INMARTECH 2018

MAINTAIN AND EXPAND YOUR SEAFLOOR OBSERVATORY BY INSTALLING A SEA FLOOR RESIDENT AUV / ROV SYSTEM

October 16th, 2018

Chris Roper
Saab Seaeye

OUR **BROAD OFFERING**

SAAB NO LONGER BUILDS CARS

UNMANNED SYSTEMS

Saab's expertise in aeronautics, underwater, sensors and system integration gives us a leading position in the development of Unmanned Systems

- Skeldar, unmanned helicopter,
- Neuron program, unmanned air fighter, European cooperation to be completed in 2012
- AUV62 R&D program supported from the Swedish Navy since 1999
- Double Eagle SAROV hybrid (AUV/ROV) delivered 2010
- Sabertooth Seafloor Resident hybrid (AUV/ROV) Program started 2011 ongoing

UNDERWATER SYSTEMS
OVER A HUNDRED YEARS OF HISTORY


1910
First Swedish developed torpedo the M12 is built in Karlskrona


1976
Saab built advanced WROV


1985
First 360 degree manoeuvrability ROV developed


1988
Torpedo 2000 developed


1989
First AUV delivered


1993
First survey ROV system developed with autopilot


2003
Double Eagle MkIII capable of 6+ knots


2008
Double Eagle SAROV Hybrid AUV/ROV


2009
First Jaguar electric WROV delivered


2010
Cougar XTi delivered


2011
Sabertooth introduced


2013
Leopard vehicle developed


2016
SeaWasp Developed

Underwater Systems

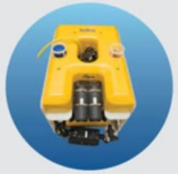
- **1910** Torpedoes developed for Swedish Navy in Karlskrona
- **1941** Company relocates to Motala
- **1981** SUTEC Company is formed
- **1991** Saab acquires SUTEC
- **2007** Saab acquires Seaeye
- **2013** Saab Seaeye acquires Hydro-Lek
- **2016** Saab acquires NDI

1986
Seaeye Marine is founded

Seaeye

1991
Seaeye Surveyor is introduced

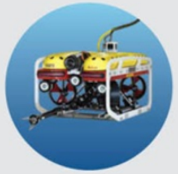
1996
Seaeye Tiger ROV launched



1997
Seaeye Panther WROV launched

1999
Seaeye Marine acquired by Hydrovision

2002
Seaeye Falcon inshore ROV launched



2004
Seaeye Cougar light WROV launched

2007
Seaeye acquired by Saab Underwater Systems

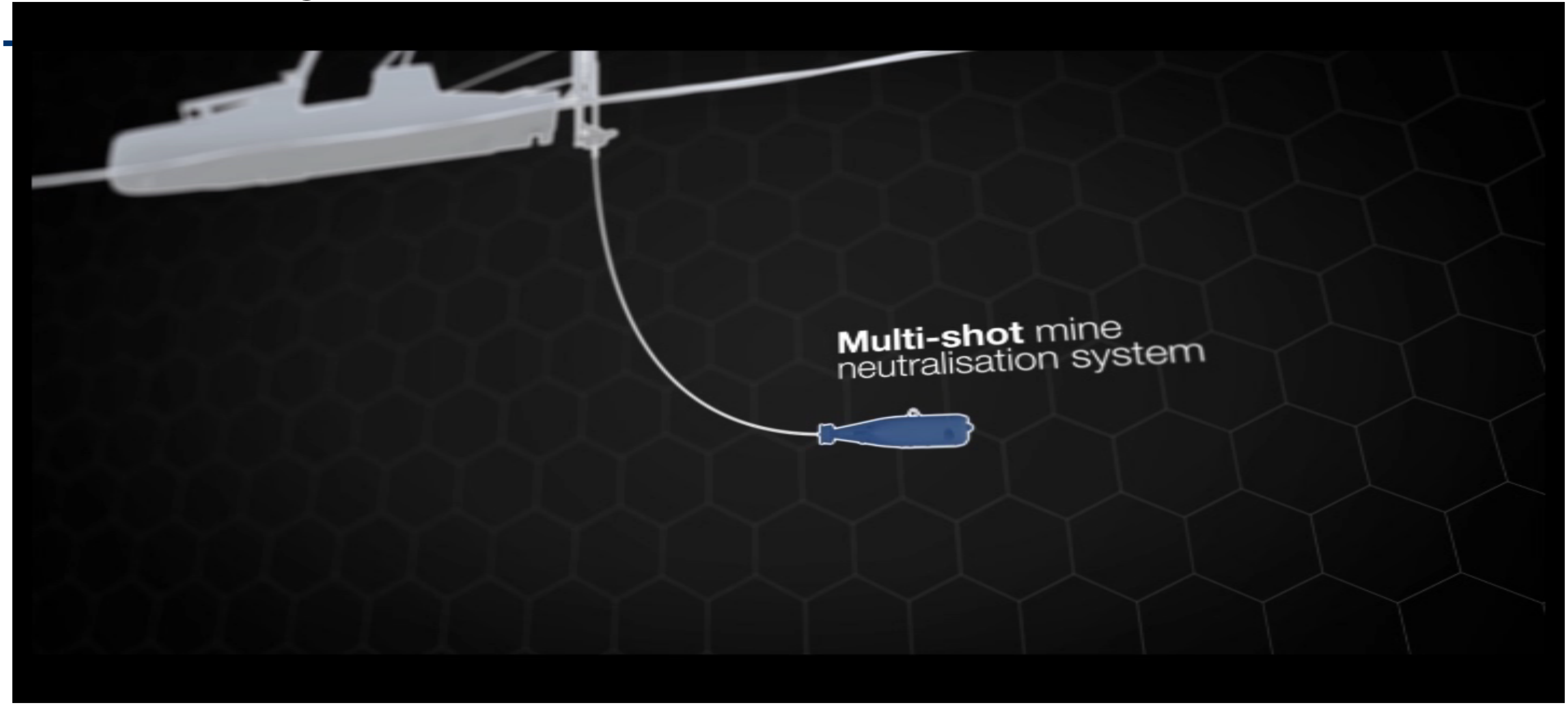
2013
Saab Seaeye acquired Hydro-Lek Ltd

SAAB UNDERWATER SYSTEMS PORTFOLIO

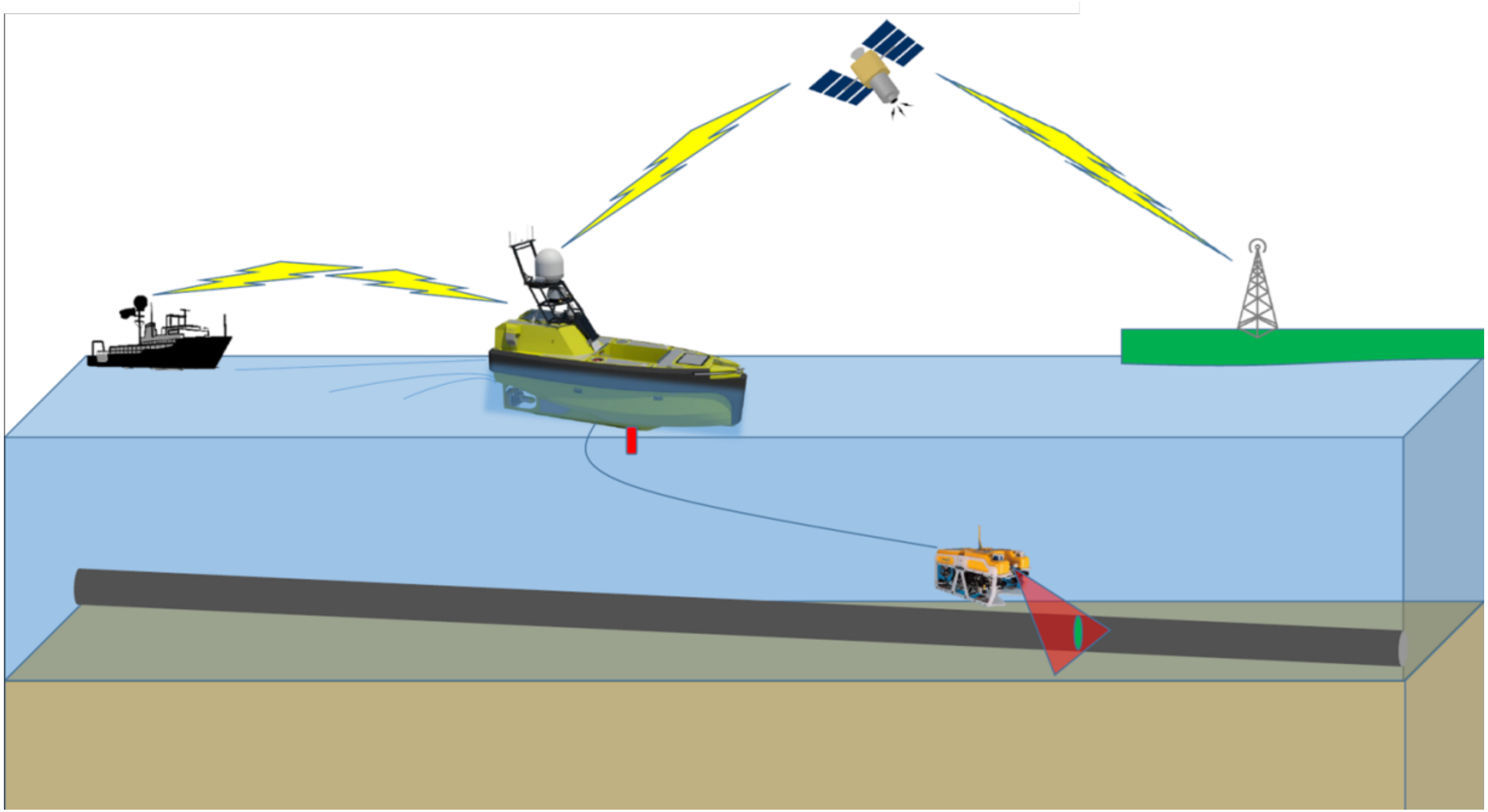
ALL ELECTRIC COMMERCIAL VEHICLE PLATFORMS

