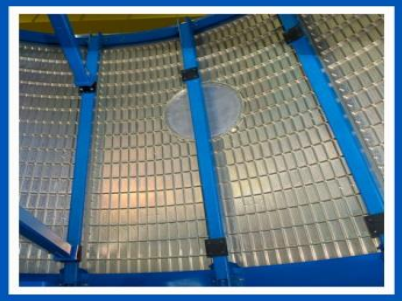
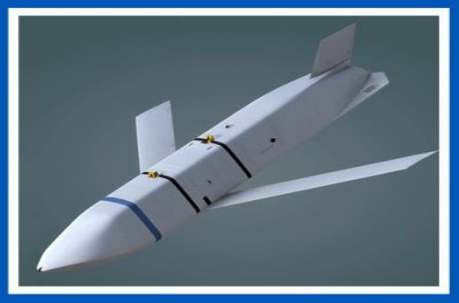








# Expanding MCM Capabilities Using Commercial Sensors and Solutions

Ed Cheesman , Sr. Mgr. – Sales & BD, Teledyne Marine

**Underwater Defence & Security 2023**



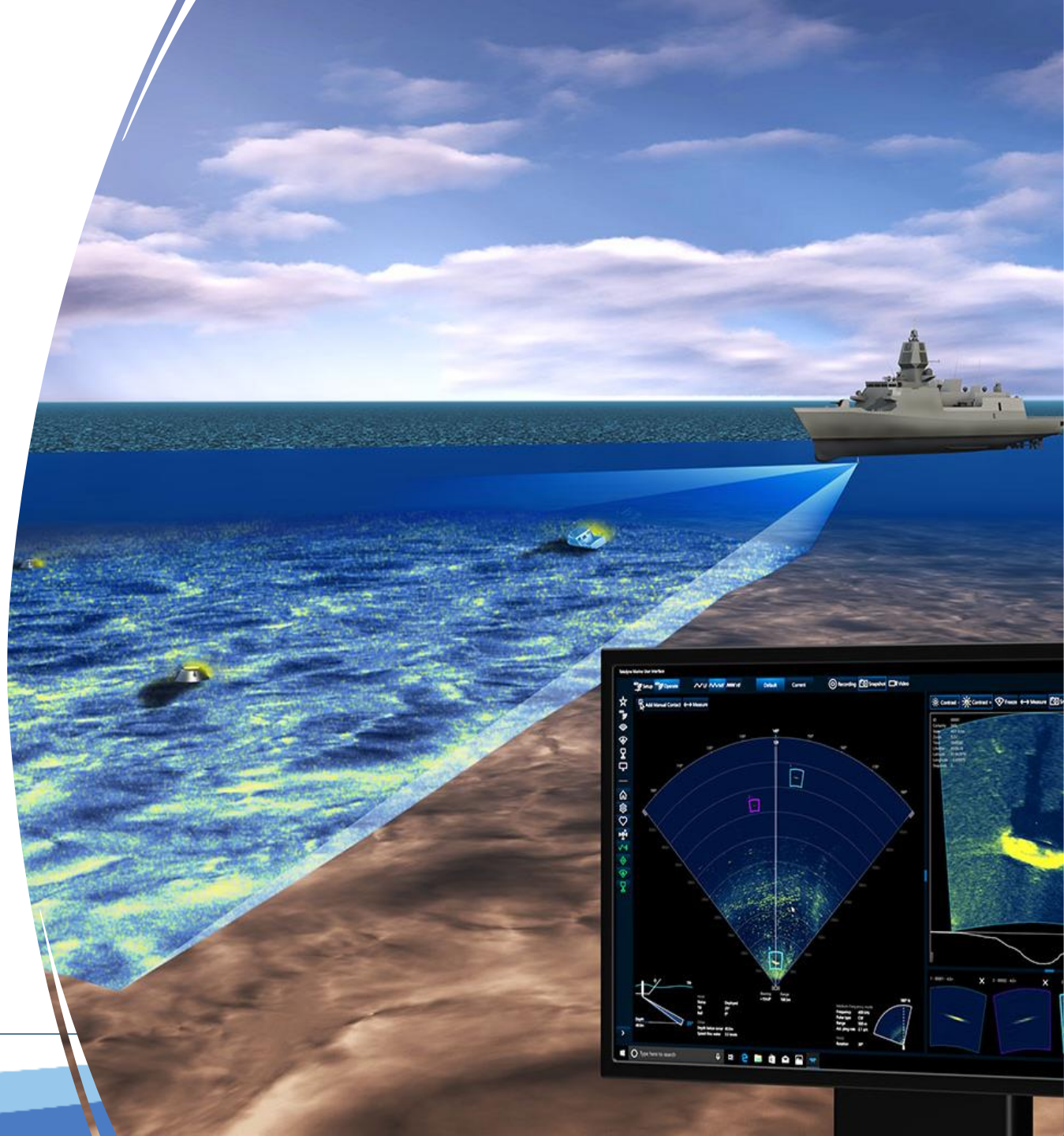
TELEDYNE TECHNOLOGIES
Everywhereyoulook™

# Introduction

## Expanding MCM capabilities using commercial sensors and solutions

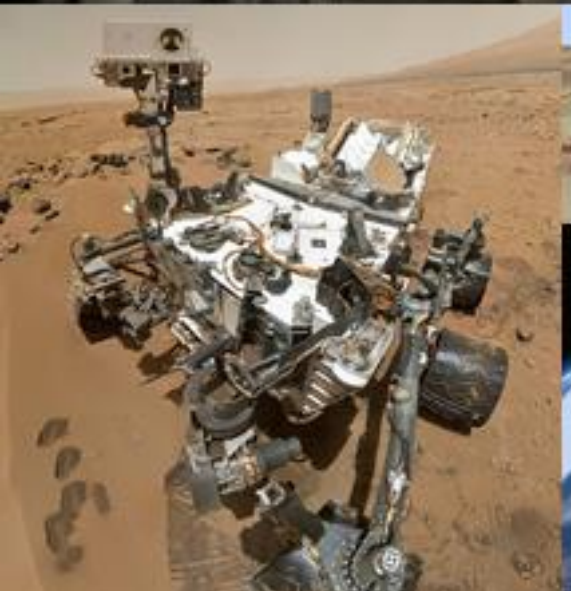
### Overview:

