A Strategic Engineering Management Approach to Innovation and Organizational Sustainability: An Addition to the Engineering Management Curriculum?

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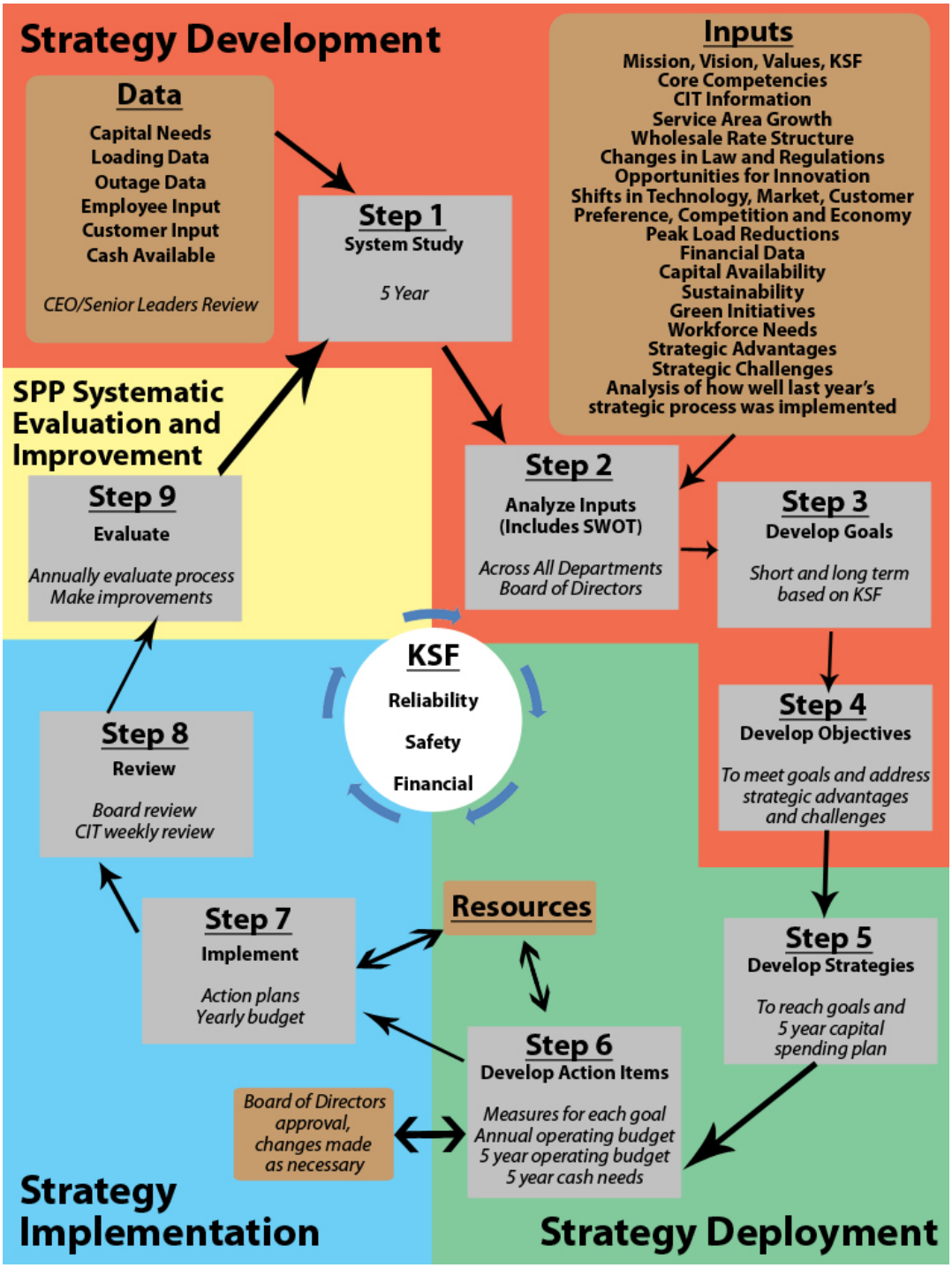
Abstract and Introduction

The Baldrige National Performance Excellence Criteria (2013 -2014)[1] places increased emphasis on organizational sustainability in terms of societal, environmental, and financial impacts; and innovation as a discontinuous change in engineering designs and/or business models. Such concepts may become important considerations for engineering managers in today's global marketplace. Engineering management educators may become a major player in transforming compliance with performance specifications into an enhanced competitive business advantage by offering a total systems approach to managing innovation while ensuring the long term viability of the business itself. Throughout this article the authors use the Baldrige definition of sustainability/ organizational sustainability as cited above. However, from the Engineering Management perspective care must be taken to acknowledge that sustainability in the engineering profession often focuses on the environmental component of the triple bottom line as is true for "leadership in energy and environmental design". The business literature often speaks of "a sustainable competitive advantage" underscoring the marketing and financial aspects. The total systems approach suggested in this article takes a strategic engineering approach to conducting trade-offs to determine impacts of alternative strategies that might place different levels of importance on the components of sustainability given in the Baldridge definition. The applied research presented in this paper provides a conceptual framework for translating strategy into implementation results via a modified Plan – Do – Check – Act Shewhart / Deming improvement opportunity identification and corrective action closed loop management cycle. The framework given in Figure 1 has proven effective in introducing discontinuous innovations in an engineering technology business and has three best practices embedded that have enhanced internal efficiencies as well.

This framework may also make a contribution to those in higher education faced with the challenge of reforming engineering education in the Engineering Management curriculum. Engineering design has always involved innovation. However, from a management perspective, the creative step in the process requires a combination of business and engineering skills in order to create value that a customer is willing to pay a premium to receive. With today's demands placed upon the engineering curriculum, little room is available for additional courses. Therefore, ways to embed these business and technology issues into our current engineering management courses could result in significant benefits. This paper also provides a practical example of one organization's transformation from an electrical power distribution organization that expanded their customer provided services to include Internet, telephone and cable services over a fiber optic network through the systematic and simultaneous implementation of innovation and organizational sustainability principles. Of their almost 33,000 electric customers, over 14,000 also purchase one or more of the fiber optic offerings and the company is operating this business segment in the black. Now the organization continues to explore smart grid approaches to improve reliability and level electrical power system load demands.

