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2006-2007 SPE distinguished lecturer program

# RESERVES MANAGEMENT AND AUDITABILITY

# CRITICAL REQUIREMENTS IN TODAY'S OIL & GAS INDUSTRY

T HARRISON

Santos Ltd.

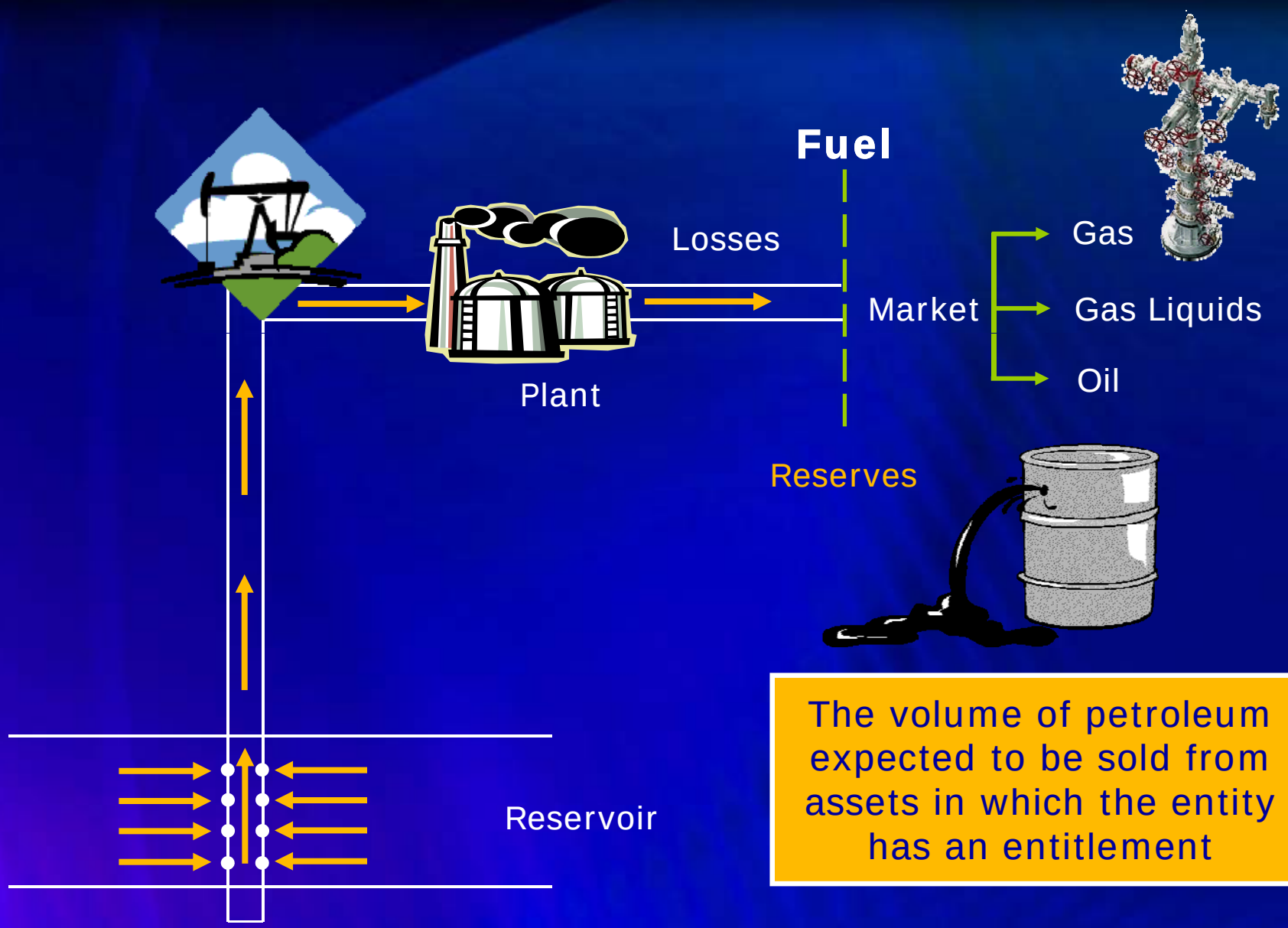
# Agenda

- Reserves and resources – what are they?
- From production forecasts to reserves
- Uncertainty and risk
- SPE/WPC/AAPG resource framework
- Workflow and audit trail
- 2007 Revisions to SPE/WPC/AAPG System

