SPE Distinguished Lecturer Program

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Production Optimisation: A Gas Lift Odyssey

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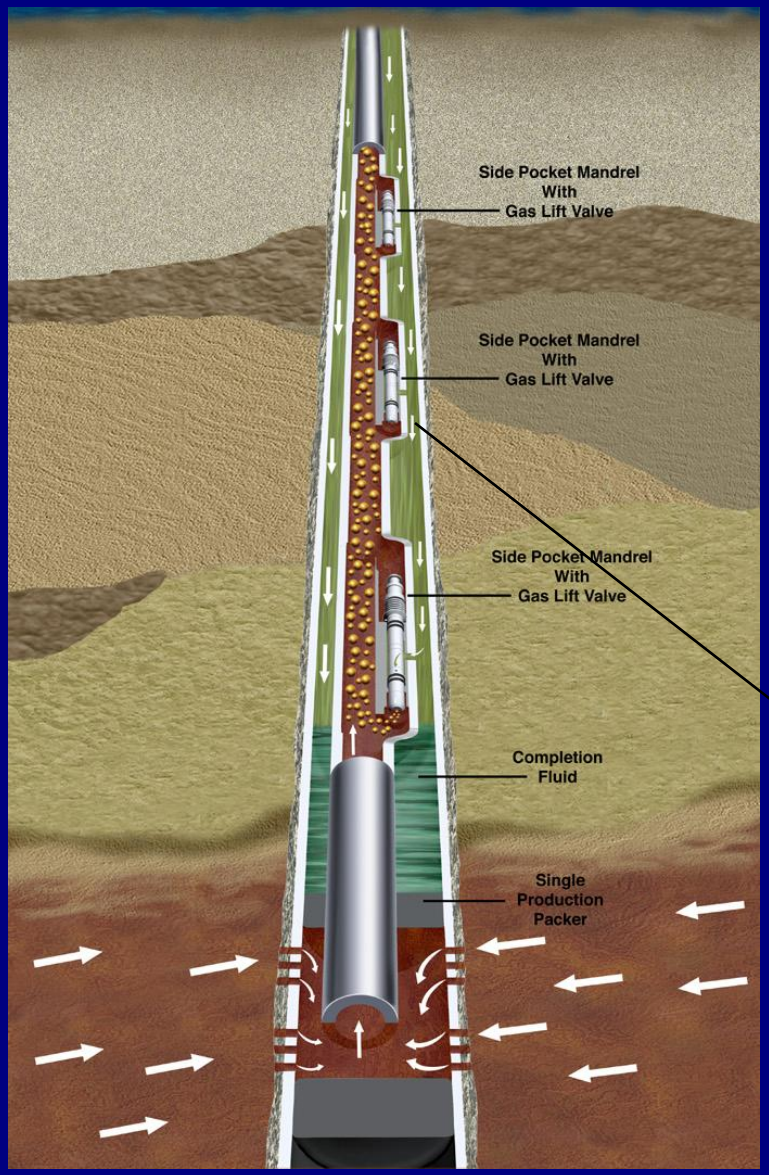
Senergy

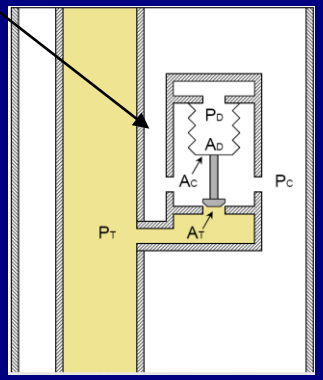
Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

Objectives

- Examine various levels of gas lift “optimisation” in current practice.
- Review recent advances in gas lift technology.
- Identify key challenges for future gas lift operations.

Gas Lift Perspective



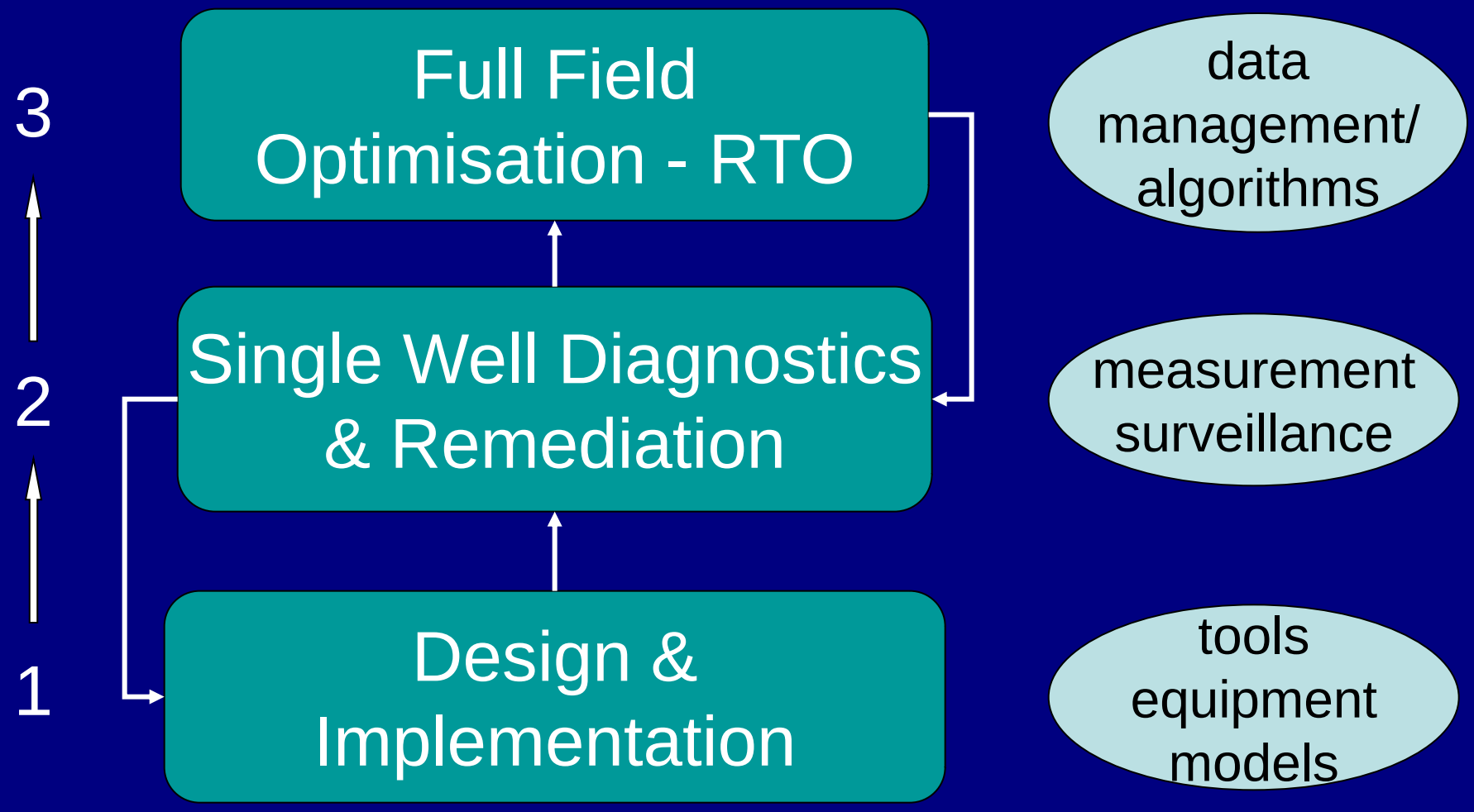


Gas Lift as % of Artificial Lift Production

BP	46%	2002
ExxonMobil	53%	2004
Petrobras	89%	Campos Basin
Shell	64%	2001
Qatar Petroleum	35%	2008; of total oil
PCSB Malaysia	40%	2002; of total oil

source: www.alrdc.com

Stages of Gas Lift Optimisation



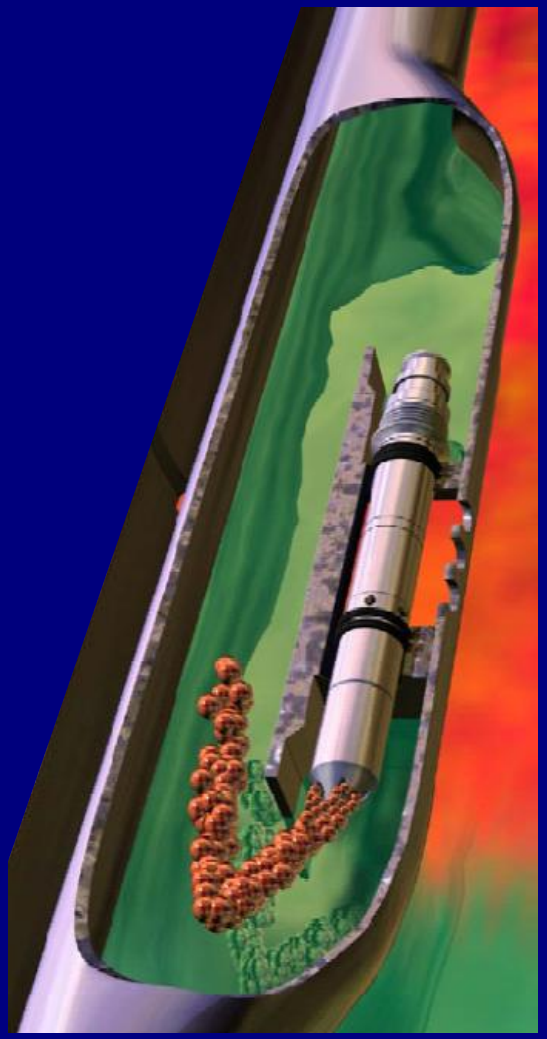
problems & evolving solutions exist at each level

