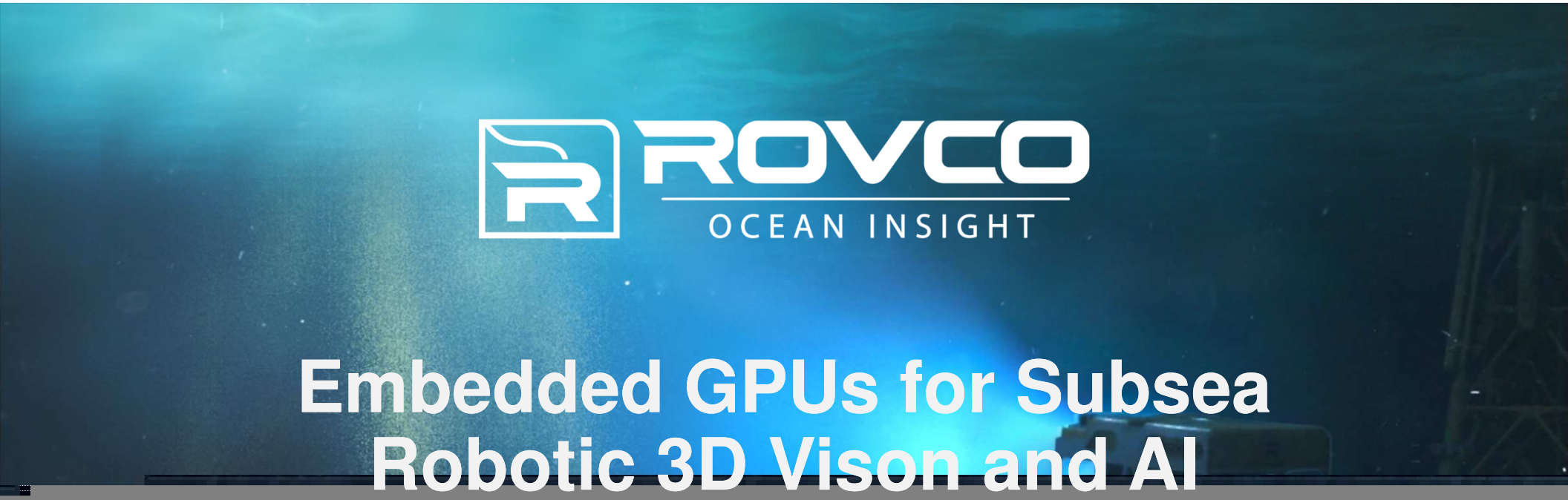


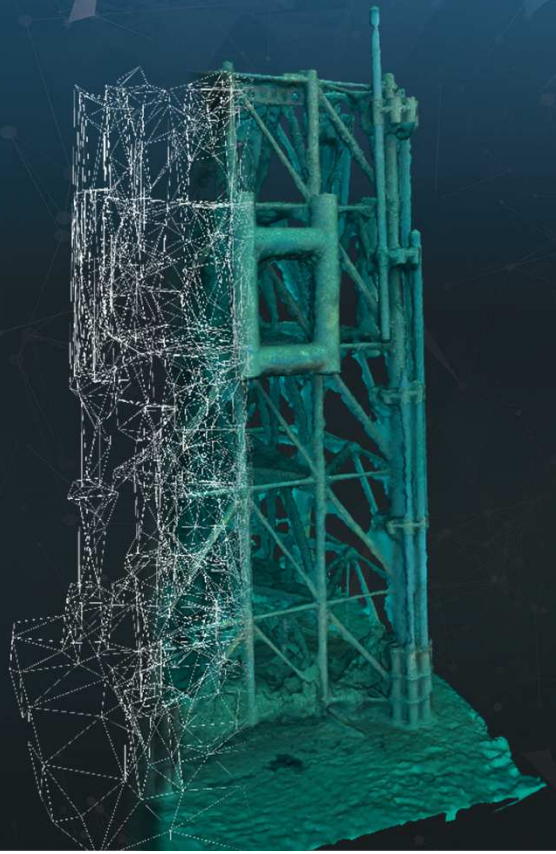
Embedded GPUs for Subsea Robotic 3D Vison and AI

GTC Europe 2018

Dr Iain Wallace, CTO
wallace@rovco.com

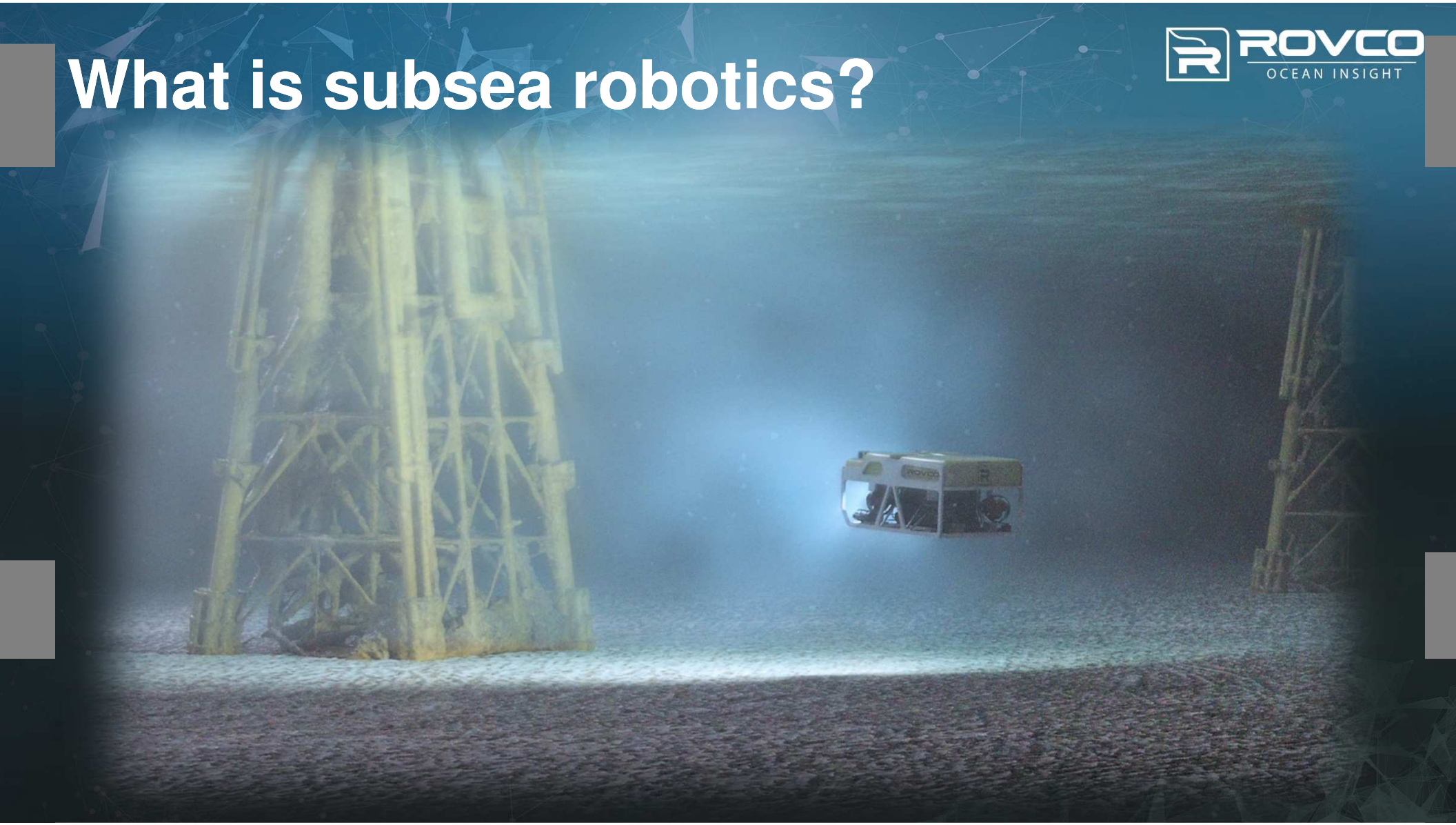
Introducing Rovco

20 Staff based in Bristol, UK
5 ROVs – Survey Class
Hydrographic Survey & ROV

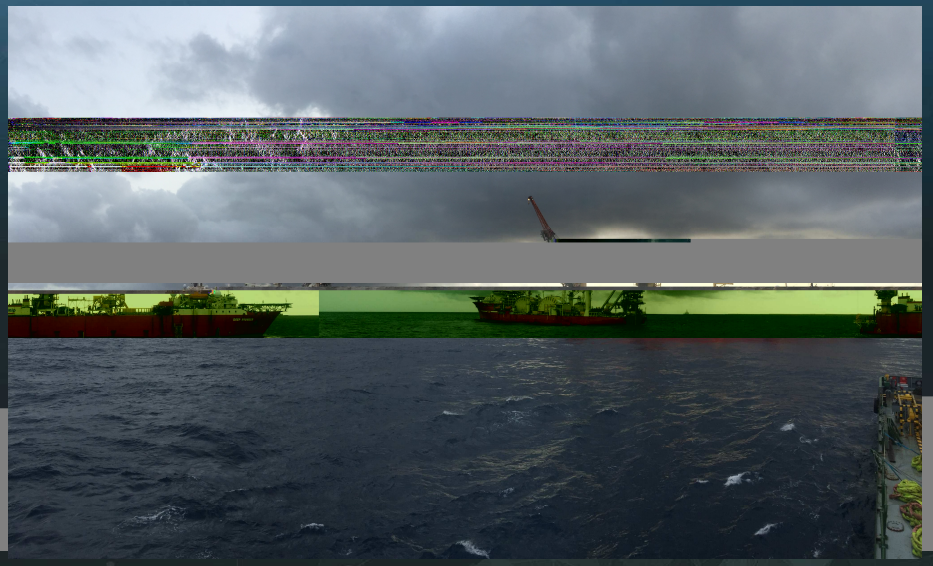


Dr Iain Wallace
CTO
PhD – Artificial Intelligence
Mars Rover Vision Systems
UK & European Space Agency

What is subsea robotics?



