A Systematic Approach for Well Completion Equipment Benchmarking and Reliability Analysis based on Experience Data

SPE Gulf Coast Section Luncheon,
Norris Westchase Center, Houston, TX
February 18th, 2015

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ExproSoft

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Presentation Outline

- Brief introduction
- Reliability theory basics
- Reliability parameters and KPIs
- Equipment failure data - example
- Case study examples – application of data in decision making
- Benchmarking; equipment, assets/fields, wells
- The work processes of data
- Concluding remarks, Q&A

ExproSoft Company Profile

Company providing oil and gas operators with data, software, and expert services to increase uptime through improved well equipment performance and fact based decision making.

WELLMASTER RMS
Solution for collecting, structuring, and distributing well equipment experience & failure data. Well performance analytics – Reliability Management System.

WELLMASTER IMS
Well integrity management system for monitoring, reporting and analyzing the integrity of wells.

EXPERT SERVICES
Industry experts providing 3rd party assessment on risk issues, equipment reliability, well integrity, and OPEX analysis.

- HQ in Trondheim. Norway, offices in Houston, TX, Abu Dhabi (UAE)
- Experts in well integrity & reliability
- 32 years experience of collecting & analyzing data
- Established in 2000

WellMaster RMS

WellMaster RMS is software solution providing reliability data for well equipment.

INCREASE PRODUCTION
Reduce deferred production by using reliability data when planning well design and creating maintenance schedules.

REDUCE INTERVENTION COST
Use reliability data to evaluate well cases, benchmark vendors, and move from urgency repairs to planned maintenance.

UNDERSTAND FAILURES & RISK
Use real data as more precise decision support. Improved knowledge transfer with full well history available in one system.

MANAGE WELL EQUIPMENT DATA
Digitalize structured and unstructured data in WellMaster, and provide reliability data to existing systems.

THE WELLMASTER DATABASE

WellMaster – The world's largest repository of well completion equipment history

THE DATA
Experience and failure data for well equipment.

THE PROCESS
Started in 1983, and collected through a Joint Industry Project*, managed by ExproSoft from 2000.

THE ANALYSES
Utilized by participating operators as decision support for field/well planning and well integrity mitigation

- Total well count: **4,850 wells**
- Well history: **38,750 years**
- Equipment history: **4,500 failures**

*Renamed to WellMaster Program – global data sharing & subscription service

STUDIES POWERED BY WELLMASTER

Expert Services on…

FIELD & WELL DEVELOPMENT PLANNING

- OPEX simulation
- Completion design optimization
- Well equipment reliability assessment
- Test, maintenance, and intervention planning

WELL RISK ASSESSMENTS

- Quantitative Risk Analysis (QRA)
- Qualitative expert assessments

TECHNOLOGY QUALIFICATION

- Requirements specification
- Gap analysis
- Qualification program

Reliability – theoretical basis

- Time to failure is assumed to be exponentially distributed with parameter/failure rate λ.

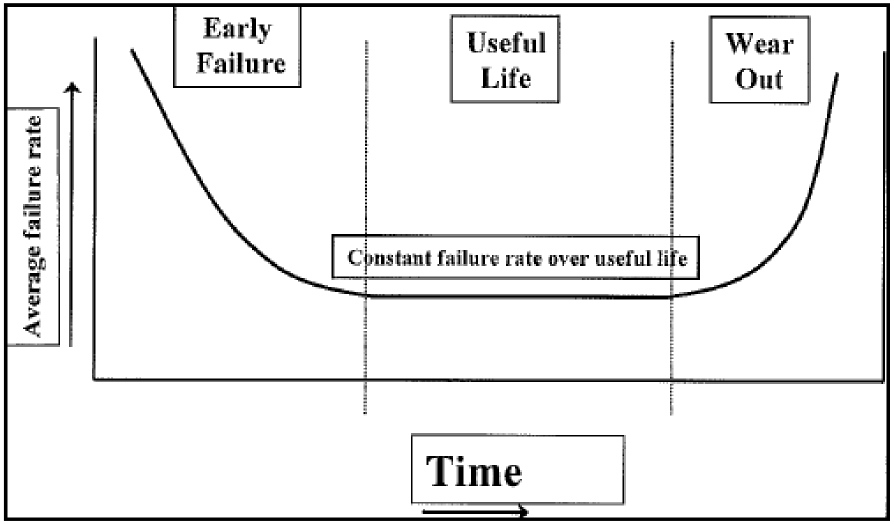
- Assuming the 'bath-tub' model for reliability of well equipment. The analysis considers the time period with constant failure rate.