The Prize

- Design & Implementation
  - More production can be safely gas lifted
  - Avoidance of costly workovers/re-entries
- Single Well Remediation
  - 0-25% on flowing wells
  - Revival of shut-in wells
- Full Field Optimisation
  - 2-5% oil increase of field wide production
  - Up to 40% improvement in gas injection efficiency
  - Sustained production increases with Real Time Optimisation (RTO)

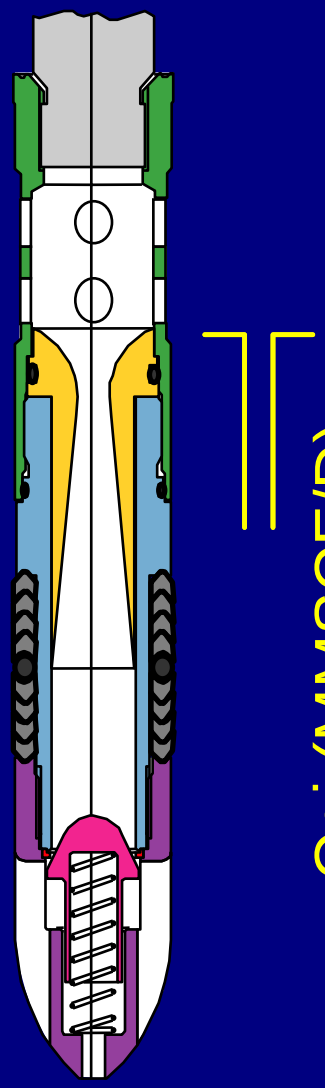
Stage 1: Evolving Challenges in Gas Lift Design & Implementation

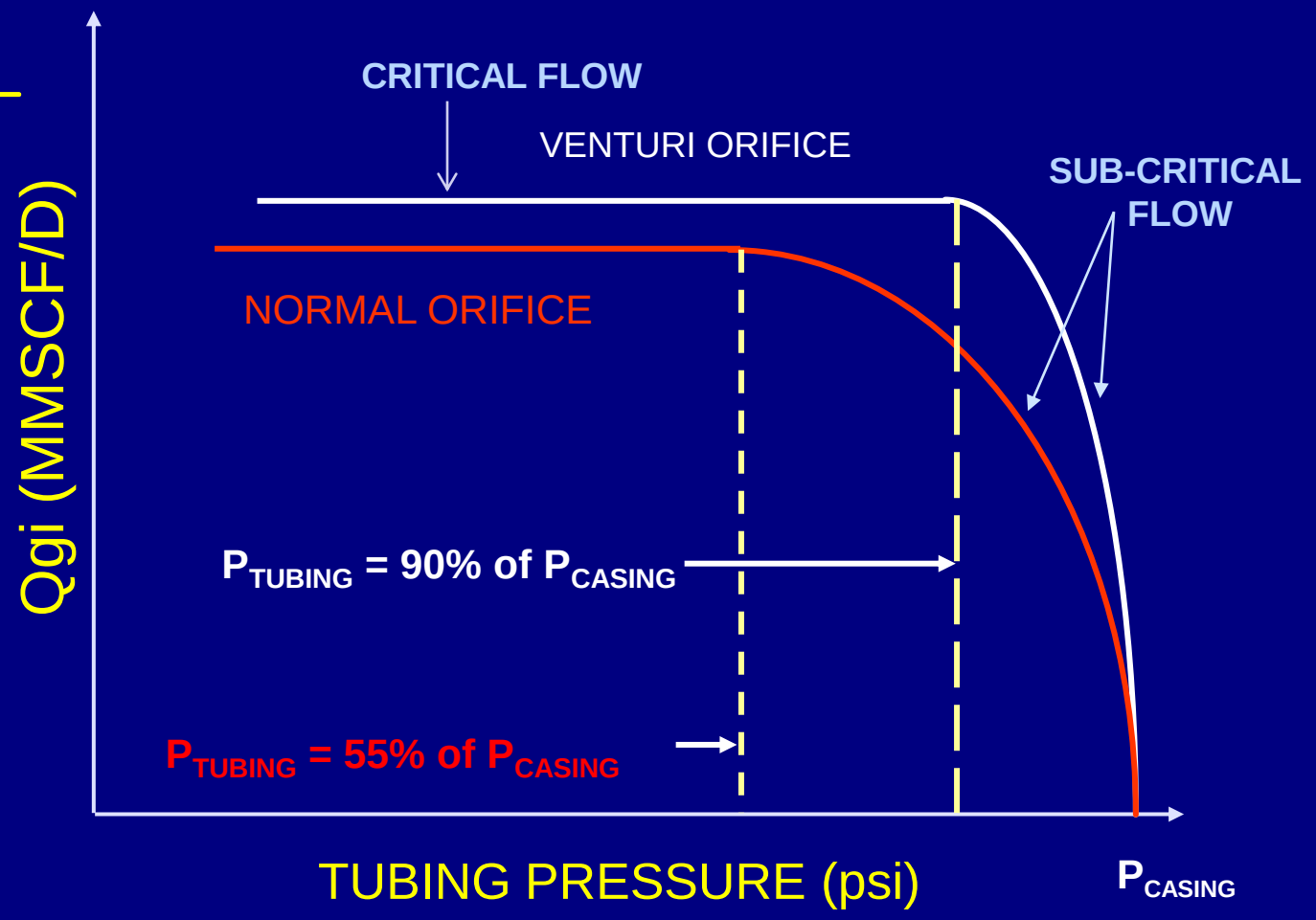
- Gas Lift Rate Control
- Deep Water Completions
- Well Integrity
- Gas Lift Valve Reliability



