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Business risk in early design: an approach

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BUSINESS RISK IN EARLY DESIGN: AN APPROACH

by

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ABSTRACT

The Business Risk in Early Design (B-RED) method is a tool used to determine the potential risks in business, in the early business development stages. In order to launch a successful business in today's competitive market environment, the business should equip itself to face the risks involved in business. If the potential risks are identified even before the launch of the business, then there is an opportunity to avert risks with little or no impact to the budget and schedule. The B-RED method presented in this thesis helps entrepreneurs and people with little or no experience in business to identify the likely risks. This method is demonstrated using a business failure case as an example. The method of populating the database is also described in the thesis. Results obtained show that the B-RED method can be effectively used to identify the potential risks involved in the business by utilizing the historical business failure data. The risks are presented in the form of a chart by classifying them into low, moderate, and high risk elements.

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INTRODUCTION

The Business Risk in Early Design (B-RED) Method focuses on identifying the potential business risks in the early stages of business development. Businesses that have identified risks will be better equipped and will have more cost effective manner of dealing with them. B-RED method utilizes the concept of RED method. Paper I presents the procedure to conduct the B-RED analysis. No prior business knowledge about business failures is required to use this method, other than the functions of business under study. The information from the historical business failures is effectively cataloged and utilized by B-RED to suggest potential risk areas the businesses need to consider.

Past business failures can be efficiently cataloged to prevent future failures. Relevant information to document includes description of the failure, organizational level of the failure, and its causes. The required information of business failures comes from a variety of sources such as news and business magazines, academic journals, in-house corporate reports, etc. This important information about business failures will assist in launching successful new businesses. Paper II presents the procedure for populating the B-RED database using the information obtained from various business failures. Using the database the potential business risks can be effectively determined.

PAPER I

BUSINESS RISK IN EARLY DESIGN: AN APPROACH

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Abstract

Competitive advantages erode at an ever increasing rate in today's fast-paced, knowledge-based environments (Burgers et al., 2007). Nine out of ten new businesses fail within their first two years (Gardner Business Solutions, 2002). Business failure can be defined as a situation that a firm cannot pay lenders, preferred stock shareholders, and suppliers, a bill is overdrawn, or the law makes the firm go bankruptcy (Dimitras et al., 1996). A business failure not only affects a company or an organization, but may generate social functions and impact a country's economic performance (Rong-Ho et al., 2008). Businesses are always associated with risks that can never be fully evaded due to many practical limitations. These practical limitations include but are not limited to available data, methodologies, time, and financial support. In business, 'cost' not only relates to money, but also to loss of efficiency and loss of customer or supplier satisfaction (ERP-Project Management, 2007). Risk assessment is an area of significant concern for numerous businesses in today's capricious marketplace because the outage resulting from such risks can seriously affect visibility of business operations, profitability, quality of service, and convenience (Long, 1997). Bettis (1983) suggested that managing business risks lies at the heart of competitive strategy. This paper presents a function based mathematical mapping of the Business Risk in Early Design (B-RED) method for preliminary risk assessments based on historical business failures. A B-RED preliminary risk assessment of Arthur Andersen is discussed as an example. Arthur Andersen was once the most powerful and highly respected accounting firm in the world (Toffler, 2005). The steps to overcoming risks by performing B-RED in the initial business development phases are discussed in Section 3.2.

Keywords

Business, Risk Analysis, Failure Mode, Function, Component

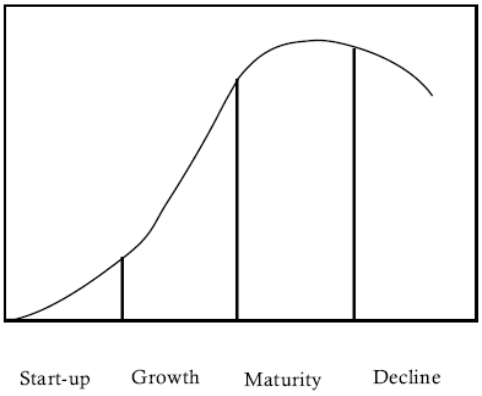
1. Introduction

An average of more than 500,000 businesses failed in the United States during each of the ten recessions that have occurred since the end of World War II (Pierce II et al., 2006). It is widely known that business growth and survival depends on both internal and external factors (West Pacific Marketing Consultants, 2007). Internal factors include a key management team, selling and marketing power, etc. External factors include the environment in which the businesses function, and the relationships with government institutions and business partners (West Pacific Marketing Consultants, 2007). While most challenges such as rapidly changing market conditions and increasing customer demands for quality, value, and service -- can be anticipated; some challenges like increased competitive pressures from domestic and foreign competitors will be completely unpredictable (Mercer Delta Executive Learning Center, 2006). However, if a business is to be successful, its management must be observant of all matters which are likely to have an impact on its feasibility and must then demonstrate skills in project management, risk management, etc. to mitigate threats (Conrad et al., 2005).

When any business fails, its 'stakeholders' – investors, employees, suppliers, and customers – stand to lose financially. Unpaid creditors will often have to write off their debts and the investors usually lose their invested money. For these reasons, large business enterprise failures will lead indirectly to financial problems or even insolvency for individuals and businesses that have a financial stake in such businesses (European Federation of Accountants, 2004). At the same time, the survival of other associated businesses with which the failed business trades are threatened.

Every business has a life span that is represented by its business life cycle. A business life cycle normally contains four stages: Start-up, Growth, Maturity, and Decline, as shown in **Exhibit 1** (Ag Decision Maker, 2007). Most business life cycles will experience a sluggish start-up and growth stage, a short maturity stage, and a rather quick decline stage (Ag Decision Maker, 2007). Business disasters are the result not of one mistake, but of a series of mistakes. In any business the top level management needs to learn to identify the patterns of mistakes that pave the way for most business disasters and to mitigate a mistake or a series of mistakes to avoid full scale crisis management.

Exhibit 1. Business Life Cycle (Ag Decision Maker, 2007)



Risk is the chance that an undesirable event will occur and the consequences of all its possible outcomes (Grantham Lough et al., 2005; Gray et al., 2000). In today's competitive business environment every organization operates with risk. It is important to evaluate and reduce risks to the lowest possible level, so that they do not manifest themselves at a later stage in the business life cycle (Ag Decision Maker, 2007), when it will become exceedingly difficult to overcome the upshot of avoiding risk mitigation. The new business risk assessment method presented in this paper is aimed at assisting management by providing preliminary risk assessments for businesses based on archived knowledge of past failures. Since the greatest opportunity to minimize risks occurs in the start-up phase of the business, a tool that utilizes failure analysis to estimate risk in this phase will be beneficial to deal with potential risks by appropriate planning.

This paper focuses on identifying business risks. Businesses that have identified risks will be better equipped and will have a more cost effective manner of dealing with them. The Business Risk in Early Design (B-RED) method, presented in this paper, utilizes the wealth of information from historical business failures, by effectively cataloging them and using that information to suggest the potential risk areas that businesses need to consider. B-RED utilizes the concept of Risk in Early Design (RED) method. RED method was developed by Grantham Lough et al. (2006a) to identify and assess electro-mechanical design risks by linking historical product failures to functionality.

2. Related Work

2.1 Business Risk Assessment Practices

According to Hoosian (2003), typically in any business risk assessment process there are four types of risk categories: People, Process, System, and External events. The people category

includes risks such as non-familiarity of the staff with guidelines and procedures, failure of staff to comply with procedures, etc. The process category includes risks such as process failure and inadequate controls in operational processes. The system category includes risks such as failure of the application system to meet user requirements and absence of built-in control measures to the application system. The external event category includes risks such as fraud by customers, legal action taken by customers due to fraud committed by the internal staff. Using this data, risk in banking products can be analyzed using the operational process of the product. For example consider the product ATM in a bank. The operational processes for the ATM are identified and for each operation process the magnitude of risk impact (in terms of loss amount) and likelihood (in terms of number of incidents) for each of the four risk categories as described above are analyzed. Magnitude of either 1 (high) or 0 (low) is assigned to the extent of risk impact or likelihood for each risk category. Consider a risk impact value of 1 assigned to the failure of an application system and a likelihood value of 0 assigned for no occurrences of such failure. It falls in the medium-high risk quadrant of the risk quadrant grid, which consists of four quadrants: low risk, medium-high risk, medium-low risk and high risk (Hoosian, 2003). The advantages of this process are that each risk category is assigned with a magnitude of high or low and are presented in a risk quadrant grid for easy visualization. The drawbacks of this process are that it is not applied in the early phases of business planning, or/and historical business failure information is not utilized to conduct risk assessment.

Planning an effective response is too late if disaster has struck and significant downtime has been incurred (Long, 1997). In the business interruption risk assessment by Long (1997), first the analysis framework is established, i.e. selecting specific areas of concern for examination based on facility, process, or operation under review. Then the downtime scenarios are identified. The scenarios are described in detail and grouped by impact or equipment type, allowing for the combinations of multiple causes with similar outcomes. The scenarios are then assigned with overall risk levels by defining suitable ranges of likelihood (i.e. 0.0001 – 0.01/yr) and consequence (i.e. 0-5). These ranges are developed on the basis of type of facility, process, or operation (Long, 1997). For example, in fire and explosion scenario as described by Long (1997), a data center where numerous pieces of computer equipment are situated on raised floors is considered which often has characteristics that present a fire hazard. Under the raised floor there is extensive cabling with PVC insulation. The fire in data center areas can arise due to problems with wiring, electronic components or electrical distribution systems. The extensive cabling under the raised floors enhances the fire risk. The probability of fire occurring in a data center is usually estimated to be ‘somewhat likely’ (0.0001 – 0.01/yr), based on historical accident data in

combination with site specific data. Fire in a data center can result in a significant downtime of a week or more. Thus using this risk analysis, the risks for business interruptions can be assessed and risk control alternatives can be put in place. The risk control alternatives for the example considered can include a pre-action sprinkler system and beneath the raised floor. The alternative is to install a 'very early smoke detection system' (Long, 1997). The advantages of this process are: it helps to fully understand the risks to operations and the measures that can minimize the probabilities and consequences, and the methodology combines historical accident data and site specific data to estimate the probability. The drawbacks of this process are that the risk assessment is not conducted during early business planning stages, and historical business failure data is not cataloged for use in business interruption risk assessment.

Peltier Associates' (2007) Facilitated Risk Analysis Process (FRAP), analyzes one system, application or segment of a business process at a time. A team of individuals that includes business managers and support groups meet and brainstorm potential threats, vulnerabilities, etc. Impacts to the business operations are then analyzed and threats and risks are prioritized. The FRAP process is used by information security professionals, project management, auditing, physical security, facilities management, or any organization that needs to determine what action the organization must take on a specific security issue. For example, if a system or segment of business process such as accounting is being examined, then threats such as fraud or attempts to access private information. are obtained by brainstorming. The impacts to the business operations are then analyzed by assigned numerical values to the threats (i.e. 1-10). In this case, fraud is assigned an impact value of 10. Similarly, the team assigns values to the vulnerabilities. A vulnerability value of 5 is assigned for fraud. Finally, the risks and threats are prioritized based on the impact and vulnerability values (Bidgoli, 2006; Peltier, 2000; Peltier Associates, 2007). The benefits of using FRAP are – it identifies and prioritizes risks to the enterprise, and it takes advantage of people who know the organization best. Some drawbacks of FRAP are: it is purely qualitative, i.e. it makes no attempt to quantify probabilities and magnitude, the team's experience sets the priorities, and this process is not applied in the early stages of business development and does not utilize the historical business failure information.

The most apparent drawback of the business risk analysis processes described above is that the processes are not applied in early stages of business development. This stresses a need for a method which can help identify the potential risk areas in business in the early business development stages, when modifications to the business plans can be made without significant changes to the budget and schedule. Historical business failure data contains a wealth of information which should be efficiently used to prevent future business failures. None of the

business risk analysis processes described above systematically utilize historical business failure data for effectively determining the potential risks. This stresses the need for a more efficient system to catalog and utilize historical business failure data to identify the potential business risk areas even before the launch of business. B-RED addresses such issues by effectively utilizing consistent terminology to catalog historical business failure data. B-RED method is based on the concept developed for the Risk in Early Design (RED) method by Grantham Lough et al. (2006a).

2.2 The Risk in Early Design (RED) Method

Grantham Lough et al. (2005, 2006a, 2006b) developed the Risk in Early Design (RED) theory in which a product's functions are mapped to potential failures and likelihood and consequence based on relevant cataloged historical failure information. The consequence and likelihood calculations used in RED theory are shown in **Exhibit 2**. Equation (1) is used to obtain the function-failure mode matrix using cataloged historical failure modes.

$$\mathbf{EC \times CF = EF} \qquad \mathbf{(1)}$$

The matrices in Equation (1) are the function-component matrix (**EC**), the component-failure matrix (**CF**), and the function-failure matrix (**EF**).

The efforts to examine multiple electro-mechanical products led to the presentation of some basic heuristics that assume a fully populated database of related historical failures. The categories in the RED heuristics: system level, subsystem level, human centric, and unmanned, are described below (Grantham Lough et al., 2006a).

System Level is a stage of design that considers the product as a whole.

Subsystem Level is a stage of design that considers subsystems or smaller pieces of the product.

Human centric is a product that requires human input for its operation.

Unmanned product is a product that does not require direct human interaction during operation.

The summary of the heuristics is presented in **Exhibit 3.**

RED uses matrix based risk assessment to easily identify specific function-failure mode combinations that have historically occurred and to quantify that information into consequence and likelihood (Grantham Lough et al., publication pending). Because this method uses documented historical function-failure combinations, even novices are able to use it to determine potential risks in the products. Also, RED's historical foundation helps to remove personal bias by providing a database with which to ascertain consequence and likelihood values (Grantham

Lough et al., publication pending). RED can even be applied in the early conceptual phases of product design. Avoiding risks at this stage is less costly because the physical form is not yet chosen for the product.

Communication of RED risks is manipulated so that the risks are compatible with the risk fever chart (Office of the Under Secretary of Defense, 1999). The RED method is mapped such that both consequence and likelihood have integer values ranging from one to five. This chart consists of a plot of consequence versus likelihood of risks. This chart is easy to read because risk elements are classified into three categories, high, moderate, and low risk, and they are given different color codes. The fever chart is populated with risk data produced by the RED procedure and plotted according to associated values for the consequence and likelihood taken from the appropriate mapping matrices (Grantham Lough et al., 2006a).

Exhibit 2. RED Likelihood and Consequence Mapping Summary (Grantham Lough et al., 2006b)

	L1-Prod	L2-Agg	C1-Max	C2-Ave Aug
	$l_{ij} = \text{int}\left\{5\frac{ef_{prod_{ij}}}{\max_{\substack{1\le i\le n\\ 1\le j\le m}}(ef_{prod_{ij}})}\right\}$ (2)	$l_{ij} = \text{int}\left\{5\frac{ef_{prod_{ij}}}{\max_{\substack{1\le i\le n\\ 1\le j\le m}}(ef_{agg_{ij}})}\right\}$ (3)	$c_{ik} = \max_{1\le j\le m}(ec_{ij}cf'_{jk})$ (4)	$c_{ik} = \text{int}\left(\frac{1}{h}\sum_{1\le j\le m} ec_{ij}cf'_{jk}\right)$ (5)
Pros	▪ Provides hierarchy of probable product specific risks ▪ Conservative estimate of risk probability ▪ Reduced dependency on data concentration of failure database	▪ Risk likelihoods are relative to all recorded failure occurrences ▪ Does not overestimate risk likelihood for low occurrence failures in database	▪ Conservative risk estimate ▪ Focuses designer's attention directly to severe failures	▪ Average risk estimate ▪ Not dependent on a single severe failure occurrence ▪ Considers only relevant function-component-failure combinations
Cons	▪ May provide too much attention to a low occurrence failure	▪ Can downplay risks with low failure occurrence in database ▪ Risk likelihood is directly related to the number and distribution of all recorded failures in the database	▪ A single severe failure will dominate the risk analysis regardless of occurrences of lesser severity ▪ Single severity value dependence prevents risk value from representing all recorded failures	▪ Severity of a failure can be diminished with many occurrences of a less severe case ▪ Highly dependent on the combination of number of recorded failures and their severity values

Exhibit 3. RED Heuristics (Grantham Lough et al., 2006a)

		Product Type	
		Human Centric	Unmanned
Design Level	System Level	L2, C1	L2, C2
	Subsystem Level	L1, C1	L1, C2

Grantham Lough et al. (2006a) illustrate RED risk assessment performed on a functional model of a Thermal Control Subsystem. Thousands of anomaly reports for various missions and subsystems are contained in the Problem/Failure Reporting (P/FR) database at Jet Propulsion Laboratory (Grantham Lough et al., 2006a). One such subsystem is a Thermal Control Subsystem. From the functional model of Thermal Control Subsystem, the functions from the functional basis were collected and used to select entries of function-component (**EC**) matrix. Using the **EC** matrix thus formed, the product specific function failure ($\mathbf{EF_{prod}}$) matrix was determined. $\mathbf{EF_{prod}}$ lists only function-failure pairings that are relevant to a particular product, which in this case is the Thermal Control Subsystem. Next, the risk likelihood and consequence calculations, using equations as shown in **Exhibit 2** were performed using the function-component (**EC**) matrix and component-failure severity (**CF'**) matrix. The L1 likelihood mapping is used as a risk assessment in the subsystem design level, while L2 mapping is used at a system design level. The C1 consequence mapping is used in risk assessments which involve human related products, while C2 mapping is better suited for unmanned products (Grantham Lough et al., 2006a). The pros and cons for each of these mappings are shown in **Exhibit 2**. The risk fever chart from the four RED risk assessments performed on thermal control subsystem risk assessments are shown in **Exhibit 4.** All the risk assessments produced 73 risk elements. Some sample risk elements from Thermal Control Subsystem RED risk assessments are shown in **Exhibit 5.** The risk elements contain specific functions at risk for a specific failure mode, with a consequence and likelihood combination.

