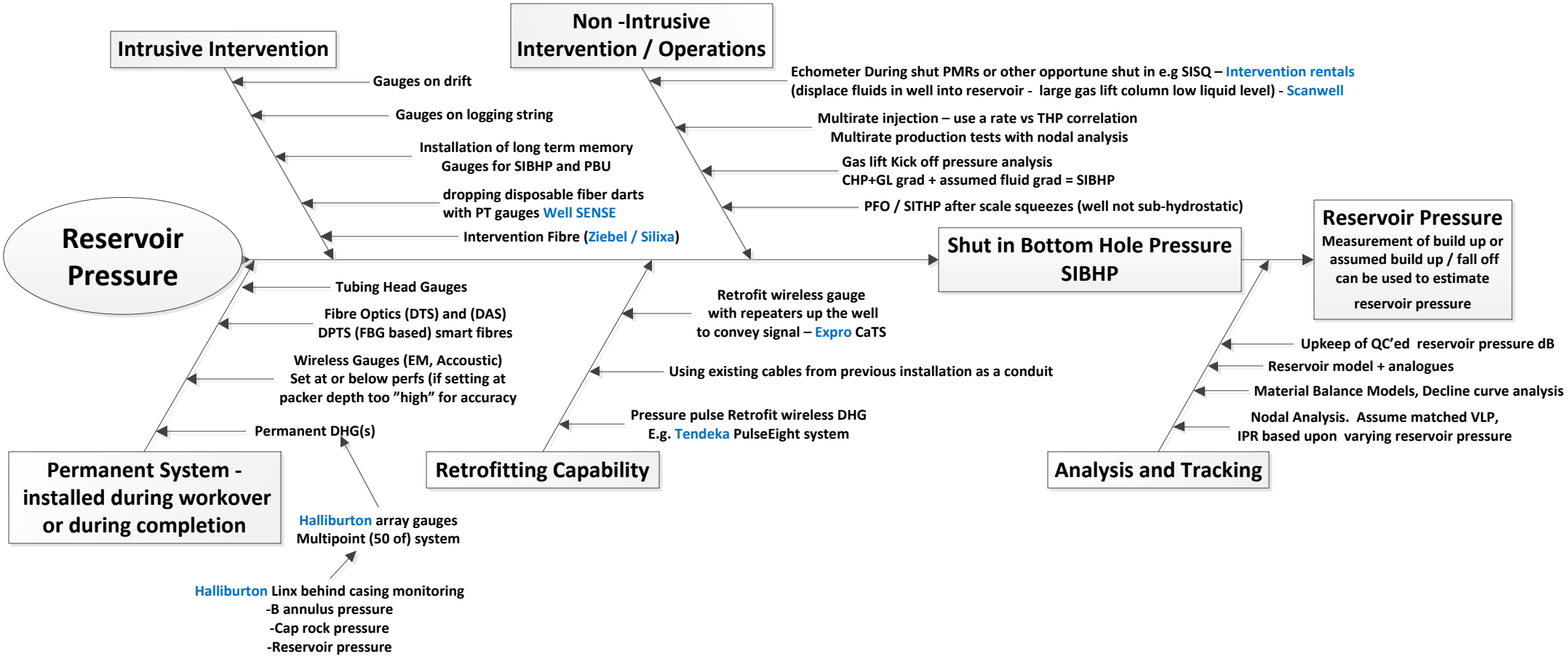
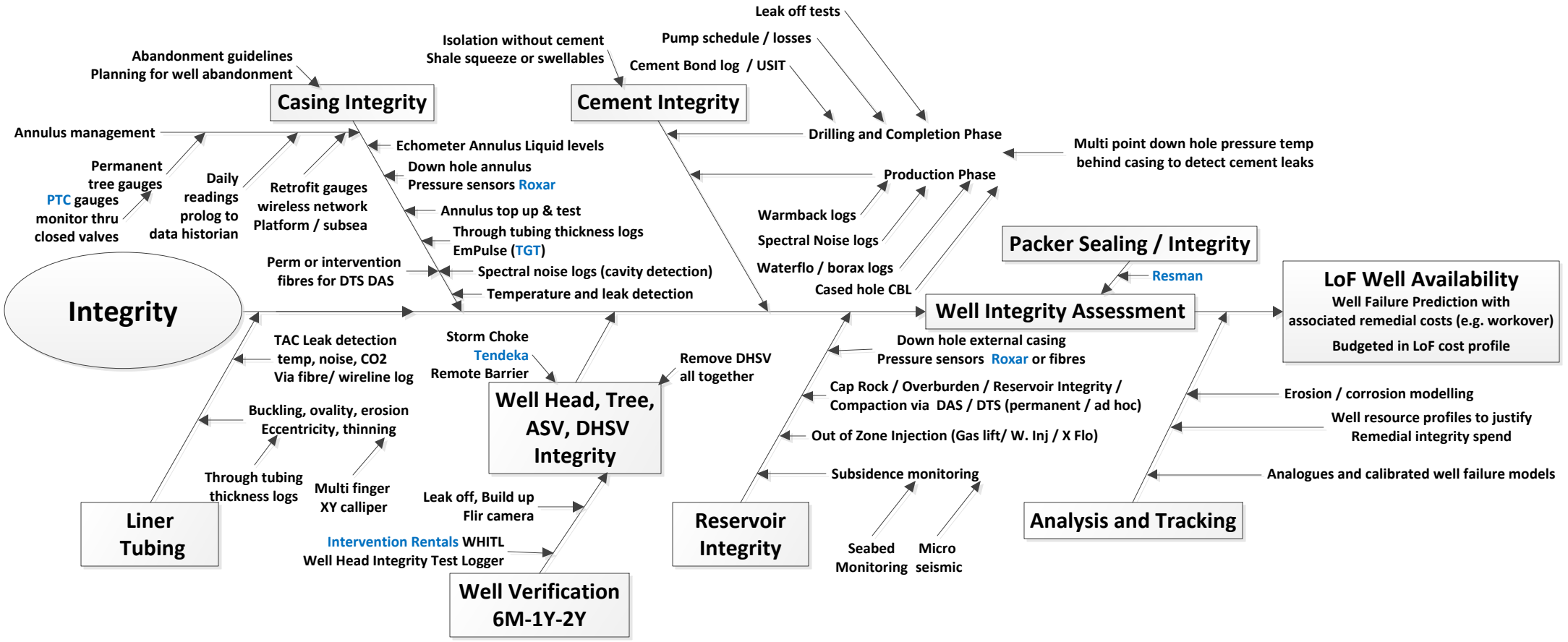
Inwell Flow Surveillance
& Control Seminar

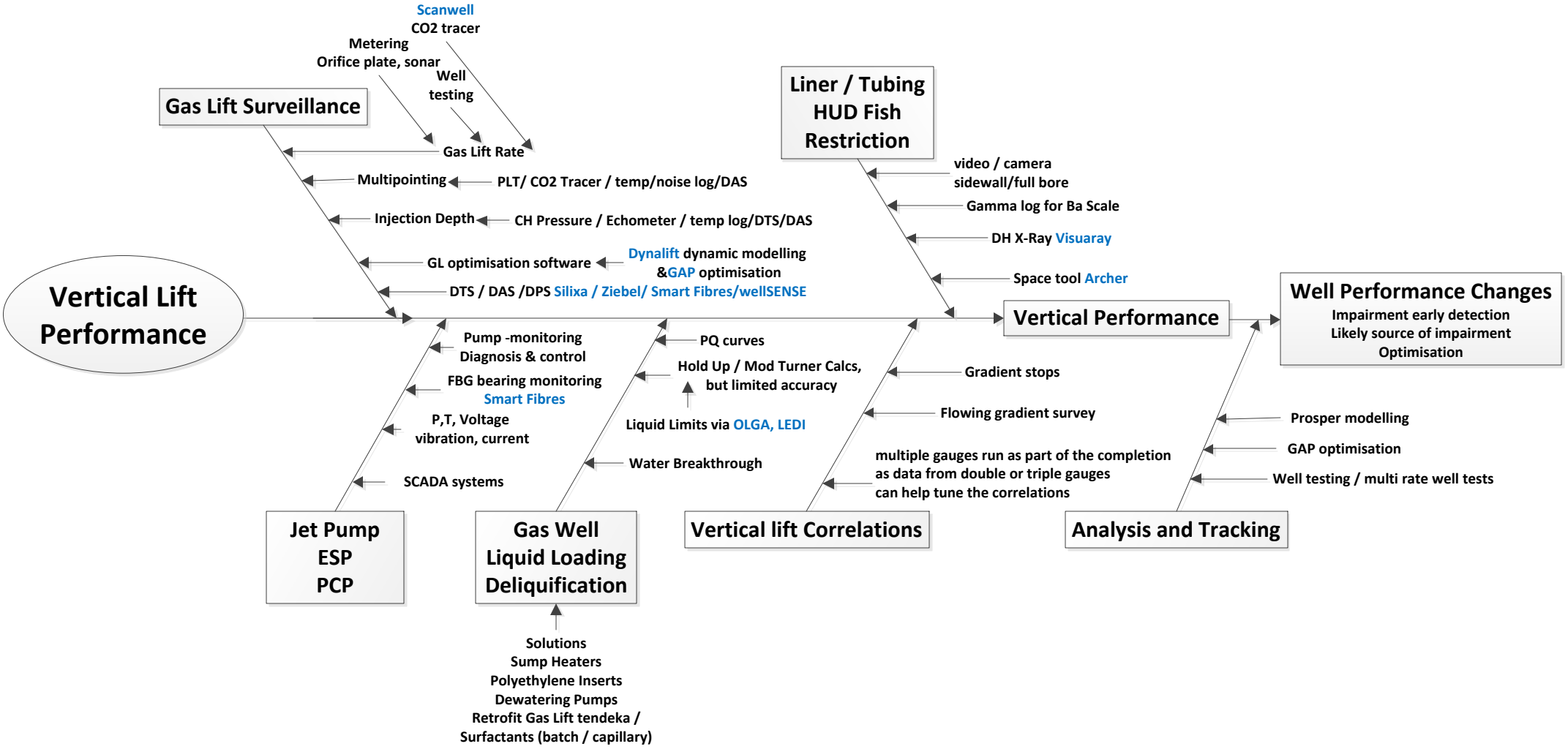
# Surveillance Fishbones

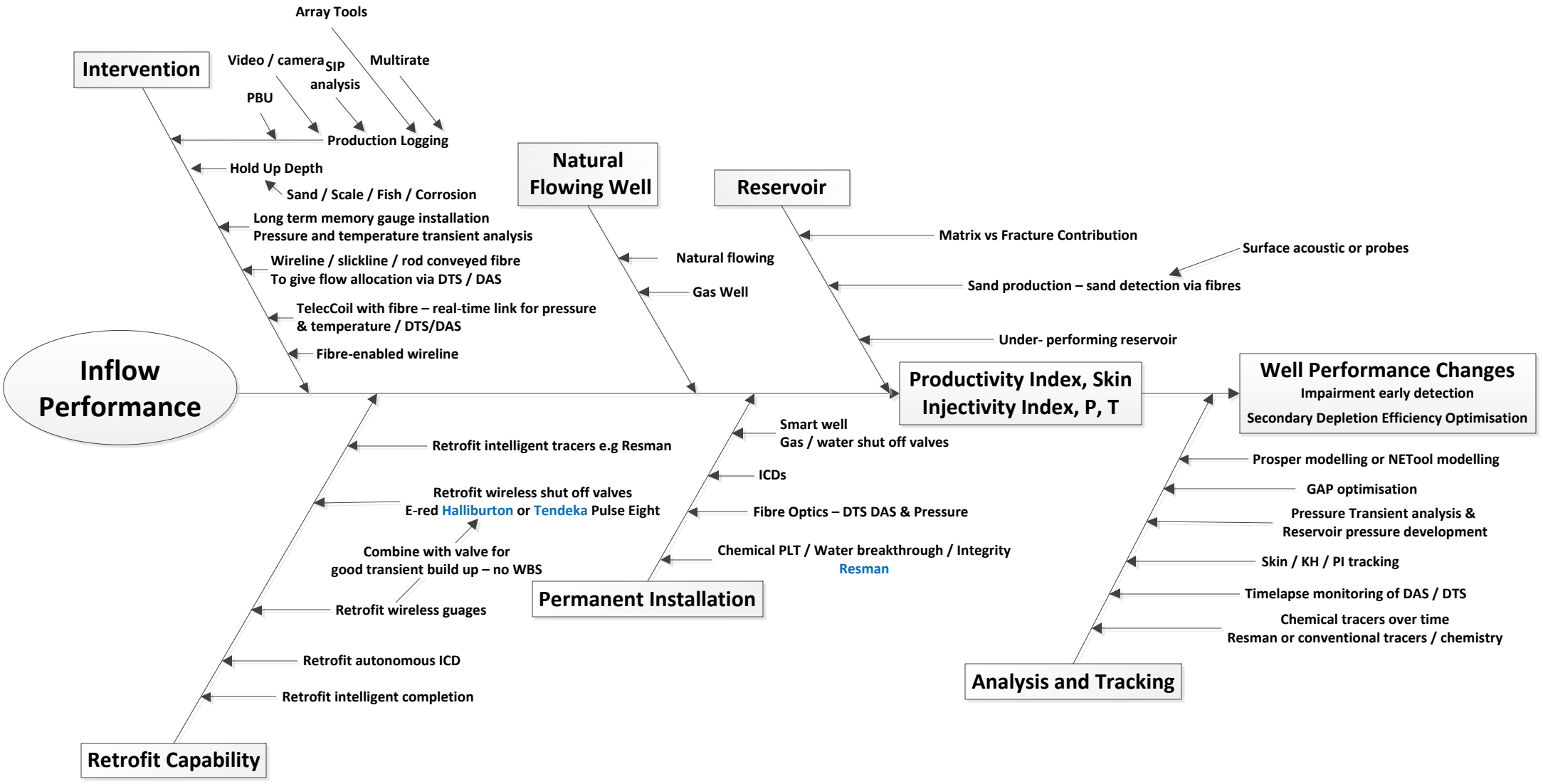
## A collaborative output from the SPE Aberdeen 3rd Inwell Flow Surveillance & Control Seminar 3 October 2017

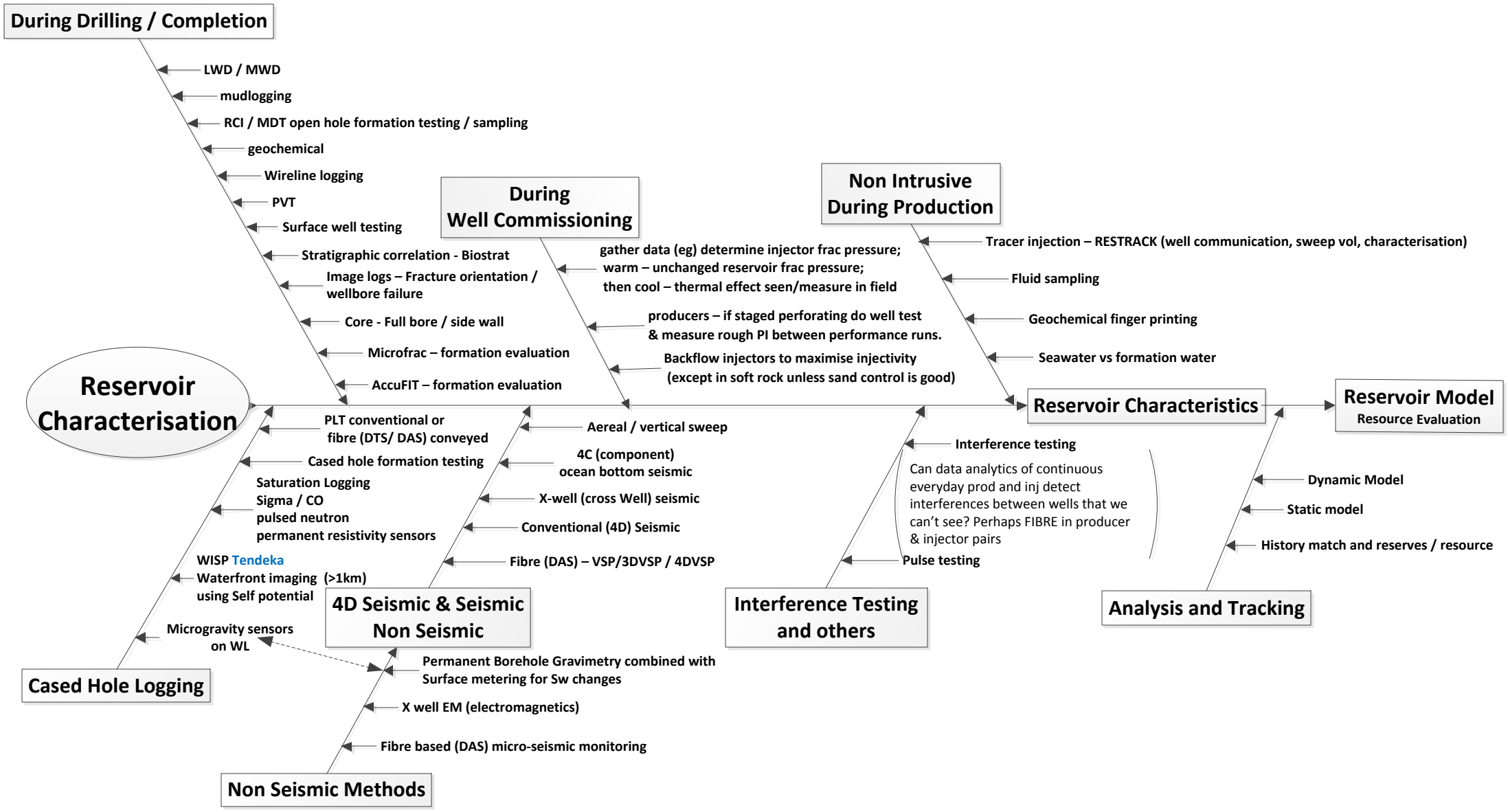
The Surveillance Fishbones are a product of breakout session by the participants of the SPE Aberdeen's 3rd Inwell Flow Surveillance and Control Seminar 3rd October 2017.
The output is a snapshot of the collective input and knowledge on the day and is by no means a definitive list. The information presented is not representative of the conference sponsors.
The fishbones are intended to be an introduction to the various tools and techniques that exist in the oilfield to study various reservoir, wells and optimisation themes.
They are grouped into the themes of pressure, integrity, vertical lift, inflow performance, reservoir characterisation and well testing & performance.
Different tools and techniques should be easily searched for and discovered on the web, the fishbones should serve as a handy reminder or a prompt for engineers and managers.
