

Information Infrastructures: the oil and gas industry

EricM

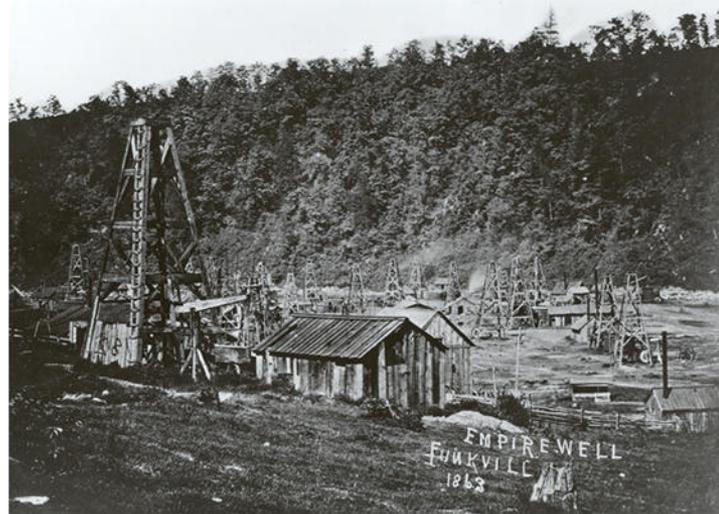
INF 3290, Sept, 2012

Significant sector economically

- **SPU**, about USD 600 billion (2012)
- "Handlingsregel" 4%
- Employment: **250.000**
- Directly + indirectly 40% of income ?
- **Innovation**, investments

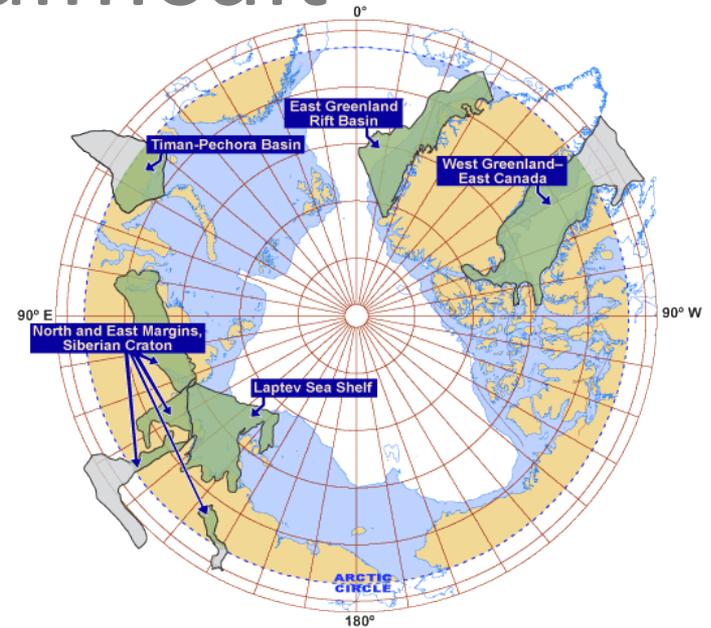
History

- Rough-necks
- "Just drill!"
- In **Norway**: the Americans
- **Knowledge**, capacity
 - Regulation
 - Institutions
- Theory & practice



Increasingly difficult

- Remote
- Politically sensitive
- Hostile **environment**
- Deep
- **High**-pressure/ temp



Specialisation: outsourcing

- Operators
- Rig owners
- Drilling
- Maintenance/
constructions
- Equipment
- Services
- Ex.: Schlumberger