Exhibit 4. Thermal Control Subsystem RED Risk Assessments (Grantham Lough et al., 2006a)

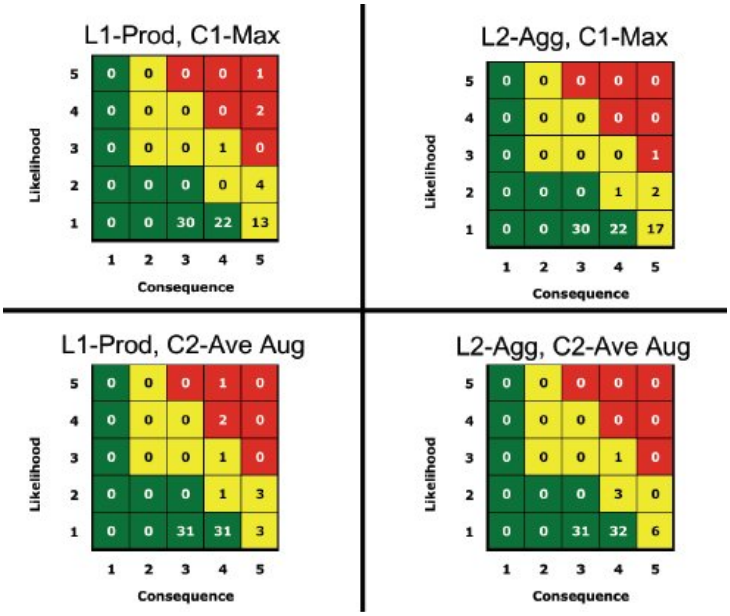


Exhibit 5. Sample Risk Elements from Thermal Control Subsystem RED Risk Assessments (Grantham Lough et al., 2006a)

Risk Element Statement	(C1,L1)	(C1,L2)	(C2,L1)	(C2,L2)
Export thermal energy fails due to high cycle fatigue	(5,5)	(5,3)	(4,5)	(4,3)
Export thermal energy fails due to yielding	(4,3)	(4,2)	(4,3)	(4,2)
Guide gas fails due to thermal fatigue	(5,2)	(5,1)	(5,2)	(5,1)

This underlying RED method theory is utilized to analyze risks for businesses and identify the potential risks that businesses will face, during early planning stages. A set of related taxonomies for business components, business functions and business failure modes were developed to support the analyses. The following section describes the Business Risk in Early Design (B-RED) method.

3. Business Risk in Early Design (B-RED)

The B-RED method utilizes the concept of RED method (Grantham Lough et al., 2006a) for assessing risks in the business domain. B-RED method has its own business function, component, and failure mode taxonomies, which are used to catalog historical business failure data in the B-RED database. The business taxonomies are utilized to identify the potential risk areas in the early phases of business development. These risks are then mapped to the risk fever chart, which shows the high, moderate and low risk elements using different color codes. The business taxonomies developed for the proof of concept of B-RED are described in the following section and steps for performing B-RED are described in Section 3.2.

3.1 Taxonomies for Classifying Business Risks

To effectively identify and prevent potential business failures, communication of the business development information is essential. A number of methods are used to categorize the business functions, components and failures, which makes interpretation for business developers difficult. Hence, a database with uniform and consistent business domain descriptions is required for effective communication of business development information. This will also aid in efficiently capturing the historical business failure data. The following sections describes the business failure mode, business component and business function taxonomies.

3.1.1 Business Failure Mode Taxonomy

The electro-mechanical failure mode taxonomy (Tumer et al., 2003) was developed to improve risk communication and enable risk calculation of electromechanical products. Likewise, the taxonomy of business failures was developed for the B-RED method to improve communication of business risks. In the 2000 report, "Behavioral Cause Analysis of the 1999 Bonfire Structure Collapse at Texas A&M University", Performance Improvement International (PII) (2000) developed a list of business failures that includes management, organizational and human failure modes. They used this list of failure modes for event investigation and prevention and business performance improvement (Performance Improvement International, 1997). Some examples of failure modes generated by PII include inadequate attention to emerging problems, unawareness of legal implications, and inadequate scope. This list of failure modes is used in the business failure mode taxonomy. Some failure modes which were evident from the investigation of business failure case studies were not included in this list generated by PII, and this required efforts to focus on other sources to derive the required failure modes, as detailed below.

In the business failure case study of Enron, failure due to accounting irregularities was quite evident (Tesfatsion, 2008). Young (2002) in his book 'Accounting Irregularities and Financial Fraud: A Corporate Governance Guide', describes financial fraud. The term 'irregularities' refers to intentional misstatements in financial statements generated and may also involve intentional misapplication of accounting principles (Young, 2002). The failure mode 'accounting irregularities' was not adequately described in the list of failure modes generated by PII, and was identified from the book authored by Young (2002) to be used in the business failure mode taxonomy.

In Devising Business Strategies by Business Plan Software (2007), a list of basic reasons for business failure is given. Some of the basic reasons include failure modes such as overoptimistic projections or overtrading, and ineffective financial and managerial control systems which are not adequately described in the list of failure modes generated by PII. Hence, the business failure mode taxonomy was updated with these failure modes identified from Business Plan Software (2007).

Sims et al. (2003) in their paper on Enron Ethics say that Enron executives' attention was clearly focused on profits, power, greed and influence. Hamilton et al. (2006) in the book 'Greed and Corporate Failure: The Lessons from Recent Disasters' describe why companies fail. This book describes some main causes for the corporate failures, such as greed, hubris and, a desire for power. Since none of the failure modes in the business failure mode taxonomy effectively

described greed and desire, the failure mode ‘personal desire and greed’ was included in the taxonomy.

The business failure mode taxonomy thus developed, consists of fifty failure modes identified from the sources as described above. This taxonomy presents a preliminary set of failure modes for proof of concept of B-RED method. This initial set of failure modes presented is not the complete set. Further literature reviews including business failure case studies are required to keep developing this taxonomy. Also, the taxonomy needs to be tested and verified to establish validity, exactness, accuracy and completeness. This forms the scope of future work. **Exhibit 6** shows the business failure mode taxonomy with definitions.

Exhibit 6. Business Failure Mode Taxonomy

Failure Mode	Definition	Source
Inadequate attention to emerging problems	Repetitive organizational crises, in morale, work practice, etc.	Performance Improvement International, 2000
Unawareness of legal implications	High Insurance claims; high legal risks; trend of losing critical legal cases in the industry.	
Unawareness of regulatory implications	Sudden loss of profits due to regulation changes; un-preparedness for new regulations; inadequate response to regulatory changes.	
Unawareness of new technology	New technology used by competitors; rapid loss of market due to obsolete technology.	
Inadequate scope	Omission of necessary functions in procedures.	
Inadequate assessment of challenges	Not meeting business plan goals due to unexpected factors.	
Inadequate scope of control	Some aspects of performance out of control; erratic performance.	
Inadequate interface requirements	Actions required by one program belonging to a program that is inadequate.	
Insufficient detail	Vagueness in procedures.	
Cognitive overload	High volume of irrelevant information.	
Not familiar with availability of information	Not knowing some key, available information in decision making.	
Excessive implementation requirements	Staff ignoring the programs; staff work overload.	
Perceived pressure to complete task	Not paying attention to secondary tasks or indications during a task of perceived tight schedule.	

Exhibit 6. Business Failure Mode Taxonomy (contd.)

Failure Mode	Definition	Source
Task too complex	Task assignments requiring memorizing or comprehension of complex concepts or situations task too complex to complete on schedule.	Performance Improvement International, 2000
On the job distraction	Work overload; handling more than seven tasks simultaneously; noise or frequent interruptions.	
Habit Intrusion	Perform tasks mainly based on past experience without fully understanding the current situation	
Mindset	Decision making without seeking the facts and evidence objectively.	
Wrong assumptions	Erroneous assumptions used in decision making.	
Lack of information validation	Erroneous information used in decision making.	
Shortcuts evoked	Shortcuts are used to accelerate the job completion; perceived pressure to complete work.	
Inappropriate order	Conflicting directions from supervision; inadequate work priority.	
Inadequate tracking	No or inadequate tracking system for task status.	
Tunnel vision	Actions or decisions without assessing the entire situation.	
Not familiar with job performance standards	Not knowing supervision's expectation of performance standards.	
Not familiar with task	First time performance of task; infrequent performance of complex task.	
Inadequate motivation	Low morale; low spirit; tardiness; irresponsiveness; argumentative.	
Boredom	loss of alertness because of little amount of task stimuli.	
Lapse of memory	Loss of memory regarding previously learned skills.	
Reflex	Inappropriate action based on wrong intuition.	
Overconfidence	Underestimating the task complexity, scope or depth; lack of adequate contingency planning.	
Lack of commitment to program implementation	Slow program implementation.	
Inadequate program monitoring	Lack of proper program improvement over time.	
Lack of program evaluation process	Repetitive program failure without corrections.	
Conflicting program requirements	Different actions requested by two or more programs for a given situation.	
Inadequate self verification process	Program breakdown by single human error; high program failure rate, poor procedural quality.	

Exhibit 6. Business Failure Mode Taxonomy (contd.)

Failure Mode	Definition	Source
Inadequate function or structure	Specific type of work not performed; specific type of issue not addressed.	Performance Improvement International, 2000
Inadequate work prioritization	Staff work overload; over-run committed budget.	
Inadequate communication within organization	Important issues not addressed; breakdown of normal work process, low staff morale.	
Unawareness of market changes	Persistent and continuous profit loss; new product failure; high promotion cost.	
Unawareness of union conflicts	Hostility of union; sabotage refusal to participate in improvement tasks.	
Inadequate definition of business objectives	No vision; no strategic position; lack of market focus.	
Inadequate assessment of company capabilities	Not meeting business plan goals; below expectation performance to respond to challenges.	
Inadequate business plan execution	Minimum attention to execution; low quality of task output; no periodical review.	
Vague or unclear expectations	Expectations not known by affected personnel.	
Inadequate accountability system	Low morale; poor performance; committed actions not carried out.	
Accounting irregularities	Deliberate misstatement of some aspect of financial performance.	Young, 2002
Personal desire and Greed	Personal desire and Greed.	Hamilton et al., 2006
Inadequate business plan	Lack of details; inadequate accountability; tracking and closure.	Performance Improvement International, 2000
Overoptimistic projections or overtrading	Overoptimistic projections or overtrading.	Business Plan Software, 2007
Ineffective financial and managerial control systems	Ineffective financial & managerial control systems.	

3.1.2 Business Component Taxonomy

A business component is a unit of functionality that manages a single business abstraction (Microsoft Dynamics Developer Center, 2007). For example, a business component finance and accounting can be created to manage payroll activities. In this example the unit of functionality is finance, accounting and payroll activity which forms the business abstraction. According to experts, there are three different levels of management (Management-Hub.com, 2007). These levels of management, which are also units of functionality and have assigned

duties, include top level management, consisting of a board of directors, managing directors or executive committee members; middle level management, consisting of managers such as personnel, production, sales, marketing, resource, and finance; and lower or operating level management, consisting of foremen, supervisors, and daily laborers (Management-Hub.com, 2007). In the business failure case studies such as those of Enron and WorldCom, some of the failure modes are attributed to particular management levels. Hence, these levels of management identified by management-hub.com (2007) are used in the business component taxonomy. In the business failure case studies, some of the failures related to specific units of functionality, hence other sources were referred to as detailed below.

System Transformation's (2004) Contingency Planning Methodology lists general shared services and functions common to most businesses. Some of the examples of these are legal, project management, marketing, human resources, etc. These services and functions act as units of functionality that manage a single business abstraction and are added to the list of business components identified from management-hub.com, since the existing terms only described the levels of management and did not present a precise unit of functionality.

The business component taxonomy, thus developed consists of nineteen business component names identified from sources as described above. These represent the initial set of names and the taxonomy will keep developing as new business components are encountered during investigation of business failure case studies. Also, the taxonomy needs to be tested and verified to establish validity, exactness, accuracy and completeness. This forms the scope of future work. **Exhibit 7** shows the business component taxonomy with definitions. The definitions contained in **Exhibit 7** are a compilation from various sources.

Exhibit 7. Business Component Taxonomy

Components	Definition
Audit & Compliance	A department that evaluates additions or changes in internal control processes coincident with their development and implementation, keeps the executive committee informed of emerging trends and best practices in internal auditing, assists in the investigation of significant suspected fraudulent activities within the organization, and assures reporting to the Executive Committee on the results, as appropriate. (Metropolitan Water District of Southern California, 2008)
Administration	A department that provides support and service for the activities of the Board, and performs staff functions regarding administrative and agency-wide issues. (Socialstyrelsen, 2007)

Exhibit 7. Business Component Taxonomy (contd.)

Components	Definition
Communications	A department that supports communications with constituents and media by facilitating an accurate, timely, and consistent information flow and providing advice as appropriate; supports day-to-day operational needs of the corporation by providing proactive communications advice, products and services; and facilitates and ensures consistent and accurate communications with employees. (Corporate Communications, 2007)
Engineering/R&D	A department that ensures that the new product meets the product specification, develops products to budget, develops product on time, and develops products to meet the target production cost. (Industrial Management, 2008)
Finance & Accounting	A department that provides financial accounting and support services related to general accounting, payments, purchase orders, invoicing and collections, travel, financial systems, financial reports, month-end and year-end closings, and other services; directs departmental accounting and consolidated financial reporting, with emphasis on issuance of audited financial statements that receive an unqualified audit opinion, as well as provision of financial information that supports management decision-making. (Accounting Department, 2007)
Facilities	A department that provides all utilities that are needed to operate the various buildings, such as natural gas, electricity, sewer, water, janitorial service and garbage service; maintains all lawn and planting areas for all city buildings and properties. (Fleet and Facilities Division, 2008)
Human Resources	A department that provides the following services: recruitment and selection, promotions, discipline and grievance advice, contracts of employment, terms and conditions of service, health and safety, induction, training and development, advice to management and staff on personnel issues, probation reports, absence records, increments, monthly staffing statistical reporting employee relations, performance management, compliance with employment law, job evaluation, policy formulation to comply with best practice, retirements (medical and early), occupational and career guidance, redundancy advice, resignations, termination of employment. (Human Resources Department, 2008)
IT Division	A department that manages and keeps the system up-to date, creates and maintains customer database for effective communication, links the companies with head office and regional offices in a well coordinated manner. (IT Department, 2007.)
Legal	A department that is responsible for the provision of legal advice to the Board and staff of company on general legal and commercial matters. (Legal Department, 2007)
Low Level Management	A level of organization in which supervisors maintain standards of the quality of the manufactured product; assign duties to the workers as per plan and schedules given by top and middle level management. (Management-Hub.com, 2007)

Exhibit 7. Business Component Taxonomy (contd.)

Components	Definition
Marketing	A department which helps market the company with focus on customer; by monitoring competition; communicating internally, managing budget etc. (The Brand Builder Blog, 2007)
Middle Level Management	A level of organization which follows the rules and policies formulated by top management; motivates personnel for higher productivity; gives recommendations to top management etc. (Management-Hub.com, 2007)
Operations	A department that is responsible for the overall management and control of the company and its general administration. (Operations Department, 2007)
Project management	A department which is involved in implementation projects management, partner network service and definitions of the products new functions. (Project Management Department 2007)
Purchasing	A department responsible for manually placing a small percentage of organization's purchase order. (Dominick, 2006)
Security	A department that provides a safe and secure environment for employees to work and for customers to do business. It provides protection and defense against real or anticipated threats. (Security Education Systems, 2008)
Sales	A department which prepares or directs the preparation of sales manuals, giving detailed information about company and products. (Sales Department, 2007)
Top Level Management	A level of organization which sets key objectives, policies and identifying factors essential for the development of the enterprise; making appointments to the top position in the enterprise such as managers, department heads etc. (Management-Hub.com, 2007)
Training	A department which assesses training needs; creates training or development specification and plan training and evaluation. (Chapman, 2007)

3.1.3 Business Function Taxonomy

In engineering, all products and artifacts have some intended reason behind their existence: the product or artifact function (Hirtz et al., 2002). Similarly, the business components are units of functionality that manage single business abstraction (Microsoft Dynamics Developer Center, 2007). The business function taxonomy was developed to describe the business units functionally. In order to maintain consistency in the representation of business unit functionality, the business functions are represented by functions and flow, as in the functional basis for electro-mechanical products. The function descriptor is a verb and the flow descriptor is an object. In the functional basis the flows can be energy, material or signal. However, in the business function taxonomy there is no analogous equivalent of flow generalization categories as of now. The business functions can be represented using any combination of verb and an object from the

business function taxonomy. Such representations will help in describing the business functions in the same manner by different people.

The representation of business function using verb-object format was developed by studying the nineteen business components from the business component taxonomy. From the definitions of these business components, many functions and flow based terminologies were recorded. From these a list of functions and related flows was extracted, as shown in the business function taxonomy below. For example, from business component taxonomy the definition for Top Level Management includes 'level of organization which sets key objectives'. From this statement, a function-flow combination 'setting objectives' was extracted in which 'set' forms the function and 'objective' forms the flow. The list of functions and flows thus obtained was condensed by removing synonyms and eliminating functions and flows which were specializations of more generic functions and flows respectively. For example, functions such as 'provide' and 'supply' were condensed to include only one generic term 'provide' and synonymous functions such as 'communicate' and 'convey' were condensed to one function 'communicate' in the business function taxonomy. This list of functions and flows represents the business function taxonomy.

