

E&P Business Transformation

Reserves – Technology – Information {RTI} Strategy

Working Paper

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Declaration:

The work and its contents are based fully on the learning and investigation of the author. The report is assimilated completely through the author's perception and experience in the E&P industry. The author is solely responsible for the opinion and inferences.

Abstract

Reserves (R) – make and break E&P companies. Its value and reliability are THE most valuable asset. The [reserves hopper](#) – evolution from Resources to Reserves needs maximum management focus all over. Management stage-gates to reserves maturity are necessary and sufficient for good governance.

Technology (T) – is a wide array of methods providing variable assessment of reserves. KPI of technology is assessed from the quantum and reliability of reserves. Value of Information (VoI) from technology is measurable through its impact on reserves.

Information (I) – is not IT department function. Technologies create conforming, conflicting and contradicting information about reserves. Best of Computer Science methods are needed to assimilate the data and drive information → knowledge and → wisdom in developing E&P business. Information strategy is the foundation for developing the Technology into [4th Paradigm of Science](#).

Reserves accrue from Technology through robust Information.

These 3 dimensions {R–T–I} are brought forward into a E&P business management model as necessary and sufficient factors for success. The business performance metrics are simplified using these 3 dimensions and entire organizational stage-gates are mapped to reserves maturity.

Preface

My reason for writing this is driven by my career that oscillated between Geoscience and Computer Science in Petroleum Exploration & Production (E&P) industry. Inspired and committed to a small phrase Davis (1973) penned in his book –

“ ... when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: ... you have scarcely in your thoughts advanced to the state of science. ...” Lord Kelvin.

Quantitative methods and measurement became a focus of my work practice. I taught computer-based techniques for data organization and analysis to Petroleum Geologists, both students and professionals since 1980s. I still find the work of Harbaugh and Bonham Carter (1970) and Jones, Hamilton and Johnson's (1986) fascinating! Between 2006 and 2015, I functioned as CIO at an independent E&P company of a large Indian Corporate. The first initiative was to delink E-mails from being a document repository and establish a modern document management system. We found a great idea and implementation in tagging People-Process-Digital Record in a commercial product offered by “[Pointcross](#)”. The concept and strength of [Business Information Framework \(BIF\)](#) evolved from their technology offering.

A ‘Reserves Assurance’ function was formed in the company and I steered its establishment and execution. In that capacity, the entire ‘[Reserves Hopper](#)’ and activities that lead to its progress came under my study. Most of the Technology initiatives came for my review. The complete overlook to the impact on the ‘reserves maturity’ became an eye opener. Technology is often pursued just for the sake of technology!

2006, the company engaged a major E&P service provider to help in business process reorganisation. I inherited that project. Again in 2014–15 the entire corporate engaged into a major Business Transformation (BT) exercise. SAP became the synonym for ‘Silver Bullet’. That is when the [R-T-I](#) model got conceived to reorient the philosophy and metrics of BT.

The original material of R-T-I was submitted in 2015 to the company supporting simplification of the BT guidelines. A ‘Digital Information Strategy’ and cascading measures to all functions in the corporate was also proposed. Four years down, I located the material and thought it may be useful to the community at large. It was a pleasant surprise to see a [recent note by Deloitte](#) that stood firmly committed to IT model of Information, while the R-T-I model differentiated IT from Computer Science. This approach favours transforming E&P methods and technologies inline with 2020-Science.

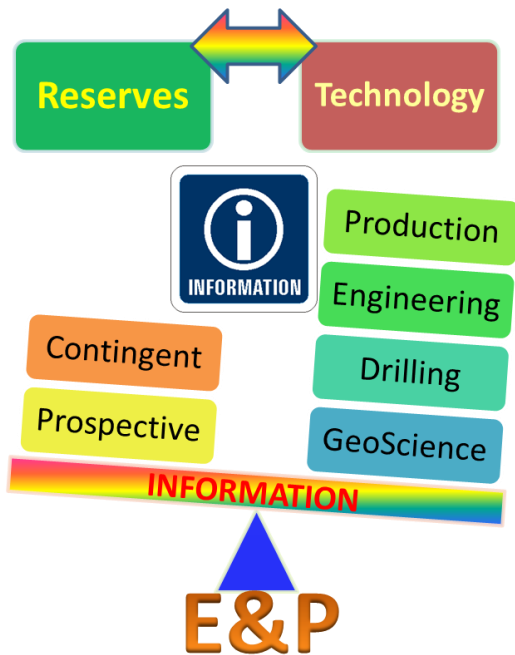
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Executive Summary

E&P – Petroleum Upstream business is conventionally described with 5 stages of maturity: Explore → Appraise → Develop → Produce & → Abandon. With over ~60 different disciplines of sciences and technologies, hundreds of incoherent workflows, uncertainties, risks, cost, value, environmental and regulatory dimensions – the business model and framework are very complex.

The 21st century information age allows E&P to be portrayed as a business focused on 3 areas.



11-Feb-15

Figure 1 R–T–I model. Reserves are the outcome of Information provided by Technologies

1. Reserves : Reserves (including all kinds of resource maturity) is the singular central focus and objective of the E&P business. E&P business without reserves is not conceivable. Successful E&P is all about management of [reserves hopper](#) and its significant milestones.

2. Technology : The myriad sciences, engineering, and technology are conventionally grouped into many specializations. Geosciences (e.g. seismic acquisition ← → reservoir characterization), drilling, engineering (reservoir, design, process etc.), production and management form the classical organization disciplines. All of them strive to – i) describe the reserves; ii) refine the reserves; iii) establish reserves reliability; and iv) convert the reserves to revenue.

3. Information : The diverse sets of technology used in reserves assessment are inherently contradicting, conflicting and disparate. They generate complex and highly conditional information that carries – volume, velocity, veracity, and variety. A very significant trait of E&P information is the extreme range in their ‘scale of support’. Such information needs most modern and advanced methods from statistics and computer sciences to arrive at reliable and actionable guide on reserves. These approaches are not part of any standard IT department or part of the skill sets of any conventional E&P domains.

This streamlining of E&P business into Reserves ↔ Technology ↔ Information is expanded in this note, to provide stages of organization management and maturity for achieving sustainable and successful E&P. This model can support current organizational approaches and facilitate to Learning and Innovation centric blue ocean opportunities.

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Introduction to Reserves Centric E&P framework

“Reserves” differentiates the E&P business from other Petroleum Midstream and Downstream ventures. The access to variety of technology, operational excellence, and management practices is common with the other Petroleum business segments. The complex manifestation of “reserves” makes E&P a – i) Knowledge Intensive; ii) Uncertainty prone and iii) Disproportionately high cost: high value opportunity.

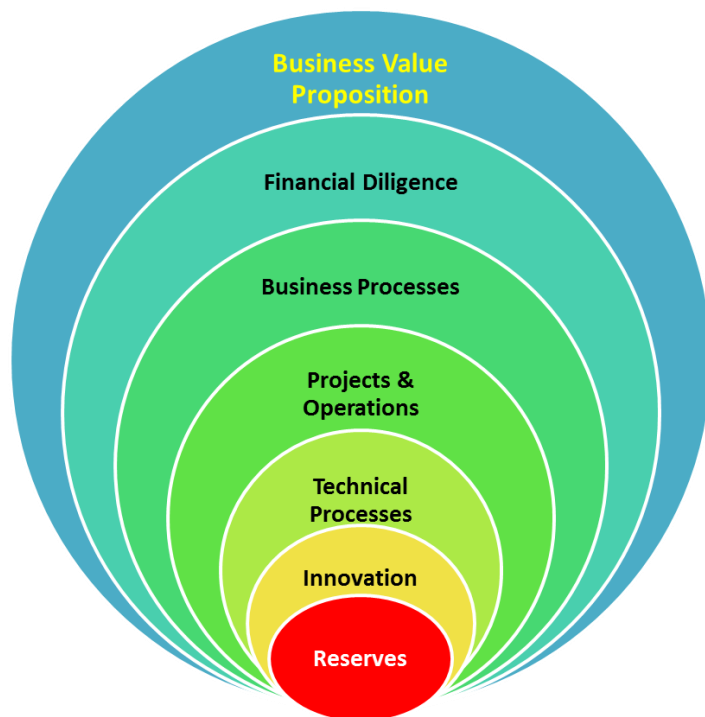


Figure 2 Reserves are Critical*, the Purpose and Central focus of E&P

automatic (Finance processes, disclosures etc.). Procurement, HR, Support-services, IT (Classical) are seldom critical. Lot of other activities tends to be mainly desired*!

Reserves – Technology – Information union is Essential* for E&P.

Conventional E&P Business models

Petroleum upstream business models are largely similar in all companies.

* A 4-level classification of functions is used herein. 1. **Critical** {stalls or terminates functions – showstopper for business}; 2. **Essential** {clear, consistent, definite and measurable impact}; 3. **Required** {Implied, expected or projected impact proposition}; and 4. **Desired** {Socio-political, multiple wishful impacts – often qualitative and futuristic}.

Clarity and commitment to place “reserves” at the core of the entire E&P business framework is essential.

Conducting E&P business with unraveled focus to the performance of the “reserves” is crucial for success.

The entire business model, organizational structures, risk matrices, governance, regulations, decision stage-gates and financing is proposed to be built around this central value proposition of “Reserves”.

Reserves are not only necessary but also largely sufficient criteria for success of E&P.