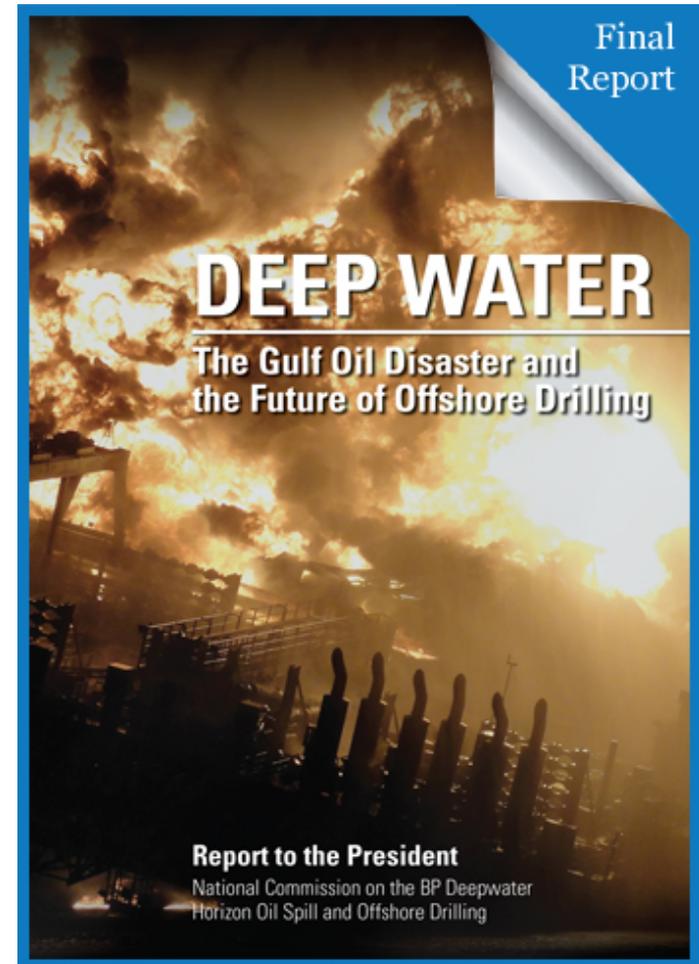
FMC



KONGSBERG

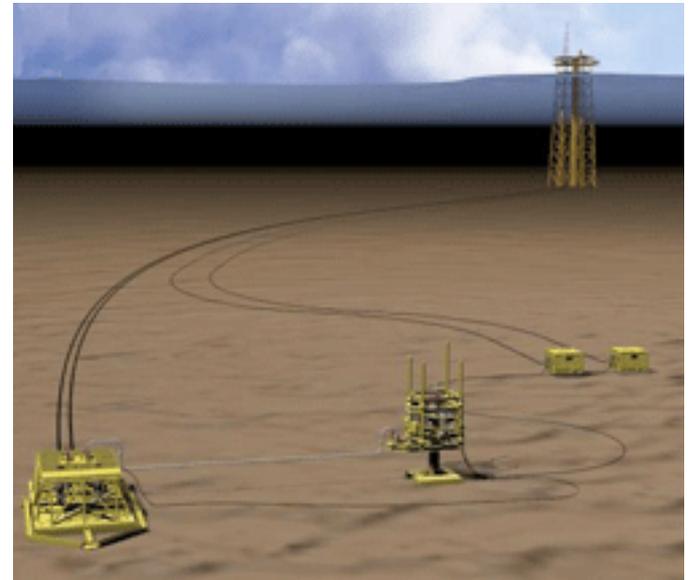
Deepwater Horizon

- Gulf of Mexico, April 2010
- Deep water/ high pressure
 - Water depth 1500m, well 10.000m, 6000 psi/400 bar
- "Every well is unique"
- Understanding **information**:
Transocean's email to BP
- "Gransking av gassutblåsning på **Snorre A**, brønn 34/7-P31 A"
28.11.2004, PTIL



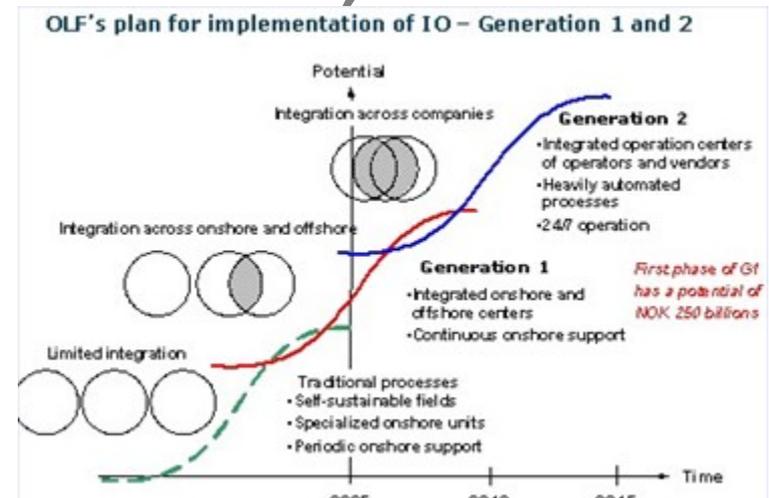
Subsea

- Unmanned
- **Sensors** (temp, pressure, resistency, radioactivity, vibration, composition)
- Not **sci-fi**: most rapid growth
- **Norway**: 50% production today
- Pressure for efficiency + innovation
- Knowledge-intensive/
Norway



Integrated operations, IO

- High expectations
- On vs. offshore
- Disciplines
 - Geologists
 - Geophysicists
 - Reservoir engineers
 - Production engineers
 - Production eng.
 - Well maintenance eng
- Assets
- Systems, an "ecology"



“More collaboration”

