

OPERATIONAL CONTINUITY USING UNMANNED SURFACE VEHICLES

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SAILDRONE

SAILDRONE IS A LEADING UNMANNED SURFACE VEHICLE (USV) MANUFACTURER, OPERATOR AND PROVIDER OF CRITICAL OCEAN DATA SERVICES FOR DEFENSE AND CIVILIAN USG PARTNERS

 U.S. COAST GUARDS	 NGA	 SOUTHCOM
 NSW	 NOAA	 DIU
 NOAA	 NASA	 PMEL
 WOODS HOLE	 SCRIPPS	 U OF RHODE ISLAND

DEPLOYABLE ASSETS:

100 x USV (23ft)

1 x MUSV (72ft)

MANUFACTURING CAPACITY:

1 USV PER DAY



U.S. OWNED AND OPERATED COMPANY BASED IN ALAMEDA, CA
U.S. BASED MANUFACTURING (IN FORMER NAVAL AIR STATION FACILITY)

NEW STRESSES ON DEEP OCEAN REGIONS REQUIRE NEW SOLUTIONS TO AUGMENT INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE



THE NEED FOR IN-SITU OCEAN DATA IS RISING PUTTING PRESSURE ON MANNED RESEARCH SHIPS FOR BATHYMETRY, WEATHER FORECASTING, FISHERIES MANAGEMENT

SAILDRONE COLLECTS DATA AT SCALE AND ENABLES NEW INSIGHTS



USING LONG ENDURANCE AUTONOMOUS VEHICLES AS A KEY ENABLER

Atmospheric Measurements

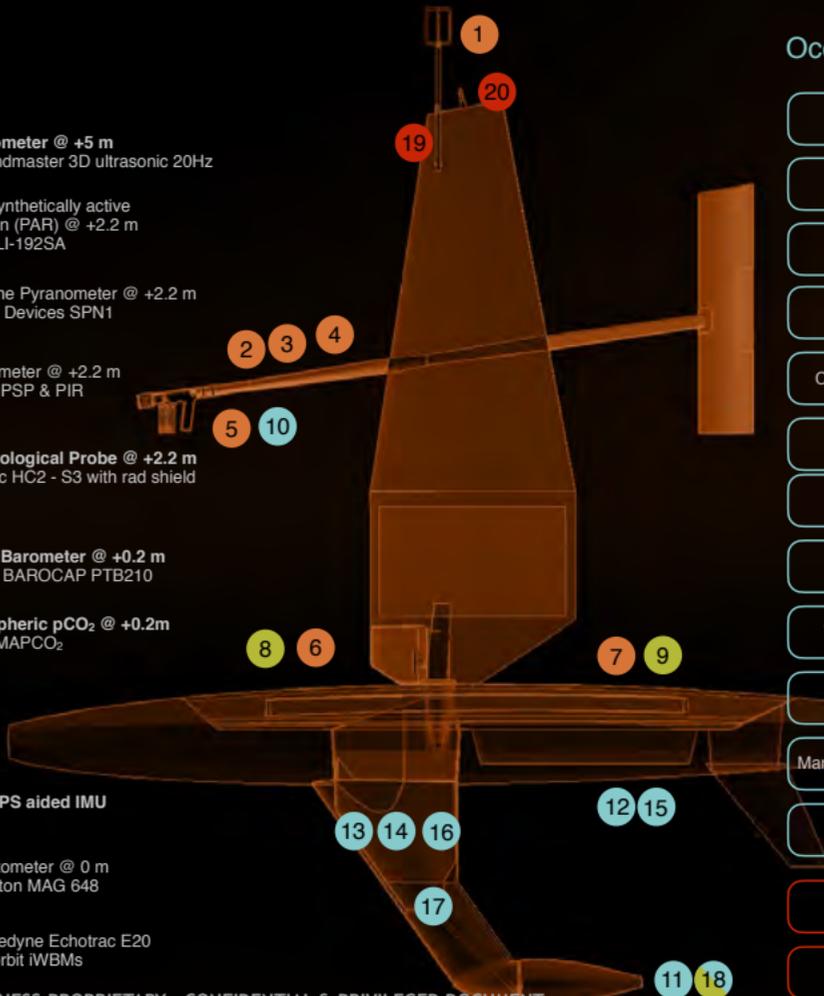
- 1** Wind Speed
Anemometer @ +5 m
Gill Windmaster 3D ultrasonic 20Hz
- 1** Wind Direction
- 2** Radiation
Photosynthetically active radiation (PAR) @ +2.2 m
LI-Cor LI-192SA
- 3** Sunshine Pyranometer @ +2.2 m
Delta-T Devices SPN1
- 4** Pyranometer @ +2.2 m
Eppley PSP & PIR
- 5** Air Temperature
Meteorological Probe @ +2.2 m
Rotronic HC2 - S3 with rad shield
- 5** Relative Humidity
- 6** Pressure
Digital Barometer @ +0.2 m
Vaisala BAROCAP PTB210
- 7** pCO₂
Atmospheric pCO₂ @ +0.2m
PMEL MAPCO₂

Physical Measurements

- 8** Wave Height & Period
Dual GPS aided IMU
- 9** Magnetic Field
Magnetometer @ 0 m
Barrington MAG 648
- 18** Bathymetry
SB: Teledyne Echotrac E20
MB: Norbit iWBMs

Ocean Measurements

- 10** Skin Temperature
SST IR Pyrometer @ +2.2 m
Heitronics CT15.2
- 11** Ocean Currents
ADCP @ -0.2 m
Teledyne RDI Workhorse 300 kHz
- 12** pH
pH Sensor @ -0.5m
Honeywell Durafet
- 13** Chl - a
Fluorometer @ -0.2 m
RBR Chl-a Fluorometer or
Seabird Scientific WET labs
Eco Triplet
- 13** CDOM Concentration
- 13** Red Backscatter
- 14** Dissolved Oxygen
Oxygen Optode @ -0.5 m
Aanderaa 4831 or RBR DO
- 15** pCO₂
Dissolved pCO₂ @ -0.5 m
PMEL MAPCO₂
- 16** Water Temperature
Thermosalinograph @ -0.5 m
RBR CTD or
Teledyne RDI Citadel TS-NH
or Sea-Bird Scientific CTD
- 16** Salinity
- 17** Marine Mammal Acoustics
Passive Acoustic Recorder
Acousonde
- 18** Fish Biomass
SIMRAD Echo Sounder @ -2.5 m
SIMRAD EK80 (WBT Mini)
- 19** AIS
Class B AIS Transceiver
- 20** Camera Array
Saildrone M/L Camera Array
with onboard GPU processing



SAILDRONE IS FULFILLING A WIDE RANGE OF MISSION OBJECTIVES



MARITIME DOMAIN AWARENESS

Monitor illegal traffic in any area

core sensors
+
AIS
Smart cameras



BATHYMETRY

Accurate charting for safe surface and sub-surface navigation

core sensors
+
multi-beam echo sounders
sound velocity profile



METOCAN

improve forecasting or satellite cal/val

core sensors
+
ADCP
radiometers



FISH BIOMASS

Manage sustainable fisheries

core sensors
+
echo-sounder



EMERGENCY RESPONSE

Detect and track oil seeps and spills

core sensors
+
oil detector
echo-sounder



SURFACE FLUXES

Heat and Carbon fluxes (air-sea interaction)

core sensors
+
pCO2
pH



ANIMAL TRACKING

Track tagged fish and mammals

core sensors
+
acoustic tag receiver
hydrophone



DATA RELAY

Harvest data from seabed sensors

core sensors
+
acoustic modems
long range radio

SCIENCE DATA QUALITY RIGOROUSLY TESTED BY NOAA, NASA



“Comparisons with shipboard measurements showed good agreement, inspiring confidence in these new instrument platforms.”

