"Never make predictions.........

..........especially about the future"

Cost-effective seabed mapping and pipeline survey

Establishing a small network of AUV docking stations on the NCS – a proposal

Dialogkonferanse_Autonom_overvaking_av_subsea_rorledninger, Haugesund.

Tom Glancy, 15th December 2016

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COST-EFFECTIVE SURVEY / INSPECTION – WHAT DOES THIS MEAN?

- Efficient (how well something is done; eg fast, low use of fuel, etc)

- Effective (how useful something is; doing the right thing)

Robot grass clipper:

- Efficient? 

- Effective? 

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WHAT ARE WE LOOKING FOR IN SURVEY / INSPECTION DATA?

I. Quality:

- Not necessarily *high* quality => fit-for-purpose

II. Money:

- Low price

III. Time:

- Some tasks are time-critical; many are not

How to tackle this?

i. Do **less** (or none!): may be more effective; not necessarily more efficient

ii. Do it **quicker**: could work with same price per km (focus on speed)
We have recently seen a radical increase in ROV speeds......

iii. Do it at same speed, but with **lower price** per km (focus on price)
Spread rates are now well down, but are they sustainable?

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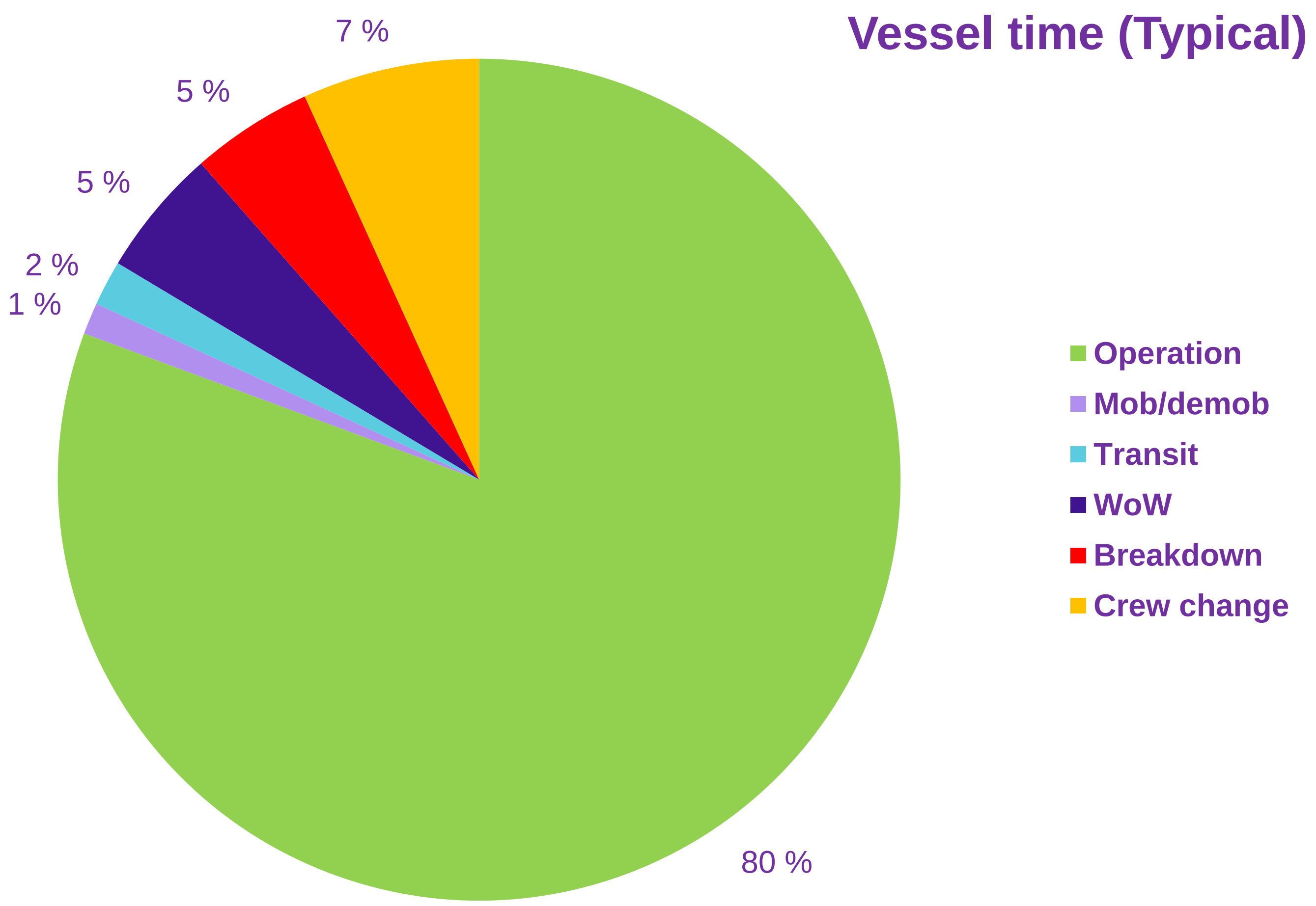
ARE THERE ANY OTHER OBVIOUS EFFICIENCY SAVINGS TO BE MADE?



LET’S LOOK A LITTLE CLOSER AT THE «OPERATIONAL» TIME.....

This figure includes:

- Internal transits
- Setup / line changes
- DP trials
- Calibrations
- Verifications
- ROV launch/dive/recovery

We see that a significant % of this is not really ***productive*** (ie data gathering) time

But while all this is going on a relatively expensive vessel + crew is being paid for

SO WHAT CAN BE DONE TO CHANGE THIS?