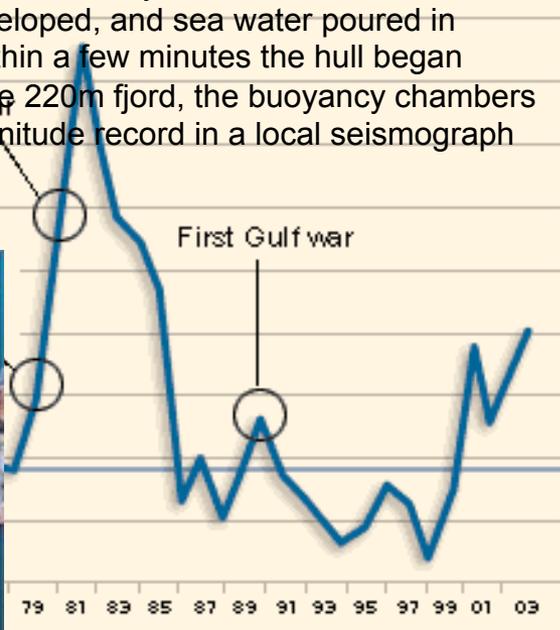
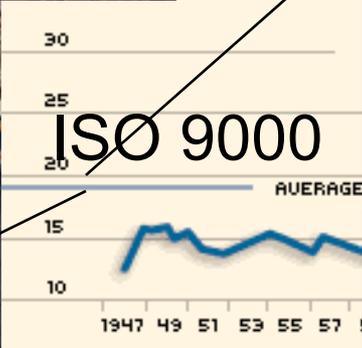
- Over time: experience sharing
- Over assets
- Traditionally: **local**
- Disciplines, systems



Ex.: Lotus Notes Statoil (1992-)

Oil and war Crude oil price per barrel in 1996 dollars. Source: WTRG Economics

As the hull was lowered to the 99m mark, rumbling noises were heard followed by the sound of water pouring in. The hull had failed and a serious crack had developed, and sea water poured in at a rate of 100 tonnes per minute. The crew used the deballasting pumps to deal with. Within a few minutes the hull began sinking. The structure sank deeper into the 220m fjord, the buoyancy chambers impacted the floor of the fjord creating a 3.0 magnitude record in a local seismograph.



