



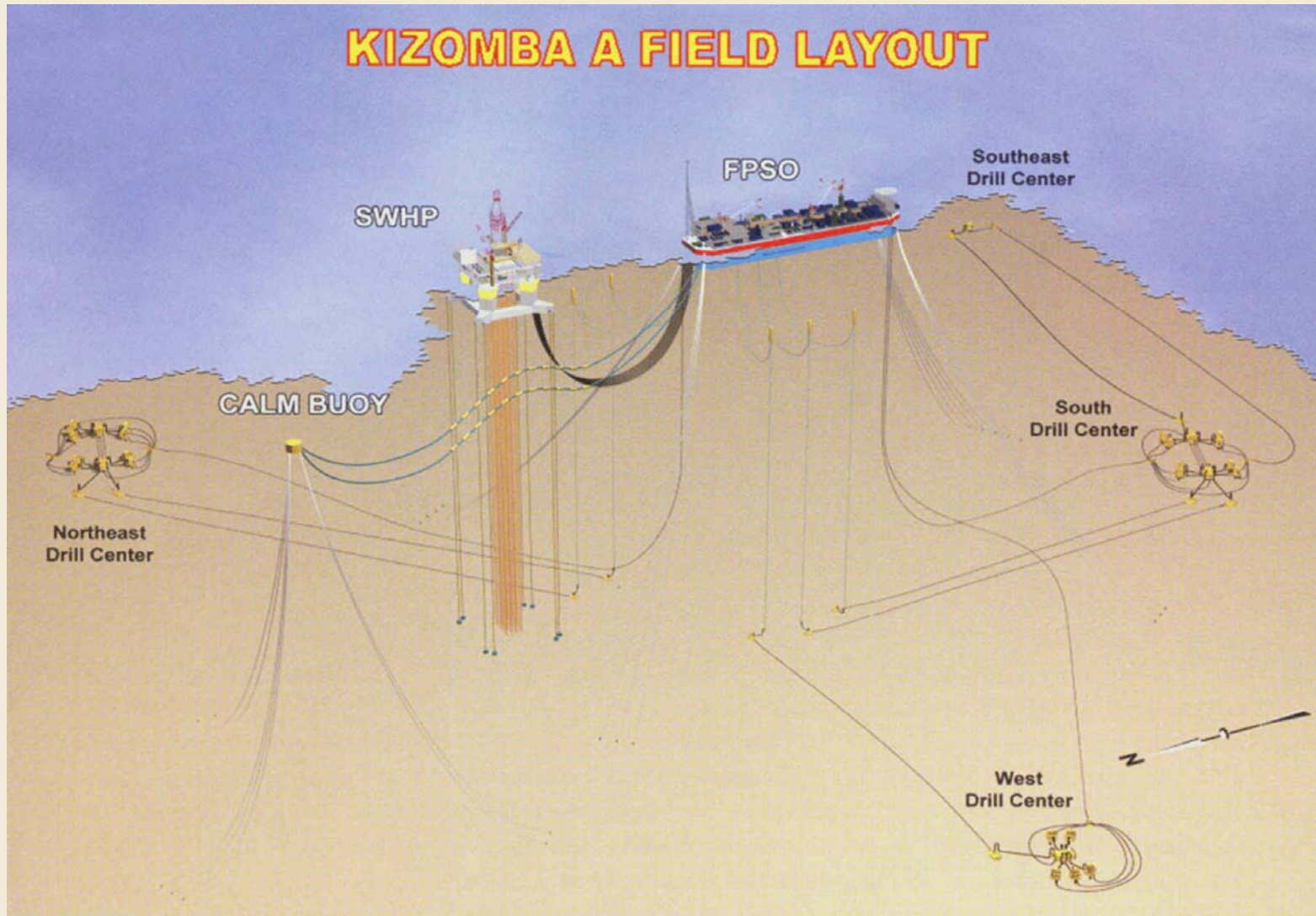
Deepwater Spoolpiece Metrology and INS

ir. Wilbert Brink

AVANS Hogeschool - 16 June 2009

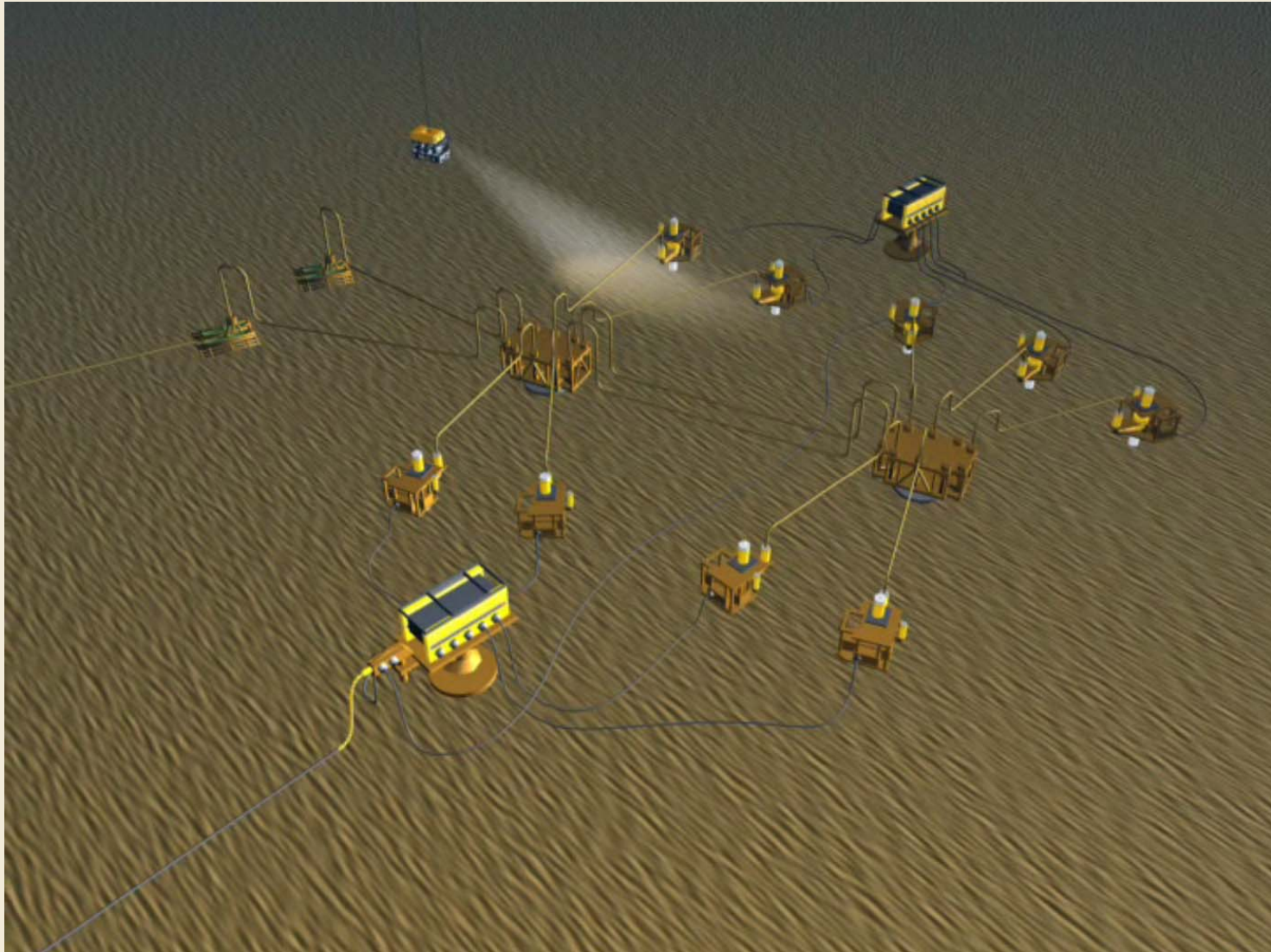


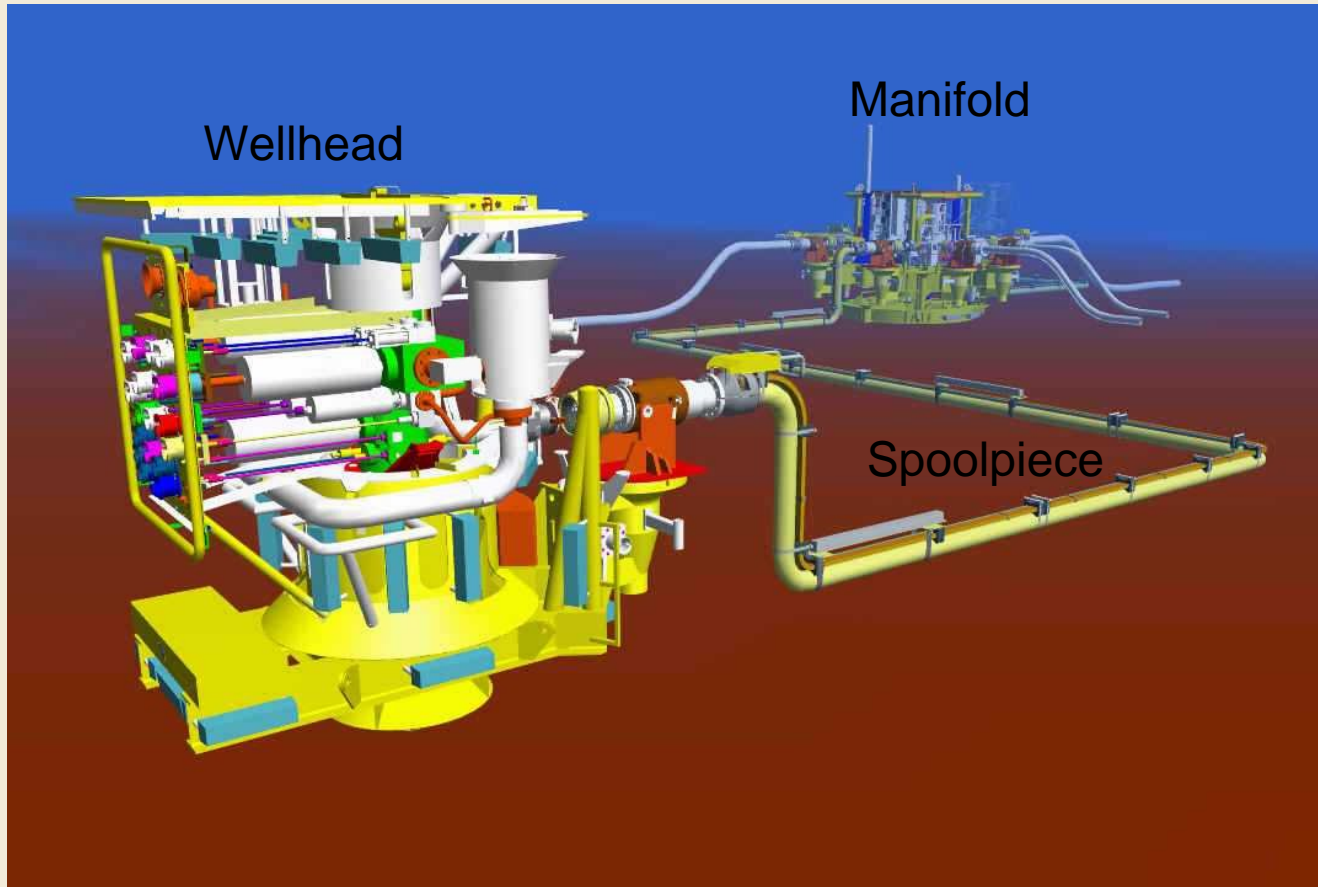
- What is a deepwater spoolpiece metrology ?
- What is the classical way of doing a metrology?
- How can we do a metrology with inertial technology ?





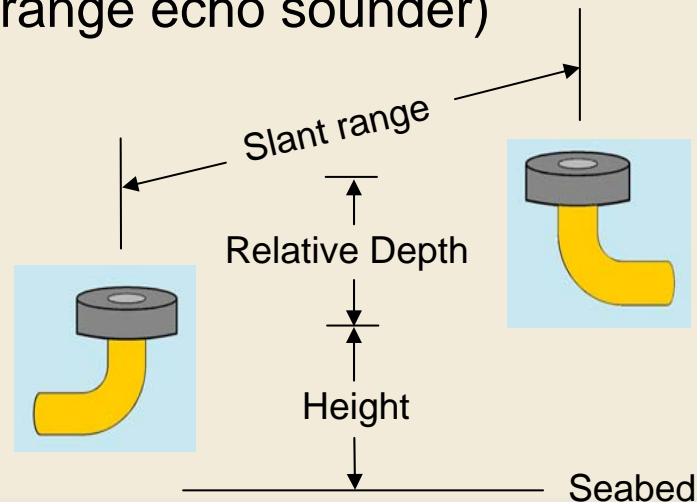
Deepwater Drill Centre



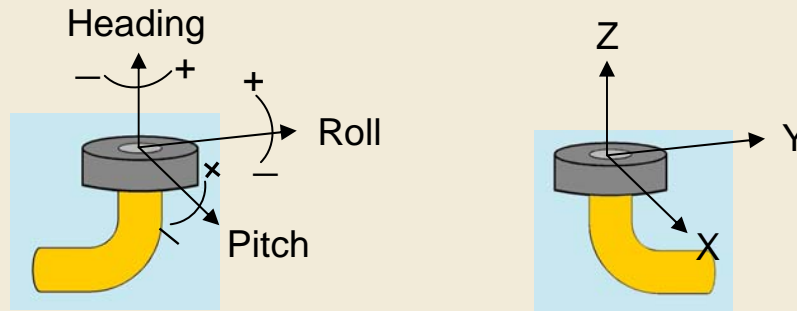


Objective is to determine geometry between the two flange faces

- 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)



- 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
 - $\Delta X / \Delta Y / \Delta Z : \pm 50 - 100 \text{ mm}$
 - Relative attitudes of flange face centers
 - $\Delta R_x / \Delta R_y / \Delta R_z : \pm 0.5 - 1.0^\circ$

