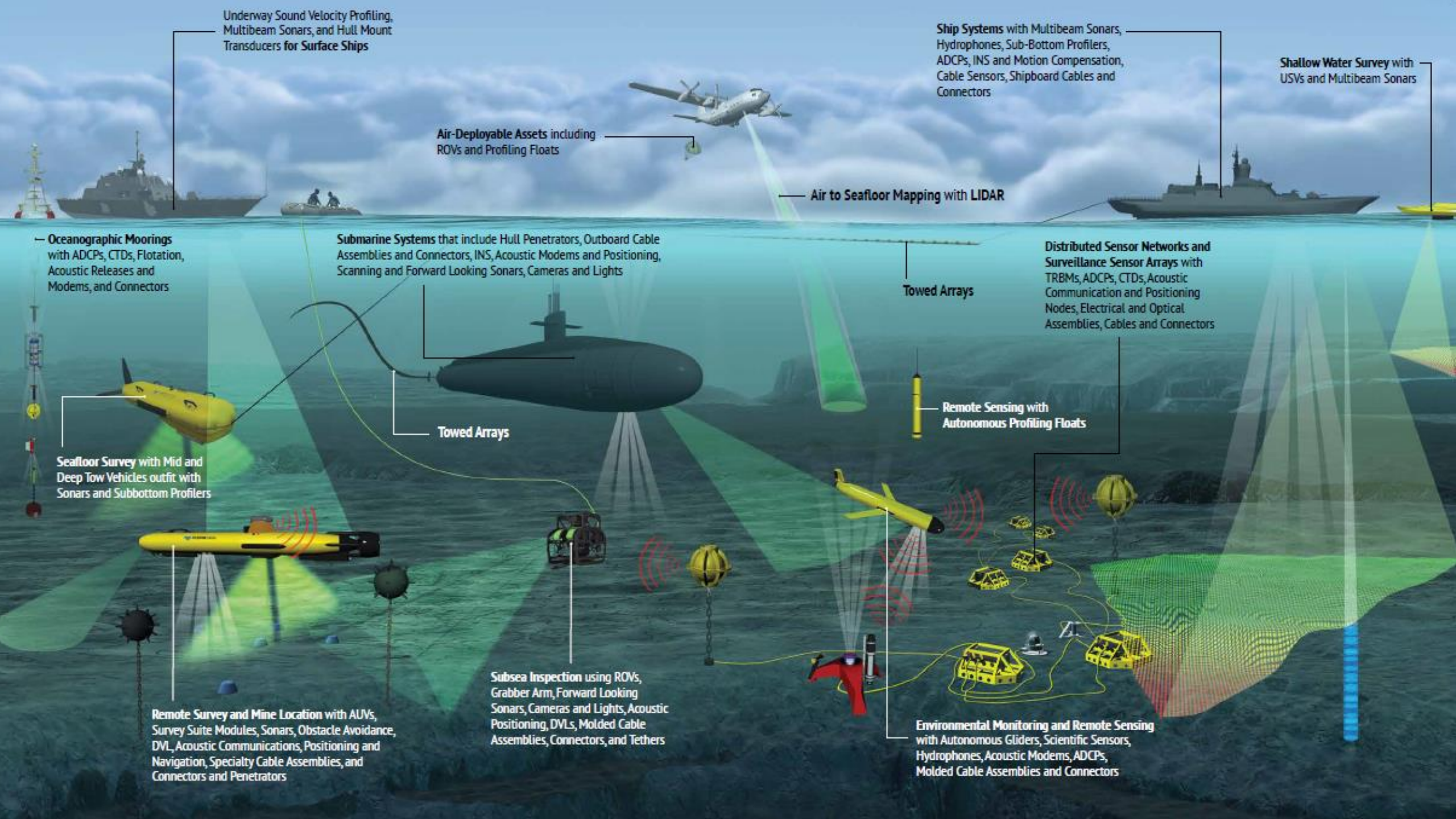
Expanding MCM capabilities using commercial sensors and solutions

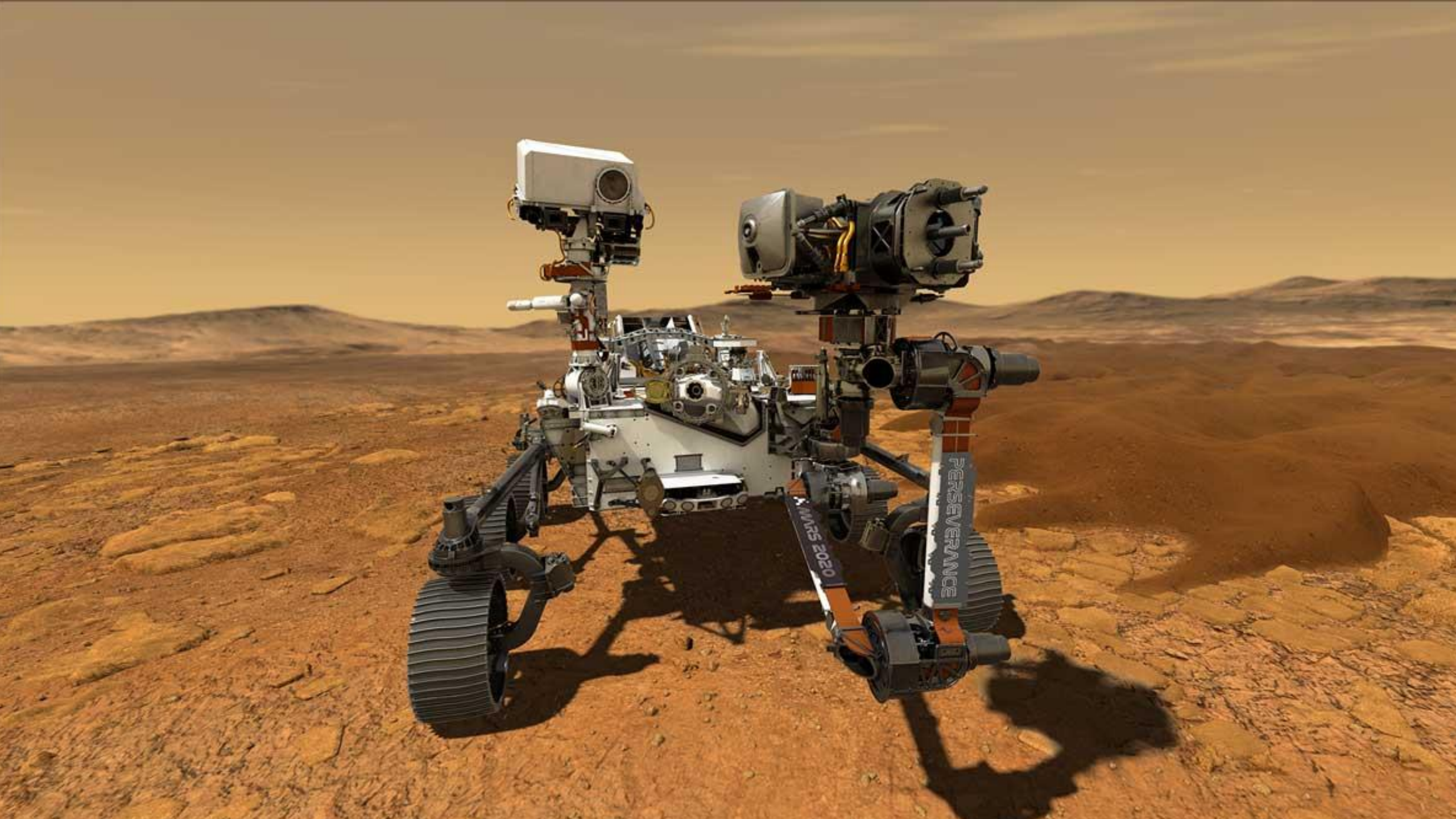
Overview:

- Brief introduction to Teledyne
- Forward Looking Sonar solutions
- Advanced algorithms and processing platforms
- Presentation of some recent data



