Dynamic Positioning Committee

Marine Technology Society

Sensors II

Using Doppler Logs for Safer DP Drilling

Dr. Richard Stephens

Allan Meahan, John Flint

Alstom Power Conversion

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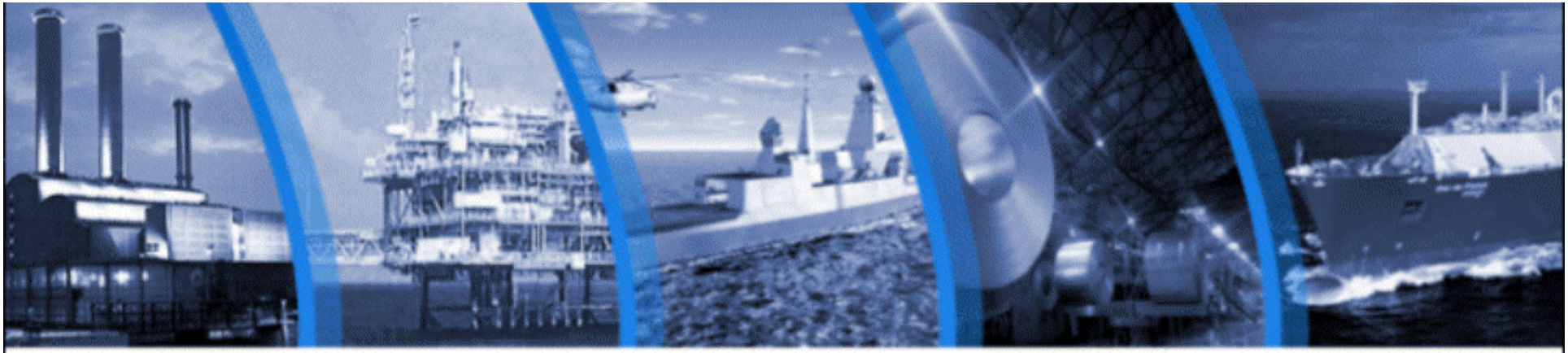

APC Power Conversion

Using Doppler logs for safer DP in drilling

Richard Stephens
Allan Meahan, John Flint

Outline

APC

- DP and PMEs
- Doppler log (speed log)
- Achieving independence
- Simulation results
- Full scale trial data

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Summary

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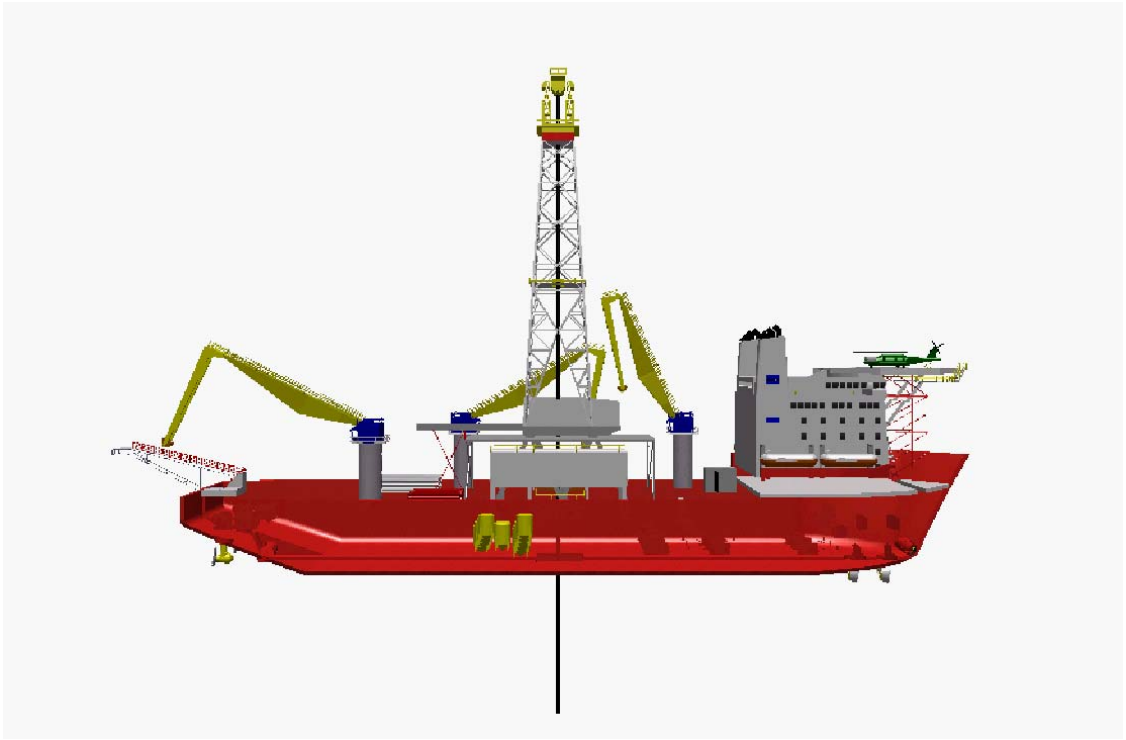
- The problem
  - lack of independent PMEs
- Loss of PMEs leads to:
  - down time
  - delay
  - incidents
- The solution
  - use Doppler log as back up



