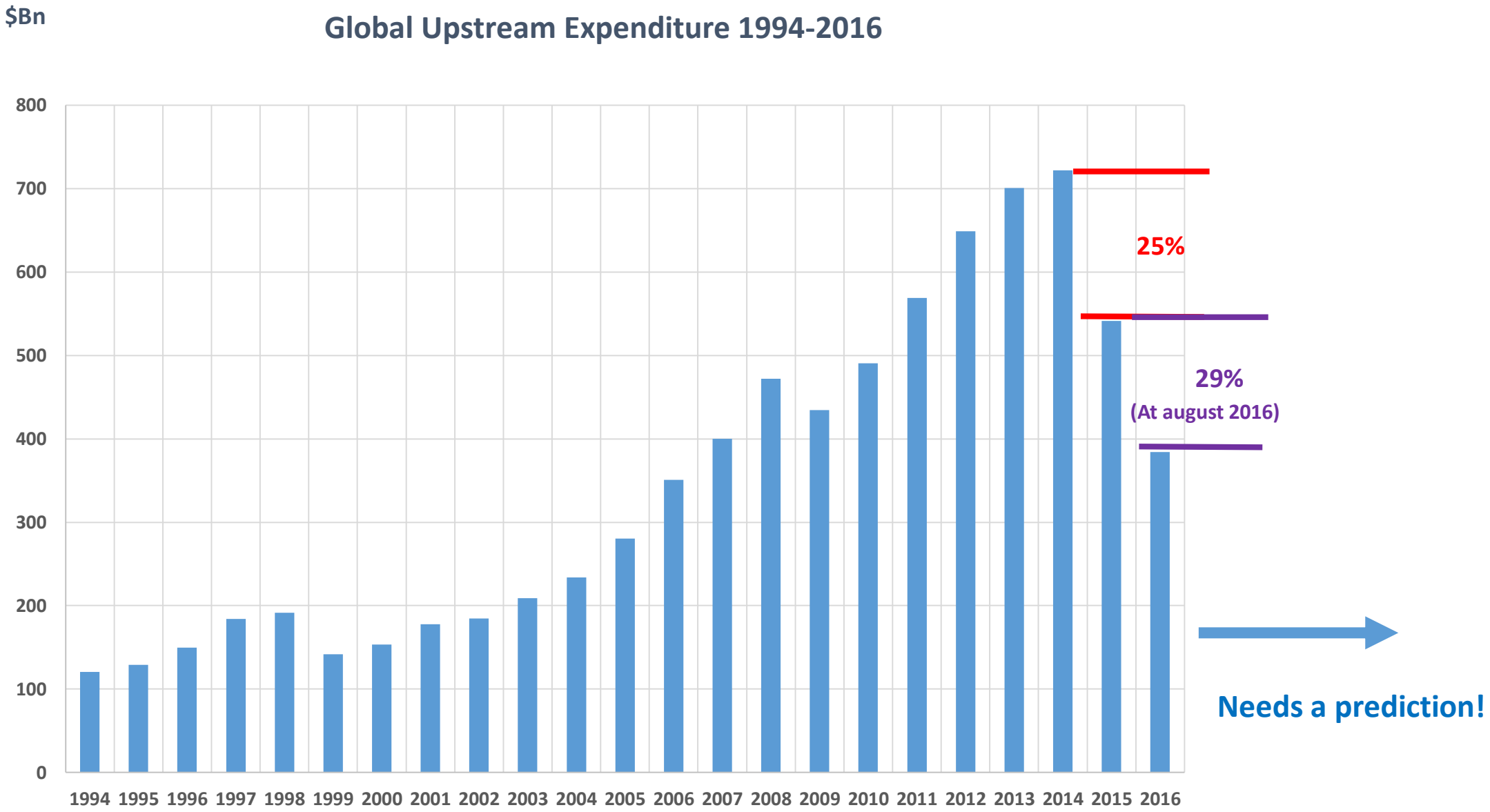
E&P Downturns and Upturns

1986 re-visited

and a prediction for the future

Ian Jack

September 2016

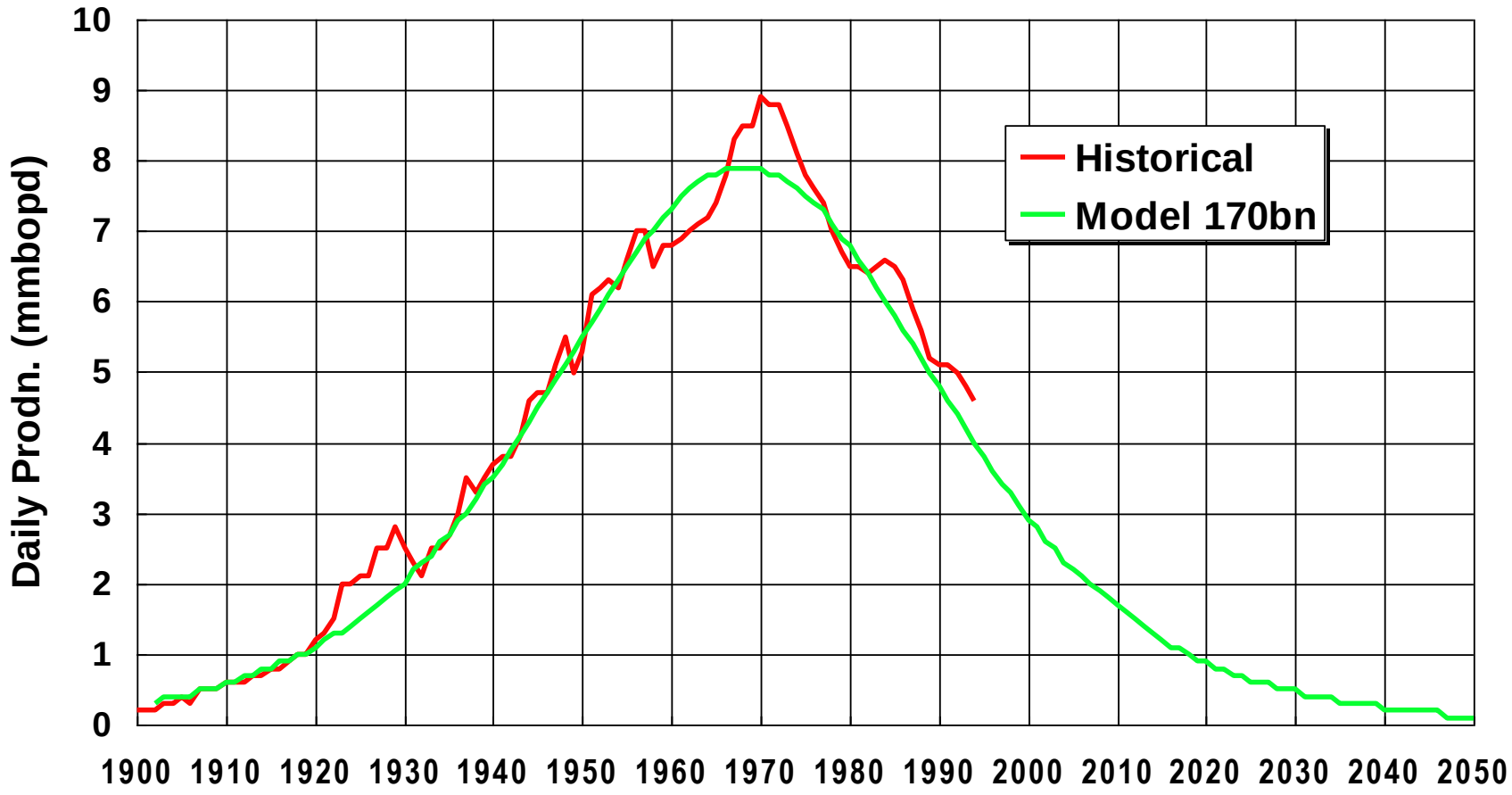


Not inflation adjusted

Sources: EIA, TGS, SEB Research. Includes property acquisition, production expense, Exploration & Development expenditure

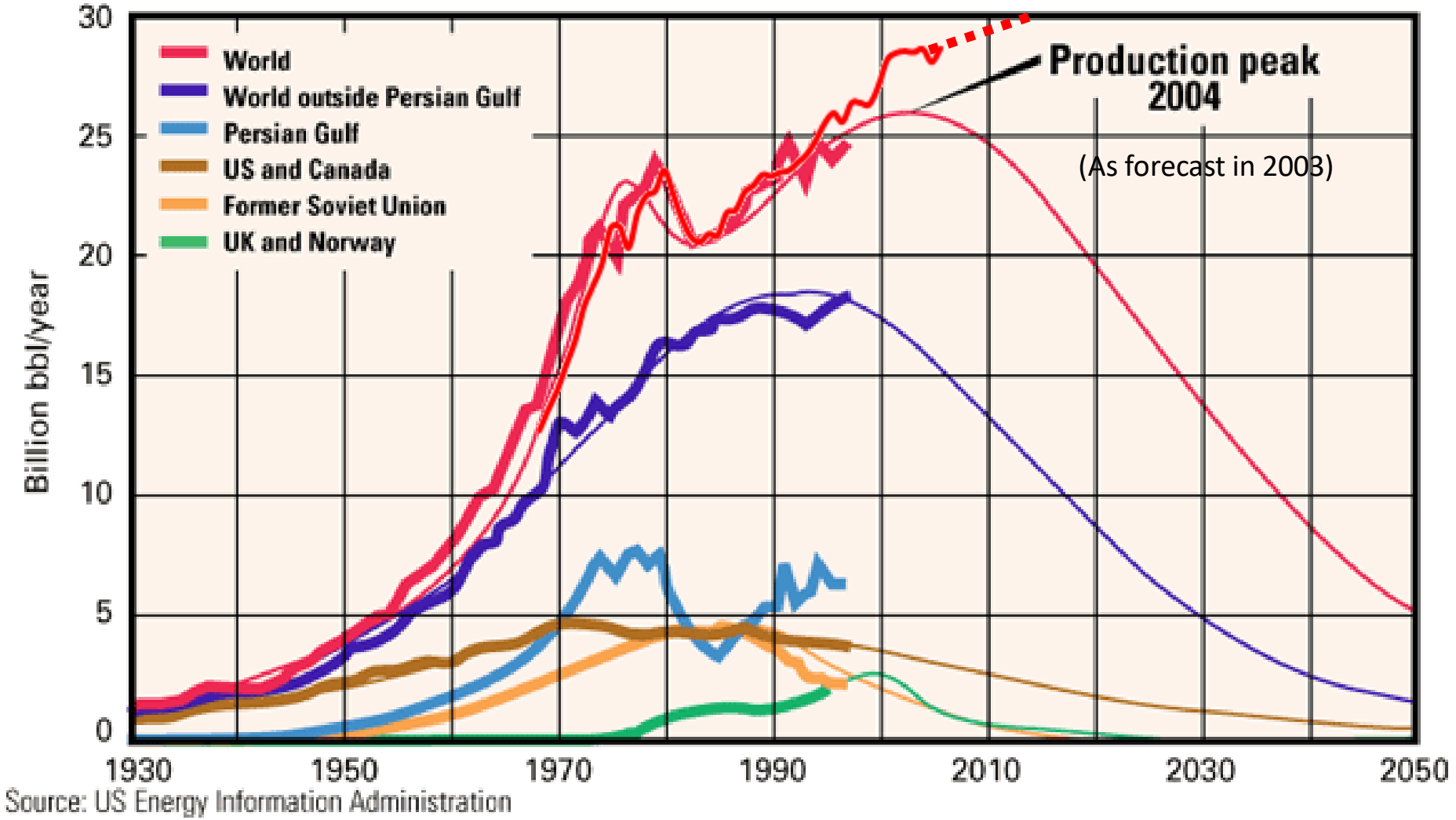
- Making predictions in the oil business
- What the major predictors predict for 2040
- Apply some perspective
- A look at the previous Big Downturn, 1986
- **A prediction !**
- What happens after a downturn

Lower 48 Oil Production to 1994



Global Production forecast

(Campbell-Laherrère 2003)



Oil & Gas Journal, July 14 2003

THE TIMES

The Times
January 18, 2008

World not running out of oil, say experts

Carl Mortished, World Business Editor

Doom-laden forecasts that world oil supplies are poised to fall off the edge of a cliff are wide of the mark, according to leading oil industry experts who gave warning that human factors, not geology, will drive the oil market.

A landmark study of more than 800 oilfields by Cambridge Energy Research Associates (Cera) has concluded that rates of decline are only 4.5 per cent a year, almost half the rate previously believed, leading the consultancy to conclude that oil output will continue to rise over the next decade.

THE TIMES

From The Times
January 25, 2008

Shell chief fears oil shortage in seven years

Carl Mortished, World Business Editor

World demand for oil and gas will outstrip supply within seven years, according to Royal Dutch Shell.

The oil multinational is predicting that conventional supplies will not keep pace with soaring population growth and the rapid pace of economic development.

Jeroen van der Veer, Shell's chief executive, said in an e-mail to the company's staff this week that output of conventional oil and gas was close to peaking. He wrote: "Shell estimates that after 2015 supplies of easy-to-access oil and gas will no longer keep up with demand."

THE TIMES

June 8 2016

Shell slashes spending and warns cuts will continue

Robin Pagnamenta, Energy Editor

June 8 2016, 12:01am, The Times

Ben van Beurden, chief executive, said the company was prepared for a scenario in which oil prices remain "lower forever"

Royal Dutch Shell announced plans yesterday to leave up to ten countries and cut billions of dollars in spending as it presses ahead with its £35 billion takeover of BG Group in the face of sharply lower oil prices.

Oil Prices Lower Forever? Hard Times In A Failing Global Economy

FRIDAY, JULY 15, 2016

Art Berman

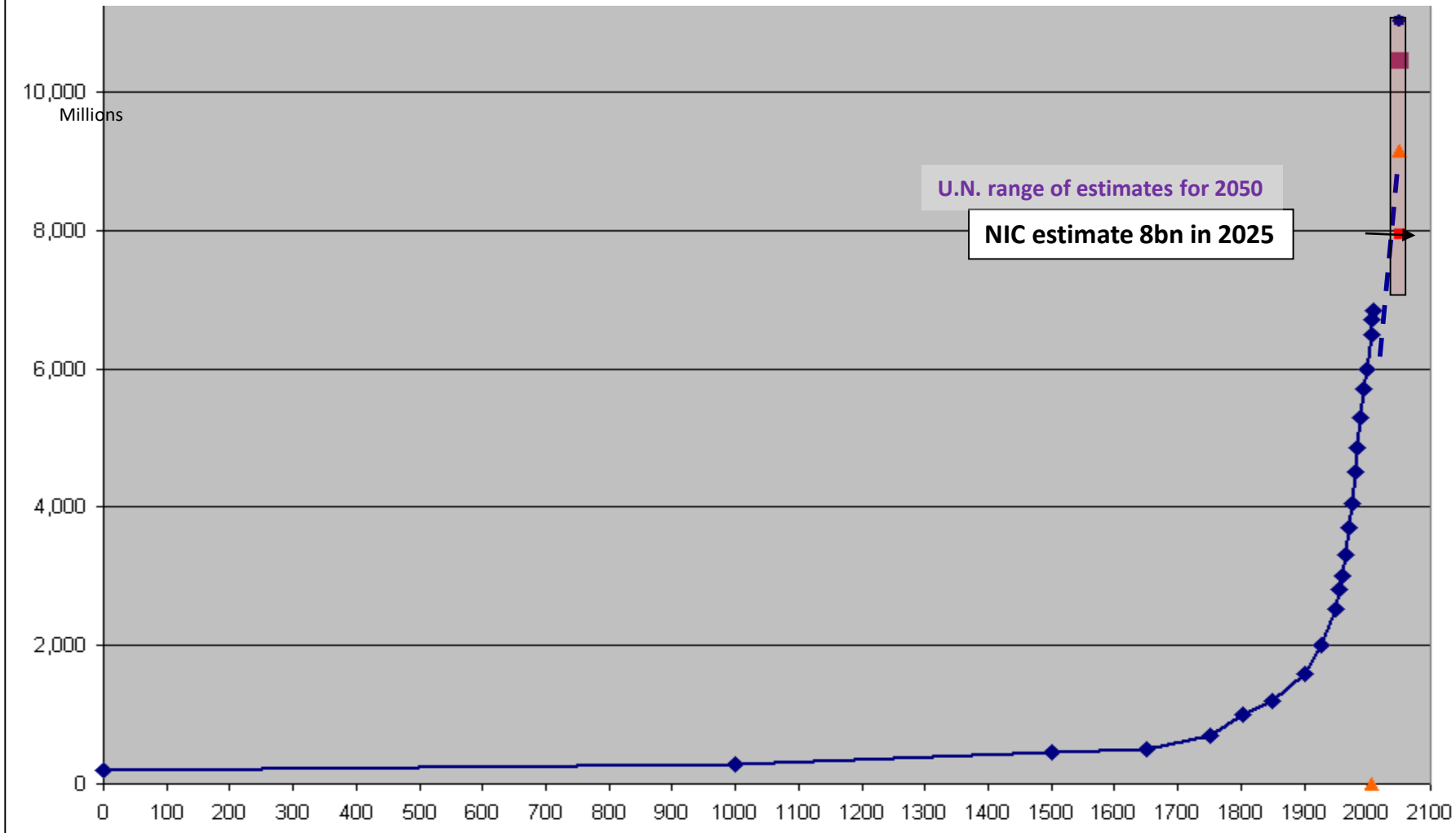
from The Petroleum Truth Report

More articles by this author

Original article

Two years into the global oil-price collapse, it seems unlikely that prices will return to sustained levels above $70 per barrel any time soon or perhaps, ever. That is because the global economy is exhausted. **OUCH!**

