

**Research Article**

Never Underestimate the Power of a Backhoe: Integrating Single Points of Failure into Strategic Planning

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Abstract

SWOT (strengths, weaknesses, opportunities, threats) analysis is probably used more often than any other management technique in strategic decision making. There appears to be a greater emphasis, however, on identifying strengths and opportunities while weaknesses and threats are examined less closely. Such bias may be problematic because firms may overlook single points of failure (SPOFs), which are elements that, upon malfunction, render an entire system unavailable or unreliable. These threats and weaknesses are most often presented in information technology and engineering discussions of equipment, machine, and device breakdowns, but may have applicability in a number of other areas important to organizations including people; materials and supplies; methods and processes; and shock events—natural and human-made disasters. To be resilient in today's 24-7, 365 days a year global business world, it is critical that organizations effectively anticipate, evaluate, prepare for, and mitigate SPOF risks that can have a seriously negative impact on a firm's performance. The paper concludes with a three-step approach to help managers reduce and effectively respond to SPOFs. Companies that integrate the concept of SPOFs into their strategic planning could develop high-impact management skill, leading to improved corporate profitability.

Keywords: Single points of failure; risk management; strategic planning

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Introduction

The world of work has become less predictable and more uncertain for organizations. To deal with this

situation and to help ensure their survival and growth, firms in recent years have heightened their interest in strategic planning [1]. Furthermore, research has found a generally positive relationship between strategic

planning and performance [2, 3, 4].

One strategic management planning technique widely used in industry and extensively taught in business schools is SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis which focuses on the examination of a business's internal and external environment with the aim of identifying internal strengths in order to take advantage of its external opportunities and avoid external threats, while addressing the business's weaknesses [5, 6].

Some research suggests that in performing SWOT analyses executives in firms tend to emphasize strengths and opportunities over weaknesses and threats [7]. This is consistent with findings that management tends to highlight good news more than bad news [8] that risks tend to be underestimated [9] that people's estimations of the future are often unrealistically optimistic [10, 11] and that most individuals have a slightly positive bias [12, 13]. There is even evidence that humans may be hard-wired for optimism [14].

While optimism, even mildly distorted positive perceptions, may be adaptive [15, 16] and is highly promoted in America [17], any advantage arising out of unrealistic optimism is likely to come at a cost. For example, an unrealistic positive assessment of financial risk is widely seen as a contributing factor to the 2008 global economic collapse [18, 19] and findings from Hmieleski and Baron [20] suggest that entrepreneurs' dispositional optimism may be negatively related to firm performance (revenue and employment growth). Also, Finkelstein [21] conducted a six-year, in-depth examination of 51 companies and found that executives of failed companies often clung to inaccurate views of reality that consistently underestimated obstacles. He noted that: "There was a regular lack of open-mindedness and devil's advocacy. Instead, blind adherence to 'positive thinking' became a dominant corporate value that was often at the foundation of organizational failure" [22]. It seems that managers' view of the future got in the way of the realities of the present, and when reality did surface, it was often whitewashed for reasons of face-saving and hubris.

Thus, there appears to be an unwarranted emphasis on positivity in organizations and what may be needed

is a more balanced SWOT approach which carefully examines weaknesses and threats confronting firms that, if not properly managed, become disruptive events that can escalate into emergencies, crises, or even disasters. This is exactly what a single point of failure (SPOF) analysis does.

Consider the picture above as involving a SPOF in the following hypothetical setting. An information technology (IT) executive at Orbitz, the online travel and hotel booking site, looked out her office window and saw the pictured backhoe. The firm went offline shortly thereafter because multiple electric cables entered the same conduit outside the building and this backhoe took them out all at once when it cut the lines with a single scoop. The power of this backhoe serves as a potent reminder of how suddenly a seemingly innocuous and trivial factor can morph into a very significant problem. Squirrels, like backhoes, can also exert considerable influence. This was vividly demonstrated when NASDAQ's entire data center was shut down because a squirrel chewed a power line [23]. Trouble, confusion, and chaos quickly developed at these facilities because of such incidents, referred to as a SPOF.

While the idea and application of SPOFs is often presented in IT and computer applications, this paper will show that it has applicability across a number of organizational domains and should be a key consideration in firms' strategic management deliberations as organizations conduct SWOT analyses, particularly weaknesses and threats. After a brief review of the definition of a SPOF, we discuss broad areas where SPOFs are likely to create problems and how addressing SPOFs in these areas contribute to a resilient organization. The paper concludes with a series of recommendations that could help improve management skills, thereby leading to stronger business performance and increased profitability.

Literature Review

Defining Single Points of Failure

A general definition of a SPOF is a point in a system

where, if a failure occurs, there is no redundancy (duplication of critical components or functions of a system with the intention of increasing reliability of the system) or backup to compensate for it so a failure could incapacitate an entire system, process, or business [24]. A SPOF involves those critical items and points of contact that, if disrupted, often cause serious problems [25]. SPOFs are the Achilles' heel of any organization and may significantly disrupt operations. They must be identified and contingencies developed so when a failure happens—and it will—organizations can quickly move to work around it. A dramatic example of a SPOF would be engine failure in a single-engine airplane.

In industrial networking and other contexts, a SPOF is “a part of a system which, if it fails, will stop the entire system from working” [26]. It is a critical system (sometimes called mission critical) component with the ability to cease or severely impede system operations during a failure. Other examples of SPOFs can be seen in companies with single products, like emerging bio-technology firms that have yet to receive full regulatory approval. If they do not receive favorable treatment for their product then the SPOF becomes the regulatory process, which, if not approved, could be catastrophic for their investors. Or, businesses that have over-reliance on one customer or supplier or depend on short-term funding (which, in turn, is dependent on credit ratings issued by a few like-minded, like-acting companies), are subject to quick and dramatic ends to their existence if these keystone parties fail or walk away. Also, consider a commonly used construction design for a residential building where fan coils are installed in each apartment and a lone large hot water boiler for the complex is used. The heater can be considered a SPOF.

Often times, firms can live with SPOFs on purpose due to resource limitations or opportunity costs reasons. If fixing a SPOF problem will cost a million dollars it might be better to accept that the potential down time is the better option if something goes wrong. Whether this is, or is not true in any given situation, is a complex business question much more than it is a technical matter [27].

Finally, it could also be that while there is some

redundancy built-in the system there was also a failure to think things through properly [25,24]. For example, a firm that needed high online availability had two Internet suppliers to provide assistance should one experience problems and become unavailable. Unfortunately, both providers ran their cables through the same physical conduit and if one errant backhoe severed the conduit, this redundancy was rendered useless.

