



Statoil

Challenges and Possibilities with Fiber Optics Subsea and In-Well

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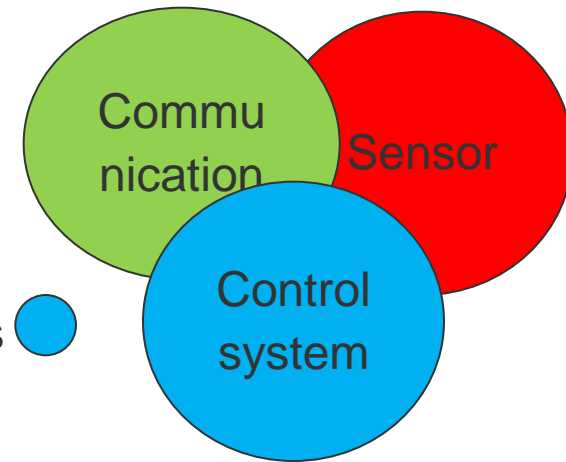
Advanced Wells and Production Optimization

Introduction

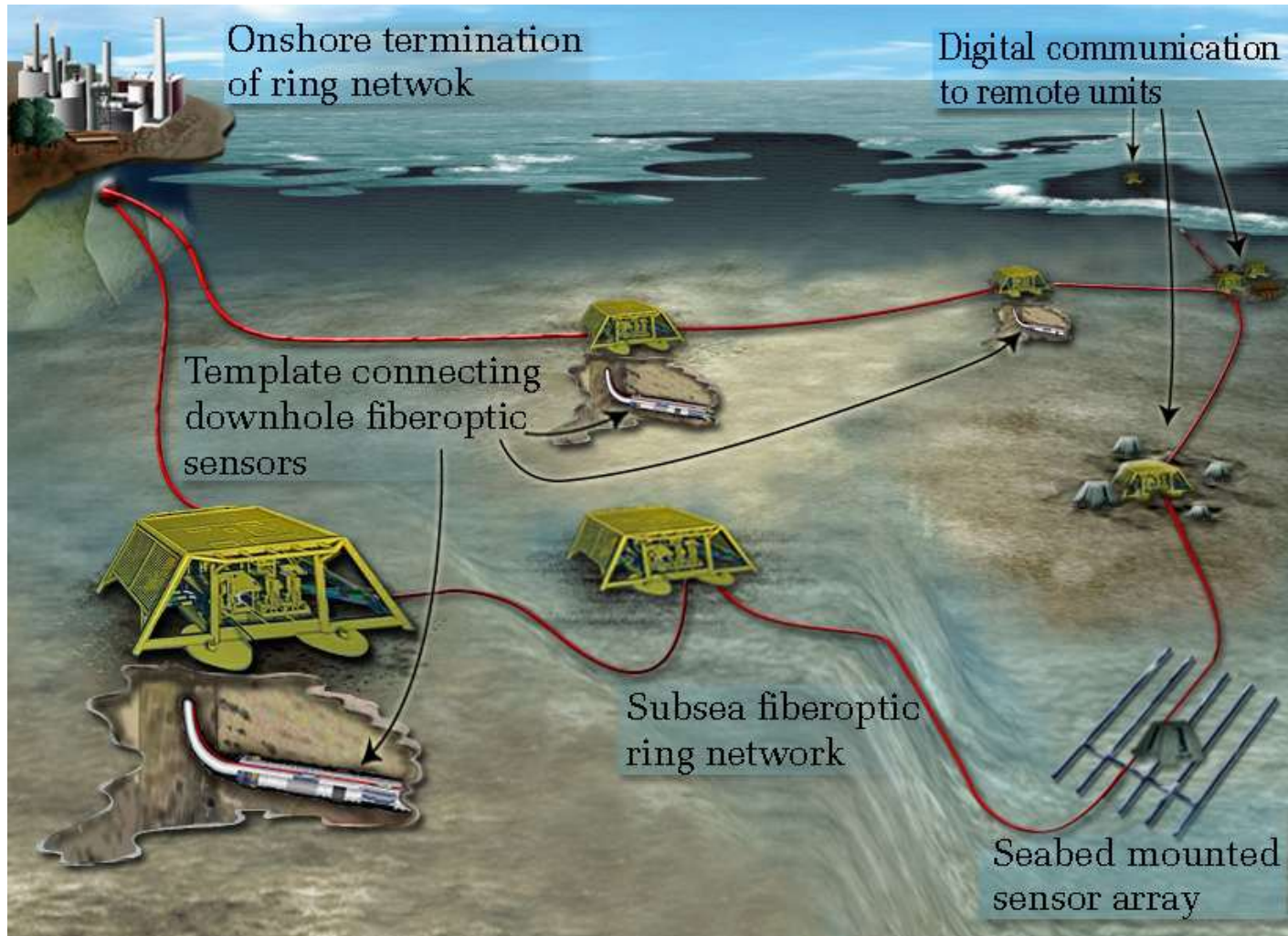
- Some background
- Example from two Statoil subsea projects
 - Integrated Fiber Optic Subsea System
 - Integrated Environmental Monitoring
- Challenges subsea
- Challenges with increasing amount of data
- Fiber sensors
- Conclusions