THE USE OF SAILDRONES TO EXAMINE SPRING CONDITIONS IN THE BERING SEA: INSTRUMENT COMPARISONS, SEA ICE MELTWATER AND YUKON RIVER PLUME STUDIES.

“The Saildrones performed well in the harsh conditions of the Bering Sea and demonstrated the potential of this innovative platform to advance ecosystem research.”

ADVANCES IN ECOSYSTEM RESEARCH: SAILDRONE SURVEYS OF OCEANOGRAPHY, FISH, AND MARINE MAMMALS IN THE BERING SEA. OCEANOGRAPHY 30(2):113-115,

“A platform that is ready for ocean research missions from the tropics to the Arctic.”

“THE USE OF SAILDRONES TO EXAMINE SPRING CONDITIONS IN THE BERING SEA: VEHICLE SPECIFICATION AND MISSION PERFORMANCE,” OCEANS 2015 - MTS/IEEE WASHINGTON, WASHINGTON, DC, 2015, PP. 1-6.

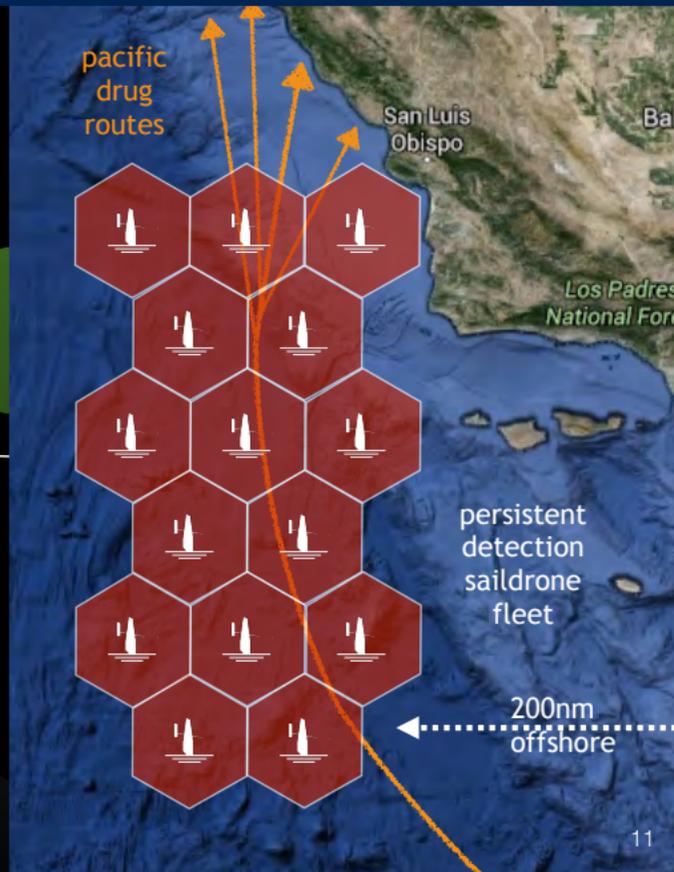
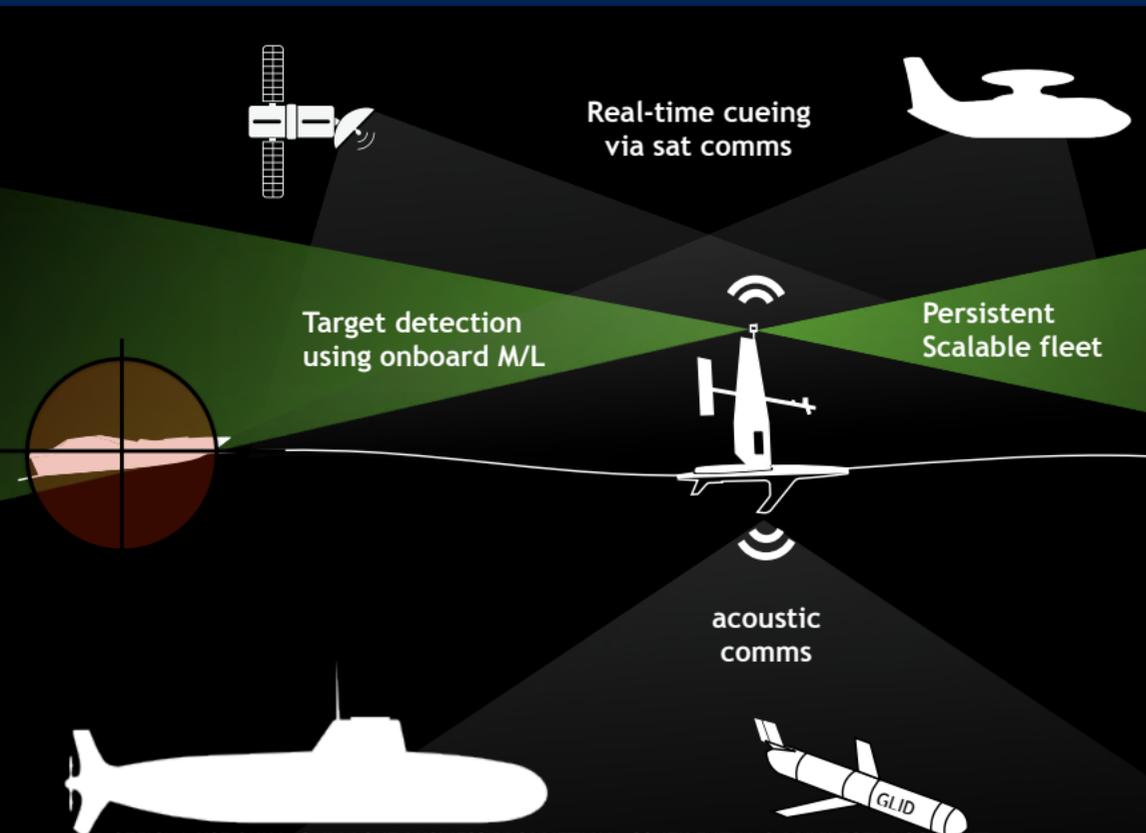
OVER 20 PEER-REVIEWED PUBLICATIONS AFFIRMING DATA QUALITY

