Measuring Systems Engineering Success:

Insights from Baseball

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Abstract. Optimizing the efficiency of socio-technical systems and determining accurate measurements of performance is a critical issue in many systems engineering enterprises. In our analysis we explore some of the recurring themes of Michael Lewis's study of baseball, depicted in the best selling book *Moneyball*, and we make the connection to corresponding systems engineering principles of interest. The paper will focus on the systems engineering roadmap inspired by Lewis' study for developing and refining a meaningful set of metrics for organizational transformation. The following steps are highlighted to convey this transformation with the assistance of metrics: identify and understand value in the enterprise and your organization; consider an integrated system focus in your organization; use cost analysis methods to implement a strategy for executing the transformation; and manage risk throughout operations and improve the process continuously.

Introduction: Studies of Socio-Technical Systems

One of the most complex issues in the evaluation of a working system is that of human interactions. Unlike the interactions of inanimate objects, there are no exact equations known that can define the interfacing of the most complex systems ever made: those of human beings. Socio-technical systems is defined as "broad: systems in which both human and non-human elements interact, where the social or management dimensions tend to dominate" (MIT 2001). The most common problems that businesses struggle with often relate to how to motivate their employees to do the right job, not just the job right. With this comes the challenge of developing a performance measurement system that is truly indicative of the value their employees are adding to the organization. Equally important is the understanding of waste in an enterprise. Understanding the magnitude of value added and waste in an enterprise has become critical in enterprise success, and can be summed up as follows:

"No matter how complex the situation, good systems engineering involves putting value measurements on the important parameters of desired goals and performance of pertinent data, and of the specifications of the people and equipment and other components of the system" (Ramo & St Clair 1998).

The studies of socio-technical systems aim to evaluate the design of an enterprise, and the processes and actions within it (Cherns 1987). The end result of this systems analysis will be to

provide engineers, as architects of organizations and processes, with the analytical tools and mindset necessary for improving any socio-technical system. It is important to consider systems analysis as a method of continuous improvement rather than a discreet process one can employ and then disregard until a later date. One the key principle, described by Albert Cherns in his 1987 reevaluation of socio-technical designs, is that "we all know that the present period of transition is not between past and future stable state but really between one period of transition and another" (Cherns 1987). To properly consider these systems one must first recognize that design for improvement is a never ending quest – as apposed to a one time process improvement initiative.

The aforementioned reference to continuous improvement is referred to as *kaizen* in the evaluation of lean systems (Womack & Jones 2003). Ideas posed by lean thinking and socio-technical analyses converge with respect to promoting continuous improvement and the flow of value in a system. In the journey to becoming a lean or efficient enterprise, a common challenge remains, which is how to measure the performance and value of personnel without promoting inefficient behaviors and encouraging enterprise optimization. Many frameworks have been produced to evaluate the performance of an individual, to include: strategic measurement and reporting technique (SMART), The Balanced Scorecard, European Foundation for Quality Management, The Performance Prism, A Framework for Design and Audit, and a Framework for Factors Effecting Evolution (Mahidhar 2005). The problem with these frameworks is not that they are generic or too high level, but rather they fail to capture the entirety of a lean enterprise. To understand the value of a human asset, performance metrics need to portray the magnitudes of causal relationships, promote long term enterprise benefit, and be adaptable to cover dynamic relationships and environments (Mahidhar 2005).

Systems Engineering & Baseball

An Introduction to Lewis' Philosophy

We offer a metaphor from professional sports, one that is helpful in developing measures of success in systems engineering. This metaphor is inspired by the work of Michael Lewis, who set out to examine one of the most human intensive business systems in the world – Major League Baseball (MLB) – described in his book, *Moneyball* (Lewis 2004). While the focus of the book is the world of professional baseball, Lewis unveils truths about performance measurement that provide insight to systems engineering metrics. In addition to Lewis, other authors have used baseball as an analogy to describe systems engineering principles. The frameworks, ideas, and connections made by these authors in the realm of systems engineering and baseball will be addressed in this section. Subsequently, this paper explores several of the recurring themes of Lewis' study; his methods and findings are described, the connection is made to systems engineering topics such as value, cost, and risk.

According to Lewis, the motivation for *Moneyball* was the Oakland Athletics, a poorly-funded baseball team that somehow repeatedly managed to defy the odds and win despite having one of the lowest payrolls of all professional baseball teams. Whereas many observers wrote the team off as lucky – Lewis and others were interested in exploring the underlying reasons for their success. What emerged was a philosophy that brought to light a revolutionary method for determining the value of players in the industry – a new approach on metric significance and evaluation. The basis for this philosophy was developed by a statistician named Bill James, who openly advocated for the usage of these methods for many years with little luck until the Oakland

Athletics showed interest in the approach. The findings and methodologies depicted by Lewis in his analysis of baseball have since been widely replicated by many other teams around the world attempting to employ the same lessons to their own franchises. We propose that systems engineers can also leverage this approach to better understand how to measure key aspects of systems engineering.

