



Smart Production Monitoring Enabled by Virtual Well Metering

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woodplc.com

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- What is VMS?
- Wood Experience with VMS
- Differences Between VMS and Multiphase Meters
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Safety and Flexibility

- Going to Site is sometimes critical to project success because design does not always match actual.
- Be prepared for things that can go wrong before you go to site.



What is VMS?

Virtual Metering System (VMS)

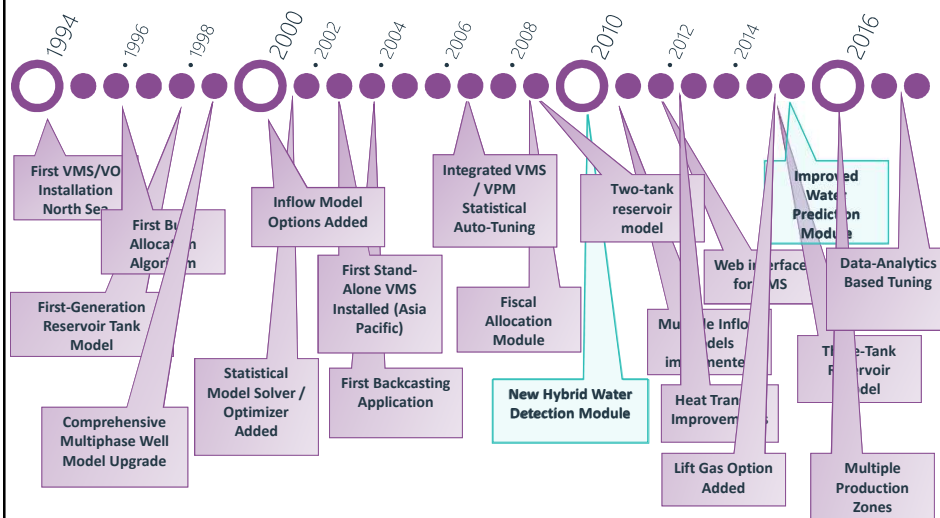
VMS – Inferential Metering System Calculates flowrates (G/O/W) using typical instrumentation data around well, e.g. Ps & Ts before & after the choke.

Wood Experience with VMS

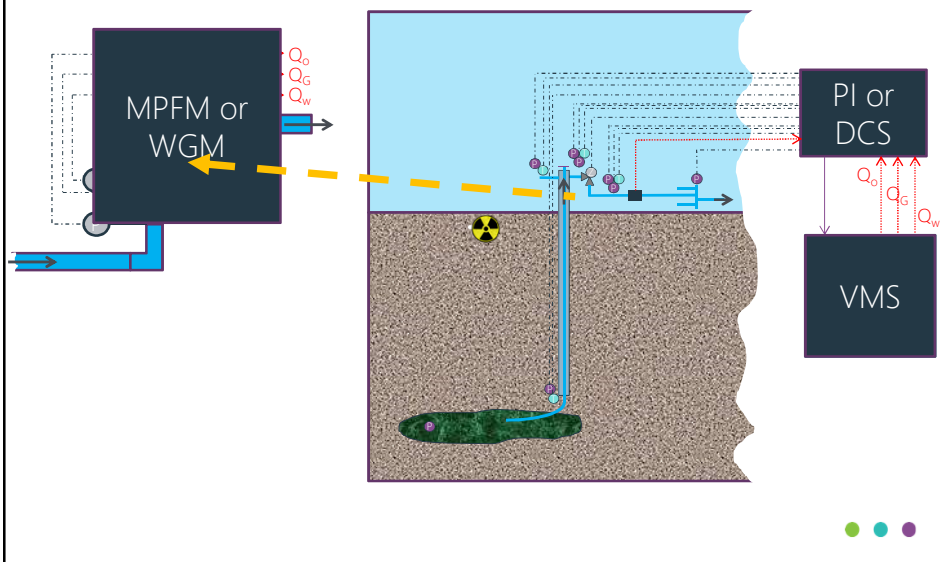
- Over 25 years of installing and maintaining online, real-time dynamic modeling technology for upstream production operations (Virtuoso®)
- 150+ custom installations in 20+ different countries for over 30 different companies
- Virtual Metering Technology deployed in 50+ Platforms, 75+ Reservoirs, nearly 1000 Wells – thousands of well-years of VMS performance experience
- Globally installed and most still being maintained
- First system delivered in 1994 – ran until the platform was Decommissioned in October 2018.



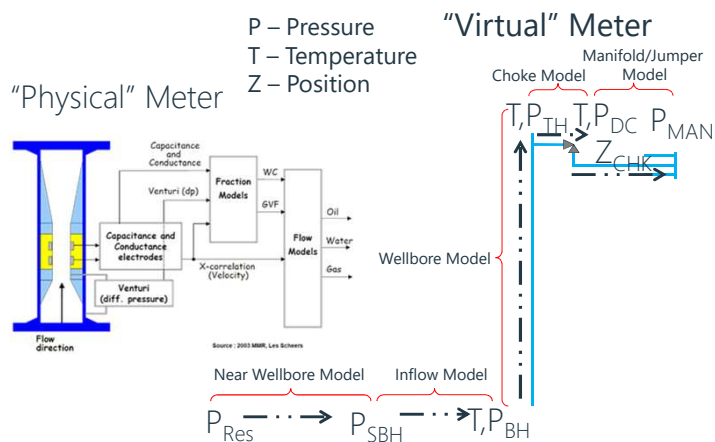
VMS Evolution and Applications



Wellhead Metering



VMS and Physical Meter Models



dP in millibars - .010 bar <<<< dP in hundreds of bars

VMS Methods

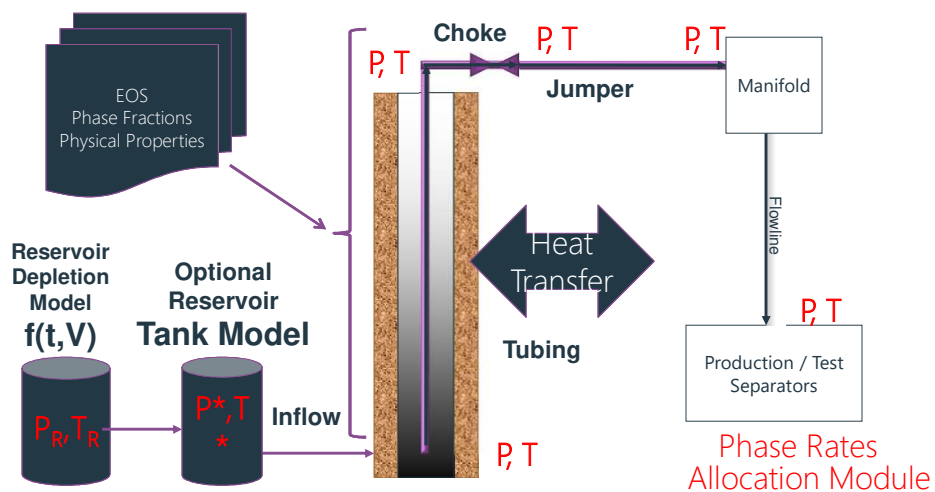
- Very robust, software/model-based solution for calculating wellhead flow rates from conventional well instrumentation