This proposal is built on a single premise:

“That the support vessel is the main cost-driver in the performance of offshore seabed mapping / pipeline surveys”

Remove the need for the vessel and a significant percentage of the cost of the operations is removed

SO HOW DO WE DO THIS?

Use of AUVs

- Been around for decades; but used in combination with a support vessel
- Has not resulted in a radical change

Use of resident AUVs

- Now, finally, we have got rid of the vessel
- But, again, there has been no radical change in the way we do things as a result of the availability of this technology

Why has this not changed anything?

- The single docking station approach is problematic as the volume of work at a single, permanent site does not (and in many cases may never) justify investment in a dedicated, resident Autonomous Underwater Vehicle.

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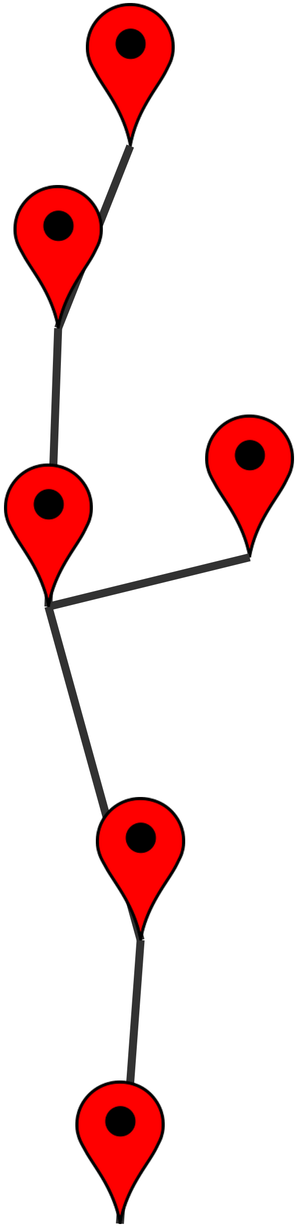
SO HOW DO WE DO THIS (cont.)?

The key to unlocking the true potential of the AUV lies in providing the capability for the vehicle to transit, subsea, between different activity clusters (ref grass clipper analogy)



With this capability provided (by means of establishing a small network of docking stations) the business case is altered *fundamentally*

Highlights:

- Vessel-free (almost)
- 24/7 availability
- Weather-independent
- Free of site-based personnel
- Zero emissions

BEFORE WE GO ANY FURTHER:

What this proposal is not (and never will be).......

It is NOT a WROV replacement:
for many marine ops there is just no other option than to use a vessel c/w WROV

What AUVs can't do…..

…..and probably never will be able to do well…
- Construction Support
- Pipeline Commissioning (PCO)
- Repair
- Well Intervention
- Module Handling
- Crane Work
- Etc, etc.

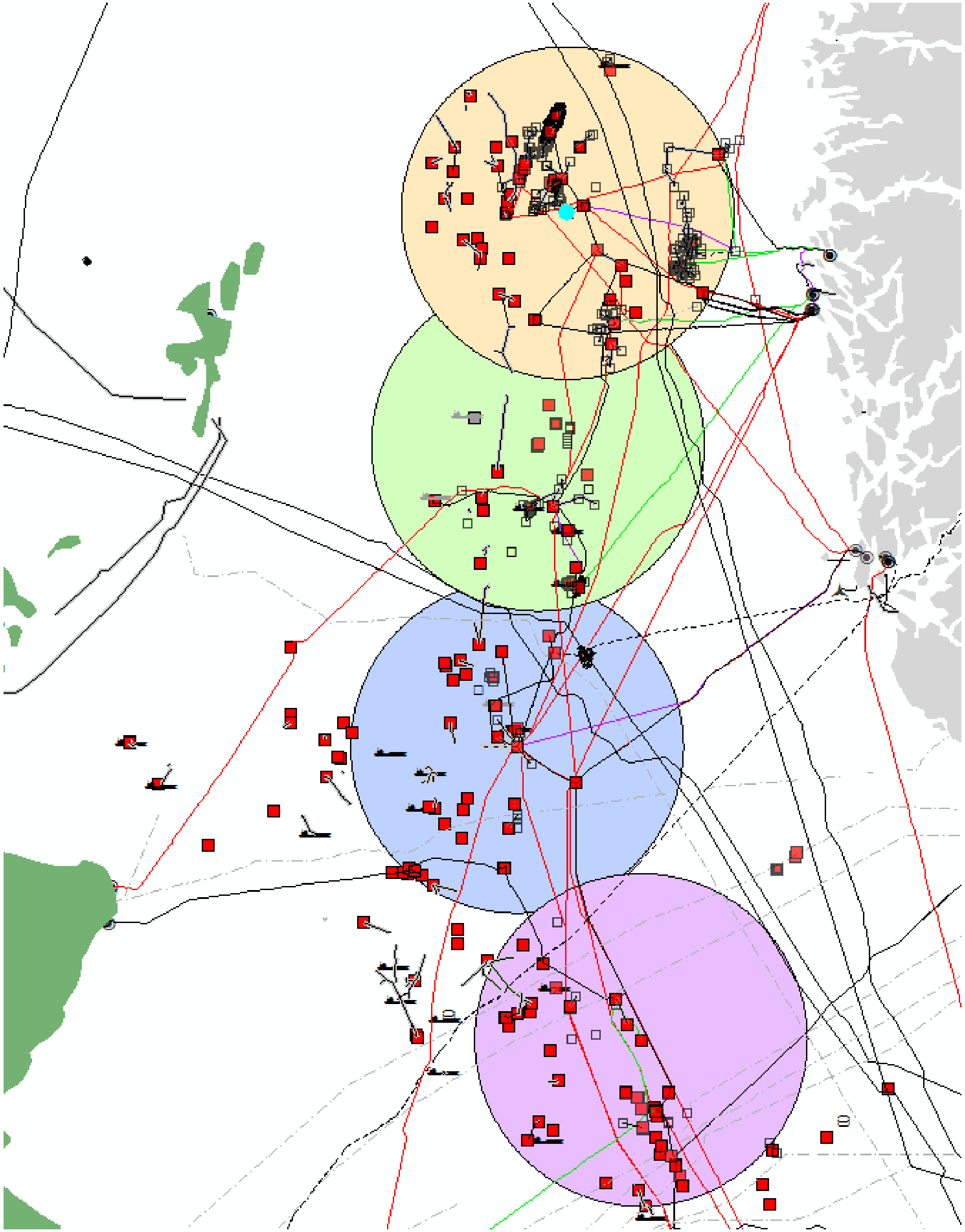
We are talking about a tool for survey/inspection..... (and, perhaps, light intervention)