- Failure rate with x number of failures in data set and t total time in service for components in the data set:

  $$\lambda = x / t$$

  Mean Time To Failure:

  $$MTTF = 1 / \lambda = t / x$$



Assumption on exponential distribution can be tested in Survival Probability plot with statistical distribution curve fit and Weibull parameter estimation.

UNDERSTANDING SUCCESSES AND FAILURES

- Well integrity and reliability
- Well equipment from tubing hanger down included in completions reliability data (primary/secondary barriers, completion, casing)

Item	Service Time [yrs]	Item Population	Failure Mode	Number of Failures	MTTF [yrs]
TR-SCSSV (FLAPPER)	4476.8	2600	Fail to close on demand (FTC)	16	279.8
			Leakage in closed position (LCP)	25	179.1
			Premature valve closure (PCL)	13	344.4
			Fail to open on command (FTO)	3	1492.3
			Control line to well communication (CLW)	4	1119.2
			Well to control line communication (WCL)	4	1119.2
			Other (OTH)	6	746.1
			All	**71**	**63.1**

Failure Mode definitions for completion equipment allows consistency in failure reporting. Allows lost production failures to be separated from lost integrity failures.

EQUIPMENT COVERAGE

- PMV
- PWV
- PSV
- PCV
- XOV
- KV
- AMV
- AWV
- ASV
- ACV
- AAV
- HASCV
- SIV
- MIV
- Crown plug
- Tree cap
- ITC
- Wellhead connector
- Wellhead
- PT
- TT
- PT/TT
- Multiphase meter
- Subsea Control Module
- Tubing hanger
- Tubing
- Hydraulic control line
- Chemical injection line
- Electric control line
- Fiber optical control line
- Power cable
- TRSCSSV
- TRSCASSV
- WRSCSSV
- Water injection valve
- TRCIV
- WRCIV
- GLV
- Dummy GLV
- SPM
- ESP assembly
- PDG
- PBR seal assembly
- Tubing anchor
- Production packer
- ASV packer
- Bridge plug
- Mechanical sliding sleeve
- ICV control module
- ICV
- FIV
- Wire-wrapped screen
- Pre-packed screen
- Premium screen
- Expandable screen
- Slotted liner
- Gravel pack screen
- Chemical consolidation
- Production casing
- Intermediate casing
- Surface casing
- Production casing cement
- Intermediate casing cement
- Surface casing cement
- Formation
- Other subsea
- Other surface
- Other unconventional