- Uses all available instrumentation (P,T,Z) from perforation to manifold
- Nine standard methods* combined statistically to determine best flow rate estimate
- Uses first-principles of heat, mass, & momentum transfer, coupled with thermodynamics engine for phase behavior and physical property calculation

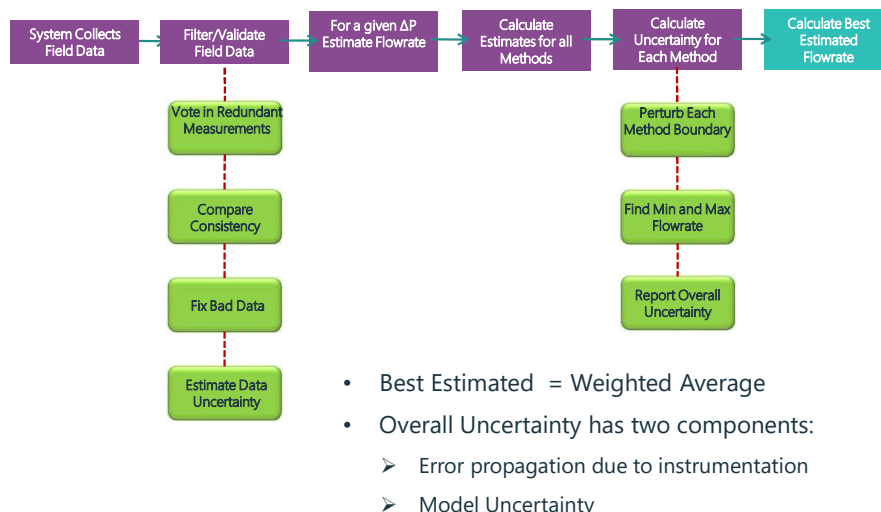


- A smart meter and well surveillance tool which is remotely readable and configurable

How VMS Works - VMS Models



VMS Calculation Procedure



Benefits of VMS

- Has been used in lieu of subsea multiphase meters.
- **Has been used for surveillance and an insurance policy for subsea metering**
- Can be used / installed retrospectively (brown field applications)
- Very robust – uptime of 99.9%+
- improved decision making
- Increased accuracy of estimating remaining recoverable hydrocarbons
- Enhanced real-time well and reservoir surveillance and management (watch the physics)
- **Cost of VMS usually order of magnitude less than MPFM**
- Can be Tuned Based on LACT Meters
- Production allocation & cumulative production to facilitate history matching
- **Can be used to Find Meter Factors for Multiphase Meters**

Well Status Overview

Well Status

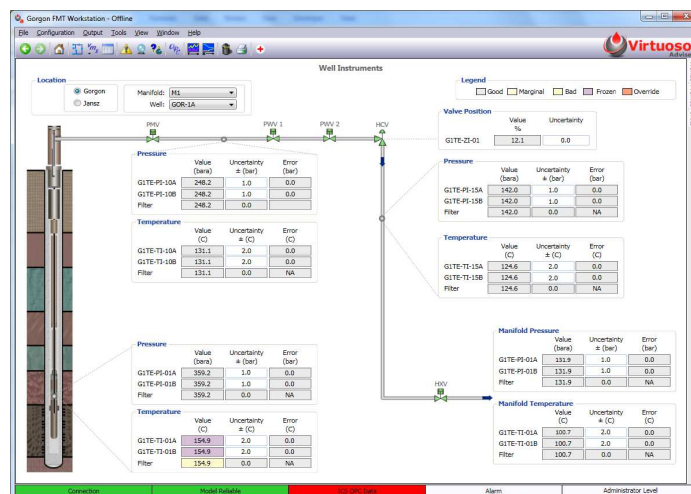
Well	Choke %	PM1	PM2	Pressure		Gas Flowrate		Condensate Flowrate		Water Flowrate	
				Bottom Hole	Tubing Head	Calculated	Measured	Calculated	Measured	Calculated	Measured
H1	1A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	1B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	1C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	1D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	1E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H2	2A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	2B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	2C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	2D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	2E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H3	3A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	3B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	3C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	3D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	3E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H4	4A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	4B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	4C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	4D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	4E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H5	5A 13.2			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	5B 13.2			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	5C 13.2			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	5D 13.2			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	5E 13.2			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H6	6A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	6B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	6C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	6D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	6E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H7	7A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	7B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	7C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	7D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	7E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H8	8A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	8B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	8C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	8D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	8E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H9	9A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	9B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	9C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	9D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	9E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H10	10A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	10B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	10C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	10D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	10E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H11	11A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	11B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	11C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	11D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	11E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H12	12A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	12B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	12C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	12D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	12E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H13	13A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	13B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	13C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	13D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	13E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H14	14A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	14B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	14C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	14D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	14E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H15	15A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	15B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	15C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	15D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	15E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H16	16A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	16B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	16C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	16D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	16E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H17	17A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	17B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	17C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	17D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	17E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H18	18A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	18B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	18C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	18D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	18E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H19	19A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	19B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	19C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	19D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	19E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H20	20A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	20B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	20C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	20D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	20E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H21	21A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	21B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	21C 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	21D 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	21E 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
H22	22A 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	22B 10.1			281.2	240.2	211.91	214.41	0.0	1.3	1.8	0.7
	22C 10.1			281.2	240.2	211.91	214.41	0.0	1.		

