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Enterprise Systems Value-Based R&D Portfolio Analytics: Methods, Processes, and Tools

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14. ABSTRACT

Investments in business development can be both highly volatile and uncertain, typically spanning a long period of time, and dependent on the development and leveraging of internal and external ?know-how?. As a result, traditional valuation methods are often inadequate and must be enhanced to account for the uncertainties and opportunities offered by a portfolio of R&D investments. The work outlined in this research extends previous research regarding value-based R&D portfolio management [A] ? [D], and the process of characterizing, assessing, and managing R&D portfolio value [E] ? [K]. The principal focus of this research is to better understand the process of characterizing, assessing, and managing R&D portfolio value; as well as leveraging associated process artifacts for better evidence-based decision making and enhanced business efficiency and effectiveness across the enterprise [L] ? [O]. This effort involved the following phases and associated activities ? In the Discovery Phase activities concentrated on identifying and evaluating artifacts associated with the ARDEC R&D portfolio and strategic business development processes. ? The Analysis Phase focused on mining and analyzing the identified artifacts with specific attention to how each artifact is created, managed, and used as part of the portfolio planning and business development processes. ? In the Synthesis Phase efforts were directed at developing a framework for business opportunity identification with specific attention to highlighting opportunity characteristics, prioritization, and focus. ? In the Proof of Concept Phase, examples were drawn from existing portfolio/project research and best practices [P] ? [T] as a means of illustrating how the framework could be used to enhance the evidence-based decision making process within the enterprise. Finally, the results of this effort have been used to develop a research roadmap, which outlines by phase the research activities associated with the development of an evidence-based decision making process, its underlying analytical framework, and its use.

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Investments in business development can be both highly volatile and uncertain, typically spanning a long period of time, and dependent on the development and leveraging of internal and external "know-how". As a result, traditional valuation methods are often inadequate and must be enhanced to account for the uncertainties and opportunities offered by a portfolio of R&D investments. The work outlined in this research extends previous research regarding value-based R&D portfolio management [A] – [D], and the process of characterizing, assessing, and managing R&D portfolio value [E] – [K].

The principal focus of this research is to better understand the process of characterizing, assessing, and managing R&D portfolio value; as well as leveraging associated process artifacts for better evidence-based decision making and enhanced business efficiency and effectiveness across the enterprise [L] – [O].

This effort involved the following phases and associated activities:

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The Intelligent Enterprise

In today's business environment (Figure 1), companies are trying to exploit data and advanced analytics to answer key questions about their suppliers, customers, products, and operations. In a sense they are searching for answers to these questions as a means of more intelligently guiding their business decisions. The intended end result of their efforts are to use data and analytics to guide the enterprise from an "as is" state to a desired "to be" state. Intelligent organizations look to leverage an evidence-based decision making process to enhance the efficiency (better manage costs) and effectiveness (increase value) of the organization's R&D project portfolio.

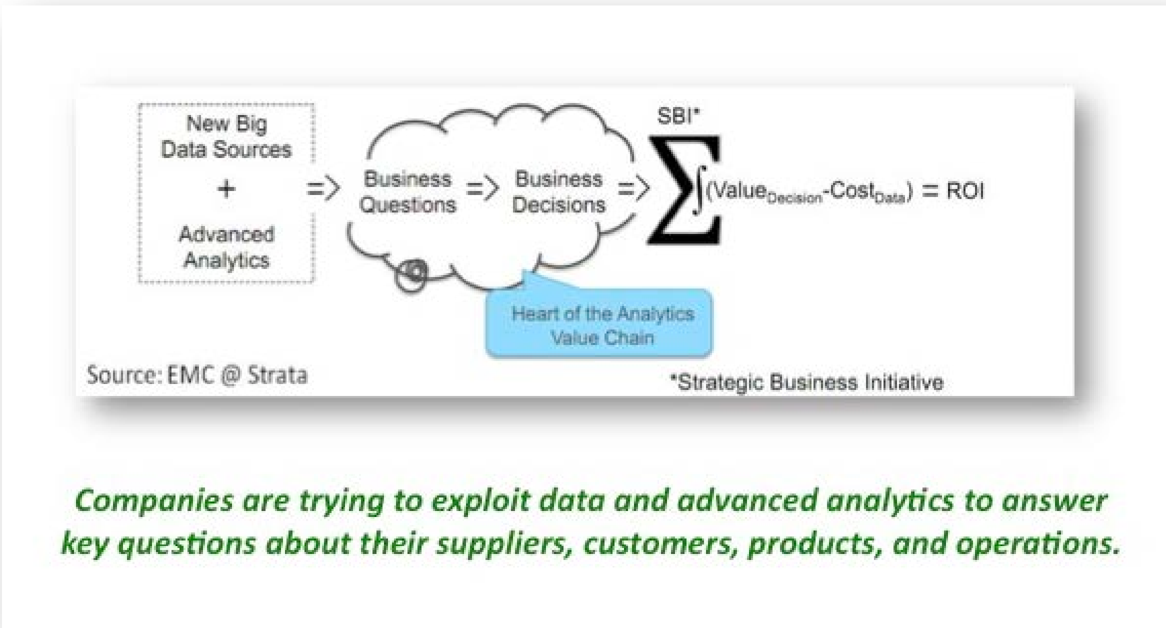

Figure 1 Answering Strategic Questions

Within the intelligent enterprise, organizations search for answers to key business questions regarding their suppliers, customers, operations, and resources. This effort (Figure 2) involves the integration of decision analytics with knowledge management within the enterprise.

Knowledge management involves a set of activities associated with the creation, management, sharing, and discovery of evidence contained in internal and external data artifacts. Within the enterprise reporting and visualization tools are necessary to carry out these activities. Decision analytics leverages tools and methods to enhance the organizations ability to answer key questions about their suppliers, customers, products, and operations.