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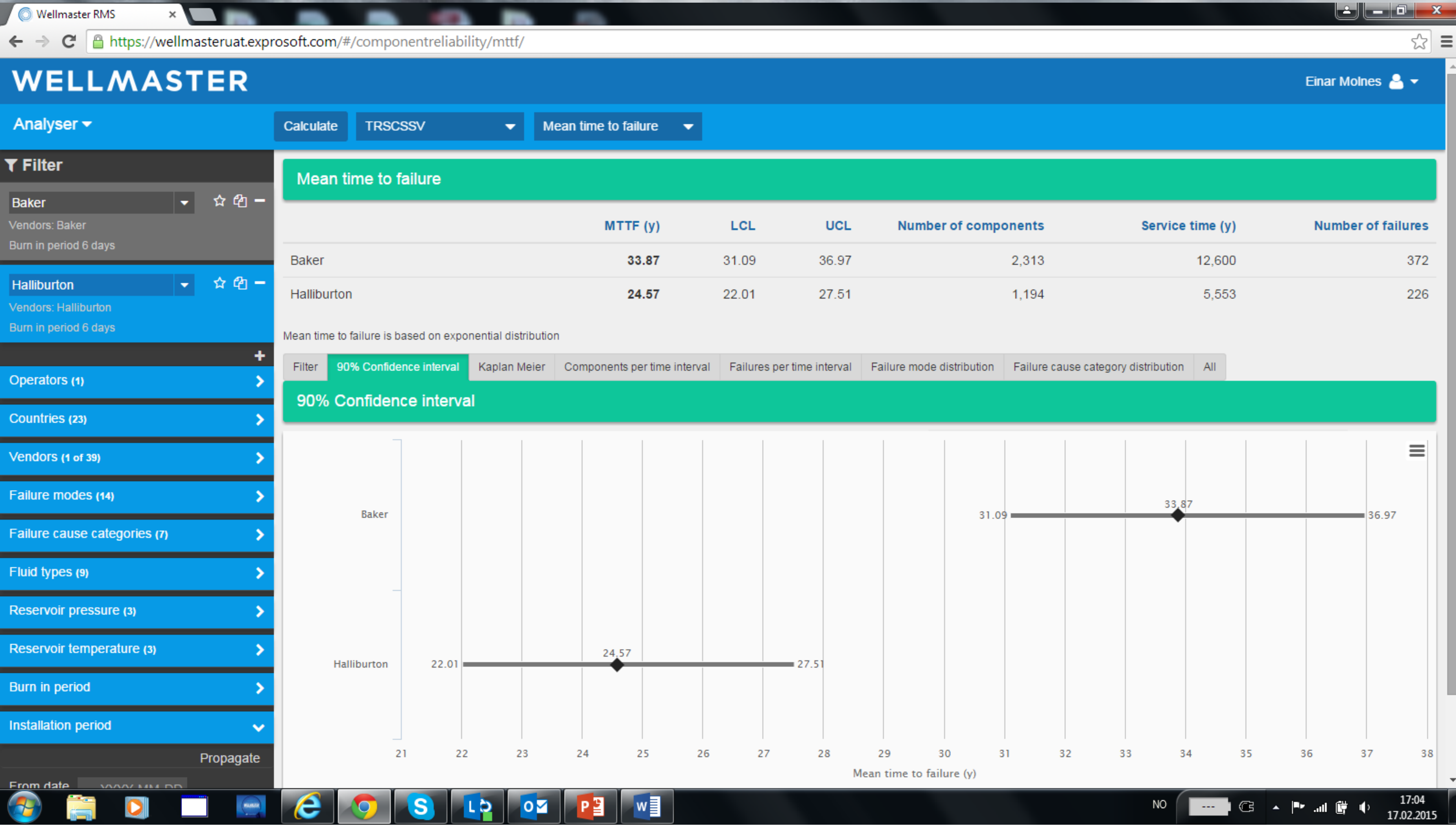
Sample Analysis: Benchmarking TR-SCSSV performance



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Reliability Based KPIs

- Mean time to failure (MTTF)
- Failure rate
- Survival probability
- Probability of failure on demand (PFD)
- Safety integrity level (SIL)
- Mean residual life (MRL)
- Blowout probability level (BPL) and blowout escalation risk (BER)
- Life cycle cost/life cycle profit (LCC/LCP)

APPLYING DATA IN DECISION MAKING: OPEX SIMULATIONS

- Expert studies for **accurate well performance predictions** comparing alternative field development scenarios
- Make better decisions from an improved understanding of the **operational and financial risks** involved with development projects
- Life-cycle event and cost/income simulator tailor-made for wells in both subsea and platform field developments
- Reliability input data derived from WellMaster

WellMaster OPEX: Simulation methodology

INPUT DATA

Event occurrence and consequence data:

- Equipment failures
- Reservoir events
- Planned activities
- Various well types are defined and modelled