The business function taxonomy presented consists of an initial set of functions and flows which can be used to describe the business components. However, it is not a complete set and further literature reviews and business failure case studies are needed to keep the taxonomy developing. **Exhibit 8** shows the business function taxonomy with definitions.

Exhibit 8. Business Function Taxonomy

Functions	Definition
Set	to allot as a task. (Merriam Webster, 1999) Ex. setting lessons for the children to work upon at home.
Identify	to establish the identity of. (Merriam Webster, 1999) Ex. establish identity of a biological specimen.
Follow	to be or act in accordance with. (Merriam Webster, 1999) Ex. follow directions.
Motivate	to provide with a motive. (Merriam Webster, 1999) Ex. questions that excite and motivate youth.
Accomplish	to bring to completion. (Merriam Webster, 1999) Ex. we can accomplish the job in an hour.
Hire	to engage the personal services of for a set sum. (Merriam Webster, 1999) Ex. hire a crew.

Exhibit 8. Business Function Taxonomy (contd.)

Functions	Definition
Collect	to gather or exact from a number of persons or sources. Ex. collect taxes.
Maintain	to continue or persevere in. (Merriam Webster, 1999) Ex. couldn't maintain his composure.
Review	to go over or examine critically or deliberately. (Merriam Webster, 1999) Ex. reviewed the results of the study.
Assign	to appoint as a duty or task. (Merriam Webster, 1999) Ex. assigns 20 pages for homework.
Process	to subject to or handle through an established usually routine set of procedures. (Merriam Webster, 1999) Ex. process insurance claims.
Advertise	to make publicly and generally known. (Merriam Webster, 1999) Ex. advertising their readiness to make concessions.
Develop	to work out the possibilities of. (Merriam Webster, 1999) Ex. develop an idea
Perform	to do in a formal manner or according to prescribed ritual. (Merriam Webster, 1999) Ex. performed gymnastics.
Prepare	to make ready beforehand for some purpose, use, or activity. (Merriam Webster, 1999) Ex. prepare food for dinner.
Provide	to supply or make available. (Merriam Webster, 1999) Ex. provided new uniforms for the band.
Ensure	to make sure, certain, or safe. (Merriam Webster, 1999) Ex. the government has ensured the safety of the refugees.
Communicate	to convey knowledge of or information about. (Merriam Webster, 1999) Ex. communicate a story.
Facilitate	help bring about. (Merriam Webster, 1999) Ex. facilitate growth.
Counsel	to give advice to. (Merriam Webster, 1999) Ex. counsel management.
Evaluate	to determine the significance, worth, or condition of usually by careful appraisal and study. (Merriam Webster, 1999) Ex. evaluate policies.
Support	to uphold or defend as valid or right. (Merriam Webster, 1999) Ex. supports fair play.
Administer	to manage or supervise the execution, use, or conduct of . (Merriam Webster, 1999) Ex. administer a trust fund.
Initiate	to cause or facilitate the beginning of. (Merriam Webster, 1999) Ex. initiate a program of reform.

Exhibit 8. Business Function Taxonomy (contd.)

Flows	Definition
Objectives	something toward which effort is directed. (Merriam Webster, 1999) Ex. children achieved their objectives.
Factors	one that actively contributes to the production of a result. (Merriam Webster, 1999) Ex. price wasn't a factor in the decision.
Rules	prescribed guide for conduct or action. (Merriam Webster, 1999) Ex. traffic rules.
Personnel	body of persons usually employed. (Merriam Webster, 1999) Ex. hire personnel.
Goals	the end toward which effort is directed. (Merriam Webster, 1999) Ex. achieve goals.
People	human beings making up a group or assembly or linked by a common interest. (Merriam Webster, 1999) Ex. gather people
Report	a usually detailed account or statement. (Merriam Webster, 1999) Ex. a news report.
Quality	an inherent feature. (Merriam Webster, 1999) Ex. had a quality of stridence.
Work	specific task, duty, function, or assignment often being a part or phase of some larger activity. (Merriam Webster, 1999) Ex. assigned work.
Duties	assigned service or business. (Merriam Webster, 1999) Ex. performed duties.
Payroll	the money to be distributed. (Merriam Webster, 1999) Ex. process payroll.
Product	something (as a service) that is marketed or sold as a commodity. (Merriam Webster, 1999) Ex. new product.
Policies	a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions. (Merriam Webster, 1999) Ex. amend policies.
Staff functions	Staff: personnel who assist a director in carrying out an assigned task; Function: group of related actions contributing to a larger action. (Merriam Webster, 1999) Staff Function: group of actions carried out by personnel. Ex. perform staff functions.

Exhibit 8. Business Function Taxonomy (contd.)

Flows	Definition
Financial statement	Financial: relating to finance; Statement: a report of facts or opinions. (Merriam Webster, 1999) Financial Statement: a report of facts or opinions relating to finance. Ex. accounting department generates financial statement.
Administration	performance of executive duties. (Merriam Webster, 1999) Ex. maintain administration.
Overall Management	the conducting or supervising of something (as a business). (Merriam Webster, 1999) Ex. group provided management.
Utilities	a service (as light, power, or water) provided by a public utility. (Merriam Webster, 1999) Ex. company provided utilities.
Communication	process by which information is exchanged between individuals through a common system of symbols, signs, or behavior. (Merriam Webster, 1999) Ex. the function of pheromones in insect communication.
Property	something owned or possessed. (Merriam Webster, 1999) Ex. purchased property.
Data	factual information (as measurements or statistics) used as a basis for reasoning, discussion, or calculation. (Merriam Webster, 1999) Ex. the data is plentiful and easily available.
Message	an underlying theme or idea. (Merriam Webster, 1999) Ex. convey message.
Legal Issues	Legal: pertaining to law; Issue: that which proceeds from something. (Skeat, 1968) Legal Issue: that which proceeds from something pertaining to law. Ex. discussion on legal issues.
Control processes	Control: power or authority to guide and manage; Process: a natural phenomenon marked by gradual changes that lead toward a particular result. (Merriam Webster, 1999) Control Process: a phenomenon of power or authority to guide and manage, marked by gradual change. Ex. ineffective control processes.
Interface	the means by which interaction or communication is achieved at an interface. (Merriam Webster, 1999) Ex. interface between organizations.
Management Decision Making	Decision: act or process of deciding; Management: collective body of those who manage. (Merriam Webster, 1999) Management Decision Making: process of decision by a collective body of those who manage. Ex. management decision making for transportation problems.

Exhibit 8. Business Function Taxonomy (contd.)

Flows	Definition
Staffing	to supply with a staff or with workers. (Merriam Webster, 1999) Ex. staffing is done by human resources.
Training	the state of being trained. (Merriam Webster, 1999) Ex. underwent training.
Performance Management	Performance: Execution of an action; Management: conducting or supervising of something. (Merriam Webster, 1999) Performance Management: supervising execution of an action. Ex. performance management includes activities to ensure that goals are consistently being met in an effective and efficient manner
Career Development	Career: profession for which one trains and which is undertaken as a permanent calling; Development: act, process, or result of developing. (Merriam Webster, 1999) Career Development: act, process, or result of development professionally. Ex. career development grants support women.
Changes	substitution of one for another. (Fowler, 1934) Ex. foliage changing color.

3.1.4 Database Generation

The quality of the B-RED outputs depends largely on the quality of captured historical failure data. A good failure knowledge-base is required for obtaining reliable estimates of business risks using B-RED. Availability of the failure knowledge-base, therefore, is the primary requirement for the B-RED analysis. Case studies of ten business failures were conducted and the failure information from the case studies was extracted and cataloged. The study included the investigation of business failure case studies in a variety of fields, including profit, non-profit, and political organization failures, such as Iridium, WorldCom, Enron, Aspire, Barings, Boo.Com, Daewoo, HIH Insurance, Bank of Credit and Commerce International, and Japan's Political Reform. This small database was used for the proof of concept for B-RED. The business failure case studies were examined to extract the failure and classify it in the B-RED database. The data thus extracted was combined to build a failure knowledge-base by populating **EC** and **CF** matrices to obtain the **EF** matrix, as described in Equation (1). Equation (1) describes an equation for RED. However, B-RED uses RED equations exactly. Additionally, business failure severities are recorded in the component-failure severity (**CF'**) matrix. In order to perform the B-RED analysis, development of these failure and severity knowledge-bases is a necessary prerequisite. As failures are encountered, they will be incorporated into the database and used to

manage risk. Further, studies will be performed on the database that will determine the appropriate size and make up of the database to ensure accurate risk assessments. However, that is outside the scope of this work.

3.2 Steps for Performing B-RED

As in the RED method developed by Grantham Lough et al., in B-RED the functional requirements of the business are fed into the failure knowledge base to generate a list of potential risks. This list of risks will help management incorporate safeguards against high risk failures or find ways to mitigate specific failures. Risk analysis techniques benefit from an easily-obtainable starting set of potential risks that help management evade the incidents which will cause considerable losses for the business in later stages. The steps involved in performing B-RED follow.

Step 0: Database Population

One of the most vital requirements for performing B-RED is to have a database of historical business failure data. In order to generate such a database, a considerable number of business failures must be examined. Information about business failures can come from a variety of credible sources, including news and business magazines, academic journals, in-house corporate reports, etc. Once a failed business is identified, then a detailed study of the causes of its failure is conducted. These causes are further analyzed in an effort to select the corresponding failed business component and failure mode from the business component taxonomy and business failure mode taxonomy, respectively. Failure severity is assigned to the failure modes based on impact to business revenues on a 1 to 5 scale, with 5 bearing most severe impact. Finally, the last step in database construction is to obtain the functionality of the failed components.

The **EC** and **CF** matrices, their product (the **EF** matrix), and the **CF'** matrix created using the business failure cases as described in previous section 3.1.4. The **EC**, **CF**, **CF'** and **EF** matrices are shown in **Exhibits 9-12.** These matrices represent the repository based on historical business failure information and will be used to analyze Arthur Andersen. In this phase only the desired functionality of Arthur Andersen will be known.

Exhibit 9. Function-Component (EC) Matrix

EC Matrix	Top Level Management	Middle Level Management	Low Level Management	Finance & Accounting	Marketing	Sales	Operations	IT Division	Engineering/R&D	Administration	Facilities	Communications	Legal	Audit & Compliance	Project management	Purchasing	Security	Human Resources
Setting Objectives	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Identify Factors	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Follow rules	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Motivate Personnel	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Accomplish Goals	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Hire People	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Collect Report	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintain Quality	0	0	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Review Work	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Assign Duties	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Process Payroll	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Advertise Product	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
Issue Policy statement	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Develop Product	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Perform Staff functions	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Prepare Financial statement	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit 10. Component-Failure (CF) Matrix

Component/Failure	Lack of attention to emerging issues	Unawareness of legal implications	Unawareness of regulatory implications	Inadequate use of new technology	Inadequate programmatic scope	Inadequate assessment of challenges	Inadequate scope of control	Indequate interface requirements	Insufficient programmatic detail	Cognitive load	Not familiar with availability of information	Excessive implementation requirements	Perceived pressure to complete task	Task too complex	On-the-job distraction	Habit Intrusion
Top Level Management	10	5	3	1	1	24	2	0	0	0	1	3	3	0	0	3
Middle Level Management	2	0	0	1	0	4	1	0	0	0	2	0	0	0	0	1
Low Level Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finance & Accounting	2	4	2	0	0	6	1	0	0	0	1	0	0	0	0	1
Marketing	5	0	0	2	1	6	0	0	0	0	1	1	1	0	0	4
Sales	3	0	0	1	1	2	0	0	0	0	1	1	1	0	0	3
Operations	2	0	0	0	1	2	0	0	0	0	0	1	1	0	0	1
IT Division	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Engineering/R&D	2	0	0	1	1	3	1	0	0	0	0	2	2	0	0	2
Administration	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Facilities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Communications	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Legal	0	2	1	0	0	2	1	0	0	0	0	0	0	0	0	1
Audit & Compliance	1	5	2	0	0	6	1	0	0	0	0	0	0	0	0	1

Exhibit 11. Component-Failure Severity (CF') Matrix

Component/Failure Severity	Lack of attention to emerging issues	Unawareness of legal implications	Unawareness of regulatory implications	Inadequate use of new technology	Inadequate programmatic scope	Inadequate assessment of challenges	Inadequate scope of control	Indequate interface requirements	Insufficient programmatic detail	Cognitive load	Not familiar with availability of information	Excessive implementation requirements	Perceived pressure to complete task	Task too complex	On-the-job distraction	Habit Intrusion	Mindset	Wrong Assumptions	Lack of information validation
Top Level Management	4	5	5	3	4	5	4	0	0	0	3	5	5	0	0	4	5	5	5
Middle Level Management	3	0	0	3	0	4	4	0	0	0	5	0	0	0	0	3	5	5	5
Low Level Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finance & Accounting	5	5	5	0	0	5	4	0	0	0	5	0	0	0	0	5	5	0	5
Marketing	4	0	0	4	4	5	0	0	0	0	3	4	4	0	0	4	4	3	3
Sales	4	0	0	3	4	4	0	0	0	0	3	4	4	0	0	4	5	5	5
Operations	4	0	0	0	4	4	0	0	0	0	0	4	4	0	0	4	4	3	0
IT Division	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Engineering/R&D	4	0	0	4	4	5	5	0	0	0	0	5	5	0	0	4	4	0	0
Administration	3	0	0	0	0	3	0	0	0	0	5	0	0	0	0	0	5	3	0
Facilities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Communications	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
Legal	0	5	5	0	0	5	4	0	0	0	0	0	0	0	0	5	5	0	5
Audit & Compliance	5	5	5	0	0	5	4	0	0	0	0	0	0	0	0	5	5	0	5
Project management	0	0	4	0	0	4	0	0	0	0	5	0	0	0	0	0	5	0	0
Purchasing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Security	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Human Resources	0	0	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0

Exhibit 12. Function-Failure (EF) Matrix

EF Matrix	Lack of attention to emerging issues	Unawareness of legal implications	Unawareness of regulatory implications	Inadequate use of new technology	Inadequate programmatic scope	Inadequate assessment of challenges	Inadequate scope of control	Indequate interface requirements	Insufficient programmatic detail	Cognitive load	Not familiar with availability of information	Excessive implementation requirements	Perceived pressure to complete task
Setting Objectives	10	5	3	1	1	24	2	0	0	0	1	3	3
Accomplish Goals	19	9	5	4	2	40	4	0	0	0	5	4	4
Hire People	10	5	3	1	1	26	3	0	0	0	1	3	3
Assign Duties	12	5	6	2	1	29	3	0	0	0	4	3	3
Process Payroll	2	4	2	0	0	8	2	0	0	0	1	0	0
Develop Product	2	0	0	1	1	3	1	0	0	0	0	2	2
Prepare Financial statement	2	4	2	0	0	6	1	0	0	0	1	0	0
Communicate Data	12	5	3	2	1	28	3	0	0	0	4	3	3
Communicate Message	12	5	3	2	1	28	3	0	0	0	4	3	3

Step 1: Determine Function-Failures

After the functions of the business have been determined, they are used to generate the function-failure matrix **(EF)** matrix as a part of B-RED, as described in Equation (1). Equation (1) describes an equation for RED and B-RED utilizes the RED equations exactly. During early phases of business development, only the desired functionalities of the business are known. In B-RED these functionalities are expressed in the form of function and flow by utilizing the business function taxonomy. For Arthur Andersen, the following functions were determined: set objectives, accomplish goals, hire people, assign duties, process payroll, develop product, prepare financial statement, communicate data, communicate message and administer staffing.

In the test example of Arthur Andersen, a set of potential failures based on the intended functionality are represented in **Exhibit 12**. The first line in the matrix implies that *Setting Objectives* can possibly fail by *inadequate assessment of challenges, overconfidence, bad business strategy, lack of attention to emerging issues, etc.* The definitions of these failure modes are given in the failure mode taxonomy in **Exhibit 6.** Similarly, the other rows in the matrix give corresponding failures for other functionalities. The number in the corresponding cell indicates the number of times the functionality has failed by the given failure mode.

Step 2: Risk Calculations

The next step in B-RED process is to apply the consequence and likelihood mapping. Normally, the formulations provided in Equations (2) through (5) are used to attach likelihood and consequence data to the potential failures and arrive at identifiable risks. For B-RED, only Equations (3) and (4) are used to calculate the likelihood and consequence respectively. **Exhibit 13** below shows, how Equations (3) and (4) were used in RED and why these equations are used in B-RED. Given these three elements (EF, C1, and L2), combined risk items are identified and quantified.

Exhibit 13. Mapping Equations L2 and C1

	RED	B-RED
L2 = $l_{ij} = \text{int}\left\{5\frac{ef_{prod_{ij}}}{\max\limits_{\substack{1\le i\le n\\ 1\le j\le m}}(ef_{agg_{ij}})}\right\}$	Used at system design level.	Business under analysis is considered as a system.
C1 = $c_{ik} = \max\limits_{1\le j\le m}(ec_{ij}cf'_{jk})$	Used for risk assessments which involve human related products.	All businesses require human intervention.

In the test example of Arthur Andersen, the EF matrix is obtained by selecting functions relevant to Arthur Andersen, as shown in **Exhibit 12**. Then, consequence mapping, C1, and likelihood mapping, L2, are applied to obtain C1 and L2 matrices, as shown in **Exhibits 14 and 15,** respectively. The entries in the C1 matrix indicate the consequence (severity) of a particular function-failure combination and the entries in the L2 matrix indicate the likelihood of a particular function failing by a corresponding failure mode. By matching data from each of the entries, risk statements can then be constructed.