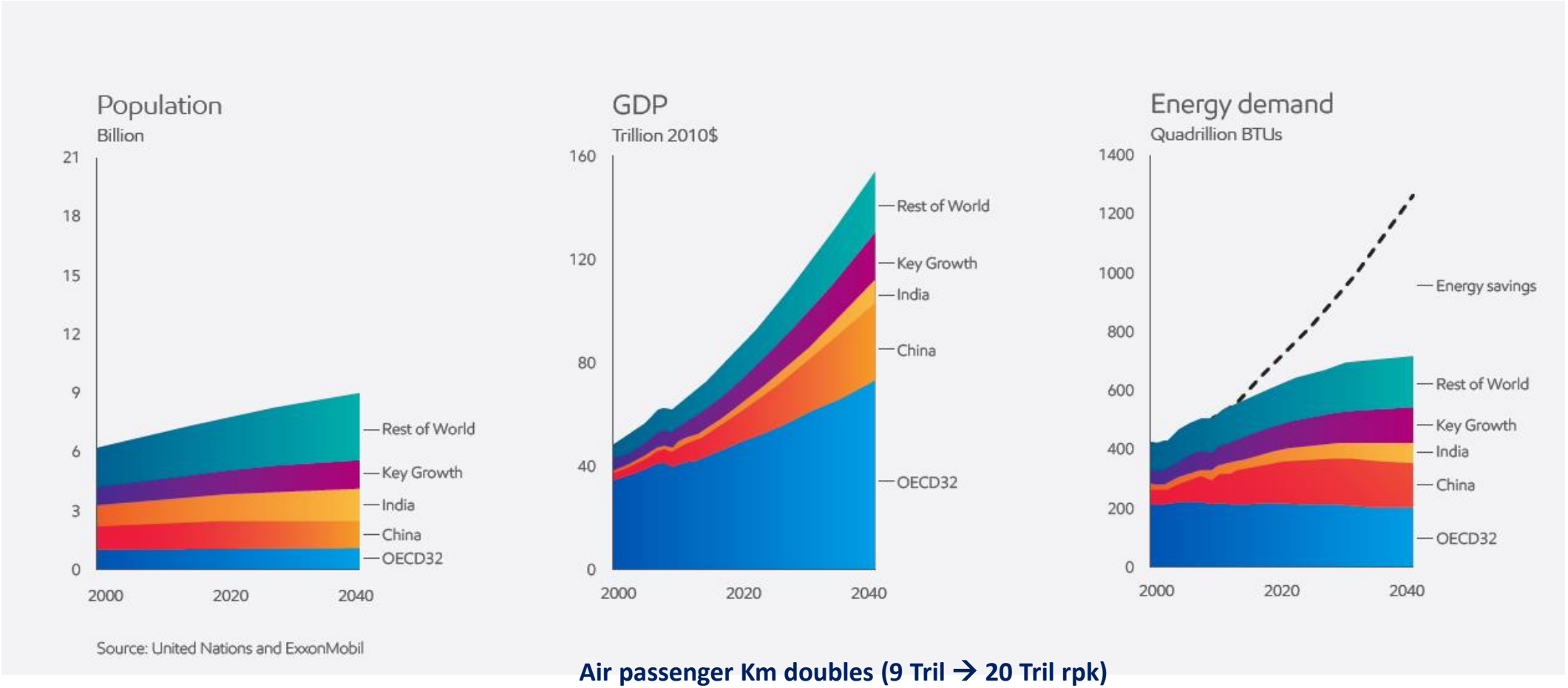
World population estimates, AD1 - AD2016, and projections



Sources: Population Reference Bureau, United Nations, NIC, World Bank

Searching for the bigger picture – the main drivers for oil & gas consumption

World population, GDP, and Energy demand

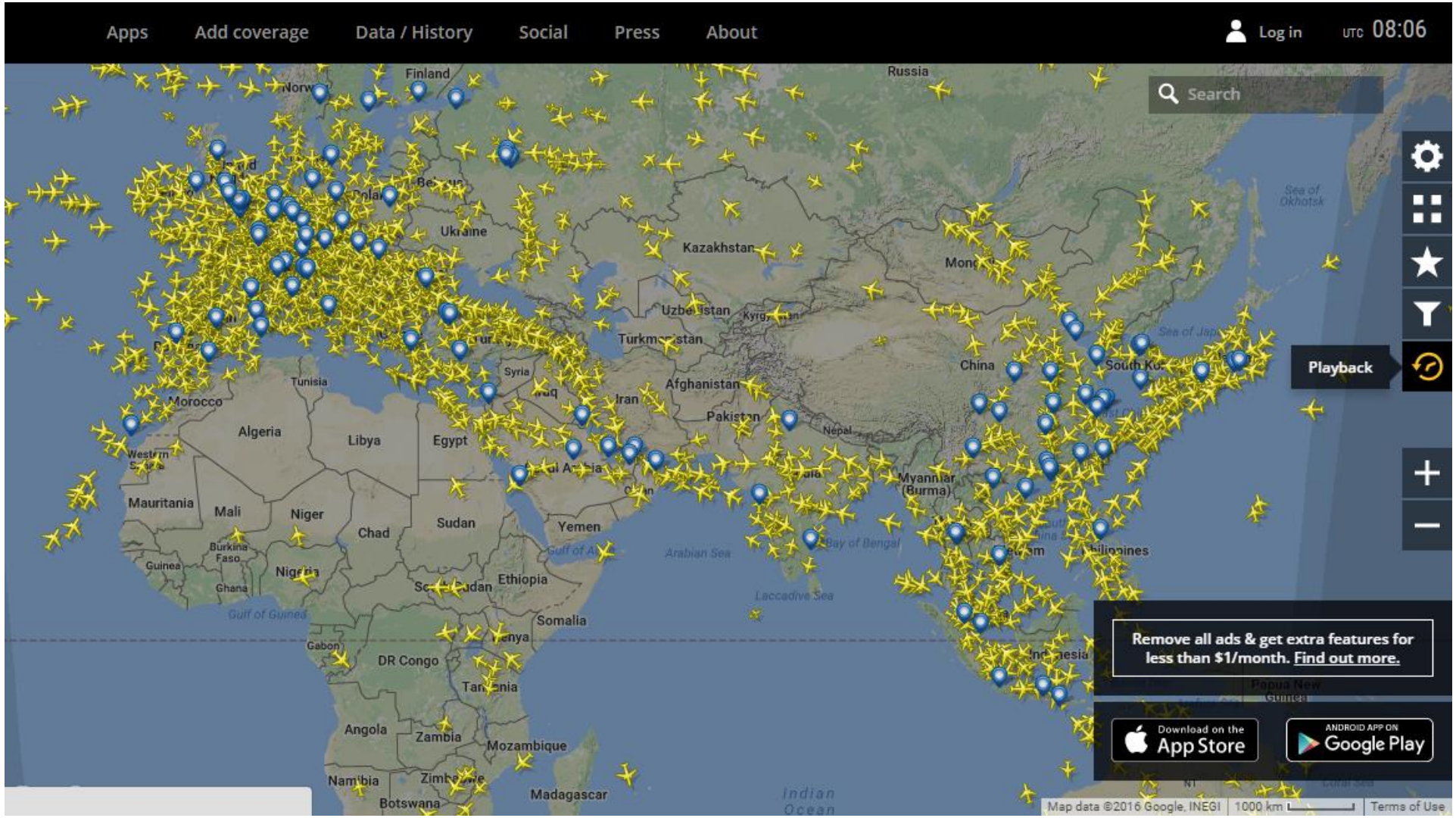


Air passenger Km doubles (9 Tril → 20 Tril rpk)
No. of cars doubles (1.1Bn → 2Bn)
No. of trucks doubles (377mm → 790mm)
Seaborne trade doubles (54 → 116 TrTonMiles)
(Bernstein, 2016)

Source: "The outlook for energy – a view to 2040" ExxonMobil 2015

ExxonMobil
Taking on the world's toughest energy challenges.

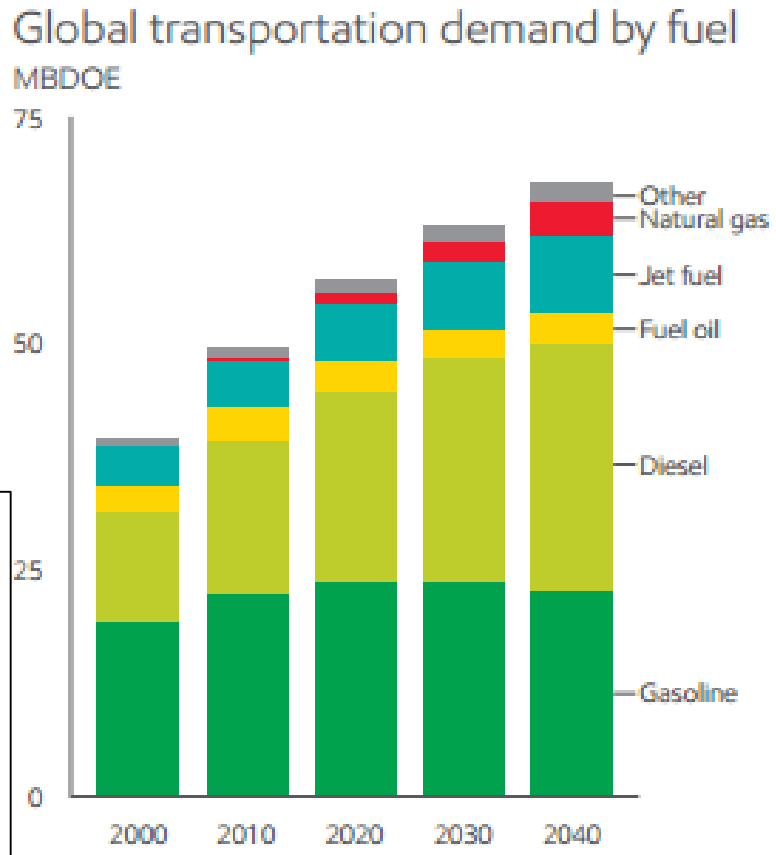
Flights airborne at 08:06 GMT 9 September 2016



Oil will remain the world's primary fuel

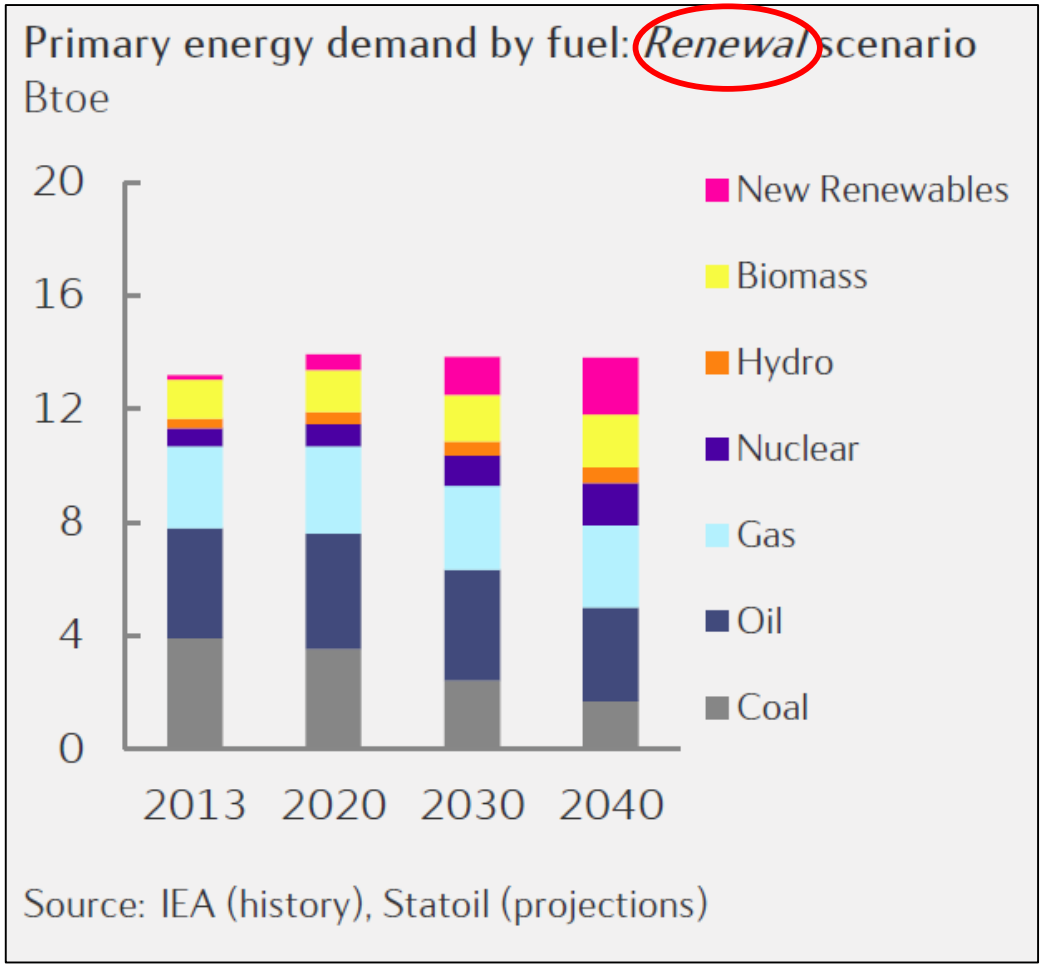
We expect oil to continue to be the world's leading fuel, driven by demand for transportation fuels and by the chemical industry, where oil provides the feedstock to make plastics and other advanced materials.