SPOFs, identified as weaknesses or threats, are undesirable in any system requiring high availability during their stated hours of operation. Today's businesses often require systems that are operational 24 hours a day. Indeed, Marks [28] noted that “Enterprises of all sizes demand 24/7 application delivery. Server failures, maintenance downtime, and bad weather aren't excuses” (p. 43). High availability and reliability embody the idea of anywhere and anytime access to services, tools, and data and is the enabler of visions of a future with companies having no physical offices or of global companies with completely integrated and unified IT systems. If such systems fail the quality of the service or product provided may be significantly compromised, customer confidence lost, and in time consumers may go elsewhere for more reliable business [24].

Potential Single Points of Failure

IT professionals might think of a pesky router that could fail causing an entire office to lose Internet access. This is a common and very apt example, but the point is to look beyond the obvious IT hardware that is typically associated with SPOFs. With this in mind, five broad areas where SPOFs can be identified are addressed. They are in no particular order. These include Equipment, Machines, and Devices; People; Materials and Supplies; Methods; and Shock Events as outlined in Table 1 and described below. Readers will notice overlap among some of the content areas as they are not orthogonal, and some information may actually be contained in two or more areas. A brief discussion of potential SPOFs in these areas follows. This is not an exhaustive list but should provide some key examples that firms may use to begin identifying such weaknesses and threats.

Table 1 Potential Single Points of Failure

Equipment, machines, and devices	Due to lacking redundancy/backup equipment
People	Lack of cross-training employees and/or succession planning
Methods	Caused by lean management, less inventory
Materials and supplies	Due to poor supply chains or scarcity of supply
Shock Events	Caused by nature and/or man-made crises

Equipment, machines, and devices

Historically, SPOFs have been identified with respect to equipment, machine, or device failure (e.g., transformers, power distribution units, and switches) in IT-related areas. For example, a typical laptop has one keyboard, one screen, and one CPU, all of which represent a SPOF. A set of dual servers with redundant hard drives and multiple network connections is built for high-availability, however, and so it would take a lot more to go wrong before a failure is experienced.

Consider a recent example: “Southwest Airlines expects some lingering delays Saturday morning after a system-side computer failure caused it to ground 250 flights for nearly three hours late Friday night. ... The computer system was ‘running at full capacity’ by early Saturday. Before that, though, officials used a backup system that was much more sluggish” [29]. This incident followed other airline computer difficulties. In April, 2013 American Airlines grounded all of its flights nationwide for several hours due to computer problems. The airline ultimately canceled 970 flights. And in 2012, United Airlines had two major outages: one in August which delayed 580 flights and another in November negatively impacted 636 flights.

SPOFs can occur in other, less technologically advanced areas. For instance, the owner of the lawn care company may have spare parts ready for the repair of the mower or edger, in case it fails. At a higher level, he or she may have a second mower or edger that they can bring to the job site. Finally, at the highest level, they may have enough equipment available to completely replace everything at the work site in the case of

multiple failures. In sum, one machine equals a SPOF.

Various engineering applications, especially reliability engineering, safety engineering, and quality engineering have been used to identify and correct SPOFs including Reliability Hazard Analysis, Event Tree Analysis, What-If /Checklist Analysis and Failure Mode and Effects Analysis (FMEA). The most widely utilized approach is FMEA which was developed during World War II and is recognized as an essential function in design from concept through to the development of every conceivable type of equipment. It is commonly defined as a systematic process for identifying potential design and process failures before they occur, with the intent to eliminate them or minimize the risk associated with them [30]. A detailed discussion of these engineering protocols is, however, beyond the scope of this paper.

People

An individual’s given skillset or knowledge set, if removed, can be devastating to an organization and may also be considered a SPOF. For example, if a firm had only one person who can control a critical server, then that person is a SPOF. If that same person suddenly has to take an extended leave or had something unfortunate happen to them, the organization may or may not be able complete the tasks associated with that critical server until the missing resource is replaced. However, if the business had previously insisted that the key person train another individual or two, then the system could continue to function at some level without the original resource. In

this case, the enterprise has just built redundancy into its staff and eliminated a SPOF.

Regrettably, all too often leaders allow people to become SPOFs. A human SPOF is a person whose absence (sickness, physical or mental disability, death, resignation, termination, moral incapacity, etc.) may endanger the well-being of a business. These are people who are in strategic positions and who have power over important aspects of an organization with no one else to replace them in case of a failure. Sometimes companies depend too much on one salesperson for their revenues and when he or she leaves the organization's survival becomes problematic. Similarly, some organizational functions have been managed exclusively by one person within the firm without back-up of documented procedures or individuals cross-trained in the specialty.

People SPOFs involve the information, knowledge, and skills they possess. It could be an employee—the firm's top engineer or the individual who handles servers. If something happens to that person then the situation can quickly escalate to a disaster if the business needs passwords or system keywords or encryption codes to get its data or its clients' data. It could be that one person in the organization knows the combination to the safe or the bank account PIN or the password. These SPOFs are probably the riskiest of all [31].

Human SPOFs also often happen in project management where a team member who is the sole possessor of critical knowledge leaves the project suddenly. Additionally, the research literature attributes the long-term failure of many downsizing efforts to its destroying organizational memory [32,33], often defined as the accumulated body of data, information, and knowledge created in the course of a firm's existence [34]. To prevent this SPOF where someone's departure or termination causes a subsequent hardship or disruption due to that person's company knowledge ("He knew where all the bodies were buried") the organization must ensure that no single employee knows all [35].

This may be particularly important from an information security standpoint where limiting access to knowledge and information is a key tenet [35]. When an individual possesses anything others require that he or she alone

controls, that person makes others dependent on them and therefore they gain power and clout over others [36,37]. There is no doubt that information is a source of power [38]. Interestingly, these people SPOFs are often created by the individuals themselves in order to enhance their influence because of the information and the knowledge that they possess [39]. Remaining a SPOF is the goal of many of these persons because if no one else can do their job, they will have a strategic advantage over others and will not have to worry about their job security. Those individuals can be identified because they: 1) avoid documenting their procedures or information; 2) do not take off for holidays and vacations; 3) insist on being on call 24/7; and 4) keep their supervisors uninformed about their work activities [40].

Consider some examples. Imagine telling a global sales force that the business cannot pay their commission this month because the compensation specialist was sick. Likewise, when a purchasing manager was on vacation, vendors were not paid because no one in the office knew the detailed, but unwritten, procedures for paying these sellers. A university that had significantly increased its online presence using Blackboard, a Web-based learning management system designed to support fully online courses, came undone for some time because the lone in-house administrator of this course delivery system decided to retire on short notice to help care for her husband who was injured in an automobile accident.

Executives should carefully review these aircraft incidents. Shortly after 4p.m. on a snowy January 30, 1980, a Kellogg Company aircraft crashed into frigid Lake Michigan just after an attempted takeoff at Meigs Field, Chicago, Illinois. Of the four advertising executives and two crewmembers aboard, one passenger and one crewmember were killed; the other four persons were injured seriously. The aircraft was destroyed [41]. In 1981 Texasgulf, Inc. lost six key executives when its corporate jet crashed at Westchester Counter Airport in New York and a 1987 crash of PSA Flight 1771 killed the president and three other managers of Chevron USA and three officials of Pacific Bell [42].