# Reserves

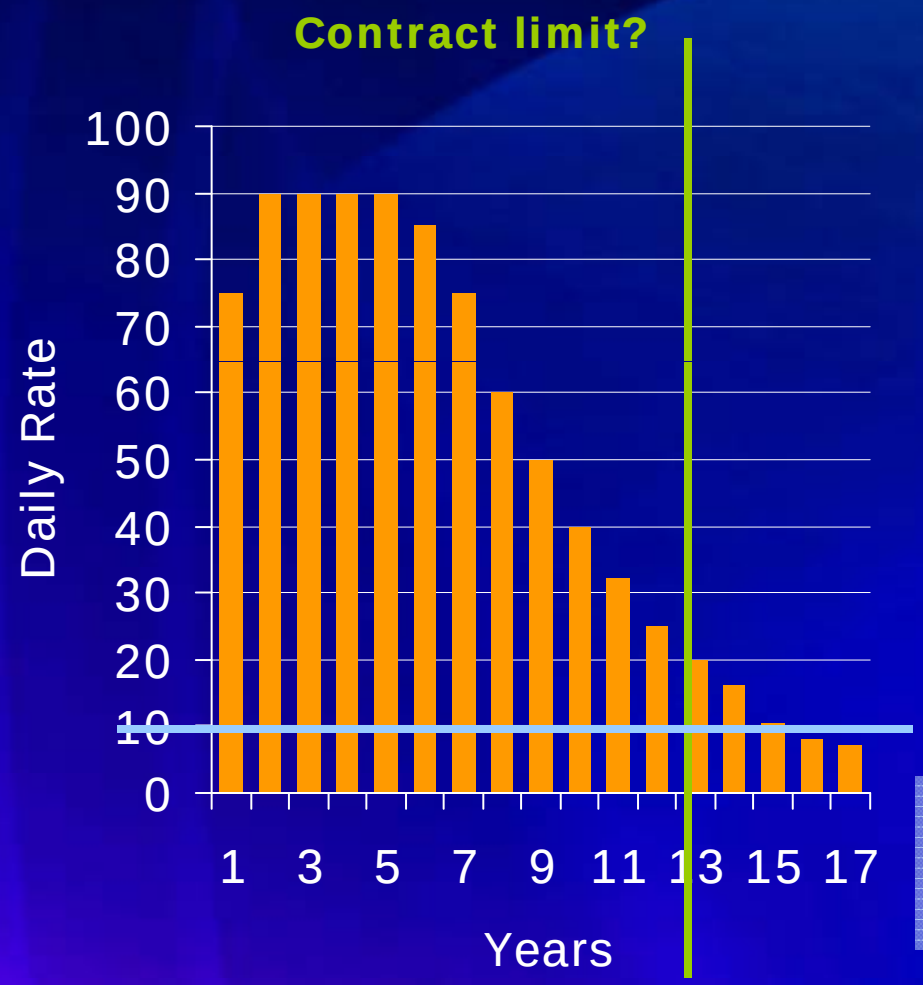
- Reserves are remaining quantities of hydrocarbons to be commercially produced from a known accumulation as of a given date under stated definitions and economic conditions.

# Reserves – What are they?




The volume of petroleum expected to be sold from assets in which the entity has an entitlement

# What are resources (and reserves)?




- Resources (and reserves) are…
  - The summation of the future saleable production
  - From a given date forward
  - Up to the economic or contract limit
  - NOT just a volume!

**Economic limit? (price and cost dependent)**

# Key tests for reserves

- Are the hydrocarbons discovered?
- What entitlement do you have to hydrocarbons?
- Is the project commercial?
- What is the market for the hydrocarbons, especially for gas?
- What commitment is there to develop infrastructure?
- NONE of these tests (directly) mention volume!!!!