Source Weatherford

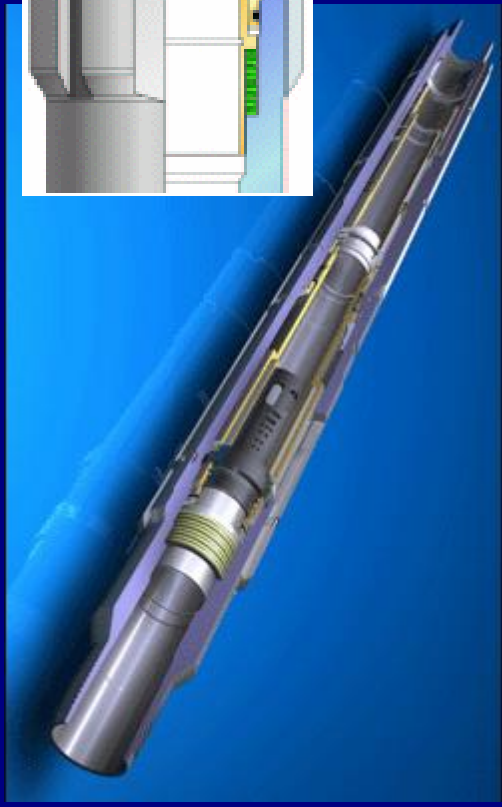
Venturi Orifice Valve





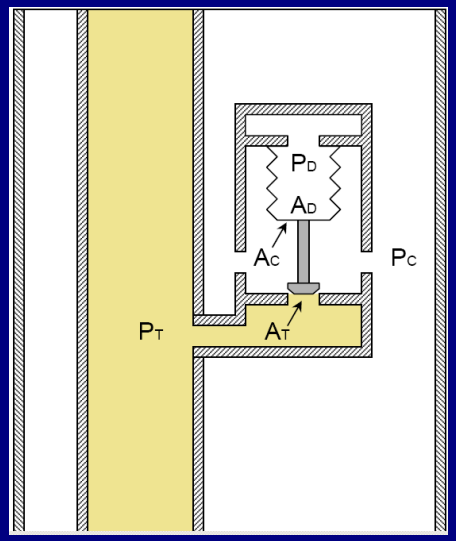
Surface Controlled Gas Injection Valve

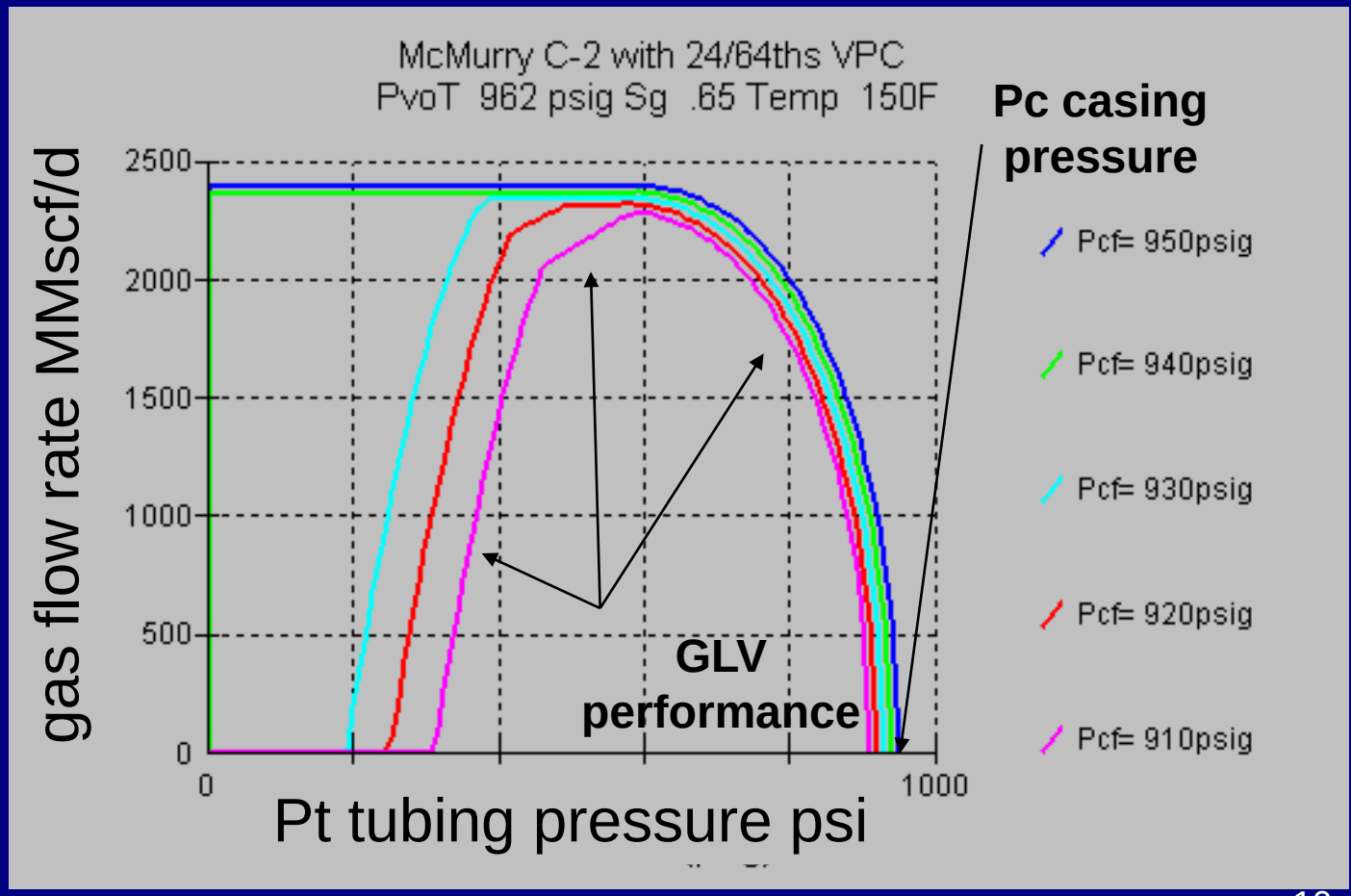
- Features - ajustability
  - orifice size can change as well conditions change without intervention
  - reduces risk of erosion. Can remain “full open” during unloading and then close to necessary orifice size.
  - controlling lift gas originating from a gas zone in same well as the oil reservoir (“auto” GL)
- Current Issues
  - Not a new technology
  - Specific applications
    - e.g. subsea installations w/o GL control at WH
    - SMART wells
  - Expensive for existing developments
  - Hydraulic vs. electric control (cable?)
    - Electric cable downhole “…one $2 O-Ring causes US million dollar workovers…”



Advanced Gas Lift Valve Modelling

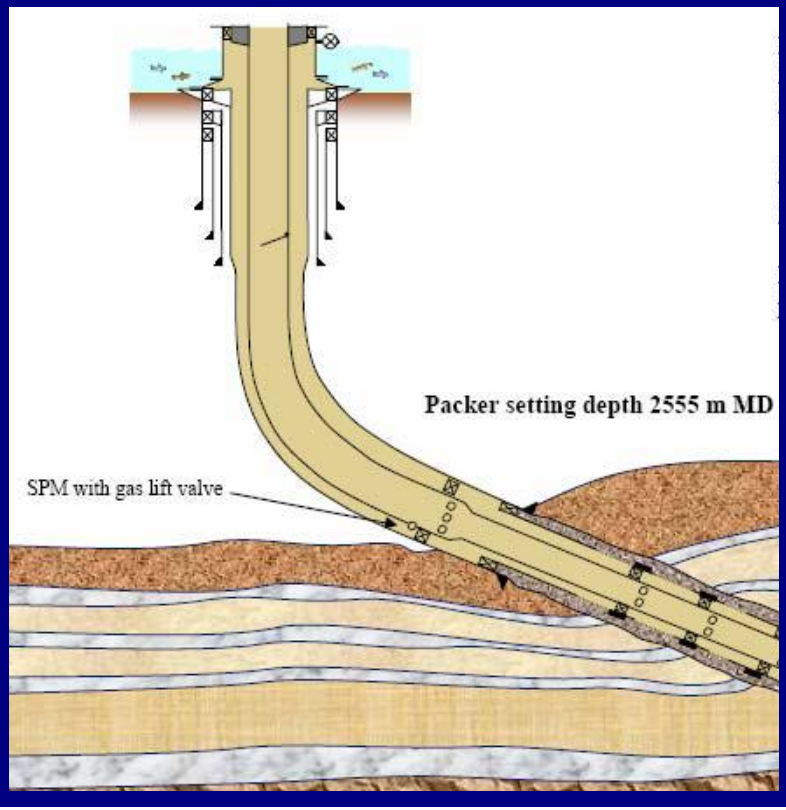
actual gas rate through IPO as a function of valve performance (inflow) and tubing performance (outflow)

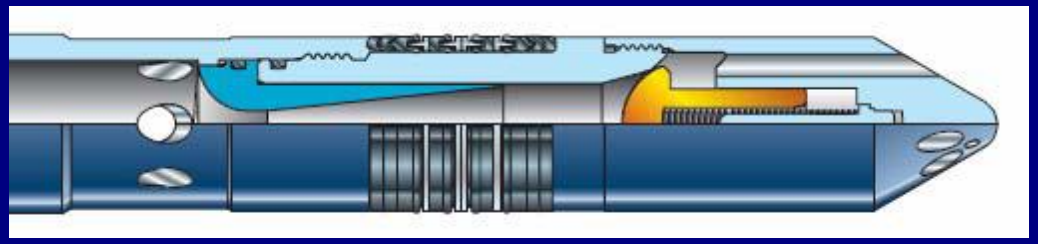




High Pressure Injection Valve

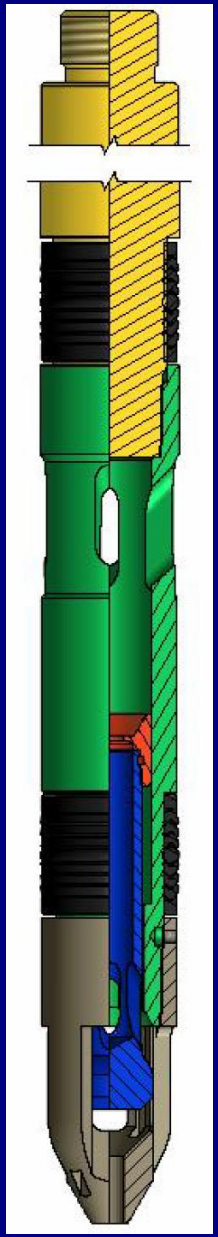
- Features
  - meets “zero intervention” philosophy set for subsea developments
    - High reliability orifice
    - No unloading valves required
    - Fewer leakage paths
  - IPO valves to 5000 psi; Orifice valves to 7500 psi. 10MMscf/d
  - premium materials/elastomers
  - flow path limits erosion
- Current Issues
  - requires a minimum gas injection rate for well stability
  - requires a higher injection pressure (compression)
  - potential valve erosion
  - no flexibility