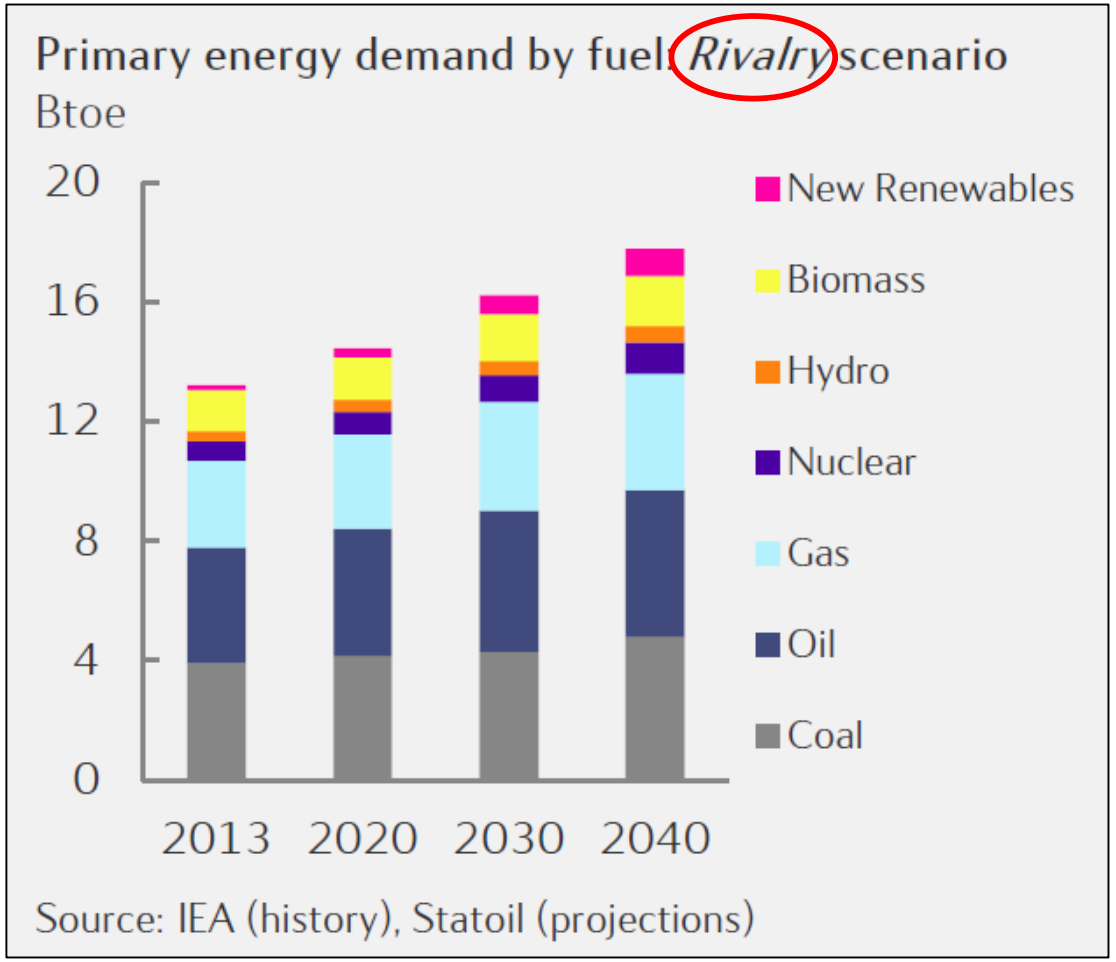
- Close to 95 percent of current transportation energy needs are met by oil
- Gasoline demand flattens as vehicle fuel economy improves rapidly
- Demand for diesel grows 45 percent 2014-2040 as truck and marine needs expand
- Jet fuel demand to rise by 55 percent as air travel keeps increasing worldwide
- Natural gas grows as a transport fuel, mainly for commercial fleets



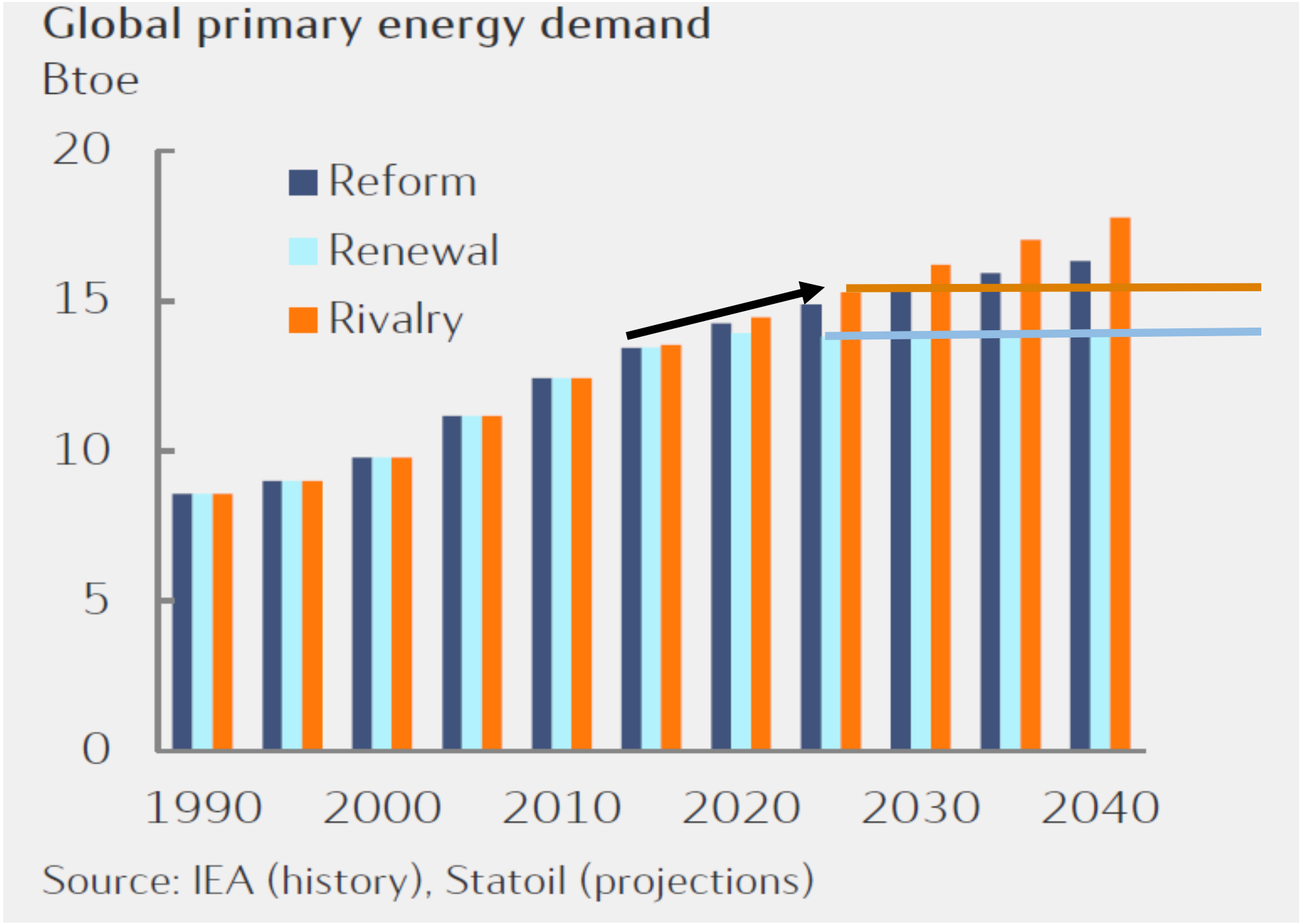
Source: "The outlook for energy – a view to 2040" ExxonMobil 2016

Statoil's forecast
Primary Energy Demand by Fuel Type
....with different scenarios





(Source: Statoil, Energy Perspectives 2016)


Global primary energy demand
Btoe
20
15
10
5
0
Reform
Renewal
Rivalry
1990
2000
2010
2020
2030
2040
Source: IEA (history), Statoil (projections)

The EIA's forecast (May 2016)

Key findings in the IEO2016 Reference case

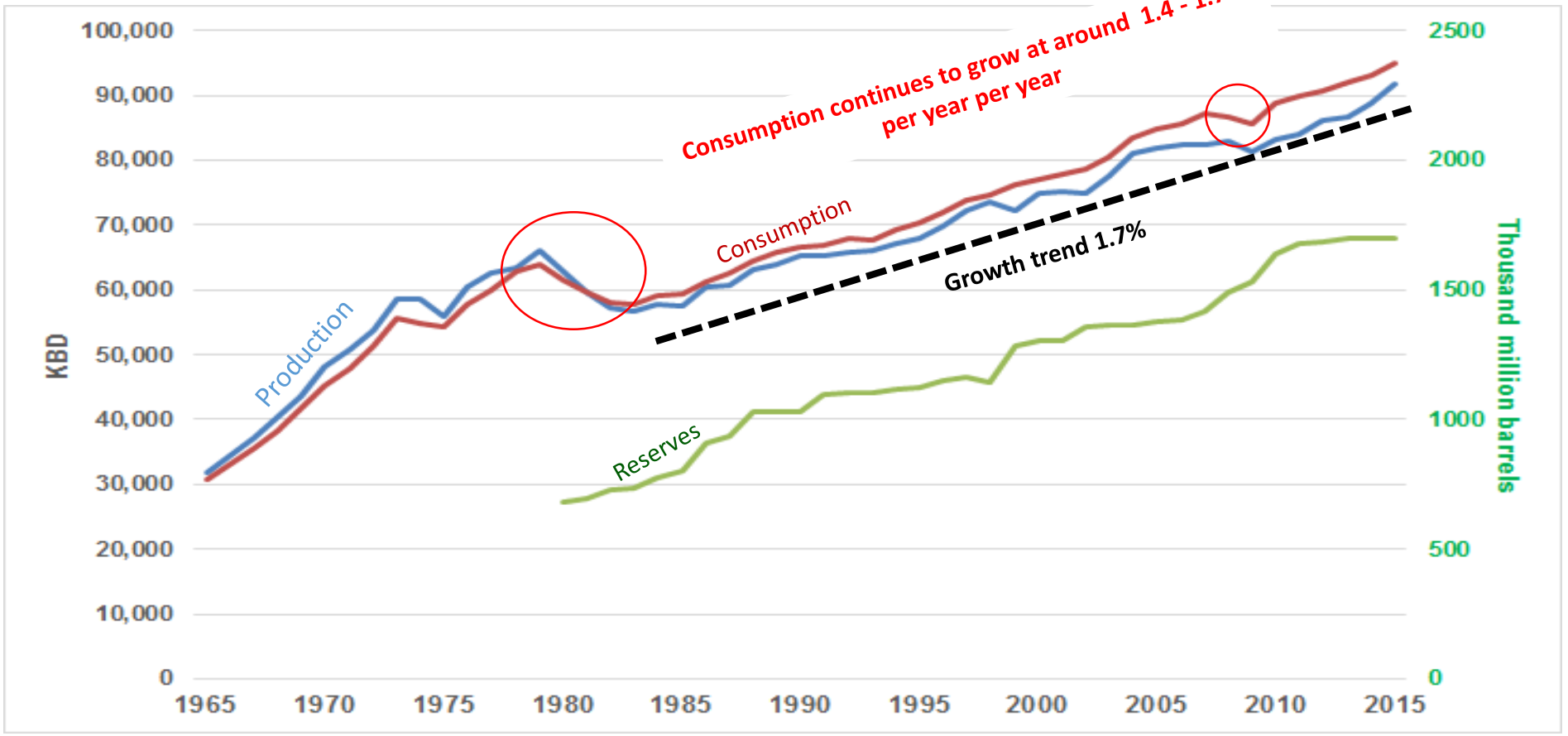
- World energy consumption increases from 549 quadrillion Btu in 2012 to 629 quadrillion Btu in 2020 and then to 815 quadrillion Btu in 2040, a 48% increase (1.4%/year). Non-OECD Asia (including China and India) account for more than half of the increase.

- The industrial sector continues to account for the largest share of delivered energy consumption; the world industrial sector still consumes over half of global delivered energy in 2040.

- Renewable energy is the world's fastest-growing energy source, increasing by 2.6%/year; nuclear energy grows by 2.3%/year, from 4% of the global total in 2012 to 6% in 2040.

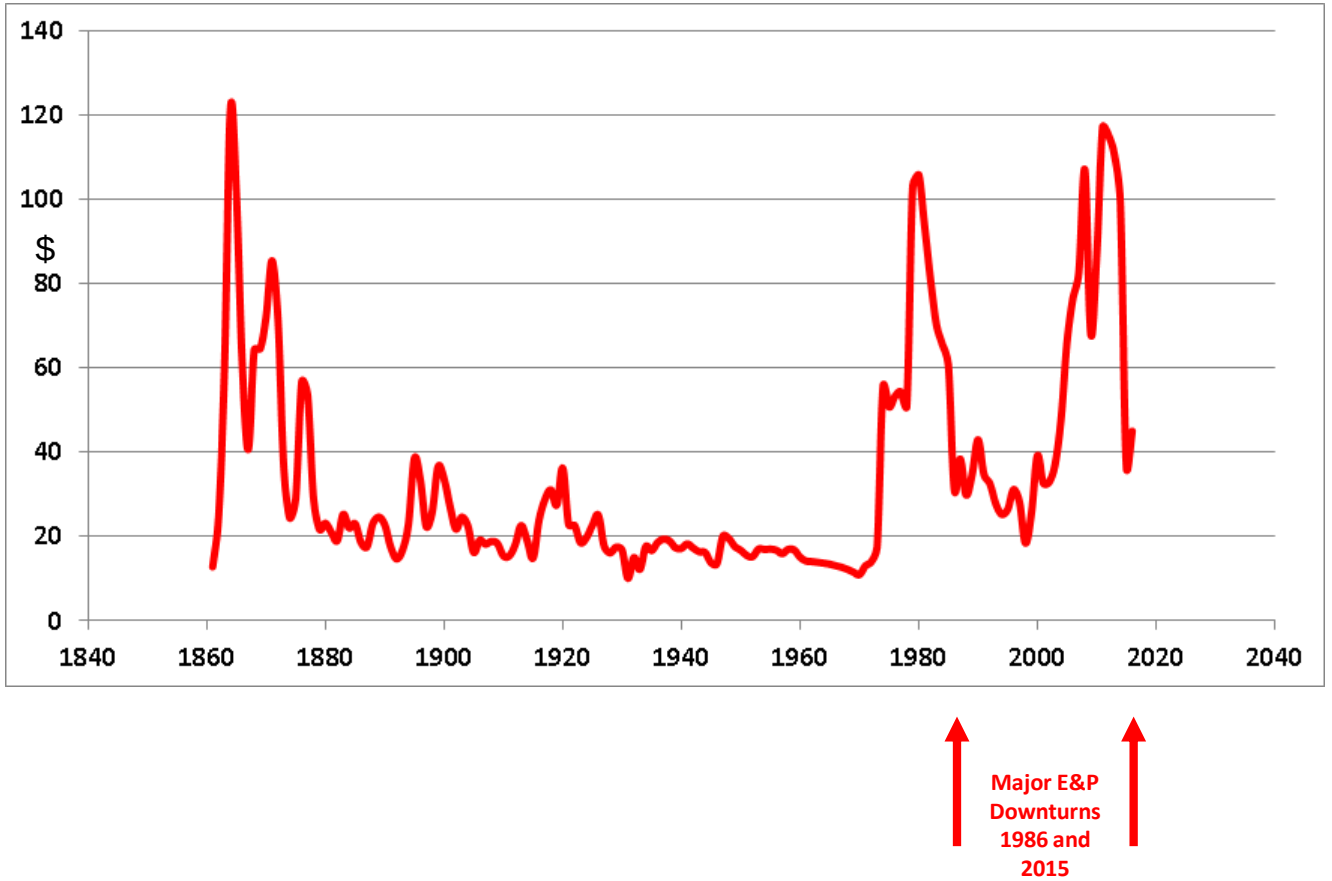
- Fossil fuels continue to supply more than three-fourths of world energy use in 2040.