History – Statoil

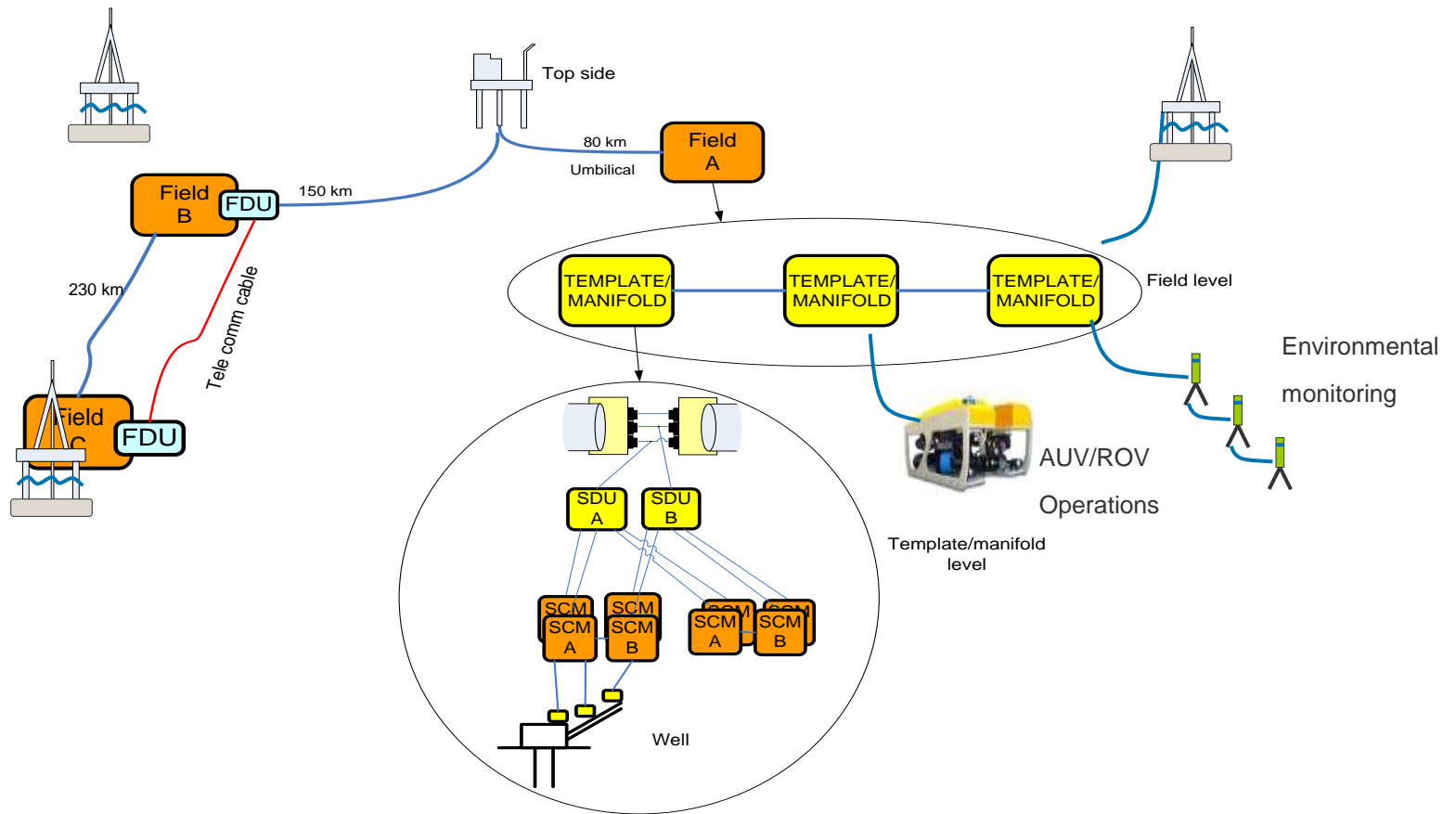
- First attempts on fiber PT gauges ~1994 ●
- Troll A – Power and Fiber communication cable 1995 ●
- First fields with fiber (not used then) in umbilical late 1990s ●
- Fiber dedicated communication cables late 1999 ★
- Troll pilot (subsea separation) fiber in control system 2000 ●
- Tampnet AS formed 2001 ★
- Fiber PT gauges and flow meter regular installation from ~2004 ★
- Snøhvit fiber based communication in production control system 140 km 2005 ●
- Ormen lange, Tyrihans, Gjøa, Vega...Most major developments fiber control system.... ~2006 -> ★
- Direct Electric Heating with distributed temperature sensing Tyrihans 2007 ★
- Permanent seabed seismic pilot Snorre 2008 ●



IFOSS – Integrated Fiber Optic Subsea System



Overview of possible integrated fiber optic infrastructure



IFOSS – a key for IO subsea ?