| MARITIME DOMAIN AWARENESS

U.S. COAST GUARDS PILOTING MARITIME DOMAIN AWARENESS IN FY20



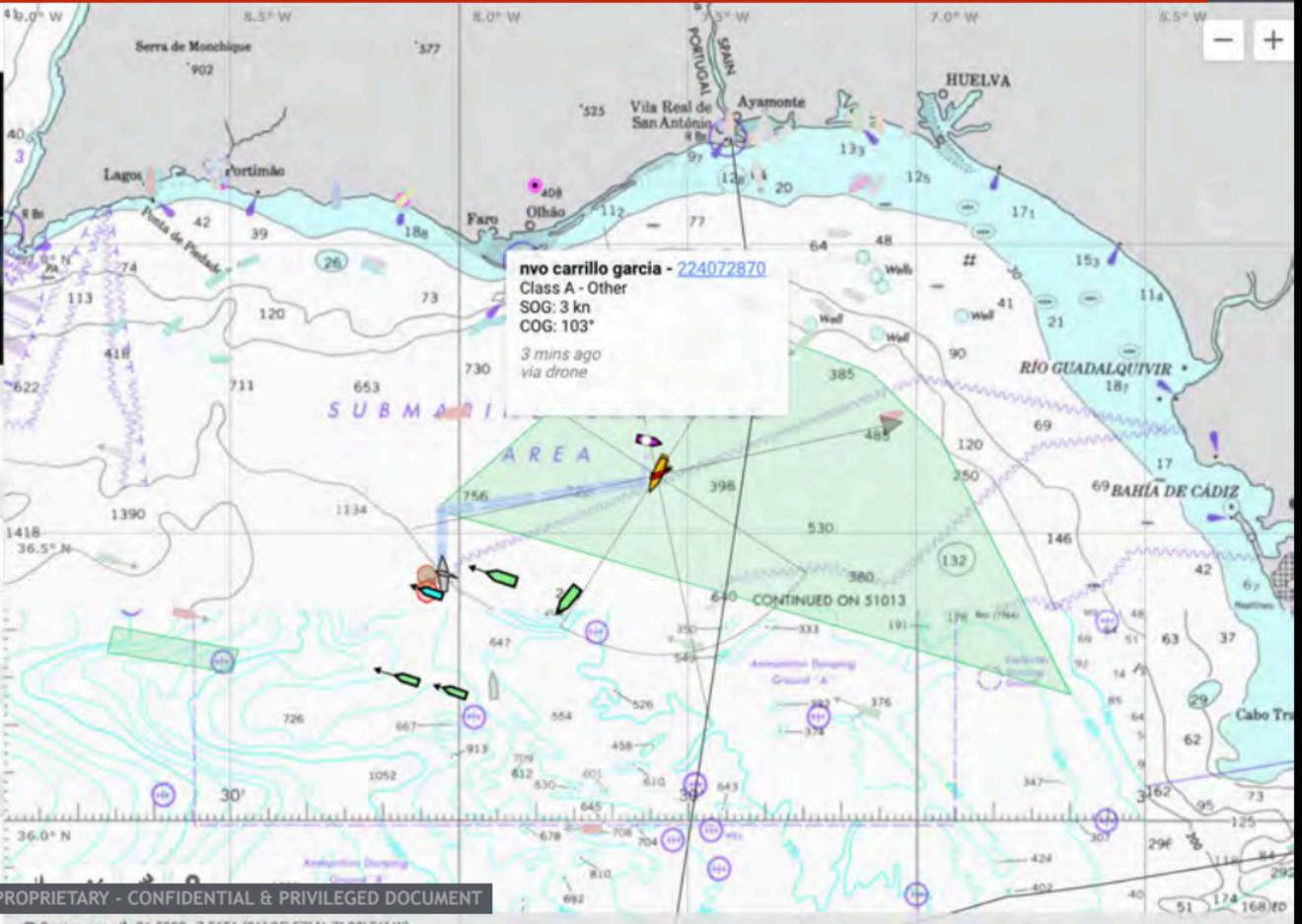
USVs ENABLE PERSISTENT AND SCALABLE MARITIME DOMAIN AWARENESS



TARGET DETECTION FUSING AUTOMATED IDENTIFICATION SYSTEM (AIS)



Environment		
WIND 8.94 kts →	WAVE 1.012 m period: 9.85 sec	CURRENT FORECAST 0.25 kts ↖
Navigation		
SOG 1.267 kts mean: 1.506 kts	TAIL 22.5 ° port	ROLL -14.8 ° peak: -23.8 °
HDG 204.2 °	RUDDER 0.9 ° port	COG 199.2 °
Power		
BATTERY 92.0 %	NET POWER -27.9 W	HYDRO POWER n/a
Auxiliary		
AIS Broadcast	LIGHT Off	CAMERA Scheduled



TARGET DETECTION USING ONBOARD CAMERAS AND MACHINE LEARNING

FLIR

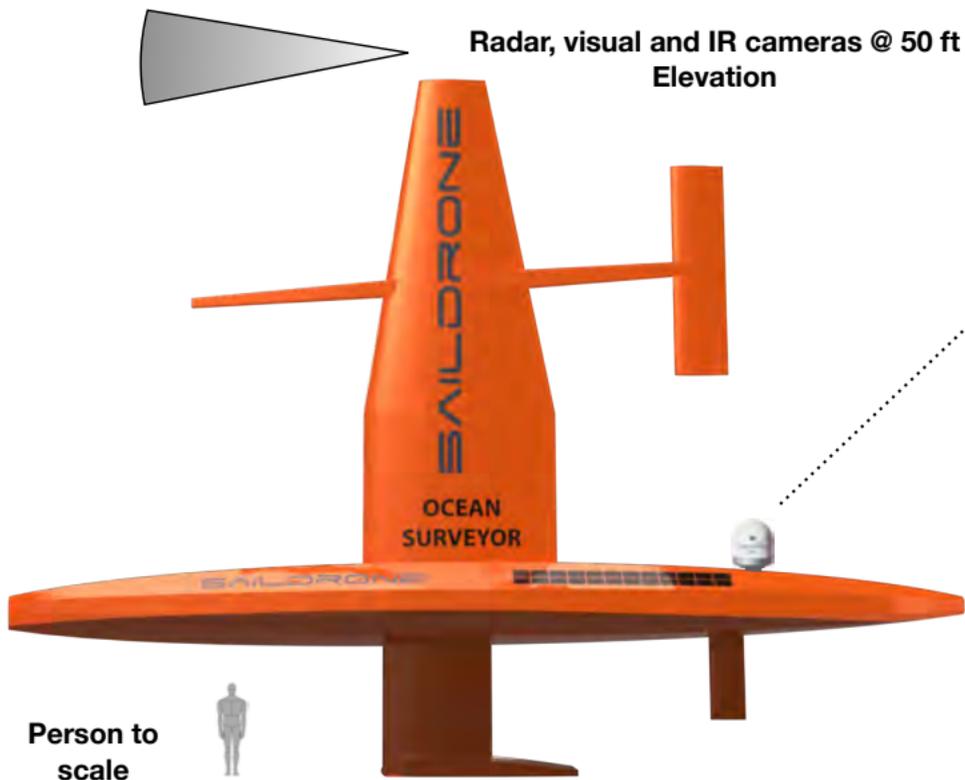
191 deg



IR VESSEL DETECTION USING ONBOARD
ML AND CV TECHNIQUES



THE 72FT-LONG SAILDRONE MUSV OPERATES **RADAR, VISUAL, IR CAMERAS** AT 50FT ELEVATION (EQUIVALENT HEIGHT TO SHIP BRIDGE)



Remote Bridge, manned 24/7

- **Conforms to COLREGS**
- **Onboard processing of bathymetry data and target detection**

SAILDRONE HAS COLLECTED MILLIONS OF IN-SITU IMAGES TO TRAIN M/L ALGORITHM IN WIDE VARIETY OF OCEAN CONDITIONS

Advanced Photo Search

Drone

All Drones

From Date

2019-12-20T18:52:44.226Z

Order

DESC

Tagged

Select Tag...

