DEEPOCEAN

Functional and flexible vs Fast and Furious
- a development project to build the optimal survey ROV

FFU Seminar – 28th January 2016

- Making a difference

Presentation outline

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- Background - Goals
- Survey ROV Evolution
- Design process
- Equipment configuration
- Test Results
- iTMS

Superior Survey ROV

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Background

- DeepOcean is continually focusing on new technology in order to keep the position as the preferred supplier for survey and pipeline inspection work. A key project to achieve this has been the development of a new generation Survey ROV, the Superior.
- Several stages of concept evaluation and design reviews have led to concept consisting of a modular ROV and iTMS.
- DeepOcean has received support from Gassco for CFD analysis and from Norges Forskningsråds program Demo 2000 for testing and commercialisation of the ROV.
- The contract with Kystdesign was signed April 2014, detailed engineering started 1st September 2014.
- ROV was delivered to DeepOcean in June 2015.

Superior Survey ROV

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Main Design Requirements

- ✓ Large, stable vehicle with optimal placement of sensors for acoustically silent environment.
- ✓ Reliable construction capable of 24/7 operations all year around in the North Sea.
- ✓ High Fly Acoustic survey speed of 4 knots at 400m without iTMS.
- High Fly Acoustic survey speed of 4 knots at 1000m with iTMS.
- ✓ Capability of performing «traditional» visual inspections close to pipeline. Ability to carry pipetracker.
- ✓ Latest generation Multibeam Echosounders allowing acquisition of high density bathymetric data at high speed.
- ➢ New camera and laser system acquiring very high density point clouds close to pipe and high quality still pictures.

Survey ROV Evolution

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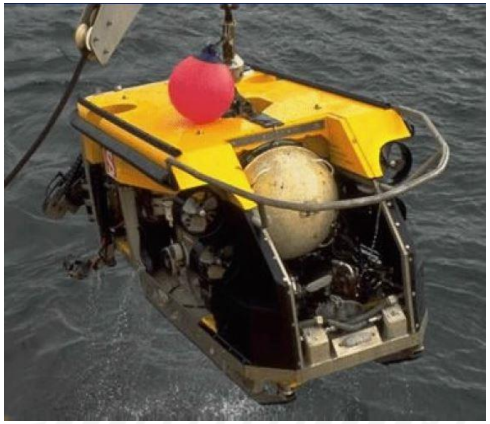
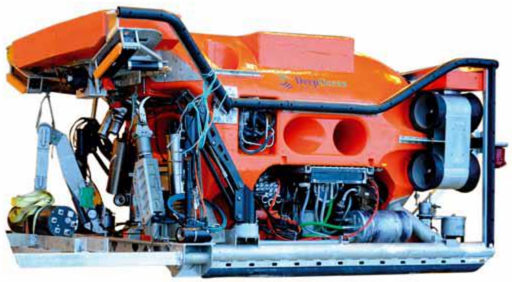
Scorpio - 1980



Solo 1 1984

HiROV – 1998-2000



Solo 2 - 2001

Survey ROV Evolution

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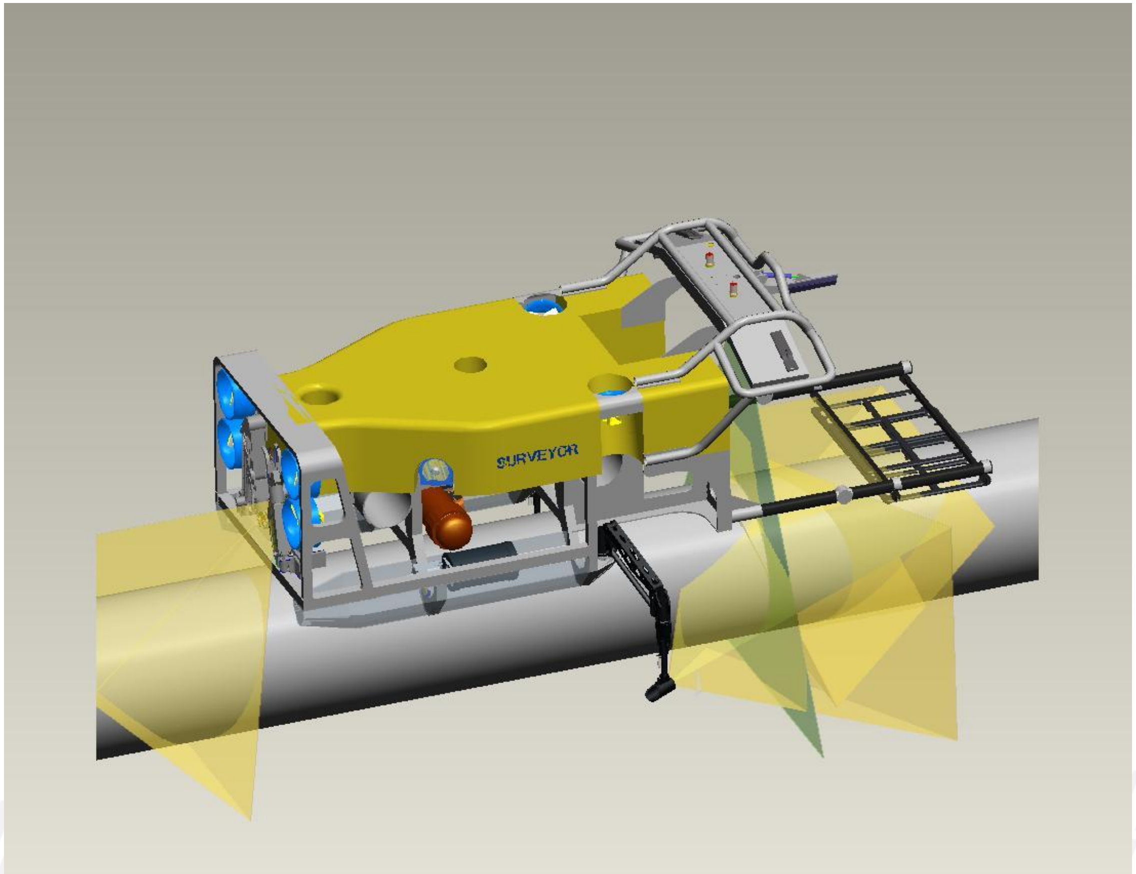
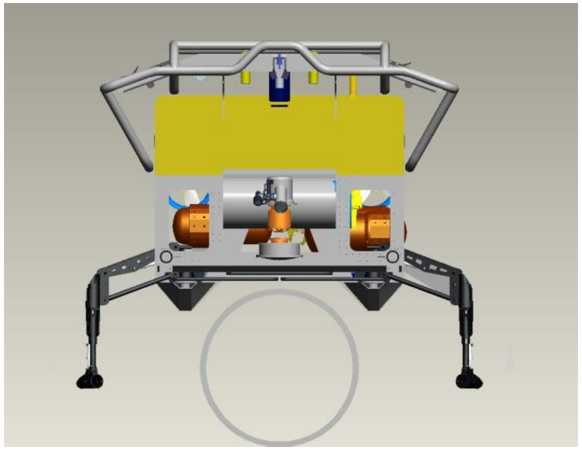
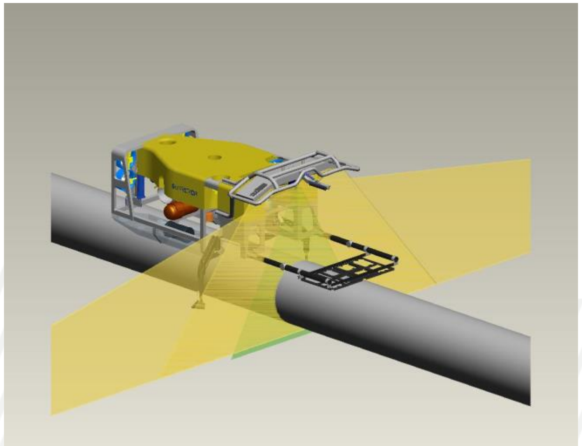
Surveyor – Developed 2006 – never built







Survey ROV Evolution

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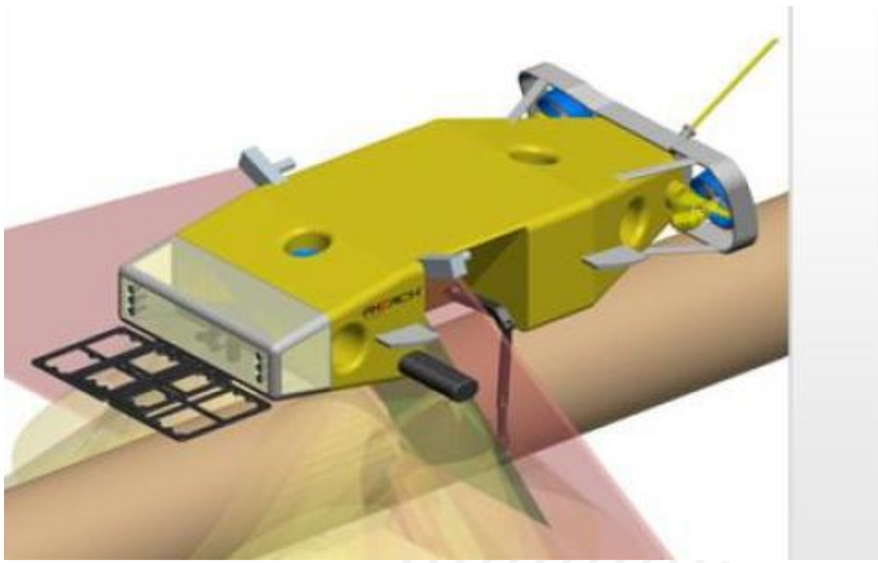
2009/2010 Reach Subsea - Surveyor



Designs concepts - Ideas

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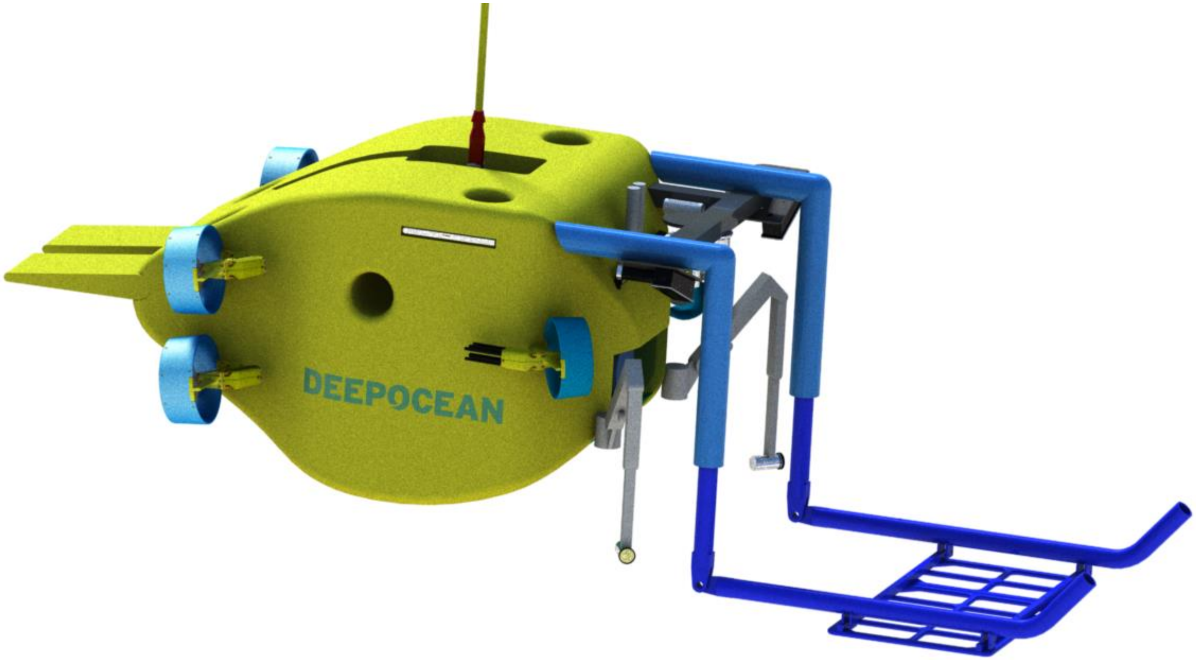
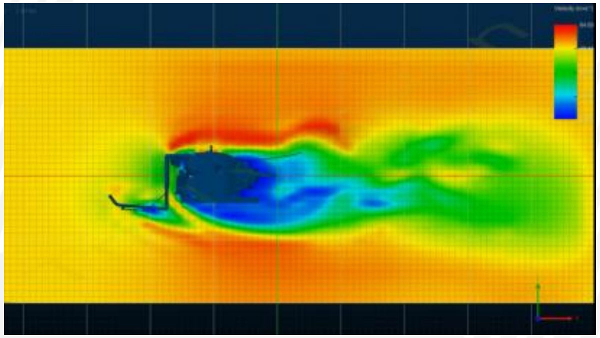
2012

