Deepwater Spoolpiece Metrology and INS

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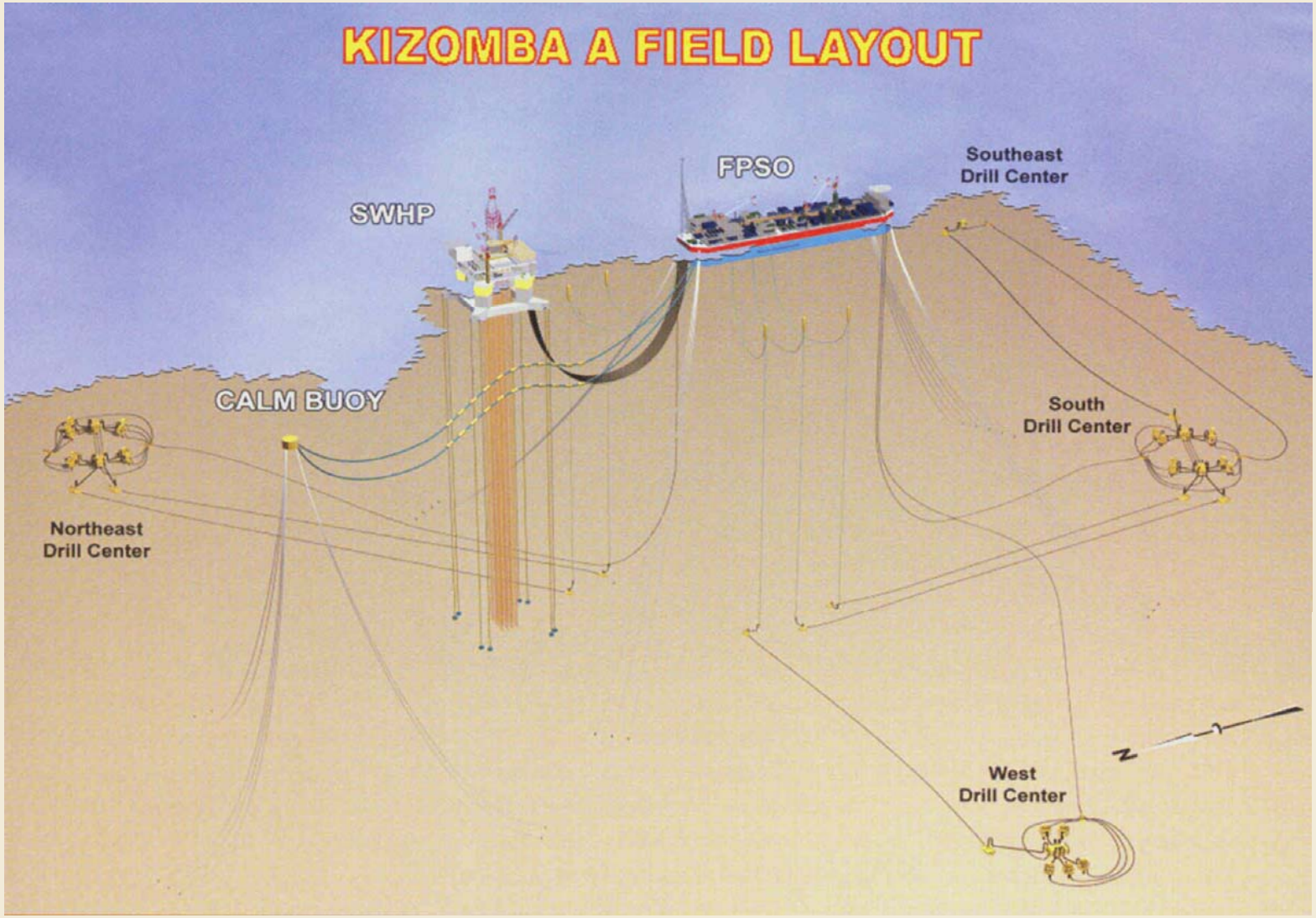
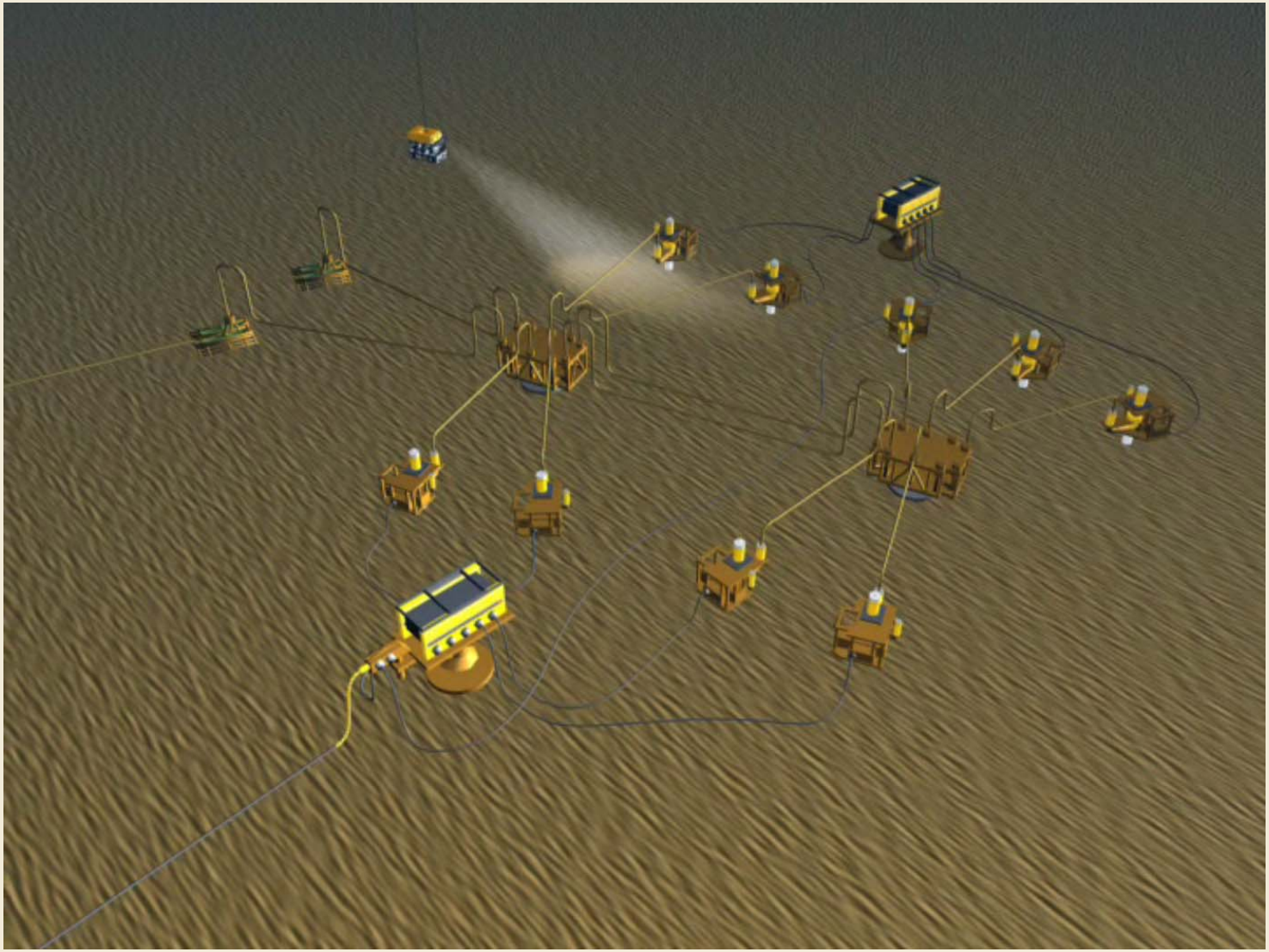
- What is a deepwater spoolpiece metrology ?
- What is the classical way of doing a metrology?
- How can we do a metrology with inertial technology ?