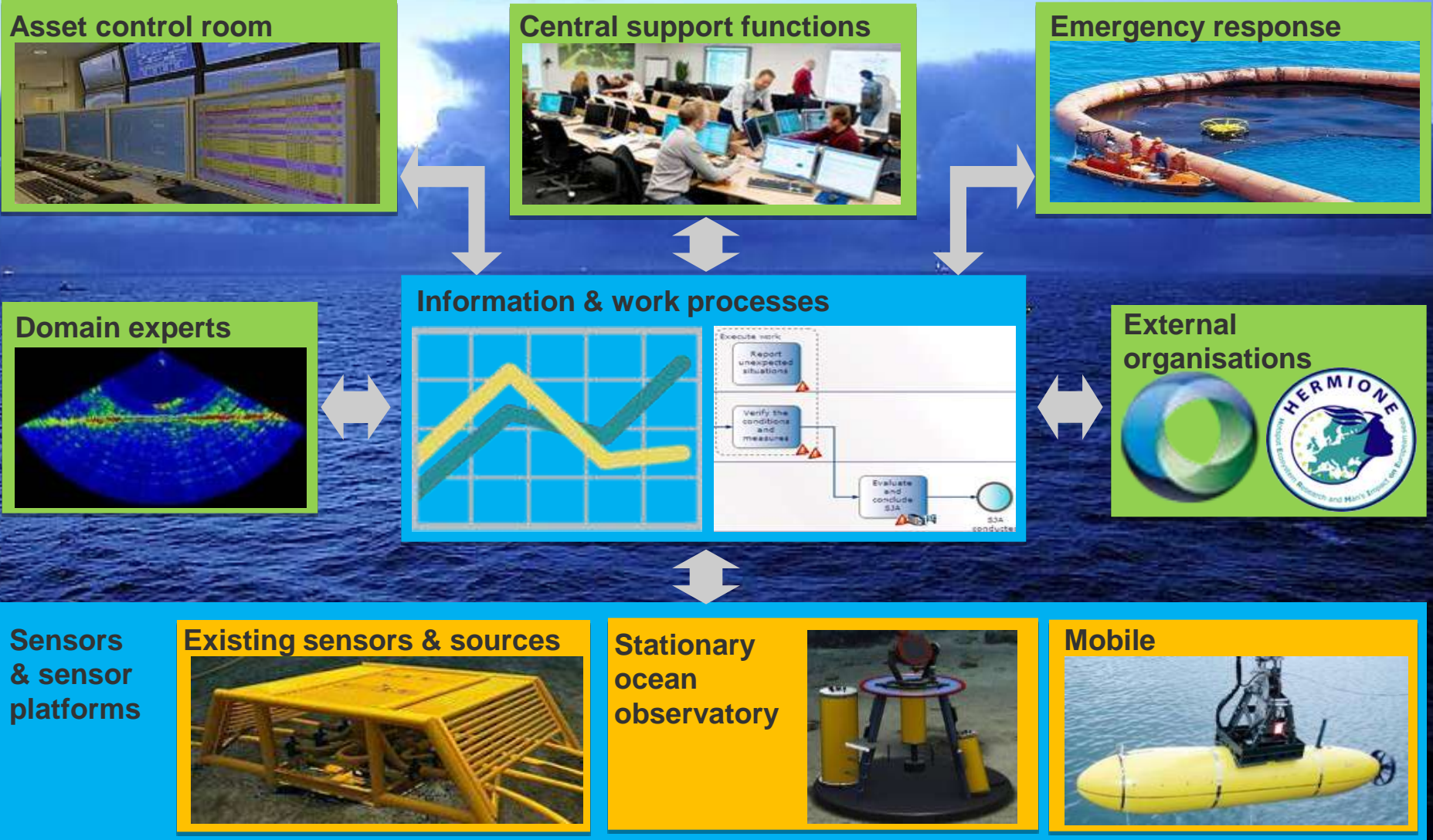
- An approach to Subsea (and downhole) connectivity that will reduce or eliminate the difference between dry trees and subsea installations.
- Open up to new applications in the subsea environment.
- Standards for connectivity with open interfaces - New ISO 13628-6 (IWIS, SIIS Level2-CANbus and Level3-Ethernet)
- Managed data network at subsea installation (layered security)
- High bandwidth (Gigabit Ethernet) in backbone
- We should build a data network to last for 25 years+ !!
- In new technical requirements for later enhancements for as well as redundancy for primary systems:
 - available digital sensor interface(s) per control module
 - a spare fiber pair per template.