Remote Control & Deployment via USV

Hosted Systems Controller From Shore



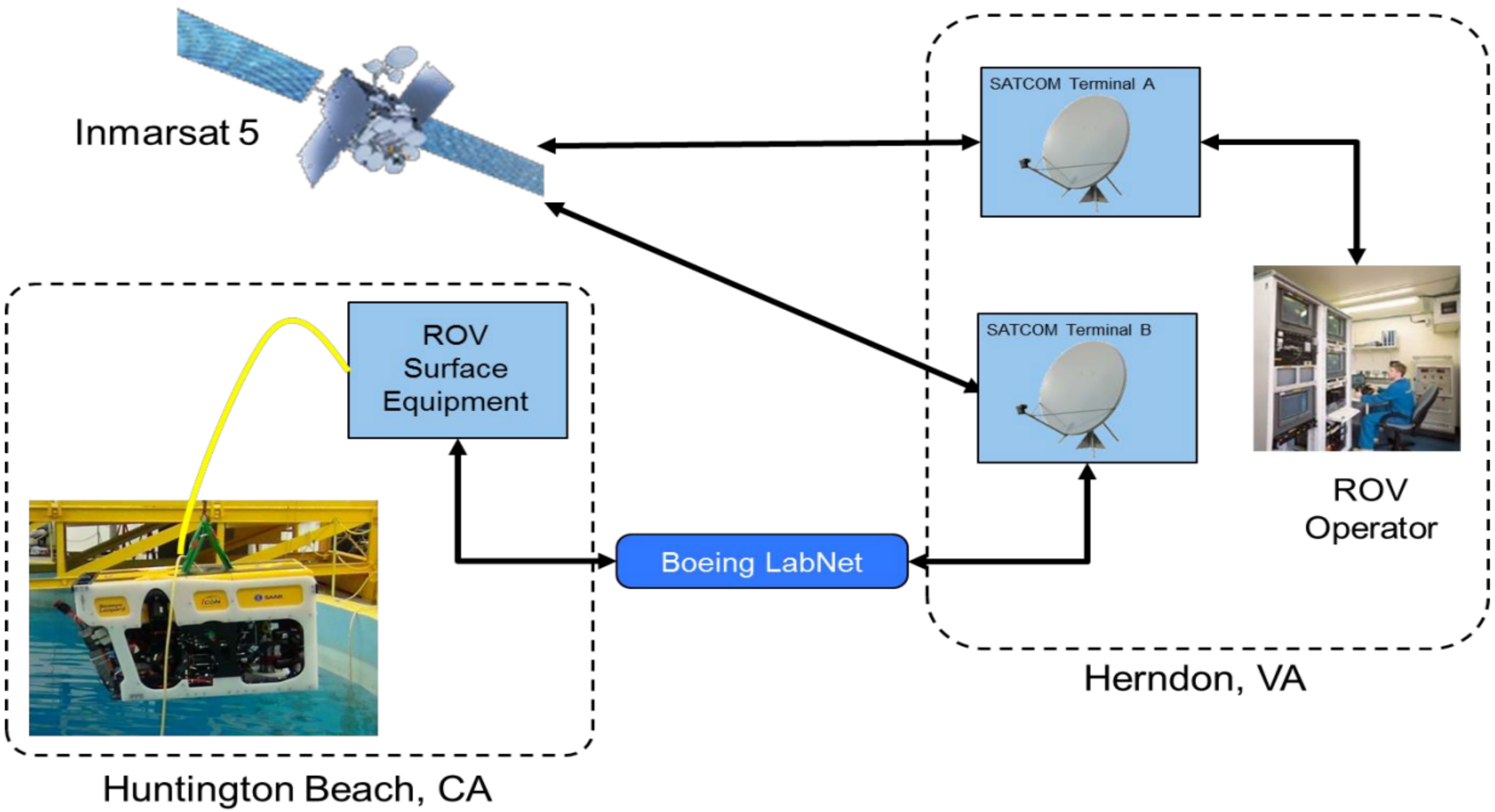
PIONEERING NEW SOLUTIONS



Telepresence Operation & Support Requirements

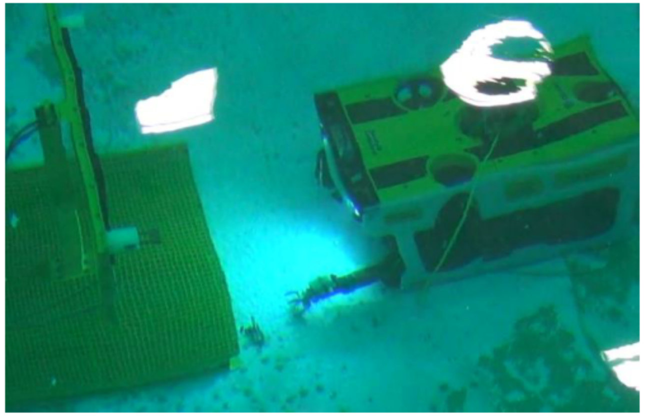
- Operation with limited bandwidth and increased latency
- Fallback behavior/plan to handle faults if communication is lost
- Remote system integrity monitoring
- High reliability and preemptive maintenance
- Support and repair by non-dedicated personnel

SAAB Leopard Operation over SATCOM



Mating a Connector

Relocate a Shackle



Testing Showed Control of SAAB Leopard over SATCOM is Feasible

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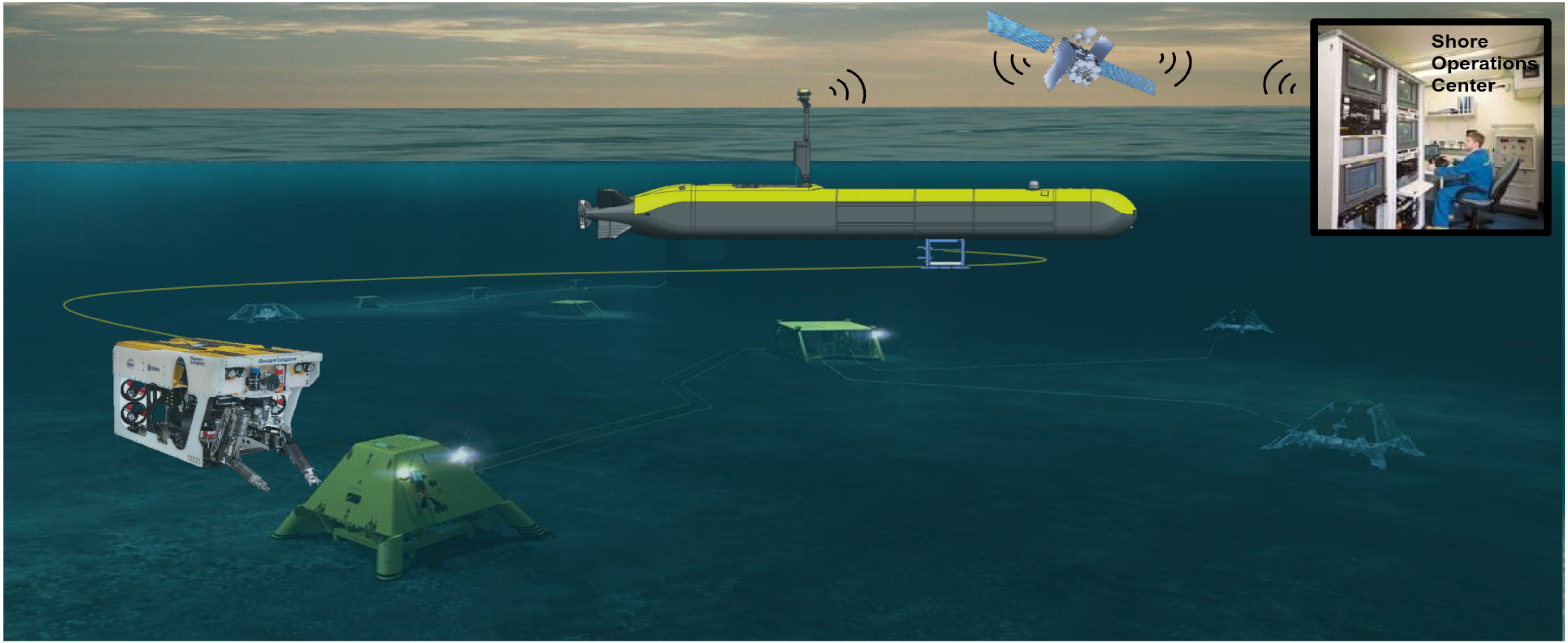
Subsea Intervention with Echo Voyager & SAAB Leopard



