Using Collective System Design to Define and Communicate Organization Goals and Related Solutions

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Abstract:

One global movement to increase organizational efficiency is the "lean" movement and while lean implementations in organizations have had positive impact, there remain concerns about the rate and sustainability of successful implementation. This paper discusses the use of Collective System Design as a way to deal with these concerns for lean initiatives and other systematic changes in organizations. Collective System Design provides a language for describing a system design with the goals of a system stated as Functional Requirements met by particular means, called Physical Solutions that are proposed as a hypothesis to achieve Functional Requirements. This paper describes the Collective System Design methodology and provides a manufacturing system re-design case evaluation that examines the synergy with Value Stream Mapping. Leadership implications are then examined based on the case-study research.

Keywords: Collective System Design, Sustaining Lean, Axiomatic Design, Organizational Goals and Metrics, Goals, Line of Sight

In the increasingly competitive global marketplace, the people in organizations are constantly searching for ways to be more competitive. This search has led organizations to seek interventions and methods that help to increase overall productivity. One major source of ideas for greater efficiency has been the Toyota Production System (TPS), with organizations looking to apply the ideas and methods of Toyota to their own processes (Monden, 2012; Ohno, 1988; Shingo, 1989; Sugimori et al., 1977). The TPS is focused on the reduction of system-wide waste and reduction in the amount of effort and resources spent on non-value added production processes (Holweg, 2007; Shingo, 1989). This reduction is accomplished in large part by understanding the "gemba" or work that is done in manufacturing and by people in the enterprise establishing shared understanding of value stream functional requirements and a "dynamic learning capability" (Holweg, 2007, pg. 422) where all parties in the enterprise strive for a more effective enterprise. The ideas behind TPS are the primary basis for the school of thought labeled in the United States as "lean" (Holweg, 2007; Womack, Jones, & Roos, 1990).

While lean interventions can have significant impact on organizational effectiveness (Shah & Ward, 2003; Spear & Bowen, 1999) there are concerns about the success of implementing lean (Guimarães & de Carvhalho, 2014; Bhasin, 2012; Deflorin & Scherrer-Rathje, 2012; Scherrer-Rathje, Boyle, & Deflorin, 2009) and the sustainability of lean initiatives (Harris, Stone, Mayeshiba, Componation, & Farrington, 2014; Cochran, 2017). Some estimates suggest that less than 10% of all lean interventions sustain three years after they are implemented (Cochran & Kawada, 2012).

This paper discusses the use of Collective System Design (CSD), an enterprise and manufacturing system design implementation approach that has been developed in response to problems that many enterprises face in implementing and sustaining TPS, Lean and Lean-Six Sigma initiatives (Cochran, 2006). CSD emphasizes the need for collective agreement on the nature of the goals that an organization seeks to accomplish and the means by which the goals are being reached. CSD provides a language for system design to codify the understanding gained during a system design and learning process (Cochran & Barnes, 2013, Cochran. 2007b).

The CSD approach provides an open framework that draws on the TPS, Six-Sigma, Lean-Six Sigma, Drum-Buffer-Rope, Factory Physics and Principles of Systems (Cochran, 2006; 2007a; Cochran et al., 2001; Forrester, 1990; Hopp & Spearman, 2000; Shingo, 1989**)** taking the elements that best help to build the collective agreement on goals that facilitate sustainability. CSD works as a tool to codify "the thinking" behind organizational processes by first expressing system purpose (stated as non-numerical, non-financial system design objectives, called Functional Requirements (FRs), and then associating proposed solutions to achieve the specified purpose, called Physical Solutions (PSs) (Cochran, 2007a; Womack & Roos, 1996). CSD uses an axiomatic design approach in connecting the domain of needed functions with the physical domain of how those functions are accomplished (Khayal & Farid, 2015; Suh, Cochran & Lima, 1998).

This framework of CSD enables the visibility and the flexibility of a team to identify new system purpose based on new or changing customer needs, which is achieved in part by separating the functional purpose of the enterprise system from the means by which the purpose is achieved (Cochran, 2006). Each proposed Physical Solution (PS) is treated as a hypothesis to achieve the system intention expressed by each Functional Requirement (FR). A system design is expressed by the resulting Enterprise System Design Map to provide an overall picture of each objective (FR) and means of achievement of the objective with a PS (Cochran & Kawada, 2012; Spear & Bowen, 1999).

CSD facilitates a collective agreement approach that seeks to involve employees at all levels in the initiative with a common understanding of what goals the organization desires to accomplish and how it is attempting to accomplish them. Research has found that goals can have significant positive impact on a worker's level of performance, motivation and where the worker focuses attention (Locke & Latham, 2002). The motivation of workers in lean initiatives has been highlighted as a needed area of greater consideration (Harris, G., et al, 2014). The language of CSD enables shared understanding to achieve what is called in the management literature, "line-of-sight," where an employee can understand and see how his or her actions connect with organization missions and strategies. Line-of-sight has been found to

relate to greater worker performance and to help build both social and human capital (Buller & McEvoy, 2012).