Mercedes Bionic and Box-fish





Designs concepts - Ideas

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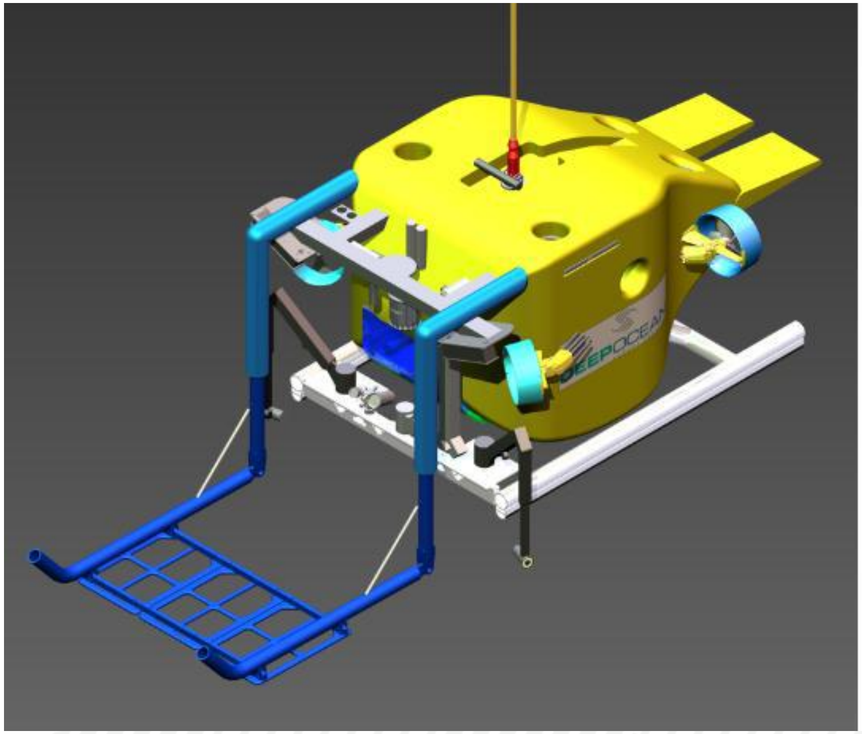
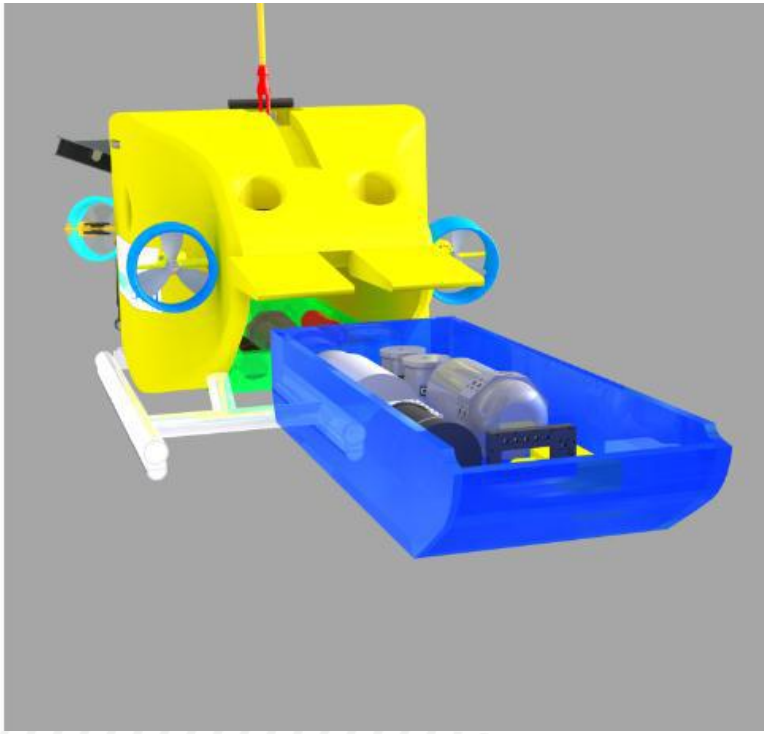
2012





With Skid and «hot-swappable drawer» for fast mode changes

Designs concepts - Ideas

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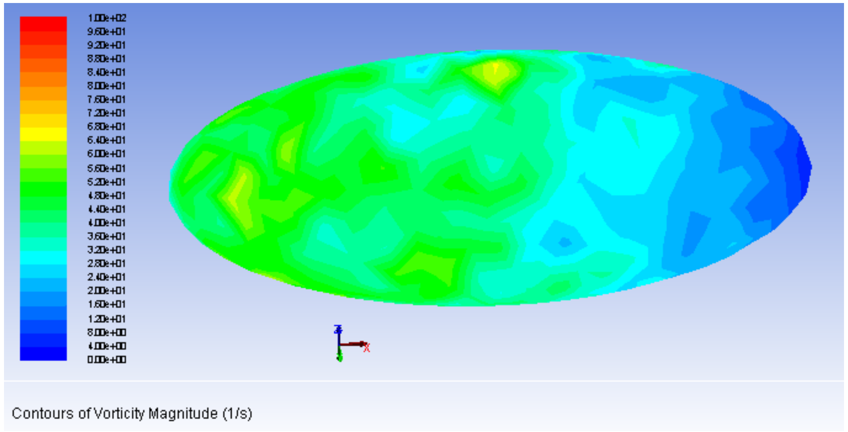
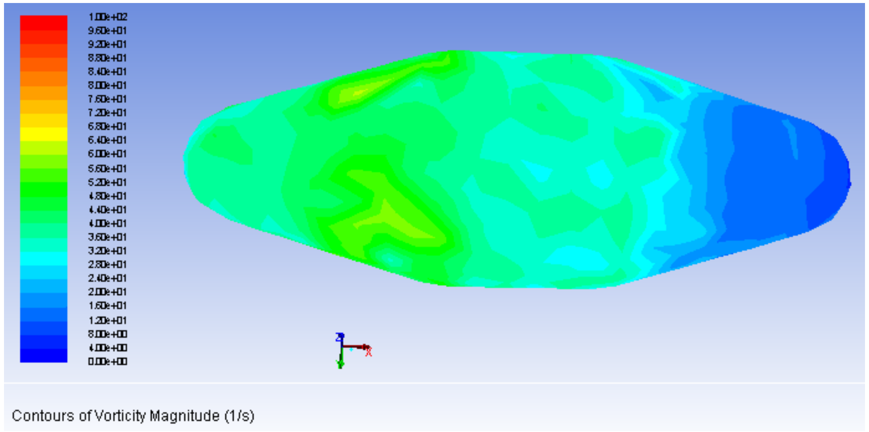
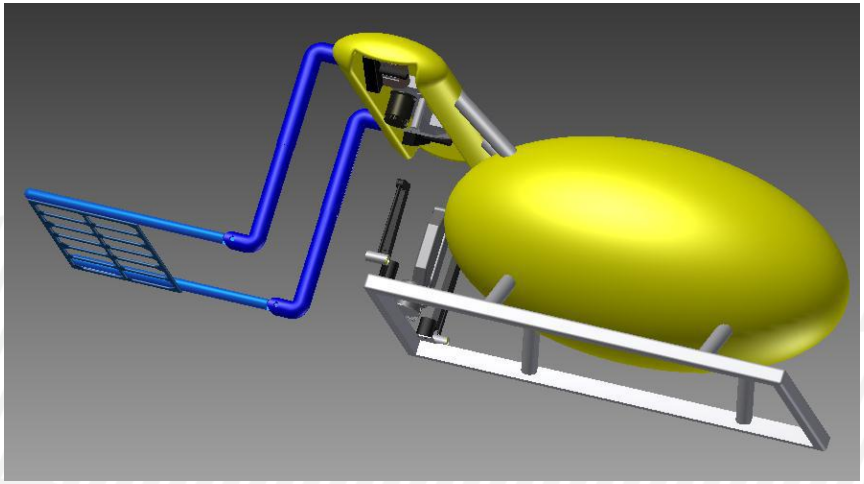
“Optimum design of a survey ROV with respect to water resistance and turbulence”







Master Thesis at University of Stavanger, by Ørjan Gloppen, 2012.

Designs concepts - Ideas

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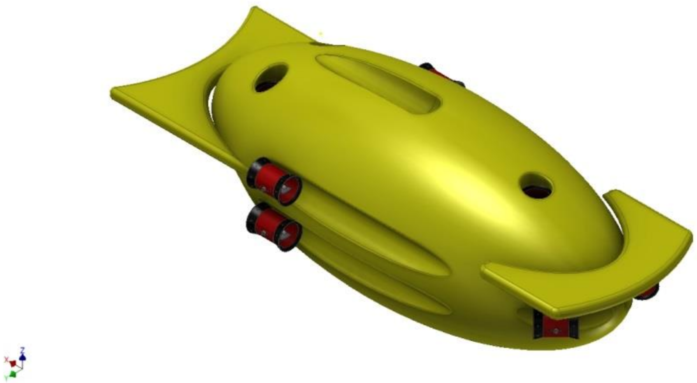
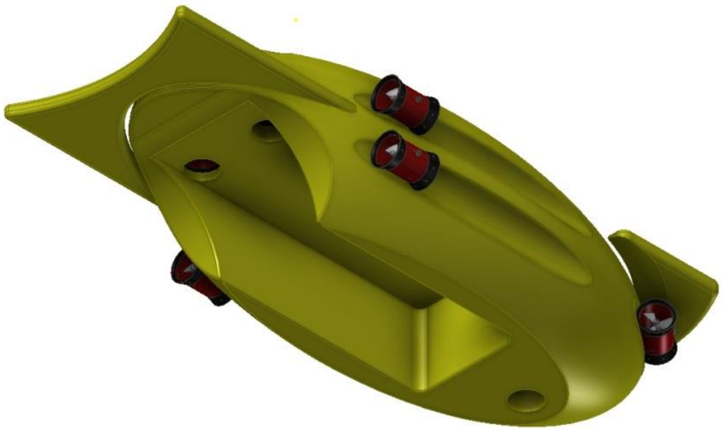
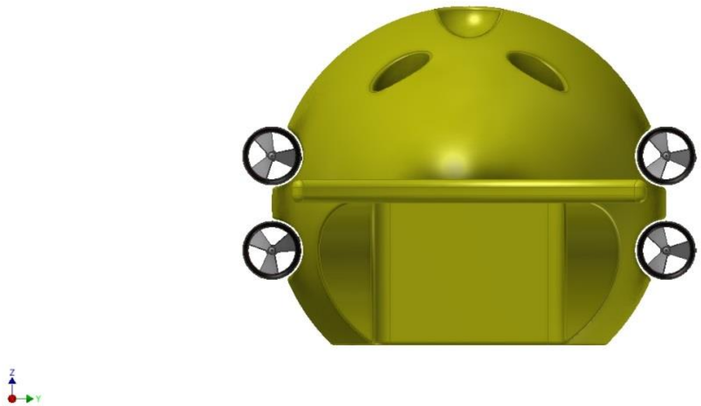
May 2013 - Zeppeliner







Designs concepts - Ideas

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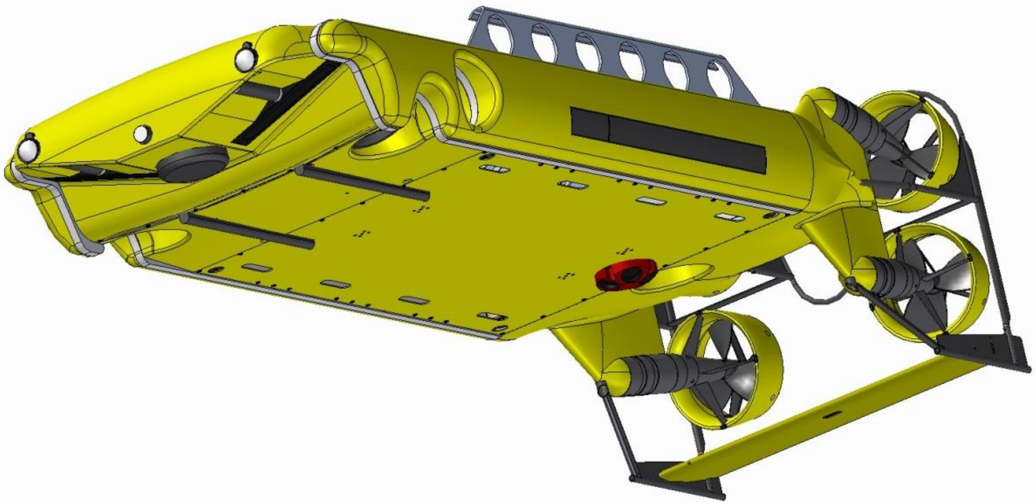
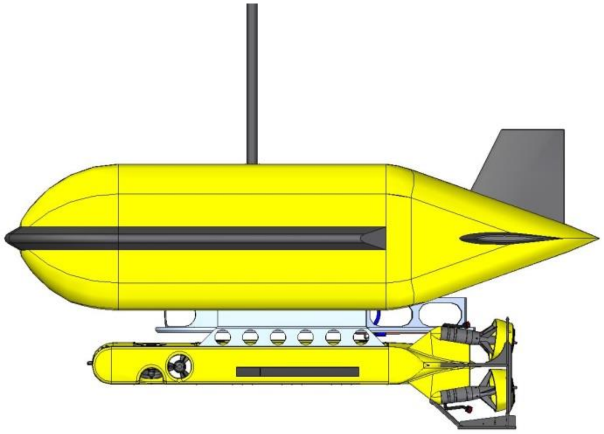
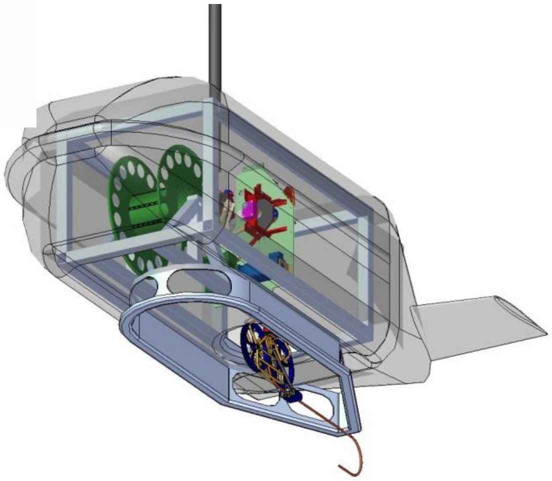
June – September 2013