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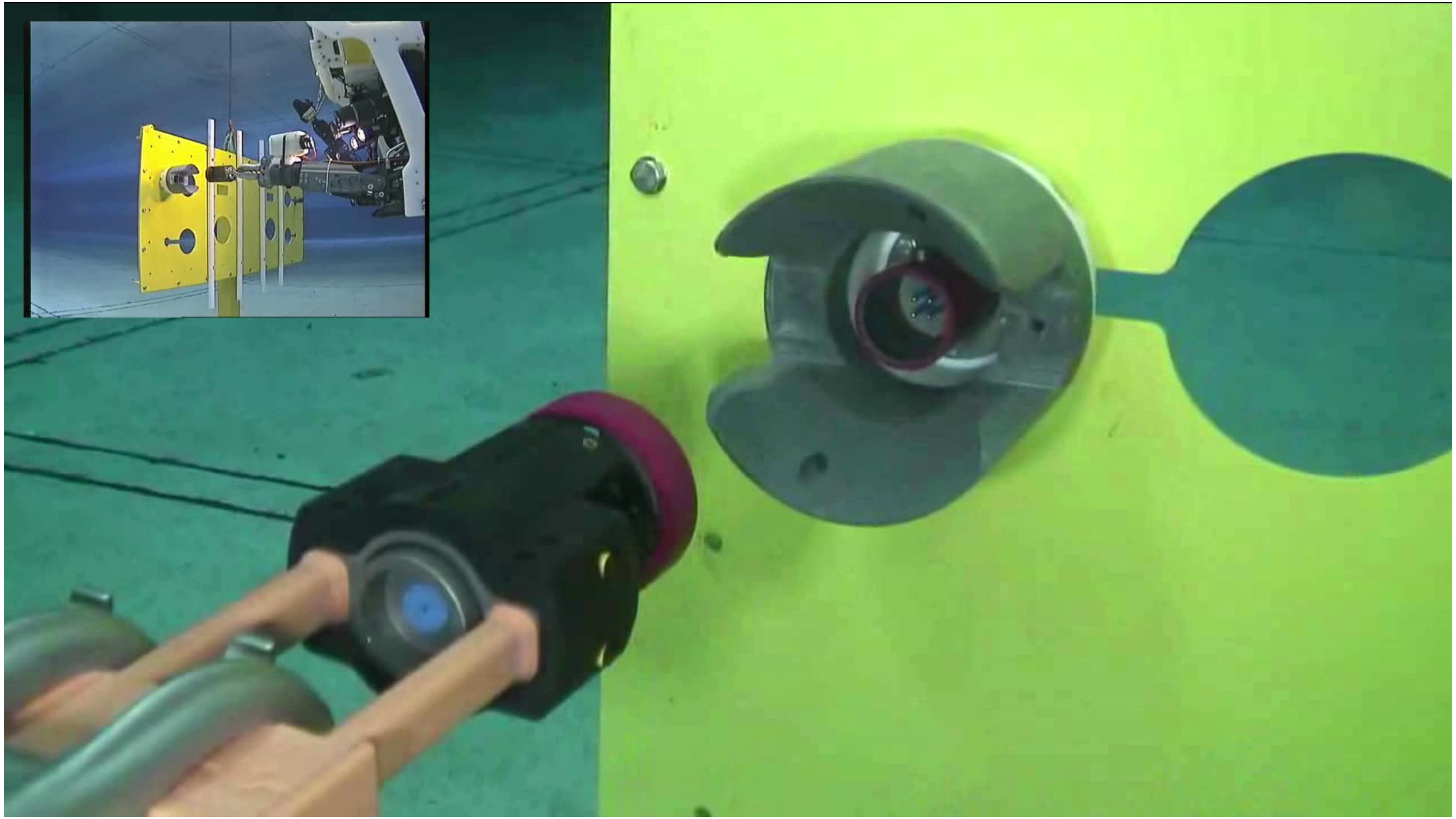
TELE PRESENCE

- A Leopard system was trialled extensively through the second half of 2017 with Boeing
- The vehicle was operated through Boeing's own satellite link
  - ROV west coast USA, operator east coast USA
- The satellite link was adjusted extensively during the trials and FAT to test and stress the ROV control system:-
  - Bandwidth – 1.6Mb/S (min) to 5Mb/S (max)
  - Latency – 0.5S (min) to 3S (max)
  - Data throughput* – 100% (max) to 80% (min)
- ROV missions included:- pre-planned (waypoint) survey, on the fly survey, manipulator intervention on static infrastructure, connecting – disconnecting - moving – reconnecting ODI connectors into ROV panel (with and without connector guide funnel fitted)
- The ROV system passed FAT/trials 17Q4, TMS upgrade to the system passed FAT/trials 18Q1

* Percentage of data sent arriving at destination (uplink/downlink).
Data was "dropped" continuously on a random basis

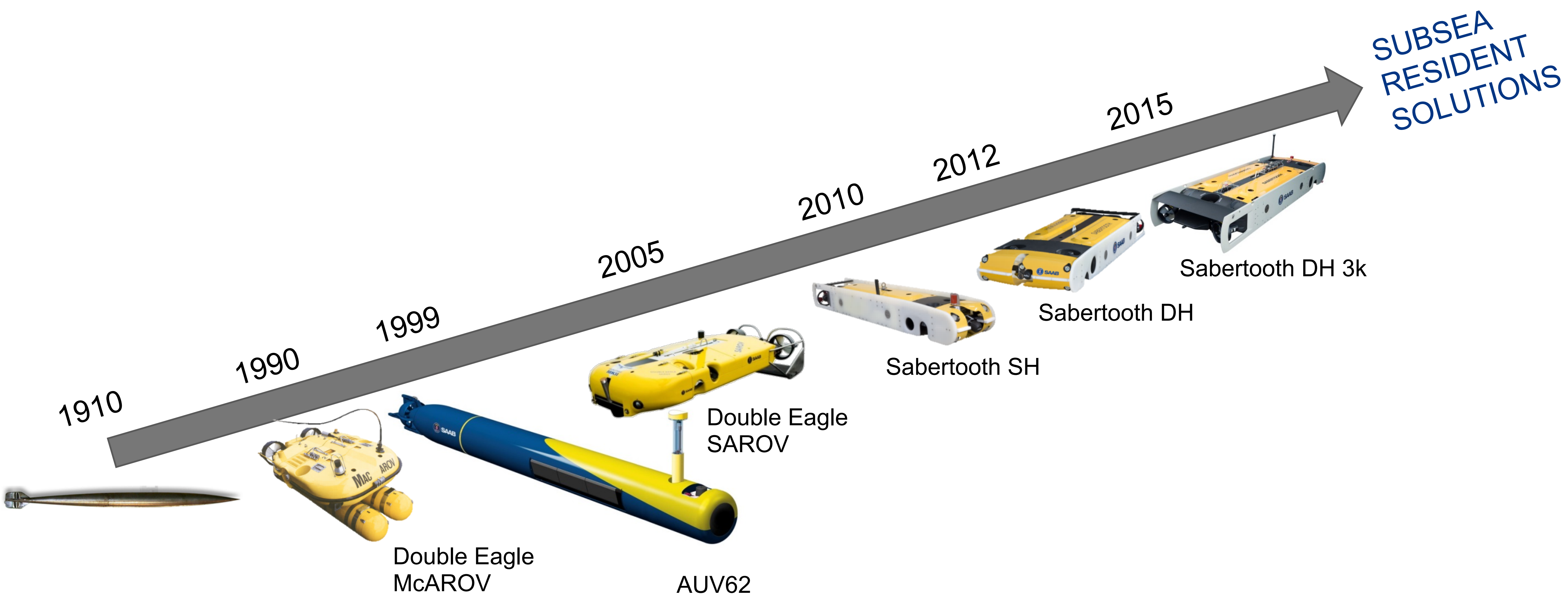
STEP BY STEP CONTROLS

- Enables precise control by unskilled operator
- Will work even with low bandwidth and high latency
- Used with joystick (incremental position control) or touch screen click

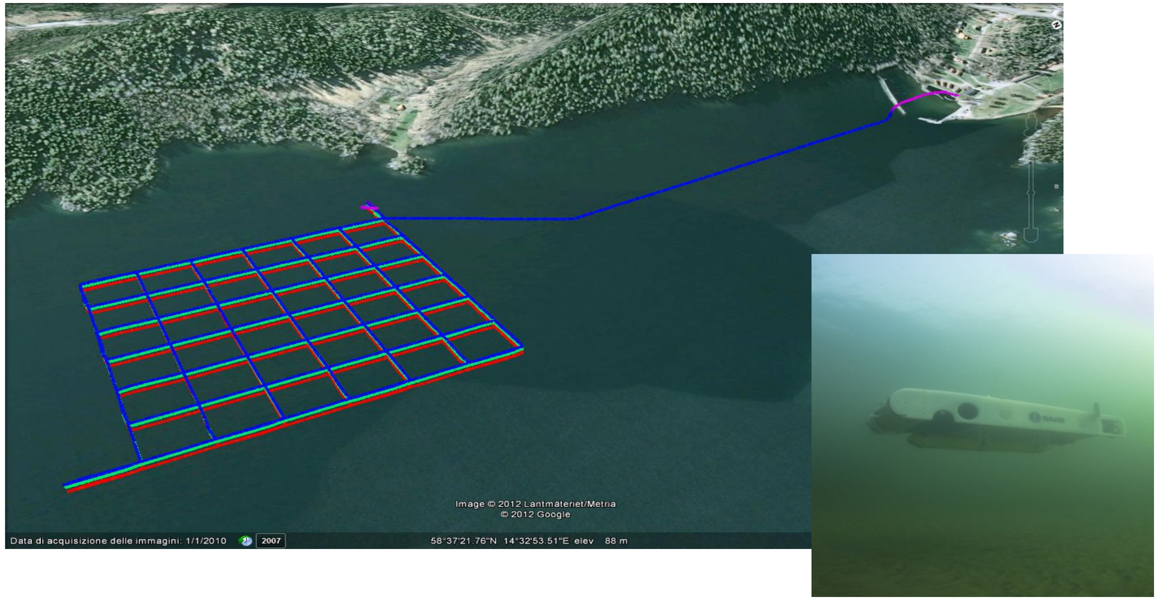


Tether-less Hybrid systems

SAAB´S AUV DEVELOPMENT HISTORY

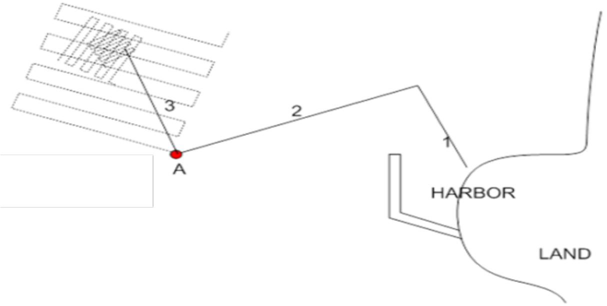


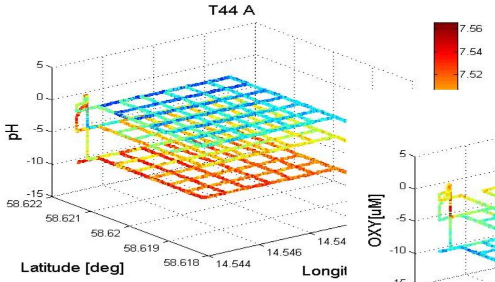
CLEANSEA ENI
ENVIRONMENTAL MONITORING SYSTEM