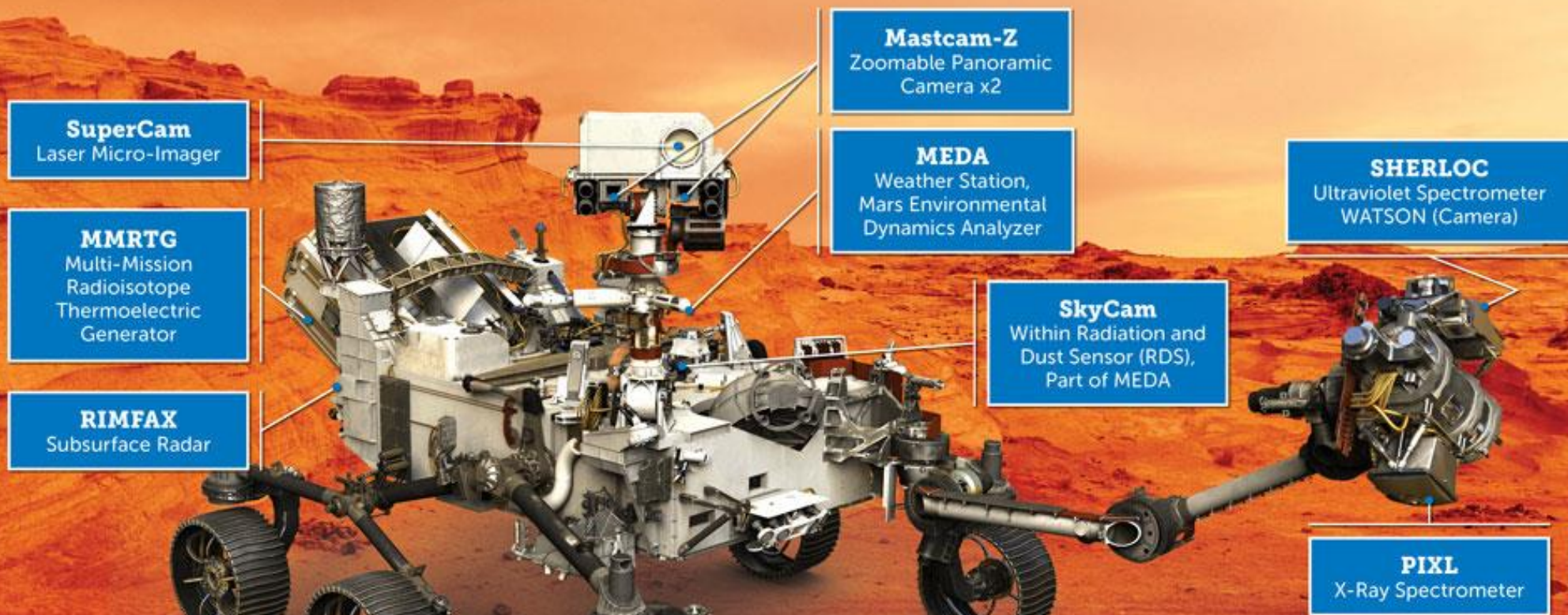




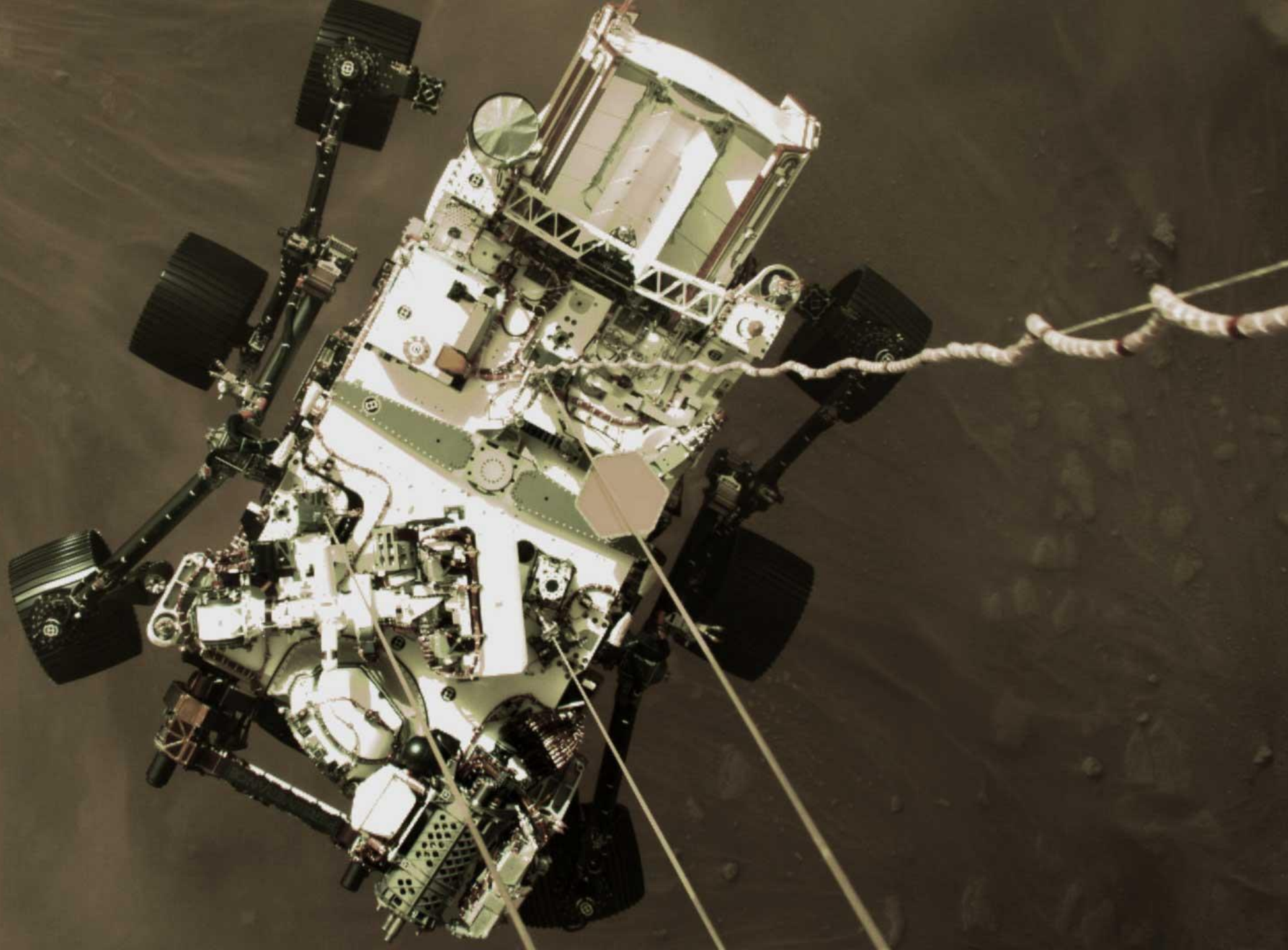


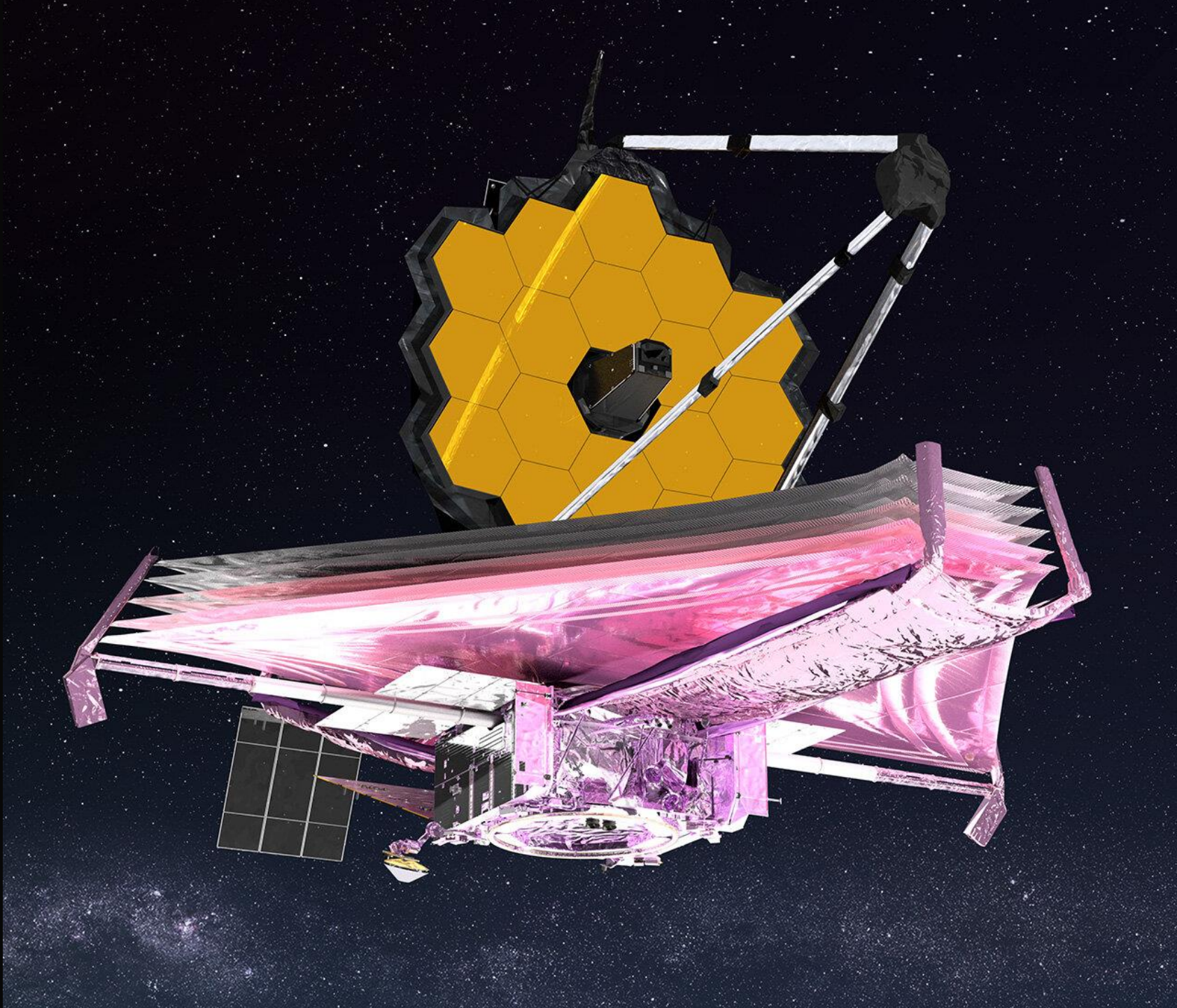
Mars 2020 Perseverance

Instruments & Power Source



Teledyne e2v Teledyne Acton Instruments	SHERLOC	CCD Image Sensor Conditioning Optics, Lenses, Mirrors
Teledyne e2v Teledyne Judson	SuperCam	CCD Image Sensor Infrared Photodiodes
Teledyne DALSA	SkyCam	CCD Image Sensor
Teledyne Energy Systems	MMRTG	Power Unit



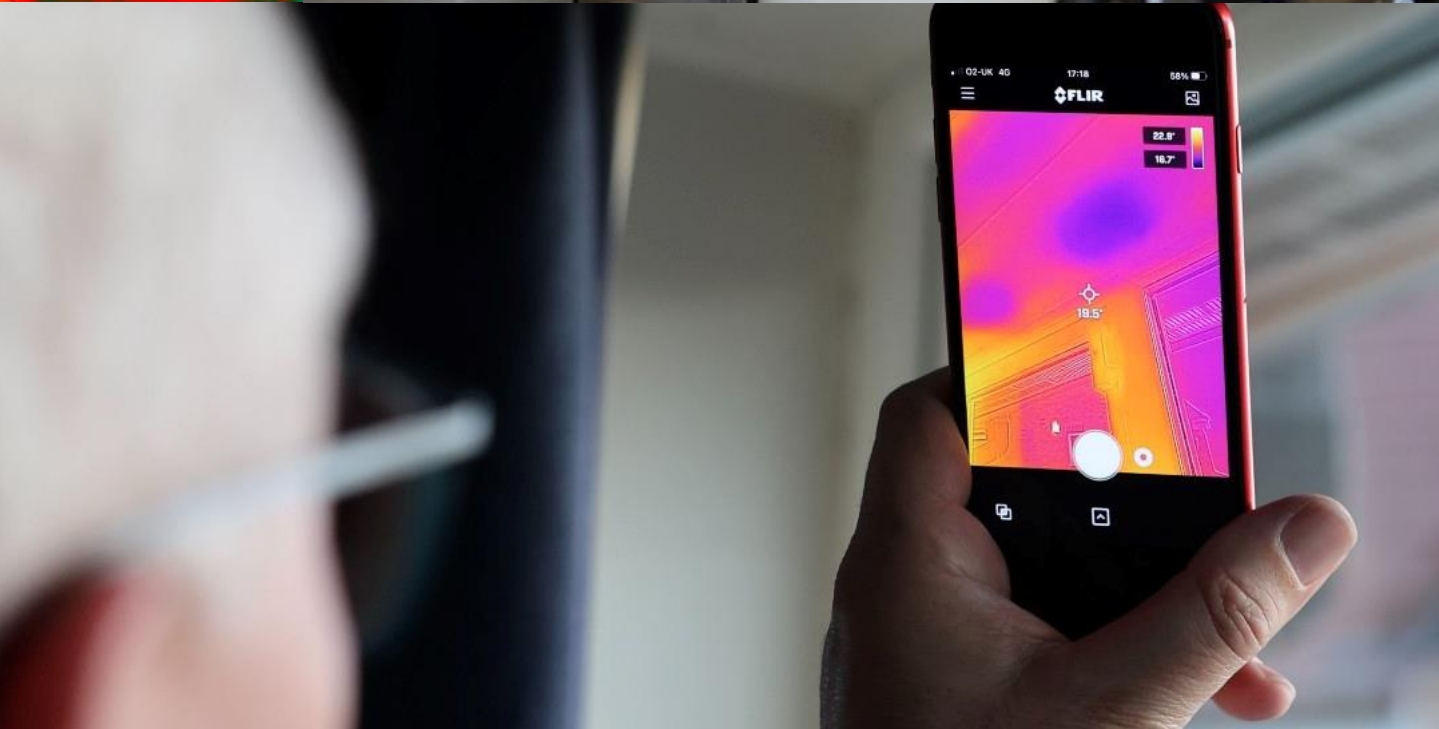
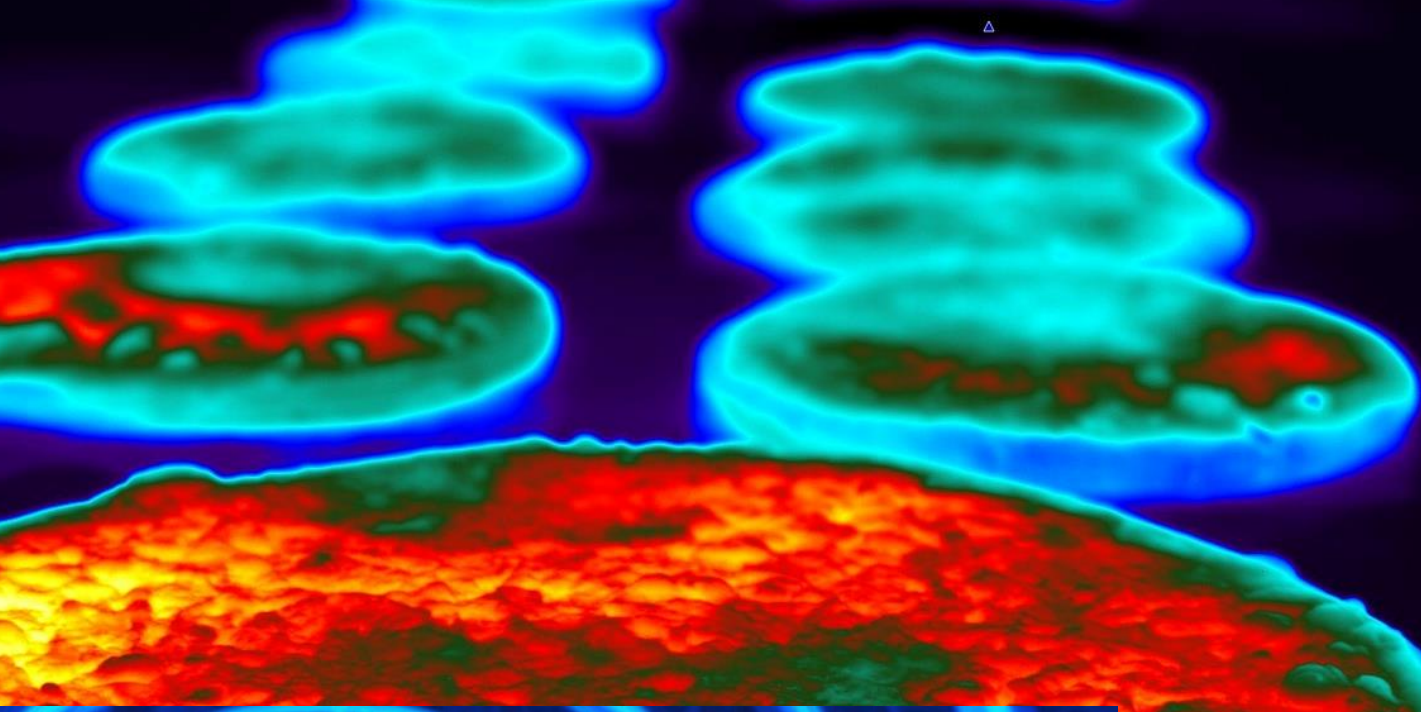