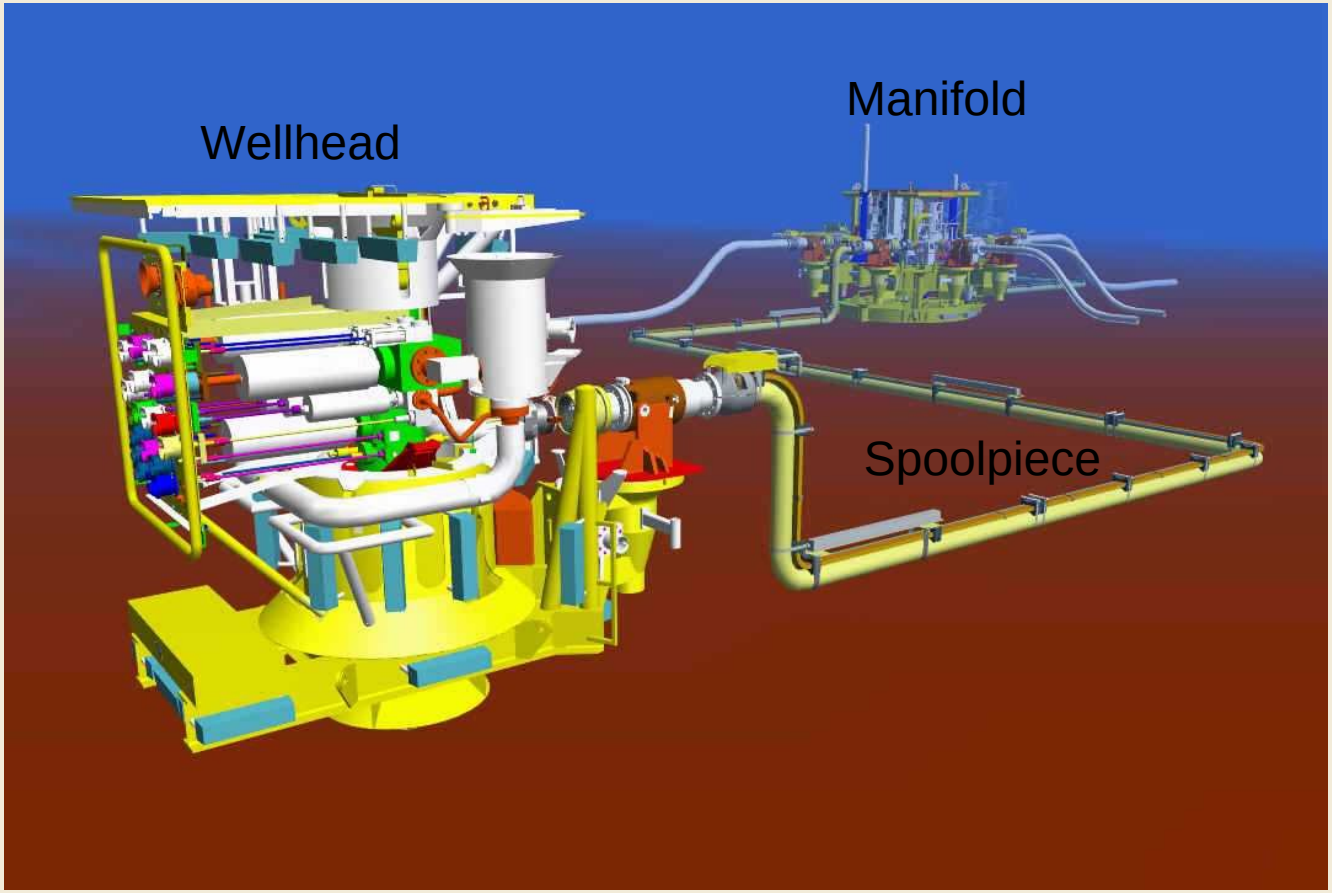
Deepwater Field Development



Deepwater Drill Centre



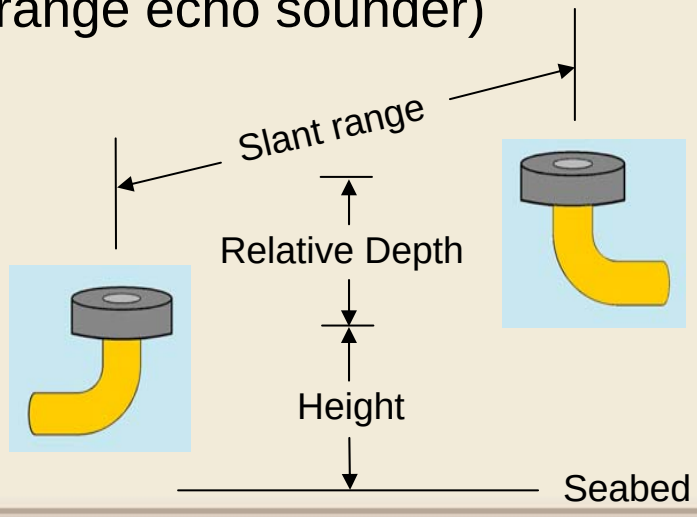
Spoolpiece



Spoolpiece Metrology Objective

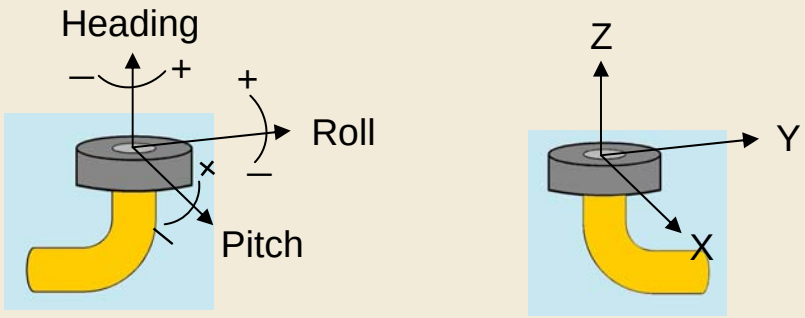
Objective is to determine geometry between the two flange faces