2.1 DECISION ANALYTICS AND KNOWLEDGE MANAGEMENT

The key tools and methods consist of:

- Forecasting – which involves analyzing historical time series data to provide insights regarding future decisions.
- Data mining – which involves mining transactional data bases.
- Statistics – which is used to facilitate the interpretation of numerical data.
- Text analytics – which involves uncovering insights from large collections of unstructured data.
- Optimization – which looks to analyze evidence in support of making decisions likely to produce optimal results.

Within the intelligent enterprise, organizations focus on leveraging decision analytics and knowledge management to guide them on a path from insight to value.

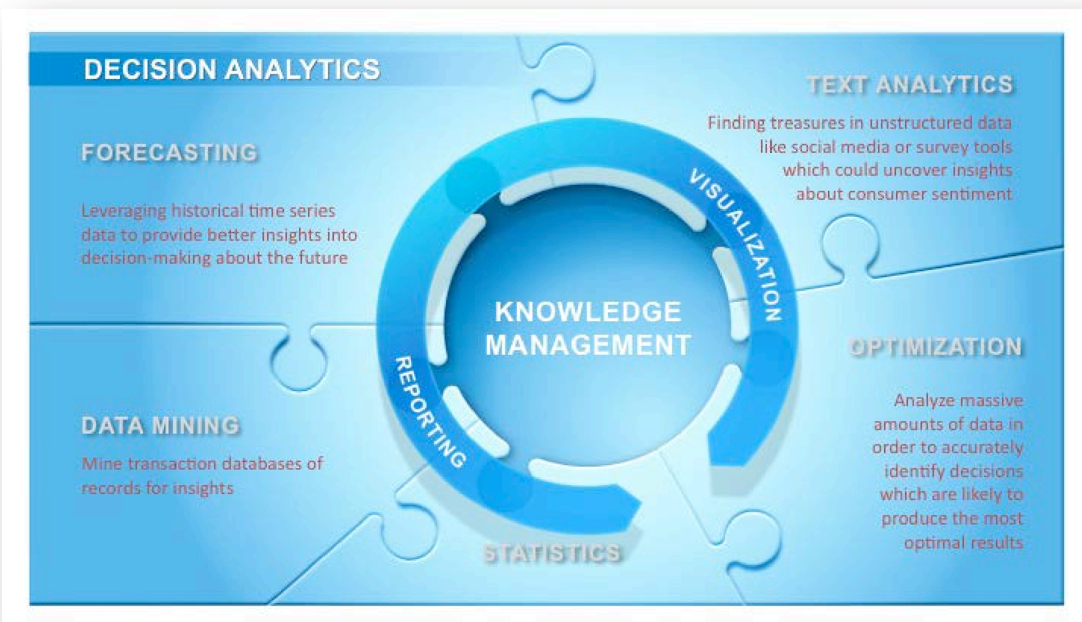

Figure 2 Decision Analytics

Today, executives are interested in better managing the enterprise through analytics, running their businesses on data-driven decisions, and using advanced analytics to help them better identify the best actions to take under conditions of increasing uncertainty and risk.

As highlighted by La Valle, et al. [1], "Senior executives now want businesses run on data-driven decisions. They want scenarios and simulations that provide immediate guidance on the best actions to take when disruptions occur — disruptions ranging from unexpected competitors or an earthquake in a supply zone to a customer signaling a desire to switch providers."

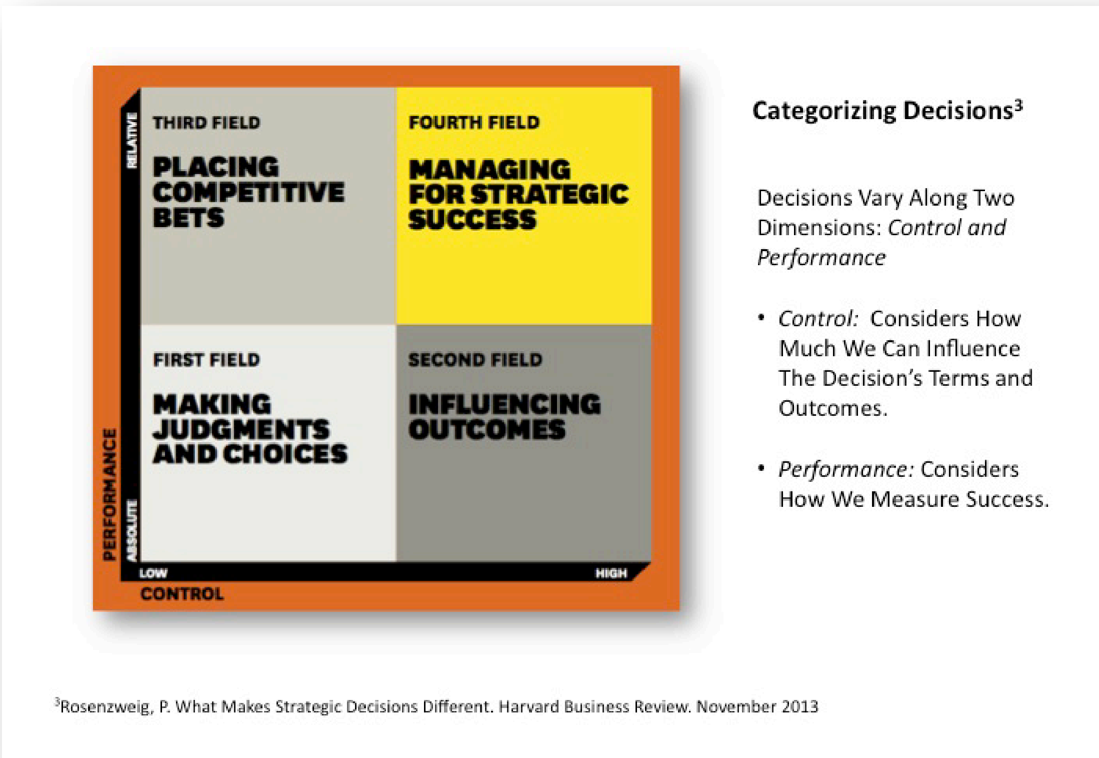

Figure 3 Strategic Decision Making

However, not all decisions are alike (Figure 3). Rosenzweig [2] highlighted the need to categorize decisions along two dimensions – control and performance. Where control considers how much we can influence the decision's terms and outcomes, and where performance considers how we measure success. Given this structure, the process of making strategic decisions involves understanding how best to make decisions given the decision's type. Rosenzweig highlighted that enterprise decisions will fall into one of four fields, namely:

- First field decisions – ones with a low degree of control and an absolute level of performance are all about making judgments and choices.
- Second field decisions – ones with a high degree of control and an absolute level of performance are all about influencing outcomes.