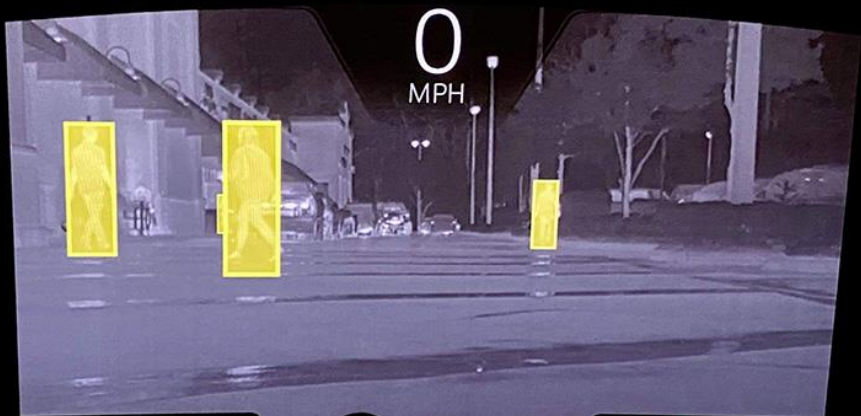
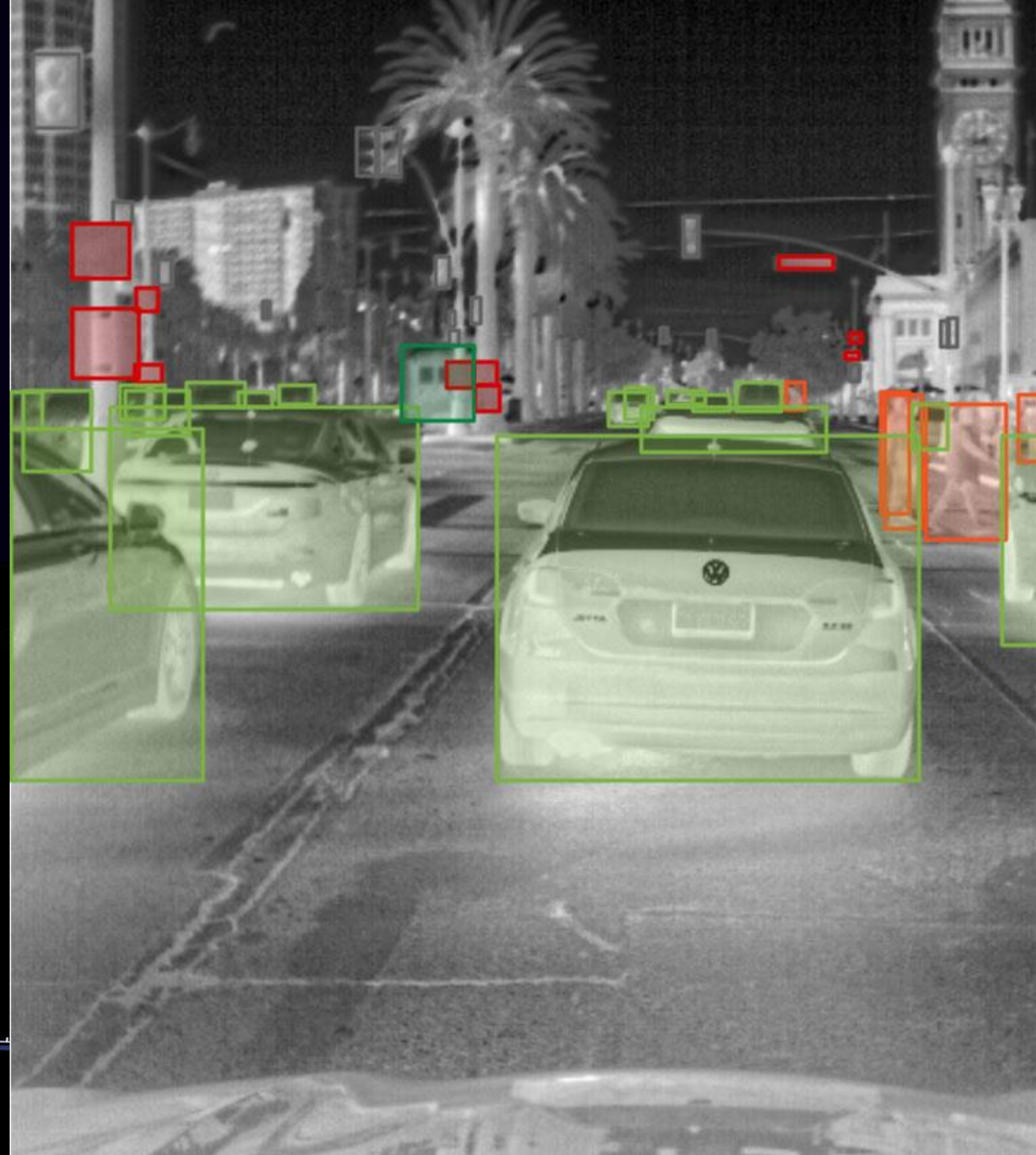












STOP

mi

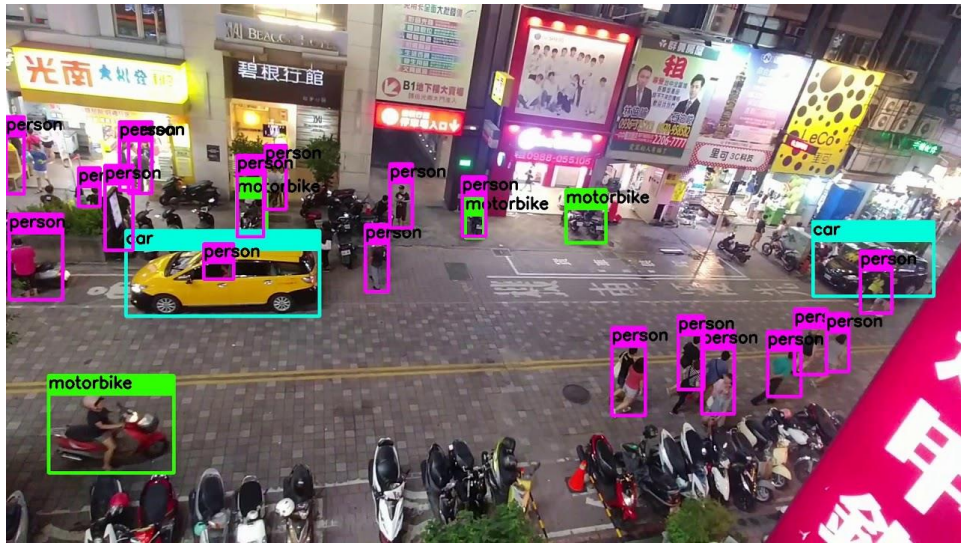


RPMx1000



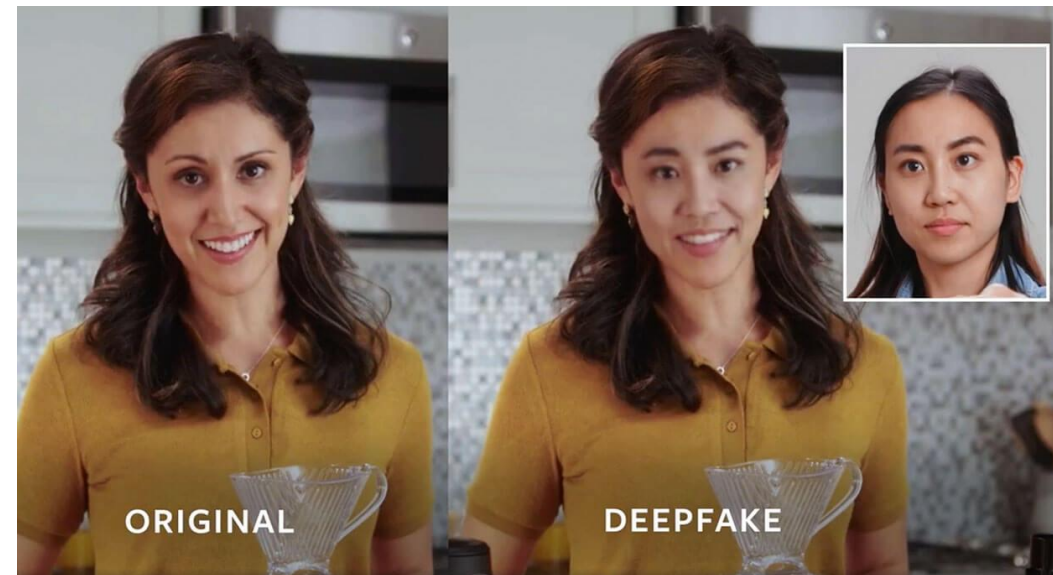
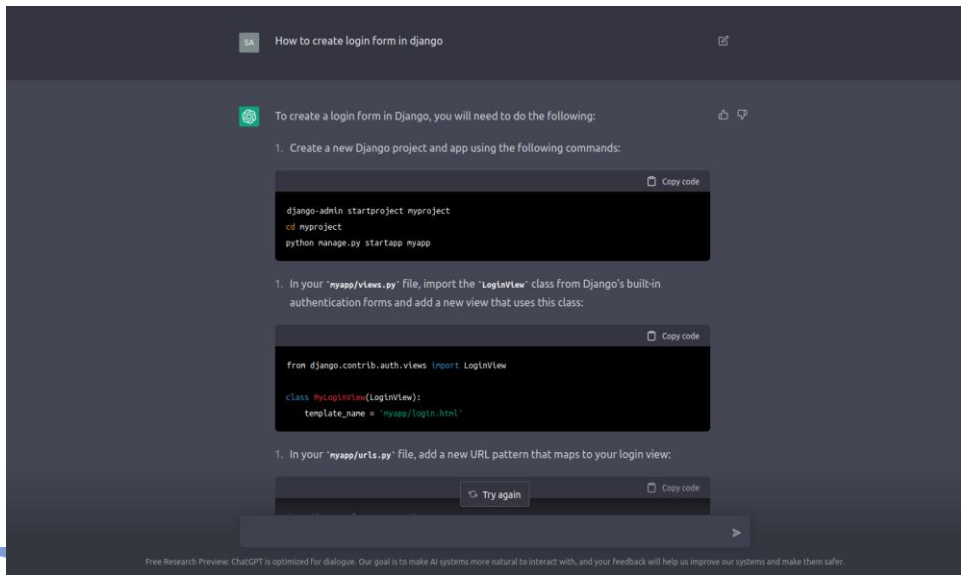
305mi AUTO