Figure 1: A Strategic Engineering Management Approach to Innovation and Organizational Sustainability with Embedded Best Practices



In the September 2013 ***Prism,*** Ferreiro suggests that: "our [engineering] students should learn to think strategically about systems design and management."[2] Perhaps the framework given in Figure 1 of our article makes a contribution by providing guideposts for achieving this important objective. The article also gives three management process benchmarks that could be embedded

in a systems engineering course to underscore the importance of addressing combined business and engineering challenges systematically. These processes are: 1) listening to the voice of the customer to address marketing issues; 2) a "check-act-plan-do" process for piloting and proving innovations without disrupting the existing embedded management procedures; and 3) storytelling to systematically communicate mission, vision and values and provide springboards to imagine discontinuous improvements for improving customer satisfaction and achieving organizational sustainability. In this context, organizational sustainability is measured by a weighted combination of economic, environmental, and societal benefits.

This paper was inspired by the keynote challenge to "accelerate the rate of change in engineering" education and the companion Panel presentation and dialogue on "Systems Thinking using Baldrige in Engineering Colleges" at the 2010 ASEE National Conference. It builds upon a stream of applied research conducted in partnership between East Tennessee State University (ETSU) and Bristol Tennessee Essential Services (BTES). Please see the Baldrige National Quality Program, 2013-2014 Education Criteria,[1] Czuchry et al. (2010)[3]& (2012)[4]; and Heise et al. (2013).[5] The authors have benefited from participation in the Baldrige based Tennessee Center for Performance Excellence (TNCPE) process and three have served as examiners, members of the panel of judges, and/or members of the board. Baldrige based systems thinking using Balridge has been especially helpful in improving innovation and organizational sustainability results and could become an important success factor in resolving current debates and discussions on engineering management in the 21st century.

One of the challenges faced, especially by large and medium sized businesses, is how innovation can be fostered without destroying the efficiency and effectiveness of existing business processes. How can a strategic approach to solving such complex problems be taught in our engineering management curriculum without disrupting our current four year BS and/or expanding our MS engineering programs? The aim of this paper is to suggest a framework for implementing a systems thinking and management approach to shed some light on a path that others may want to follow.[2] Please see Figure 1. In order to accomplish this overarching purpose our technical approach was comprised of several steps: 1) Explore innovation as a discontinuous change in engineering designs and/or business models; 2) Factor innovation's role into organizational sustainability measured in terms of societal, environmental, and financial impacts; 3) Use relevant literature and the BTES proven experience to suggest a Strategic Engineering Management approach to innovation without disrupting existing operational processes and procedures; 4) Demonstrate the improvements in operational efficiencies and strategic effectiveness with measured performance; and 5) Consider implications of these factors in terms of the ongoing transformation in Engineering Management Program. To the extent that the framework, processes, and results serve as benchmarks for innovative changes in the Engineering Management curriculum; a contribution will be made.

In summary, the three major aims of this article are to suggest a process for implementing innovation without disrupting existing legacy systems; to provide guideposts for a senior level or graduate level engineering management course with an embedded Baldrige based systems thinking and management process, and to illustrate the process and framework with a real example in a technology based organization that has deployed the Baldrige process and

experienced discontinuous improvements in both their deployed technologies and business models.

Study Setting

Bristol Tennessee Essential Services (BTES) is a municipally-owned electric utility that also provides an advanced fiber optic network that supports its electric system. BTES provides service to almost 33,000 electric customers in a 280-square-mile service area in the City of Bristol and Sullivan County, Tennessee. On December 15, 2004, the BTES Board of Directors changed the name of the organization from Bristol Tennessee Electric System to Bristol Tennessee Essential Services after a communications consultant verified the name value of "BTES" in the community.

KEY SUCCESS FACTORS	
Reliability	in providing service to our customers
Safety	in everything we do
Financial	stability to sustain our organization and maintain the amount of money that we leave in our customers' pockets

BTES' overarching objective is to provide the highest reliability of services at the lowest cost while doing so with one of the best safety records in the nation. They must provide reliable, safe, cost-effective service and properly allocate costs to survive, grow and meet the needs of their present and future customers. Driven by the reliability factor a fiber optic communications system was installed to link substations to ensure that they could control their own facilities on a daily basis and, most importantly, during an outage. The system is comprised of 944 miles of fiber optic cable to support the electric system and its capabilities. This fiber optic infrastructure provides a business opportunity to offer Internet, telephone and cable television services which combine to provide about 15 percent of annual revenues. The fiber optic system has allowed BTES to implement many innovations for their customers. Those customers with fiber optic services to their homes have automatic power outage detection and reporting, automatic meter reading, voltage monitoring, theft detection, and monitoring of BTES' water heaters. These services and programs are designed to support the electric system and promote the prudent use of electricity, as opposed to gas, while promoting energy efficiency. Strategic alignment is achieved by comparing results on BTES' Key Success Factors (KSF) by factor basis.

The engineering management curriculum is charged with providing skills that develop and/or enhance leaders rather than followers. Although some may view engineering management challenges as similar to those in a business management curriculum, in reality managers in technology based companies must understand and be competent in the technologies that are core competencies of their organization. Most acknowledge this need as true in large technologies in the chemical, glass, information technology, aero space and electrical power industries. However, the authors' experiences suggest that this need is also acute in small and medium sized organizations, too. For example Enhanced Systems Engineering (a small 20 person engineering

company) has partnered with BTES (small to medium sized firm) and ETSU (a large organization) to develop closed loop control strategies for smart grid applications. These strategies have been implemented as part of a successful Small Business Innovation Research (SBIR) Grant Phase I successfully completed and Phase II currently targeted to be completed in August of 2014. The SBIR grants have been funded by the Department of Energy and the Tennessee Valley Authority (TVA) is considering application of the findings. Please see results of the Panel Discussion at the 2012 Association of Global Business Annual Meeting.[6,7,8]

In today's global and fast paced economy, small businesses represent more than 99.7 percent of all businesses and employ 57.4 million people (Small Business Administration, September 28, 2006).[9] Hence it becomes increasingly important for the engineering curriculum to prepare engineering students with strategic thinking and systems analysis and design capabilities for this sector of the economy as well.