Functions directly contributing to reserve definition, creation and validation are often “Essential” *. Business functions in a socio-economic-legal environment, the operational requirements are also mandatory and/or

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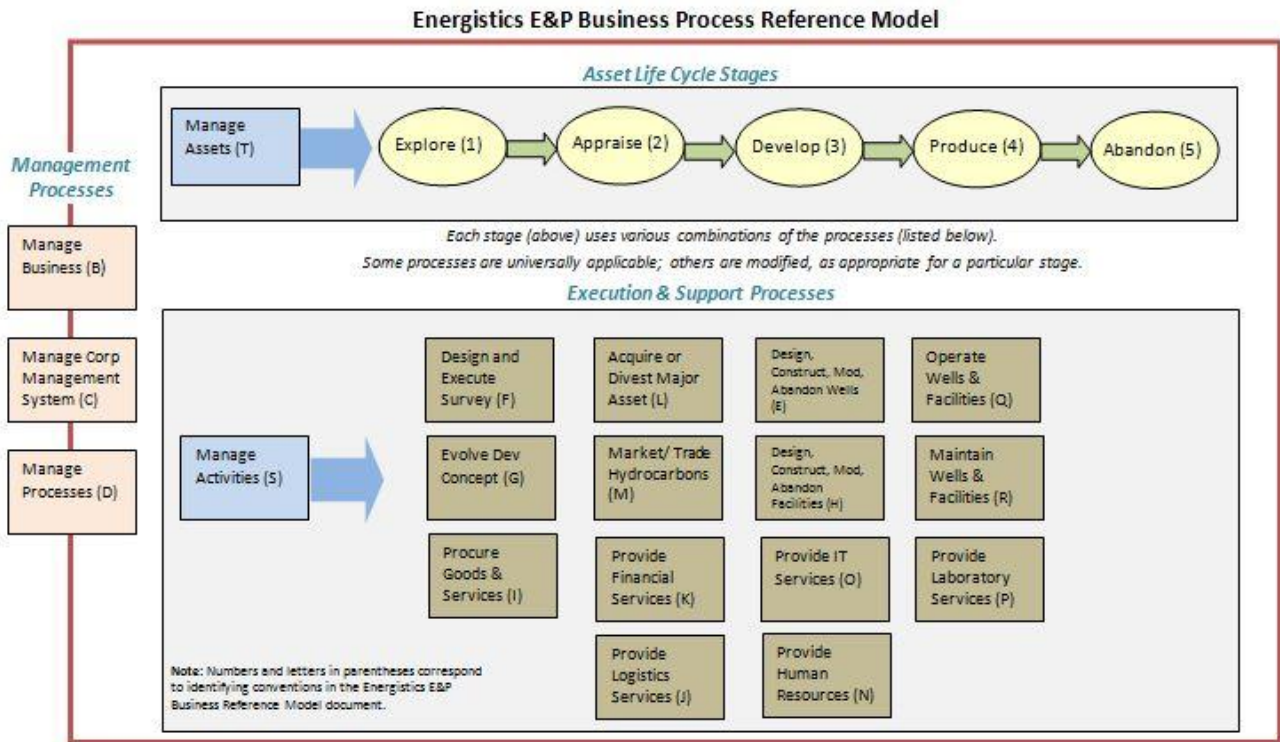


Figure 3 E&P Reference model. Taken from <http://www.energistics.org/standards-development/e-p-business-process-reference-model> on Feb, 2015

Its variants often with desired organizational subgroups form most business transformation exercises. One example model is shown below. In this example, E&P company with ~16 departments or groups is conceived

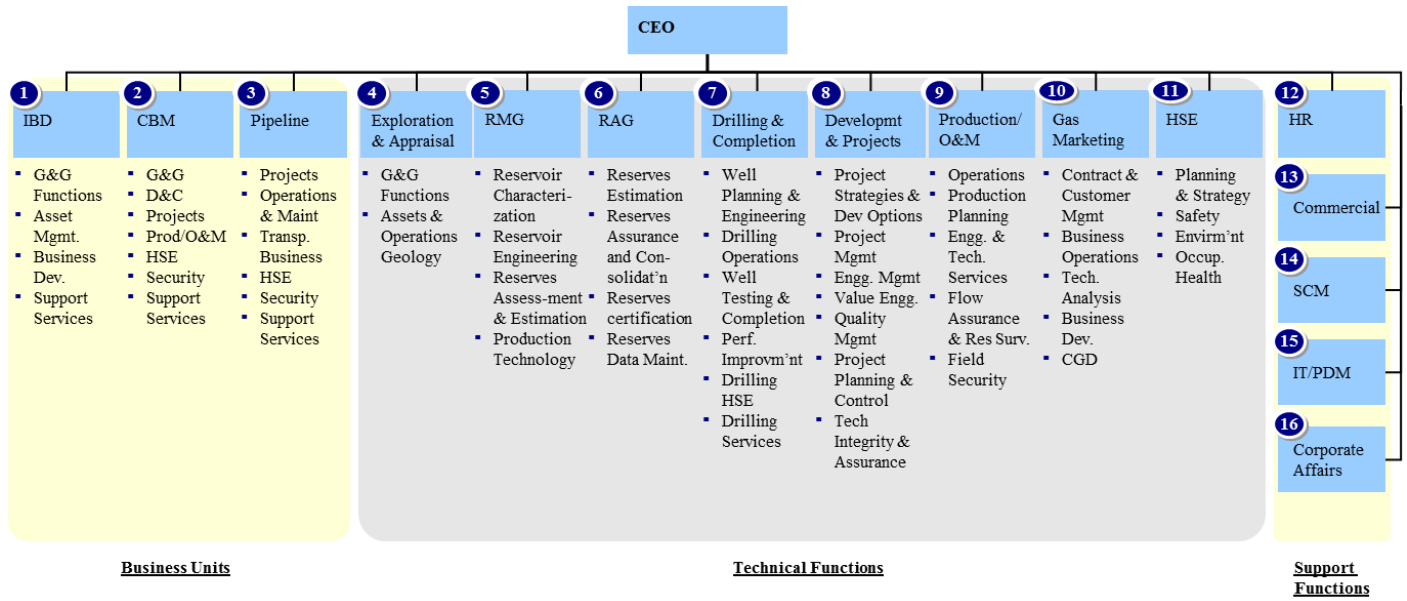


Figure 4 Typical E&P Organization structure

The Reserves transits through its maturity level within various E&P assets assessing from a Basin (Block) taken during acquisition to the Facility (Producing HC). A composition in these THREE dimensions – i) Reserves–

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maturity, ii) Functional Organization and iii) Assets into a single model is presented below. This encapsulates the maturity stage-gates of reserves and the elements of business that achieve it.

This is a well-known description of the E&P business canvas. Expanding this provides the {R-T-I} framework.

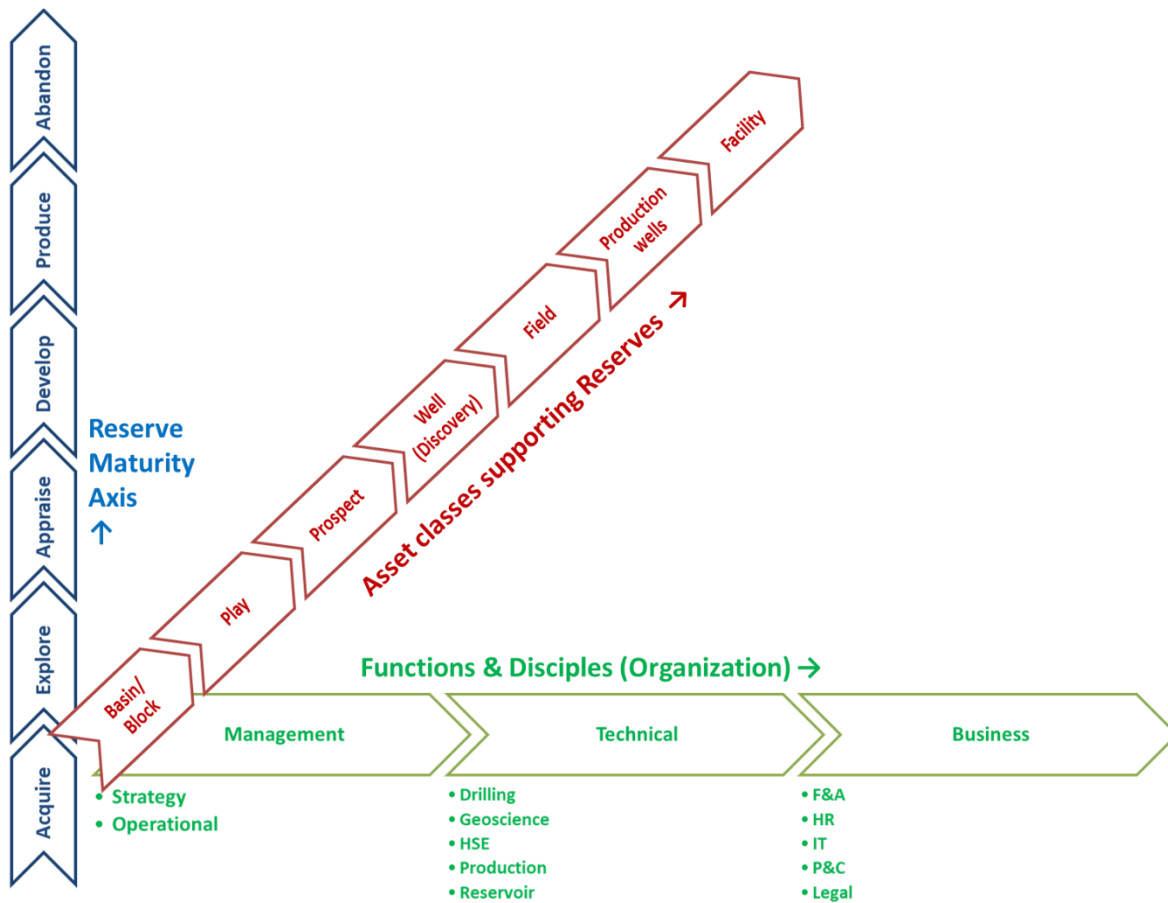


Figure 5 3D presentation of E&P business

Literature available including the [process hierarchy model of APQC](#) expands on the lower level decomposition of this model. Every E&P consulting and transformation exercise, essentially works around and tweaks the established model to suite their own variant.

Common pitfalls

1. Diffuses focus from RESERVES as the central theme and purpose of E&P. Often more and more tasks, policies and bureaucracy is added without providing the necessary value.
2. KPI and other management measures get off from the critical business objective – reserves.
3. Little or no differentiation possible among companies or business units.
4. Feeling of satisfaction and achievement from ornamental remodels to address business performance or aspiration.
5. Business decision making state-gates are seldom aligned to centrality of ‘reserves maturity’.