Machine Learning & Artificial Intelligence



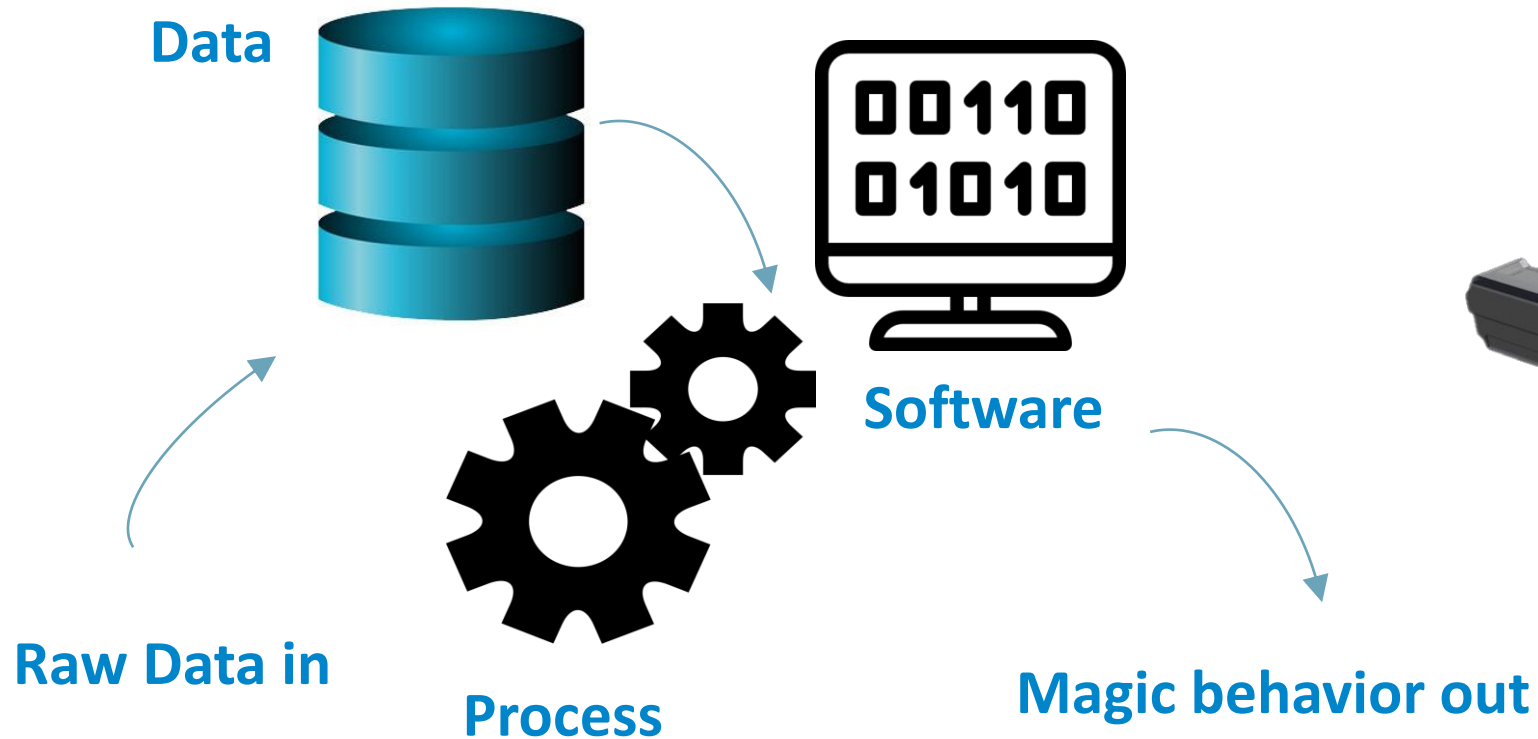
Media is full of stories about the use of Machine Learning:

- Image processing, target recognition, automation and monitoring
- ChatGPT – answering questions with surprising accuracy
- Deep fakes, re-rendering people, “cheating” with looks and voice



Machine Learning & Artificial Intelligence for Sonars

Machine Learning” is on the rise, but can we use for sonar data and specifically in the context of MCM?



Forward looking sonars product range



BlueView



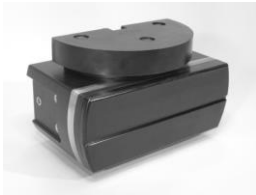
Compact imaging sonar



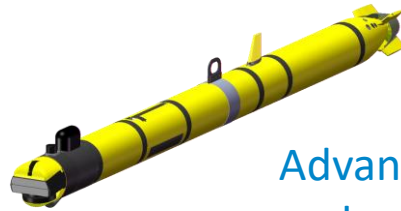
SeaBat F20/50



High Performance Obstacle Avoidance Sonar



SeaBat F30



Advanced Terrain Mapping and navigation Sonar



SeaBat F110/7123-MkII



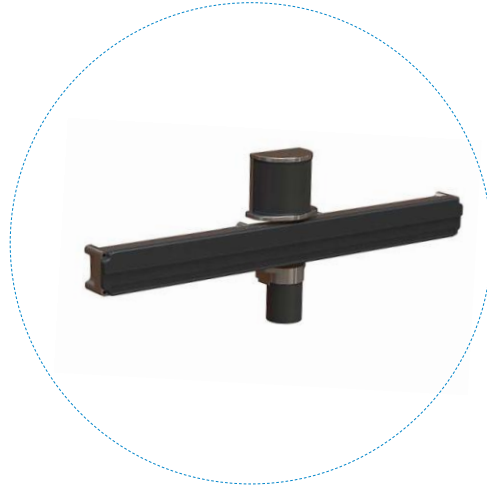
Search & Detection Sonar, and MCM Sonar



Hull Mounted Sonar Solutions



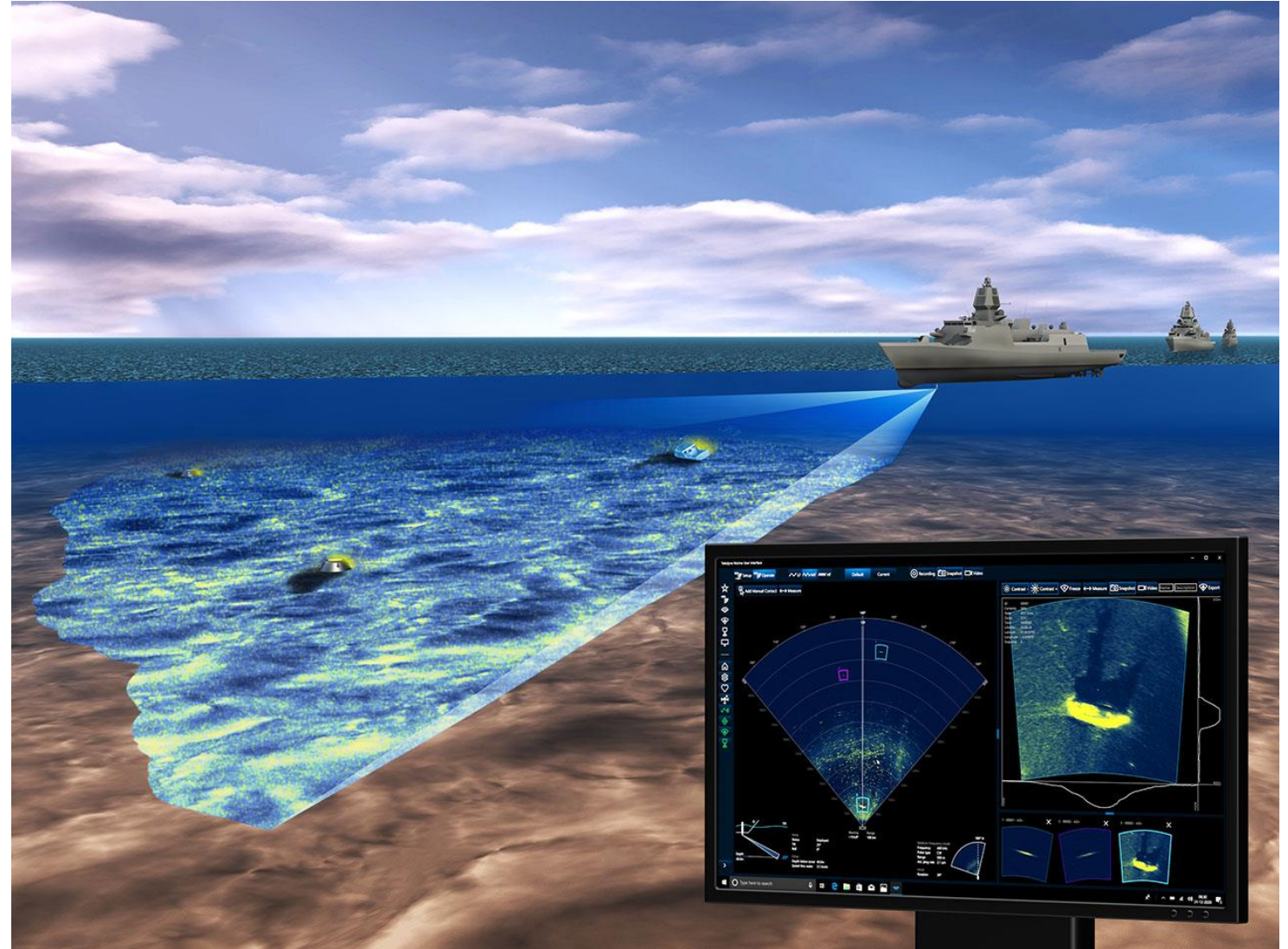
SeaBat 7123-Mk2
on hoist



SeaBat 7123-Mk2
Sonar head

Triple frequency band for high flexibility of use and better resolution at close ranges

- **Low Frequency (100kHz)** long range detection
- **Medium Frequency (200kHz)** medium range and for shallow waters and reverberant environments.
- **High Frequency (400kHz)** mode provides high resolution for classification with good shadow detail.



SeaBat 7123-MkII first orders



2 x SeaBat 7123MkII order for Asia with hoist system

C2 System supplier:



\$Multi Million orders for delivery in 2023-2024

- First ordered delivered the base system and a well working sonar with CAD Box
- Strong pipeline for further orders
- Additional functionality added with ongoing orders



HMS Quorn will be refurbished before being handed over to Lithuania in 2024 (MOD photo)

1 x SeaBat 7123-MkII for European NATO

C2 System supplier:



NEW ORDER!