Just like MLB, the world is riddled with market inefficiencies in several enterprises and opportunities for continuous improvement are plentiful. Such is true not only for companies with the greatest influence or market share; but for stakeholders – like the Oakland Athletics – that have significantly less resources than their competitors whom they are forced to compete against. We attempt to translate the principles from *Moneyball – The Art of Winning an Unfair Game*, to the systems engineering domain throughout this paper.

A Brief History & Overview of Baseball

The origins of ball and stick games are somewhat blurry as they date back to the mid sixteenth century in Europe. As the Europeans brought their culture across the Atlantic Ocean with the eventual settlement of the North America, the earliest references of baseball in the United States date back to 1792 in Pittsfield, Massachusetts. Leagues with rules began to form in the mid-1840s, and shortly after in 1876 the organizational structure that is seen today in Major League Baseball was founded. Today, baseball has become an increasingly popular sport in not only North America, but in areas such as: Asia, South America, Central America, and the Caribbean. In fact, this growing sport not only has professional leagues in North America, but there are even many other foreign professional leagues growing in other countries, such as Japan and Mexico.

The object of the game is to score runs, and the team with the most runs at the end of nine periods (called innings) wins. A run is scored by a player hitting a ball with a wooden bat, running to a base safely, and proceeding counterclockwise to the next bases when possible in attempts to get home to the original base and be awarded a run. A game is not defined by time, but rather by "outs" and "innings." Each team has one hitting opportunity in an inning. On defense, the pitcher of the ball has eight fielders assisting him in getting batters or base-runners out until they have achieved the third out of the inning. A pitcher can strike a batter out by throwing three strikes, but could "walk" a batter on base if they throw four non-hittable pitches. The interaction between pitchers and batters is the most paramount in the game, since it is the principal point of action for each party to achieve either outs or runs respectively. The reason this interaction is so important is because it is where outs – which limit one's offensive potential – are initiated. The ability to measure the output and abilities of players will be an important concept in this analysis.

The responsibility of developing strategies, evaluating talent, and assembling a successful team is primarily that of the General Manager (GM). Managers, however; are different than General Managers and are in charge of on field operations and decision making during a baseball game. In attempts to construct the best team possible, General Managers are always looking for methods and ways to maximize talent with respect to their opposition within economic constraints; much like how an organization desires to stay ahead of their competitors.

This analysis will ultimately show how the unique and revolutionary performance measurement techniques used by one General Manager gave him a better understanding of value and a strategic advantage over other teams. The goal for managers is to win as many games as possible, with the hope of eventually making it to the Playoffs (top 8 of 30 teams) in order to

have a chance to win the championship. Since the market for players in baseball is without salary limits, teams with more economic resources are more likely to attract higher quality players and hence win the most games. This situation is analogous to how organizations with larger market share have more resources in a free market and hold a strategic advantage over others.

Contrary to typical expectations in a free market economy, one baseball team managed to be successful year after year despite a significant deficiency in resources – the Oakland Athletics. The defiance of this general law in baseball around the 2002 season inspired the question of interest for Lewis's study – how does a team with a mid-to-low budget habitually compete against teams with much higher budgets? Our study is broader as it will in turn evaluate how the measurement philosophy introduced by Lewis can be applied to systems engineering.

Historical Connections between Systems Engineering & Baseball

Baseball has been used by INCOSE authors to illustrate certain systems engineering concepts. The following papers have made the connection to baseball and concepts such as: maturity modeling, the SIMILAR process, and the Zachman framework for organizational modeling.

Maturity Modeling. The first connection between baseball and systems engineering portrays how a software engineer applied maturity modeling concepts to the development of his baseball team. This study emphasizes the evaluation of how well a process is established and managed, in addition to some of the risk with regards to placing too much effort on the implementation process (Armstrong 1998).

In the beginning, the softball team was in trouble, as they did not act in coordination as a team but rather as a chaotic group of individuals. This state is compared to being at a Capability Maturity Model (CMM) level one, wherein there is minimal definition of processes and success is mainly a dependent on the skills and abilities of individuals. The team established a group to evaluate team processes and develop a model for success, ultimately hoping to reach maturity level five – characterized by continuous process improvement and learning.

One critical reflection of the process was noted that the challenge needs to be "to obtain the greatest improvement in performance for the least investment" (Armstrong 1998). By recognizing the magnitudes of the positives and the negatives that a process induces, one can determine the value it adds. Similarly, it was noted that process improvement, although pertinent, is not the end objective. It needs to be understood that individual skill does indeed play a role in socio-technical systems, and the overall quality of the product, which is as a function of both individual skill and the process, needs to be the center of attention.

