



## HUGIN 1000 and HISAS 1030: Efficient High-quality Seabed Mapping Under Ice

Bjørn Jalving, Per Espen Hagen, Øystein Engelhardtson, Einar Gustafson, Nick Burchill



KONGSBERG

# Outline

- Forming of the HUGIN System
- Under Ice Operational Concept
- Geophysical Survey Suite for Under Ice Survey
- Risk Reduction in AUV Under Ice Survey
- Summary

## Forming of the HUGIN System

# Forming of the HUGIN System

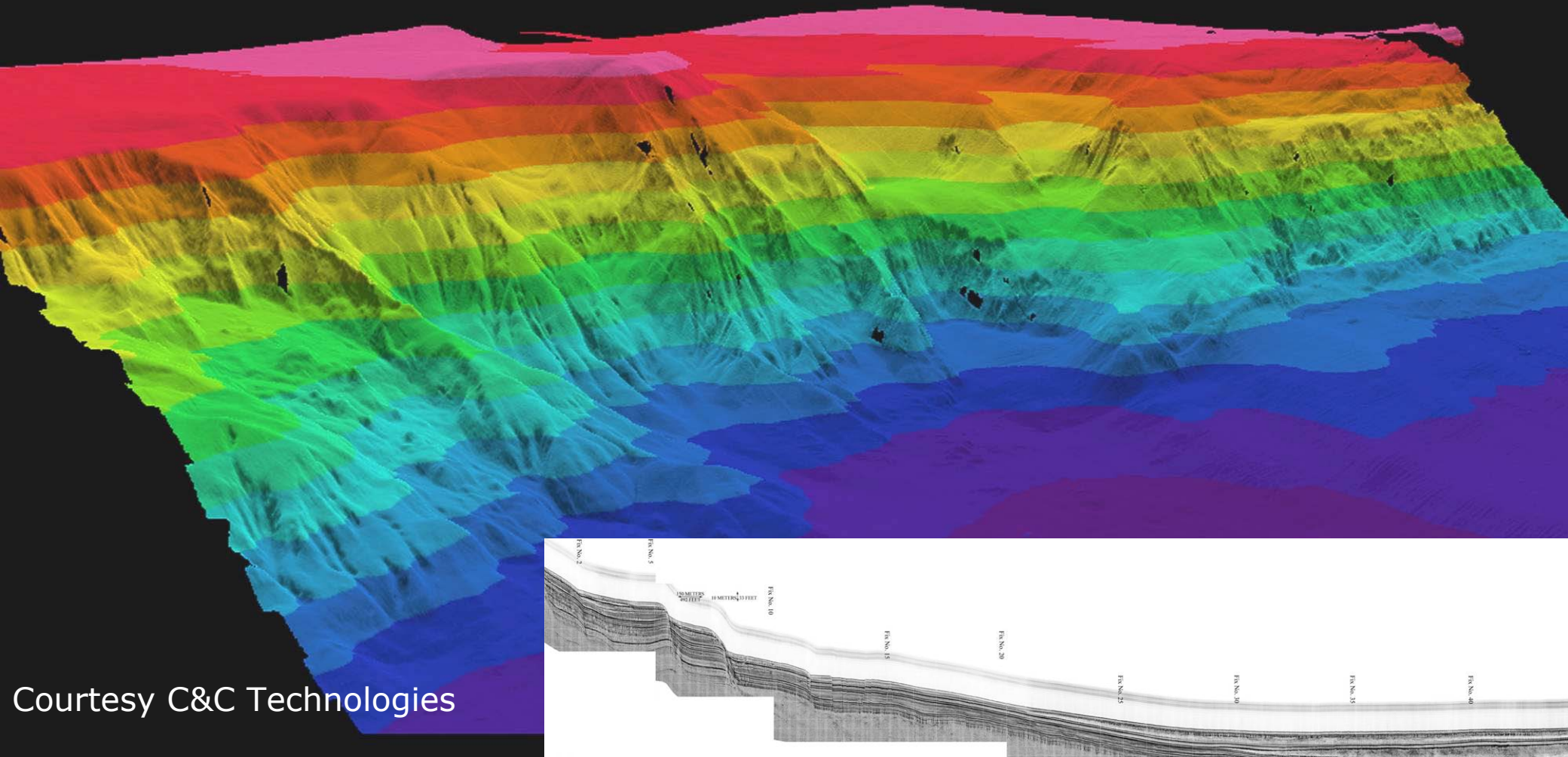


- Development of the world's first offshore oil and gas AUV survey system 1995- 1997 in tight co-operation with StatoilHydro.
  - Integration of multiple high end offshore survey sensors
  - Extreme focus on navigation accuracy
  - Long endurance
  - Launch and recovery system for harsh operations in the North Sea
- Close co-operation between the Royal Norwegian Navy, FFI and Kongsberg Maritime for development of the HUGIN 1000 system for naval MCM and REA.
  - High resolution, high area coverage rate synthetic aperture sonar for detection and classification.
  - Autonomy
  - Complete AUV system for naval applications
- Operations in real and demanding applications from the beginning
- Accumulation of vast operational experience





