



Enhancement of seismic monitoring in hydrocarbon reservoirs

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1. Scientific objectives

- The Horizon 2020 project **FracRisk** aims at developing a knowledge base for helping minimize the environmental footprint of shale-gas exploration and exploitation
- Here we detail recent enhancements in seismic techniques applied in hydrocarbon reservoir monitoring

2. Motivation

The oil-gas industry is undergoing a long period of instability. Technology is one way in which one can leverage progress in the current turbulent environment. There is a tremendous need to develop technological solutions that are more efficient, more economical and more sustainable in the short to long term.

In this context, the role of monitoring is fundamental. It helps improve knowledge of the reservoir, and set up good operation practice for a safer hydrocarbon extraction.

There is also an ongoing perception of a big change in reservoir technology, especially the seismic sector; this raises the question of how the seismic sector could be more efficient.

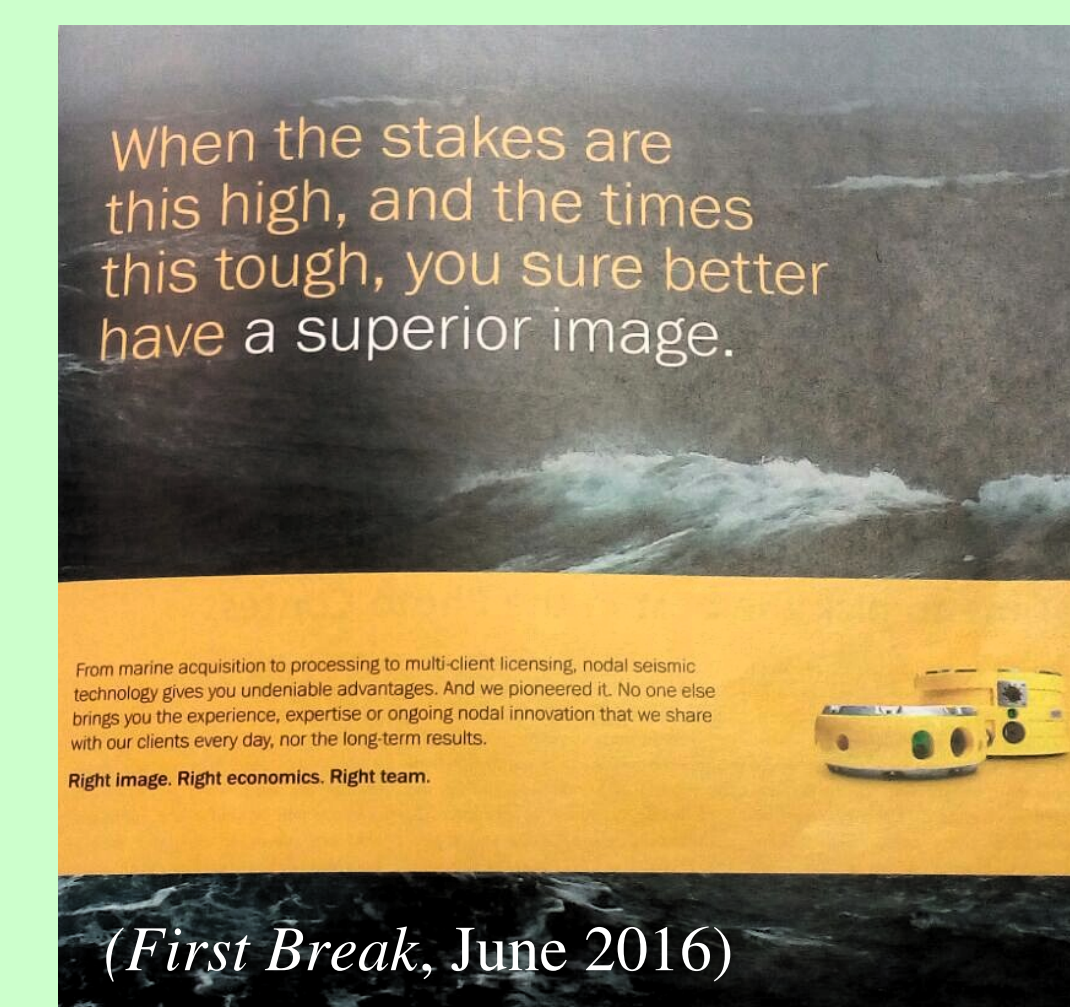
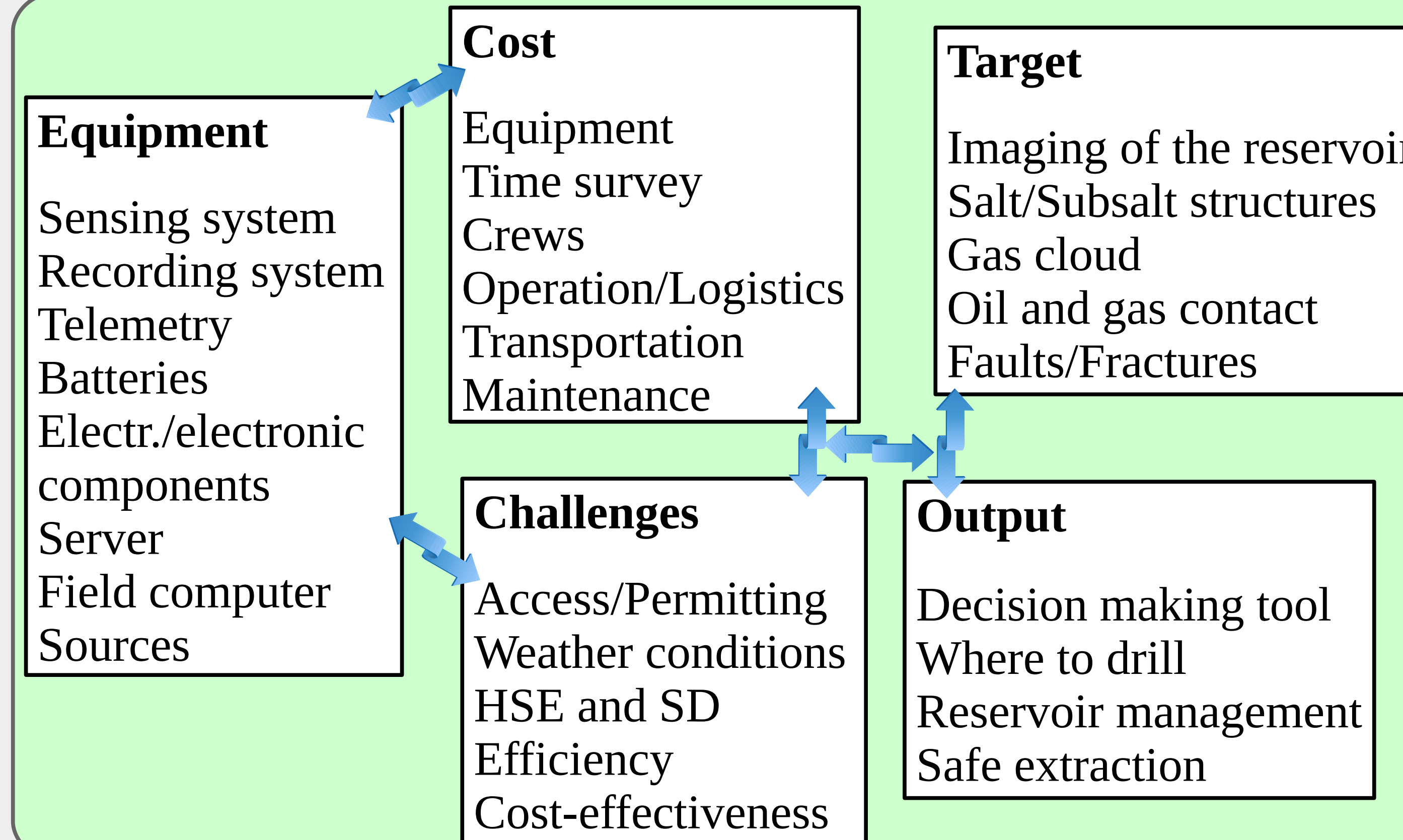


Fig. 1 An example of how the seismic service industry is reacting to evolve quickly and meet the oil-gas industry's changing needs

How can FracRisk exploit this momentum ... ?