1994

1996

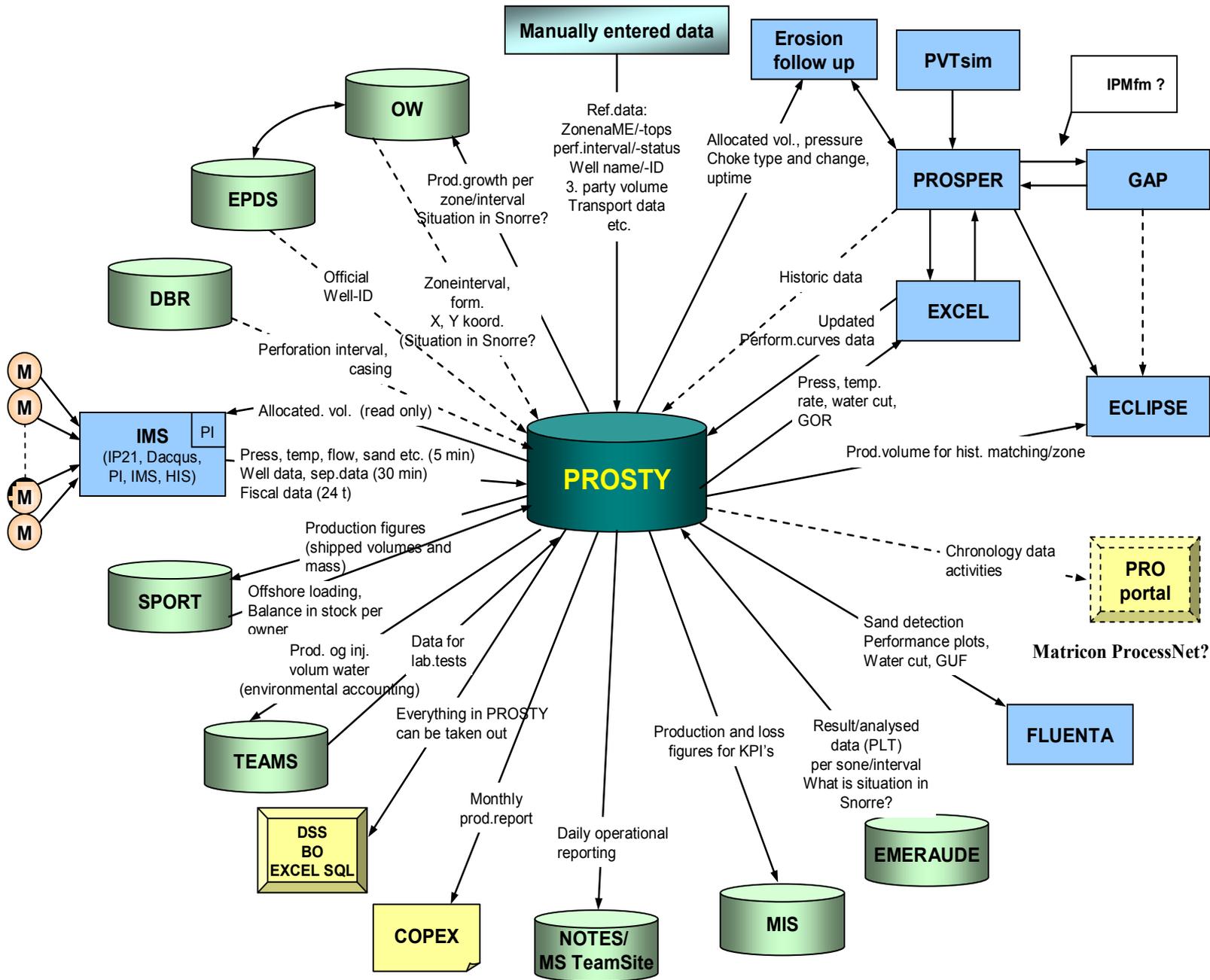
1998

MS Sharepoint (2002 -)

- LN: effective locally
 - But ‘out of control’ with estimated 5000 databases so locating relevant information stored outside your immediate project scope was non-trivial
- NYSE: Sarbanes-Oxley act (**SOX**) / Basel II, post-Enron
- MS Sharepoint: “out of the box”
- Unlike SAP/ BRA prosjektet (USD 300m)

Drowning in information

- Numerous systems
- Massive amounts of structured data
- Summaries in free text
- Historical knowledge
- **Excel!**



Unstructured data

Historic stratification

- **Index** to locate: age/ IT platform
- Partial but never complete transition between platforms
- **Legacy**

”If you didn’t follow the well from its inception, there is no way you can know where to find the information or what kind of information that is available. Thus, it is also impossible to just use the search engine”

“that’s how [referring to file servers] we were working onshore before we got Lotus Notes. It was so much information in use that we were not able to quit with it and fully migrate to LN. So this [file servers] lived further with LN. Later we got [LN Team sites]... and then file servers and **LN lived further because it was impossible to migrate with all the historical data we needed**. When you need it [the historical system(s)] you can always add some new information to it... **[smiling]**. So now you have file servers, Lotus Notes and MSP... when something new comes [after MSP], we will probably still keep those three old ones” [smiling] (manager responsible for operational support).

Well history

34/10-B-28, BRØNNHISTORIE

Opplyst 13.06.07

STATUS

Stokk	Internall and 928	Internall a170 928	IC-oppløst-brønn	Ajant	Støtt
Tidstid	4766 - 4820	1970-1983	100	Sydpole 1991	Nov 1994
Tidstid 10	4338 - 4433	1974-1975	100	Sydpole 1991	Sydpole 1991
Tidstid 11	4369 - 4463	1974-1975	100	Sydpole 1991	Sydpole 1991
Tidstid 14	4369 - 4463	1974-1975	100	Sydpole 1991	Sydpole 1991

INNLIEDNING

- Bøen- og kjepp- periode - 4.7.1993 - 17.8.1993
- Produksjonsstart - 02.10.1993
- Formål - Produksjon i Taburet og Nese, Segment H6
- Resultat - B-28 er boret i segment H6 og presterer Nese og Taburet. Ytelse kn gjennom reservoaret er fra 527 til 1007. Bønen og grusen fra Kitt til gjenne. Bøen Kitt gjennom i bønen i sønerve med program. Bøen Kitt har TD kom inn 10 m grusen programet