SIMILAR Process. Another systems engineering paper used baseball in a different manner, portraying how the illusion of the rising fastball could be described and explained using the systems engineering SIMILAR process. The steps in the SIMILAR process entail: stating a problem, investigating alternatives, modeling the system, integrating, launching the system, assessing performance, and re-evaluating. The usefulness of such a process may be difficult to understand without reference, so the process was applied to a relatively easy to follow and non-proprietary example – the perception of the rising fastball (Bahill & Baldwin 2003).

The perceived problem is that batters and many baseball experts believe there to be a pitch that literally rises before it reaches home plate. Although it is possible for the ball's spin to exert an upward force, the most spin ever put on a ball by a pitcher has not yielded enough force to

oppose that of gravity when thrown at the slightest downward angle. In order to investigate this phenomenon, simulations were studied relating the trajectories of baseballs at different speeds and human eye tracking strategies. The system model showed that if a batter anticipated a 90 mile per hour (mph) pitch and received a 95 mile per hour pitch, the batter would expect the pitch to be lower than it actually is – hence explaining the "rising" perception that the batters describe when they realize they swung below the ball. Using the SIMILAR model, the authors were also able to explain the phenomenon of the "breaking" curve ball and discuss how pitchers can use these illusions and others to establish an effective strategy to get batters out (Bahill & Baldwin 2003).

Zachman Framework. As a final example of how systems engineering has incorporated baseball into the development and depiction of key concepts, we consider a paper that used baseball as an organization to demonstrate the Zachman Framework's ability to develop meaningful models and relationships (Botta & Bahill 2004). The Zachman Framework for enterprise architecture is "a matrix, were the six rows represent different perspectives of the organization and the six columns illustrate the items, or models, viewed from each perspective" (Zachman 1987).

From top to bottom, the rows represent: scope, business model, system model, technology model, detailed representation, and the real system. From left to right, columns correspond to the categories of: what, how, where, who, when, and why. The relationship between the contents of the cells moving downward in a column conveys a model relating the perspectives of all stakeholders together. With regards to the enterprise as a whole, the authors note that an advantage of this framework is that it "covers everything and does not repeat anything" – allowing for a full enterprise analysis with the conjunction of the models formed by the columns (Botta & Bahill 2004).

To give an example of how the framework can be used to portray meaningful relationships, consider the "why" column as shown in Table 1. By moving down the following column, one can understand the relationships between different perspectives and understand the motivation for each.

Table 1. Description of Motivational Model for Baseball Enterprise Stakeholders – Modified from the Zachman Framework (Botta & Bahill 2004)

WHY (motivation)	
Scope	Society is motivated by baseball as entertainment and can be accessed through television, personal attendance, radio, and internet.
Business Model	Team owners are motivated by power, ego, and money.
System Model	General Managers are motivated to trade players and structure their team such that they can have a winning season.
Technology Model	A Manager is motivated to select a starting line-up and pitcher based on who gives their team the best chance to win.
Detailed Representation	Batters and pitchers are motivated based on system state conditions to select the right batting strategy or pitch sequence accordingly.
Real System	"Why people think the things they do and make the decisions they do."

The Systems Engineering Roadmap Unveiled by Lewis's Study

As these authors have used baseball as a means to describe a different variety of concepts and tools from systems engineering and socio-technical systems, our paper focuses on the systems engineering roadmap inspired by Lewis' study. This roadmap entails the development and refinement of a meaningful set of metrics for both conveying value of assets and transforming one's enterprise. We will put a twist on the traditional connection of considering baseball in our paper by drawing out metrics principles unveiled by Lewis and applying them to the systems engineering domain – to highlight what baseball has taught systems engineering – the art of succeeding in an unfair world.

Since the book was depicted from the views of a General Manager, there are limitations for the lessons learned. Moreover, these lessons were derived from and principally pertain to the perspectives of the General Manager and their use of metrics to build a team. More strategic stakeholders, such as owners, have values not emphasized in the study. What this tactical managerial perspective does teach us; however, is how to integrate the values of all stakeholders into a functional process that aims at satisfying everyone.

The four high level roadmap steps that the Oakland Athletics' General Manager took to transform his baseball team were as follows: (1) identify and understand value in the enterprise and your organization; (2) consider an integrated system focus in your organization; (3) use cost analysis methods to implement a strategy for executing the transformation; and (4) manage risk throughout operations and improve the process continuously. These critical steps and metric considerations along the way are considered in figure 1 below. Using metrics to relate progress in these sequential steps Beane was effectively able to manage his team to success. To assist the reader in following this roadmap, the sections are broken up by examples from *Moneyball* followed with corresponding systems engineering parallels. In order to understand how the highlighted steps relate to the big-picture transformation plan, Figure 1 will be revisited in the paper.

The systematic method for transforming an organization show below displays the necessary steps one should initiate to promote change in a structured fashion. Within each step, there are multiple sub-steps that require communication and execution from various components of an organization to achieve. Moreover, between every major step, metric considerations that can align progress are identified. The top of the roadmap represents the broadest advances that need to be undergone, mostly on strategic levels of an organization. As the model progresses (top-down), increasingly more stakeholders are involved and need to be considered for effective execution of the transformation.