High Performance Back Check

- Increasing industry emphasis on valve & well integrity
- New valves
  - valve & tubing become first barrier element
  - metal to metal seal at back check
  - spring activated (protected from flow)
  - flow geometry optimised for seal area protection
  - 10,000 psi, 20-180°C, 8.5 MMscf/d
- Qualifies as barrier element under Norsok D10 and StatoilHydro
  - Eliminates need for annular safety valve
  - fewer well interventions/opex
  - deep well performance & integrity



Gas Lift Valve Reliability

- Valve performance
  - Valve Performance Clearing House (joint industry project)
- Valve testing
  - Equipment: Automatic Validation Tester (AVT)
  - QA/QC, valve histories
- Revised API/ISO standards & procedures

Source Decker Technology Inc.

AVT II advanced valve test bench

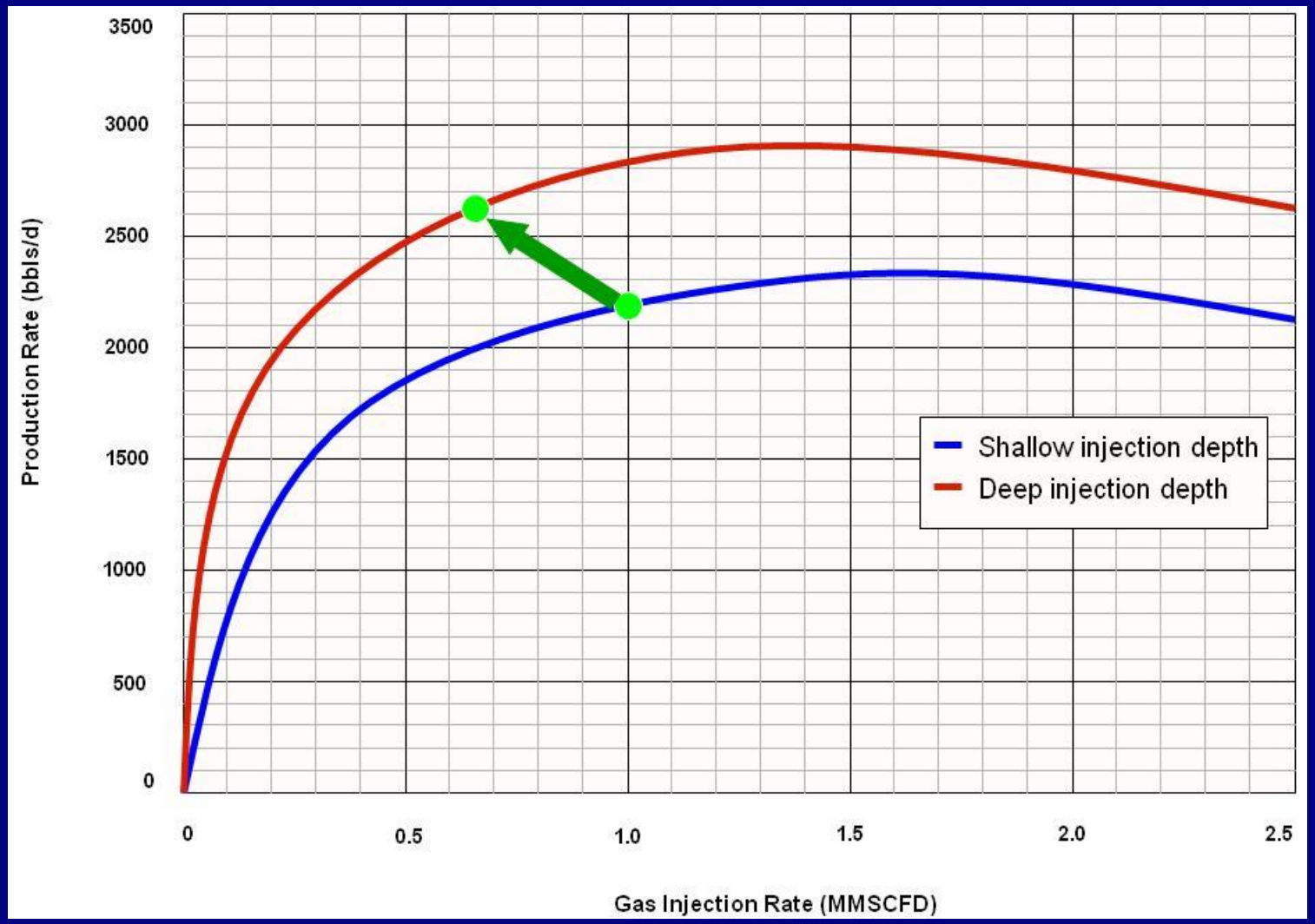
Stage 1

- Advances in equipment, software, standards and testing make gas lift designs more robust , repeatable and secure.

Stage 2: Single Well Diagnostics & Remediation

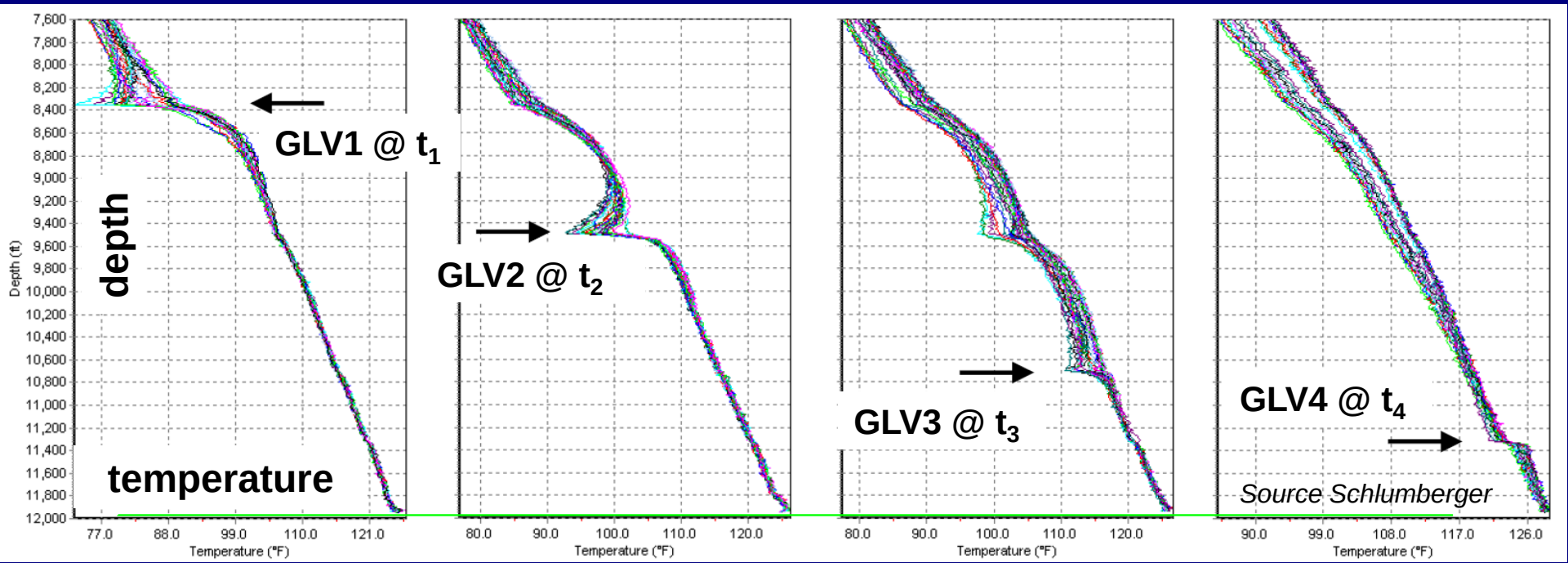
- Maintaining optimum gas injection
  - Valve behaviour
  - Injection depth
- Technology
  - Moving beyond Flowing Gradient Survey + nodal analysis
  - Sensor improvements
  - Dynamic well modelling
  - Multiwell surveillance
- Challenges
  - Increased data load -> overload
  - Increasing lack of gas lift engineering expertise
  - "…gas lift works, even if it's broken!"