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

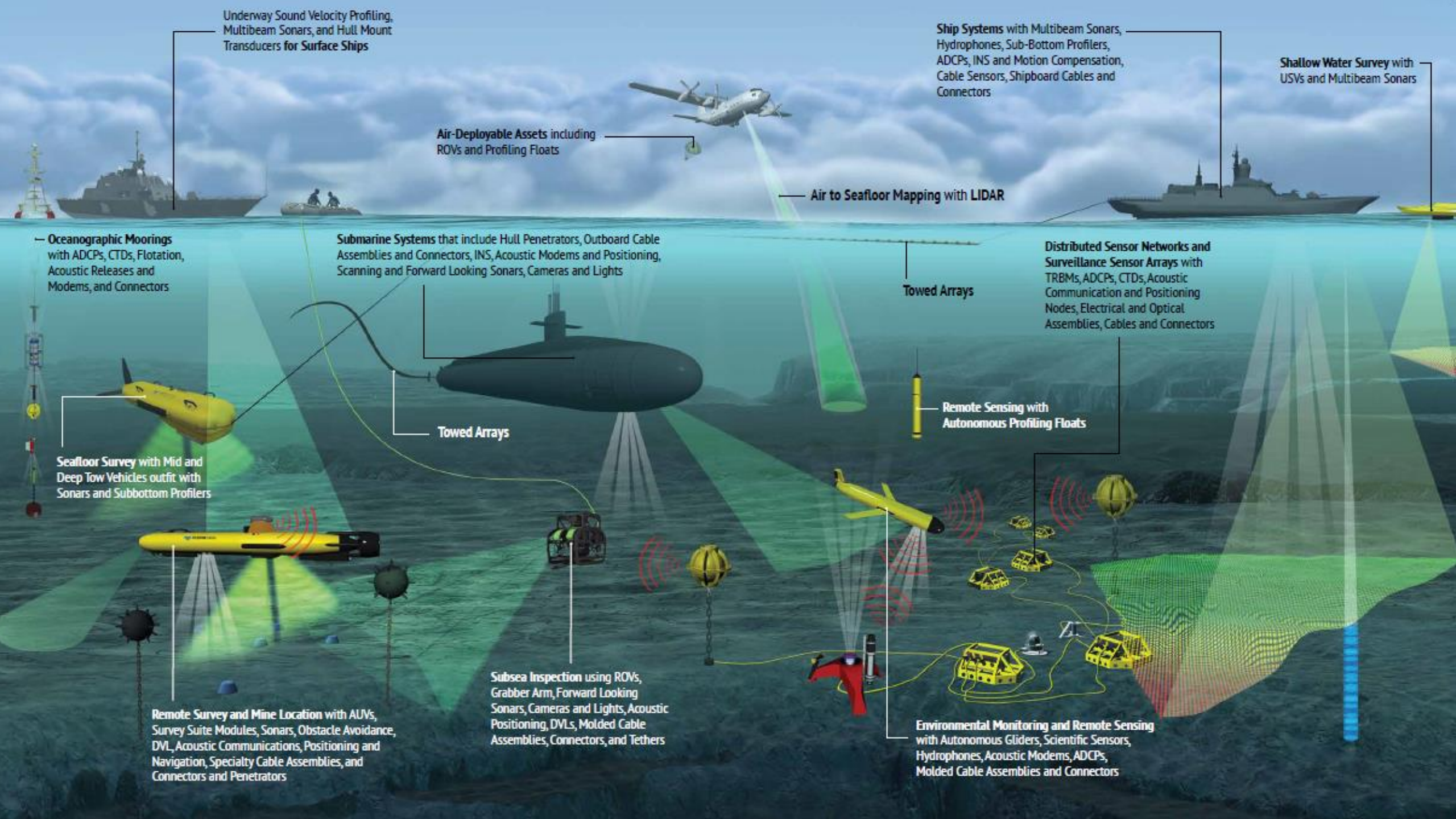


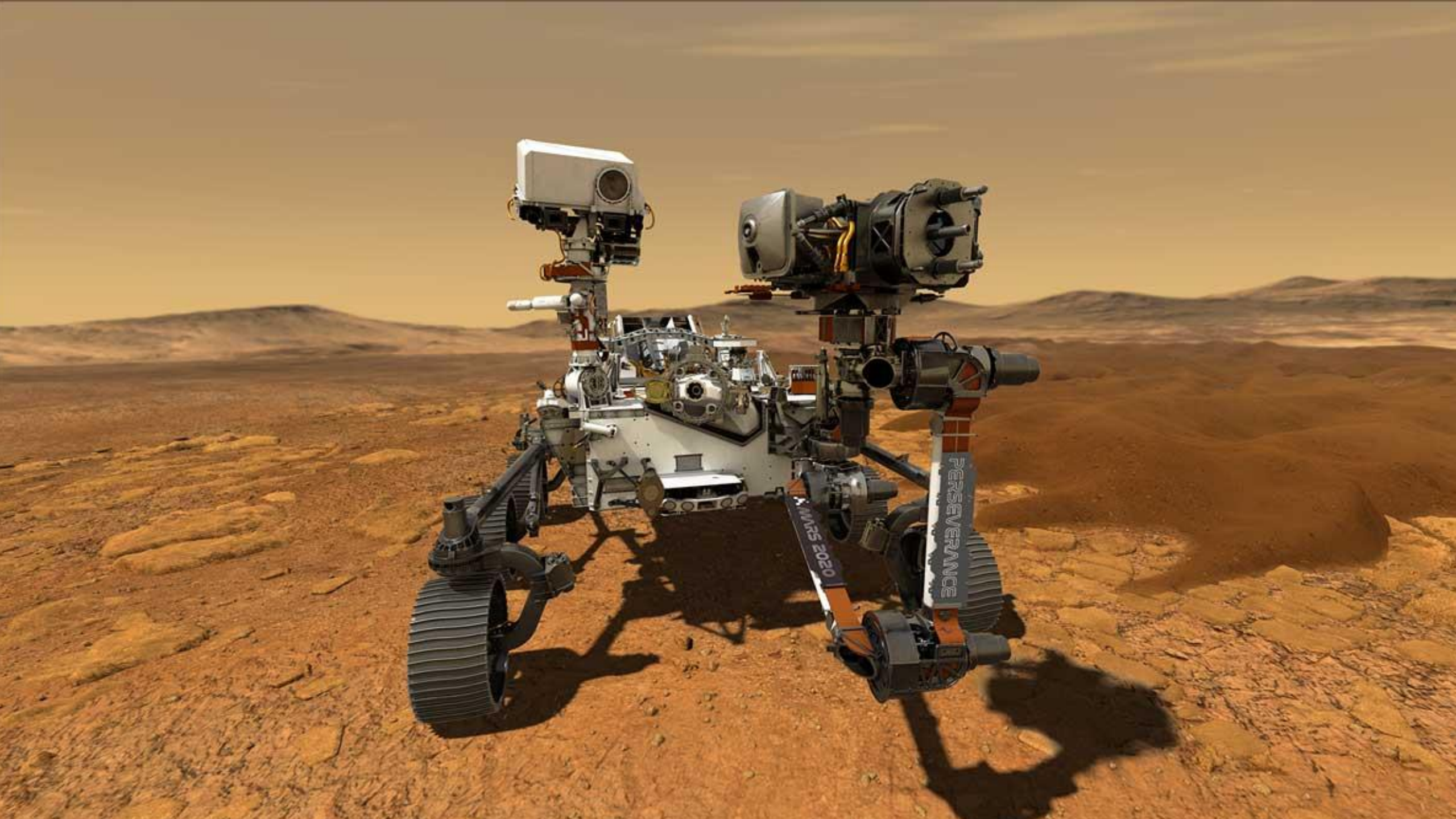






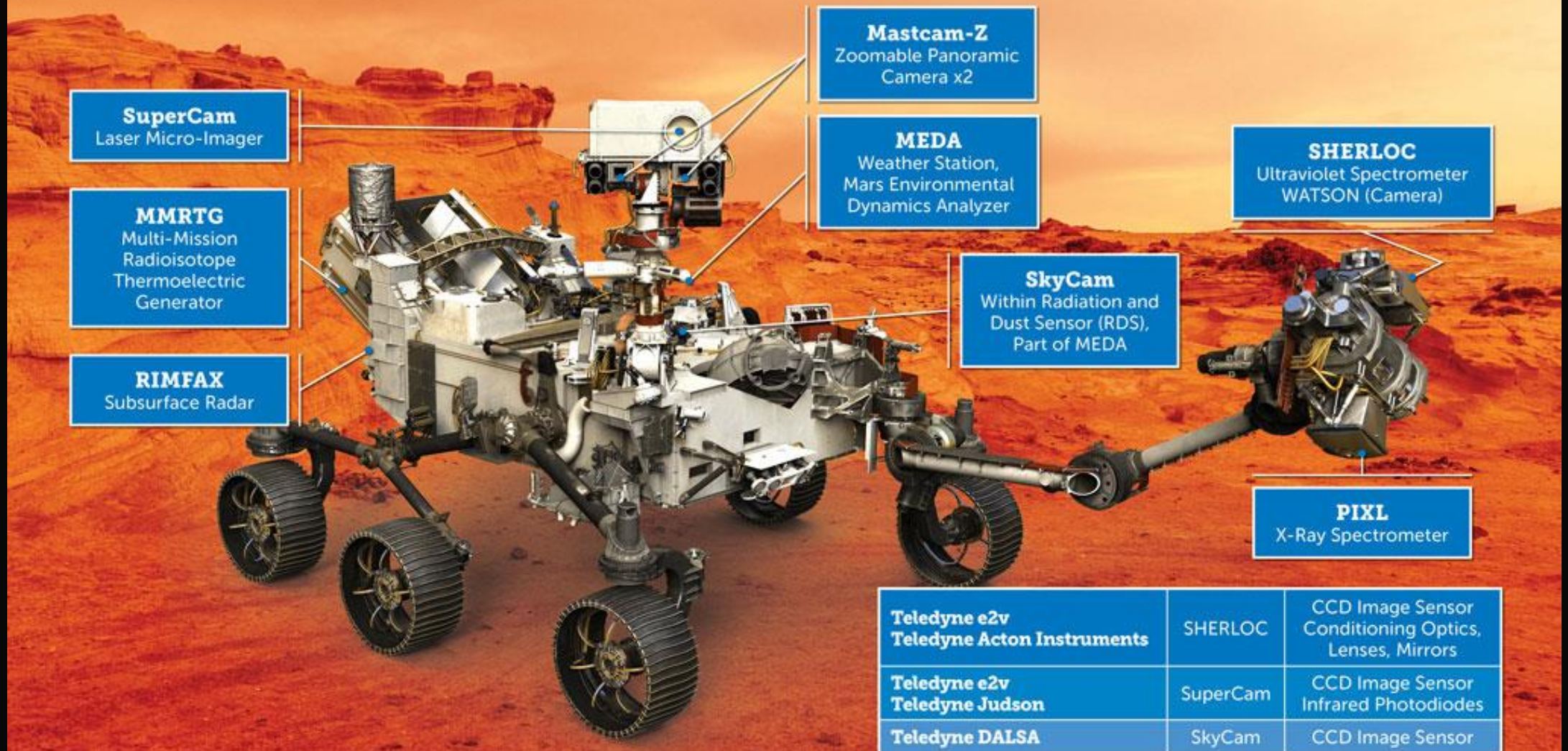


Underway Sound Velocity Profiling, Multibeam Sonars, and Hull Mount Transducers for Surface Ships
Ship Systems with Multibeam Sonars, Hydrophones, Sub-Bottom Profilers, ADCPs, INS and Motion Compensation, Cable Sensors, Shipboard Cables and Connectors
Shallow Water Survey with USVs and Multibeam Sonars
Air-Deployable Assets including ROVs and Profiling Floats
Air to Seafloor Mapping with LIDAR
Oceanographic Moorings with ADCPs, CTDs, Flotation, Acoustic Releases and Modems, and Connectors
Submarine Systems that include Hull Penetrators, Outboard Cable Assemblies and Connectors, INS, Acoustic Modems and Positioning, Scanning and Forward Looking Sonars, Cameras and Lights
Towed Arrays
Distributed Sensor Networks and Surveillance Sensor Arrays with TRBMs, ADCPs, CTDs, Acoustic Communication and Positioning Nodes, Electrical and Optical Assemblies, Cables and Connectors
Towed Arrays
Remote Sensing with Autonomous Profiling Floats
Seafloor Survey with Mid and Deep Tow Vehicles outfit with Sonars and Subbottom Profilers
Remote Survey and Mine Location with AUVs, Survey Suite Modules, Sonars, Obstacle Avoidance, DVL, Acoustic Communications, Positioning and Navigation, Specialty Cable Assemblies, and Connectors and Penetrators
Subsea Inspection using ROVs, Grabber Arm, Forward Looking Sonars, Cameras and Lights, Acoustic Positioning, DVLs, Molded Cable Assemblies, Connectors, and Tethers
Environmental Monitoring and Remote Sensing with Autonomous Gliders, Scientific Sensors, Hydrophones, Acoustic Modems, ADCPs, Molded Cable Assemblies and Connectors