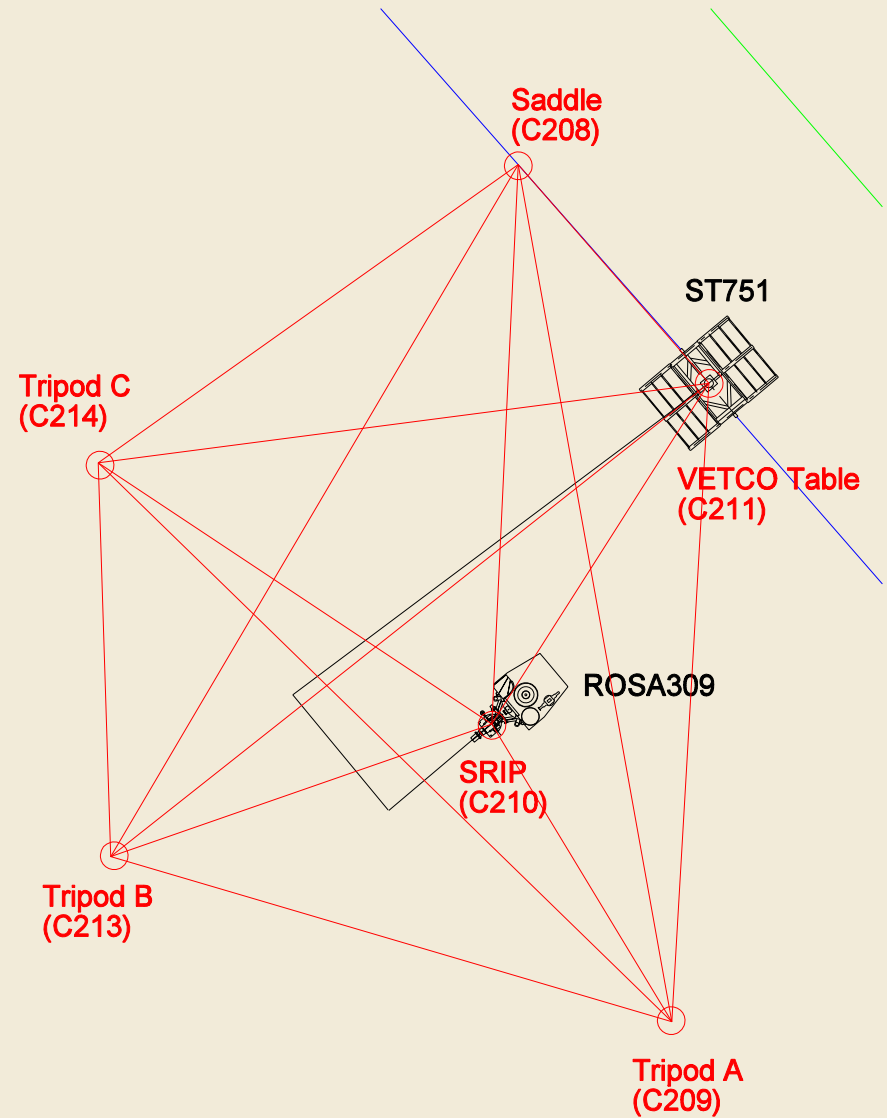
Remember, measurements to be performed at ~1500m water depth!



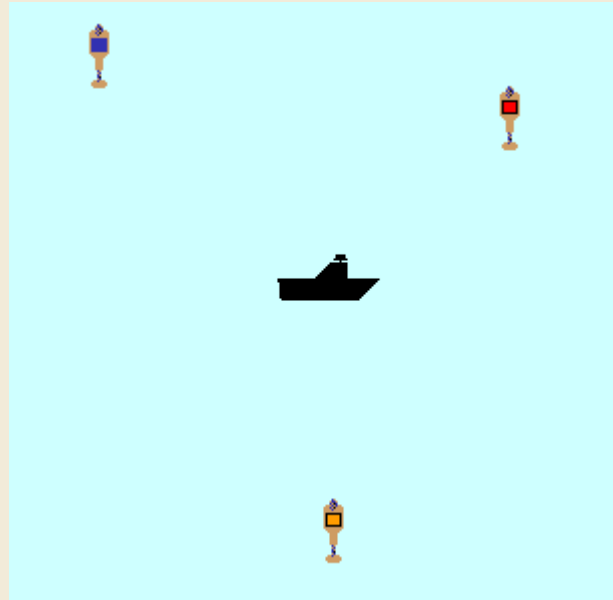
Long Baseline (LBL) Transponder Array

Transponders deployed to

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



- LBL 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

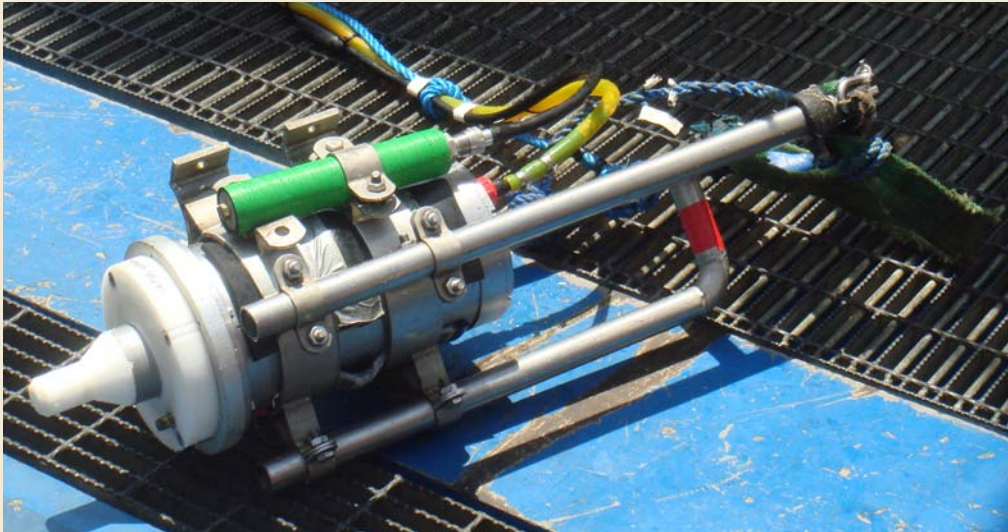
- Male metrology stab
- Female metrology receptacle
- Used to fit equipment (Transponder, FOG, DQ) on structure or equipment interface tool





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 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



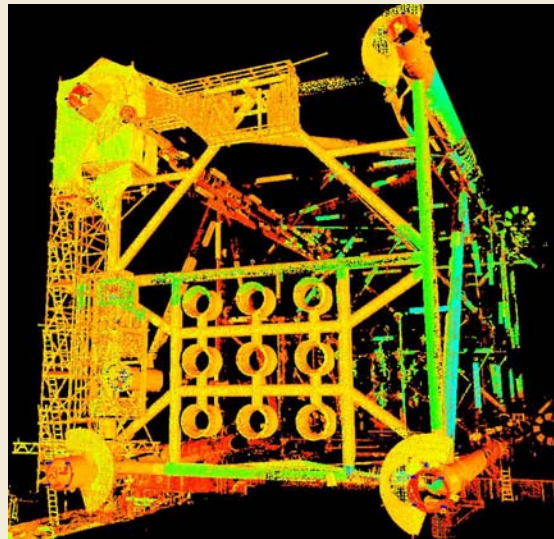


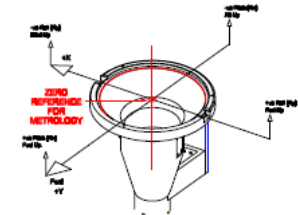
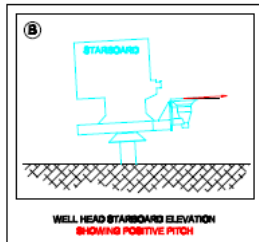
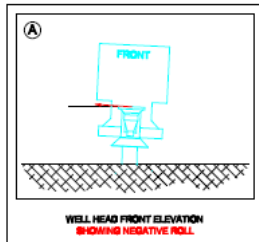
Task plan – Summary of all field operations

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

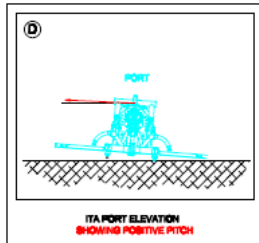
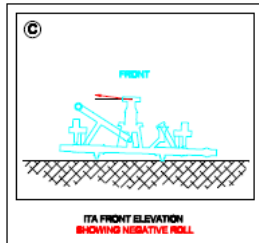
Field operations organised in such a way that minimum vessel time is required!