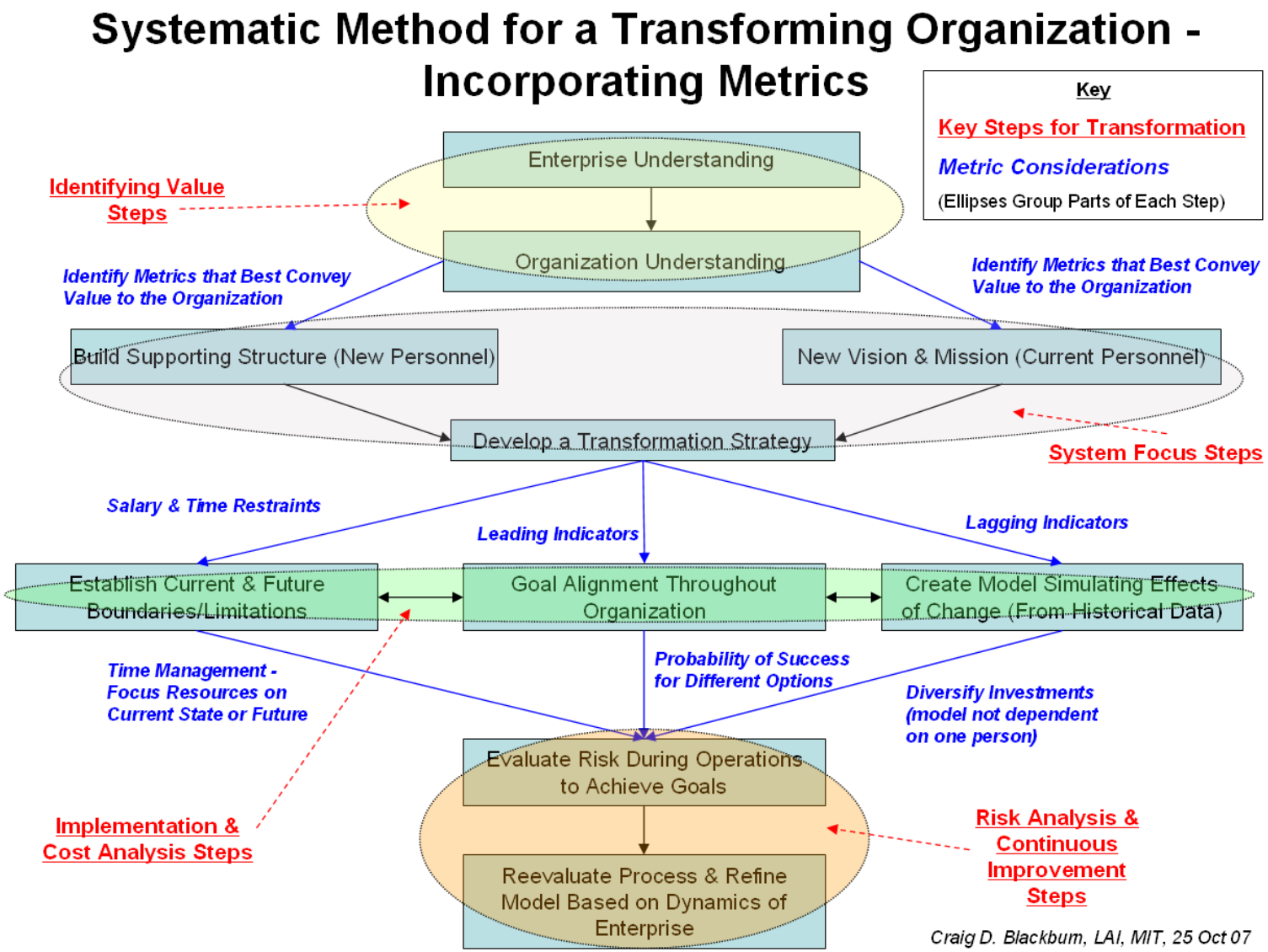

Figure 1. Systematic Method for a Transforming Organization – Incorporating Metrics

Identifying & Estimating Value

How the Oakland A's Re-Defined Value: Playing a Different Game

Talent evaluation and player value in MLB had historically been determined by a system of scouts, most of which had no analytical experience but rather just that of having played the game first hand. The metrics they had used for evaluating a player had never been altered except marginally over time with the advent of new technologies, such as how pitchers can be better evaluated via radar and pitch tracking devices that track the exact trajectory of a throw from the mound to the plate. What the General Manager was about to do, without even knowing it, was employ systems thinking principles to establish effective metrics, simply by asking "How does this measure relate to a desired output of the process?" (Kitterman 2005). Old measures that did not have enough of an impact on the desired output, such as speed, were thrown out; and meaningful metrics, such as on base percentage, were considered. The Oakland GM was the first to reject traditional metrics and to use a revolutionary method of thinking, one that had been around for decades yet never implemented or taken seriously, which redefined value completely.