.....and only where there is an *activity cluster* where the *volume of work* justifies the investment in the costly infrastructure

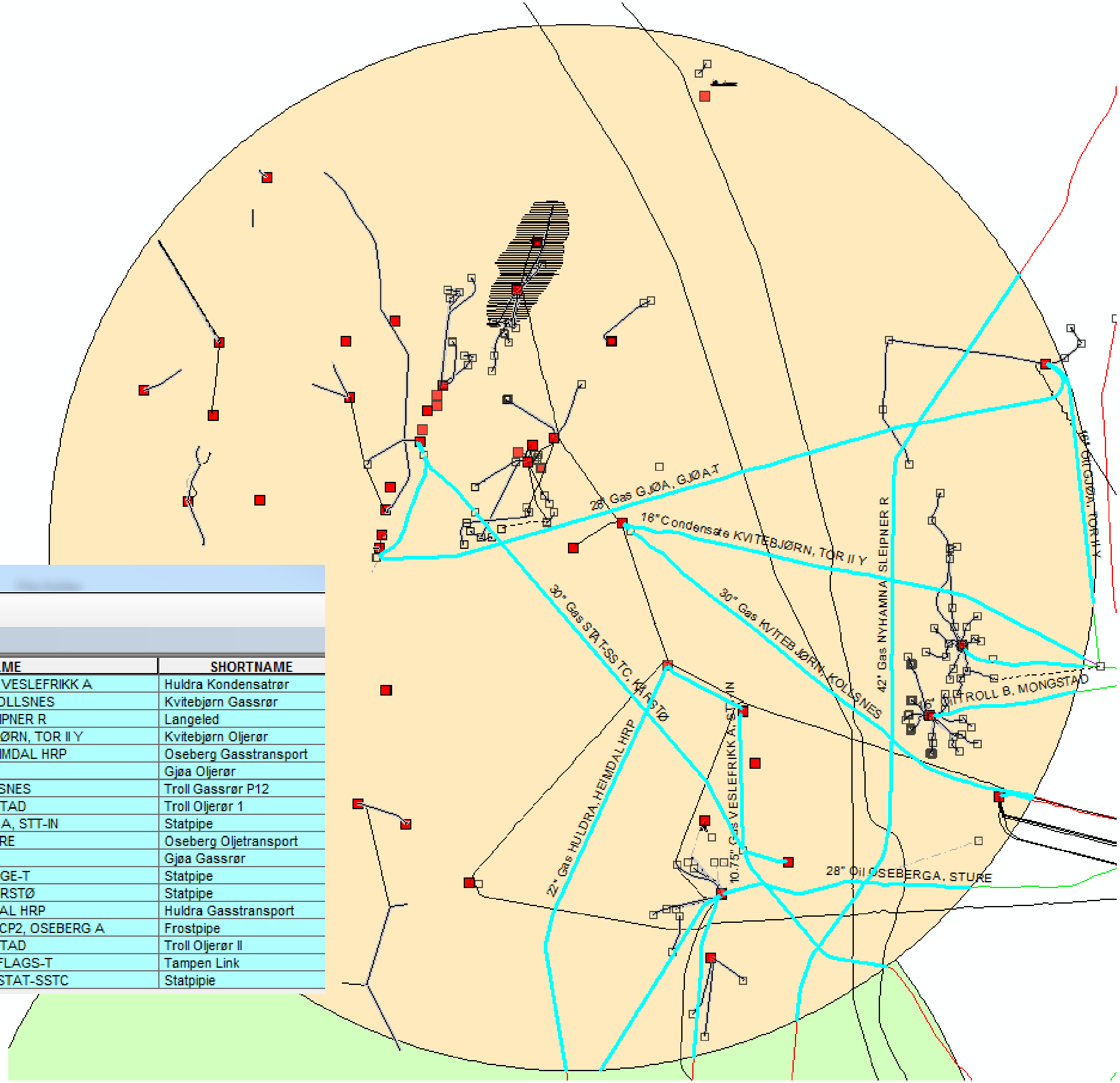
Map and statistics from GIS

50NM RADIUS

Need not be very *efficient* but could be very *effective*......