Exhibit 14. C1 Matrix

C1 Matrix	Lack of attention to emerging issues	Unawareness of legal implications	Unawareness of regulatory implications	Inadequate use of new technology	Inadequate programmatic scope	Inadequate assessment of challenges	Inadequate scope of control	Indequate interface requirements	Insufficient programmatic detail	Cognitive load	Not familiar with availability of information	Excessive implementation requirements	Perceived pressure to complete task	Task too complex	On-the-job distraction	Habit Intrusion	Mindset	Wrong Assumptions	Lack of information validation	Shortcuts evoked	Inappropriate order	Inadequte tracking
Setting Objectives	4	5	5	3	4	5	4	0	0	0	3	5	5	0	0	4	5	5	5	0	4	5
Accomplish Goals	5	5	5	4	4	5	4	0	0	0	5	5	5	0	0	5	5	5	5	5	4	5
Hire People	4	5	5	3	4	5	4	0	0	0	3	5	5	0	0	4	5	5	5	0	4	5
Assign Duties	4	5	5	3	4	5	4	0	0	0	5	5	5	0	0	4	5	5	5	0	4	5
Process Payroll	5	5	5	0	0	5	4	0	0	0	5	0	0	0	0	5	5	0	5	5	2	5
Develop Product	4	0	0	4	4	5	5	0	0	0	0	5	5	0	0	4	4	0	0	0	4	0
Prepare Financial statement	5	5	5	0	0	5	4	0	0	0	5	0	0	0	0	5	5	0	5	5	0	5
Communicate Data	4	5	5	3	4	5	4	0	0	0	5	5	5	0	0	4	5	5	5	0	4	5
Communicate Message	4	5	5	3	4	5	4	0	0	0	5	5	5	0	0	4	5	5	5	0	4	5
Determine Efficiency	5	5	5	3	4	5	4	0	0	0	5	5	5	0	0	5	5	5	5	5	4	5
Administer Staffing	5	5	5	0	0	5	4	0	0	0	5	0	0	0	0	5	5	0	5	5	2	5

Exhibit 15. L2 Matrix

L2 Matrix	Lack of attention to emerging issues	Unawareness of legal implications	Unawareness of regulatory implications	Inadequate use of new technology	Inadequate programmatic scope	Inadequate assessment of challenges	Inadequate scope of control	Indequate interface requirements	Insufficient programmatic detail	Cognitive load	Not familiar with availability of information	Excessive implementation requirements	Perceived pressure to complete task	Task too complex	On-the-job distraction	Habit Intrusion	Mindset	Wrong Assumptions	Lack of information validation	Shortcuts evoked	Inappropriate order	Inadequte tracking
Setting Objectives	1	1	1	1	1	3	1	0	0	0	1	1	1	0	0	1	1	1	1	0	1	1
Accomplish Goals	2	1	1	1	1	5	1	0	0	0	1	1	1	0	0	1	3	1	1	1	1	1
Hire People	1	1	1	1	1	3	1	0	0	0	1	1	1	0	0	1	1	1	1	0	1	1
Assign Duties	2	1	1	1	1	4	1	0	0	0	1	1	1	0	0	1	2	1	1	0	1	1
Process Payroll	1	1	1	0	0	1	1	0	0	0	1	0	0	0	0	1	1	0	1	1	1	1
Develop Product	1	0	0	1	1	1	1	0	0	0	0	1	1	0	0	1	1	0	0	0	1	0
Prepare Financial statement	1	1	1	0	0	1	1	0	0	0	1	0	0	0	0	1	1	0	1	1	0	1
Communicate Data	2	1	1	1	1	4	1	0	0	0	1	1	1	0	0	1	2	1	1	0	1	1
Communicate Message	2	1	1	1	1	4	1	0	0	0	1	1	1	0	0	1	2	1	1	0	1	1
Determine Efficiency	2	2	1	1	1	5	1	0	0	0	1	1	1	0	0	1	2	1	1	1	1	2
Administer Staffing	1	1	1	0	0	1	1	0	0	0	1	0	0	0	0	1	1	0	1	1	1	1

Step 3: Risk Result Communication

A B-RED risk analysis yields important pieces of information for businesses such as the specific function, failure mode, likelihood, and consequence for each risk. In order to comprehend the states of business risks, proper communication of these elements is required. Hence, these items are plotted on a risk fever chart (Office of the Under Secretary of Defense, 1999). The risk fever chart allows risk statements to be condensed into low, medium, and high risk elements by plotting each of the risk statements according to the coordinates given by C and L matrices. In B-RED it is the coordinates given by C1 and L2 matrices. This indicates the overall business risk. This method was followed to produce the fever chart shown in **Exhibit 16**.

The fever chart generated for the Arthur Andersen test example, shown in **Exhibit 16**, indicates that 259 potential failures fall in the moderate risk zone, 28 in the high risk zone and 131 are present in the low risk zone. Visually, the chart conveys that the majority of potential failures (225) lie in moderate risk zone. This chart effectively communicates that *process payroll* failing due to *inappropriate order (conflicting directions from supervision; inadequate work priority)* is not as risky as *accomplish goals* failing due to *inadequate business plan (lack of details; inadequate accountability; tracking and closure)*, as shown by the risk statements generated with corresponding consequence-likelihood values in **Exhibit 17**.

Exhibit 16. Risk Fever Chart for C1L2 Mapping

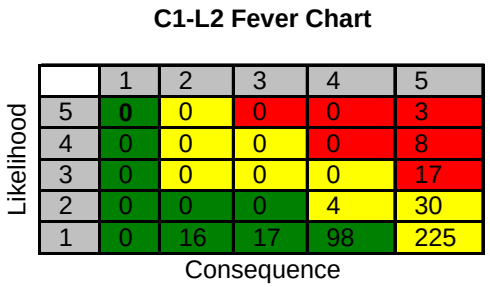


Exhibit 17. Sample Risk Elements from Arthur Andersen B-RED Risk Assessment

Risk Element Statement	(C1,L2)
Accomplish goals fails due to inadequate business plan	(5,5)
Administer staffing fails due to inadequate business plan	(5,1)
Assign duties fails due to personal desire and greed	(5,3)
Accomplish goals fails due to lack of committemnt to program implementation	(4,2)
Process payroll fails due to inappropriate order	(2,1)

4. Conclusion

The purpose of this paper was to demonstrate how the RED method for assessing electromechanical product risks was applied to the business domain to create the B-RED method for assessing business risks. During the early phases of business development, there are many opportunities to avert risks with minimal impact on budget and schedule by making changes to the business plan. B-RED is an effective method that can be applied in early business development stages. Potential areas of risk for the businesses are determined using the cataloged historical business failure data even before startup. The current B-RED database was obtained through the investigation of ten business case studies. This small current database is used for proof of concept of B-RED. Many more cases need to be added to the database to ensure the accuracy of B-RED risk assessments. This paper presents the procedure to conduct the B-RED analysis. No prior business knowledge about business failures is required to use this method, other than the functions of business under study. B-RED thus proves to be an efficient tool for determining business risks in early business planning stages by identifying the potential business risks utilizing historical business failure data.

5. Future Work

Future work on this topic will involve analyzing and validating the current database and developing the database to include many more business failures which will help form a more complete database and thus improve accuracy of B-RED risk assessments. Also, the taxonomies developed for B-RED analysis needs to be evaluated.

References:

Accounting Department, "Finance and Accounting Newsletter," CSU Fullerton - Auxiliary Services Corporation, 7:1Q (2007), http://csufasc.org/forms/ACCOUNTING (accessed December 14, 2007).

Ag Decision Maker, "Understanding Farm Business Transfers," Iowa State University, http://www.extension.iastate.edu/AgDM/wholefarm/pdf/c4-10.pdf (accessed November 5, 2007).

Allen, Gemmy, 1998, "Supervision," RonJon Publishing, Inc. (1998), http://ollie.dcccd.edu/MGMT1374/book_contents/2planning/plng_process/plng_process.htm (accessed November 7, 2007).

Anderson, Carl R., Carl P. Zeithaml, "Stage of the Product Life Cycle, Business Strategy, and Business Performance," *Academy of Management Journal, 27:1* (1984), pp. 6-7.

Bettis, Richard A., "Modern Financial Theory, Corporate Strategy and Public Policy: Three Conundrums," *The Academy of Management Review, 8:3* (July 1983), pp. 1-3.

Bidgoli, Hossein, *Handbook of Information Security*, John Wiley and Sons (2006).

Burgers Henri J., Frans A. J. Van Den Bosch, and Henk W. Volberda, "Why New Business Development Projects Fail: Coping with the Differences of Technological versus Market Knowledge," *Long Range Planning* (2007), pp. 1-2.

Business Plan Software, "Devising Business Strategies," PlanWare, http://www.planware.org/businessstrategies.htm (accessed December 16, 2007).

Chapman, Alan, "Training Process Ideas and Outline Process," Businessballs.com, http://www.businessballs.com/traindev.htm (accessed December 18, 2007).

Conrad, James M., and Yesim Sireli, "Learning Project Management Skills in Senior Design Courses," *35th ASEE/IEEE frontiers in education conference* (October 2005), pp. 1-6.

Corporate Communications, "Corporate Communications Department," City of Vaughan, http://www.city.vaughan.on.ca/vaughan/departments/corporate_communications/services.cfm (accessed December 12, 2007).

Dimitras, A. I., S. H. Zanakis, and C. Zopounidis, "A survey of business failures with an emphasis on prediction methods and industrial applications," *European Journal of Operational Research*, (1996), pp. 487–513.

Dominick, C., "10 Signs of a modern purchasing department," Edition #94 (2006), http://www.nextlevelpurchasing.com/articles/purchasing-department-goals.html (accessed January 2, 2008).

ERP-Project Management, “Risk Management in Business operations,” ERP Knowledge Base (2007), http://erp.ittoolbox.com/groups/strategy-planning/erp-projectmanagement (accessed November 5, 2007).

European Federation of Accountants (FEE), “Avoiding Business Failure: A Guide for SME’s,” *European Federation of Accountants* (October 2004), pp. 4-22.

Fleet and Facilities Division, "Facilities Maintenance," The City of Milwaukie, http://www.cityofmilwaukie.org/departments/fleetfac/fleetfac.html (accessed January 2, 2008).

Fowler, Henry Watson, *The Concise Oxford Dictionary of Current English*, Oxford University Press (1934).

Gardner Business Solutions, “Why do 9 of 10 new businesses fail within their first two years?,” (2002), http://gardnerbusiness.com/failures.htm (accessed November 5, 2007).

Grantham Lough, K.A., R.B. Stone, and I.Y. Tumer, “Failure Prevention through Effective Cataloging and Utilization of Historical Failure Events,” *Journal of Engineering Failure Analysis*, publication pending.

Grantham Lough, K., Robert Stone, and Irem Y. Tumer, “Function Based Risk Assessment: Mapping Function to Likelihood,” *Proceedings of 2005 ASME International Design Engineering Technical Conference*, American Society of Mechanical Engineers (September 2005), pp. 1-8.

Grantham Lough, K., Robert B. Stone, and Irem Tumer, “Prescribing and Implementing the Risk in Early Design (RED) method,” *Proceedings of 2005 ASME International Design Engineering Technical Conference*, American Society of Mechanical Engineers (September 2006a), pp. 1-9.

Grantham Lough, K., Robert B. Stone, and Irem Tumer, “Risk in Early Design (RED) Method: Likelihood and Consequence Formulations,” *Proceedings of 2005 ASME International Design Engineering Technical Conference*, American Society of Mechanical Engineers (September 2006b), pp. 1-10.

Gray, Clifford F., and Erik W. Larson, *Project Management: The Managerial Process*, McGraw-Hill (2000), pp. 139-156.

Hamilton, Stewart, and Alicia Micklethwait, *Greed and Corporate Failure: The Lessons from Recent Disasters*, Palgrave Macmillan (2006).

Hirtz, Julie, Robert B. Stone, Daniel A. McAdams, Simon Szykman, and Kristin L. Wood, "A Functional Basis for Engineering Design: Reconciling and Evolving Previous Efforts," *National Institute of Standards and Technology*, US Department of Commerce (February 2002), pp. 1-21.

Hoosian, Shamsudin, "Summary of the risk assessment methodology used for the preparation of the Control Self-Assessment (CSA)," Auditnet (2003), http://www.audit net.org/docs/Risk_CSA.pdf (accessed January 2, 2008).

Human Resources Department, "Human Resources Department - Staffing and Structure," Highlands and Islands Airports Ltd., http://www.hial.co.uk/human-resources-department-staffing-structure.pdf (accessed January 2, 2008).

Industrial Management, "Development of New Products," University of Bolton, http://www.ami.ac.uk/courses/ami4088_im/unit_02/index.asp#2.1 (accessed January 1, 2008).

IT Department, "IT Department functions," Dr. CAFE, http://www.dr-cafe.com/non-flash/about_us/company_profile.html (accessed December 28, 2007).

Legal Department, "Legal Department Functions," Elexon-The Balancing and Settlement Code Company, http://www.elexon.co.uk/contact/executiveTeam/departments.aspx (accessed December 15, 2007).

Long, Marian H., "Business Interruption Risk Assessment: A Multi-Disciplinary approach," Disaster Recovery Journal (1997) http://www.drj.com/new2dr/w3_029.htm (accessed November 5, 2007).

Management-Hub.com, "Why there is a need for different levels in Management," http://www.management-hub.com/business-enterprise-management.html (accessed December 18, 2007)

McLean, Bethany, and Peter Elkind, *The smartest guys in the room: The amazing rise and Scandalous fall of Enron*, Portfolio (2003).

Mercer Delta Executive Learning Center, "The Global leadership imperative," Mercer Delta Organizational Consulting (2006), http://elc.mercerdelta.com (accessed January 2, 2008).

Merriam Webster, *Merriam-Webster's Collegiate Dictionary (10th Edition)*, Merriam-Webster, Inc. (1999).

Metropolitan Water District of Southern California, "Audit Department," http://www.mwdh2o.com/mwdh2o/pages/audit/audit01.html (accessed - January 2, 2008).

Microsoft Dynamics Developer Center, "Business Components," Microsoft Developer Network, http://msdn2.microsoft.com/en-us/library/aa475166.aspx (accessed December 18, 2007).

Office of the Under Secretary of Defense, “DSMC Risk Management Guide for DoD Acquisition,” 2nd Edition, Defense Systems Management College Press, Fort Belvoir, VA (May 1999), http://www.mitre-corporation.com/work/sepo/toolkits/risk/taxonomies/files/DOD_RM_Guide_2Ed.pdf (accessed January 2, 2008).

Operations Department, "Operations department Functions", ESV - The Swedish National Financial Management Authority http://www.esv.se (accessed December 16, 2007).

Pearce II, John A., and Steven C. Michael, “Strategies to Prevent Economic Recessions from Causing Business Failure,” *Business Horizons*, (2006), pp. 201-209.

Peltier, Thomas R., “Effective Risk Analysis,” Netigy – Driving E-Business Performance (2000), http://csrc.nist.gov/nissc/2000/proceedings/papers/304slide.pdf (accessed January 2, 2008)

Peltier Associates, “Facilitated Risk Analysis Process (FRAP),” http://www.peltierassociates.com/frap.htm (accessed November 6, 2007).

Performance Improvement International, “Behavioral Cause Analysis of the 1999 Bonfire Structure collapse at Texas A&M University,” Report 00-1429, May 2000, Revision 0, pp. 46-48, http://www.chron.com/content/chronicle/special/bonfire/report/signatures.pdf (accessed January 2, 2008).

Performance Improvement International, “Projects,” Performance Improvement International L.L.C. (1997), http://www.piionline.com/projects.html (accessed November 17, 2007).

Powers, William Jr., “Report of Investigation,” Special Investigation Committee of the Board of Directors of Enron Corp. (February 1, 2002), http://fl1.findlaw.com/news.findlaw.com/wp/docs/enron/specinv020102rpt1.pdf (accessed January 2, 2008).

Project Management Department, "Project Management Department Functions," Y Soft Ltd., http://www.ysoft.eu/project-management.html (accessed December 20, 2007).

Rong-Ho, Lin, Chun-Ling Chuang, and Huang Kuan-Wei, “Developing a business failure prediction model via RST, GRA and CBR, *Expert Systems with Applications* (2008), pp. 1.

Sales Department, "Functions of Sales Management," Basic Stuff, http://www.basic-stuff.com/business/salesmanship/sales-department.htm (accessed December 20, 2007).

Security Education Systems, "The Security Function," http://www.nvo.com/ses/securityprogramseminar (accessed January 2, 2008).

Sims, Ronald R., and Johannes Brinkmann, “Enron Ethics,” *Journal of Business Ethics, 45:3* (2003), pp. 243-256.

Skeat, Walter W., *An Etymological Dictionary of the English Language*, Oxford University Press (1968).

Socialstyrelsen, "Administrative Department," The National Board of Health and Welfare, http://www.socialstyrelsen.se/en/about/Administrative_department.htm (accessed December 12, 2007).

Stone, Robert B., Irem Y. Tumer, and Michael Van Wei, "The Function Failure Design Method," *ASME Journal of Mechanical Design*, American Society of Mechanical Engineers (2003), pp. 1-32.

System Transformation, "Business Risk Analysis," Tactical Strategy Group (March 2004), http://www.systemtransformation.com/Cont_Plan_Methodologies (accessed November 7, 2007).

Tesfatsion, Leigh S., "The Enron scandal and Moral Hazard," Lecture notes at Department of Economics, Iowa State University, http://www.econ.iastate.edu/classes/econ353/tesfatsion/enron.pdf (accessed January 2, 2008).

The Brand Builder blog, "The functions of marketing department," http://thebrandbuilder.blogspot.com/2007/03/functions-of-marketing-department.html (accessed December 16, 2007).