Tests are more about “Project Maturity”

# From production forecasts to reserves

Sum of existing plus behind pipe production

+

Sum of production from future development

to

Technical or economic or contract or legal limit whichever is first

# Production forecasts – uncertainties

1. Reservoir consistency/continuity
2. Drive mechanism
3. Water/gas break through
4. Damage/damage removal
5. Suction pressure profile
6. Impact & timing of development
7. Mechanical integrity
8. Fluid composition
9. Metering accuracy
10. Vertical lift
11. IOR impact
12. Market
13. Weather

How do we ever get it right?

# Reserves are functions of technology

*The Story of Kern River Oil Reserve*

- Discovered in 1899.
- After 43 years of operation,
  it had reserves of 54 million barrels.
- In next 43 years,
  it produced, not 54 but 730 million barrels.
- At the end of that time, in 1986, it had “remaining reserves” of about 900 million barrels.
- At end 2000 the field had produced 1,760 million barrels

*Adelman, 1987*

# Reserves uncertainties

1. Production forecast uncertainties
2. Price uncertainty
3. Cost uncertainty (both Capex & Opex)
4. Commercial/legal/political uncertainty

# History of reserves definitions

| Year | Organisation | Comments |
|---|---|---|
| 1936 | American Petroleum Institute (API) | Oil reserves definitions - first use of term "proved reserves" |
| 1946 | American Gas Association (AGA) | Gas reserve definitions |
| 1946–1979 | API & AGA | Published annual 1P U.S. reports of oil, gas and NGL's |
| 1964 | Society of Petroleum Engineers (SPE) | Adopted proved reserves definitions similar to API |
| 1978 | U.S. Securities & Exchange Commission (SEC) | Issued definitions for proved reserves |
| 1981 | SPE | Issued revised definitions for proved reserves |

# History of reserves definitions

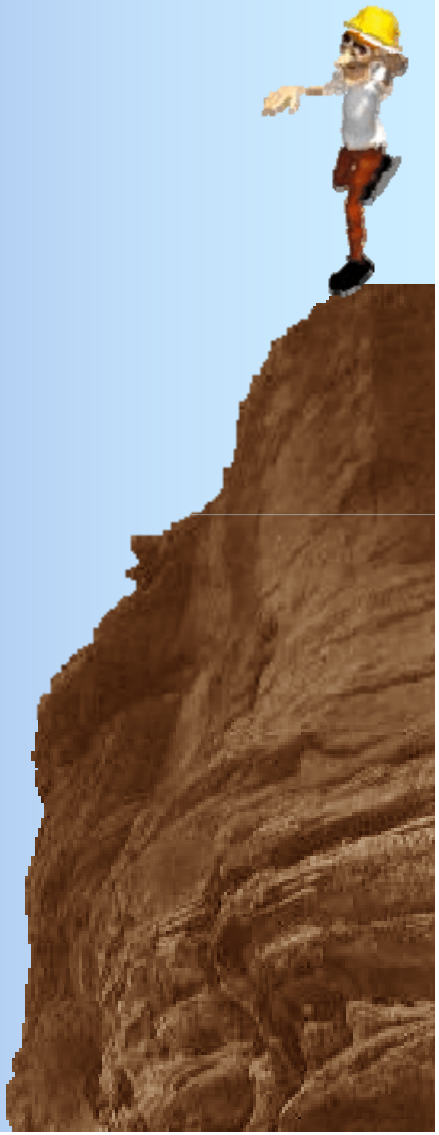
| Year | Organisation | Comments |
|---|---|---|
| 1983 | World Petroleum Congresses (WPC)* | Issued expanded definitions for reserves and resources |
| 1987 | SPE + WPC | Published independent definitions for 1P, 2P & 3P reserves |
| 1997 | SPE/WPC | Jointly adopt 1P, 2P & 3P reserve definitions – deterministic & probabilistic |
| 2000 | SPE/WPC/AAPG | Issue full petroleum resource framework definitions |
| 2001 | SPE/WPC/AAPG | Issue evaluation guidelines for reserves & resources |
| 2007 | SPE/WPC/AAPG/SPEE | Combined & updated definitions & guideline for reserve & resources - PRMS |

