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See Your Reservoir in HD™



Industry Academia Relations

Many Points of Light - Illuminating Innovation
through Collaboration

March 23, 2012, San Diego State University, 9th Annual ACSESS Forum



Motivation

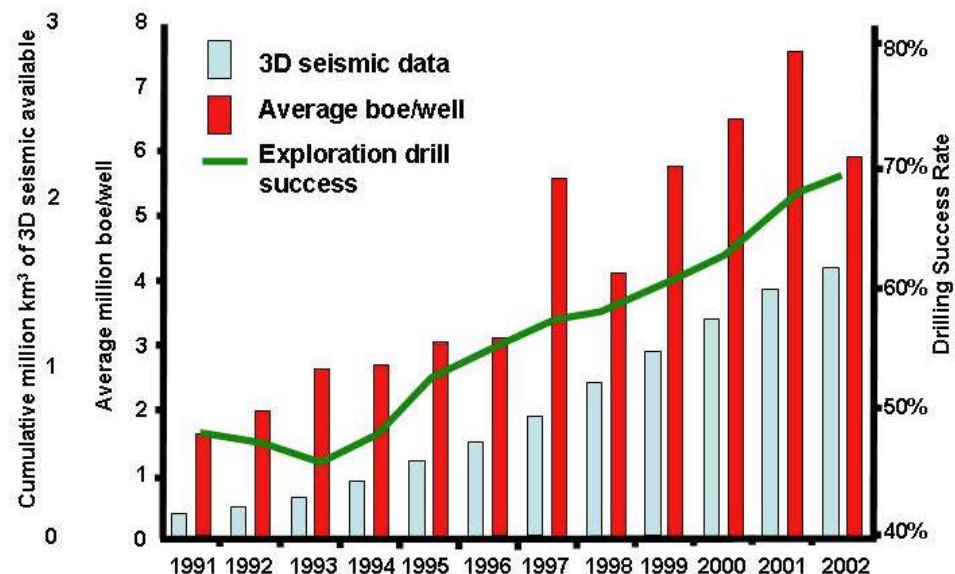
- Mutually tap into the many points of light --- experts are distributed among academia and industry in our increasingly specialized, virtual world
- Moore's Law is alive and well, not just in transistor density but in Insight Velocity
- Diverse, collaborative thinking is critical to driving the most creative innovations
- Leverage a diminishing pool of research funding to drive innovation and competitiveness
- Work with the best and brightest students as they hone their skills and gain experience
- History of proven success



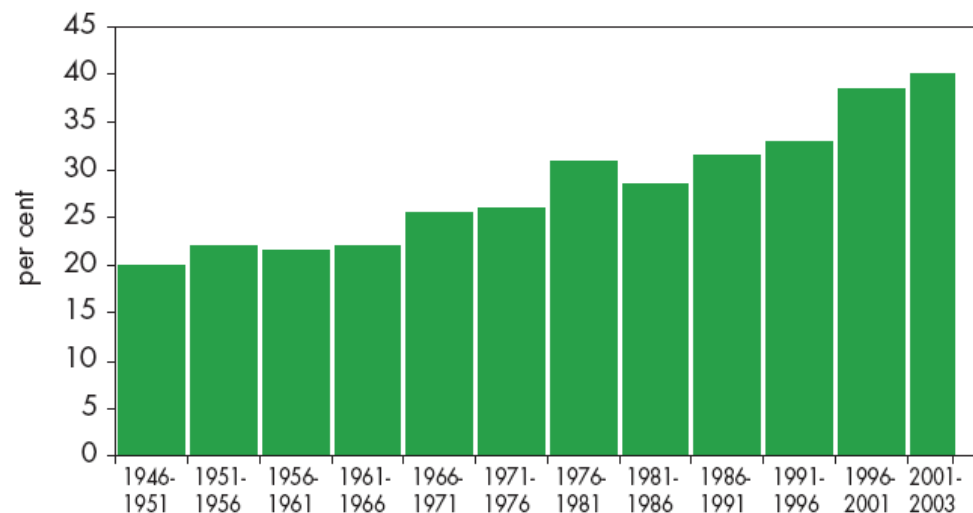
Drilling Success Rates – Improving with Better Data



- Field geology, subsurface well log analysis and 2D seismic data left tremendous uncertainty in the analysis (*"Oil is found in the minds of men" – Wallace Pratt*)
- Gradual acceptance of 3D seismic in the middle 1980's, first in exploration then in production increased success rates, but this is also a function of drilling in familiar basins
- As 3D data volumes grew, so followed success rates.
- The next challenges are recovery factor and booking reserves