Challenges with fiberoptics subsea

- Still not as experienced as with other technology –still unnecessary mistakes costing time and money, particularly during installation and commissioning.
- Ability to integrate a fiber sensor with the structure where the sensing is needed (typical example a long pipeline)
- Subsea wet mate connectors
 - Cost
 - Flexibility (still not the patch panel of the computer room)
 - Still not proven reconnection after many years in the the sea (partly since hardly any system that has passed commissioning have needed repair)

Integrated Environmental Monitoring



Background photo: Harald Pettersen

Current practice - challenges

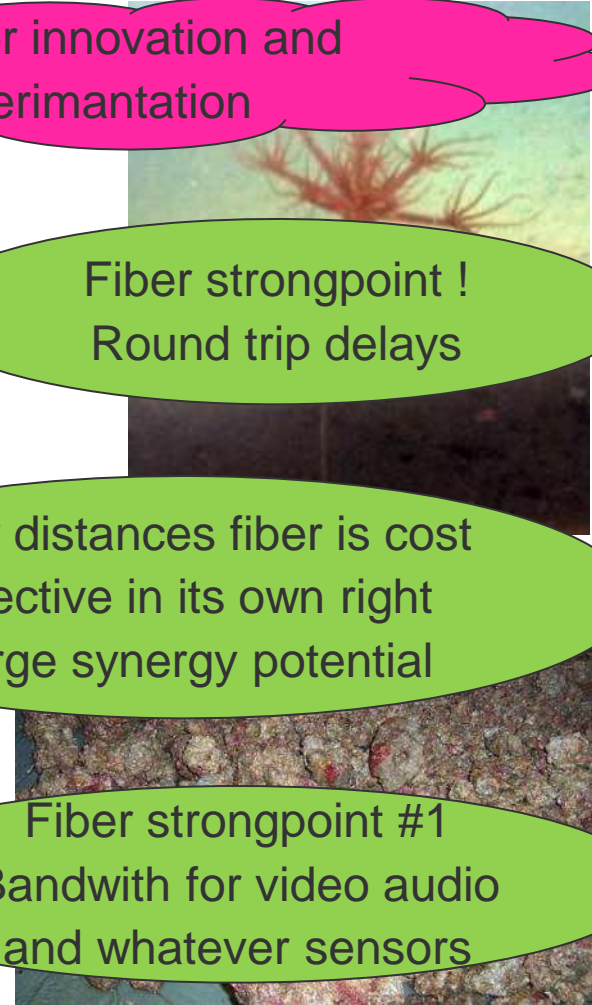
- Flexibility
 - Monitoring must be suited to the actual habitat
 - Physical sampling may harm sensitive habitats
- Response time of point sampling
 - Significant time lag between impact occurrence and detection
- Cost-effectiveness
 - Can be improved through integration in design and operations
- Automatic detection
 - Gas leakages and acute discharges

Room for innovation and experimentation

Fiber strongpoint !
Round trip delays

Over distances fiber is cost effective in its own right
Large synergy potential

Fiber strongpoint #1
Bandwith for video audio and whatever sensors

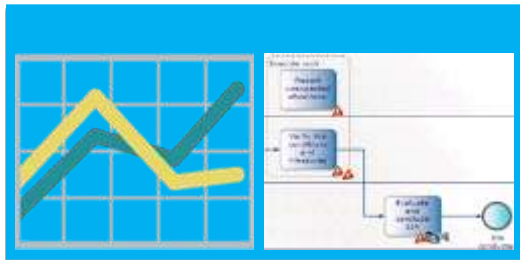


Vision 2020: Prudent operation and licence to operate

Integrated Environmental Monitoring



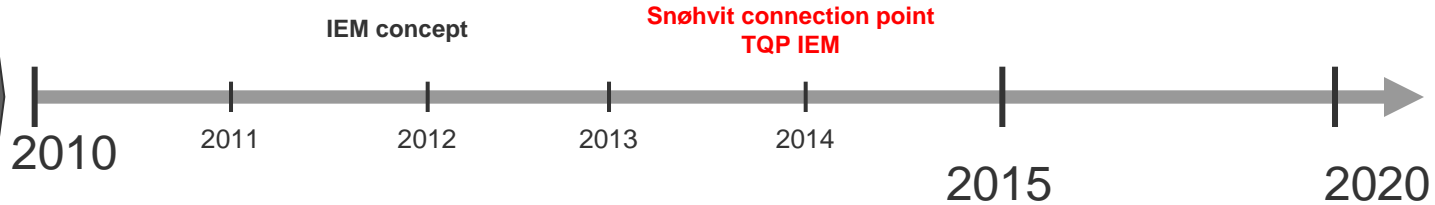
External collaboration initiation
IT architectural design
Concept of data and power management