Toffler, Barbara L., "Final Accounting," Mid-American Journal of Business, 20:2 (2005), pp. 66-68.

Tumer, Irem Y., Robert B. Stone, and David G. Bell, "Requirements for a Failure Mode Taxonomy for use in Conceptual Design," *Proceedings of the International Conference on Engineering Design*, Stockholm (August 2003), pp.1-8.

West Pacific Marketing Consultants, "Global Marketing Business Plan," Bplans.com, http://www.bplans.com/sample_business_plans/Professional_Services_Business_Plans/Global_Marketing_Business_Plan (accessed November 6, 2007).

Young, Michael R., *Accounting Irregularities and Financial Fraud: A Corporate Governance Guide*, 2nd Edition, CCH Inc. (2002).

Paper II

PREVENTING BUSINESS FAILURES THROUGH EFFECTIVE CATALOGING OF HISTORICAL BUSINESS EVENTS

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Abstract

Business growth represents a positive contribution to the nation's economic expansion, but it takes more than a good idea for businesses to succeed (Holland, 1998). According to Holland (1998) the failure rate for new businesses is 70% to 80% in the first year and only about half of those businesses which survive the first year will remain in business the next five years. In order for a business to succeed in this increasingly competitive market, a method of identifying business risks and preventing business failures before the business is launched, i.e., in the early stages of business planning, is needed. Past business failures should be effectively leveraged to prevent future failures. An efficient method of documenting business failures is needed to utilize the wealth of hidden information about historical business failures. This paper presents the formulation of a database to support the business failure prevention method, Business Risk in Early Design (B-RED). The B-RED method adapts and demonstrates the corresponding Risk in Early Design (RED) method (Grantham Lough et al., 2006a; Grantham Lough et al., 2006b) of assessing electromechanical product risks to the business domain. B-RED helps budding entrepreneurs identify relevant risks in the early phases of business development by effectively using a database derived from historical business failure case studies.

Keywords
Business, Risk Analysis, Failure Mode, Function, Component, Taxonomy

1. Introduction

Managing business risks lies at the heart of competitive strategy (Bettis, 1983). Business growth represents a positive contribution to nation's economic expansion, but it takes more than a good idea for businesses to succeed (Holland, 1998). Thorough study of the market and advance financial planning are some key factors for success. However, some amount of risk is involved in

every business, even after systematic planning. Hence, risk analysis is a necessary ingredient for any business to succeed.

Past business failures can be efficiently cataloged in order to prevent future failures. Relevant information to document includes a description of the failure, organizational level of the failure, and its causes. This important information about business failures will assist in launching successful new businesses. However, it is not practical for a busy entrepreneur to research every past business failure while managing the startup of a firm. Therefore, an efficient method of documenting business failures is required to enable use of the wealth of hidden information about historical business failures to contribute to the success of a new company. An efficient system would map the risks involved in a new business venture according to previous risks using a database of recorded business failures. The user would not be required to have any prior knowledge about the business failures. Therefore, even novices with no prior experience in business could use the B-RED method.

2. Background

2.1 Current Business Risk Assessment Practices

Peltier Associates' (2007) Facilitated Risk Analysis Process (FRAP), identifies and prioritizes organizational risks by examining assets, threats, and vulnerabilities to establish the probabilities of threats occurring and the associated costs if they occur. The FRAP process is used by information security professionals, project management, auditing, physical security, facilities management, or any organization that needs to determine what action the organization must take on a specific security issue. For example, if a system or segment of business process such as project management is being examined, then, in the first phase, the pre-FRAP meeting, initial team members are chosen and the scope of review are determined. In the second phase, the FRAP session, the roles (owner, team leader, facilitator) for team members are established. The outputs from phase one are then reviewed to ensure all team members are on the common basis of understanding. Brainstorming is then conducted in which all team members contribute risks that are of concern to them. These risks are prioritized by the team along two dimensions, vulnerability and impact. In phase three, the post-FRAP meetings, outputs from phase two are reviewed and outputs such as identification of existing controls, and a final report are generated. (Bidgoli, 2006; Peltier, 2000; Peltier Associates, 2007). The benefits of using FRAP are: it identifies and prioritizes risks to the enterprise, and it takes advantage of people who know the organization best. Some drawbacks of FRAP are: it's purely qualitative, i.e. it makes no attempt to quantify probabilities and magnitude, the team's experience sets the priorities, the process is

not applied in the early stages of business development, and the historical business failure information is not utilized.

Business Risk Assessment by i2E Inc. (2007) stresses the importance of analyzing the business opportunity with respect to five areas of risk: product, market, business, finance, and execution. This business risk assessment tool identifies the general risk for each of these five areas with respect to each stage of commercialization such as Investigation, Feasibility, Development, Introduction, Growth and Maturity. Finally, i2E Inc. Business Risk Assessment tool identifies the action items that should be completed to mitigate each level of risk. This process is used by innovators and entrepreneurs to take a newly developed technology from earliest concept to validating the business potential. For example, if an innovator has a new product idea with positive market potential, then the risk in the product area and investigation stage will be: the product may not be feasible or lacks unique qualities and cannot be protected, and the corresponding action items will be defining concept, confirming critical assumptions, and determining technology. For the same product the risk in the product area and introduction stage will be: the demonstrating product features reveal a limited market driven functionality. The related action items will be: developing production prototype, determining production process, and designing field support system (i2E Inc., 2007). The benefits of this process are: action items to be completed to mitigate each level of risk are specified, and general risks for each of the five risk areas such as product, market, business, finance, and execution are given. The drawbacks of this process are: the innovators or entrepreneurs need to have sound business domain knowledge, and the process does not utilize the historical business failure data.

System Transformation's (2004) Business Risk Analysis focuses on risks and probabilities to compute business processes' criticality. The criticality is determined for each business function such as marketing, finance, and sales. The probabilities and risks are then multiplied to determine the ultimate importance of creating a contingency for a specific failure with a specific business function. A contingency plan is a well thought out, alternate or radical course of action that avoids disruptions in normal business operations due to any type of operational error. In order to evaluate risks, each business function is evaluated in regards to the impact that would occur if the function were interrupted, unavailable or significantly changed. The probabilities are recorded using a 1-5 rating factor given in System Transformation's Business Risk Analysis. The risk and probability are multiplied to get the criticality score. This process can be used by the management in any organization and the responsibilities are divided among executives, management, and staff within the business units. A unit can be any division, facility or department. For example, in order to determine the criticality of the sales function, first

the risk ratings are evaluated in regard to the impacts that would occur if the function were interrupted. Types of events that might adversely affect the business function and the upside and downside of various failure scenarios for Sales department are also considered to determine risks. Then, probabilities are assigned to the failure scenarios determined. This means that a sales function (risk rating = 5) could be impaired because of a business partner failure (probability of 60%) or could fail due to a system failure (probability of 20%). After determining the risks and probabilities, they are multiplied to get the criticality score (System Transformation, 2004). The benefits of this process are: numerical values for criticality of business functions of organization can be determined, and business functions requiring contingency plan can be prioritized using criticality scores. The drawbacks of this process are: changes to the existing contingency plan or the creation of a new contingency plan is required with new developments in business functions, the process does not utilize historical business failure information, and the process is not applied in the early business development stages.

According to State Office of Risk Management (2007) (SORM) the structured approach to risk evaluation involves four steps: asset and threat identification, quantification of potential losses, assessment of vulnerabilities, and evaluation of solutions or mitigating factors. SORM provided guidelines that form the direction and basis for developing and implementing a comprehensive risk management program to reduce property, liability, and worker's compensation losses in each state agency in State of Texas. For example, consider a state agency conducting risk analysis. In the first step, it lists and categorizes its assets (which can be physical assets owned by the organization or financial assets). Suppose that an intangible asset such as reputation is considered. Next, the areas of risks are listed by categories such as policies and procedures, communications, marketing, and customer interface, etc. The risks identified are then assessed through structured walk-through and what-if scenarios. The potential losses are then quantified by seeking outside opinions from consultants, etc. At times best guess estimates are made to establish losses resulting from having to restore a tarnished reputation. The impact and probability of potential losses are multiplied to get a numerical value for risk which can be used to rank risks from the most serious to the most trivial (State office of risk management, 2007). The advantages of this process are: the process minimizes exposure to financial losses, and there is reduction in the expenditure of claims. Some drawbacks of this process are: the risk analysis process is not applied in the early business development stage of state agencies, and the historical business failure data is not cataloged and used.

The drawbacks of the business risk analysis processes described above stresses a need for a method which can help identify the potential risk areas in business in the early business

development stages, when modifications to the business plans can be made without significant changes to the budget and schedule. The historical business failure data contains a wealth of information which should be efficiently used to prevent future business failures. None of the business risk analysis processes described above utilize the historical business failure data. This stresses the need for more effective system for cataloging and utilizing historical business failure data to identify the potential business risk areas even before the launch of business. B-RED addresses such issues by effectively utilizing consistent terminology to catalog historical business failure data.

2.2 Business Risk Taxonomies

In 2000 report, "Behavioral Cause Analysis of the 1999 Bonfire Structure Collapse at Texas A&M University", Performance Improvement International (PII), provides a list of business failures which includes management, organizational, and human failure modes. PII uses this list of failure modes for event investigation and prevention, business performance improvement, etc (Performance Improvement International, 1997). Some examples of PII failure modes include unawareness of legal implications, wrong assumptions, inadequate motivation and inadequate attention to emerging problems.

Young (2002) in his book "Accounting Irregularities and Financial Fraud: A Corporate Governance Guide", describes about financial fraud. In April 1998, misstated financial results at Cedant Corporation's newly acquired CUC International unit led to a $ 14 billion loss in market capital (Young, 2002). According to this book, highly publicized financial misreporting problems have also surfaced at Lucent, Xerox, Anicom, Mercury Finance, Boston Scientific, Sunbeam, Penguin, Informix, etc. Statement on Auditing Standards No.53 defines "Errors and Irregularities" as: *errors* refers to unintentional misstatements in financial statements, while *irregularities* refers to intentional misstatements in financial statements generated and may also involve intentional misapplication of accounting principles (Young, 2002).

In Devising Business Strategies by Business Plan Software (2007), it is said that the venture is most prone to failure in the first three years of its operation. They also give a list of basic reasons for business failure such as, overoptimistic projections or overtrading, ineffective financial and managerial control systems, lack of innovation, inappropriate business location, and unreal expectations. The causes for failure can be anticipated by executing appropriate strategies such as using market research to confirm demand and assess suitability of proposed offerings, creating a management team to offset any gaps in experience, and raising equity to reduce exposure to interest rate changes (Business Plan Software, 2007).

Hamilton et al. (2006) in the book “Greed and Corporate Failure: The Lessons from Recent Disasters” examines why companies fail. The authors’ postulate that the reasons companies fail are few, and all too common. This book describes some main causes for the corporate failures, such as greed, hubris and, a desire for power; poor strategic decisions; failure of internal controls and ineffective boards; dominant CEO’s, etc.

In any particular enterprise, the number of levels of management depends on size of the enterprise, market value and nature of production based on quality as well as quantity (Management-Hub.com, 2007). For example, if a large volume of different kinds of products are manufactured by an enterprise, then there is a need for several layers of management, which would help bring about better inter-relationship between the employees of the organization. According to experts, there are three different levels of management (Management-Hub.com, 2007). These levels of management include top level management, consisting of a board of directors, managing directors or executive committee members; middle level management, consisting of managers such as personnel, production, sales, marketing, resource, and finance; and lower or operating level management, consisting of foremen, supervisors, and daily laborers (Management-Hub.com, 2007).

System Transformation’s (2004) Contingency Planning Methodology is a set of instructions and ideas to aid in collecting the information required to identify, assess and manage contingency and crisis management teams. The purpose of business risk analysis in contingency planning methodology is to determine the 'Criticality' of each business function and prioritize them to decide which require a contingency plan and which can be ignored and eliminated. A list of general shared services and functions common to most businesses is provided for business risk analysis by System Transformation (2004). Some of the examples of these are legal, project management, marketing, human resources, facilities, audit and compliance, finance and accounting, etc.

In this paper, for the business risk analysis we develop and utilize taxonomies which are populated using the historical business failure data. This concept of risk analysis is derived from Risk in Early Design (RED) theory, originally developed for electromechanical components, by Grantham Lough et al. (2005, 2006a, 2006b). The following section describes the RED method.

2.3 The Risk in Early Design (RED) Method

Grantham Lough et al. (2005, 2006a, 2006b) developed the Risk in Early Design (RED) theory which translates recorded information about function and failure into categorized risk likelihood and consequence elements for a product. The likelihood and consequence calculations

used in RED theory are shown in **Exhibit 1.** Equation (1) is used to obtain the function-failure mode matrix by using cataloged historical failure modes and presents this data in a comprehensible matrix format.

$$\mathbf{EC \times CF = EF} \qquad \mathbf{(1)}$$

The matrices in Equation (1) are the function-component matrix (**EC**), the component-failure matrix (**CF**), and the function-failure matrix (**EF**) (Grantham Lough et al., publication pending).

RED uses matrix based risk assessment to easily identify specific function-failure mode combinations that have historically occurred and to quantify that information into a likelihood and consequence based on the outcome of the historical events (Grantham Lough et al., publication pending). Because this method uses documented historical function-failure combinations, even novices will be able to use it to determine a product's potential risks.

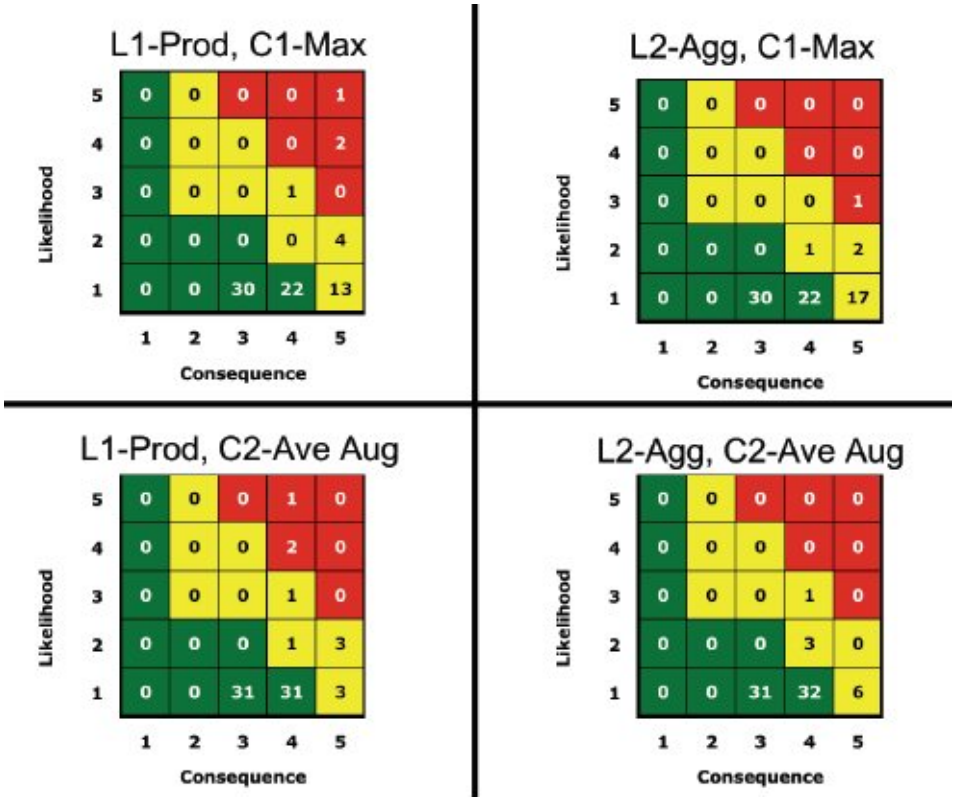
Communication of the risk is manipulated such that the risks are compatible with the risk fever chart originated by Defense Acquisition University (DAU) (Office of the Under Secretary of Defense, 1999). This chart consists of a plot of consequence versus likelihood of risks. RED method mapping is done such that both consequence and likelihood have integer values ranging from one to five. This chart is easy to read because the risk elements are classified into three categories: high, moderate, and low risk elements and given different color codes such as red, yellow and green.

Grantham Lough et al. (2006a) illustrate RED risk assessment performed on a functional model of a Thermal Control Subsystem. From the functional model of Thermal Control Subsystem, the functions from the functional basis were collected and used to select entries of function-component (**EC**) matrix. Using the **EC** matrix thus formed, the product specific function failure (EF_{prod}) matrix was determined. Next, the risk likelihood and consequence calculations, using equations as shown in **Exhibit 1** were performed using the function-component (**EC**) matrix and component-failure severity (**CF'**) matrix. The risk fever chart from the four RED risk assessments performed on thermal control subsystem risk assessments are shown in **Exhibit 2.** In all, 73 risk elements were produced from the risk assessments. For example, one of the risk statements obtained from the risk assessment on the Thermal Control Subsystem is *Export thermal energy fails due to high cycle fatigue (5,5).* This risk element indicates that the function (export thermal energy) is at risk for the specific failure mode (high cycle fatigue) with a consequence and likelihood combination of 5, 5.