Saab Sabertooth







iTMS concept appears

Designs concepts - Ideas

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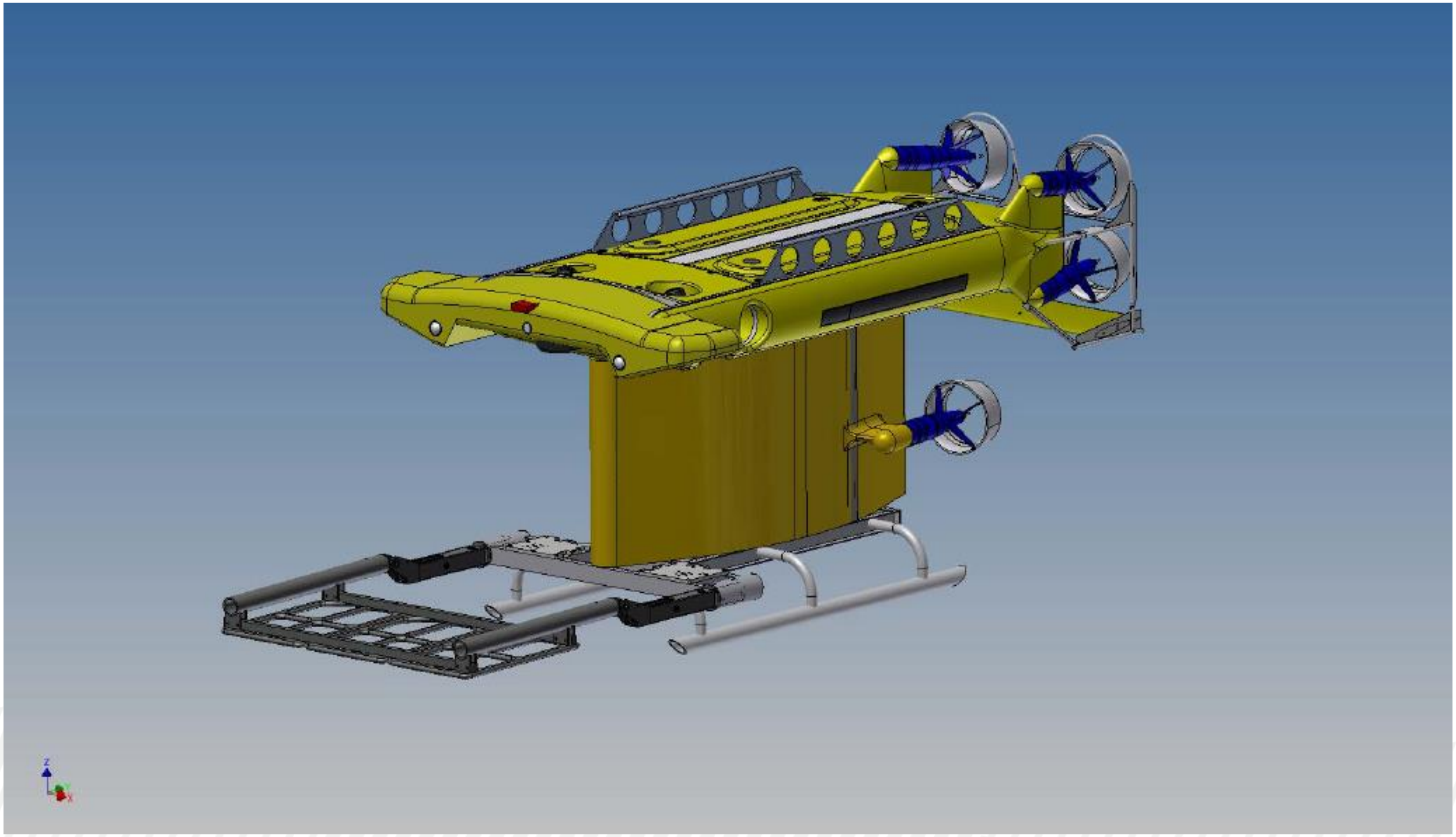
Sabertooth – with skid



Designs concepts - Ideas

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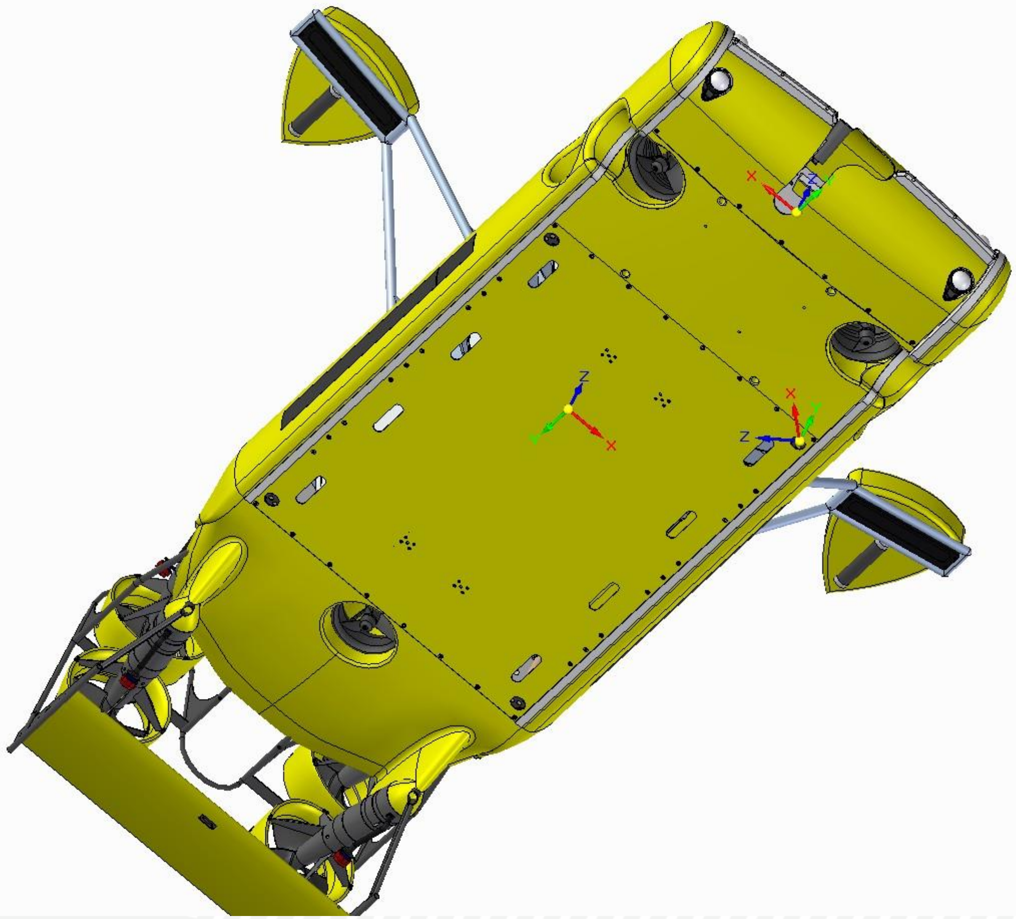
Sabertooth – with wings!



Designs concepts - Ideas

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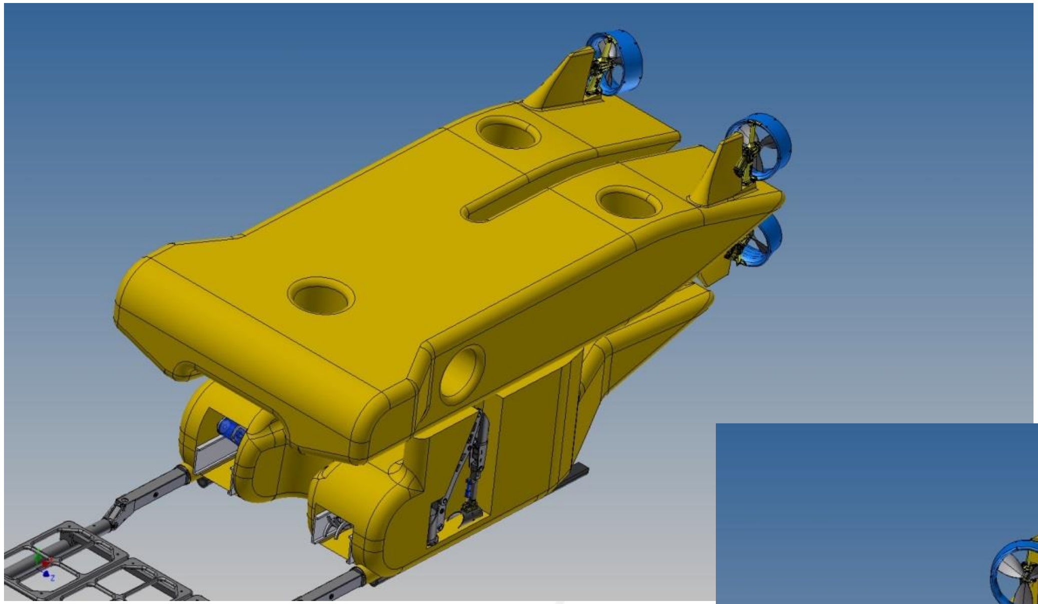
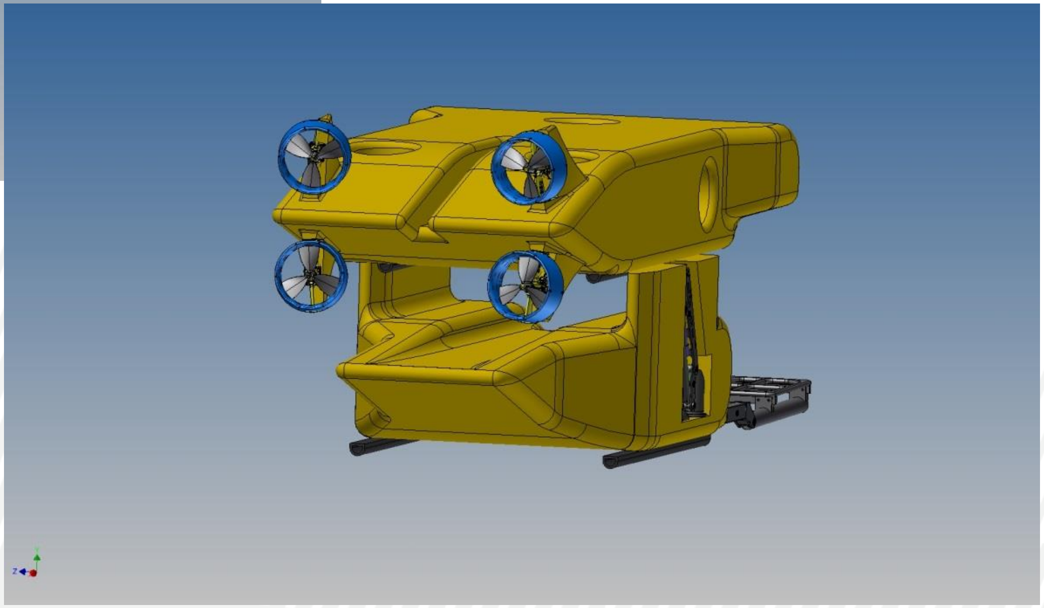
December 2013