The concept of publishing a surveillance toolbox arose of out the Oil and Gas UK's Reservoir and Wells Optimisation Taskgroup's annual forum where the challenge to get appropriate surveillance was identified in the top 5 initiatives that could promote more production benefitting interventions. The SPE surveillance committee adopted the initiative and incorporated it into their 2017 agenda.
Distribution and use of the diagrams is widely encouraged by the SPE's surveillance organising committee, any updates, forgotten best practices or new techniques can be incorporated into a similar breakout session in the conference to be held in 2019.

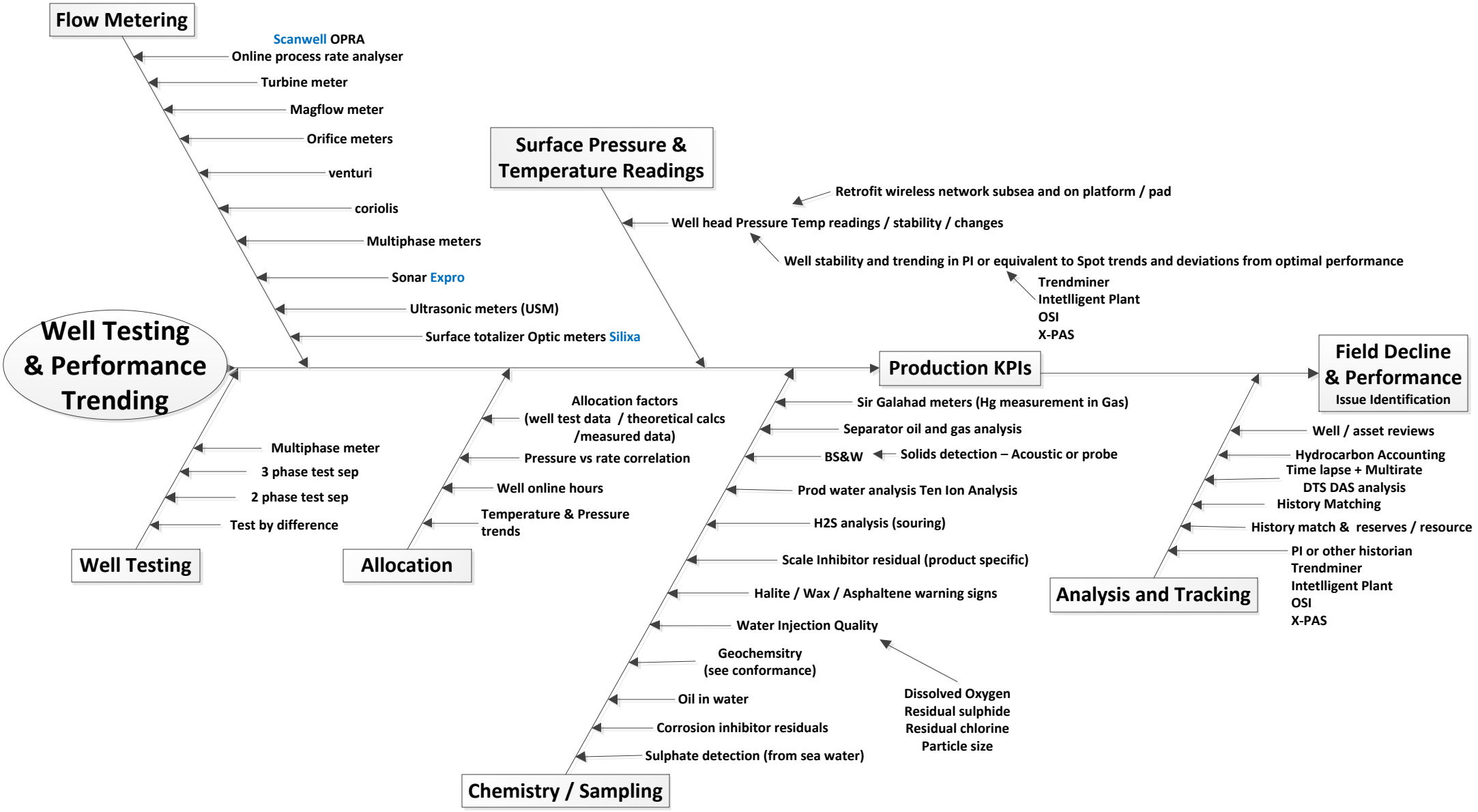

Reservoir Pressure
Intrusive Intervention
Gauges on drift
Gauges on logging string
Installation of long term memory Gauges for SIBHP and PBU
dropping disposable fiber darts with PT gauges Well SENSE
Intervention Fibre (Ziebel / Silixa)
Non -Intrusive Intervention / Operations
Echometer During shut PMRs or other opportune shut in e.g SISQ – Intervention rentals
(displace fluids in well into reservoir - large gas lift column low liquid level) - Scanwell
Multirate injection – use a rate vs THP correlation
Multirate production tests with nodal analysis
Gas lift Kick off pressure analysis