IEM work processes and analytical tool



IEM pilot/first implementation



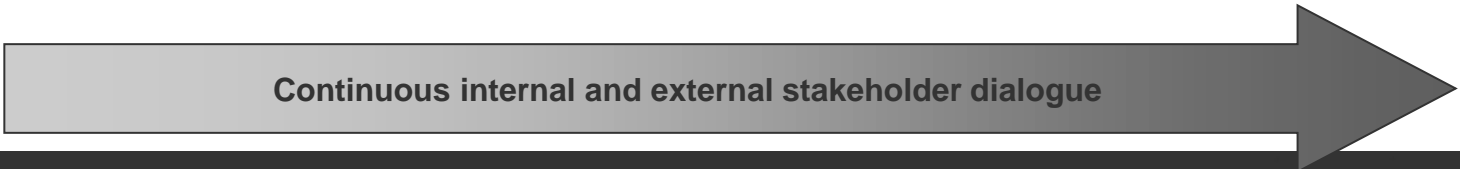
Peregrino online data
Talking clamps pilot
Nordland VII ocean observatory time series data

Leak detection pilot
Next generation lander technology

mobile platform pilot

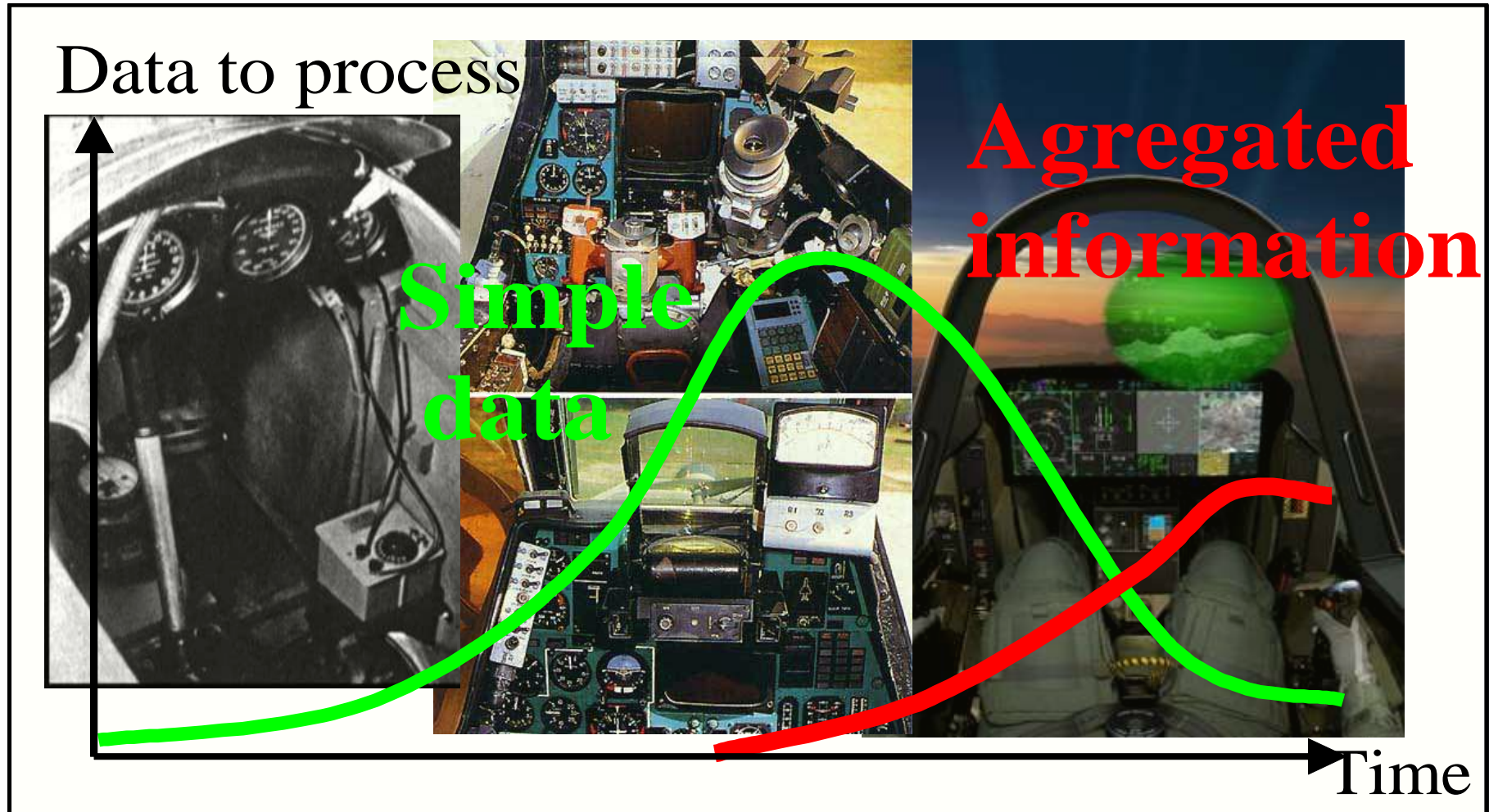
NOON observatories
Technology for leakage detection
Underwater hyper spectral imager