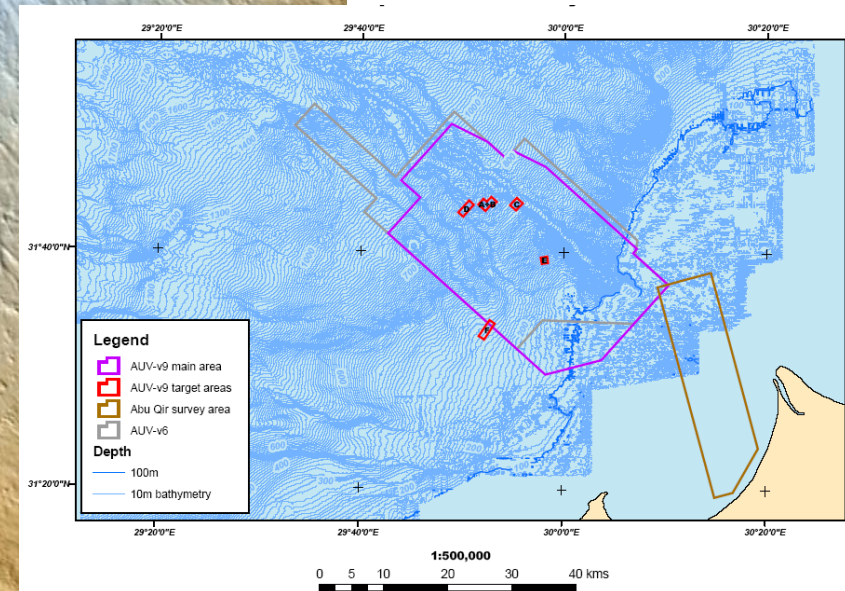
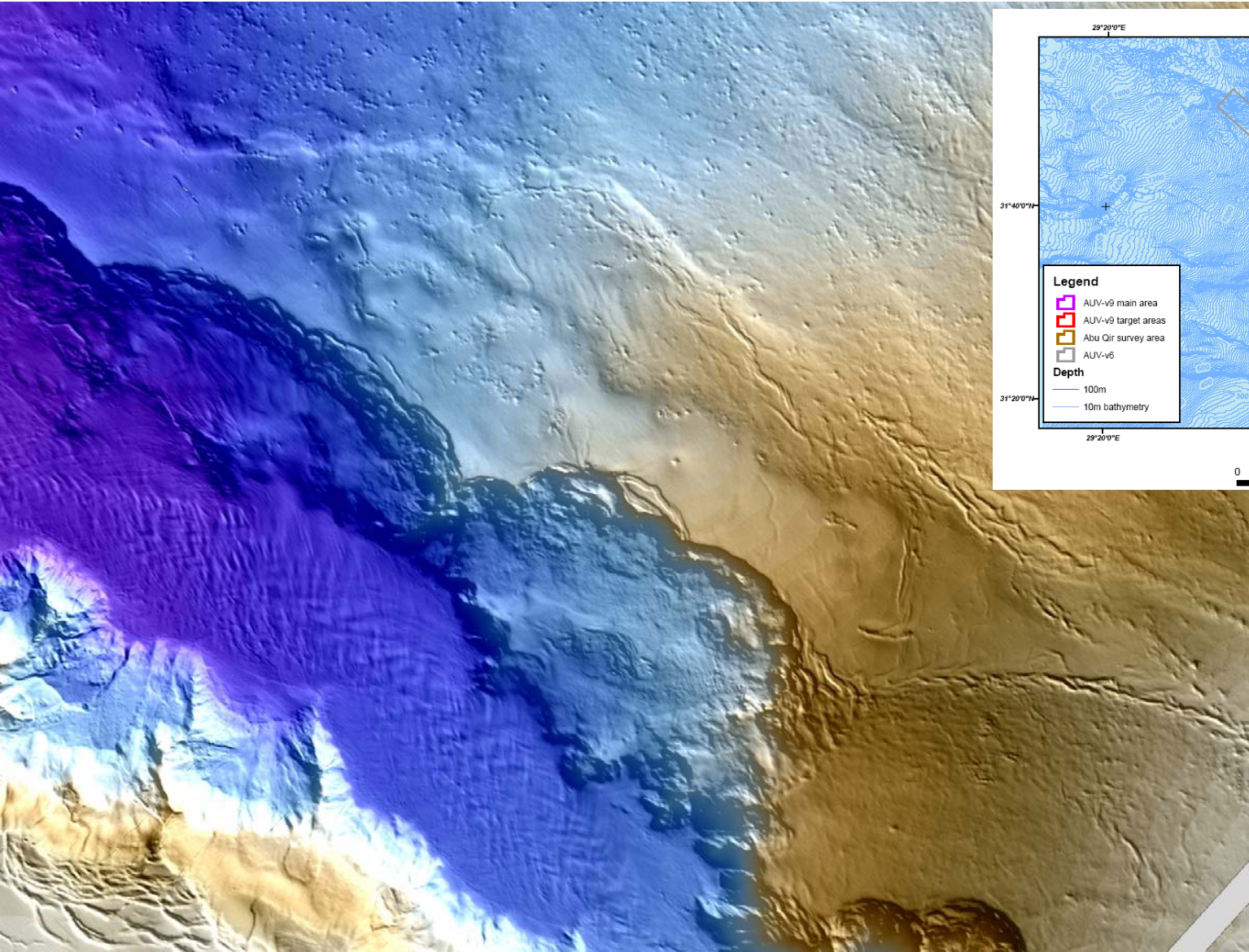
# GOM Sigsbee Escarpment - Swath Bathymetry