CHP+GL grad + assumed fluid grad = SIBHP
PFO / SITHP after scale squeezes (well not sub-hydrostatic)
Shut in Bottom Hole Pressure SIBHP
Reservoir Pressure
Measurement of build up or assumed build up / fall off can be used to estimate reservoir pressure
Tubing Head Gauges
Fibre Optics (DTS) and (DAS) DPTS (FBG based) smart fibres
Wireless Gauges (EM, Accoustic) Set at or below perfs (if setting at packer depth too "high" for accuracy
Permanent DHG(s)
Permanent System - installed during workover or during completion
Halliburton array gauges Multipoint (50 of) system
Halliburton Linx behind casing monitoring
-B annulus pressure
-Cap rock pressure
-Reservoir pressure
Retrofit wireless gauge with repeaters up the well to convey signal – Expro CaTS
Using existing cables from previous installation as a conduit
Pressure pulse Retrofit wireless DHG
E.g. Tendeka PulseEight system
Retrofitting Capability
Upkeep of QC'ed reservoir pressure dB
Reservoir model + analogues
Material Balance Models, Decline curve analysis
Nodal Analysis. Assume matched VLP, IPR based upon varying reservoir pressure
Analysis and Tracking


Integrity
Casing Integrity
Abandonment guidelines
Planning for well abandonment
Annulus management
Permanent tree gauges