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Dynamic positioning

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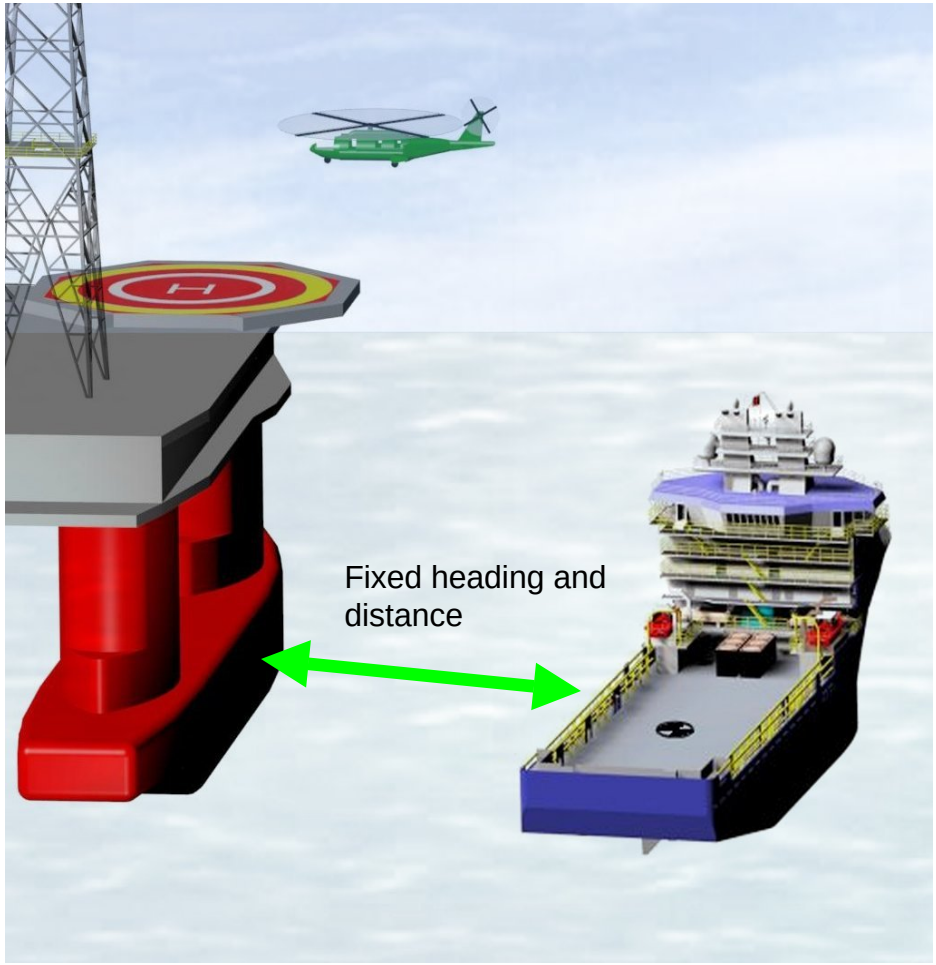
- Maintains vessel in fixed position relative to a fixed reference point
- Fixed heading
- Position controlled by PME
- Heading controlled by gyro-compass
- Position and heading can be changed whilst in DP Mode



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Position measurement

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- For DP a reliable, continuous and accurate position measurement equipment (PME) is required.
- For Class II and III operation, 3 PMEs are required with 2 measuring techniques.
  - OSV's typically have two absolute and one relative position reference systems
  - Drilling Rigs typically have two DGPS/Glonass and two dual acoustics (USBL/LBL)

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Class II/III triple voting system

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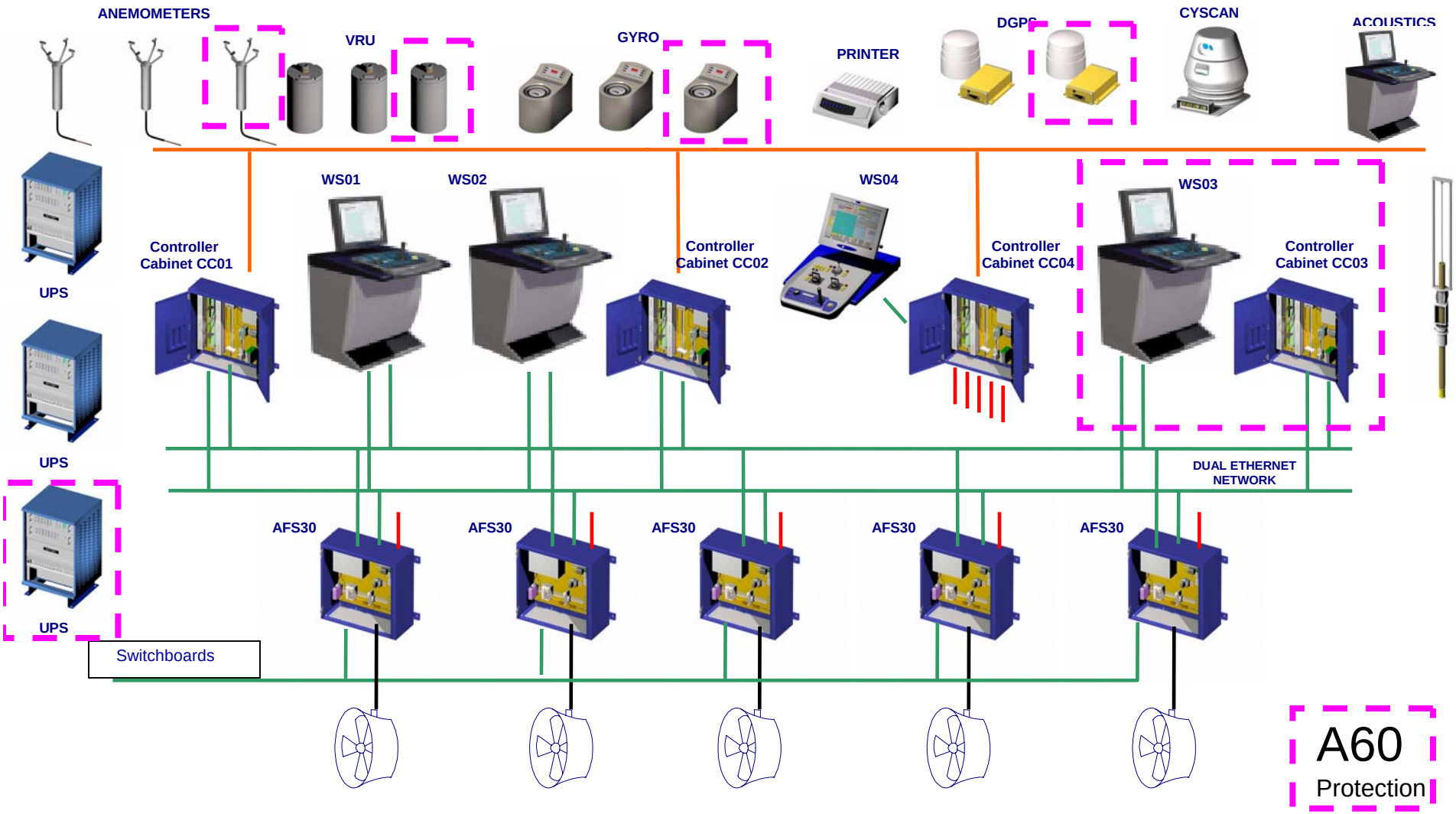