Designs concepts - Ideas

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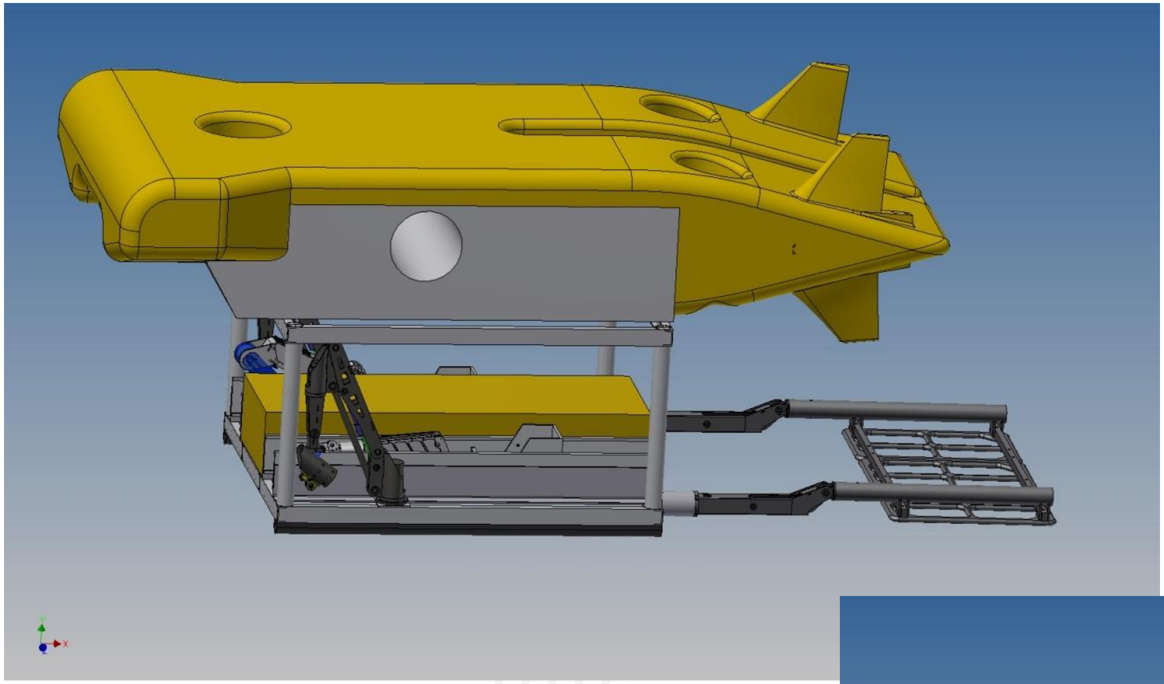
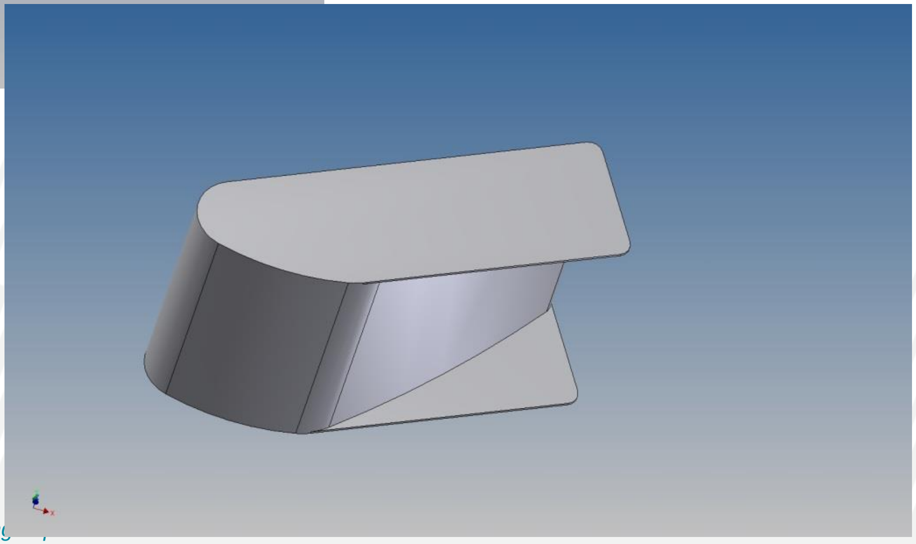
January 2014





- First inverted wing for iTMS on the table

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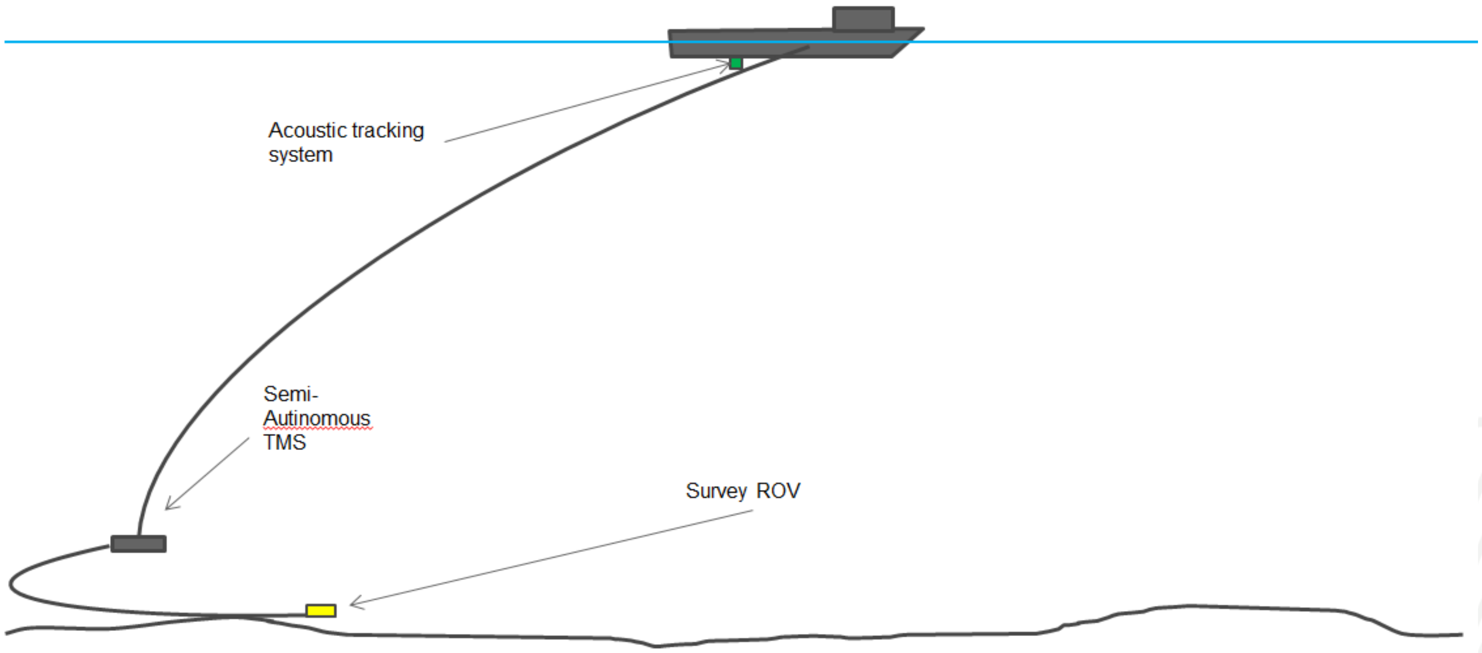
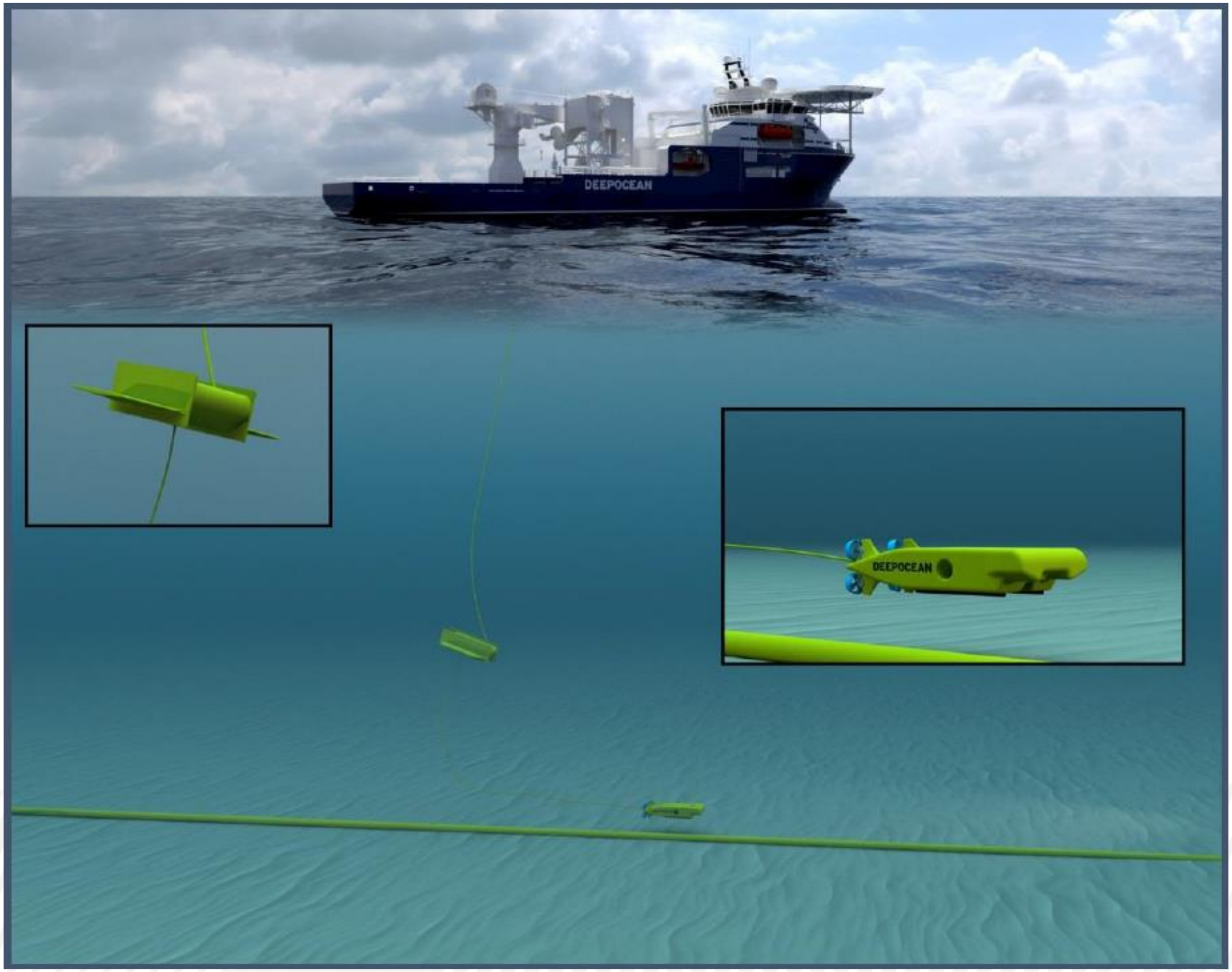
- Semi-autonomous TMS system with hydrodynamic shape and depressor features and constant tension on tether are new additions to concept.