Courtesy C&C Technologies

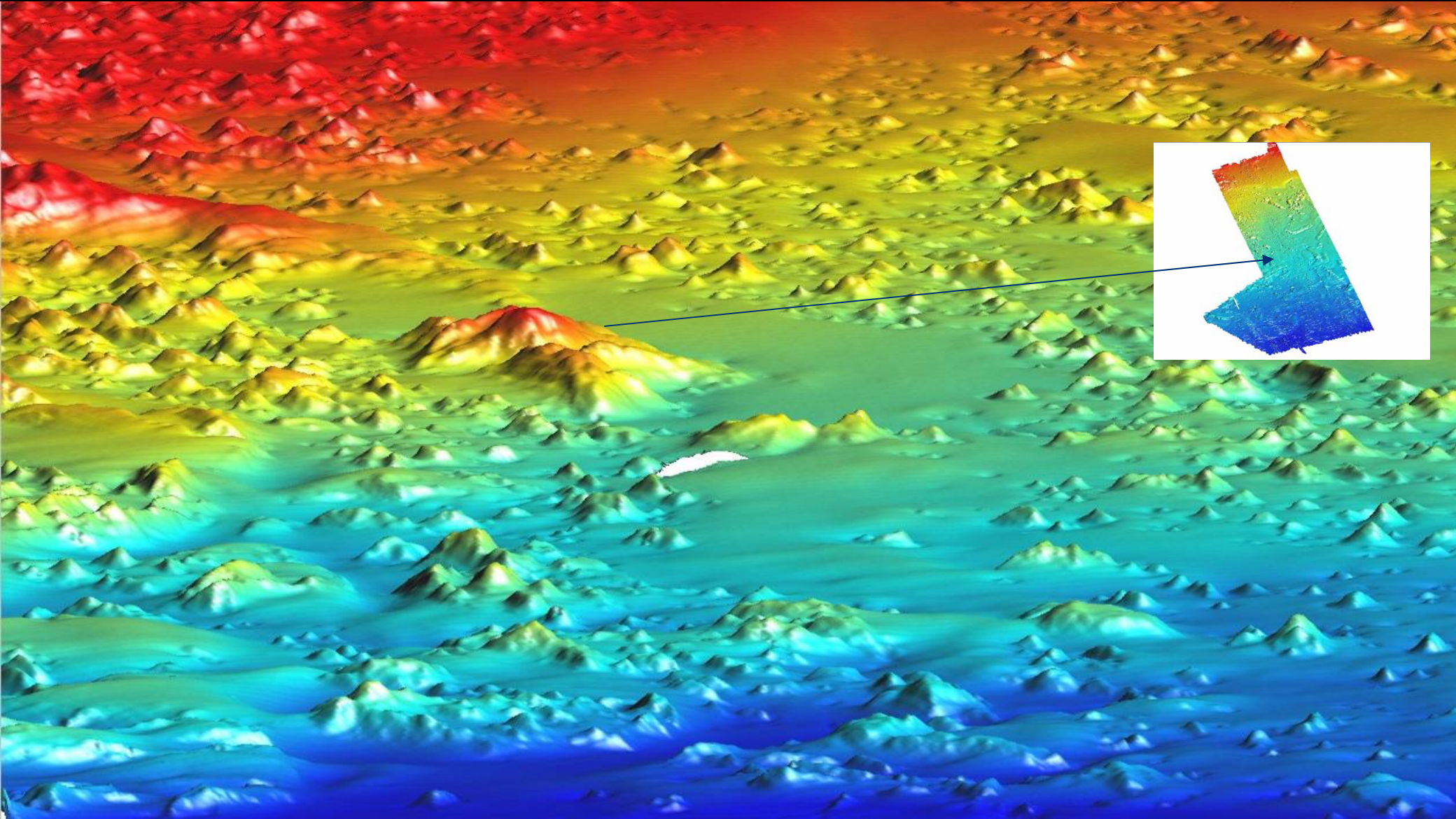


# BP Egypt West Nile Delta - Raven

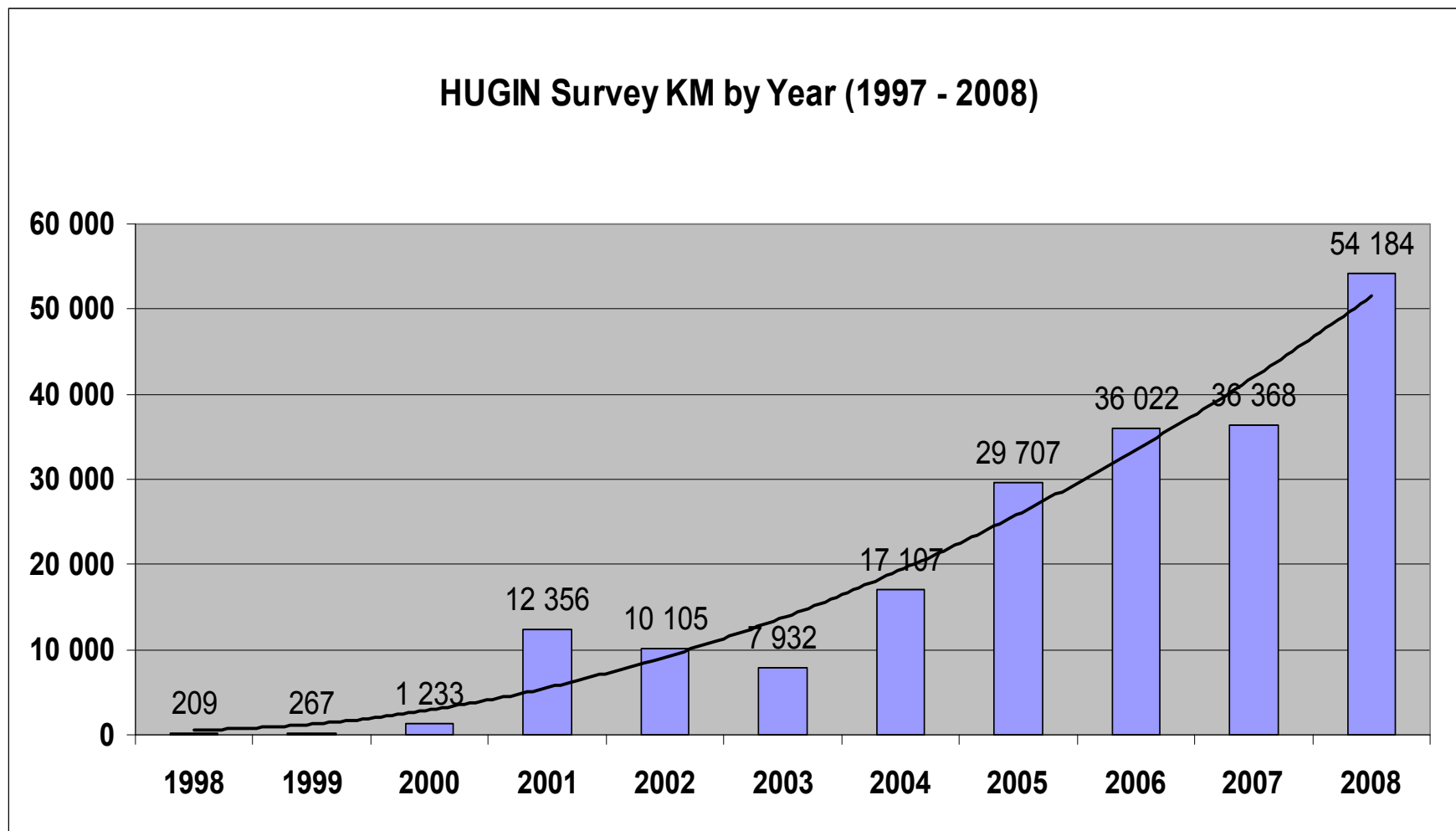




# Norsk Hydro's Ormen Lange Field, 2002



# HUGIN Survey Kilometer per 2008 for Oil & Gas Survey Industry





# Under Ice Operational Concept

# AUV Under Ice Survey Operations

- Conventional seabed mapping with icebreakers
  - Time consuming
  - Challenge to run straight lines
  - Challenge with ice under multibeam echo sounder
- AUV contributions:
  - Accurate following of planned survey lines
  - Increased mapping efficiency
  - Increased data quality
  - Increased mapping resolution
  - Simultaneous recording of full geophysical sensor suite and oceanographic data



# Operational Concept for Large Area Mapping

- AUV is operated from icebreaker
- Icebreaker brings AUV into area of interest
- Large under ice areas are effectively mapped by the combination of ice breaker and long range AUV equipped with high area coverage rate sensors
- Icebreaker provides capability to recover the AUV in case of an emergency situation



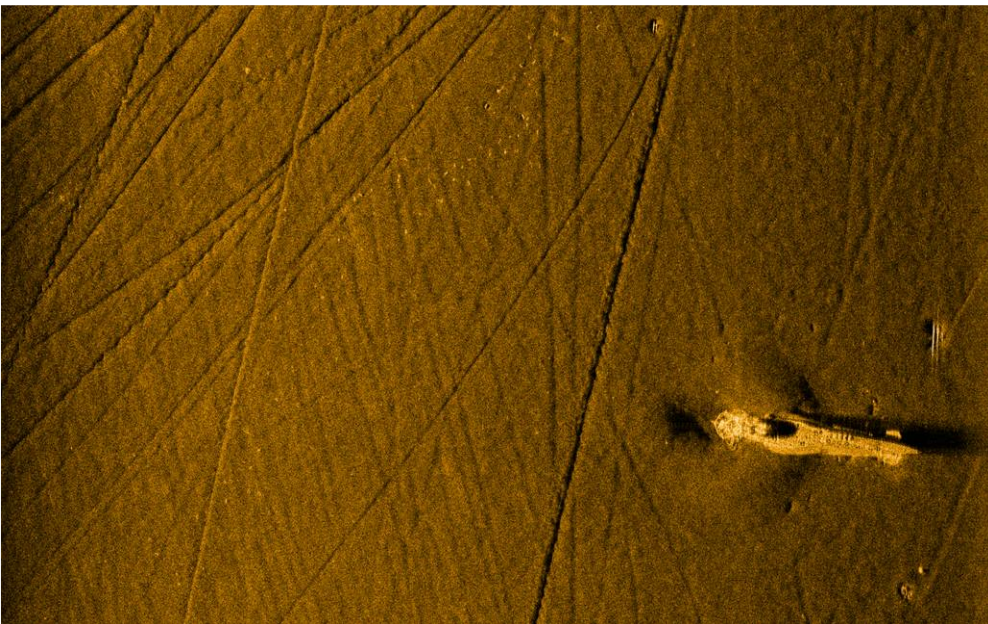
(Picture of KV Svalbard. Shown for illustration purposes.)