After Boutte, 2004



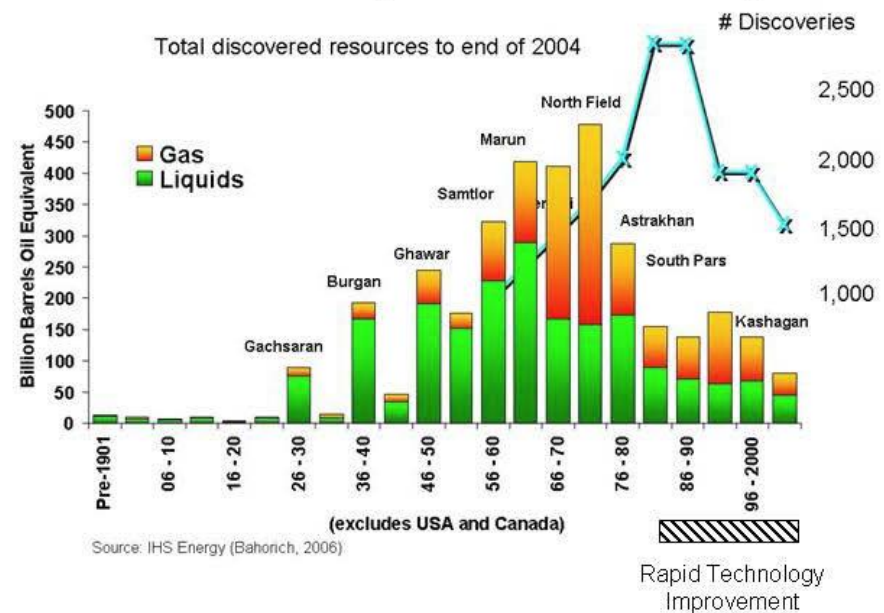
The Energy Industry Focus has Changed



Exploration is not what it used to be

- Exploration discoveries are contribute decreasing amounts to reserve additions with most major activity in ultra deep water and complex geology
- Field extensions, overlooked oil, deeper plays and advanced recovery deliver reserves at low risk
- Unconventional resources are dominating the landscape onshore
- Chaotic commodity pricing has driven the decision discussion to focus on value. While technology remains the platform for growth, the proof points have changed along with the audience.

Oil and Gas Discovery Rate Peaked Decades Ago



Shales and Reservoir Management



- **Unconventional Resources**
 - Over 2 trillion barrels of oil in place
 - Over 800 billion believed recoverable with today's technology – leaves 1.2 tbo left behind
 - 827 TCF recoverable gas
- **Recoveries**
 - Today, these reserves are recovered by drilling technologies
 - Imaging and reservoir management methods are coming into play rapidly by some companies, more slowly by others

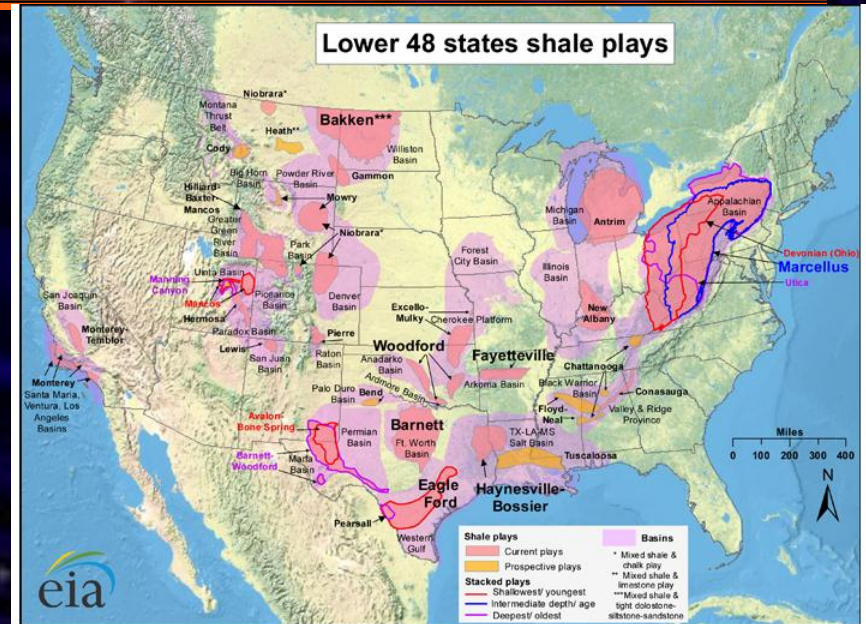
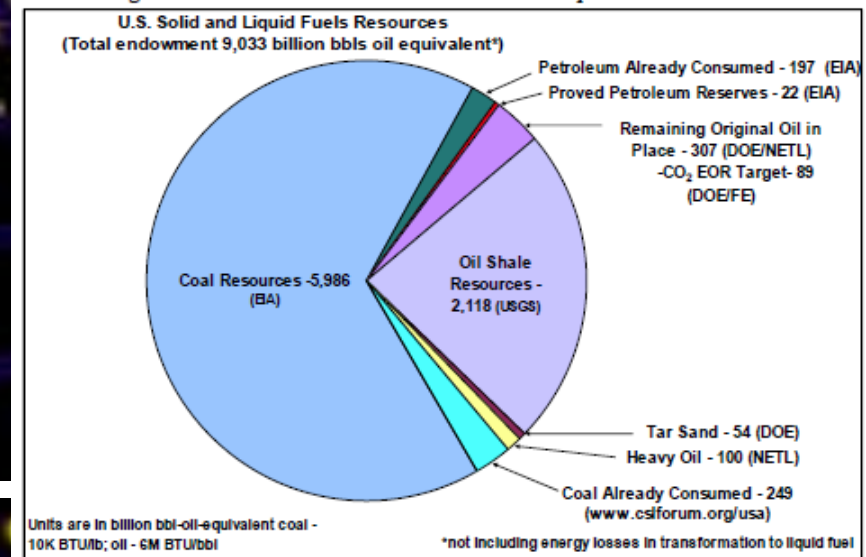