- Third field decisions – ones with a low degree of control and a relative level of performance are all about placing competitive bets.
- Finally, fourth field decisions – ones with a high degree of control and a relative level of performance are all about managing for strategic success.

2.2 Decision Model

The decision model at ARDEC (Figure 4) can be viewed as a process whereby internal and external data and information regarding the current business is collected, synthesized, and analyzed resulting in a recommendation. Strategic and tactical decisions based on these recommendations have a direct impact on resource allocation, enterprise collaboration, thrust area prioritization, portfolio planning, as well as the tracking and managing of business opportunities and customer relations [3] – [4] – [5].

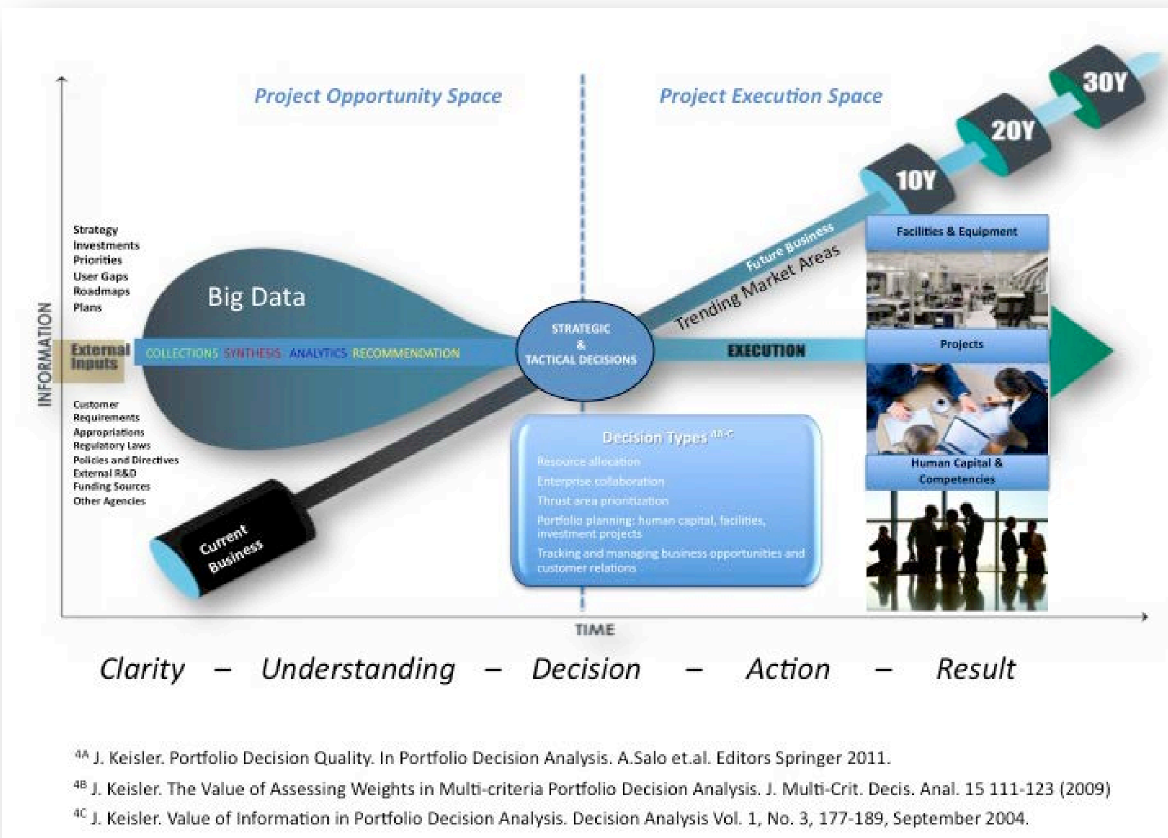

Figure 4 ARDEC Decision Model

Overall, decisions made within this process impact either in the project opportunity space or the project execution space. The ARDEC decision model is used to steer the enterprise forward. Enhancing the decision model to better leverage knowledge management and decision analytics will enhance the ARDEC's ability to steer more effectively toward both its short-term as well as long term goals.

2.3 DECISION FRAMEWORK

Knowledge management and decision analytics are the foundation for the decision framework (Figure 5) necessary for steering the ARDEC enterprise. By appropriately categorizing the portfolio of projects under consideration with respect to performance and control, the enterprise can then match the decision type with an intended action. Input into the framework are the organizational and customer needs and opportunities as captured in the project proposal process.