# Geophysical Survey Suite for Under Ice Surveys

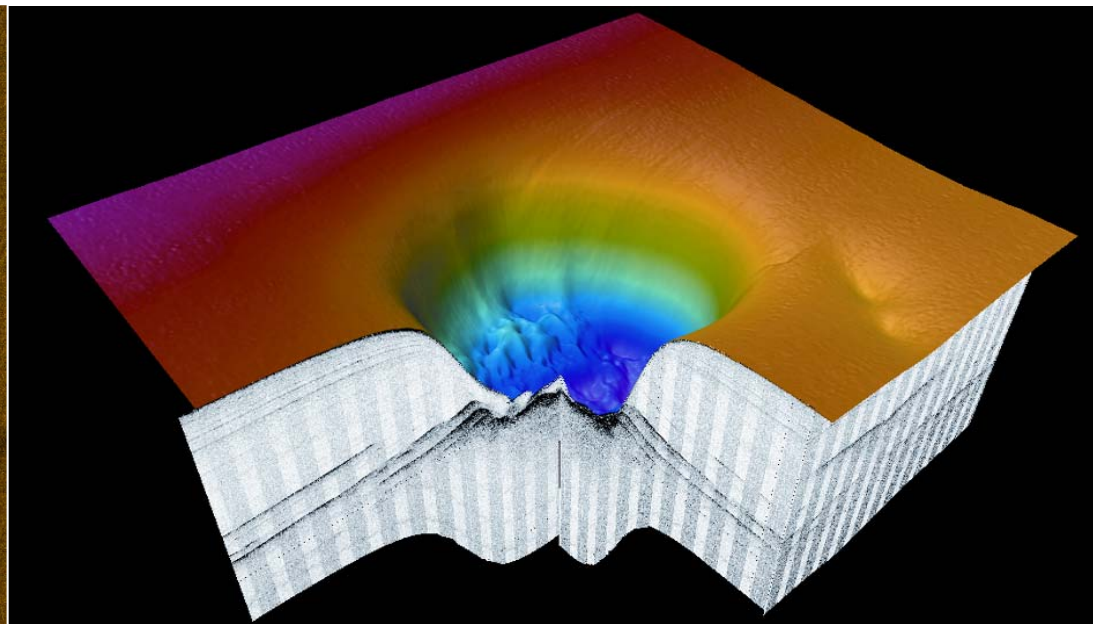
# Standard Geophysical and Oceanographic Sensor Suite

- Bathymetry
- Imagery
- Sub-bottom structure
- Digital still camera
- Sea current profiles
- Temperature, salinity



Acoustic imagery

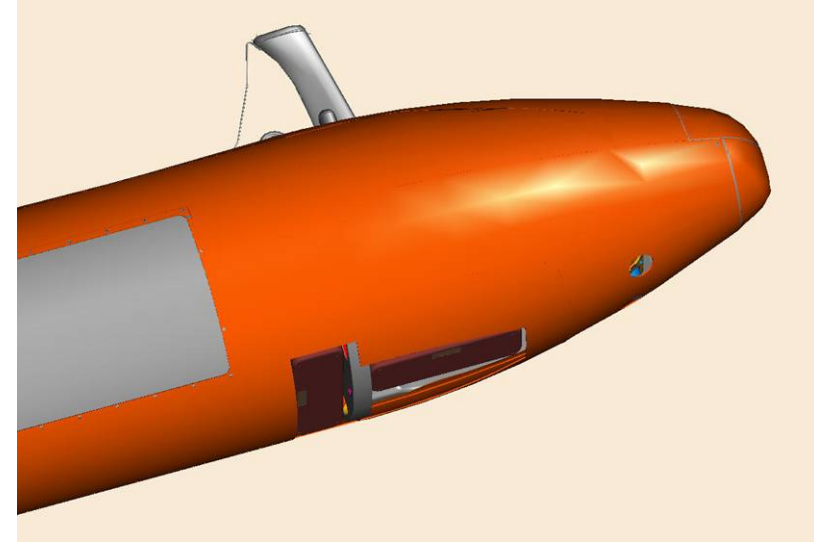
HISAS 1030 on HUGIN 1000, 50 - 220 m range



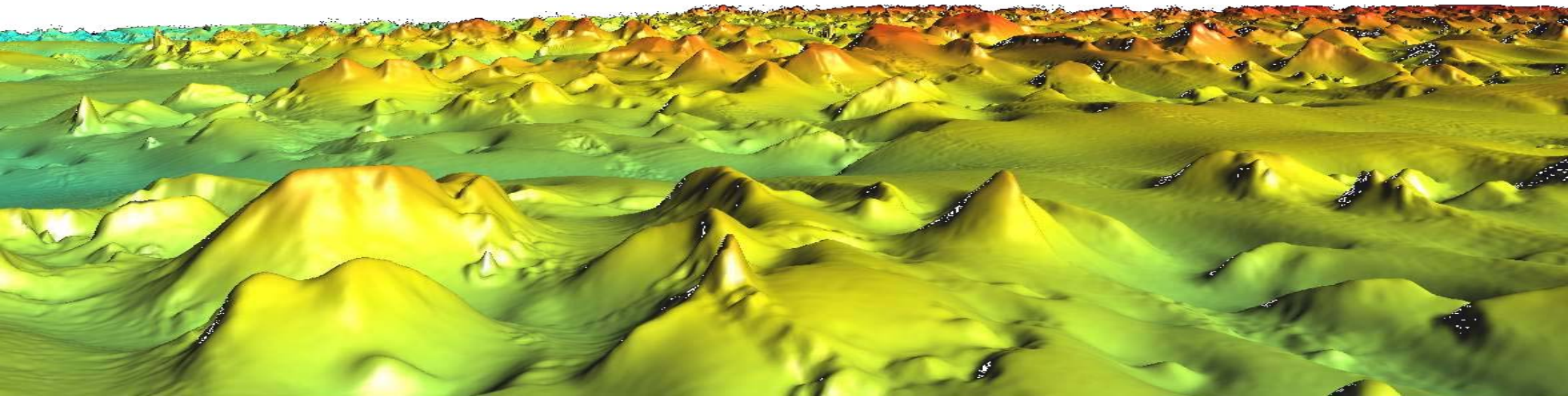
Bathymetry and sub-bottom data  
Courtesy C&C Technologies

# Multibeam Echo Sounder

- The first MBE was fitted to HUGIN in 1996
- MBEs on HUGIN AUVs
  - EM 3000
  - EM 2000
  - EM 3002
  - EM 2040 (from Fall 2010)



HUGIN 1000 with EM 2040





# Bathymetry Solutions and Swath Widths

- High frequency multibeam systems
    - EM 3002: Max swath = 150 m
    - EM 2000: Max swath = 200 m
  - Synthetic aperture sonar: HISAS 1030 bathymetry
    - Max swath = 500 m
- ⇒ HISAS 1030 can double area coverage rate compared to AUVs with only multibeam echo sounder.
- ⇒ Increased area coverage rate allows mapping of larger areas at lower cost and inherently lower risk due to speed.