Such losses have prompted organizations to implement management succession planning [43] and for organizations to implement travel policies that might limit such SPOFs. For instance, at Northwestern Mutual Life Insurance Company of Milwaukee, the president

and only one of the three executive vice presidents may fly together and no more than three executive officers may be on the same plane. The policy also indicated that no more than six officers may fly together, and if the officers are all from the same department then the maximum traveling together is three [42].

This issue of human SPOFs can be raised by asking two questions regarding key people: “What will we do if ‘Joe’ wins the Lottery?” or “What will we do if ‘Josephine’ falls under a bus?” Such questions are euphuisms to describe a myriad of scenarios to consider in which each case the outcome is the same—Joe or Josephine, along with all of their skills, experience, and specific knowledge, are no longer part of the firm.

Methods

A third area where SPOFs might be located is in the methods, tactics, and procedures used by businesses. The continuing focus on operational efficiency and cost optimization has been a strategic priority over the last several decades, helping corporations lower the cost of manufacturing through outsourcing, off-shoring, and other practices. Cost reduction efforts have often outweighed other strategic priorities leading to vulnerabilities [44]. Here we discuss lean thinking and management, diversification, centralization/decentralization, and outsourcing.

Lean management and thinking. Lean manufacturing, lean enterprise, or lean production, often simply referred to as lean management [45,46] is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Essentially, lean is centered on preserving value with less work.

Lean thinking embodies a set of design principles that guide an organization to deliver its purpose more effectively while continuously improving service delivery, and systematically reducing all forms of waste and ultimately contributing positively to society. Pioneered in organizations around the world but maybe most famously in Japan, lean thinking looks at each organization as an inter-connected *system*. By providing a method for every department and person to work together to improve the quality of their work, and to eliminate everything that does not add value (termed

waste and including rework, delays, errors, breakdowns, bureaucracy, etc.), the enterprise can systematically improve its business.

Companies that once kept backup inventory in place may have exposed themselves to additional risk as they concentrated on working with fewer redundancies. One lean management technique is the just-in-time (JIT) inventory system. JIT (also known as lean production or stockless production) is a system in which component parts arrive from suppliers just as they are needed at each stage of production. By minimizing inventory, JIT frees up resources to employ elsewhere in the company. JIT began to be adopted in the U.S. in the 1980’s (General Electric was an early adopter), and the JIT/lean concepts are now widely accepted and used.

With no stocks to fall back on, a disruption in deliveries to the business could force production to cease on very short notice—a SPOF. Such was the case with an explosion at Evonik Industries AG plant in Marl, Germany in March, 2012 which removed about 40 percent of the world’s 220 million pounds of annual Nylon 12 capacity, a high-performance and high-cost material having a precise blend of chemicals that resists reacting with gasoline and brake fluids. The JIT inventory approach practiced by many of these automobile manufacturers created a SPOF and this production shortfall at a single German auto-parts supplier created chaos in the global car business [47]. Perhaps there is room for not only “just-in-time” but also for “just-in-case.”

Often lean thinking has been interpreted as the “doing more with less” imperative to reduce overhead, maximize efficiencies, and eliminate redundancies. Redundancy elimination has become popular in recent years [48]. However, this tactic can be problematic because redundant configurations (back-ups) have historically been employed to mitigate SPOFs [24]. Indeed, minimizing SPOFs through redundancy is a fundamental tenant of mission-critical elements and refers to an activity, device, service, or system whose failure or disruption will cause a failure in (business) operations and an inability to carry out its mission [49]. For example, the U.S. space shuttle had four back-up computers so as to eliminate SPOFs on the orbiter [50].

Support for redundancy was also indicated as critical

for the survival of the New York Stock Exchange (NYSE) and American Stock Exchange (ASE). In a letter to the Securities and Exchange Commission Bloomberg Tradebook [51] noted "... that the events of September 11 have taught us that we should reduce our reliance on single points of failure and that redundant, geographically dispersed facilities are needed to provide a sound systemic infrastructure for the securities markets and to ensure continuity in the event of a major, wide-scale disruption."

Finally, consider the sad situation of Land Rover, the British automobile manufacturer, found itself in when there was no redundancy or backup. In 2001, UPF Thompson, Land Rover's *only* supplier of chassis for the Discovery SUV, declared bankruptcy protection. Land Rover was unable to predict the impending bankruptcy in order to take preventive actions. By some accounts, the director of purchasing at Land Rover had 900 accounts to manage and did not maintain a close relationship with UPF Thompson and eventually it demanded \$US65 million from Land Rover in exchange for resuming chassis shipments [52]. The result was an out-of-court settlement payment from Land Rover to UPF Thompson to stop a delay in the supply of chassis shipments [53].

Does redundancy eliminate failure? Absolutely not! Redundancy serves as the response to when failure occurs, but one should never assume that buying duplicate components or installing dual processes is all that is necessary. In many cases, the systems are designed and installed without full analysis of the entire chain. This means the owner has made large investments in, for instance, costly additional power and cooling equipment and yet be vulnerable to one circuit breaker, valve, or other SPOF in the infrastructure that has either been overlooked or misunderstood.

Moreover, built-in redundancy can be expensive. Consider the case of Morgan Stanley, the famous investment bank. After The World Trade Center (WTC) bombing occurred on February 26, 1993 in which six people were killed and more than a thousand injured, senior management recongized that working in such a symbolic center of the U.S. commercial power made the company vulnerable to attention from terrorists and possible future attack and thus launched a program of preparedness which involved three recovery sites where employees could congregate and business could take place if the WTC workplace was disrupted. As indicated by

former President and COO Robert G. Scott, "Multiple backup sites seemed like an incredible extravagance on September 10 [2001], but on September 12 [2001], they seemed like genius" [54]. Redundancy—planned and well-thought out—is not a bad word as some argue today!

Diversification. Diversification is a second method presented. It was mentioned in the *Bible* as a valuable strategy some 3000 years ago: "Invest in seven ventures, yes, in eight; you do not know what disaster may come upon the land" [55]. Failure to diversify may lead to increased SPOFs.

Diversification could be referred to as incorporating the idiomatic phrase, "Don't put all your eggs in one basket," meaning that an organization should not focus all its resources on one hope, possibility, person, supplier, customer, course of action, or avenue of success. If that one thing fails the firm will be "broken" and left with nothing (no eggs). Businesses should consider spreading their assets or eggs or anything else of value. Then it has a few baskets, and if one is dropped then it is not so devastating.