PRODUKSJON

- Eksper Ved 2



Sarepta Arena

34/10-B-28, BRØNNHISTORIE

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- Eksper Ved 2



Document Library - Microsoft Internet Explorer provided by StatoilHydro

StatollHydro

Document Library

Item Name	Status	Modified By	Activity	Category	Event Date
NOS oppfølging	Done	15.01.2007	Knut Måren	Production management	20.08.2007
Gulstørnsvet	Done	15.01.2007	Knut Måren	Production management	20.08.2007
2007 program resultat og avvik	Done	15.01.2007	Knut Måren	Production management	05.08.2007
Faktor (SD) betaler i SAP	Done	15.01.2007	Knut Måren	Production management	10.05.2007
Forside N-3-345-05	Final	15.01.2007	Knut Måren	Production management	15.01.2008
Procedure for quality check of MMs to IS	Done	15.01.2007	Erik Aspenes	Production management	12.09.2007
Partskjermer kortlager zoner	Done	15.01.2007	Erik Aspenes	Production management	11.01.2008
N34H prosessjon for oppfølging	Done	15.01.2007	Knut Måren	Production management	02.05.2007
CFSA1 Prosjekt 2006	Done	23.01.2007	Arne-Henrik Fagstad	Production management	15.01.2008
MAANNT_Lite_2007	Done	24.01.2007	Knut Måren	Production management	28.03.2007
Diagnose - Oppfølging av N-34H	Done	30.01.2007	Knut Måren	Production management	15.01.2008
SDT av N-34H etter lønng forelegg	Done	08.02.2007	Knut Måren	Production management	08.01.2008
N34H prosessjon etter forelegg	Done	22.02.2007	Knut Måren	Production management	02.05.2007
Oppfølging av brenn N-34H	Final	21.02.2007	Knut Måren	Production management	20.02.2007
Beregning av innstrømskrav ved oppfølging av SDT	Done	24.02.2007	Knut Måren	Production management	23.01.2008
N34H prosessjon_mms_2007_wv2	Done	25.02.2007	Knut Måren	Production management	02.05.2007
N-34H oppfølging	Done	05.03.2007	Knut Måren	Production management	15.01.2008

Shared disk

Lotus Notes

Sharepoint

”We develop a increased understanding of how wells interact through the production history. The key is to see the wells together since the optimization of one well might lead to loss of overall production given the right circumstances. When doing this evaluation and analysis work we juggle between parameters; temperature, pressure, water production, production rates, gas and availability of equipment in the offshore process plant.”

History & overview

“Over the time it becomes difficult to have overview... especially with oldest documents [which are by default in the end of the list]. There are 160 documents now [in a team site library] and this well is only halfway finished. In addition, you have documents in workspaces [user shows number of workspaces on the screen]. Sometimes documents are duplicated [in team site library and workspaces, but sometimes you find them only in one place. It would be possible to have everything in one place, but **people do not want to miss overview over documents** e.g. related to Recommendation to Drill) process so they create a workspace. So if you have used particular TS a lot you can find information, because you know what to look for... but very often you have to go and ask people where things are stored...” (Drilling engineer;

History

- Biography of wells
- Mature fields, decades
- Different IT platforms
- Ex.: Gullfaks A

The screenshot displays a Windows desktop environment. The top window is a file explorer showing a folder named '34-10-B-28, BRØNNHISTORIE'. It contains a document titled 'Oppsett 13.06.07' and a table with columns: 'Sone', 'Interval', 'Interval', 'Kontroll', 'Åpnet', and 'Slengt'. Below the table is a search bar and a list of documents with columns: 'Tittel', 'Ansvarlig', 'Følt/Endet', 'Status/Dokumenttype', and 'År'. The second window is a 'Document Library' for 'Gullfaks Site Production Management'. It shows a table of documents with columns: 'Type Name', 'Status', 'Modified', 'Mounted By', 'Activity', 'Category', and 'Scan Date'. The third window is a table titled 'Start dato' with columns 'Start dato' and 'Operasjon'. The table lists dates from 17.03.2002 to 02.05.2005 and corresponding operations like 'Oppbløsing', 'brønntest', 'vanngjennom', 'Støvsprøving', and 'Vannprøve fra på Drammen'.

Sone	Interval	Interval	Kontroll	Åpnet	Slengt
Sone 3	4760 - 4800	1070/1080	300	19.06.07	12.04.04
Sone 18	4380 - 4430	1070/1072	200	12.04.04	12.04.04

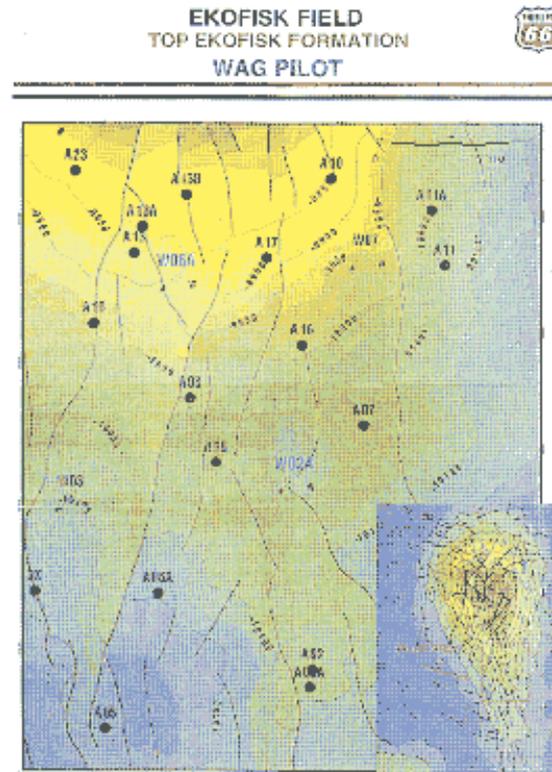
Tittel	Ansvarlig	Følt/Endet	Status/Dokumenttype	År
DI-AV444 TILGIFASE BRØNNPLANLEGGING (TF ERLEND ELDHOLM	INGE HARALD AULIE	01.01.2010	INHT PLAN	
DI-B-01 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-B-24 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-B-30 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-01 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-02 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-03 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-04 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-05 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-06 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-07 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-08 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-09 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-10 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-11 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-12 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-13 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-14 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-15 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-16 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-17 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-18 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-19 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-20 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-21 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-22 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-23 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-24 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-25 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-26 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-27 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-28 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-29 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	
DI-C-30 BRØNN-ANLEGGSDATA	INGE HARALD AULIE	01.01.2008	INHT PLAN	