Inadequacies

1. It is based on 20th century concepts of differentiation, manufacturing and operational principles.

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2. Islands of different disciplines and functions emerge with conflicting interests and goals.
3. Most significantly, it doesn't leverage the advantage of 21st century science and technology.
4. Periodic reorganization by emphasizing on one axis or other is common business transformation exercise in all E&P companies. Shifting from a Discipline organization –to– Asset organization is routine BT.

The reorganization efforts in my professional experience had little or no REAL difference to their approach or performance on the reserves in a 10–20–year timeframe. It is not surprising that companies go in cycles with these exercises as a periodic ritual on the common E&P model.

Evolving to any levels of excellence is not visible by simple juggling of standard model.

CAUTION : Major IOCs largely appear to follow these same framework elements. Their sustenance and performance are different due to –1) Large and diverse size; 2) Integrity and Work culture; 3) Technology ownership and 4) Innovation funnel.

Herein, the new “DISRUPTIVE” R–T–I {Reserves \leftrightarrow Technology \leftrightarrow Information} E&P framework is introduced. It is agnostic to organization model, which could be any variant of the existing classical – Discipline based, or Asset based implementation. Each of the elements are separately defined and discussed. Top–Down actions are proposed and their relationships to conventional business model are explained. New opportunities and values are created from the R–T–I model.

1. Centrality of Reserves

The oil and gas natural resources found by an E&P entity are its most important economic asset. Reserves are capital assets in the financial statements of E&P companies. The sustenance of the E&P entity depends on the amount, quality and growth of the reserves, accessible to extract and sell. Resources are the source of cash inflows from this maturity track and provide the basis for borrowing and for raising equity finance ([PWC, 2011](#)).

Reserves as commonly understood by top management are the market capital from the volumes, in the annual financial reports. Strong reserves and reserves replacement are accepted measures of E&P company performance and efficiency.

Reserves and resources have a pervasive impact on an E&P company's financial statements, impacting on a number of significant areas – most importantly the TRUST with all the stake–holders (including Public, Government, Regulator, Partners, Customers and Suppliers).

While all this is well understood, practically none of the company's job roles and governance measures enforces attention (or accountability) to this. The central premise of this R–T–I model is – refocus of every work in the company towards one of the 3 (RTI) deliverables.

Every task of E&P business exists ONLY FOR THE PURPOSE of Reserves.

2. Technology is the Driving force

Technology in E&P is analogous with Health and Pharma. In diversity, depth and delivery, the spectrum of E&P technology is very intense. There are >60 different specializations and technical areas in a typical E&P company. The complex interplay of nature, measurement, assessment and recovery methods are aggravated by the largely subjective and empirical scientific methods of the industry. Most E&P companies operate on the

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fringe of the E&P technology – often being the consumers of service companies and consultant guidance. IOCs are different due to their own focused leadership and performance of technology.

Three levels of Technology positioning are stated here: i) Owner; ii) Adaptive Enhancer; and iii) Consumer or User. Being there among the technology users is often enough for profitable performance under opportune circumstances. Growth, Sustenance and Leadership in Reserves needs consistent deployment and growth of TECHNOLOGY.

Like Healthcare and Pharma, the diversity of technology needs in E&P drives professionals from different backgrounds to work together. For transfer of work processes, diligence and inference, these diverse sets of professionals get organized into likeminded groups. That is how E&P companies get organized.

Reliable Reserves accrue from Dependable Technology.

3. Information is the medium to reserves

The technology canvas of E&P is wide and creates extreme diversity of data and information about reserves. Inherent uncertainty in the methods and range of possible solutions generates conforming and conflicting information. E&P information have all 4 dimensions (4Vs) of “Big Data” – i) Volumes; ii) Velocity; iii) Variety and iv) Veracity. This significantly compounds the information management – which often is the ‘limiting factor’ for reliable assessment of RESERVES.



Figure 6 4-Vs in the data and information deluge at E&P.

A vast majority of E&P Sciences and Engineering are empirical. There is little or no structured vocabulary or a formal defined process. Analysis and Interpretations are subjective and varied. Databases are privy to E&P companies. Unlike subjects like Genomics, Digital Astronomy or Medicine, there is nearly no collaborative (crowd sourced) information synthesis. While, the

TECHNOLOGY can provide reliable RESERVES only through Mature INFORMATION MANAGEMENT.

E&P organizations do not distinguish common IT department from Computer Science. Specific attention to Information architectures, Digital Information Strategy is camouflaged under the Information Security and Database functions in

vogue.

The conventional IT department managing “infrastructure” and “applications” provides only necessary foundation to information systems. They (IT department) or the Technology teams (G&G, Reservoir etc.) are ill-equipped to deliver any reasonable Information Innovations or real ‘Information Technology’.

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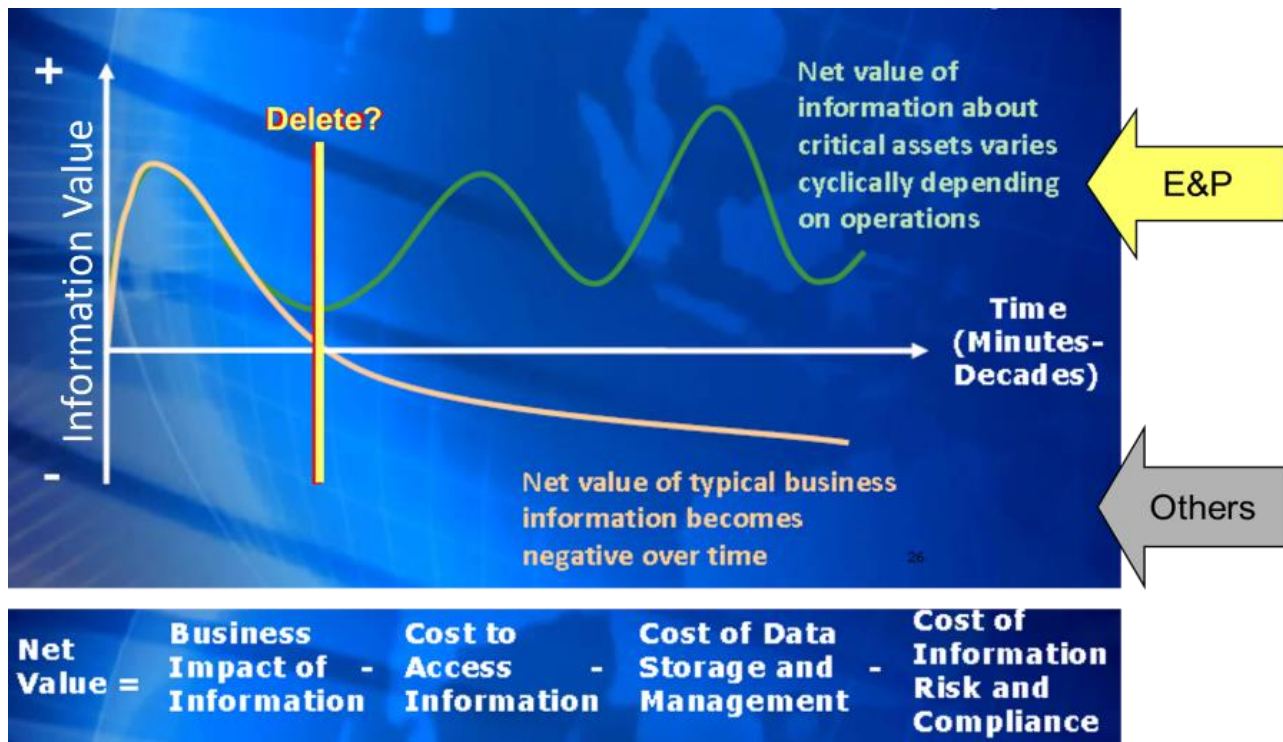


Figure 7 Value and impact of Data and Information. E&P and other businesses (Personal communication, Alan Nunn, 2008)

INFORMATION becomes the first LOOSE link in the R \leftrightarrow T \leftrightarrow I chain.

Each of these 3 dimensions – Reserves – Technology – Information will be expanded with –

1. Significance
2. Customers and Relationships
3. Innovation requirements
4. Policies
5. Operating Process
6. Growth model

1. Resources & Reserves

One of the most common misnomers is about considering the SPE/ AAPG/ SEC/ PRMS definition of “reserves” as the consideration only for top-level business decision making and not for every individual function of E&P. Reserves are not JUST the final numbers that go into annual reports of the company – it is the progressive chain of assets in E&P with increasing supply, certainty of volumes, and value.

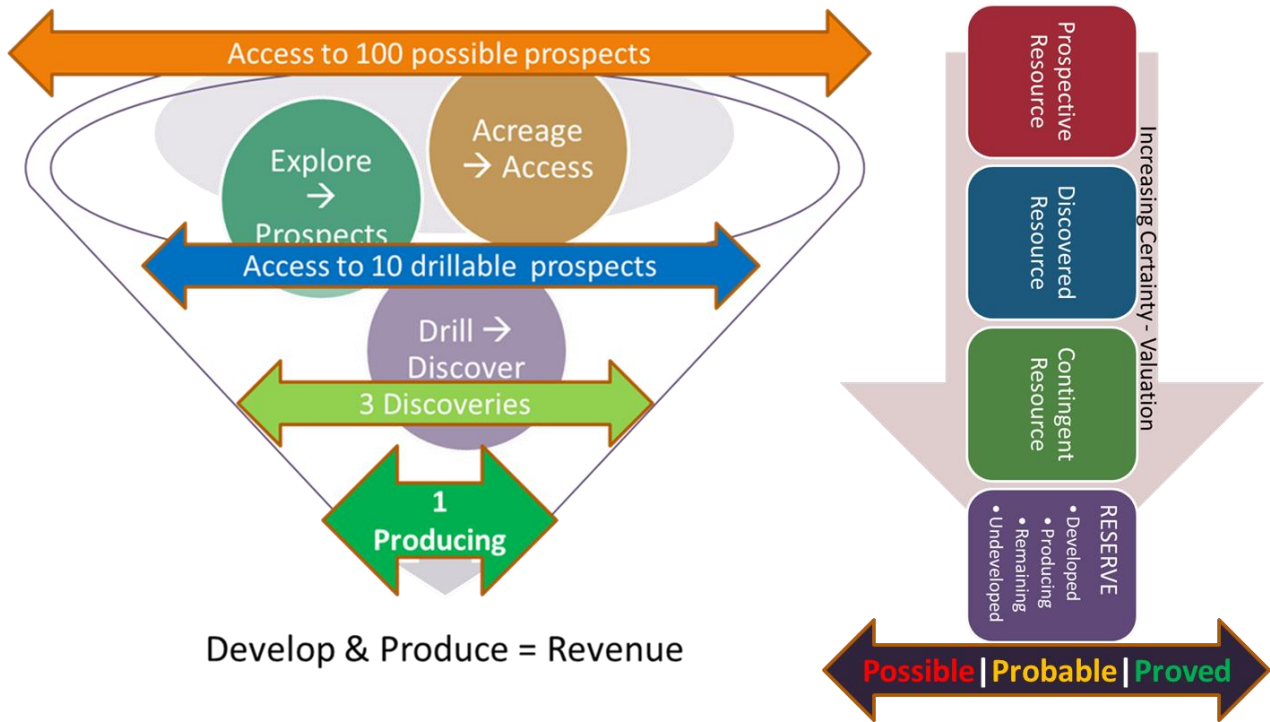


Figure 8 Petroleum Reserves Hopper. Progressive refinement and maturity of Resources –to– Reserves