Proposed high speed Survey ROV concept



Superior Survey ROV



MUST - Metas

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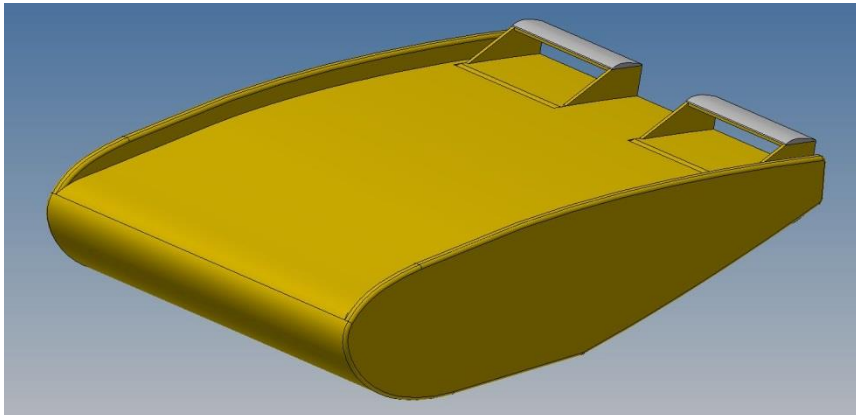
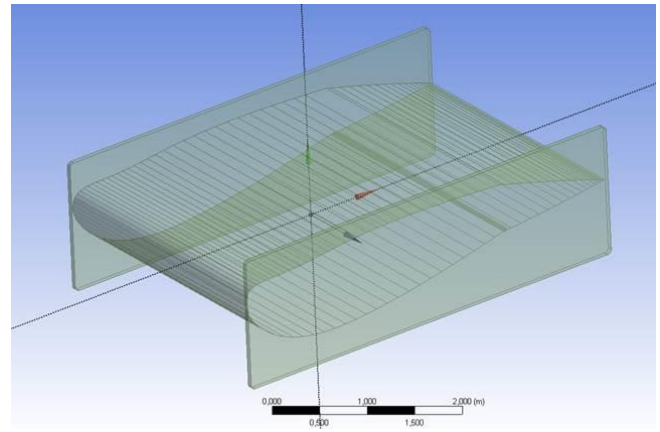
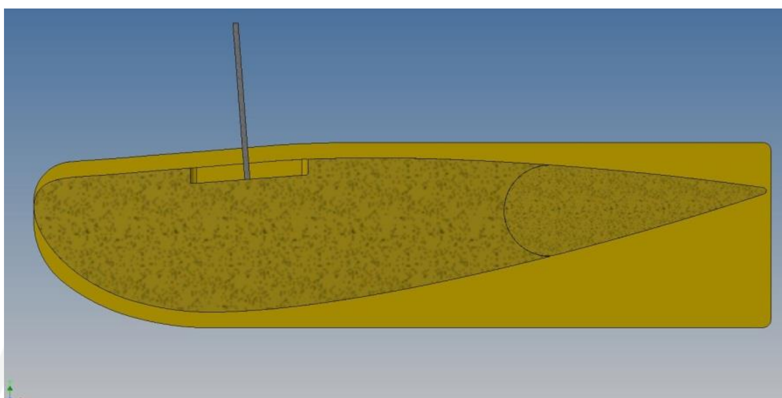
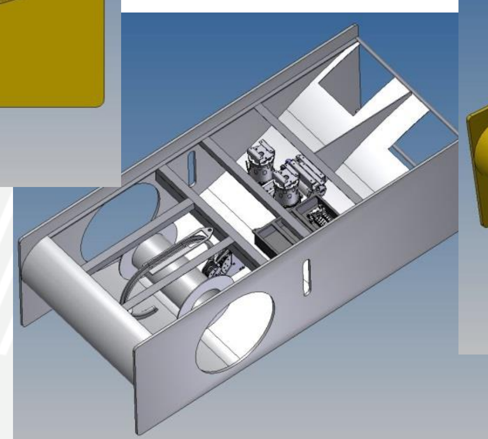
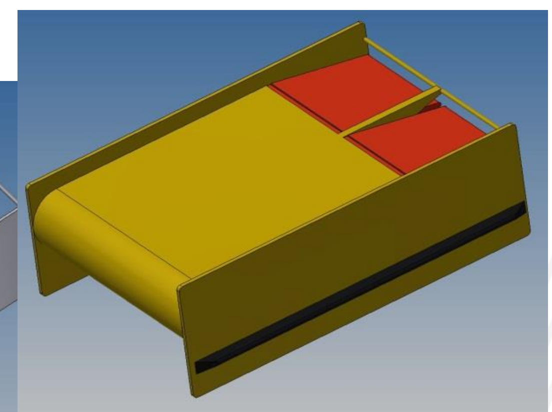
iTMS





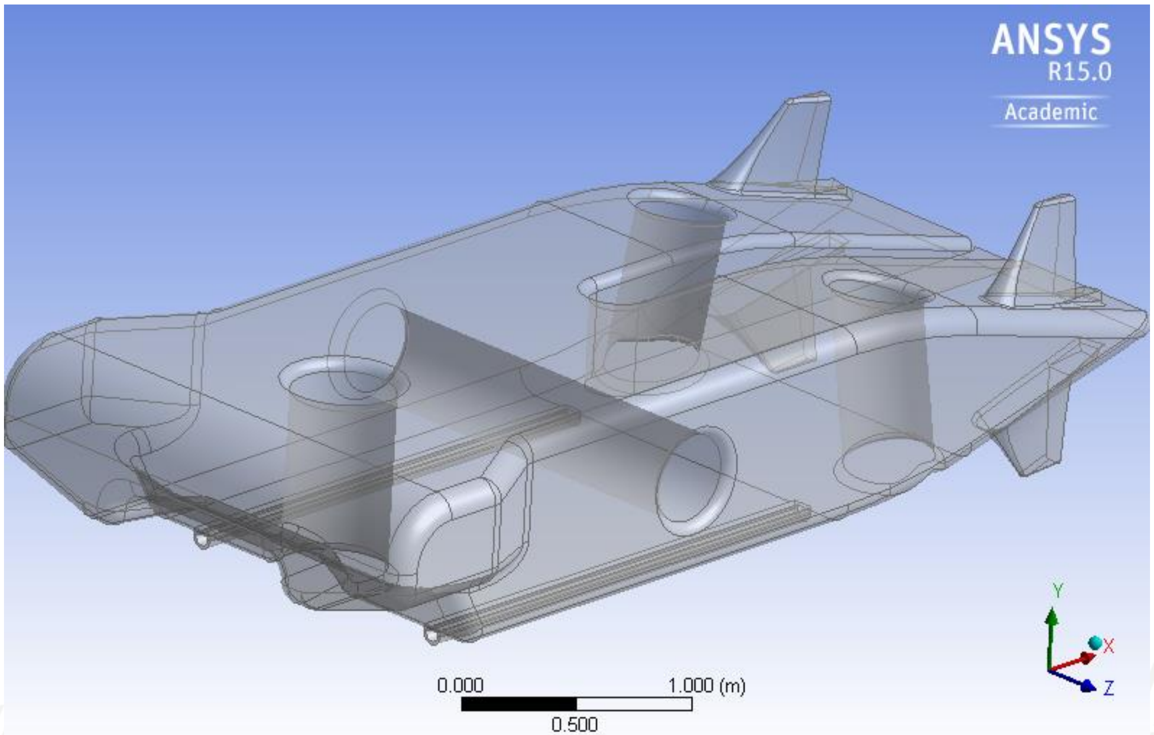


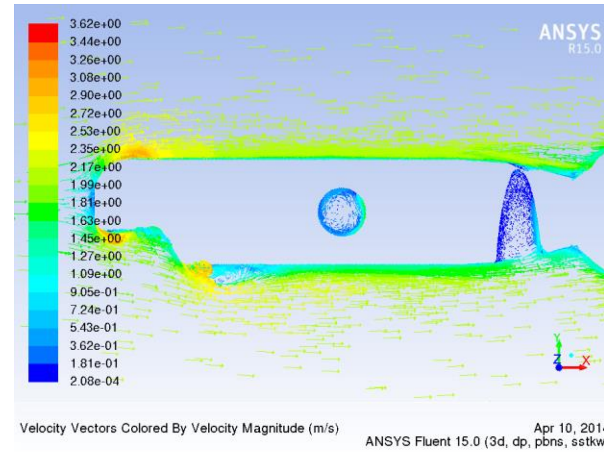


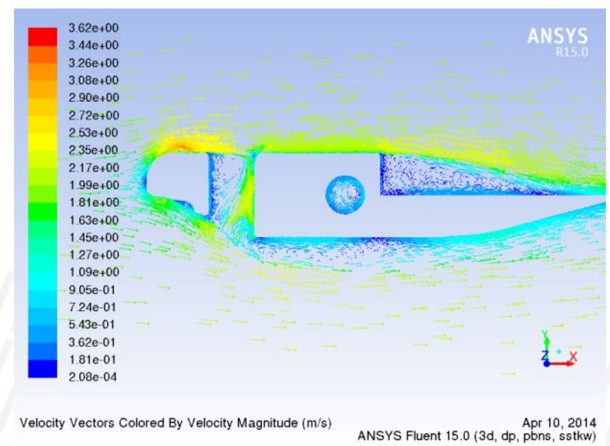


April 2014

Supported by Gassco



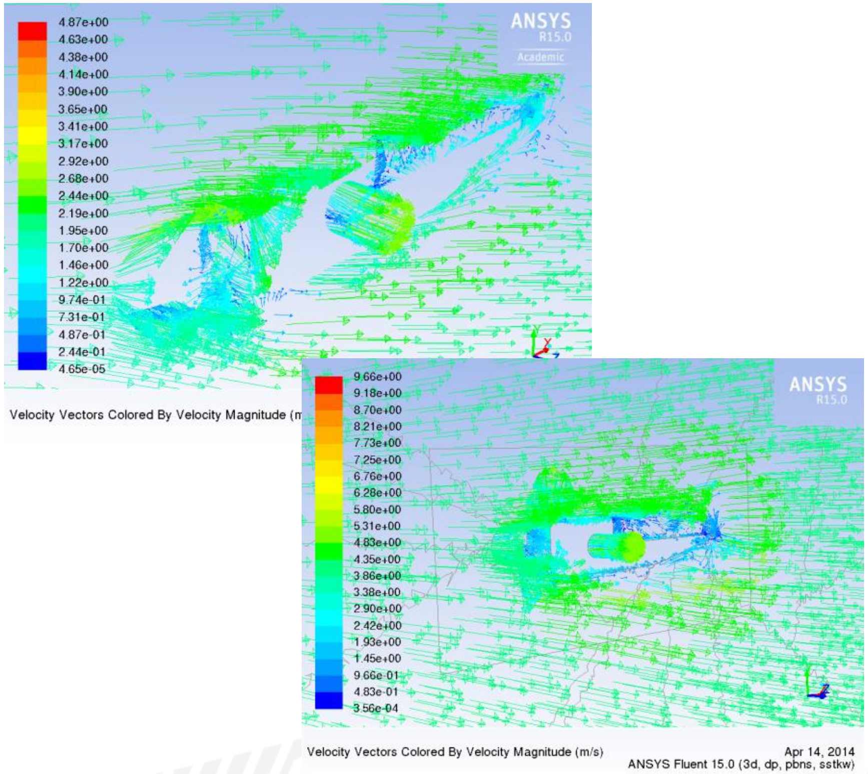




- We considered 4 cases: ROV plane of symmetry is parallel to the flow direction and flow speed at 2 and 4 m/s, ROV going at 45° to the flow direction, ROV going at 81° to the flow direction.

CFD Analysis - Polytec

Results



	ROV Parallel to flow	ROV Parallel to flow	ROV heading 45 deg.	ROV heading 81 deg.
Velocity, m/s	2	4	2	2
Reynolds number	2,05E+06	4,10E+06	2,05E+06	2,05E+06
Drag, N	941	3650	1904	1976
Cros-section, m2	2,1412	2,1412	4,4327	4,4117
Drag coefficient	0,214377	0,207884	0,209529	0,218488

- ROV drag coefficient is very good if compared with wing-shaped object.
- When the direction of the ROV is not parallel to its plane of symmetry the ROV will experience higher drag. This is mostly due to higher cross-section area, while the drag coefficient does not change.
- The drag coefficient can be treated as constant (not depending on the ROV speed) within the given range of velocities.

Final design

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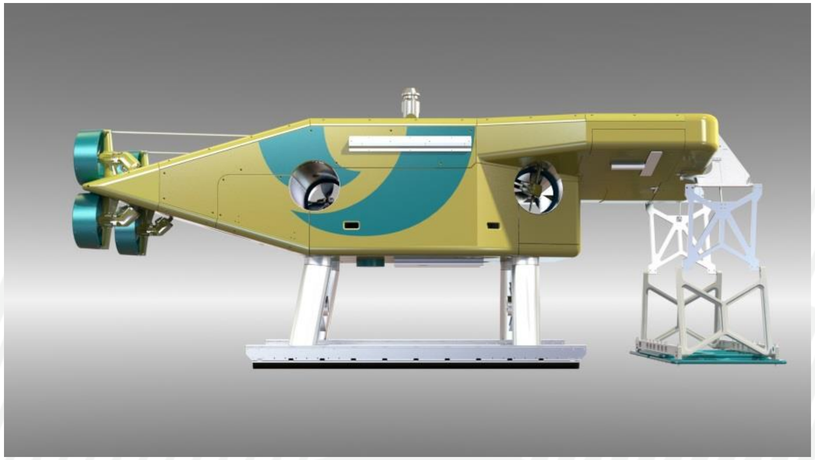

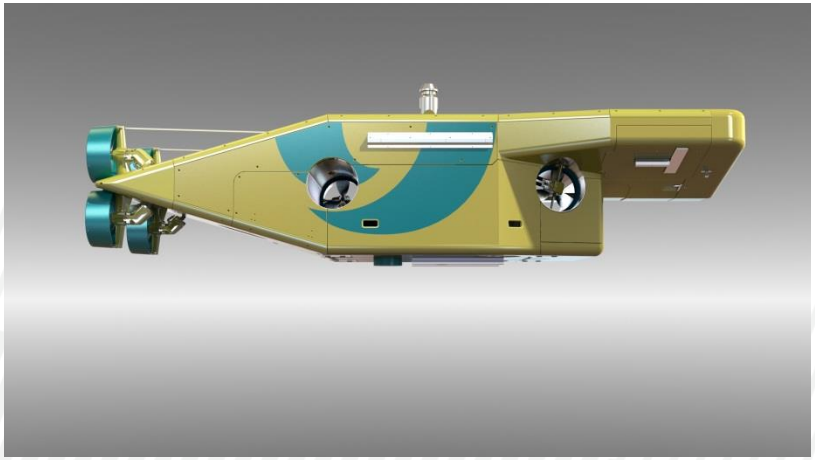

Superior Survey ROV – Equipment Config.