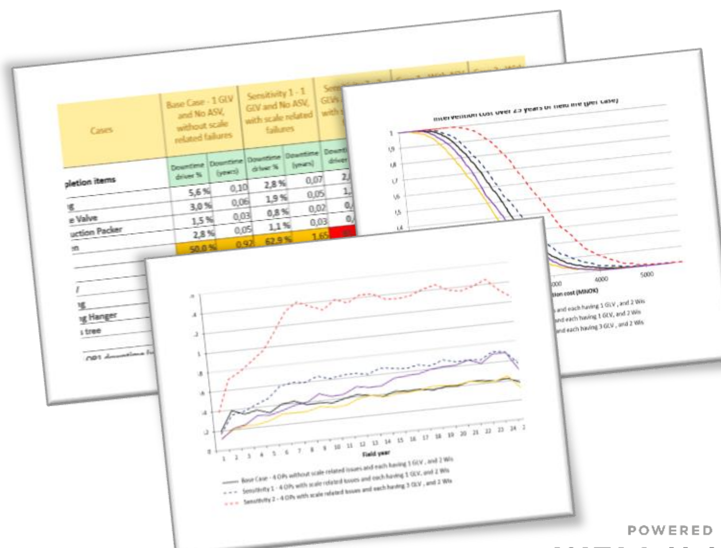
Intervention/work-over data and resources cost data:

- Time consumption data
- Vessel availability data
- Campaign data
- Seasonal factors
- Planned-, direct-, and vessel cost data

OPEX SIMULATION OUTPUT

More than 20 reports available, including results on:

- Economics (NPV, cash-flow, etc.)
- Well downtime
- Intervention and work-over frequencies
- Operating costs
- Well production performance (income modeling)
- Field level reports (all wells)



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CASE STUDY:
OPEX FIELD DEVELOPMENT, 40 YEARS LIFETIME

Well regularity and intervention study for a field development in 2013

MAIN OBJECTIVES, WELL LEVEL

- Well downtime
- Well downtime contributors
- Intervention frequency (pumping, WL, CT, work-overs/ side tracks)
- Well downtime distribution (uncertainty) analysis

MAIN OBJECTIVES, FIELD LEVEL

- Intervention costs
- Cost contributors
- Intervention cost distribution (uncertainty) analysis

WELL TYPES

- Gas lifted oil producers (OP)
- Water injectors (WI)
- Disposal wells

CASES DEFINITION

Platform Level:

- Platform of 25 wells and with integrated rig assuming platform life of 40 years
- Platform of 25 wells without integrated rig assuming platform life of 40 years

Well Level:

- Platform gas-lifted OP, lifetime 40 years
- Platform WI, lifetime 40 years
- Platform Disposal well, lifetime 40 years

The client provided input on production/reservoir/ scale management related events/interventions

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Case study:

OPEX Field Development, 40 Years Lifetime

MAIN ASSUMPTIONS

- Tubing material 13% Cr for OPs and 25% Cr for WIs
- Tubing retrievable DHSV with insert valve capability (wireline operation)
- Annulus safety system; Gas lift assumed to start after 3 years of production start-up

MAIN ASSUMPTIONS – PRODUCTION/RESERVOIR MANAGEMENT

- PLT – preventative measure after start up (OPs and WIs)
- PLT at major change in well behaviour – 1 per well life (for OPs only)
- Water gas shut off operations for OPs only – 1 CT operation per well life
- Acid treatment every second year for WIs

COST ASSUMPTIONS (BASED ON CLIENT INPUT)

- Work-over operations:
  - integrated rig: 14,3 million US$ and (if side-track) 33,6 million US$
  - without integrated rig: 32,6 million US$ and (if side-track) 69,3 million US$
- Wireline operations: 1,75 million US$