This paper gives managers a clear description of the CSD methodology and represents the collaboration of scholars in management and systems engineering. The purpose is to illustrate how CSD can be applied to organizations engaging in enterprise transformation. The structure of this paper is to first give a description of the CSD approach and how it is used to establish the goals of organizational value streams and how those goals are reached and improved. The paper then describes how CSD is used to design a new enterprise or organization, or to re-design an existing enterprise or organization. This is followed with a case evaluation of a manufacturing company that went through a transformation and evaluation based on CSD principles. The paper then gives five recommendations for CSD application in any organization. The paper concludes by discussing the implications of CSD for enterprise transformation.

Collective System Design

The Collective System Design (CSD) methodology is a way to first clearly define the goals that drive organizational actions and then connect the means by which these goals can be reached in the workplace. These goals do not need to be financial in nature and can often be about quality of service, time, or other customer needs. The approach creates a common language by which managers, designers, and workers can communicate the "what" and "how" of organizational goals and means of achievement. Too often in organizations it is assumed that everyone is in agreement on a goal and a course of action when in fact people may have very different ideas and understanding of the goal. It has been argued that changing thinking is crucial to success in lean implementations (Guimarães & de Carvhalho, 2014; Cochran, 2007b). For example, an organization might have a goal of, "Minimize the time to provide a product to a customer." Workers might all agree to that goal but might have different ideas of what is an appropriate way to achieve that goal, such as how an engineer interacts with a customer. An organization may get quick service to customers but at a cost of poor quality of service that is unacceptable.

The CSD approach also helps to reduce the common problem found in organizations where the ends are often confused with the means of achievement (Cochran & Barnes, 2013; Johnson and Bröms, 2000). As noted in Shingo (1989), organizations often look to incremental changes in current way of doing things rather than systemic solutions that do have much greater impact. Solutions are often framed as to how they relate to a current situation rather than in what may be the best way to actually meet an organization goal.

CSD is an evolution from the Manufacturing System Design Decomposition (MSDD) research that was originally applied to the design of manufacturing systems (Cochran et al.,2001; Cochran & Dobbs, 2001) but can be applied in any organizational setting such as hospitals (Khayal & Farid, 2015; Graban, 2011; Cochran & Swartz, 2015; Cochran, Lia, Vanover, & Foley, 2016b), offices, and service industries (Cochran & Barnes, 2013). The approach is flexible enough to be applied to any context.

CSD is based around two important concepts: defining the goals the organization has for a product or service with Functional Requirements and then choosing the means by which those goals are actually met in the workplace by Physical Solutions. The MSDD is the manufacturing part of an overall Enterprise System Design Map will be a series of Functional Requirements and Physical Solutions mapping out exactly what the organization wants done and how it goes about doing it. This mapping clearly decomposes the goals of the organization (Functional Requirements) and what are the means for reaching those goals (Physical Solutions).

The Functional Requirement (FR) is what the organization must achieve to satisfy the customer when delivering a product or service. For instance, an organization might have the goal of excellent customer service. This goal would then be represented by a number of Functional Requirements (FRs) related to excellence in customer service in delivering the product to the customer. Organizational actions are then taken with the idea of providing excellent customer service. Specific system design FRs in this case could be things like, “Minimize the time to provide the product or service” or “Provide a product that the customer likes (Quality).” Actions are taken to work toward these FRs and other organizational FRs. This focus helps to identity and eliminate organizational actions and behaviors that are not related to

important organizational goals and thus would be a waste of time and resources. Organizations will often have several FRs that are being acted on at once.

The Physical Solutions (PS) state the ways that the FRs are accomplished. PSs represent solutions within the organization, such as people, techniques, technologies and processes. For example, the FR of "Provide excellent customer service" could be met in an organization through PSs such as "On-time delivery of product," "Rapid response to customer questions" or "Customer script read by employee." The PS represents the way in which that organizational goal is proposed to be fulfilled by the design. Each FR has only one PS that is currently being used to achieve the FR. The correct PS for an FR is something that can be modified or changed over time. The current PS should be the best current solution to an FR but a more effective PS may be implemented when discovered. In this way, we see the PS as a hypothesis of how to best meet the FR that is tested through use and analysis of results. The approach builds on Spear and Bowen (1999) in which all work is considered to be a hypothesis to achieve a desired result in the Deoxyribonucleic Acid (DNA) of TPS.

For one example, Taco Bell may have an FR of "Provide customer with desired quality food." In the past, the PS for this requirement was to "Offer a consistent menu all day and late night." While this might have been a decent solution in the past, customer desire for breakfast being served could have led to a new PS of, "Offer unique breakfast items." So, the Taco Bell FR of "Provide customer with desired quality food" is now better met by modifying the PS to allow the offering of a breakfast menu. This change represents a change in the "system design."