- Determination of offsets (ΔX , ΔY , ΔZ) and misalignments (ΔR_x , ΔR_y , ΔR_z) between
 - Flange face centreand
 - 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





RECEPTACLE SHOWING PITCH & ROLL CONVENTION AND REFERENCE DATUM



- NOTES:**
- Views (A)(B)(C)(D) illustrate the measured output.
 - Local coordinate frame on well and ITA hubs.
 - X-axis of well-head hub aligned with centre of buoyancy on locator ring.
 - X-axis of ITA hub parallel to centreline of water injection pipelines.
 - Y-axis aligned with axis of jumper.
 - Well Datum reference point is projected centre of receptacle at 40mm below the top-most surface. ITA datum reference point is 80mm below top surface of pressure cap at projected centre of receptacle.
 - All quoted pitch and roll values for the Well receptacle refer to the RECEPTACLE and not the well.
 - Structure side elevation views are not to scale and are for reference only.

NOTES:

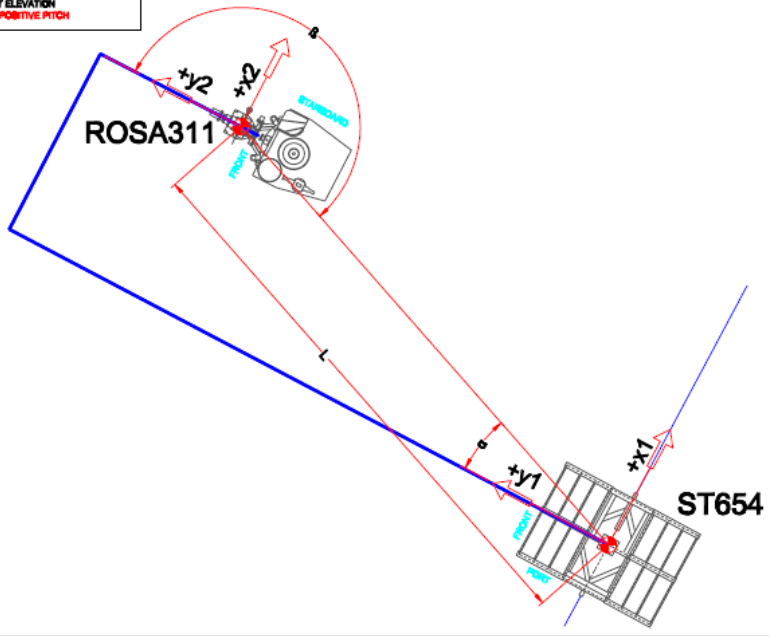
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Project Name	Client Ref	Survey Ref	Survey Date
Client Name	Client Ref	Survey Ref	Survey Date

GEODEIC PARAMETERS:

IONOSPHERIC CORRECTION	REFLECTION	Unpaired Transmitter Receiver
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WELL Hub Datum Point Pitch, RX2	0.32 °
WELL Hub Datum Point Roll, RY2	-0.13 °
WELL Hub height above seabed	2.88 m
ITA Hub Pitch, RX1	0.34 °
ITA Hub Roll, RY1	-1.68 °
ITA Hub height above seabed	2.35 m
Horizontal distance L between Hub Datum Points	28.34 m
Horizontal angle alpha between Y1 axis and direct line between reference points	17.7 °
Horizontal angle beta between Y2 axis and direct line between reference points	198.1 °
Difference in elevation DZ between reference points ITA DEEPER THAN WELL	0.78 m



KEY PLAN:

Issue No.	Issue Date	Issue Description
1	2024-01-15	Initial Issue

Project: Rosa Development

Title: METROLOGY SURVEY RESULTS
JUMPER ID 06 WJ81
ITA ST654 to WELL ROSA311

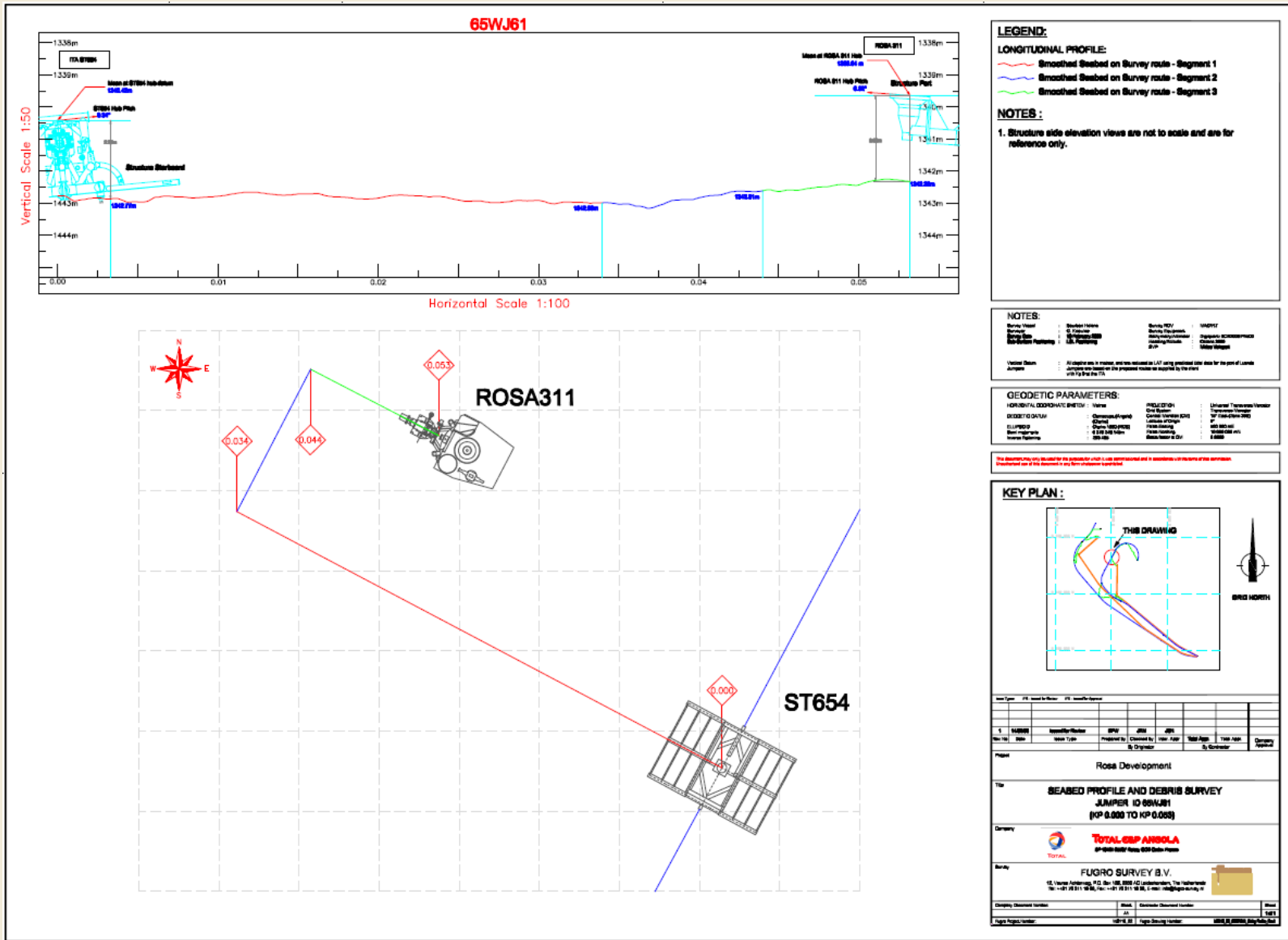
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Client Name	Block	Structure Number	Sheet
Client Name	Block	Structure Number	Sheet