# HISAS 1030

## Multi-Aspect Interferometric SAS



- Specifications:
  - Image resolution better than 5x5 cm (theoretical: 2x2 cm)
  - Range 175-200 m @ 4 knots; 230-260 m @ 3 knots; or 10 x altitude
  - Typical SAS bathymetry resolution 10x10 cm
  - 20-40° multi-aspect capability
  - Frequency and bandwidth configurable within 50 to 120 kHz; 85-115 kHz typical configuration
- First version in use on HUGIN in March 2005

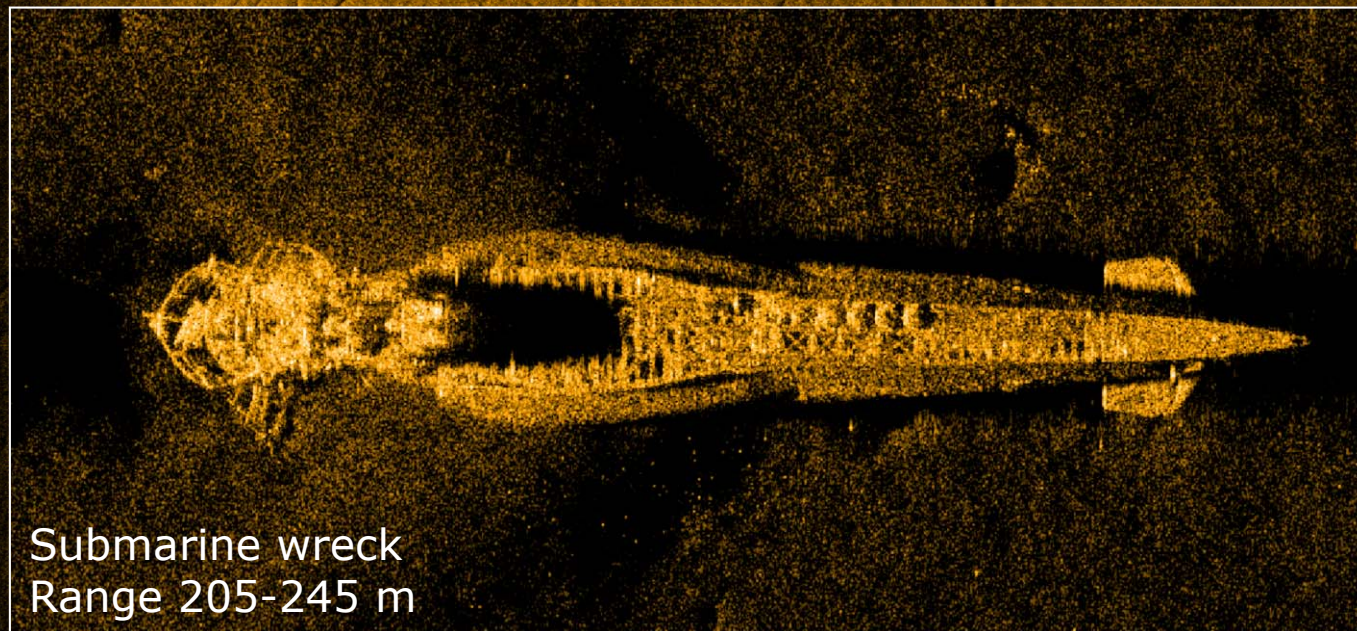
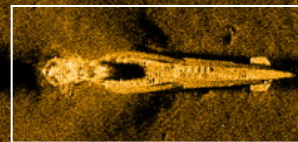


# HISAS 1030 Example Data

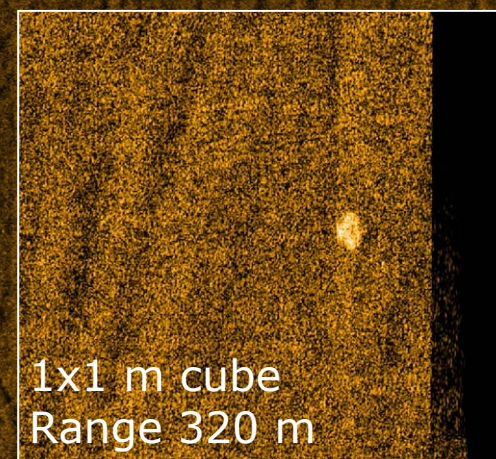
HISAS 1030 on HUGIN 1000-MR  
Range 45-325 m  
AUV altitude 40 m  
Speed 2.3 knots



# HISAS 1030 Example Data

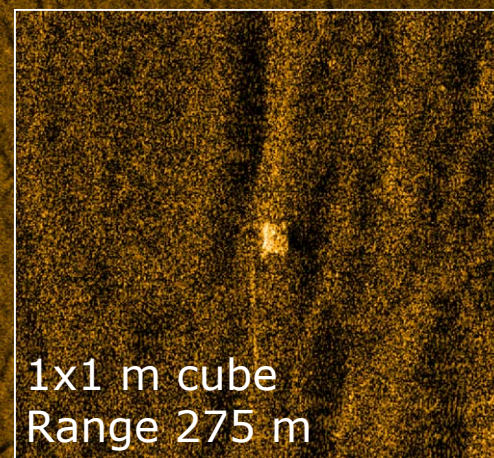


Submarine wreck  
Range 205-245 m

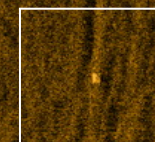


1x1 m cube  
Range 320 m

HISAS 1030 on HUGIN 1000-MR  
Range 45-325 m  
AUV altitude 40 m  
Speed 2.3 knots