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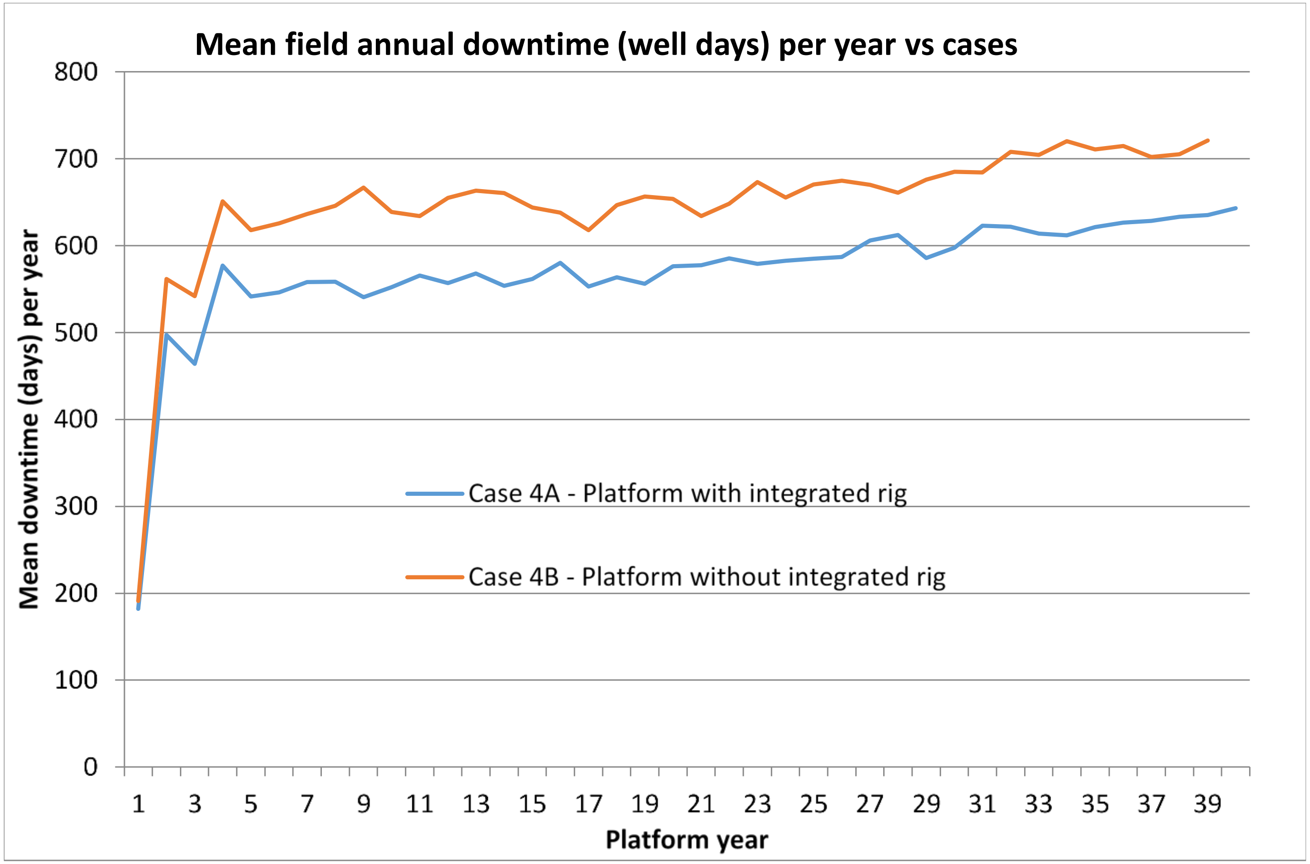
CASE STUDY:
OPEX FIELD DEVELOPMENT, 40 YEARS LIFETIME

Simulation results – Platform Cases (25 wells)