Figure 2. America's Endowment of Solid and Liquid Fuels Resources





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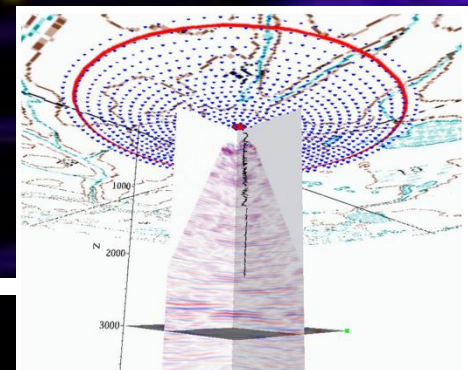
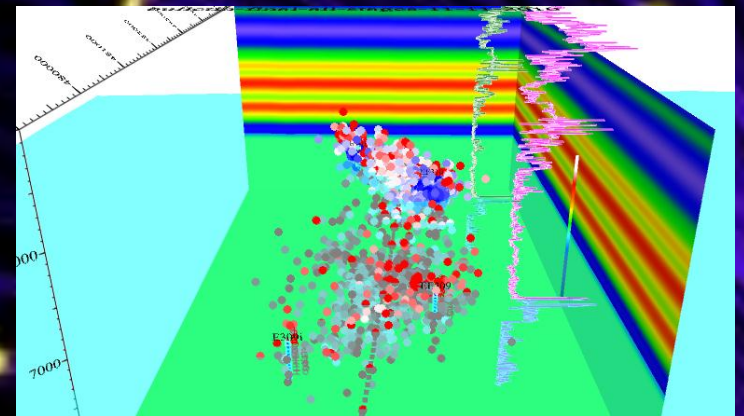
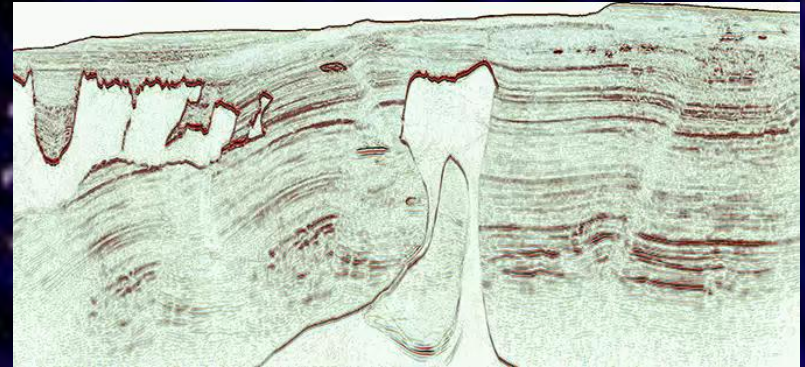
Technical and Computing Challenges

Seismic Data



Seismic data historically have been and continue to be exceptionally large volumes, but modern data sets impart additional computing challenges

- Subsalt imaging – pre-stack depth imaging including RTM , wide azimuth and interferometry
- Accurate microseismic analysis, near real time
- Increased frequency and aperture
- Denser sampling rates (.25ms) to combat aliasing of microseismic and shearwave data
- Elastic inversion to derive physical rock properties
- Correlation to Fluid flow models

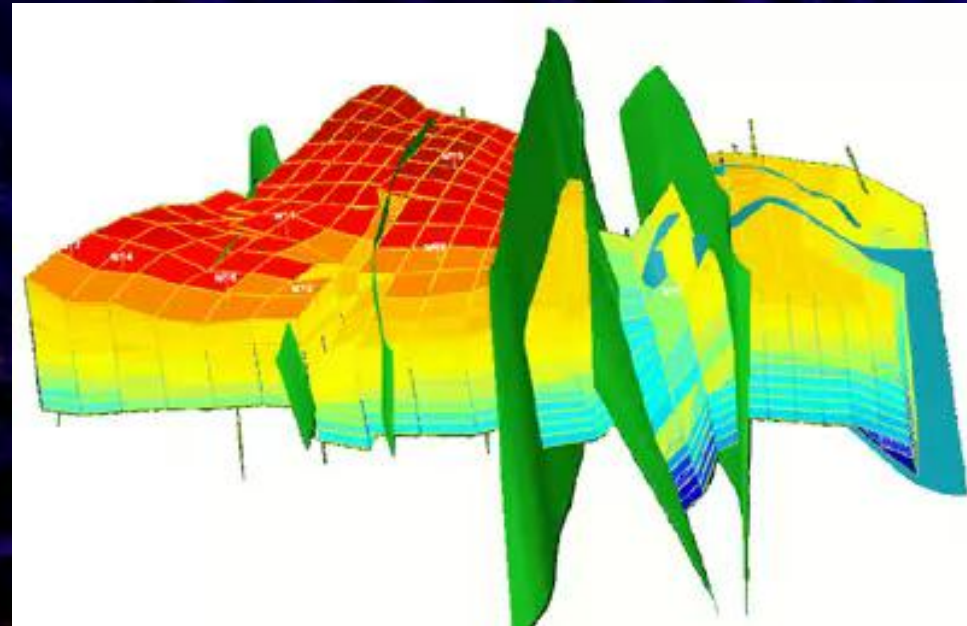


Dynamic Reservoir Characterization



Data Integration and Modeling

- Rock properties
- Fluid properties
- Seismic attributes
- Kinematic analysis
- Fracability
- Stress orientations
- Fluid saturations
- Stratigraphic variation
- **Outputs**
 - Optimized well spacing
 - Optimized well number
 - Drilling and stimulation programs
 - Coordinate with facilities and resource capacities
 - Balance with capital spending