PIPELINES

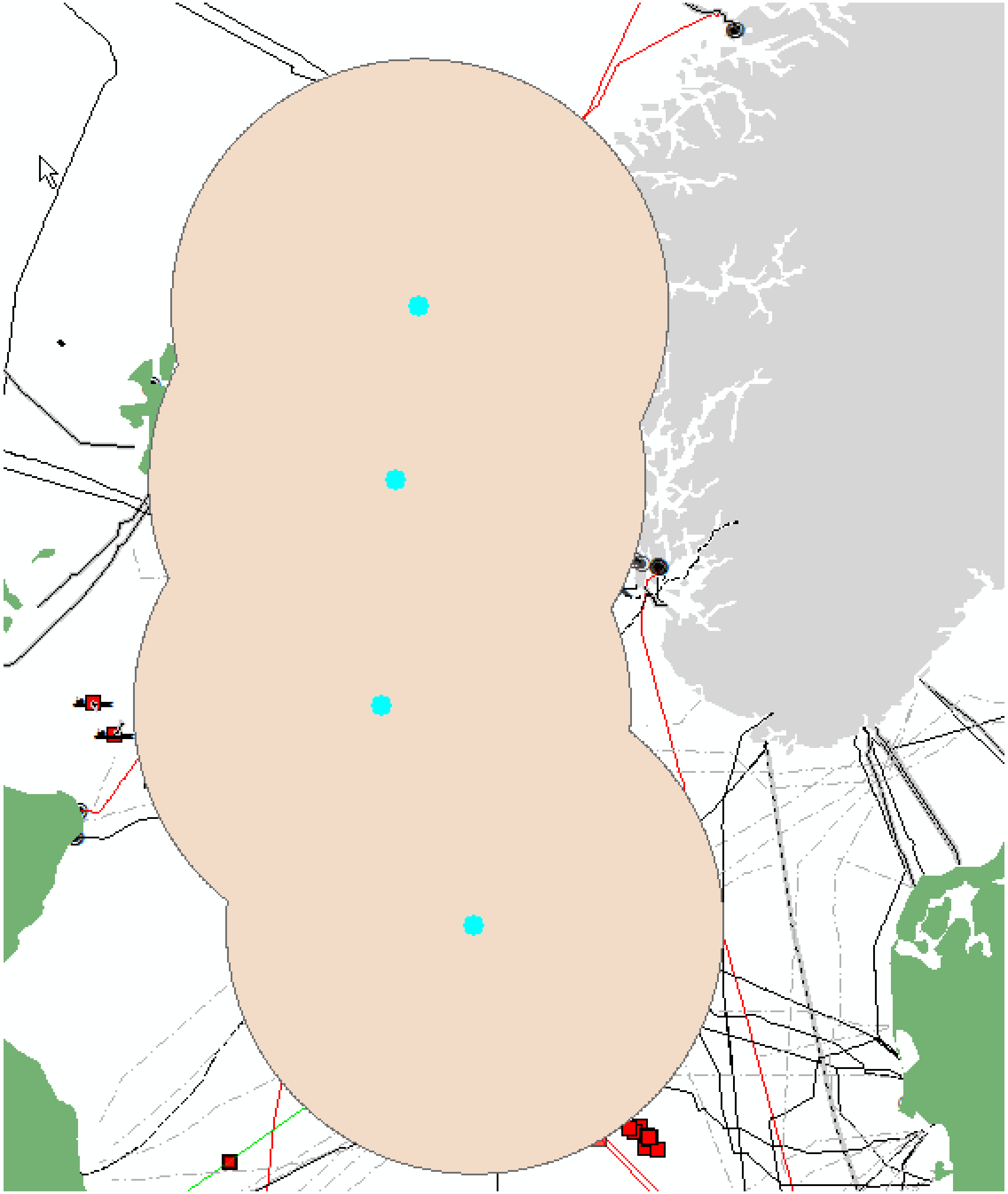


Table

cut_pipes3

FID	Shape *	NAME	SHORTNAME
0	Polyline	8" Condensate HULDRA, VESLEFRIKK A	Huldra Kondensatrør
1	Polyline	30" Gas KVITEBJØRN, KOLLSNES	Kvitebjørn Gassrør
2	Polyline	42" Gas NYHAMNA, SLEIPNER R	Langeled
3	Polyline	16" Condensate KVITEBJØRN, TOR II Y	Kvitebjørn Oljerør
4	Polyline	36" Gas OSEBERG D, HEIMDAL HRP	Oseberg Gasstransport
5	Polyline	16" Oil GJØA, TOR II Y	Gjøa Oljerør
6	Polyline	36" Gas TROLL A, KOLLSNES	Troll Gassrør P12
7	Polyline	16" Oil TROLL B, MONGSTAD	Troll Oljerør 1
8	Polyline	10.75" Gas VESLEFRIKK A, STT-IN	Statpipe
9	Polyline	28" Oil OSEBERG A, STURE	Oseberg Oljetransport
10	Polyline	28" Gas GJØA, GJØA-T	Gjøa Gassrør
11	Polyline	8.625" Gas BRAGE, BRAGE-T	Statpipe
12	Polyline	30" Gas STAT-SSTC, KÅRSTØ	Statpipe
13	Polyline	22" Gas HULDRA, HEIMDAL HRP	Huldra Gasstransport
14	Polyline	16" Condensate FRIGG TCP2, OSEBERG A	Frostpipe
15	Polyline	20" Oil TROLL C, MONGSTAD	Troll Oljerør II
16	Polyline	32" Gas STATFJORD B, FLAGS-T	Tampen Link
17	Polyline	30" Gas STATFJORD B, STAT-SSTC	Statpipe

100NM RADIUS?