User Tags

Machine Tags

Search

Drone Photosets

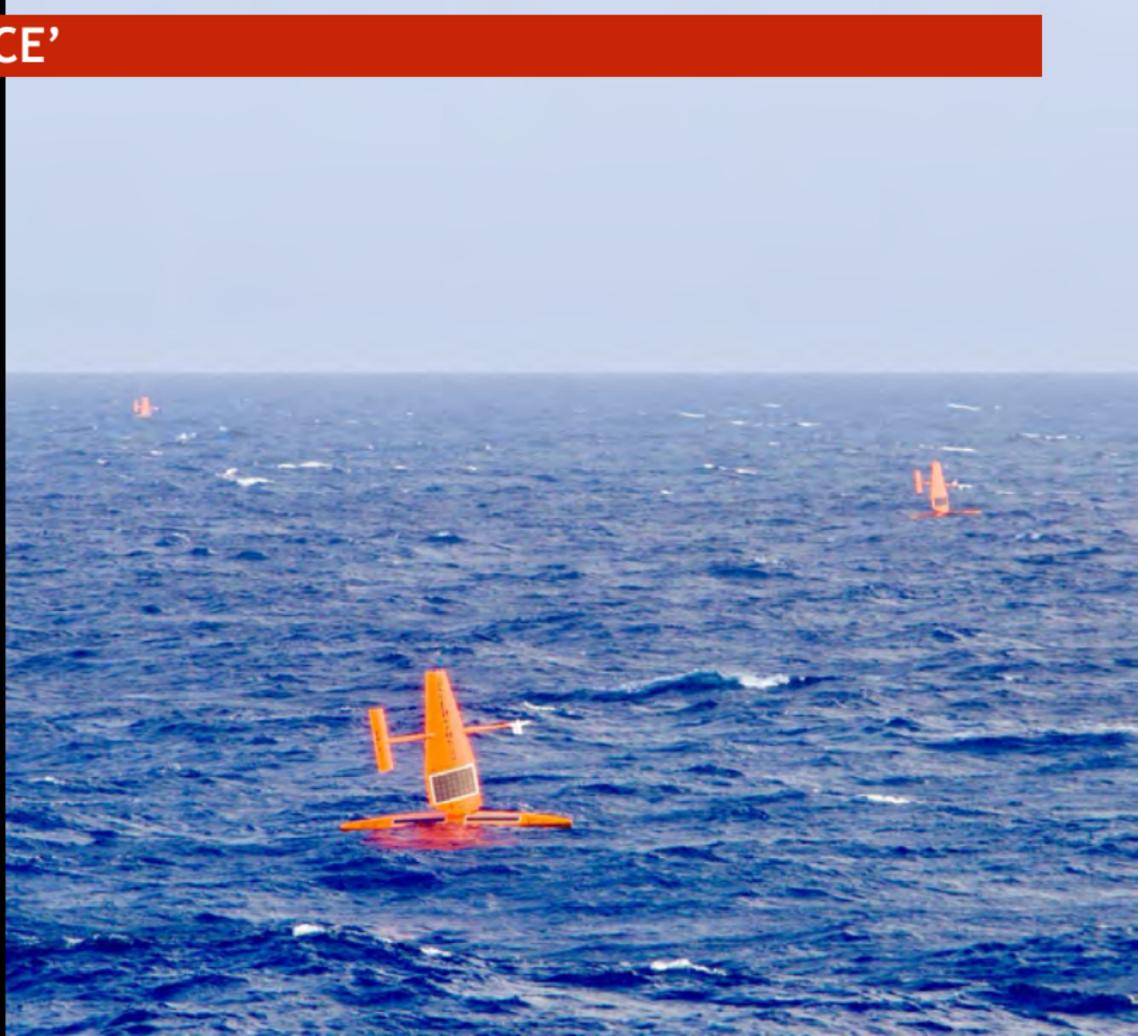
Show Detections



MDA CONOPS: 'PICKET FENCE'

The SAILDRONE USVs can be arranged in a straight line 'array' to detect all vessels trying to transit through a defined area

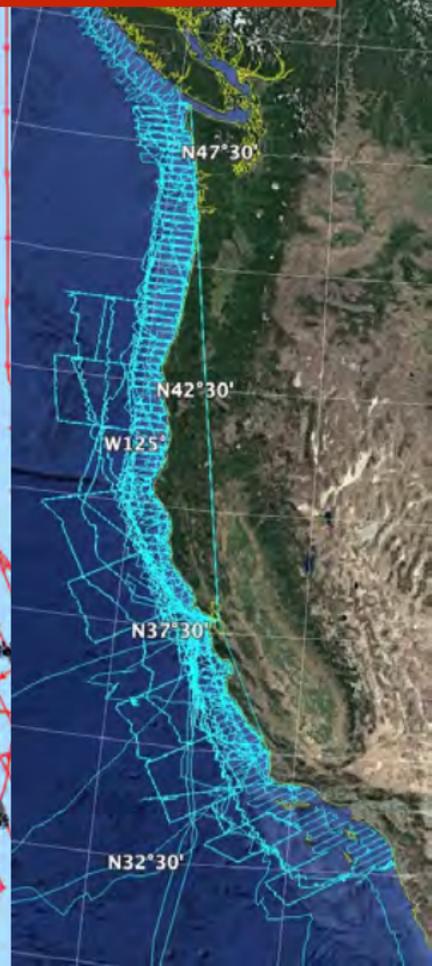
- Vehicle spacing is less than 2 x the detection range to avoid gaps in the array
- The SAILDRONE picket fence formation can detect all targets transiting an area
-



MDA CONOPS: SEARCH AND RESCUE

Sailing patterns designed to detect stationary or drifting objects

- If the target that is required to be detected is stationary or drifting without power, then a stationary picket fence may not be the best formation to find that object.
- Instead, the SAILDRONE USVs can perform typical Search and Rescue (SAR) patterns, such as a ladder and spiral, zigzag etc.
- The USVs can be organized into an array and perform the coordinated SAR patterns
-



MDA CONOPS: ILLEGAL FISHING

Detection of fishing activities in an illegal fishing scenario

- SAILDRONE USVs can capture the presence of any vessel in an area of interest and send back images to assist vessel type identification.
- This supports the requirements for monitoring fishing grounds and detecting illegal fishing activities.



MDA CONOPS: PORTS AND SHIPPING

Port and shipping lane surveillance

- Saildrone fleets can perform port security and surveillance
- Located far enough from shore to be out of sight, but close enough to the shipping lanes to capture traffic entering and leaving any port
- Saildrones can detect traffic to and from the port, and to provide imagery that can assist in verification that the ship details associated with the AIS signals received from targets match the physical appearance of the vessel



C2ISTAR & C3: MDA DATA FEED

Saildrone MDA Data Feed in Mission Portal presents timeline of detections

The MDA Feed provides:

- Photos of detections
- Additional metadata about detected vessels
- Show detections over time and geographically



C2ISTAR & C3: NEAR-REAL TIME DETECTION ALERTS

3 types of detections are presented in the MDA data feed

- “Dark” target- Visual, no AIS
- “Distant” target - AIS, no visual
- “Verified” target - ML & AIS

All detections include

- Time stamp
- Photo from USV onboard camera
- USV ID
- Target ID
- Sea state (wind speed and wave height)

Targets with AIS signal will include additional metadata from the AIS signal and Marine Traffic (e.g. image, vessel type)

“Dark” target- Visual, no AIS

29 1630Z
JUL 20 ⚠

No AIS Signal Detected
SD-1076 detected an unknown vessel bearing 310°.



WSPD 7.0 KTS WVHT 1.5 FT ID 123450000

“Distant” target - AIS, no visual

29 1630Z
JUL 20 ⚠

AIS signal detected. No visual detection.
SD-1075 detected a vessel 7.837 N, -53.395 W but could not confirm visually.