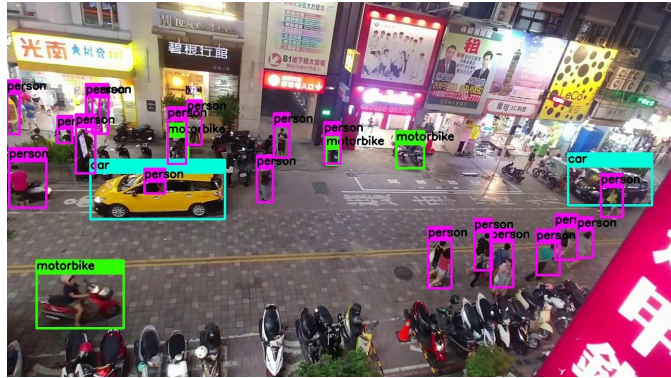


SeaBat 7123MkII order for Asia with hoist system



Machine Learning and AI – can be difficult for real time sonar data

Open Source starting point:



A vast ecosystem of possibilities to adopt from:



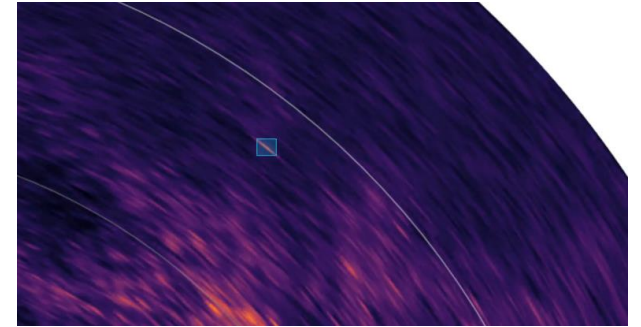
Challenges, for applying to real-time sonar:

Data volumes are large, 700 Mbit/s
For SeaBat 7123-MkII and T51

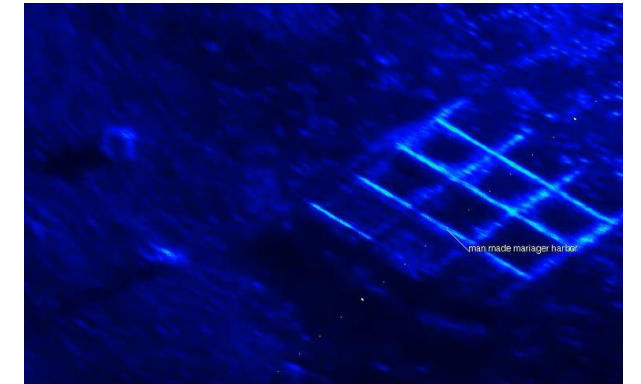
Data from a sonar is
“skewed”

Sonar Raw Data

Variance in data over range:



Long range, tiny “blips in data”



Short range, “image like”

Applying Machine Learning to sonar data at Teledyne Marine

Introducing the Advanced Compute Unit, ACU

Teledyne's sonar instruments are stable products developed and refined over long timeframes

The **Advanced Compute Unit** is an add-on unit designed to add enormous amounts of computational power and support frequent updates to software.

- Ruggedized Rack mounted 2U unit
- Based on the Framework from Nvidia
- Complete 7K Sonar integrated
- Supporting ONNX standard ML model integration
- Can be opened for integration (OEM/commercial/defense)



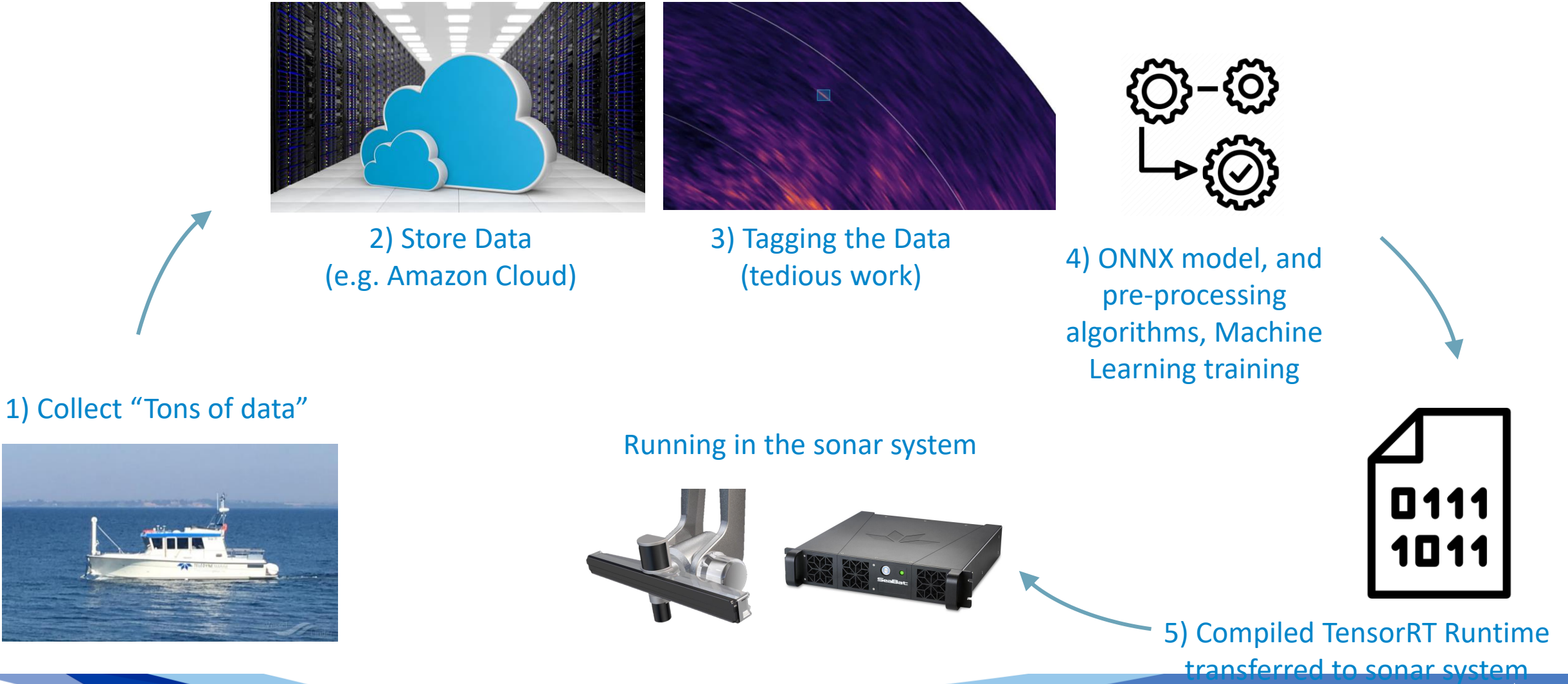
Machine Learning
Cloud Computing
Image Rendering
Signal Processing
Artificial Intelligence
Automation
Algorithms
Connectivity



**ACU Industrial grade
Compute Unit
+50 TOPS capable**

Machine Learning for Sonar systems – workflow offered

Workflow



Introducing Machine Learning for Sonar systems – Collecting “tons of data”

Amazon S3 ×

Buckets

- Access Points
- Object Lambda Access Points
- Multi-Region Access Points
- Batch Operations
- Access analyzer for S3

Block Public Access settings for this account

Storage Lens

- Dashboards
- AWS Organizations settings

Feature spotlight

AWS Marketplace for S3

Amazon S3 > tdy-marine.raw-7k > 2020-09-07Mariager/ > s7k/

s7k/ Copy S3 URI

Objects | Properties

Objects (15)

Objects are the fundamental entities stored in Amazon S3. You can use [Amazon S3 inventory](#) to get a list of all objects in your bucket. For others to access your objects, you'll need to explicitly grant them permissions. [Learn more](#)

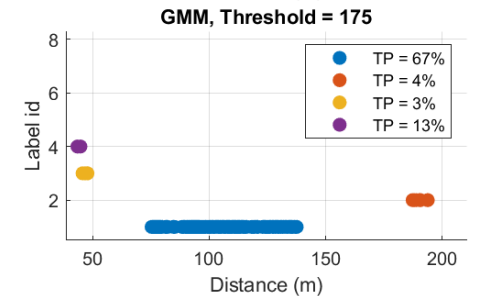
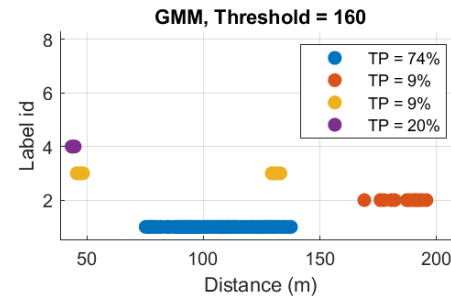
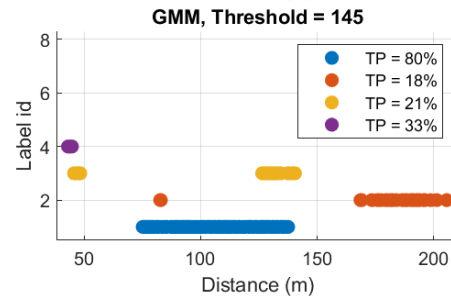
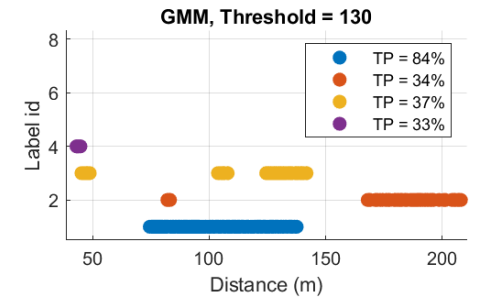
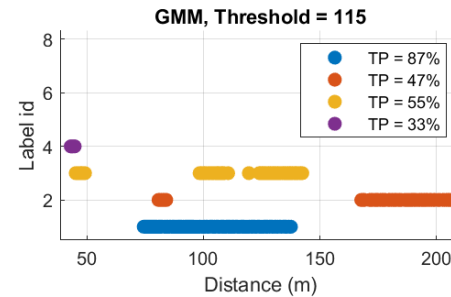
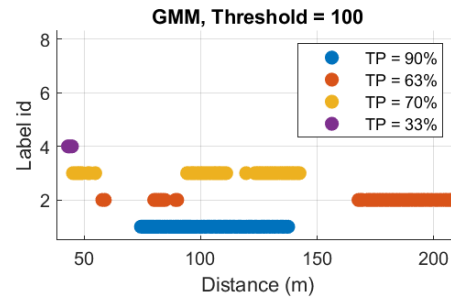
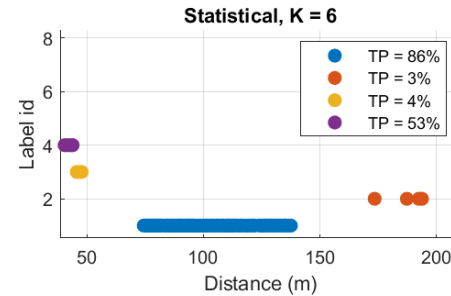
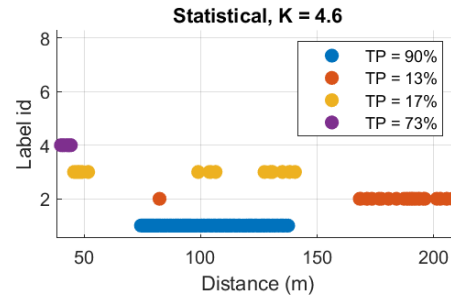
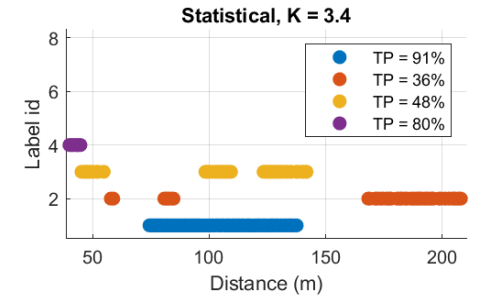
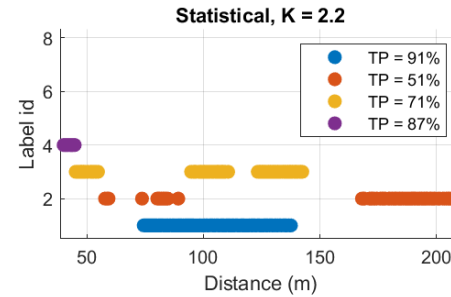
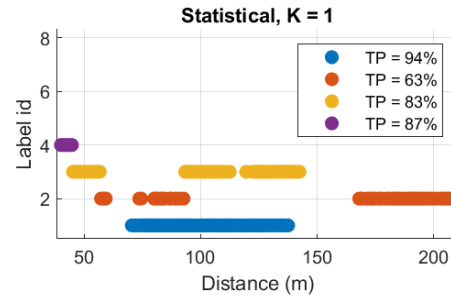
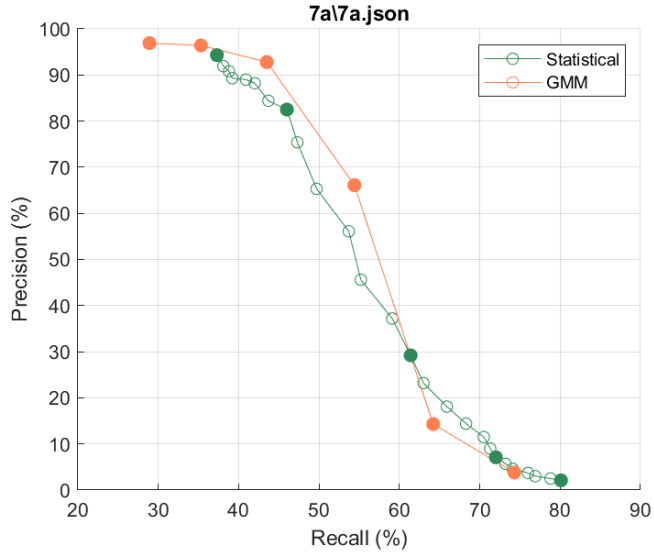
Refresh Copy S3 URI Copy URL Download Open Delete Actions Create folder Upload

