Sparse LBL aided INS for Subsea Positioning

Edward Moller
Global Business Manager – Construction Survey
What is LBL?

- GPS Network
What is LBL?

We turn GPS upside down
LBL installed in a subsea field development
LBL - The Good and the Bad

GOOD

Accurate & precise

Works in all water depths

Redundancy / Robust

Availability of trained operators

Not so good

Time to install & transponder day rate

Update rate / time for average fix

Can we keep the good and remove/improve the not so good?
Adding INS
What is Inertial Navigation?

• An Inertial Navigation System (INS) uses measurements provided by accelerometers and gyroscopes to compute position and orientation relative to a known starting point.

• If we know where we started (e.g. initial position) and we know how fast we have moved and in which direction, we can reasonably determine where we are now.

• Inertial Navigation is inherently self contained, very precise and provides very high update rates.
Free Inertial Navigation

Free Inertial Drift
Small errors in acceleration and angular rate measurements lead to progressively larger navigation errors – “free initial drift”
Velocity aiding from a DVL can reduce the drift

Adding a calibrated DVL
The DVL will reduce but not correct the drift

Navigation error will be less than 0.1% of the distance travelled
Adding LBL range aiding further reduces drift

Example shows exaggerated error
Adding LBL range aiding further reduces drift
Geometry plays a part

Example shows exaggerated error
Single transponder aided INS

Wow, so we only need a single transponder?

- North Africa 2012

- 1st phase LBL arrays installed for structure placement
- 2nd phase plan to Sparse LBL array INS for general ROV navigation
Single transponder aided INS ROV Setup
Sparse LBL INS Result 1

- Single transponder 800m range
- Recommended minimum of two transponder ranging not achieved
- Full LBL array position used as the reference
- Sparse LBL position fix within 20cm
- Average position fix taken with a 2 sigma of only 2.4cm
- Every INS position calculated at 100Hz meaning that average fixing is not required
Sparse LBL INS Result 2

- Later that day, another position fix was taken with similar precision but now on the other side of the structure
- Why has it moved?

- This location was actually visible to two transponders and the other shift had used both transponders for aiding
How can sparse LBL INS be wrong?

A long term systematic error in your aiding source will directly result in an error of the INS position, e.g. transponder positions, sound velocity.
Using sparse LBL aided INS in a relative mode

- Result so far is that we can navigate with Sparse LBL INS but extra operational diligence required. How about using it relatively then?
- Gulf of Mexico 2013
- 1km final section of umbilical lay requiring 1.5m positioning at overage loop to ensure relative accuracy to target box
Using sparse LBL aided INS in a relative mode

- Three beacon array calibrated using traditional baselines, known coordinates and box-in.
- A 50 x 50m SLAM box-in manoeuvre was used to check the array calibration.
- Range residuals confirmed to be <0.2m (1 sigma)
Using sparse LBL aided INS in a relative mode

SPRINT Sparse LBL ROV (Blue) ties in exactly with the structure position

<10cm Spread when static
Why we really need at least 2 transponders

Transponder to the side of the ROV
Error ellipse gives good cross track (DCC) performance
Along track error is large
Why we really need at least 2 transponders

Transponder behind the ROV

Error ellipse gives good along track error

Cross track (DCC) performance is poor
Why we really need at least 2 transponders

- At least 2 transponders needed

A transponder to the side and another behind the ROV

The 90° angle of cut gives us the perfect error ellipse
Sparse LBL aided INS as a field positioning system

- If we only have two transponders visible at any one point, then we can’t run a traditional LBL baseline calibration
- To cover large areas, we’d have a lot of boxins to do which consumes vessel time. That will take as long or longer than installing those transponders
- Let’s go back to our LBL array and see if we can get away with using less transponders

- Gulf of Mexico 2013
- Original LBL array comprises of 30 Compatts
The 30 Compatt LBL array

The array offers;
- Good Geometry for calibration and tracking
- Has been adjusted using DTM terrain data to ensure line of sight
The 30 Compatt LBL array

Positioning performance is achievable.
Marginal detectable errors that could cause a position bust are negligible thanks to the redundancy of ranges associated with LBL.
30 Compatts reduced to 15

First attempt to create a sparse array

30 Compatts down to 15
The 15 Compatt LBL array

The array still appears strong and can be baseline calibrated.
The 15 Compatt LBL array

Centimetric positioning performance is still achievable
The 15 Compatt LBL array

However marginal detectable errors could cause a position bust of 1m which would go undetected !!!
An 18 Compatt LBL array

The array is increased from 15 to 18 Compatts
The 18 Compatt LBL array

Centimetric positioning performance is still achievable
The 18 Compatt LBL array

Now the marginal detectable errors are within positional requirements. The array has gone from 30 to 18 transponders. That’s 40% less 😊
During the project, the sparse LBL aided INS position provided comparable positions to that of full LBL.

INS = BLUE
LBL = GREEN

The INS provided a much smoother and higher update track and continued when LBL reference was lost or degraded.
LBL aided INS - The Good and the Bad

**GOOD**
- Accurate & precise
- Works in all water depths
- Redundancy / Robust
- Availability of trained operators

**Sparse LBL aided INS**

**Not so good**
- Time to install & transponder day rate
- Update rate / time for average fix
Sparse LBL aided INS - CONCLUSIONS

- Single transponder/range sparse LBL is possible but not recommended for survey as position errors can go unnoticed.
- Sonardynes support network can help you with both planning, training & offshore support to ensure your projects will be successful.
INS makes an ideal contribution to full LBL whereby we can:

1. Reduce transponder numbers by approx 50% saving vessel time and transponder day rate yet still calibrate for near LBL performance
2. Maintain the redundancy and low risk positioning offered by LBL
3. Provide a faster update rate and track during acoustic drop outs.

QUESTIONS?
Answer to a question on achievable accuracies

What is the achievable accuracy of sparse LBL aided INS?

• Entirely dependant on the positional accuracy of the reference transponders used and all the system errors (Boxins, Ranges, Sound Speed, DVL, Depth, etc).

• If you are using a suitable number/geometry of accurate reference transponders, accurate ranges with diagnostics (Wideband2) and all errors are removed as best as possible, then you could achieve positioning near to a well calibrated LBL array.

• INS cannot improve the position derived from poor reference transponder positions (weak LBL arrays) i.e. it will not fix a bad LBL array or poor boxed in reference transponder.