PTC gauges monitor thru closed valves
Daily readings prolog to data historian
Retrofit gauges wireless network Platform / subsea
Echometer Annulus Liquid levels
Down hole annulus Pressure sensors Roxar
Annulus top up & test
Through tubing thickness logs EmPulse (TGT)
Spectral noise logs (cavity detection)
Temperature and leak detection
Perm or intervention fibres for DTS DAS
Cement Integrity
Isolation without cement
Shale squeeze or swellables
Cement Bond log / USIT
Pump schedule / losses
Leak off tests
Drilling and Completion Phase
Production Phase
Multi point down hole pressure temp behind casing to detect cement leaks
Warmback logs
Spectral Noise logs
Waterflo / borax logs
Cased hole CBL
Packer Sealing / Integrity
Resman
Well Integrity Assessment
LoF Well Availability
Well Failure Prediction with associated remedial costs (e.g. workover)
Budgeted in LoF cost profile
Down hole external casing Pressure sensors Roxar or fibres
Cap Rock / Overburden / Reservoir Integrity / Compaction via DAS / DTS (permanent / ad hoc)
Out of Zone Injection (Gas lift/ W. Inj / X Flo)
Subsidence monitoring
Seabed Monitoring
Micro seismic
Reservoir Integrity
Erosion / corrosion modelling
Well resource profiles to justify Remedial integrity spend
Analogues and calibrated well failure models