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- Dualhead Reson 7125 MBE – FP 4 incl. Full Rate Dual Head

- Edgetech 2200 M – Combined 300/600 kHz Sidescan Sonar and 1-12 kHz SBP
- INS: Kongsberg HAIN and IXBlue PHINS
- New retractable pipetracker frame
- 2 x Doppler Velocity Log

Superior Survey ROV – Equipment Config.

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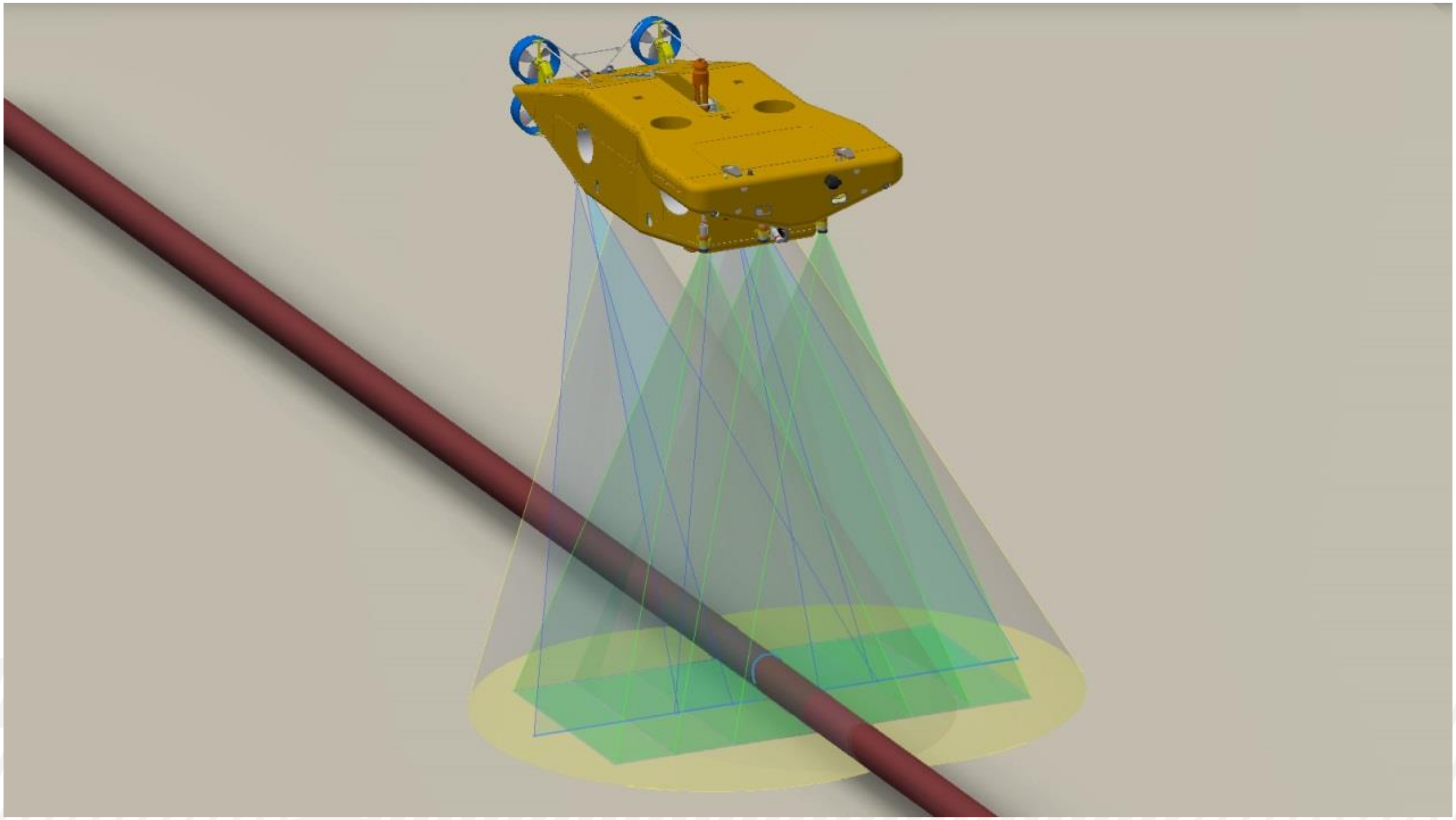
- CATHX Ocean High definition laser profiler and stills camera system



Still photos

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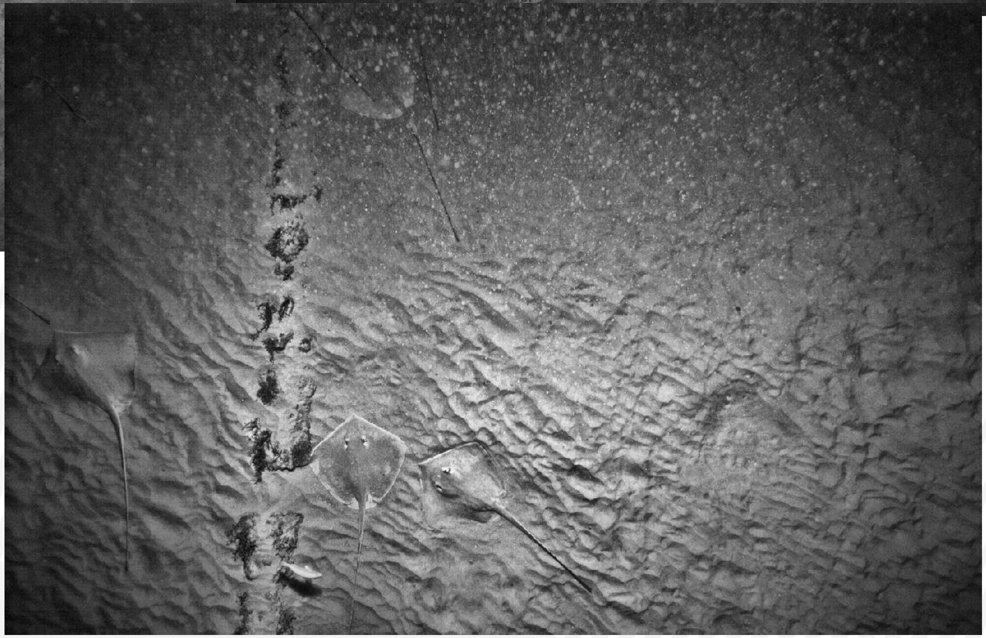
TILECAM pictures



Laser profiling

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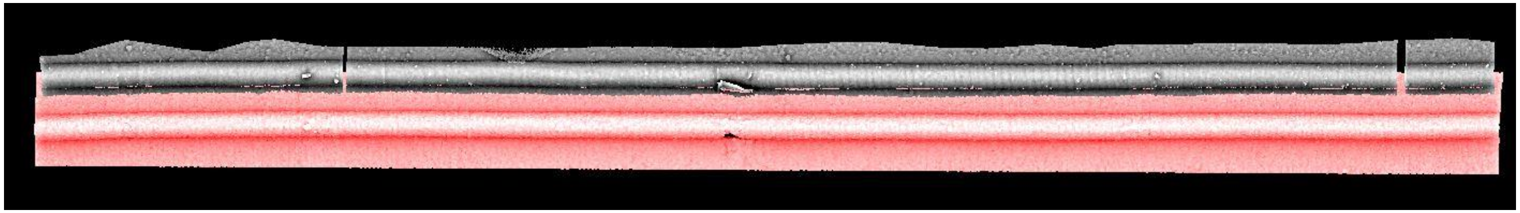
Comparison of laser data with multibeam echosounder (MBES) data

The 45m of surveyed 0.6m diameter pipeline shows the positioning to match the MBES exactly. Image shown below shows the MBES data offset from the laser data for comparison purposes.

The data density of the laser data is vastly greater than the data density of the MBES data with a 20-fold increase on the MBES data density. The lower image shows boxes of the same size (0.8m x 0.8m) over the same spot on the pipeline. The laser data contains 32,000 pings while the MBES data contains just 1,500 pings.

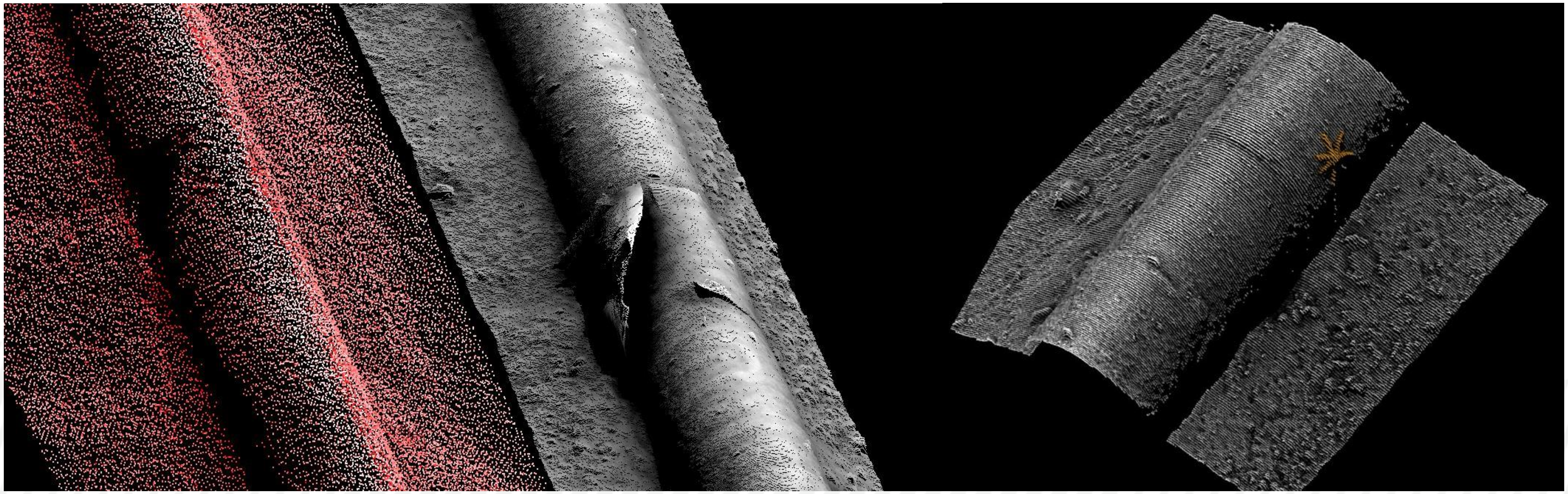


Laser profiling

Comparison of laser data with multibeam echosounder (MBES) data

The laser also detects features far better than the MBES partly due to its increased data density and resolution and also due to the method of detection, using light compared to acoustics. The left image below shows a loose wrap around a pipe joint. The MBES data (coloured red) for this section shows only a hole in the data.

The right image shows an anode on the pipe. The level of resolution and data density would allow this anode's depletion percentage to be measured with a high degree of accuracy. Also note the starfish which has been coloured orange for visual reference.



Ready for testing

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SUPERIOR ROV WITH SKID ATTACHED FOR PIPELINE SURVEY

Sea Acceptance Test – July 2015

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- Near perfect station-keeping
- Ability for ROV to follow predetermined .rlx runline
- Pipeline Survey speeds up to 3.46 Knots
- Seabed Mapping speeds up to 5.31 Knots (a new DeepOcean survey record) all with just 1° of pitch and -2° roll constant.)
- Ability to increase on these survey speeds and motions with some thruster tweaking from Kystdesign
- 6 very happy ROV pilots!

SUPERIOR ROV WITH SKID REMOVED FOR SEABED MAPPING SURVEYS

Superior Survey ROV

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- The Superior was mobilised and calibrated in Haugesund in October 2015 for the Statoil Frame Agreement.
- Three type of jobs were performed:
  - Visual pipeline inspection
  - Visual/Pipetracking survey
  - Acoustic Inspection survey
- **Modular design ensures flexibility** - All three types of survey were performed at a significantly higher survey speed than previously:
- Visual and pipetracker survey at average speeds of up to 1.5 m/s – more than 80% increase.
- Seabed mapping and acoustic inspection survey at up to 2.3 m/s – approx. 100 % increase.
- ROV delivers same and higher quality data due to increased stability and less noise!