Spool route bathymetry profile

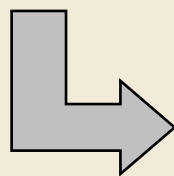
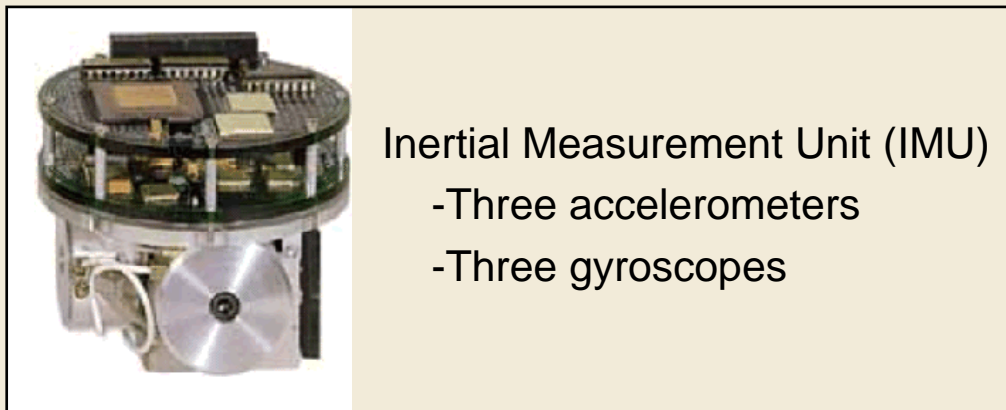




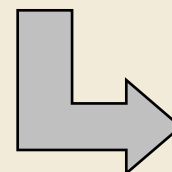
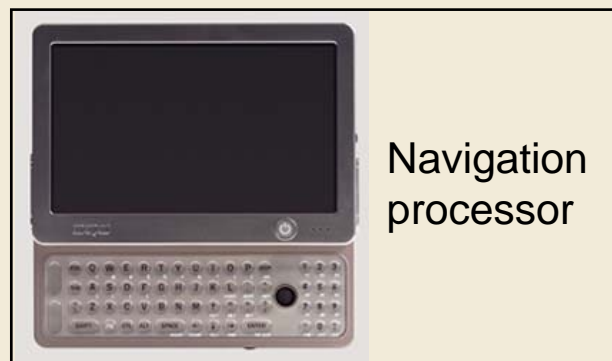
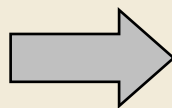
Alternatives for Acoustic Metrology

- 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 = Inertial Navigation **S**ystem