Analysis and Tracking
Storm Choke
Tendeka
Remote Barrier
Remove DHSV all together
Well Head, Tree, ASV, DHSV Integrity
Leak off, Build up
Flir camera
Intervention Rentals WHITL
Well Head Integrity Test Logger
Well Verification 6M-1Y-2Y
TAC Leak detection temp, noise, CO2 Via fibre/ wireline log
Buckling, ovality, erosion Eccentricity, thinning
Through tubing thickness logs
Multi finger XY calliper
Liner Tubing


Vertical Lift Performance
Gas Lift Surveillance
Scanwell
CO2 tracer
Metering
Orifice plate, sonar
Well testing
Gas Lift Rate
Multipointing
PLT/ CO2 Tracer / temp/noise log/DAS
Injection Depth
CH Pressure / Echometer / temp log/DTS/DAS
GL optimisation software
Dynalift dynamic modelling &GAP optimisation
DTS / DAS /DPS Silixa / Ziebel/ Smart Fibres/wellSENSE
Liner / Tubing HUD Fish Restriction
video / camera sidewall/full bore
Gamma log for Ba Scale
DH X-Ray Visuaray
Space tool Archer
Vertical Performance
Well Performance Changes
Impairment early detection
Likely source of impairment
Optimisation
Pump -monitoring Diagnosis & control
FBG bearing monitoring Smart Fibres
P,T, Voltage vibration, current
SCADA systems
Jet Pump ESP PCP
PQ curves
Hold Up / Mod Turner Calcs, but limited accuracy
Liquid Limits via OLGA, LEDI