Global Oil Consumption & Production, Reserves 1965-2015

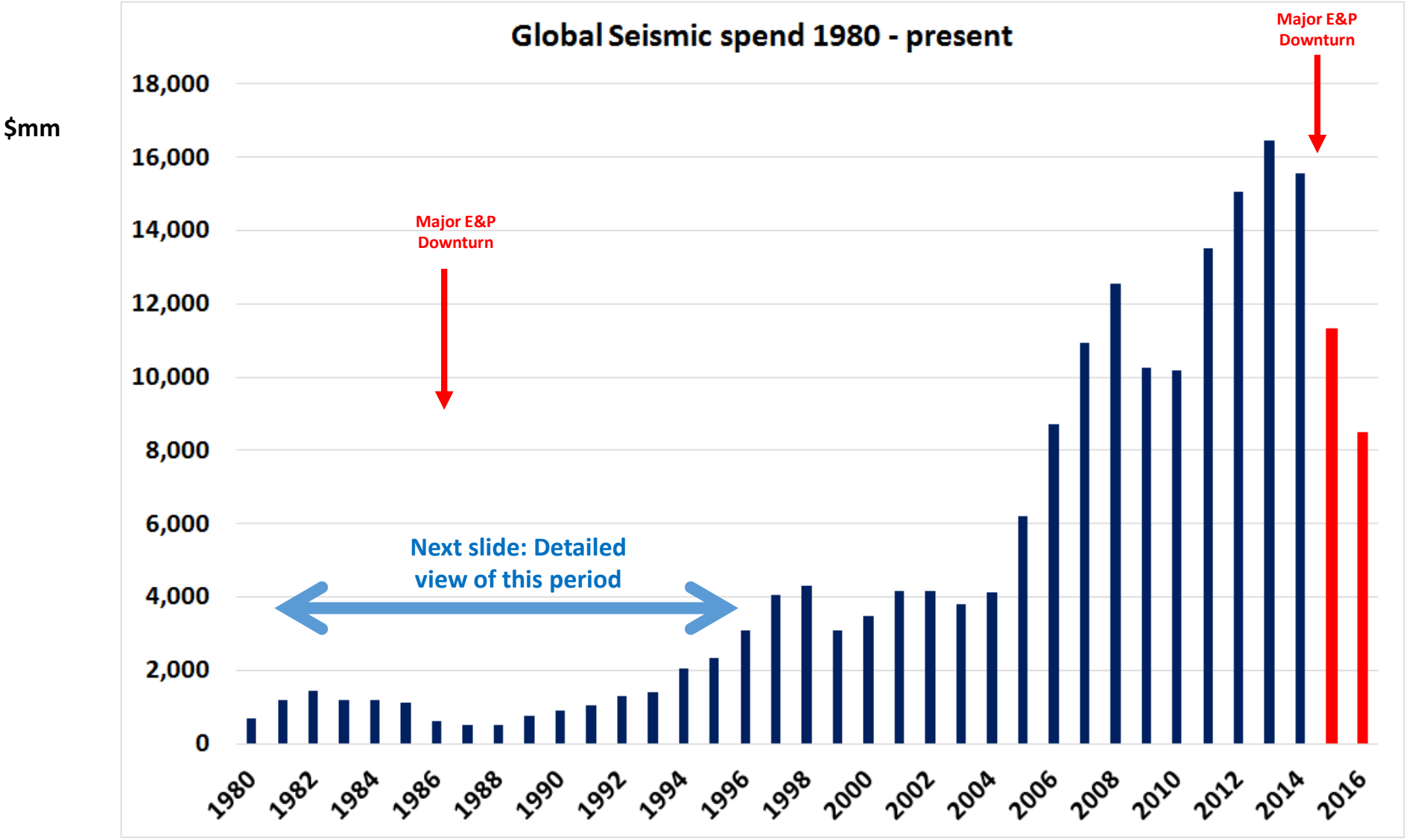


Source: BP Statistical Review of World Energy 2016

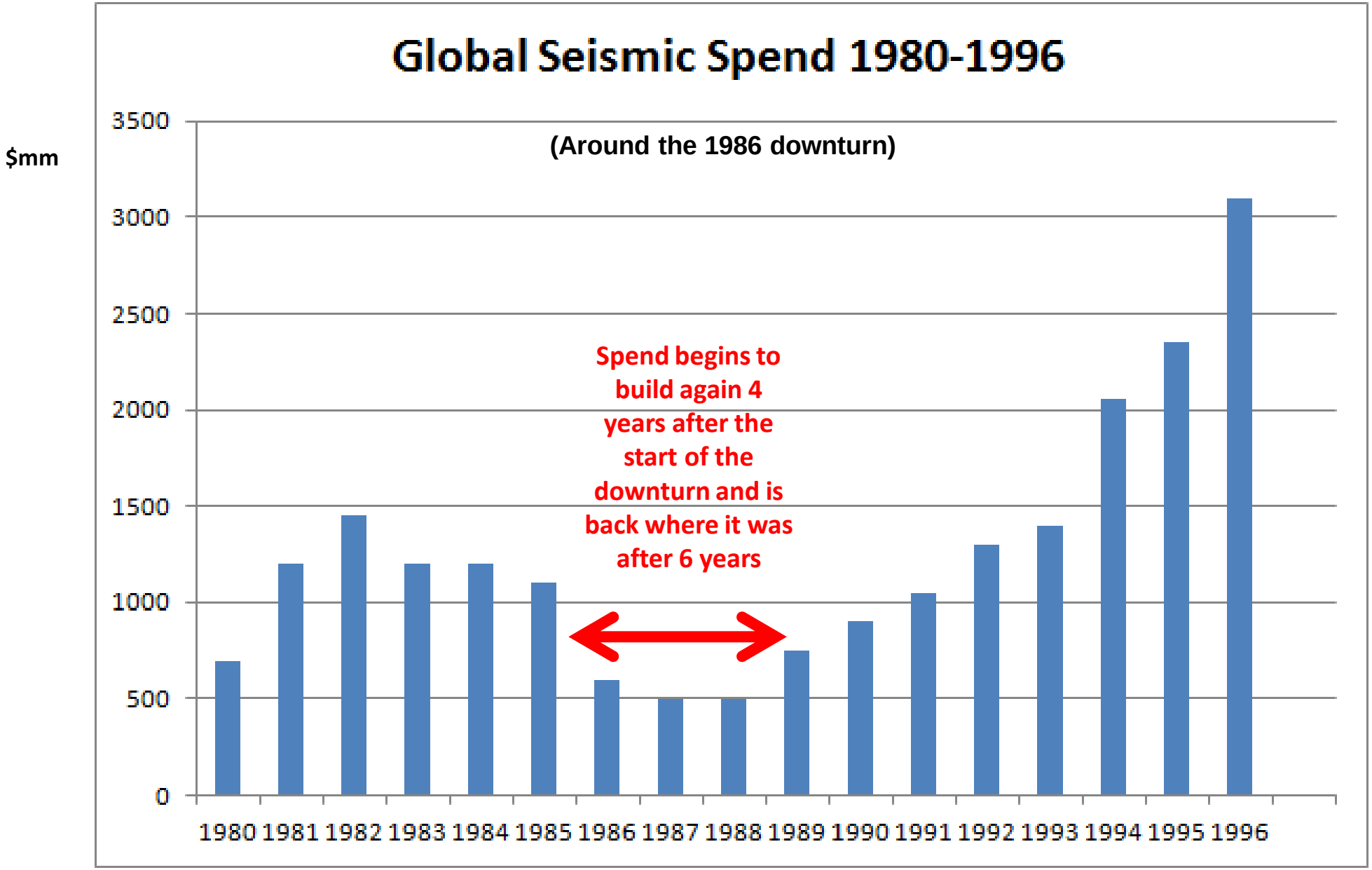
Oil price (Inflation adjusted) from 1860



Source: BP statistical review of world energy 2015



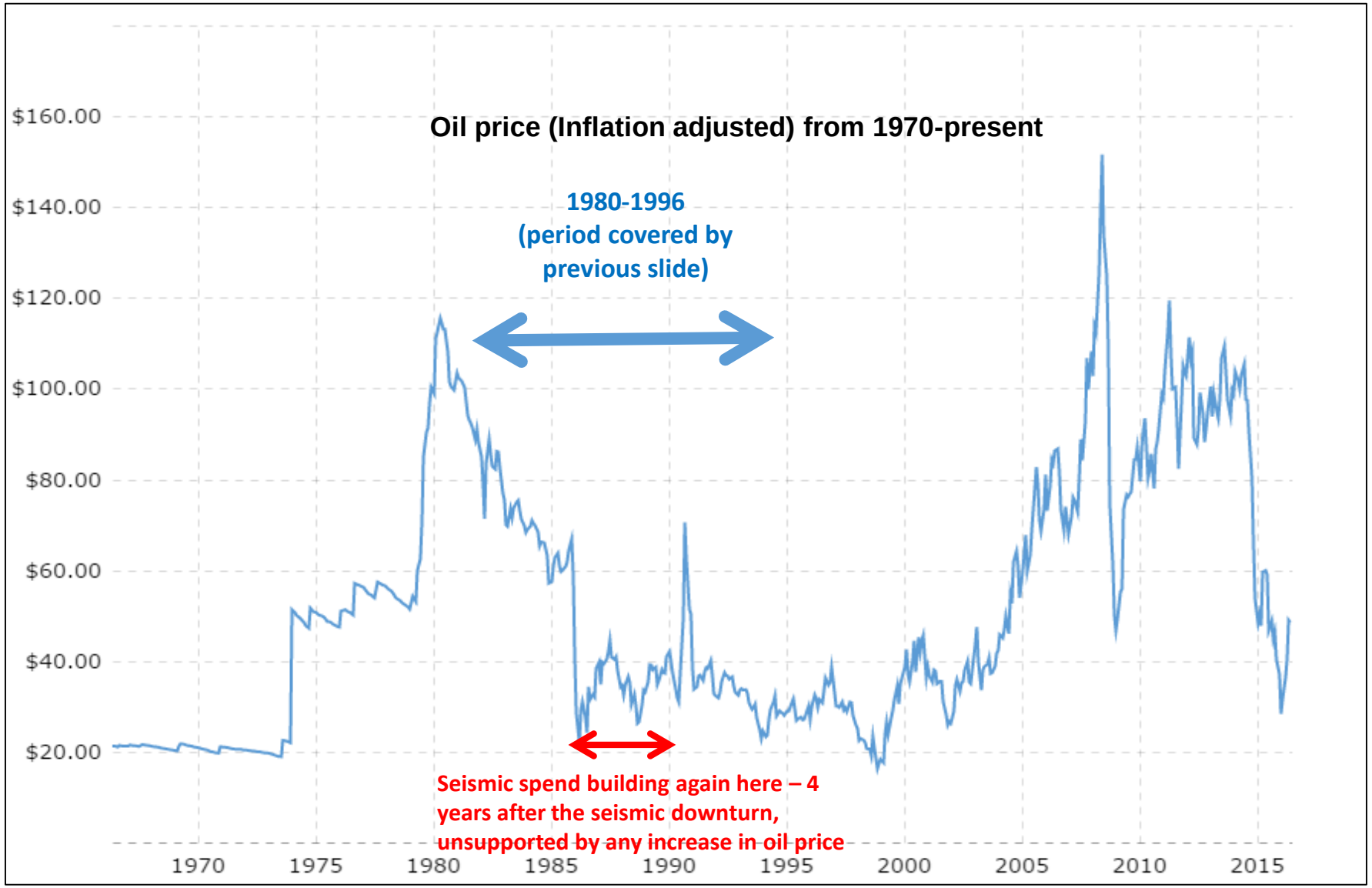
Sources: Various (Barclays Capital, Pareto, Rystad, ION, TGS, Arab News, Rigzone, Oil & Gas Journal) 2015 and 2016 are estimates



Sources: Various (Barclays Capital, Pareto, Rystad, ION, TGS, Arab News, Rigzone, Oil & Gas Journal)

The oil price might stay around $50 for a while – get used to it

My prediction --- the seismic spend will begin to build again within two years



Source of oil price: www.macrotrends.net

Norway, Holland, and several cities worldwide intend to make it less and less attractive to purchase or drive petrol or diesel cars – from about 2025

What's the same as in 1986?

- Continued growth in population, GDP, and energy demand
- Continued growth in energy consumption
- Political actions produce strong perturbation in oil price
- Oil companies beginning to worry about reserves & growth
- Increased attention to EOR
- Older reservoirs are more depleted, and newer ones are smaller
- Big cost reductions take place across E&P
- Massive lay-offs
- Consolidation (mergers, takeovers, failures etc)
- "New Technology" becomes the norm, as prices have come down, and we need the images. And, R&D departments have been active during the downturn
- No signs of a global "Peak Oil" -- yet
- Average recovery factors remain low ~35%

What's different from 1986?

- "Unconventional" production has perturbed the market and may continue to do so
- Increasing pressure from environmental issues and energy efficiency initiatives
- General realisation that there are still huge reserves but that technology breakthroughs will be needed to access them
- Is the "Global Economy" less stable? Or even exhausted?
- Oil companies are under greater price and efficiency pressures
- Some "disruptive technologies" may be just over the horizon

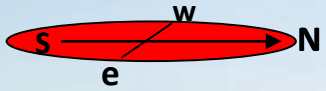
- "Blended Sources"
- "Broadband" towed streamer surveys
- The move towards ocean-bottom recording
  - "PRM" or "LoFS" systems
  - Nodes on the seabed
- Data Integration
- Nodes on land surveys
- New technologies arriving from "left field"

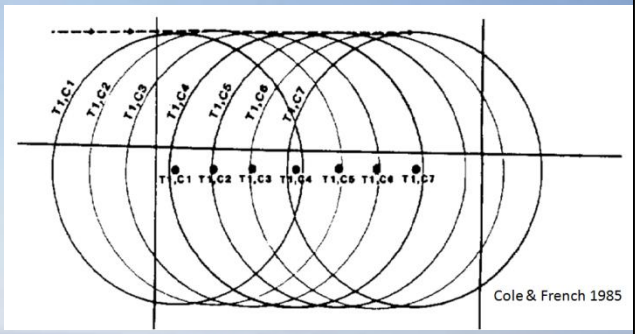
Lesson from the mid-80's -- new technology becomes the norm

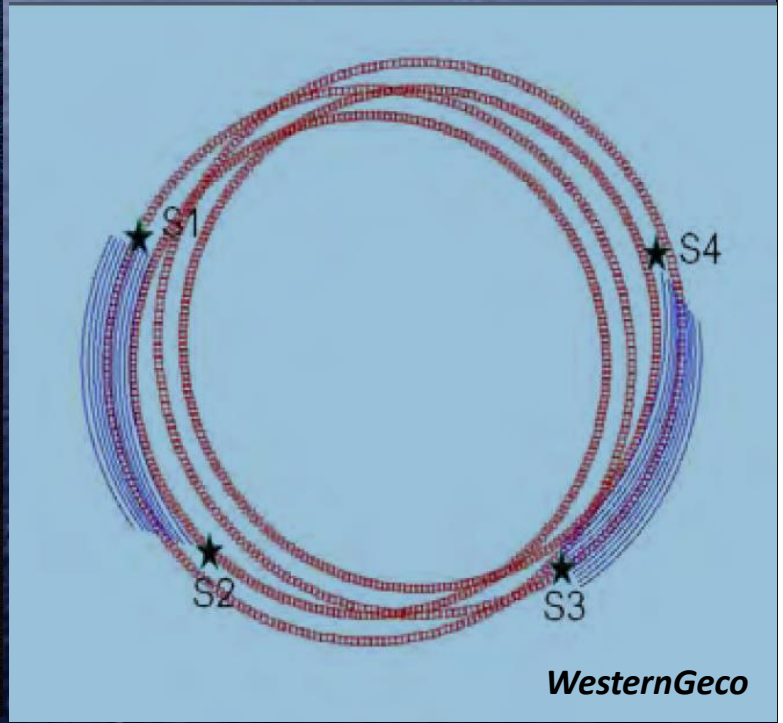
Geco – first 2-cable vessel ~1985
First 3-cable vessel, 1990

The Geco Beta

Multi-Azimuth marine acquisition
….will become the norm







Seismic technology trends 2000-2014

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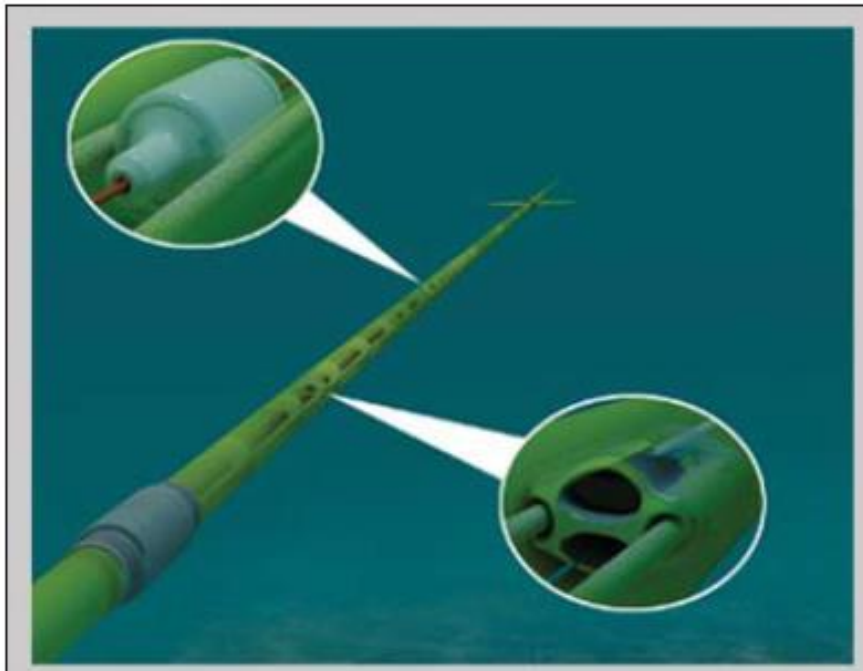