3. Seismic monitoring



4. Land seismic enhancement

Cable-free solutions. Autonomous nodal systems

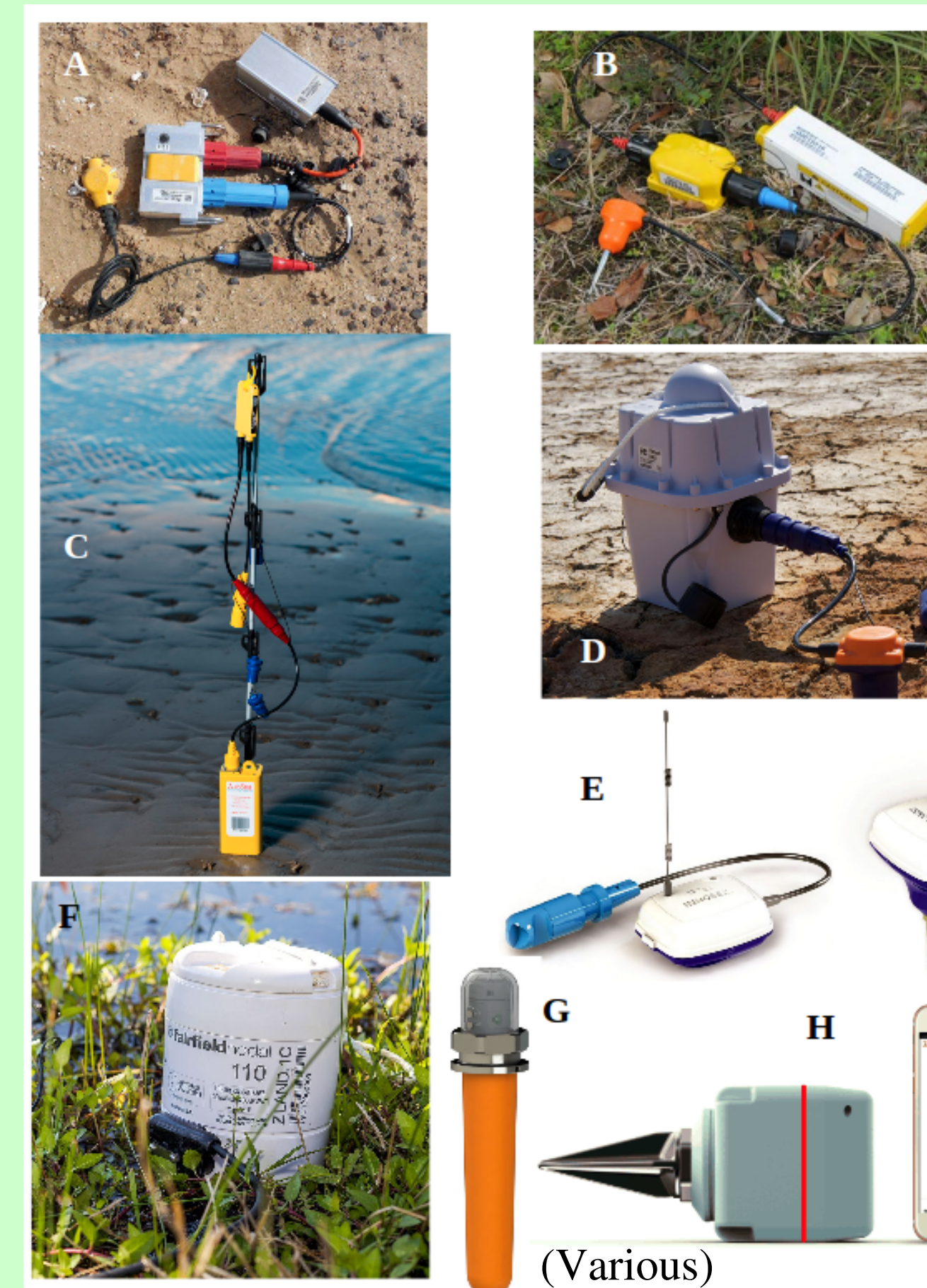


Fig. 3 Examples of some of the most used nodal systems in seismic acquisition

Telemetry

- Blind
- Radio (RF)
- RF Real-time

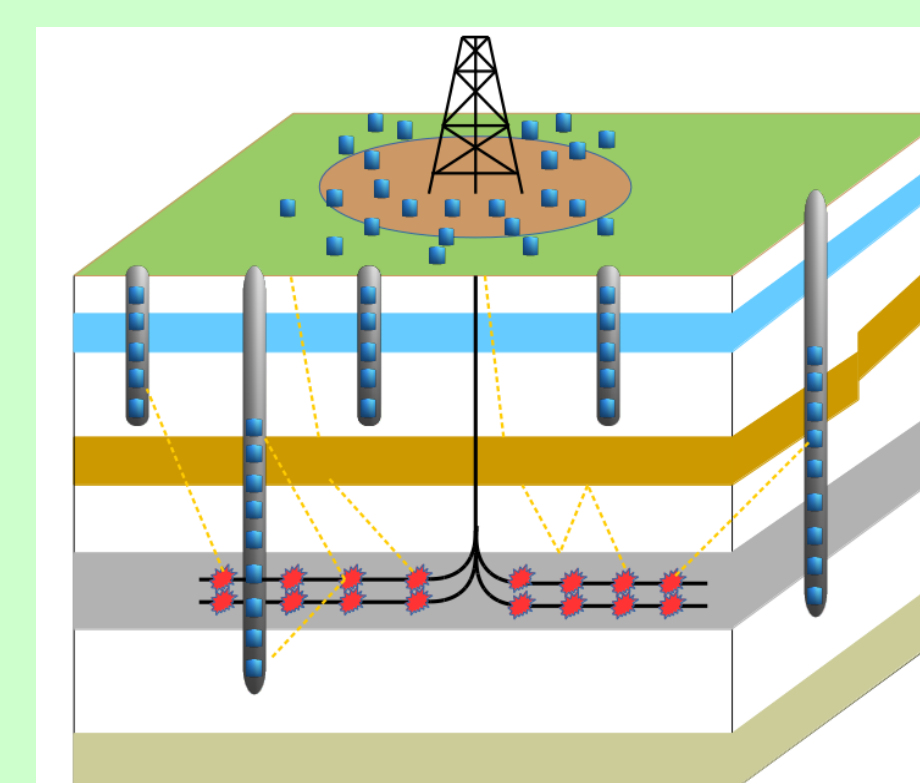


Fig. 2 Land seismic monitoring designs: surface, deep or shallow borehole

**1C or 3C MEMS
Broadband technology**

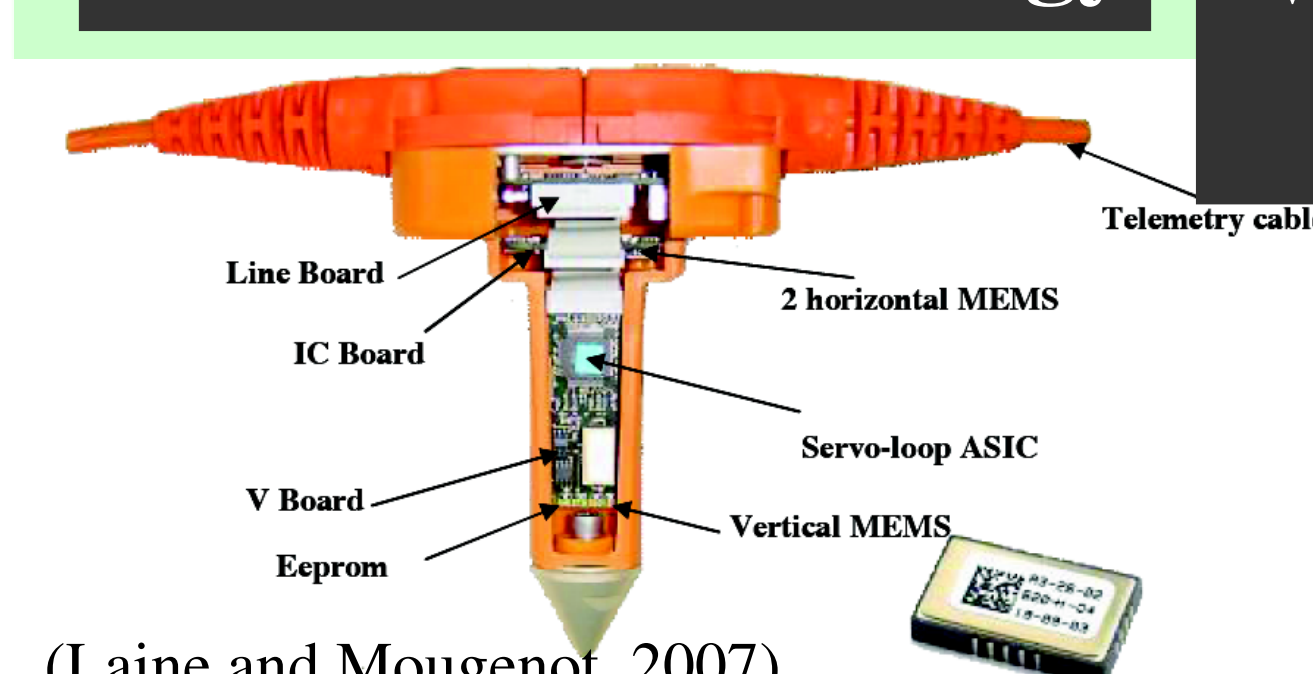


Fig. 4 Examples of a MEMS broadband accelerometer (DSU3)

**Low frequency
Wide spectrum
Deeper**

**Broadband
Receivers
(e.g. nodes)
Sources
(e.g. vibrators)**

5. Hydraulic Fracturing (HF) monitoring

A. What could be the 'best' monitoring strategy of HF?

- Operators have choice: cabled or cable-free nodal solutions?
- Need for real-time information to be transmitted to drilling engineers

Challenges with cables



Fig. 5 Surface monitoring challenges. Yellow spots are stream crossings, where it can be difficult to deploy cables