- ### Comparison to LACT

The chart displays Volume Rate (bbl) on the Y-axis (0 to 100,000) against time on the X-axis (Mar 23 to May 04). The legend indicates four data series: LACT (red), Total Separator (blue), Topside Meters (green), and Subsea MPFM (cyan). The LACT and Total Separator data show high-frequency, high-amplitude fluctuations, with several peaks exceeding 80,000 bbl. The Topside Meters and Subsea MPFM data show much lower and more stable volume rates, generally between 40,000 and 60,000 bbl.

Location	Gain
Train 1	1.0531
Train 2	1.0838
A Topside	1.0024
B Topside	1.0246
C Topside	1.0017
D Topside	1.0046
Riser A	0.9492
Riser B	0.9448
Riser C	0.9744
Riser D	0.9363
RiserE	0.9600

Sensor Status Summary



Data Filtering

Process Data Configuration

Data Handler: ICS Data Handler Display Mode: Overview Scroll Tip: VarName

Drag a column header here to group by that column.

Location	VarName	Description	TagName	OnlineTagName	FieldValue	ZOTType	Data Type	CurValue	Override	OverrideStatus	MSValue
Gorgon_SS	Process Gorgon_SS Well GBIC.MEGInj...	GBIC-C Well MEG Injection	ES_Pipel...	G4TB-FI-15	0.002271	INP/IT	Single	0.002271	0	☐	0.002271
Gorgon_SS	Process Gorgon_SS Well GBIC.MEGInj...	GBIC-C Well MEG Injection V...	NA	G4TB-LV-20-X01	-9999.97	INP/IT	Boolean	-9999.97	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.MEGInj...	GBIC-C Well MEG Injection V...	NA	G4TB-LV-25-X01	-9999.97	INP/IT	Boolean	-9999.97	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.PMAt...	GBIC-C Well Pressure Below...	ES_GBL...	G4TB-P1-05A	2.681101...	INP/IT	Single	2.681101...	0	☐	2.681101...
Gorgon_SS	Process Gorgon_SS Well GBIC.PMAt...	GBIC-C Well Pressure Below...	ES_GBL...	G4TB-P1-05B	2.681101...	INP/IT	Single	2.681101...	0	☐	2.681101...
Gorgon_SS	Process Gorgon_SS Well GBIC.PMAt...	GBIC-C Well Temperature B...	ES_GBL...	G4TB-T1-05A	405.2782	INP/IT	Single	405.2782	0	☐	405.2782
Gorgon_SS	Process Gorgon_SS Well GBIC.PMAt...	GBIC-C Well Temperature B...	ES_GBL...	G4TB-T1-05B	405.2782	INP/IT	Single	405.2782	0	☐	405.2782
Gorgon_SS	Process Gorgon_SS Well GBIC.SCSISV...	GBIC-C Well SCSISV Valve Po...	ES_Pipel...	G4TB-LV-01-X01	1	INP/IT	Boolean	1	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.NAWM...	GBIC Well Flowrate Selector	NA	G4TB-FI-05-H01	-9999.97	INP/IT	Single	-9999.97	0	☐	0
Gorgon_SS	Process Gorgon_SS Well GBIC.NAWM...	GBIC Well Flowrate Selector	NA	G4TB-FI-15-H01	-9999.97	INP/IT	Single	-9999.97	1	☒	1
Gorgon_SS	Process Gorgon_SS Well GBIC.Water...	GBIC-C Well Water Flowrate	ES_Pipel...	G4TB-FI-05-F05	0.001914	INP/IT	Single	0.001914	0	☐	0.001914
Gorgon_SS	Process Gorgon_SS Well GBIC.WingV...	GBIC-C Well Wing Valve 1 P...	ES_GBL...	G4TB-Z1-10	1	INP/IT	Boolean	1	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.WingV...	GBIC-C Well Wing Valve 2 P...	ES_GBL...	G4TB-LV-10-X01	1	INP/IT	Boolean	1	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.ChemI...	GBIC-8 Well Chemical Inject...	NA	G3TA-FI-35	-9999.97	INP/IT	Single	-9999.97	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.ChemI...	GBIC-8 Well Chemical Inject...	NA	G3TA-FI-40	-9999.97	INP/IT	Single	-9999.97	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.ChemI...	GBIC-8 Well Chemical Inject...	ES_Pipel...	G3TA-FI-10	0	INP/IT	Single	0	0	☐	0
Gorgon_SS	Process Gorgon_SS Well GBIC.ChemI...	GBIC-8 Well Chemical Inject...	NA	G3TA-LV-50-X01	-9999.97	INP/IT	Boolean	-9999.97	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.ChemI...	GBIC-8 Well Chemical Inject...	NA	G3TA-LV-55-X01	-9999.97	INP/IT	Boolean	-9999.97	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.ChemI...	GBIC-8 Well Chemical Mater...	NA	G3TA-LV-15-X01	-9999.97	INP/IT	Single	-9999.97	0	☐	1
Gorgon_SS	Process Gorgon_SS Well GBIC.ChemI...	GBIC-8 Well Choke Valve Po...	ES_GBL...	G3TA-Z1-01	0.005441	INP/IT	Single	0.005441	0	☐	0.005441

Legend: Good Status (Green), Bad Status (Red), Frozen Data (Grey), Override (Orange), Override and Future (Light Orange), Tag 'NA' and Future (Light Grey)