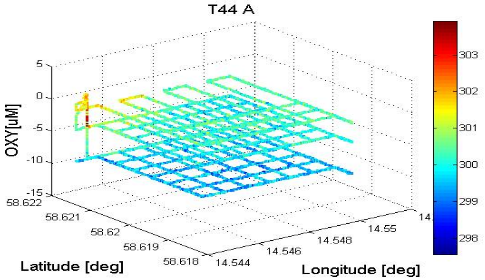


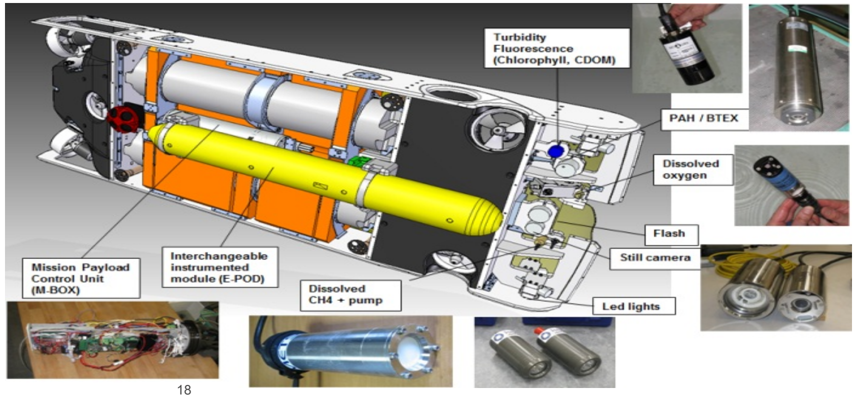
- **General oil spill detection**; pre-planned paths, along flowlines, around SPS templates and manifolds
- **Leak detection and localization;** hydrocarbon from flowlines
- **Visual inspection;** SPS structures such as ROV panels on manifolds or similar
- **Interchangeable payload**; instrumented module

<u>Reactive control</u>
Homing & navigation







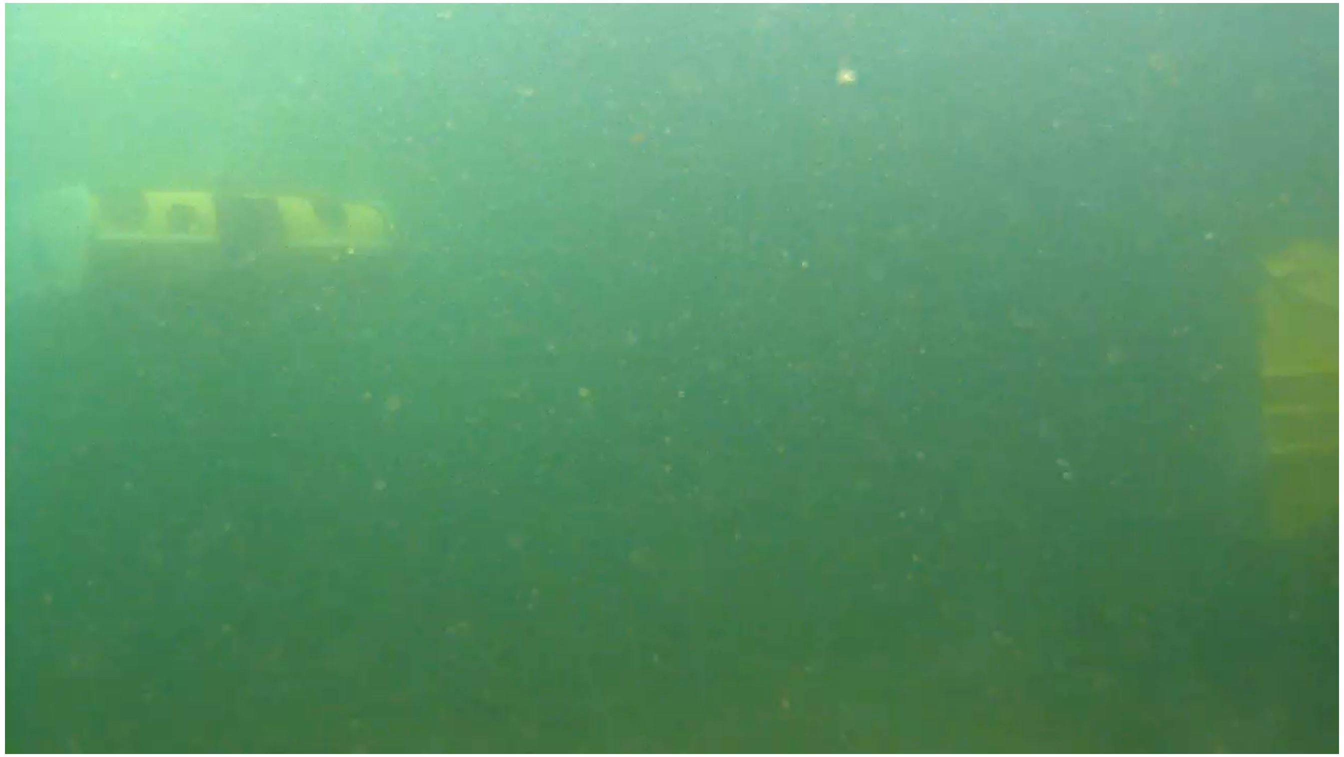


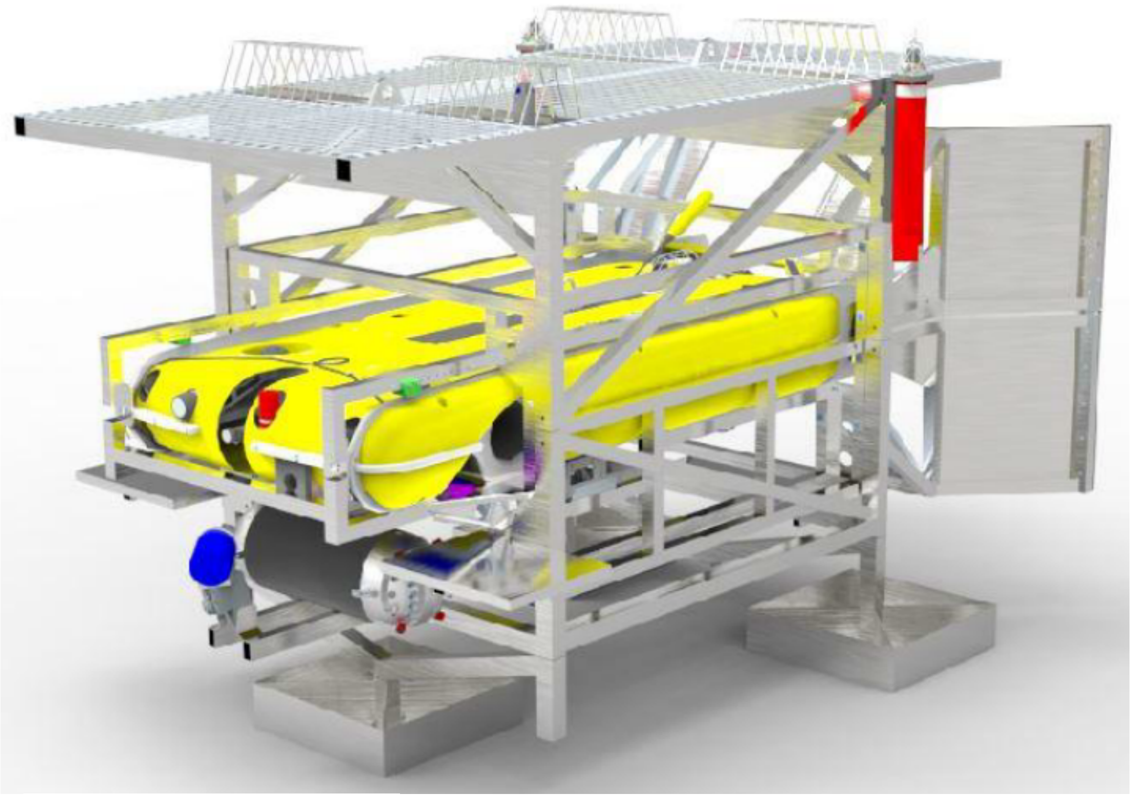
SABERTOOTH HYBRID - ROV/AUV

FEATURES

- Single- or Double hull configuration
- Three modes of operation
  - AUV
  - ROV
  - HYBRID
- Deep water capabilities
  - 1200 – 3000 m (4500 m)
- Long excursion range
- 6 DOF control system
- Payload adaptability
- A subsea resident system