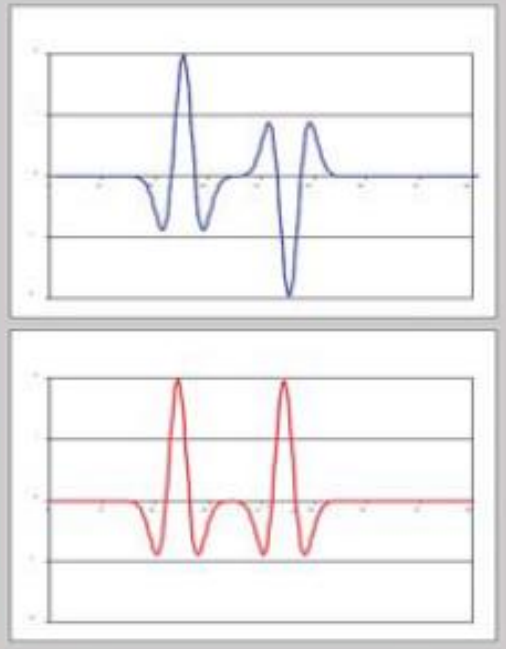

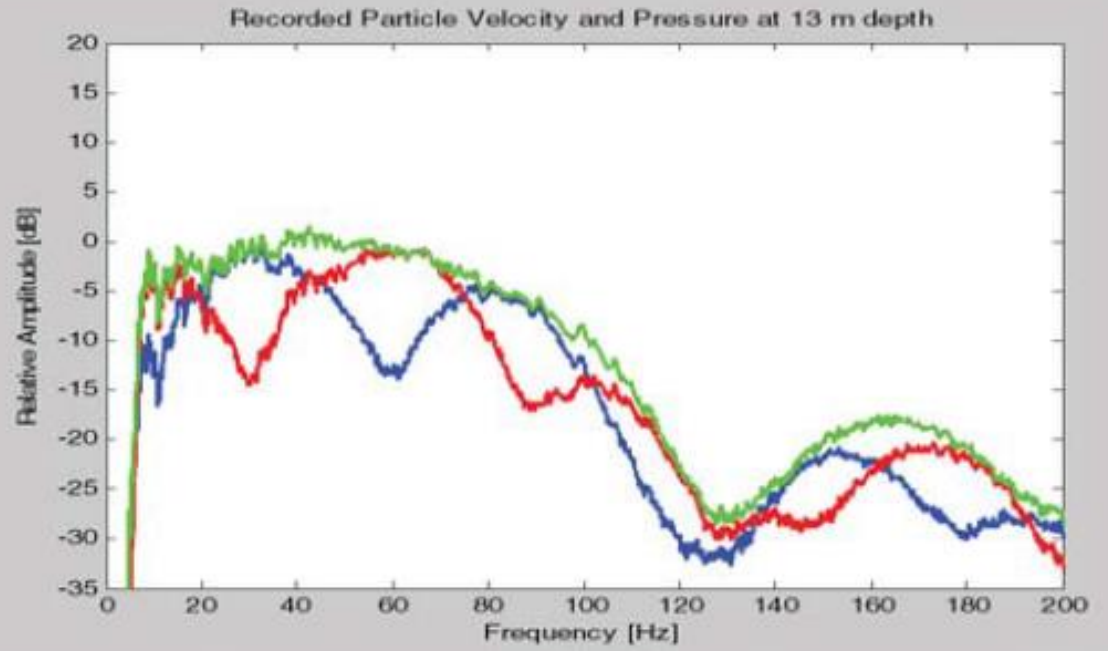

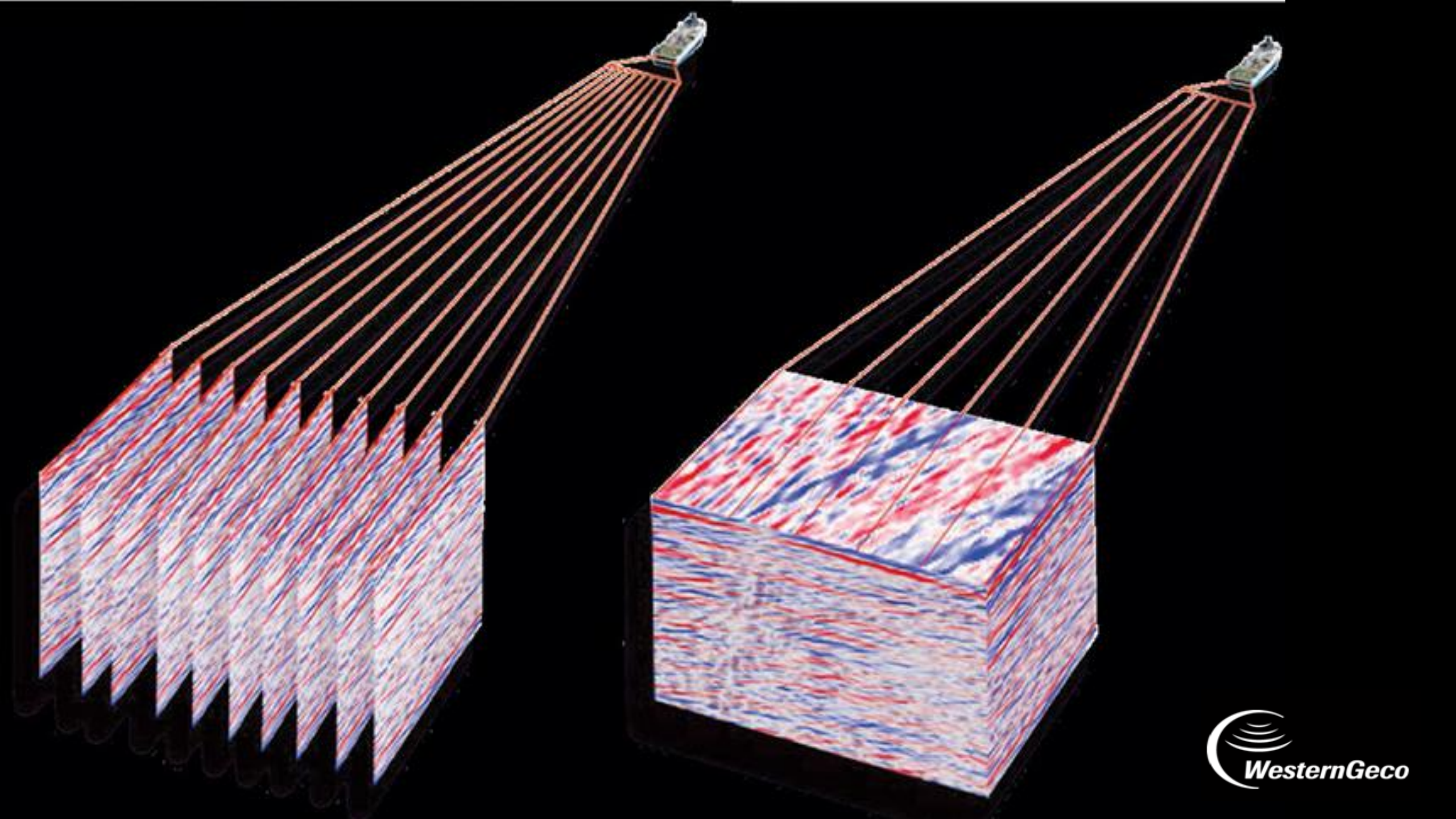
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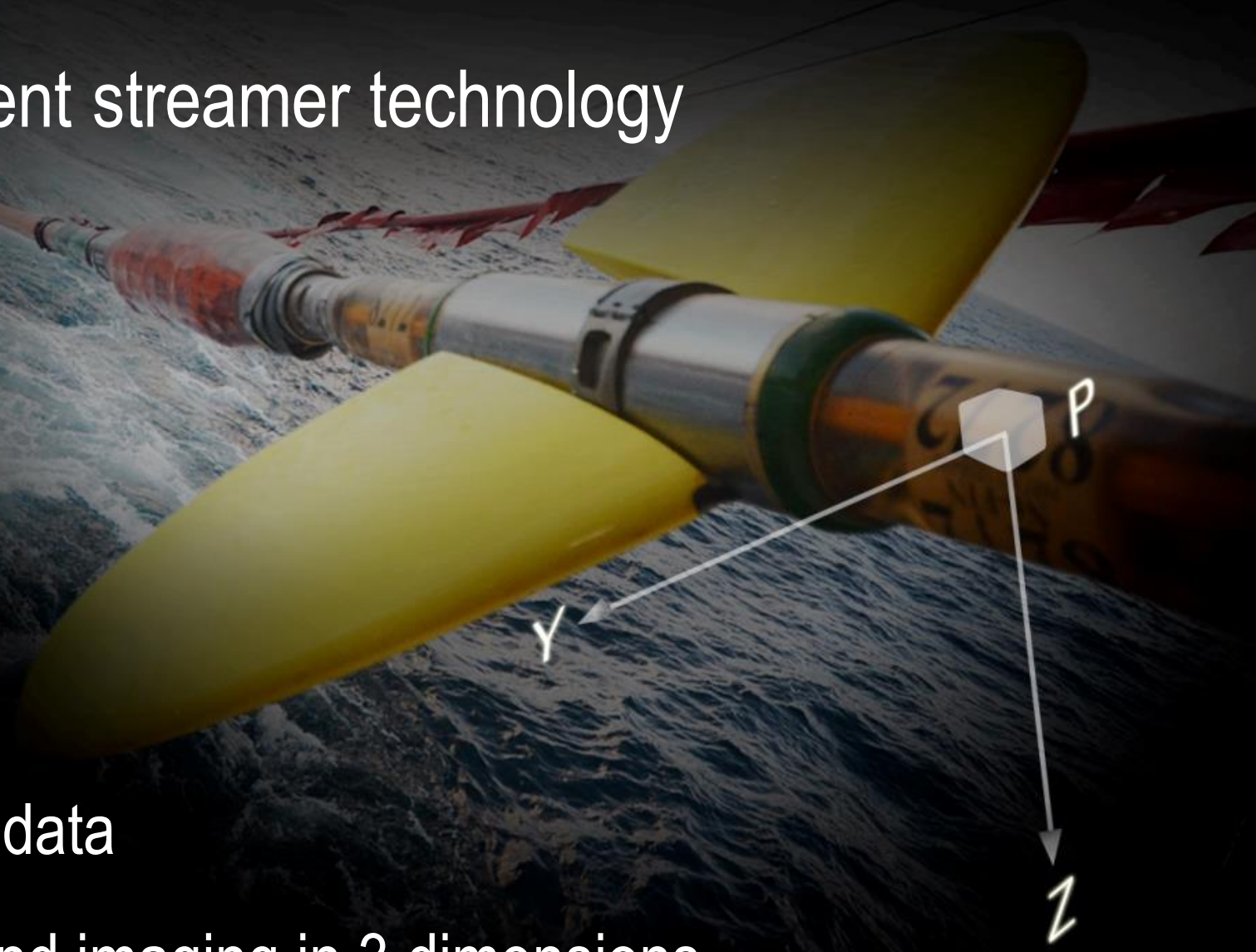
IsoMetrix multi-measurement streamer technology



$$\nabla P = -\rho \, \partial V / \partial t$$

- **P & Z** gives 2D broadband data
- ***adding*** **Y** enables broadband imaging in 3 dimensions
- by wavefield reconstruction and 3D deghosting

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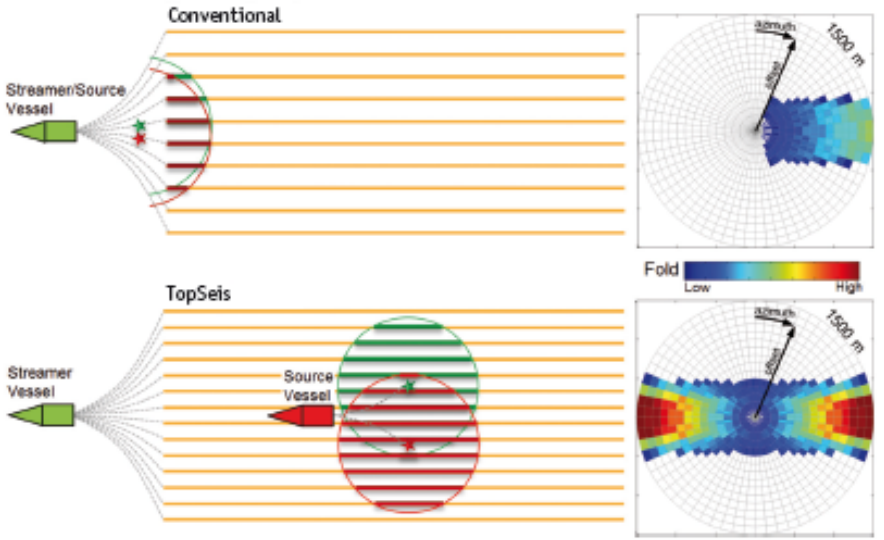
Acquisition – Marine

TopSeis

A unique solution for acquiring near offsets

TopSeis™ is a next-generation marine towed-streamer acquisition solution, delivering a step-change in imaging for shallow targets by providing massively increased near-offset coverage from a split spread with zero offsets. It is an innovative multi-vessel acquisition solution, deploying the source over the spread, combined with tailor-made proprietary seismic processing algorithms. TopSeis has been designed and developed by the combined efforts of multiple business lines in CGG in partnership with Lundin Norway AS, to overcome the specific challenge of the lack of near offsets inherent in conventional towed-streamer 3D seismic.



Conventional and TopSeis marine acquisition layouts with corresponding offset/azimuth rose plots with offsets up to 1500 m. The highlighted circles show near-offset data surrounding the airgun source arrays.

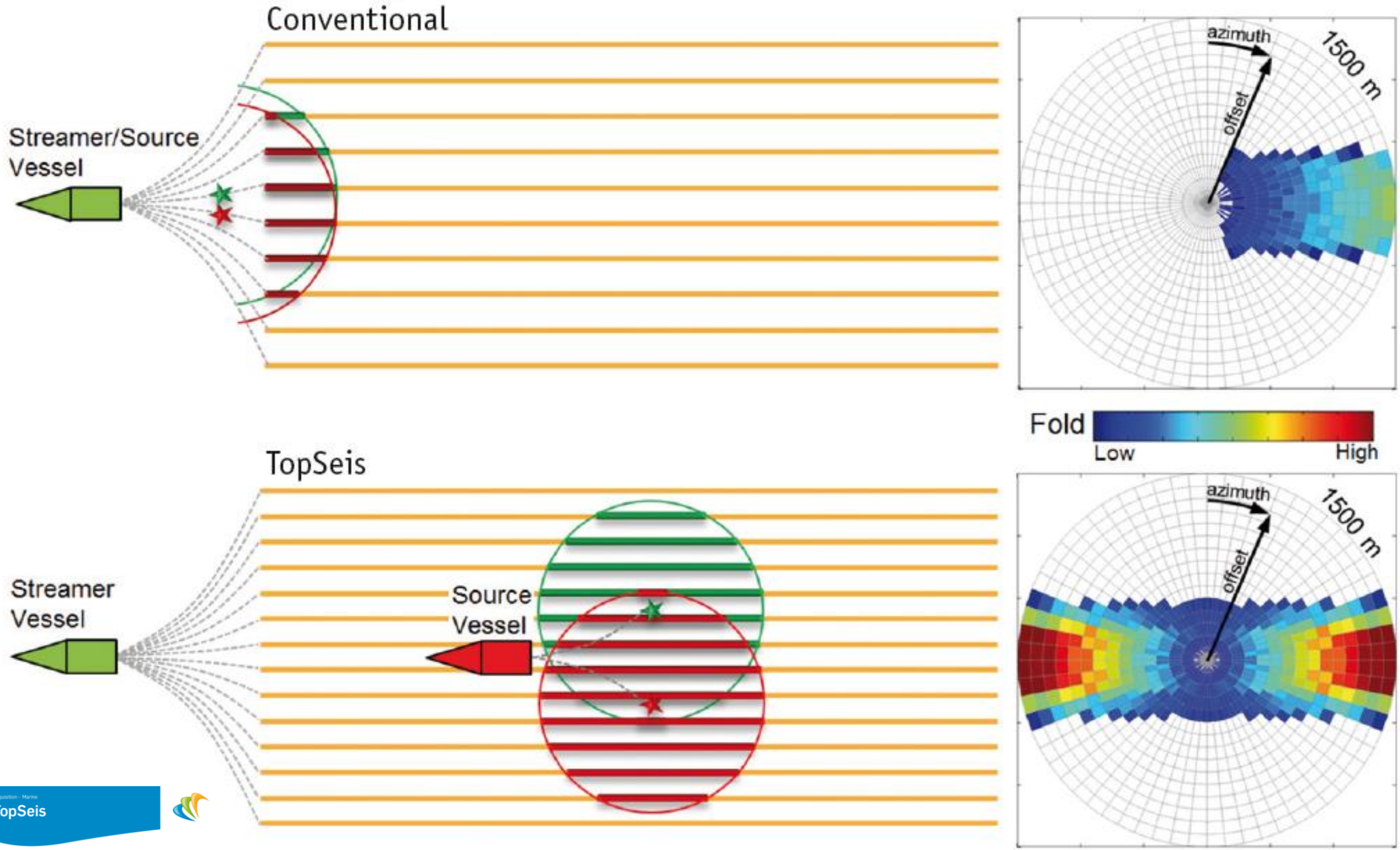
Benefits

- Enhanced imaging of shallow and intermediate reservoirs in water depths deeper than 100m
- Better S/N from increased fold
- Improved AVO from increased fold and recorded zero-offset data
- Considerably lower-cost solution than OBS
- Anticipated better multiple attenuation from increased near-offset coverage