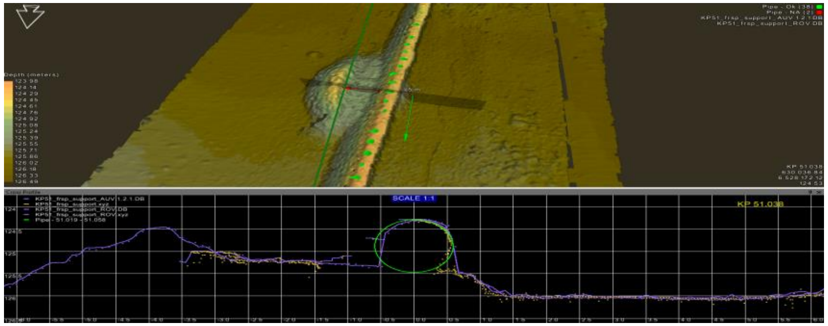


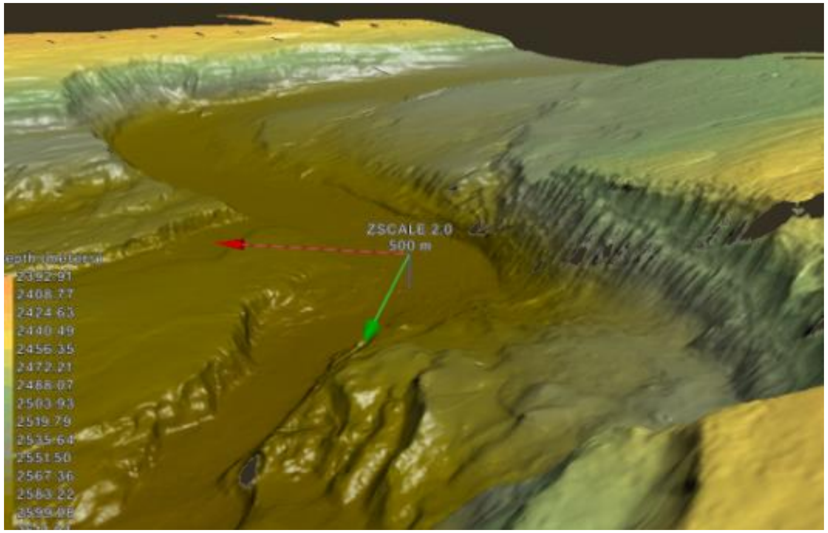
APPLICATIONS

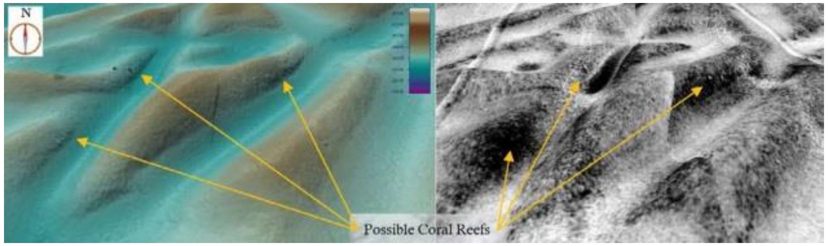
- Pipeline Surveys
- Seabed Mapping
- Environmental Surveys
- IMR – eg, valve operation (could influence/simpify the design of subsea structures)

BUT to make this more attractive (or feasible) we could look beyond traditional O&G applications done for a single operator:

- JV with, or lease to, other operators?
- Civilian mapping applications?
- Surveillance / Security applications?
- Military mapping applications?







BUSINESS CASE

Costs

- Cost of *developing/designing* suitable docking stations
- Cost of *optimising* vehicles to operate in residential mode
- Cost of *installing* docking stations
- Cost of *maintaining* docking stations /vehicles(s)
- Cost of *operating* system (including “recovery service” for ‘broken down’ vehicles….)

Benefits

Of the order XXXNOK / day for each operational day where vessel is not required

Simple OPEX cost comparison:

Assumptions:

Eg 200 days of work for “subsea sensor platform” (ROV or AUV)

BUT: Do we have sufficient *volume* of this type of work on the NCS?

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BUSINESS CASE (cont.) - PRODUCTION EFFICIENCY (PE)

IMR applications

“The real ‘carrot’ in light intervention capability lies in how 24/7 accessibility to tools that could operate valves etc. *could allow us to “slim down” subsea installations* and construct them with fewer actuated valves, i.e. with fewer cables and connections that represent a risk for breakdown (ie, reduced CAPEX).”

Hypothetical situation:

Installation X experiences 6 to 12 days per year of unplanned downtime of wells due to shut-in of a subsea well while awaiting a light intervention which could be solved with a suitable AUV (e.g. choke or valve needs adjustment)

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Other potential benefits: HSSEQ

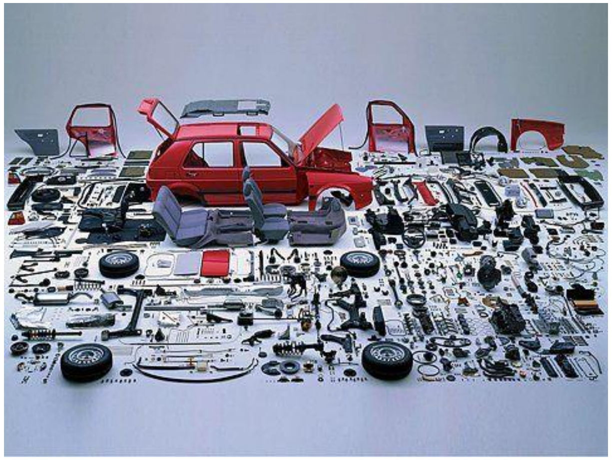
Health & Safety (HSSEQ):
remove the site-based people

Security (HSSEQ):
surveillance role?

Environment (HSSEQ):
«Zero emissions»; No more WOW; Oil spill monitoring & response?

Quality (HSSEQ):
More data; more information; better decision making

SYSTEM COMPONENTS



- AUV(s)
- Docking Stations (+ interfaces to power & comms)
- Operations Centre (on land)
- Maintainance, Repair & Breakdown Recovery Service
- Navigational Augmentation (as required)

SYSTEM COMPONENTS – AUV

Key Issues:

- Degree of autonomy
- Risks / Reliability / Restrictions
- Design (hover or not…)

DEGREE OF AUTONOMY

A key question:
Where are we with AUTONOMY?