**Concept for mobile platforms
Biological sensor development**



The flying analogy

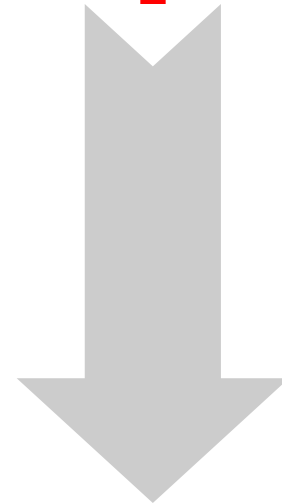
Bare necessities – death by data – fly by wire



Users – data flow – moderate data volume

Control room	daily use production	low data rate, critical
Support center on shore	when required	data on demand
Sensor supplier Sensor maintenance	household data (software download..)	moderate and infrequent
In house expert center	production details or equipment health	moderate to high data rate
External experts (Sensor supplier)	sensor diagnostics and raw data	high data rate data privacy can become an issue
Well controlled 3rd party (Controlled and certified if required)	connectivity when need (drilling rig when on well)	expect increasing bandwidth security a concern
External non-controlled 3rd party (e.g. universities)	data we want to be publically available	low criticality often high bandwidth security risk

Criticality



Potential bandwidth

The challenges for fiber based sensing

- How to utilize the more exotic and data intensive sensors in daily operations
- Tubing hanger penetrations – particularly subsea
- Connectivity to lower completion and hence the sandface
- Availability and field proven marinized instruments for subsea applications
- Electrical systems are catching-up for reliability on most temperatures

The good side of fiber based sensing

- Basic sensor needs are covered with fiber optic sensors (well accepted)
 - Pressure Temperature gauges
 - The raw capturing of distributed temperature (DTS) and the easiest of the applications such as
 - heated flow lines and electrical power cables (high power)
 - gas lift operation,
 - warm back in injectors
 - producers with a geothermal distinguishable inflow profile.
 - Permanent installed seismic
- Strong interest and development in the high temperature applications such as SAGD producers for heavy oil – progress appear to be steady
- New sensors and solutions still emerging and improving (no sign of the end ...)

Opportunities for distributed sensing

Generally for distributed sensors:

- For any light pulse traveling down a fiber a small fraction of light is backscattered
- Time of flight of returned signal gives position
- Overall length sets a limit to pulse repetition ratio and hence ultimate recording rate (e.g. 5 km 20 kHz)
- Generally noise is not biased, hence time resolution can be traded with precision (over a very wide range)