- Required values for design of spoolpiece
  - Horizontal distance between the two flange face centers
    - LBL transponder array (geodetic network adjustment)
  - Depth difference between the two flange face centers
    - Digiquartz or strain gauge depth sensor
  - Height of the two flange face centers above the seabed / mud mat
    - Altimeter (short range echo sounder)



Spoolpiece Metrology Objective

- Required values for design of spoolpiece (cont'd)
  - Bathymetric profile along the proposed spool route
    - Altimeter combined with depth sensor
  - Attitude difference between the two flanges
    - Fibre Optic Gyro (FOG) and Inclinometers



Spoolpiece Metrology Tolerances

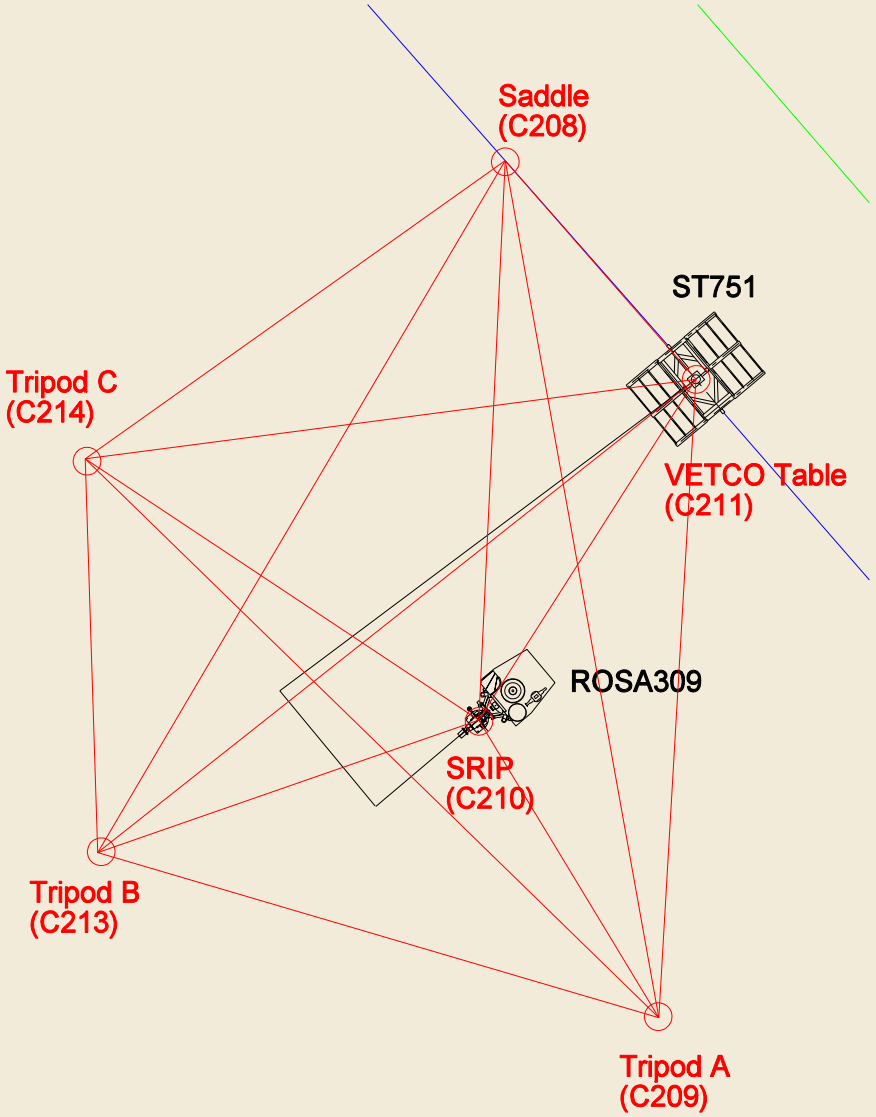
- Strict tolerances (typical values)
  - Relative positions of flange face centers
    - ΔX / ΔY / ΔZ : $\pm$ 50 – 100 mm
  - Relative attitudes of flange face centers
    - ΔRx / ΔRy / ΔRz : $\pm$ 0.5 – 1.0°

Remember, measurements to be performed at ~1500m water depth!

Long Baseline (LBL) Transponder Array

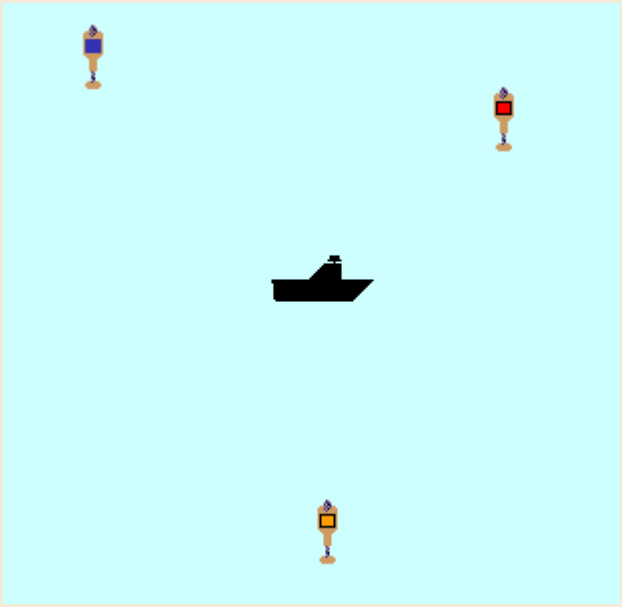
Transponders deployed to

- Seabed (tripod stand required)
- Pipeline (saddle tool required)
- Structures (specific interface tools required)



LBL Acoustic Positioning

- LBL requires a set of minimum three seabed transponders, known as an **array**
- Position within array calculated based on ranges measured to minimum three array transponders with known (relative) coordinates (**trilateration** principle)

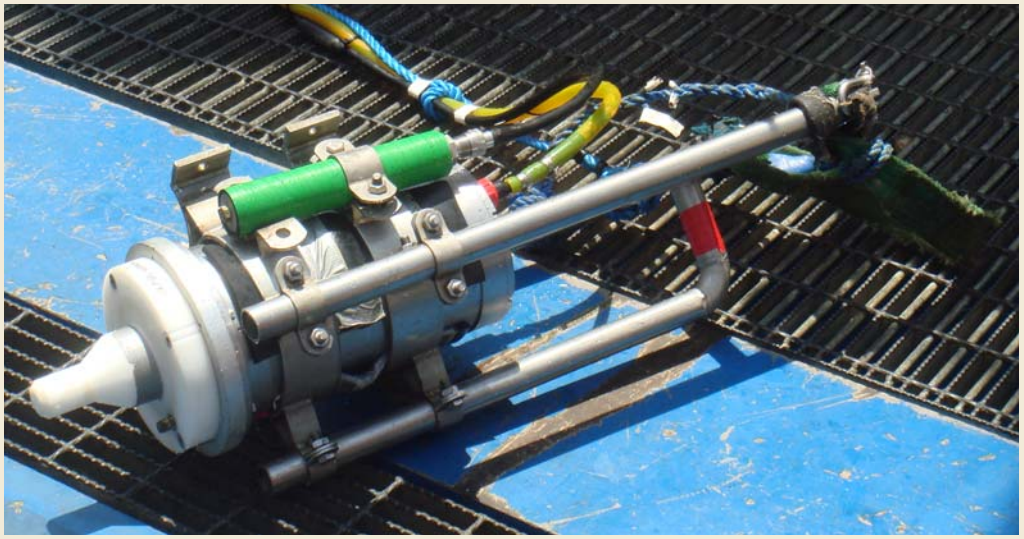


Metrology Stab/Receptacle Interface – Transponder

- Male metrology stab
- Female metrology receptacle
- Used to fit equipment (Transponder, FOG, DQ) on structure or equipment interface tool