Background and Relevant Literature

Engineering design has always involved innovation. However, from a management perspective, the creative step in the process requires a combination of business and engineering skills in order to create value that a customer is willing to pay a premium to receive. With today's demands placed upon the engineering curriculum, little room is available for additional courses. Therefore ways to embed these business and technology issues into our current engineering management courses could result in significant benefits.

Higher education is still unclear about how a strategic approach to innovation and organizational sustainability should be taught. In this article, we are suggesting that Engineering Management and Systems Engineering are vital core competencies that could make a substantial contribution in clarifying the strategic nature of these important capabilities. From a commercialization of technology view it is essential to create innovative products and business models that are profitable while meeting environmental constraints and benefiting society.

Moreover, companies struggle to develop and introduce new process and service innovations (Hultink et al., Hauser et al.);[10,11] and higher education is faced with a compounded problem of teaching the required skills while simultaneously applying innovation to reinvent itself. See Wiebe, H.A., [12] and Using The Baldrige Criteria To Reengineer Higher Education (2010).[1] This challenge became a theme of the 2010 ASEE National Conference and contributed to the sparse published works that comprise the current body of knowledge; and has recently been echoed by Ferriro in the September 2013 *Prism*.[2]

A clear challenge before us is to facilitate a teaching and learning environment grounded in theory, tempered by practical experiential prudent risk-taking in a highly nonlinear technology and business global business arena. Three best practices/processes that can be tailored to help create this learning environment are discussed in turn below.

1) Listening to the voice of the customer to address marketing issues:

Listening to the voice of the customers is one of the best practices that proved successful in our applied research. Since numerous six sigma projects have been discussed in the literature, this technique could be implemented in the Engineering Management curriculum at both the undergraduate and graduate levels. One caveat is important. General Electric and others that have embraced six sigma projects have found the revolutionary changes leading to product innovations diminish over time. Perhaps a systems approach works best by strategically separating innovations into two classes. One class of innovation is called "six sigma" or piecewise innovations that preserve the legacy processes. The second class of innovation is those that create whole new product lines exemplified by Apple; and in our research by the revolutionary innovations in both technology and business models resulting from BTES' fiber optic services. In these revolutionary situations, the customer does not and cannot recognize the value of the product innovation and could not have provided product requirements or specifications, a priori.

Many discontinuous nonlinear improvements are possible with a two-phased/pronged approach. The first prong is provided by Figure 1 and the CAP DO process (practice two (2) below) combined with the voice of the customer. An advantage of prong one is that legacy systems are modified in smaller nonlinear steps proven by pilot projects and then implemented with minimal risk to changing processes that are working fine. As described below, customer feedback, ideas, problems and potential improvement opportunities can be systematically addressed. Root causes of problems, once identified, can lead to innovations that add value to each component of the sustainability objective function. The revolutionary changes in both technology and business models are often best addressed using the "just imagine" component of the technology and business narrative suggested in the third best practice discussed below.

BTES uses their website to gain feedback from their customers as well. Customers take advantage of the "Contact Us" form on a regular basis to provide feedback, make suggestions, and ask questions about services. This feedback is deployed by the Customer Service Department to the appropriate department for action and response which is then fed into their weekly Continuous Improvement Team (CIT) meeting to review for improvements. This information is then fed into and aligned with their Strategic Planning Process (SPP), as appropriate.

One example in which BTES systematically utilized information gathered from the various customer listening methods and implemented a change utilizing the CAP DO process, is offering the ability to apply for new services online. Previously, for a customer to apply for new services, they would have to either come to the BTES office to complete the application or fax the application and supporting documentation to the office. Utilizing feedback gathered from listening to their customers, BTES revamped their website, including the online application for new service, in which a customer can complete the application and submit all supporting documentation completely online, without having to come to the office. They monitor customer usage by tracking the number of responses and strive to increase that number through advertising this feature.

BTES reviews listening methods weekly during their CIT meeting and annually during the SPP to ensure the most effective methods are being used. See Figure 2. All customer listening

methods must help BTES achieve its mission. As changes and improvements are made, these are deployed through the communication process. BTES' customer listening methods are aligned throughout BTES by providing input into their SPP and helping them to be successful through their KSF. The information is deployed, reviewed for improvements, and aligned as stated above through the weekly CIT meeting and SPP.

Figure 2: Improvement Initiative Process (IIP)

Potential customers are identified through listening methods including their Supervisor of Engineering's attendance at the weekly City of Bristol meeting to discuss future expansions and

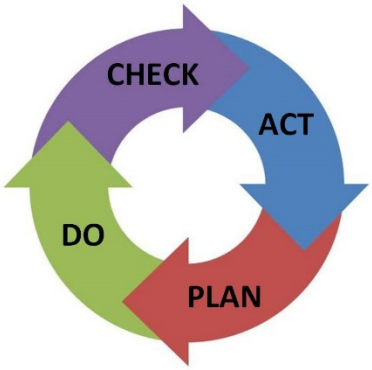
planned subdivisions. BTES' Business Development Manager also makes regular contact with local industries to discuss their needs, expansion possibilities and their satisfaction with the services they are receiving. Her economic development efforts are considered some of the best and she provides training for the State of Tennessee to promote and educate the state on economic development. Findings through these listening methods are deployed and reviewed during the weekly CIT meeting and provides input into the SPP, specifically for planning and budgeting for new businesses coming to their area.

In 2012, BTES worked with the City of Bristol, Tennessee; State of Tennessee; TVA; and NETWORKS-Sullivan Partnership to identify and assist seven businesses with expansions or relocations to the Bristol area, resulting in the potential for 375 new jobs. This metric is tracked each year. Potential customer information is reviewed during the SPP and is documented in the annual Strategic Business Plan (SBP). Previous projects are reviewed and major upcoming projects (including subdivision developments, industry expansions, etc.) are documented. Capital needs are reviewed on an annual basis and five year budgets projections are made. All major projects are placed in the bi-annual system study, as appropriate.

