DYNAMIC POSITIONING CONFERENCE

OCTOBER 9-11, 2017

PERFORMANCE

Application of Navigation Grade Inertial Navigation Systems to provide tighter Station Keeping Capability and to improve reliability and monitoring of Position Reference Systems on MODUs

Bill Gilmour

Chevron

Application of Navigation Grade Inertial Navigation Systems to provide tighter Station Keeping Capability and to improve reliability and monitoring of Position Reference Systems on MODUs

Bill Gilmour
Team Lead – Subsea Survey & GIS
MTS DP Conference – Oct 11, 2017

human energy®

© 2017 Chevron Corporation

Abstract

‘Application of Navigation Grade Inertial Navigation Systems to provide tighter Station Keeping Capability and to improve reliability and monitoring of Position Reference Systems on MODUs.’

Chevron is specifying an INS Centric approach to DP station keeping, that will improve stability of the real time MODU positioning and increase operational uptime in the event of a loss of some or all, of the position reference sensors. The presentation will provide the rationale around this approach and preliminary configuration of the INS/PRS set up. Once deployed, detailed Well Specific Operating Guidelines and improved position reference system monitoring will significantly aid the DPO in any decision-making process and provide a longer uptime operational window.”

© 2017 Chevron Corporation

Position Reference Systems and INS for Dynamic Position Station Keeping

TOPICS

1. Targets
2. GNSS (Global Navigation Satellite Systems)
3. Acoustic Positioning Systems
4. Electric Riser Angle Monitoring System
5. INS (Inertial Navigation Systems)
6. Configuration diagram
7. SWOT Analysis
8. Summary

© 2017 Chevron Corporation

Position Reference Sensors input to DP System for an HP/HT MODU

Targets:

- Station Keeping Capability with zero chance of DP run off due to Position Reference Sensors
- Quick recovery in case of Blackout condition
- Integration of Riser Monitoring System
- Conformance with new TECHOP guidance notes from Marine Technology Society.

© 2017 Chevron Corporation

Satellite Navigation Systems (GNSS)

Significant changes in Satellite Navigation are taking place, and will be well established by 2020.

System	Origin	# of current satellites	# by 2020
GPS	USA	32	32
Glonass	Russia	24	24
Galileo	Europe	8	30
BeiDou	China	22	35

Current capability uses Precise Point Positioning, to be augmented with precise satellite clock and orbit corrections.

Systems provide decimeter levels of accuracy in X,Y and elevation.

Tightly coupled solutions with INS are common and deeply coupled solutions can enable a faster recovery rate from a total system failure.

© 2017 Chevron Corporation

Acoustic Positioning Systems

Most modern acoustic systems are based on digital signal processing, and are very reliable, even in noisy conditions.

Current practice is two arrays of five transponders interrogated/received by separate transducers

Some acoustic systems are offering inertial coupling, but the initial use of inertial system is loosely coupled and tends to just smooth and gap fill by interpolation from position or ranges

More recent tightly coupled offerings allow improved integrity and continued positioning during range drop outs. This may allow reduction in number of transponders required.

© 2017 Chevron Corporation

Electric Riser Angle Monitoring System

Requirements

- Primary purpose of station keeping is to keep the differential angle across the flex joint above the LMRP as close to zero as possible.

Hardware

- BOP control system hardware manufacturers currently supply sub-standard inclinometer sensors. As a result, system has not generally been used as an input to DP Control System. Some acoustic options are offered.
- Adopting a more accurate and higher update inclinometer sensor (1Hz - 10Hz) will provide differential ERA solution that does not suffer from locally induced vibration (low pass) effects and should be easily implemented via Mux.
- Riser models and water current data (ADCP) may assist in the algorithms.

Software

- Differential angle is the fundamental need for station keeping of MODU's and we can directly measure and model the dynamics of the flex joint to react to the movement of the vessel at the surface.
- Recommends course to steer to reduce differential angle.
- Alarm system when thresholds are lost.

© 2017 Chevron Corporation

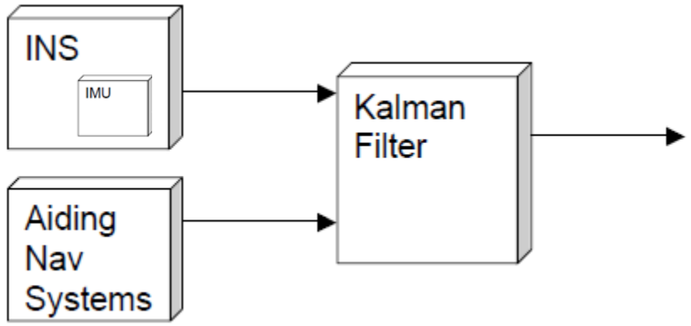
Alternative Inertial Navigation Approach
INS Centric

- Each INS is aided by GNSS and acoustic position reference.
- The INS measures the vessels movement using its internal gyros a accelerometers to calculate and output a unique position, velocity, a attitude solution complete with quality data.
- Years of development and testing has gone into the advanced screening abilities of these INS's allowing them to identify any position reference problems then screen out the suspect data. The INS is much more efficient at this task compared with a traditional DP system
- The use of 'navigation' grade INS's removes the need for separate MRU's and gyros.
- Unaided navigation grade INS systems drift about 1m in 120 secs or 20m in 900 secs (15 mins).