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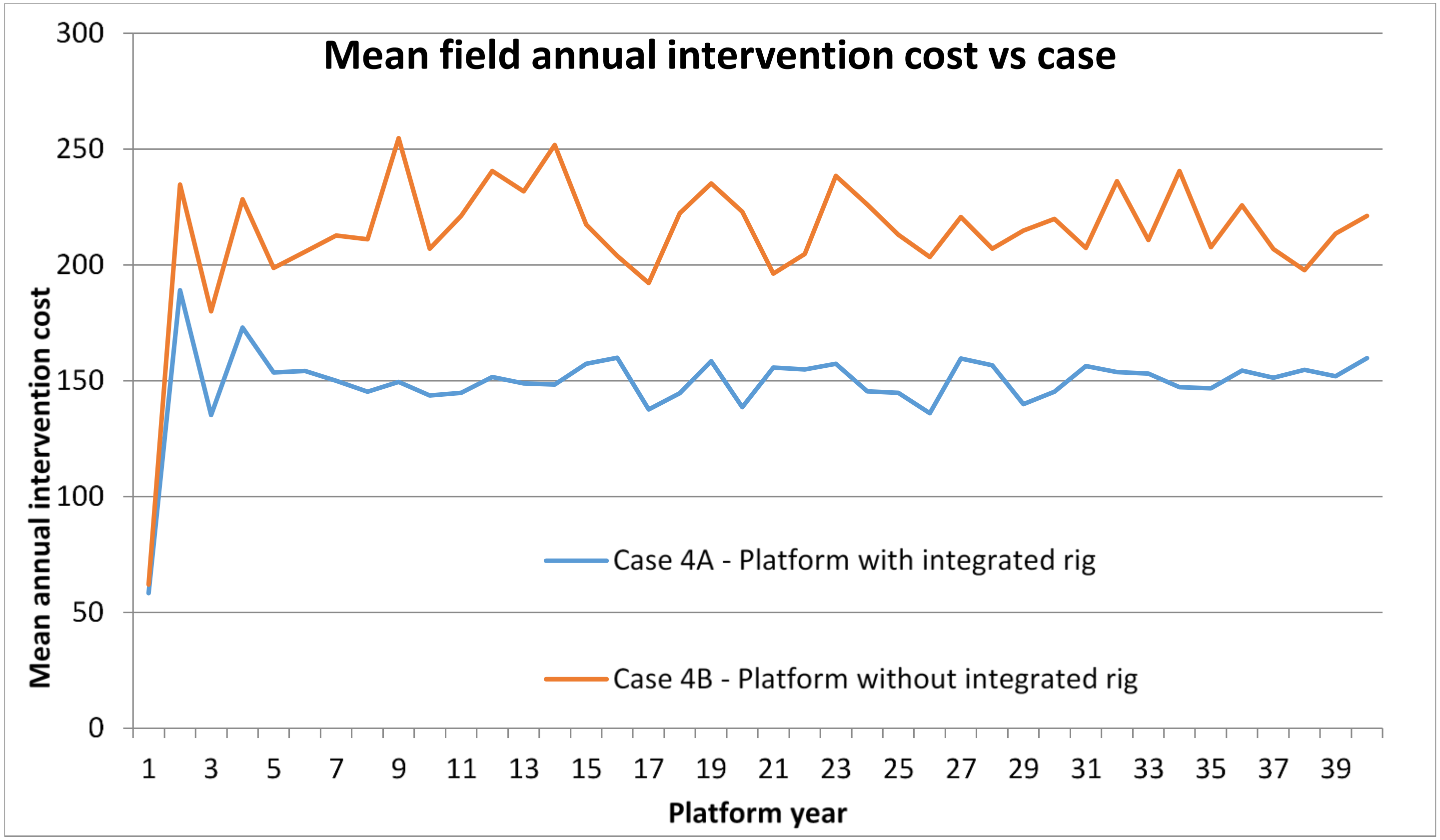
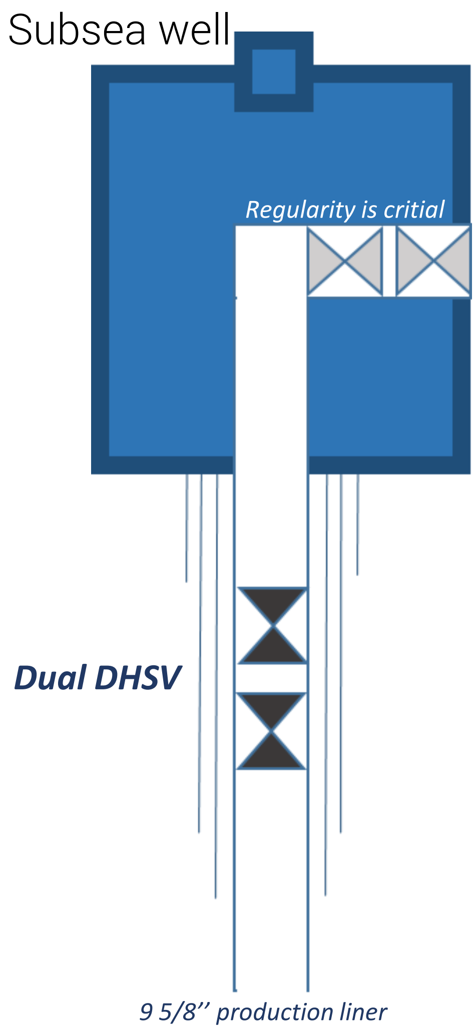