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Independence

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- Independent PMEs must not have a common mode of failure.
  - multiple (D)GPS systems are not really independent
- Better safety could be achieved with a wider range of available independent PMEs

PME types

APC

- Common PME's used for DP include:-
  - Acoustics
  - DGPS
  - Taut wire
  - Laser systems:
    - CyScan
    - Fanbeam
  - Radar systems
- Other options include:-
  - Darps/Artemis
  - Inertial navigation system (INS)

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EXPENSIVE

SETUP TIME

INITIAL TRAINING

DEDICATED

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EXPENSIVE TO OSV AND RIG

SETUP TIME

TRAINING ON OSV AND RIG

DEDICATED

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PME types

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MEDIUM TO HIGH COST

INITIAL SETUP TIME

MINIMAL TRAINING

DEDICATED

OFFERS OTHER INFORMATION ON HEADING/PITCH/ROLL/ POSITION AIDED

Limitations

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- Each PME type is subject to limitations
  - GPS: ionospheric interference
  - GPS: rig shadowing satellites
  - GPS: correction updates can be up to 60 seconds
- Deep water introduces problems:
  - acoustics noise and update rate
  - taut wire not available
- Laser Systems
  - short range
  - line of sight
  - weather (snow, fog)

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Doppler log

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- Dual axis Doppler log
  - known/proven product used by mariners on larger vessels
  - velocity information for bottom and water track
  - surge and sway axes
  - independent of other PMEs
  - back up for PME failure
  - ‘fill-in’ for slow acoustic update rates
  - used in Kalman filter to estimate vessel velocity and position
  - provides useful information to the operators for normal manual operations
- Why use this type of measurement?
  - Past history with cable layers using Doppler log with auto speed mode

Adding Dopplers to KF

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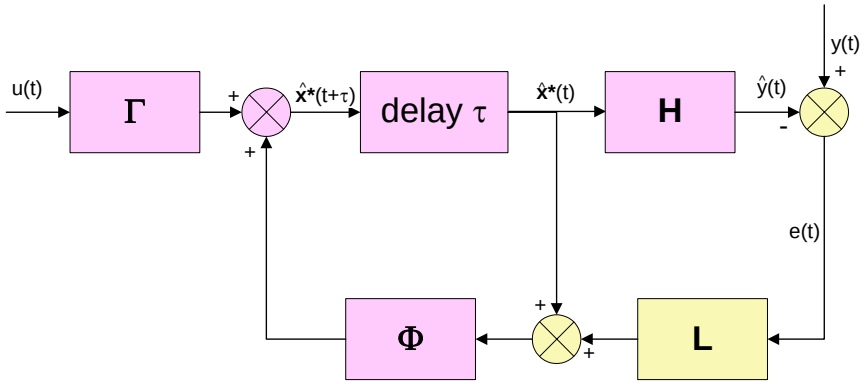
- The KF structure allows Doppler measurements to be utilised in a straightforward manner to give optimal estimates of vessel state.
- Properties of the measurement system can be built into the model for improved accuracy.
- For water lock, estimation of current (velocity offset) is easily included.



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Achieving independence

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- Offsets identified in the DP system
- Not ‘tightly coupled’ to (D)GPS
- Fault detection is included in DP system
- Fault tolerant strategies are required to avoid corruption of velocity estimates

Dependent PMEs

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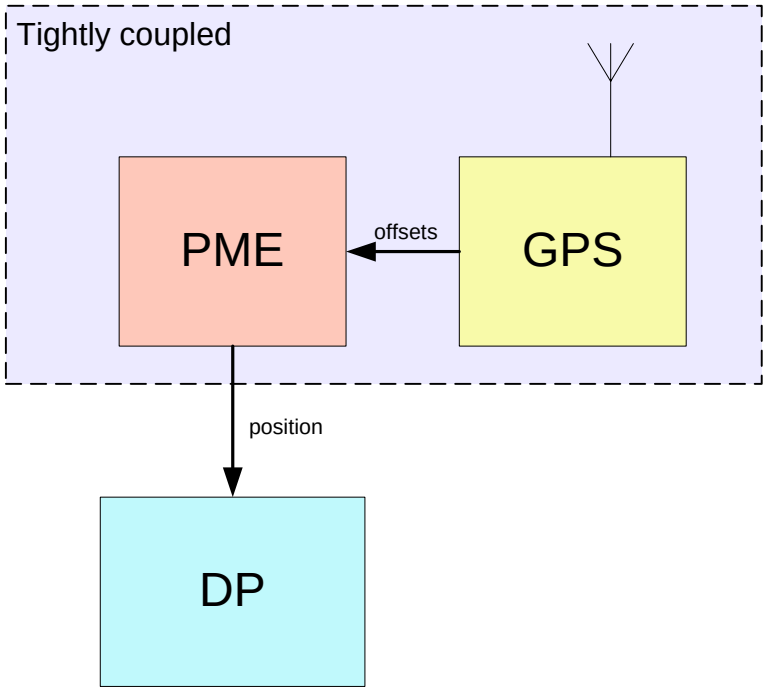
- PME directly communicates with GPS
- PME system calculates offsets
- Combined position sent to DP
- Cannot be considered independent of GPS