Process Data Connection Last Read Time: 01/03/2012 14:17:46

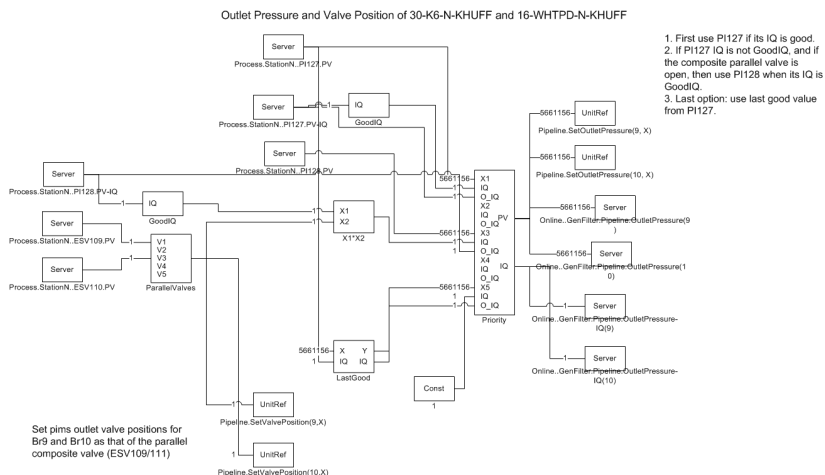
Action: Reload, Clear Settings, Apply

Connection: Model Status: ICS OPC Data: Alarm: View Data Load

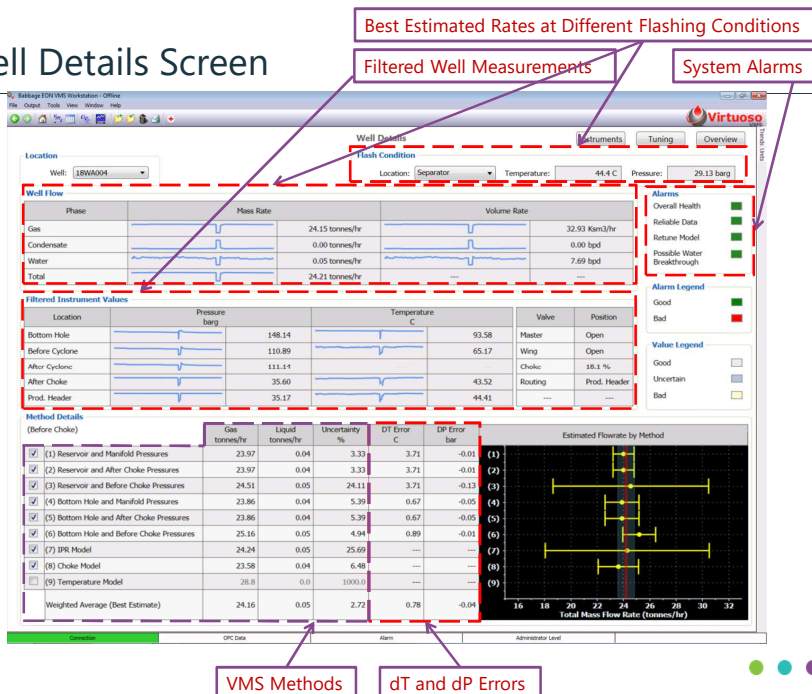
Field Data Filtering and Reconciliation in VMS

- Data Treatment Methods
 - Gross error detection and isolation using statistical tests, global tests, nodal tests, measurements tests, unbiased estimate techniques
 - Data filtering and reconciliation algorithms
- Outlier Removal and Best Filter Definition
 - Deliver a dataset which closer to the true process state than raw data

Chameleon™ Filters



Well Details Screen



VMS – Accuracy and Field Performance

Accuracy depends on a range of issues:

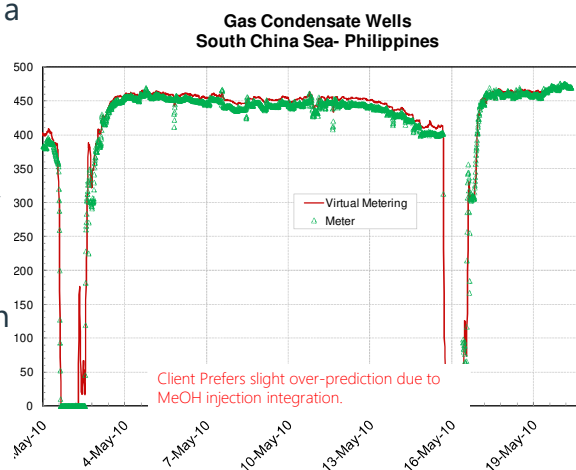
- Fluid type
- Instrumentation & Accuracy
- Ability to accurately Tune

Out of the box (design data)

~ ±10-15% Gas & Liquid Rates

Tuned

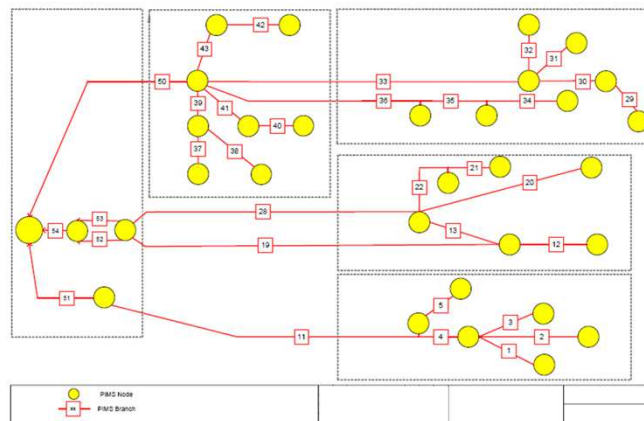
~ ±1-5% Gas & Liquid Rates



VMS Lite vs Regular VMS

- VMS Lite uses 2 methods instead of 9.
- VMS Lite Typically Used when No Bottom Hole Pressure Measurement
- Used in Cases where Data Analytics Required to Estimate Flowrate from Each Well
 - In one case – no well tests for 5 to 15 years.
 - 1 Fiscal Meter for 20 Wells Located 40 km Away
 - Reservoir Engineers Only have Field Wide View Models not well by well view
 - Need Ability to Simulate 6 months of Data in 5 seconds for Functional Evaluation for Data Analytic Fitting Methods