Metrology Stab/Receptacle Interface – FOG/Digiquartz

- Metal frame that holds a FOG and Digiquartz pressure sensor
- Equipped with male metrology stab



Trouser Plate Interface

- Trouser plate used in Dalia field offshore Angola
- Placed over well hub
- Equipped with female metrology receptacle to hold Transponder or FOG/DQ tool

ROV Docking Bar Interface

- ROV docking bar for structure / hub heading determination
- Usually located on SRIP tool
- Also found as an integral part of the structures

Equipment and Interface Tool Installation

- All operations performed by ROV

Metrology Task plan

Task plan – Summary of all field operations

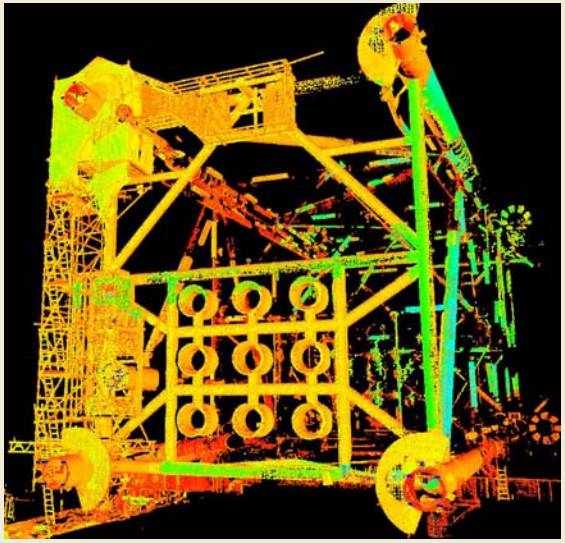
1. Gyro calibration
2. Preparations of equipment and interface tools
3. Installation of equipment and tools sub sea
4. Heading loop
5. Depth loop
6. Inclination measurements
7. Baselines observations and array calibration
8. Bathymetric survey of spool route
9. Recovery of interface tools and equipment

Field operations organised in such a way that minimum vessel time is required!

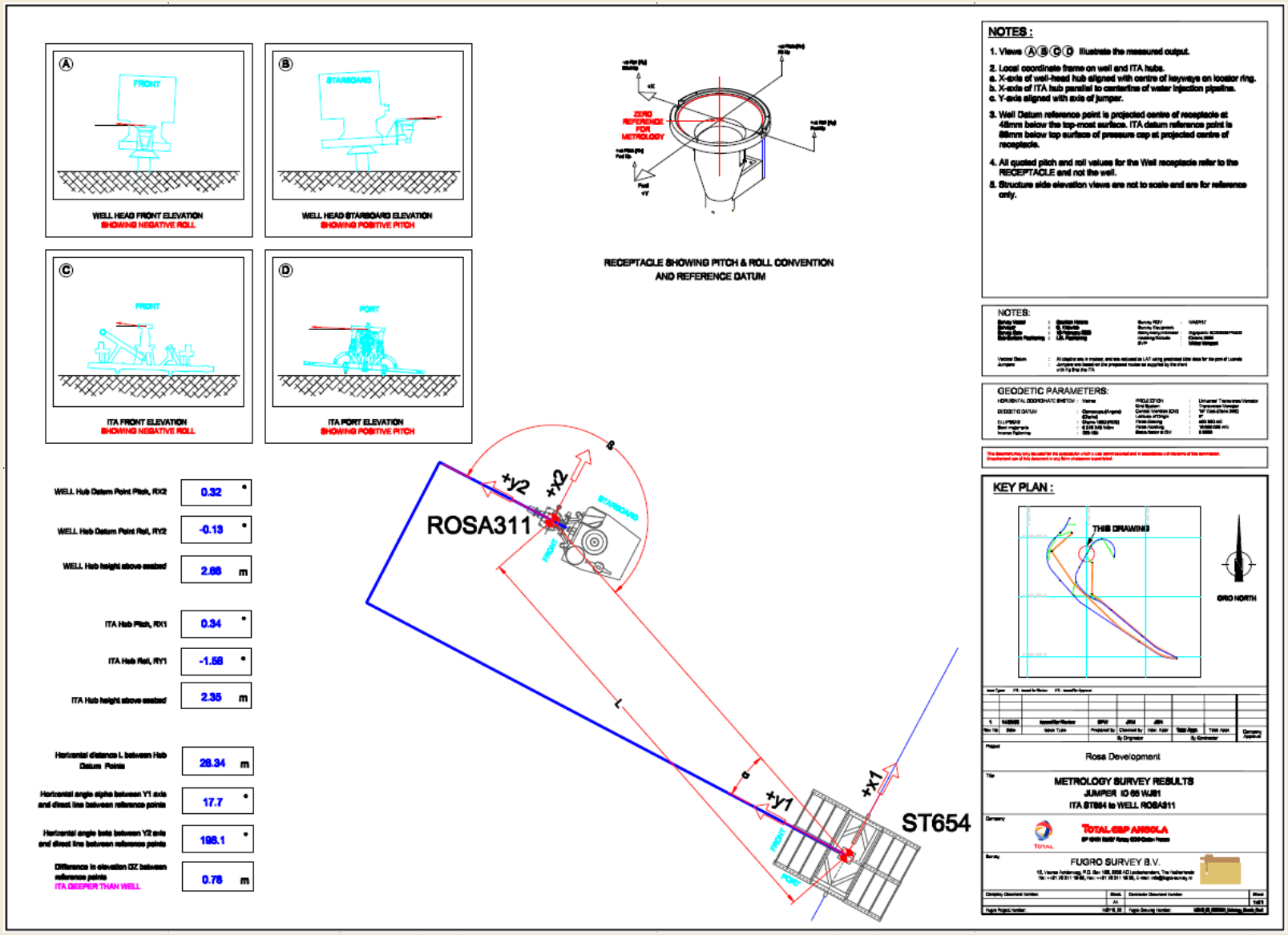
Dimensional Control Survey

- Determination of offsets (ΔX, ΔY, ΔZ) and misalignments (ΔRx, ΔRy, ΔRz) between
  - Flange face centre