*World Petroleum Congresses has subsequently been renamed "World Petroleum Council"

# Risk and uncertainty

**There is a RISK that I am going to fall off this cliff.**

**I am UNCERTAIN how far it is to the bottom!**



# SPE/WPC/AAPG SYSTEM

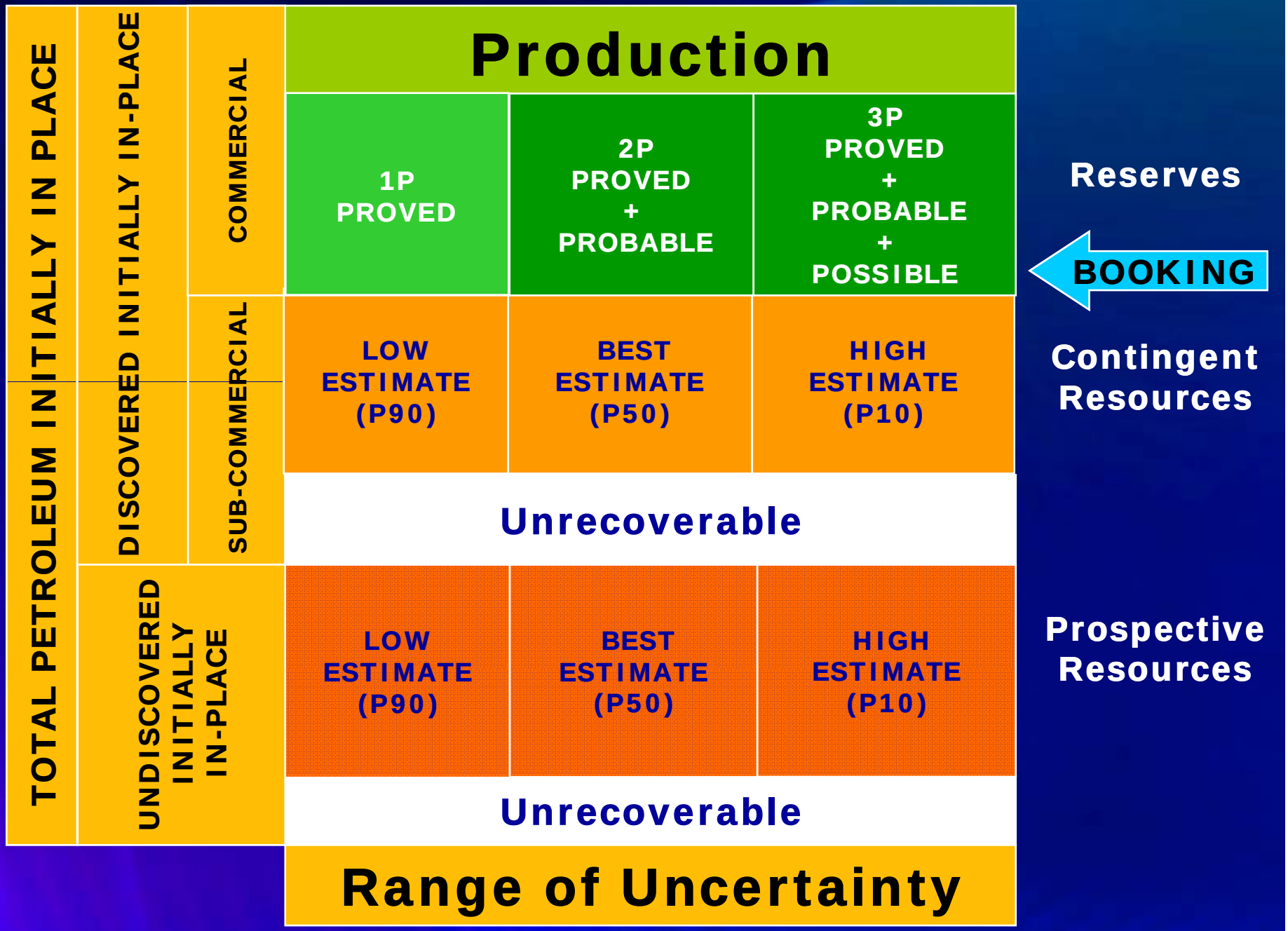
**Consistent approach to assessment of risk and uncertainty for all assets**

**RISK ... project maturity**

Will the project go ahead?