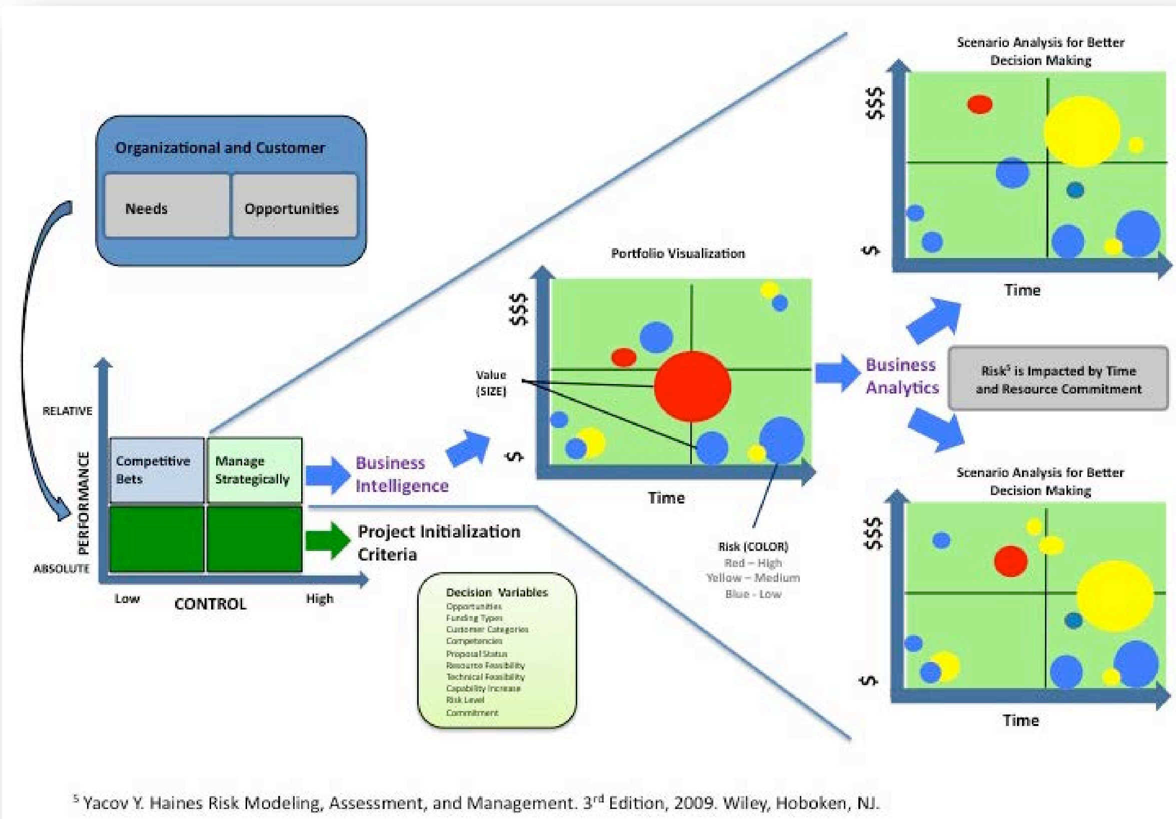

Figure 5 Decision Framework

Decision actions are guided by a range of decision variables, these include: opportunities, funding types, customer categories, competencies, proposal status, resource feasibility, technical feasibility, capability increase, risk level and commitment.

Decisions involving projects with an absolute level of performance can be guided through established project initialization and management criteria. However, projects with a relative level of performance and a low degree of control – competitive bets, would be enhanced through the effective application of business intelligence in the decision making process. Projects that require a high degree of strategic management – those with a relative level of performance, but a high degree of control need to be managed strategically. Strategic decisions associated with these projects would be significantly enhanced through the application of business intelligence as well as business analytics. In this context, business analytics (specifically, scenario analysis of the impact of time and resource commitment on project risk) [6] would enable enterprise decisions to be made in a more effective manner.

2.3.1 Decision Process

R&D portfolio decisions have a maturity level associated with them (Figure 6). The underlying process is one of collection, use, analysis, and decision. Key to the decision process maturity level of the enterprise is insuring that we instrument the enterprise appropriately.

Instrumentation asks the question – are we collecting the "right" data? Next comes the use and analysis of the data collected to identify gaps between the current and desired state of the enterprise (as seen through its portfolio of projects). Identifying gaps asks the question – are we using the data the "right" way? Finally, decisions are made with the intent of making a corrective action, based on evidence. Corrective actions associated with closing gaps ask the question – what is the overall impact of our decisions for the enterprise? As decision maturity grows, decisions move from those whose impact is to enhance efficiency to those that enhance effectiveness.