2) "Check-Act-Plan-Do" for piloting and proving innovations without disrupting the existing embedded management procedures:

Check-Act-Plan Do or CAP DO (Figure 3) is one of the most successful best practices concerning the continuous improvement initiatives deployed by BTES.

Figure 3: Check-Act-Plan-Do (CAP DO)



BTES improves work processes by reviewing the key measures during weekly departmental meetings and the CIT meeting, Step 14 (Figure 1). As work processes are improved and changed (Figure 1, Step 14) using their CAP DO improvement process, they are updated in training modules and deployed through their communication process.

Improvement opportunities are identified through review of measurements and internal and external feedback.

Feedback from customers, suppliers, and partners all play a part in determining key processes and their requirements. Review of this data occurs weekly in the CIT meeting and at department

meetings. When an opportunity is identified, a cross functional team begins research to determine what changes can be made using the CAP DO process. This team designs an improved process, key requirements and key measures required to track performance. The design is reviewed by senior leadership and then tested. The design is modified, as needed, and then implemented. The CAP DO process is continuously applied to the process. Process improvements are prioritized by senior leaders based on cost-benefit and resource availability.

Creating an environment that supports innovative ideas:

Through conference attendance; partnerships with local, regional, state and national organizations; and research, BTES has many innovative initiatives in place. These include their fiber-to-the-home network which provides Internet speeds up to one Gigabit per second, Load Managed Water Heater Program, voltage regulation, Meter Data Management Program, green initiatives through an electric vehicle and charging stations, and an Economic Development Loan Program.

The weekly CIT meeting is the central point to where innovations are discussed. Although some innovations have resulted through BTES' Improvement Initiative Process (IIP) of reviewing their opportunities for improvement and positive data, not all innovations come from this source. It is the place, however, where their workforce brings innovative ideas to discuss. Input from the community is also reviewed, as appropriate, and plans are made during their SPP and budgeted accordingly.

Their innovative programs not only support their KSF but help them to be sustainable in the future by promoting community development and effective use of their electricity. BTES continually reviews their metrics to be financially stable and provide reliable, safe electric service while looking for innovations. Senior leaders promote these programs through community presentations; being active on community, state and national committees and boards; and partnering with local organizations including ETSU.

3) Storytelling to systematically communicate mission, vision and values and provide springboards to imagine discontinuous improvements for improving customer satisfaction and achieving organizational sustainability:

Several types of stories based on their purpose, content, and other criteria have been identified through research. Denning identified seven types of stories based on the purpose of which they are used. Springboard stories should spark action according to Denning.[13] Other stories are used "to communicate who you are, transmit values, communicate who the firm is, foster collaboration, tame the grapevine and share knowledge." However, Snowden classified stories into "four types based on their simplicity/complexity and the type of message conveyed."[14] Snowden argues that Myths are simple stories which spread rapidly and have "different decay rates;" fables are more complex and therefore the content is difficult to repeat but the listener remembers the message; viruses are "predatory, parasitical, symbiotic stories" and archetypes are stories "owning up to failure or characterizing good/bad behaviors."

Wijetunge (2012) argues further that stories can be used as a powerful problem solving tool.[15] However, there are also drawbacks to stories. As individual stories are told from the perspective of the individual, it represents a single point of view. The individual's perception might be different to another individual. In addition to this, there can be the danger of 'story selling' instead of objectively telling the story which is described by Carr and Ann (2011) in their article "The use and abuse of storytelling in organizations."[16] Furthermore, Wijetunge argues as stories can attract and absorb the listener, it can be difficult to critically evaluate the stories knowledge and content.[15]

According to Escalfoni, Braganholo and Borges (2011), innovation is the fundamental source of value creation in organizations.[17] Furthermore, they argue that the innovation process has to be systematic as complex factors relating to the organizational culture make the innovation process challenging. Phase 1 is to collect the stories which are used during an innovative process. BTES' senior leaders use the storytelling technique "to build and maintain the BTES culture" by focusing on BTES' values and KSF. Furthermore, stories are used to "train others, promote ethical behavior, and understand BTES' practices." BTES uses the storytelling process as a systematic tool throughout the entire organization during "weekly meetings and individually." Senior leaders use the CAP DO approach (Check-Act-Plan-Do) to systematic learning, decision making and improvement. Paul Smith states in an interview with Forbes, that people can be lead with a good story.[18] Smith mentions that "you can't even successfully order people to follow the rules because nobody reads the rulebook." However, people will pay attention and read a story about a guy who broke the rules and got fired, or an employee who followed the rules and got a raise. This way of leading would be more useful than reading the rulebook Smith argues.[18]