Are we ready to let a vehicle loose without the close supervision of – and possibility for intervention from – a support vessel?

Consider the lack of commercial track record for use of AUVs in fully autonomous mode

DEGREE OF AUTONOMY – SOME DEFINITIONS

Manual
The system is fully controlled or manipulated by a human operator, in real-time

Automatic
The system does not make choices– it follows a program

Autonomous
The system does make choices - it attempts to accomplish its objectives without human intervention, even when encountering unanticipated events

Intelligent
Artificial intelligence: the system is able to act appropriately in an uncertain environment and is capable of modifying the way in which it achieves its objectives

In the context of using ROV/AUV:
Manual: conventional use of ROV

Automatic: Supervised AUV (or, more correctly, UUV)

Autonomous: Unsupervised AUV

RISKS: CAN THE VEHICLE BECOME ENTANGLED IN FISHING NETS…..?

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RISKS

What else can go wrong?

Can the vehicle become lost?
Yes.

Can the vehicle float to the surface?
Yes.

Can the vehicle get stuck on the bottom?
Yes.

Can the vehicle interfere with other subsea operations?
Yes.

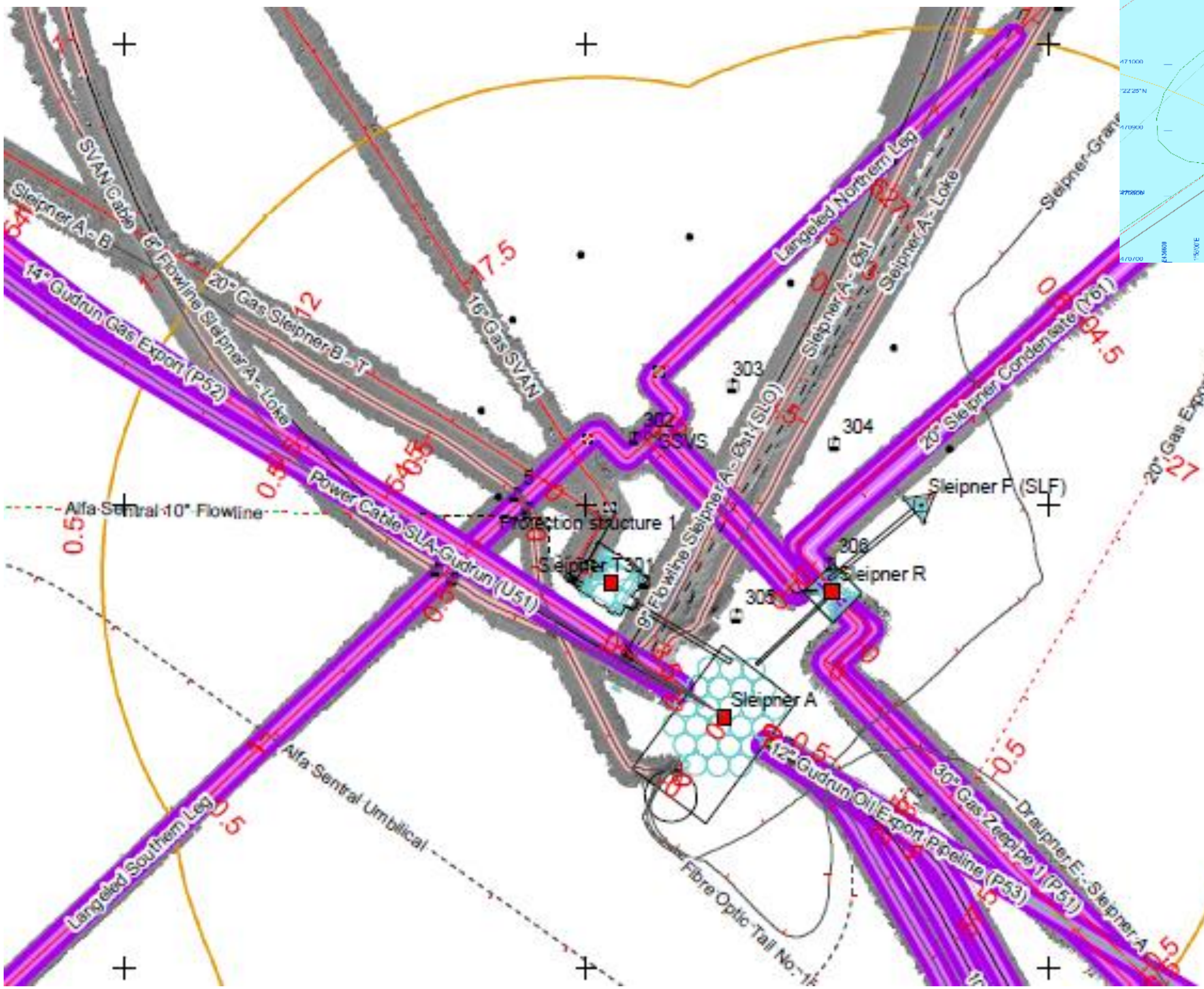
Can the onboard sensors fail?
Yes. They will fail.

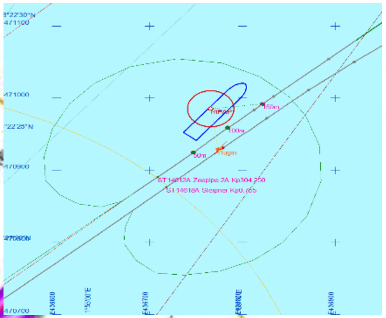
Can the vehicle breakdown?
Yes. It will breakdown.

