Doing More with Less

Field Development Survey

Presentation Agenda

01 How the industry sees survey operations / lifecycle

02 Where should we be focusing on improvements?

03 Analysis and planning improvements

04 Zupt's Subsea Toolbox – Fusion Splice

05 Sparse LBL – the devil is in the details

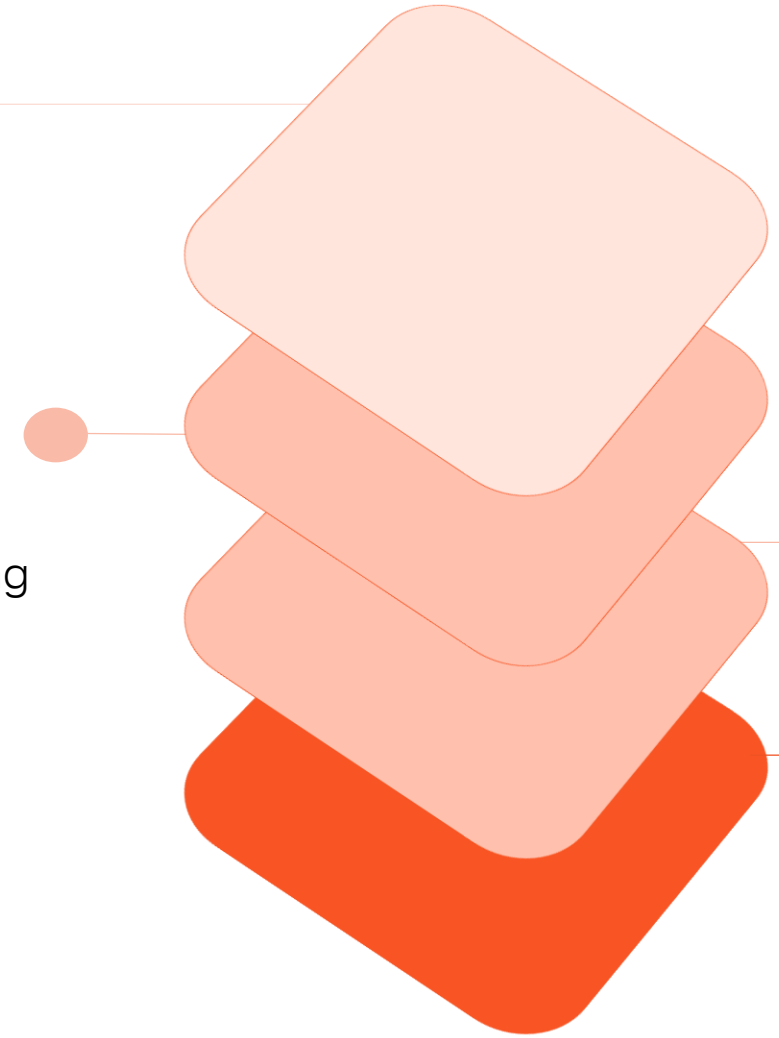
06 Operational improvements (including calibration)

07 Post processing improvements

Looking at survey operations

Bid Stage
Scope of work – provided by client
Bid review, preparation and estimation

Job Awarded
Onshore preparation
Write the procedure
Equipment integration, testing



Improvements can be made throughout the cycle, but should we start?

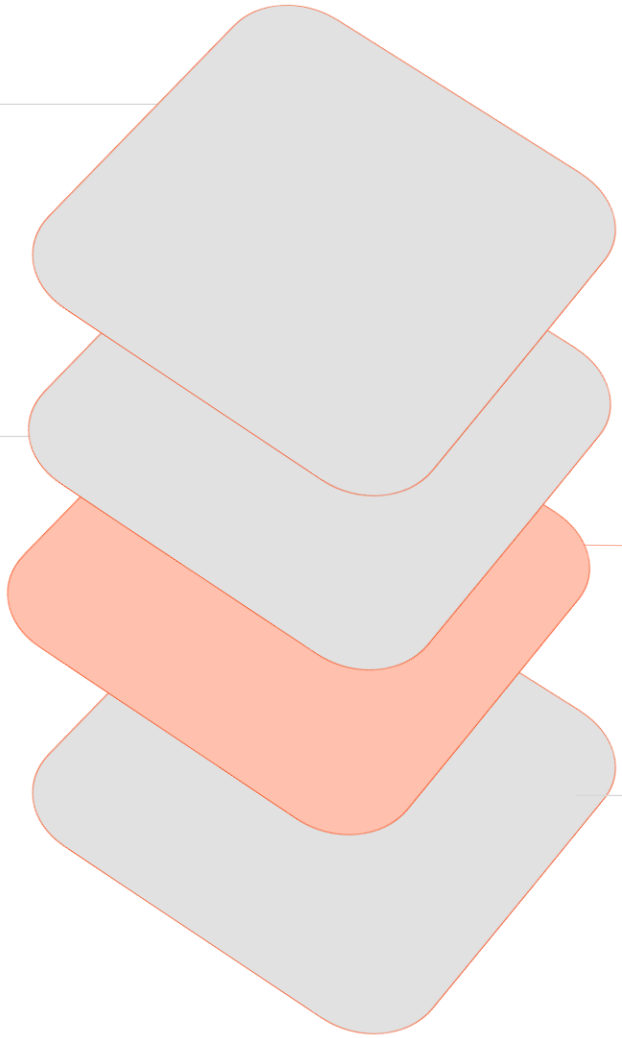
Offshore activities
Offshore vessel/ROV mobilization
Equipment deployment/calibration
Survey operations