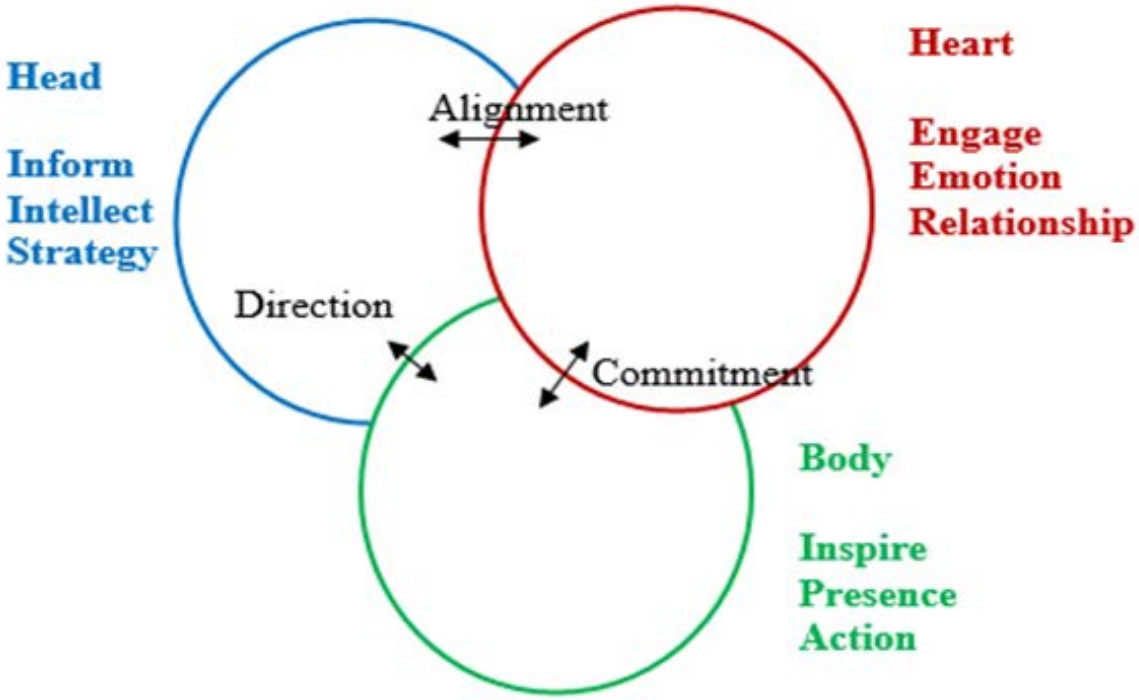
Alexander Mackenzie argues in his article "Storytelling is at the Heart of Leadership" that good leaders are good storytellers. Mackenzie states that the aim of a story is to either "Inform: share intellectually what we know, Engage: to communicate in a way that captures the attention of the audience; or Inspire: to stimulate imaginative curiosity."[19] Mackenzie introduces a framework for effective storytelling which combines the head, heart and body. See Figure 4.

The important transformation of a story as a strategic tool is necessary in order to not be seen as an anecdote. BTES uses stories systematically to build organizational culture. Denning argues in the book "The Leader's Guide to Radical Management" that sustainable storytelling is essential as people sitting around telling each other stories does not get anything done in the organization.[13]

Denning mentions six steps for "establishing a sustainable culture of storytelling":

1. Support and motivate high-quality interactive human relationships.
2. Stories should be recognized as one of the ways to support and develop high-quality interactive human relationships, but not the only one.
3. The organization's goal should be to satisfy, delight and serve other people.
4. Self-organizing teams should be established to conduct work.
5. Work should be done in "relatively short cycles."
6. Open communication is necessary.

Figure 4: Mackenzie Framework for Effective Storytelling



BTES uses stories to motivate and build continuous improvement throughout all processes. For example, the safety story is used to explain why processes are a certain way and educate employees about their key success factors. BTES' key success factors are reliability, safety, and financial factors. Looking at BTES' SPP (Strategic Planning Process), the KSF are involved and therefore affect BTES' strategy development, strategy deployment and strategy implementation process.

Members of the organization begin to feel connected to a larger community and a higher purpose."[20] A study taken out by Glisson and Durick (1988) looking at human service organizations states that leadership has an influence on the commitment to the organization.[21]

Another story BTES uses is the story of employees working directly with the customer. Employees have meetings and reviews where documented processes are being discussed with the continuous improvement team - which will be discussed in more detail in the following pages. Cause-and-Effect Analysis is being used to find gaps and to close loops in the process. Employees who do very well tell their stories of how they communicate with customers in order to achieve a better learning effect for other employees.

Example of BTES Best Practices Story

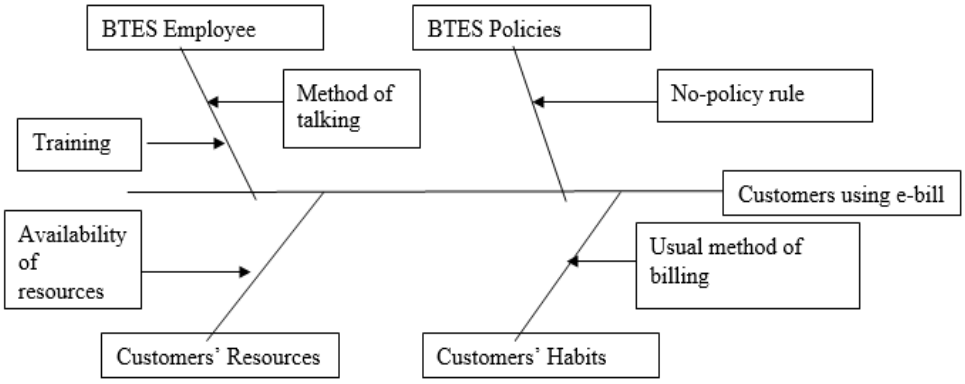
BTES uses stories to educate their employees about best practices which improves training, education, and understanding of the job. For example, a story that is told at BTES to show employee empowerment and exceeding their customers' expectations is the E-bill/Alerts story.

A Customer Service Representative was filling in at the receptionist position one afternoon and noticed that several customers had to come to her window and ask for their account number and balance of their bill before going to the cashier's window to make their payment. Instead of just giving the customer this information and going about her day, she felt empowered to change her process and possibly help the customer from having to request this information in the future. She took a few extra minutes and offered the customer some programs that would tell them this information automatically which included BTES' e-bill program and text message/e-mail alerts program.

At the weekly Customer Service meeting, it was noticed that this particular Customer Service Representative's data showed that her sales in the BTES e-bill program and alerts program were significantly higher than previous weeks and higher than the other Customer Service Representatives' data in those areas. She explained the change she made while sitting at the receptionist position, and the decision was made to implement this improvement into the standard process so that everyone would use this process in the future.

The above story is told at BTES to show how all employees are empowered to make decisions in order to help meet the customer's needs, test the process on their own to see if improvements were made, and ultimately exceed the customer's expectations. This also shows how employees are continuously using the CAP DO process. See Figure 5.

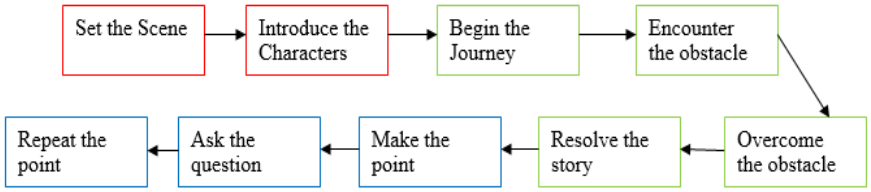
Figure 5: Creating a Systematic Storytelling Process



BTES uses 3 core points in order to create a strong story.