**UNCERTAINTY...**

What is the range of estimated recoverable volumes if the project does go ahead?


TOTAL PETROLEUM INITIALLY IN PLACE
DISCOVERED INITIALLY IN-PLACE
UNDISCOVERED INITIALLY IN-PLACE
COMMERCIAL
SUB-COMMERCIAL
Production
1P PROVED
2P PROVED + PROBABLE
3P PROVED + PROBABLE + POSSIBLE
LOW ESTIMATE (P90)
BEST ESTIMATE (P50)
HIGH ESTIMATE (P10)
Unrecoverable
LOW ESTIMATE (P90)
BEST ESTIMATE (P50)
HIGH ESTIMATE (P10)
Unrecoverable
Range of Uncertainty
Reserves
BOOKING
Contingent Resources
Prospective Resources

# Reserves – A sub-set of resources

Prospective Resources – Exploration Potential

**Exploration Discovery**

Contingent Resources – Sub-Commerical

**Commercialised**

Reserves – Commercial

**Developed**

Production – Sales

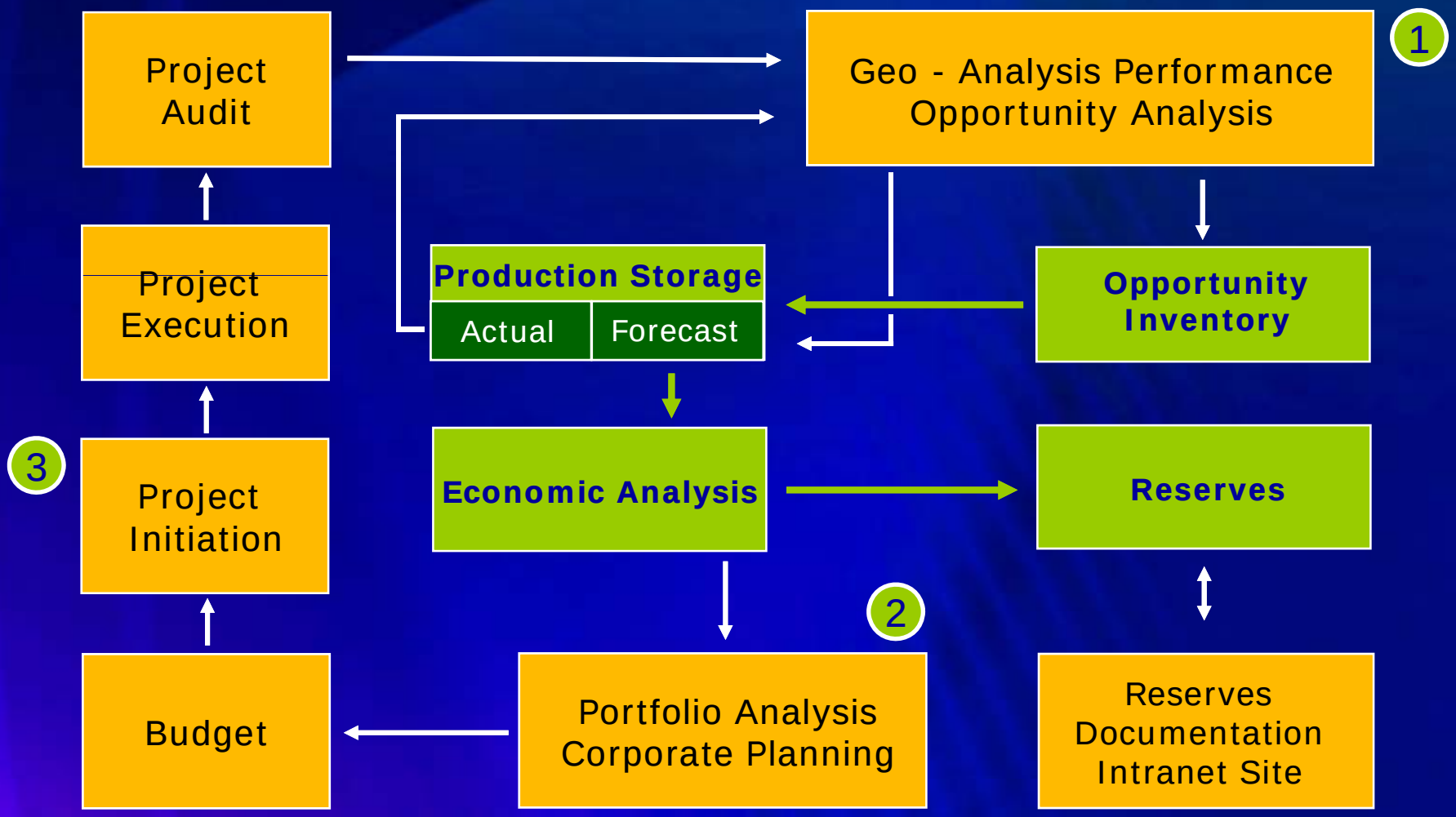
# From production to reserves & beyond

**The work flow – Key elements:**

- Production actuals & forecasts
- Geo/engineering analysis
- Development opportunity inventory
- Economic analysis

**"The Worktable"**

# Process framework – the "Worktable"



# Benefits of the worktable

- Managing assets for value and not just volume
- Ensure the same forecast is used for cashflows, reserves and all planning purposes
- Asset forecasts visible to all levels of company
- Improve data quality and professional's productivity

# Guiding principles

1. Single point ownership of forecasts, reserves and cashflows for each asset
2. Appropriately defined involvement and responsibilities
3. Data standardised: right data in the right place, at the right time, in the right format
4. Allow real time access and roll-ups of asset data
5. Single source data entry and handling – access often

# A few general comments

- Reserves must be part of general workflow of asset teams
- Projects, production history, production forecasts, and economic analysis, are all inextricably linked to reserves and portfolio analysis.