Improving Lift Efficiency



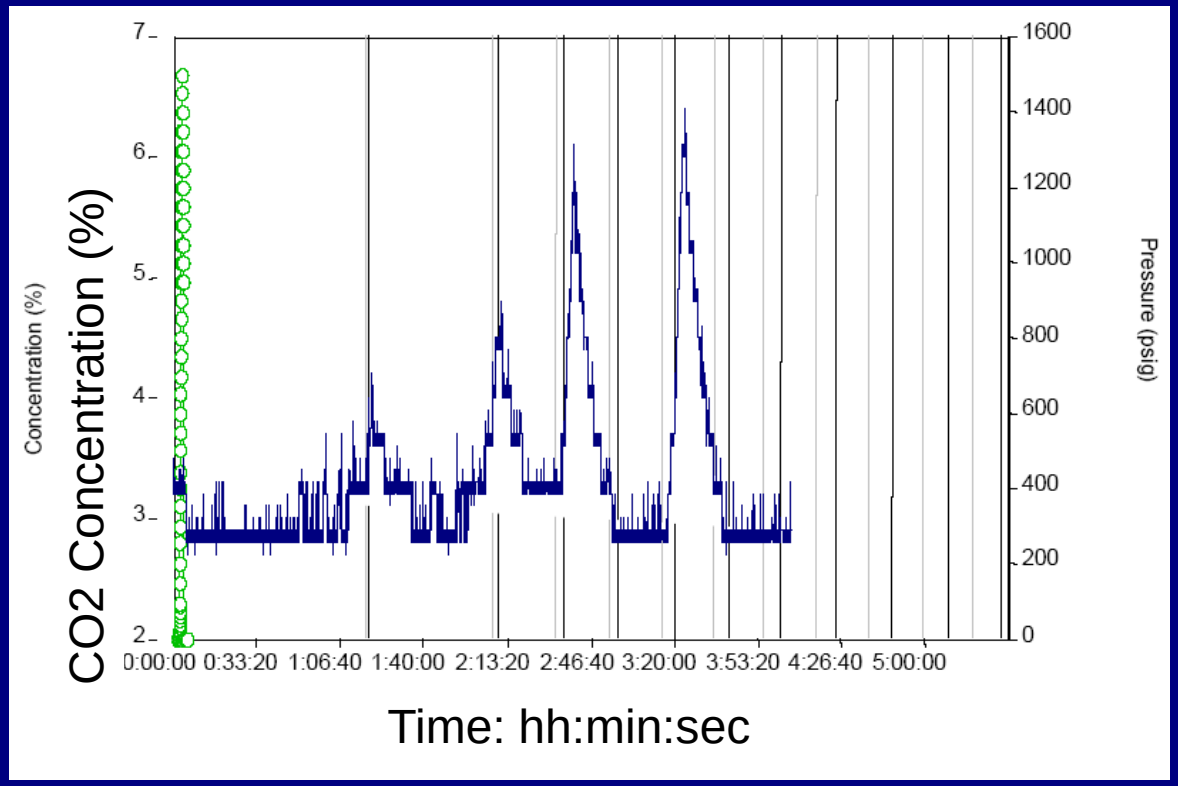
Fibre Optics – Distributed Temperature Sensors/Systems (DTS)

- Simultaneous real time measurements through entire completion
- Permanent installation or slick line
- Temperature vs time vs depth



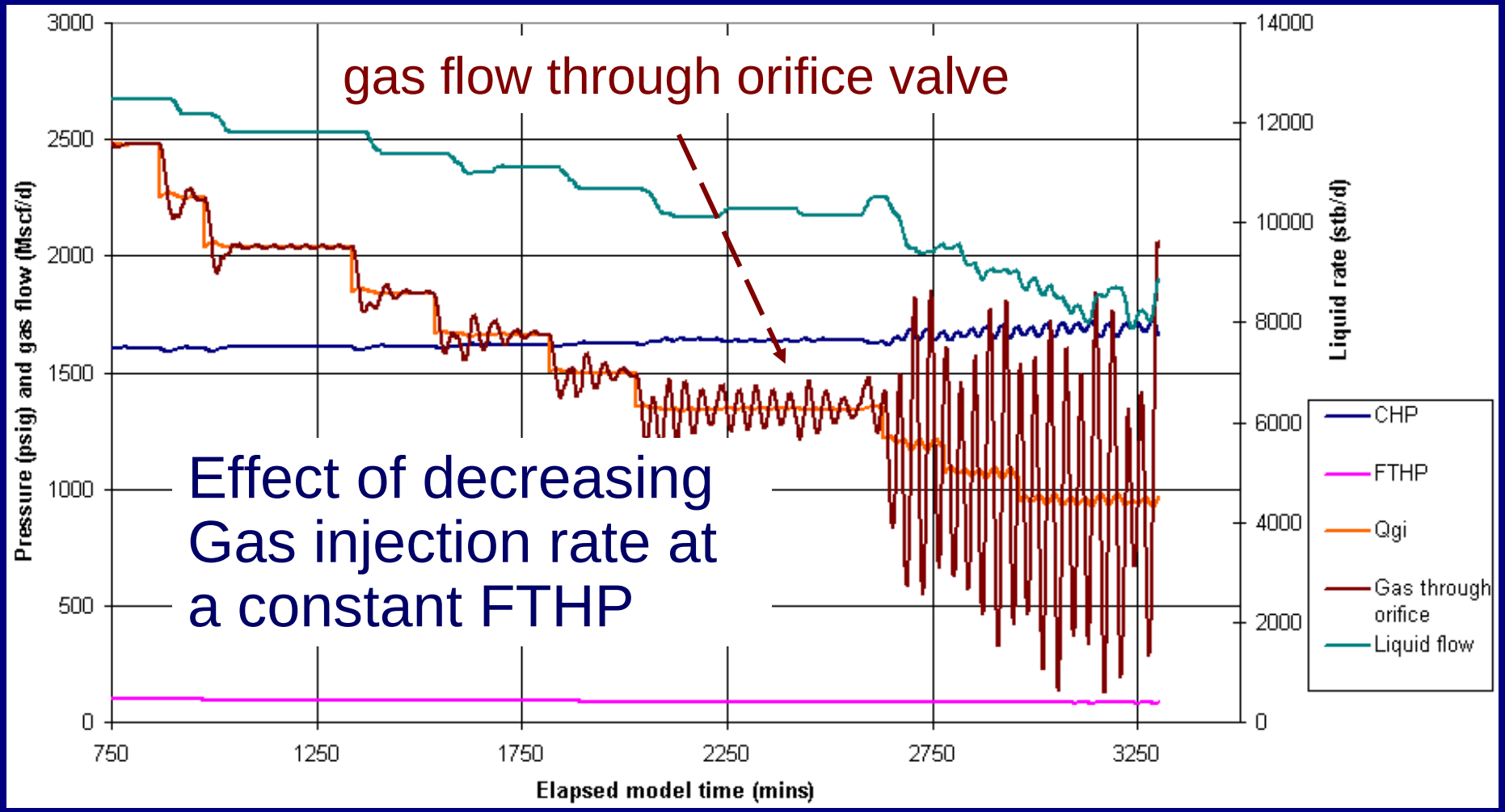
CO2 Tracer Injection

- CO2 slug injected into GL supply line
- Produced fluid stream analysed at well head vs. time.
- CO2 peaks correlate with active GL valve or leaks.
- GLV verification & tubing integrity.
- Features:
  - No shut-in
  - No downhole tools
  - Alternative to flowing gradient survey (FGS)
  - HSE