View Details ~

WSPD 7.0 KTS WVHT 1.5 FT ID 123450000

“Verified” target - ML & AIS

09 1322Z
JUL 20 Ⓞ

SD-1074 detected a vessel at 7.837 N, -53.395 W.



View Details ~

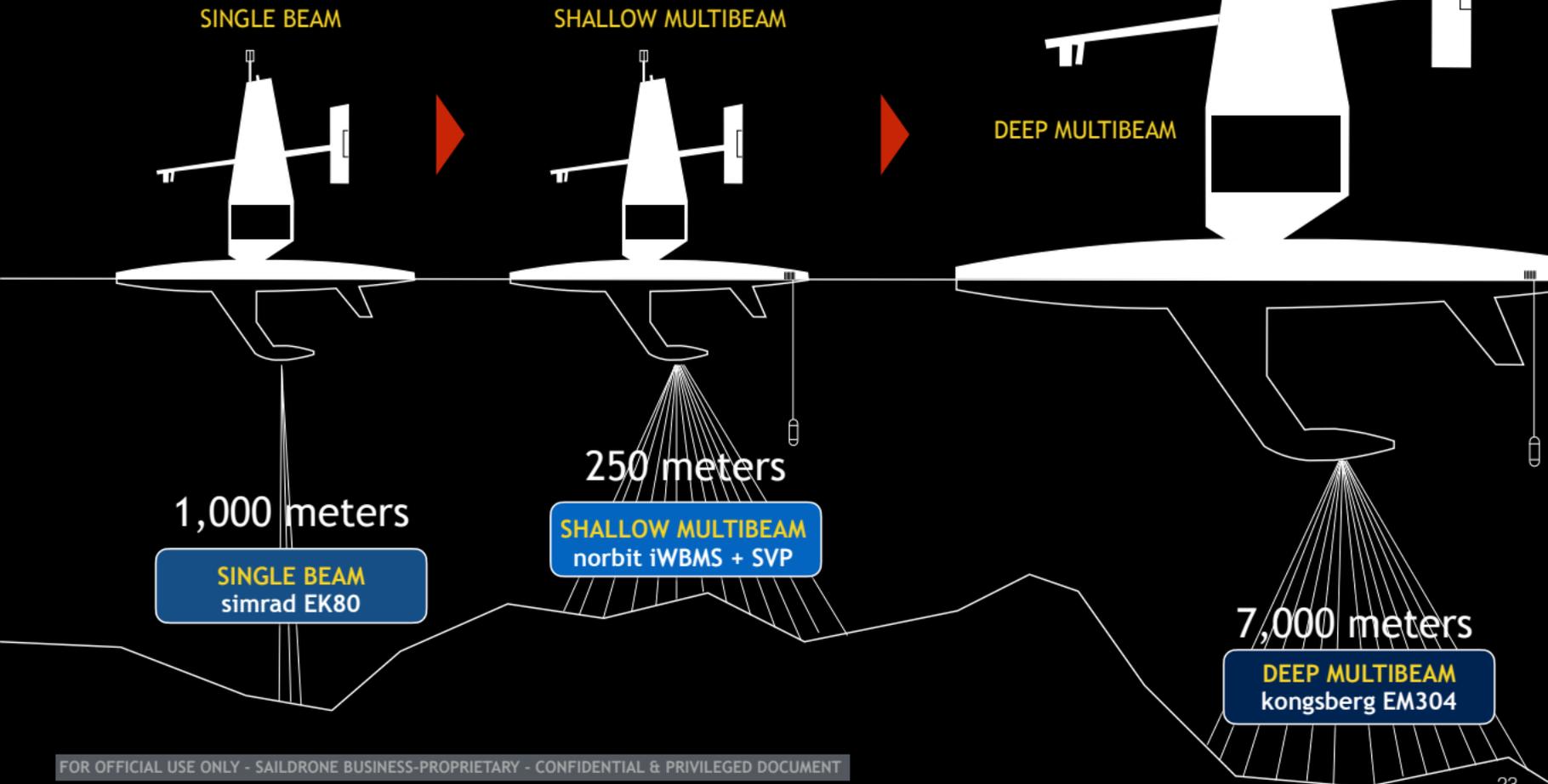
NAME	Atalante	
MMSI	227222000	TYPE Research Vessel
SOG	7.4 kts	RANGE 1.2 NM
		COG 134°



WSPD 7.0 KTS WVHT 1.5 FT ID 123450000

| BATHYMETRY

SAILDRONE - AUTONOMOUS BATHYMETRY CAPABILITY

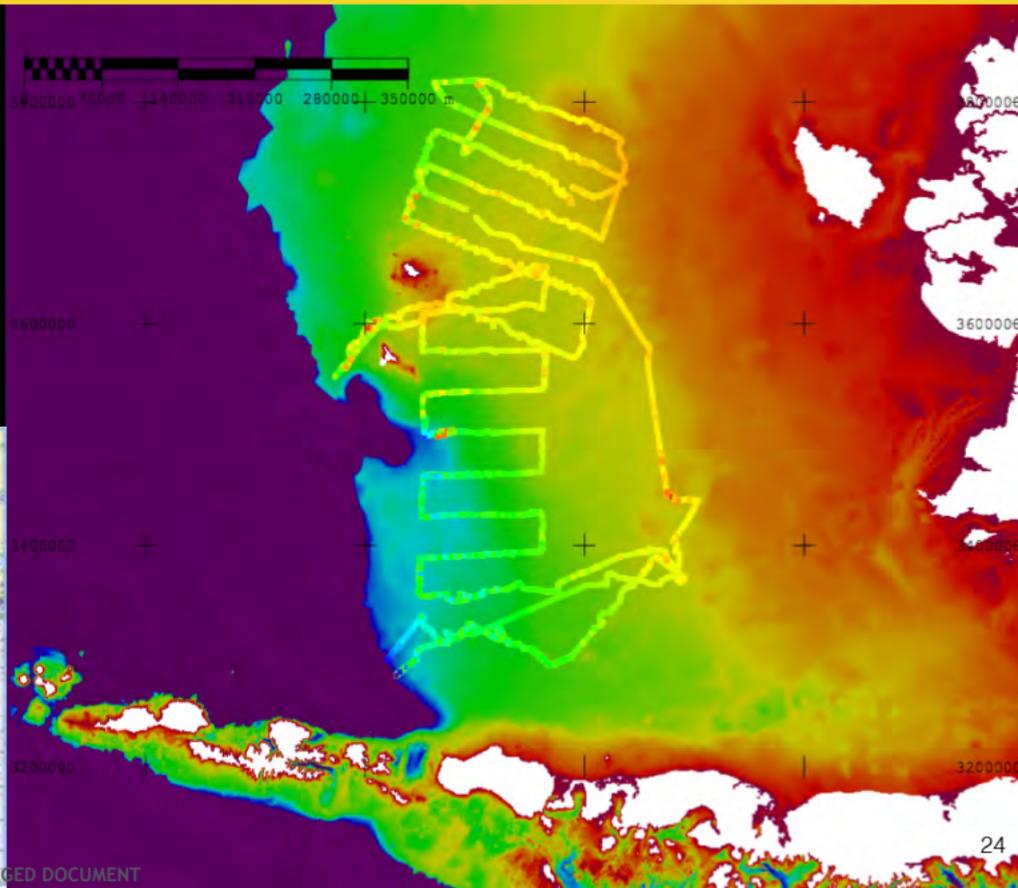
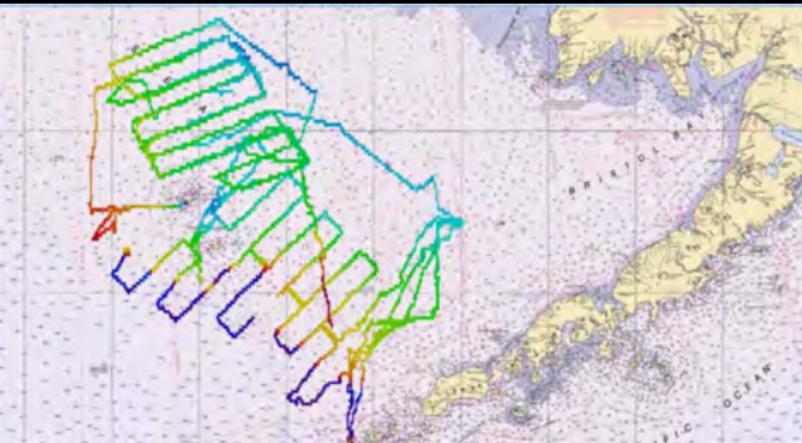