Water Breakthrough
Gas Well Liquid Loading Deliquification
Solutions
Sump Heaters
Polyethylene Inserts
Dewatering Pumps
Retrofit Gas Lift tendeka /
Surfactants (batch / capillary)
Gradient stops
Flowing gradient survey
multiple gauges run as part of the completion as data from double or triple gauges can help tune the correlations
Vertical lift Correlations
Prosper modelling
GAP optimisation
Well testing / multi rate well tests
Analysis and Tracking


Inflow Performance
Intervention
Array Tools
Video / camera
SIP analysis
Multirate
PBU
Production Logging
Hold Up Depth
Sand / Scale / Fish / Corrosion
Long term memory gauge installation
Pressure and temperature transient analysis
Wireline / slickline / rod conveyed fibre
To give flow allocation via DTS / DAS
TelecCoil with fibre – real-time link for pressure & temperature / DTS/DAS
Fibre-enabled wireline
Natural Flowing Well
Natural flowing
Gas Well
Reservoir
Matrix vs Fracture Contribution
Surface acoustic or probes
Sand production – sand detection via fibres
Under- performing reservoir
Productivity Index, Skin Injectivity Index, P, T
Well Performance Changes
Impairment early detection
Secondary Depletion Efficiency Optimisation
Permanent Installation
Smart well
Gas / water shut off valves