Exhibit 1. RED Likelihood and Consequence Mapping Summary (Grantham Lough et al., 2006b)

	L1-Prod	L2-Agg	C1-Max	C2-Ave Aug
	$l_{ij} = \text{int}\left\{5\frac{ef_{prod_{ij}}}{\max_{\substack{1\le i\le n\\ 1\le j\le m}}(ef_{prod_{ij}})}\right\}$ (2)	$l_{ij} = \text{int}\left\{5\frac{ef_{prod_{ij}}}{\max_{\substack{1\le i\le n\\ 1\le j\le m}}(ef_{agg_{ij}})}\right\}$ (3)	$c_{ik} = \max_{1\le j\le m}(ec_{ij}cf'_{jk})$ (4)	$c_{ik} = \text{int}\left(\frac{1}{h}\sum_{1\le j\le m} ec_{ij}cf'_{jk}\right)$ (5)
Pros	▪ Provides hierarchy of probable product specific risks ▪ Conservative estimate of risk probability ▪ Reduced dependency on data concentration of failure database	▪ Risk likelihoods are relative to all recorded failure occurrences ▪ Does not overestimate risk likelihood for low occurrence failures in database	▪ Conservative risk estimate ▪ Focuses designer's attention directly to severe failures	▪ Average risk estimate ▪ Not dependent on a single severe failure occurrence ▪ Considers only relevant function-component-failure combinations
Cons	▪ May provide too much attention to a low occurrence failure	▪ Can downplay risks with low failure occurrence in database ▪ Risk likelihood is directly related to the number and distribution of all recorded failures in the database	▪ A single severe failure will dominate the risk analysis regardless of occurrences of lesser severity ▪ Single severity value dependence prevents risk value from representing all recorded failures	▪ Severity of a failure can be diminished with many occurrences of a less severe case ▪ Highly dependent on the combination of number of recorded failures and their severity values

Exhibit 2. Thermal Control Subsystem RED Risk Assessments (Grantham Lough et al., 2006a)

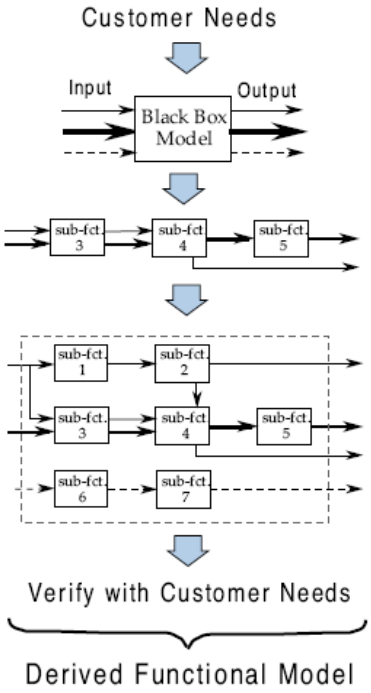


2.3.1 RED Taxonomies:

2.3.1.1 Functional Basis

A *Functional Model* is a pictorial description of a product or process. It provides an abstract, yet direct, method for understanding and representing an overall product or artifact function (Hirtz et al., 2002). The most well known approach to create functional modeling of a product is that of Pahl and Beitz, where the overall function is modeled and decomposed into sub-functions operating on the flows of energy, material, and signals. The process of deriving a functional model involves 1) identifying flows that address customer needs, 2) generating a black box model, 3) creating function chains for each input flow, 4) aggregating functional chains into functional model, and 5) verifying the functional model with customer needs (Kurfman et al., 2003). **Exhibit 3** shows the steps of functional model derivation method.

Exhibit 3. Steps of the Functional Model Derivation Method (Kurfman et al., 2003)



A standardized set of function related terminology leads to repeatable and meaningful results from formal functional representation, which is referred to as *Functional Basis*. In order to associate the qualities of mathematical basis with a function vocabulary of design, the word basis was chosen. Hirtz et al. (2002) applied and evolved the functional basis as part of a method to identify modular product architectures. Their basis gave functional models a common vocabulary and identified a stopping point for decomposition by specifying that function and flow words be

chosen from a certain level. The reconciled functional basis is flexible enough to form functional descriptions that follow the standard verb-object format as well as other formats, which are possible as long as the function and flow descriptors are expressed correctly at desired level of specification (Hirtz et al., 2002). **Exhibit 4** shows the excerpt of Functional Basis representation.

Exhibit 4. Excerpt of Functional Basis Representation (Hirtz et al., 2002)

Class (Primary)	*Secondary*	*Tertiary*	
Material	Human		H
	Gas		H
	Liquid		Li
	Solid	Object	R
		Particulate	
		Composite	
	Plasma		
	Mixture	Gas-gas	
		Liquid-liquid	
		Solid-solid	A

2.3.1.2 Component Taxonomy

According to Greer et al. (2003) components represent the fundamental artifacts from which mechanical systems are constructed. Using only those names found in the component taxonomy, detailing of any mechanical device is allowed by a basic set of names that was complied. The complete set of names resulted in 114 terms, produced from applicable literature and technical reference publications. The methodology for gathering the component names was based on a search of various technical reference books, design texts, museum nomenclature, dictionaries, and general expertise with many products and devices. It was found that there was huge improvement in design communication due to existence of component taxonomy. Example terms in the taxonomy include actuator, guide, lever, and rotor (Greer et al., 2003). **Exhibit 5** shows an excerpt of Component Taxonomy.

Exhibit 5. Excerpt of Component Taxonomy (Greer et al., 2003)

Name	Synonyms	Class	
1. Actuator		Function	Any devic
2. Agitator	Mover, stirrer	Function	A mechani liquids, su
3. Arm	Limb, appendage	Nature	Any struct
4. Axle	Stub axle, beam axle, axle shaft	Simple Mach.	A supporti
5. Ball	Sphere, orb, globe	Geometry	A round o
6. Band	Belt, Strap, Girdle, Band, Restraint, Strip, Leash, Tie, Lash	Geometry	An flexibl motion bet A narrow
7. Bar	Rod, pole, staff,	Geometry	Long piec

2.3.1.3 Failure Mode Taxonomy

The failure mode taxonomy presents a physics based explanation of potential failure modes (Tumer et al., 2003). In addition to the initial set of electrical failure modes, the failure modes taxonomy was extended to include materials and components like elastomers, plastics, printed circuit boards and glue joints. Designers get a true understanding of the failure's nature by physics based description of the failure mode. Additionally, because a physics-based description provides an understanding of the failure modes at their most elemental state, such characterizations provide a standardized failure mode taxonomy which is necessary to prevent ambiguity when describing failures, hence providing designers with a repeatable and reusable vocabulary with which to work (Tumer et al., 2003). An excerpt of Failure Mode taxonomy is shown in **Exhibit 6**.

Exhibit 6. Excerpt of Failure Mode Taxonomy (Tumer et al., 2003)

Primary Identifier	Secondary Identifier	Failure Mode
(Thermal) Fluctuating thermal load	Fluctuating loads or deformations induced	Thermal fatigue
	High temperature Elastic deformation	Temperature induced deformation
	Thermal gradients produce differential thermal strains lead to yielding or fracture	Thermal shock
(Galling & Seizure) Sliding surfaces	Combination of loads, sliding velocities, temperatures, lubricants produce surface destruction	Galling
	Two parts virtually welded together	Seizure

3. Business Risk In Early Design (B-RED) Method

The B-RED method utilizes the RED method theory developed by Grantham Lough et al. (2006a) in the business risk domain. A list of potential risks is generated by feeding the functional requirements of the business into the B-RED failure knowledge base. One of the important requirements for performing B-RED is to have a database of historical business failures. Such a database is generated by studying a number of business failure case studies. The current B-RED database was obtained by investigation of ten business failure case studies. This small current database is used for the proof of the concept.

On identifying a failed business, an investigation is carried out to ascertain the causes of failure. The causes of failure are further analyzed to obtain the details of failed component and its function, and failure mode. These are related to the terms in the business component taxonomy and business failure mode taxonomy respectively. The failure severity information is also obtained from the business failure case study. The method of populating the database to support B-RED is detailed in Section 4. The taxonomies used in the B-RED method are described in the

following sections. The **EC** and **CF** matrices, and their product (the **EF** matrix) and the **CF'** matrix are created using the business failure cases and these represent the database which will be used to determine the business risks. This database is used to analyze the Arthur Andersen, by supposing that Arthur Andersen is in early phases of its development, when only the desired functionality will be known. Arthur Andersen was once most powerful and highly respected accounting firm in the world (Toffler, 2005).

First, the functions of the Arthur Andersen are determined. Using these functions, a function-failure (EF) matrix is generated as a part of B-RED by selecting relevant functions from the **EC** matrix. An excerpt of the **EF** matrix generated is shown below in **Exhibit 7**. The next step in B-RED process is to apply the consequence and likelihood mapping. Normally, the formulations provided in Equations (2) through (5) are used to attach likelihood and consequence data to the potential failures and arrive at identifiable risks. For B-RED, only Equations (3) and (4) are used to calculate the likelihood and consequence respectively. **Exhibit 8** below shows, how Equations (3) and (4) were used in RED and why these equations are used in B-RED. Given these three elements (EF, C1, and L2), combined risk items are identified and quantified. Finally, consequence mapping C1 and likelihood mapping L2 are applied to obtain C1 and L2 matrices. By matching data from each of the entries, a risk statement can be constructed.

By performing the risk calculations, information such as function, failure mode, likelihood and consequence for each business risk is obtained. These items are plotted on a risk fever chart (Office of Under Secretary of Defense, 1999) which allows risk statements to be condensed into low, medium and high risk elements. This indicates the overall business risks. For Arthur Andersen, the risk fever chart conveys that 259 potential failures fall into moderate risk zone.

Exhibit 7. Excerpt of EF Matrix for Arthur Andersen

EF Matrix	Lack of attention to emerging issues	Unawareness of legal implications	Unawareness of regulatory implications	Inadequate use of new technology	Inadequate programmatic scope	Inadequate assessment of challenges
Setting Objectives	10	5	3	1	1	24
Accomplish Goals	19	9	5	4	2	40
Hire People	10	5	3	1	1	26
Assign Duties	12	5	6	2	1	29
Process Payroll	2	4	2	0	0	8

Exhibit 8. Mapping Equations L2 and C1

	RED	B-RED
L2 = $l_{ij} = \text{int}\left\{5\frac{ef_{prod_{ij}}}{\max_{\substack{1\le i\le n\\1\le j\le m}}(ef_{agg_{ij}})}\right\}$	Used at system design level.	Business under analysis is considered as a system.
C1 = $c_{ik} = \max_{1\le j\le m}(ec_{ij}cf'_{jk})$	Used for risk assessments which involve human related products.	All businesses require human intervention.

3.1 Business Failure Mode Taxonomy

The electro-mechanical failure mode taxonomy was developed to improve risk communication of electromechanical products. Similarly, the taxonomy of business failures was developed for the B-RED method, to improve communication of business risks. Majority of the failure modes in the business failure mode taxonomy come from the list of failure modes generated by Performance Improvement International (PII) in their 2000 report, "Behavioral Cause Analysis of the 1999 Bonfire Structure Collapse at Texas A&M University" (refer Section 2.2). This list of failure modes consists of definitions for each of them and covers management, organizational and human failure modes and is hence utilized in the business failure mode taxonomy.

In the business failure case study of Enron, failure due to accounting irregularities was quite evident (Tesfatsion, 2008). Young (2002) in his book 'Accounting Irregularities and Financial Fraud: A Corporate Governance Guide', describes about financial fraud (refer Section 2.2). The failure mode 'accounting irregularities' was not adequately described in the list of failure modes generated by PII, and was identified from the book authored by Young (2002), to be used in the business failure mode taxonomy.

In Devising Business Strategies by Business Plan Software (2007), a list of basic reasons for business failure is given (refer Section 2.2). Some of the failure modes identified from this list such as overoptimistic projections or overtrading, and ineffective financial and managerial control systems are not adequately described in the list of failure modes generated by PII. Hence, the business failure mode taxonomy was updated with these failure modes identified from Business Plan Software (2007).

Sims et al. (2003) in their paper on Enron Ethics say that Enron executives' attention was clearly focused on profits, power, greed and influence. Hamilton et al. (2006) in the book 'Greed and Corporate Failure: The Lessons from Recent Disasters' describe about why companies fail (refer Section 2.2). None of the failure mode in the business failure mode taxonomy effectively

describes about greed and desire. Because this failure mode was apparent in business failure case studies of Enron and WorldCom, the failure mode 'personal desire and greed' was included in the taxonomy.

The failure modes identified from various sources as described above, make up the business failure mode taxonomy. This taxonomy presents a preliminary set of failure modes for proof of concept of B-RED method. This initial set of failure modes presented is not the complete set. Further literature reviews including business failure case studies is required to keep this taxonomy developing. Also, the taxonomy needs to be tested and verified to establish validity, exactness, accuracy and completeness. This forms the scope of future work. **Exhibit 9** shows the business failure mode taxonomy with definitions.

Exhibit 9. Business Failure Mode Taxonomy

Failure Mode	Definition	Source
Inadequate attention to emerging problems	Repetitive organizational crises, in morale, work practice, etc.	Performance Improvement International, 2000
Unawareness of legal implications	High Insurance claims; high legal risks; trend of losing critical legal cases in the industry.	
Unawareness of regulatory implications	Sudden loss of profits due to regulation changes; un-preparedness for new regulations; inadequate response to regulatory changes.	
Unawareness of new technology	New technology used by competitors; rapid loss of market due to obsolete technology.	
Inadequate scope	Omission of necessary functions in procedures.	
Inadequate assessment of challenges	Not meeting business plan goals due to unexpected factors.	
Inadequate scope of control	Some aspects of performance out of control; erratic performance.	
Inadequate interface requirements	Actions required by one program belonging to a program that is inadequate.	
Insufficient detail	Vagueness in procedures.	
Cognitive overload	High volume of irrelevant information.	
Not familiar with availability of information	Not knowing some key, available information in decision making.	
Excessive implementation requirements	Staff ignoring the programs; staff work overload.	
Perceived pressure to complete task	Not paying attention to secondary tasks or indications during a task of perceived tight schedule.	

Exhibit 9. Business Failure Mode Taxonomy (contd.)

Failure Mode	Definition	Source
Task too complex	Task assignments requiring memorizing or comprehension of complex concepts or situations task too complex to complete on schedule.	Performance Improvement International, 2000
On the job distraction	Work overload; handling more than seven tasks simultaneously; noise or frequent interruptions.	
Habit Intrusion	Perform tasks mainly based on past experience without fully understanding the current situation	
Mindset	Decision making without seeking the facts and evidence objectively.	
Wrong assumptions	Erroneous assumptions used in decision making.	
Lack of information validation	Erroneous information used in decision making.	
Shortcuts evoked	Shortcuts are used to accelerate the job completion; perceived pressure to complete work.	
Inappropriate order	Conflicting directions from supervision; inadequate work priority.	
Inadequate tracking	No or inadequate tracking system for task status.	
Tunnel vision	Actions or decisions without assessing the entire situation.	
Not familiar with job performance standards	Not knowing supervision's expectation of performance standards.	
Not familiar with task	First time performance of task; infrequent performance of complex task.	
Inadequate motivation	Low morale; low spirit; tardiness; irresponsiveness; argumentative.	
Boredom	loss of alertness because of little amount of task stimuli.	
Lapse of memory	Loss of memory regarding previously learned skills.	
Reflex	Inappropriate action based on wrong intuition.	
Overconfidence	Underestimating the task complexity, scope or depth; lack of adequate contingency planning.	
Lack of commitment to program implementation	Slow program implementation.	
Inadequate program monitoring	Lack of proper program improvement over time.	
Lack of program evaluation process	Repetitive program failure without corrections.	
Conflicting program requirements	Different actions requested by two or more programs for a given situation.	
Inadequate self verification process	Program breakdown by single human error; high program failure rate, poor procedural quality.	

Exhibit 9. Business Failure Mode Taxonomy (contd.)

Failure Mode	Definition	Source
Inadequate function or structure	Specific type of work not performed; specific type of issue not addressed.	Performance Improvement International, 2000
Inadequate work prioritization	Staff work overload; over-run committed budget.	
Inadequate communication within organization	Important issues not addressed; breakdown of normal work process, low staff morale.	
Unawareness of market changes	Persistent and continuous profit loss; new product failure; high promotion cost.	
Unawareness of union conflicts	Hostility of union; sabotage refusal to participate in improvement tasks.	
Inadequate definition of business objectives	No vision; no strategic position; lack of market focus.	
Inadequate assessment of company capabilities	Not meeting business plan goals; below expectation performance to respond to challenges.	
Inadequate business plan execution	Minimum attention to execution; low quality of task output; no periodical review.	
Vague or unclear expectations	Expectations not known by affected personnel.	
Inadequate accountability system	Low morale; poor performance; committed actions not carried out.	
Accounting irregularities	Deliberate misstatement of some aspect of financial performance.	Young, 2002
Personal desire and Greed	Personal desire and Greed.	Hamilton et al., 2006
Inadequate business plan	Lack of details; inadequate accountability; tracking and closure.	Performance Improvement International, 2000
Overoptimistic projections or overtrading	Overoptimistic projections or overtrading.	Business Plan Software, 2007
Ineffective financial and managerial control systems	Ineffective financial & managerial control systems.	

3.2 Business Component Taxonomy

A business component is a unit of functionality that manages a single business abstraction (Microsoft Dynamics Developer Center, 2007). For example, a business component finance and accounting can be created to manage payroll activities. In this example the unit of functionality is finance and accounting and payroll activity forms the business abstraction. According to experts, there are three different levels of management (Management-Hub.com, 2007). These levels of management, which are also units of functionality and have assigned

duties, include top level management, middle level management and lower or operating level management (refer Section 2.2). In the business failure case studies conducted for Aspire, Daewoo, Barings, Enron, etc., some of the failure modes are attributed to the management levels. Hence, these levels of management identified from management-hub.com (2007) are used in the business component taxonomy.

System Transformation's (2004) Contingency Planning Methodology lists general shared services and functions common to most businesses (refer Section 2.2). These services and functions act as units of functionality that manage a single business abstraction and are added to the list of business components identified from management-hub.com, since the existing terms did not adequately describe these components.