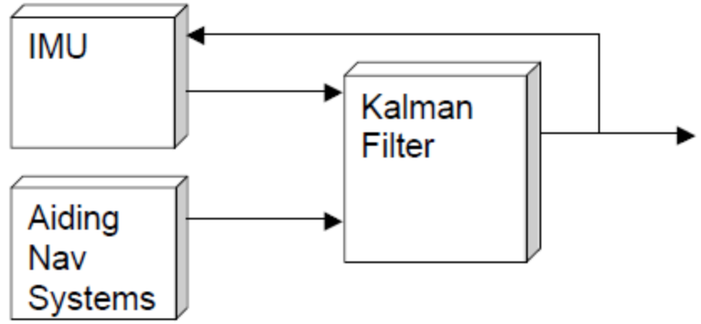
i.e. - If you lose all PRS (GNSS and acoustic) you still maintain watch circle for long enough to make a good decision. Any unaided INS drift can still be monitored against the riser monitoring system.

© 2017 Chevron Corporation

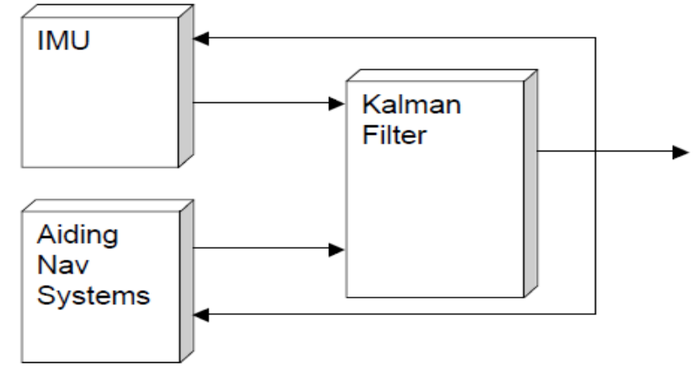
INS and PRS coupling



Loosely Coupled
PRS provides position and quality.
INS provides position and velocity.
Useful to increase update rate and bridge gaps in PRS data



Tightly Coupled
PRS provides raw range and noise level.
IMU provides raw acceleration and direction.
Kalman feedback resets INS drift each position update



Deeply Coupled
PRS provides raw range and noise level
IMU provides raw acceleration and direction.
Kalman resets INS drift each position update
Kalman updates PRS position
Potential for faster GNSS recovery time after loss

© 2017 Chevron Corporation

Inertial Navigation Systems

An Inertial Navigation System (INS) works by detecting the current rate of acceleration (using accelerometers) and detects changes in rotational attributes (pitch/roll/yaw) using gyroscopes.