CURRENT CAPABILITY: SINGLE BEAM BATHYMETRY

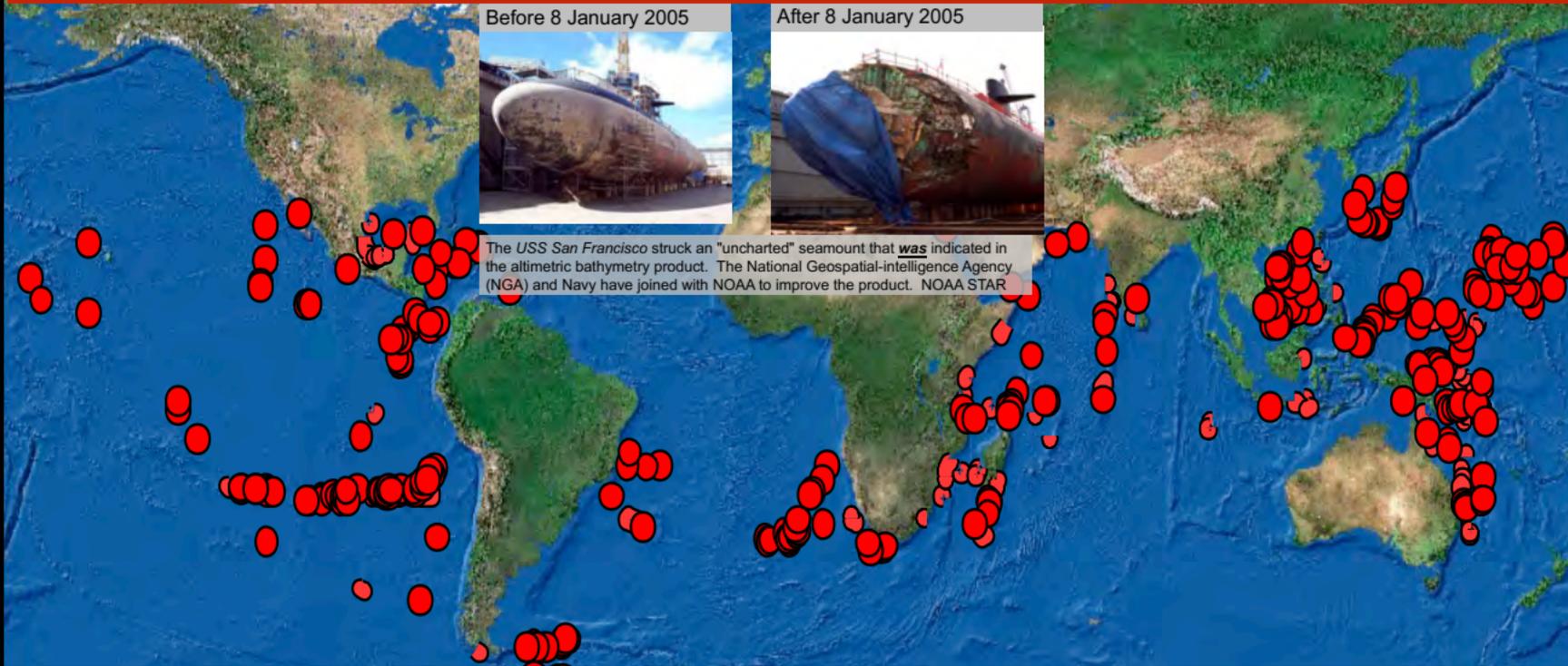
BATHYMETRY DATA USED BY NOAA TO UPDATE CHARTED DEPTHS

“The data from this system is internally consistent, compares well with the NOAA r/v Rainier with little observable bias, and generally is consistent with currently charted soundings. We recommend updating charted depths with the gridded depths from this system, particularly in areas currently with sparse or no coverage.”

- NOAA Office of Coast Survey



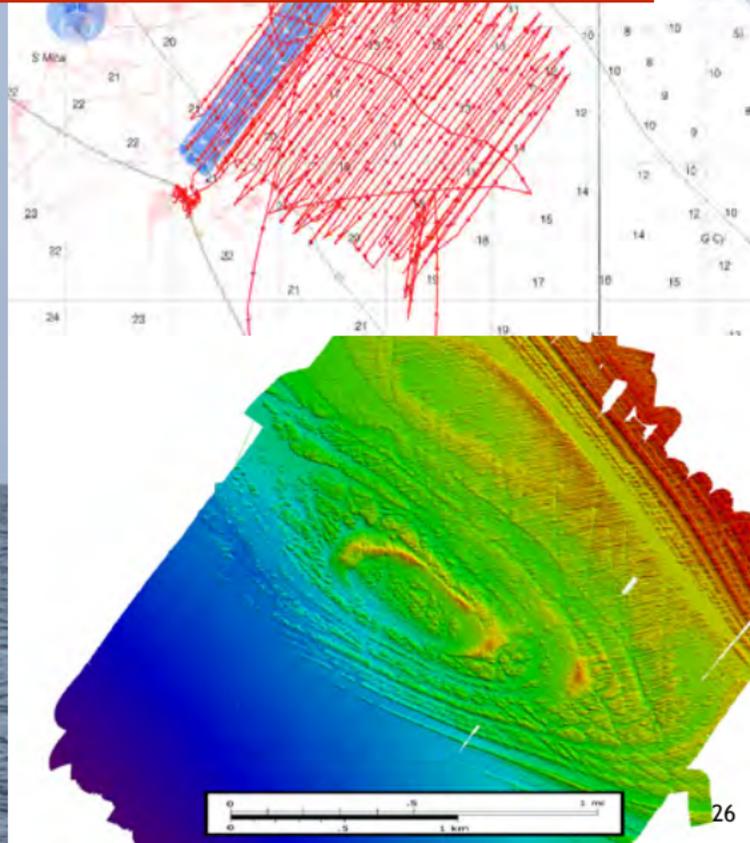
NGA IS CURRENTLY RUNNING A SAILDRONE PILOT MISSION TO ASSESS DATA QUALITY, WITH THE OBJECTIVE TO HELP RESOLVE SUBMERGED HAZARDS IN THE DEEP OCEAN



692 seamounts predicted by altimetry are prioritized for Navy surveys.