**They can and should be a single workflow – the asset value chain**

- Keeps users happy – link systems to facilitate single point data entry – get IT to do the work!
- Internal reserves audit function must be separated from those tasked with meeting company targets
- Good internal reserves audit is better than external reserves audit
- Include credible external expertise in the reserves review process – Reviewers not doers

# Major Changes in Proposed 2007 SPE/WPC/AAPG/SPEE RMS

| Revision | Comment |
|---|---|
| Combines 4 previous guidance documents into single "Petroleum Resources Management System":<br>1997 SPE/WPC Petroleum Reserves Guidelines<br>2000 SPE/WPC/AAPG Petroleum Resources Classification and Definitions<br>2001 SPE/WPC/AAPG Guidelines for the Evaluation of Petroleum Reserves & Resources<br>2005 SPE/WPC/AAPG Glossary of Terms | Separate documents combined, abbreviated and clarified |

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# Thank you for your attention

Any Questions?

# BACKUP SLIDES

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# Contingent resource to reserves

- Project must be commercial:
  Economics must be run to differentiate technical from commercial
  *Minimal risk of project not proceeding*
- Demonstrate commitment to develop and place on production within reasonable time frame:
  - Project Sanction
  - Plan of Development
  - Gas Sales Agreement/Spot Market
- Reasonable Level of technical uncertainty:
  - Is low side break-even?
  - Is the uncertainty such that the company is unable to commit to go ahead with project?

*If the project does not proceed reserves may need to be de-booked*

LOWER RANGE OF UNCERTAINTY

# Undiscovered to discovered

## Prospective resource to contingent resource

- Must have been penetrated by a well

  Adjacent fault blocks – sealing/non sealing – down dip/up dip?