The same scenario can be observed in personal financial investment and stocks purchases. If a person invests their money in a single portfolio of stocks or in a single project trusting that it would succeed, the investor is putting their money in a SPOF position. Such a strategy exposes investors to the risk of losing that investment. Hauser [56] reports that in the case of Enron, many employees had too much of their 401k plan invested in Enron company stock when in 2001 the stock fell and lost almost 99% of value in six weeks. Approximately 11,000 Enron employees lost \$1 billion in their retirement investment accounts. This is why it is important to diversify financial investments to avoid risks [57]. A well balanced portfolio of investments helps spread resources around in a way that will not cause any considerable financial losses in case the investment does not succeed. Moreover, some researchers have further argued that geographic diversification in one's portfolio would generate superior risk-adjusted returns by reducing overall risk while capturing some of the higher rates of return offered by the emerging markets of Asia, India, and Latin America [58, 59].

As indicated earlier, geographic dispersion was advocated to partially dissipate SPOFs in the securities business [51]. Such geographic diversification will help eliminate SPOFs and may be particularly important after a disturbing event like the

eruption of the Icelandic volcano Eyjafjallajökull in April, 2010 which caused chaos in supply chains the world over. As air traffic to and from northern Europe ceased, many companies sourcing from the region scrambled to make alternate arrangements. Nissan, for example, obtained pneumatic tire pressure sensors from only one plant in Ireland. When the airspace closed, planes could no longer service the Irish plant and Nissan's supply of the sensors was quickly exhausted. The company was forced to temporarily suspend production at its plants in Fukuoka and Kanagawa, Japan and the disruption barred the production of several thousand vehicles resulting in significant unplanned costs [25].

The importance of geographic dispersion in minimizing risk and maximizing uptime was once again in play in October, 2012 when hurricane Sandy devastated the Northeast (particularly New York and New Jersey) causing an estimated \$68B in losses. Firms with multiple locations outside the coastal areas of New York and New Jersey were impacted less severely than those having only one location in the areas hit by the super storm or several sites all within the storm's destruction zone.

A key learning take-away is that if organizations are going to source mission-critical parts from any supplier—local or overseas—they would do well to make sure they have at least one alternate means of getting it, preferably from another geographic region. That, or pay to stockpile it close to home. Make sure everything is not hinging on one SPOF. These options to eliminate SPOFs cost money and time but compared to the cost of failing to deliver it may be money well spent.

Another example of “geographical diversification” was illustrated by NASA's design of space shuttle. Not only were catastrophic failures (SPOFs) minimized by spreading redundancy among several simplex circuit computers but these computers were also physically located in various parts of the spacecraft [50] so that a problem (e.g., mini explosion) in one location of the orbiter would not destroy all the essential components.

Other SPOF problems related to diversification involves over-reliance on one customer or supplier. It can happen where, over time, the business derives most of its revenue or profit from a single customer. This can happen for many reasons, including, but not limited to having a great relationship with the customer, or doing business with a much

larger customer. While this is natural in a start-up, overreliance on a single customer often puts the supplier company at high risk, as effects from economic downturns could have a negative ripple effect to the suppliers' business. The risk is that if anything should happen to impair an organization's ability to sell to this customer, its own business profitability is put at significant risk. Firms are well advised to review their customer list periodically to determine whether a significant portion of their revenue is earned from one customer or just a few customers. It is also prudent to have contingency plans in place for how a business should respond in the event such significant customers are lost.

A business can also become over dependent on a supplier, for example, when a key part of a firm's product is available from only one supplier. If that supplier stops producing it, an organization may be required to redesign their product to accommodate parts from other sources. Consequently, the business is unable to continue producing and selling its product until this issue is resolved. Cash flow and profitability could be severely impaired. It is recommended that firms evaluate their suppliers periodically and determine whether alternate sources of necessary supplies or parts are available.

Interestingly, this concern is seemingly at odds with quality guru Edwards Deming's [60] suggestion that organizations “Move towards a single supplier for any one item, on a long term relationship of loyalty and trust” (p. 23). According to Deming, multiple suppliers mean variation between materials and moving toward a single supplier and creating a strong relationship with that supplier will eliminate or reduce variation and layers of management that has to manage all the suppliers. He argued that robust quality arrangements cannot be adequately arranged across a multitude of suppliers. Deming's advocacy of single source long-term relationships seems to conflict with the identification of SPOFs and the importance of having redundancies as a tool to eliminate them. Perhaps a compromise position would be to have a small number of suppliers with which an organization should develop close working relationships.

Centralization/decentralization. Centralization involves the positioning of key departments, functions, and/or personnel at one place. It is where resources are consolidated in a single location and if damage occurs to that resource then all dependent systems are affected.

The primary advantage of centralized systems is their simplicity. Because all data is concentrated in one site, centralized systems are easily managed and have few questions of data consistency or coherence. Centralized systems are also relatively easy to secure, since there is only one host to be protected. Such a structure can be managed by a small team or an individual. The traditional argument for centralization was that it created economies of scale with lower costs, simplicity of implementation, and allowed specialization of tasks that improved staff efficiency [61, 62]. Moreover, administrative overhead is low because all changes, maintenance, repair, replacement, and security are made in a single location and such changes affects the entire system.

The drawback of centralization is the system's heavy reliance on a few central components; if the elements are disrupted, either accidentally or through hostile action, the system and its peripheral components are severely affected. Indeed, centralized anything can become a SPOF for all applications [63, 62]. Sony, Citigroup, and the US government are just a few of many organizations that have discovered that storing large amounts of sensitive data on single, centralized networks or in single databases while cost effective, makes them highly desirable targets for cyber-thieves. If the security protecting them has a SPOF, the personal or embarrassing information in those files may find its way to criminals, public websites, or other places where it could cause great harm. These may not be fatal events for those organizations, but they are bound to be costly and affect their ability to achieve corporate goals for quite some time [64]. Organizations that use centralized architectures incur significant vulnerabilities and the risks grow exponentially because of the SPOF inherent in such systems and because they present attractive targets for terrorists and hackers. "Centralized systems look strong, but when they fail, they fail catastrophically" [65]. As one commentator noted, I am not in favor of a centralized computing approach any more than I like the idea of having one huge power plant lighting up half a state—it's just bad design, because there is no fault tolerance when everything relies on one provider [66].

In contrast to centralized structures, distributed

systems often require several teams or multiple individuals. Administrative overhead is higher because the changes must be implemented in numerous locations. Maintaining homogeneity across the system becomes more difficult as the number of access control points increases. "Decentralized access control does not have a SPOF" (p. 27) [67]. If an access control point fails, other access control points may be able to balance the load until the critical point is repaired, plus objects that do not rely upon the failed access control point can continue to interact normally. In a decentralized set-up, multiple elements/factors need to be serviced and monitored individually, which increases costs. Decentralized data is more cumbersome, requires time-consuming maintenance, and generates higher costs than centralized storage—but has no SPOFs.