Post survey activities (offshore/onshore)
Post processing
Reporting

Most Focus Improvements on Offshore Operations

Bid Stage
Scope of work – provided by client
Bid review, preparation and estimation

Awarded – Onshore preparation
Write the procedure
Equipment preparation onshore



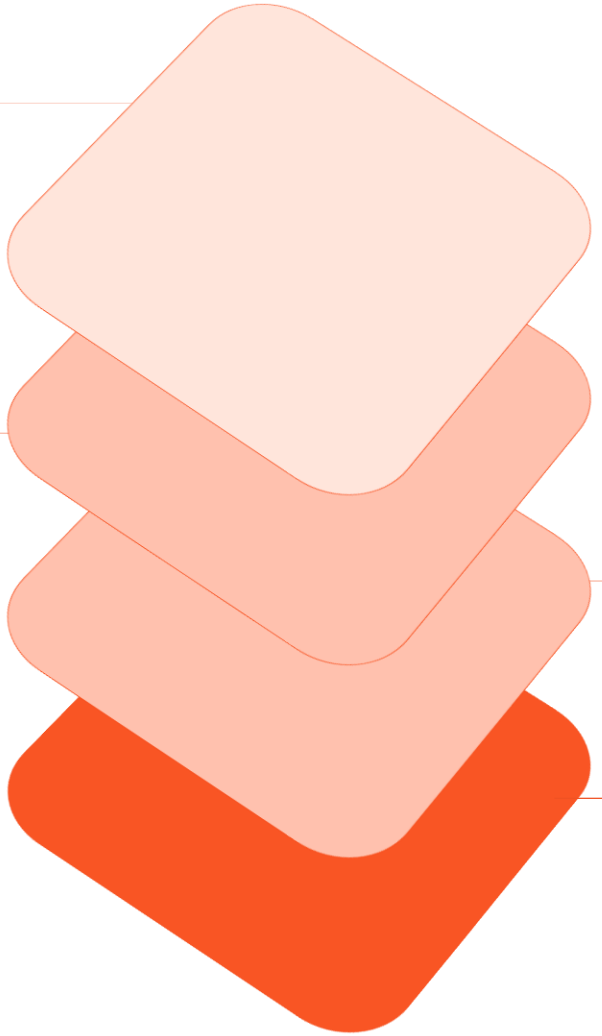
Offshore activities
Offshore vessel/ROV mobilization
Equipment deployment/calibration
Survey operations

Post survey activities (offshore/onshore)
Post processing
Reporting

Zupt Focuses on More Than Just Offshore Operations

Bid Stage
Scope of work – provided by client
Bid review, preparation and estimation

Awarded – Onshore preparation
Write the procedure
Equipment preparation onshore



Improvements and efficiency gains can be realized throughout the entire project lifecycle

Offshore activities
Offshore vessel/ROV mobilization
Equipment deployment/calibration
Survey operations

Post survey activities (offshore/onshore)
Post processing
Reporting

Intelligently Filling the Gap

The primary focus is to optimize the tools deployed for the required accuracy (absolute or relative).

As an example: if you need 2m (absolute or relative?) seabed positioning accuracy in 2,500m of water, there is an alternative to LBL. The need for “better than USBL” doesn’t always mean LBL.

Through our evaluation process, we design a solution using the positioning and survey tools available to ensure the accuracy required is delivered as operationally efficient as possible.