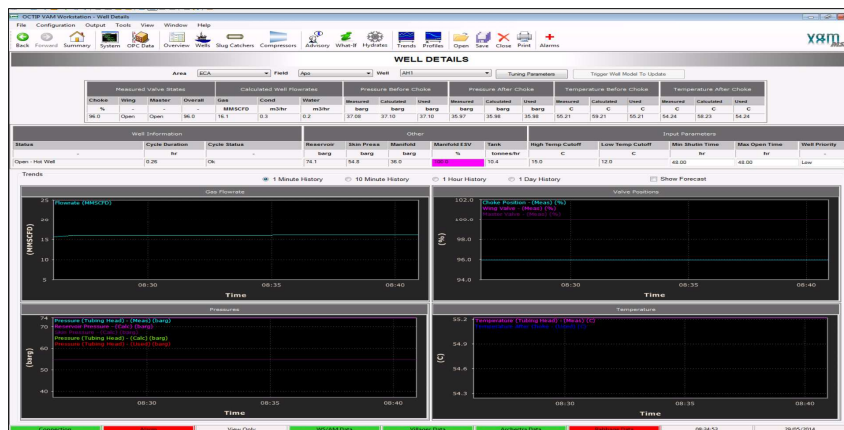
Example Application of VMS-Lite



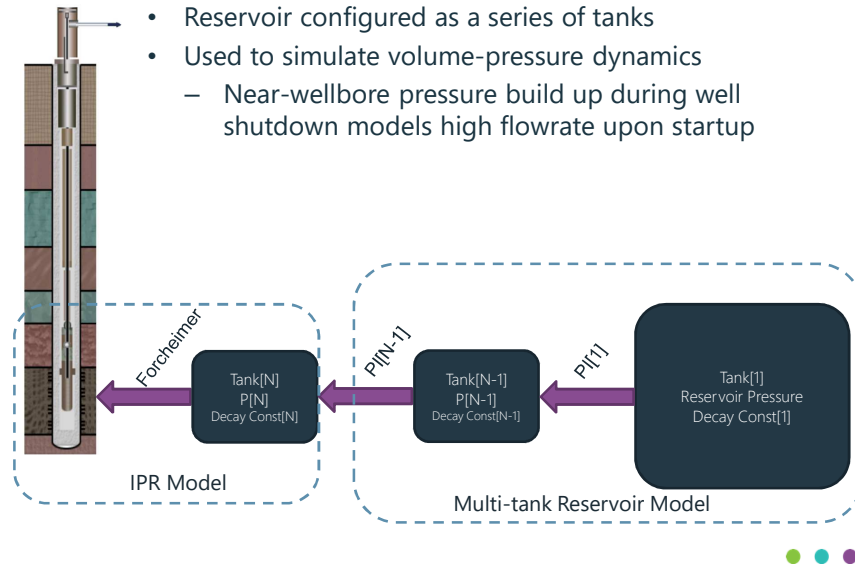
Three Fiscal Meters
Three Allocation Meters
100 Wells



VMS-Lite Example Screen

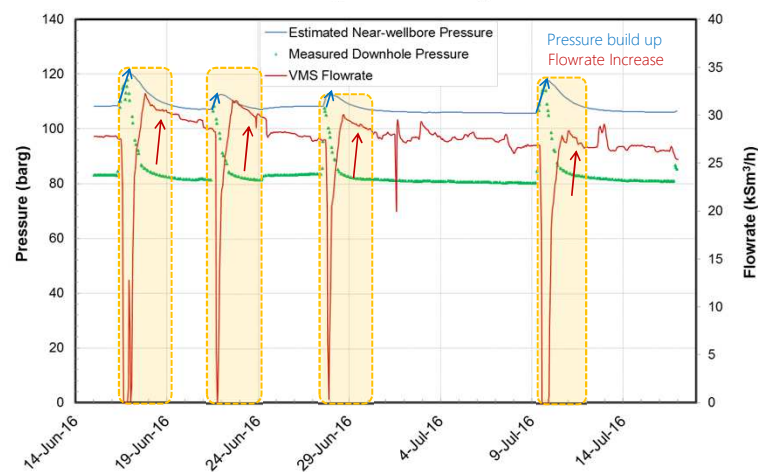


Multi-Tank Implementation



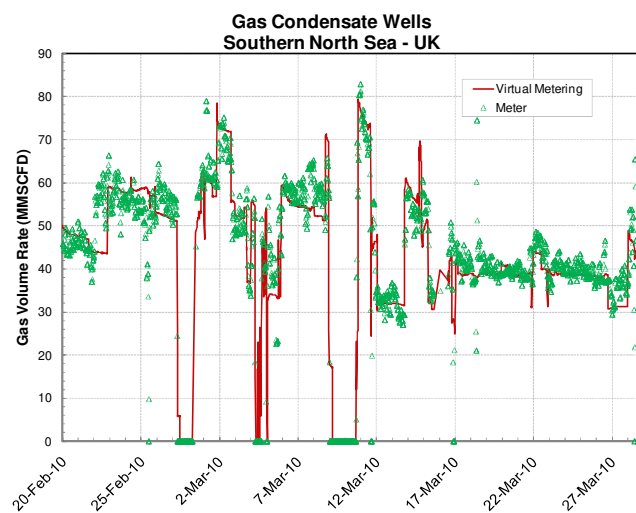
Multi-Tank Implementation

Well B5 - Multi-Tank Pressures and VMS Flowrate
Field Development

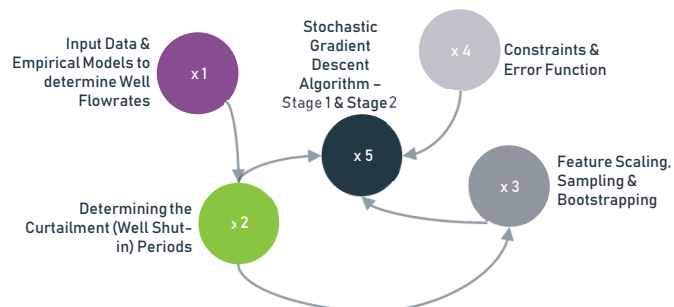


Fitting VMS-Lite Using Data Analytics

- Minimize the error for the following predictions
- Cumulative Flowrate of all wells compared to total (by difference)
- Flowing Well Head Temperature
- Pipeline Pressure Drop
- Shut-in Pressure Buildup



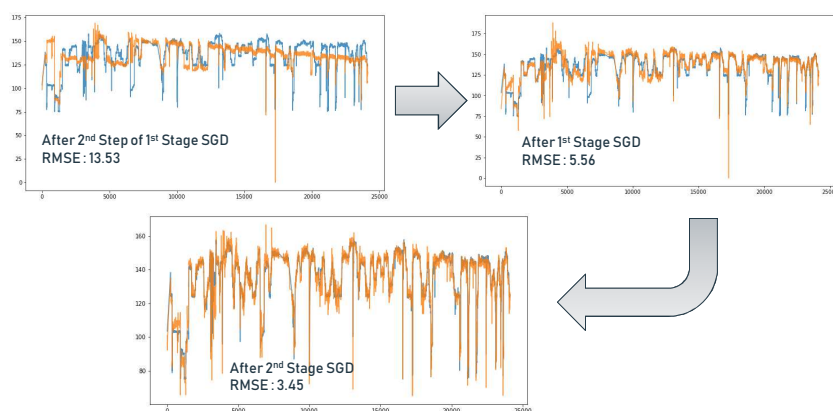
VMS LITE PYTHON MODEL IN A NUTSHELL



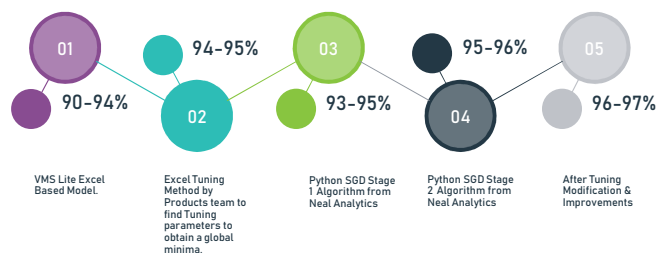
21

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RESULTS - STOCHASTIC GRADIENT DESCENT