Outsourcing. A final consideration includes outsourcing which involves contracting out in-house functions to outside firms [68]. The strategy behind outsourcing is one where the organization focuses on its core competencies and then hires out the remaining business functions to contractors [69]. Core competencies are particular strengths relative to other organizations in the industry, which provide the fundamental basis for the provision of added value [70]. A key reason for outsourcing is cost reduction [71] and Domberger and his team found that organizations that outsource services are able to cut costs by about 20% without affecting service quality [72,73,74]. Another important reason for outsourcing is that it allows firms to focus on their core responsibilities and address more strategic issues [70].

It remains important, however, what kinds of operations and activities are outsourced. Some commentators [75, 76, 69] suggest that only non-mission critical services be outsourced including such activities as web site development/hosting, janitorial services, security services, courier services, payroll services, window cleaning, and catering. This enables firms to focus on their core competencies and mission critical activities whose disruption or interruption often result in the collapse of business operations. Unfortunately, Dorasamy, Marimuthu, Jayabalan, Raman, and Kaliannan [77] reported that some firms are off-loading even their core business operations (i.e., mission critical) and are therefore

exposing themselves unnecessarily to SPOFs. They found in their study that 33% of core business operations were outsourced, representing a possible significant threat to firm performance.

Kumar and Eickhoff [75] suggest that if a job, task, or function is a core competency it is still possible that it can be outsourced, provided it gets through three tests. First, if the processes, equipment, capital, and employees are in place to deliver to customer needs, then there is no need to outsource. If it truly is a core competency, the determination of which is problematic for many firms [70], then the company should be able to provide value and should not give the business to someone else. Secondly, if the quality is sufficient to meet customer demands, the function should not be outsourced. Finally, one last exception to the core competency rule is that if the needs are short-term, that is, if the marginal increase in capacity provided by the supplier meets the needs for the organization, then outsourcing can still be considered. Regrettably, many firms do not go through such a systematic process and leave themselves open to SPOFs—the outsourced vendors and suppliers.

A noteworthy disadvantage to outsourcing, particularly strategic functions, is that an organization is putting part of its company in someone else's hands. Senior administrators have to ask themselves if the outsourced company can be trusted, if they think it will stay in business, and if they can adapt to the firm's growing and changing needs. A clue from former Intel CEO, Andy Grove, on how firms should respond is indicated in the title of his classic text—*Only the Paranoid Survive* [78].

Shock events

A shock event refers to “a sudden and unexpected event that may cause significant stress in individual organizations, seriously threatening their profitability and existence” (p, 616) [79]. Shock events refer to major happenings caused by either natural phenomena such as hurricanes or human-induced calamities like terrorism that create major disturbances in organizations. Adversities come, often without warning and it is therefore essential for companies to identify SPOFs in cases of shock events. What is needed is a focus on the need to be able to withstand the unexpected.

While many companies plan for their financial growth and success, many do not take productive steps in advance to deal with such shock events and the SPOFs they often create. Considering possible scenarios and how best to prevent, prepare and provide interventions allows organizations to become better prepared to handle crises [80]. In scenario planning a group of executives set out to develop a small number of scenarios—stories about how the future might unfold and how this might affect an issue that confronts or threatens them. Schwartz [81] describes scenarios as stories that can help firms recognize and adapt to changing aspects of their present environment. They form a method for articulating the different pathways that might exist for it tomorrow, and finding appropriate movements down each of those possible paths. Scenario planning, as a strategy for crisis management, provides a mechanism to think through the different ways these scenarios could develop and the best business response. Through crisis management planning, organizations can be better prepared to handle unforeseen events that may cause serious or irreparable damage. Broad shock events considered here include natural and people-made crises. Such shock events need to be seen as important concerns for managers.

Natural crisis. Natural disasters are presented in many forms—storms, floods, wild fires, mud slides, tsunamis, volcanic eruptions, pollution, avalanches, hurricanes, typhoons, and epidemics. No one likes to reflect on the possibility of a disaster. Yet disasters do occur and it is important to think about the factors that could impact business success before they occur [82]. A number of firms have been severely impacted by a recent spate of environmental disturbances outside the direct control of organizations. These issues can be considered SPOFs for firms and while not controllable can disrupt or suspend an organization's (or plant's) operation. Today's business environment requires a robust review to deal with significant unexpected catastrophic events or incidents should they develop.

Consider the following recent incidents reported by Morley [83] and how far the consequences of such risks can extend:

- Icelandic Volcano (2010)—Volcanic ash in the atmosphere shutdown much of Europe's airspace for a

number of days, bringing significant disruption to air freight shipments

- Japanese Earthquake/Tsunami (2011)—Earthquake brought severe devastation to utility infrastructures and the resulting tsunami brought longer term disruption to global supply chains due to many factories being flooded causing production to be halted
- Thailand Floods (2011)—High tech supply chains were severely impacted by the floods in Thailand which resulted in the disruption in the supply of key components such as hard disk drives to the computer industry.

People-made crises. On the other hand, people-made disasters appear due to the accidents and hostile acts, such as fires, arson, industrial explosions, cybercrime, computer viruses, union strikes, political upheaval, riots, insurgency, crime, terrorism, or war. The negative impact is obviously influencing the international economic environment. For example, the Asian economic crisis in 1997 had a profound negative effect on regional as well as international commerce.

Or consider the March 18, 2000 ten-minute fire in an assembly unit at a supplier plant in Albuquerque, New Mexico which caused a supply chain crisis for the cell phone division of Ericsson [84]. Though the fire was small and no workers were injured, the assembly unit was in a clean room. The resulting sprinkler and smoke damage caused the assembly unit at the supplier plant to shut down for three weeks, and the unit required six months to return to 50 percent efficiency. The assembly unit operated without replacement equipment for years (i.e., no redundancy). Ericsson was solely reliant on the supplier for a particular component and, because of the lack of supply from the assembly unit, production of the cell phone at Ericsson stopped. What elevated this to crisis level was that the fire occurred at a booming market window, which Ericsson subsequently missed completely. The \$200 million physical loss was covered by business interruption insurance, but this SPOF was a nontrivial contributor to Ericsson's eventual exit from the cell phone business altogether [53].

Other people-made disasters might include political and social challenges. They are wide-ranging and have different impacts on organizations, depending on sector, geographic location, and type of operation. Some

businesses are prone to social and political risk because of the location of their facilities, their product and customer characteristics, the nature of their employment relationships, or industry characteristics, etc. Well-known examples include Nike, Wal-Mart, and Shell, as well as the notorious social risks associated with industries like mining, footwear, toys, apparel, and chemicals. Also, varying social and political risks, and degrees of risk, affect companies located in specific countries or regions of the world.

Political risk can generally be understood as execution of political power that threatens a company's value including such actions as bomb threats, acts of terrorism, civil unrest, confinement or imprisonment of employees/family, legal or regulatory change; military coup; nationalization or unilateral expropriation, and kidnappings.