Autonomous Docking, Inductive Charging & Data Transfer

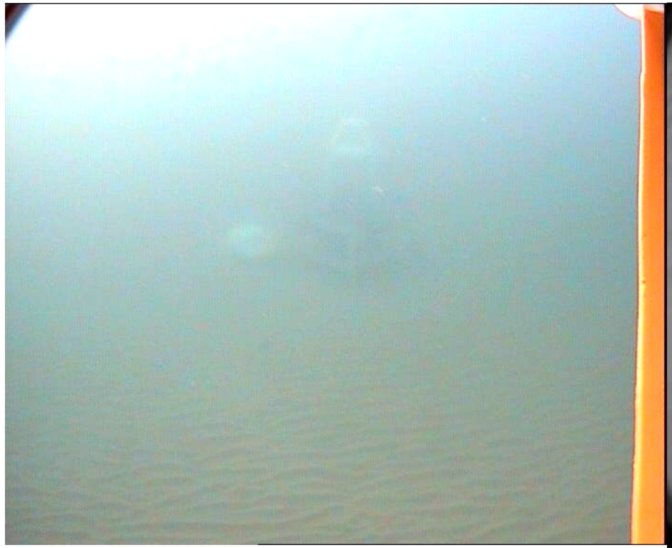


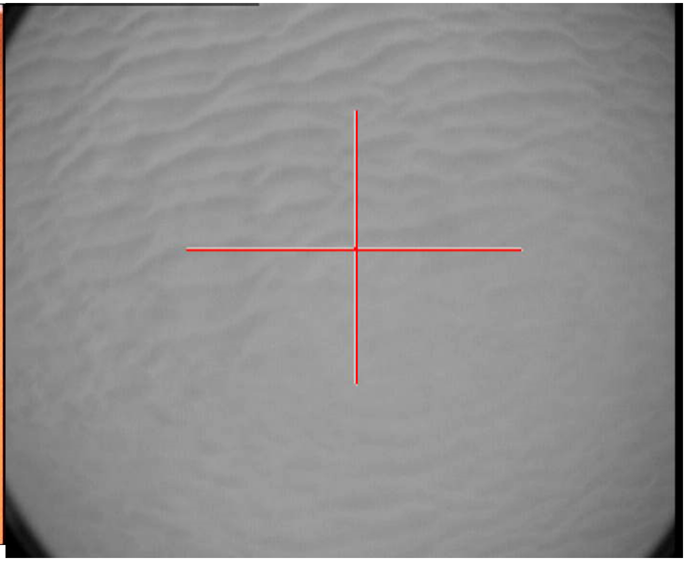


Sonardyne
SOUND IN DEPTH

AUTONOMOUS DOCKING ON SENSOR STAND, INDUCTIVE RECHARGING OF SENSOR & DATA HARVESTING

Offshore Sensor Data Harvesting Saab demonstrated this capability in 2013 under contract to Chevron.

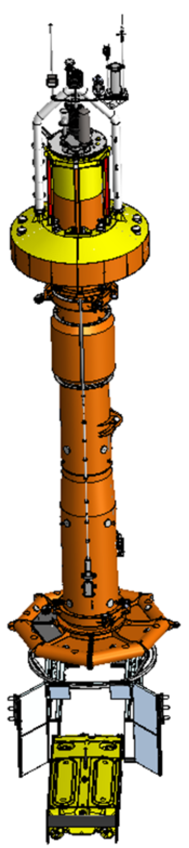


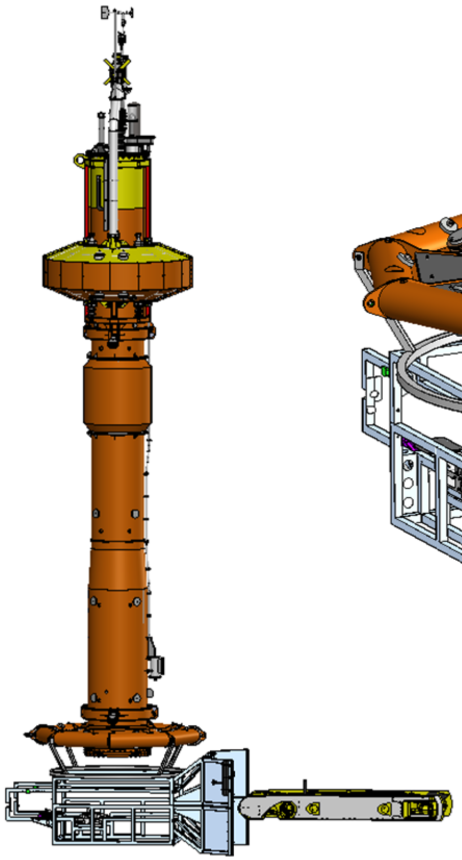


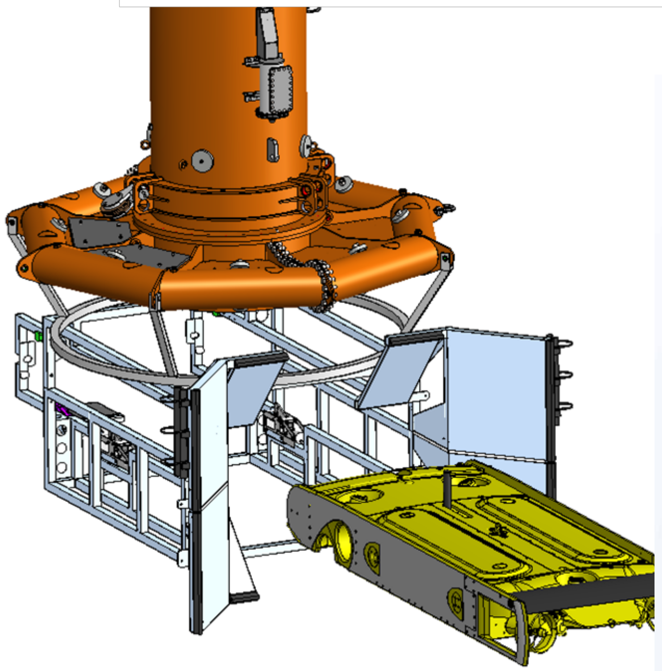
EXPAND YOUR SEAFLOOR OBSERVATORY BY 40 MILES IN ALL DIRECTIONS WITHOUT ADDING ANY ADDITIONAL CABLE

- Sabertooth is fitted with 30 kWh of onboard battery power which allows up to an 80 miles round trip.
- Install a new sensor on the seafloor up to 40 miles from your current seafloor node. In AUV mode Sabertooth can transit to, upload the collected data from, recharge the sensor and upload the new data when Sabertooth returns to its seafloor network connected docking station.
- This capability allows you to expand your seafloor observatory by 40 miles in all direction.
- No cable between sensors = Expansion at a greatly reduced cost.