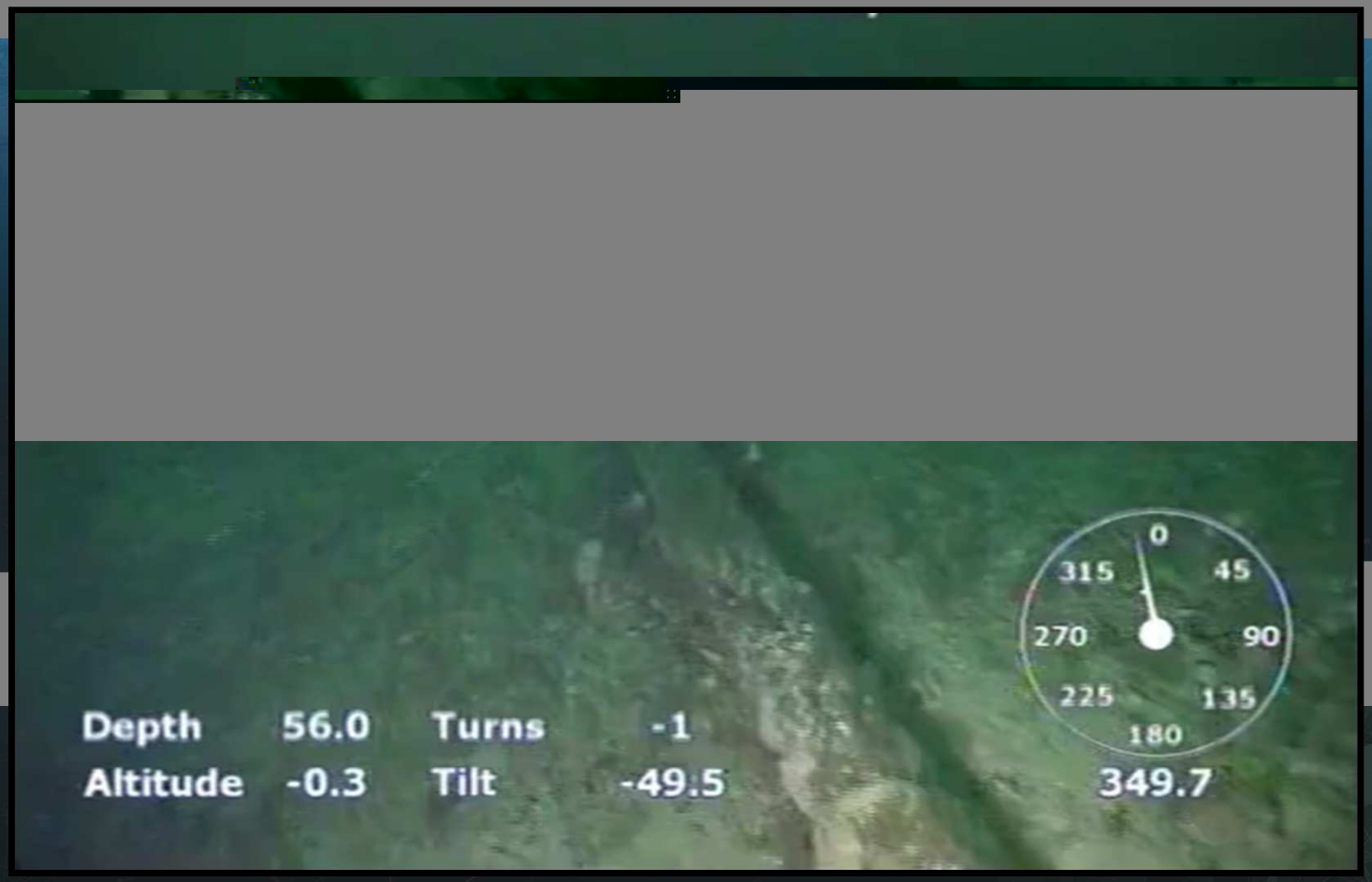
Harsh Environment



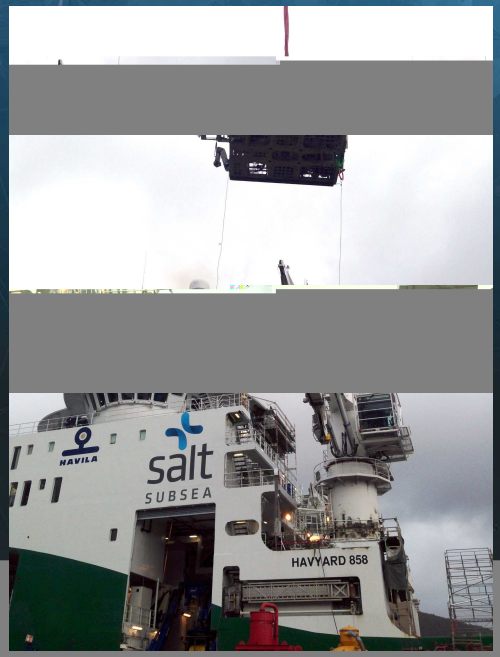
Typical Work

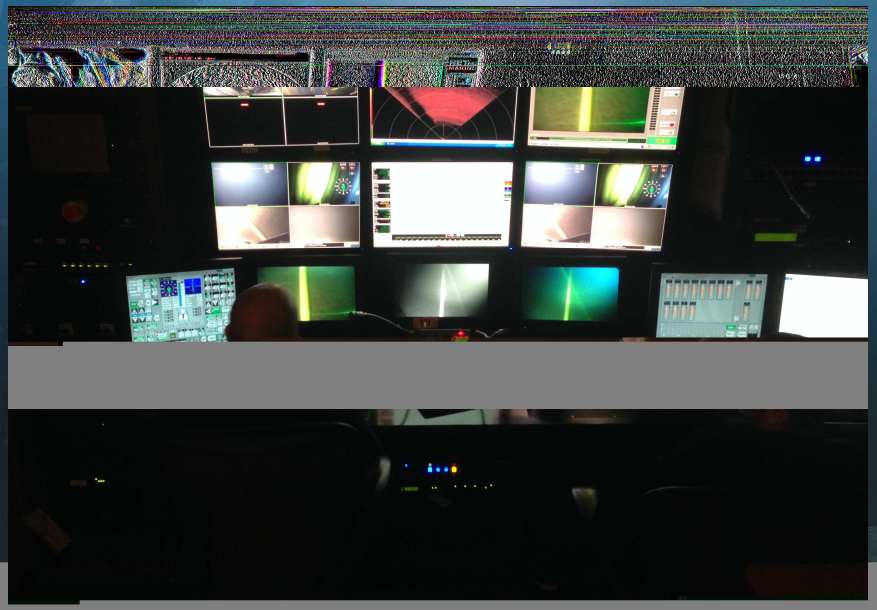
- Wind Turbines
- Oil Rigs
- Cables (electricity and comms)
- Pipelines
- Harbours
- Mooring Chains
- Tanks
- Tunnels
- Seabed