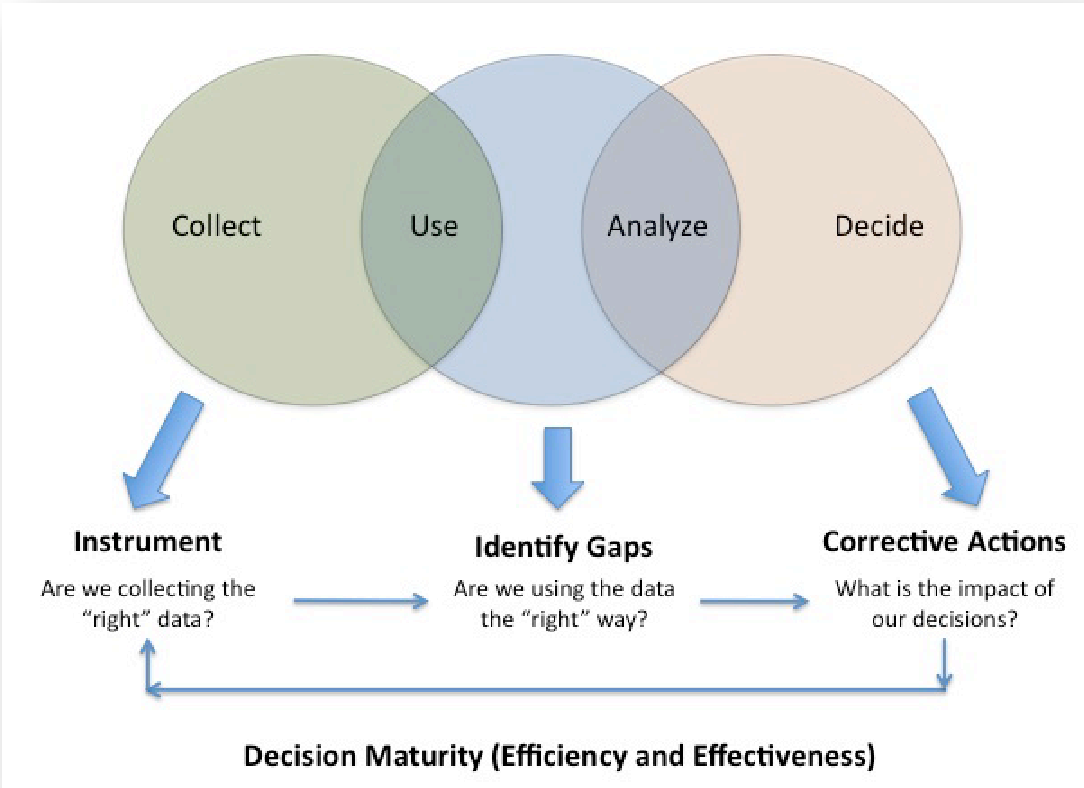

Figure 6 Decision Process

Although R&D portfolio decisions are focused on making decisions about how best to allocate resources, facilitate collaboration, prioritize areas, enhance facilities, track and manage business opportunities – very much like any other business enterprise. There are two very important distinctions. First, R&D projects are subject to technical uncertainty [7] – where an individual activity failure can result in an overall project failure. Second, R&D projects tend to have a number of possible outcomes, each having some degree of uncertainty associated with them [8]. These two factors make decision making under uncertainty a key issue to be addressed as part of the decision making process.

2.3.2 Assessment Methods

There are four assessment methodologies [9] associated with the decision variables of interest used in the proposed decision model, these are:

- ***Quantitative Methods*** use quantitative input data and adopt strict procedures, such as mathematic algorithms, plus the calculation of financial and economic indices, to obtain a quantitative output.
- ***Semi-Quantitative Methods*** use both quantitative and qualitative data, adopt strict procedures and obtain a quantitative output. They differ from the previous methods in that subjective evaluations are also made during the selection procedure.
- ***Semi-Qualitative Methods*** use qualitative data and adopt a process that is strict but much less sophisticated than the two previous categories to obtain a quantitative output.
- ***Qualitative Methods*** use only qualitative data and select projects with a decision-making process that involves comparing the opinions of several actors to obtain a qualitative output.

Each methodology has costs associated with both the collection of the data and the involvement of subject matter expertise involved in both the assessment and analysis of the data.

2.3.3 Assessment Factors

Portfolio decisions are made within the context of certain assessment factors which influence the decision making process, namely:

Economic Factors use subjective forecasting input.

- ***Technology Factors*** use subjective project technical content (including gaps complexity, competency, resource and equipment availability) input.
- ***Market Factors*** use product life cycle, competition, market demand input.
- ***Strategic Factors*** use compliance with corporate strategy, length of product life cycle, development of new competencies, etc. as input.
- ***Risk and Uncertainty Factors*** use technical success (gap between required technology and state of the art), commercial or market success, and economic success (expected outcome) as input.
- ***Coherence Factors*** use strategic features (pursuit of multiple objectives) with interdependencies in resource utilization, technical and outcome interdependencies as input.

2.3.4 Enterprise Decision Process

As we turn our attention to the process of enhancing the enterprise decision making process (Figure 7) surrounding the R&D portfolio. The instrumentation of opportunities, funding types, customer categories, competencies, proposal status, resource feasibility, technical feasibility, capability increase, risk level and commitment – facilitates the identification of gaps in resource allocation, enterprise collaboration, thrust area prioritization, portfolio planning, and the tracking and management of business opportunities and customer relations.

Decisions regarding the appropriate corrective actions to take will impact the enterprise from the standpoint of investments in facilities and equipment, the undertaking of projects, and the enhancement of human capital and the development of needed competencies. Overall the process of instrumenting, gap identification, and corrective action occurs on an ongoing basis. Each time an organization goes through the process it seeks to find the answers to the appropriate questions concerning its customers, suppliers, products, and operations.