The pioneers who first advocated this reevaluation of metrics in baseball were an aggregate of dedicated sports fans and statisticians led by Bill James. This method was centered on one fundamental concept of the game – outs. The potential production of an offense is only limited by outs, not time. Over time and through enthusiasm from the stakeholders (fans), systems were developed wherein a player's value could be determined by their direct production of runs. These systems removed influences outside of the players' control; such as where the fielders were standing during the play, which inherently effects whether the play is an out regardless of how well the ball was hit. By removing as many of these external factors as possible from an occasion one can develop a better measure of value. As it turns out, when not getting out is considered a credit to a player's value, player ratings begin to look much different. Using this new system, the team was able to see value where other could not, and do so cheaply – they were indeed "playing a different game" (Lewis 2004).

Value Measurement in an Enterprise

In order to understand a system, one needs to know what value is being delivered to the consumer and what actions are being taken to deliver this value. To define and evaluate a system, metrics need to be established that connect the attributes or characteristics of production to a product's end value. Furthermore, organizations must be certain they are considering metrics that will allow for the maximum long term gain, since "once the enterprise is committed to these metrics, the metrics gain tremendous inertia" and "it is extremely hard to refocus the enterprise on new goals" (Hauser & Katz 1998). Metrics need to be consistent with promoting actions that add value to production. The following heuristic illustrates this point:

"If we measure what we wish to encourage, the areas that we focus upon will improve" (LAI 2000).

In an enterprise, it is important to always re-consider the value of a product or service. Constant awareness of value and the ability to measure it keeps an enterprise focused and ensures the needs of the consumer are being met. An effective system of metrics is developed when the principal aspects influencing the production process are related to how value is

perceived by the customer.

The first step one needs to take to establish a proper measurement system in their enterprise is to identify value in the most general sense and expand outward from there. After value from the customer's perspective is defined, the actions employees and stakeholders make that influence this value stream can be examined. Metrics for actions that directly provide value to the customer then can be developed and a system for optimizing value implemented. Additionally, some metrics might be more indicative of value than others, so metrics need to be weighted accordingly.

The ability to collect, analyze, and interpret metrics has been improving over time as innovative thinking has advanced. With this notion, it is not far fetched to say that enterprises need to be ready to adopt metric development systems that can accommodate for the changing environment. Similar to how a recent emphasis has been placed on metric research and development in baseball, in industry it has been expressed that:

"Research has not kept pace with these new demands in an environment where it is no longer sufficient to simply let metrics evolve over time—we must learn how to proactively design and manage them" (Melnyk, Stewart, & Swink, 2004).

The challenges that engineers and managers will encounter by improving their current measurement systems are significant. Cultural resistance might be encountered from all levels of the organization, from lack of leadership support to lack of employee buy-in. The most effective way to integrate new measurement into an enterprise is to show stakeholders the cause and effect relationships that influence value and reward the pursuit of value accordingly. Defining performance measurement systems that, instead of promoting specific actions, promote value should be the goal for any effective manager.

Team Focus: Making the System the Star

System State Success on the Field

When the new strategy was developed by Beane, the GM of the Oakland Athletics, the first step he took regarding his organization was to: add a supporting structure that could facilitate the new needs of the organization; and bring the current stakeholders, including the scouts and the Manager, up to speed with the new mission and vision. After this support has been constructed, the group was able to focus on developing strategy that could make the team better.

In addition to being able to analyze value added by individual components to the production output, it is imperative to evaluate team synergy and situational performance. Lewis indicates that many situations can be measured regarding how one will perform under different levels of stress and in different surroundings. There is a lot to be said for putting the right pieces in the right places, not just throwing them together at random.

Synergy & the Effects of Team Focus. Before we discuss how one needs to perform in different circumstances, Lewis relates scoring runs to a process. The first manager that thought to consider a line-up as a run-producing system was Sandy Alderson, former Oakland GM and mentor of Billy Beane, and Lewis discusses this enlightenment with the following passage:

"Scoring runs was, in the new view, less an art or talent than a process. If you made the process routine – if you got every player doing his part on the production line – you could

pay a lot less for runs than the going rate … The system's central tenant was, in [Sandy] Alderson's words, 'the system was the star. The reason the system works is that everyone buys into it. If they don't, there is a weakness in the system'" (Lewis 2004).

This production line mentality enlightened managers to start putting more thought into engineering an aggregate line-up to maximize potential. There were three rules to Alderson's approach: all batters must act like lead off men, the goal is to get on base; all batters need to have the power to hit home-runs, since pitchers would then pitch more cautiously and walk batters more; and if you have the ability to hit, the process of hitting is more mental than physical and it needs to be approached as such. With these three guiding rules, Alderson began to engineer a line-up that he believed could maximize the runs production process.