Current Robotic Survey



Current Robotic Survey



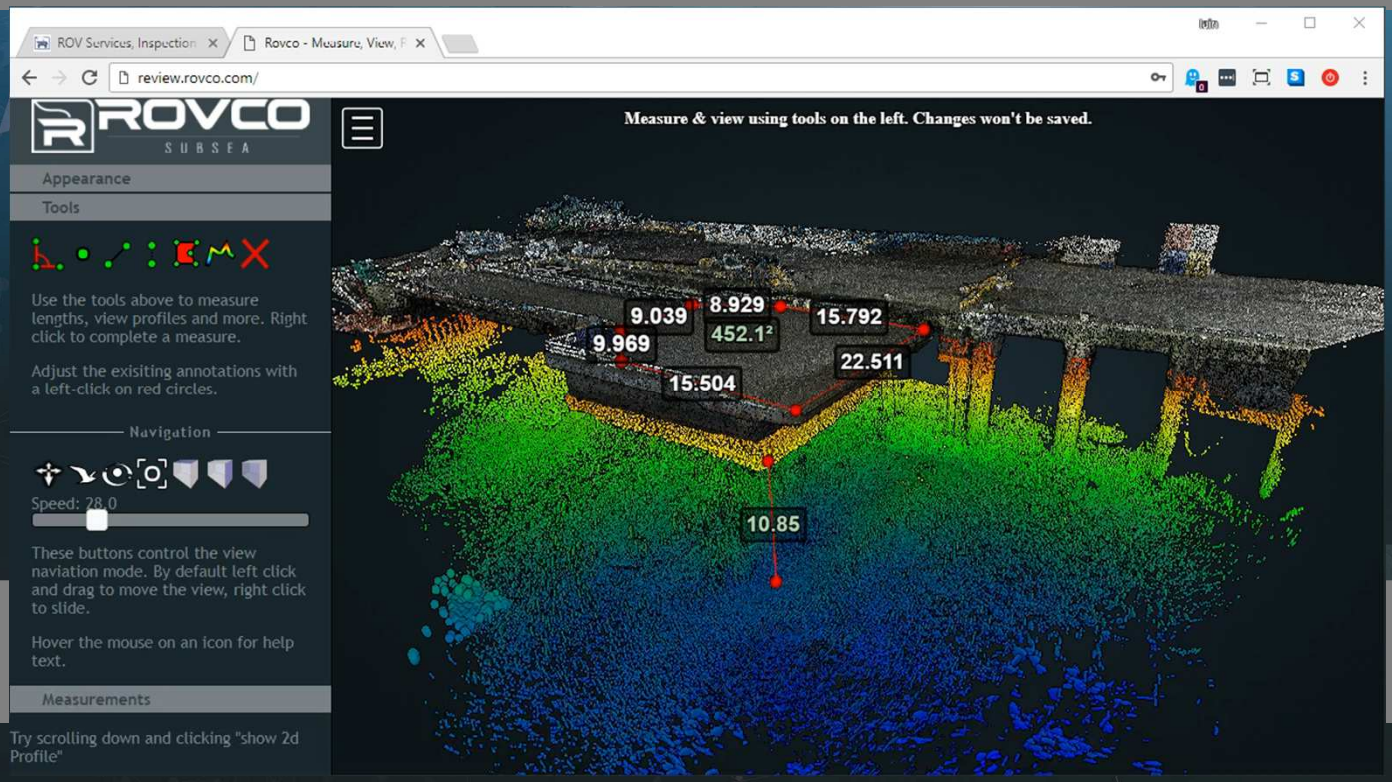


Downsides:

Hours of video, team sizes on board, data management, data analysis

What do we mean by 3D?

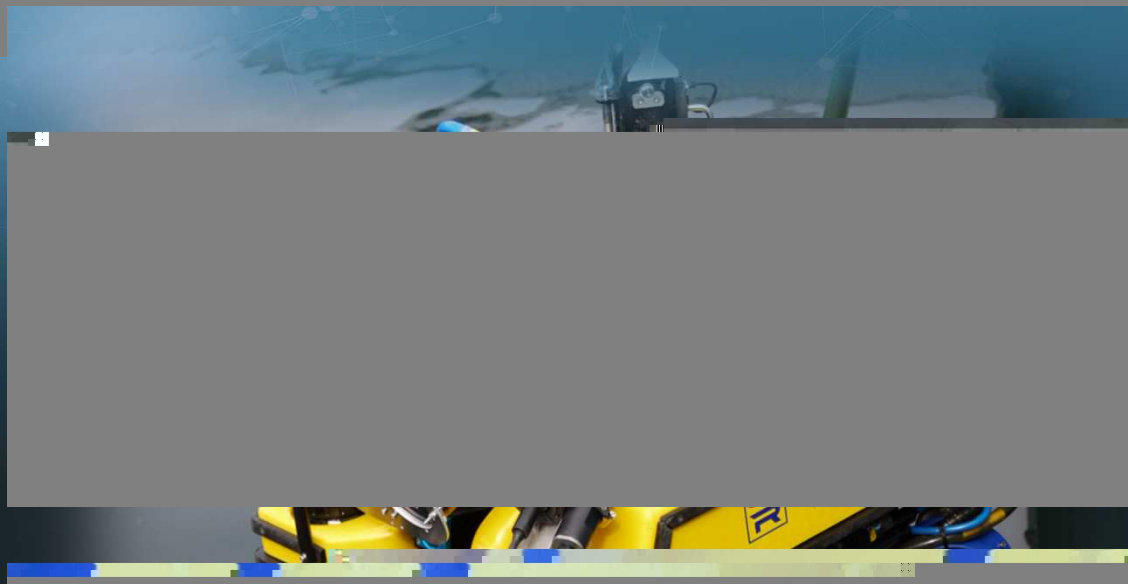
Fast, Shareable, Metric



Introducing an ROV

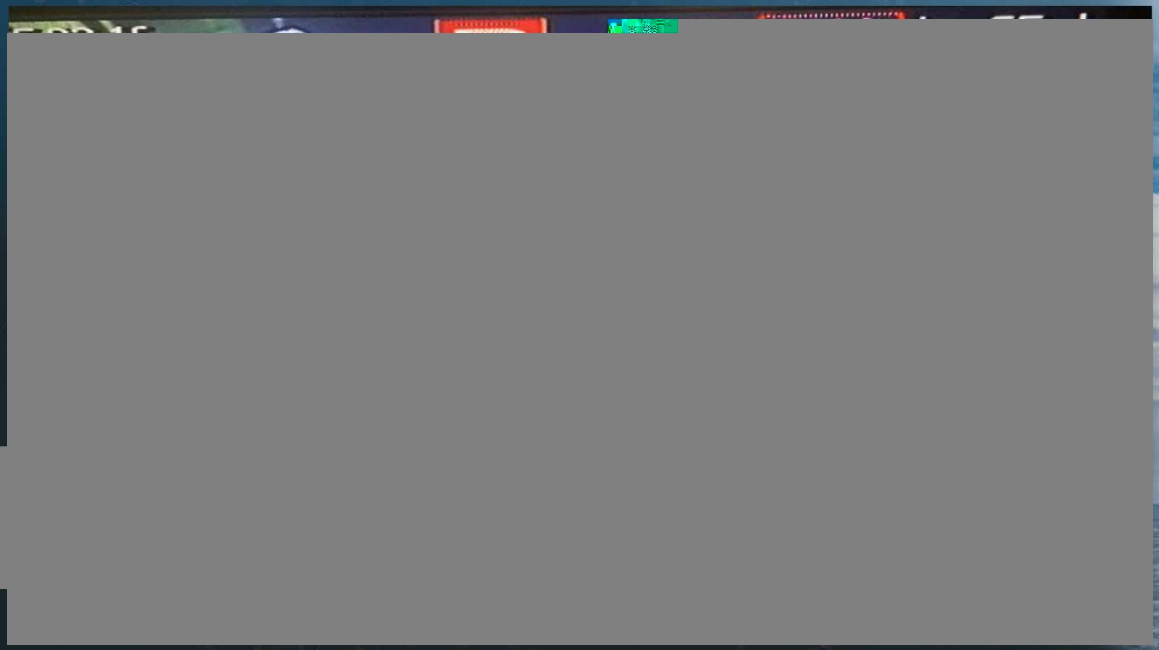
Typical Observation Class ROV

- Thrusters & 4-DOF
- 3.5 knots speed
- 300m depth rating
- SD cameras, sonar, lights, depth sensors etc.
- 85kg in air, 12kg payload
- Processing top-side



…this one is not typical.

...and they get bigger



Challenges

- Pressure
- Water
- Sealed Enclosure
- Heat (power!)