Therefore, for each FR, there is a PS that is designed or chosen to accomplish that FR. This approach allows for a more complete specification of how an organization determines, communicates and reaches its goals. This approach is implemented by the Enterprise System Design Map, where high-level FRs and PSs are decomposed and structured to clearly define how an organization will work to reach its goals. An example diagram of a full Enterprise System Design Map is shown in Figure 1.

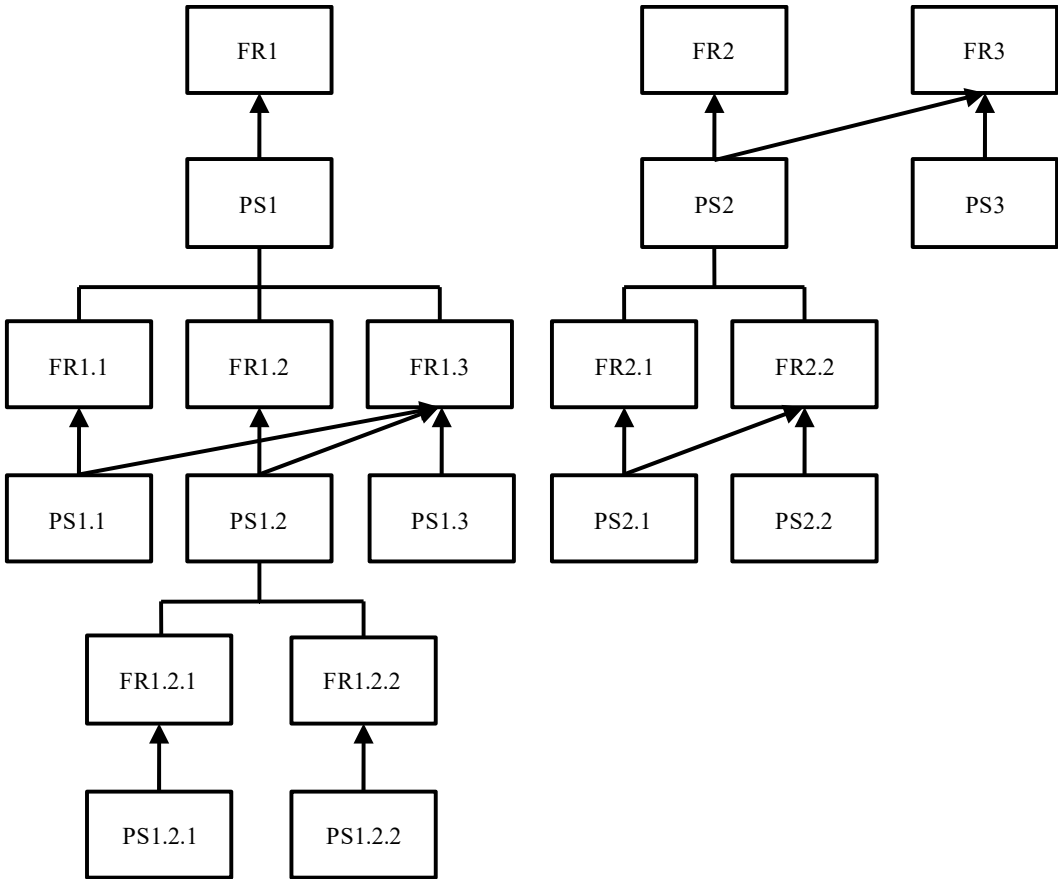

Figure 1. Illustration of Enterprise System Design Map

In system design mapping, higher level PSs have their own FRs needed to accomplish them. So for example, if an organization has an FR of "FR1: On time construction of customer orders" it may have a PS of "PS1: Computerized inventory system" – which is a physical thing or entity. For that PS to be fully implemented it needs to be specified what exactly the physical system needs to accomplish. In this case, the lower level FRs specify what the computerized inventory system needs to be able to do, such as, "FR1.1: Keep track of level of items in inventory" and "FR1.2 Note when inventory items are used." These lower level FRs would then have their own PSs to allow them to be accomplished, such as, "PS1.1 Have item bins automatically calculate the number of items by weight," and "PS1.2 Scan items as they are being taken for use." So the multiple levels of FRs and related PSs allow us to specify exactly what behaviors and processes need to be done to reach our desired top level FR. These lower level PSs are implemented as "Standard Work," the actual physical actions a worker or machine needs to do (Cochran

et al, 2014). Standard Work is done uniformly from shift to shift, from worker to worker, as standardization of a process is necessary to make it improvable (Deming, 2000; Ohno, 1988). This approach creates a clear connection between what a worker is doing and organizational goals. The Enterprise System Design Map allows workers to see those connections and ultimately consider how changes in their own behaviors might help to better meet the organizational goals described by the FRs. This approach fits with the concept in the human resource literature of line-of-sight, as it makes a clear connection between organizational strategy and implementation in the mind of workers (For a review of the line of sight research area, see Buller & McEvoy, 2012). For more on the technical aspects of system design mapping and impact in making investment decisions, please see the work of Cochran, Arinez, Duda, and Linck (2001), Cochran & Dobbs (2001), Cochran (2006), and Cochran, Hendricks, Barnes, and Bi (2016).