- INS falls into this category



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Independent PMEs

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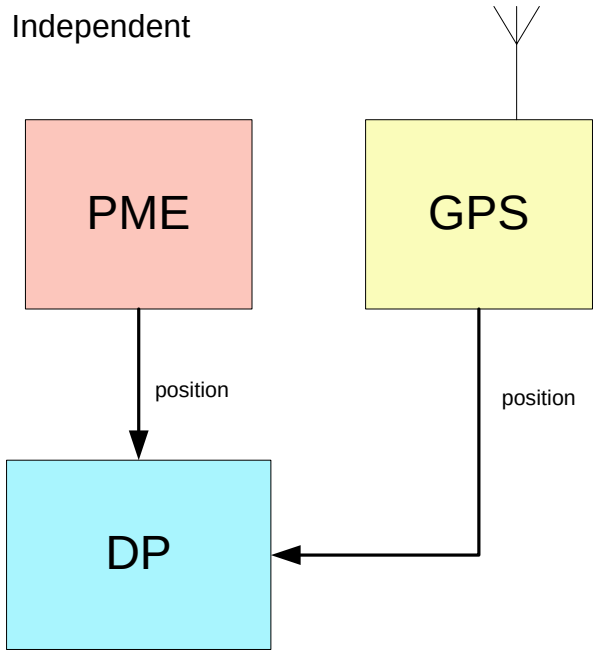
- No interconnection between PME and GPS
- DP system calculates offsets
- DP system performs fault detection
- DP system has the ability to reconfigure when a fault is detected



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Simulations

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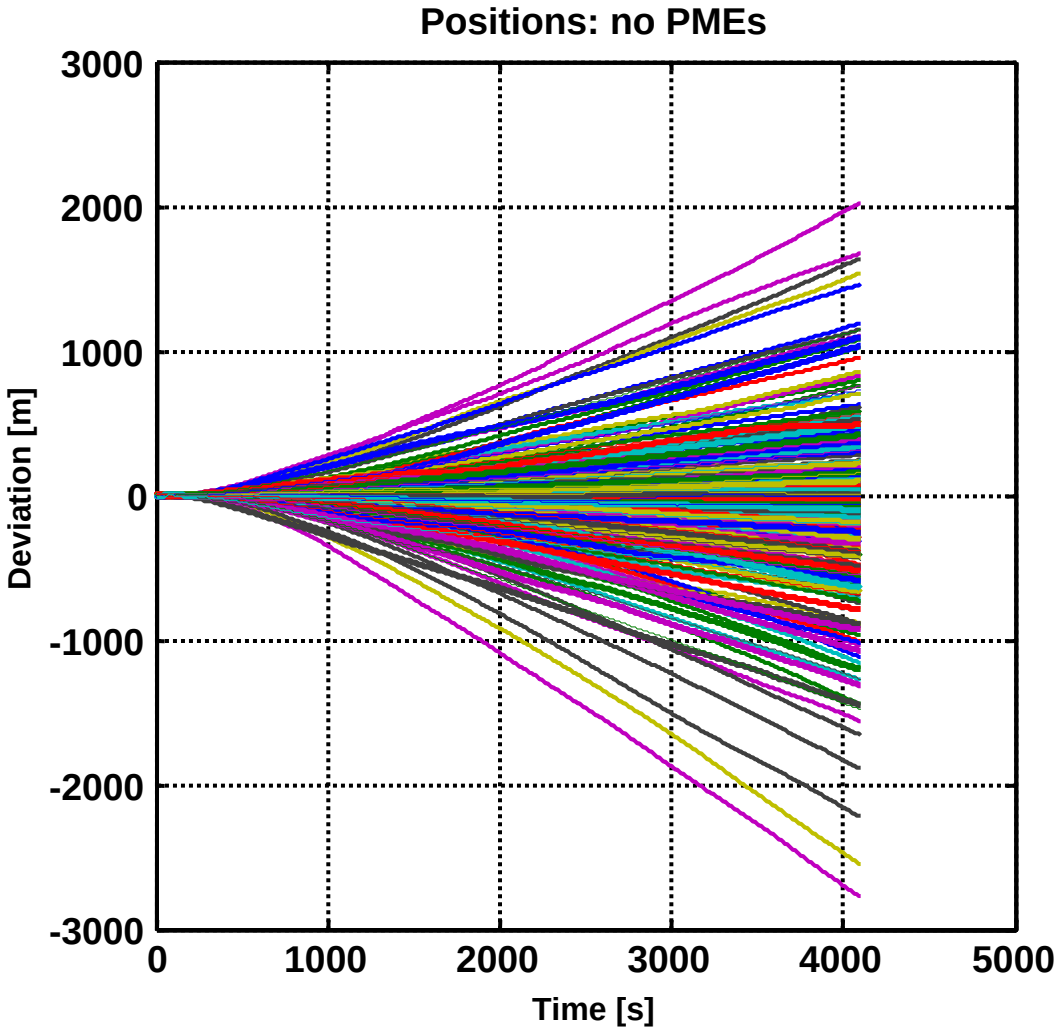
- Simulation results
  - Monte Carlo multiple runs
  - randomly generated starting conditions
  - DGPS fails after 100 s