PERSEVERANCE
MARS 2020

# Mars 2020 Perseverance

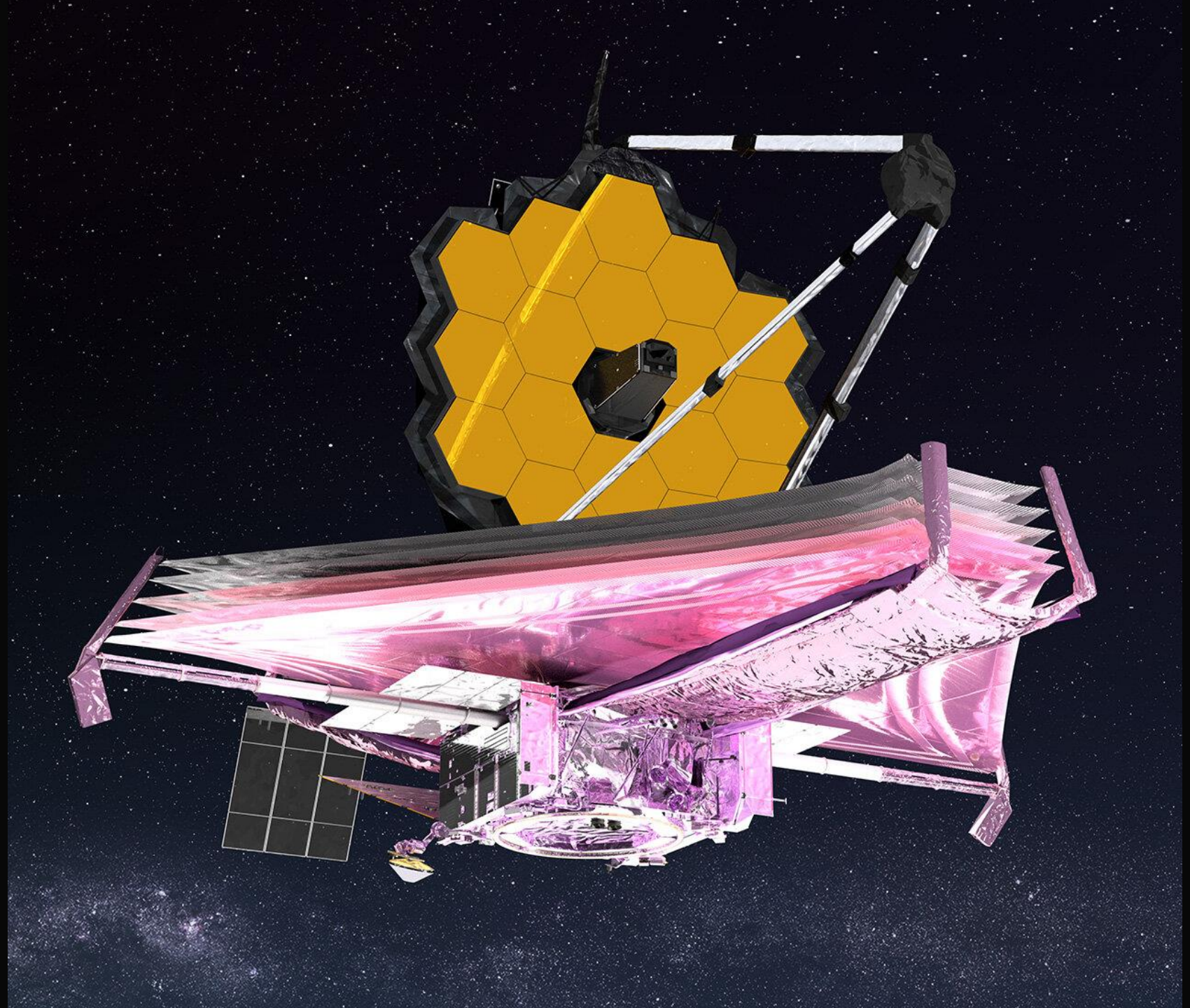
## Instruments & Power Source

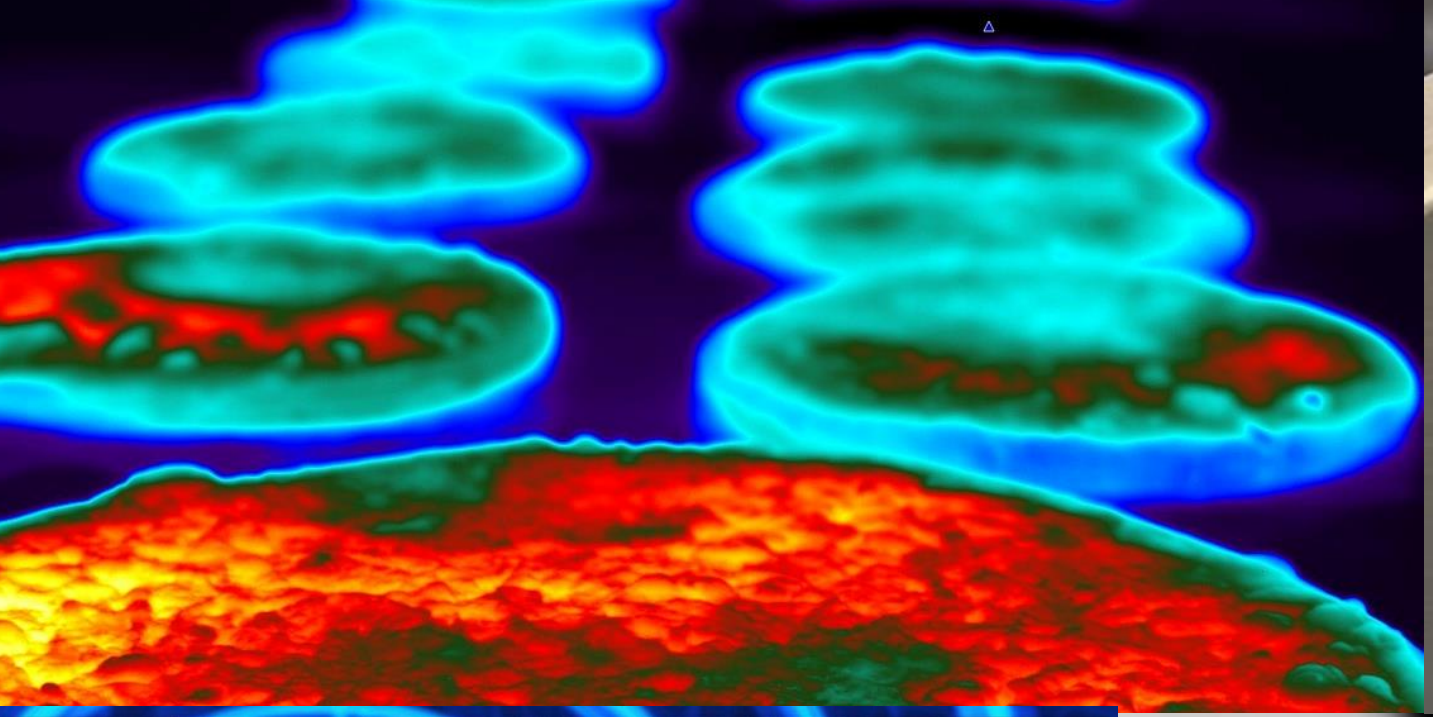
TELEDYNE IMAGING
Everywhereyoulook™




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

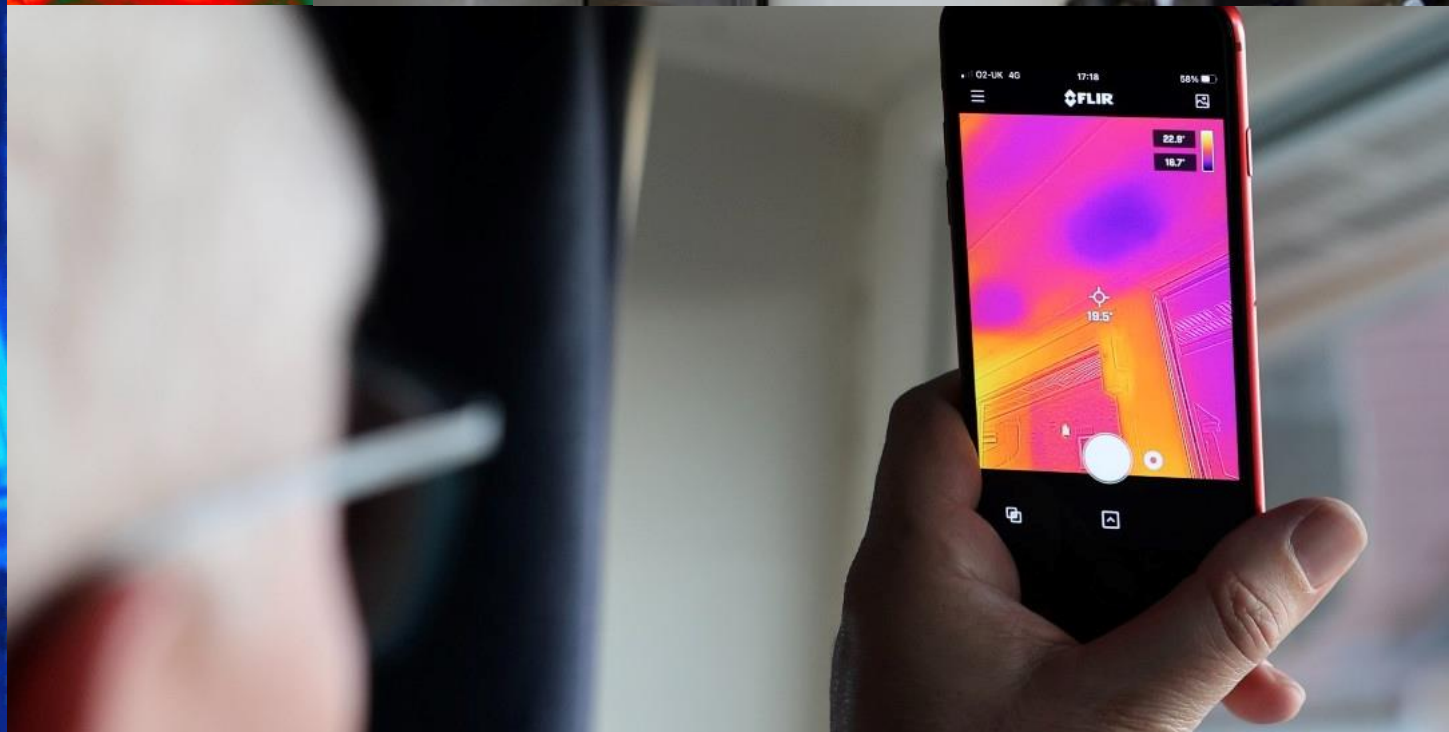
Perseverance Image: NASA/JPL-Caltech | 2021.01.05

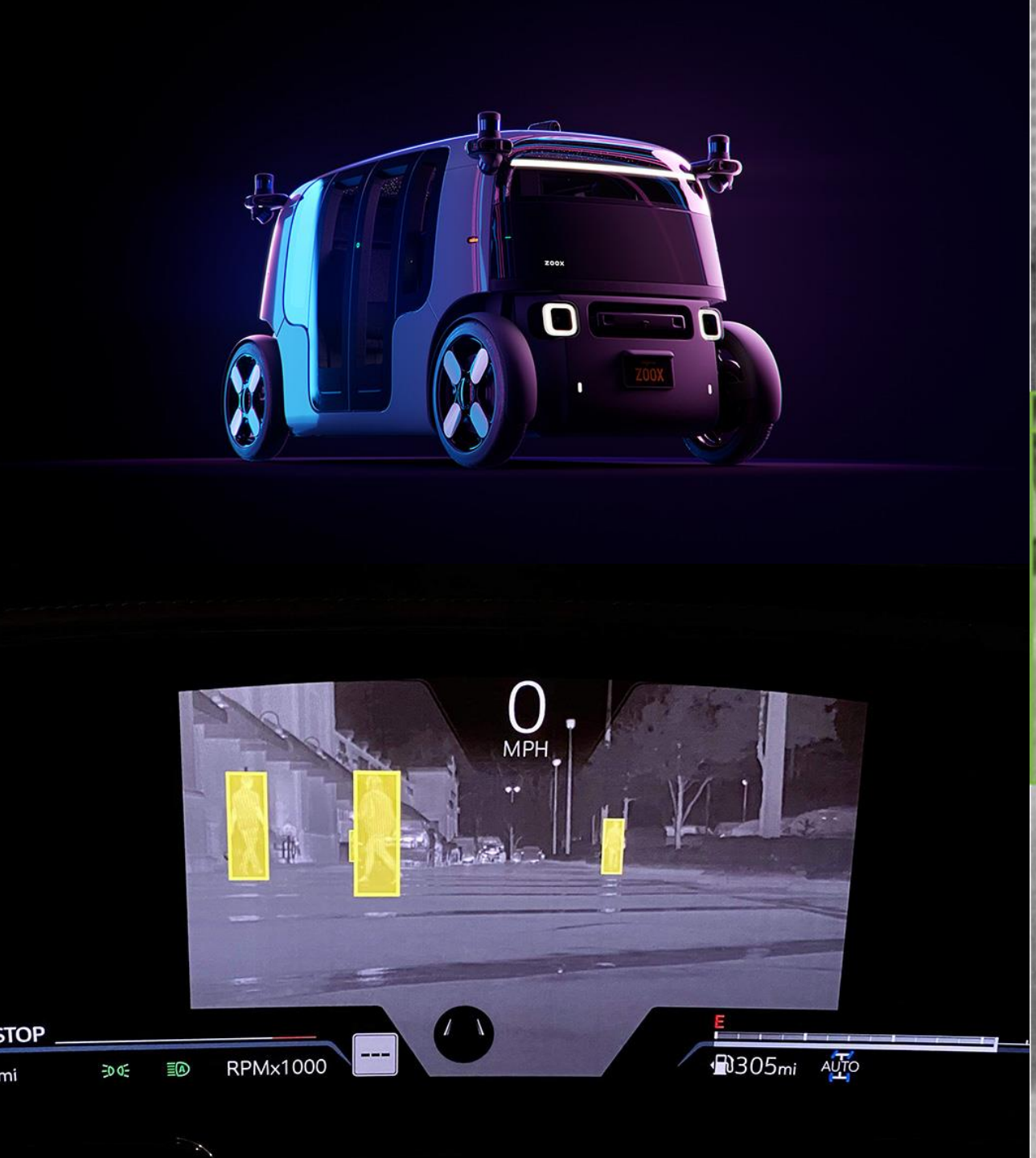





TELEDYNE TAPTONE
Everywhereyoulook


CAM 5
12 : 28 : 32
ID : 254876658
36.9 °C
ID : 758426592
37.2 °C
BIOMETRIC IDENTIFICATION : ON
BODY TEMPERATURE DETECTION: ON