What is AI - Prediction

Subsea Robotic 3D Vision and AI

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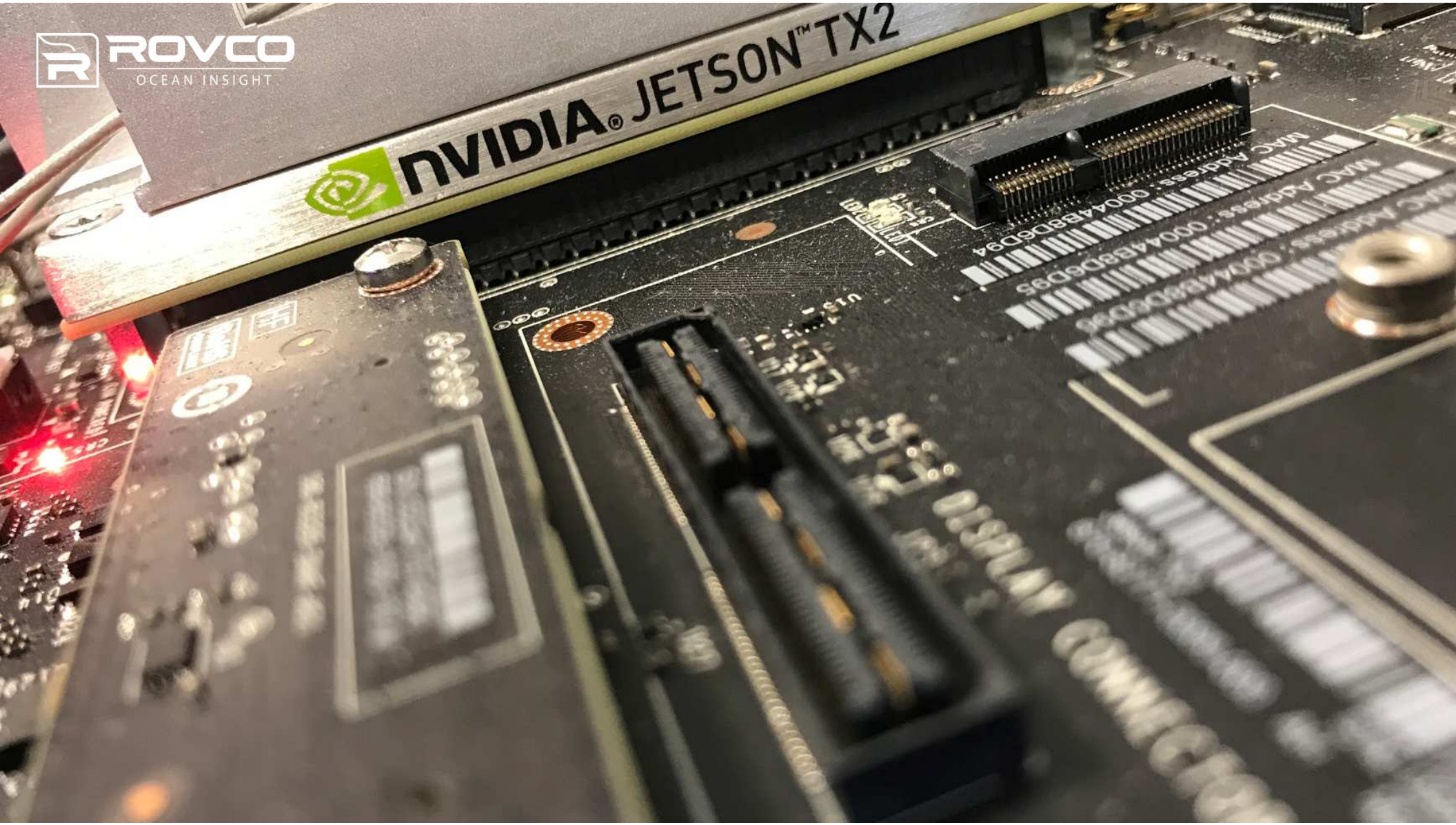
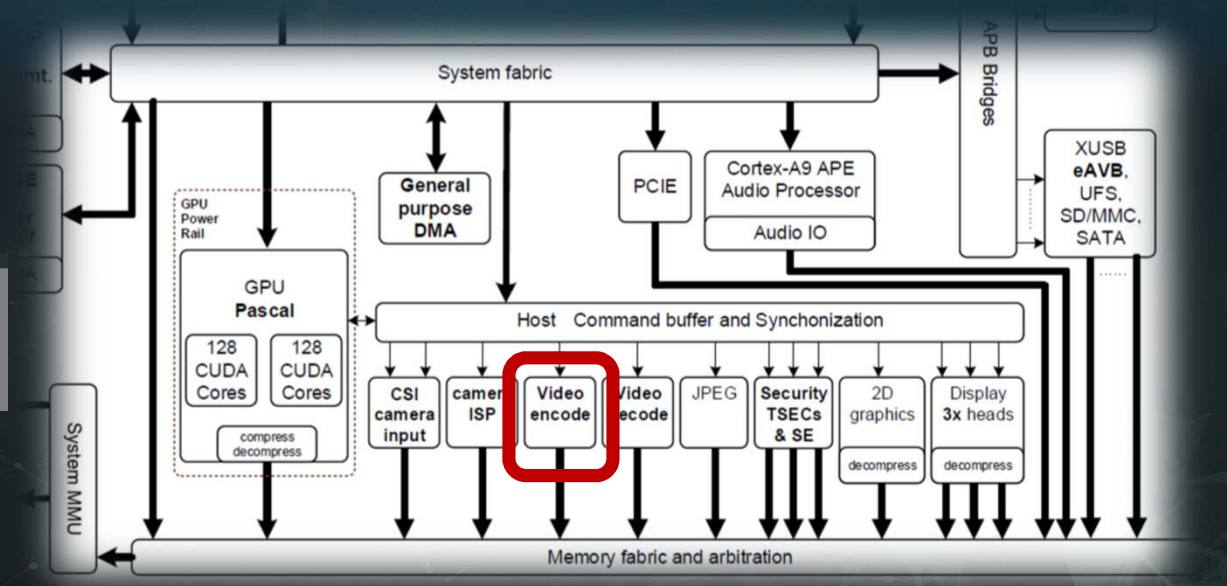

ROVCO
OCEAN INSIGHT
NVIDIA® JETSON™ TX2

Video – high performance at the edge

- Huge camera bandwidth
  - E.g. 4K YUV420@30Hz = 4.16Gbps
- Need for quality, low latency and performance
  - … and low power.
- Jetson ideal



Measuring Jetson Power Consumption

ROVCO OCEAN INSIGHT

- Power, voltage, temperature, frequency…
  - All in the /sys tree!
- Easy to log programmatically or in a script.
- GPU Temperature (30.5C):

```
nvidia@tegra-ubuntu:~$ cat /sys/devices/virtual/thermal/thermal_zone2/type
GPU-therm
nvidia@tegra-ubuntu:~$ cat /sys/devices/virtual/thermal/thermal_zone2/temp
30500
```

- GPU Power (153mW):

```
nvidia@tegra-ubuntu:~$ cat /sys/bus/i2c/drivers/ina3221x/0-0040/iio:device0/rail_name_0
VDD_SYS_GPU
nvidia@tegra-ubuntu:~$ cat /sys/bus/i2c/drivers/ina3221x/0-0040/iio:device0/in_power0_input
153
```

Measuring Jetson Power Consumption

Generate a test video stream, 4K, YUV420,30fps (4.16Gbps!):

```
gst-launch-1.0 videotestsrc !
'video/x-raw,
format=(string)I420,width=(int)3840,
height=(int)2160,framerate=(fraction)30/1’ !
fakesink
```

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OCEAN INSIGHT

Display 1080p, encode 4K HEVC 100Mbps to disk, stream 10Mbps h264 1080p:

```
gst-launch-1.0 videotestsrc ! 'video/x-raw,
format=(string)I420,width=(int)3840,
height=(int)2160,framerate=(fraction)30/1' ! nvvidconv !
'video/x-raw(memory:NVMM),format=(string)I420,width=(int) 3840,
height=(int)2160' ! tee name=t1 t1. ! queue ! nvvidconv !
'video/x-raw(memory:NVMM), width=(int)1920, height=(int)1080' !
tee name=t2 t2. ! queue ! nvvidconv ! nveglglessink sync=false
t1. ! queue ! 'video/x-raw(memory:NVMM), width=(int)3840,
height=(int)2160' ! omxh265enc bitrate=10000000 ! matroskamux !
queue ! filesink location=test_4k.mkv sync=false t2. ! queue !
omxh264enc control-rate=2 bitrate=10000000 ! 'video/x-h264,
stream-format=(string)byte-stream' ! h264parse ! rtph264pay
mtu=1400 ! queue ! udpsink host=192.168.1.58 port=5000
sync=false async=false
```

ROVCO OCEAN INSIGHT

Display 1080p, encode 4K HEVC 100Mbps to disk, stream 10Mbps h264 1080p.

```
gst-launch-1.0 videotestsrc ! 'video/x-raw,
format=(string)I420,width=(int)3840,
height=(int)2160,framerate=(fraction)30/1' ! nvvidconv !
'video/x-raw(memory:NVMM),format=(string)I420,width=(int)3840,
height=(int)2160' ! tee name=t1 t1. ! queue ! nvvidconv !
'video/x-raw(memory:NVMM), width=(int)1920, height=(int)1080' !
tee name=t2 t2. ! queue ! nvvidconv ! nveglglessink sync=false
t1. ! queue ! 'video/x-raw(memory:NVMM), width=(int)3840,
height=(int)2160' ! omxh265enc bitrate=10000000 ! matroskamux !
queue ! filesink location=test_4k.mkv sync=false t2. ! queue !
omxh264enc control-rate=2 bitrate=10000000 ! 'video/x-h264,
stream-format=(string)byte-stream' ! h264parse ! rtph264pay
mtu=1400 ! queue ! udpsink host=192.168.1.58 port=5000
sync=false async=false
```

ROVCO OCEAN INSIGHT

encode 4K HEVC 100Mbps

```
gst-launch-1.0 videotestsrc ! 'video/x-raw,
format=(string)I420,width=(int)3840,
height=(int)2160,framerate=(fraction)30/1' ! nvvidconv !
'video/x-raw(memory:NVMM),format=(string)I420,width=(int)3840,
height=(int)2160' ! tee name=t1 t1. ! queue ! nvvidconv !
'video/x-raw(memory:NVMM), width=(int)1920, height=(int)1080' !
tee name=t2 t2. ! queue ! nvvidconv ! nveglglessink sync=false
t1. ! queue ! 'video/x-raw(memory:NVMM), width=(int)3840,
height=(int)2160' ! omxh265enc bitrate=10000000 ! matroskamux !
queue ! filesink location=test_4k.mkv sync=false t2. ! queue !
omxh264enc control-rate=2 bitrate=10000000 ! 'video/x-h264,
stream-format=(string)byte-stream' ! h264parse ! rtph264pay
mtu=1400 ! queue ! udpsink host=192.168.1.58 port=5000
sync=false async=false
```