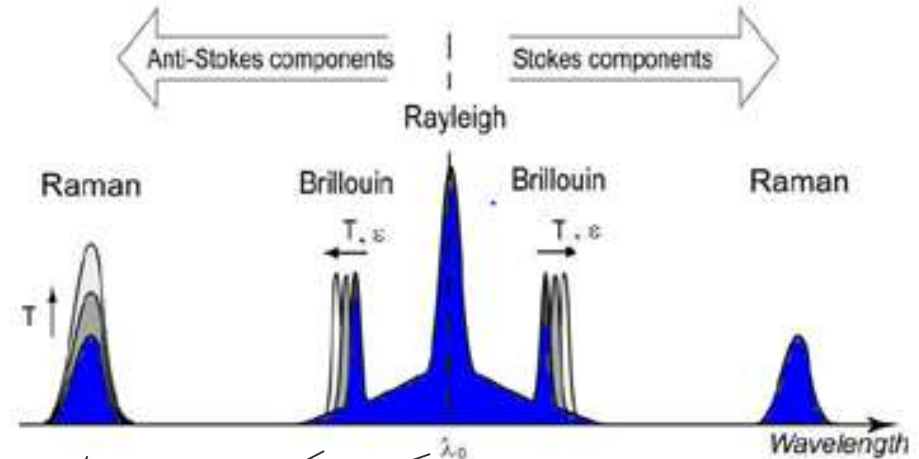
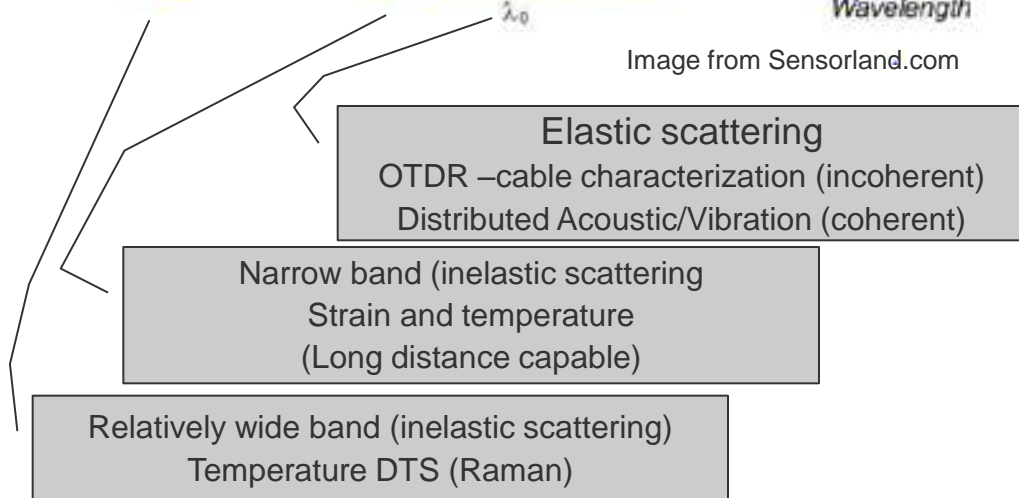