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<input type="checkbox"/>	200kHz_Interleaved_E/	Folder	-	-	-
<input type="checkbox"/>	200kHz_Interleaved_N/	Folder	-	-	-
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<input type="checkbox"/>	Background/	Folder	-	-	-

Introducing Machine Learning for Sonar systems – Tagging data and evaluation

The screenshot displays the Labelbox web application interface. At the top, the browser window shows 'Labelbox - Chromium' and the date 'Oct 5 14:45'. The main content area features a large, semi-circular sonar ping visualization labeled 'Ping number 15499'. The visualization is a heatmap where colors range from dark purple to bright orange, representing different intensity levels. Concentric white arcs are overlaid on the ping, with distance markers at 50 m, 100 m, 150 m, and 200 m. A small blue square annotation is visible on the left side of the ping. To the left of the main visualization is a placeholder box with a white 'X' on a grey background. Below the main visualization is a timeline for annotations, showing a sequence of small blue circles representing individual frames. The timeline is labeled 'ANNOTATIONS' and 'Training Mine (4)'. The current frame is 'Frame: 3 / 216', and the timeline shows a total of 103 frames. The interface also includes a search bar, navigation icons, and a 'Save' button.

Introducing Machine Learning for Sonar systems – “Training” the system



Introducing Machine Learning for Sonar systems – Open Source tools for 7K

Working with Sonar Data, we provide support over our Github/Teledyne-Marine for customers

Teledyne Marine - GitHub

https://github.com/Teledyne-Marine

Why GitHub? Team Enterprise Explore Marketplace Pricing Search Sign in Sign up

Teledyne Marine
Earth for now <http://www.teledynemarine.com> harvey.stoelinga@teledyne.com

Overview Repositories 5 Packages People Projects

Popular repositories

- 7k** (Public) - Teledyne Marine 7k protocol for marine sensor interfacing. C 10 stars, 2 forks.
- Wayfinder** (Public) - Python driver for communication with a Teledyne Marine Wayfinder DVL. Python 4 stars, 2 forks.
- pyread7k** (Public) - Pyread7k is a library for reading 7k files. It provides a high-level interface to the data in a file, with an API that is a compromise between being ergonomic, while still being easy to correlate w... Python 3 stars, 1 fork.
- PDDecoder** (Public) - C Library to decode Teledyne RD Instruments (TRDI) PD data types, such as PD0 and waves packets. C++ 2 stars, 1 fork.

People

This organization has no public members. You must be a member to see who is in this organization.

Top languages

- Python
- C++
- C

TELEDYNE MARINE
Everywhereyoulook™

Pyplot7k

Pyplot7k is a library for plotting 7k data.

Installation

The library can be installed using pip, directly from PyPI, or from the Teledyne github repository as seen below. All dependencies should be automatically installed.

```
pip install pyplot7k
pip install git+https://github.com/Teledyne-Marine/pyplot7k.git
```

Getting started

Working with pyplot7k is quite intuitive. In its most basic form, a wedge can be created by simply passing a pyread7k ping into plot_wedge_from_ping().

```
from pyread7k import PingDataset, PingType
from pyplot7k import *
import matplotlib.pyplot as plt

dataset = PingDataset('path/to/file.7k', include_ping_type=True, skip_ping_type=True)
ping = dataset[0] # First ping of the dataset

fig, ax = plt.subplots()
plot_wedge_from_ping(
    ping,
    ax=ax,
)
plt.show()
```

Output example

Dependencies

- Python 3.8 or later
- pyread7k
- numpy
- scikit-image
- matplotlib

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Applying Machine Learning & AI to sonar data

Examples of use of Machine Learning with sonar data



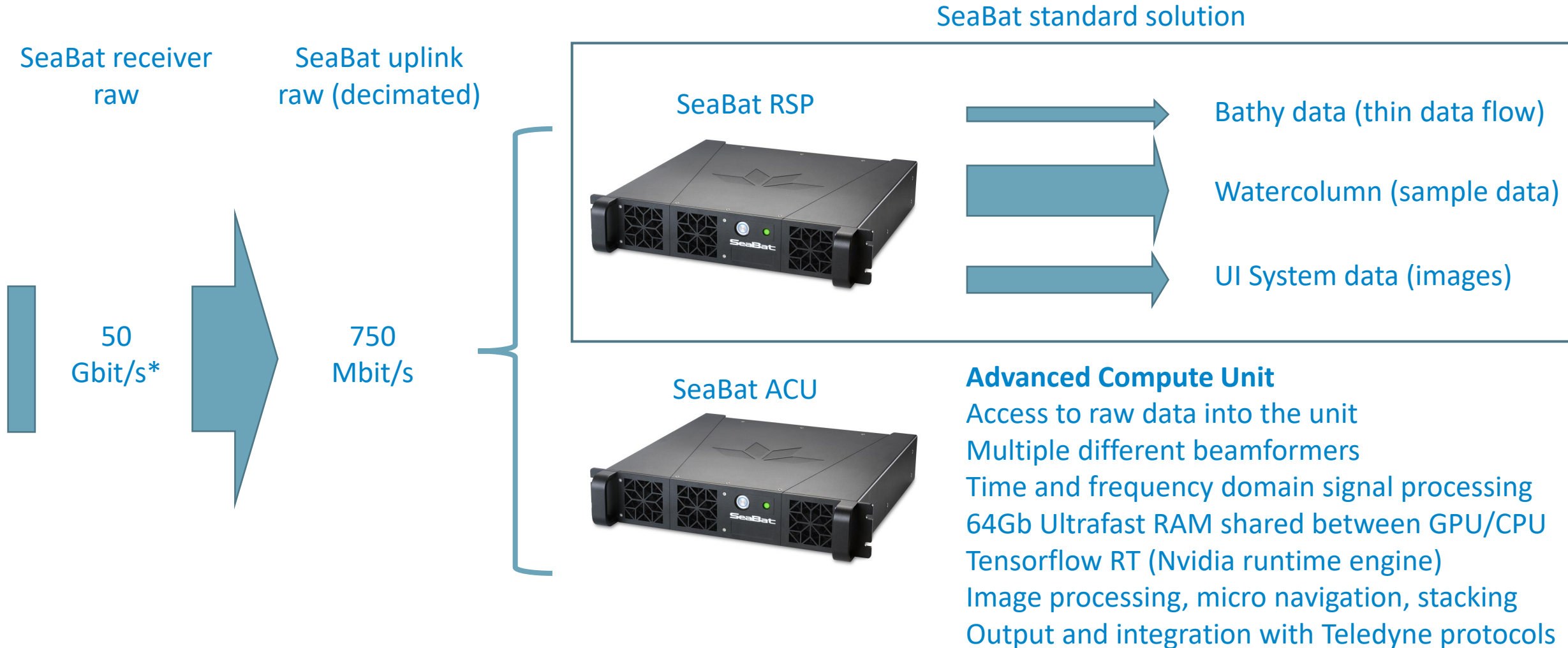
ACU Unit



SeaBat 7123-MkII for detecting Mines

What does the Advanced Compute Unit offer?

Data flow and signal processing



* SeaBat T51 dataflow at frontend, equal to 10.000 Netflix HD movies streaming

Example actual use of the Advanced Compute Unit

Search and Detection system for a "forward looker"

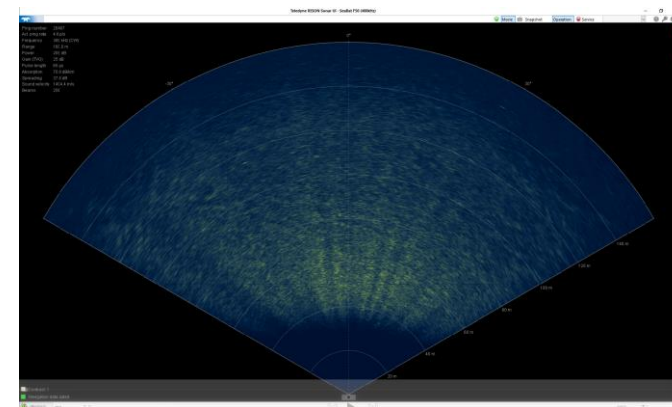
Uplink

750
Mbit/s

SeaBat RSP



UI System, wedge image



SeaBat ACU



Detector (Machine Learning)



Target tracking



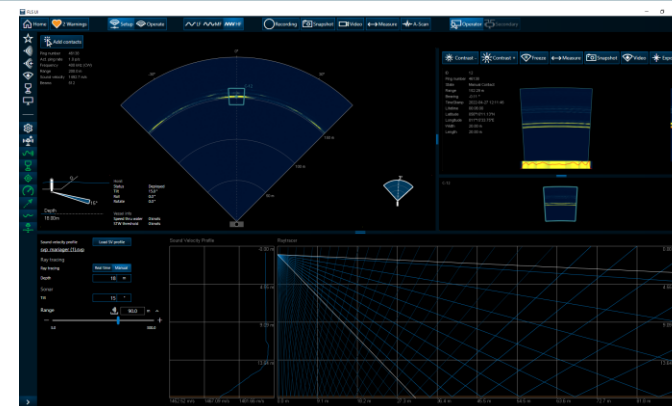
Sound Velocity calculations



UI System, zoom images

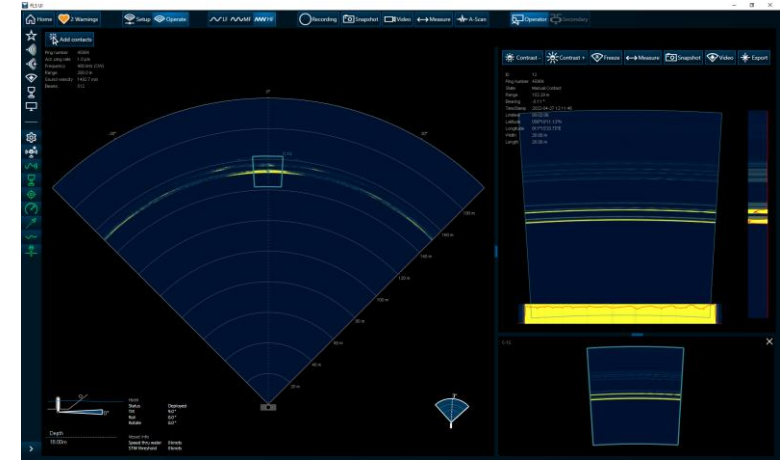
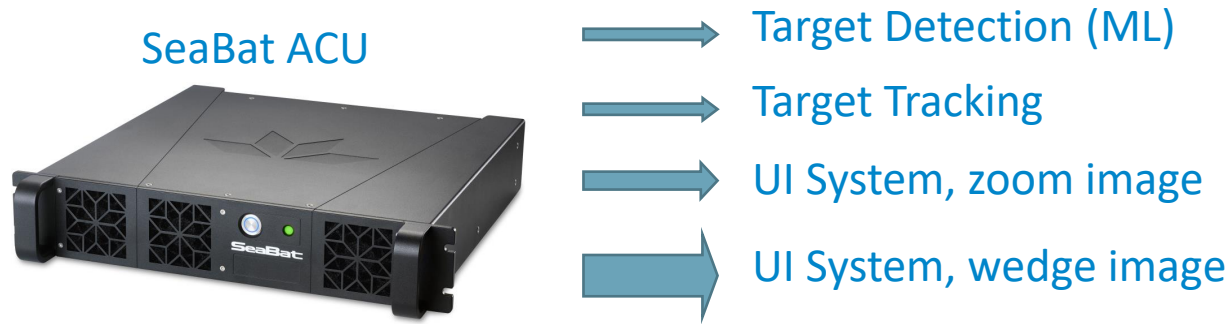