- In general – moveable hydrocarbon must be shown to flow to surface or at least some recovery

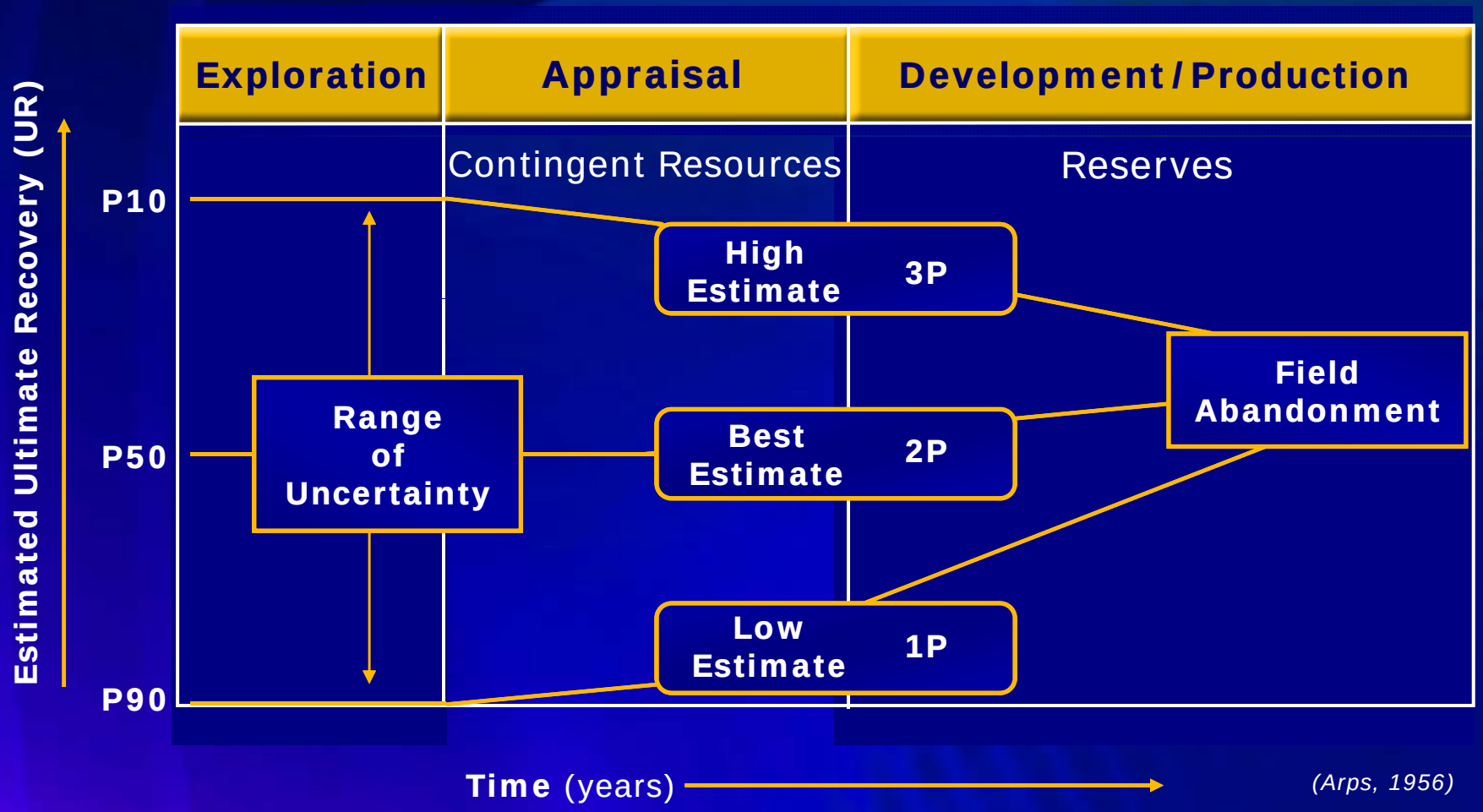
- Where log and/or core data exist – may be OK if there is a good 'geologically comparable' analogy nearby

  Key words: "Nearby" & " Geologically Comparable"

Note: Commercial/economic analysis of discovery not required for Contingent Resources

LARGE RANGE OF UNCERTAINTY

# Tracking Volumetric Uncertainty




*(Arps, 1956)*

NB: Reserves = UR - Production

- Complete Petroleum resource system from Undiscovered to Production
- Incorporates series of ‘gates’ or decision points