Also, important to successful CSD is proper measurement of FRs and PSs. Good measures are crucial for success and sustainability in organizational transformation (Guimarães and de Carvhalho, 2014). Measurement of how well an FR is being reached helps to determine if the PSs used are effective. This design approach of relating performance measures to the FR, called FR_M, helps the organization know if modifications need to be made to a PS, or if a new choice of PS is needed (Cochran & Barnes, 2013).

Evaluation of the PS implementation is called a PS_M. This type of measure determines whether the PS is being implemented correctly; it does not determine whether the desired goal is being achieved, which is the purpose of the measure on the FR_M. If a PS is not being implemented correctly, the PS will not be having the impact it should. To expand on the example mentioned above, if the PS for inventory management is scanning parts as they are removed, the method might not be working because workers are choosing not to do the actual scanning (a failure in doing the PS correctly) rather than the PS itself being ineffective.

A significant benefit of CSD is that the common language and clearly specified organizational goals (FRs) and solutions to meet those goals (PSs) that it creates allows for workers across different

levels of an organization to understand and be involved in decisions. Thus, workers can understand why an enterprise transformation is being made based on existing goals and how such a transformation is met through work-related activities. An aspect of success that is too often ignored is the crucial role workers across job levels have on changing and improving how work is done to better achieve FRs, and thus, creates a dynamic learning capability (Holweg, 2007).

In descriptions of TPS, credit for sustaining success is often given to the top-level designers of the system, Taiichi Ohno and Shigeo Shingo (Holweg, 2007). While both people were instrumental in TPS, many of the actual improvements to the production process made in Toyota over time came from lower level managers and workers themselves (Holweg, 2007). While a lean or lean-like system can be created by a higher-level manager or industrial engineer, it is sustained and improved in large part due to the actions of lower-level workers. CSD offers a language by which workers understand system goals and do behaviors toward those goals. For the desired result to happen, CSD needs to be paired with organizational policies and leadership that encourages workers to be part of decision-making processes and to engage them in their own critical thinking.

As noted in Harris et al. (2014), the motivation of workers in a lean initiative is too often ignored. Workers being included in the process of setting the goals and making sure a common language is shared will help workers to understand and feel connected to the actual process. This practice on the part of leaders and managers should in turn help the workers to be more motivated and to contribute to achieving the goals of the organization. In the goal setting literature, goals that are not accepted by a person do not help enterprise performance, rather performance is negatively impacted (Locke & Latham, 2002; Erez & Zidon, 1984). Additionally, performance measures that are not tied to FRs may influence workers to "bend the rules" to maximize their rewards, circumventing the system goals (Azar, 2007; Bly, 2008). The CSD process, thus, can play a crucial role in helping goal acceptance among a workforce. Next the paper illustrates how CSD is being used to transform an organization in conjunction with Value Stream Mapping.

Case Evaluation with Collective System Design

A Value Stream Mapping workshop with a client company was conducted over a period of five days. During the workshops, the Value Stream Mapping was applied to several different product lines. One single product line/Value Stream became the implementation focus by company team members and is similarly the focus of this case evaluation.

The company team is in the process of implementing the new Value Stream. To determine the overall achievement of system Functional Requirements, the leadership team decided to evaluate the new Value Stream implementation with the Manufacturing System Design Decomposition (MSDD) self-evaluation questionnaire (Cochran, Foley, and Bi, 2017). The application of steps 4 through 7 of the overall CSD methodology shown in Figure 2 resulted in the development of the MSDD and questionnaire used to evaluate the manufacturing system design of the Value Stream.