FLIR


ZOOX
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MPH
STOP
mi
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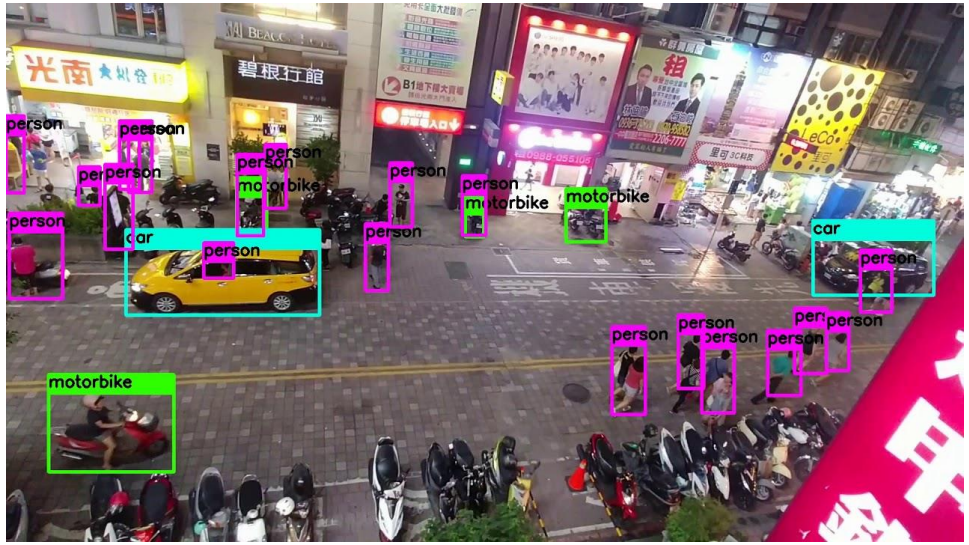
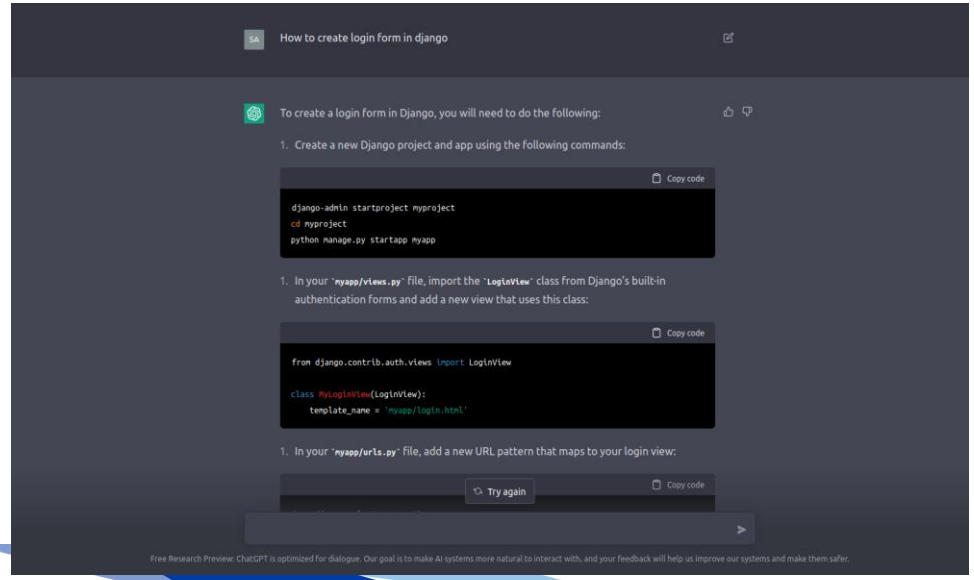
305mi
AUTO

# Machine Learning & Artificial Intelligence



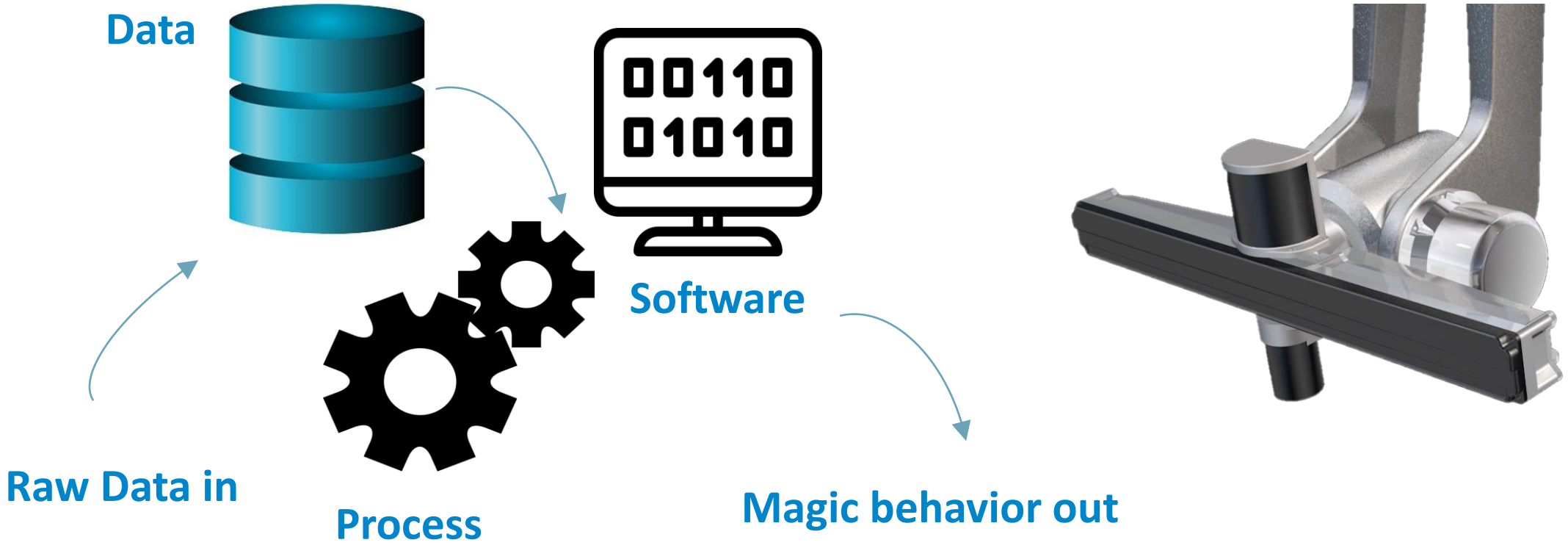




**Media is full of stories about the use of Machine Learning:**

- 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?



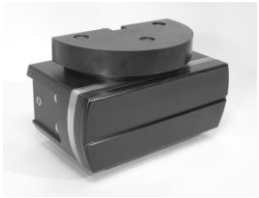
# Forward looking sonars product range

BlueView

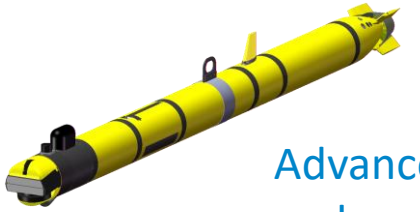
Compact imaging sonar

SeaBat F20/50

High Performance Obstacle Avoidance Sonar



SeaBat F30



Advanced Terrain Mapping
and navigation Sonar

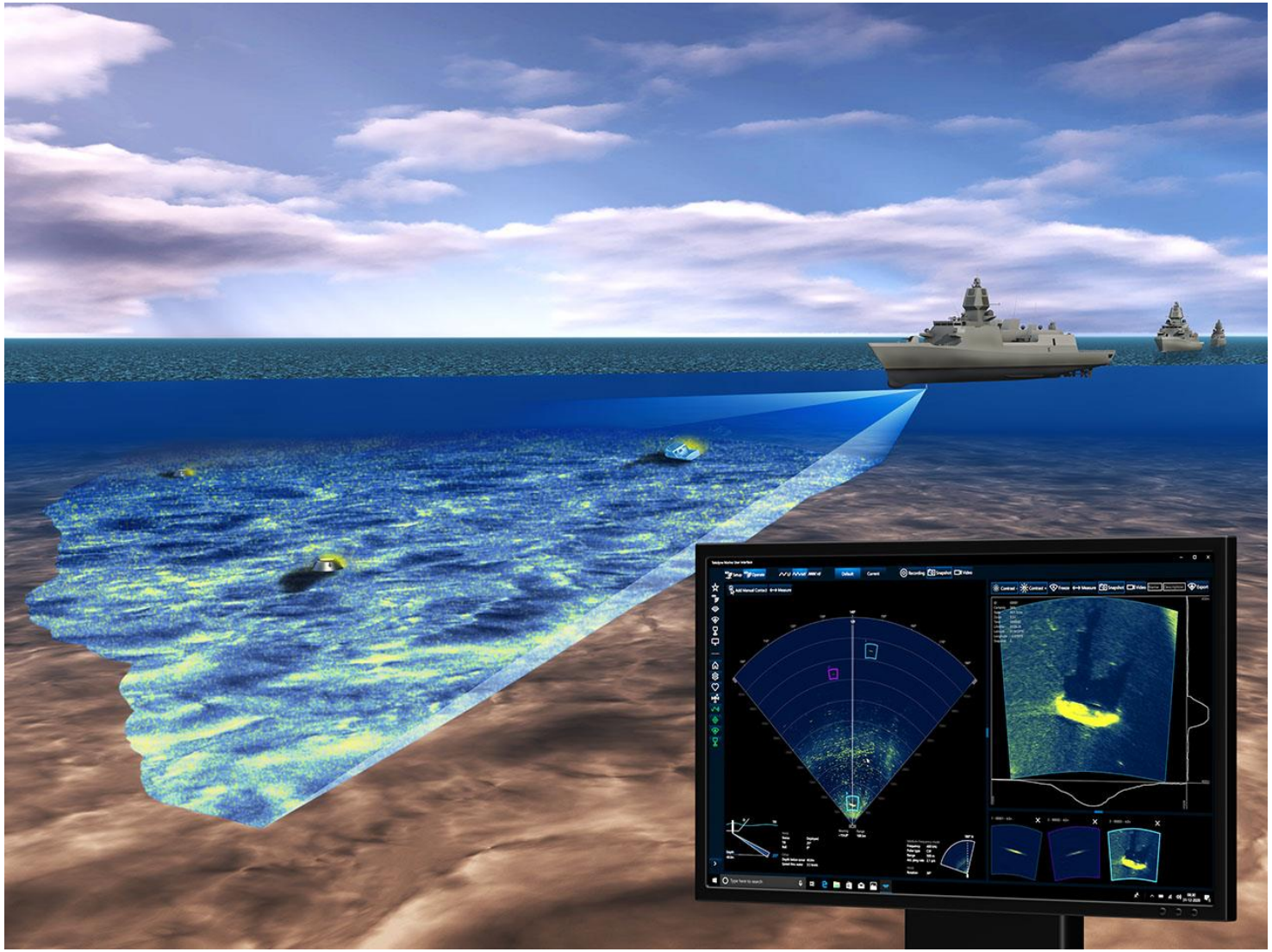
SeaBat F110/7123-MkII

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:**

ANSCHÜTZ


**1 x SeaBat 7123-MkII for European NATO**

**C2 System supplier:**

idRobotica

NEW ORDER!