Type Name	Status	Modified	Mounted By	Activity	Category	Scan Date
MOS oppsettning	Draft	15.01.2007	Hård Hålen	Production management	Production equipment/Process	20.05.2007
Gullfaks-04	Draft	15.01.2007	Hård Hålen	Production management	Production profile and forecast	28.12.2007
2007prognose resultat og avvik	Draft	15.01.2007	Hård Hålen	Production management	Well information	09.09.2007
Fatvær OSD vester SAP	Draft	15.01.2007	Hård Hålen	Production management	Well information	10.05.2007
Prosjekt N-3-24-01	Final	15.01.2007	Hård Hålen	Production management	Pressure data	15.01.2008
Procedure for quality check of H&M TS	Draft	18.01.2007	ERK Aspenes	Production management	Production allocation	12.09.2007
Perforerings kontrollrapport	Draft	18.01.2007	ERK Aspenes	Production management	Production data analysis	11.01.2008
N3M_presentation for oppsettning	Draft	19.01.2007	Hård Hålen	Well information	Well information	02.05.2007
OF&T prosjekt 2006	Draft	23.01.2007	Ayn-w@gh	Production management	Production history	15.01.2008
N3M_L1M_2007	Draft	24.01.2007	Hård Hålen	Production management	Well information	28.03.2007
Dagrapport - Oppsettning av N-34H	Draft	30.01.2007	Hård Hålen	Production management	Well information	14.01.2008
S&T av N-3-24H etter boring forløp	Draft	08.02.2007	Hård Hålen	Production management	Well information	08.01.2008
N3M_presentation etter oppsettning	Draft	22.02.2007	Hård Hålen	Production management	Well information	02.05.2007
Oppsett av brønn N-34H	Final	23.02.2007	Hård Hålen	Production management	Well information	20.02.2007
Begring av brønn N-34H ved oppsettning_21.04.07	Draft	24.02.2007	Hård Hålen	Production management	Production management	23.01.2008
N3M_presentation_well_2007_ym2	Draft	25.02.2007	Hård Hålen	Production management	Well information	02.05.2007
N-34H_oppsettning	Draft	05.03.2007	Hård Hålen	Production	Data acquisition / purchase	15.01.2008

Start dato	Operasjon
17.03.2002	Oppbløsing
23.04.2002	
23.05.2003	brønntest
29.09.2004	vanngjennom
04.04.2005	Støvsprøving
02.05.2005	Vannprøve fra på Drammen

Ex: Well planning

“To use reservoir models for well planning is very dangerous!...You look at the model, but also all the other data you have: other wells in the area, you look at the seismic, you look at recent data not included in the model. You have a whole portfolio of data you use”



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Heterogeneity, local variation

“The reason why we spend so much time searching for previous experience is to assess whether it is at all possible to conduct a specific intervention. Earlier experience could indicate specific failures that would prohibit us from doing an intervention. Rather than discovering this when we are onboard the vessel, we find this 1 or 2 months before the operation. For instance, recently we discovered that the control system on the x-mas tree [equipment installed on the sea floor, cf. Figure 3] was not compatible with our equipment.” (LWI engineer)



Local (cont' ed)

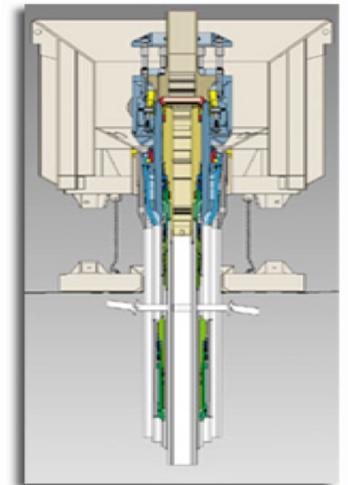
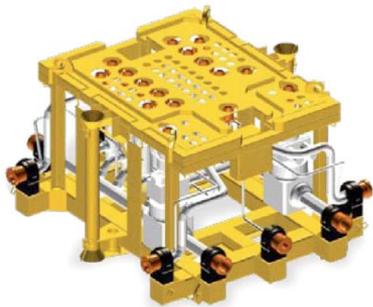
“Every well is unique”