Radio real-time telemetry

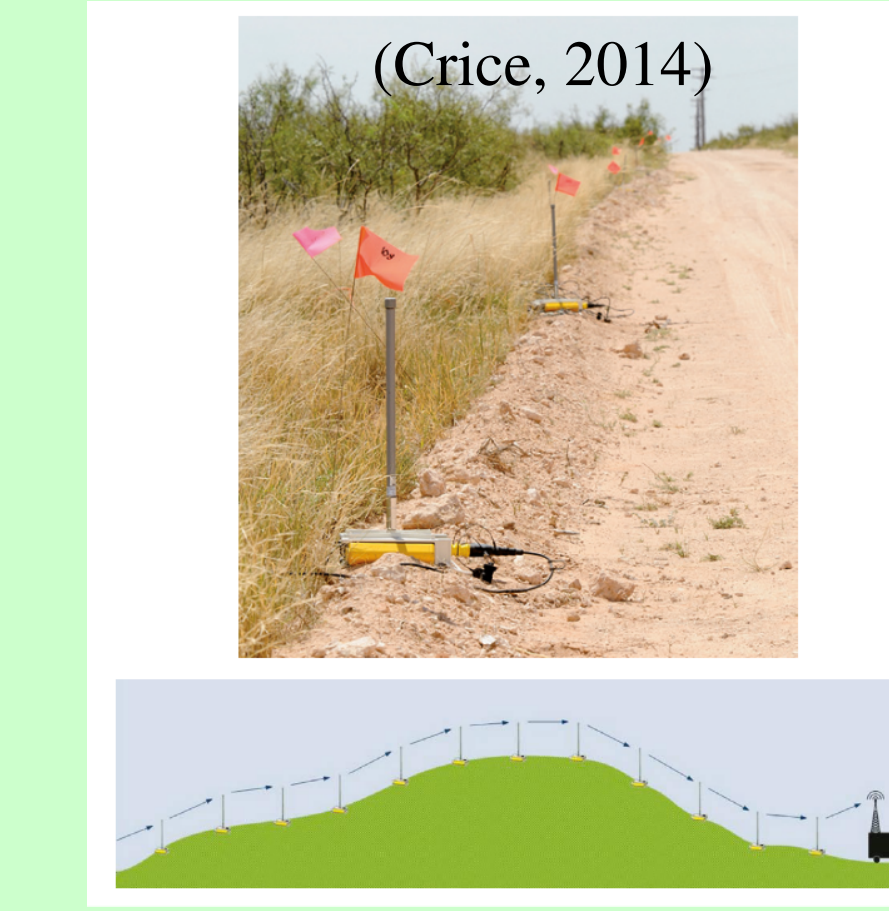


Fig. 6 Example of a real-time radio-relay transmission telemetry

Need for real-time monitoring of geohazards

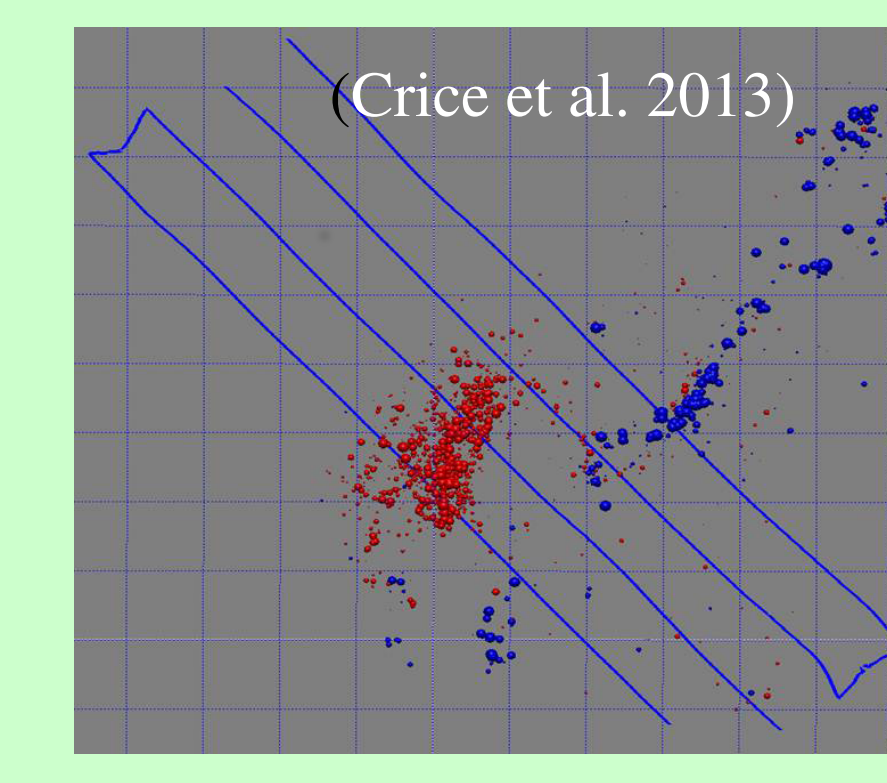


Fig. 7 Monitoring conducted with blind nodal systems. Flow went outside the targeted area