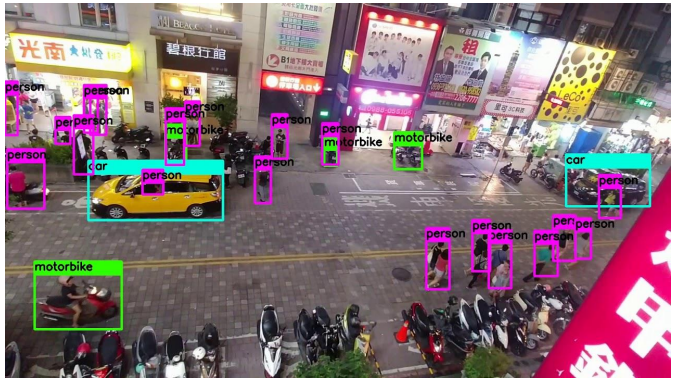

**SeaBat 7123MkII order for Asia with hoist system**

**$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

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

## Open Source starting point:




A vast ecosystem of possibilities to adopt from:

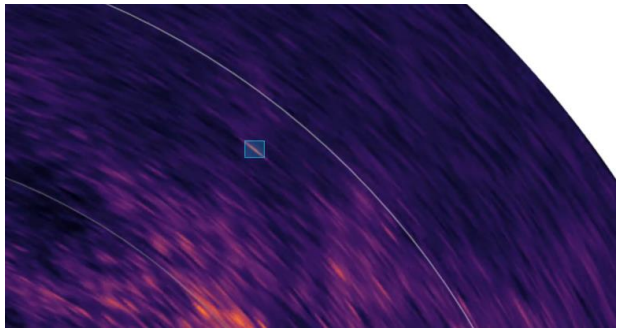
## Challenges, for applying to real-time sonar:

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

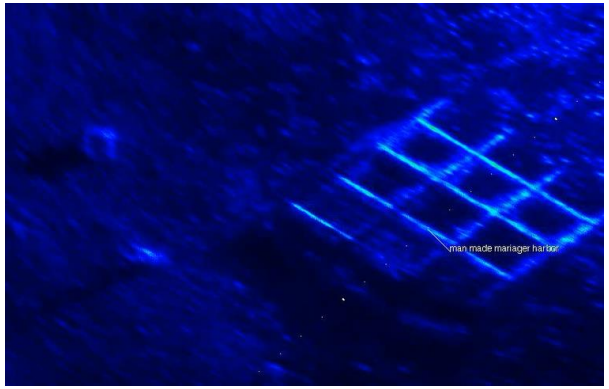
Data from a sonar is "skewed"

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)

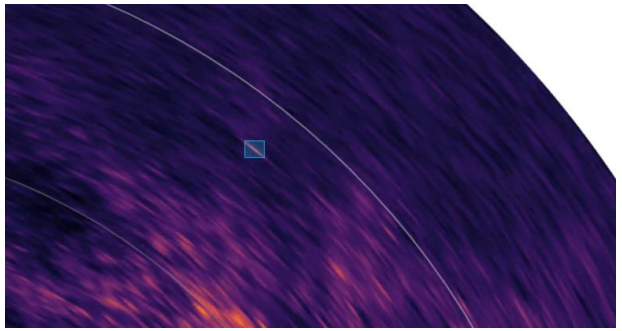

Machine Learning
Artificial Intelligence
Cloud Computing
Automation
Image Rendering
Algorithms
Signal Processing
Connectivity


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

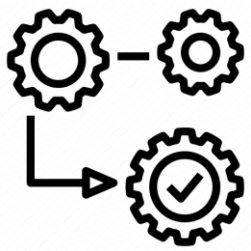
# Machine Learning for Sonar systems – workflow offered

## Workflow

2) Store Data
(e.g. Amazon Cloud)



3) Tagging the Data
(tedious work)



4) ONNX model, and pre-processing algorithms, Machine Learning training

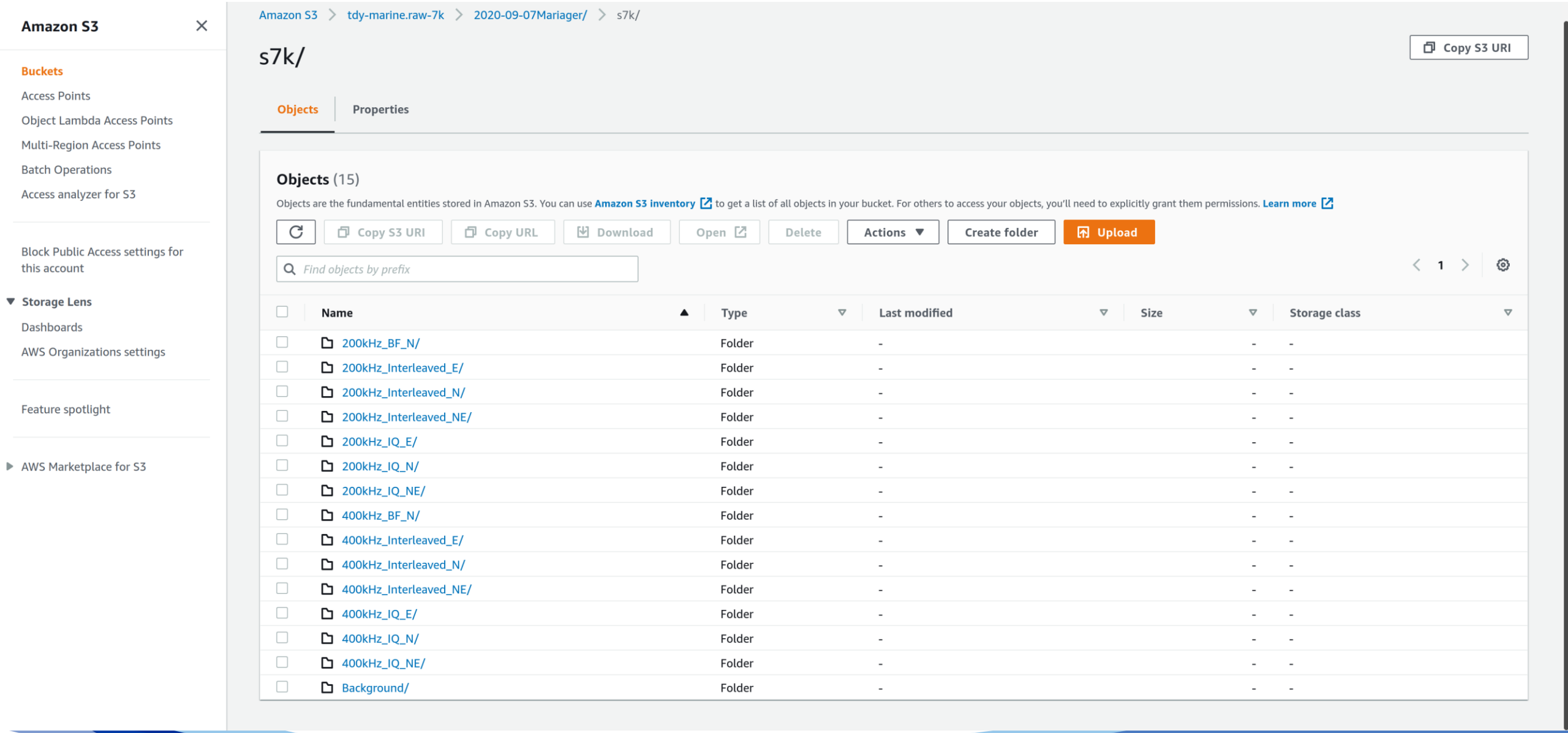
1) Collect “Tons of data”

Running in the sonar system

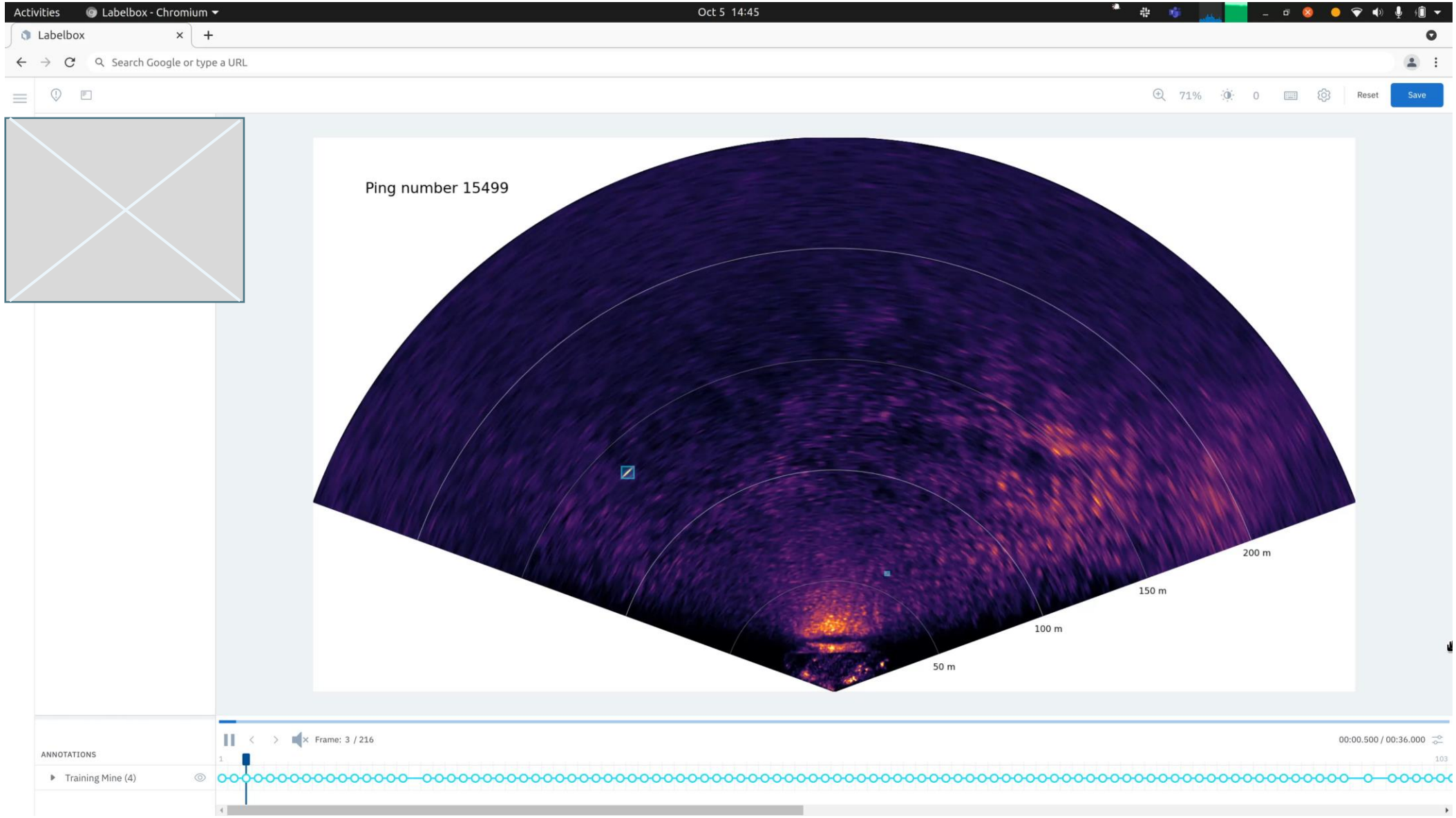


5) Compiled TensorRT Runtime transferred to sonar system

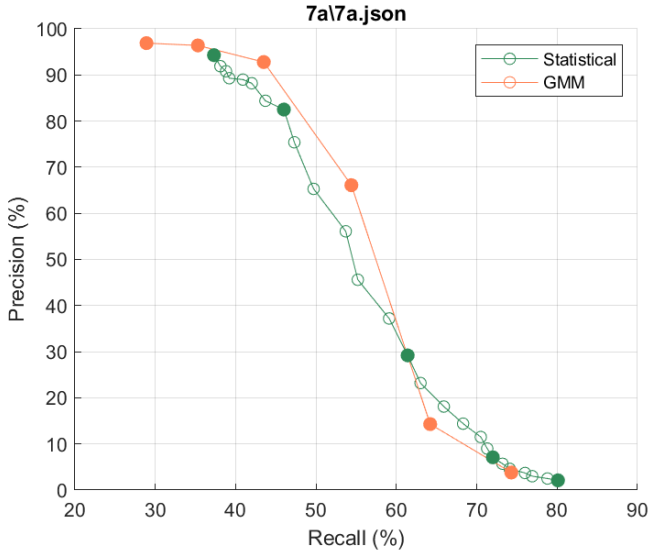
# Introducing Machine Learning for Sonar systems – Collecting “tons of data”