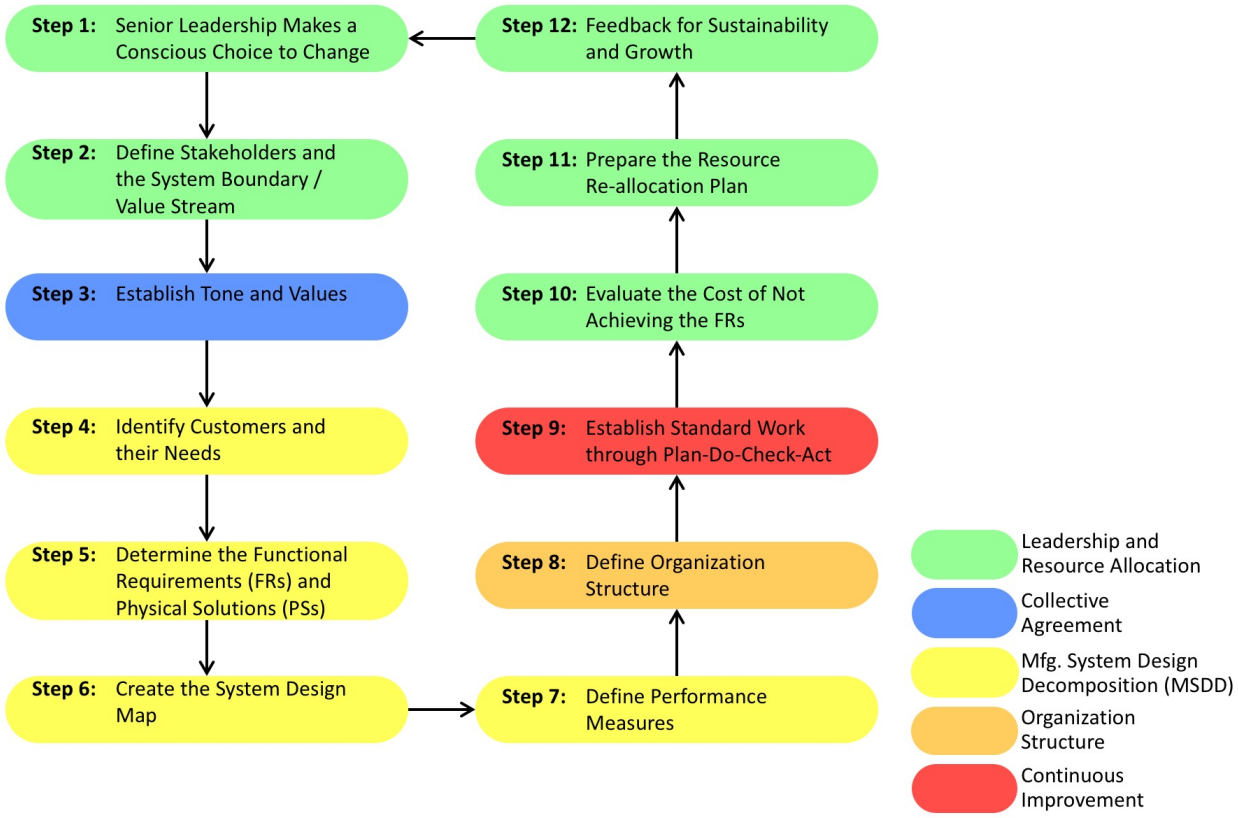

Figure 2. Steps of the Collective System Design Methodology

Figure 3 provides the results of the MSDD self-evaluation questionnaire which is a graphical representation of the Functional Requirements that are being achieved based on a 5 point Likert Scale. FR achievement was considered very poor with a 1 to 2 average response on the survey, a score in the range of 2 to 3 is considered poor achievement, while a score of 3 to 4 is moderate achievement, a 4 to 4.5 is good achievement and a score of 4.5 to 5.0 is considered very good achievement of an FR.

Figure 4 defines the expected achievement of the FRs after the new Value Stream implementation. The graphic illustrates that many more FRs are being achieved as good or very good after the system has been re-designed using Value Stream Mapping. Figures 3 and 4 illustrate a key point in lean system implementation that single project implementations of lean do not always achieve all FRs of the system design. The MSDD case evaluation shown here illustrates that the MSDD provides a roadmap for lean implementation and a way to gage the achievement of the FRs associated with lean implementation as specified by the MSDD. The MSDD is a way of describing the FRs that must be achieved to achieve what Toyota originally called "True North."