Considering Situational Performance in Baseball. It has long been identified by Bill James that the lack of measurement of situational performance in MLB is inadequate and unacceptable, given the amount of data they had access to but were reluctant to use. James' frustration is exemplified with the following criticism of MLB:

"We as analysts of the game are blocked off from the basic source of information which we need to undertake an incalculable variety of investigative studies" (James 1984).

James identified some of the many metrics that describe the "system" state of the game, influence player and managerial decisions, and could be recorded with ease. For example, the amount of pitches being thrown by pitchers had not been recorded, although the understanding of pitcher fatigue had been of paramount consideration for manager decisions late in games. James noted that good metrics removed biases wherein metrics were obscured by factors players could not influence. Over time, James' philosophy became accepted across the baseball world, and attaining critical metrics that affected the decision making processes and described performance with respect to the system state of the game was highly prioritized.

System State Success for an Organization

For any organization undergoing transformation, leadership and management needs to ensure a support structure is in place to implement the changing mission and vision. Some new talents and positions might need to be added, and current decision makers will need to be educated about the new changes. Together, this structure will develop a strategy for transformation.

As is true in baseball, it is imperative that all stakeholders in this support structure believe in the system. Just as James understood the values of synergy in a process and how performance was highly dependent on situations, organizations with harder to define metrics have adapted this understanding as well. The importance for an organization in establishing a structure that can facilitate change is expressed as follows:

"Alignment and understanding around vision, strategy and goals must occur within a corporation across all organizations before the corporation can operate at its highest efficiency" (Salter 2007).

Synergy & the Effects of Organizational Focus. Similar to baseball, the effects of the aggregate working together should be greater than the sum of the individual talents. As this concept can be expressed in many ways, it is best summed up in the following statement

"Choosing the appropriate aggregation of functions is critical in the design of systems" (Rechtin 1991).

The tools that all employees need to have are the analytical abilities to examine industry related problems they are confronted with. As baseball is mental and players need to understand the abilities of those they are put into a system with, so is work. By understanding the nature of a problem a worker is confronted with, at a minimum they need to know where to go or to whom they can go to in order to put themselves in a position to evaluate the problem more accurately. Managers need to evaluate the effects of synergy and facilitate intra-office and intra-enterprise communication to the best of their ability

Integrating Situational Performance in an Enterprise. The aforementioned effects of synergy can help managers begin to put employees on the right job to optimize production, but that is not all that needs to be done – the effects need to be measured with respect to performance in differing circumstances. Similarly to how performance based metrics were used by managers to make decisions about maximizing production during baseball games, the following thought depicts how managers at work need a metric system that portrays situational-based performance information:

"The goal of any performance measurement system is to provide the right people with the right performance-related information at the right time" (Harbour 1997).

In this example, the managers being provided with situational performance information at the appropriate times allows them to allocate resources, perhaps the number of people to assign to a project, such that they can maximize the probability of program success. Managers need to keep track of the quality and quantity of work getting done in different situations and make correct assumptions accordingly.

Implementation & Cost Analysis

The Price of Winning

In conjunction with systems analysis and estimation of value, significant lessons learned can be drawn from baseball with respect to implementation and cost analysis. The most important considerations for implementation are to: understand the boundaries of the system and your resource limitations, establish reasonable goals, and to create a model that can simulate the effects of change and transformation on the output of the system. As a team with fewer resources than others: the Athletics understood their boundaries and used leading indicators to predict which players could help the team achieve its goals for the least cost, and used lagging indicators to develop a predictive model for production that guided transformation.

Managing Team Salary. Unfortunately for the Oakland Athletics, they were limited by a budget, one much lower than their competitors. The top team in the league, the New York Yankees, had a payroll around $126 million in 2002 with perhaps another $100 million at their disposal if it became necessary. Compared to the teams the Athletics most frequently competed against alone: the Texas Rangers had a salary of $109 million, the Seattle Mariners a salary of $86 million, and the Anaheim Angels a salary of $63 million. Oakland had $40 million.

With this significant disadvantage came limitations in spending. The Athletics could not afford to spend $20 million on a high quality player, since they wouldn't have enough money to

field the rest of the team. What this meant was that Oakland had to employ their metric system to find good bargains or good value – which they could attain by implementing their metric system and by being active at the trade deadline. In addition to not being able to pay high quality players, the Athletics could not even afford to have average players. The average player salary in MLB was $2.3 million, and at the start of the season the Oakland Athletics' average salary was around $1.5 million (65% lower than the average salary). These characteristics of the market situation forced Beane to sign the cheapest players he thought would produce the aggregate results needed to make the Playoffs based on the metrics system and models described above. This method was effective in maximizing results and minimizing costs – a recipe for success that prevailed year after year.