# Focal Points for Corporate Governance

1. Undiscovered (Prospective Resource) → Discovered Hydrocarbon (Contingent Resource)
2. Discovered (Contingent Resource) → Discovered – Commercial (Reserves)
3. Unproved Reserves (Probable & Possible) → Proved Reserves (Proved)

- First two transition points relate to ‘Project Maturity’ – both technical and commercial
- Third transition point relates to ‘ Project Uncertainty’ – mainly technical

# Attributes of Proved Reserves

**Reasonable Certainty**

- High degree of confidence
- If Probabilistic methods used – 90% chance reserves will exceed estimate
- Fluid contacts or LKH or as indicated by **definitive** geo/eng or performance data
- Undeveloped – within defined area – reasonable certainty formation is laterally continuous & contains commercially recoverable hydrocarbons

**Commercially Recoverable**

- Commitment to go ahead with project
- Evidence of commercial productivity
- Legal entitlement

**Current Economic Conditions**

- Price & cost forecasts based on historical data
- Economic Limit
- Appropriate contract obligations & Government regulations
- PSC Complexities

# Attributes of proved + probable reserves

**More likely than not to be recoverable**

- Middle ground – best estimate
- If Probabilistic methods used – 50% chance reserves will equal or exceed estimate
- Fluid contacts or as indicated by geo/eng or performance data – if no indicative data – half way between LKH & LCC often used

**Commercially recoverable**

- Commitment to go ahead with project
- Less stringent evidence of commercial productivity
- Legal entitlement

**Reasonably improved economic, technical & operating methods**

- Reasonably improved Price & cost forecasts
- If fault separated from proved area – included if faulted area higher than proved area
- Appropriate contract obligations & Government regulations PSC Complexities
- PSC Complexities

# Attributes of proved + probable + possible reserves

**Less likely to be recoverable than 2P reserves**

- High Side Estimate – Upside potential
- If Probabilistic methods used – 10% chance reserves will equal or exceed estimate
- Fluid contacts or as indicated by geo/eng or performance data – if no indicative data – LCC often used

**Commercially recoverable**

- Commitment to go ahead with project
- May not currently be shown to be commercially producible
- Legal entitlement

**Reasonably improved economic, technical & operating methods**

- Reasonably improved Price & cost forecasts
- If fault separated from proved area – included if faulted area lower than proved area
- Appropriate contract obligations & Government regulations
- PSC Complexities

# Developed & undeveloped reserves

**Developed**

- Production from Existing Completions
- Behind pipe if only minor expenditure
- Compression restaging

**Undeveloped**

- New wells/deepening existing wells
- Connections & recompilations
- Additional compression

# Aggregation of accumulations

- Probabilistic up to ‘project’ level where project has common sales point
- Arithmetic above project level
- Arithmetic assumes dependant variables & probabilistic assumes independent
- Real World = somewhere between the two
- Project under way to include probabilistic summation in Volts reporting

# Aggregation of accumulations continued

- Probabilistic versus arithmetic
- Probabilistic will tend to over-estimate the low side if there are dependencies between the distributions
- Arithmetic will tend to under-estimate the low side if the distributions are independent
- Probabilistic methods assume a continuous distribution not three deterministic estimates
- In a probabilistic world the sum of the individual components will not equal the sum of the total

# Contingent resources continued

**Contingent resources are "contingent" on overcoming a barrier in order to become reserves:**

**Development pending**:

Requires further data acquisition and/or evaluation in order to confirm commerciality

**Development on hold**:

Of significant size, but awaiting development of a market or removal of other constraints to development, - may be technical, environmental, or political.

**Development not viable:**

No current plans to develop or to acquire additional data at this time due to limited production potential.

# Coal Seam Methane (CSM)

- Classified by same convention as conventional oil & gas reserves:
  - But; CSM reserves more related to volume of coal & ability of coal to liberate gas rather than estimate of recoverable gas in pore spaces as in conventional reservoirs
- 1P, 2P & 3P limits in CSM fields not defined by conventional contacts (LKG,HKW,LCC) as most coal contains gas absorbed onto coal surface independent of structural location
- CSM fields located in a variety of structural settings such as anticlines, synclines & monoclines
- CSM resource comprises volume of gas throughout coal and surrounding strata