- Know your point: only have one or two points you would like to deliver.
- Know your audience: you have to know who your target group is and what the target group wants.
- Know when to quit: do not overdo it, as it is essential for a strong and successful story to deliver the message to the audience and know when to stop if the audience is losing attention.

9 steps are used by BTES in order to create a story:



The first two steps are the beginning of the story (red), then the next four are the middle part (green), and the last three are the end (blue).

BTES' storytelling approach focuses on their KSF. BTES creates teams to "foster an organizational culture that focuses on BTES' values of stewardship, relationships, honesty, integrity, respect, and accountability which are delivered through stories." As previously discussed, a continuous improvement team is in place that includes key employees from each department. The CIT meets on a weekly basis to discuss issues, new ideas, processes, and projects. BTES uses Sysdine, an online program accessible from any computer in the building, which gives senior leaders and supervisors the ability to track the effectiveness of BTES' learning and development system. Sysdine also allows departments to train employees through documented process which take the employees through the process step by step with pictures. Looking at documented improvements, BTES has had zero breaches in ethical behaviors, whereas other utilities, average a 5 percent rate per year. This shows that BTES' storytelling approach to promoting legal and ethical behaviors has been very successful.

Results

Results are important in the context of using the three best practices to illustrate the need for a total systems approach to implementing a prudent risk strategy in engineering management scenarios. In this context, we factored innovation's role into organizational sustainability measured in terms of societal, environmental, and financial impacts. In terms of societal impact, BTES measures their customers' satisfaction and dissatisfaction through reliability and rates. BTES' customers are satisfied when their electric power is on. When they experience a power outage, they are dissatisfied. According to 2012 outage data, BTES has a 99.984 percent customer satisfaction rate. BTES also keeps record of customer communications through emails, customer interaction, and newsletter comments complimenting BTES on their high reliability rate and the quickness in restoring power outages.

BTES' electric rates also play a role in customer satisfaction. Their customers want the most cost effective service, and therefore are more satisfied when they pay an electric rate that is lower than neighboring utilities. During 2012, BTES customers paid an average of one cent less per kWh than two neighboring utilities and almost three cents less per kWh than the national average. BTES provides lower electric rates than neighboring utilities and the national average, even though Tennessee Valley Authority (TVA) supplied local power companies pay the same price to TVA for their electric service.

In term of organizational sustainability impact, BTES uses the IIP (Figure 2) as another method of measuring customer satisfaction, dissatisfaction and loyalty. Each department tracks their opportunities for improvement and their positive communications and presents them to other team members and senior leaders for review. Each department selects their highest opportunities for improvement and does an improvement review to find ways to reduce or eliminate the problem which is then reported out at the next weekly meeting. This ensures that tracking communications are leading to actionable information and will lead to process improvements.

BTES also utilizes the Existing Industry Program to determine customer satisfaction, dissatisfaction, and loyalty. During an Industry Annual Visit, the BTES Business Development Manager goes into the community to visit with Industrial and Commercial customers face-to-face and one-on-one to identify threats to staying in business, possible community obstacles, and opportunities for assistance with growth of new jobs, electric load, and new investment in the community. This program is a preventative and proactive approach to identifying potential red flags and gaps that could result in the company leaving the community. The feedback from this innovative listening method is integrated into the BTES IIP (Figure 2).

BTES not only measures customer engagement through daily communications which are measured through the Opportunity for Improvement (OFI) and positives, they also measure services purchased per customer which is a direct indicator of customer engagement. This number continues to increase, showing that customers are engaged. If the electric customers were not engaged with BTES, they would not continue to purchase the other services BTES offers. BTES also recently conducted a survey sampling of their customers to determine how they would rate BTES' services to their experiences with other providers. Over 95 percent of respondents rated BTES services as better than or same as their previous service experiences in all categories.

TVA is the primary source of information for comparing BTES to other electric distribution utilities on reliability and rates. Other sources include: American Public Power Association (APPA), Tennessee Valley Public Power Association (TVPPA), Tennessee Municipal Electric Power Association (TMEPA), Electric Power Research Institute (EPRI), and individual utilities. BTES' top comparisons are on their KSF of providing reliable, safe and cost-effective electric service. BTES is best in class in all of these areas. Comparable data and resources are reviewed on an annual basis during the SPP to ensure the most effective methods and best resources are being utilized and to ensure alignment through the KSF. Data from these resources are discussed in the weekly CIT meeting and deployed through their communication process, weekly departmental meetings, postings throughout the BTES building, and the monthly employee newsletter.

BTES ensures complaints are entered into their systems and analyzed through review and tracking of Customer Service's and Help Desk's daily interactions with customers. Senior leaders review telephone calls and perform walk-arounds to ensure appropriate procedures are being followed. Each communication, whether by telephone, walk-in, email or fax, is documented and reviewed daily. These are integrated with their OFIs and systematically monitored through their IIP (Figure 2).

One example of a major process that was improved based on the analysis of customer complaint data (OFIs) and implemented through BTES' IIP was the addition of the budget billing option for new customers. Budget bill and level monthly billing is a convenient way for customers to budget their finances to pay their electric bills. Level monthly billing customers are billed based on a rolling 12 month average of electric usage at their address. In the past, customers only qualified for level monthly billing after 12 months of service at the same address. When customers on level monthly billing would move to a different address, they would not qualify to remain on level monthly billing until they had 12 months of service at their new address. Through their variety of customer listening methods and analysis of customer complaints, BTES implemented budget billing as an option for these customers to be able to continue to be billed based on an average. Through their IIP, the number of participants in the budget billing program is tracked and reviewed during CIT meeting, and the availability of this new option is presented to every new customer with the application for new service.