Leading & Lagging Indicators of Player Performance. To establish a cost effective plan for success, the Athletics used leading indicators to predict potential for cheaper players. The characteristics of a player's game that they thought would translate into successes as the ballplayer developed were considered – such as their patience. Lagging indicators from historical data were used to create and calibrate predictive models that simulated the effects of decisions. Once the desired production level had been established, the team used their models to determine a strategy for how to attain the necessary production while minimizing costs.

With the assistance of these models, the Oakland GM was able to determine how many runs the team would need in a season to generate the amount of wins necessary to make the playoffs. The first calculation the Athletics made, was that 95 wins would be the number needed to get the team to the playoffs. With the previously considered $40 million for spending, it would cost Oakland $420,000 per win at this rate. Using this metric as a baseline for success, it was then evaluated how many runs would be needed more than their opponents to win this many games – 135. The calculations for the A's team that year predicted between 800-820 runs scored with only 650-670 runs against, allowing them to win between 93 and 97 games. These calculations guided managerial decisions, and at the end of the 2002 season the team scored 800 runs, allowed 654, and won 103 games – 1st in their division (Lewis 2004).

Putting a Price on Organizational Value

Before implementing strategies, an organization needs to understand its resource limitations, develop manageable goals, and create a model to simulate the effects of decisions on the impending transformation. Leading and Lagging indicators can be used analogous to how they are used in the above example, and used to evaluate relationships between production needed and the salary that needs to be spent for that production. The importance of indicators in enterprise architecting is expressed as follows:

"Measures can be used both to judge outcomes as well as predict the future. Lagging indicators are important to show actual outcomes, while leading indicators are vital because they can be used to gleam information, guide decision making and assess likelihood for success" (Mahidhar 2005).

Matching Job to Task. When your organization is the Oakland Athletics in an enterprise, with competitors the size of the New York Yankees, smart budgeting needs to be employed. Before one determines who to hire, it needs to be determined what jobs need to be done. Obviously, maximizing resources will not entail paying an engineer to perform clerical work. However, not hiring enough workers will more than likely lead to a larger drop in production and more

inefficiency than hiring too many workers. This situation is analogous to how Bill Beane might rather pay an extra $2 million for a producing hitter instead of having a hole in his line-up that would hinder potential production significantly.

The challenge with managing salary, as it is alluded to above, is determining how much money one can spend on a specific job. Just as Beane had few players making a salary close to the league average, an organization can determine how many resources to allocate to less important jobs. If tasks are tedious but require an adequate level of understanding, would you rather pay minimum for a new engineering college graduate or would you rather pay an experienced employee almost double?

Leading & Lagging Indicators of Worker Performance. Just as baseball had used historical data to create and calibrate models for success, organizations can do the same. Past performance can easily be evaluated based on the amount of money invested in previous years and the subsequent results. After determining what level of production is needed in order to accomplish their mission, a business can develop metrics accordingly that will focus on developing an aggregate to meet that necessary production level at the lowest cost attainable**.**

As Beane would use patience as an indicator for future success at the plate, organizations can evaluate potential employees and partners based on characteristics that they believe will translate into success – such as focus and dedication. With this as a consideration, instead of paying premiums for workers, one can identify the younger or older workers that will fit the needs of the company cheaply. A limitation to this methodology of hiring would be the cost of retraining paid by an organization if employee turnover is too rapid or if there is a steep learning curve because you still need veteran players (experienced workers).

As baseball players can be evaluated by lagging indicators, employees can as well. Looking at one's performance over time and focusing on the characteristics that can help or hurt production are what need to be found in the hiring process, and data can be found in the form of recommendations, prior work records, and other means. As was true in baseball – a model for success can be created using leading and lagging indicators to establish a transformation plan that fits with the organizations limitations and goals.

Operation Refinement & Risk Analysis

Assessing Player Value

One of the issues that the Oakland Athletics were faced to deal with on a yearly basis was how to define value at the trading deadline, the last point at which teams can acquire assets or trade overpaid players. If the team sells young valuable players for a player that will leave at the end of the season, the value he can add for those few months needs to be more than the long term loss of the other player. Conversely, a team will only sell off a productive asset if they are sure they will not meet their goals that season and this asset has little future value.

Diversifying Player Investments. In the consideration of cost, it is mentioned that the team could not afford to pay one player $20 million, since they would not be able to put together a starting line-up of even marginal players. Even if it fits their established model perfectly to pay $12 million for one player's production, what is to happen if that player gets injured? Now the GM would have an entire roster of marginal players with no potential to make-up the production needed for success indicated by the model. Such an investment would be a big risk considering the grind of a 162 game season – not including Pre-Season and Playoffs.