Social risk, on the other hand, relates to the potential impact of such things as the infringement of the rights of indigenous peoples and challenges by stakeholders due to negative perceptions of business practices—all of which can jeopardize a company's value [85]. Consider the social risks encountered by the following organizations:

- Nike was accused of employing children as young as ten years old in Cambodia and Pakistan to produce sneakers, clothing, and footballs, leading to consumer boycotts. Most consumers did not differentiate between the company and its subcontractors;
- Food and beverage companies have been associated with the obesity epidemic; McDonald's has been accused of encouraging obesity through marketing its products and Kellogg's has experienced reputational costs because of the high sugar levels in (particularly) children's cereals;
- Prescription drugs and their producers (e.g., Merck) have been linked to developing countries' lack of access to essential medicines. HIV/AIDS drug producers were boycotted because they would not lower product prices in South Africa [85].

More recent shock events involve terrorism threats and activity. Acts of terrorism may be defined as "a

systematic and persistent strategy practiced by a state or political group against another state or group through a campaign of acts of violence to achieve political, social or religious ends” (p. 252) [86]. These shadowy, mobile, and unpredictable forces have become an integral part of business in the international context and may present SPOFs for firms.

Materials and supplies

One of the major factors affecting a manufacturing firm’s ability to sell its products is procurement of materials and shipment of supplies in a timely and cost-effective manner. Two key areas where SPOFs can surface in this area include resource scarcity and supply chain considerations.

Scarcity. The world’s growing population, an increase in GDP levels, and changing lifestyles are causing consumption levels to rise globally—creating a higher demand for resources. Governments and companies are becoming increasingly cognizant of the scope, importance, and urgency of the scarcity of both renewable and nonrenewable natural resources including energy, water, land, and minerals. In a series of interviews to see what impact such a scarcity would have, and where, over the next five years, PricewaterhouseCoopers [87] interviewed 69 senior executives in seven different manufacturing industries across the three regions of The Americas, Asia Pacific, and Europe.

The study found that the risk arising from minerals and metals scarcity is expected to increase across all industries in the next five years. Among the minerals and metals on the “critical” list are:

- Lithium: used in wind turbines and lithium-ion batteries in hybrid cars.
- Beryllium: a lightweight component used in military equipment and in the aerospace industry in high-speed aircraft, missiles, space vehicles and communication satellites.
- Cobalt: a material used in industrial manufacturing. Used in jet turbine engines and automotive rechargeable batteries.
- Tantalum: used in mobile phones, computers and automotive electronics.

- Fluorspar: used in construction, cement, glass, iron and steel castings.

Managing scarcity is about ensuring that the right amount of materials and resources are present in the right place in the right form. Two dimensions play a role here: physical, and political. Physical scarcity relates to the availability of resources and is affected by the depletion of non-renewable reserves and the sufficiency of renewable resources and stocks. The geopolitical dimension relates to the functioning of policy and involves such aspects as trade barriers, export disruptions, and national and international conflicts. For example, the Chinese government placed a restriction on the export of rare earth materials which effectively meant that key electronic components could not be manufactured. China holds nearly 90% of the world’s supply of rare earth materials at the moment which presents a significant SPOF for some organizations [88].

Supply chains. The interconnected web of suppliers, production facilities, and related systems used to accomplish this feat is globally referred to as the supply chain [89]. Many companies switched from “local” suppliers to “low cost” and often distant suppliers on the basis of cost optimization, without considering the cost of risks caused by this strategic maneuver. Larger companies today frequently buy from smaller suppliers in very remote areas of the globe. The extended supply chain now has many additional points of potential failure, requiring new approaches to risk management. Companies face longer logistics lead times as well as new and unfamiliar risk profiles encompassing natural disasters, epidemics, and social, political, or monetary instability. A global supply chain also increases risks related to supply chain integrity, compliance, and quality control. By stretching supply chains across borders, any small mistake or interruption along the way can easily become a crisis [90]. A crisis in a supply chain has the potential to put a complete stop to production and shipping [91].

Additionally, relationships with remote partners are subject to differences in business and cultural practices. Such risks are difficult to forecast and monitor, creating gaps in the risk management capability for most companies. Realizing the systemic nature of supply

chain risks, some companies are reviewing their purchasing strategies and practices, and rethinking the way they are doing business so as to not let a supply chain become a SPOF.

A supplier may be affected by a customer in another market, as the customer difficulties trickle into their own market and cause supply chain disruptions. Unavoidable macroeconomic factors may also play heavily into the ability of suppliers to deliver. For example, in many markets, firms with mature and robust supply chains were subject to supplier bankruptcies and closures in the recession of 2008/2009 [92]. To reinforce this concern one should remember the situation indicated earlier when Land Rover realized that a single supplier of their chassis declared bankruptcy resulting in a production stoppage.

Civil unrest, shifts in government, and other similar situations may also have widespread effects on the availability of goods and services throughout a global supply chain [93]. Storms and other natural phenomenon may also disrupt shipping routes or prevent access to key ports and hubs. Moreover, the devastation of the 2011 Japanese earthquake/tsunami/nuclear disaster highlighted the need to look further upstream, beyond first-tier suppliers, to ensure that all the companies are not all in turn sourcing components from a single supplier. It is important to know and review a firm's suppliers' suppliers [94, 95]. Many second and third tier suppliers of components and materials used to make components were shut down by the Japanese disaster. This was important because before the earthquake/tsunami Japan supplied 90 per cent of the world's specialist resins used in the semiconductor industry. Felsted [94] noted that as a result of this catastrophe there will be a greater role for third party aggregators, which hold inventories for companies—but at a cost.

To limit SPOFs in their supply chains firms should consider utilizing multiple sources. Maintaining multiple sources for a single component or product line can appear cost prohibitive in that economies of scale may be foregone. However, the return on that investment is realized quickly in a crisis. Further, the effects of purchasing power based on reduced quantities can be mitigated in a multiple source environment by using the competition among the sources as a leverage tool [96].

These five broad areas highlight where SPOFs are

likely to be located in organizations. This is not an exhaustive list and other areas may be identified. The idea is that organizations should periodically and systematically analyze these areas where risks due to SPOFs are greatest and develop strategies that mitigate their impact and in so doing create a resilient firm.

Resiliency

Mann [97] noted that everyone should expect all systems to fail at some point in time. For those seeking to better govern their organizations, the focus must therefore be on creating systems that respond well to problems—ones that break well. No organization operates without an occasional hiccup. The goal is to successfully manage these missteps—to be resilient which Horne and Orr [98] refer to as “a fundamental quality of individuals, groups, organizations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior” (p. 31). It involves the ability to bounce back from untoward events [99]. Greed, accident, or malice may have harmful results, but, barring something truly apocalyptic, a resilient system can absorb such results without its overall health being threatened.

Resilience is about being able to overcome the unexpected. Researchers have identified several characteristics associated with resilience: the ability to face down reality [100], flexibility and adaptiveness [101], forward planning [102], improvisation [103], and skill in correcting errors and learning from them [104].