Intelligent Oilfields – Fusion of Static and Dynamic Data



- **Data**
 - Reservoir properties
 - Reservoir dynamics
 - Geology
 - Geophysics
 - Petrophysics
 - Facilities
- **Networks and Communications**
 - Real time sensor networks
 - Advanced computing
 - Ubiquitous visualization
 - Collaborative systems
 - Remote access
- **Information, skill and knowledge rich**





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Research Challenges

Effect of Oil Price on Oil and Gas Research



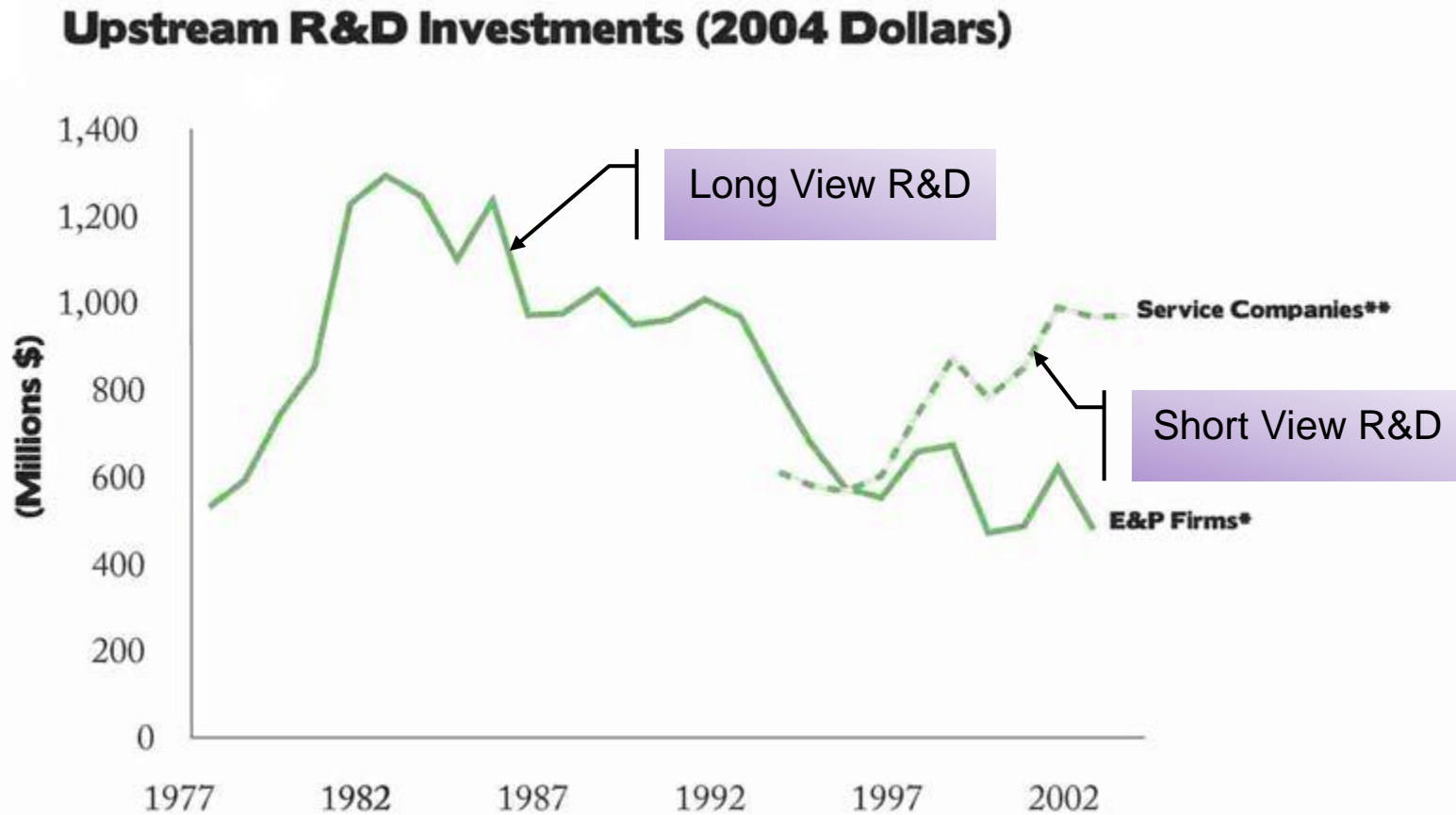
**Inflation Adjusted
Monthly CRUDE OIL PRICES**
(1946-Present) In December 2011 Dollars
© www.InflationData.com
Updated 1/19/2012



Closure of many
corporate research labs

Source of Data:
Oil Prices- www.ioga.com/Special/crudeoil_Hist.htm
CPI-U Inflation index- www.bls.gov

Shift in Research and Development Centers



Upstream R&D investments over time
[Lawson, 2006, reference 4].