BUOY CONCEPT DEVELOPMENT

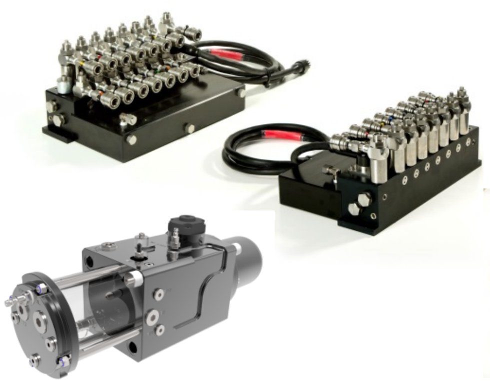


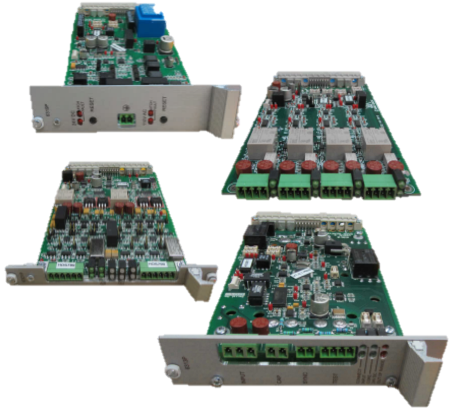


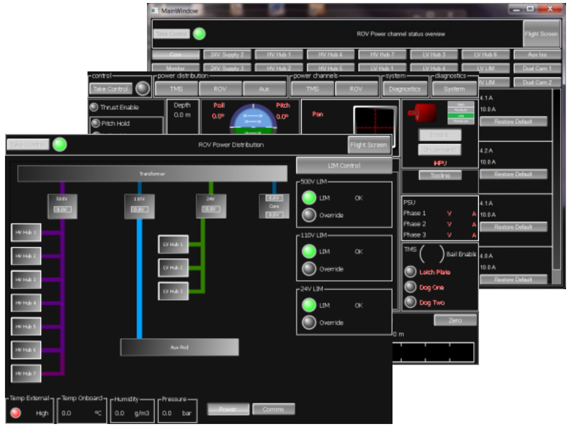


ICON COMMON TECHNOLOGY PLATFORM

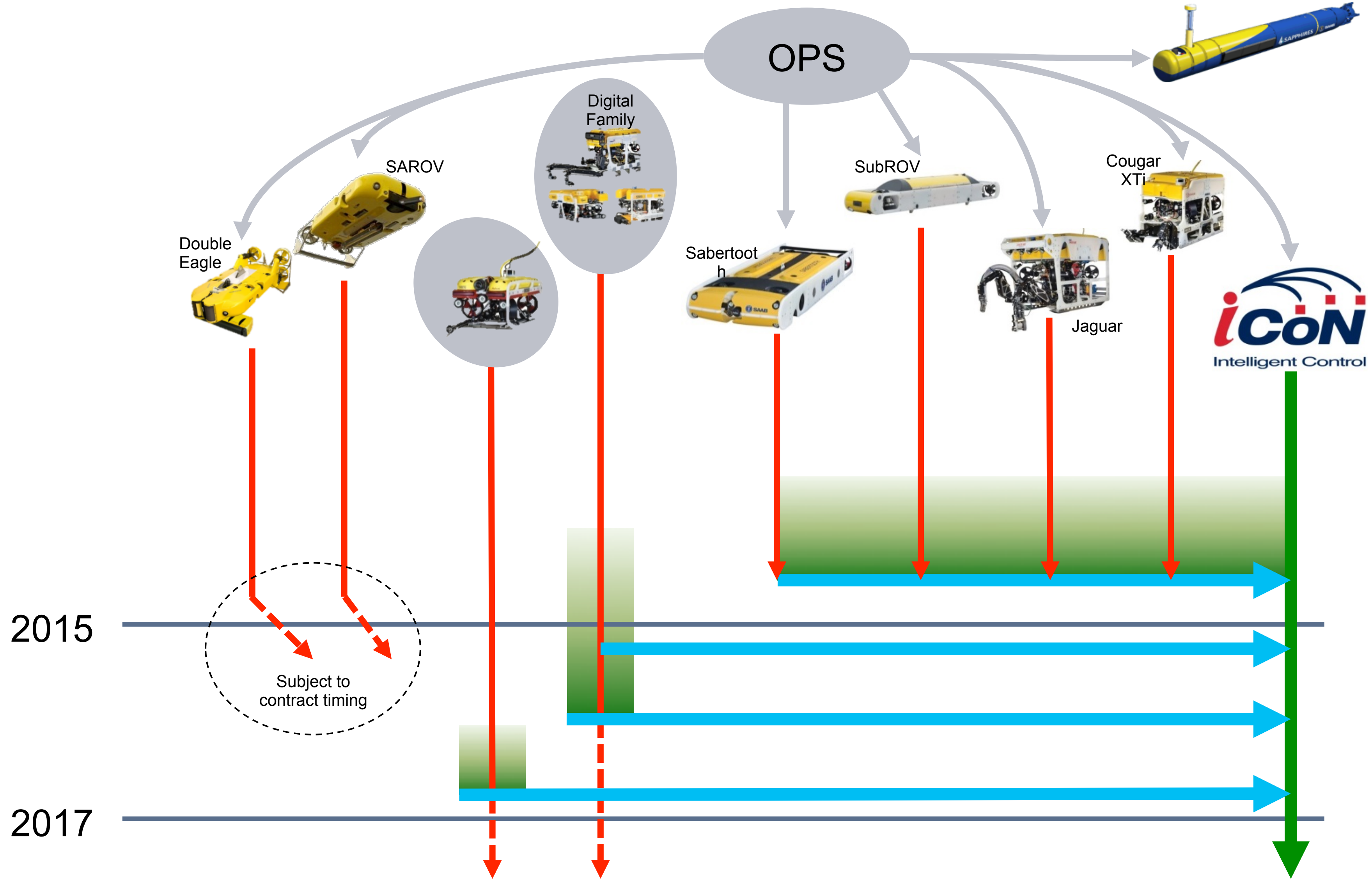
SAAB SEAEYE iCON



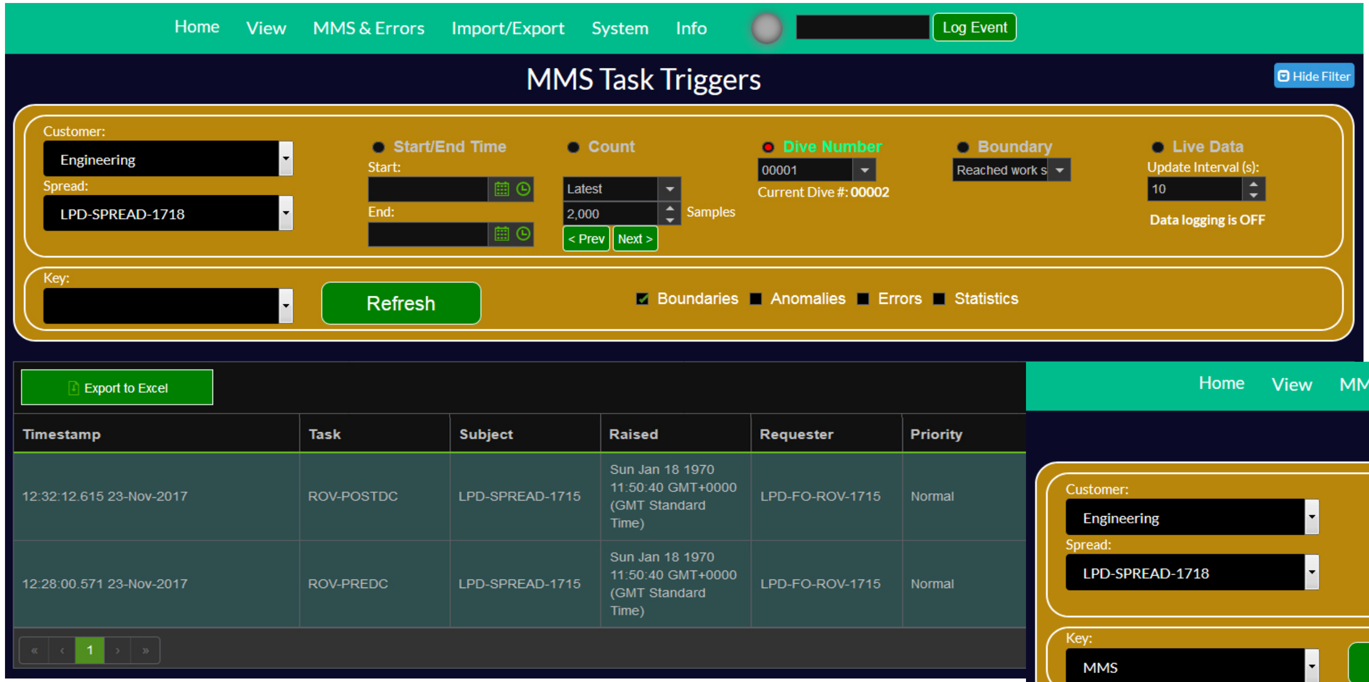


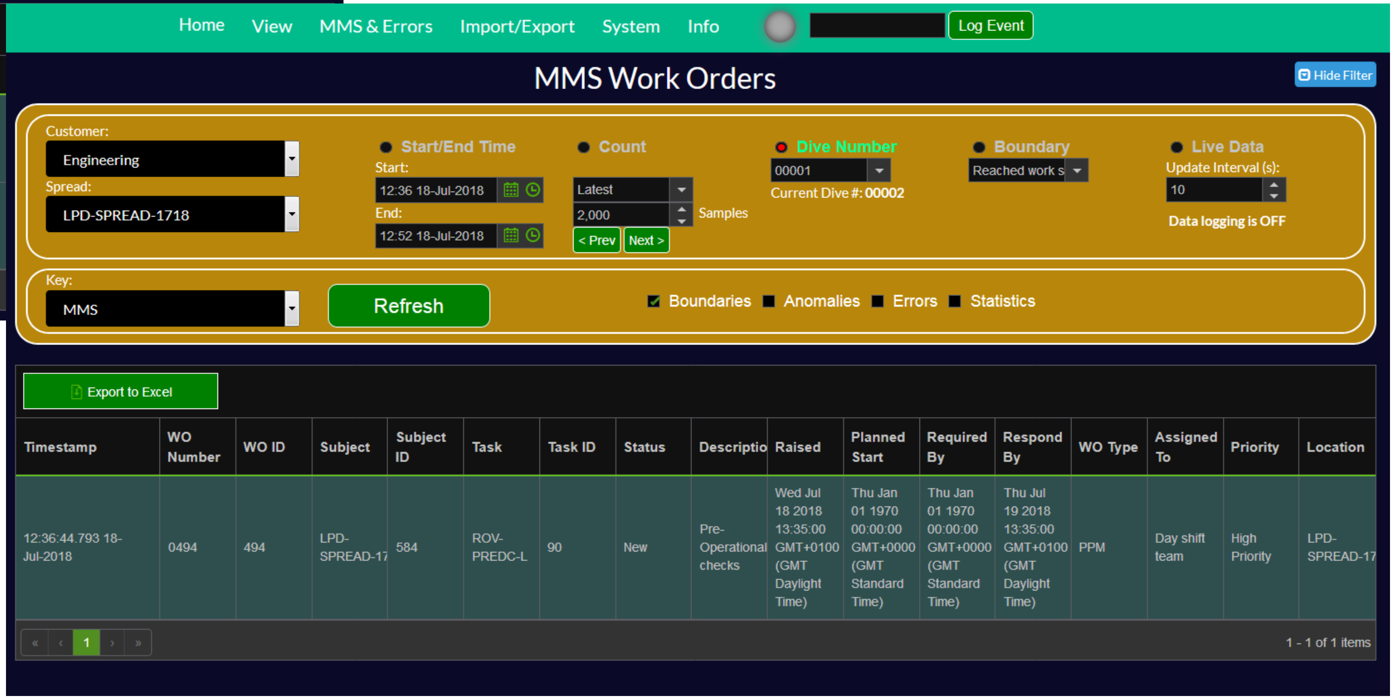


COMMON SOFTWARE



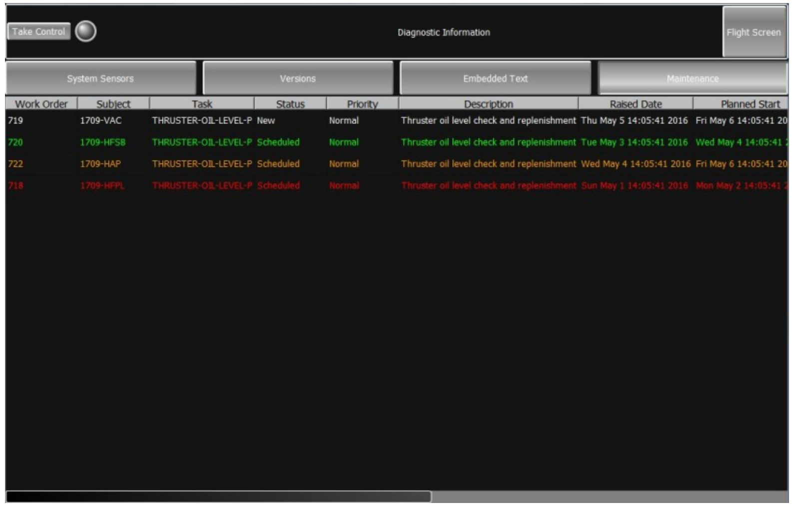
ICON SYSTEM MONITOR – PREVENTATIVE MAINTENANCE