Unless E&P Company focuses on all levels of this hopper – “Reserves” as the capital asset shall remain fragile. The modulation of organization culture at every level to direct all efforts towards the reserves maturity is the emphasis of R–T–I model.

Reserves as Strategy in Business Governance

The SIGNIFICANCE of the resource hopper leading to capitalized “reserves” is a 100 year old wisdom. The business strategy and measures (BSC, KPI, and Role–Accountabilities etc.) require clearly articulating and developing measures of direct significance to reserves.

Along the pathway to generating revenue from reserves, a wide variety of studies, facilities, and technologies are drawn upon. Some give progress, while others stay in shelves. Value of Information (VoI) is an important metric to determine relevance of a study. E&P largely avoids doing strict VoI determination. It is not uncommon to see a high–quality multi–component seismic acquisition or an ultra–modern well logging becoming non–contributor to the reserves. A host of reservoir characterization studies often have indeterminable VoI to the business purpose – reserves.

The [4–Level classification](#) scheme applied to reserves focus will allow ranking technology (surveys, studies, projects etc.) and information between Critical and Desired. Business management using VoI and criticality to reserves is very effective. In the same way, several reviews, stage–gates occur in the business processes. Many

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them fail to address impact to reserves hopper. They are superfluous and can be de-emphasised to have business review along reserves hopper.

R-T-I model identifies 10 clear stage-gates in the complete business process of E&P. Each of these stage-gates directly addresses the reserves maturity. A suitable information model that captures the submissions at these 10 stage-gates and tracking their outcomes 5,10 or 15 years later is a powerful approach to systematic improvement in the R-T-I process.

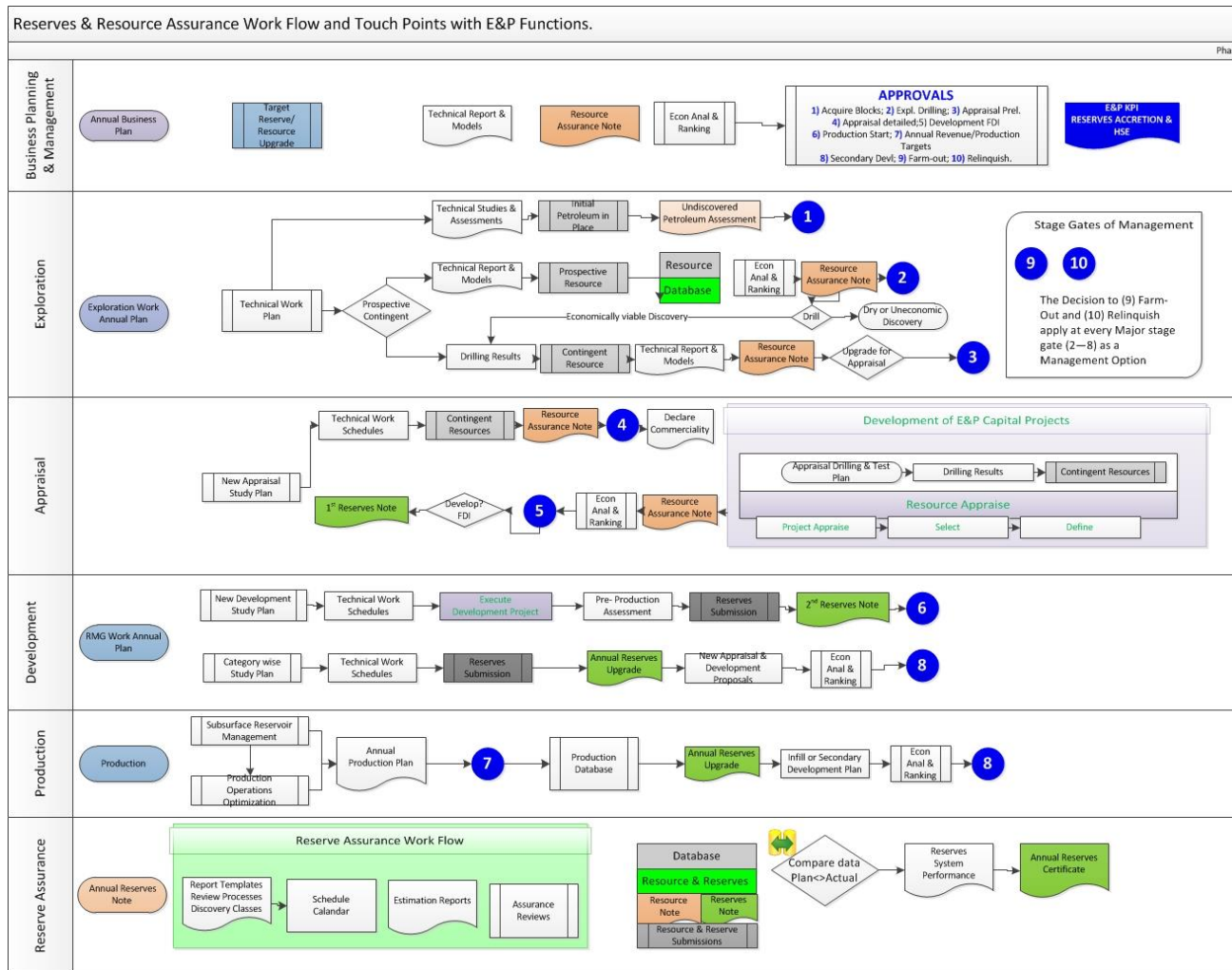


Figure 9 E&P Business process flow with 10 stage-gates addressing directly the reserves maturity and progression

The “maturity” of resources into “Reserves” and into “Revenue” comprises of 8 stage-gates where the operating process needs to assess and benchmark the resources. Six of them are shown in the Table. Stage-gate 7 is annual reserves notes and stage-gate 8 occurs when secondary (major infill) and tertiary development programs are proposed.

1. Assess and record Prospective Resources being estimated with cost-value-time proposition
2. Decision to Drill bases on prognosticated resources from the Play or Prospect
3. Estimate of Prospective Contingent Resources justifying Appraisal
4. Completion and acceptance of Appraisal. Declaration of Commerciality. Establish likelihood to Develop

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5. First Reserve Note on Approved and committed Development
6. Reservoir Management: 2nd and Periodic Reserve Note on producing asset.
7. Produced Volumes and Remaining Reserves. Annual Reserves declaration.
8. Reserves upgrade with additional development.
9. Farm-out or Farm-in decisions to manage uncertainty and risk. Applies to every one of the 1–8 stage-gates
10. Relinquish: Decision to exit. Applies at every one of the 1–8 stage-gates.

Stage-Gate	E&P Phase	Objective	Assessed Resource	Range	Use
1	Acquire	Assess the Prospective resources being bid for and their value	Prospective	High	Starting Reference
2	Explore	Estimate the resources from Prospects for Drilling. Ranking for Drilling decisions	Prospective	High, Prospect Specific	Drilling Rank, Decision
3	Appraise	Discovery assessed for appraisal program. Commercial viability determination	Contingent	Medium, Field Specific	Invest in Appraisal, Farm-out decisions
4	Commerciality	Post appraisal assessment of the field for suitable commercial development	Contingent	Medium-Low, Major factors covered	Declaration, Regulatory
5	Develop	Commercially viable field for development investment. Approval of Development scheme and plans. COMMITMENT	Reserves	Medium, Within Economic Limits	FDP, Commitment Regulatory report
6	Produce	Assess the reserves and production profiles from developed field. Define Operational and Depletion strategy.	Reserves	Low, Predicted Production profiles robust	Important Reference, Regulatory & Public value
7	Produce	Annual Cyclic updates and refinement	Reserves	Low, Largely certain	Annual Reports
8	Produce	Major upgrades in development scheme. Large infill program, Secondary & Tertiary development schemes	Reserves	Medium, Within Economic Limits	FDP, Commitment Regulatory report
9	ANY	Farm-out, JV or other decisions	Resources or Reserves	Medium - High	Farmout Strategy
10	ANY	Relinquish or abandon	Resources or Reserves	Medium - High	Exit

Table 1 Business Review and approval stage-gates aligned with 'Reserves Maturity'.

All major investment decisions occur at these stage-gates based on Resources & Reserves.

While this is broadly the E&P business management model proposed in R–T–I framework, its efficacy and effectiveness come from the strong metrics placed on Information Management. Like many aspects of human endeavour, there are a wide range of also-ran claims about information management. Benchmarking with Science and Technology enterprises outside the realm of E&P, like Medicine, Biosciences, Digital Physics are needed to decipher the maturity path.

Data Intensive Scientific Discovery (DISD) or 4th Paradigm Science is practised at the Sciences and Technology at the forefront of the disruptive transformation. E&P needs to get on with basics of the DISD to use R–T–I model efficiently.