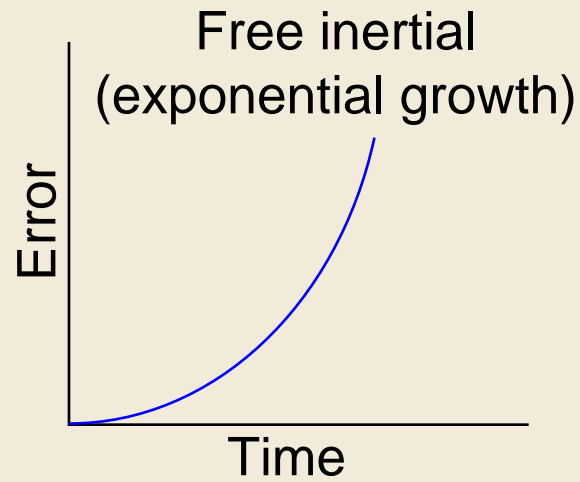
Acceleration
Attitude rate



Position
Velocity
Attitude

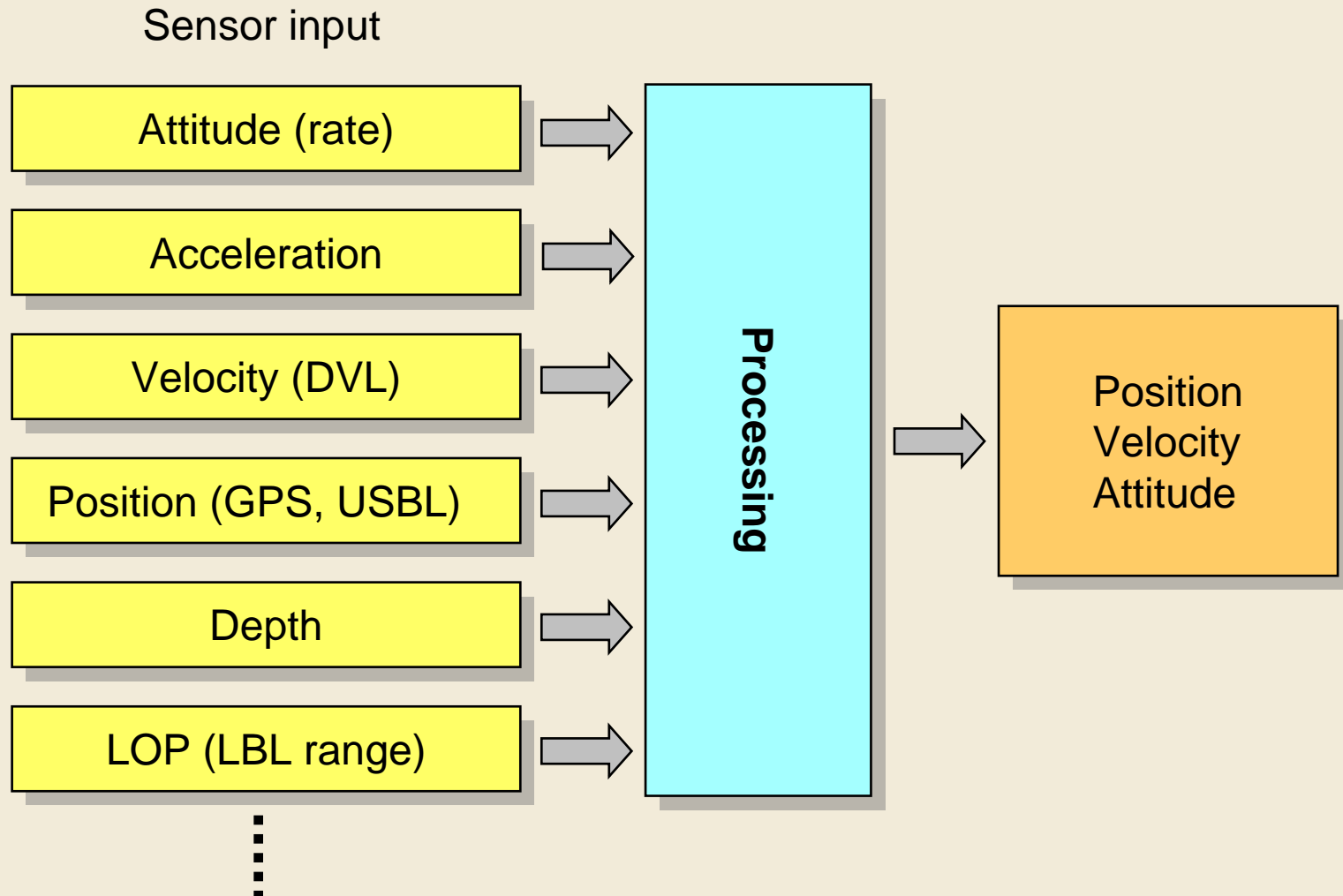


INS Position Error Growth





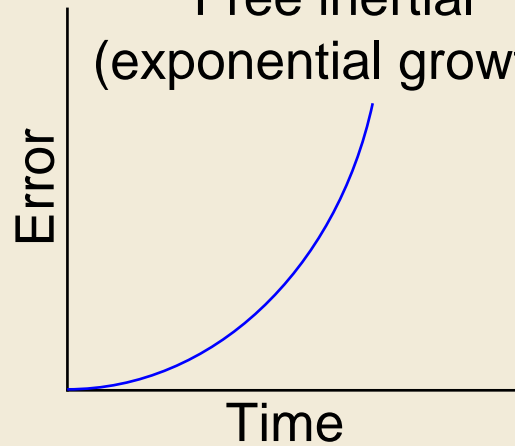
Integrated System (Aided INS)



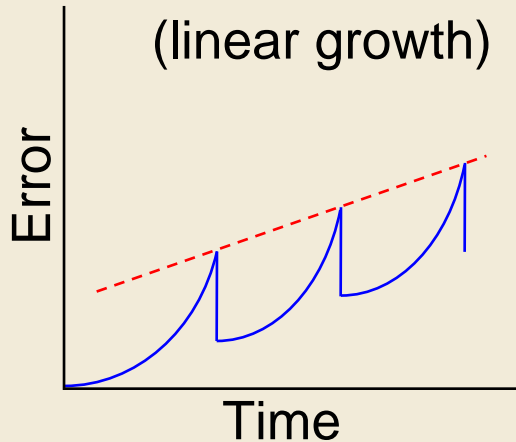


Position Error Growth

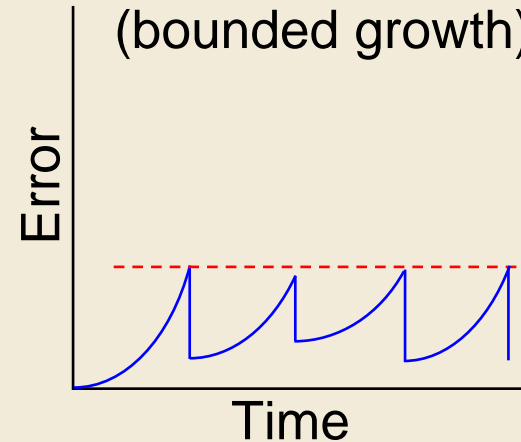
Free inertial
(exponential growth)



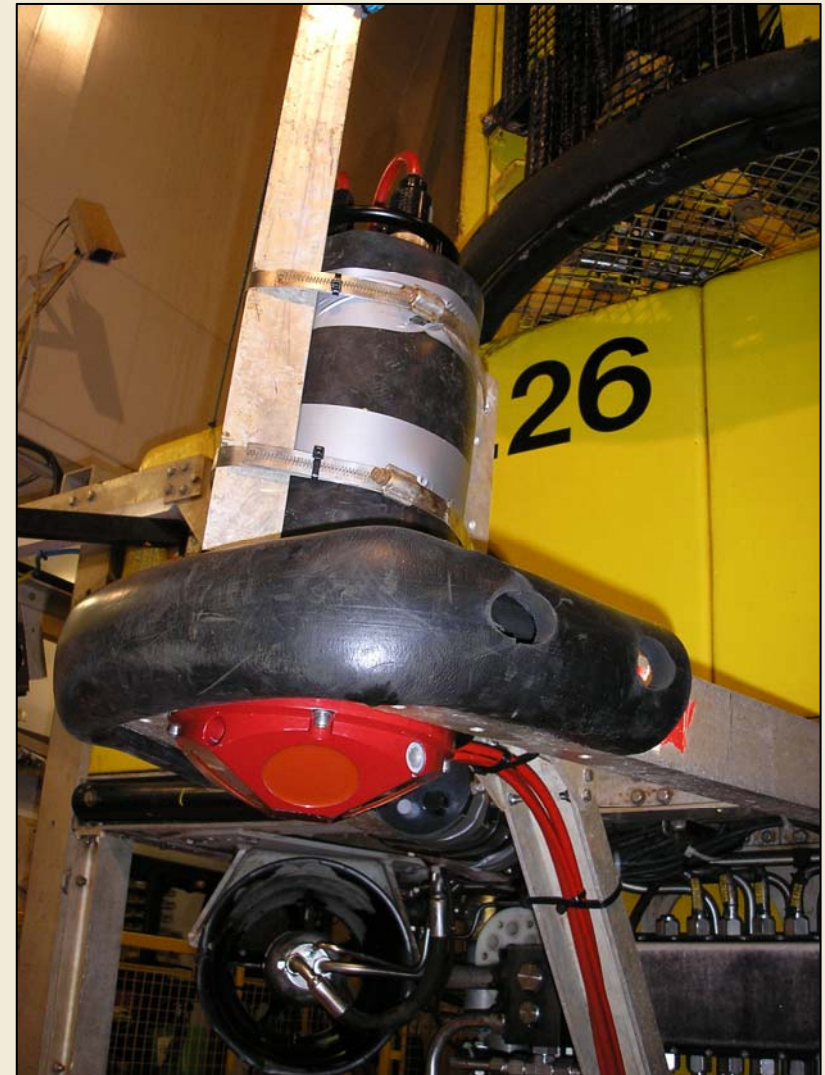
DVL aided
(linear growth)



LOP/position and DVL aided
(bounded growth)