Features

- High fold with increased near-offset coverage
- High resolution
- Dense crossline separation
- Zero offsets
- Crossline offsets
- Full azimuth at near offsets

CGG
Passion for Geoscience


Conventional
Streamer/Source
Vessel
azimuth
offset
1500 m
Fold
Low
High
TopSeis
Streamer
Vessel
Source
Vessel
azimuth
offset
1500 m

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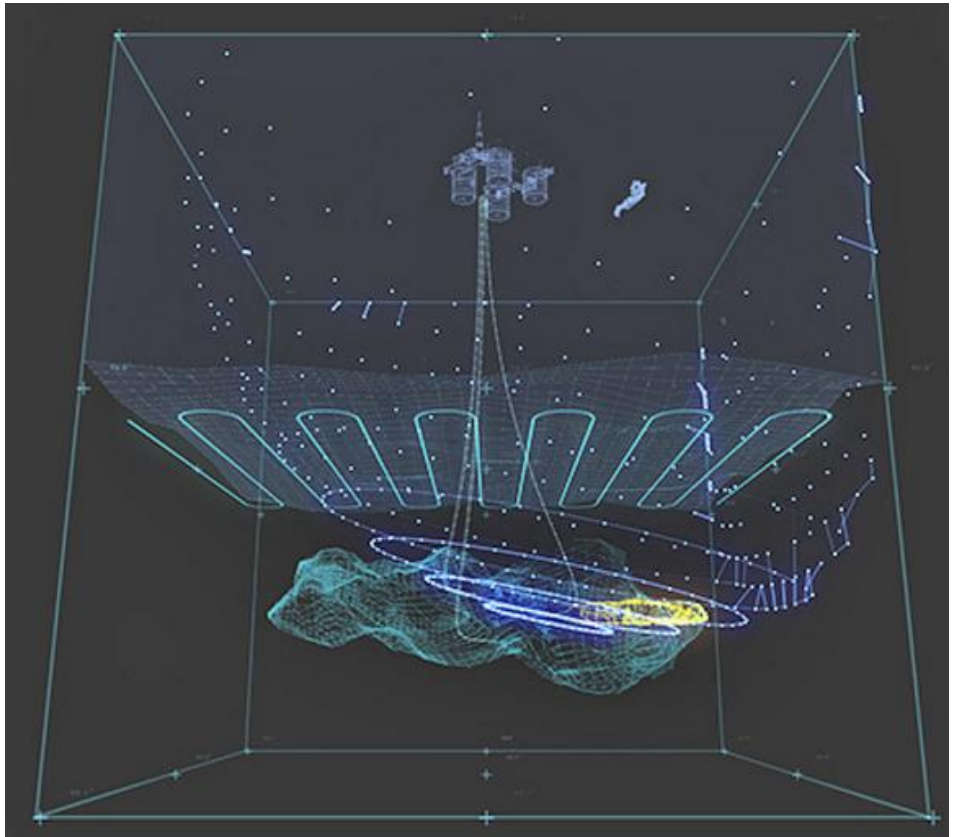
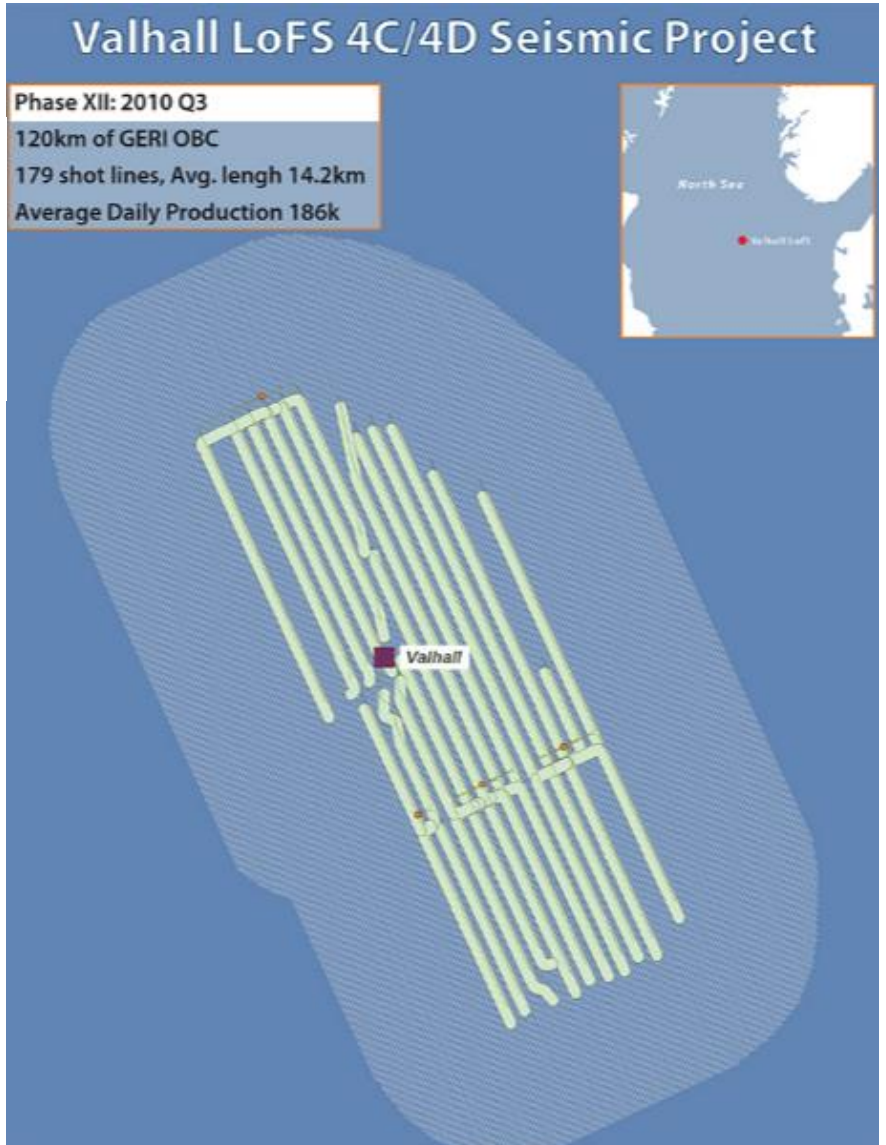


bp

ConocoPhillips

Statoil



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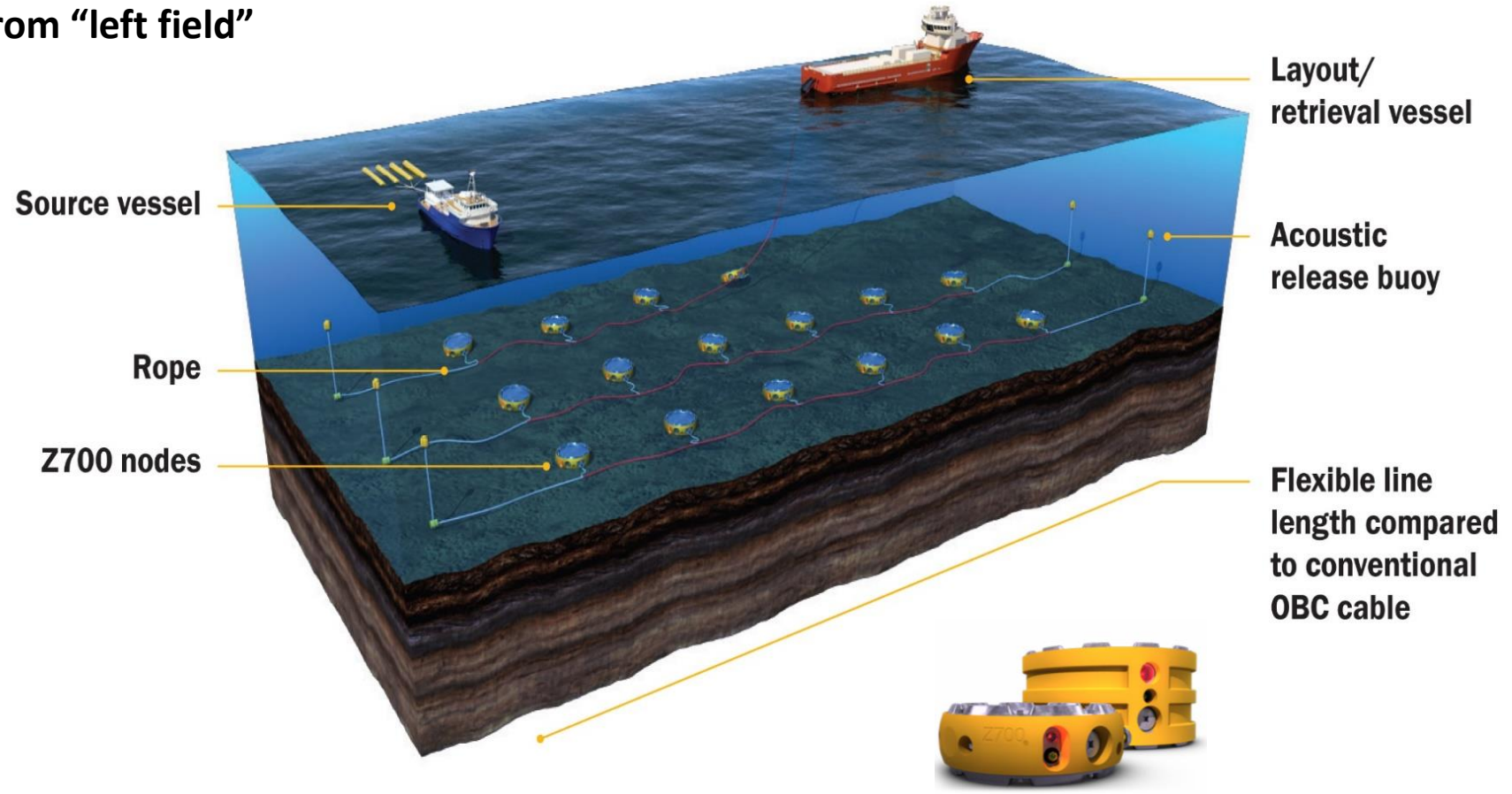
2016 OB survey:

Cost per ocean-bottom trace is 10% of that in 2010. Project uses 9000 nodes and Blended Sources.



fairfieldnodal

inApril is ready to deliver the most cost effective and complete seabed seismic system available on the market today, Venator. A total rethink in the design, cost, operational efficiency and safety within seabed acquisition.

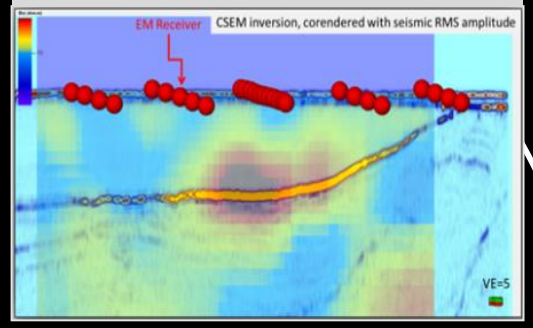
- **More than 10,000 nodes from one vessel**
- **Km^2 cost reduced by up to 70% compared to other OBS systems**
- **High speed deployment and recovery improves efficiency significantly**
- Totally hands free and fully automated back deck operations
- Built in positioning transponder
- 100 day battery life
- Same system for all applications and water depths down to 3000m