Corporates and E&P business unit

Vision, Mission, Objectives and Goal are very standard method of presenting corporate and business unit direction. E&P companies form a part of a bigger corporate handling the entire Petroleum Value-chain. Stated below is one such organizational presentation of corporate values and direction.



Figure 10 Typical Corporate Vision

The Corporate Strategy provides a framework for the E&P business. The factors – i) Shareholder Value; ii) Employee Value; iii) Customer Value and iv) Societal Value. These need to be translated to goals and targets in a) Reserves; b) Technology and c) Information.

Absence of Information focus or KPI centred on Information eliminates the role of 'Computer Science' and treats conventional 'IT Department' as custodian of Information. Neither 'Information' nor 'Technology' is the forte of IT service department. This undermines the depth of appreciation of information structure, semantics and synthesis.

An attempt is presented to take the classic corporate value statement and use it for reserves centric E&P. Metrics and measurement of the elements in the below table maintain the Reserves focus, while following the corporate strategic value vision. Every one of these elements can be objectively decomposed to give targets and measures to various UJRs and organization-units.

[Resource Hopper](#) and Reserves make [SMART](#) strategic element.

Revenue, Public Opinion, Brand Promise and share-holder value – all emanate (only) from RESERVES

Customer relationships of E&P business are largely with Government or Regulator. The Midstream and Downstream petroleum companies are consumers. Public at large is affected mostly by HSE and other land or water contentions only. Corporate Social Responsibility (CSR) addresses the social interface and Innovation touches Employee value proposition.

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VALUES↓	E&P Dimensions→	Reserves	Technology	Information
Corporate Vision↓				
Shareholder	Portfolio			
	Shareholder Returns Long-term Reward	→ Strong Hopper → RESERVES VOLUME	→ Technology Position → Maturity of Resource : Reserves	→ Resource : Reserve efficiency
Employee	Learning Organization Career Progression Employee Value	→ Adapt & Learn methods → Reliable assessments → Respect and Reputation	→ Competency Ladders → Technology levels → Performance to Reserves	→ KM activities
	Innovation Experience Brand Promise	→ Downstream Industry → Government Experience → Regulator Relations (++)	→ New Techniques → Technology Ventures → Global Reputation	→ IP and Products
Societal	Job Creation Innovation Ecology & Environment	→ Energy Security → Independence (India) → Green fuel (Gas)	→ Green Technology → Energy Efficiency	
	Safe Operations Digital Technology Capital Productivity Operational Excellence	→ Reliable (Guarentee) Production profiles → Highest EUR factors	→ Big-Data Analytics → Measurement systems → Global E&P data str. → Predictive Operations → Robotic / Machine Intelligence	→ Predictive HSE → Data Intensive Science → Verification & Audit → New Benchmark in Ops

Table 2 Aligning *Corporate Vision elements* to Reserves Focus in E&P using R–T–I framework

Innovation

The R–T–I model makes Technology and Information activities unabatedly pointing to “Reserves”. This brings a performance metric different from the conventional E&P process approaches. Every technological innovation or business transformation requires a “Value Proposition” in “Reserves”. Agile platform for ‘Reserves Assurance’ and adaptive measures of ‘Reserves impact’ are necessary to apply this framework. Correctly deployed, R–T–I framework provides consistent methods to spur innovation.

While, Technology innovation is established in major IOCs and Service Providers, Information innovation derives focus in the R–T–I model. Here, Information is elevated to the level the 21st century Science seeks and has high potential of significant breakthroughs.

There are no silver bullets.

Reserves & Reserves Assurance

Reserves assessment is a complex, cyclic and committed process touching almost every technology aspect of E&P. Earliest efforts to establish the nomenclature and description of Petroleum Reserves is traced to 1937 by API (for mainly Oil) and to 1947 by AGA (for Gas). AAPG and SPE nomenclature for current reserve definitions is named as [PRMS](#). The [SPE/PRMS](#) resource–reserve nomenclature as used to point the business process stage–gates R–T–I framework is proposing

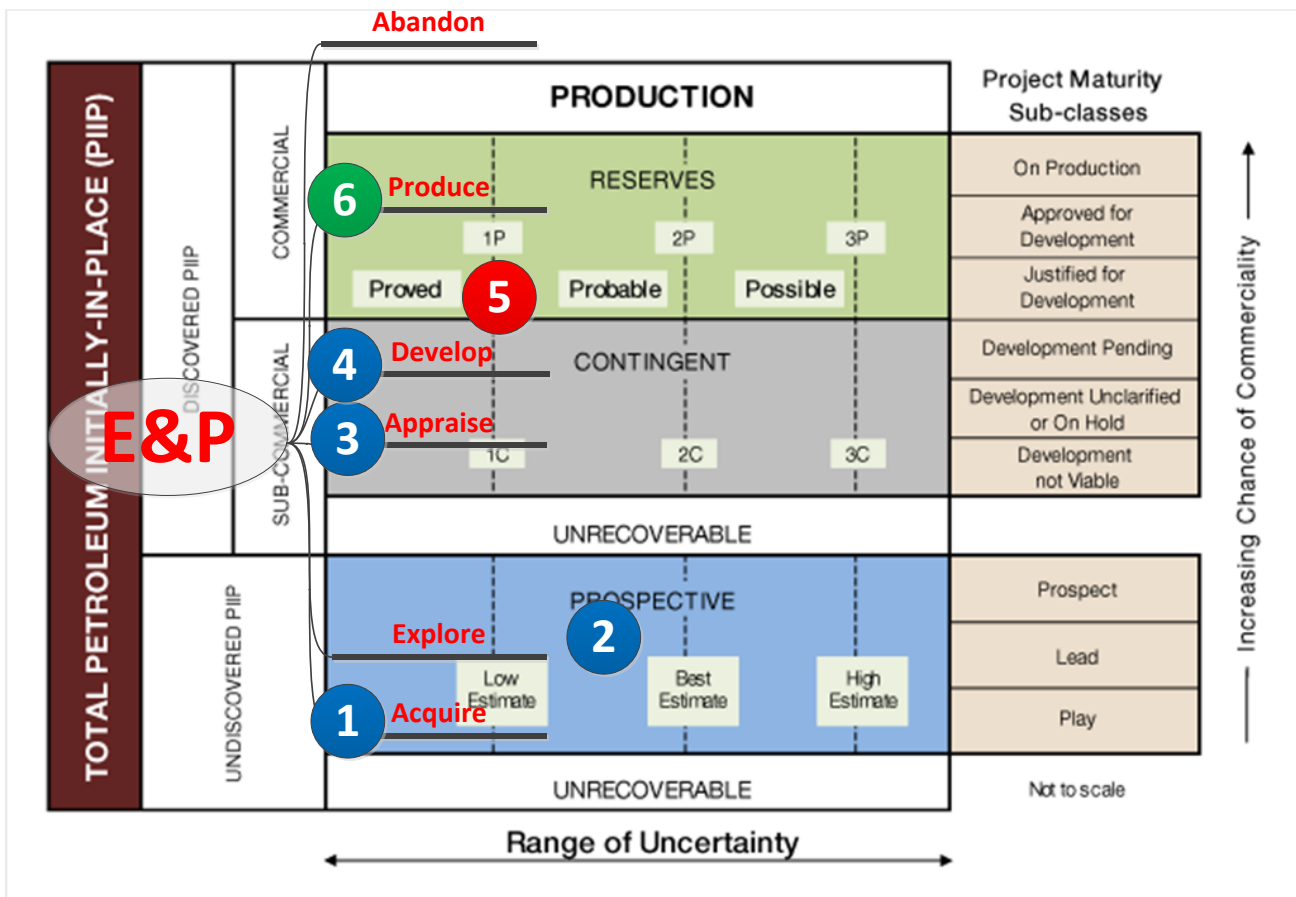


Figure 11 SPE/AAPG – PRMS reserves definition scheme with the R–T–I model stage–gate points

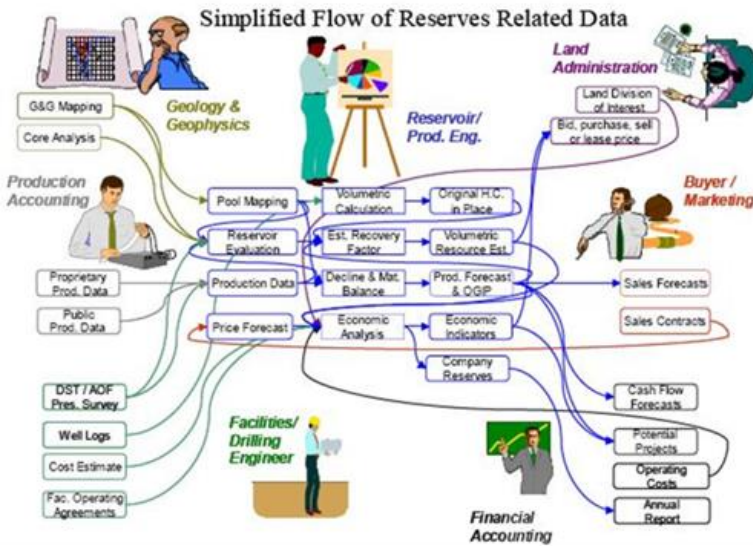
The Reserves Hopper is ridden with numerous levels of assessment of the volume and probabilistic designation of the estimation uncertainty. The data and information pathway towards any reserve estimation is very complex and cyclic.

Reserves policies concern with 3 areas:

1. Nomenclature and description of resource and reserves assessments
2. Standards and methods of estimation, validation and verification
3. Reporting

Performance of E&P is defined by the Reserves. However, the performance of “reserves policies” is based on:

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<http://www.ppdm.org/wiki/images/Reservedataflow.JPG>

Figure 12 Cartoon showing a simplified data flow in assessment of reserves

1. Strength and Quality of policy framework;
2. Methodology and systematics of adherence; and
3. Strong learning and capabilities towards execution of all steps of policy.

Reserves can be strong and reliable – i) by random chance; ii) by strong competency and coherency of technical organization; and iii) unique information culture. However, due to the prejudices and pressures of business functions, there is always conflict with Technical assessment and information integrity.