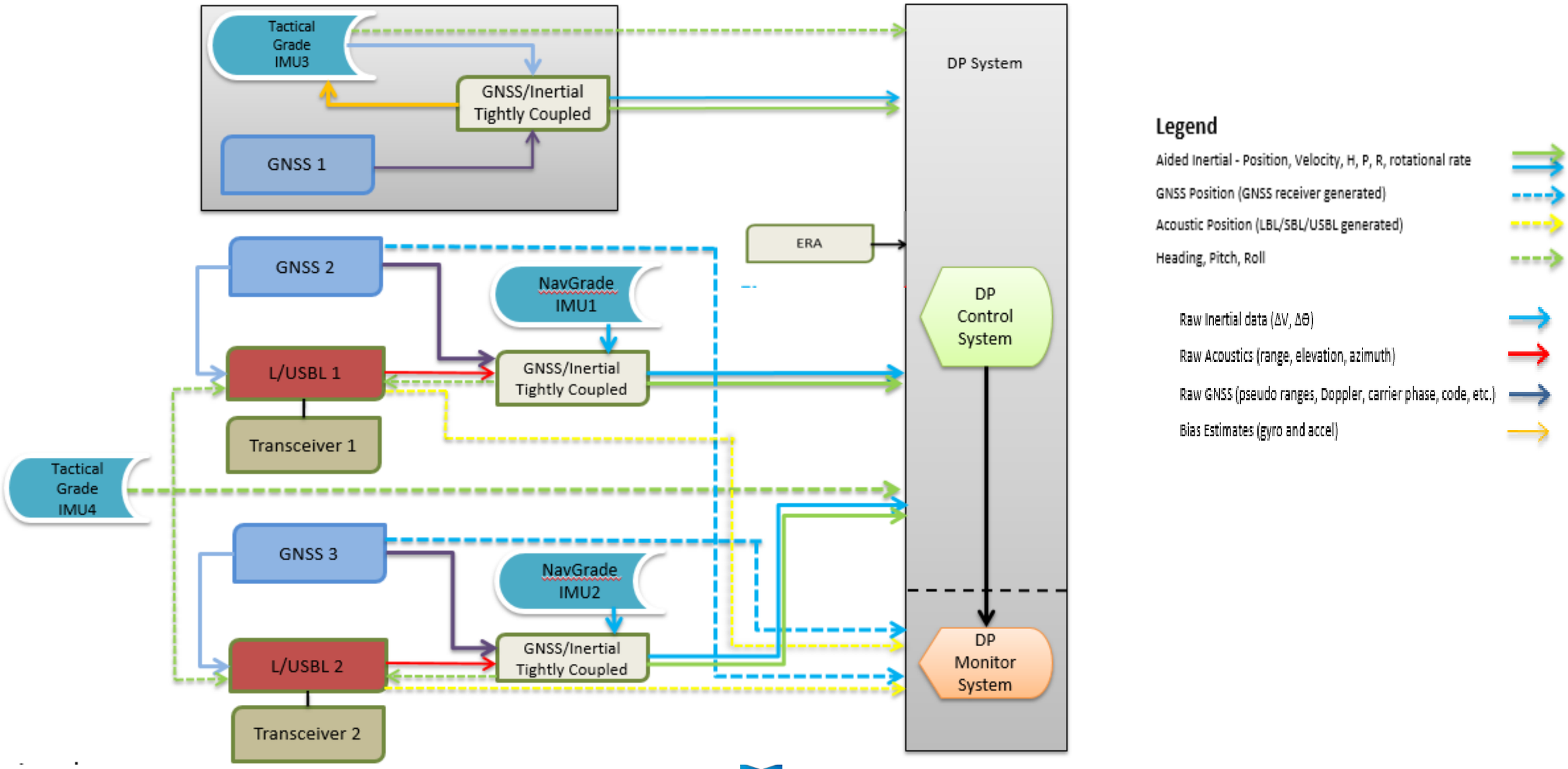
System selection is based on requirement for detection of angular rotation and the system drift.

Sensor	heading	pitch/roll	drift	Approx cost
Gyroscope	~1° secLat			$20,000
IMU		0.5°		$8,000
INS (low grade)	<0.1° secLat	<0.1°	1m in 30s 20m in 120s	$45,000
INS (navigation grade)	<0.02°sec lat	<0.01°	0.8 n.mile/hour 1m in 120s 20m in 15mins	$100,000
INS (high grade)	<0.03°	<0.01	1m in 20mins 20m in 2.5 hrs	>$250,000

Free drift of 20m in 15 mins with zero PRS updates provides DPO/Master time to react.

© 2017 Chevron Corporation

Proposed Configuration Diagram



© 2017 Chevron Corporation

SWOT ANALYSIS
INS Centric PRS System

Strengths

- Faster position update rate;
- Robust position estimation (Kalman Filter);
- Rapid detection of PRS drift;
- Robust quality control of position estimation;
- Maximum integrity and availability of position;
- Decreases dependency on any primary PRS system;
- PRS data is time stamped prior to input to DPCS;
- The high rate INS data is aided by the slower PRS system;

Weaknesses

- Increases data flow complexity of DPCS;
- Requires a navigation grade INS;
- Increases the cost of the DP system;
- Very reliant on INS solution;

Opportunities

- Can facilitate a longer ride through of PRS loss;
- Provides an independent means of fault detection using raw measurements;
- Potential to utilize several combinations of PRS solutions;
- Correct weight appropriation via the Kalman filter;
- Better utilization of all PRS data rather than data rejection;
- New monitoring system will provide constant analysis of data quality enabling DPO to easily analyze what may be going on
- DPCS has the ability to utilize standard PRS solutions in event of an INS filter divergence;
- Provides facility for a more robust Riser Angle Monitoring solution;

Threats

- System requires extensive onshore & offshore testing;
- Class societies will need to approve this system design;
- Current proposed system not in complete alignment with draft MTS TechOP_ODP_14(D);

© 2017 Chevron Corporation

Summary

Specification:

An Inertial Navigation System Centric approach is specified into the RFQ for a HP/HT MODU.

An Independent Monitoring system is included.

An improved Electronic Riser Angle monitoring system will provide additional information.

Current Status:

RFQ for HP/HT MODU in clarification stage.

Continued engagement of PRS suppliers and DP manufacturers.

Future Status:

INS Centric testing will be included in HP/HT MODU FEED with WSOG developed

Engage early with Class Society.

AIM IS TO PROVIDE STATION KEEPING CAPABILITY WITH ZERO CHANCE OF DP RUN OFF DUE TO POSITION REFERENCE SENSORS

© 2017 Chevron Corporation

Questions?

bill.gilmour@chevron.com