ICDs
Fibre Optics – DTS DAS & Pressure
Chemical PLT / Water breakthrough / Integrity
Resman
Retrofit Capability
Retrofit intelligent tracers e.g Resman
Retrofit wireless shut off valves
E-red Halliburton or Tendeka Pulse Eight
Combine with valve for good transient build up – no WBS
Retrofit wireless guages
Retrofit autonomous ICD
Retrofit intelligent completion
Analysis and Tracking
Prosper modelling or NETool modelling
GAP optimisation
Pressure Transient analysis & Reservoir pressure development
Skin / KH / PI tracking
Timelapse monitoring of DAS / DTS
Chemical tracers over time
Resman or conventional tracers / chemistry


Reservoir Characterisation
During Drilling / Completion
LWD / MWD
mudlogging
RCI / MDT open hole formation testing / sampling
geochemical
Wireline logging
PVT
Surface well testing
Stratigraphic correlation - Biostrat
Image logs – Fracture orientation / wellbore failure
Core - Full bore / side wall
Microfrac – formation evaluation
AccuFIT – formation evaluation
During Well Commissioning
gather data (eg) determine injector frac pressure; warm – unchanged reservoir frac pressure; then cool – thermal effect seen/measure in field
producers – if staged perforating do well test & measure rough PI between performance runs.