Image from Sensorland.com



Presentation of complex data – gas lift valve operation

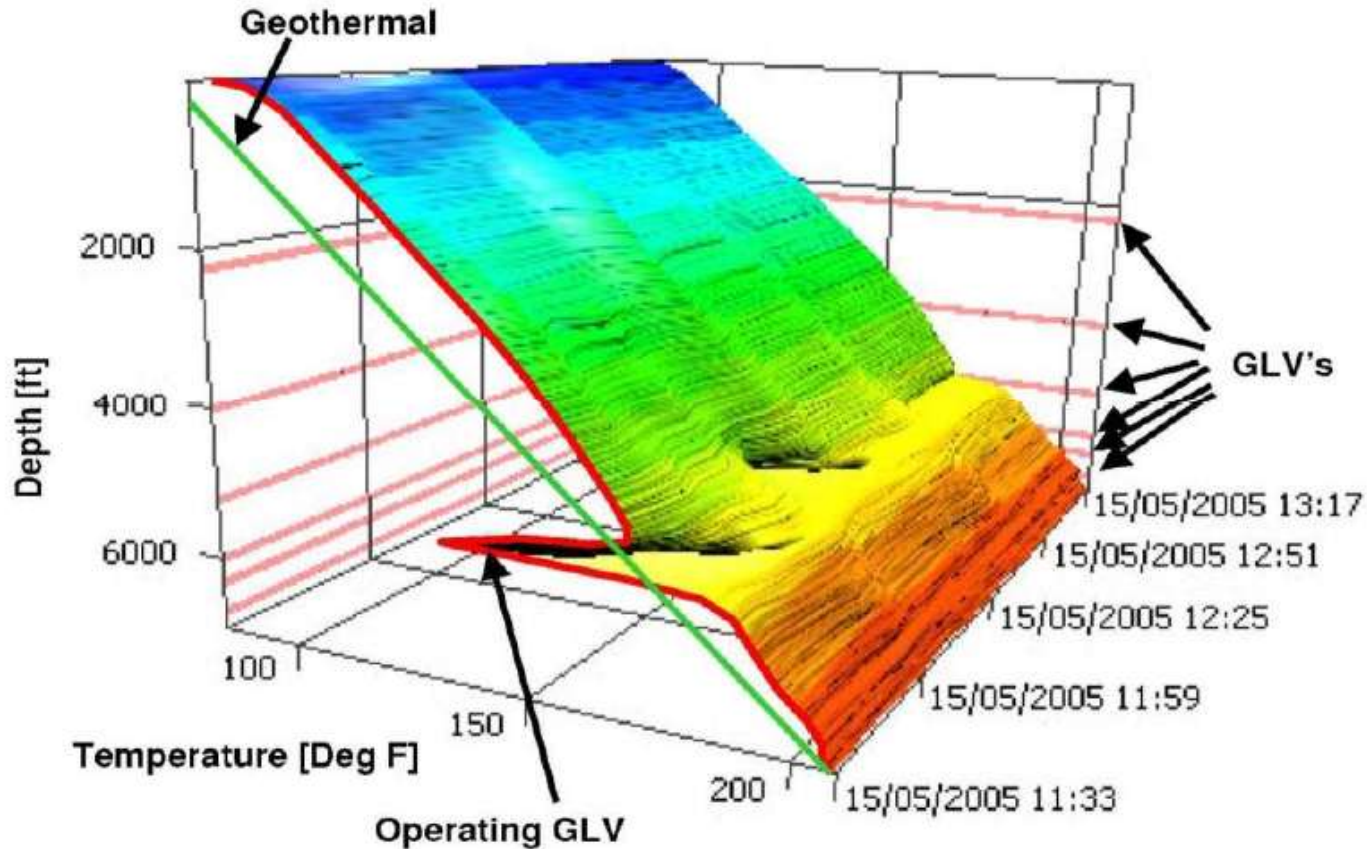


Image from Sensortran
AAPG/PTTC e-Symposium 09

Distributed Acoustics in a well - a new insight

- The equivalent of having thousands of microphones distributed along the length of a downhole cable.
- New possibility for being present at all locations at all time in the well. Novel instruments make use of advances in coherent detection techniques, fast electronics and signal processing.
 - Characterizing semi-stationary conditions
 - Capturing transient events
- (Next presentation will give more details of one such project)

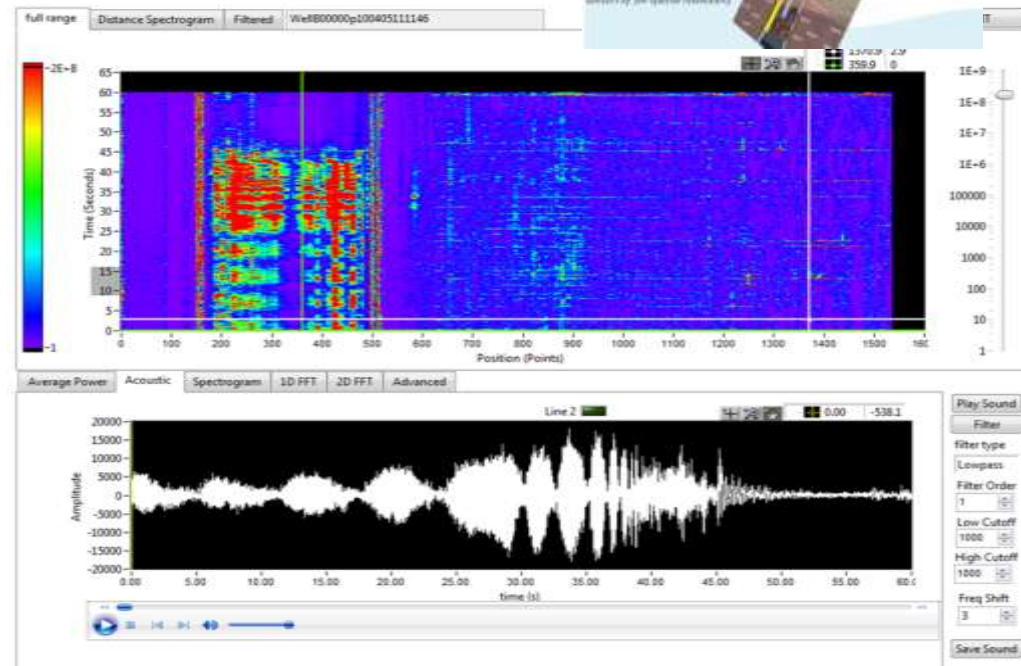
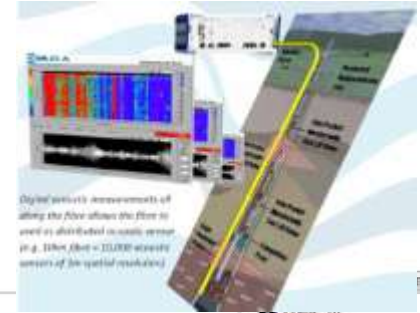


Image Silixa/Wetherford/Statoil

Conclusions

- Fiber is present in almost any project, and will be considered in almost any new project for the applications where the technology is proven
- Fiber in communication/control system
 - is more the rule than the exception
 - new ISO 13628-6 opens subsea to more high speed interfaces and flexibility
- Fiber in sensing
 - new sensing opportunities exist and still arise.
 - uptake is slow except where there is
 - a proven reliability advantage
 - a swift work process from sensor data to decision making
 - the subsea infrastructure will allow to take on new sensors (Statoil)

Thank you

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and Production Optimization

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