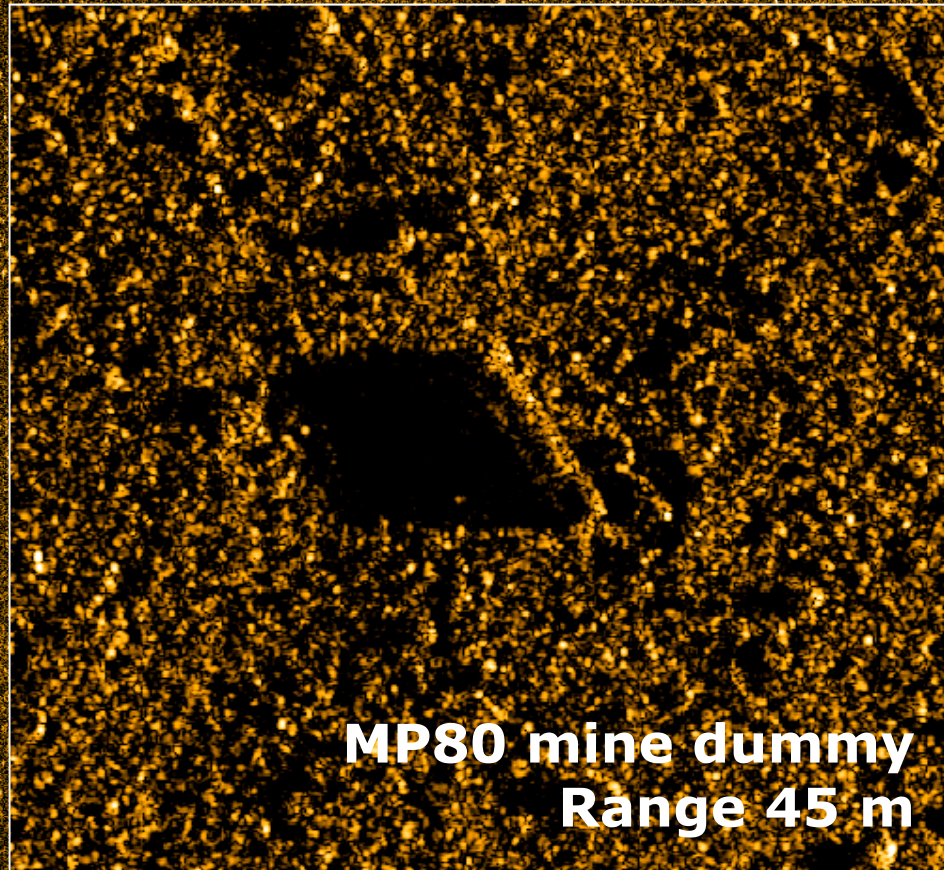


1x1 m cube  
Range 275 m





# HISAS: Very Shallow Water Operation

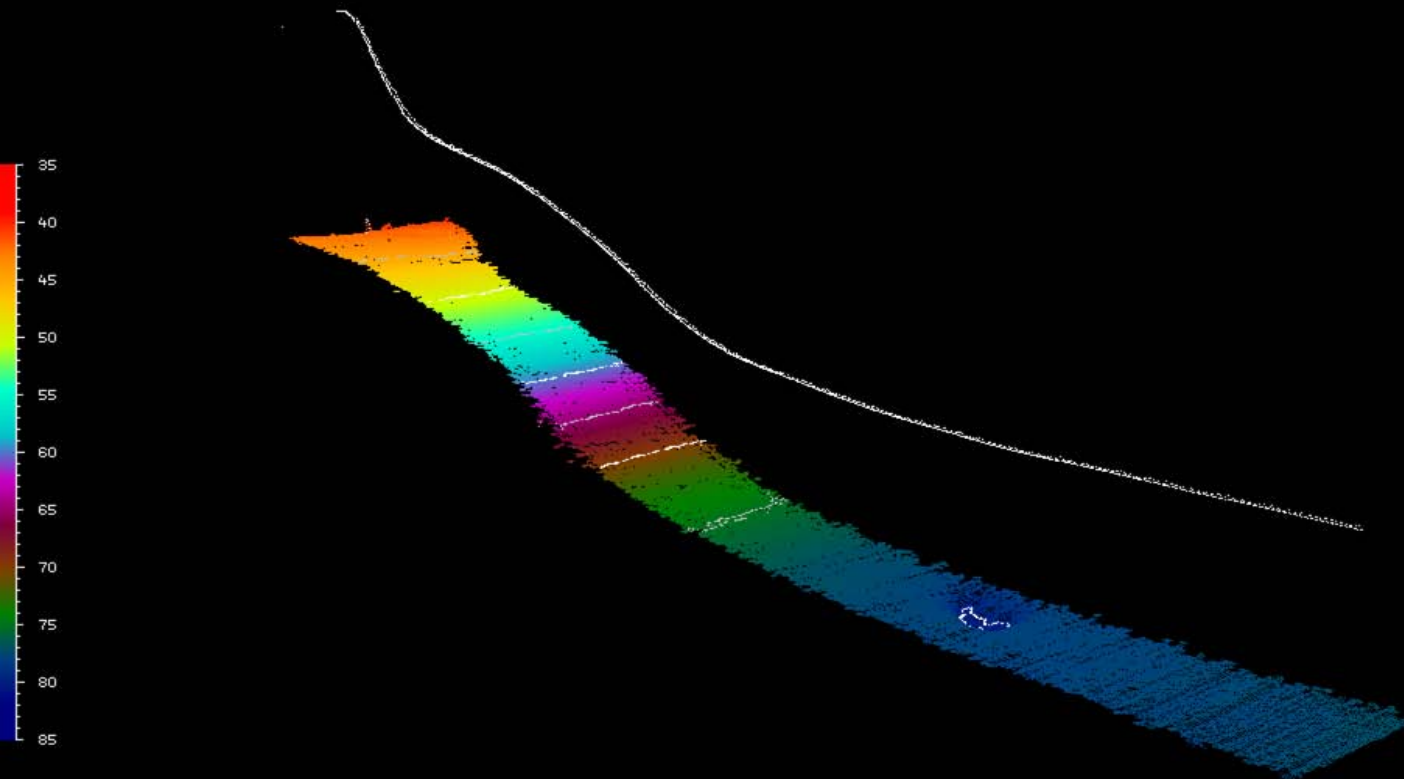


**MP80 mine dummy**  
**Range 45 m**

Water depth 10-13 m  
AUV depth 3 m  
Range 15-95 m  
Speed 4 knots



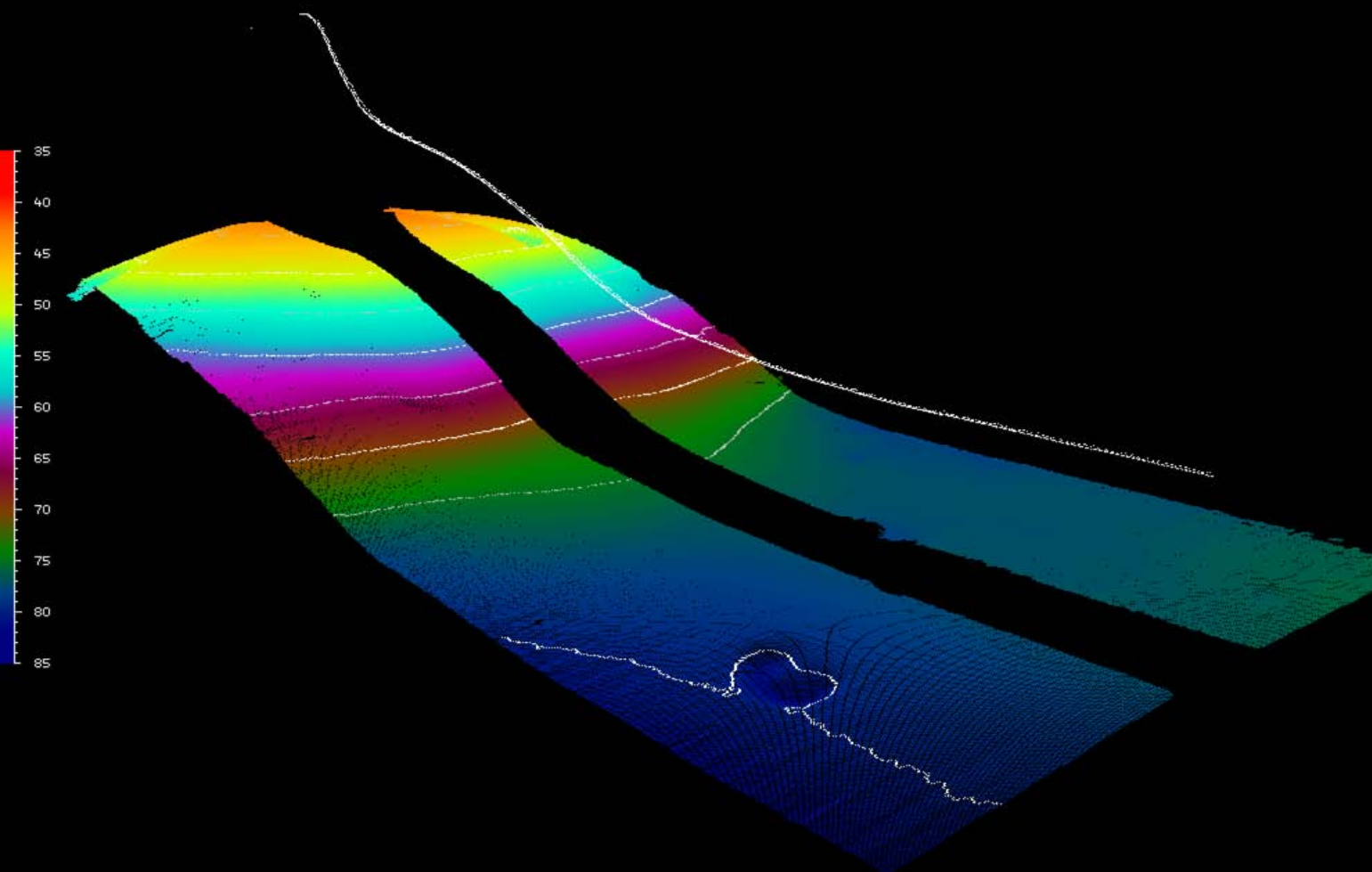
# Bathymetry from Multi-beam Echo Sounder