UI System, wedge image



Example actual use of the Advanced Compute Unit

Search and Dection system for a "forward looker"

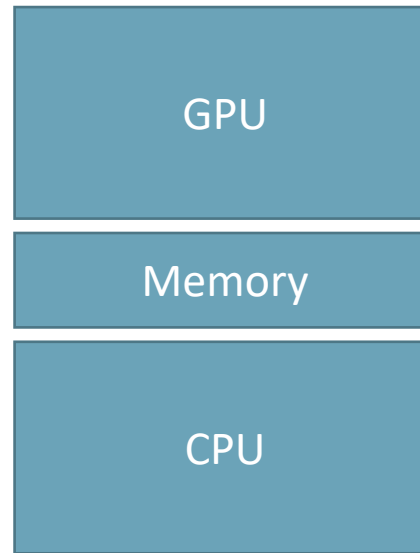


What is "inside the box"

750 Mbit/s → Raw data in

System include support for:

- * Raw receiver data
- * 7K interface (Navigation etc.)
- * Storage, streaming out
- * Processing pipeline to GPU



GPU processing (Nvidia)

- * CUDA modules for multiple purposes
 - * Beamformers, time, frequency and special
 - * Image processing over multiple pings
 - * Image normalization algorithms
 - * Navigation system, 3D navigation at sample level
 - * Detection system, statistical detector/sample level
 - * Detection system, machine learning type
 - * Tracking in 3D space, over time
 - * Zoom window signal processing, window rendering
- All running with full throughput of data (real time)!*

* SeaBat 7123-MkII dataflow at frontend, equal to 10.000 Netflix HD movies streaming

Example actual use of the Advanced Compute Unit

Flexibility to pick selected datasets for special processing

1 channel
1 Ping sample data:

30.000

sample 0

512 channel
1 Ping sample data:

15.000.000
samples

Ch 0,1, ... 512

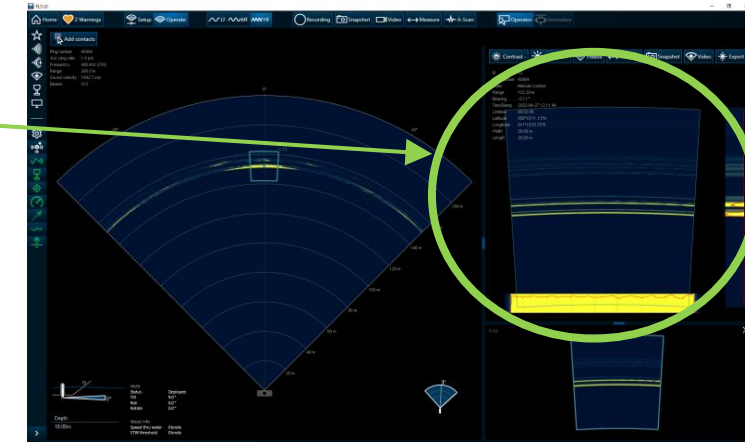
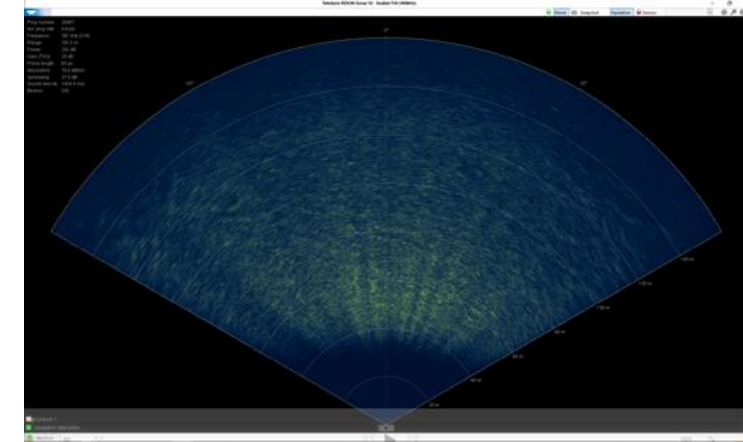
Full Wedge display
900 x 700 pixels
Compressed image
to 8 bit values

SeaBat ACU

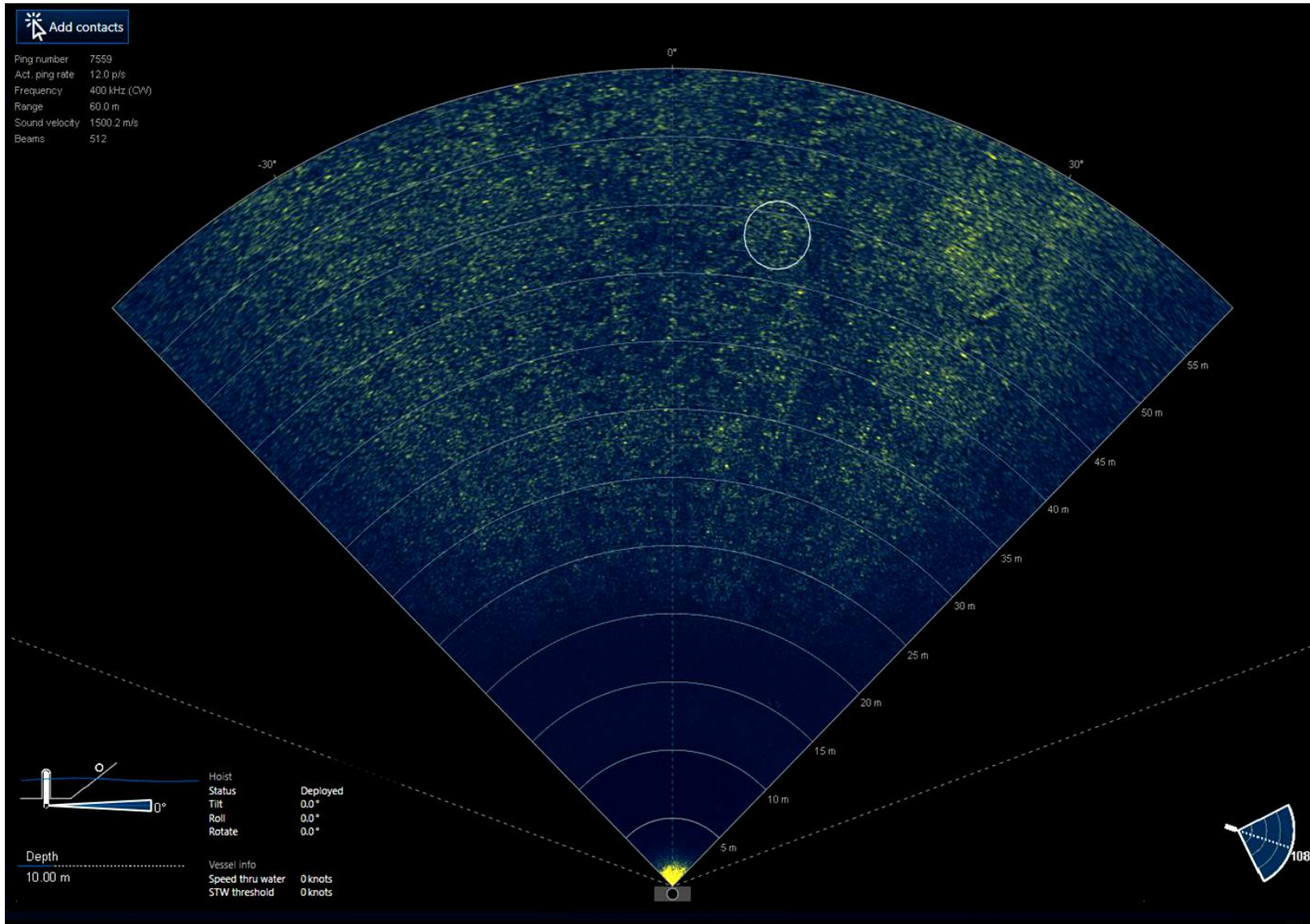


Selected dataset, picked from the total dataset.
Beamformed individually for a ZOOM window.
Stacked, 24bit data

SeaBat standard solution



Example actual use of the Advanced Compute Unit



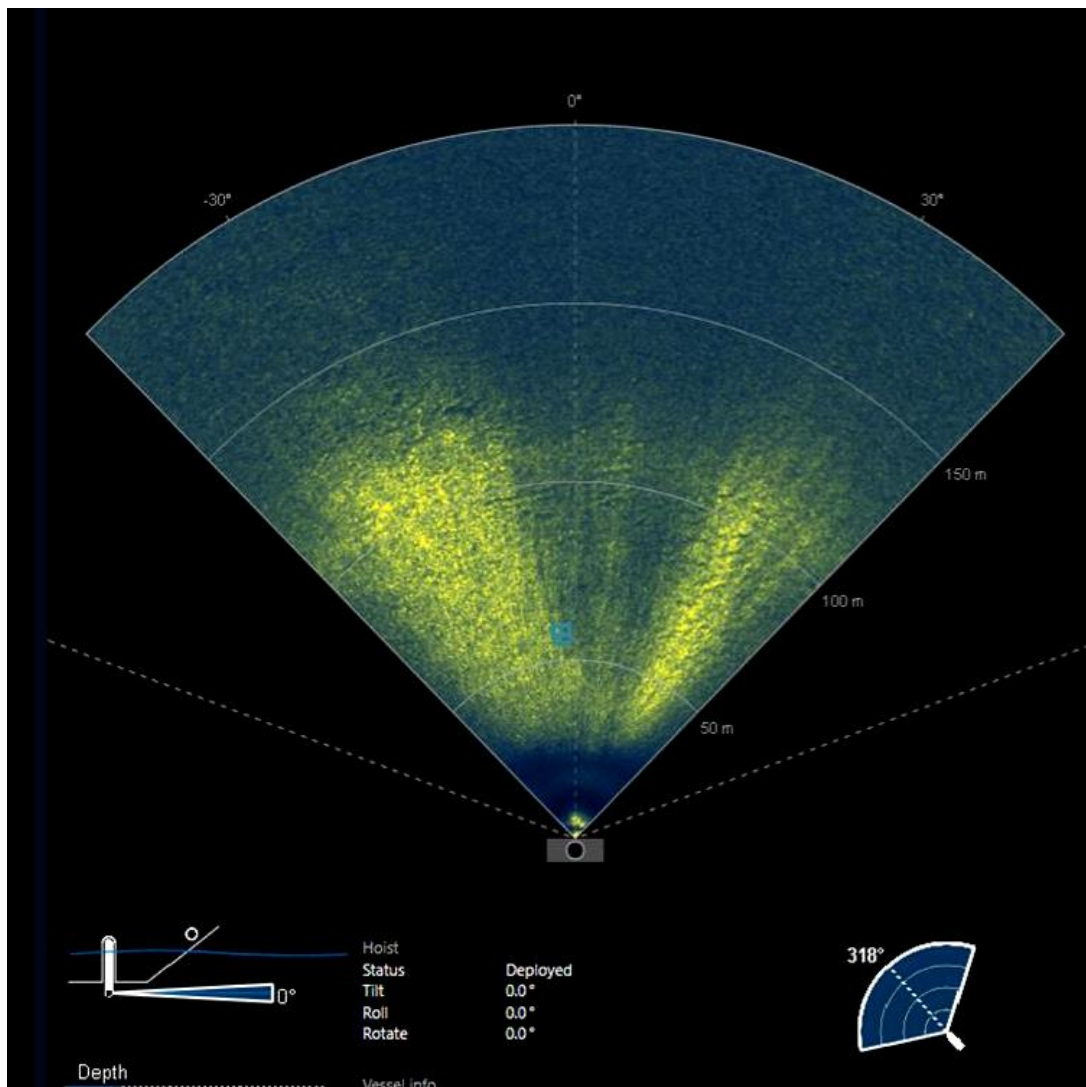
Stabilizing the Image in the ACU
With GPU running algorithms