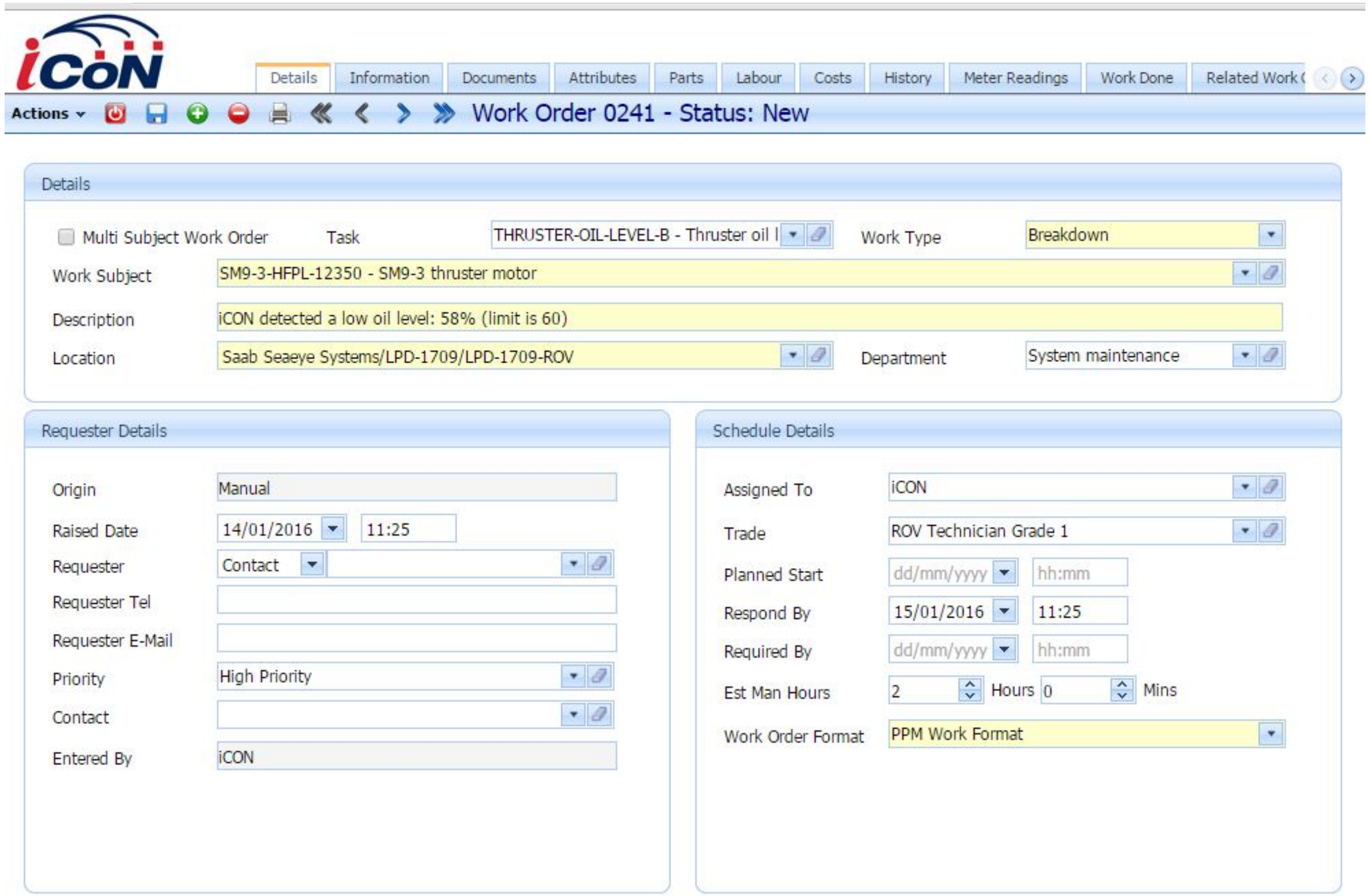




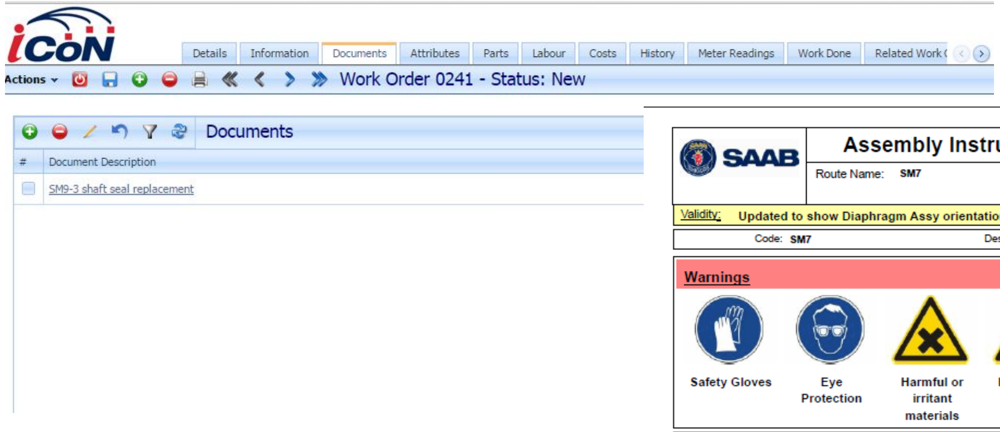
WORK ORDERS

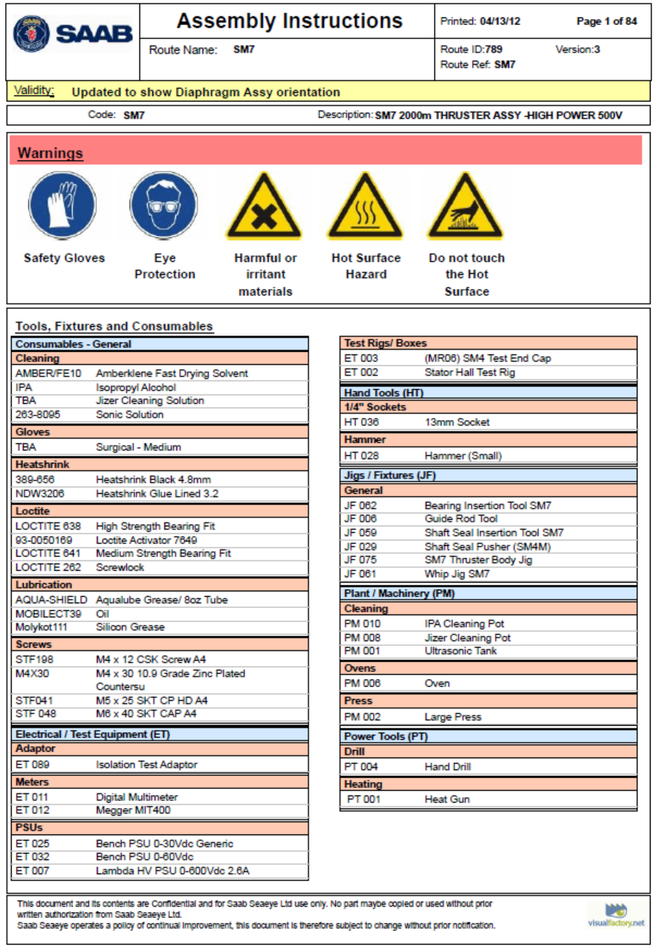

control
power distribution
power channels
system
Thrust Enable
Depth
12.6 m
Altitude
27.2 m
Roll
Pitch
Pitch Hold
Roll Hold
Bottom Lock
Station Keeping
Reverse Mode
Heading Hold
Depth Hold
Altitude Hold
Thrusters
Lights
Cameras
Tooling
089°
0.00 kts
Spooling Enabled
Latch Plate
Latch One
Latch Two
Maintenance
Showing event (0/2)
ROV Turns 0.2
Tether Deployed
133.0 m


Diagnostic Information
System Sensors
Versions
Embedded Text
Maintenance


iCON
Details
Information
Documents
Attributes
Parts
Labour
Costs
History
Meter Readings
Work Done
Actions
Work Order 0241 - Status: New
Details
Multi Subject Work Order
Task
THRUSTER-OIL-LEVEL-B - Thruster oil l
Work Type
Breakdown
Work Subject
SM9-3-HFPL-12350 - SM9-3 thruster motor
Description
iCON detected a low oil level: 58% (limit is 60)
Location
Saab Seaeye Systems/LPD-1709/LPD-1709-ROV
Department
System maintenance
Requester Details
Origin
Manual
Raised Date
14/01/2016
11:25
Requester
Contact
Requester Tel
Requester E-Mail
Priority
High Priority
Contact
Entered By
iCON
Schedule Details
Assigned To
iCON
Trade
ROV Technician Grade 1
Planned Start
Respond By
15/01/2016
11:25
Required By
Est Man Hours
2
Hours
0
Mins
Work Order Format
PPM Work Format

ONLINE INSTRUCTIONS





Assembly Instructions

Printed: 04/13/12 Page 1 of 84

Route Name: SM7 Route ID:789 Version:3 Route Ref: SM7

Validity: Updated to show Diaphragm Assy orientation

Code: SM7 Description: SM7 2000m THRUSTER ASSY -HIGH POWER 500V

Warnings

Safety Gloves | Eye Protection | Harmful or irritant materials | Hot Surface Hazard | Do not touch the Hot Surface