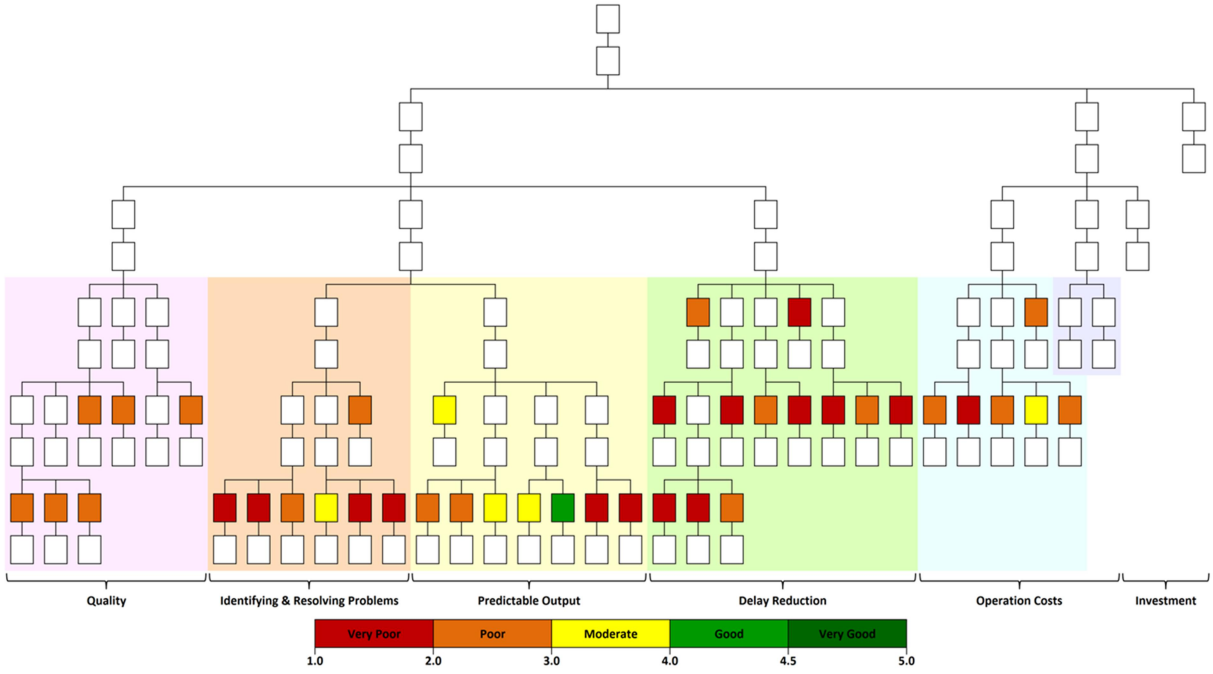

Figure 3. Evaluation of original system design

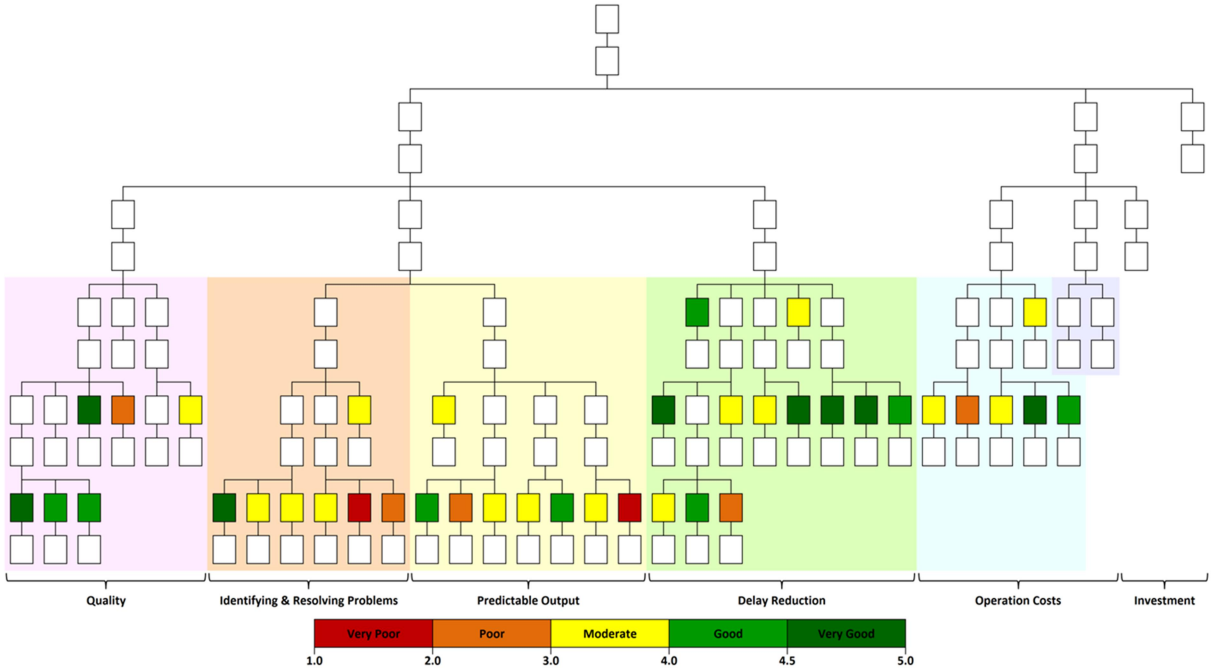

Figure 4. Evaluation of expected results of system re-design

For the client company, the MSDD was adopted as the leadership's team Collective System Design. Instead of developing a new system design map for their enterprise, the leadership team decided to adopt the use of the MSDD. In practice, some companies will adopt the use of the MSDD, while other company leadership teams extend the MSDD to include other FR - PS relationships that are not illustrated by the MSDD, while others will develop a completely new Enterprise System Design Map for their company.

Table 1 ties the business performance results to the achievement of system-design FRs. The research hypothesis ties the achievement of system FRs in the MSDD to better system performance. Evaluation of the statement that aligning the enterprise to achieve the system FRs results in an improvement in overall business performance is conducted through hypothesis testing. The null hypothesis is that business performance is unaffected by the achievement of system FRs.