CASE STUDY (ORMEN LANGE):

ROBUST WELL DESIGN REQUIRED FOR HIGH IMPACT WELLS



THE CASE: **WELL SUBJECT TO SHUT-IN**

- Production loss: Each well produce 2.5% of UK gas market (original field design)
- High intervention costs (1000m water depth)

WHAT WE DID: **PROJECTS**

- Ormen Lange Intervention Requirement Study (Phases I-II)
- Reliability Qualification for Large Bore DHSV (Phases I-III)
- Risk Assessment of Subsea X-mas Trees for Ormen Lange
- Risk evaluation of Ormen Lange well barriers
- Ormen Lange SCSSV Testing Study

THE RESULT: **ROBUST WELLS**

- Robust well design
- No shut-in due to DHSV failures for 7 years (18 wells, 160 valve years in operation)
- Significant intervention costs avoided

- Savings > $ 200 mill (estimated)

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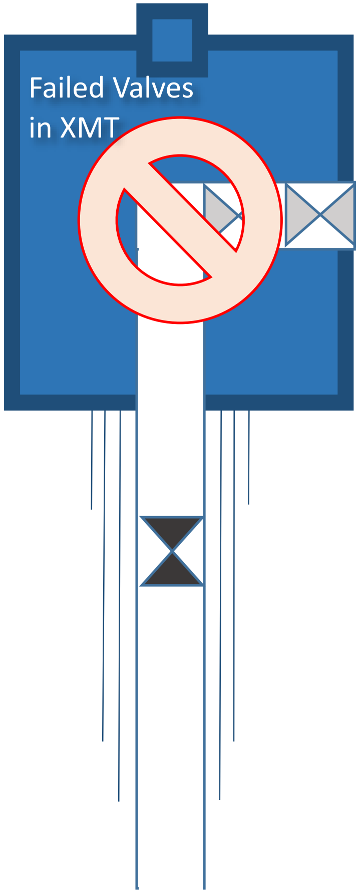
CASE STUDY:
FAILED XMT VALVES – EFFECT OF RISK REDUCING MEASURES

Subsea Well



THE CASE: **WELL SUBJECT TO SHUT-IN**

- Workover - 20 days per well
- Production loss field 1: 23 000 brl/20 days
- Production loss field 2: 16 500 brl/20 days

WHAT WE DID: **PROJECT**

- Quantitative Risk Analysis study (QRA)

THE RESULT: **CONTINUED PRODUCTION**

- WellMaster allowed:
  - Evaluation of risk for well/XMT designs with failed valves
  - Evaluation of risk reducing measures
  - Fact-based decision to continue producing

- Savings > $ 8 mill (estimated)