05.02.2008  
HUGIN 1000-MR

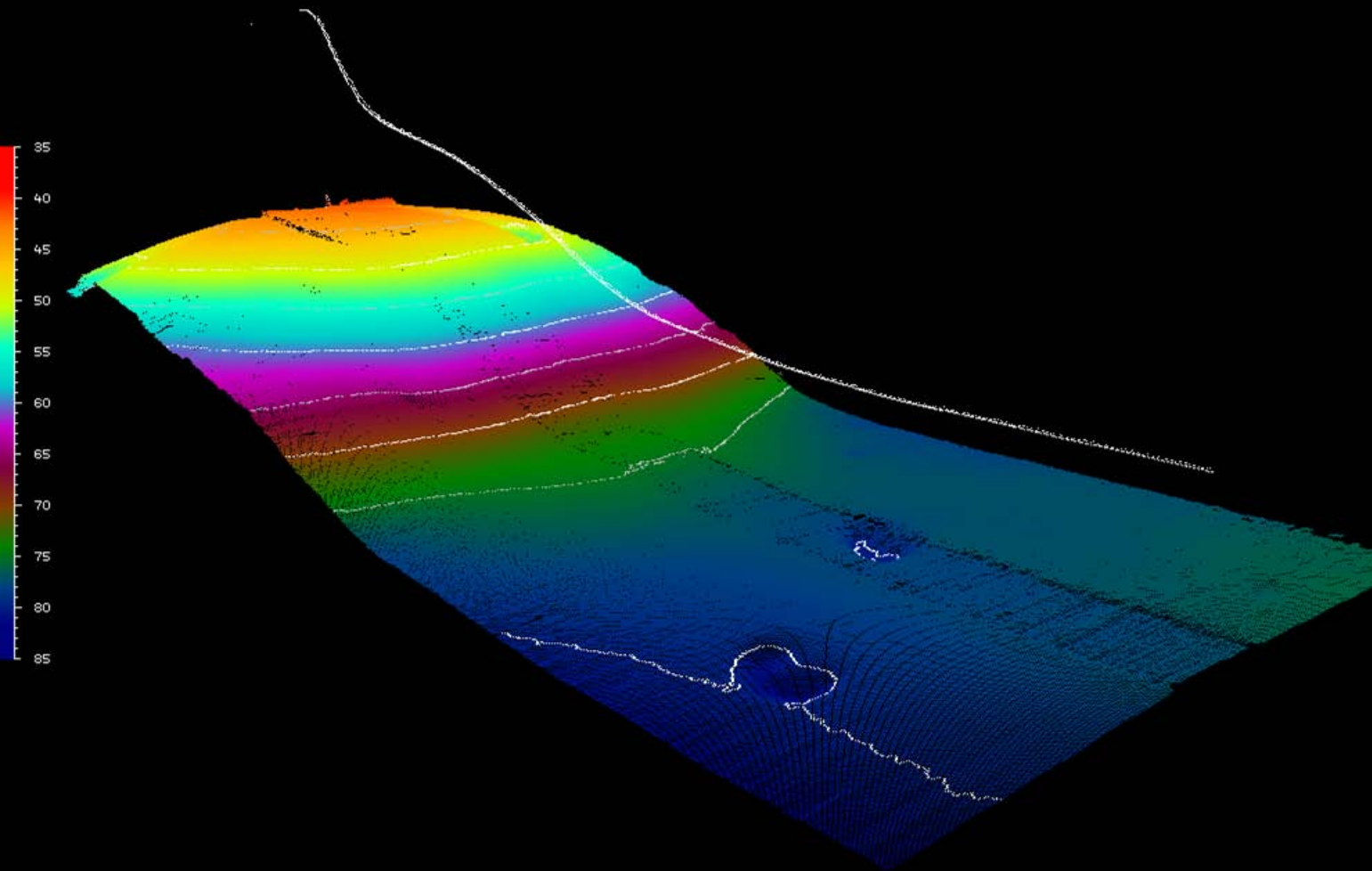


# HISAS 1030 Sidescan Bathymetry



05.02.2008  
HUGIN 1000-MR

# Merged Bathymetry



05.02.2008  
HUGIN 1000-MR

# Risk Reduction in AUV Under Ice Survey



# Risk Reduction in AUV Under Ice Survey

## Ship subsystems:

- Communication and localization systems
- Launch and recovery system
- ROV
- UAV or helicopter



Photo: S. Gerland  
For illustration purposes.

## AUV subsystems for under ice operations:

- Redundancy, error detection and error handling
- Navigation
- Anti-collision
- Communication and localization systems
- Battery
- Launch and recovery



Fundamental requirement: Proven, robust and high performing AUV platform.

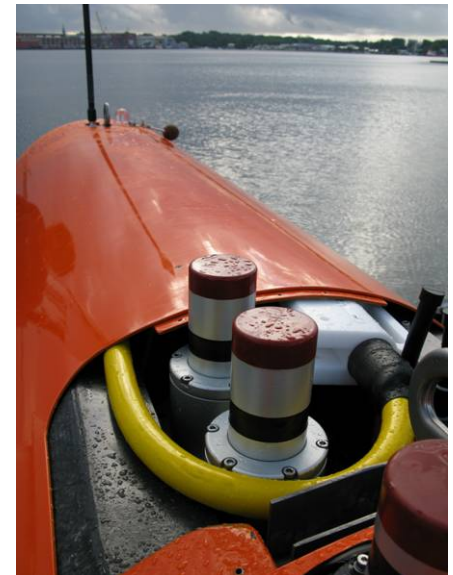
# HUGIN 1000 Communication and Localization Systems for Under Ice



System	Horizontal range	Communication	Localization
USBL	~ 4 km (~ 10 km @ 12 kHz)	Built in comm link	Measures range and bearing
Ship based acoustic link	~ 4 km, (10 km, 20 km)	Basic function	AUV transmits position estimate
Underwater transponders on sea bottom	Range as above. Underwater networks can provide very long range.	Basic function	AUV transmits position estimate
RF through ice	Goal: 1 km	Basic function	1. Range dependent variation in signal strength 2. AUV transmits position estimate
RF	~ 5 km	Basic function	AUV transmits position estimate
GPS-Iridium	Global when on surface	Basic function	1. Built in GPS receiver 2. AUV transmits position estimate
Flash beacon	Visual	No	Visual