Backflow injectors to maximise injectivity (except in soft rock unless sand control is good)
Non Intrusive During Production
Tracer injection – RESTRACK (well communication, sweep vol, characterisation)
Fluid sampling
Geochemical finger printing
Seawater vs formation water
Reservoir Characteristics
Reservoir Model
Resource Evaluation
PLT conventional or fibre (DTS/ DAS) conveyed
Cased hole formation testing
Saturation Logging
Sigma / CO
pulsed neutron
permanent resistivity sensors
WISP Tendeka
Waterfront imaging (>1km) using Self potential
Micrograv sensors on WL
Cased Hole Logging
Aereal / vertical sweep
4C (component) ocean bottom seismic
X-well (cross Well) seismic
Conventional (4D) Seismic
Fibre (DAS) – VSP/3DVSP / 4DVSP
4D Seismic & Seismic Non Seismic
Permanent Borehole Gravimetry combined with Surface metering for Sw changes
X well EM (electromagnetics)
Fibre based (DAS) micro-seismic monitoring
Non Seismic Methods
Interference testing
Can data analytics of continuous everyday prod and inj detect interferences between wells that we can't see? Perhaps FIBRE in producer & injector pairs
Pulse testing
Interference Testing and others
Dynamic Model
Static model
History match and reserves / resource
Analysis and Tracking


Flow Metering
Scanwell OPRA
Online process rate analyser
Turbine meter
Magflow meter
Orifice meters
venturi
coriolis
Multiphase meters
Sonar Expro
Ultrasonic meters (USM)
Surface totalizer Optic meters Silixa
Surface Pressure & Temperature Readings
Retrofit wireless network subsea and on platform / pad
Well head Pressure Temp readings / stability / changes
Well stability and trending in PI or equivalent to Spot trends and deviations from optimal performance
Trendminer
Intetlligent Plant
OSI
X-PAS
Well Testing & Performance Trending
Production KPIs
Sir Galahad meters (Hg measurement in Gas)
Separator oil and gas analysis
BS&W
Solids detection – Acoustic or probe
Prod water analysis Ten Ion Analysis
H2S analysis (souring)
Scale Inhibitor residual (product specific)
Halite / Wax / Asphaltene warning signs
Water Injection Quality
Geochemsitry (see conformance)
Oil in water
Corrosion inhibitor residuals
Sulphate detection (from sea water)
Chemistry / Sampling
Dissolved Oxygen
Residual sulphide
Residual chlorine
Particle size
Field Decline & Performance
Issue Identification
Well / asset reviews
Hydrocarbon Accounting
Time lapse + Multirate
DTS DAS analysis
History Matching
History match & reserves / resource
PI or other historian
Trendminer
Intetlligent Plant
OSI
X-PAS
Analysis and Tracking
Multiphase meter
3 phase test sep
2 phase test sep
Test by difference
Well Testing
Allocation factors (well test data / theoretical calcs /measured data)
Pressure vs rate correlation
Well online hours
Temperature & Pressure trends
Allocation