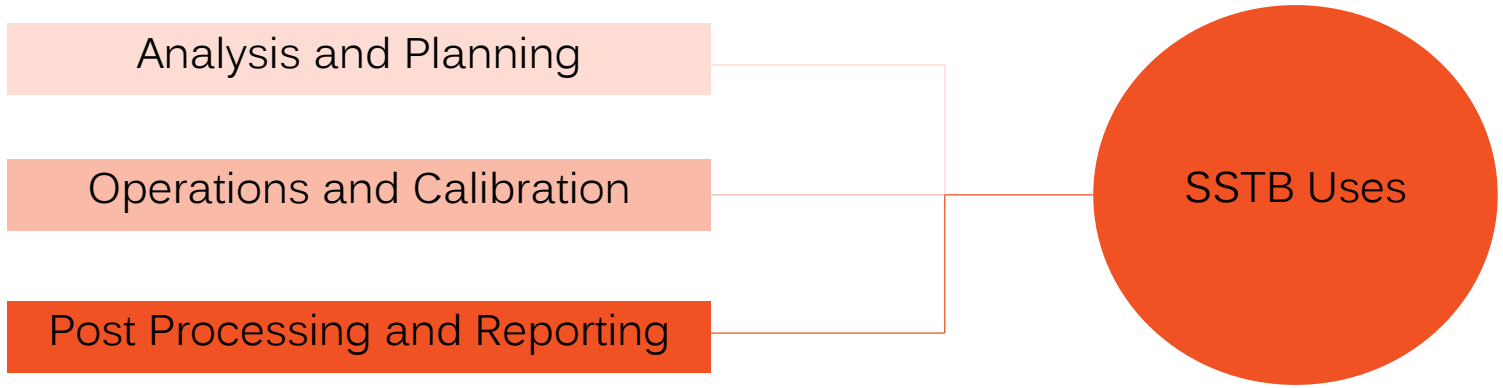
Well calibrated USBL	0.1% (do we really get this?)
USBL/INS	improved precision (not accuracy)
Sparse LBL	0.75 – 2 meters (fills the gap)
LBL	<0.5m relative (when needed), absolute ??

Subsea Toolbox Software - SSTB

Zupt's "Subsea Toolbox" is a collection of software tools that provide planning, real time acquisition support and post processing solutions.

Originally the Subsea Toolbox consisted of "lumps of code" we used to optimize, calibrate, plan, and process field development survey projects. This suite of programs and simulations has evolved into what we now call the Subsea Toolbox.

We analyze, plan, execute, and process a unique solution, designed specifically for each project.

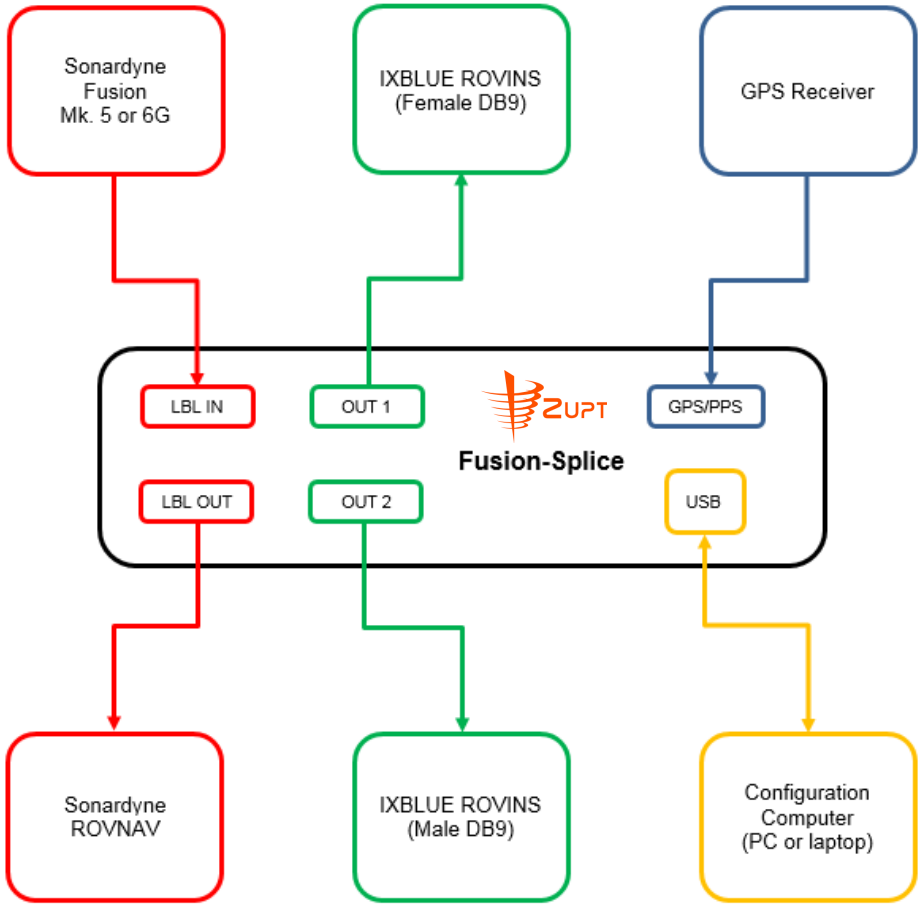


What is Fusion Splice (FS)?