The Declining Innovation in Majors

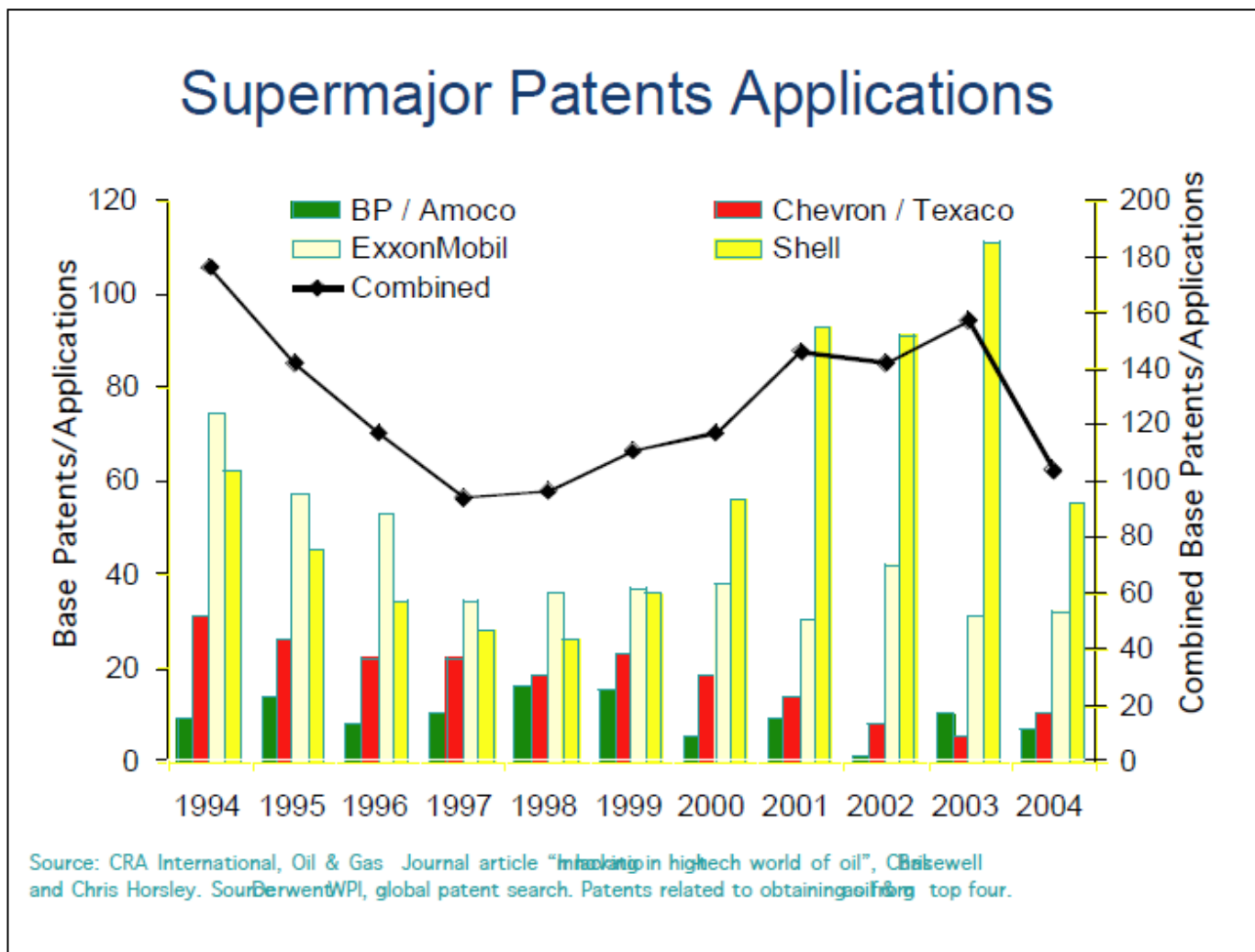
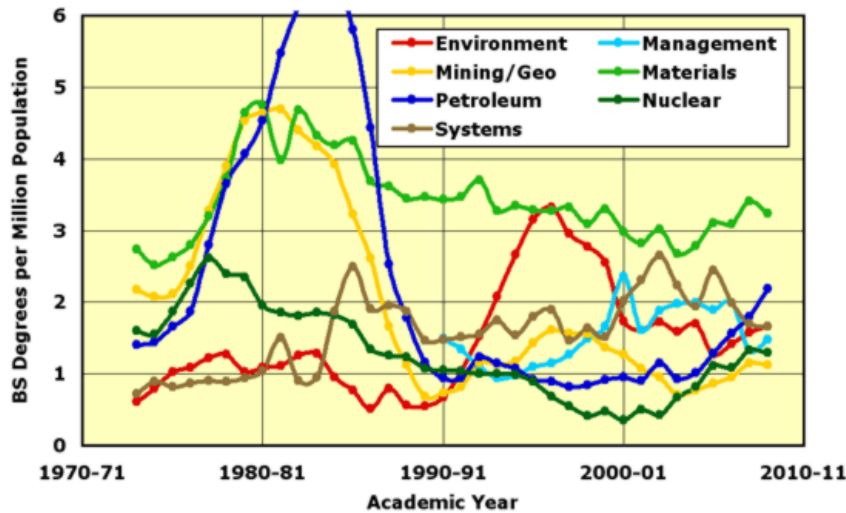


Figure VA.4. Supermajor patent applications by year.