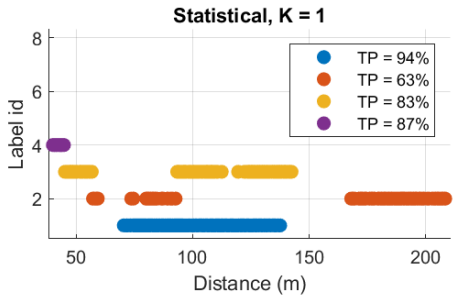


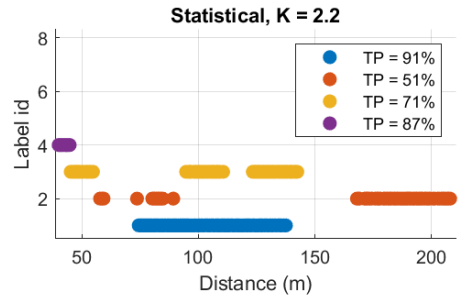
# Introducing Machine Learning for Sonar systems – Tagging data and evaluation

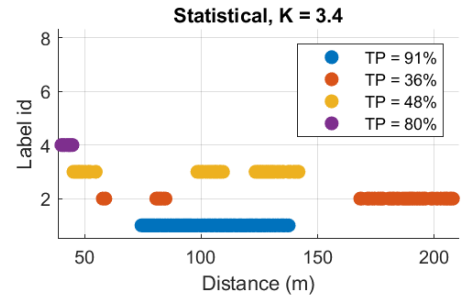


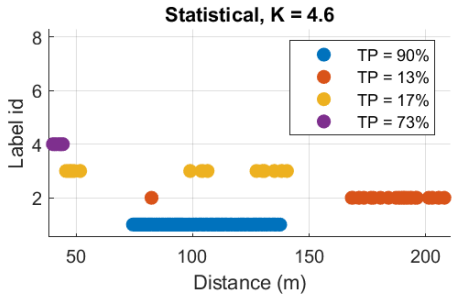
# Introducing Machine Learning for Sonar systems – “Training” the system

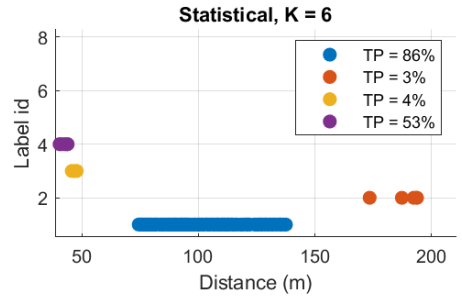


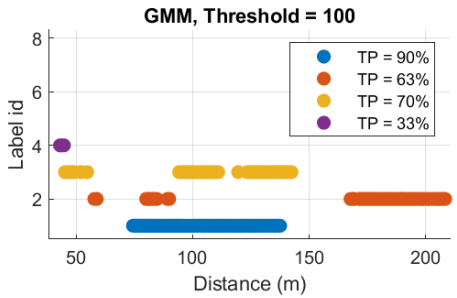



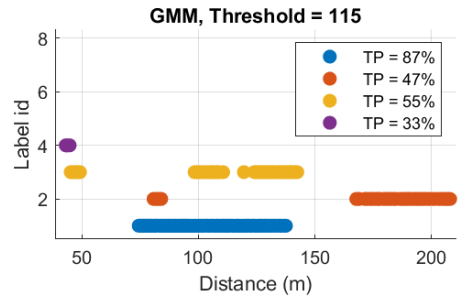



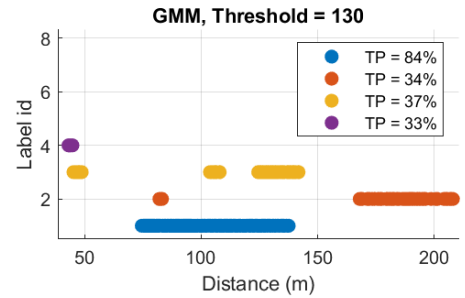



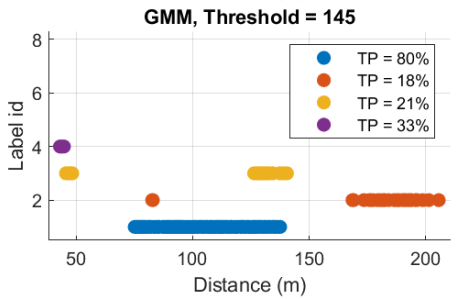



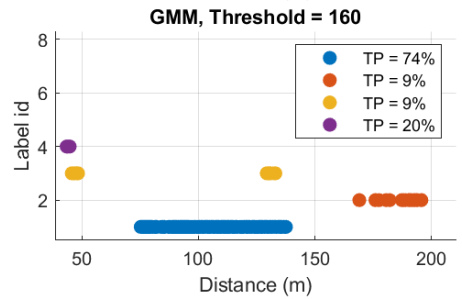



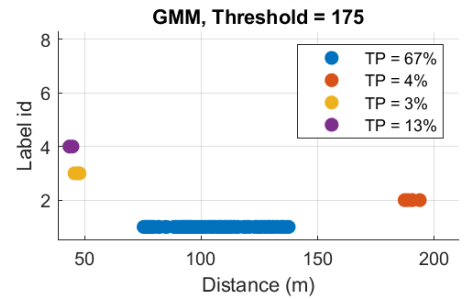



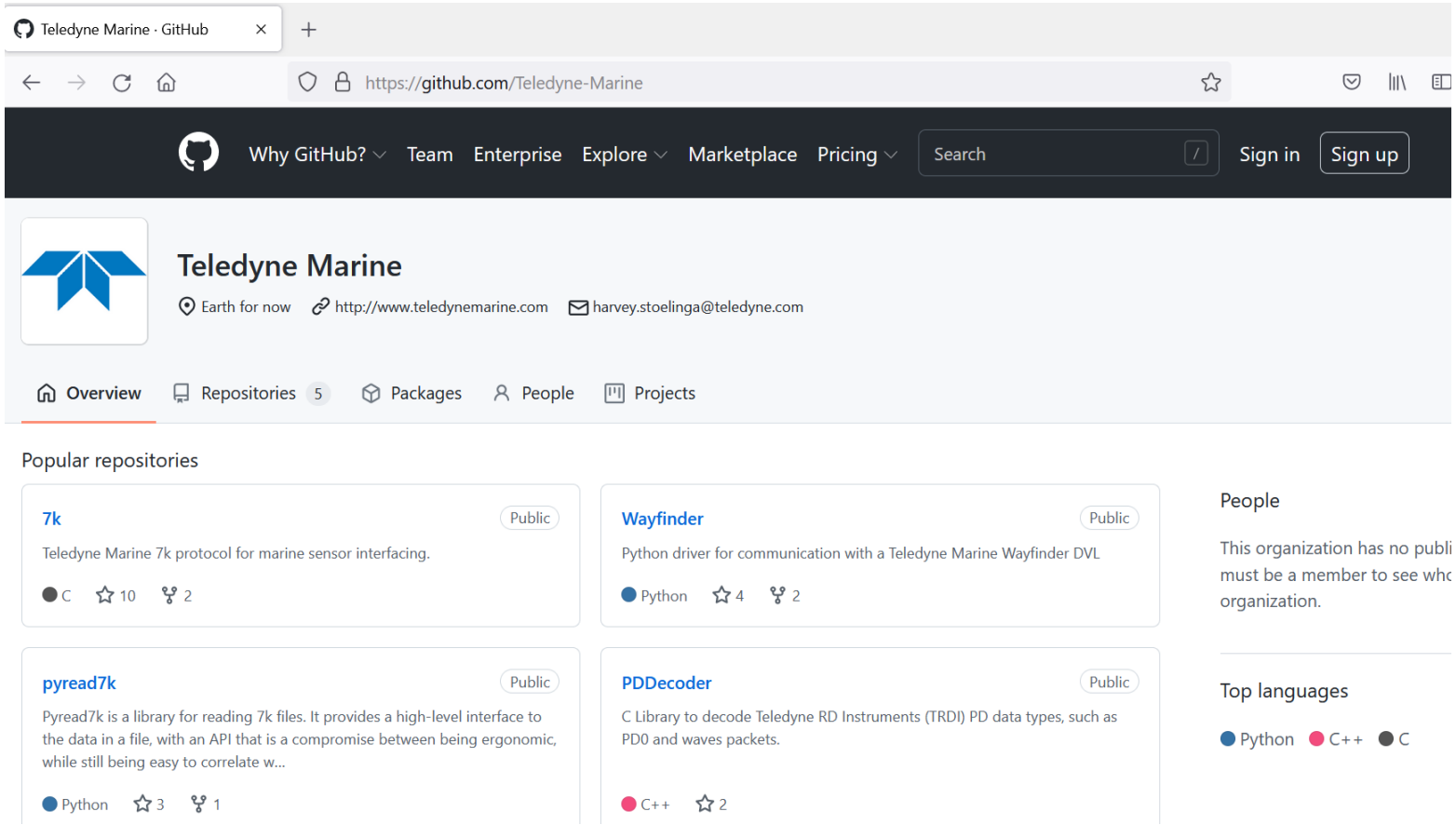



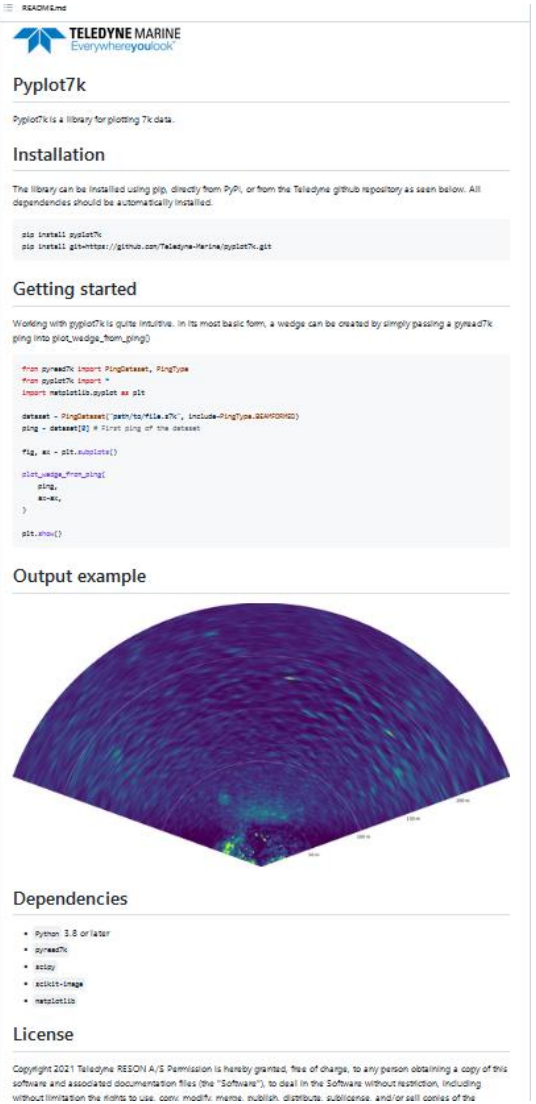



# Introducing Machine Learning for Sonar systems – Open Source tools for 7K

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



# 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 receiver raw

SeaBat uplink raw (decimated)