Toggleing between On/Off

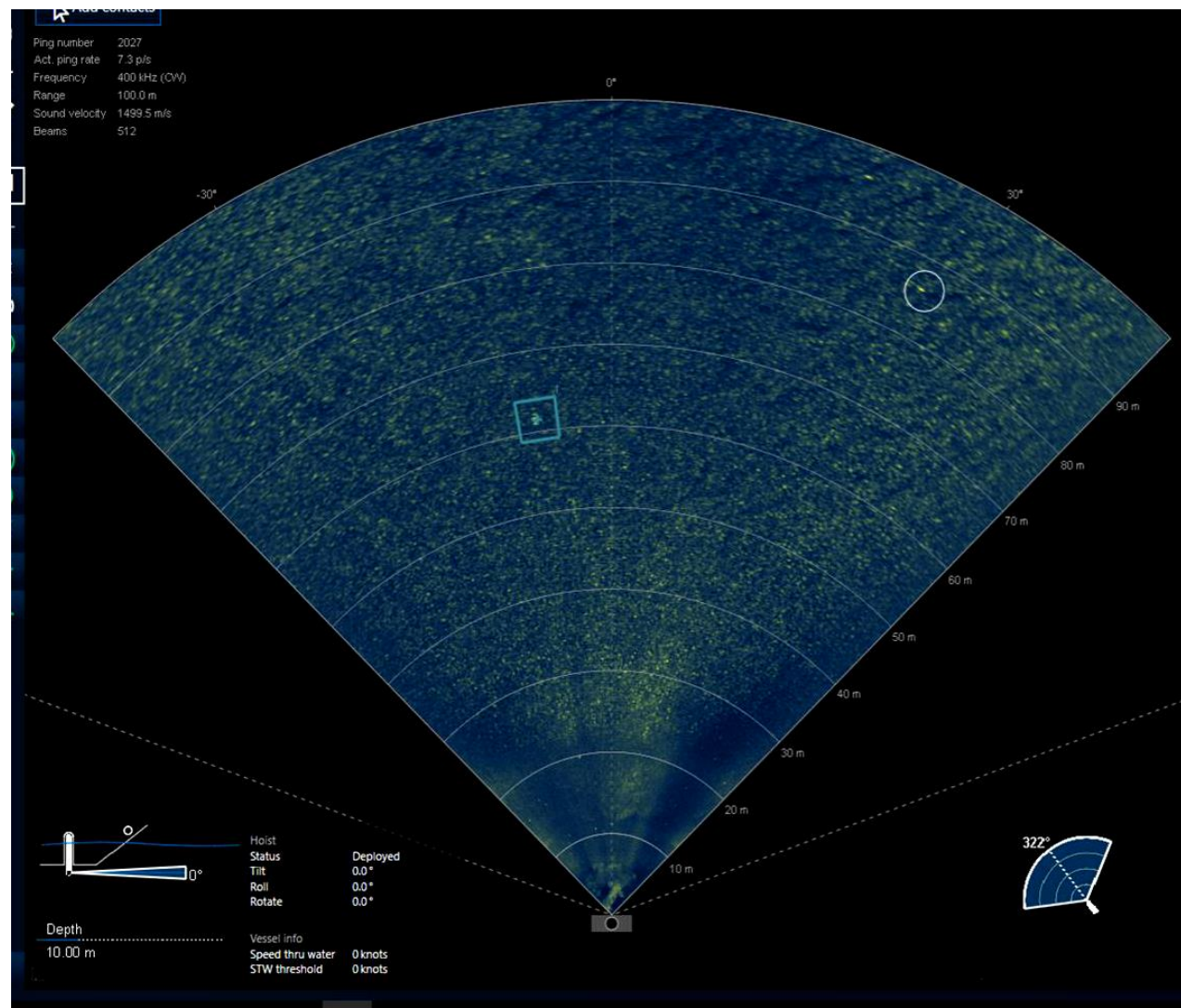
Uncontrolled Technology Subject to Restrictions Contained on the Cover Page

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Example actual use of the Advanced Compute Unit



Normal Forward looking Sonar Image



ACU "Beamnormalization algorithm" evens the sonar image

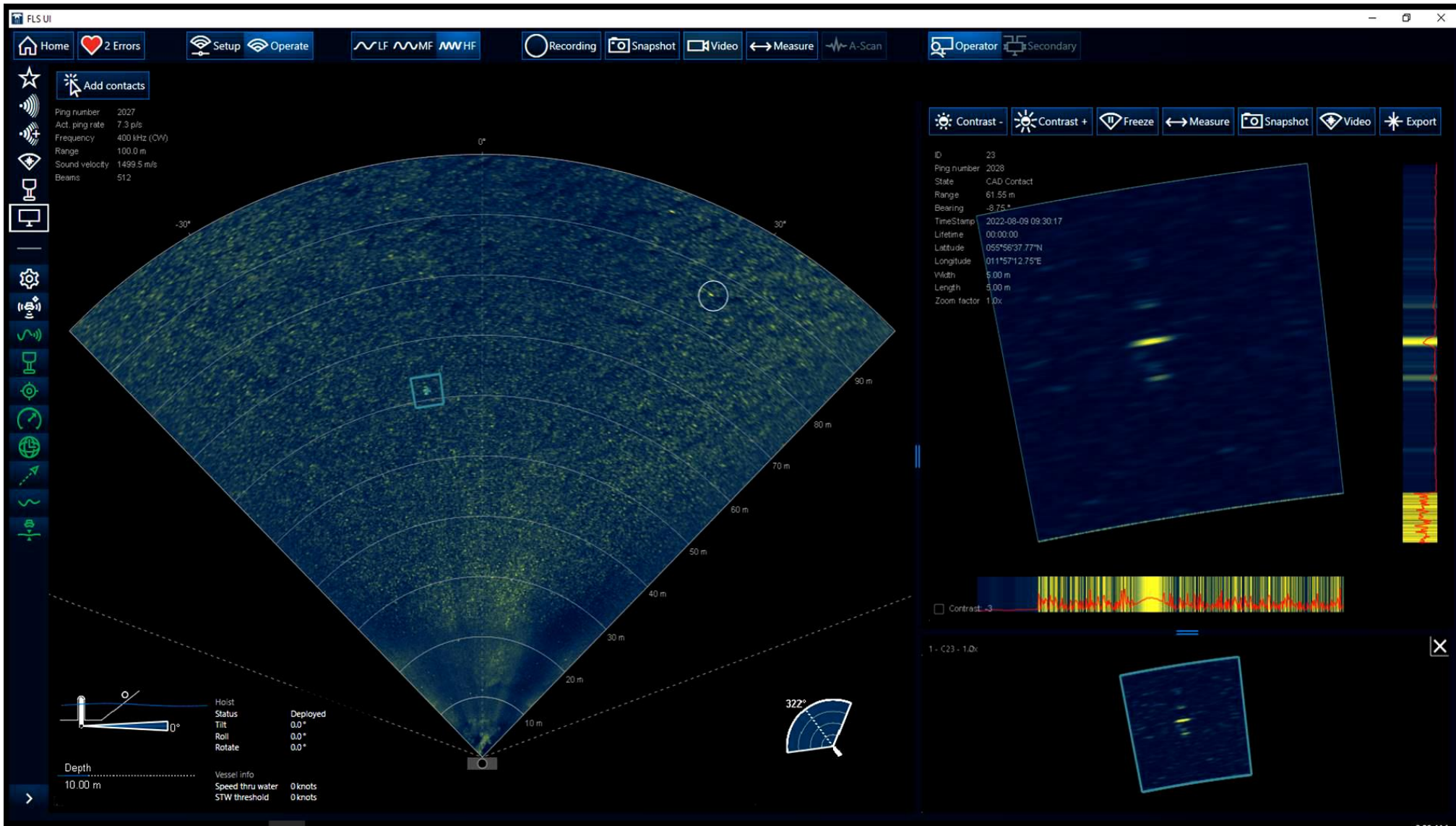
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Example actual use of the Advanced Compute Unit



← New ZOOM window

Machine Learning based Detector system Behind the scene



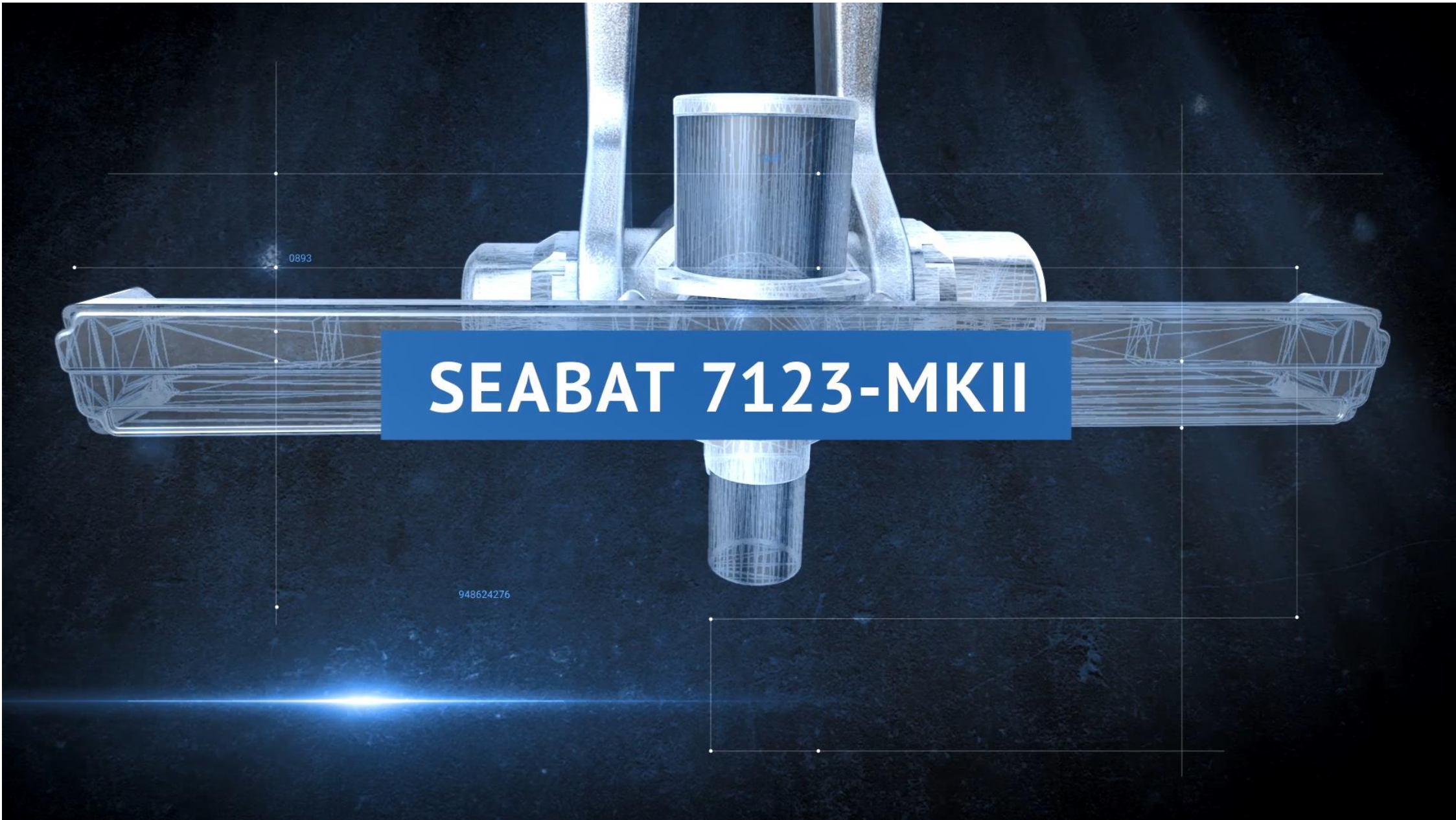
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TELEDYNE MARINE
Everywhere you look™

Q&A



SEABAT 7123-MKII

0893

948624276