Facing down reality

A common belief about resilience is that it stems from an optimistic nature [54]. That is true but only as long as such optimism does not distort an organization's sense of reality. In adverse conditions, bright-sided thinking can actually be dysfunctional [17]. This was highlighted by management scholar Jim Collins who in his best-selling book, *Good to Great* [100], noted that superior companies practice this mind-set. Collins [100] discussed the Stockdale Paradox, named after Admiral James Stockdale, who was the highest ranking U.S. military officer held captive for eight years during

the Vietnam War. Interestingly, Admiral Stockdale indicated that it was always the most optimistic of his prison mates who failed to survive: “They were the ones who said, ‘We’re going to be out by Christmas.’ And Christmas would come, and Christmas would go. Then they’d say, ‘We’re going to be out by Easter.’ And Easter would come, and Easter would go. And then Thanksgiving, and then it would be Christmas again. And they died of a broken heart” (p.84) [100].

What the optimists failed to do was confront the reality of their situation. They preferred the ostrich approach, sticking their heads in the sand and hoping that the difficulties would just disappear. That self-delusion might have made it easier on them in the short-term, but when they were eventually forced to face reality, it had become too much and they could not handle it. Stockdale approached difficult situations with a very different mindset. He confronted the worst aspects of his current status with an optimistic faith: “You will prevail in the end, regardless of the difficulties. AND at the same time... You must confront the most brutal facts of your current reality, whatever they might be.”[105]

The Stockdale Paradox suggests that firms as well as individuals must be ruthlessly honest in identifying their SPOFs yet maintain a faith that they can overcome such obstacles. Hamel and Väikangas[106] said it similarly in their discussion of resilient organizations: “We must face the world as it is” (p. 56);and noted executive Jack Welch exhorted his managers to “Face reality as it is, not as it was or as you wish it to be” [107]. Believing that all is well is a self-deception which has no place in business.

This analysis can begin by simply asking key organizational members to assess where the firm may be dependent with respect to the broad areas identified: People; Methods; Materials and Supplies; Equipment, Machines, and Devices; and Shock Events. If the answer is “yes” then the firm will have identified potential SPOFs and may be “putting all its eggs into one basket” where the business runs the risk of the entire enterprise depending on that one element, the failure of which may disable the entire system/organization.

Flexible and adaptive

A second characteristic of resilient firms is flexibility.

Organizational success “... rides on resilience—on the ability to dynamically reinvent business models and strategies as circumstances change. ... In the past, executives had the luxury of assuming that business models were more or less immortal. Companies always had to work to get better, of course, but they seldom had to get different—not at their core, not in their essence. Today, getting different is the imperative” (p. 53) [106]. By learning how to be more adaptable, companies are better equipped to respond when faced with a crisis. Resilient firms often utilize these events as opportunities to branch out in new directions. While some businesses may be crushed by abrupt changes, highly resilient organizations are flexible and thus able to adapt and thrive.

Engaging suppliers and their networks in devising makeshift solutions to temporary disruptions is a flexibility strategy. So are policies that encourage flexibility regarding when and where work is done. Grobber and de Bruyn [108] found that employees who are familiar with telework and virtual workspaces adapt more quickly and are more productive following a crisis. In addition, research studies by Leslie, Park, and Mehng [109] and Sheffi and Rice [110] demonstrates that flexible work practices contribute to greater employee resilience, productivity, and commitment, in addition to lower levels of stress.

An example of flexibility and adaptation involved a 1997 fire at an Aisin factory in Japan which destroyed most of the precision machine tools used to manufacture P-valves rear brakes to prevent skidding. Toyota got 99% of its P-valves from Aisin. As a just-in-time manufacturer, Toyota had only several days’ supply of valves in its plants resulting in twenty plants closing which forced a production shortage of 14,000 cars per day. While the fire was still burning, Toyota and Aisin immediately collaborated to make emergency requests of their networks of suppliers. Aisin helped other suppliers improvise different production techniques, providing them with detailed plans and technical support. Two days after the fire, the first valves were fabricated and a week later, Toyota’s production line was back to normal, and five days of missed production were quickly made up. Two months later, Aisin resumed production at pre-fire levels [53].

Forward planning

Once SPOFs have been identified resilient organizations develop protocols to eliminate or attenuate their possible negative impact. Most corporations realize that the cost of effective risk management inherent in analyzing SPOFs is significantly lower than the cost of dealing with disruptions or failures. Forward planning measures pay for themselves many times over. In the context of heightened pressures on operating costs and the need to permanently improve business efficiency, the risk function will play a key role in identifying the best opportunities to rebalance operational efficiency with risk management. This is a key step to avoid unnecessary vulnerability in the operating model.

Proactive risk management is a common characteristic among successfully managed crises. Such decisions are made prior to the beginning of a crisis and usually made under more desirable circumstances, with more time for deliberation and implementation. Those companies that anticipated the potential for crisis and analyzed the potential effects on the supply chain were better suited to mitigate damages and potentially gain from a crisis [53]. As with the other positive key characteristics analyzed, systematic risk management requires an initial investment based on the potential risk, but has a positive return in a crisis.

Resilient organizations do not wait for errors to strike before responding to them. Rather, they prepare for inevitable surprises “by expanding general knowledge and technical facility, and generalized command over resources” (p. 221) [111]. If dependencies are identified then the organization can develop contingency plans to deal with several possible future events addressing these dependencies. As indicated earlier, SPOFs are often avoided by means of redundancy and in addressing these issues it might be helpful to recall that resilient organizations practice: “Redundancy: Backup, backup, backup. Never leave yourself with just one path of escape or rescue” (p. 92) [65]. Resilient organizations build in cushions against disruptions. The most obvious approach is the development of redundant systems—backup capacity, larger inventories, higher staffing levels, financial reserves, and the like. But those are costly and not always efficient. Improvisation may offer an alternative approach.

Improvisation

While planning is an important aspect of resilient organizations, as indicated earlier, prior theory also points to several reasons why improvisation can be a valuable and effective approach characteristic of resilient organizations and becomes a good complement to planning [112]. Vera and Crossan [113] “define improvisation as the spontaneous and creative process of attempting to achieve an objective in a new way. As a spontaneous process, improvisation is extemporaneous, unpremeditated, and unplanned. As a creative process, improvisation attempts to develop something new and useful to the situation although it does not always achieve this” (p. 728). Bruner [114] argued that such creativity is “figuring out how to use what you already know in order to go beyond what you currently think” (p. 183).

Resilient firms imagine possibilities and display inventiveness in solving problems and encourage people to be creative and spontaneously to solve problems that arise all day long.

Improvisation can be an effective choice when a firm faces environmental turbulence that requires action in a time frame that is shorter than a regular planning cycle. For example, Egge [115] describes how a salesperson might improvise when immediate action is required in the face of changing client demands; Dickson [116] suggests that fast learning and adaptation without much advance planning are important to firm survival; and Moorman and Miner [117] describe how a team improvised a new product formula in response to a surprise introduction of a competitive product.