Source ALRDC/AppSmiths

Dynamic GL Simulation



e.g. Dynalift™, OLGA™, FlowLift™

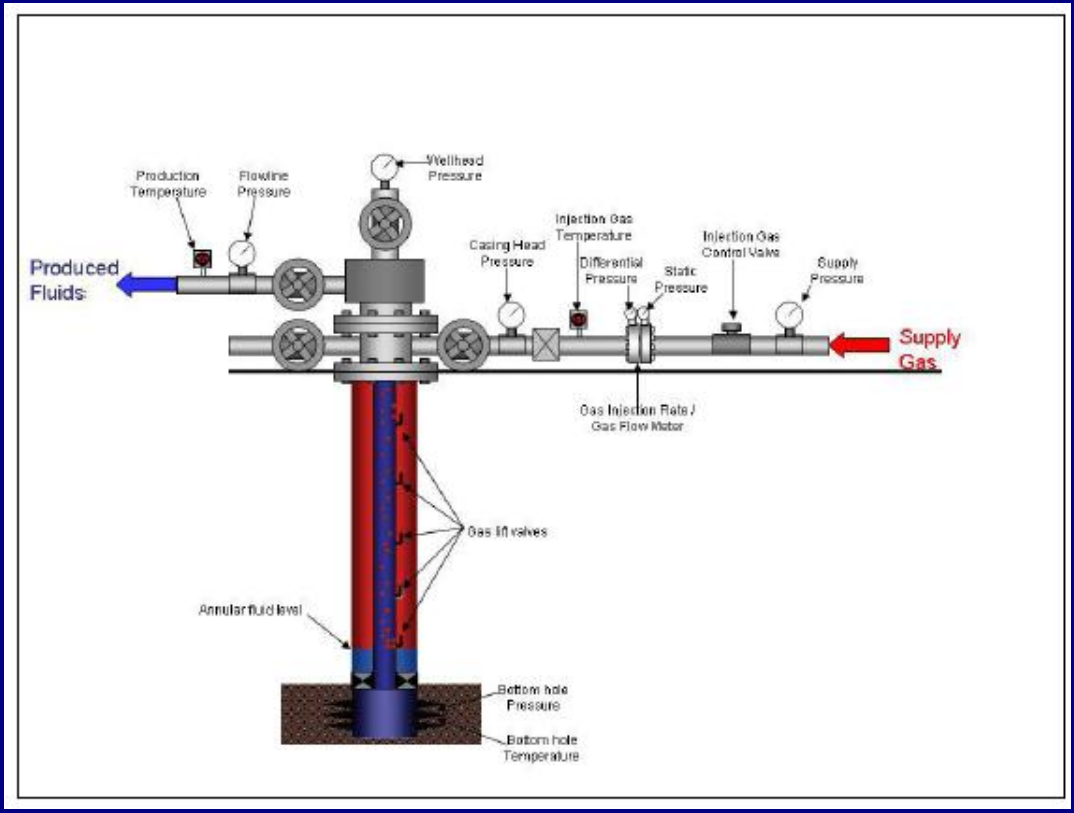
Improved Data Management

- On line data acquisition, storage and analysis
- Conceived for large fields (100's of wells)
- Surveillance: display, sorting, trending
- Management by exception: alarms/flags
- Offline analysis using engineering applications
- Storage of well service histories

Desktop Intelligence: “Smart” Diagnostics

Artificial Intelligence – a virtual “robot”

- Monitor GL well data: CHP/THP, prod/inj rates, GLV data…
- Expert System knowledge base: initial “expert” input: define a range of abnormal conditions. Trainable, probabilistic, expandable.
- Data assessment: pattern recognition, intelligent systems, machine learning.
- Diagnostics: provides results & recommendations



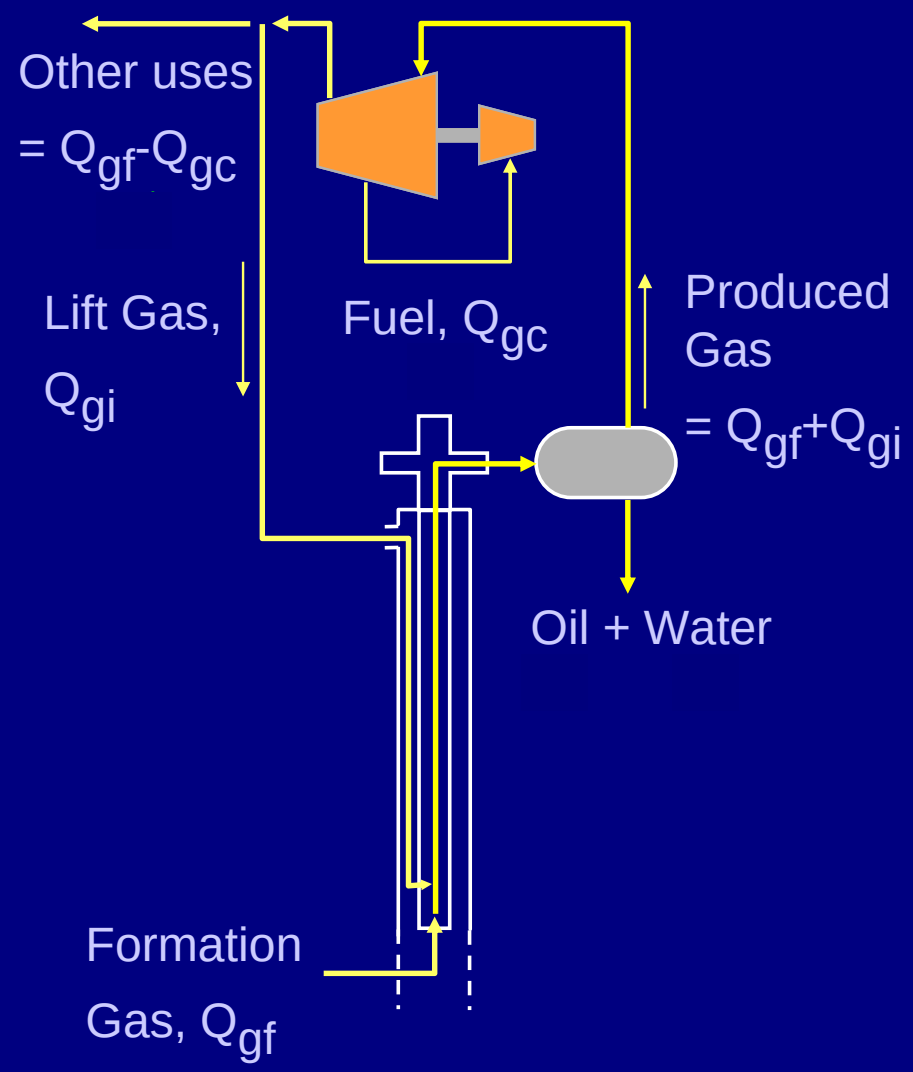
Source Weatherford

Stage 2

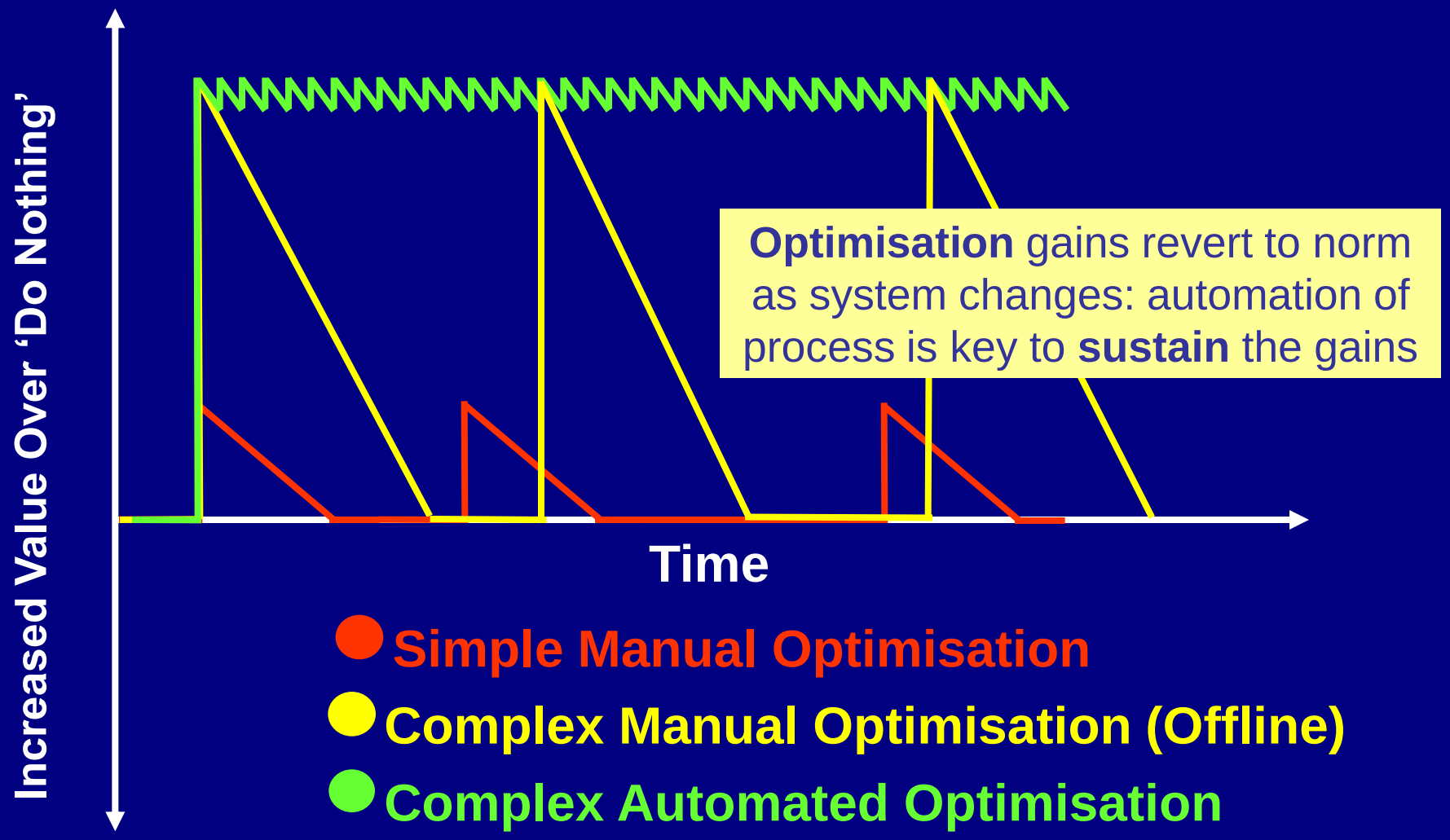
- Advances in sensors, data acquisition & storage, and diagnostics provide methods (tailored or generic) for improved well surveillance, intervention and planning.