Implications for Engineering Management Education

One of the challenges faced in Engineering Management Education is to create a learning environment with a balance of theory and practice that helps students "learn to think strategically about systems design and management."[2] The purpose of this paper is to suggest a framework that provides guideposts for accomplishing this important task. In this section we walk through Figure 1 in some detail suggesting how tailoring might be used to augment a senior or graduate level course in Engineering Management. Then we suggest that each of the three processes that have been called best practices might also be tailored to accomplish similar teaching and learning objectives. These processes are: 1) listening to the voice of the customer to address marketing issues; 2) a "check-act-plan-do" process for piloting and proving innovations without disrupting the existing embedded management procedures; and 3) storytelling to systematically communicate mission, vision and values and provide springboards to imagine discontinuous improvements for improving customer satisfaction and achieving organizational sustainability. In this context organizational sustainability is measured by a weighted combination of economic, environmental, and societal benefits.

Let's view the framework in Figure 1 through the Engineering Management lens from the instructor's perspective. Baldrige provides a backdrop from a systems perspective and identifies what needs to be accomplished with strategic thinking. One definition of strategic thinking that we find helpful is: this is the process that goes on in the engineer's head as she attempts to link the product or service design to the value a customer is willing to pay a premium to receive. Since the Baldrige process is not prescriptive by design; we depart and suggest ways strategy and tactics can be taught. Although different pathways are certainly possible, we hope that the suggested guideposts become common to all. Feedback from the 2014 ASEE Annual Meeting will be helpful in guiding our future applied research in this regard.

Notice the Key Success Factors are central to framework. (Please see Figure 1) A helpful engineering definition is these are the handful of things (three to five) that must be done for the organization to first survive and then thrive. Ideally, when everyone is aware of the organization's mission, vision, and values, the key success factors become the thrusts or vectors that ensure alignment of the work that must be performed to be successful. As engineers, we

choose “Key” rather than “Critical” to distinguish factors that might appear on the time critical path identified in Project Management literature. An early teaching point becomes work that is not aligned with the key vectors has components of waste that could often be eliminated using lean principles.

Please refer to Figure 1 for the discussion that follows. Strategic planning is comprised of two parts: strategy development and strategy deployment. An important teaching point is “traditionally in many organizations strategic plans sat on shelves and gathered dust.” Students will often ask, “Why?” Such a question stimulates a wonderful teaching and learning moment. The instructor may proceed on one of several pathways at this point. At the graduate level something along these lines has proven successful. Please notice that steps one through four take considerable time and thought to implement. Data is comprised of both engineering and business components. Technical inputs, for example the power distribution industry are comprised of loading and outage data. Business inputs are capital needs, employee and customer inputs, and cash available. Step two is common to many if not most strategic planning processes. A Strengths/Weaknesses; Opportunities/Threats (SWOT) analysis is usually conducted over a five year planning horizon. The planning horizon is generally determined by the pace of change of technology and (see inputs) the market dynamics that are influenced by shifts in technology, market, customer preference, competition and the economy. For example, in a highly dynamic software industry where agile project management dominates, the planning horizon may be two to three years maximum; while community infrastructure planning horizons are as long as 25 years. Most often, strategic planning processes complete steps one through four and document their strategic goals and objectives. Perhaps this is a good place to pause and have the class engage in a guided dialogue. The instructor then guides the discussion as suggested below.

What happens in steps five and six? These are fundamental steps in the strategic planning process because they translate strategy in to deployable action plans when resources are appropriately allocated. Naturally, this is another important guidepost. Without achievable actions and appropriate resources, allocated strategies become hopes and wishes without a realistic probability of success. Many engineers find this to be an eureka moment!

Hence steps one through six represent a best practice for strategic planning because appropriate data and inputs are gathered and evaluated (steps one and two); goals and objectives are developed and aligned with the key success factors (steps three and four); appropriate strategies are developed for the planning horizon (step five), and strategies are translated into achievable action plans (step six). When appropriate human, financial, and equipment resources are systemically assigned to mitigate risks, the “Plan” portion of the Plan – Do – Check – Act (PDCA) improvement cycle is completed.

Step seven represents the interface and transition to the operational plan by assigning annual budgets. This also represents the “Do” portion of the PDCA. Step eight is the review process that is embedded in operations via the CIT weekly review meetings. This is the Check step in the operational plan with short term dynamics; compared with the annual SPP Systematic Evaluation and Improvement process the “Check” step in the slower dynamics in the outer loop. Notice that the **“Check-Act-Plan-Do” process cited above for piloting and proving**

innovations without disrupting the existing embedded management procedures is another best practice. The reason is that this CAP DO is embedded in the operational deployment and preserves the efficiency and effectiveness of legacy processes while rapidly responding to innovations on the shorter time scale. Notice that such changes are themselves constrained by the capabilities of the baseline processes. Here engineering students often benefit by drawing relationships to six sigma projects and statistical process control limits. It is also noted that both the operational fast loop is closed when pilot projects are completed and changes are deployed; while the strategic slower loop is closed through the annual updates in the planning process.

From an Engineering Management view, we suggest that sustainability be viewed systematically as an overarching key to strategic success. Conceptually, innovations can be divided into short term improvements using the CAP DO process while longer range innovations can be conceived using the springboard stories cited above and deployed through the longer strategic process shown in Figure 1.

As ***a homework*** exercise the instructor might ask students to summarize the Framework given in Figure 1 as individuals. Then in the next class students could be asked to discuss and give brief summary presentations from each group. ***A reasonable expectation*** from an individual graduate student is summarized briefly below.

The first four steps of the Strategic Planning Process (SPP) encompass the development of the strategic plan. We develop the strategic plan using the following key process steps, shown in Figure 1.

First, BTES shows the importance of a Strategic Planning Process (SPP):

Preparation	Preparation requires key individuals to break the business into its component parts and evaluate each of those parts including implementation of total quality management techniques. Both large issues and details are addressed and considered. This process results in a better understanding of the business, objectives and strategies.
Working Document	The Strategic Business Plan, the result of the SPP, serves as a reference in decision making, in monitoring progress and as a reminder of the *who, what, why, when* and *how* that comprise the plan.
Objectives, Strategies and Action Plans	Require approval by the Board of Directors. Assures that the goals and objectives of those managing BTES on a day-to-day basis are consistent with those of the Board and, ultimately, the customers.