Statoil Test October 2015

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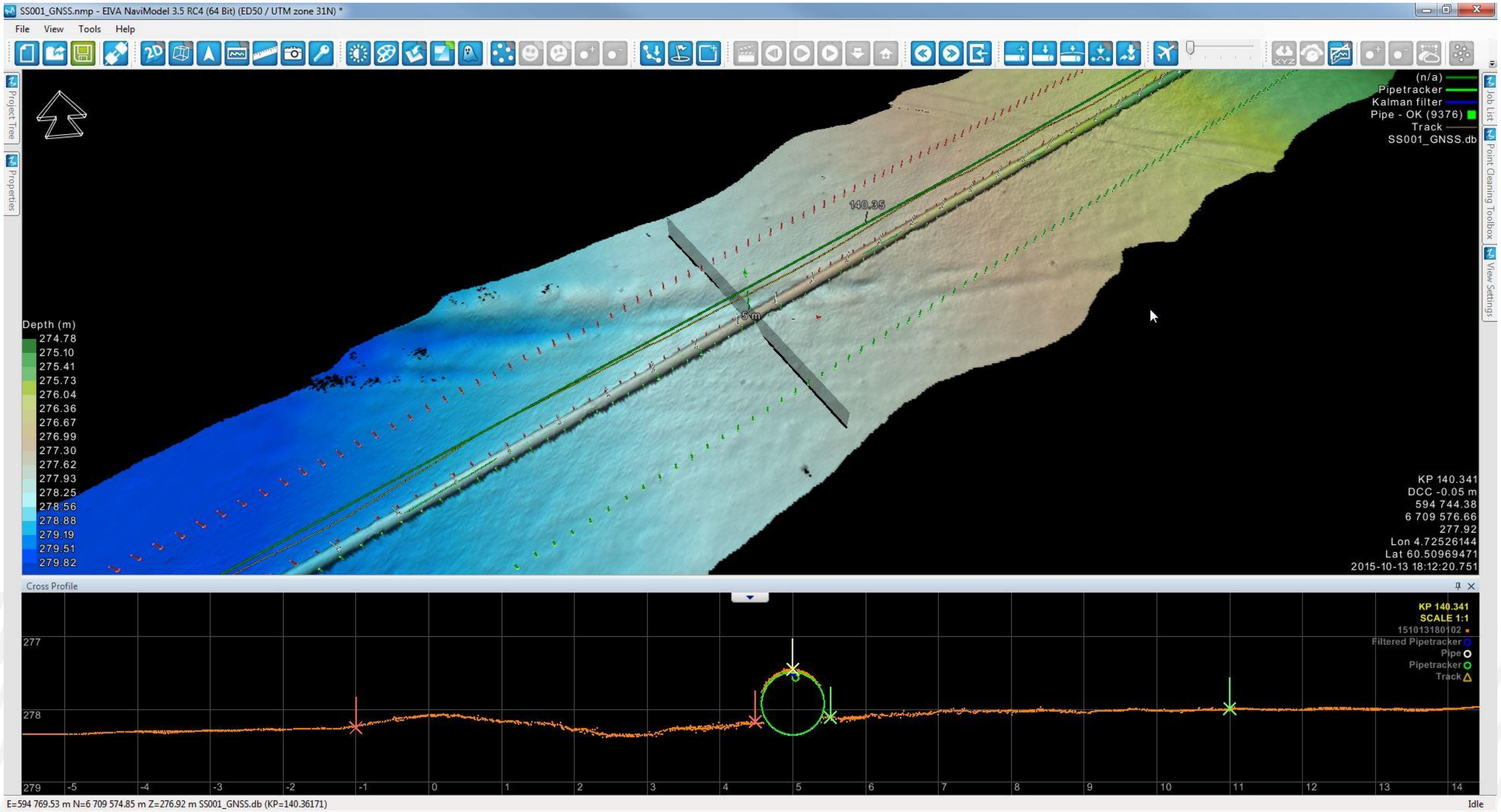
- **Visual Pipeline Inspection**
- This survey was performed at a survey speed of 1.5m/s in average over a distance of 40km. SSS and MBE data were of high quality with limited data cleaning required. The achieved DTM grid cell size was of 0.1m x 0.1m.



Statoil Test October 2015

- During the acceptance test it became evident that HD video is required for video eventing. The visual pipeline survey was successfully performed with 1920 x 1080p x 30fps.
- (Video quality is good, but picture becomes slightly blurry when paused)

- Further testing is required to find limits of speed versus video quality. In general water quality and light conditions will have a significant impact.

Statoil Test October 2015

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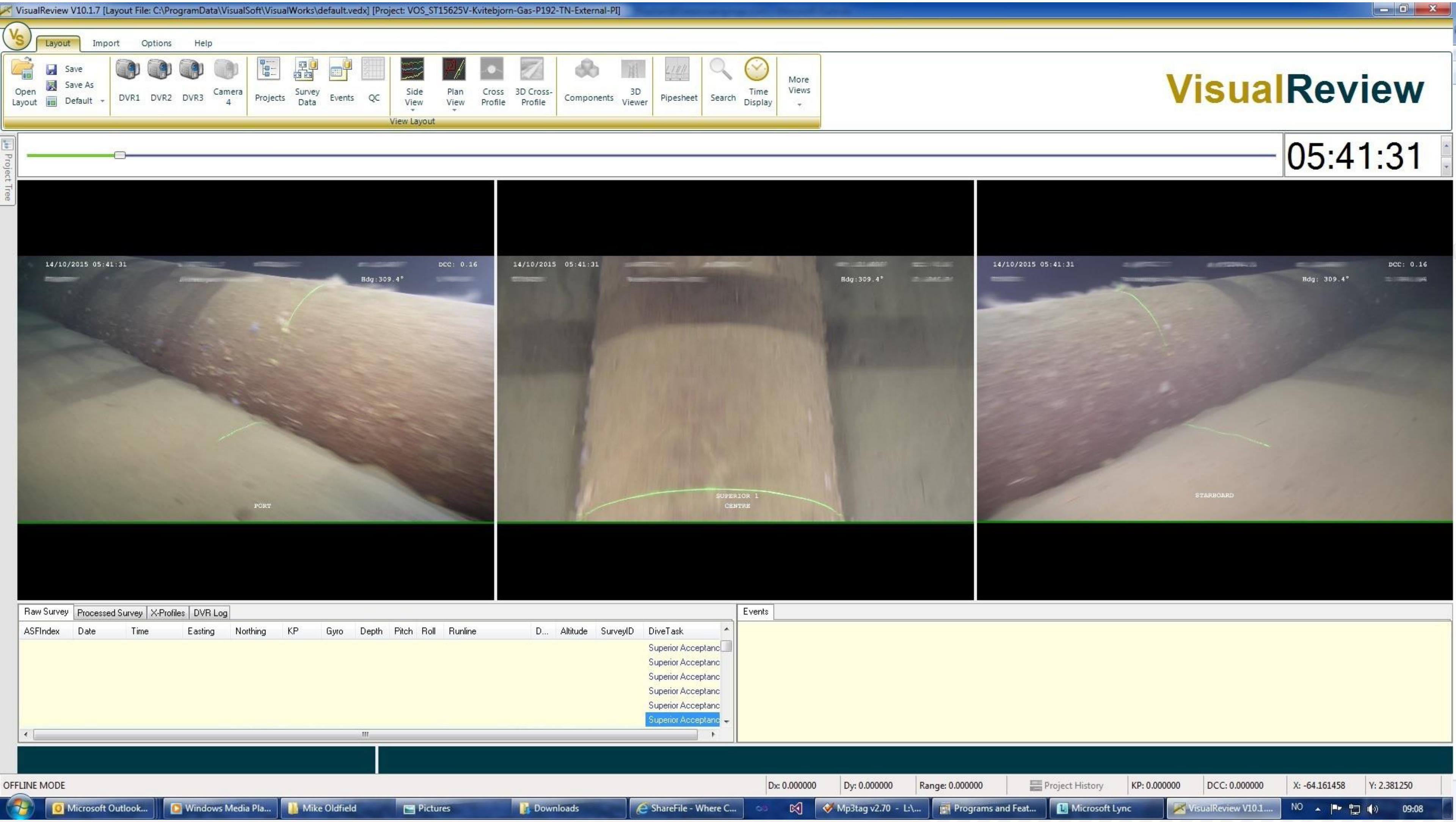

New pipetracker frame

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Statoil Test October 2015

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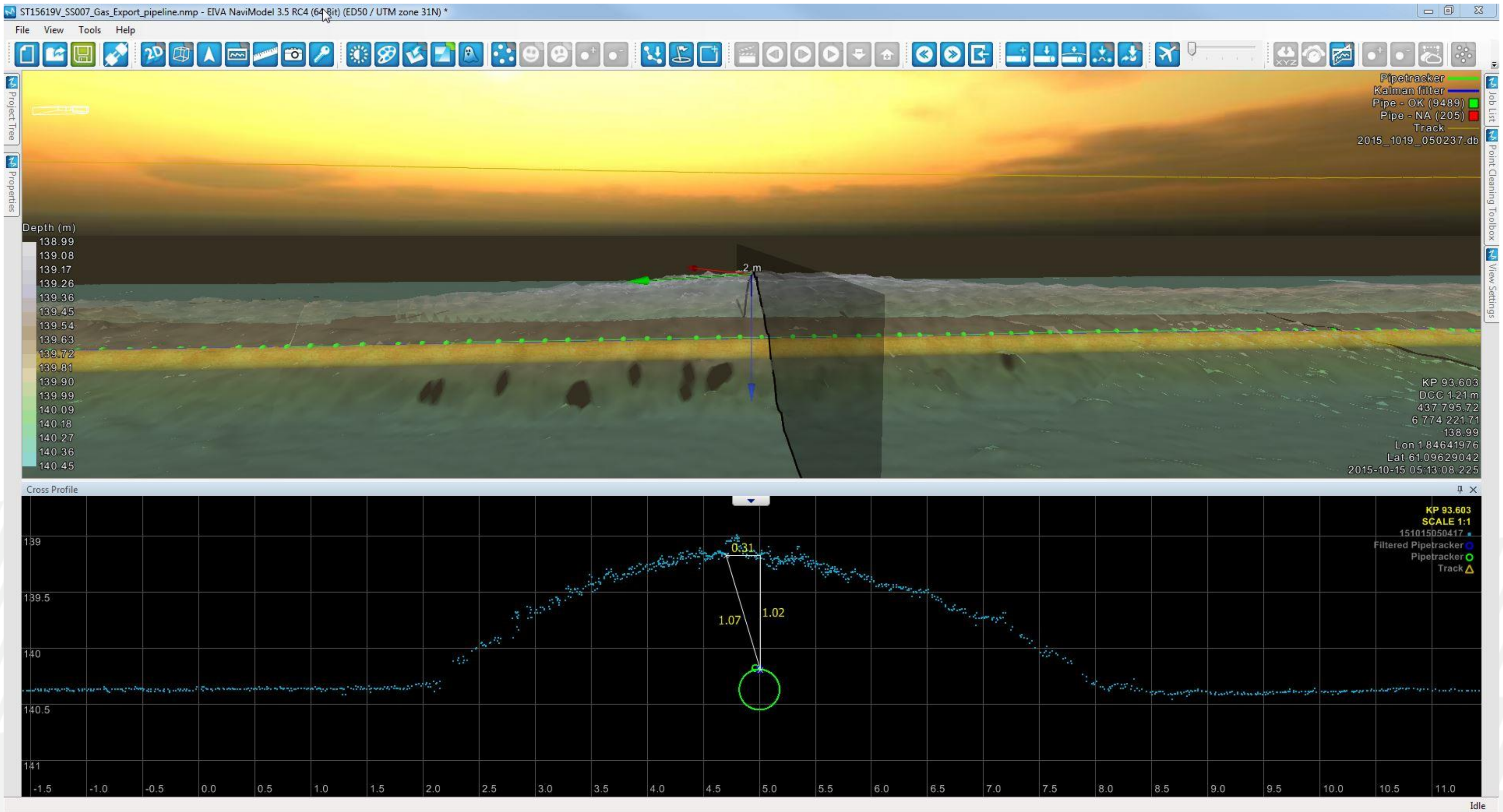
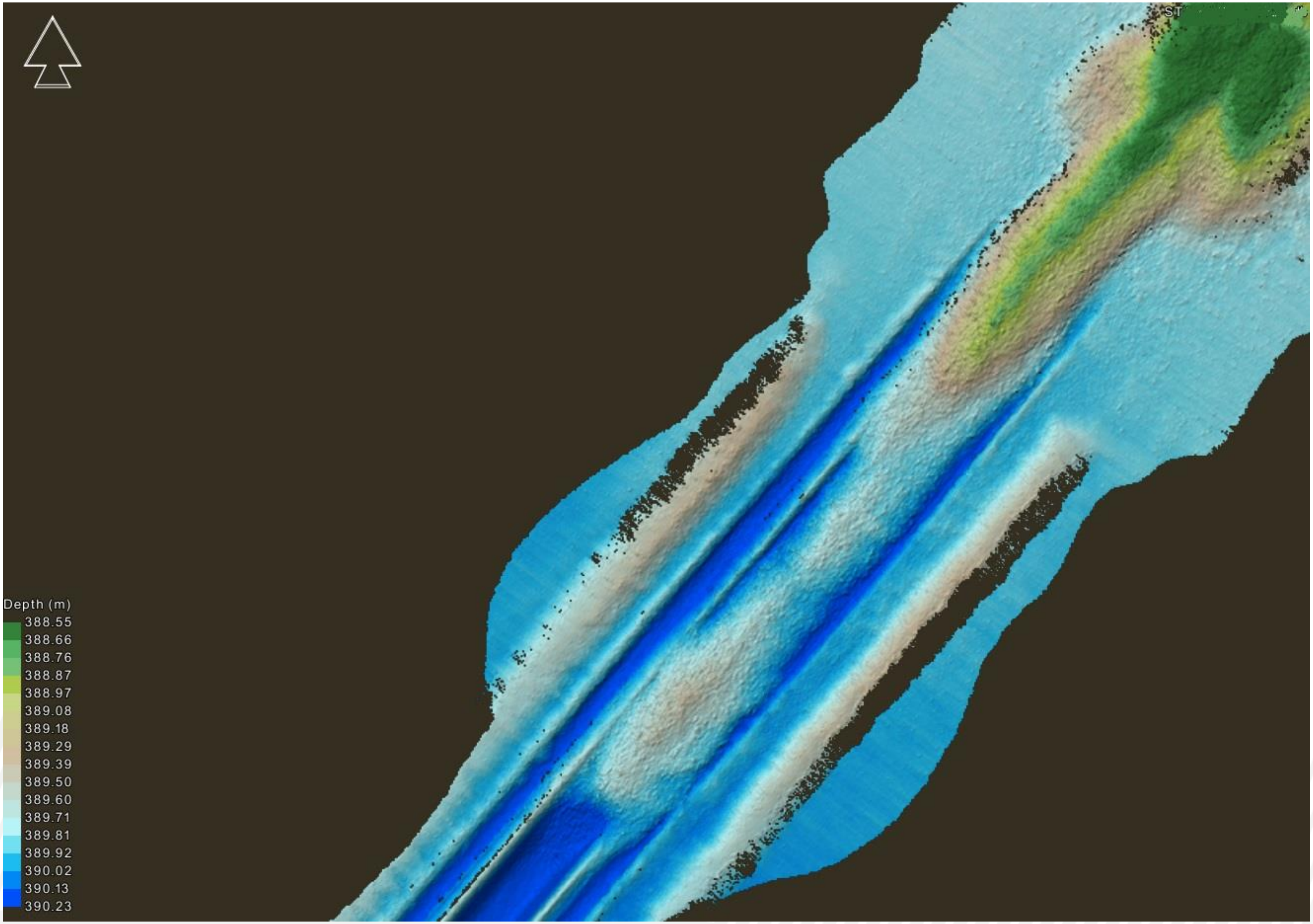
- Pipetracking was successfully performed tracking a 12" pipeline through gravel intervention down to 1.5m. In sections were the pipeline was buried in a trench, the possibility to locate the pipetracker close to the pipeline cover was limited and so was the tracking.
- The design of pipetracker mounting frame proved to be elegant, functional and in no conflict with the simultaneous recording of MBE data (typically continuous stripes in the DTM due to pipetracker beams shadowing the MBE data). The design appeared to be somehow wiggly; however during survey it was stable.