Tools, Fixtures and Consumables

Consumables - General	
Cleaning	
AMBER/FE10	Amberklene Fast Drying Solvent
IPA	Isopropyl Alcohol
TBA	Jizer Cleaning Solution
263-8095	Sonic Solution
Gloves	
TBA	Surgical - Medium
Heatshrink	
389-656	Heatshrink Black 4.8mm
NDW3206	Heatshrink Glue Lined 3.2
Loctite	
LOCTITE 638	High Strength Bearing Fit
93-0050169	Loctite Activator 7649
LOCTITE 641	Medium Strength Bearing Fit
LOCTITE 262	Screwlock
Lubrication	
AQUA-SHIELD	Aqualube Grease/ 8oz Tube
MOBILECT39	Oil
Molykot111	Silicon Grease
Screws	
STF198	M4 x 12 CSK Screw A4
M4X30	M4 x 30 10.9 Grade Zinc Plated Countersu
STF041	M5 x 25 SKT CP HD A4
STF 048	M6 x 40 SKT CAP A4
Electrical / Test Equipment (ET)	
Adaptor	
ET 089	Isolation Test Adaptor
Meters	
ET 011	Digital Multimeter
ET 012	Megger MIT400
PSUs	
ET 025	Bench PSU 0-30Vdc Generic
ET 032	Bench PSU 0-60Vdc
ET 007	Lambda HV PSU 0-600Vdc 2.6A

Test Rigs/ Boxes	
ET 003	(MR06) SM4 Test End Cap
ET 002	Stator Hall Test Rig
Hand Tools (HT)	
1/4" Sockets	
HT 036	13mm Socket
Hammer	
HT 028	Hammer (Small)
Jigs / Fixtures (JF)	
General	
JF 062	Bearing Insertion Tool SM7
JF 006	Guide Rod Tool
JF 059	Shaft Seal Insertion Tool SM7
JF 029	Shaft Seal Pusher (SM4M)
JF 075	SM7 Thruster Body Jig
JF 061	Whip Jig SM7
Plant / Machinery (PM)	
Cleaning	
PM 010	IPA Cleaning Pot
PM 008	Jizer Cleaning Pot
PM 001	Ultrasonic Tank
Ovens	
PM 006	Oven
Press	
PM 002	Large Press
Power Tools (PT)	
Drill	
PT 004	Hand Drill
Heating	
PT 001	Heat Gun

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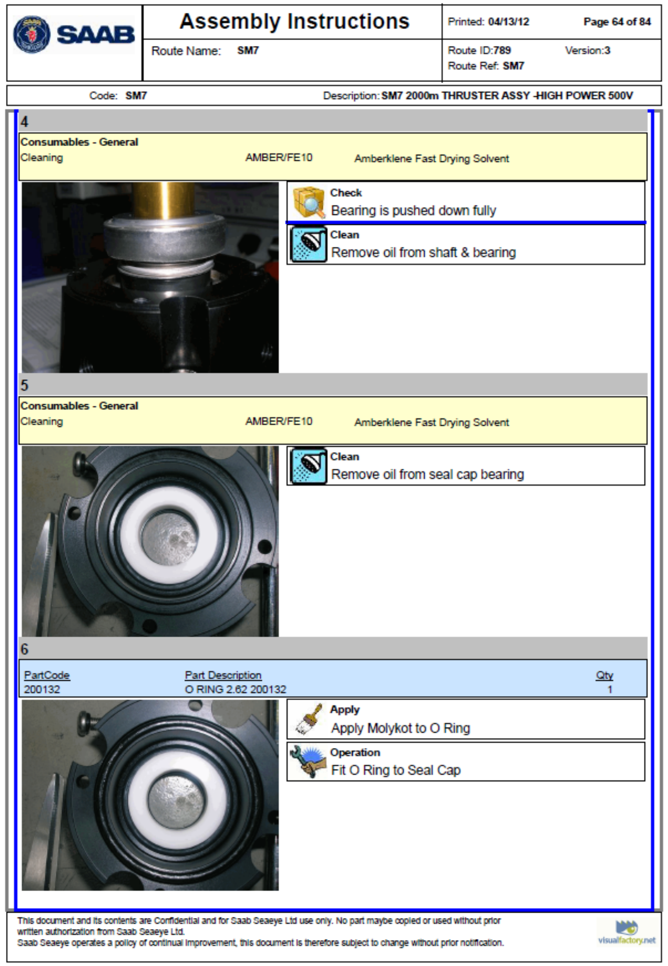

Assembly Instructions

Printed: 04/13/12 Page 64 of 84

Route Name: SM7 Route ID:789 Version:3 Route Ref: SM7

Code: SM7 Description: SM7 2000m THRUSTER ASSY -HIGH POWER 500V

4

Consumables - General
Cleaning AMBER/FE10 Amberklene Fast Drying Solvent

Check: Bearing is pushed down fully
Clean: Remove oil from shaft & bearing

5

Consumables - General
Cleaning AMBER/FE10 Amberklene Fast Drying Solvent

Clean: Remove oil from seal cap bearing

6

PartCode	Part Description	Qty
200132	O RING 2.62 200132	1

Apply: Apply Molykot to O Ring
Operation: Fit O Ring to Seal Cap

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HOLOLENS

MIXED REALITY

EDUCATION AND TRAINING APPLICATIONS

Mixed Reality Education

After Action Review for Live Instrumentation

CONDITION MONITORING & REPORTING

OPERATIONAL ENVIRONMENT VISUALISATION

Operational Environment Visualisation

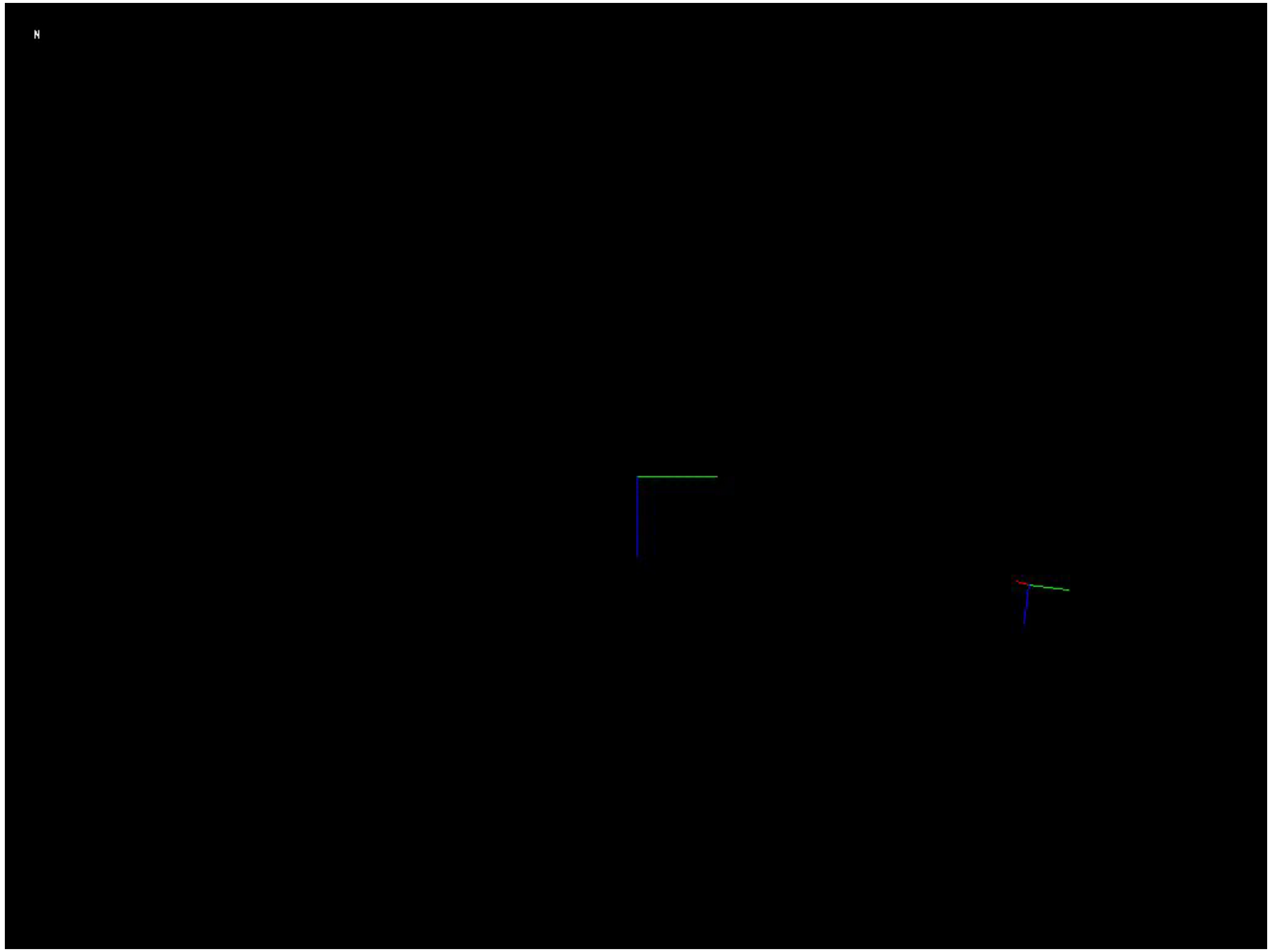
Mixed Reality Collaboration

TECHNICAL SUPPORT & REMOTE EXPERTS

MIXED REALITY

3D SLAM

- Underlying technology 15yrs old; extensively used in “air” applications
- First underwater trials in 2018. Inset display is the live video, main display is 3D point cloud reconstruction. Both displays are in the same timeframe
- Underwater trials and productionisation are ongoing
- Example applications:-
  - Improved pilot awareness (visualisation)
  - Station keeping/tracking system input
  - Input to automatic and ultimately autonomous tooling intervention systems
  - Feature measurement, change and anomaly detection



3D SLAM


Recording: off
Buffer size: 0
Speed (km/h): 5.3
Distance (m): 0.6
ToD: night (25.6)
Frame no: 58
Time: 11.6

QUESTIONS ?

October 16th, 2018

Chris Roper
Saab Seaeye