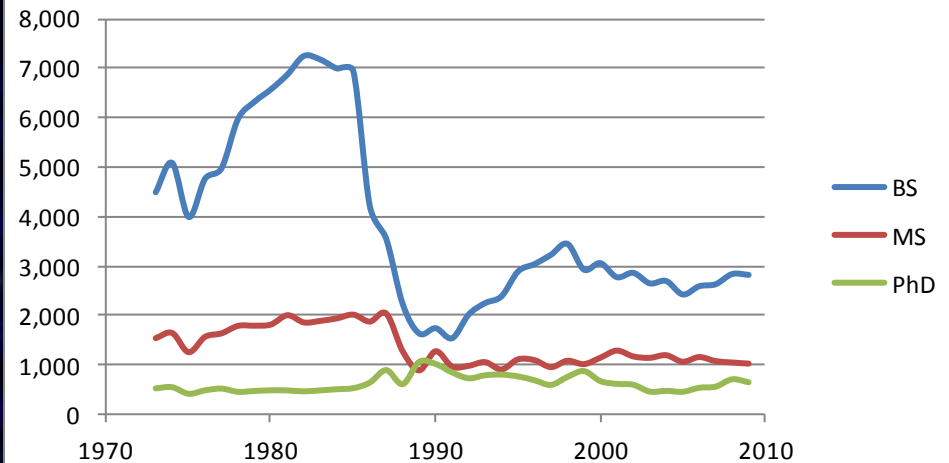
Effects of Energy Industry Uncertainties on Student Population



**BS Degrees per Million Population
Smaller Engineering Disciplines**



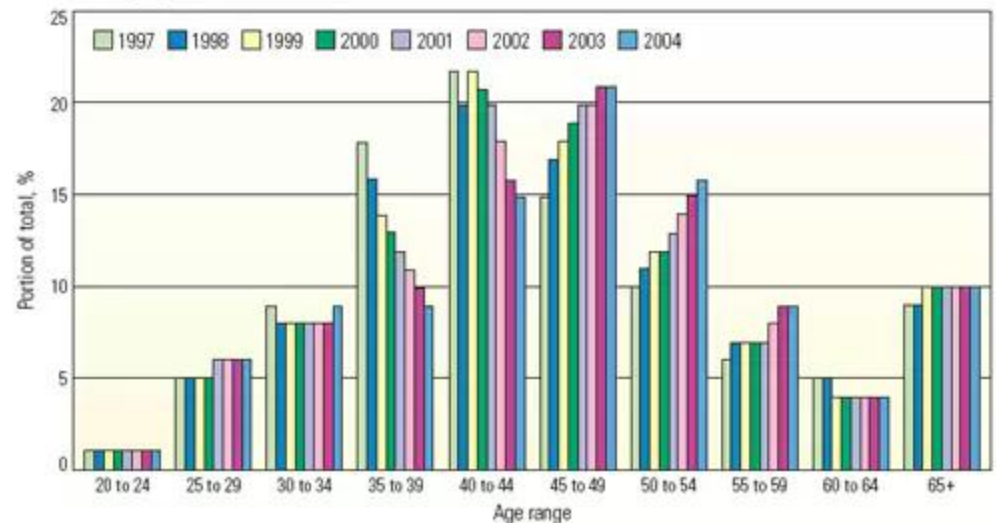
Historical Geoscience Degrees



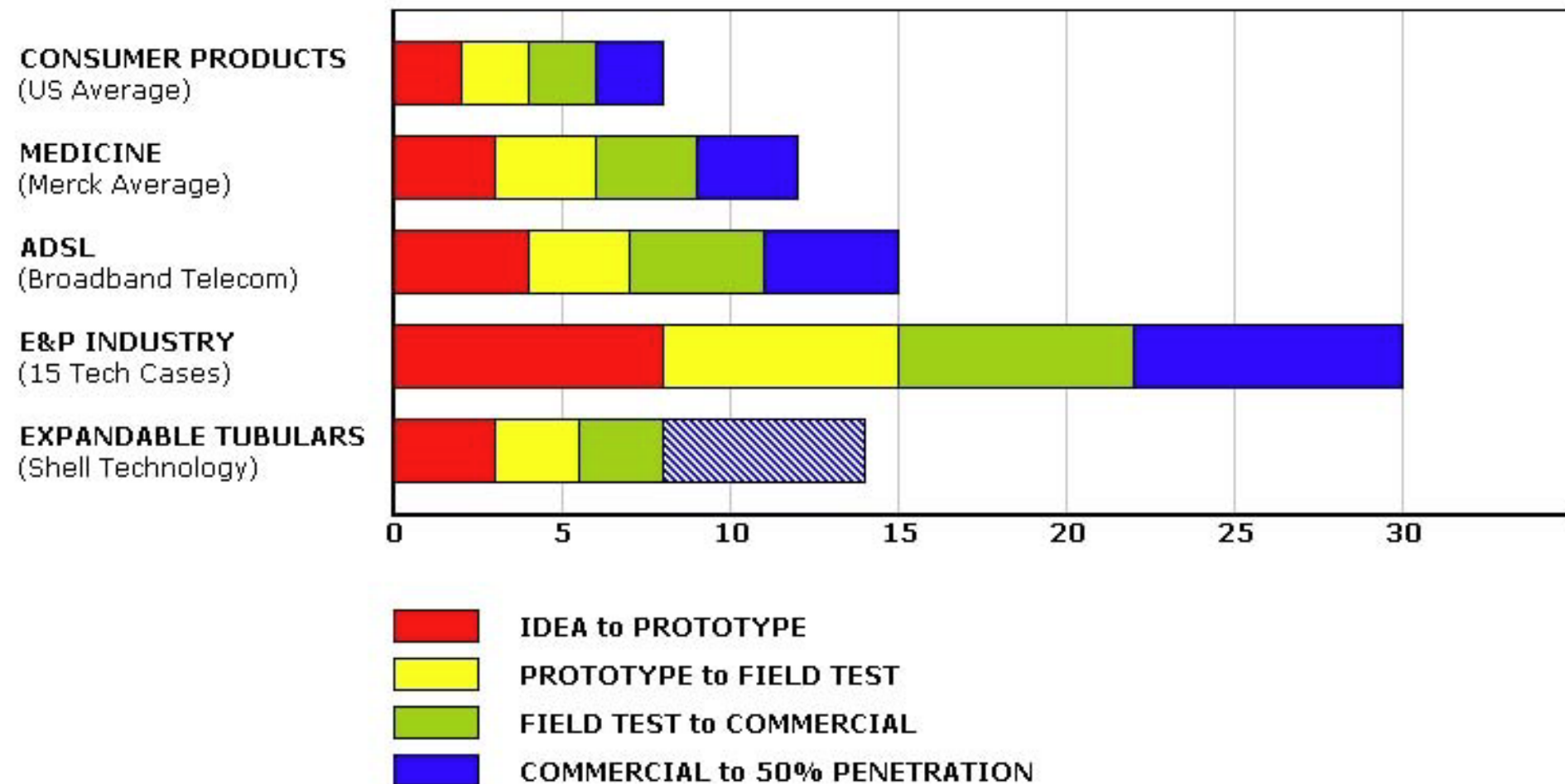
The impending –
looming – Great
Crew Change