Table 1. Comparison of FRs for New and Existing System Designs

General Mfg.	**Performance (*Exist:New*)**		**Evaluation Scores of Leaf FRs**					**Satisfied FRs**	
Measure	***Ratio***	***Percent***	***VP***	***Poor***	***Mod***	***Good***	***VG***	***Exist***	***New***
Floor Area (ft^2)	1.6:1	(-37%)	1:0	1:0	0:2	0:0	0:0	**0 / 2**	**0 / 2**
In-line Inventory	1.6:1	(-38%)	3:0	3:0	1:2	1:3	0:3	**1 / 8**	**6 / 8**
Mfg. Lead Time	2:1	(-50%)	8:0	4:1	0:4	0:3	0:4	**0 / 12**	**7 / 12**
Direct Labor (per part)	2:1	(-50%)	1:0	4:1	1:3	0:1	0:1	**0 / 6**	**2 / 6**
Indirect Labor (EQS)	1.8:1	(-44%)	8:2	2:1	4:8	1:2	0:2	**1 / 15**	**4 / 15**
Good Parts/DL Hour	0.5:1	+100%	14:2	14:4	4:13	1:7	0:7	**1 / 36**	**14 / 33**
Internal Rework Qty.	2:1	(-50%)	14:2	14:4	4:13	1:7	0:7	**1 / 36**	**14 / 33**
No. of Product Models	1:1	0%	1:0	2:1	1:1	0:0	0:2	**0 / 4**	**2 / 4**
Overall System Design			**15:2**	**18:5**	**5:16**	**1:8**	**0:8**	**1 / 39**	**16 / 39**

Table 1 shows clearly that Good Parts per Direct Labor Hour improved by 100%. The value of direct labor doubled as a result of designing the system to operate to takt time (i.e., to produce product by the system at the pace of customer demand). The improvement in direct labor efficiency is the result of implementing a new system design and not from laying employees off or cutting wages.

Internal rework quantity was reduced by 50%. Reduction of batch size provides a faster signal to recognizing quality problems and minimizes the amount of product requiring potential rework. The new design established work cells that put processes together and instantiated one-piece flow processing. This redesign facilitates improved communication and faster recognition and response to quality problems. This additionally resulted in the 37% reduction in required floor space.

The CSD and MSDD language provide a framework to achieve long-term sustainability. Value Stream Mapping is a technique of visualizing the sequence of activities an organization undertakes to deliver on a customer request (Rother & Shook, 1999). The mapping technique of those streams plays a critical role in system re-design when fully leveraged. However, when used solely as a design *exercise* or as a process to achieve incremental improvements, Value Stream Mapping fails to create the sustainable change that CSD is intended to do because of the focus on the physical material and information flow only. With CSD, the logical design (i.e., the thinking about the design) of the system is expressed and

united with the physical design (i.e., the Value Stream Map of material and information flow) that provides a roadmap and approach to facilitate continuous improvement.

Recommendations for applying Collective System Design

The Collective System Design approach offers a number of advantages to organizations. We now highlight five specific recommendations that come from the approach that could be applied in any organization today for positive impact.

Recommendation 1: Focus on what the organization is seeking to accomplish rather than what an action is going to cost.

Too often in organizations cost is focused on as the primary determinant in what actions are taken. While costs are important, organizations are able to sustain and make a profit because of what they accomplish that customers want. Taking cost considerations to the extreme, the best organizational course of action is to do nothing at all since taking action will inherently incur costs. A focus on costs can lead to a significant restriction of potential organizational actions as short terms costs are used to reject plans that may have long-term value in helping to reach organizational goals.

Collective System Design speaks to this issue by having organization actions guided by organizational goals rather than costs (Cochran, 2007b; Cochran, 2006; Cochran et al. 2001). FRs clearly set up the goals towards which the organization is working. The solutions for reaching those FRs (the PSs) are specified based on what will help meet those FRs rather than what will be the cheapest current solution. This approach helps the organization focus on the long terms needs of the organization's goals rather than short-term cost considerations and builds the capacity and products that customers actually want. A business is not designed to just reduce costs; it is designed to meet specific customer needs. The CSD approach seeks to communicate a tone in which meeting customer needs is in important and provides and Enterprise System Design Map to communicate (and to collectively agree on) the goals and means to meet customer needs to everyone in an organization.

Recommendation 2: Consider the overall system (value stream) rather than point solutions

A problem that can arise in most organizations, and even in lean systems, is a focus on making small changes and improvements to existing processes (Shingo, 1989). This narrow focus can help increase efficiency and reduce waste, but it doesn't always get at the heart of the problem, which can be that the production system itself is the issue. Fixing parts of a broken system will always be less effective than redesigning the whole system to be functional.