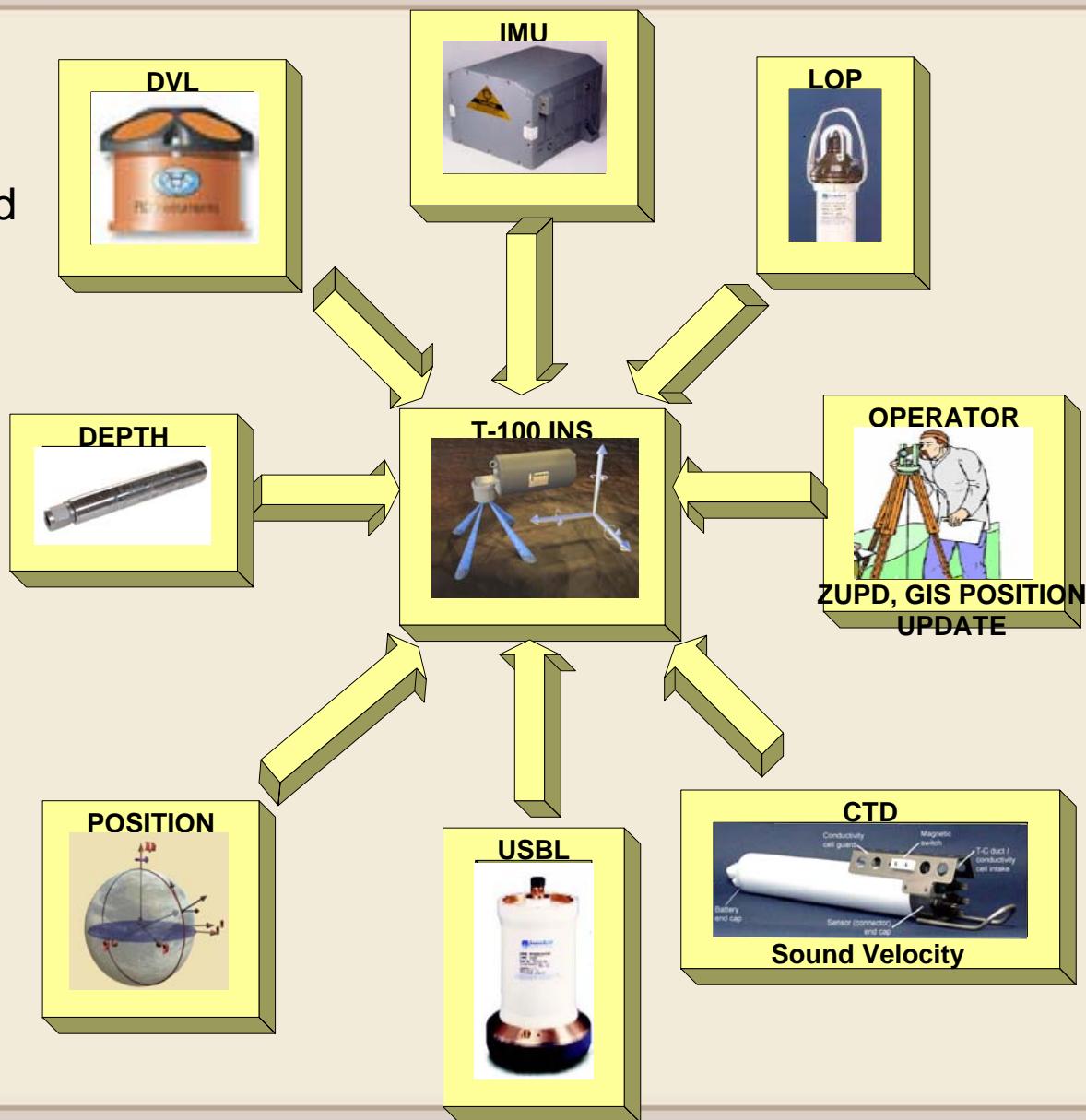


- Measure relative speed against the seabed
- Based on Doppler principle
- Also used to measure currents
- The Doppler is mounted face down on an ROV or on a vessel pole