50 Gbit/s*

750 Mbit/s

SeaBat standard solution

SeaBat RSP

Bathy data (thin data flow)

Watercolumn (sample data)

UI System data (images)

SeaBat ACU

**Advanced Compute Unit**

Access to raw data into the unit

Multiple different beamformers

Time and frequency domain signal processing

64Gb Ultrafast RAM shared between GPU/CPU

Tensorflow RT (Nvidia runtime engine)

Image processing, micro navigation, stacking

Output and integration with Teledyne protocols

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

# Example actual use of the Advanced Compute Unit

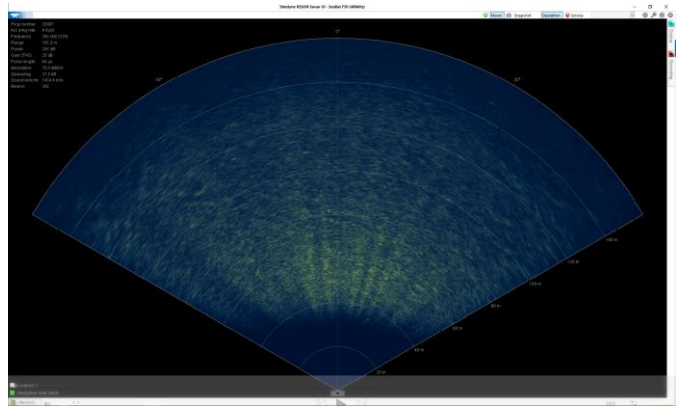
## Search and Detection system for a "forward looker"

Uplink

750 Mbit/s

SeaBat RSP


UI System, wedge image



SeaBat ACU

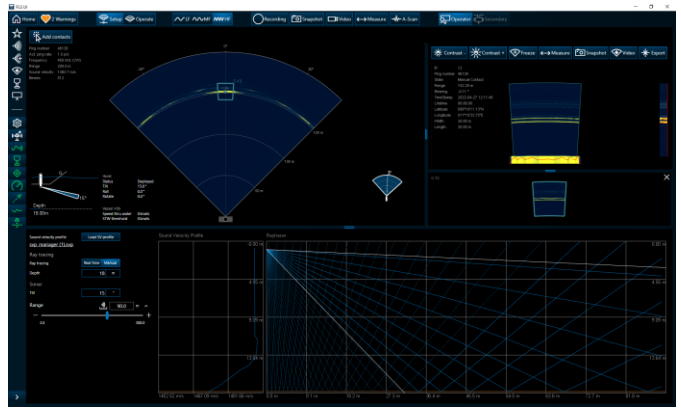

Detector (Machine Learning)

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"

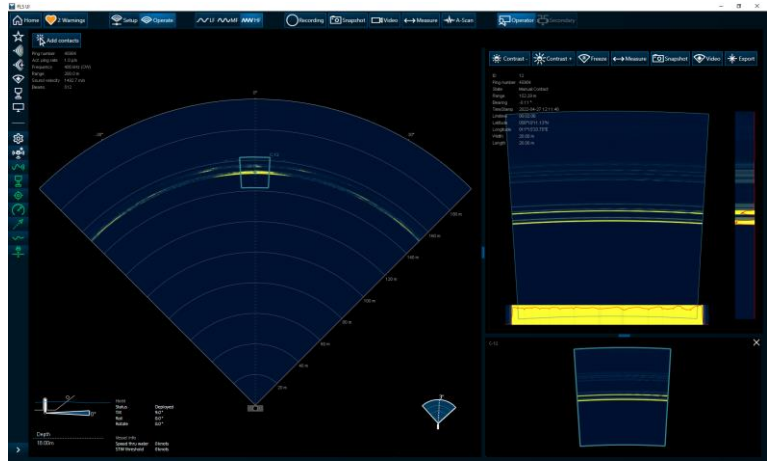
SeaBat ACU


→ Target Detection (ML)

→ Target Tracking

→ UI System, zoom image

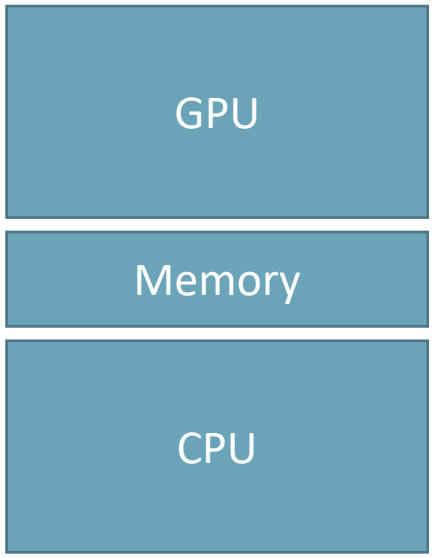
→ UI System, wedge image



## 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

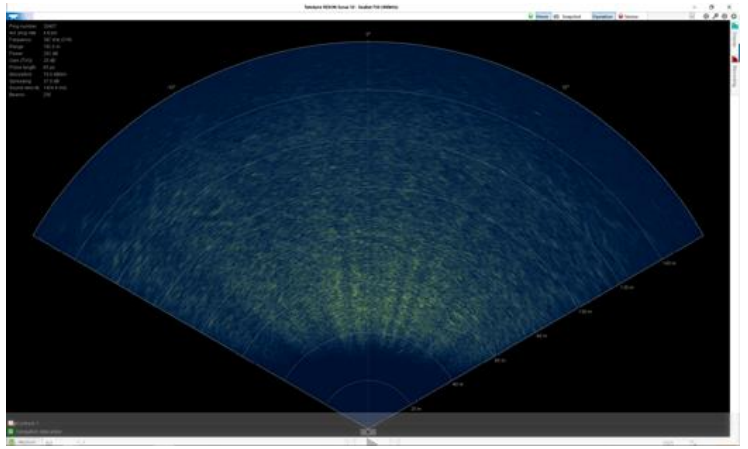
512 channel
1 Ping sample data:

15.000.000 samples

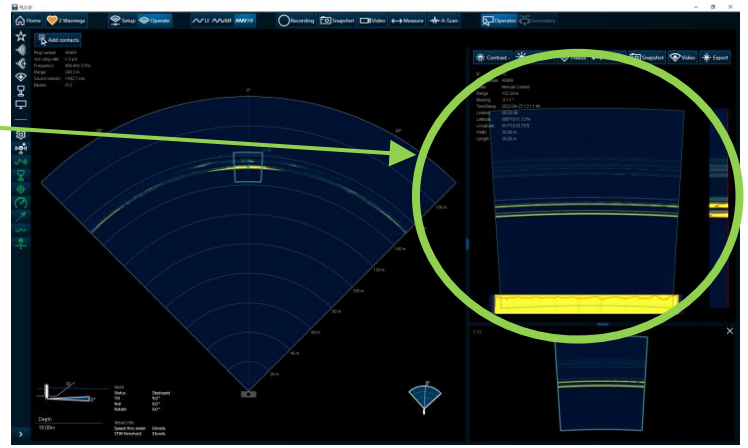
Ch 0,1, ... 512

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

SeaBat standard solution

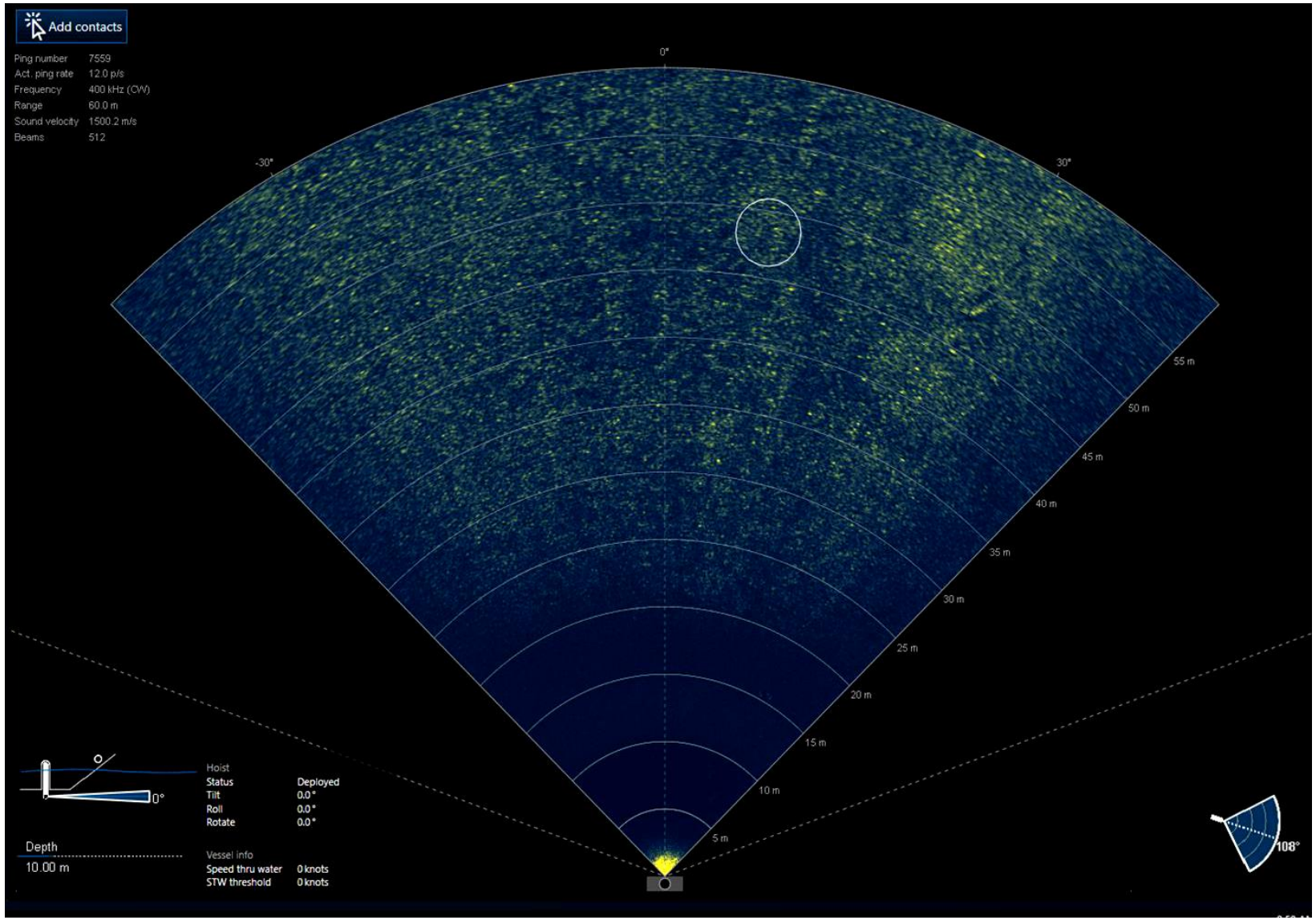


SeaBat ACU

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

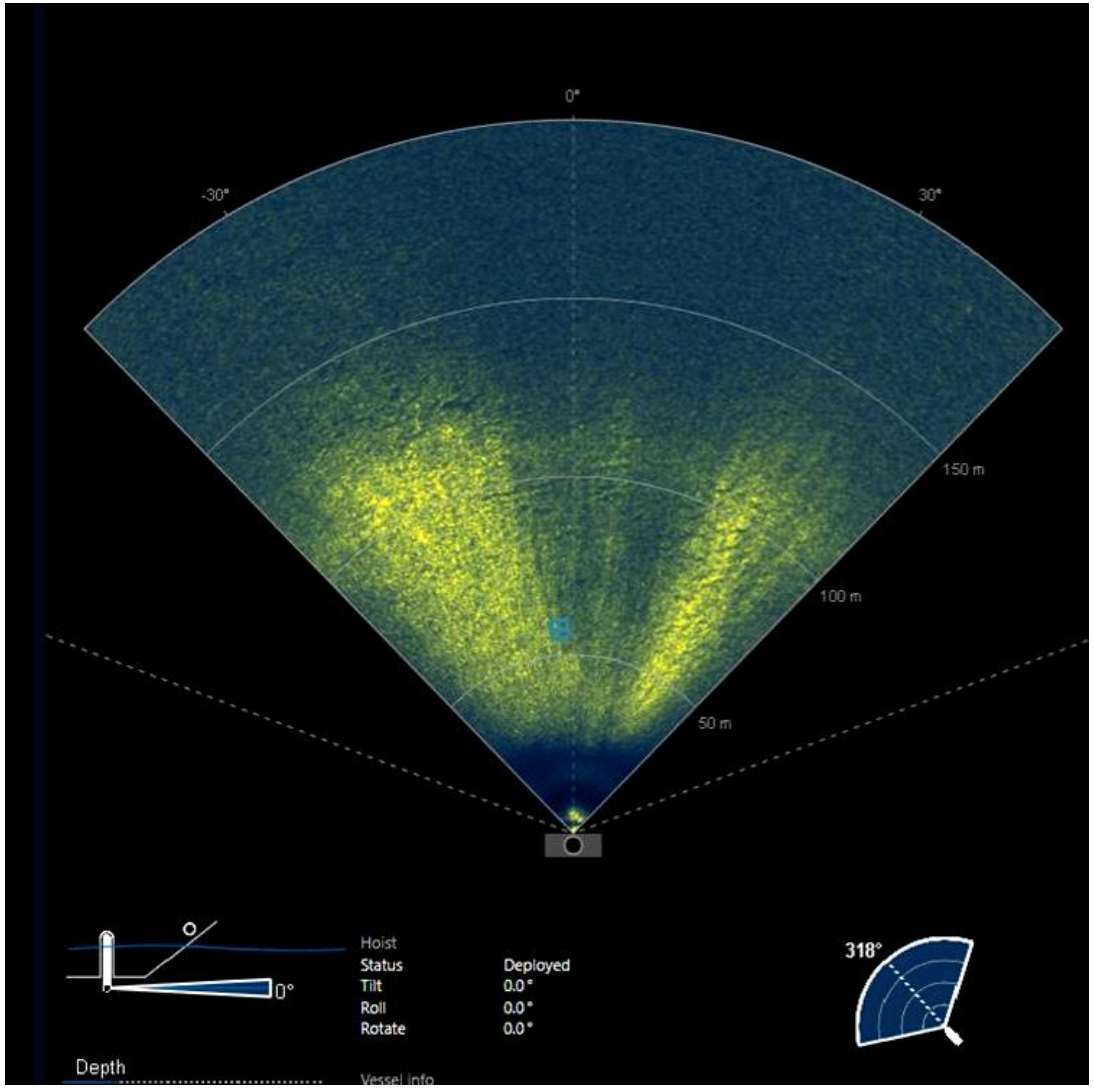
# Example actual use of the Advanced Compute Unit



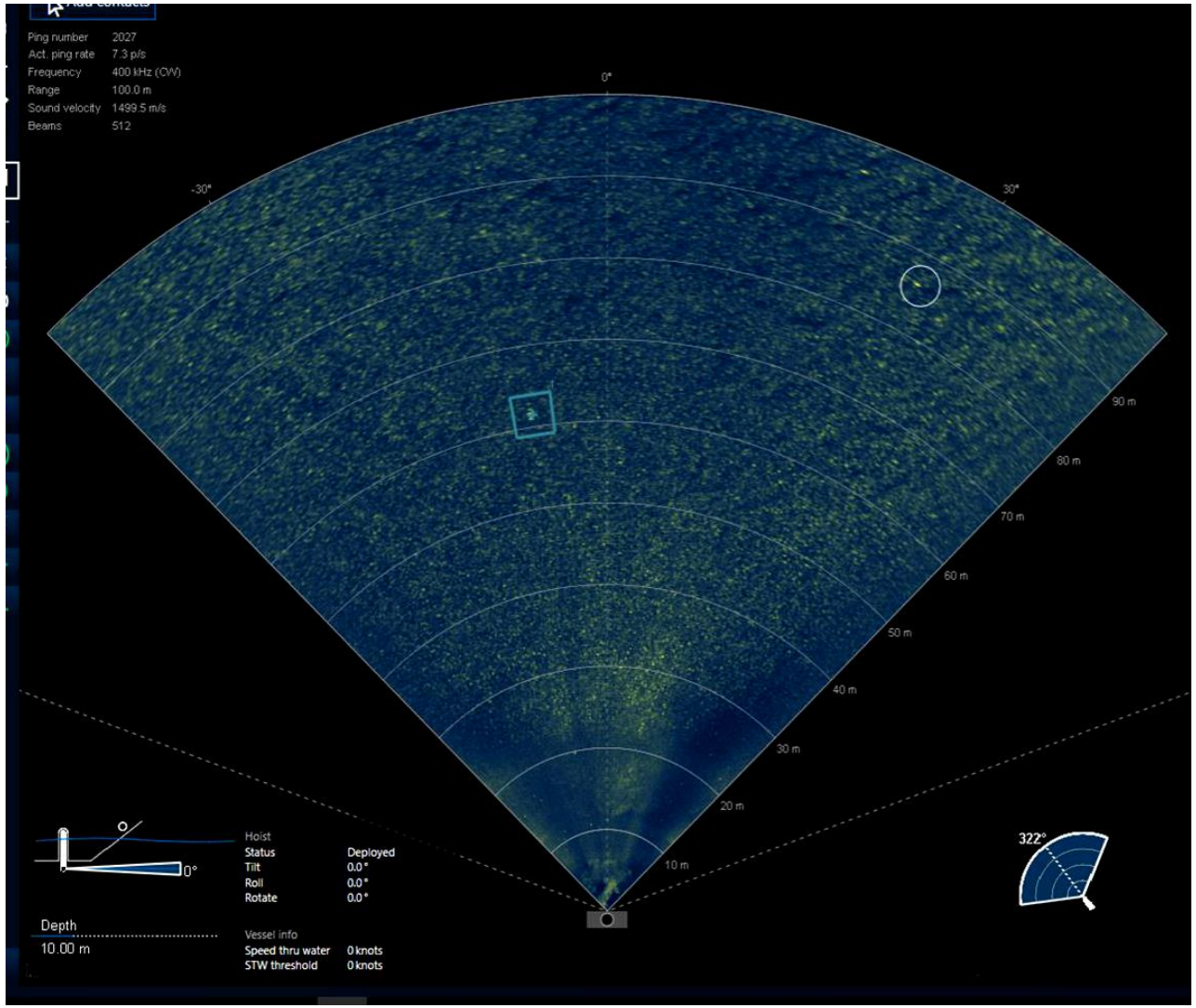

Stabilizing the Image in the ACU
With GPU running algorithms

Toggling between On/Off

# Example actual use of the Advanced Compute Unit

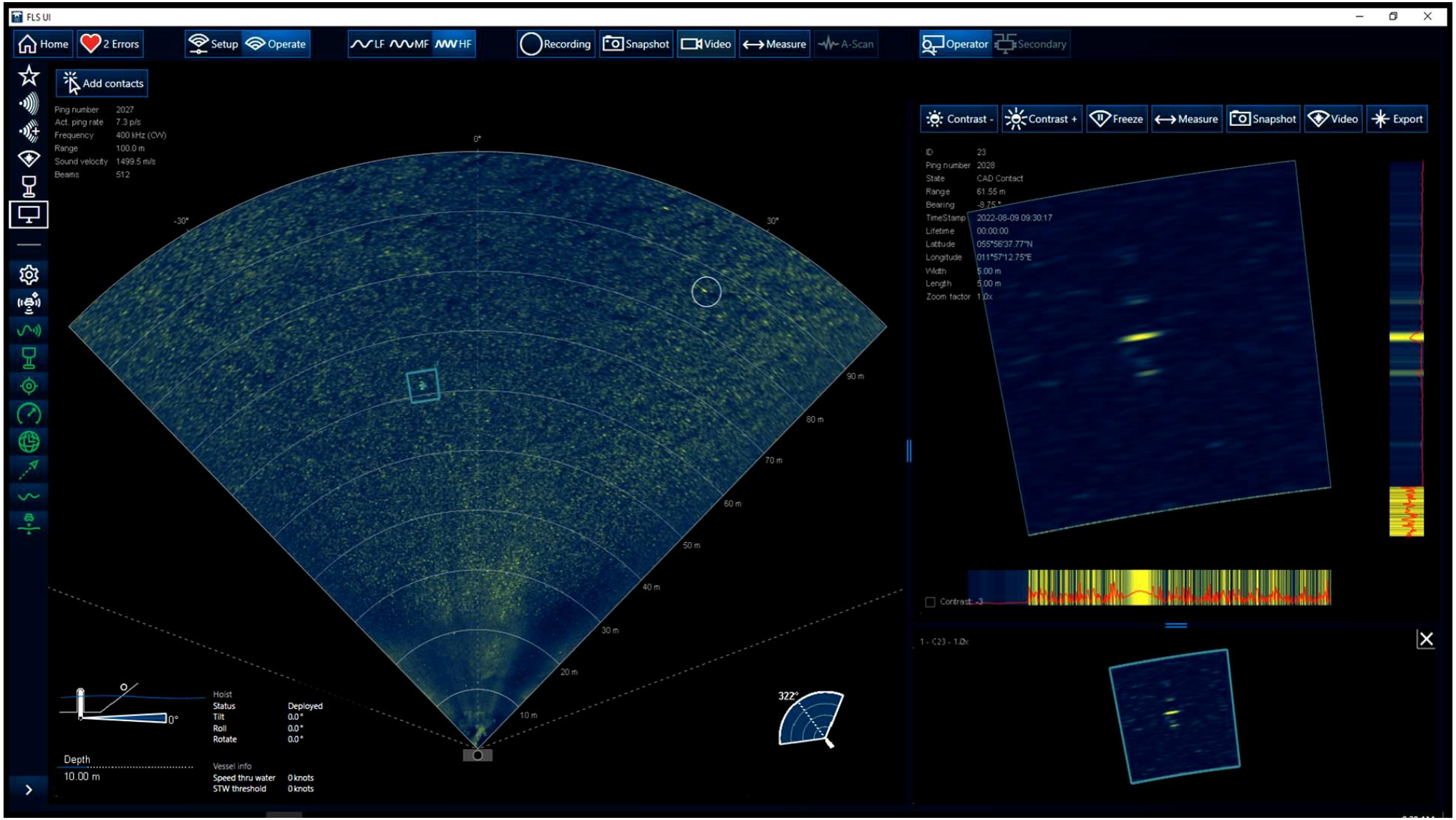



Normal Forward looking Sonar Image




ACU "Beamnormalization algorithm" evens the sonar image

# Example actual use of the Advanced Compute Unit




New ZOOM window

Machine Learning based Detector system Behind the scene

TELEDYNE MARINE
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# Q&A