Weick [118], however, worries that, because of the emphasis on spontaneity, researchers and practitioners may overlook the major investment in practice and study that precedes a performance, for example, a stunning improvisational jazz presentation. The observer may be unaware that jazz musicians have many years of experience learning the instrument, the standards, how to play together, how to blend a sound, etc. Similarly, improvisational actors learn exercises to develop the fundamental skills of listening and communication [119]. The point is that there is a foundation of expertise in improvising whether in music, theater, or management.

UPS tells its drivers to do whatever it takes to deliver packages on time. They encourage improvisation to solve all the small things that can go wrong every day. At the same time, they have clear rules and regulations, such as always putting their keys in the same place, closing truck doors the same way, making only right turns 90% of the time to save time and fuel, and so on. Those routines, combined with creative improvisation, allowed UPS to deliver packages the day after Hurricane Andrew struck, even to people temporarily living in their cars [120].

Learning from errors

Resilient organizations are concerned with high reliability and have learned to deal regularly with challenging, disruptive events. They identify practices that tend to generate problems and review past difficulties as learning opportunities. They are obsessed with failure [104]. This often starts with after-event reviews (also called incident reviews, problem investigations, or after-action reviews) in which people compare what they did in a crisis to what they intended to do, why it differed and how they will act in the future. It is a learning from experience procedure that gives learners an opportunity to systematically analyze the various actions that they selected to perform a particular task, to determine which of them was wrong or not necessary, which should be corrected, and which should be

reinforced. Individuals are asked to think about the event, project, or task, and systematically reflect on questions such as” What was supposed to happen and what actually happened and why, what worked, what did not and why, and what should be done differently next time. In sum, after-event reviews enable individuals and groups to reflect on their performance and to understand why objectives were not accomplished, to know what lessons can be drawn from their past experience, and to evaluate how these lessons can be quickly internalized to improve performance [121].

Conclusion

Recommendations for Overcoming Single Points of Failure

Firms have the ability to overcome or mitigate SPOF’s through effective use of established management techniques. These techniques outlined in Figure 1and described below can be important ways to improve overall corporate management, which could then lead to improved enterprise performance and profitability. Adopting these practices would seem to be in the best interests of corporate leaders, owners, and investors.

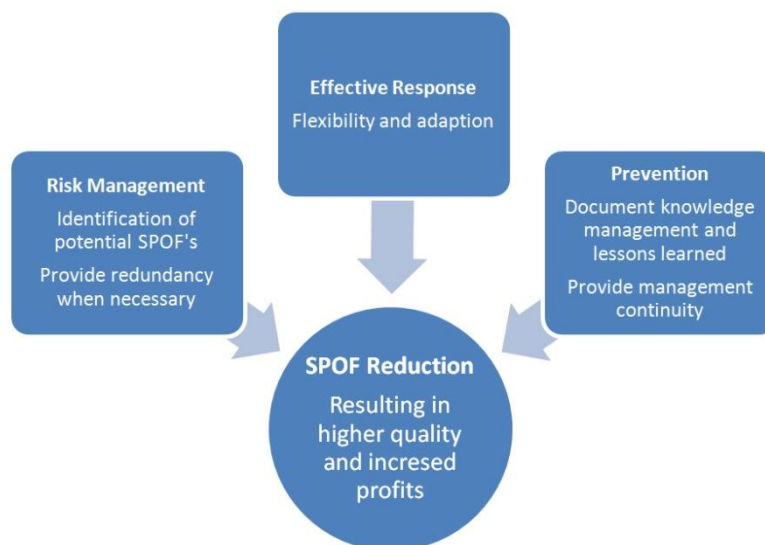


Figure 1 The three-step process to reduce Single Points of Failure.

The fast-paced business culture of today often appears so focused on speed that caution and quality often fall by the wayside. Among the more popular trade magazines today is FastCompany (www.fastcompany.com). Just by its name, one can get a sense of today's frenzied global business environment. Companies such as Federal Express base their business model (strategy) on speed, getting the product or service to the customer faster than the competition.

However, being fast is simply not enough. When facing a surgical procedure, should a person prefer the fastest surgeon or the surgeon with the best patient survival record? Or in a business context, it is simply not enough for FedEx to be fast, but to also deliver packages to the right address and in excellent condition.

Was it prudent for Edward Smith, captain of the ill-fated *Titanic* to order his ship to sail at full speed to arrive in New York ahead of schedule, contributing to the sinking of the ship? Both Captain Smith and Bruce Ismay, CEO of White Star lines, the owner of the *Titanic* believed the ship to be unsinkable and threw caution to the wind, resulting in more than 1500 passengers and crew perishing in the icy waters of the North Atlantic (www.Titanic-Facts.com).

Outstanding companies seek to provide superior quality products and services and an important step in that process is to identify potential failure points and prepare for them. We propose a three step process beginning with forward planning, including risk management. Of course, the further forward one attempts to plan, the greater the likelihood of error. Risk management attempts to reduce or eliminate SPOF's though, of course, the cost of mitigation must be less than the costs associated with failure.

Effective risk management will sometimes call for redundant systems. The authors suggest judicious use of redundancy, only where high reliability is imperative and the redundant system is cost effective. For example, it would not make sense for an automobile manufacturer to provide a redundant engine in their automobiles.

The second step is to be flexible and adaptive. Successful companies must be able to respond quickly to changing economic conditions or consumer

preferences. This becomes especially important to both high-tech companies driven by technological developments and firms operating in the fashion industry, where consumer tastes and preferences change very rapidly. Companies with flexibility and that are able to improvise have been shown to be adaptive and often also excel at improvisation. Improvisation can only be found in those companies that build a culture that values and supports creativity throughout the organization.

Being flexible and adaptive also means having a good contingency plan. Where reliability is crucial, a backup plan helps personnel to respond effectively. No plan can anticipate every contingency and it is not practical to have a backup for every possible failure. However, preparing and reviewing such a plan will serve to create awareness and to mitigate losses should a failure occur. Such a plan might include: an overall review of organizational priorities; curtailment actions for nonessential loads; failure scenarios and the action steps needed to mitigate each; and contact information for emergency/temporary equipment and support.

Finally, good prevention techniques can help reduce SPOF's. A company's organizational culture should include *knowledge management*. Studies such as one by Jha and Joshi [122] emphasize the importance of using knowledge management as the basis for developing a learning organization. Knowledge management practices should not only include best practices, but also "lessons learned", or knowledge learned from past errors. Some organizations employ "after action reports" to learn from errors and build their knowledge management base. Knowledge management and lessons learned must be documented to become a function of corporate knowledge. Likewise, management continuity helps develop sound SPOF prevention.

Together, this three-step approach to managing SPOFs could be an effective means to increase quality and improve profitability. Companies that train and encourage managers to be aware of potential SPOFs and integrating these concepts into their strategic plans will not only be practicing better management, but also potentially be improving overall corporate performance

and profitability.

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