No PMEs

APC



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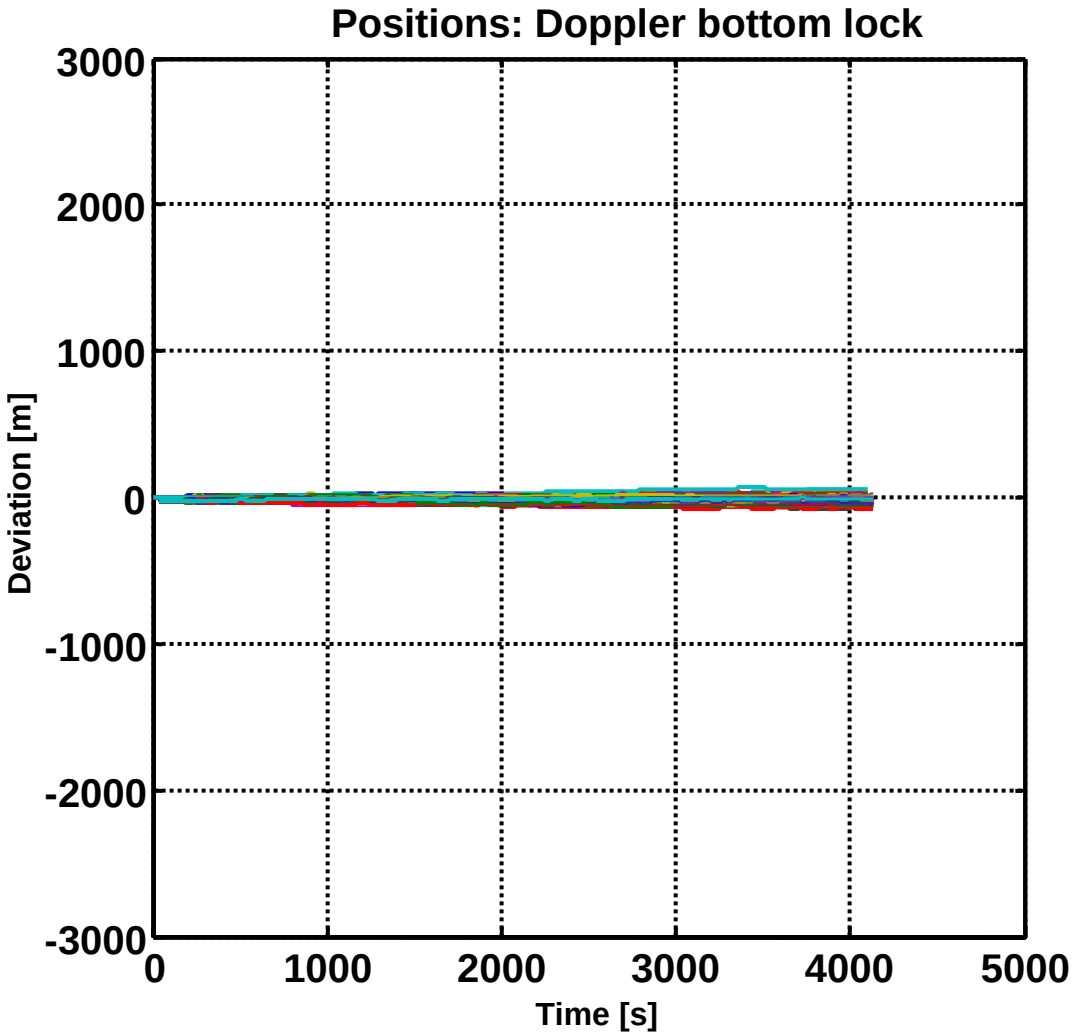
Doppler available

APC



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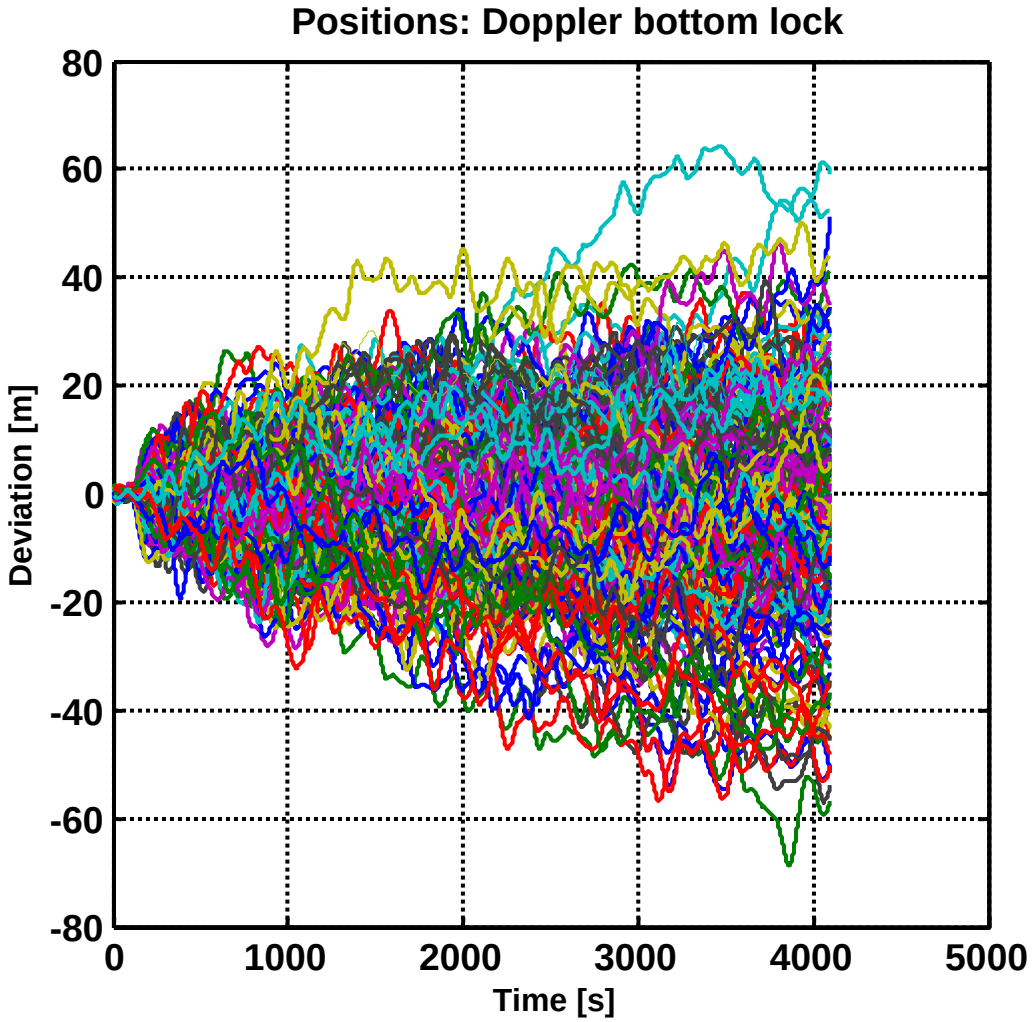
Doppler available (expanded)