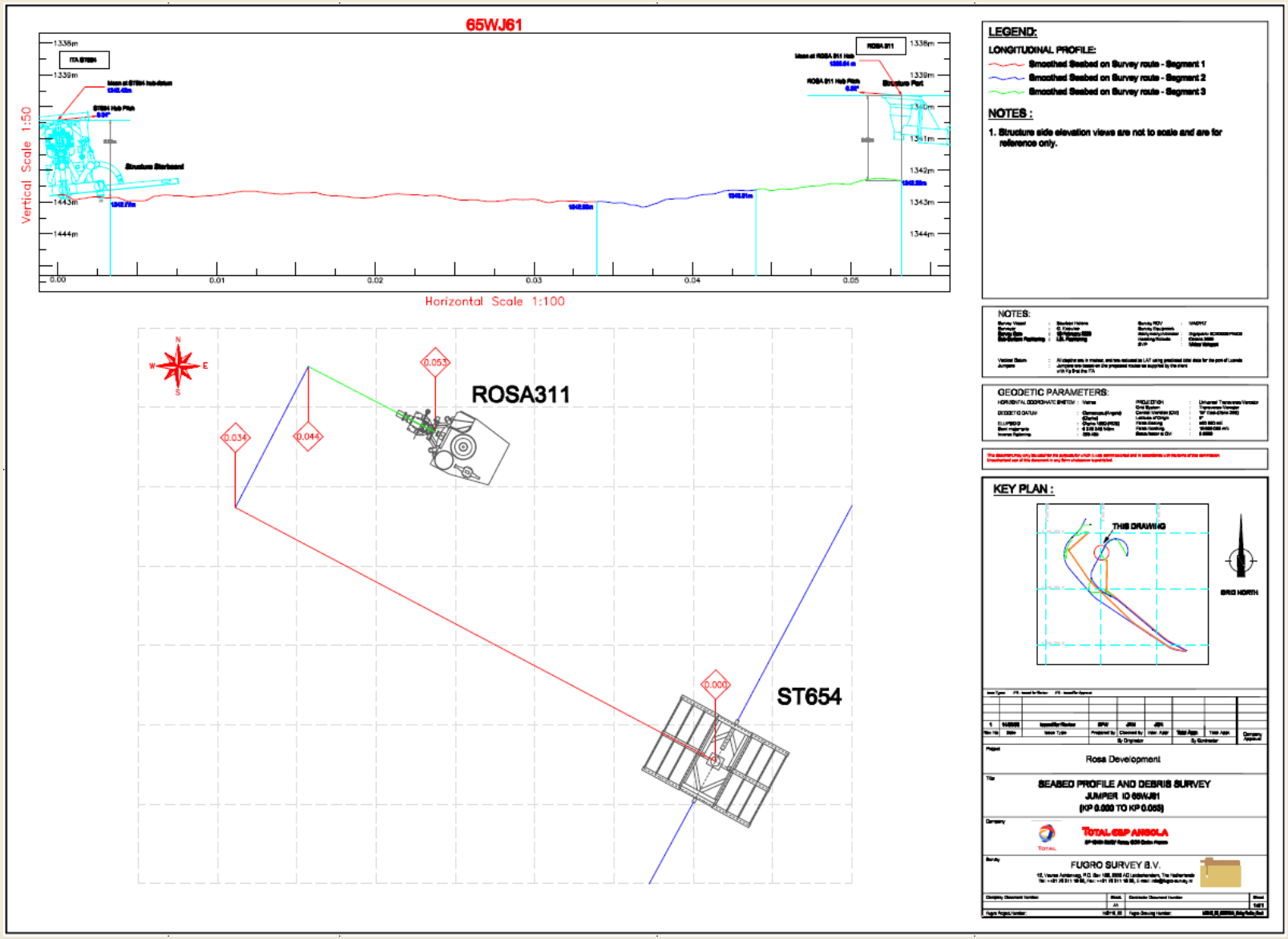
  and
  - Metrology receptacle on interface tool
- Performed in the construction yard prior to installation of structure to seabed
- Using land survey techniques (e.g. 3D laser scanning, Total Station)
- Subsea metrology measurements are corrected for these offsets and misalignments



Metrology results



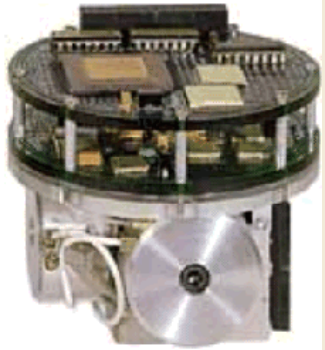
Spool route bathymetry profile



Alternatives for Acoustic Metrology

- Deployment, calibration and retrieval of LBL transponder array is **time consuming**
- Vessel time is expensive, therefore the market is looking for alternative for the classical acoustic metrology
- Several system are being proposed
  - **Inertial Navigation Systems (INS)**
  - USBL (e.g. AQUA-METRE)
  - Digital taut wire system (e.g. Smart-Wire Metrology)
  - Photogrammetry (future)

- INS = **I**nertial **N**avigation **S**ystem



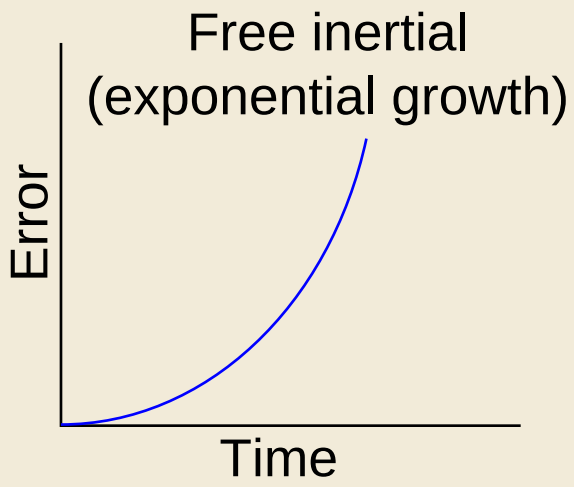
Inertial Measurement Unit (IMU)
-Three accelerometers
-Three gyroscopes