ROVCO OCEAN INSIGHT

stream 10Mbps h264

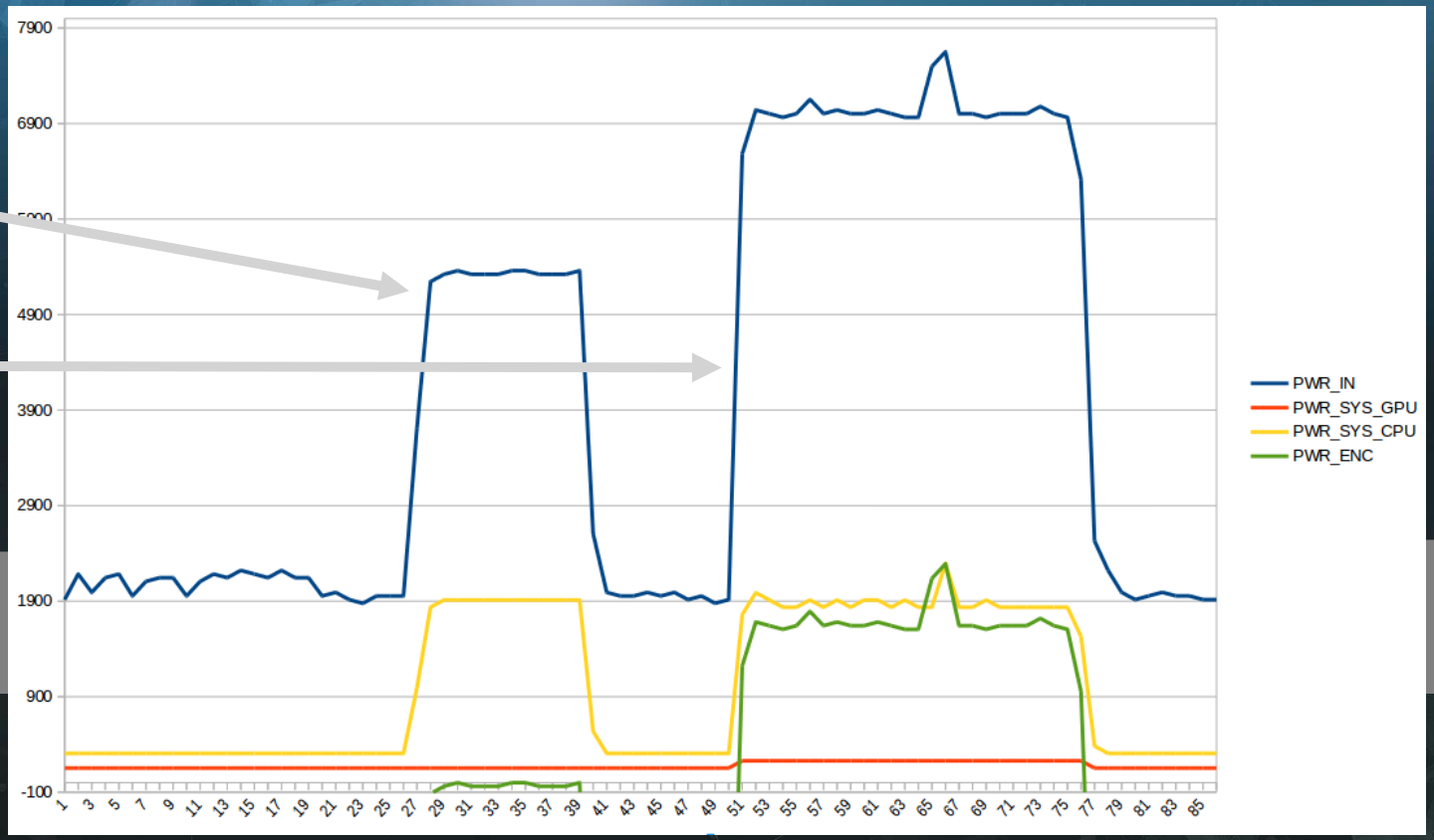
1080p:

```
gst-launch-1.0 videotestsrc ! 'video/x-raw,
format=(string)I420,width=(int)3840,
height=(int)2160,framerate=(fraction)30/1' ! nvvidconv !
'video/x-raw(memory:NVMM),format=(string)I420,width=(int)3840,
height=(int)2160' ! tee name=t1 t1. ! queue ! nvvidconv !
'video/x-raw(memory:NVMM), width=(int)1920, height=(int)1080' !
tee name=t2 t2. ! queue ! nvvidconv ! nveglglessink sync=false
t1. ! queue ! 'video/x-raw(memory:NVMM), width=(int)3840,
height=(int)2160' ! omxh265enc bitrate=10000000 ! matroskamux !
queue ! filesink location=test_4k.mkv sync=false t2. ! queue !
omxh264enc control-rate=2 bitrate=10000000 ! 'video/x-h264,
stream-format=(string)byte-stream' ! h264parse ! rtph264pay
mtu=1400 ! queue ! udpsink host=192.168.1.58 port=5000
sync=false async=false
```