APC



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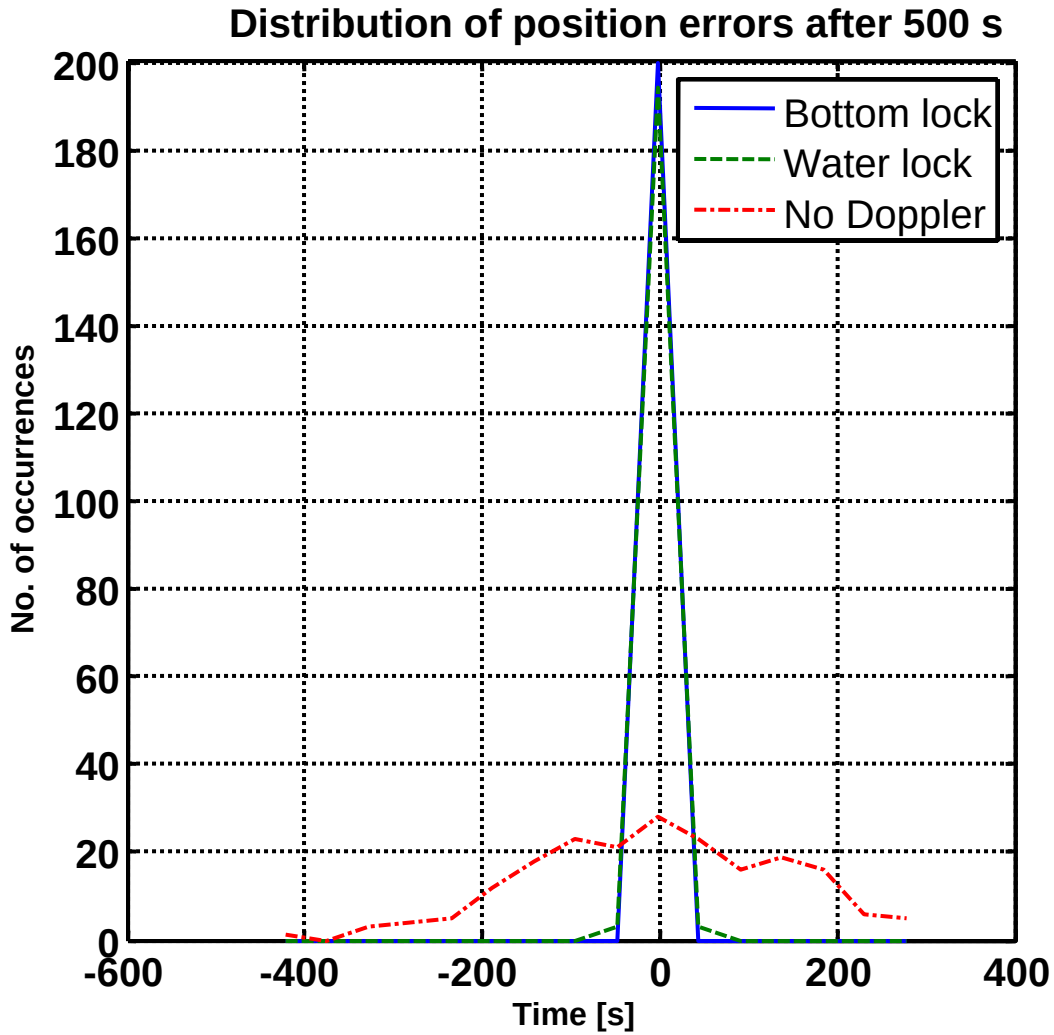
Distribution of errors

APC



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Distribution of errors

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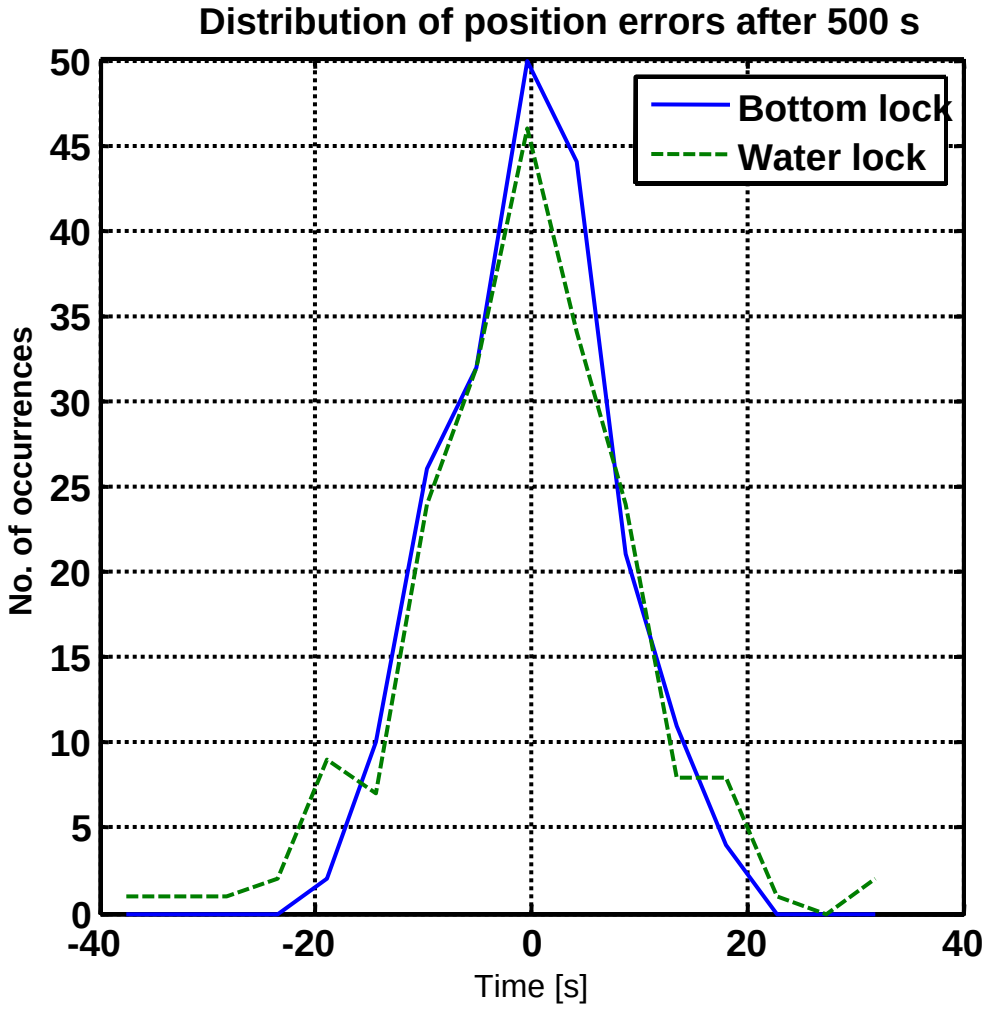