Fusion Splice is a multi channel, real time - “sniffing”, parsing, processing, string generating device.

The system reads in strings in real time (invisible to the parent system), cuts, pastes and processes specific fields and then generates required strings that are output to third party instruments.

Fusion Splice also sync’s with GNSS 1PPS so that all strings are time tagged to UTC (or client specified time).



Sparse LBL Operations

Sparse LBL can simply be described as the aiding of an INS position solution with a minimum of 2 lines of position (LOP) every ~10 seconds. These LOPs are used to constrain the INS position solution.

Fusion Splice was designed to solve a problem our customs were consistently facing:

" We have Sondardyne Compatts and an IxBlue INS, but they won't talk to each other"

Various options from different vendors (SPRINT / RAMSES / HAIN) exist but, each vendor demands that you use a complete solution from them.

Sparse LBL does not need to be a single vendor solution

Sparse LBL arrays are designed to use minimal LOPs to reliably keep the INS position solution within the required project tolerance. This tolerance will drive the location and number of transponders required.

Can we get away with 2 LOPs every 15 seconds? If a mattress laydown interferes with a range for 60 seconds, are we still within spec? Etc.

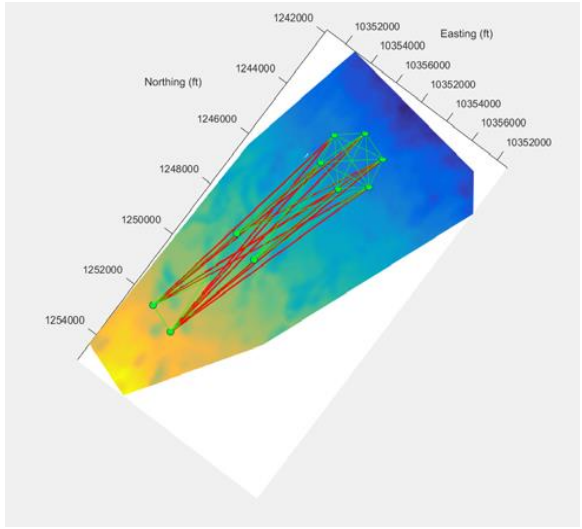
Subsea Toolbox Software – Array Analysis

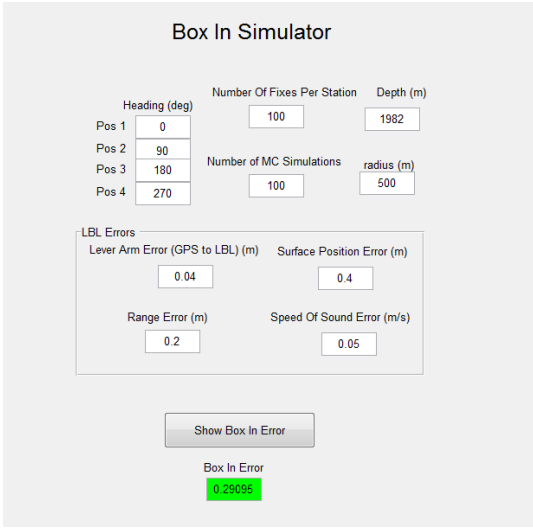
Analysis and Planning

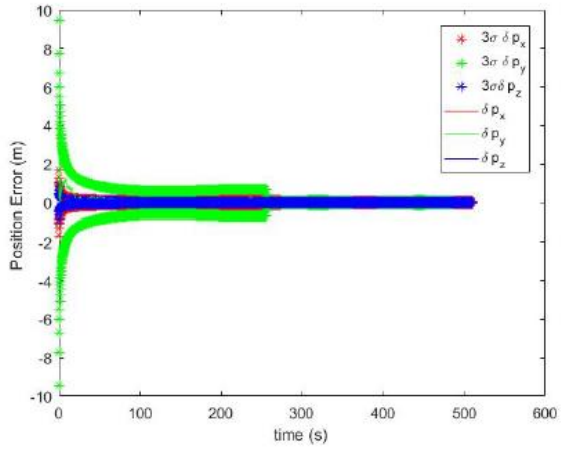
Ray bending/ray analysis tools

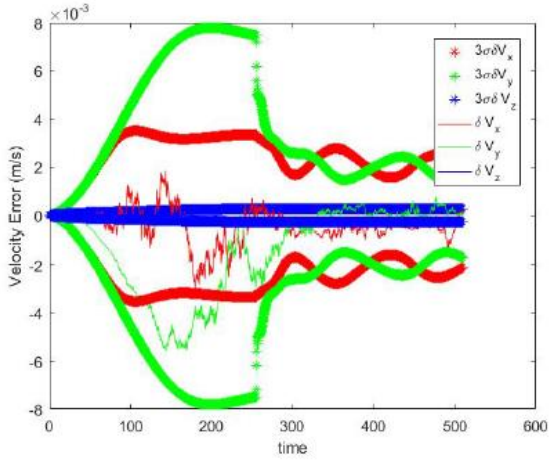
Box In Simulator – what is the optimal radius?