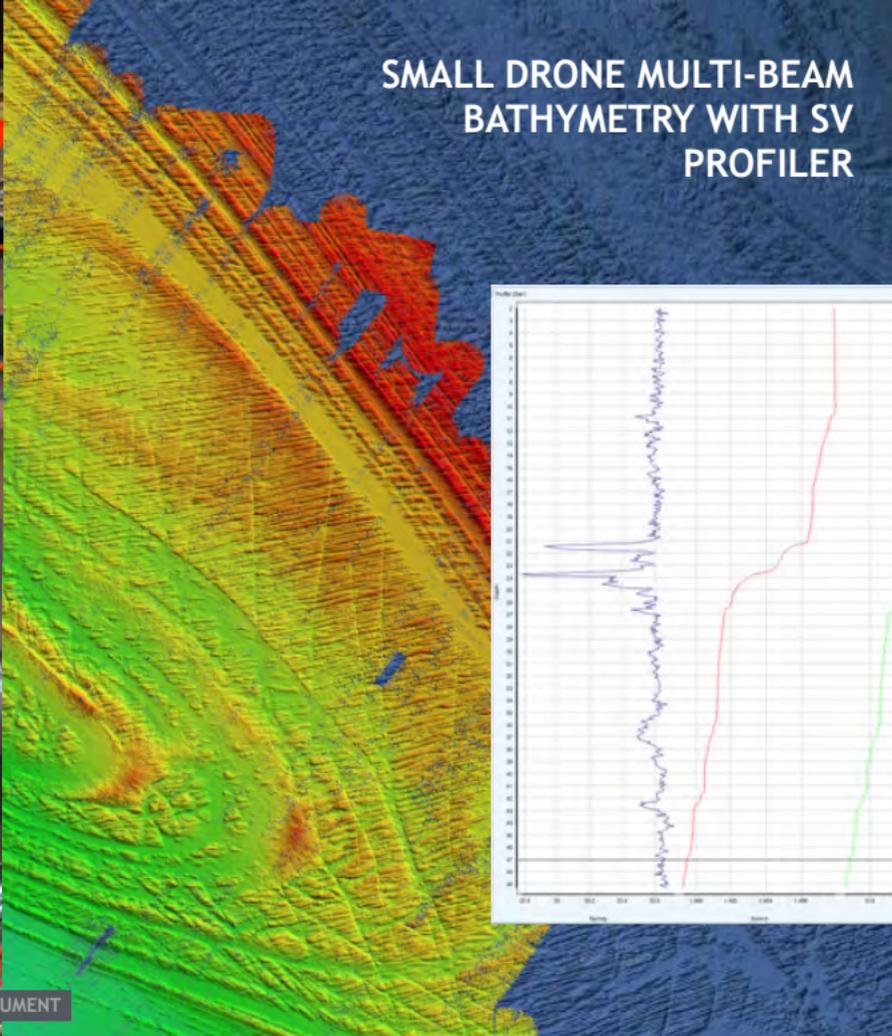
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IN PROGRESS: A SHALLOW WATER MULTIBEAM BATHYMETRY SYSTEM FOR MAPPING IN THE GULF OF MEXICO AND ALASKA (DEVELOPED WITH NOAA AND THE UNIVERSITY OF SOUTHERN MISSISSIPPI)

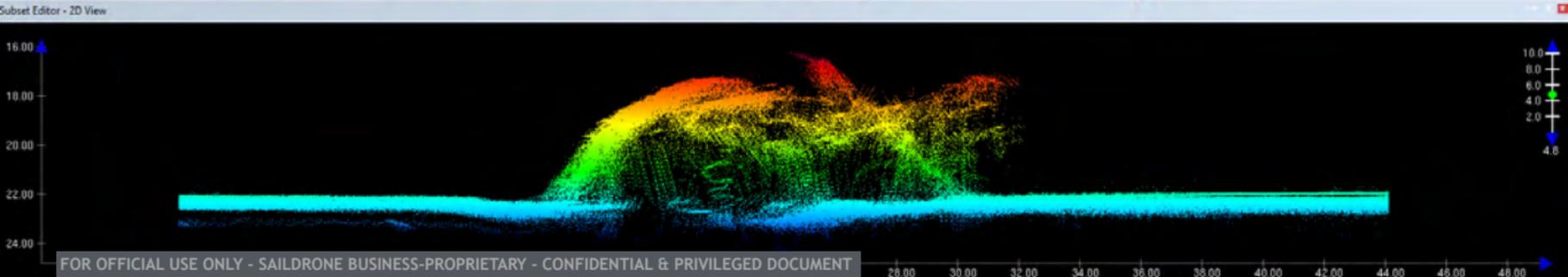
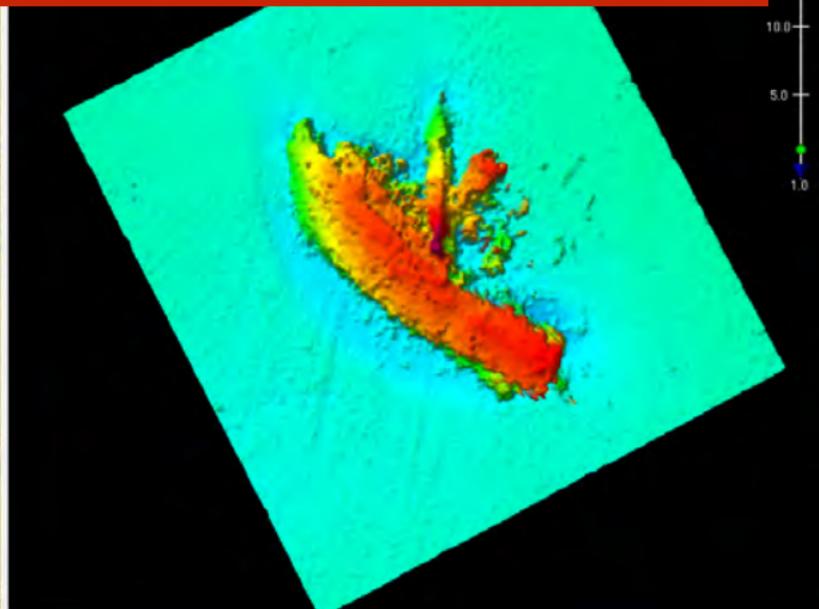
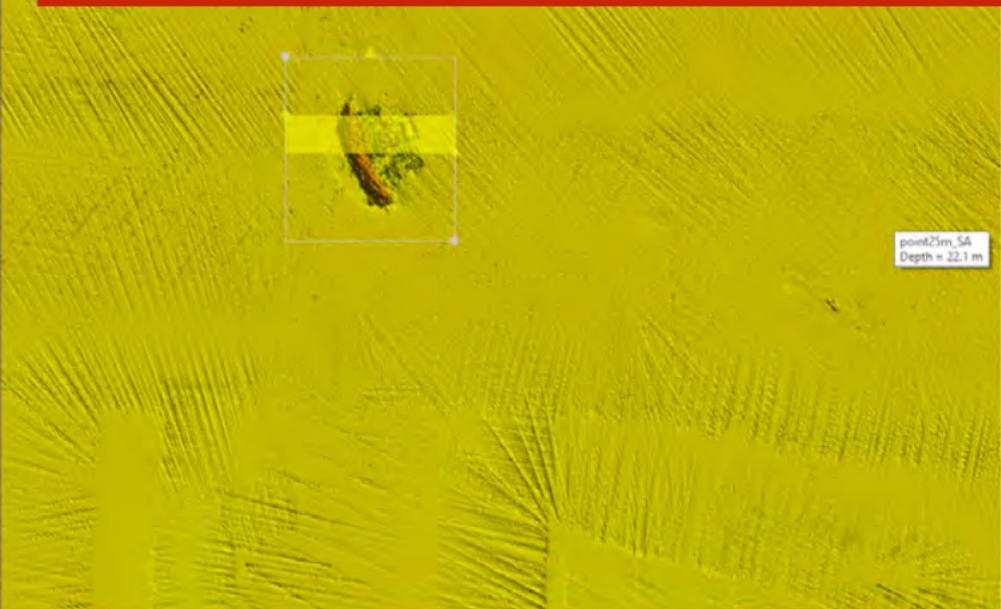