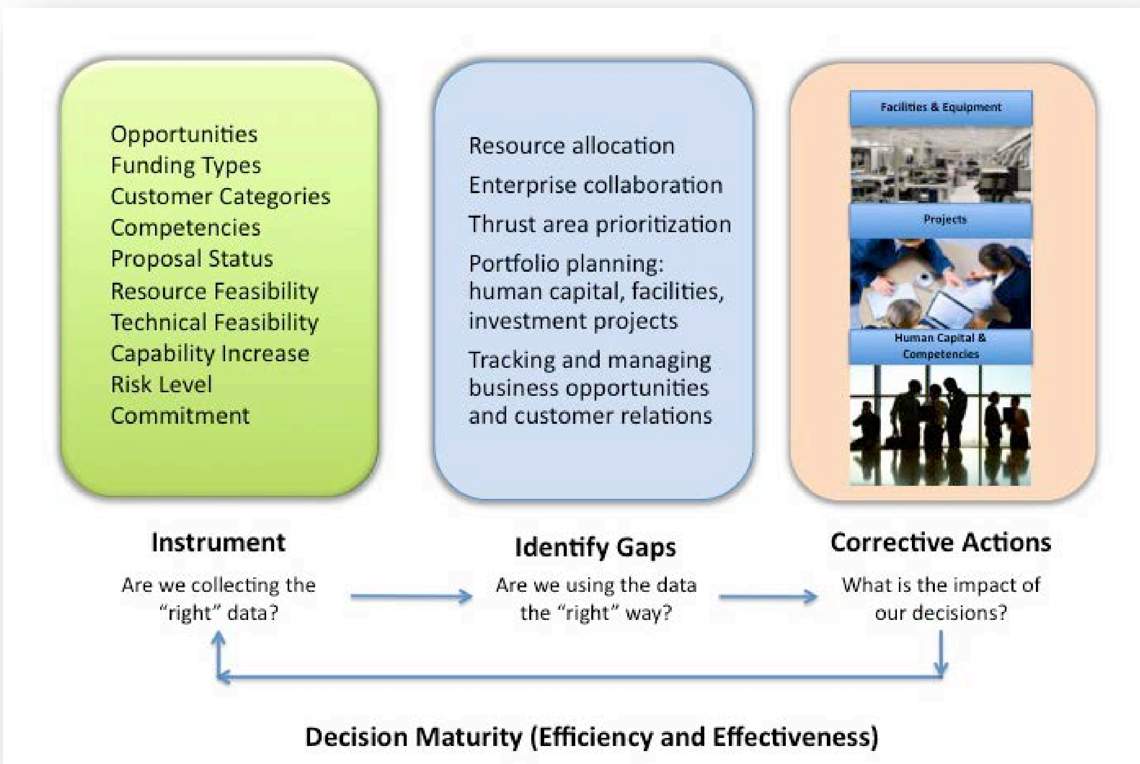

Figure 7 Portfolio Decision Process

The answers to organizational questions are often a result of the evidence collected from the instrumenting and gap identification process. The types of questions the organization can answer based on this collected evidence is very much tied to the following analytical framework.

2.3.5 Analytical Framework

This analytical framework (Figure 8) highlights the way analytics is used to pursue key questions of interest to the enterprise.

Degree of Intelligence	Analytical Tool	Questions of Interest	Areas of Focus	Maturity
Prescriptive Analytics	Stochastic Optimization Optimization	What's the best outcome including variability? What's the best that can happen?	... Projects, Products, & Customers ... Capabilities & Resources	***Insight Generation (Actionable Insights)*** Optimizing (Portfolio, Return on Resources, Outcome-Based Decisions)
Predictive Analytics	Predictive Modeling Forecasting Simulation Alerts	What will happen next, if? What if these trends continue? What could happen? What actions are needed?	... Projects, Products, & Customers ... Capabilities & Resources	***Modeling & Forecasting (What Should we do?)*** Managed (Capture Learnings, Improve Portfolio Management and Performance) ***Data Analysis (Why it Happened?)*** Defined (Enterprise Management Processes & Strategic Criteria)
Descriptive Analytics	Query/Drill Down Ad Hoc Reports Standard Reports	What exactly is the problem? How many, how often, and where? What happened?	... Projects, Products, & Customers ... Capabilities & Resources	***Reporting (What Happened?)*** Developing (Standardized Business Processes & Evaluation Criteria)

Figure 8 Analytical Framework

Descriptive analytics is used to better understand what the exact problem is, how many, how often, and where it is occurring and what is happening as a result. Questions such as these are best addressed with tools that facilitate querying and drill down, as well as ad hoc and standard reporting. Descriptive analytics is primarily concerned with "what has happened"? Predictive analytics is used to understand what will happen next, what if the trends continue, what could happen, and what actions are needed. Questions such as these are best addressed with tools that facilitate predictive modeling, forecasting, simulation and alerts. In this context modeling and forecasting focus on what should be done and data analysis on why it happened. Finally, prescriptive analytics is used to better understand what's the best that can happen, or what the best outcome could be. Questions such as these are used to generate actionable insights. Moving from the use of descriptive analytics to predictive analytics to prescriptive analytics takes considerable investment both in the type of data needed and the skill and capability of the organization to analyze it effectively.

As we look to instrument the enterprise, the decision framework needs to factor in the preferences and focus of the decision makers involved in the process. Decision preferences can be associated with the value or timing of a project, as well as the risk and uncertainty level. Decision focus can be associated with a project's technical and resource feasibility as well as the financial, customer, operational, and resource impact of a decision. Decision preferences and focus will have a significant impact on the instrumentation process – especially from the standpoint of collecting the "right" data for the enterprise.

Data collected as part of the instrumentation process will ultimately be used to identify gaps. Gaps exist when the enterprise's "as is" state differs from the enterprise's "to be" state. Addressing gaps requires evidence-based decisions, which will ultimately effect a state change. Effecting a state change involves making changes based on decision levers. Decision levers involve re-balancing a portfolio of projects (balance), re-allocating resources (resource), enhancing a projects value (benefit), improving inter-project coordination (linkage), enhancing a project timeline (acceleration), and reducing waste and improving cycle time (efficiency). Gap identification has a lot to do with gaining insight into using data in a more actionable way. Decisions around how best to close gaps will still be made with the enterprise's decision preferences in mind.

The decision framework brings together the decision levers, preferences, and focus in charting the types of corrective action to take, and although this is an ongoing process it is very much affected by the types of questions the enterprise is seeking the answers to, what the enterprise's current state is, and what the desired end state is. Corrective actions don't necessary generate the expected outcome. However the ongoing process serves as a type of feedback loop, where metrics can be used to evaluate if the project is moving in the right direction.

In the looking at the current state the answers to key business questions provide a degree of business intelligence surrounding business partners, customers, products, competencies, and projects. Decisions surrounding this information are more about developing standardized business processes and evaluation criteria – managing the enterprise more efficiently.

In looking at the future state the answers to key business questions provide a degree of business insight surrounding needed business partners, valuable customers, important products, needed competencies, and valuable projects. Decisions surrounding this information are more about defining enterprise management processes and strategic criteria, as well as capturing learnings, improving portfolio management and performance – managing the enterprise more efficiently.

2.4 Making Evidence-based Decisions

The roadmap for making evidence-based decisions (Figure 9) is primarily driven by the enterprise's value proposition. The ARDEC value proposition consists of key partners and accounts and the provisioning of needed resources to work on projects, as well as valued customer relationships, which facilitate the delivery of value to customers and stakeholders. ARDEC uses its cost structure to best manage its partners and accounts and resource structure to best manage its customer segments and relationships.