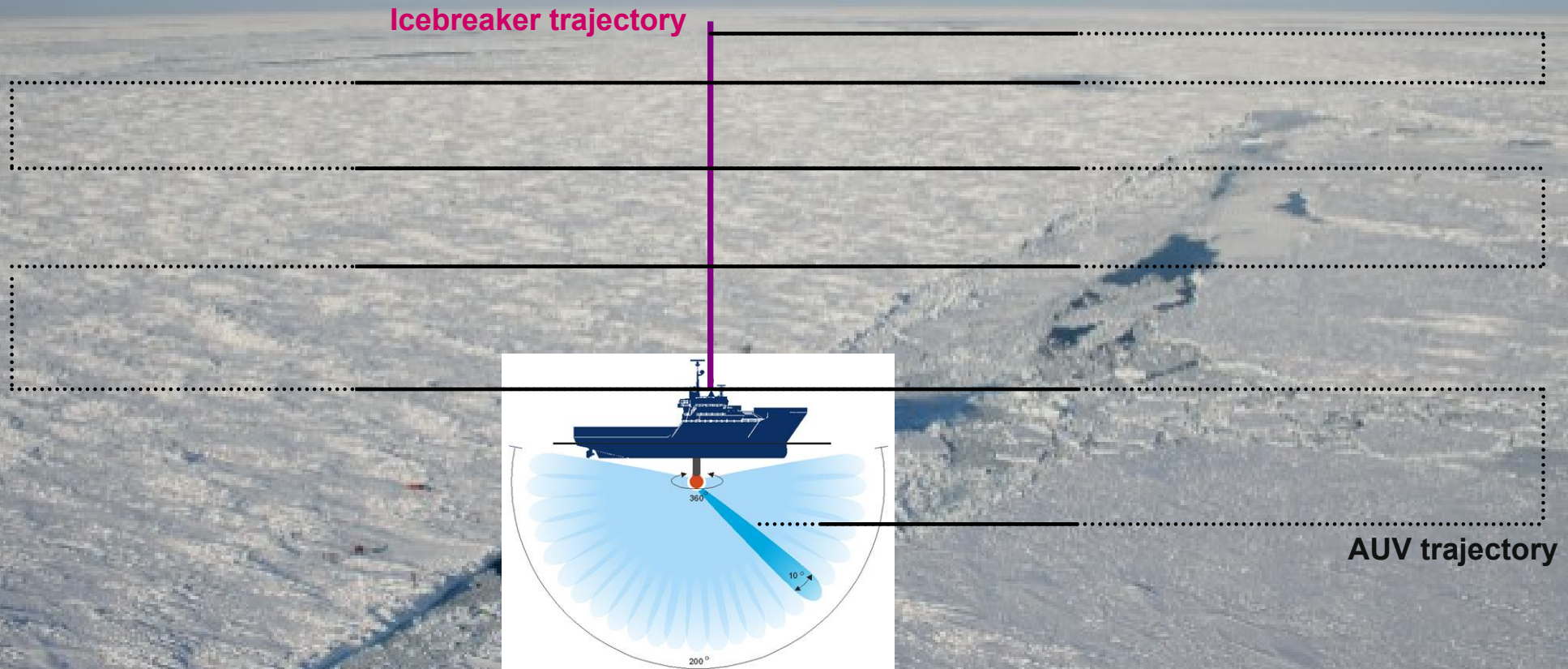
# Testing of Through Ice Localization and Communication

- In case of emergency, the support vessel can launch a helicopter or unmanned aerial vehicle for AUV localization. Alternatively, it can use RF antenna on icebreaker.
- Kongsberg Maritime and WFS is jointly developing an RF through ice emergency localization system





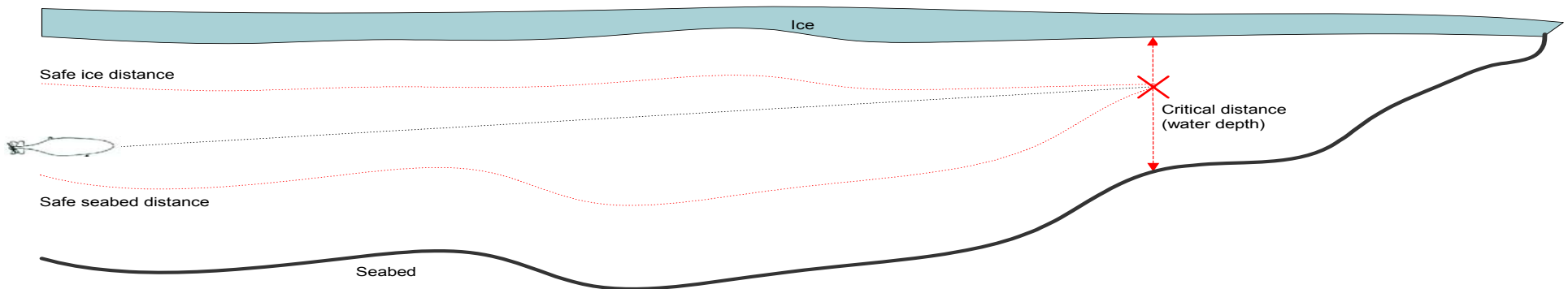
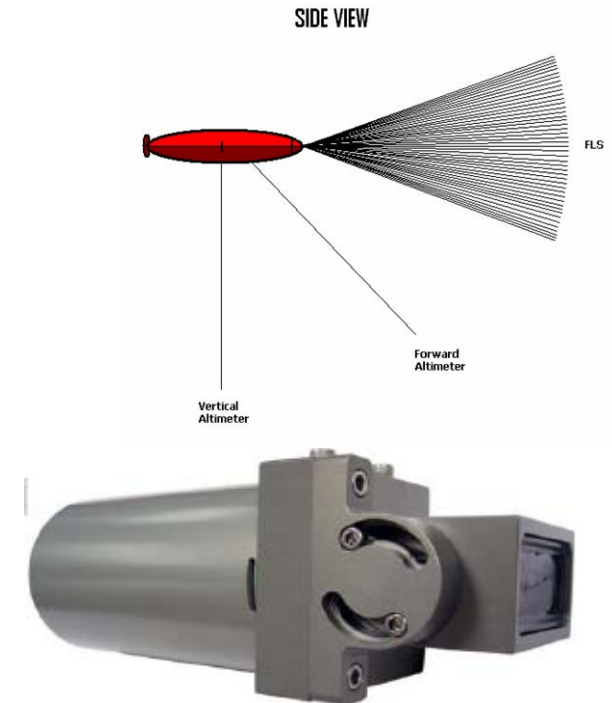
# HiPAP Navigation and Tracking Concept



**HiPAP 500 USBL system offers optimal navigation and localization throughout the water column**

# HUGIN 1000 with Under Ice Operation for Finnish Navy

- HUGIN 1000 for Finnish Navy will get under ice operation capability. First vehicle delivered 2009.
- Under ice operation is tightly integrated with the anti-collision system. Functions include:
  - Improved seabed following
  - Iceberg avoidance
  - Whale avoidance





# Summary

# Summary

- Compared to traditional methods for under ice survey, HUGIN 1000 provides:
  - Increased mapping efficiency
  - Increased data quality and mapping resolution
  - Simultaneous recording of desired geophysical and oceanographic data products: bathymetry, imagery, sub bottom data, ocean current, CTD and other.
- Large under ice areas are effectively mapped by the combination of ice-breaker and long range AUV equipped with high area coverage rate sensors
- HUGIN 1000 offers reduced risk and operational cost in under ice mapping operations
  - Robust and proven system
  - Integration with icebreaker is offered
  - The combination of multibeam echo sounder and HISAS 1030 doubles the area coverage rate for bathymetric mapping
  - HiPAP 500 USBL system for navigation and localization throughout the water column
  - Anti-collision system including iceberg and whale avoidance
  - Radio through ice emergency localization system



## Kongsberg Maritime