SMALL DRONE MULTI-BEAM BATHYMETRY WITH SV PROFILER



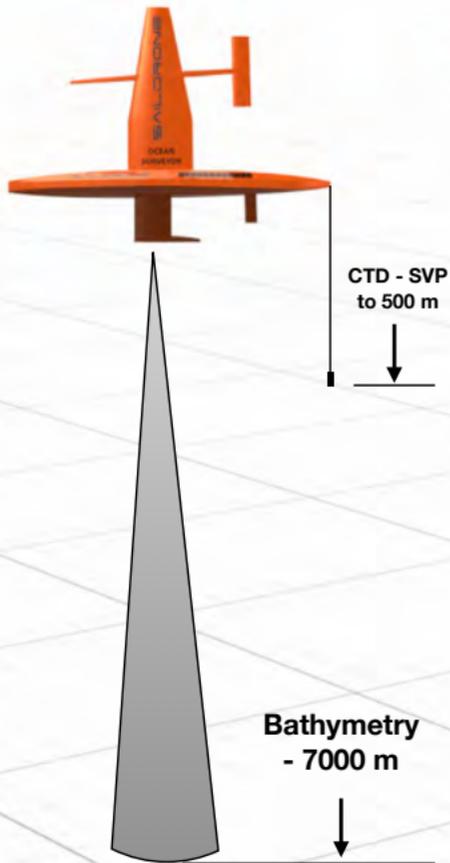
SAMPLE UNDERWATER TARGET IN GULF OF MEXICO NAVY RANGE



**NEW CAPABILITY: 72 FT SAILDRONE MUSV WILL LAUNCH IN 2020;
CAPABLE OF DEEP OCEAN MULTIBEAM MAPPING (NOPP CONTRACT)**



SAILDRONE



SAILDRONE SURVEYOR

An unmanned, long endurance, multi beam system for deep ocean

Payloads:

- Kongsberg EM 304
- Kongsberg EM 2040
- SIMRAD EK80
- SIMRAD 150 kHz ADCP
- RDI Pinnacle 45 ADCP

Stats:

- Mapping Speed: 7 Knots
- Utilization: 330 Days / Yr
- Coverage: 5000 Sq km / day
1.6m Sq km / Yr



| MISSION CONTINUITY

During the COVID-19, Saildrone can plug the gap for Bathymetry down to 1,000m anywhere in the world (and provide MDA in the OPAREA)

1 Survey Vessel



=

1 Collection Group (4 USVs)



During the COVID-19, 5 Sairdrone CG can provide bathymetry equivalent to 5 Survey vessels, for a lesser cost, with additional MDA in the OPAREA

5 Survey Vessels for 90 days

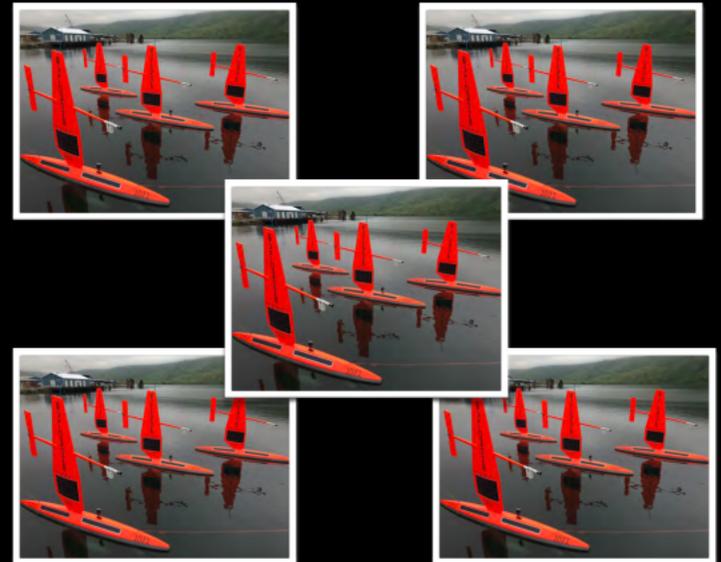
\$25k* x 90 days x 5 vessels = \$11.25m



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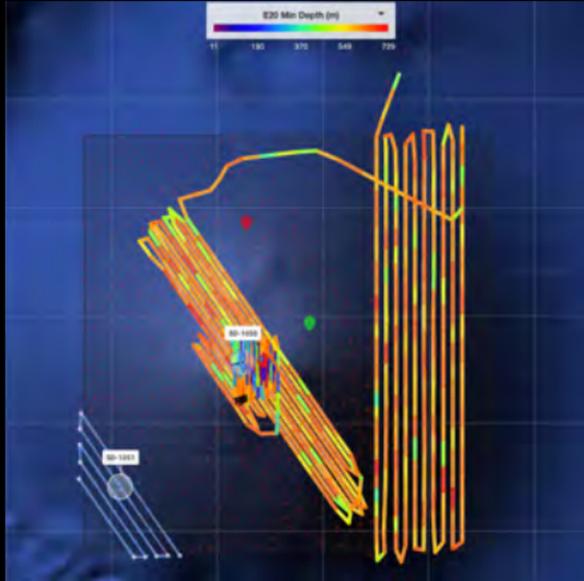
5 Collection Group (20 USVs)

\$22k x 90 days x 5 CG = \$10m

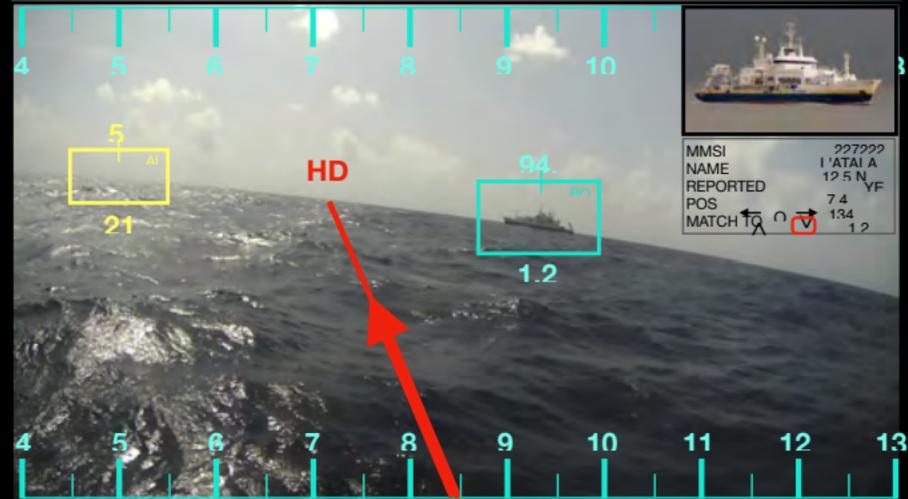


Saildrone 23ft USV fleet offers bathymetry and MDA simultaneously

IHO S-44 Bathymetry (NGA)
(SB echosounder <1,000m)



Maritime Domain Awareness (USCG)
(smart camera array with M/L)





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SAILDRONE