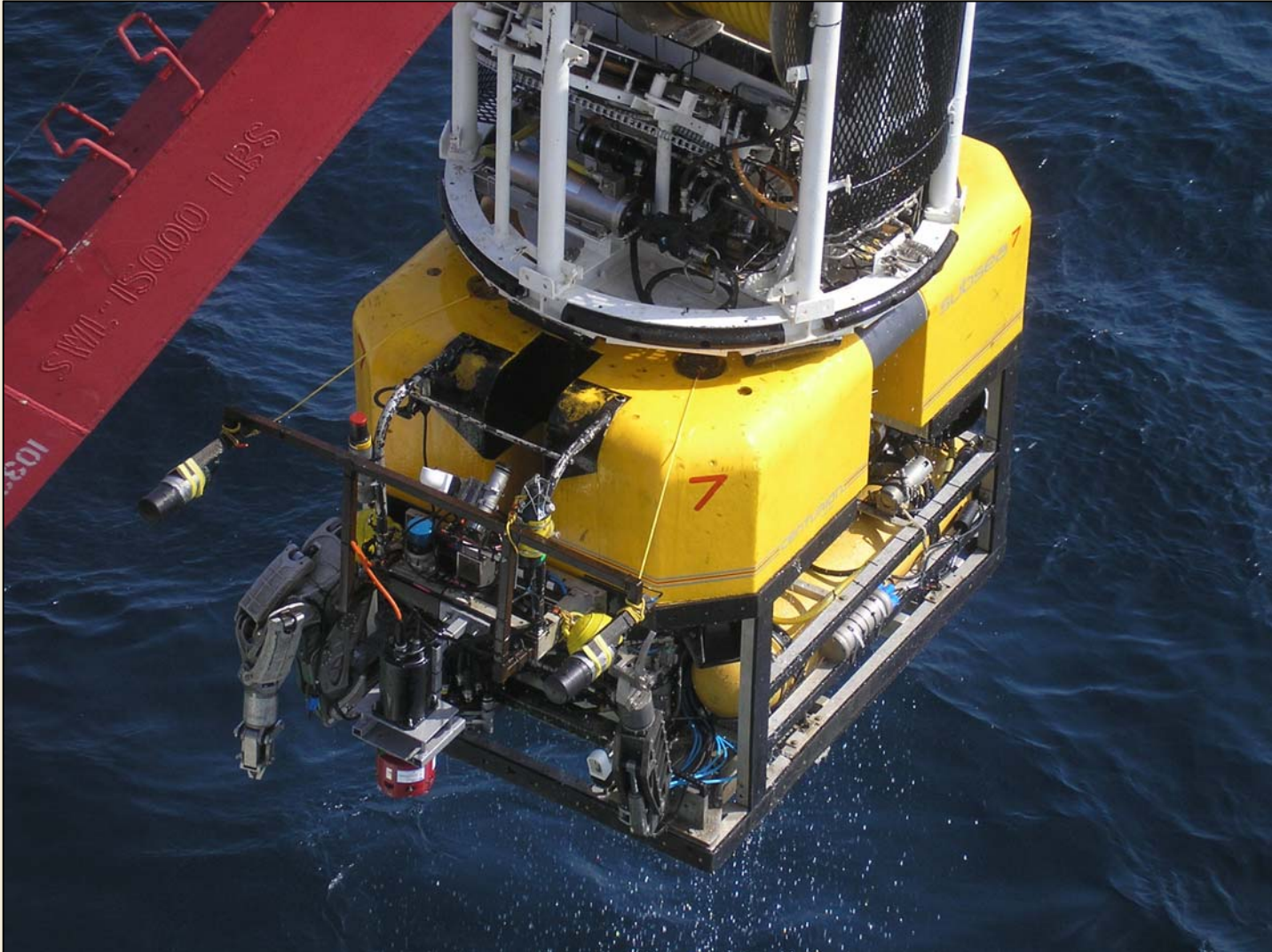


Fugro's Finetrack

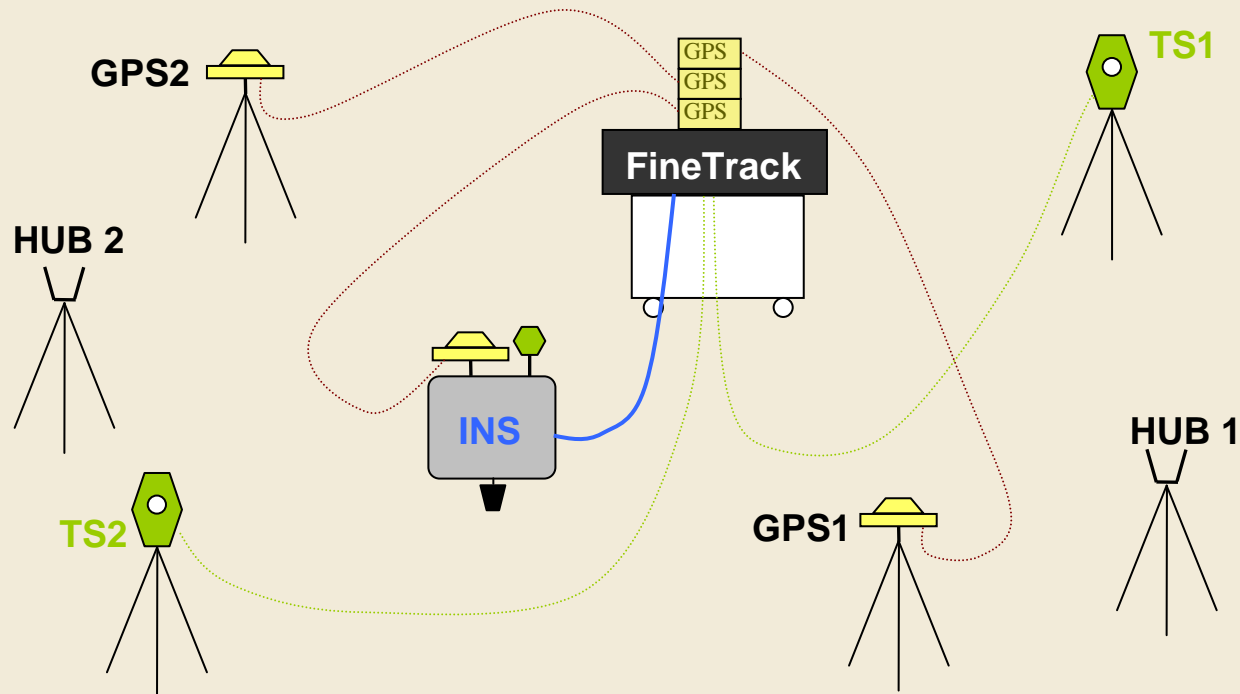
- Aided INS solution
- Loosely and tightly coupled algorithms e.g. (L200, T100)
- Hardware independent
- Quality control



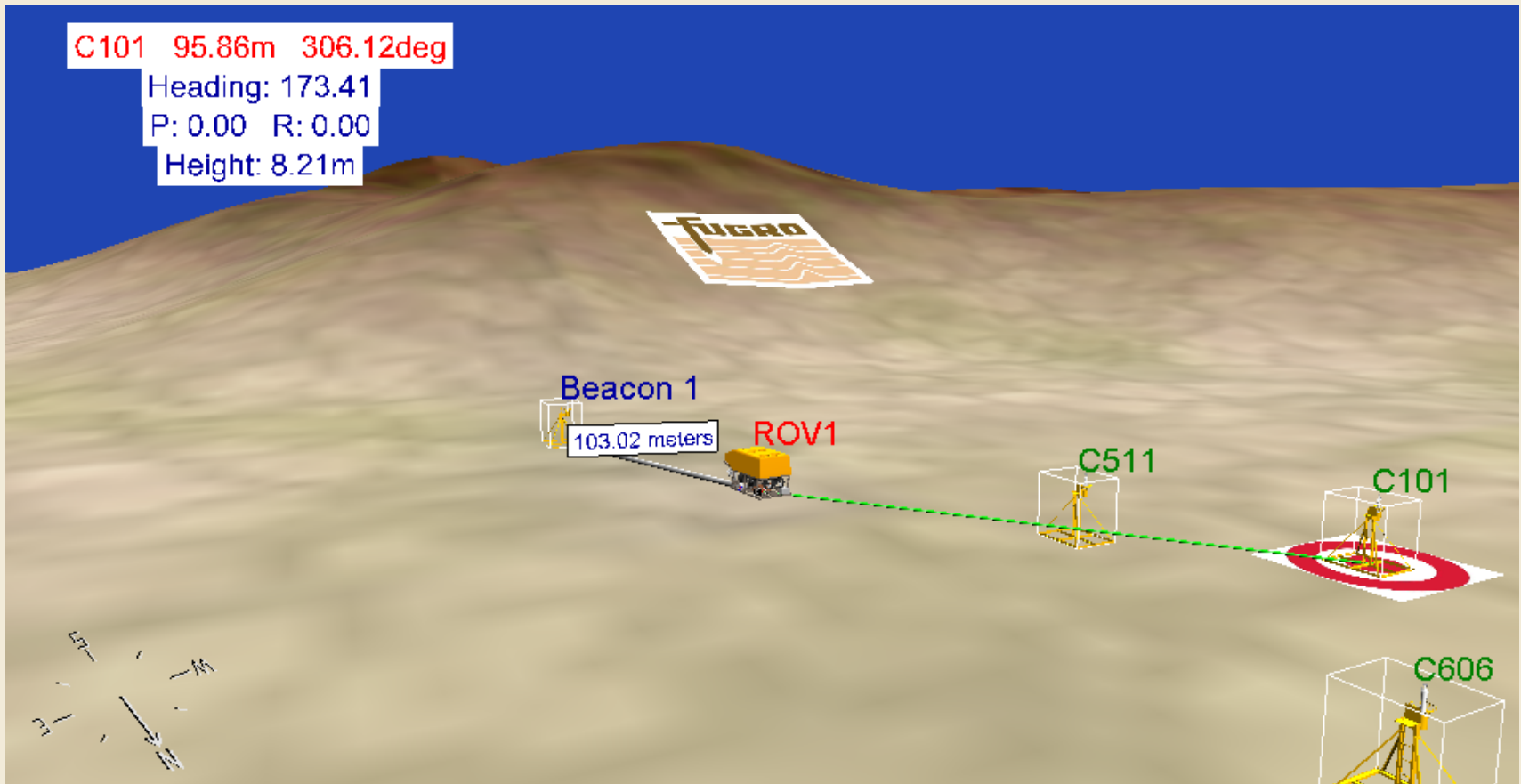




- DVL is not really usable during spoolpiece metrology
- DVL signal interfered/deteriorated when flying nearby the structures and piping
- Option: use sparse LBL ranges from 1, 2 or 3 transponders
 - No need for full array deployment
 - No need for array calibration
- Fugro Survey B.V. currently investigating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



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





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