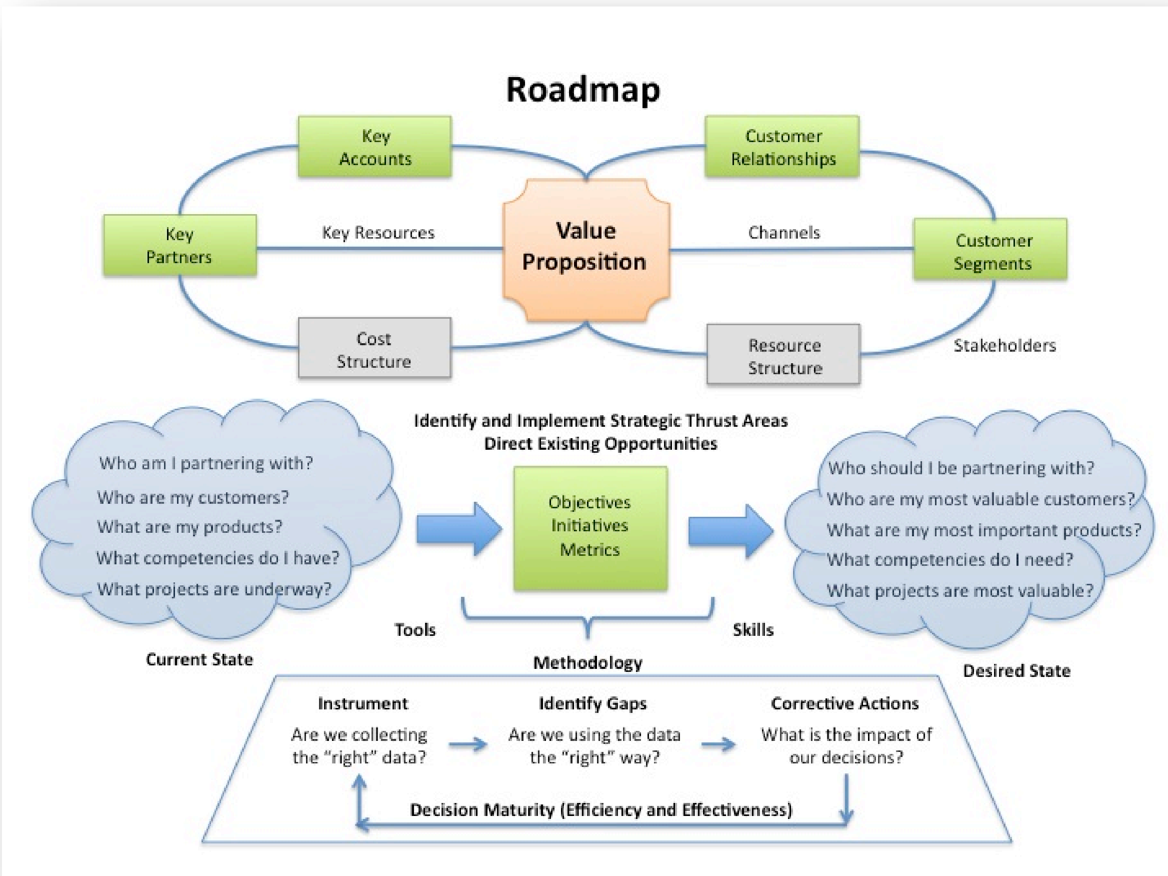

Figure 9 Evidence-Based Decision Making Roadmap

With the appropriate tools, methodology, and skills evidence-based decisions can facilitate the effective management of ARDEC's current and future portfolio of projects.

Portfolio decisions can be used to guide the enterprise in moving from a current state to a desired state; as well as in identifying and implementing new strategic initiatives and direct existing opportunities. The answers to key business questions concerning the ARDEC environment (partners, customers, products, and operations) will be of significant value in not only the management of the R&D portfolio of projects; but, in the definition of objectives, initiatives, metrics associated with them. Critical to the successful implementation of this roadmap are the tools, methods, and skills needed to actually instrument, identify, and act on the answers to key business questions of strategic significance to the enterprise.

2.4.1 METHODOLOGY

The decision analytics methodology (Figure 10) needed involves using the appropriate tools and skills with which to process internal and external data and information regarding the business question of interest.