The business component taxonomy, thus developed consists of business component names identified from sources as described above. These represent the initial set of names and the taxonomy will keep developing as new business components are encountered during investigation of business failure case studies. Also, the taxonomy needs to be tested and verified to establish validity, exactness, accuracy and completeness. This forms the scope of future work. **Exhibit 10** shows the business component taxonomy with definitions. The definitions contained in **Exhibit 10** are a compilation from various sources.

Exhibit 10. Business Component Taxonomy

Components	Definition
Audit & Compliance	A department that evaluates additions or changes in internal control processes coincident with their development and implementation, keeps the executive committee informed of emerging trends and best practices in internal auditing, assists in the investigation of significant suspected fraudulent activities within the organization, and assures reporting to the Executive Committee on the results, as appropriate. (Metropolitan Water District of Southern California, 2008)
Administration	A department that provides support and service for the activities of the Board, and performs staff functions regarding administrative and agency-wide issues. (Socialstyrelsen, 2007)
Communications	A department that supports communications with constituents and media by facilitating an accurate, timely, and consistent information flow and providing advice as appropriate; supports day-to-day operational needs of the corporation by providing proactive communications advice, products and services; and facilitates and ensures consistent and accurate communications with employees. (Corporate Communications, 2007)

Exhibit 10. Business Component Taxonomy (contd.)

Components	Definition
Engineering/R&D	A department that ensures that the new product meets the product specification, develops products to budget, develops product on time, and develops products to meet the target production cost. (Industrial Management, 2008)
Finance & Accounting	A department that provides financial accounting and support services related to general accounting, payments, purchase orders, invoicing and collections, travel, financial systems, financial reports, month-end and year-end closings, and other services; directs departmental accounting and consolidated financial reporting, with emphasis on issuance of audited financial statements that receive an unqualified audit opinion, as well as provision of financial information that supports management decision-making. (Accounting Department, 2007)
Facilities	A department that provides all utilities that are needed to operate the various buildings, such as natural gas, electricity, sewer, water, janitorial service and garbage service; maintains all lawn and planting areas for all city buildings and properties. (Fleet and Facilities Division, 2008)
Human Resources	A department that provides the following services: recruitment and selection, promotions, discipline and grievance advice, contracts of employment, terms and conditions of service, health and safety, induction, training and development, advice to management and staff on personnel issues, probation reports, absence records, increments, monthly staffing statistical reporting employee relations, performance management, compliance with employment law, job evaluation, policy formulation to comply with best practice, retirements (medical and early), occupational and career guidance, redundancy advice, resignations, termination of employment. (Human Resources Department, 2008)
IT Division	A department that manages and keeps the system up-to date, creates and maintains customer database for effective communication, links the companies with head office and regional offices in a well coordinated manner. (IT Department, 2007.)
Legal	A department that is responsible for the provision of legal advice to the Board and staff of company on general legal and commercial matters. (Legal Department, 2007)
Low Level Management	A level of organization in which supervisors maintain standards of the quality of the manufactured product; assign duties to the workers as per plan and schedules given by top and middle level management. (Management-Hub.com, 2007)
Marketing	A department which helps market the company with focus on customer, by monitoring competition; communicating internally, managing budget etc. (The Brand Builder Blog, 2007)
Middle Level Management	A level of organization which follows the rules and policies formulated by top management; motivates personnel for higher productivity; gives recommendations to top management etc. (Management-Hub.com, 2007)

Exhibit 10. Business Component Taxonomy (contd.)

Components	Definition
Operations	A department that is responsible for the overall management and control of the company and its general administration. (Operations Department, 2007)
Project management	A department which is involved in implementation projects management, partner network service and definitions of the products new functions. (Project Management Department 2007)
Purchasing	A department responsible for manually placing a small percentage of organization's purchase order. (Dominick, 2006)
Security	A department that provides a safe and secure environment for employees to work and for customers to do business. It provides protection and defense against real or anticipated threats. (Security Education Systems, 2008)
Sales	A department which prepares or directs the preparation of sales manuals, giving detailed information about company and products. (Sales Department, 2007)
Top Level Management	A level of organization which sets key objectives, policies and identifying factors essential for the development of the enterprise; making appointments to the top position in the enterprise such as managers, department heads etc. (Management-Hub.com, 2007)
Training	A department which assesses training needs; creates training or development specification and plan training and evaluation. (Chapman, 2007)

3.3 Business Function Taxonomy

In engineering design, all products and artifacts have some intended reason behind their existence: the product or artifact function (Hirtz et al., 2002). Similarly, the business components are units of functionality that manage single business abstraction (Microsoft Dynamics Developer Center, 2007). To effectively describe the business units functionally, the business function taxonomy was developed. The business functions are represented by functions and flow, as in the functional basis for electro-mechanical products, to maintain consistency in the representation of business unit functionality. The function descriptor is a verb and the flow descriptor is an object. In the functional basis flows can be energy, material or signal. However, in the business function taxonomy method there is no analogous equivalent of flow generalization categories, as of now. The business functions can be effectively described using any combination of function and flow from the business function taxonomy. Such representations will help in describing the business functions in the same manner by different people.

The representation of business function using verb-object format was developed by studying the nineteen business components from the business component taxonomy. From the definitions of these business components, many functions and flow based terminologies were recorded. From these a list of functions and related flows was extracted, as shown in the business function taxonomy below. For example, from business component taxonomy the definition for Top Level Management includes 'level of organization which sets key objectives'. From this statement, a function-flow combination 'setting objectives' was extracted, in which 'set' forms the function and 'objective' forms the flow. The list of functions and flows thus obtained was condensed by removing synonyms and eliminating functions and flows which were specializations of more generic functions and flows respectively. For example, functions such as 'provide' and 'supply' were condensed to include only one generic term 'provide' and synonymous functions such 'communicate' and 'convey' were condensed to one function 'communicate', in the business function taxonomy. This list of functions and flows represent the business function taxonomy.

The business function taxonomy presented consists of initial set of functions and flows, which can be used to describe the business components. However, it is not a complete set and further literature reviews and business failure case study investigations are needed to keep the taxonomy developing. **Exhibit 11** shows the business function taxonomy with definitions.

Exhibit 11. Business Function Taxonomy

Functions	Definition
Set	to allot as a task. (Merriam Webster, 1999) Ex. setting lessons for the children to work upon at home.
Identify	to establish the identity of. (Merriam Webster, 1999) Ex. establish identity of a biological specimen.
Follow	to be or act in accordance with. (Merriam Webster, 1999) Ex. follow directions.
Motivate	to provide with a motive. (Merriam Webster, 1999) Ex. questions that excite and motivate youth.
Accomplish	to bring to completion. (Merriam Webster, 1999) Ex. we can accomplish the job in an hour.
Hire	to engage the personal services of for a set sum. (Merriam Webster, 1999) Ex. hire a crew.

Exhibit 11. Business Function Taxonomy (contd.)

Functions	Definition
Collect	to gather or exact from a number of persons or sources. Ex. collect taxes.
Maintain	to continue or persevere in. (Merriam Webster, 1999) Ex. couldn't maintain his composure.
Review	to go over or examine critically or deliberately. (Merriam Webster, 1999) Ex. reviewed the results of the study.
Assign	to appoint as a duty or task. (Merriam Webster, 1999) Ex. assigns 20 pages for homework.
Process	to subject to or handle through an established usually routine set of procedures. (Merriam Webster, 1999) Ex. process insurance claims.
Advertise	to make publicly and generally known. (Merriam Webster, 1999) Ex. advertising their readiness to make concessions.
Develop	to work out the possibilities of. (Merriam Webster, 1999) Ex. develop an idea.
Perform	to do in a formal manner or according to prescribed ritual. (Merriam Webster, 1999) Ex. performed gymnastics.
Prepare	to make ready beforehand for some purpose, use, or activity. (Merriam Webster, 1999) Ex. prepare food for dinner.
Provide	to supply or make available. (Merriam Webster, 1999) Ex. provided new uniforms for the band.
Ensure	to make sure, certain, or safe. (Merriam Webster, 1999) Ex. the government has ensured the safety of the refugees.
Communicate	to convey knowledge of or information about. (Merriam Webster, 1999) Ex. communicate a story.
Facilitate	help bring about. (Merriam Webster, 1999) Ex. facilitate growth.
Counsel	to give advice to. (Merriam Webster, 1999) Ex. counsel management.
Evaluate	to determine the significance, worth, or condition of usually by careful appraisal and study. (Merriam Webster, 1999) Ex. evaluate policies.
Support	to uphold or defend as valid or right. (Merriam Webster, 1999) Ex. supports fair play.
Administer	to manage or supervise the execution, use, or conduct of . (Merriam Webster, 1999) Ex. administer a trust fund.
Initiate	to cause or facilitate the beginning of. (Merriam Webster, 1999) Ex. initiate a program of reform.

Exhibit 11. Business Function Taxonomy (contd.)

Exhibit 11. Business Function Taxonomy (contd.)	
Flows	**Definition**
Objectives	something toward which effort is directed. (Merriam Webster, 1999) Ex. children achieved their objectives.
Factors	one that actively contributes to the production of a result. (Merriam Webster, 1999) Ex. price wasn't a factor in the decision.
Rules	prescribed guide for conduct or action. (Merriam Webster, 1999) Ex. traffic rules.
Personnel	body of persons usually employed. (Merriam Webster, 1999) Ex. hire personnel.
Goals	the end toward which effort is directed. (Merriam Webster, 1999) Ex. achieve goals.
People	human beings making up a group or assembly or linked by a common interest. (Merriam Webster, 1999) Ex. gather people
Report	a usually detailed account or statement. (Merriam Webster, 1999) Ex. a news report.
Quality	an inherent feature. (Merriam Webster, 1999) Ex. had a quality of stridence.
Work	specific task, duty, function, or assignment often being a part or phase of some larger activity. (Merriam Webster, 1999) Ex. assigned work.
Duties	assigned service or business. (Merriam Webster, 1999) Ex. performed duties.
Payroll	the money to be distributed. (Merriam Webster, 1999) Ex. process payroll.
Product	something (as a service) that is marketed or sold as a commodity. (Merriam Webster, 1999) Ex. new product.
Policies	a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions. (Merriam Webster, 1999) Ex. amend policies.
Staff functions	Staff: personnel who assist a director in carrying out an assigned task; Function: group of related actions contributing to a larger action. (Merriam Webster, 1999) Staff Function: group of actions carried out by personnel. Ex. perform staff functions.

Exhibit 11. Business Function Taxonomy (contd.)

Flows	Definition
Financial statement	Financial: relating to finance; Statement: a report of facts or opinions. (Merriam Webster, 1999) Financial Statement: a report of facts or opinions relating to finance. Ex. accounting department generates financial statement.
Administration	performance of executive duties. (Merriam Webster, 1999) Ex. maintain administration.
Overall Management	the conducting or supervising of something (as a business). (Merriam Webster, 1999) Ex. group provided management.
Utilities	a service (as light, power, or water) provided by a public utility. (Merriam Webster, 1999) Ex. company provided utilities.
Communication	process by which information is exchanged between individuals through a common system of symbols, signs, or behavior. (Merriam Webster, 1999) Ex. the function of pheromones in insect communication.
Property	something owned or possessed. (Merriam Webster, 1999) Ex. purchased property.
Data	factual information (as measurements or statistics) used as a basis for reasoning, discussion, or calculation. (Merriam Webster, 1999) Ex. the data is plentiful and easily available.
Message	an underlying theme or idea. (Merriam Webster, 1999) Ex. convey message.
Legal Issues	Legal: pertaining to law, Issue: that which proceeds from something. (Skeat, 1968) Legal Issue: that which proceeds from something pertaining to law. Ex. discussion on legal issues.
Control processes	Control: power or authority to guide and manage; Process: a natural phenomenon marked by gradual changes that lead toward a particular result. (Merriam Webster, 1999) Control Process: a phenomenon of power or authority to guide and manage, marked by gradual change. Ex. ineffective control processes.
Interface	the means by which interaction or communication is achieved at an interface. (Merriam Webster, 1999) Ex. interface between organizations.
Management Decision Making	Decision: act or process of deciding; Management: collective body of those who manage. (Merriam Webster, 1999) Management Decision Making: process of decision by a collective body of those who manage. Ex. management decision making for transportation problems.

Exhibit 11. Business Function Taxonomy (contd.)

Flows	Definition
Staffing	to supply with a staff or with workers. (Merriam Webster, 1999) Ex. staffing is done by human resources.
Training	the state of being trained. (Merriam Webster, 1999) Ex. underwent training.
Performance Management	Performance: Execution of an action; Management: conducting or supervising of something. (Merriam Webster, 1999) Performance Management: supervising execution of an action. Ex. performance management includes activities to ensure that goals are consistently being met in an effective and efficient manner
Career Development	Career: profession for which one trains and which is undertaken as a permanent calling; Development: act, process, or result of developing. (Merriam Webster, 1999) Career Development: act, process, or result of development professionally. Ex. career development grants support women.
Changes	substitution of one for another. (Fowler, 1934) Ex. foliage changing color.

4. Populating Database to Support B-RED

In the previous section, the B-RED method of estimating the business risks by relating business functions to historically significant failure modes was discussed. A database consisting of historical business failures is required to obtain function-failure mode risk combinations. Therefore, the availability of a failure knowledge-base is the primary requirement for performing B-RED. The initial B-RED database consists of ten cases of business failures including profit, non-profit, and political entities. This small current database is used for proof of the concept of B-RED risk assessment method. Many more case studies need to be added to the database to ensure the accuracy of the B-RED risk assessments.

4.1 Populating Component-Failure (CF) Matrix

The component-failure (**CF**) matrix of B-RED has ‘components’ (from the business component taxonomy) listed along the rows and ‘failure modes’ (from the business failure mode taxonomy) listed along columns in the matrix. This matrix is used to formulate the function-failure mode (**EF**) matrix, as seen in Equation (1). It is also used in Equations (2) and (3) to calculate business risk likelihood. Historical business failure reports in the form of case studies, news report, business magazines, etc. are used to gather the information about failed business

component and its corresponding business failure mode. This information is recorded in the **CF** matrix. The excerpt of text below is from "The Enron Scandal and Moral Hazard" (Tesfatsion, 2008), pages 2, 7, and 8. This excerpt will be used throughout Section 4 to demonstrate how to populate a B-RED database.

> *• Enron, the 7th largest U.S. Company in 2001, filed for bankruptcy in December 2001.*
> *• Enron investors and retirees were left with worthless stock.*
> *• Enron was charged with securities fraud (fraudulent manipulation of publicly reported financial results, lying to SEC…)*
>
> ***Investigative Findings:***
> *1993-2001: Enron senior management used complex and murky accounting schemes*
> *• to reduce Enron's tax payments;*
> *• to inflate Enron's income and profits;*
> *• to inflate Enron's stock price and credit rating;*
> *• to hide losses in off-balance-sheet subsidiaries;*
> *• to engineer off-balance-sheet schemes to funnel money to themselves, friends, and family;*
> *• to fraudulently misrepresent Enron's financial condition in public reports.*
>
> ***Case Study of One Scheme***
> ***(Developed by Prof. Sue Ravenscroft, Accounting)***
> *• Enron's creation of over 3000 (!) partnerships started about 1993 when it teamed with Calpers (Calif. Public Retirement System) to create JEDI (Joint Energy Development Investments) fund.*
> *• Why partnerships? As long as Enron could find another partner to take at least a 3% stake, Enron was not required to report the partnership's financial condition in its own financial statements.*
> *• Enron used partnerships to hide bad bets it made on speculative assets by selling these assets to the partnerships in return for IOUs backed by Enron stock as collateral! (over $1 billion by 2002)*

The process of identifying the component and the failure mode for this example is shown in the description below.

Identifying Failure Mode: For example, in the excerpt above, the statement, "1993-2001: Enron senior management used complex and murky accounting schemes", implies that 'accounting irregularities' was the business failure from the business failure mode taxonomy, shown in **Exhibit 9.**

Identifying Component: In the excerpt above, again the statement, "1993-2001: Enron senior management used complex and murky accounting schemes", implies that 'top level management' was the failed business component from the business component taxonomy, shown in **Exhibit 10**. From this statement, it can also be deduced that the murky accounting schemes were performed by 'finance and accounting'. Hence, 'finance and accounting' will be the other failed business component from the business component taxonomy.

This analysis results in # 1, referring to the number of times the report indicates 'accounting irregularities' failure occurring, being entered in the first row - first column and second row – first column of **CF** matrix, for 'top level management' and 'finance and accounting' business components respectively. The **CF** matrix is shown in **Exhibit 14**. The above example will be used in Sections 4.2 and 4.3 to detail the population of other B-RED matrices.

4.2 Populating Component-Failure Severity (CF') Matrix

The component-failure (**CF'**) severity matrix has rows of business components and columns of business failure modes identical to that of the component-failure (**CF**) matrix. This matrix documents the severity of business failure modes and is used to calculate the risk consequence, as shown in Equations (4) and (5). In the **CF'** matrix the severity values are assigned to cells where the components are identified with failures.

Exhibit 12 shows the severity classifications based on a scale of 1-5. This scale was developed by System Transformation (2004) in their Contingency Planning Methodology. These fields are used by them for aid in determining criticality of a business function and prioritizing contingency planning efforts. The business failure case studies, however, do not give any information on the timeframes. Because of this reason, the failure severity value definitions provided by System Transformation (2004) have been modified for B-RED method to exclude

the timeframe information as shown in **Exhibit 13**. These modified severity classifications based on 1-5 scale are used for B-RED analysis.