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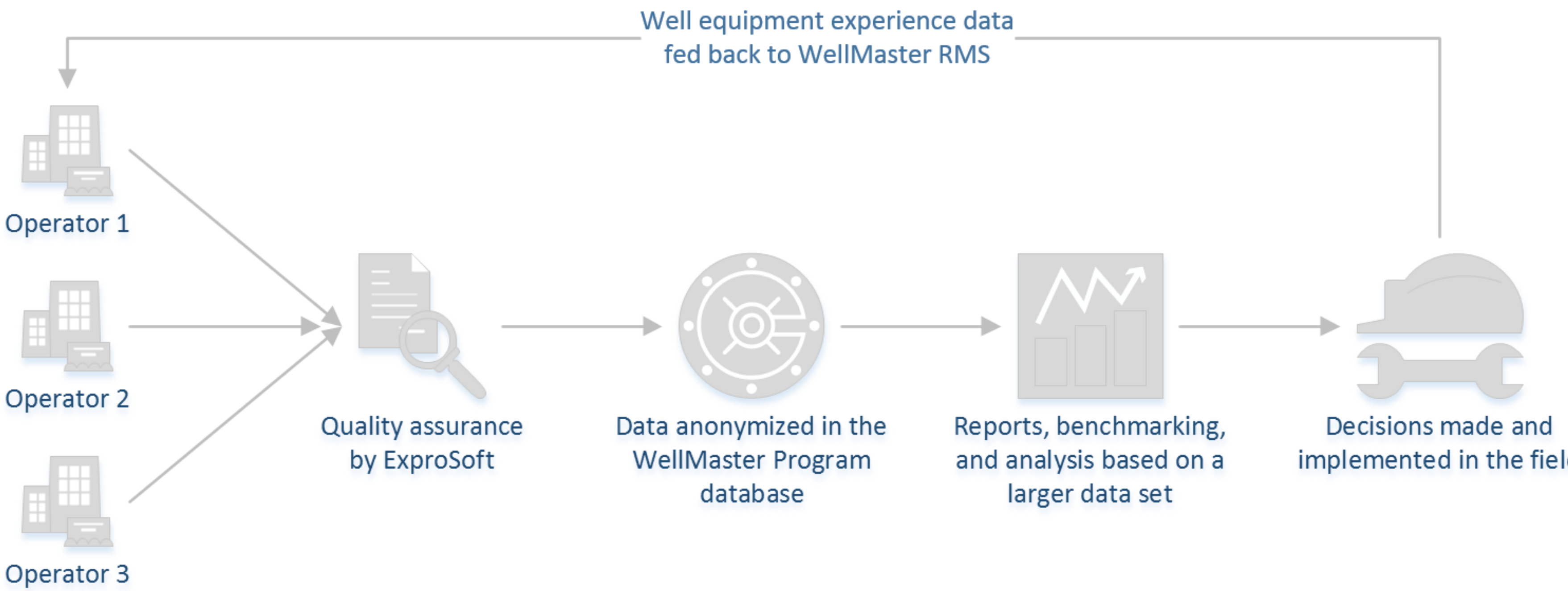
Case study (Ormen Lange):
Robust well design required for high impact wells

Manufacturer	Model group	No. of items	Total service time (years)	Average item service time (years)	No. of failures	MTTF (years)
Baker	Total for T-series	391	1071.7	2.7	11	97.4
Halliburton	Total for SP-series	201	548.8	2.7	5	109.8
Schlumberger	Total for TRM-series	158	298.9	1.9	5	59.8
All	Total	750	1919.5	2.6	21	91.4

- Data based on WellMaster completion equipment reliability data per 2002.
- Data representing generic data for across **all** well types for subject valve models.
- The valve models had the highest MTTF among all valve model entries at the time.
- Ormen Lange decision to implement qualification test program to further improve and verify reliability and reduce intervention frequency. Qualification performed as per DnV RP A203 and ExproSoft WellMaster (test program design & requirements).

WellMaster Program – Data Management Process

WellMaster Program is global sharing of data, available to WellMaster RMS clients.



All data is hosted in a cloud-based database managed by ExproSoft. Operators flag the wells for which data are to be shared, and the equipment history goes through expert quality assurance before it is anonymized and shared.

CONCLUDING REMARKS

- Track operational histories from your wells and learn from your downhole failures
- Take advantage of existing forums of collaboration and best practices
- Data need to be:
  - ✓ Consistent
  - ✓ Traceable
  - ✓ Auditable
- Fact based decisions can only come from a disciplined, quantifiable process and have resulted in significant cost savings to operators
- Improved risk and reliability levels will be documented in reliability databases with time and can be used to initiate design improvements, challenge regulations, improve performance.

Thank you!

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