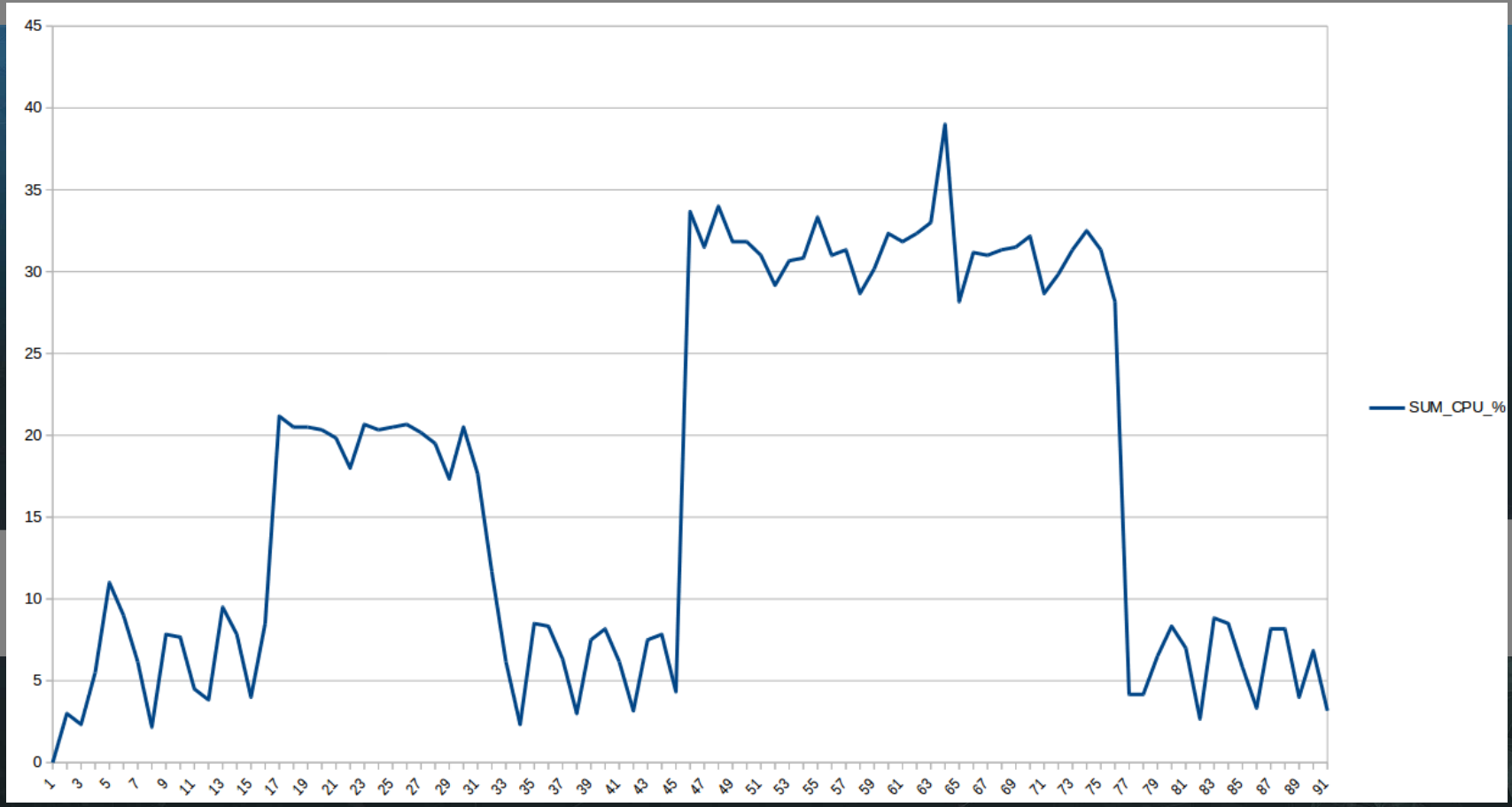
TX2 Encoding Performance - Power

Generating Test Stream

Displaying, encoding, streaming…



TX2 Encoding Performance - CPU



3D Vision Subsea

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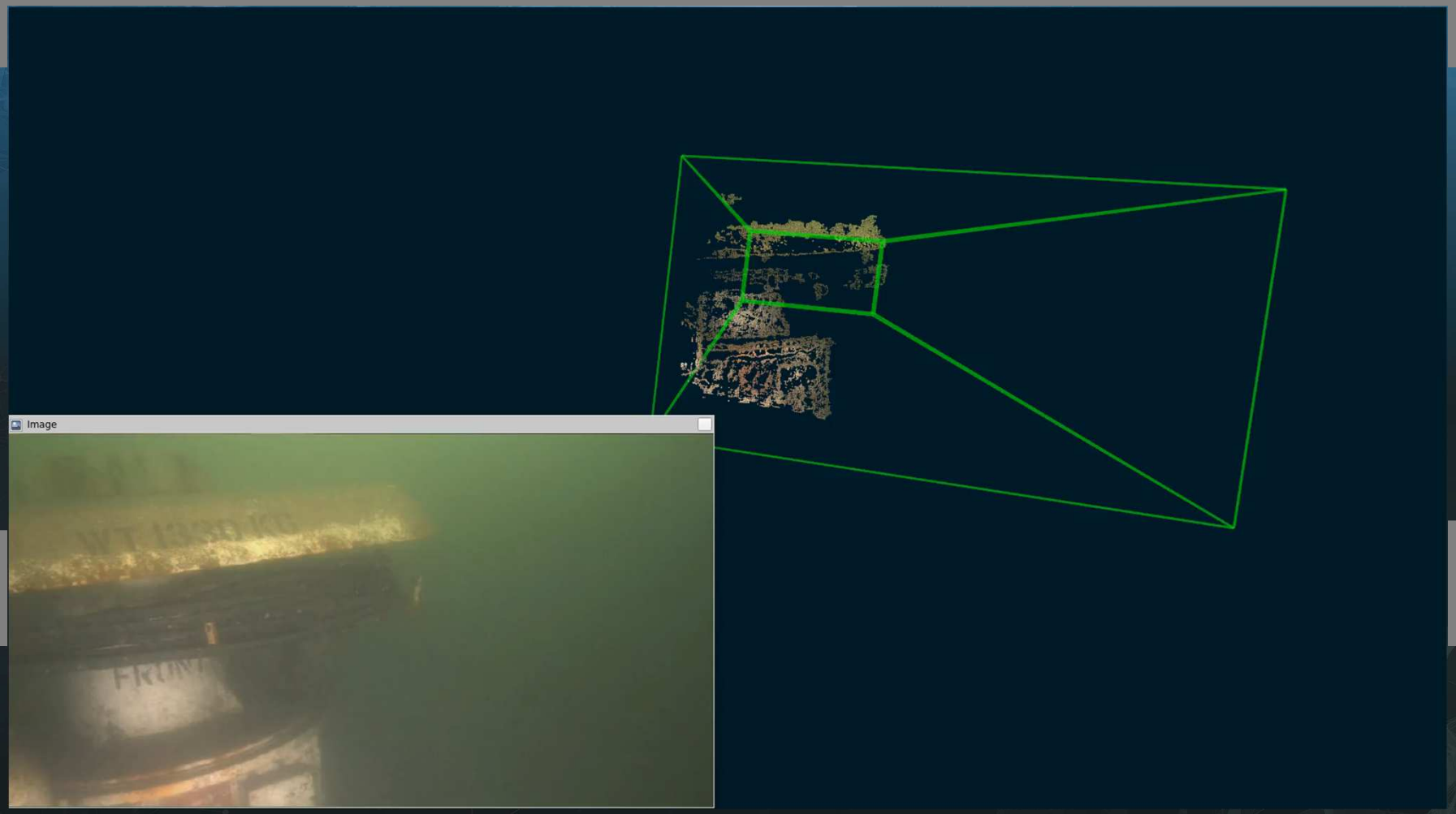
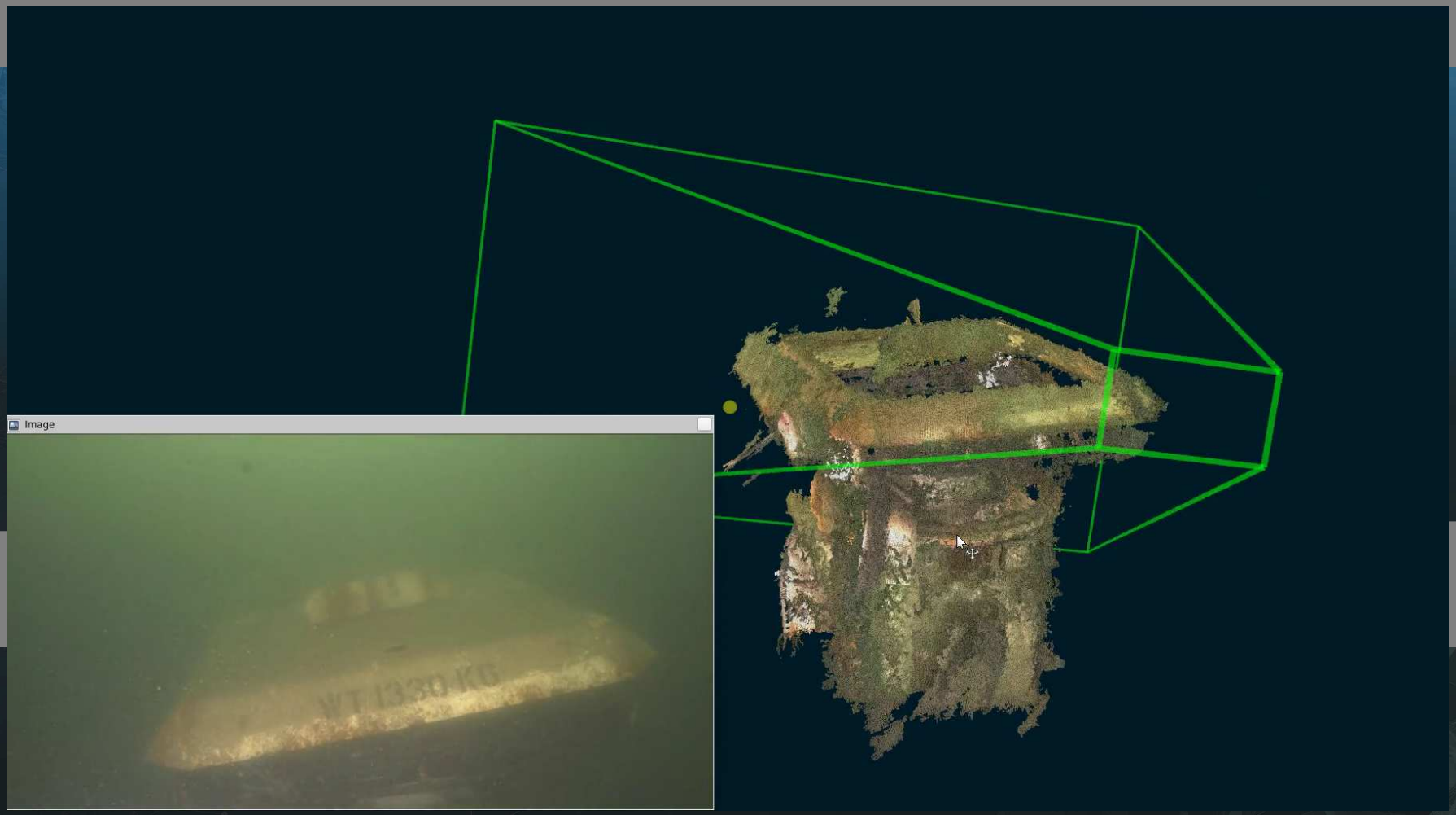


3D Vision Subsea

ROVCO
OCEAN INSIGHT



AUV3D – Live Scaled 3D

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- Hardware and software for live 3D vision.
- Cutting edge sensors and compute.
- Evaluation trials in drydock.

Innovate UK

CATAPULT Offshore Renewable Energy

AI Subsea

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IVAS – Intelligent Video Analytics for Subsea

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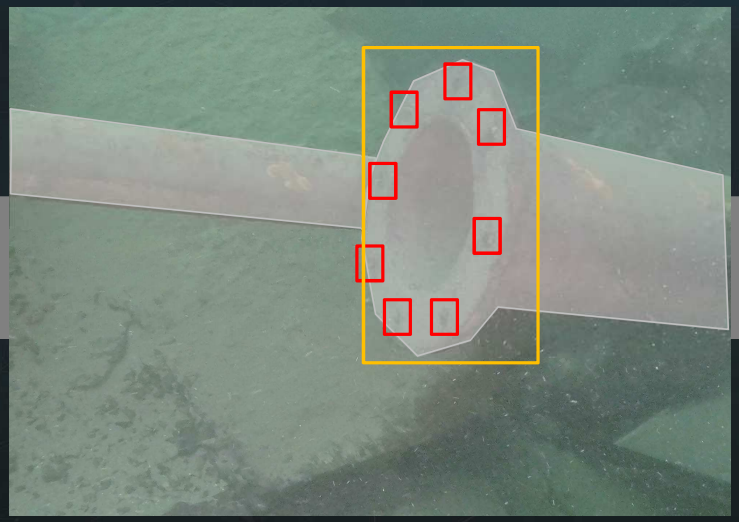
- Deep learning to extract meaningful information from video
- Repeatable, reliable video analysis
- Exploiting cutting edge research

SCORE

NVIDIA INCEPTION PROGRAM

Propelling AI startups with powerful GPU tools, tech, and deep learning expertise.