“You need to know the personality of the well”

“There is no plug & play possibilities [across vendors of subsea equipment]”

“The technical complexity of subsea equipment is challenging”

“I call the vendor for technical details [of equipment]”



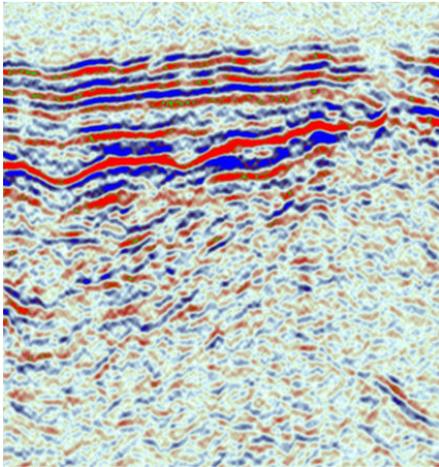
Analogues



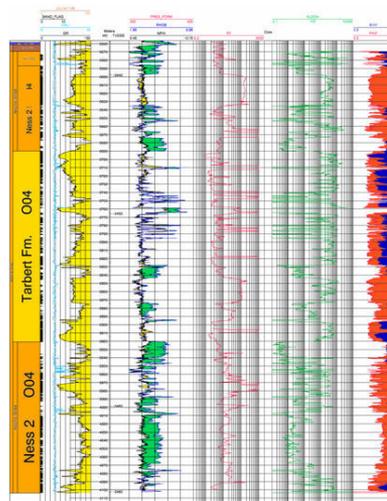
Double-check

“All of us should be aware that information in [name of the system] is not always correct. Preferably, **it should be double-checked and compared with other sources for instance [name of the system]**. For example information about equipment can be slightly wrong... for instance wrong diameter... it is critical for us to have correct information as we will have to put equipment in the well.” (well engineer)

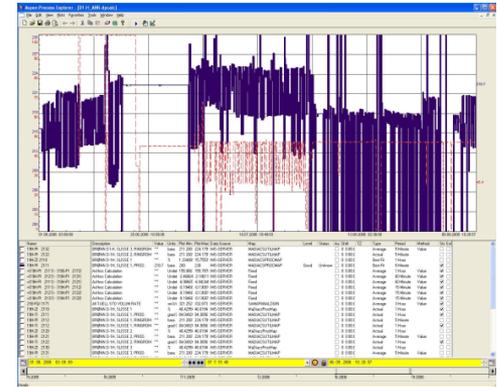
3 sources of information



Seismic
(accoustic)



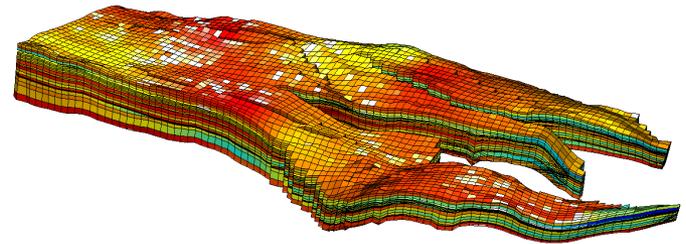
Well logs
(resistency, gamma-radiation)



Production data
(temperature, pressure)

Working with reservoir models

- Abstractions...
- ... but necessary
- Static: geology model
- **Dynamic**: reservoir model
- Computationally challenging
- Feedback: history matching