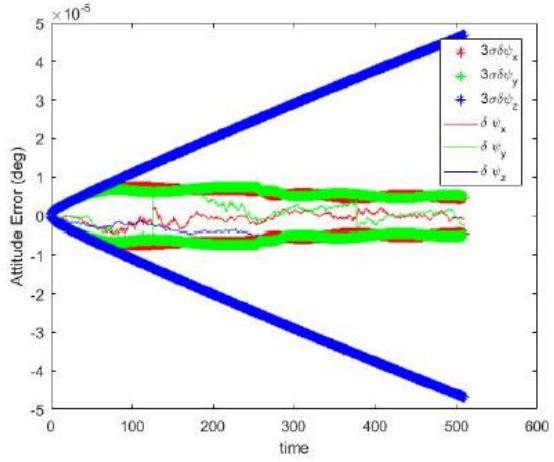
Depth aiding LBL SLAM tools











Subsea Toolbox Software - Calibration

Operations and Calibration

Real time Box-In/USBL calibration with optimal timing and use of motion, lever arms, DGNSS and acoustic (range range/USBL) data to establish the absolute coordinates of a transponder on the seabed, or for a precision USBL calibration.

Real time QC for the system operator as data is being collected.

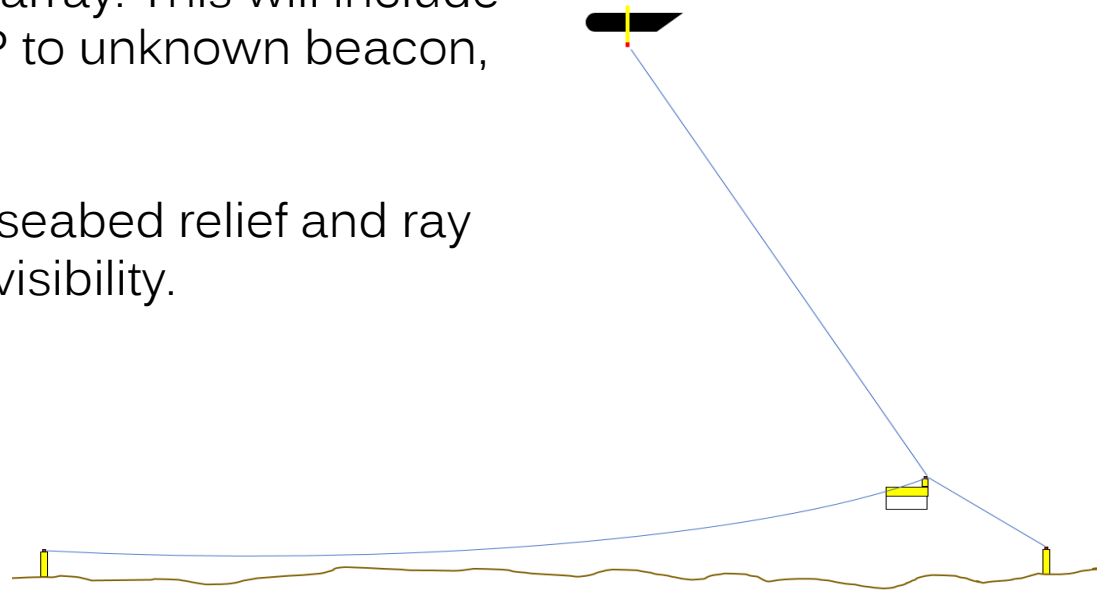
Subsea SLAM array add-on; provides for the fast addition of seabed sparse LBL transponders – propagating an array over long distances, Sensor Interfacing (Fusion Splice) for third party INS solutions (iXBlue), Full INS (C-PINS where raw IMU output is available).