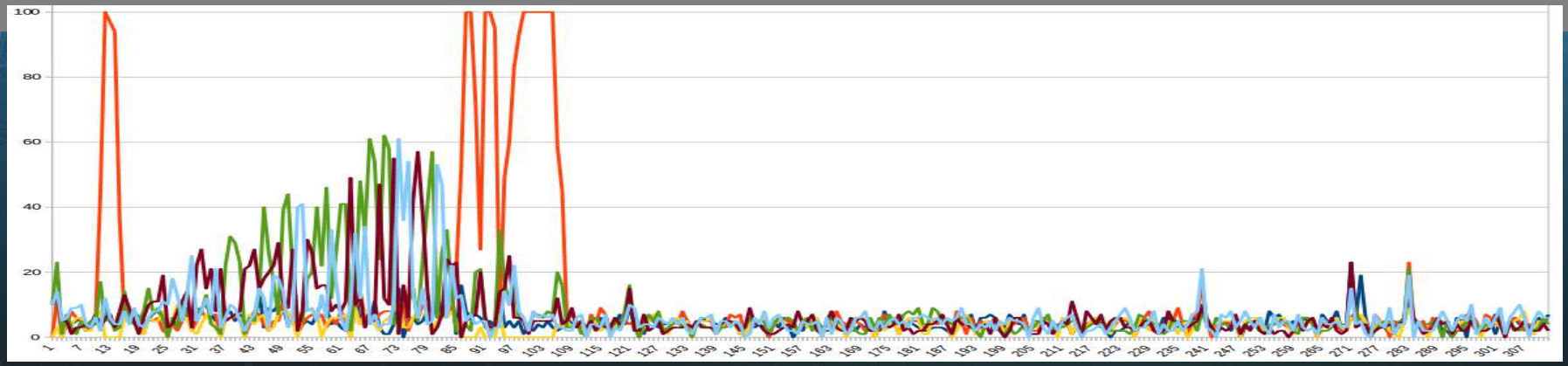


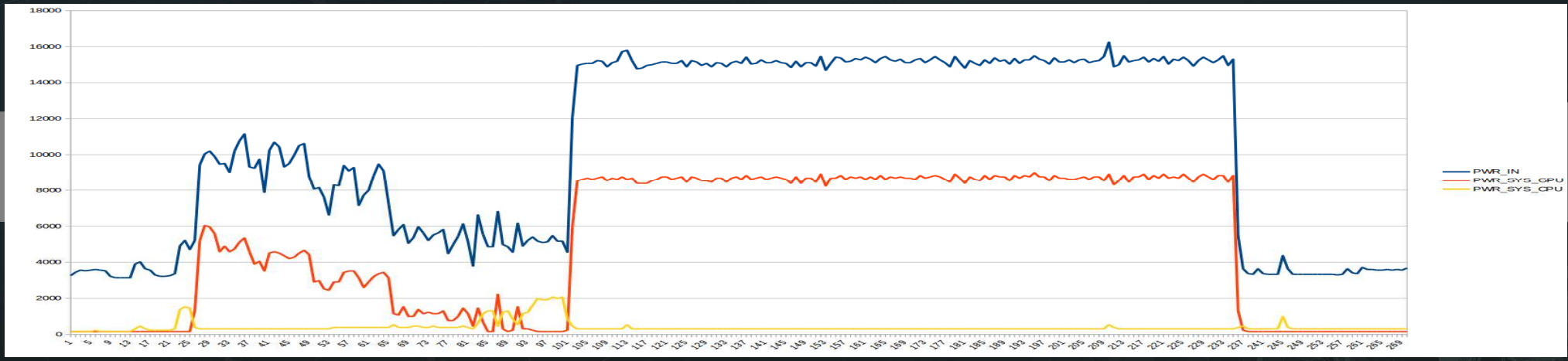
Getting the Job Done More Efficiently

- If measurement and visualisation is the job for 3D, what's the job for IVAS?
- Automating the boring and error prone.
- Generating actionable data.

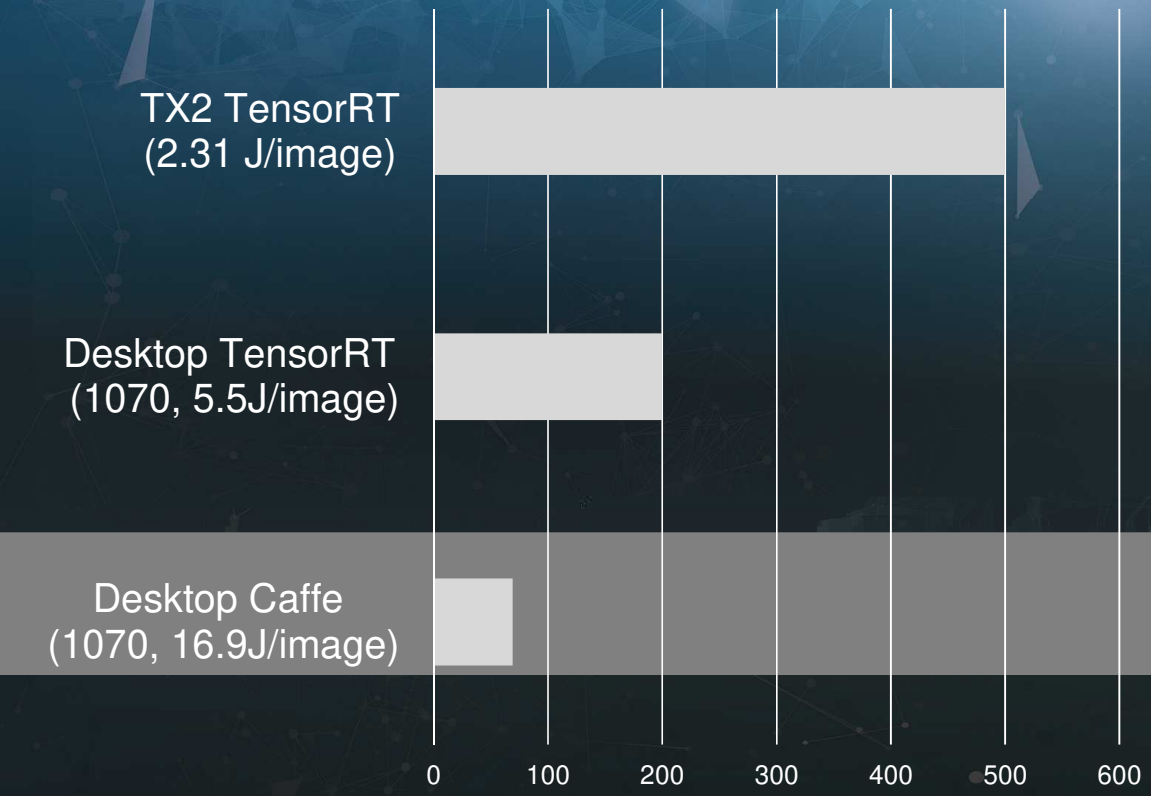
ID	Description	Date	Time	Northing	Easting	Depth	Video timestamp
1	exposed cable	11/12/2017	11:16:38 AM	5466450	365673.9	23.3	01:33:22
2	rock bag	11/12/2017	11:16:47 AM	5466452	365675.1	22.6	01:34:39
3	free span	11/12/2017	11:17:08 AM	5466453	365676.4	22.4	01:35:56
4	free span	11/12/2017	11:38:08 AM	5466454	365677.6	22.4	01:37:13
5	exposed cable	11/12/2017	11:42:40 AM	5466455	365678.8	23.1	01:38:30
6	exposed cable	11/12/2017	11:43:00 AM	5466456	365680.1	23.1	01:39:47
7	mattress	11/12/2017	11:44:02 AM	5466458	365681.3	24.2	01:41:04