inApril

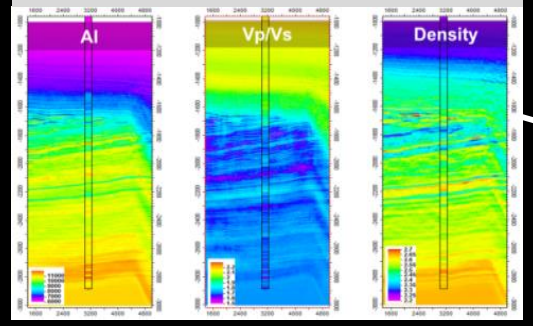
www.inapril.com

Petrophysical joint inversion using multi-physics measurements

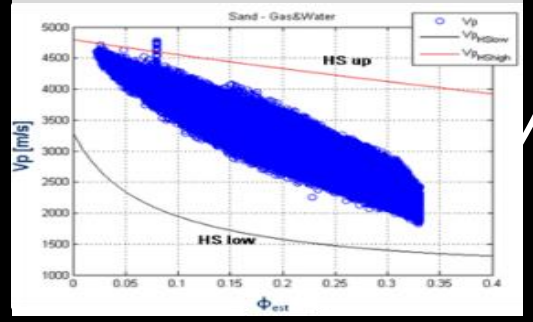
3D CSEM inversion



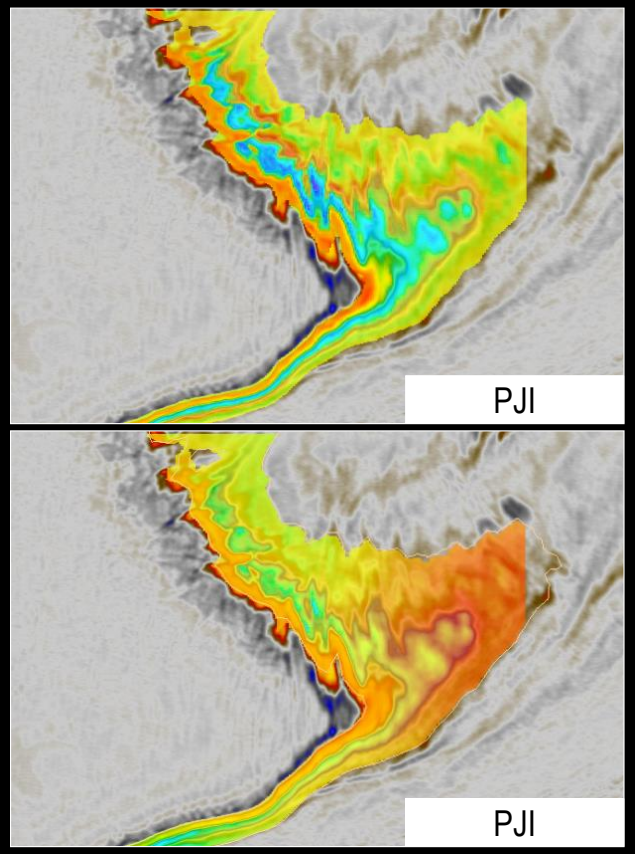
3D AVO inversion



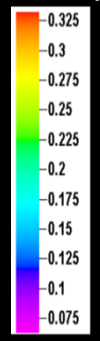
PJI at well log scale



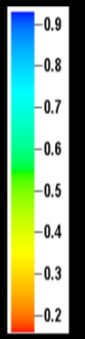
3D PJI inversion

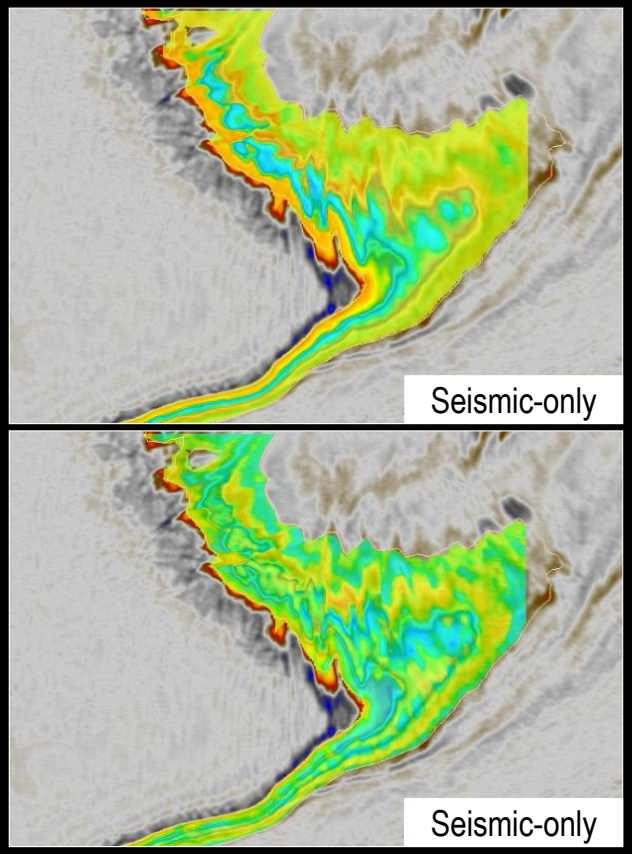


Porosity



Water saturation





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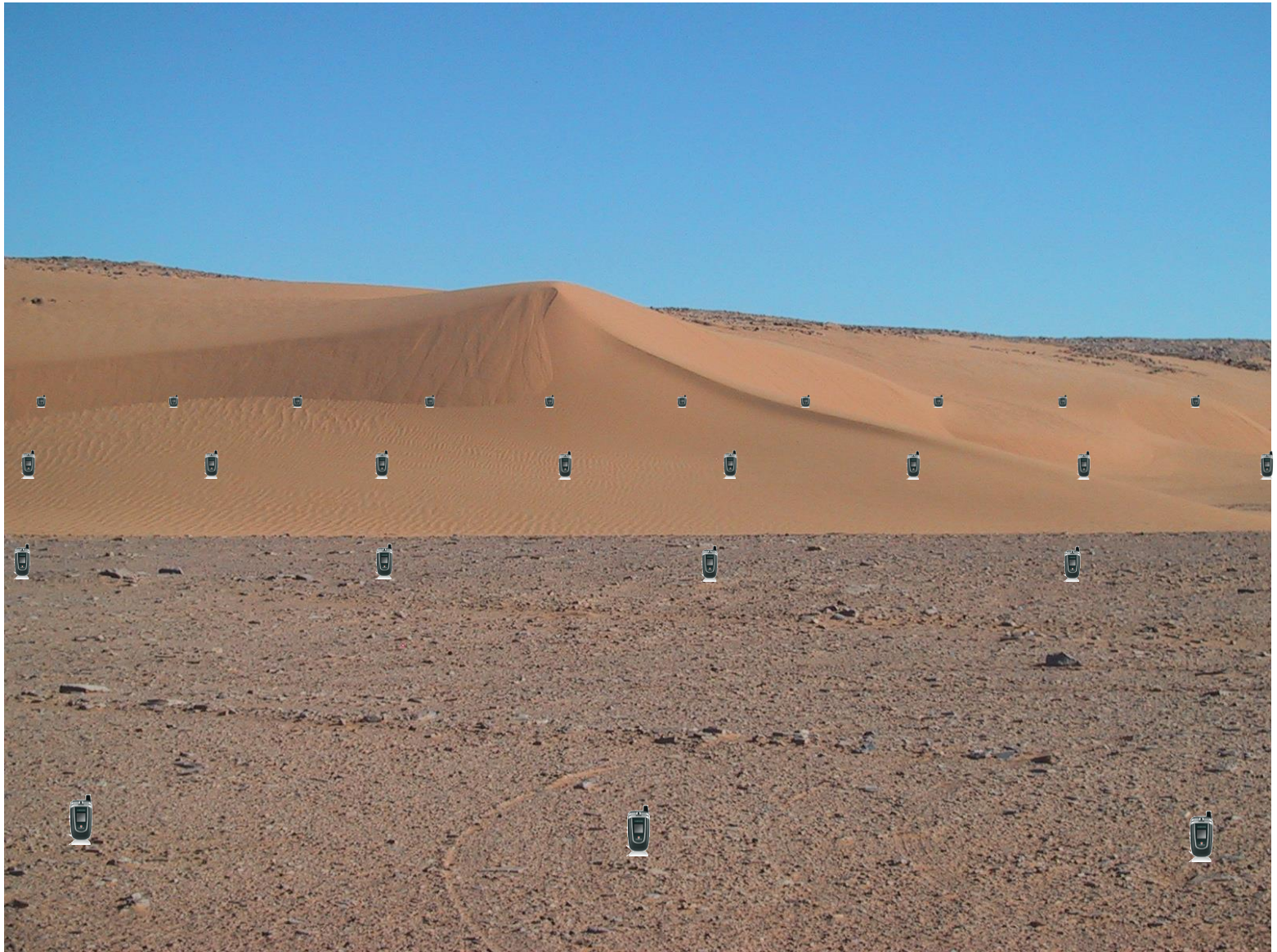
- Data Integration
- Nodes on land surveys ←
- New technologies arriving from “left field”



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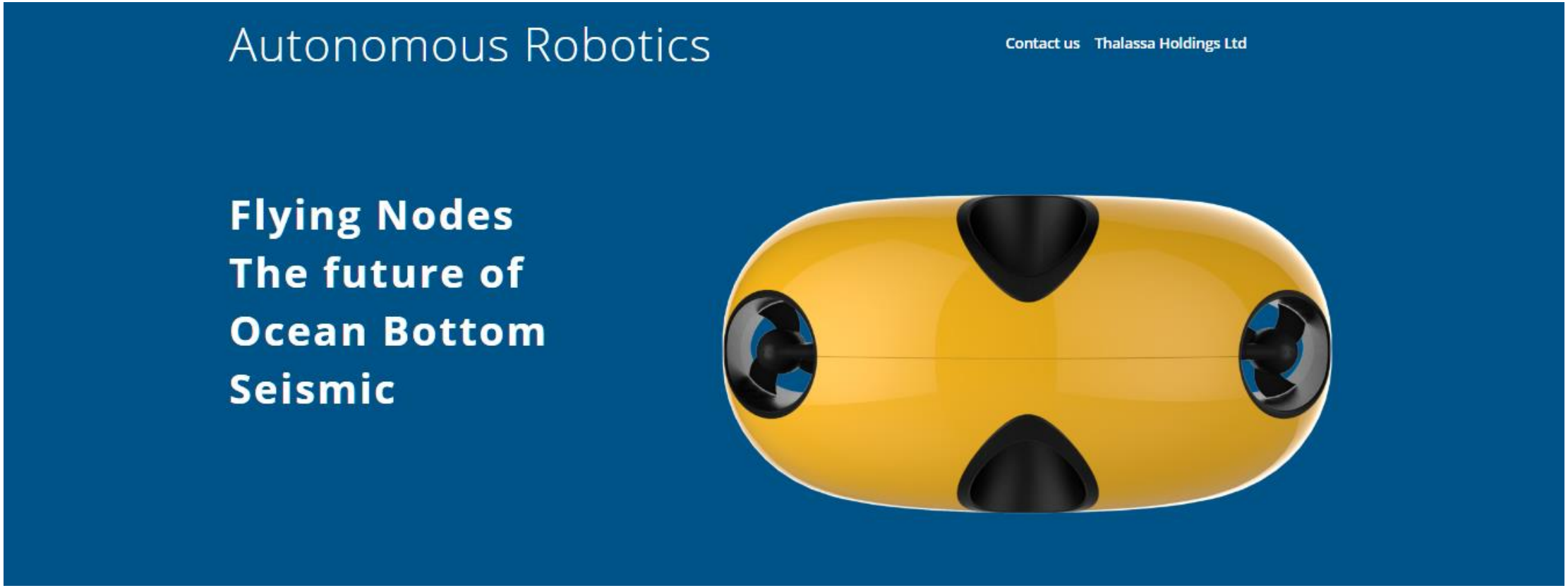
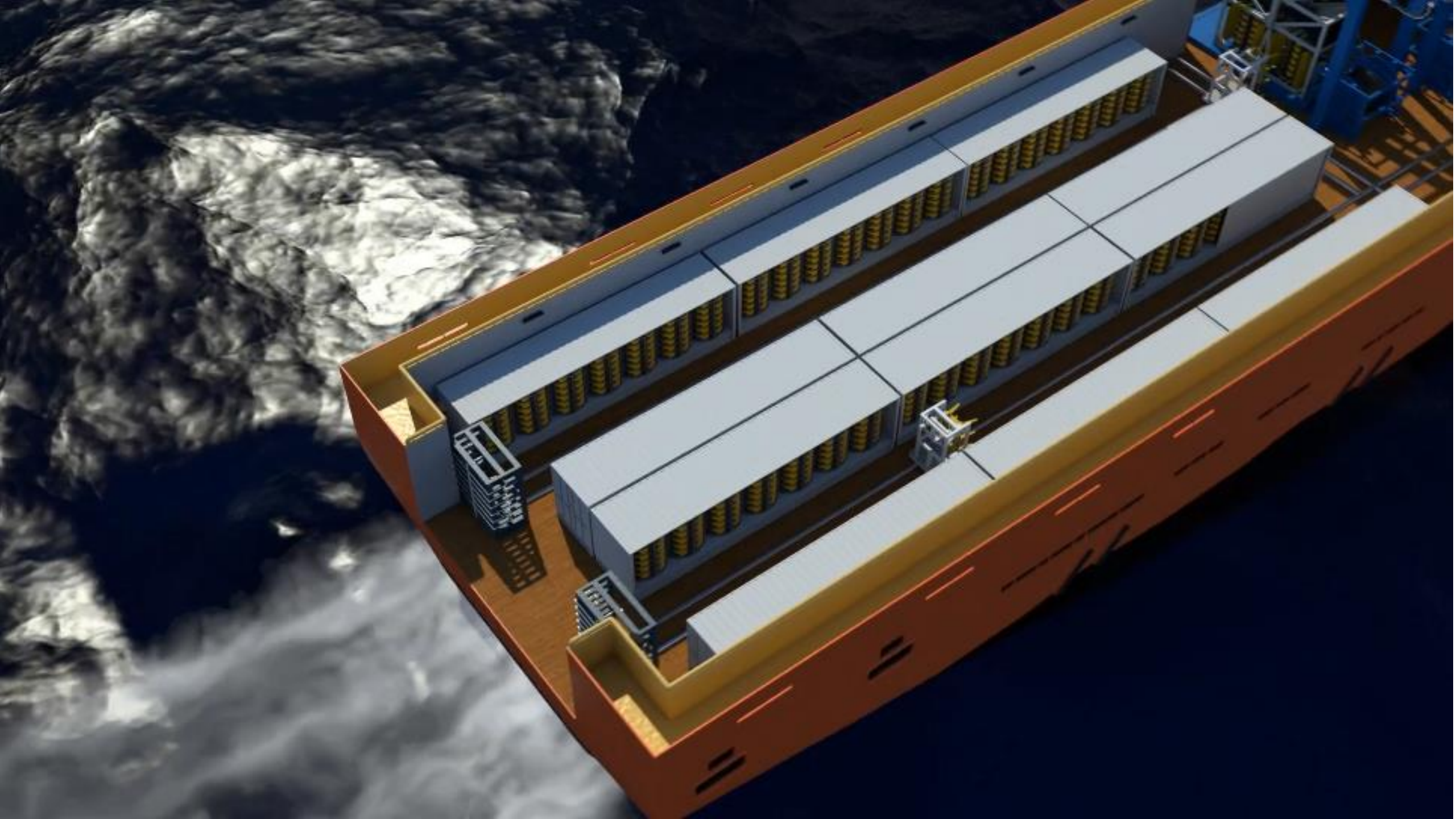
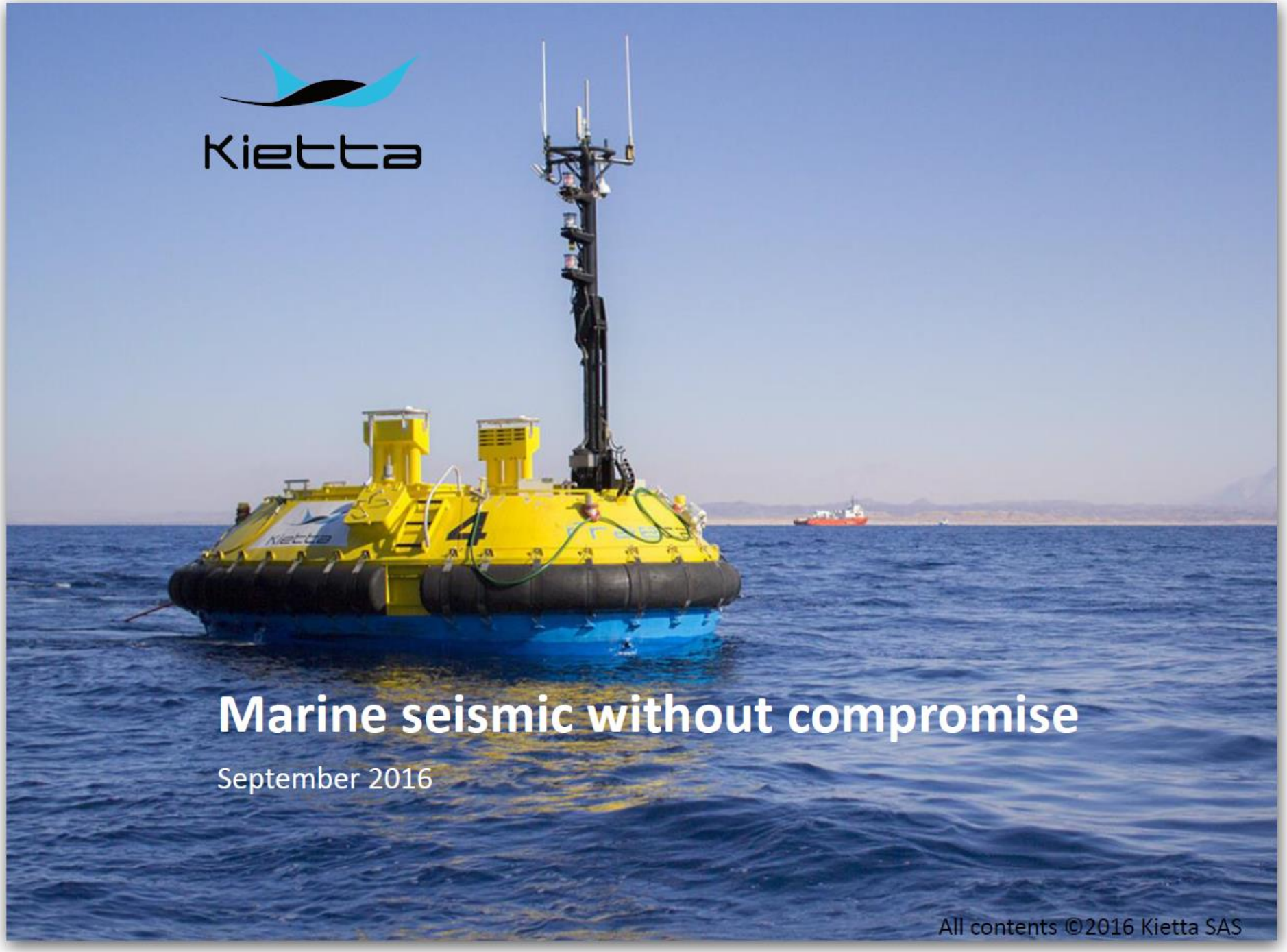
- New technologies arriving from "left field" ←

Firstly – robotics and drones! Trending in R&D







A Drone!