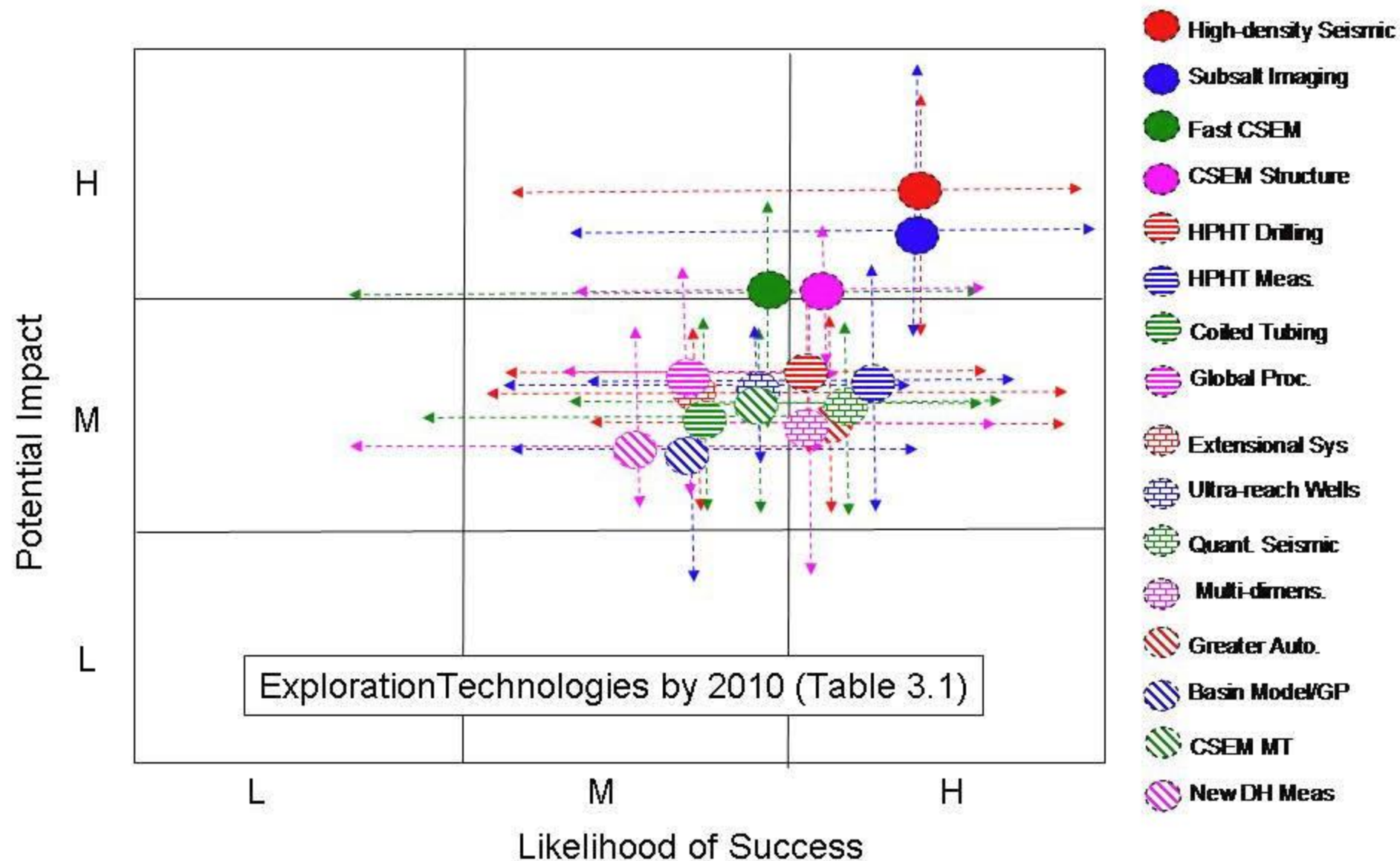
Average Age of SPE Members



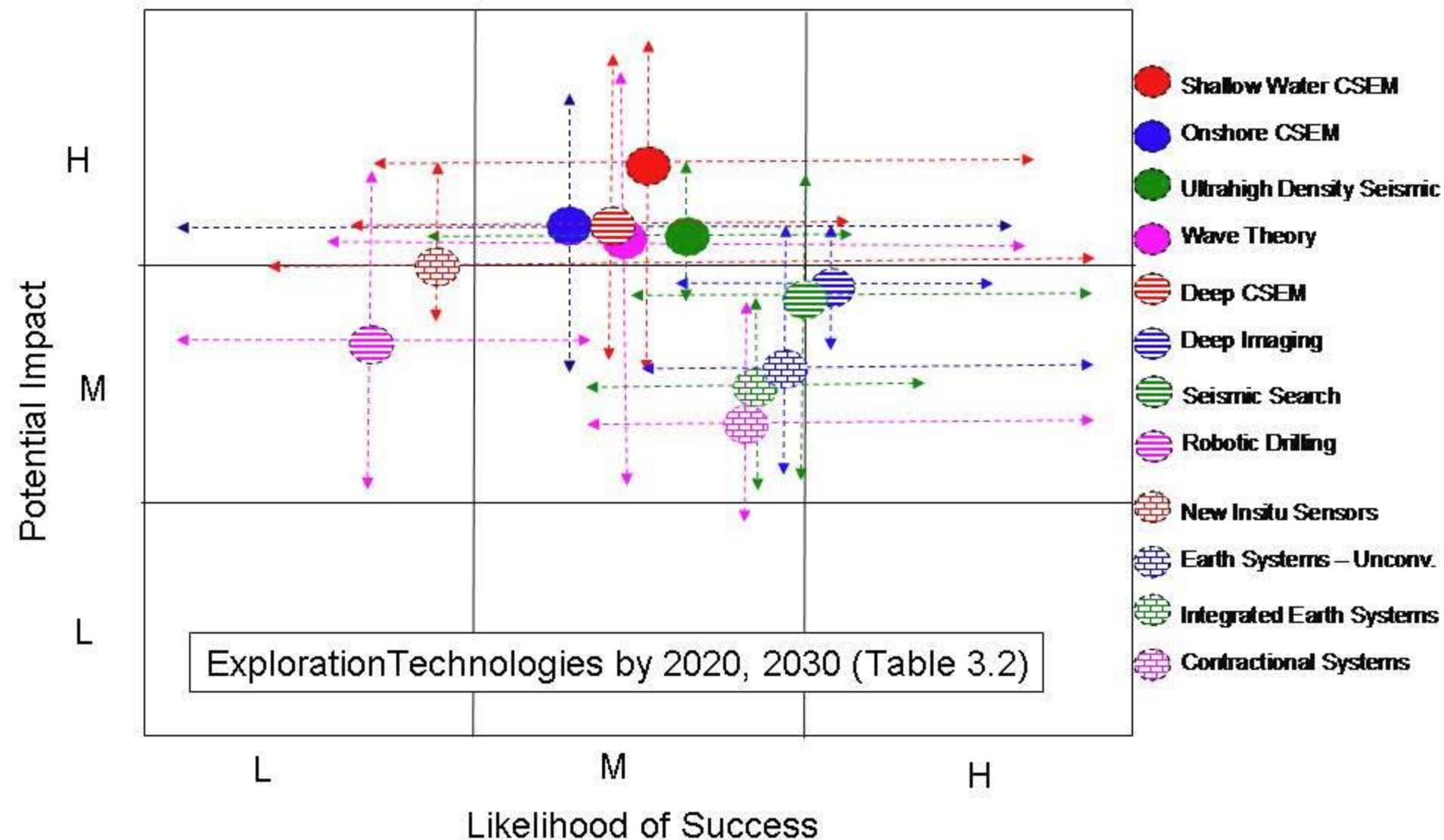
Oil and Gas R&D Acceptance Moves at a Snail's Pace



High Impact Developments Under Way – Part 1



High Impact Developments Under Way – Part 2



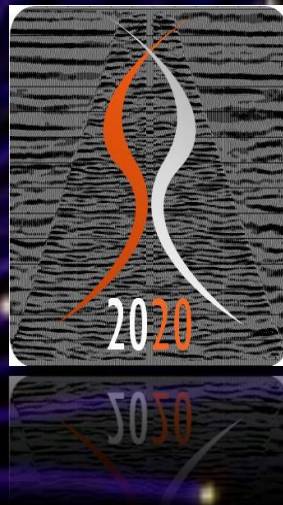


Identify appropriate new and
valuable research directions
and apply sufficient resources
to accelerate acceptance

Working Together – New CRADA



CSRC computational science research center



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Thank You