Stage 3: Field Gas Lift Optimisation

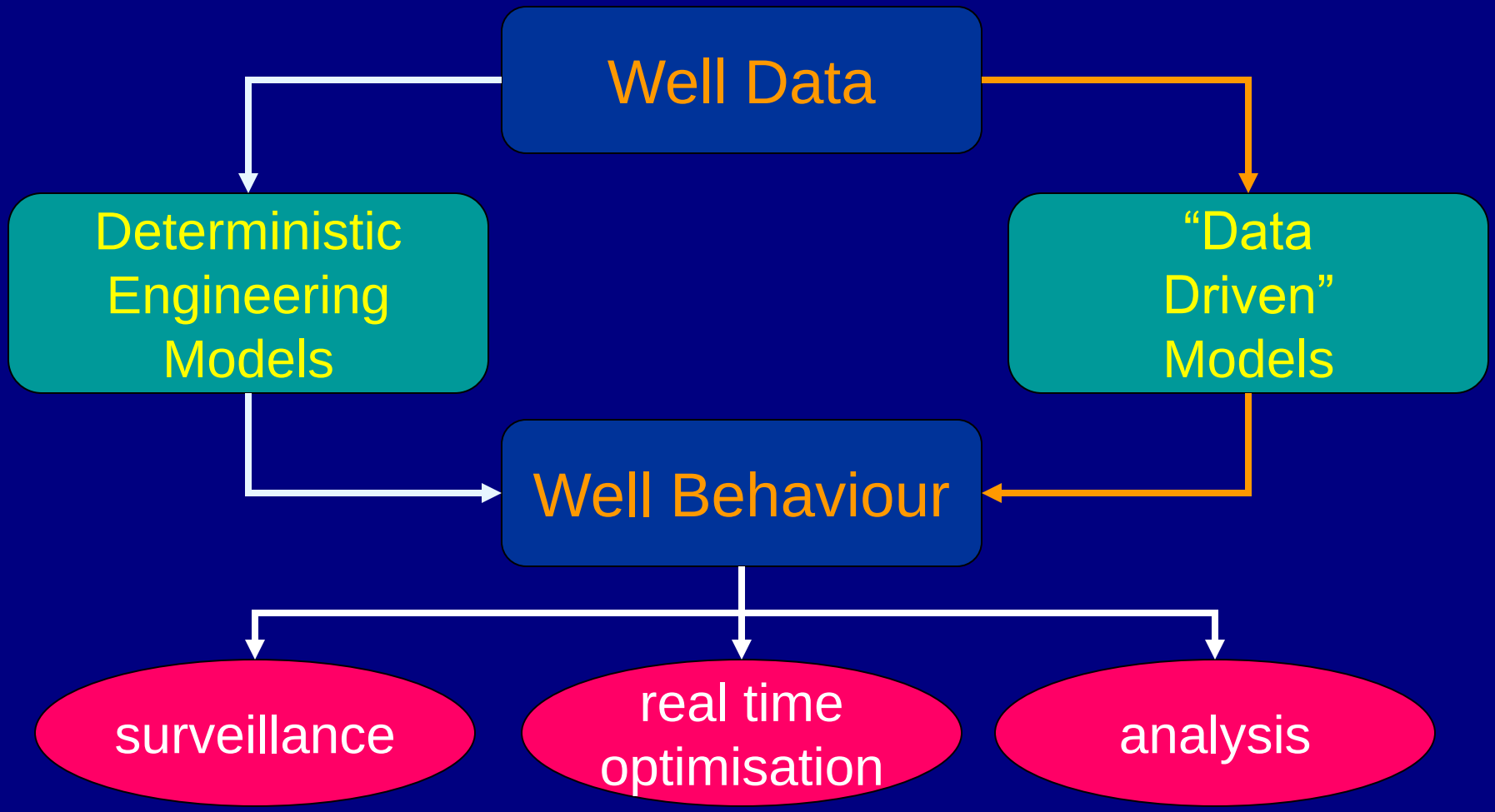
- determine (and set) optimal gas rates for each well
- high frequency (daily) optimisation
- integrated asset model
- requires adequate infrastructure in instrumentation, metering, communications.
- implementation relies on adapting people & work processes.
- “Digital Oil Field”: i-Field, Smart Field, e-Field, etc.