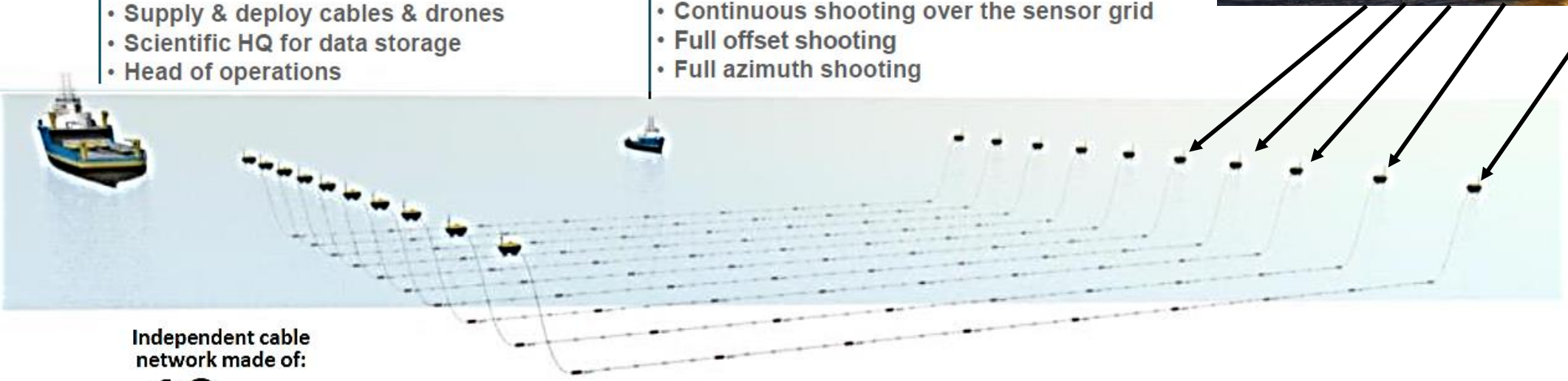
One each end of an 8km cable

And 10 cables

FreeCableTM Principles

SUPPLY & OPERATIONS BOAT
- Supply & deploy cables & drones
- Scientific HQ for data storage
- Head of operations

SOURCE BOAT
- Continuous shooting over the sensor grid
- Full offset shooting
- Full azimuth shooting



Independent cable network made of:

10 MSCs

(Midwater Stationary Cable)

Mechanically independent cables

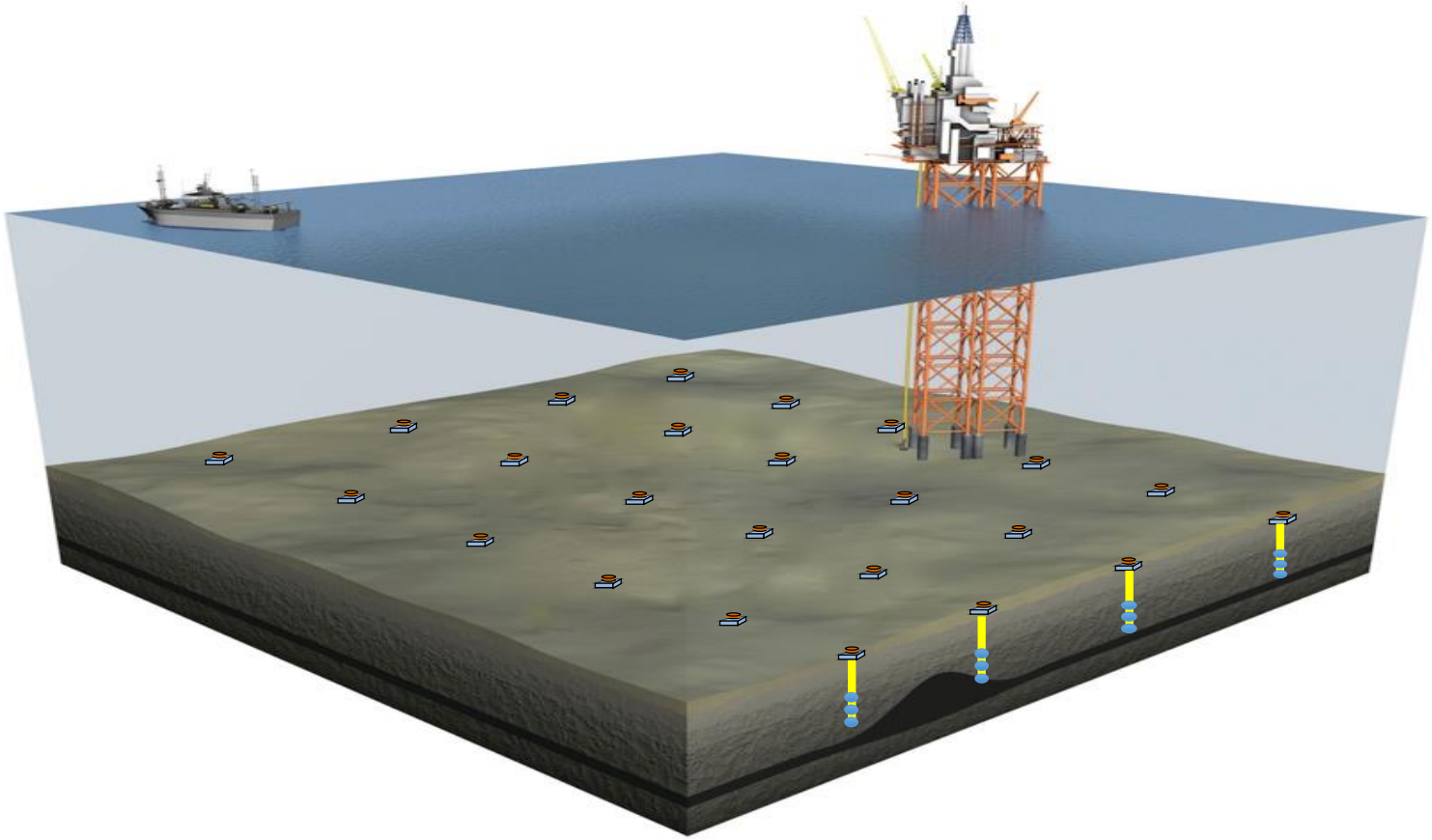
Head and Tail Recording Autonomous Vessels maintain the cables stationary

A network of parallel straight cables

Command & Control system developed to pilot stationarity of the system within currents

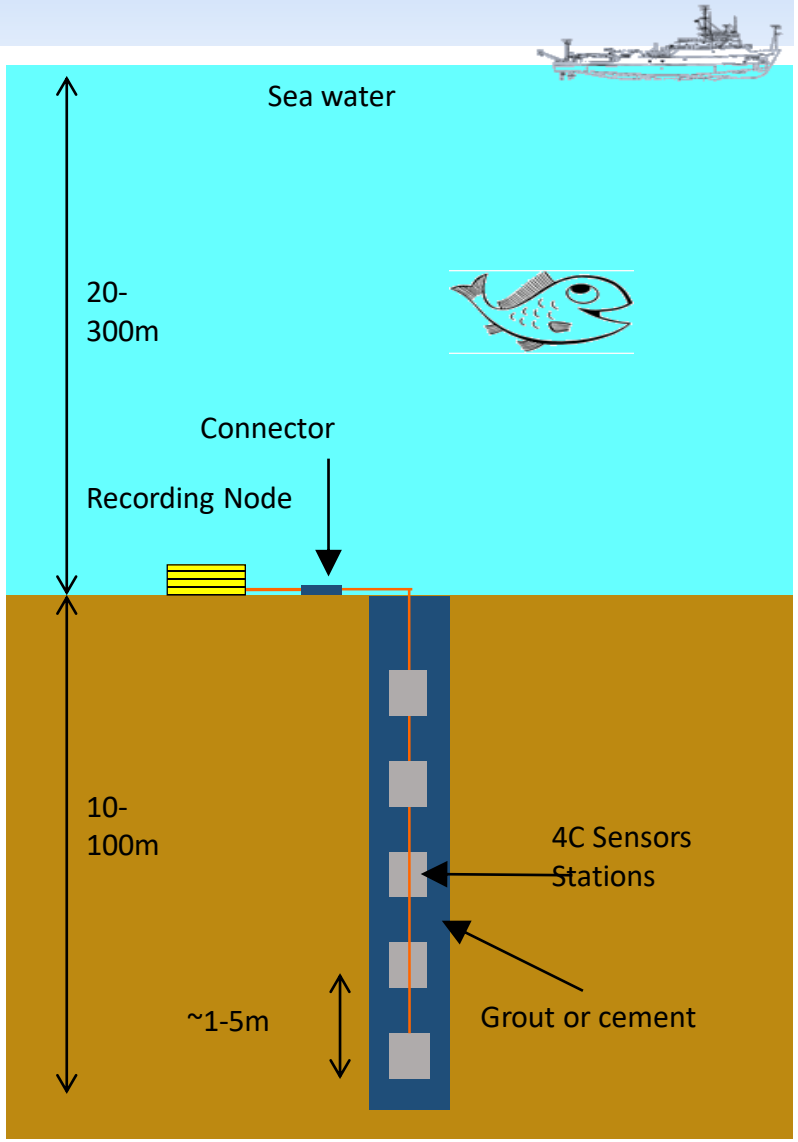
SoundSabre

SoundSabre is a node-based permanent monitoring system for offshore fields to acquire 4D seismic monitor surveys and passive microseismic data



Base System – Existing Technology

- **Vertical Receiver Array**
  - Multi-level 4C sensors & optional LF Geophones
  - Sensor levels every 1-5m
  - Buried to 50-100m
- **Seabed Recording Node**
  - Battery life 1-2 years
  - Data processing/compression
  - Data transmission via optical link



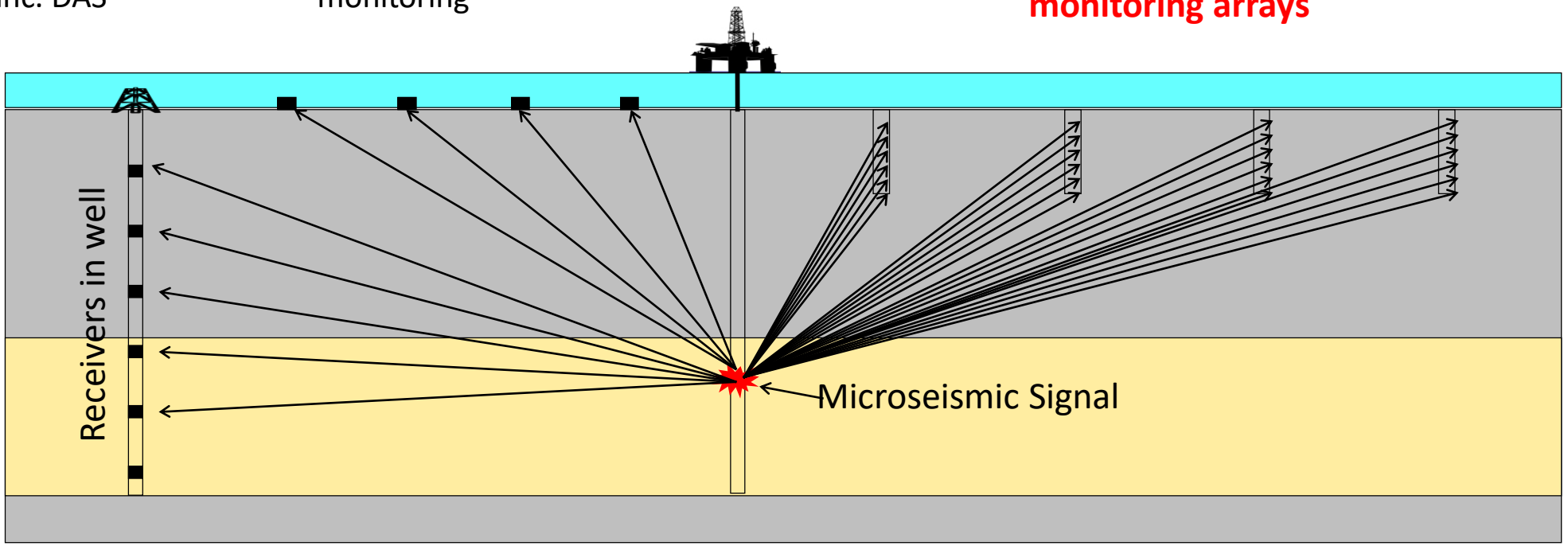
SoundSabre – key benefits

Well Monitoring inc. DAS

PRM or surface monitoring

ProductionWell

SoundSabre monitoring arrays



- Offshore Reservoir and Microseismic Monitoring
  - **Much lower costs than PRM (no trenching, no connection to platform)**
  - **Practical system for offshore monitoring**
  - **Much more sensitive than seabed systems**
  - **Low frequencies for natural seismicity**

Low Impact Seismic Sources

A Division of Chelminski Technology

The next generation of seismic sources

Geophysical quality up, Environmental impact down

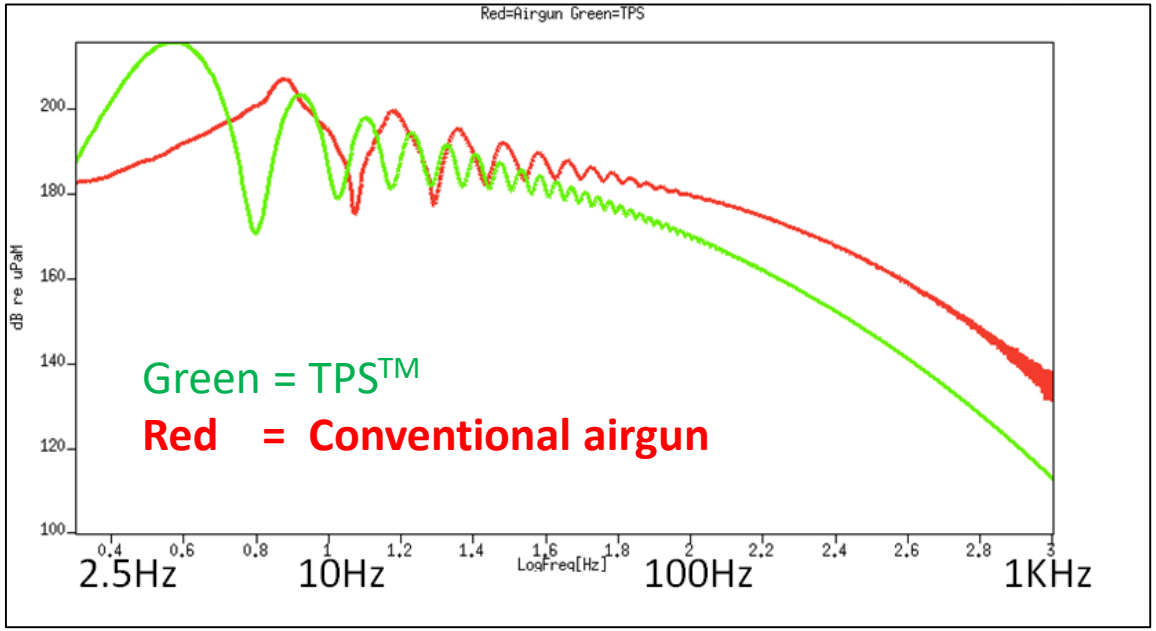
Two next generation sources from LISS:

1. Tuned Pulse Source™
   Low pressure airgun system

2. C-Vibe
   Possibly the ultimate solution long term

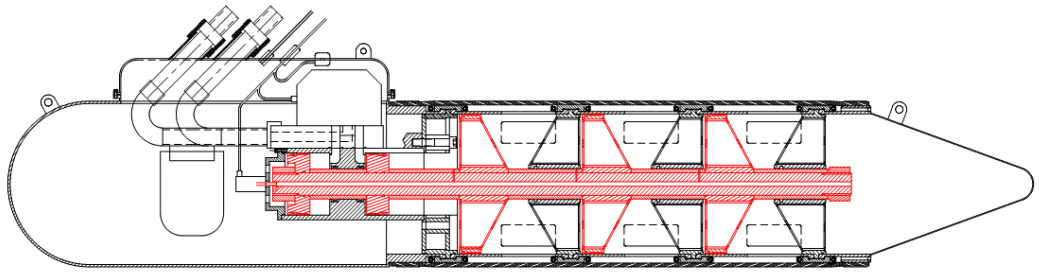
*Tuned Pulse Source™

- Stronger low frequency content – at least one complete octave lower
- Safer (lower pressure) -- and so more durable, repeatable, and predictable. No cavitation.
- Doesn't generate frequencies above 150 Hz
  (of limited use due to attenuation and scatter)
- "Plug-in replacement" – uses all existing airgun air supply, control and QC, and data processing
- True minimum phase



C-Vibe

- Multiple source units may be accurately synchronized
- Sea water can be the hydraulic fluid
- Shallow water, deep water, or drag
- Ready for prototype manufacture



* Patents and patents pending of Chelminski Technology

Modelling code with Joe Jennings of Stanford University

Drawing to a conclusion, so just to remind us…….

Investment levels are low in all traditional sources of energy supply. And even if demand growth is moderate, decline from existing sources of oil and gas virtually guarantees a future gap between demand and supply if investments do not pick up.

(Source: Statoil, Energy Perspectives 2016)

Drawing to a conclusion, so just to remind us…….

“Dismal” reserve additions in 2015

Probably even worse in 2016 (736mm bbl by July) ….about a week’s supply

Oil Price Spike Inevitable As New Discoveries Hit Seventy-Year Low

By Nick Cunningham - Aug 30, 2016, 3:28 PM CDT

Oilprice.com
1 sept 2016

The oil industry only discovered about 2.7 billion barrels of new supply in 2015, a tiny fraction of the annual average for the past fifty years. The dismal result was one of the worst performances from the oil industry in decades. 2016 could be even worse.

The 2015 figure is about one tenth of the annual average dating all the way back to 1960, according to Wood Mackenzie. Shockingly, 2015 saw the least amount of oil discovered in a calendar year since 1947. But with the massive spending cuts extending into 2016, this year the industry is on track to discover even lower volumes. As of the end of July, the global oil industry has only reported 736 million barrels of new oil discovered.

Seismic expenditure will rise again within two years

The already-established “high technologies” will become the norm

New technologies are ready for deployment

Do the math – the seismic cost only adds about $1 / barrel

Shortages of people, etc, etc

Thanks for your attention!