∴ Reserves Policy and its follow through is developed as an independent function.

A highly sensitive function of ‘Reserves Assurance’ cannot easily conduct as independent and empowered mechanism in absence of ‘survival elements’ and ‘information maturity’.

Business organization and model using the R–T–I framework provides necessary emphasis to the reserves and empowers the assurance function.

Common KPI, BSC and other measures all MUST lead to Resource–Reserve metrics to be relevant.

Stage	E&P Phase	Stage E&P Phase	Objective	Business Value	Indicator	Use
1	Acquire	2+	Explore	Volumes assessed in all prospects in all major plays ≅ Pre-Acquisition volumes	Robust Acquisition, Reliable Hopper top	Good Regional & Global Assessments Effective Exploration process Assess Exploration
2	Explore	4	Commerciality	Estimated resources from Prospect (Pre-Drilling) ≅ Commercial discovery volume	Reliable Prospect portfolio, Stable forecast	Good Technical & High Integrity assessments. Unbiased estimates Assess Technical Competency & Integrity
4	Commerciality	6	Produce	Reserves pre-production ≅ Commerciality declaration	Robust Projects, Stability of Cost-Revenue	Quality Subsurface assessments & Development Screening Regulatory Commitment, Funding Options, Growth
6	Produce	7+	Annual Update	Reserves pre-production ≅ Reserves post-Production (YoY)	Reliable Cash-Flow, Respect & Trust	Quality of Reservoir Management & Assessment + Operational Efficiency Regulatory, Cash-Flow, Respect
6 & 7	Produce	8	Develop	Reserves achievable (EUR) ≅ Reserves post-Production (YoY) ++ Additional Reserves from New Development	Reserves	Strong Sub-surface, Projects & Operational Performance Technical Respect, Brand value, Technology & Process Leadership

Table 3 Business value from standard Acquire --> Abandon E&P cycle and R–T–I stage gates

2. Technology in E&P

E&P’s quest to search, discover, develop and produce hydrocarbons requires 3 technology and knowledge elements:

1. Identifying the presence (nature and volume) of hydrocarbons in the sub-surface → Establish Contingent Resources
2. Assessing and establishing the methods for efficiently recover of hydrocarbons to the surface → Determine Reserves
3. Operating the production, processing and transportation elements → Convert Reserves to Revenue

Several largely empirical sciences, methodologies and technologies are applied in [1] and [2]. [3] is the well-developed plant – process – operational system like any other industrial production facility, which are amenable to formal optimization.

As “reserves” are outcome of steps [1] and [2] they become limiting factors (or controlling factors).

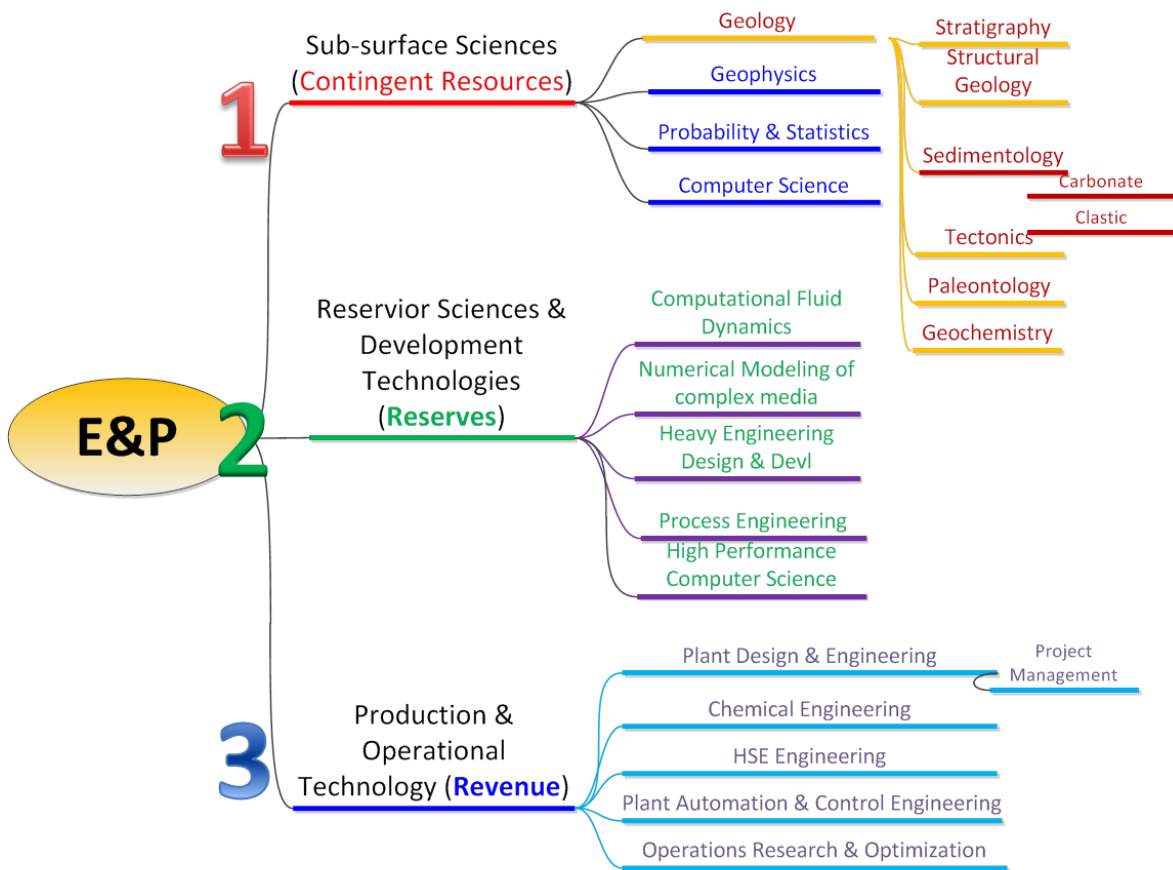


Figure 13 E&P Science, Technology and Engineering elements ordered along reserve maturity (schematic and not comprehensive)

The VALUE of the Science or Technology in E&P is verified from the RELIABILITY of the Reserves determined.

Technology as Medium in E&P Business Growth

Notwithstanding the numerous specializations and nuances in these Sciences and Technologies, they need to be managed as the source of information towards “reserves” or medium of generating “revenue” from reserves.

Technology is the creative strength of all successful E&P companies.

IOCs differ from small independent and national operators in having distinctive TECHNOLOGY strengths.

Technology dimensions

~60 distinctive sciences and technological disciplines contribute to ‘core’ of E&P functioning. All of them are advanced specializations with many companies delivering just one or more of them – as core competency and being commercially successful.

For E&P companies there are 6 aspects of valuable use (application opportunity) of any (all) of these technologies:

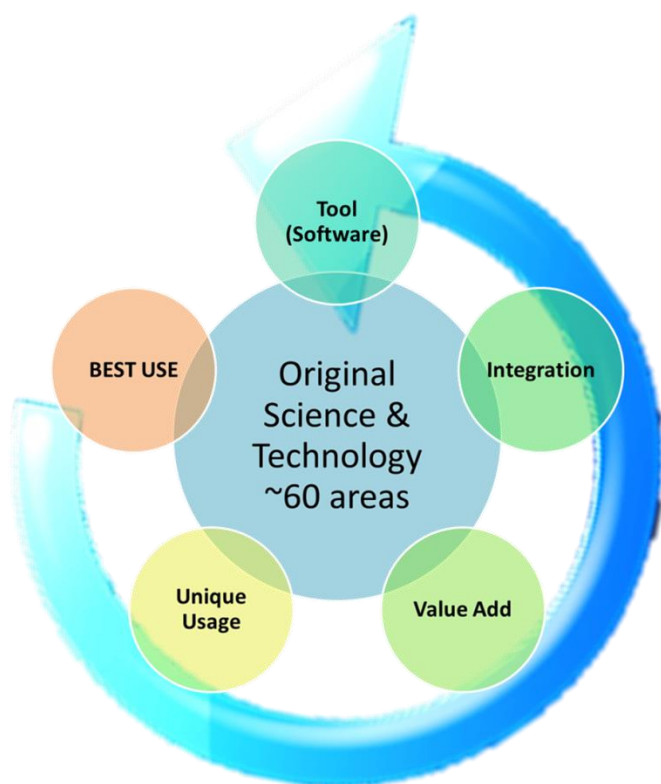


Figure 14 Six facets of Technology adaptation in E&P companies.

1. **Best Use** : Acquire and Assimilate technology from service providers or research groups → Use them effectively for Reserve accretion.
2. **Unique Usage** : Create some unique use cases – methodologies and workflows from existing technology. In-depth understanding and systematic “best use” can lead to innovation.
3. **Value addition** : Use technology components and other research elements to enhance effectiveness or application. Smart innovation for stretching beyond ‘The known’.
4. **Integration** : Apply advanced integration and cross-validation methods to commercial (known) technologies leading to deeper insights and reliability of inferences. They become strong IP of company and evolve from strong inter-disciplinary competency and teamwork.
5. **Tool (Technology)** : Develop commercially marketable tools, methods and services. Establish applicability in diverse conditions leading to leadership in technology.
6. **Core Science** : Build and advance core principles of science and technology. Evolve new paradigms and create disruptive innovation.

Success of IOCs are assigned to their Technology Leadership

Technology with Service Companies is dominant in E&P activities

Reserves – Technology – Information {RTI} Strategy

E&P workflows are technology intensive. Every aspect of technical task follows a level of the six technology dimensions [1..6].

Technology in E&P is not a COST. It drives reserves giving continuous value at every stage, whenever Reserves Focus is applied.

Integration

Considering many specializations in sciences and technology, methods for integration of data, inferences and guidance with management measures are of high significance. Reserves are outcome of such cogent and integrated information at E&P companies. Organizations need to adopt many methods across human, process and functional value chain, to achieve such thought and capability. Modern information sciences are potent in creating a high-fidelity integration once necessary information framework is established.

VALUES & BEHAVIOURS in E&P Company manifest as mature integrated and performing TECHNOLOGY.