What Beane consistently does is architect a roster of interchangeable players, and minimize the effect that disappointing production of any one player can have on the impact of the team. Instead of having one player at $20 million, it is less of a risk to pay three players around $7 million each. This is the strategy the Athletics pursued, paying three players all around that range with the next expensive player on the roster more than $2 million below the top three (Jermaine Dye - $7.2 million, David Justice - $7.0 million, Ray Durham - $6.3 million, with the fourth highest paid player being Miguel Tejada - $3.6 million). By diversifying primary investments, the team had a factor of safety that facilitated the needs of their strategy even if an injury or unforeseen problem occurred.

The Trade-Deadline. The trading deadline, as it is alluded to above, is the most influential time period for a team to structure themselves for short-term and often long-term success. This deadline represents the last day teams can attempt to trade players (assets). Teams normally will trade away future value, young players or draft picks, for value now, high quality players that have less long term benefit, or vice versa. The big question for managers becomes, "win now or win later?" Unfortunately, there rarely is an easy answer. This situation can best be described by stating "Predicting the future may be impossible, but ignoring it is irresponsible" (Rechtin 1991). It would be irresponsible not to fix a need for one's team due to the fear of being uncertain as to if it would pay off.

Before making any major transactions, the GM first needs to understand the state of the team at this time and determine what improvements need to occur to help the organization to reach its goals. If the team were to give up future assets for a one-year player and then not make the playoffs – the value added was not worth the investment – and the risky decision would be a failure. Beane was always credited with understanding what value could bring his team to the Playoffs, and what he could afford to lose. In addition to the understanding of value that Beane had, his keen ability to manage risks during this hectic period and take advantage of inefficiencies in the trading market contributed in his team's success over the years.

Managing your Organization to Success

In the business world and professional sports, the direction of one's organization or the evaluation of value is not as clear as one would desire. An organization needs to understand their position and how to manage investments to reach their goals. Moreover, in time-crunch periods like the last business quarter, it is imperative to understand the system state of your organization, how well you are doing at achieving your goals, and the likelihood of success.

"A good metric should provide current status, rate of improvement, and probability of achievement" (Nightingale 2000).

Diversifying Investments. Similar to how Beane could not afford to put all of his hopes into one player, many companies can not afford high-risk endeavors that in which failure would be imminent with the subsequent downfall of the investment. The diversity of one's investments, although they sometimes might lower ultimate potential, increases the probability for succeeding. If a business pays a lot of money for a single technology, such as e-commerce, and this technology becomes outdated or less beneficial than predicted, the output of the organization will suffer. This notion can be embodied by saying "the strengths of an organization in one context can be its weakness in another" (Rechtin, 1991). This example portrays that diversifying one's investments and technologies – in order to ensure that success is not reliant on one asset or

technology – is critical.

When considering rate of improvement, Beane was willing to invest more money in his premier young players to guarantee their presence on the team for as long as possible. Their potential was worth the risk of losing a few million since younger players are cheaper due to the risk in them possibly never achieving this potential. When considering salary in a business, improvement rates need to be considered as well. People, like players, need to be evaluated heavily based on their current progress and not on observations based on biases or previous work. If a young employee or small supplier is showing dedication and improvement in work, it might be worth it to take a smaller loss in the current state for the potential significant gains of their services if you show good faith in them early in the relationship.

The Time-Crunch. Managing risk in hectic periods is often a significant hurdle. The key for success in such a situation is, as indicated in the quotation above; knowing where you are, how well you are progressing at achieving your goals, and what your chances are for future success. Moreover, a manager must "hang on to the agony of decisions as long as possible" in order to properly analyze the situation and be confident in whatever course of action is chosen for the organization (Rechtin 1991).

Often lost in management heavy time-crunch periods is the effect these times have on workers. Just as players can leave for different teams in free agency, workers can go to different organizations if they are worked too hard and not appreciated. Managers need to determine what the benefit is of working their people extra hard in tough time-crunch times – and if overworking them is worth the risk that they might leave.

Conclusions

Bill James revolutionized baseball with his advocacy of a better system of metrics in MLB. When Beane and the Oakland Athletics enlisted the new metric principles advocated in James's baseball abstracts, they were using a well documented and refined framework that had been available for years – which other clubs had chosen to ignore. Dedication to these principles allowed the team to: identify value where others had failed too, establish a team first approach focusing on the aggregate rather than the individual, create an implementation and cost analysis process that facilitated cheap success, and manage risk throughout the process while refining their model when necessary. Success of the Oakland Athletics in recent history has encouraged other teams to employ similar principles, and the successes have been well documented across the enterprise.

The importance of metric analysis in organizational decisions have been well documented. Although there are many frameworks and principles that organizations can customize to meet their needs – many still fail to adequately consider metrics. The ideas of how to use metrics to assist in transforming one's organization are simple – so simple they can be related and depicted through the game of baseball. The motivation to exploit these organizational metrics truths is to improve entire enterprises as a whole, as James's advocacy of metrics was able to revolutionize baseball. The only question left is who will be Billy Beane of their organization?

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