Interpolate. Interconnected

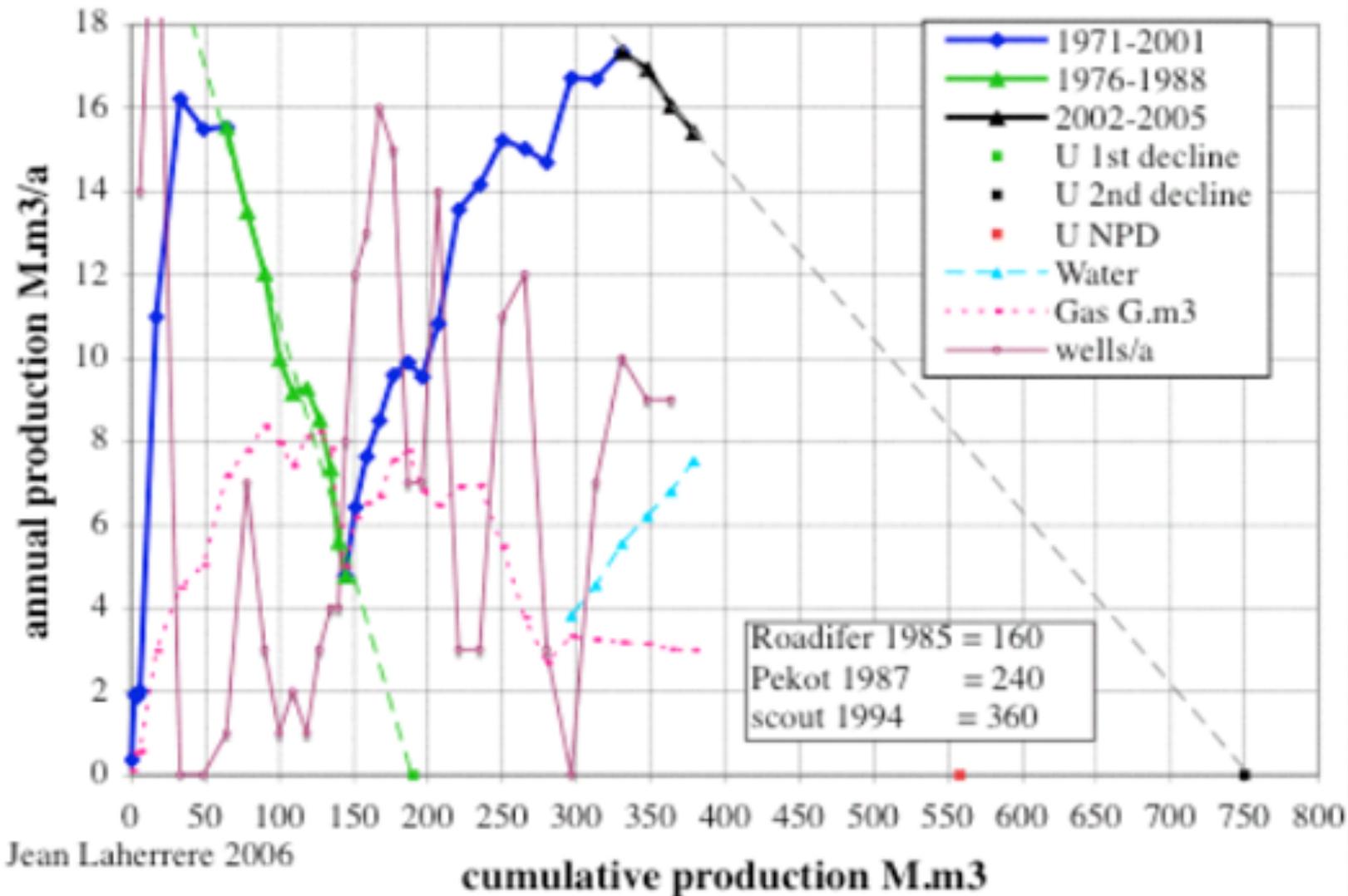
“Obviously, if you have three wells they’re going to tell you a lot about the vertical [well paths]. So you have at least the understanding of the vertical sense of the layers and you can build your sedimentological understanding... You have three wells and ... **you try to interpolate between those wells** with your information and then you try to extrapolate away from those wells into areas that are further away. And then with the help of the seismic, you try to calibrate and use the seismic to help you, and then come up with some sort of feeling about whether, you know, how much reservoir you’ve actually captured with the data you have?”

“[Then] we have to figure out, how the heck are we going to update this monster? Because, **if you start fiddling with two wells, then you do something with the rest as well.**”

Pragmatism

“[I]f we can do history matching that is the best. Because then you learn something about the flooding processes in the reservoir, in the process. **But that doesn't mean that you should use the model afterwards [laughs].** It is the understanding, the understanding of the reservoir, which is important to gain from it. And if you have that, then a good engineer will be able to work intuitively with the model he has in his head and be able to do much of his work”

Ekofisk (Norway) oil decline 1971-2005



Jean Laherrere 2006

History matching (Ekofisk)

History matching:

“Permeability changes over time, due to compacting [of the chalk]. I have never seen it before. We are at the limit of the [reservoir simulation] software’s ability which is designed for constant permeability”

“[There is] accumulated critique from the compacting of the reservoir! We have adjusted a lot, by inserting parameters. But we have not done it properly in the [static] physical model”



Conclusion

- Installed base: old system, old routines
- Integration – **sociotechnical!**
- Simplifications/models – but relative to **purpose**
- **Never** the **same**. But interesting degrees of similarity?
- Trustworthy, robust (enough) knowledge: **triangulate**