Acceleration
Attitude rate

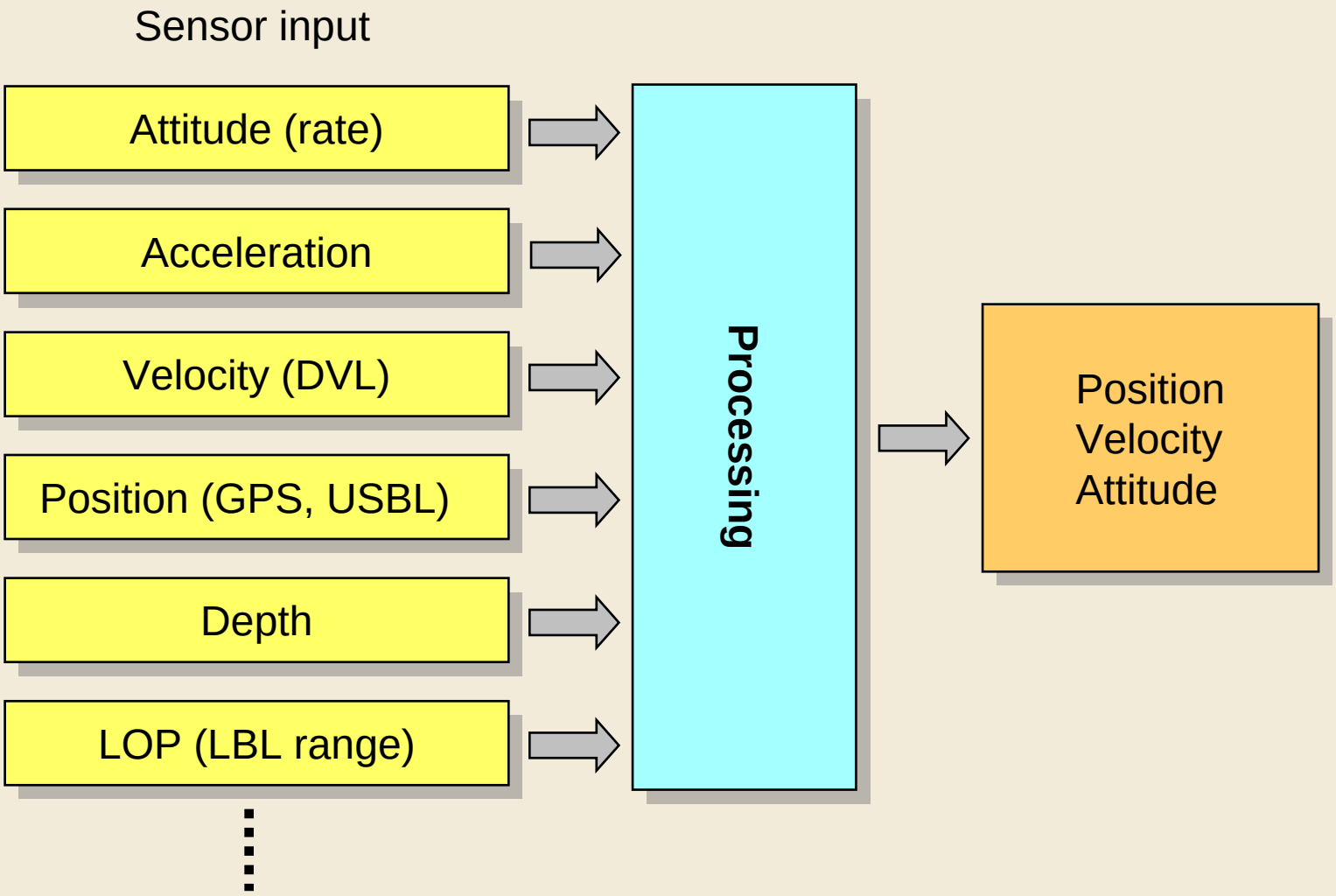
Navigation
processor

Position
Velocity
Attitude

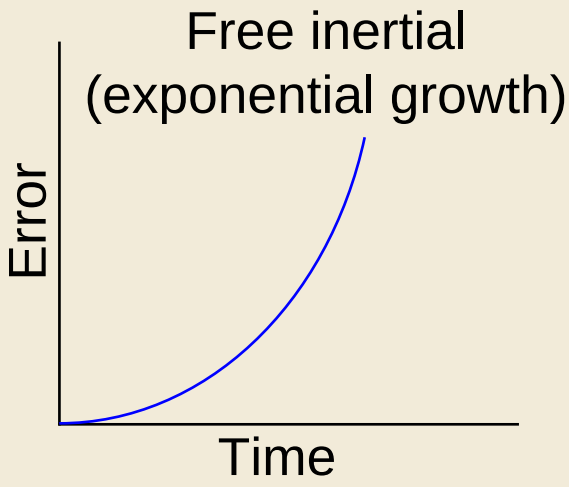
INS Position Error Growth

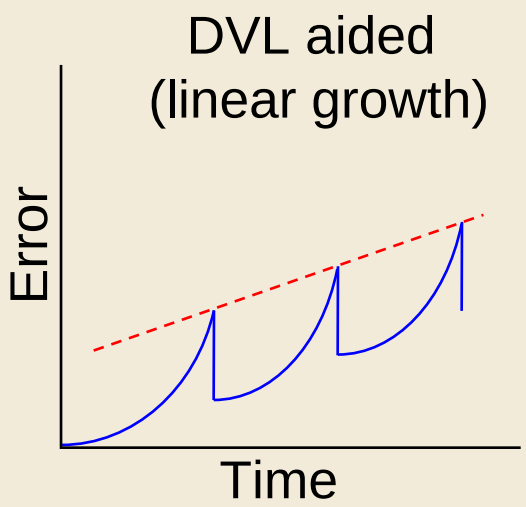


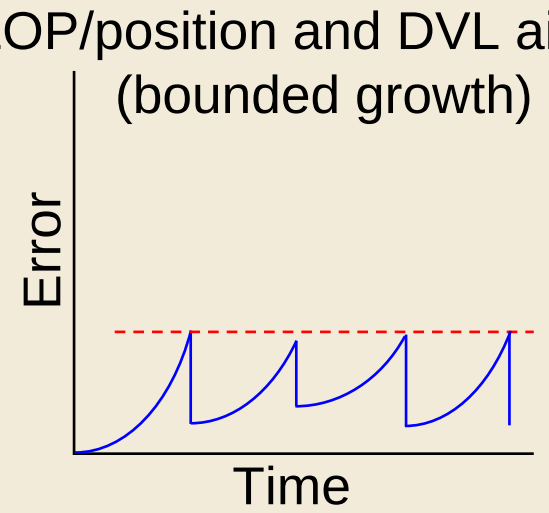
Integrated System (Aided INS)