Exhibit 12. Failure Severity Value Definitions (System Transformation, 2004)

Failure Severity Values, fsv				
1	2	3	4	5
No impact or impact does not impair business.	Minor impact, could slow business or cause problems if not fixed within 30-60 days.	Medium impact, slows business down, must be fixed in 2-4 weeks.	Major impact, public relations impact, major cost, legal or safety risk, requires fix in 1-7 days.	Difficult to easily recover, major loss of revenue or life possible, must be corrected in 24 hours.

Exhibit 13. Modified Failure Severity Value Definitions for B-RED

Failure Severity Values, fsv				
1	2	3	4	5
No impact or impact does not impair business.	Minor impact, could slow business.	Medium impact, slows business down.	Major impact, public relations impact, major cost, legal or safety risk.	Difficult to easily recover, major loss of revenue or life possible.

The example presented in Section 4.1 is used in this section to provide an example of the failure severity classification.

Identifying Failure Severity: From the example detailed in the Section 4.1, the 'accounting irregularities' failure mode caused Enron to fail and file for bankruptcy in December 2001. The 'top level management' and 'finance and accounting' departments intentionally used complex and murky accounting schemes. Hence, after this failure was discovered, the company began to collapse. Using the severity classifications in **Exhibit 13**, this failure is clearly not 1, 2, or 3, because it led to complete business failure. Since it led to major loss of revenue and bankruptcy of company, a severity value of 5 is assigned. **CF'** matrix is shown in **Exhibit 15**.

4.3 Populating Function-Component (EC) Matrix

The function-component (**EC**) matrix consists of functions from the function taxonomy along the rows and components from component taxonomy along columns. This matrix is used to calculate the function-failure (**EF**) matrix, as shown in Equation (1); risk likelihood, as shown in Equations (2) and (3); and risk consequence, as shown in Equations (4) and (5). The function of the identified component(s) that failed must be determined to populate this matrix. This

information comes from the failure narrative and is the exact functions that the component(s) was performing at the time of failure.

The example considered in the previous section, is used here to demonstrate function identification.

Identifying Function: The failed components in the example considered are 'top level management', and 'finance and accounting'. At the time of failure both failed components were involved in complex and murky accounting schemes. Hence, from this information we assign the function 'prepare financial statement' to the failed components. This analysis results in # 1 referring to the function performed by the specific failed component, being entered in first row-first column and first row-second column of the **EC** matrix, as shown in **Exhibit 16**.

4.4 Database Construction Example

In Section 4.1, a sample business failure case study of Enron was considered to demonstrate population of B-RED database. In this section, business failure case study of Iridium is provided. The intent of this example is to demonstrate the complete process of determining the matrix entities from business failure case studies. The excerpt of text below is from "Learning from Corporate Mistakes: The Rise and Fall of Iridium" (Finkelstein et al., 2000).

> ***EXECUTIVE SUMMARY***
>
> *In mid-1998, Iridium was one of the darlings of Wall Street having more than tripled in stock price in less than a year. Armed with expertise and over 1,000 patents, the company seemed poised to capture first-mover advantage in providing global telephony via a network of low-Earth-orbiting satellites. Additionally, Iridium appeared to have identified an attractive target segment after having screened over 200,000 people, interviewed 23,000 people from 42 countries, and surveyed over 3,000 corporations. Finally, analysts cited the company's experienced top management team as yet another reason Iridium's future was bright. One year later, however, Iridium's future appeared increasingly bleak. In November 1998, 11 years after engineers developed the concept for Iridium, the company launched its service. By April 1999, however, Iridium had only 10,000 customers and its CEO, Edward Staiano, resigned under pressure. By August 1999 the subscriber base had grown to only 20,000, putting Iridium in breach of its loan covenants. During the same month, Iridium filed for Chapter 11 bankruptcy, making it one of tthe 20 largest bankruptcies in U.S. history.*

Reasons for Iridium's Collapse

Iridium's partners did not provide adequate sales and marketing support. Although at first Motorola had difficulty attracting investors for Iridium, by 1994 Iridium LLC had partnerships with 18 companies including Sprint, Raytheon, Lockheed Martin, and a variety of companies from China, the Middle East, Africa, India, and Russia. In exchange for investments of $3.7 billion, the partners received equity and seats on Iridium LLC's board of directors. In 1998, 27 of the 28 directors on Iridium's board were either Iridium employees or directly appointed by Iridium's partners. Iridium's partners would ultimately control marketing, pricing, and distribution when the service came on line. Iridium's revenues came from wholesale rates for its phone service. Unfortunately for Iridium, its partners, outside the U.S. in particular, delayed setting up marketing teams and distribution channels. "The gateways were very often huge telecoms," said Stephane Chard, chief analyst at Euroconsult, a Paris-based research firm. "To them, Iridium was a tiny thing." So tiny, in fact, that Iridium's partners failed to build sales teams, create marketing plans, or set up distribution channels for their individual countries. As the Wall Street Journal reported, "with less than six months to go before the launch of the service, time became critical…Most partners didn't reveal they were behind schedule."

Identifying Failure Mode: In the excerpt above, the statements, "Iridium's partners did not provide adequate sales and marketing support" and "Iridium's partners failed to build sales teams, create marketing plans, or set up distribution channels for their individual countries", implies that 'lack of commitment to program implementation' was the business failure, from the failure mode taxonomy.

Identifying Component: In the excerpt above, again the statement, "Iridium's partners did not provide adequate sales and marketing support", implies that 'sales' and 'marketing' were the failed business component from the business component taxonomy.

Identifying Failure Severity: With reference to the excerpt above, the 'lack of commitment to program implementation' failure mode caused a setback in promotion of Iridium. Although this failure had a huge impact in sales and marketing of Iridium, there were also other major failure causes which also contributed to failure of Iridium. With due consideration to these factors, a

severity value of 3 (from **Exhibit 13**) is assigned to this failure mode, since it did have medium impact and contributed to slowdown business.

Identifying Function: The failed components in the above example are sales, and marketing. At the time of failure both failed components were involved in providing sales and marketing support to Iridium by advertising Iridium. Hence, from this information we assign the function 'advertise product' to the failed components.

The results from the analysis of two business failure case studies presented were compiled into sample matrices to demonstrate construction process of the database. **Exhibits 14, 15 and 16** represent the Component-Failure (**CF**), Component-Failure Severity (**CF'**) and Function-Component (**EC**) matrices respectively. The Function-Component matrix remains binary as other function component combinations are added. The Component-Failure matrix entries increase in number as more failures of a particular component and failure type are added, i.e. there are more than 1 failures occurring for a particular component-failure combination. The Component-Failure Severity matrix always has values between zero and five, with severity values obtained from **Exhibit 13**. When the Component-Failure Severity matrix is being populated, there may be some cases where the same component and same failure occur in different business cases, with different severities. At present these cases use the largest recorded severity as entry in matrix. This approach is more conservative and may not be appropriate for all risk analysis.

Exhibit 14. Component-Failure (CF) Matrix

Component-Failure Matrix		
CF	Accounting Irregularities	Lack of Commitment to Program Implementation
Top Level Management	1	0
Finance & Accounting	1	0
Sales	0	1
Marketing	0	1

Exhibit 15. Component-Failure Severity (CF') Matrix

Component-Failure Severity Matrix		
CF'	Accounting Irregularities	Lack of Commitment to Program Implementation
Top Level Management	5	0
Finance & Accounting	5	0
Sales	0	3
Marketing	0	3

Exhibit 16. Function-Component (EC) Matrix

Functon-Component Matrix				
EC	Top Level Management	Finance & Accounting	Sales	Marketing
Prepare Financial Statement	1	1	0	0
Advertise product	0	0	1	1

5. Conclusion

The B-RED method aids novices and entrepreneurs assess potential risks in the businesses even before the startup. This helps the entrepreneurs to be better prepared to face risks or even take control measures. This paper describes the business failure cataloging procedure to populate the B-RED database. The current B-RED database used to produce the example in Section 4 was obtained through the investigation of ten business case studies. The small current database was obtained using the process described in this paper and is used for a proof of concept of the B-RED risk assessment method only. Many more cases need to be added to the database to ensure the accuracy of the B-RED risk assessment. The procedures presented here can be used by others to populate their own databases for use with B-RED. Individual databases focusing on a particular business area such as small companies may be useful in accurately capturing risks relevant to the niche in that particular market. However, B-RED method not intended to replace other existing business risk analysis methodologies.

6. Future Work

The future work involves developing the database to include many more business failures and thus continue forming a more complete database. The current database will be analyzed and validated and an investigation will be carried out to determine the optimal database characteristics. The study will continue to capture the business failures and effectively prevent business disasters from occurring where lot of money is at stake.

References:

Accounting Department, "Finance and Accounting Newsletter," CSU Fullerton - Auxiliary Services Corporation, 7:1Q (2007), http://csufasc.org/forms/ACCOUNTING (accessed December 14, 2007).

Allen, Gemmy, 1998, "Supervision," RonJon Publishing, Inc. (1998), http://ollie.dcccd.edu/MGMT1374/book_contents/2planning/plng_process/plng_process.htm (accessed November 7, 2007).

Bettis, Richard A., "Modern Financial Theory, Corporate Strategy and Public Policy: Three Conundrums," *The Academy of Management Review, 8:3* (July 1983), pp. 1-3.

Bidgoli, Hossein, *Handbook of Information Security*, John Wiley and Sons (2006).

Business Plan Software, "Devising Business Strategies," PlanWare, http://www.planware.org/businessstrategies.htm, (accessed December 16, 2007).

Corporate Communications, "Corporate Communications Department," City of Vaughan, http://www.city.vaughan.on.ca/vaughan/departments/corporate_communications/services.cfm (accessed December 12, 2007).

Chapman, Alan, "Training Process Ideas and Outline Process," Businessballs.com, http://www.businessballs.com/traindev.htm (accessed December 18, 2007).

Dominick, C., "10 Signs of a modern purchasing department," Edition #94 (2006), http://www.nextlevelpurchasing.com/articles/purchasing-department-goals.html (accessed January 2, 2008).

Finkelstein, Sydney, and Shade H. Sanford, "Learning from Corporate Mistakes: The Rise and Fall of Iridium," *Organizational Dynamics, 29:2* (2000), pp. 1-5.

Fleet and Facilities Division, "Facilities Maintenance," The City of Milwaukie, http://www.cityofmilwaukie.org/departments/fleetfac/fleetfac.html (accessed January 2, 2008).

Grantham Lough, K. A., R. B. Stone, and I. Y. Tumer, "Failure Prevention through Effective Cataloging and Utilization of Historical Failure Events," *Journal of Engineering Failure Analysis*, publication pending.

Grantham Lough, K., Robert Stone, and Irem Y. Tumer, "Function Based Risk Assessment: Mapping Function to Likelihood," *Proceedings of 2005 ASME International Design Engineering Technical Conference*, American Society of Mechanical Engineers (September 2005), pp. 1-8.

Grantham Lough, K., Robert B. Stone, and Irem Tumer, "Prescribing and Implementing the Risk in Early Design (RED) method," *Proceedings of 2005 ASME International Design Engineering Technical Conference*, American Society of Mechanical Engineers (September 2006a), pp. 1-9.

Grantham Lough, K., Robert B. Stone, and Irem Tumer, "Risk in Early Design (RED) Method: Likelihood and Consequence Formulations," *Proceedings of 2005 ASME International Design Engineering Technical Conference*, American Society of Mechanical Engineers (September 2006b), pp. 1-10.

Greer, James L., Michael E. Stock, Robert B. Stone, and Kristin L. Wood, "Enumerating the component space: First step towards a Design Naming convention for Mechanical parts," *Proceedings of the ASME Design Engineering Technical Conference* (September 2003), pp. 1-10.

Hamilton, Stewart, and Alicia Micklethwait, *Greed and Corporate Failure: The Lessons from Recent Disasters*, Palgrave Macmillan (2006).

Hirtz, Julie, Robert B. Stone, Daniel A. McAdams, Simon Szykman, and Kristin L. Wood, "A Functional Basis for Engineering Design: Reconciling and evolving previous efforts," *National Institute of Standards and Technology*, US Department of Commerce (February 2002), pp. 1-21.

Holland, Rob, "Planning against a business failure," *Agricultural Extension Service*, The University of Tennessee, Agricultural Development Center, Info #24 (October 1998), pp. 1-4.

Human Resources Department, "Human Resources Department - Staffing and Structure," Highlands and Islands Airports Ltd., http://www.hial.co.uk/human-resources-department-staffing-structure.pdf (accessed January 2, 2008).

Industrial Management, "Development of New Products," University of Bolton, http://www.ami.ac.uk/courses/ami4088_im/unit_02/index.asp#2.1 (accessed January 1, 2008).

i2E Inc., "Business Risk Assessment," Oklahoma Commercialization Model (2007), http://beta.i2e.org/uploads/Business%20Risk%20AssessmentPDF.pdf (accessed January 2, 2008).

IT Department, "IT Department functions," Dr. CAFE, http://www.dr-cafe.com/non-flash/about_us/company_profile.html (accessed December 28, 2007).

Kurfman, Mark A., Michael E. Stock, Robert B. Stone, Jagan Rajan, and Kristin L. Wood, "Experimental Studies Assessing the Repeatability of a Functional Modeling Derivation Method," *Journal of Mechanical Design* (December 2003), pp. 1-8.

Layton, Roger, “Project Failure Modes: Lessons from the field,” NIRO Project Management (Pty) Ltd, Roger Layton Associates (Pty) Ltd., http://www.cssa.org.za (accessed January 2, 2008).

Legal Department, "Legal Department Functions," Elexon-The Balancing and Settlement Code Company, http://www.elexon.co.uk/contact/executiveTeam/departments.aspx (accessed December 15, 2007).

Management-Hub.com, “Why there is a need for different levels in Management,” http://www.management-hub.com/business-enterprise-management.html (accessed December 18, 2007).

McLean, Bethany, and Peter Elkind, *The smartest guys in the room: The amazing rise and scandalous fall of Enron*, Portfolio (2003).

Metropolitan Water District of Southern California, "Audit Department," http://www.mwdh2o.com/mwdh2o/pages/audit/audit01.html (accessed January 2, 2008).

Microsoft Dynamics Developer Center, “Business Components,” Microsoft Developer network, http://msdn2.microsoft.com/en-us/library/aa475166.aspx (accessed December 18, 2007).

Office of the Under Secretary of Defense, “DSMC Risk Management Guide for DoD acquisition,” 2nd Edition, Defense Systems Management College Press, Fort Belvoir, VA (May 1999), http://www.mitre-corporation.com/work/sepo/toolkits/risk/taxonomies/files/DOD_RM_Guide_2Ed.pdf (accessed January 2, 2008).

Operations Department, "Operations department Functions", ESV - The Swedish National Financial Management Authority http://www.esv.se (accessed December 16, 2007).

Pahl, G., and Beitz W., “Engineering Design: A Systematic Approach,” *Design Council* (1984), London.

Peltier, Thomas R., “Effective Risk Analysis,” Netigy – Driving E-Business Performance (2000), http://csrc.nist.gov/nissc/2000/proceedings/papers/304slide.pdf (accessed January 2, 2008).

Peltier Associates, “Facilitated Risk Analysis Process (FRAP),” http://www.peltier associates.com/frap.htm (accessed November 6, 2007).

Performance Improvement International, “Behavioral Cause Analysis of the 1999 Bonfire Structure collapse at Texas A&M University,” Report 00-1429, May 2000, Revision 0, pp. 46-48, http://www.chron.com/content/chronicle/special/bonfire/report/signatures.pdf (accessed January 2, 2008).

Performance Improvement International, “Projects,” Performance Improvement International, L.L.C. (1997), http://www.piionline.com/projects.html (accessed November 17, 2007).

Project Management Department, "Project Management Department Functions," Y Soft Ltd., http://www.ysoft.eu/project-management.html (accessed December 20, 2007).

Sales Department, "Functions of Sales Management," Basic Stuff, http://www.basic-stuff.com/business/salesmanship/sales-department.htm (accessed December 20, 2007).

Security Education Systems, "The Security Function," http://www.nvo.com/ses/security programseminar (accessed January 2, 2008).

Sims, Ronald R., and Johannes Brinkmann, "Enron Ethics," *Journal of Business Ethics, 45:3* (2003), pp. 243-256.

Socialstyrelsen, "Administrative Department," The National Board of Health and Welfare, http://www.socialstyrelsen.se/en/about/Administrative_department.htm (accessed December 12, 2007).

State office of risk management, "Risk Analysis," State of Texas, http://www.sorm.state.tx.us/Risk_Management/Business_Continuity/risk_components.php (accessed November 20, 2007).

Stone, Robert B., Irem Y. Tumer, and Michael Van Wie, "The Function Failure Design Method," *Journal of Mechanical Design* (May 2005), pp. 3-10.

System Transformation, "Business Risk Analysis," Tactical Strategy Group (March 2004), http://www.systemtransformation.com/Cont_Plan_Methodologies/cpgbusinessrisk.htm (accessed November 7, 2007).

Tesfatsion, Leigh S., "The Enron scandal and moral hazard," Lecture notes at Department of Economics, Iowa State University, http://www.econ.iastate.edu/classes/econ353/ tesfatsion/enron.pdf (accessed January 2, 2008).

The Brand Builder blog, "The functions of marketing department," http://thebrandbuilder.blogspot.com/2007/03/functions-of-marketing-department.html (accessed December 16, 2007).

Toffler, Barbara L., "Final Accounting," Mid-American Journal of Business, 20:2 (2005), pp. 66-68.

Tumer, Irem Y., Robert B. Stone, and David G. Bell, "Requirements for a Failure Mode Taxonomy for use in Conceptual Design," *Proceedings of the International Conference on Engineering Design*, Stockholm (August 2003), pp. 1-8.

Young, Michael R., *Accounting Irregularities and Financial Fraud: A Corporate Governance Guide*, 2nd Edition, CCH Inc. (2002).

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