Subsea Toolbox Software – Array Add On

Operations and Calibration

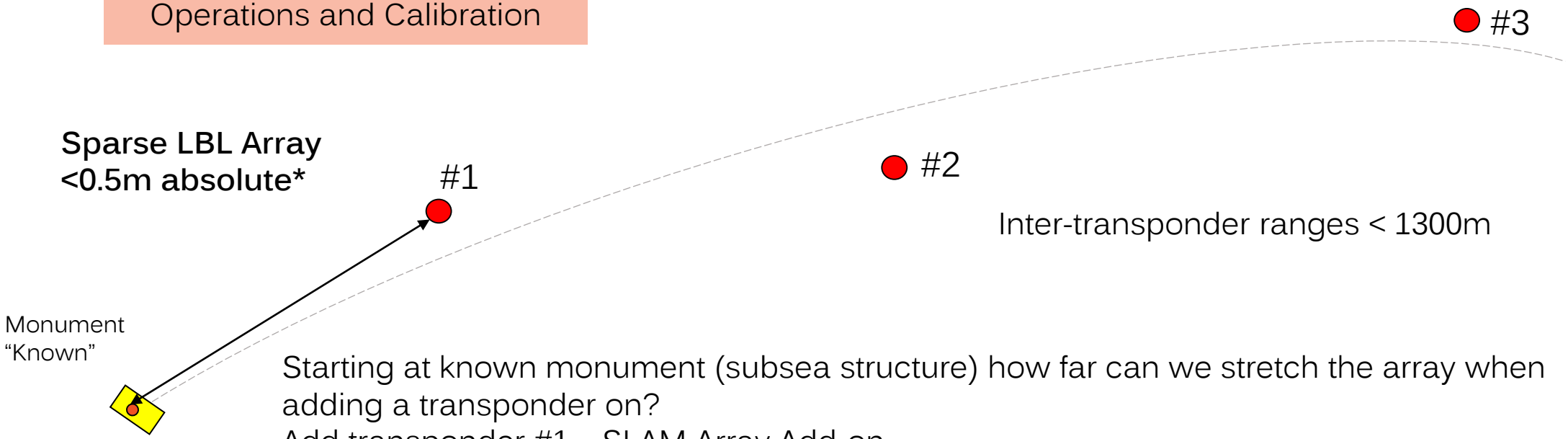
To allow long offsets between an existing transponder and a new transponder we use all observations available to efficiently and accurately add this transponder onto the Sparse array. This will include USBL from the vessel, LoP to known beacon, LoP to unknown beacon, depth and IMU.

We cannot forget about SNR, tdcr beam patters, seabed relief and ray bending issues when considering acoustic inter-visibility.