Position Error Growth







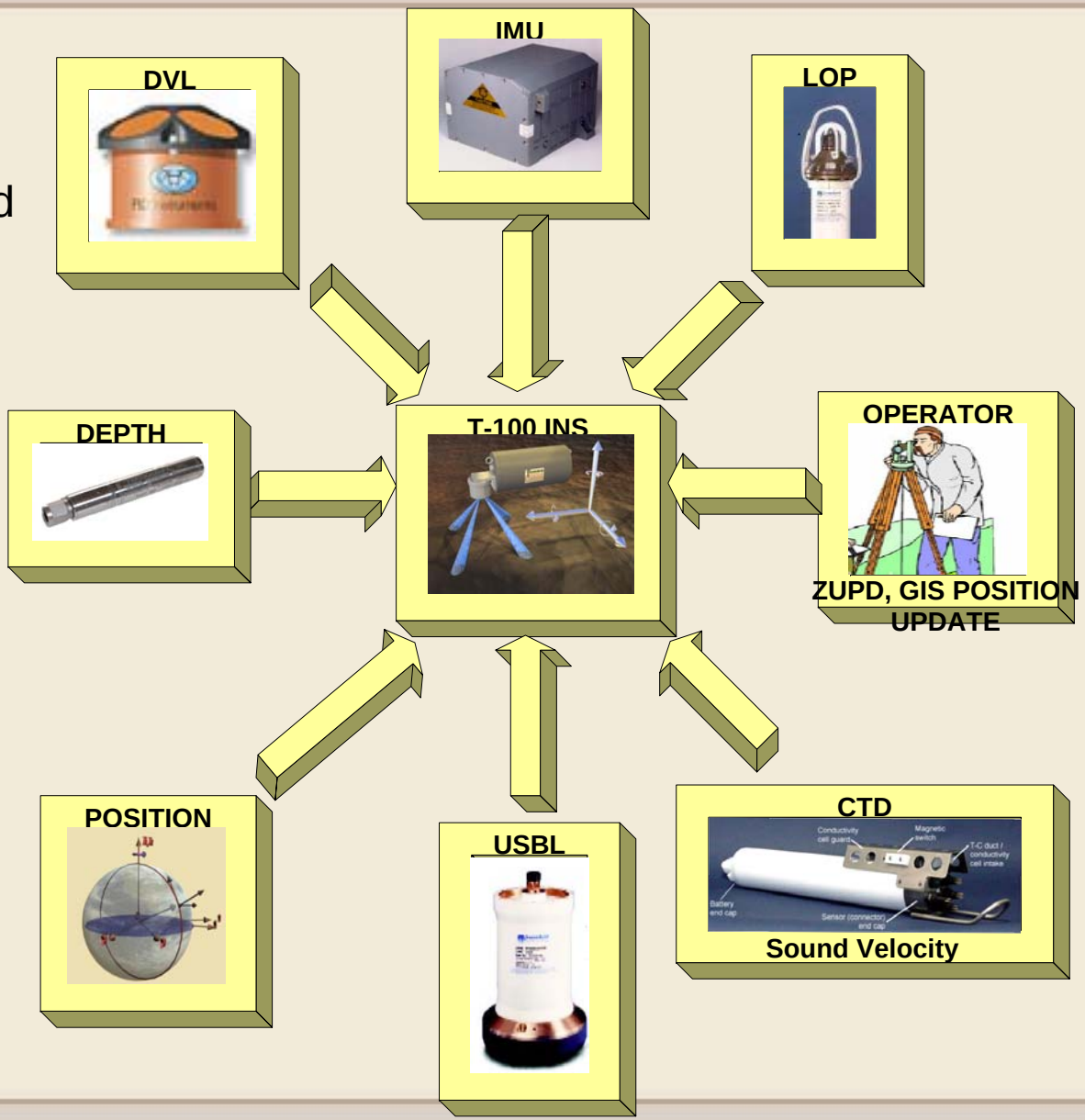
Doppler Velocity Log

- Measure relative speed against the seabed
- Based on Doppler principle
- Also used to measure currents

- The Doppler is mounted face down on an ROV or on a vessel pole

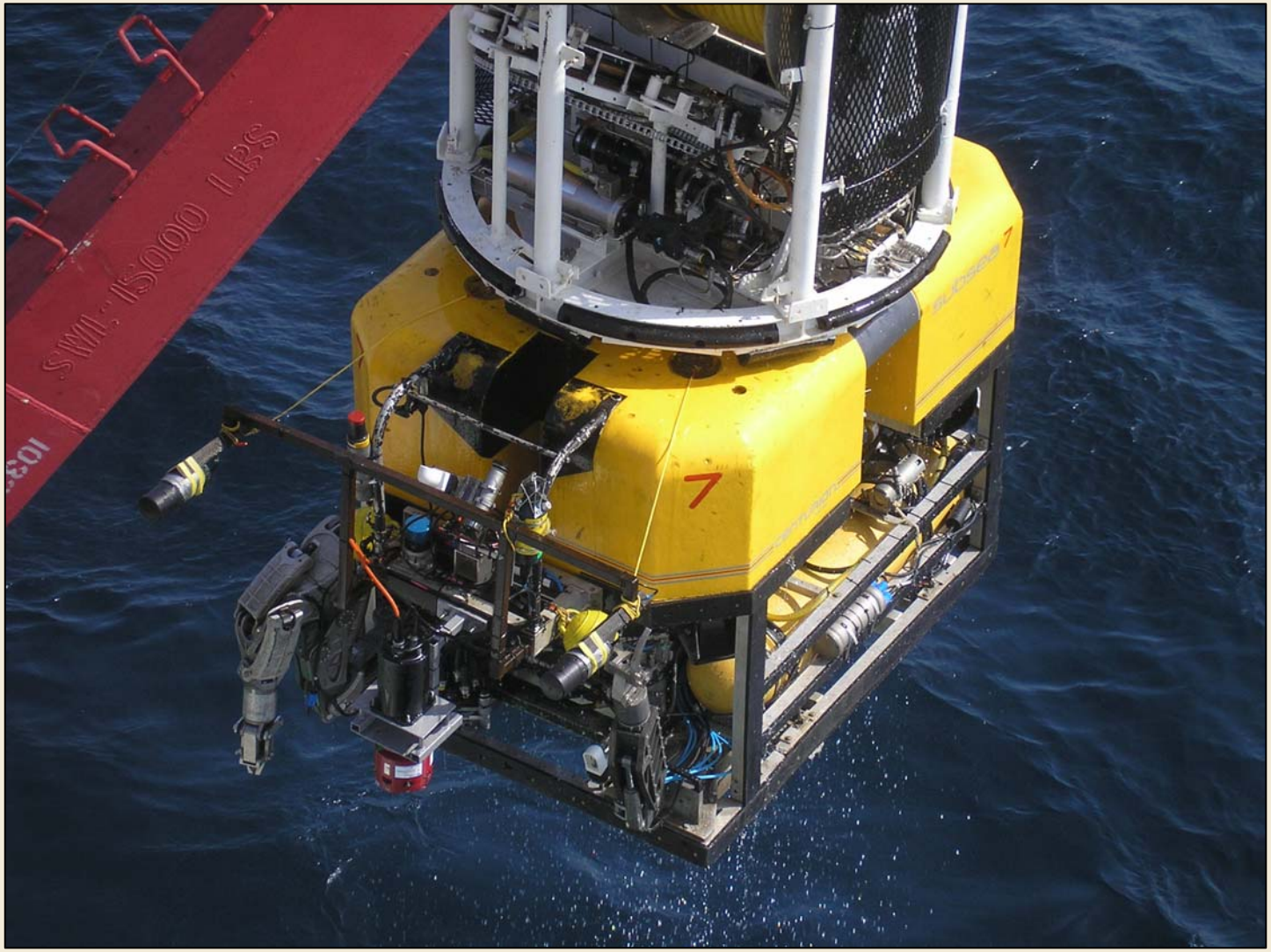
Fugro's **Finetrack**

- Aided INS solution
- Loosely and tightly coupled algorithms e.g. (L200, T100)
- Hardware independent
- Quality control