INCREASE IN ACCURACY



29

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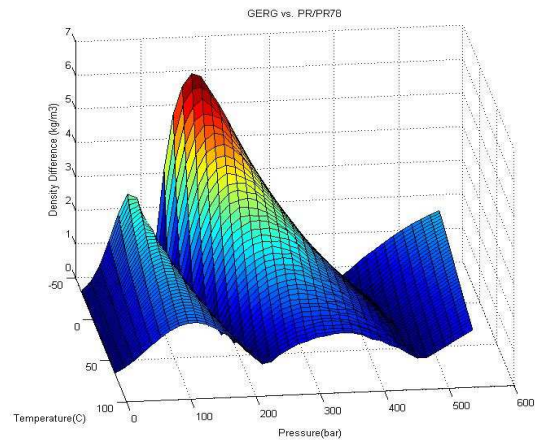


Tuning of Regular VMS

- Closing the asset mass balance - at separators (single phase meters) and custody transfer points
- Reprocessing and Analysis:
 - Choke characteristics change over time
 - › Positioner calibration
 - › Erosion
 - › Blocking of holes
 - › Choke change-out
 - Reservoir characteristics – pressure and inflow performance.
 - Small changes to composition/loading/water which change the density amount of head
 - Properties of tubing (roughness) tend to increase slightly over time
 - Hydrocarbon Viscosity/Density



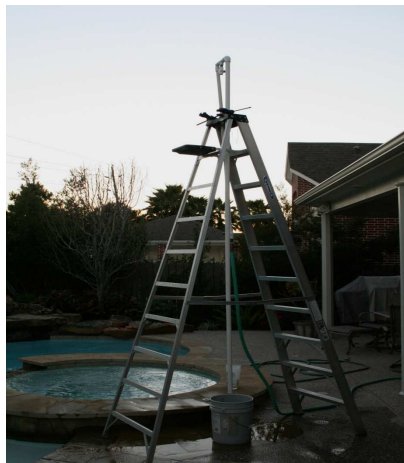
GERG VS. PR



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Sometimes Operates Outside the Envelope



- Client performed backyard experiments to clarify downcomer flow regimes and behavior



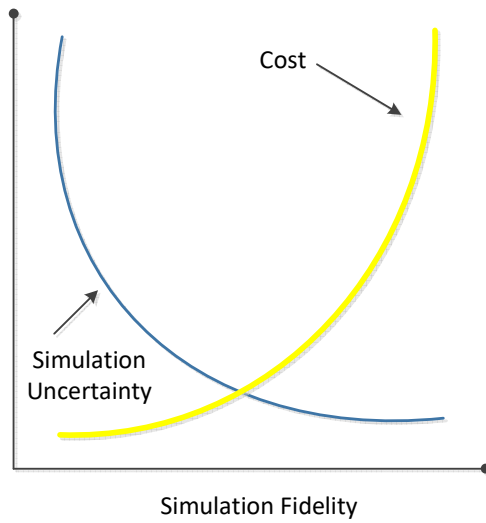
Liquid Down

Gas Bubbles

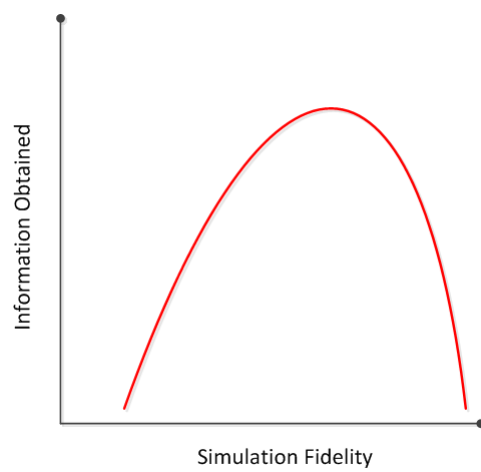
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Practical Trade-offs in Industrial Setting



Pick the Optimum Fidelity to Maximize Information Obtained

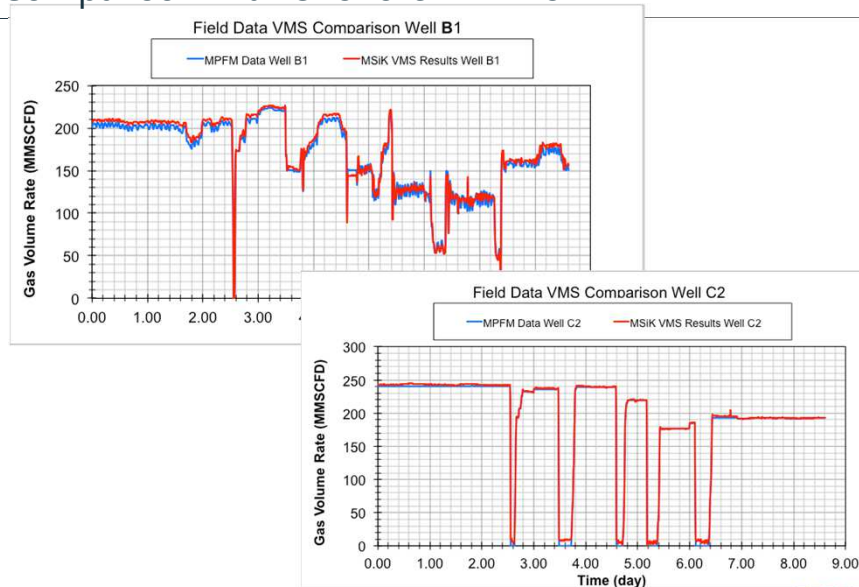


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Field Application Examples

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Comparison with Onshore MPFMs



Six Months Later ...