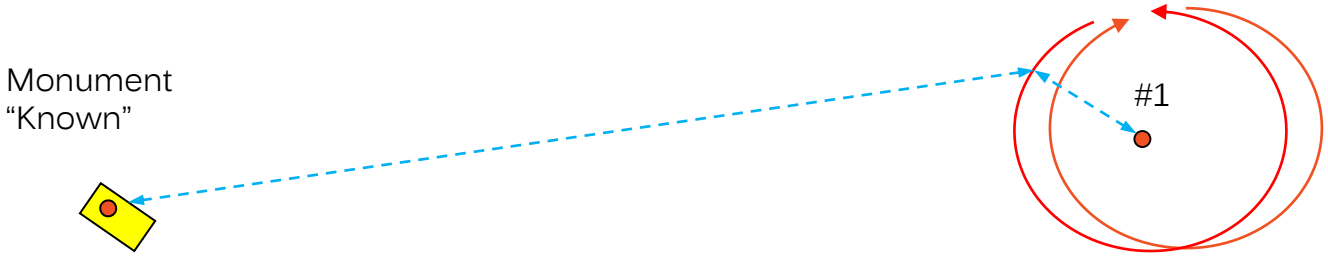


Subsea Toolbox Software – Data Collection Sequence

Operations and Calibration



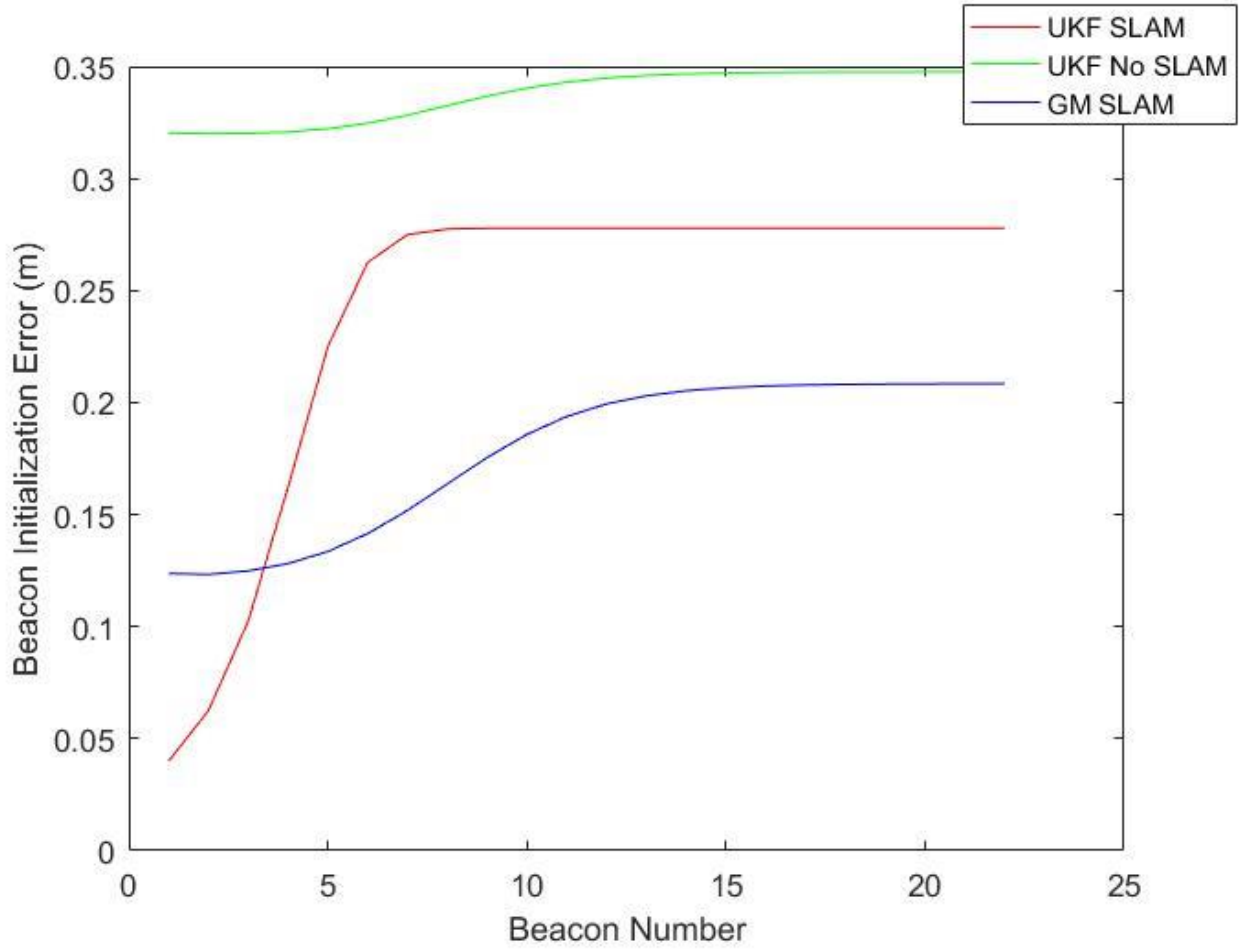
Starting at known monument (subsea structure) how far can we stretch the array when adding a transponder on?
Add transponder #1 – SLAM Array Add-on
Use this new solution to add an additional Transponder #2 – SLAM Array add-on
Same for #3 - etc.



The Benefits of SLAM (LOP, USBL, Depth, INS)

Multiple beacons can be added “linearly” onto a single existing beacon if a relative Sparse LBL positioning accuracy of ~0.4m is acceptable – indefinitely!

This has been field proven during deep water operations in early 2017.



A Note on Sparse LBL – The devil is in the details!

Operations and Calibration

SLAM array add-on has to start at a known location – a “boxed in” location, an extension of an existing array, or a known location (structure) at the seabed.

For Sparse LBL to be efficient – additional beacons need to be added onto the Sparse LBL “array” at, or beyond the maximum inter-transponder range that can be measured at the seabed.

Additional beacons are added on to the existing array using new array add on techniques. For some users this has meant that they have to deploy a Sonardyne ROVNav* on their ROV as well as a RAMSES™ ** transceiver from iXBlue.

Our software solution does not need anything apart from the ROVNav, Fusion Splice and a third party INS.

BUT – we are limited in the data available to us from industry standard ROV based INS solutions (ROVINS, PHINS, C-PINS, SPRINT etc.).