B. Monitoring HF with Permanent Buried Arrays (PBA)

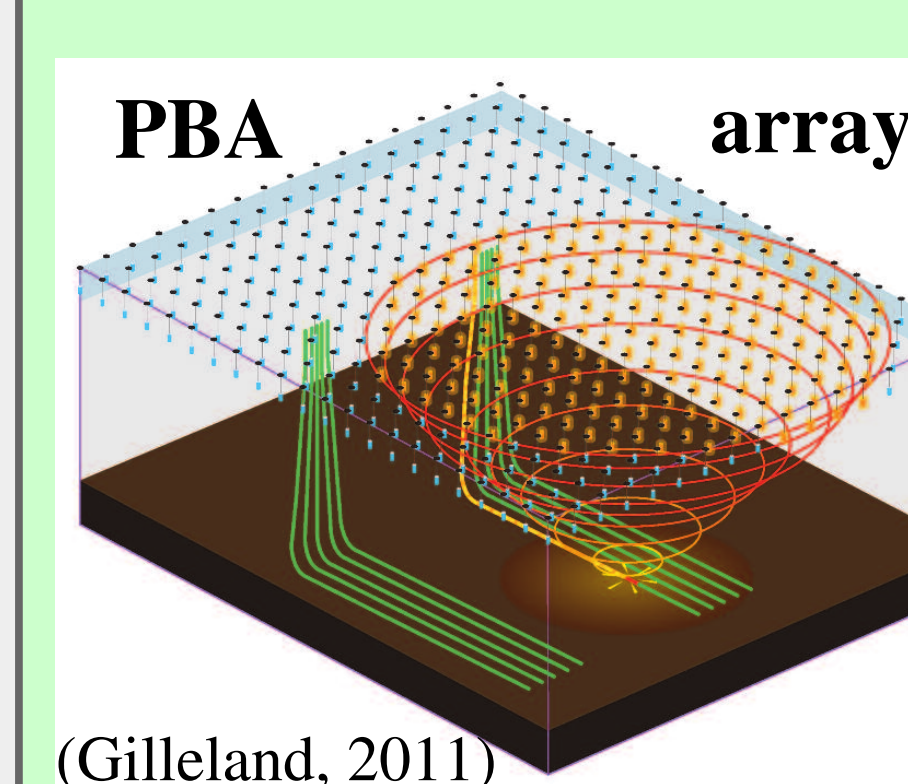


Fig. 8 Schematic application of PBA solutions in HF monitoring

- Less than 100 m depth
- Noise reduction (20 dB from surface)
- Versatility and flexibility
- Best cost-effective approach for multiple well-pads