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Deviations after 500 s

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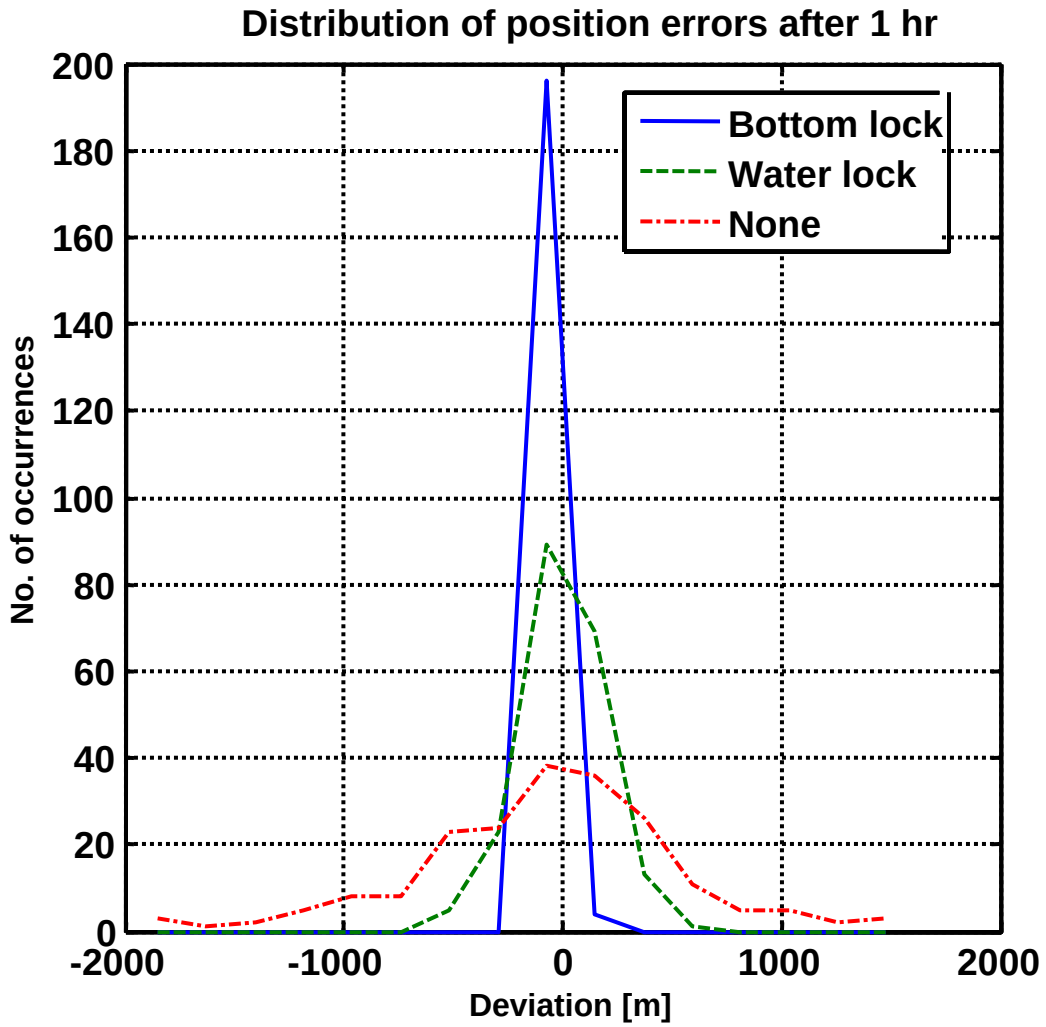
Measurement type	Position error std. dev. (m)
DGPS	1.2
Bottom lock	7.7
Water lock	10.3
None	138.8