Performance

There are some indirect measures of technology performance in E&P. These include – Publications of the personnel, IP created, Patents & Copyrights, Ph.Ds. and other distinctions etc.

RESERVES and RELIABILITY of RESERVE NOTIFICATIONS are definitive and direct performance measure of effective technology.

E&P companies with weak reserves or downsized reserve declarations need to look at their technology as failure or underperformers.

The knowledge about and control of unquantified achievements tend to be largely prejudiced.

Technology Strategy

The organizational aspiration and culture determine sustainable technology strategic options.

People, Processes and Technology (PPT) aligned with 'Data and Information' as the facilitating dimension and 'Reserves', as the target dimension is proposed.

Technology Options and value are embedded between these 3 axes.

Reserves – Technology – Information {RTI} Strategy

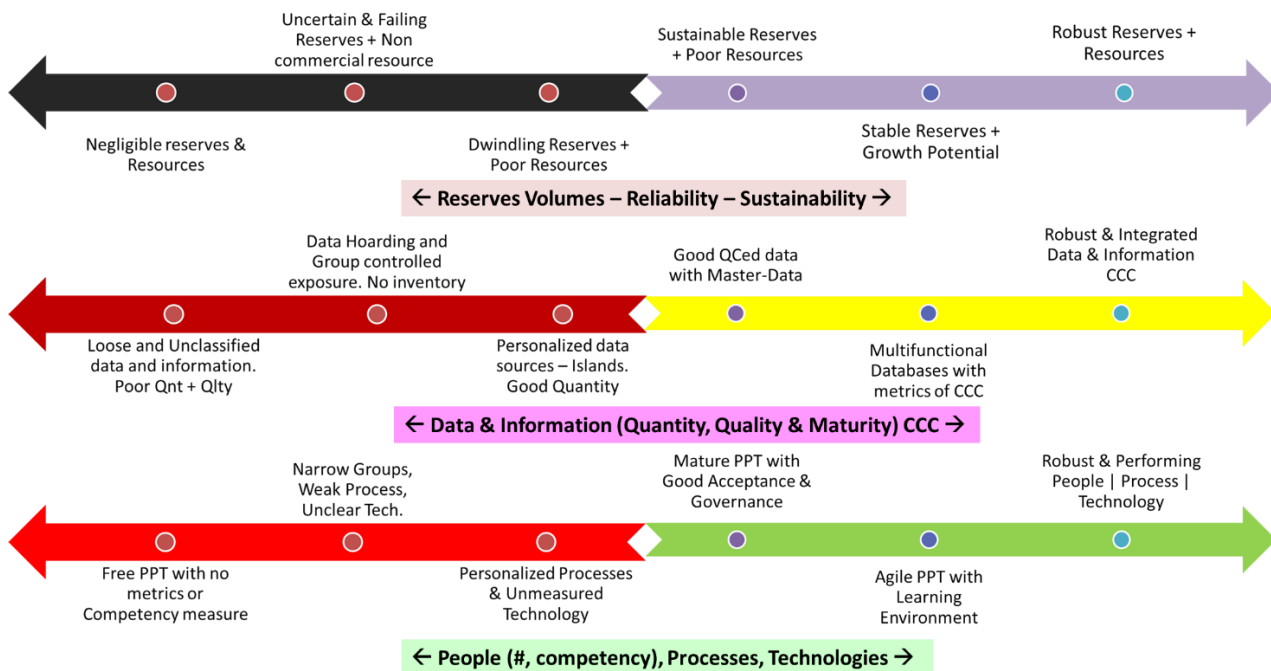


Figure 15 Technology in E&P is driven by People, Processes and Technologies. Information maturity and Reserves focus directs the outcomes

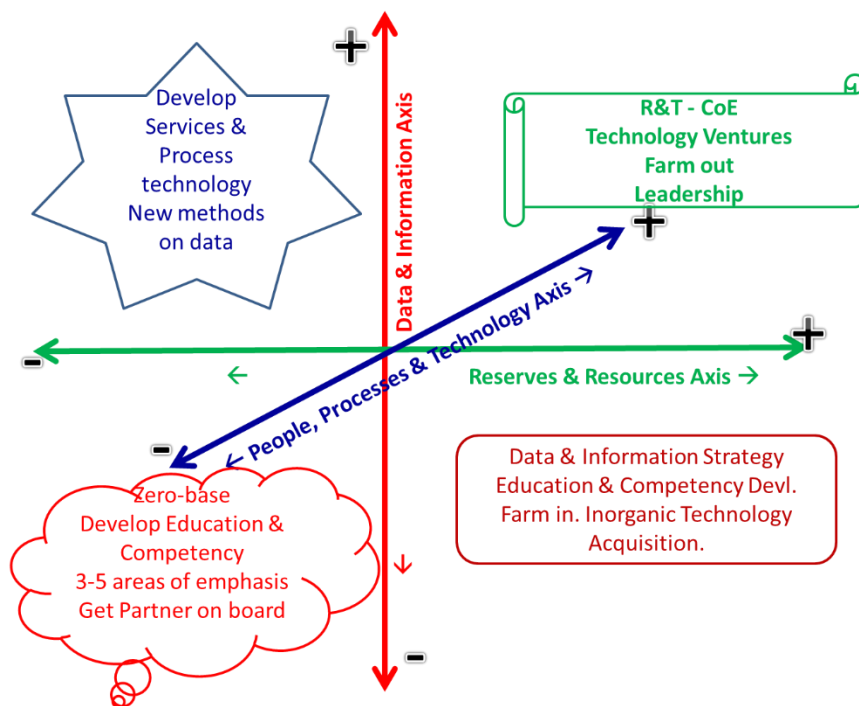


Figure 16 Conditions in the quadrants of R-T-I model for technology performance

1. Companies with strong Reserves, PPT and Data have opportunity to create technology ventures.
2. Strong Reserves with weak Data and PPT needs to work on Information Technologies and Competency methods
3. Strong PPT and Data with weak Reserves can opt to develop services and process innovation. They can develop new data intensive methods.
4. Weakness in all the 3 axes implies need for a complete relook at their education, competency, and culture.
5. Prioritizing 3-5 areas for developing a functioning, and value-creating technology base is a good beginning.

3. Information

Information is a very ubiquitous term. The context (semantics) of its use is so wide that it is difficult to assess its nature in any statement. Commonly Information Technology is abbreviated to “IT” and is mapped to an organizational function within ‘IT Department’. The classical IT Department in E&P companies neither generate ‘information’ nor ‘technology’ in strict sense of these 2 terms in R–T–I model. IT function, as commonly perceived is [neither information or technology](#).

Similar contradiction occurs for the term ‘Database’. In the all–pervasive world of Microsoft Excel, every spreadsheet is classified as a [database](#). Specialized scientific institutes place ‘pdf’ files of data tables and publish it as database. It is yet another undiscernible popular term.

4th Paradigm science, 2020–Science or Data Intensive Scientific Discovery (DISD) describe the evolution of modern scientific doctrine centred around 4 principles of computer science. The [distinction between computer science \(CS\) and computerisation](#) is needed to appreciate the principles of this new scientific methodology.

1. Databases
2. Workflow systems
3. Analytical methods
4. Presentation or Communication of Results

More details on the principles of DISD can be taken from the listed references.

For the R–T–I model of E&P business, the INFORMATION is all those pointers, leads, assertions, assessments, interpretations, inferences, predictions, measurements and performance metrics – which any (or all) of the myriad methods (in ‘technology’) create about the ‘reserves’. INFORMATION describes the entire set of details on all four principles of DISD listed above.

Data and Information in E&P

E&P is among the earliest users of large computer–based data analysis. CDP seismic surveys, well–log analysis, reservoir simulation all created high–end data processing practices. Database systems came in to use by 1980s and modern classification methods like ANN and Expert Systems got tested in the same time. E&P was recognized as forefront computer analysis arena with use of super–computers in 1990s and 2000.

The commercial power of the E&P industry always provided access to modern computer facility, while the methodology of Science slowly changed towards DISD since 1995–96.

Information in E&P has some distinctive dimensions. These favoured the early adoption of digital data processing in 1980–2000 and act as deterrents to pursuing 2020–science in this century.

1. Sensors (Geophones to modern Digital Oil field) and digital data acquisition is widely used.
2. Entire data lifecycle: Acquisition, Processing and Storage is outsourced. Service Providers extend end–to–end solutions
3. E&P Professionals DO NOT need – programming, mathematics behind data processing or any other aspect of Computer Science to remain successful
4. Secrecy due to commercial and geo–political sensitivity has made all data and analysis confidential and private to E&P companies.

Reserves – Technology – Information {RTI} Strategy

5. There is no support, effort or incentive to crowdsourcing and making any aspect of E&P information generation OPEN.

The interpretation and inference from the largely empirical and subjective nature of Sciences in E&P is highly variable for same data and analysis. Due to complete absence of structured vocabulary in entire technology spectrum, the adoption of DISD is constrained.

Information model

Figure 7 points to the lifecycle value of data and information in E&P. It is quite routine to scout for 50-year-old well completion or test data. In R–T–I model, the Information is seen as distinct and independent pointers to reserves.

1. Technology → Generates → Information
2. Information → Refines/ Defines → Reserves
3. Reserves == E&P Business KPI

People, Processes and Roles → Exist for i) Implementing/ operating Technology; ii) Derive and Organize Information; and iii) Determine/ Assess Reserves. Work Breakdown Structure (WBS), Competency Matrices, Skill profiles, Professional Ladder and Performance evaluation are commonly written down for every E&P profession (Geology, Geophysics, Petrophysics, Reservoir Engineering, Drilling, Production Engineering, Petroleum Engineering etc.). In same manner, companies create various business management and operational manuals like – Manual of Authority, Segment Leadership, Governance Meetings, Business Risk Assurance, Business Development, Integrated Planning, Finance, HR, Supply & Trading etc.

All these efforts are essentially about creating, collating, organizing and articulating **INFORMATION** for conduct of business

RESERVES is the objective of all these guidelines in E&P

This formulates the philosophy of Digital Information Framework, wherein every one of the activities in Technology, People, Processes, Roles, Business Stage-gates and other tasks is identified with a clear INFORMATION **RASCI**.