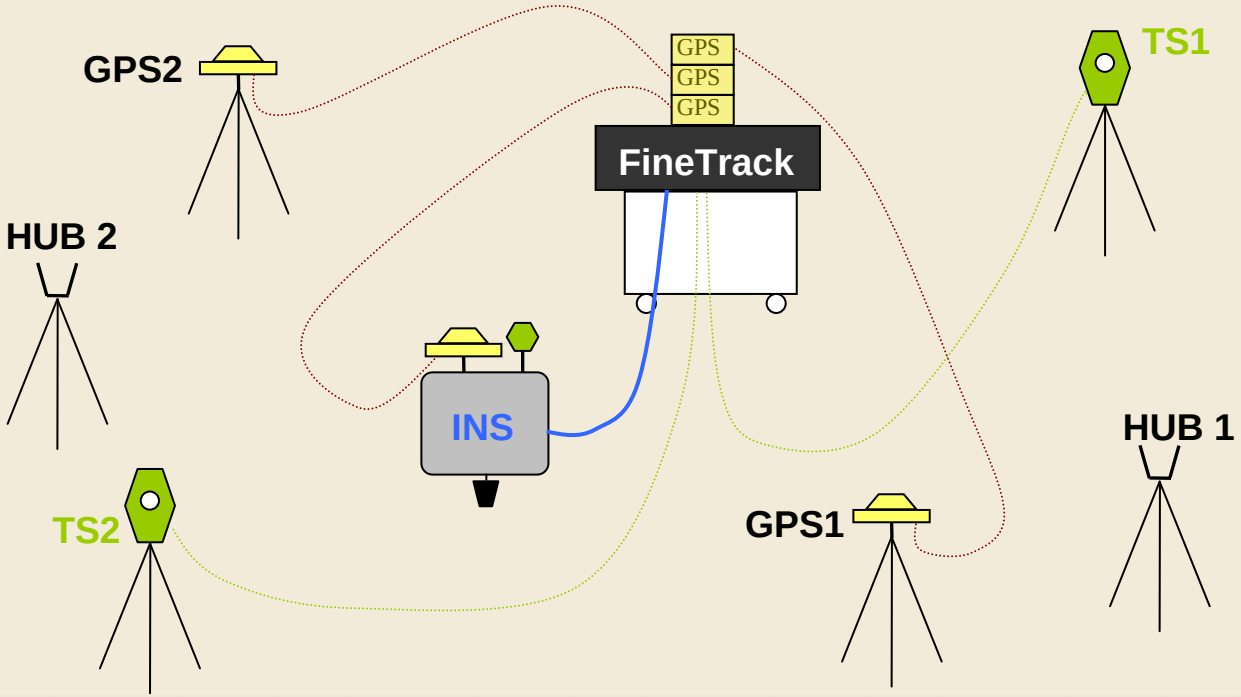
INS Mounting

INS Mounting

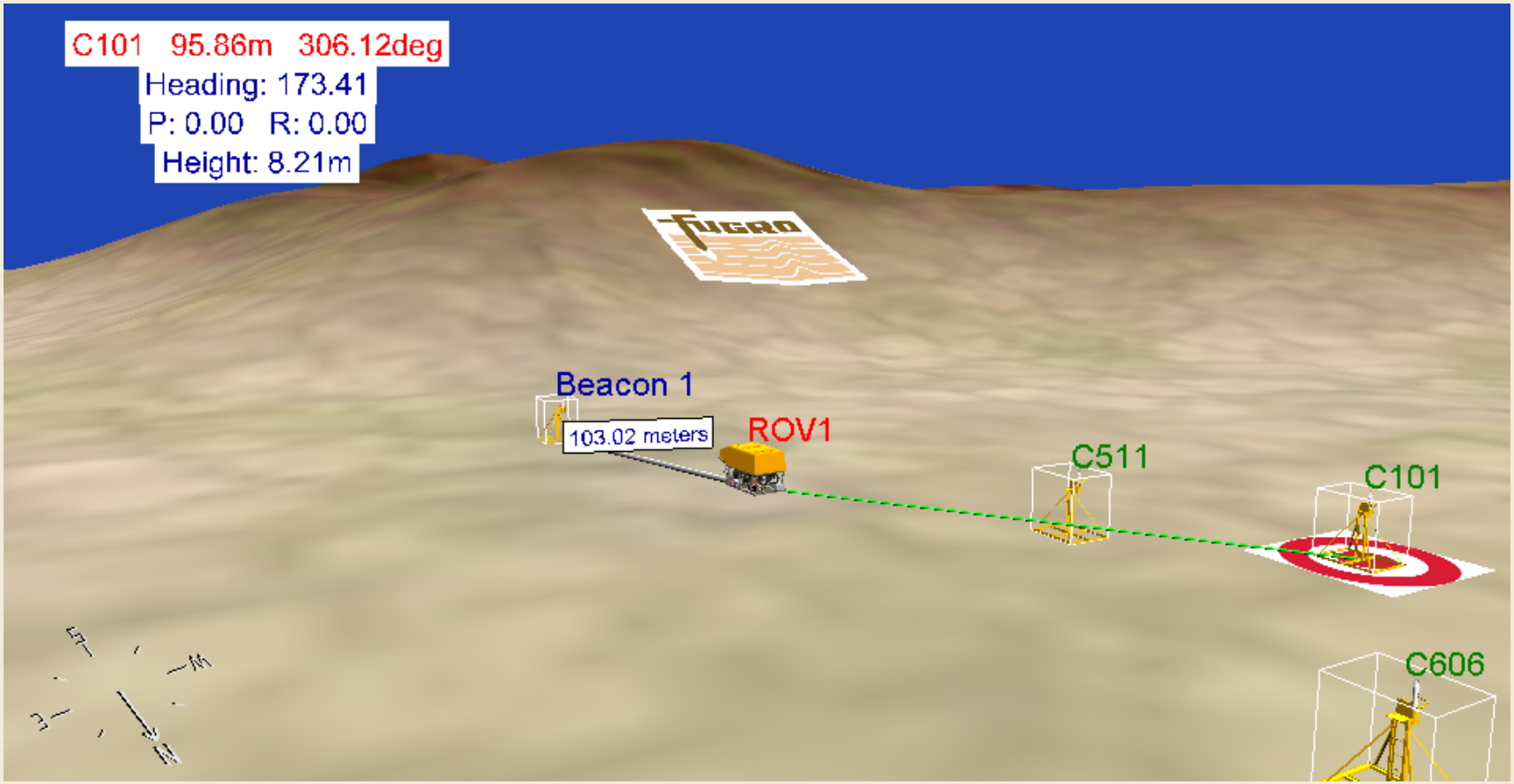


Problem

- DVL is not really usable during spoolpiece metrology
- DVL signal interfered/deteriorated when flying nearby the structures and piping
- Option: use sparse LBL ranges from 1, 2 or 3 transponders
  - No need for full array deployment
  - No need for array calibration
- Fugro Survey B.V. currently investigating feasibility



- Real-time navigation visualized in 3D
- Starfix.FineTrack combined with Starfix.Hydrovista



Conclusion

- Deepwater spoolpiece metrology dynamic area of operations with room for improvement