Errors after 1 hour

APC



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Full scale trials

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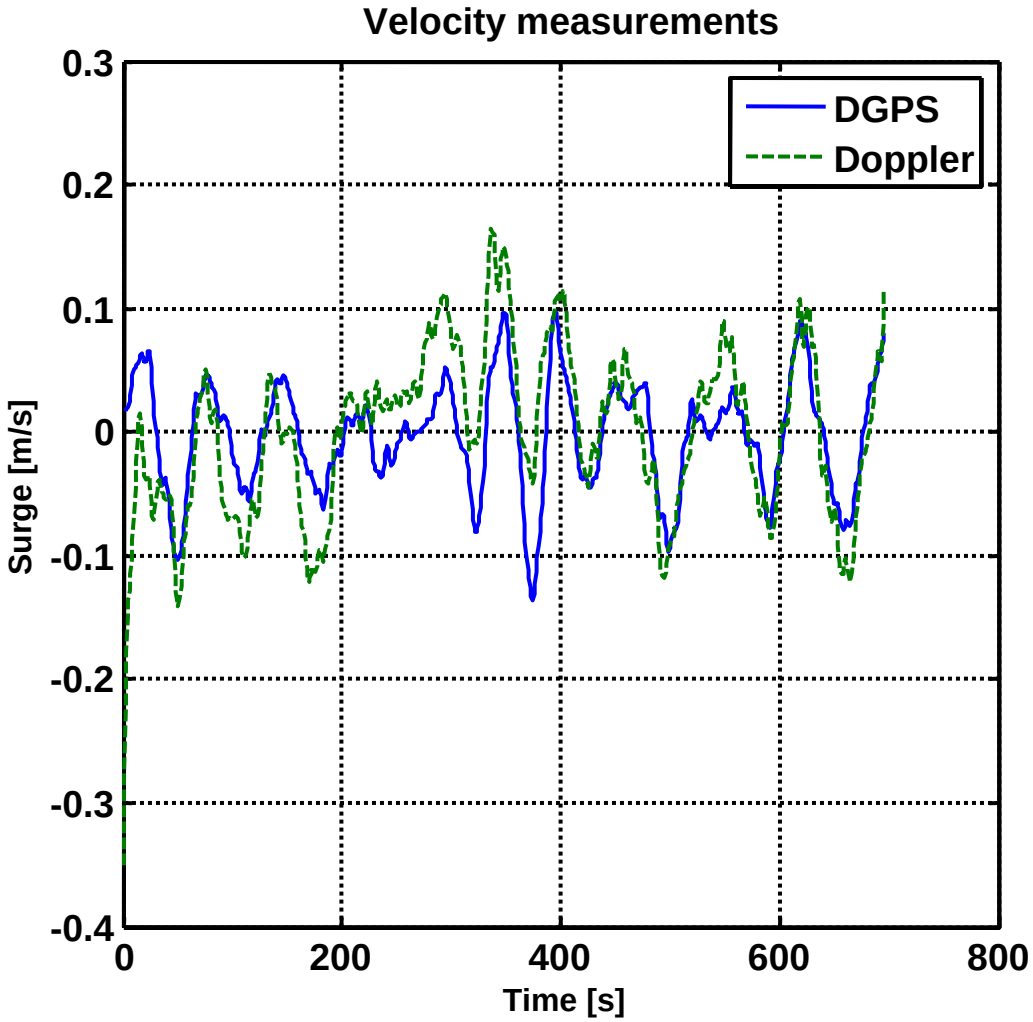
- Measurements acquired from real ship.
- GPS and Doppler measurements available.
- Measurements from both taken during DP.
- Simulation runs performed using each measurement compared to no PME.

Velocity measurements

APC



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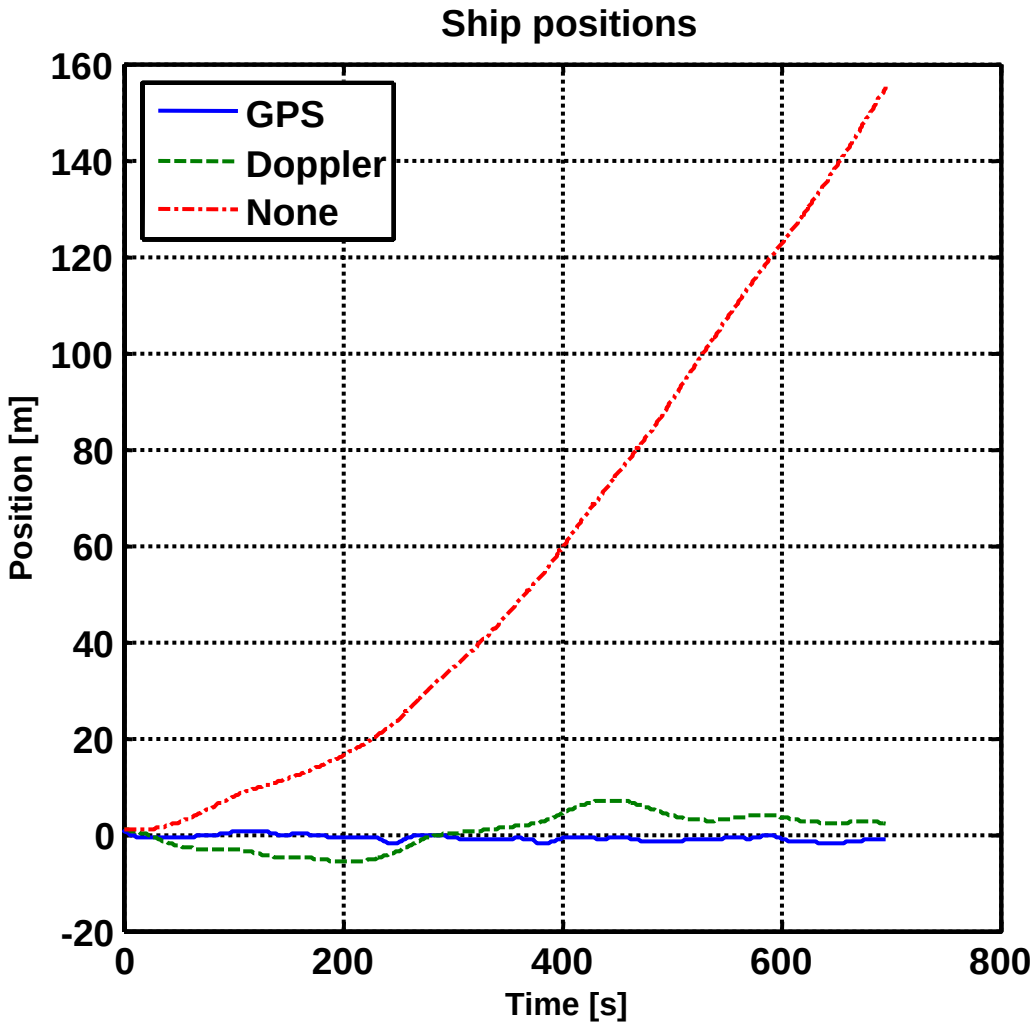
Position keeping

APC



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Conclusions

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- The more PMEs the better (position and velocity)
- PMEs must be independent
- The best place to combine measurements is the DP system itself
- Doppler logs can provide useful backup for PME failure
  - for over an hour on bottom lock (actual figures to be confirmed)
  - for minutes on water lock (actual figures to be confirmed)
- Dopplers logs give the operator an indication of fore/aft and port/stbd velocity (another visual aid) for automatic and manual manoeuvring
- Full scale trials are under way
- Follow up talks with INS manufacturers