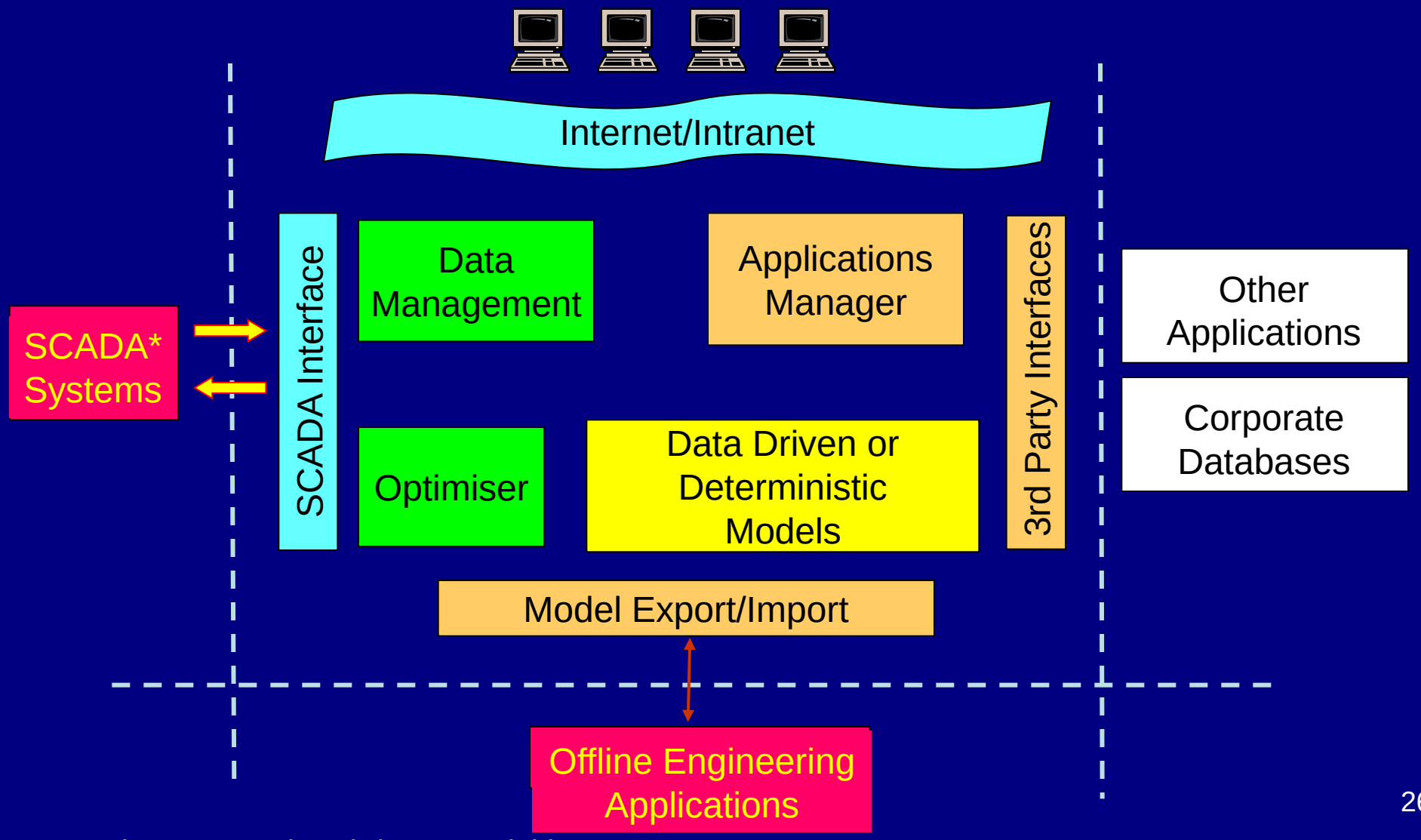
Sustainable Production Optimisation



Approaches to Field GL Optimization

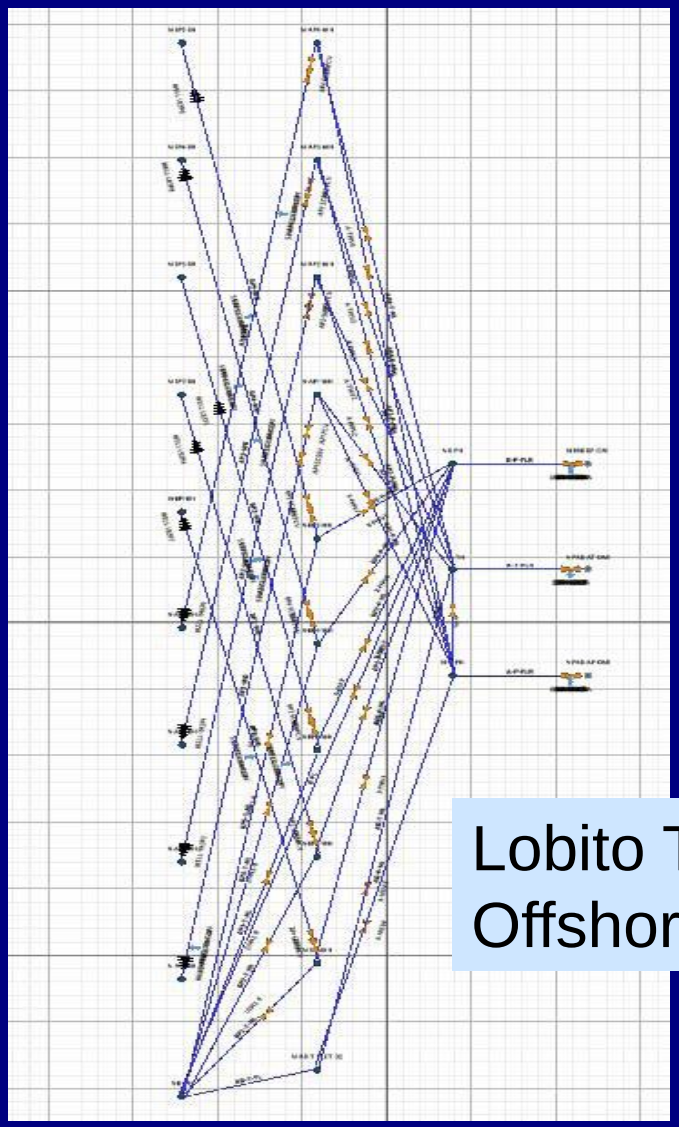


Generalised Online Real Time Optimisation (RTO) Architecture

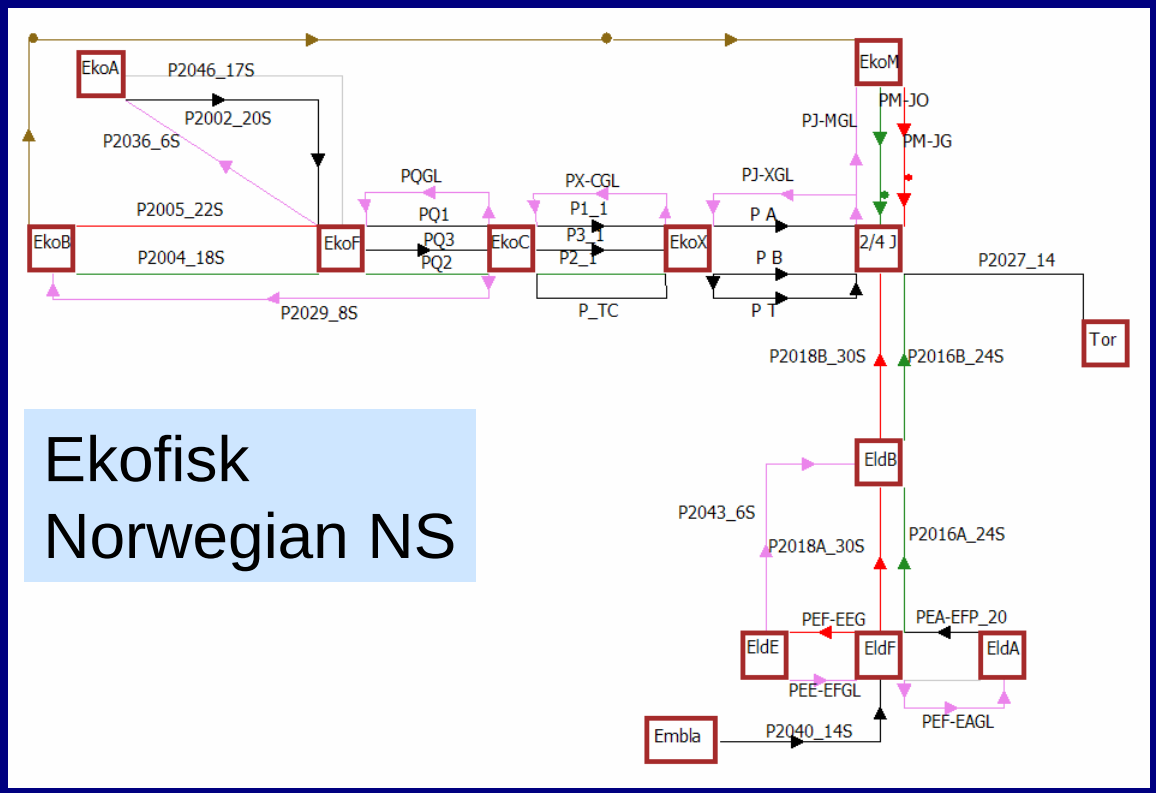


*supervisory control and data acquisition

On Line GL Optimisation Examples



Lobito Tomboco
Offshore Angola



Ekofisk
Norwegian NS

Field Optimisation: Issues & Challenges

- Individual wells must already be optimised.
- Cost of implementation: brown fields?
- Increased data availability vs. decrease in engineering knowledge.
- Reliability, calibration & maintenance of SCADA and sensors -> unmanned offshore environment?

Stage 3

- Advances in SCADA, optimisation algorithms and data management have allowed gas lifted systems to be optimised on a relative high frequency cycle, resulting in increased oil production and more efficient lift gas usage.
- Real time/on-line gas lift optimisation is now a field proven methodology.

The Prize

- Design & Implementation
  - More production can be safely gas lifted
  - Avoidance of costly workovers/re-entries
- Single Well Remediation
  - 0-25% on flowing wells
  - Revival of shut-in wells
- Full Field Optimisation
  - 2-5% oil increase of field wide production
  - Up to 40% improvement in gas injection efficiency
  - Sustained production increases with RTO

Conclusions

- The last decade has seen a step change in the understanding, surveillance, control and optimisation of the gas lift process:
  - GLV performance
  - Web based IT infrastructure
  - Optimisation algorithms & surveillance routines
  - SCADA and associated instrumentation

- Outstanding issues:
  - Measurement (notably Qgi)
  - Well testing
  - Maintenance
  - Training

Gas Lift may be robust and forgiving, however it can be improved with better applied engineering

?

Data Acquisition
Data Management

acknowledgements & thanks

- Dr. Ken Decker – Independent Consultant & VPC Chairman
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