1. INFORMATION facet of R–T–I addresses all business functions as INFORMATION functions
2. It provides a binding framework to integrate all PEOPLE–PROCESSES–&–TECHNOLOGIES through a common measurable governance.
3. Metrics of INFORMATION are – Correct, Complete and Competent; the reliability (competency) is measured on RESERVES. The functional roles become – ‘creators’, ‘consumers’ or ‘custodian’ of Information.
4. Information in Regulatory, Finance, HSE and similar functions address risk alleviation or logistic provisioning to functions directly impacting reserves.
5. E&P has multiple scales (levels or cascading hierarchy) of tasks that aggregate to provide the reserves directive. In view of this, the Information is hierarchically differentiated on the target results.
6. A consistent corporate ‘Digital Information Strategy’ provides the management and technology support.

Information Strategy

Corporates need to place INFORMATION as a strategic asset and protect it with an overarching strategy. It is now a core business process and is critical like Cashflow management or HSE management.

Every role, task and process identified as **Creator, Consumer or Custodian** to INFORMATION
 Everyone, Every-time, Everywhere to ACCESS **Correct, Complete & Competent** INFORMATION
 Every
 Performance is measured from INFORMATION fidelity.
 ZERO delay! Zero overlook! Zero mistake!

Figure 17 Vision for Information Strategy

This ideological posturing becomes a guiding principle in organizations and cascades to every functional level. Responsibility to information is captured at every level on all tasks. Appropriate digital technology to deliver full lifecycle of data and information is extended.

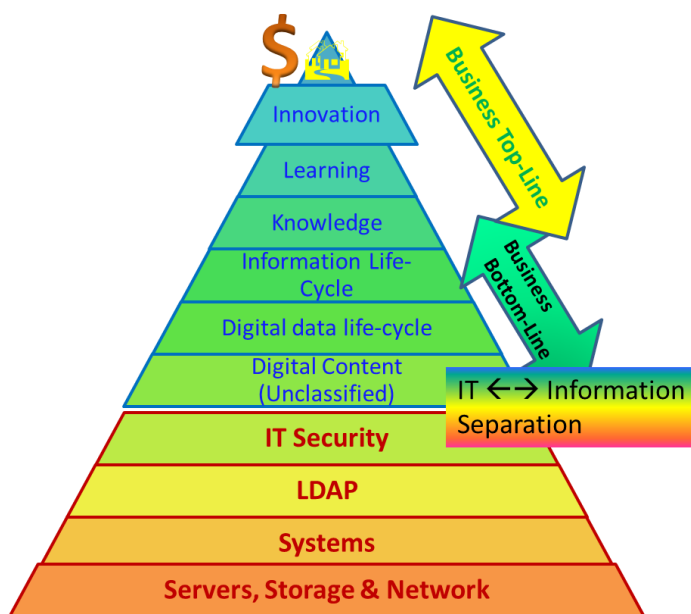


Figure 18 Information maturity and impact to business

1. IT elements are foundation to building Information architecture
2. The 3D model of E&P (Figure 5) becomes 3 dimensions (metadata classes) for classifying Information. I) Context (Which asset – Basin → Facility; What Reserves maturity stage and Under which business function); II) Process (The specific technical process) and III) Data. A workflow system helps track which role is creator, reviewer, approver, consumer and custodian of the information. Along with common IT tags, the information derives ‘interpretation’ which [Madnik and Donovan \(1974\)](#) sought in a database!
3. Database, Business Information Framework (BIF), Business Transformation (BT) and Analytical (or Artificial) Intelligence (AI) connect the Information Drivers to Enablers (Figure 19).

4. Information strategy and implementation protects the business from ‘[Nexus of Forces](#)’ in [agile](#) manner.
5. The opportunity of E&P business to adapt [2020–Science](#) is through this Information strategy

The schematic information management framework (Figure 19) emphasises how all 8 operational elements of business (including E&P) can be catered to by the model. Governance with proper metrics ensures sustainability.

Information Management Framework

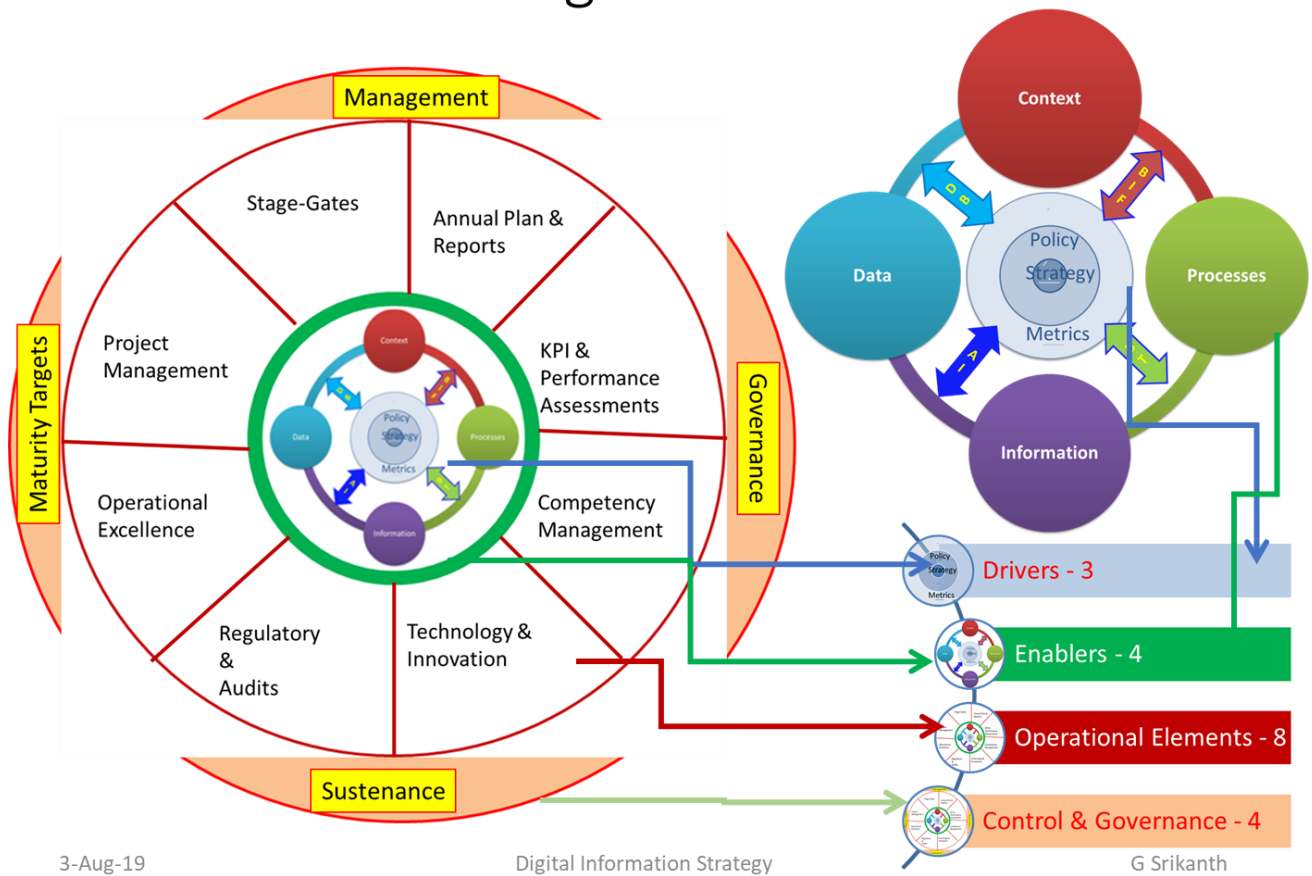


Figure 19 Digital Information strategy is implementing the Information Framework to manage every element of data and information. 3C – Correct, Complete and Competent delivery of Information.

Strategy for Implementation

E&P is a mature business. The use of computers and data is practised for 50+ years. The R–T–I model tries to show how E&P's approach is indifferent to high–performance sciences of 21st century. Climate Change, evolving alternate energy options, wicked pollution problem is largely ascribed to E&P and use (misuse) of Petroleum. Business had never really faced 'disruptive' alternatives, which makes it complacent.

R–T–I model does not interrupt the standard operating procedures in the E&P business. It reorganizes it in an agile manner to align with modern computer science. For an analogy, it is like the data kept in a 'file system' and then loaded into a 'database' system – resulting into a vastly superior ability to investigate it.

Resources & Skills: Computer Science skills are needed. The E&P professionals need to be trained or certified in CS skills. Bimodal IT organization is a good starting point.

Financials: For a cost of a deep–water exploration well, the BIF can be created. The entire transformation to R–T–I will be very nominal. Cost saved from studies and investment outside 'reserves' focus can fully fund this work.

Organization Alignment & response: The standard consultants and BT experts may not advise R–T–I model. The belief and trust to this transformation is not easy for a profitable business. I personally failed to get any appreciation to the difference between 'filesystem' and 'database' in my tenure as CIO.

Growth & Sustenance: Agile development and open technology adaption can make Growth very rapid. Sustenance is more about Organization alignment. Once E&P company realizes how many of their projects have ONLY COST and NO Value of Information (VoI), acceptance becomes natural.

1. Reserves Centric E&P framework is essential
2. Technology metric is its value to reserves hopper
3. Information models have changes following 2020–Science and need to be adopted by E&P

There is really no cost deterrent to R–T–I implementation. It is inability of leadership to understand the difference.

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2. Harbaugh, J.W., and Bonham–Carter, G. (1970). *Computer Simulation in Geology*. John Wiley. ISBN 10: 0471351369 ISBN 13: 9780471351368
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Further Reading

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<https://doi.org/10.1016/j.ins.2014.01.015> – Addresses the technologies (IT tools and techniques) in the development and deployment of DISD.
7. 4th Paradigm Geoscience. IITBombay talk 2011. <https://www.slideshare.net/srikantg/4th-paradigm-geo-science-iitb-talk-march2011> – describes the core tenets of 4th paradigm science. Examples and cases that are close to the approach in E&P are presented

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