Microseismic monitoring

PBA has become a vital tool for field development plans

In the Marcellus shale, operators gained confidence that fracking was conducted efficiently and environmentally safely

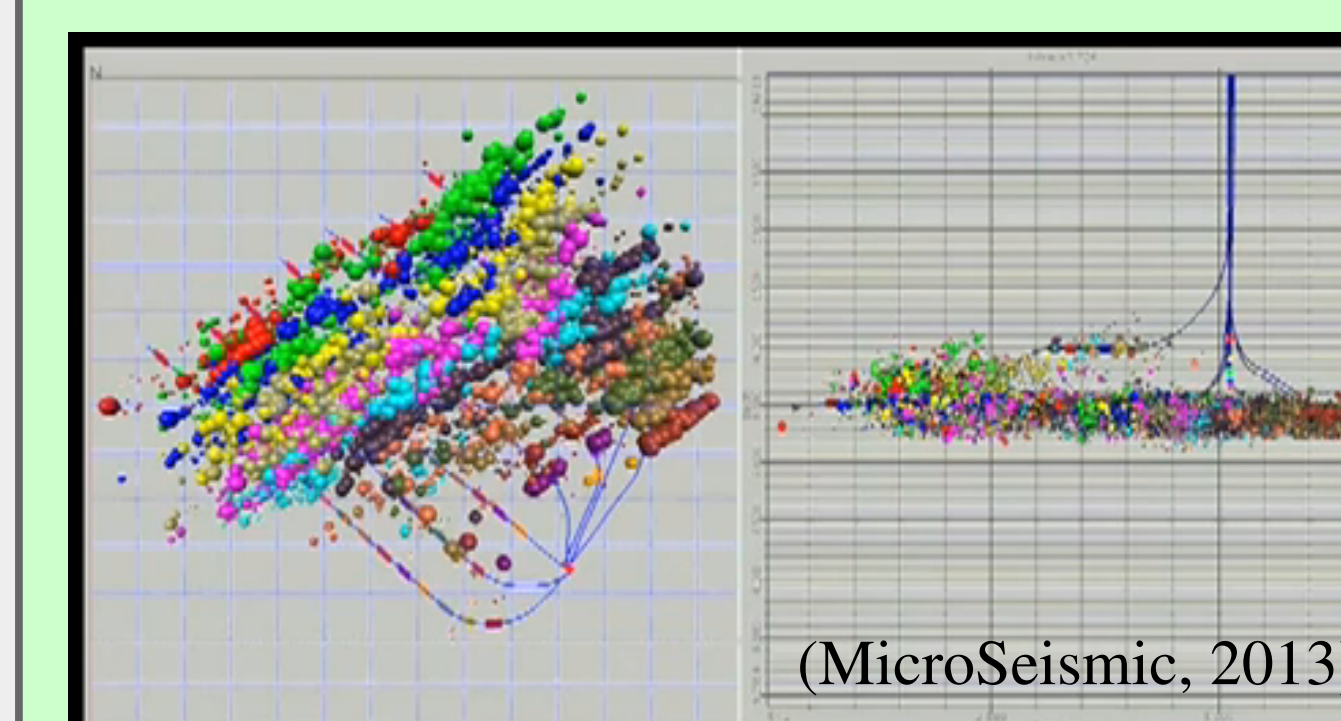


Fig. 9 Location of induced microseismic events by HF treatment in a Marcellus field

6. Limitations

Cabled systems



Cable-free systems



7. Summary

- Technology is driving a new phase in seismic monitoring of hydrocarbon reservoirs
- For guaranteeing a safer extraction, real-time telemetry solutions are needed
- In terms of technological innovation in the seismic sector, the elimination of cables introduces other problems
- Nodes are proven to decrease security issues and have less environmental impact, but signal detection is not so clear yet

References

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