BTES has set one planning horizon of five years, but has multiple planning horizons in place to help them prepare for financial and system needs. Five years is considered a period of time where there is enough stability in the data to make planning useful, but long enough to accomplish significant breakthrough changes. The short-term time horizon is set at one year as this corresponds with the budget time frame in which data are measured while providing enough time to achieve significant results.

The Strategy Development:

Step 1: Perform System Study

- Look at capital needs for the next five years.
- CEO and senior leaders review data. The specific data list used is shown in Figure 1.

Step 2: Analyze Inputs

- Determine inputs needed for SPP. The specific list of inputs used is shown in Figure 1. This includes the review of the mission, vision, values, and KSF. Sources are selected to eliminate blind spots.
- Assign appropriate senior leaders, employees and cross functional teams to collect and analyze the data from these inputs.
- Analyze and evaluate data to determine core competencies, strategic advantages and strategic challenges.
- Specific senior leaders are responsible for preparing a report of the data with analysis.
- Analyze the organization's strengths, weaknesses, opportunities for improvement and threats.
- Discuss long-term sustainability and any strategic changes that need to be made to minimize any future risks related to long-term sustainability.

Step 3: Develop Goals

- Develop 1 year and 5 year goals based on the Key Success Factors. Long term goals (up to 20 years or more) are developed in bi-annual Strategic Long-Range Major Facilities Study.
- Senior leaders and employees define key goals to be competitively excellent now and in the future. One to five goals are developed based on the data analyzed in Step 2.

Step 4: Develop Objectives

- Determine objectives that will best meet each goal.
- Utilize BTES' strategic advantages and address the strategic challenges.

BTES creates an environment for innovation and intelligent risk taking through the Continuous Improvement Team (CIT) and focus on the Key Success Factors (KSF). BTES employees are highly encouraged to continuously look for ways for BTES to improve, no matter the size of the project. Through the CIT, employees discuss areas of improvement, ideas for innovation, comparisons of other organizations, and BTES' success in future growth. Action plans are created, as necessary, and deployed through BTES' communication process. Projects are reviewed weekly during the CIT, or more often through the development of project teams. During any of these reviews, a project may be discontinued to support higher-priority opportunities, if needed. All projects and innovations at BTES must meet or exceed their KSF standards and be integrated through their mission and vision.

Through conference attendance; partnerships with local, regional, state and national organizations; and research, BTES has many innovative initiatives already in place. These include fiber-to-the-home network which provides Internet speeds up to one Gigabit per second, Load Managed Water Heater Program, voltage regulation, Meter Data Management Program, green initiatives through electric vehicles and charging stations, and an Economic Development Loan Program.

Senior leaders promote these programs through community presentations, being active on community, state and national committees and boards and partnering with local organizations including ETSU.

These programs not only support BTES' KSF but also help them to be sustainable in the future by promoting community development and effective use of the electricity.

BTES continually reviews their metrics in order to be financially stable and provide reliable, safe electric service. BTES employees are encouraged to continually look for innovations.

Strategy Deployment:
Step 5: Develop Strategies

- Develop strategies to reach goals.
- Analyze data to determine the best ways to reposition BTES so that they can more successfully achieve their mission as they move towards their vision, in a way that is consistent with their values.
- Develop five year capital spending plan.

Step 6: Develop Action Items

- Analyze or perform analysis to determine the best way to achieve strategies.
- Determine measure(s) for each goal.
- Develop current year operating budget.
- Develop five year operating budget.
- Determine five year cash needs.
- Balance resources required with action items and goals.

Strategy Implementation:
Step 7: Implement

- Execute action plans.
- Deploy yearly budget.

Step 8: Review

- Board reviews financial and other goals.
- CIT reviews weekly to determine if the progress is on plan and if the desired results are achieved. If not, actions are taken to get the plan on course or to get the desired results. This is then reported out at the next CIT meeting.

SPP Systematic Evaluation and Improvement
Step 9: Evaluate

- Annually evaluate process.
- Make improvements.

Concluding Observations

The three major aims of this article are to suggest a process for implementing innovation without disrupting existing legacy systems, to provide guideposts for a senior level or graduate level engineering management course with an embedded Baldrige based systems thinking and management process, and to illustrate the process and framework with a real example in a

technology based organization that has deployed the Baldrige process and experienced discontinuous improvements in both their deployed technologies and business models.

In order to accomplish this overarching purpose, our technical approach was comprised of several tasks: 1) Explore innovation as a discontinuous change in engineering designs and/or business models; 2) Factor innovation's role into organizational sustainability measured in terms of societal, environmental, and financial impacts; 3) Use relevant literature and the BTES proven experience to suggest a Strategic Engineering Management approach to innovation without disrupting existing operational processes and procedures; 4) Demonstrate with measured performance the improvements in operational efficiencies and strategic effectiveness; and 5) Consider implications of these factors in terms of the ongoing transformation in Engineering Management Program.

During this process we found the fundamental components of our engineering discipline to be applicable and helpful. In particular, we recognized the need for an integrative approach comprised of synthesis and analysis steps. For example, the strategic framework in Figure 1 is a synthesis of the Strategic Engineering Management Approach to Innovation and Organizational Sustainability with Embedded Best Practices. With a detailed analysis of Step 8, we found that the CAP DO process was not only a best practice, but an essential process for implementing innovation without destroying the benefits of the legacy systems. Furthermore, the technology and business narrative not only resulted in benefits in communicating mission, vision, and values as was anticipated; but also became fundamental when imagining an entirely new business unit for the broadband capabilities. These integrations between synthesis and analysis in the Baldrige context became cycles of learning for BTES on its performance excellence journey. From an Engineering Management teaching perspective, this real world illustration of cycles of learning helps explain concepts that are often difficult for business and technology students to grasp.

To the extent that the framework, processes, and results serve as benchmarks for innovative changes in the Engineering Management curriculum, a contribution has been made. However, the journey for Engineering Management educators in transforming compliance with performance specifications into an enhanced competitive business advantage by offering a total systems approach to managing innovation while ensuring the long term viability of the business itself has not been completed. Hopefully, this article will provide a springboard for discussion during the 2014 ASEE Annual Meeting.

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