Visual/Pipetracker As-Built Survey



Statoil Test October 2015

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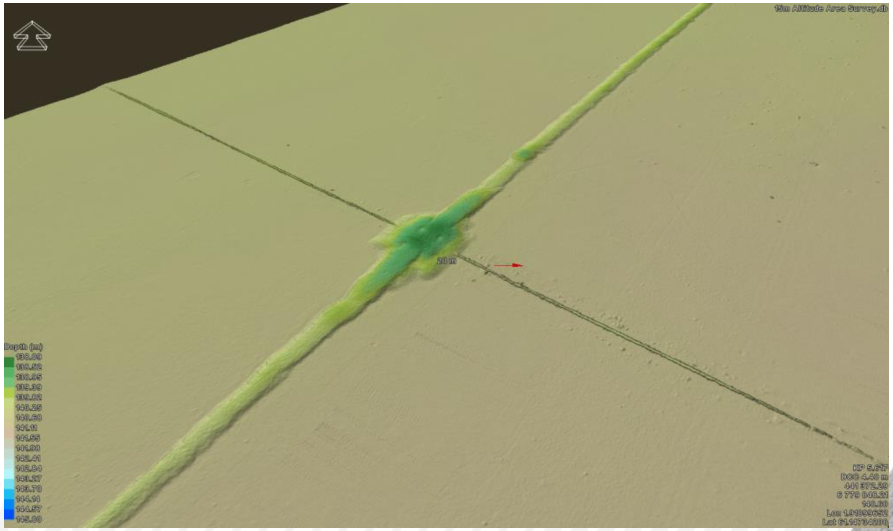
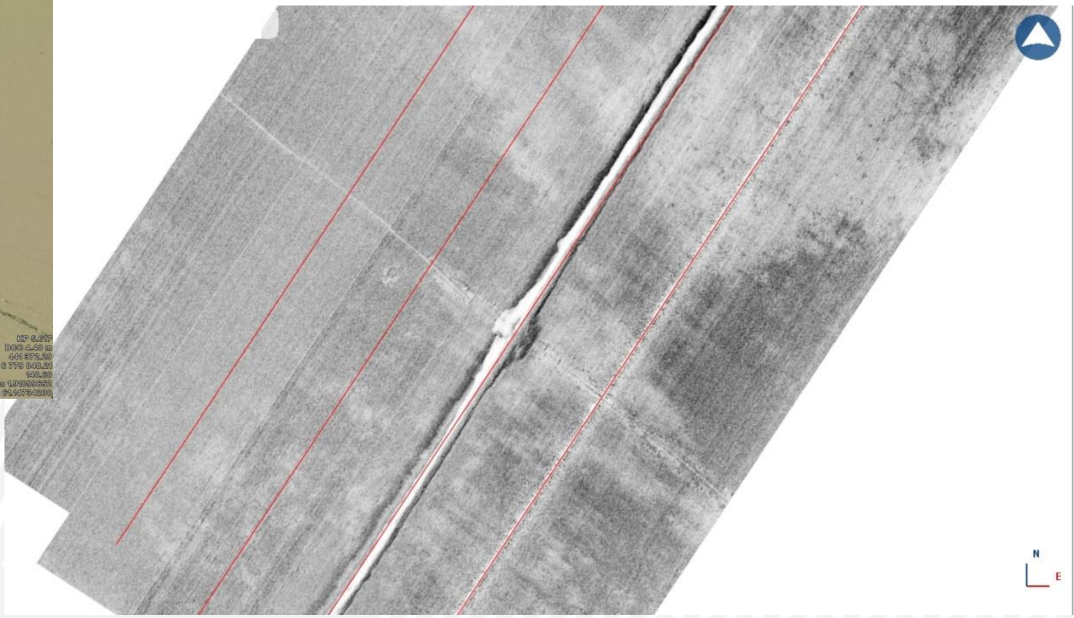
- **Site survey**
- 4 parallel lines – 15m altitude – pipeline crossing
- Average speed 2,1 m/s.
- Flat seabed – still very few artefacts in the MBE data. Pipeline position for the crossing pipe is matching very well between the different lines
- Sidescan data showing very good positional correlation with MBE data.





Statoil Test October 2015

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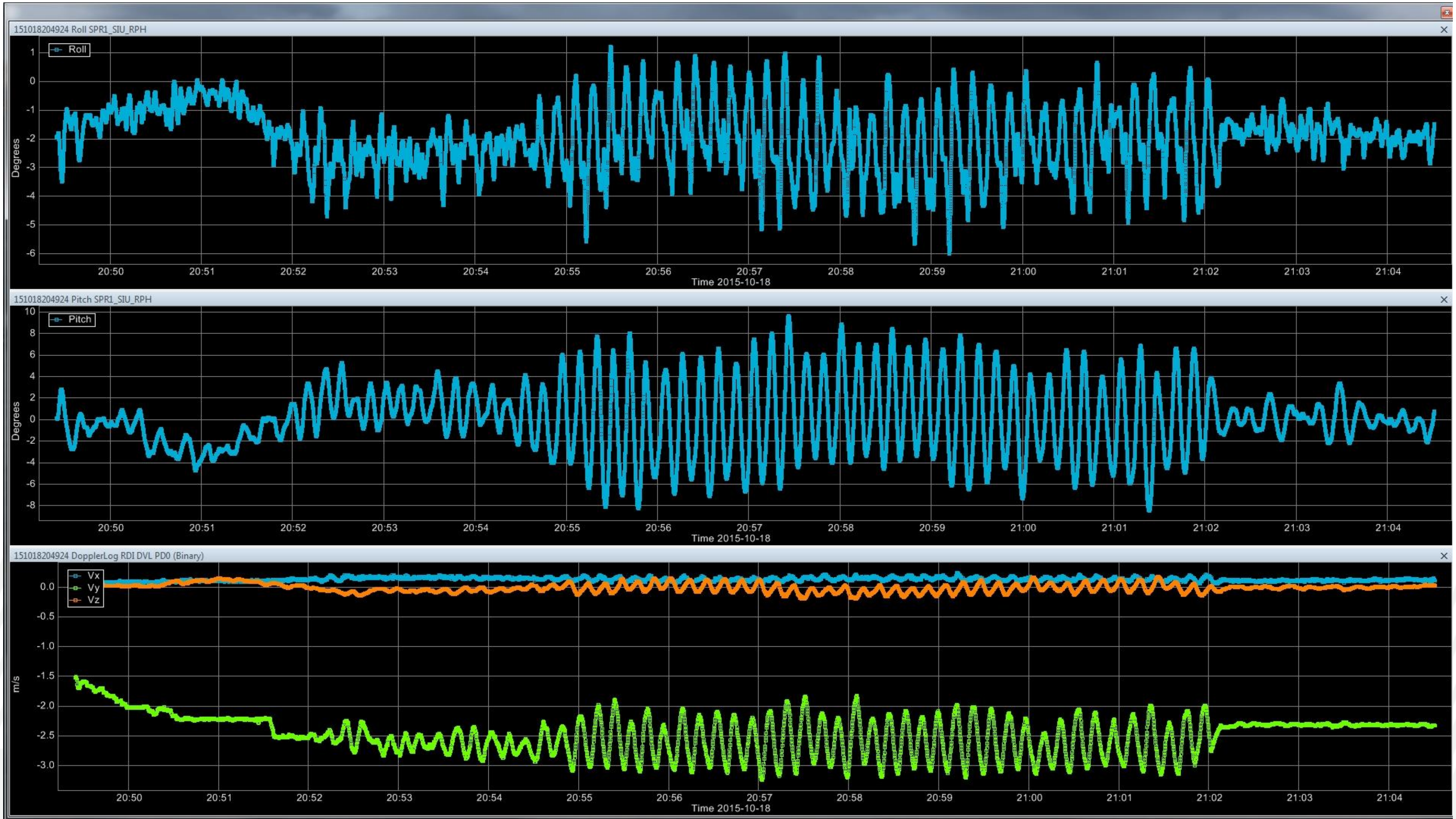
- During all three types of survey the ROV was very stable in the water column with limited variations in roll and pitch. Speed tests proved that the ROV pilots were confident in flying the ROV close to the seabed at 2.3 m/s. A maximum speed of 3 m/s was achieved during speed testing in mid-water.



Statoil Test October 2015

DEEPOCEAN

- "*Acoustic deep water surveys (or e.g. site surveys) is perfect for the Superior. The autotrack function worked very well (also during pipeline surveys). Data quality is top. The client specified grid cell size limited the survey speed. At 20m range we achieved a ping frequency of 25Hz for the dual head setup; hence we kept the survey speed to 2.0 – 2.2m/s. At the curves approaching the templates the speed was reduced to track the pipelines.*

- *Since this was the first real job/trials with the Superior setup it is not unlikely that further improvements could increase the operational speed even further; however the survey sensors will have to keep up.*"

- Above is direct quote from experience report

Conclusions

- All types of surveys were performed at a significantly higher survey speed than before.
- Autotrack is an absolute requirement at high speed (also during pipeline surveys).
- Calibrations, including time synch are critical, as the higher speed is much more unforgiving!
- HD video required:1920 x 1080p x 30fps, or possibly 60fps
- In general the data quality is very good, so processing is faster, but still needs to be reported.
- The vessel capabilities are critical for being able to maintain a high speed.
- Even further speed improvements possible when LARS with thinner umbilical is installed.
- One week SAT and testing – then straight on job!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