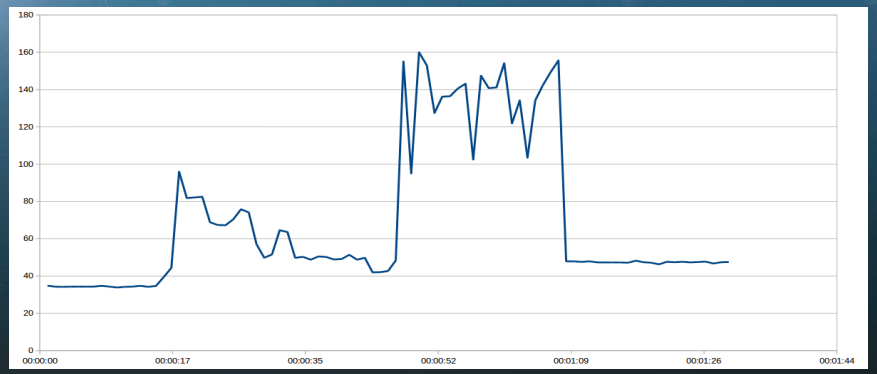
Deep Learning in the Deep

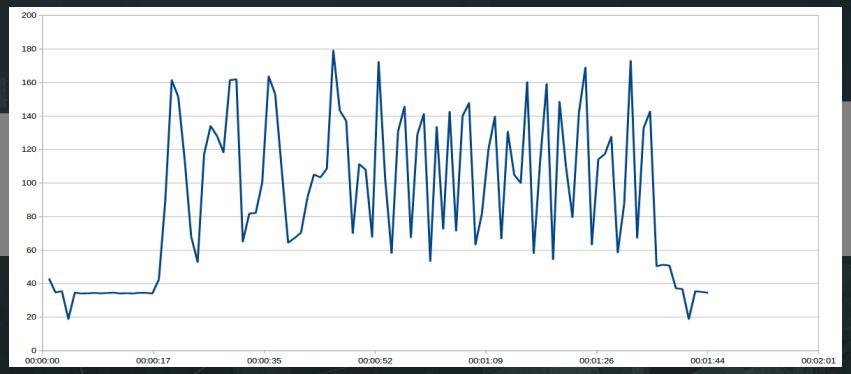




Deep Learning in the Deep







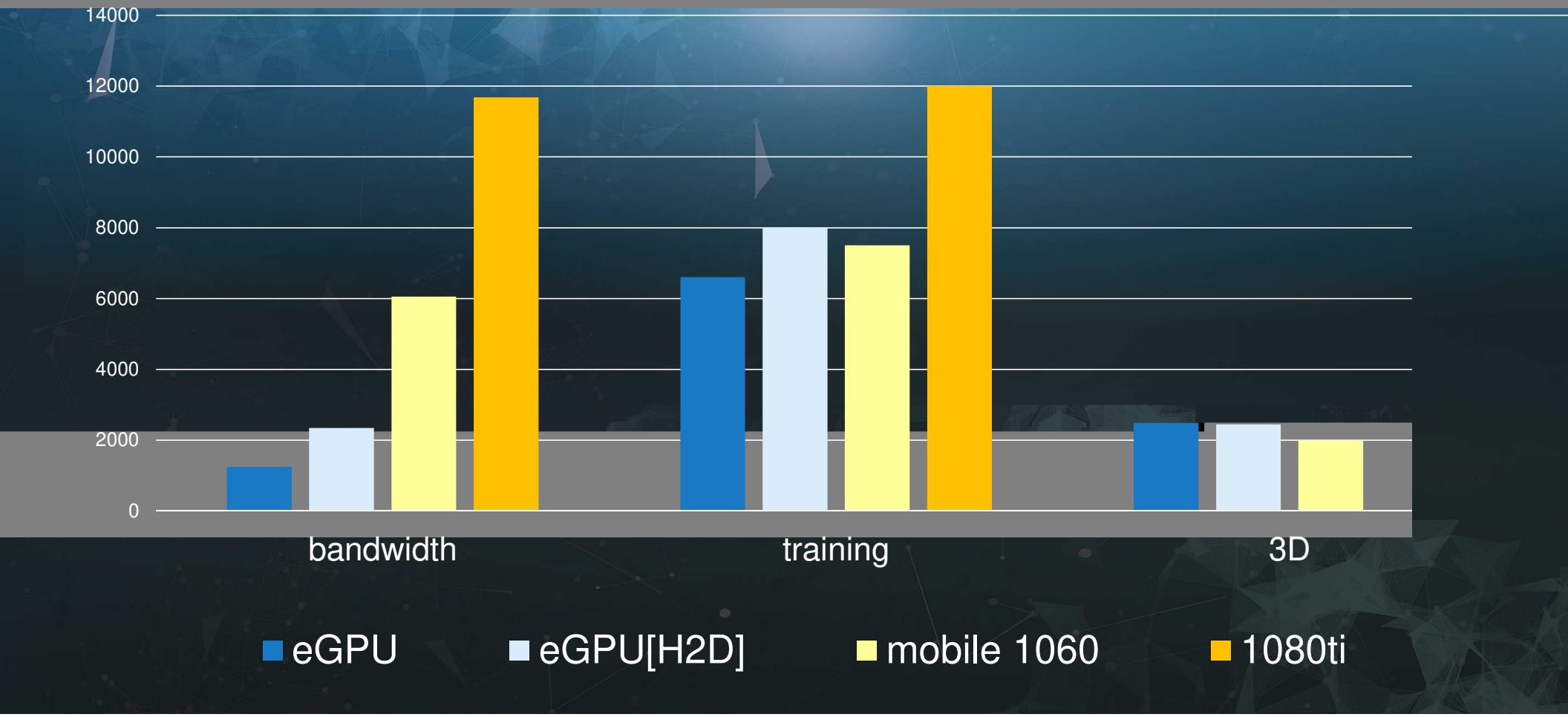
Deep Learning on my Desk

Performance

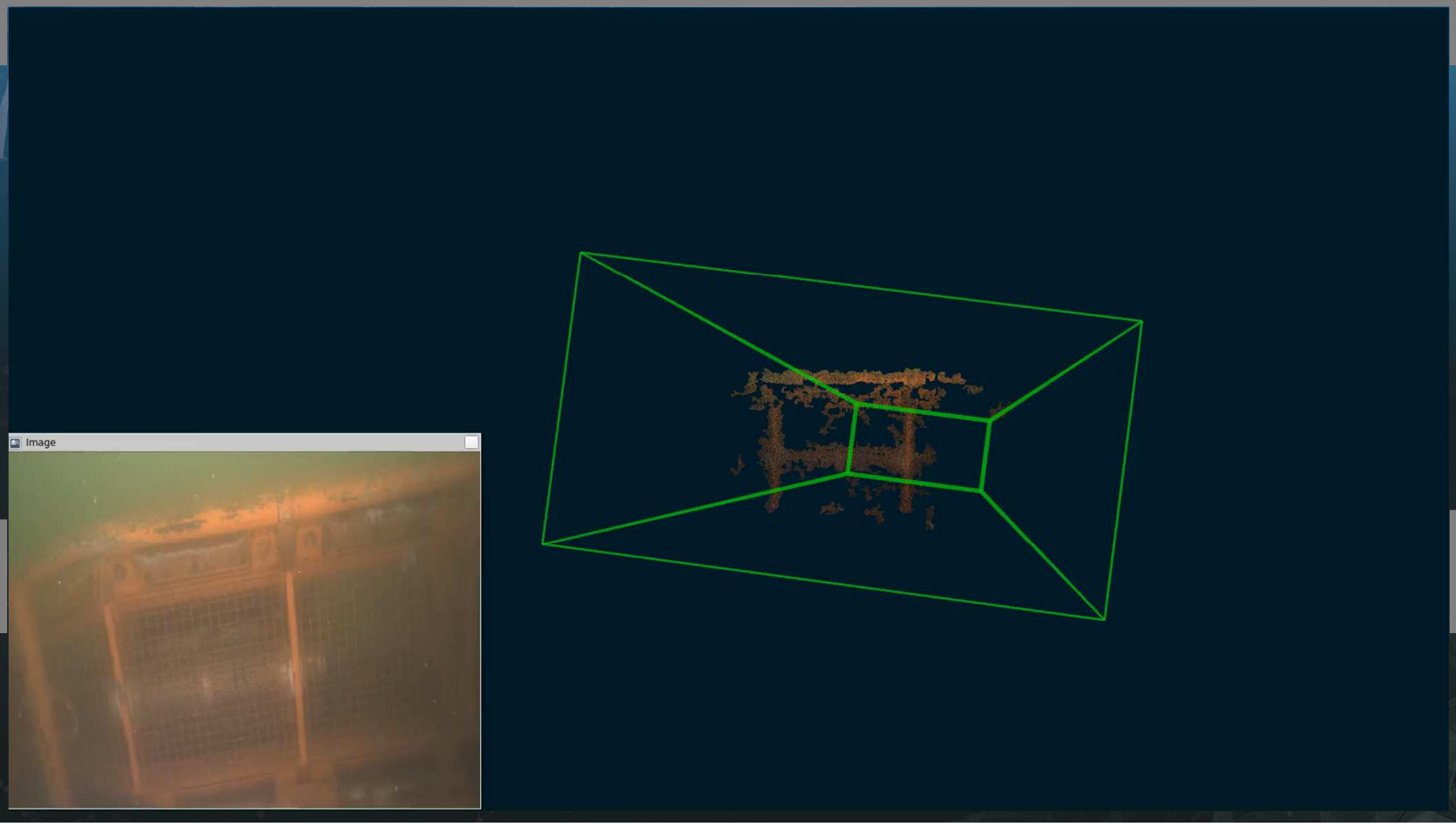
Machine Setup	Bandwidth Test[1] (MB/s)	CNN Training[2] (samples/s)	3D Performance[3]
i7-8550U (15W), GTX1070 eGPU	1,242	~6,600	2,486
i7-8550U (15W), GTX1070 eGPU [H2D firmware]	2,346	~8,000	2,443
i7-7700HQ (45W), GTX1060 (mobile)	6,052	~7,500	1,980
Xeon 2640v4 (x2, 90W), GTX1080ti	11,680	~12,000	-

[1] CUDA host-to-device bandwidth
[2] Nvidia docker, “tensorflow:18.04-py3”, CIFAR-10 training.
[3] Unigine Valley Extreme HD Benchmark

Performance



Joining it all Together



Live 3D Transmission

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Live 3D Transmission

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Live 3D Transmission

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Live 3D Transmission

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Live 3D Transmission

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Benefits and Opportunity

- Accurate measurement
- Comparison
- Easy overviews
- Better data delivery
- Pretty pictures

- Repeatable, reliable metrics – measures of risk
- New, more complete metrics
- Higher quality, more reliable assessments of asset condition

Smarter robots lead to smaller vessels and fewer people doing more, higher quality work.

AI and 3D are here, now

- Underwater is difficult and dangerous
  - Send a robot to do the job.
- Smarter robots can change the way we work.
  - Jetson helps make our robots smarter.
- Jetson is amazingly power efficient
  - Showed how to measure power
  - Examples of encoding and deep learning performance w.r.t power.
- Jetson is amazingly powerful
  - Dedicated hardware units enable tasks typical desktops struggle with.


ROVCO
OCEAN INSIGHT
Thank You
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