Well Configuration and Rate Selection

Gas Rates in FAM

Well	VMS	WGFM	WGFM Manipulated	Used	WGFM Factor %	Source Selection
	0.0	0.0	0.0	0.0	100.0	WGFM
	205.9	202.9	202.9	205.9	100.0	VMS
	0.0	0.0	0.0	0.0	100.0	VMS
	99.9	97.8	97.8	97.8	100.0	WGFM
	198.9	201.2	201.2	201.2	100.0	WGFM
	192.2	192.9	192.9	192.9	100.0	WGFM
	157.1	156.2	156.2	156.2	100.0	WGFM
	0.0	10.9	10.9	0.0	100.0	WGFM
Total	854.0	862.0	862.0	854.0		

Condensate Rates in FAM

Well	VMS	WGFM	WGFM Manipulated	Used	WGFM Factor %	Source Selection	Condensate Loading m³/km³
	0.0	0.0	0.0	0.0	100.0	WGFM Manip.	0.2226
	42.5	20.7	20.7	20.5	100.0	VMS	0.221
	0.0	0.0	0.0	0.0	238.0	VMS	0.2201
	20.6	8.2	19.5	0.0	238.0	WGFM Manip.	0.2204
	41.0	19.8	47.1	0.0	238.0	WGFM Manip.	0.2197
	39.6	16.2	38.6	0.0	238.0	WGFM Manip.	0.2190
	32.4	17.2	40.8	41.0	238.0	WGFM Manip.	0.2176
	0.0	0.1	0.1	0.0	238.0	WGFM Manip.	0.2192
Total	176.1	82.1	166.8	100.6			

Water Rates in FAM

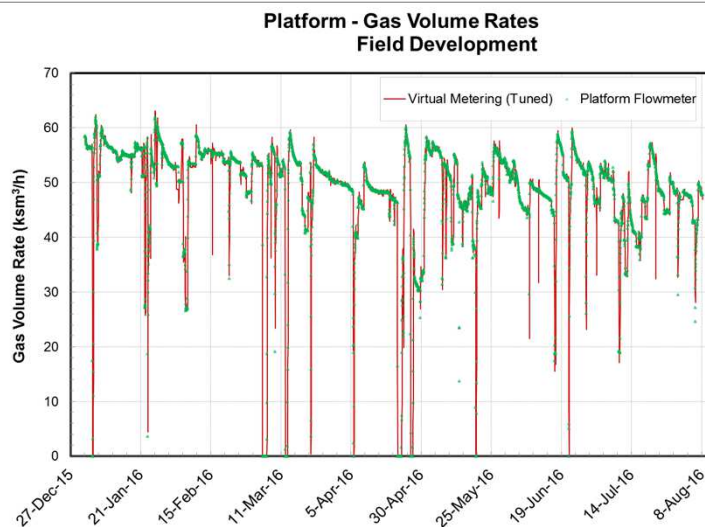
Well	VMS	WGFM	WGFM Manipulated	Used	WGFM Factor %	Source Selection	Water Loading m³/km³
	0.00	0.00	0.00	0.0	100.0	Constant Loading	0.0037
	1.20	0.11	0.11	1.2	100.0	VMS	0.0037
	0.00	0.00	0.00	0.0	120.0	VMS	0.0037
	0.58	0.57	0.62	0.8	120.0	Constant Loading	0.0037
	1.17	2.68	3.08	1.6	120.0	Constant Loading	0.0037
	1.14	0.33	0.26	1.5	120.0	Constant Loading	0.0037
	0.94	1.17	1.30	1.2	120.0	Constant Loading	0.0037
	0.00	0.00	0.00	0.0	120.0	Constant Loading	0.0037
Total	5.03	4.86	5.37	6.3			

Flash Temperatures and Pressures

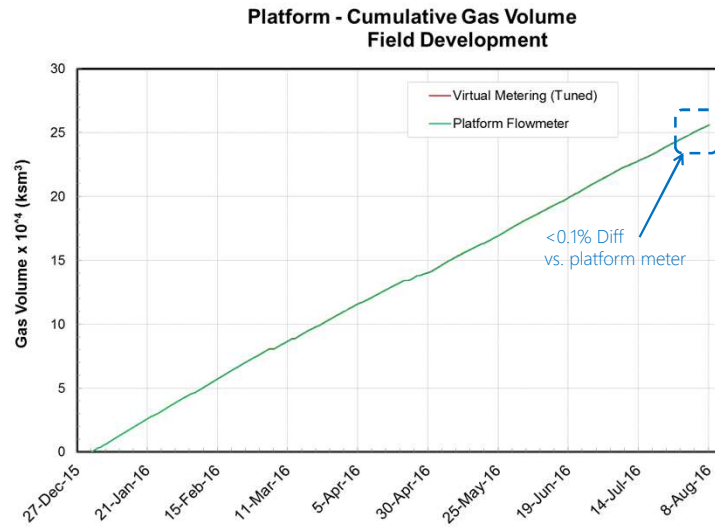
Phase	Flash Temperature °C	Flash Pressure bara
Gas	15.0	1.00
Liquid	27.0	82.01