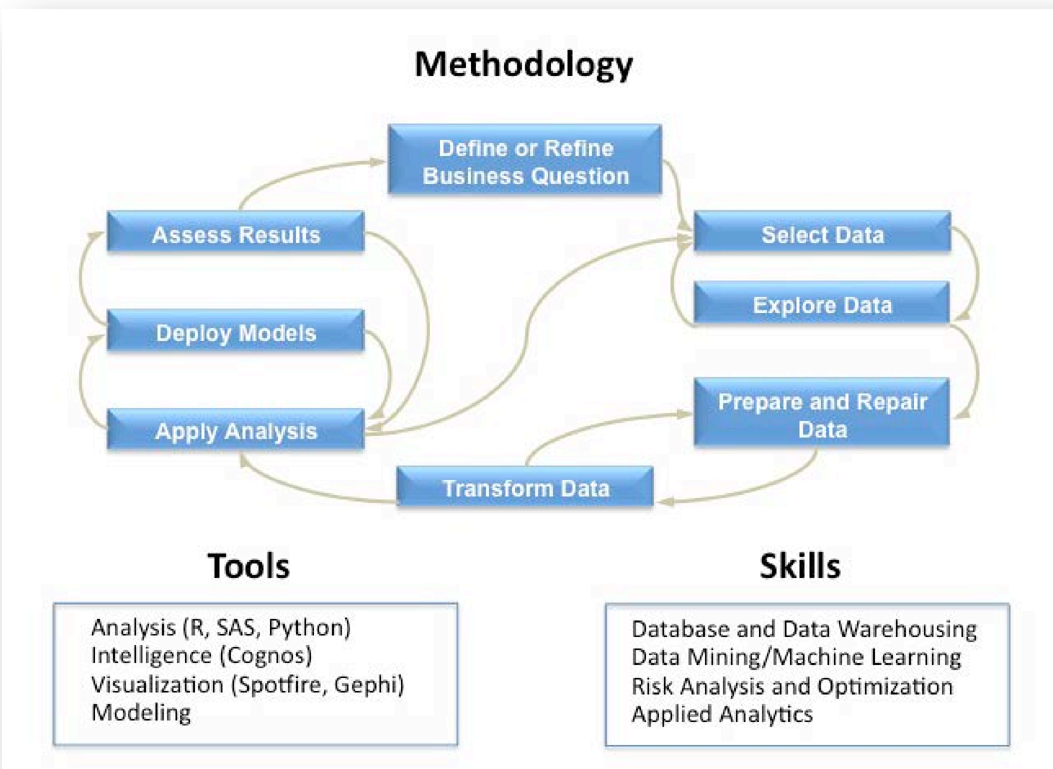

Figure 10 Decision Analytics Methodology

Before the data can be analyzed it must be selected explored, prepared and repaired, and transformed. These methodology steps are often repeated until the analysis progresses to a point where models can be developed and deployed, and results can be assessed. The process begins all over again as new questions are raised or existing questions are refined. Implementing the methodology requires, based on the type of question to be addressed, skills in database and data warehousing, data mining and machine learning, risk analysis and optimization, as well as applied analytics.

Practitioners would need to leverage tools to facilitate analysis, business intelligence, visualization, and modeling.

2.5 Roadmap Forward

The effort associated with implementing the roadmap has been broken down into five phases, as follows:

- **Phase 1** – Develop a strategic business development decision *Model*, *Framework*, and *Methodology* for use in identifying near-term portfolio opportunities including: how to prioritize them, which sectors to concentrate on, and what characteristics to look for.
- **Phase 2** – Extend the *Framework* to allow for scenario analysis to enhance the process of making portfolio decisions (first from an opportunity space and then from an execution space perspective).
- **Phase 3** – Research the impact of key enablers on the strategic business development *Framework* (from both an opportunity and execution space perspective).
- **Phase 4** – Enhance the *Framework* highlighting the process of leveraging the key enablers, taking into consideration their use in non-defense related industries (e.g., pharmaceuticals).
- **Phase 5** – Extend the *Framework* for addressing longer-term (5, 10, 20, and 30 year) strategic business development targets.

In the end, implementation of the body of work outlined in the roadmap will contribute to enhancing short term and ultimately long term enterprise value (Figure 11).

The first three phases of the roadmap outline the effort involved in implementing the strategic business development model, methodology, and framework as a means of enhancing ARDEC's tactical and strategic decision making process. The last two phases of the roadmap outline the effort involved in extending the model, methodology, and framework for use in longer-term (10, 20, 30 year outlook) strategic planning.

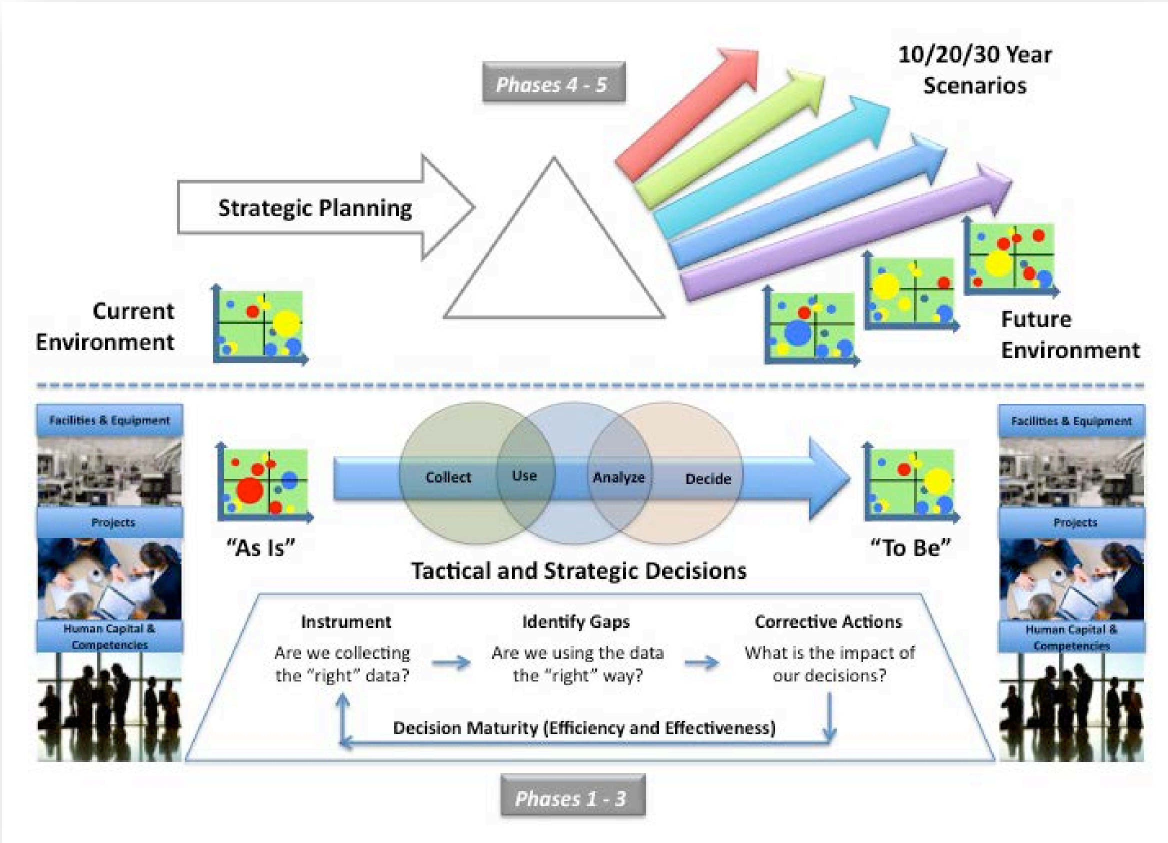

Figure 11 Roadmap

The research roadmap will help guide ARDEC's efforts to better characterize, assess, and manage the value of their R&D portfolio; as well as leverage business intelligence and analytics for better evidence-based decision making and enhanced business efficiency and effectiveness across the enterprise.

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