* ROVNav is a Sonardyne product, ** RAMSES is an iXBlue product and trademark

Subsea Toolbox Software

Post Processing and Reporting

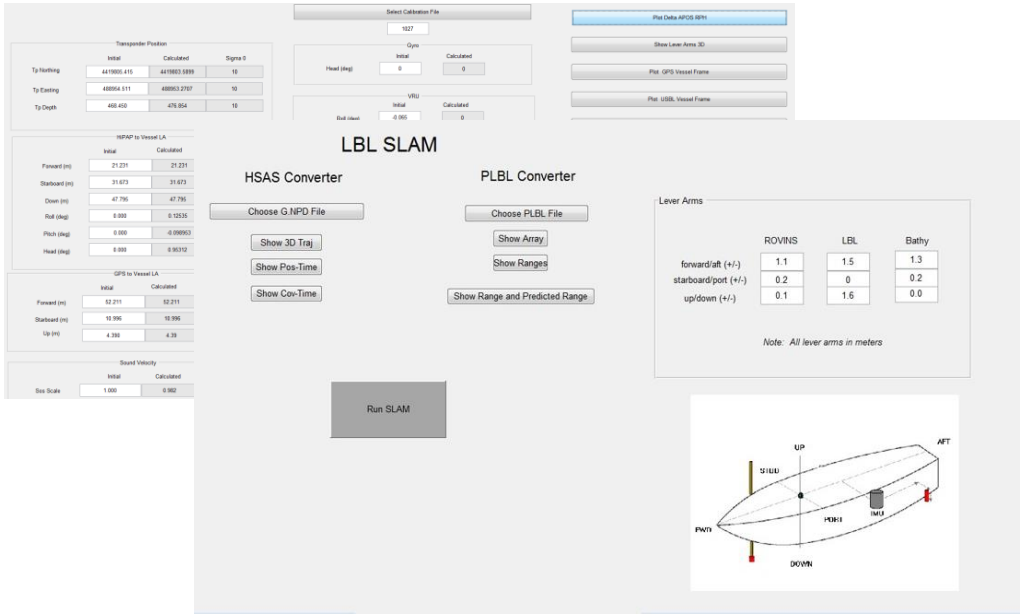
USBL Precise Calibration

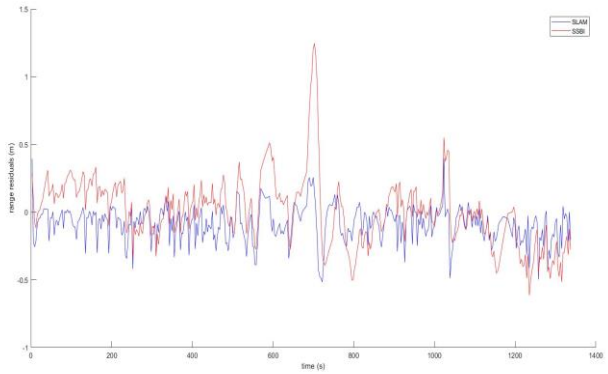
LBL SLAM post processing / reporting

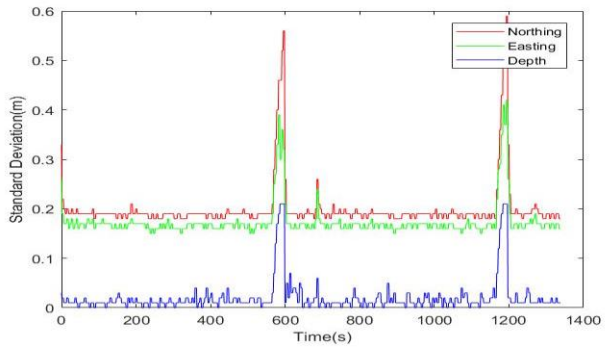
Data Visualization

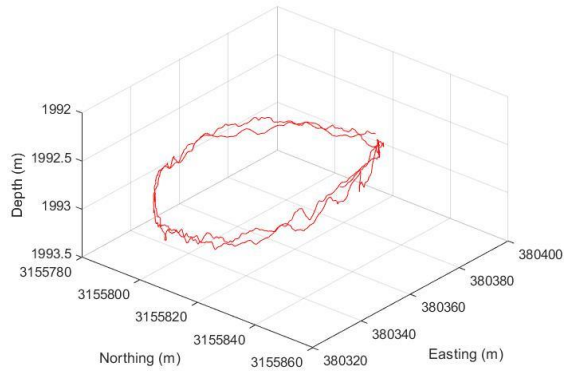
Forward Backward Smoothing for Error Reduction

Generation of high resolution 3D models









Bringing All the Tools Together

The goal of any survey design should be to meet the project tolerances without over-engineering the solution. We can bridge the gap between USBL and LBL with the optimal Sparse LBL solution.

Using **Fusion Splice** we can perform Sparse LBL operations with the equipment already on the shelf, a sole vendor is not needed.

The **Subsea Toolbox** can provide planning stage optimization by defining project procedures such as the necessary calibration method for the USBL, the ideal surface box-in radius for the absolute calibration (why waste vessel time on a 40% water depth box-in radius if not required). The inter transponder ranges expected even when, during some asset deployment components of a project, we can anticipate the loss of some LOP's. What is the target box for a CTL and how can we meet it without a full array back from the termination point.

We intelligently use all of the observables available to us. The SLAM array add-on solution allows "infinite" transponder additions by using the USBL observables to constrain the error propagation.

Conclusion

We can use the tools available today in a more efficient way

Contact Info

EMAIL

kv@zupt.com

PHONE

+1 832 295 7280

WEBSITE

www.zupt.com