OK Cancel Apply

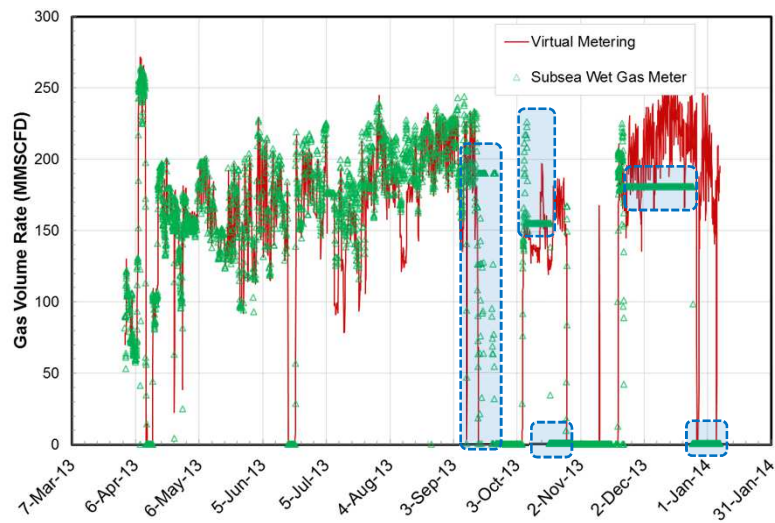
VMS vs Platform Flowmeter



VMS vs Platform Flowmeter

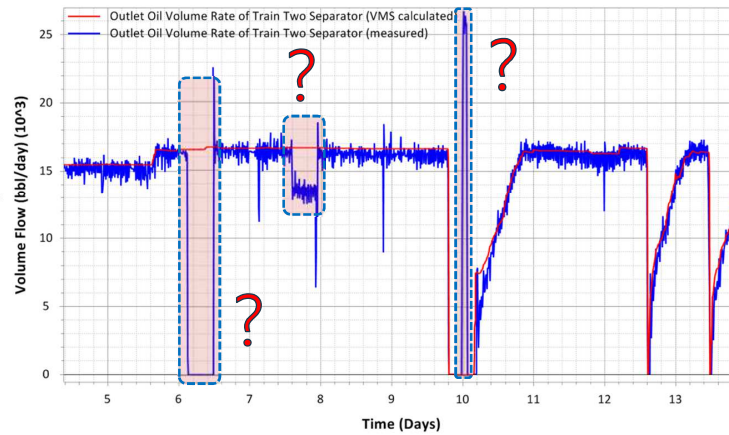


Subsea Wet Gas Meter Failures



Single-Phase Flowmeter Failures

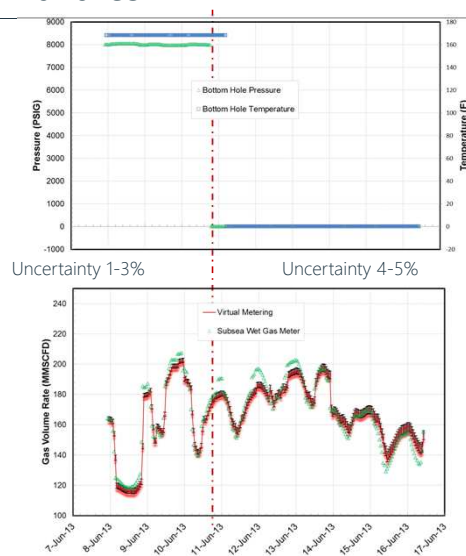
Train Two Separator Oil Rates - VMS vs Measured



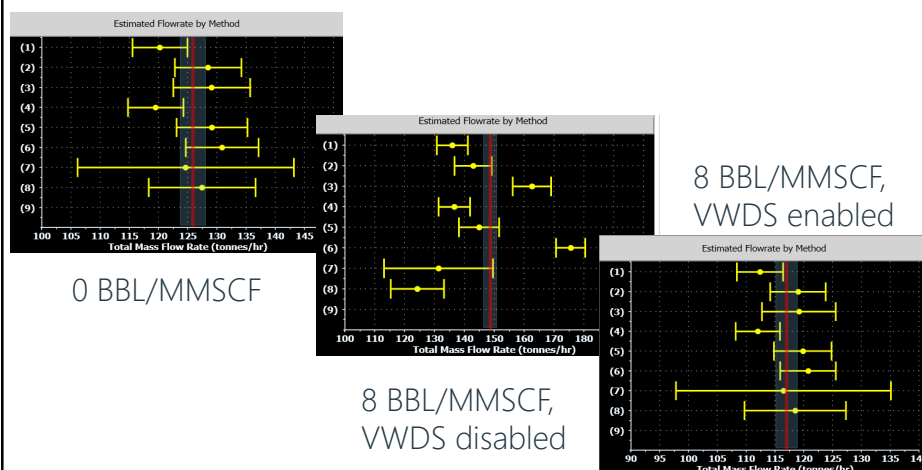
Bottom Hole Sensor Failures

On 11th June Bottom hole sensors failed.

VMS Automatically detected, and excluded results with slight increase in uncertainty



VMS Method Alignment with VWDS



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Conclusions

- Virtual metering technologies can provide significant reduction in cost as well as additional data that well tests and MPFMs do not provide
- Viable alternative technology to using physical metering and well test facilities
- Field proven technology which uses standard models developed by researchers and field data
- Online VMS technology can be used together with existing multiphase flow meters (MPFMs) to diagnose breakdown or fault of a given MPFM
- VMS technology is well suited for real-time offshore and onshore well performance monitoring, automated diagnostics, and improved reservoir management

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Well Status

[Prod Instruments](#)
[Prod Details](#)
[Prod Tuning](#)
[Inj Instruments](#)
[Inj Details](#)
[Inj Tuning](#)

Production Well Status

Manifold	Well	Choke %	PMV	PWV	Pressure psig			Calculated		
					Bottom Hole L	Bottom Hole U	Tubing Head	Oil Flowrate bopd	Gas MMSCFD	Water Flowrate bwpd
SS-MFLD	☐ D	6.4			13120.4	13013.2	8646.4	2799.5	3.84	460.7
	☐ H	6.0			14083.6	13999.4	10220.1	5096.8	19.17	0.0
SS-ILS-P01	☐ A	0.5			13563.6	13500.9	4204.6	0.0	0.00	0.0
	☐ B	21.2			11729.5	11632.9	7105.1	13290.3	18.20	0.0
SS-ILS-P02	☐ C	5.1			10321.9	10223.1	6331.7	4609.9	7.02	0.0
Total								25803.9	48.26	460.8

Injection Well Status

Well	Choke %	IMV	IWV	Pressure psig			Predicted Sandface		Calc Water Flowrate bwpd
				Bottom Hole	Downstream Choke	Upstream Choke	Pressure psig	Temperature F	
☐ E	14.5			8106.8	6032.0	6583.5	15566.3	75.4	5257.6
☐ G	0.0			16785.0	986.1	986.1	24252.1	-459.7	0.0
Total									5262.8
Total Measured									6059.6

Predicted Export Rate	5621.4 bwpd
Measured Discharge Rate	6059.6 bpd
Measured Export Pressure	4658.7 psig

Confidential



Tuning Parameters (continued)

- Predictions are based on physics
- Main tuning parameters:
 - Fluid GOR / Watercut
 - Flow path roughness
 - Interfacial surface tension
 - Fluid viscosity
 - IPR relationships
 - Reservoir depletion curves (and actual PBH-Static / TRes)
 - Cv curves, valve position
 - Other frictional losses (eg due to obstructions)
 - Thermodynamics (eg wellbore OHTC / Thermal mass)
 - Field data filtering / measurement drift
 - Model uncertainty filtering
- Often teaches you something about your system that you did not know