What else can go wrong?
Lots.

But a great deal can be done to mitigate these risks

RISKS: cont. LEGISLATION

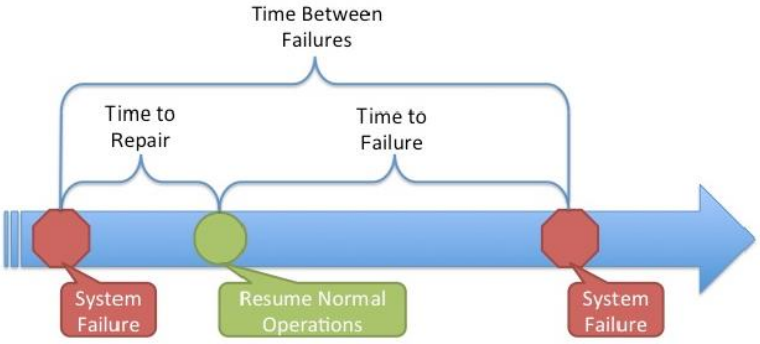




SAFETY ZONES

AUV RELIABILITY IN AUTONOMOUS / RESIDENT MODE

RELIABILITY ISSUES



- Maintenance (preventative maintenance: how often and how much?)
- Breakdown (there will be breakdown: how often is too much?)
- Need for a «Breakdown Recovery Service»
- Marine growth
- etc

- Also: reliability (& maintenance) of docking stations

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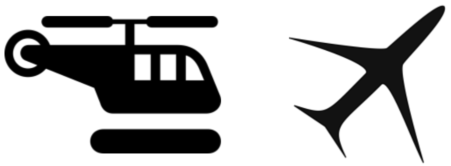
AUV DESIGN - TO HOVER OR NOT TO HOVER?



Hydrodynamic form of classic torpedo-shaped vehicle is optimised for **speed**
BUT will speed continue to be an important factor when we don't have an expensive vessel waiting?

A hover-capable vehicle can potentially do more (eg CVI, valve operations, etc)
=> better Business Case

A hover-capable vehicle is perhaps better suited to docking / undocking?

However......
We still need excellent **stability** for optimum survey data quality –is this better seved by a streamlined hydrodynamic form?

Speed may not be an issue but ***range*** (between docking stations) may be; torpedo shape allows for greater endurance with same power

SYSTEM COMPONENTS - AUV DOCKING STATIONS

Key Issues

- Design
- Cost

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AUV DOCKING STATION – DESIGN ISSUES

Function
- Power
- Comms
- Protection

Installation
- Permanent
- Mobile

Interface with vehicle(s)
- «Universal»
- Proprietary

Docking
- Fully autonomous
- Manual control

Configuration
- Single vehicle
- Multi vehicle

Power / Comms
- Connector
- Inductive

AUV DOCKING STATION – DESIGN ISSUES

Optimal situation: Standardisation «subsea USB»
but standardisation takes time

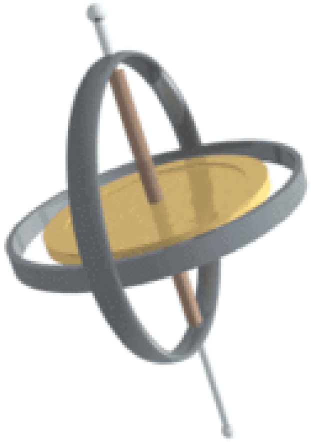
Can we get access to existing infrastructure (for power / comms)?
For new structures the best solution will be full integration

AUV DOCKING STATION ISSUES - COST

No Statoil study on this yet

Will this be a showstopper?
(or at least make it difficult to have a compelling business case?)

AUV NAVIGATIONAL ISSUES



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NAVIGATION

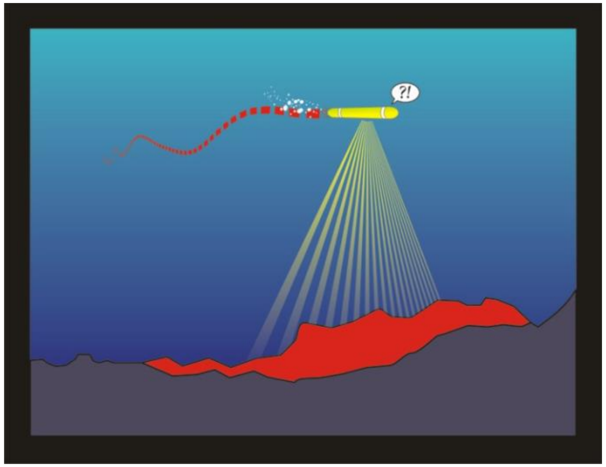


IMAGE: Stanford University Aerospace Robotics Lab

Some key issues:

Independent (only onboard sensors):

- INS, DVL, pressure depth sensor, etc
- As above, plus: GNSS

Dependent (external augmentation):

- GNSS/USBL (supervised mode)
- Array / sparse array
- Terrain navigation / pipeline tracking
- (requires input of DTM or linefile)
- Homing devices (on docking station)

Real-time:

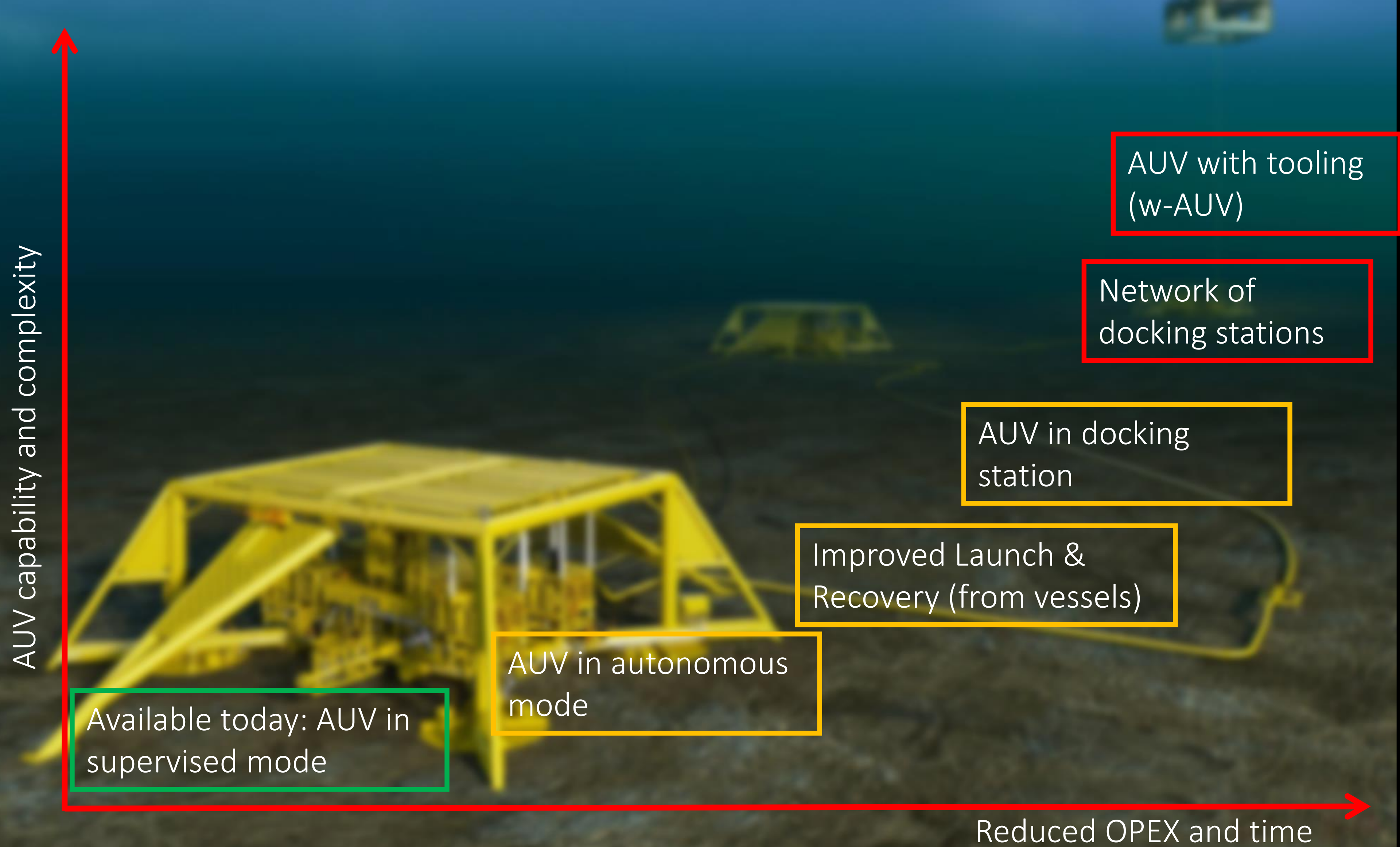
For seabed mapping – need to ensure that we survey the correct area – requires higher accuracy in real-time

Post-processed:

For other applications (eg pipeline survey) we can accept poorer quality in real-time navigation providing that improvements can be made in pp

STATOIL'S AUV STRATEGY

AUV capability map and potential pilots, 2016-2020



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WHO CAN MAKE THIS HAPPEN?

- Not the survey companies
- Not the AUV manufacturers
- Probably only the operators can be responsible for installing the infrastructure

IMPACT

Who would potentially gain from the introduction of something like this?

Statoil & other operators?

Who would lose?

Vessel operators (fewer vessel days.....?)

What about survey companies?

WILL WE EVER SEE THIS?

Key questions

Is the effort justifiable?

- *Cost of today's methods* fluctuate wildly with market conditions
- *Amount of survey* required fluctuates wildly with market conditions (even volume of so-called 'annual' survey)
- Amount of activity on NCS will tail-off (and not recover) at some point; but there will be a significant period where we operate with increasingly *aging infrastructure* – greater need for monitoring
- *Cost of developing such a system* is, as yet, unknown

Even if we can justify it in monetory terms, could we ever rely on it?

- The LCV/WROV solution is extremely robust
- AUVs' reliability in resident, autonomous mode is less well proven

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ALTERNATIVES

- Very cheap multi-purpose vessels (for ROVs and/or AUVs) – here now (but not sustainable)
- Fast ROVs - here now

- Resident ROVs (tied to a single installation)
- Resident (but not networked) AUVs (limited excursion)
- Hybrid ROV/AUVs
- Improved AUV LARS for deployment from vessels
- Combinations of the above

Or:

- Much less survey work performed.....

There are initiatives starting to emerge for Resident ROVs
The motivation behind these initiatives is mainly «IMR / light intervention»; not survey

CONCLUSIONS: LET'S WALK BEFORE WE ATTEMPT TO RUN....

Most of the needed technology is available today; including docking stations

But still need to install the docking stations
Technically we know that this is feasible; but what about the **cost**?

Most likely solution; design docking station (and necessary cabling) as integrated part of new structures

BUT the long term **reliability** of fully autonomous systems is an unknown
First step: let's use an AUV in autonomous mode........

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"The best way to predict the future.....

..........is to invent it"

There's never been a better time for good ideas

THANK YOU...

Cost-effective seabed mapping and pipeline survey

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