The Collective System Design approach achieves system goals as a whole by making no assumptions about how a process will be done. The language of CSD specifies first and foremost the goals of the system (the FRs). The PSs that follow to meet those FRs are the best means to reach them rather than necessarily the current way that things are done now. The Enterprise System Design Map that a team creates through collective agreement with CSD starts with the FRs rather than existing processes that may have been part of the problem (Cochran et al. 2001). The solutions fit the goals of the system. This way is actually an inherent part of the Toyota Production System: to determine the goals of the system, and then find the best means to reach those goals. Assumptions of keeping processes because that was how things were done before are not accepted in TPS (Johnson & Bröms, 2000, Ohno, 1988; Shingo, 1989). Thus, the enterprise transformation that is made is the one that fits the goals of the organization not what fits with just existing practice.

Recommendation 3: Clarify all aspects of the system design prior to implementation

With a focus on examining how the whole system can be efficient, the CSD approach looks to clearly define what the organization has for a goal to meet customer needs and how the organization will meet that goal. A big part of doing this process effectively is to clarify all parts of an organization's goals (FRs) and all parts of the proposed solutions (PSs). The development of an Enterprise System Design Map defines the work in the form of procedures, processes and sub-systems that must be done to accomplish enterprise FRs, for every person in an organization. The map creates greater clarity about the relationship of enterprise goals and means of achievement and provides a means for collective agreement and communicating top-level goals to the lowest-level implementation actions- that may not exist in many organizations. The map improves and communicates the line-of-sight in organizations (Buller & McEvoy,

2012). Workers will also potentially be more motivated as they see how their work supports the achievement of an organizations' goals.

With the general goals and FRs accepted, workers can use their expertise, from being close to the actual process, to suggest means and modifications to the PS that will best reach the FR. This understanding of the work or gemba makes the worker an integral part of continuous improvement as they do know their work process more intimately than someone at a higher level. Change becomes a collaborative process, rather than just orders imposed from managers detached from the actual work. The workers who do the work can develop the best and most effective solutions, rather than from someone outside of the process who may propose bad ideas or overly simplistic and superficial solutions. Thus, the best enterprise transformation is made.

Once clear definitions are made, it helps to set the stage and environment for testing the proposed solution. Reaching goals by testing as experiments to be examined according to the scientific method, does not have to be a manufacturing-only practice; it can be incorporated in any enterprise development effort (Ohno, 1988; Spear & Bowen, 1999). Understanding the full nature of the PS and the FR it is supposed to meet helps the organization to clearly see in a test whether the proposed PS succeeds or fails. Test first rather than last is a key part of this perspective (Cochran & Barnes, 2013). A solution is tested, often times with physical models that simulate work, before the solution is rolled out everywhere so that needed modifications can be made or different solutions can be created before implementation, thus avoiding a costly mistake.

Recommendation 4: Don't confuse means with ultimate goals

A common issue in organizations examining their current work processes is that means and ends gets confused (Johnson & Bröms, 2000). The ends are the goals, what the organization is trying to accomplish, while the means are simply how those ends are currently being met. Modifying those means is the main avenue by which improvement can happen but old means can take on the characteristics of ends in the minds of workers and managers. Those old methods become "how things are done" and changes are tied to keeping those old solutions and only modifying them. For example, an auto company

may think only about how to better meet customer transportation needs through modifying existing car makes and models when new designs such as hybrids, electric cars or even devices like Segway's might better meet needs for particular market segments. The potential avenues for solutions are limited due to looking at one means (existing car makes) rather than what the customer actually needs (transportation to where the customer needs to go) (Cochran & Barnes, 2013; Cochran & Pincham, 2009).

The CSD approach helps to avoid such issues by clearly defining what is the ultimate end or goal (the FR) and what is the means to reach it (the PS). This demarcation helps to avoid the confusion that can arise when means are seen as ends; it enables organizations to better see where a change should be made, instead of modifying flawed current methods.

Recommendation 5: Agreement on FRs needs to be deep and encompassing

For the success of implementing a successful system design, workers and managers at all levels need to be in agreement that the FRs are the right ones for the organization. CSD gives a language to talk about the goals of an organization and the ways an organization can work to reach them, but that doesn't in itself mean that everyone will agree. The process by which CSD unfolds will play a key part in the degree of buy in. The questions to ask to understand whether there is true collective agreement versus buy in and compliance because people are being paid are, "Were workers consulted as to the PSs being implemented? What information was considered by designers in creating the PSs? What was the involvement of top leaders? Have the FRs been stated clearly? Are the FRs tied to customer needs?"

In the process of building collective agreement on the FRs, leadership will be crucial. Leaders need to clearly communicate the FRs and its value to the internal and external customers of an organization (Scherrer-Rathje et al., 2009; Worley & Doolan, 2006). Leaders need to be open to the input of the workers and others who are close to the actual work processes. A valuable PS or modification to a PS may often come from the workers themselves due to their knowledge of the work. The input of all parties helps to make and test effective PSs and keeps the process of continual improvement going. (Holweg, 2007; Shingo, 1989).

Implications in the use of Collective System Design for Enterprise Transformation

This paper describes the CSD process and how it can be used in an organization. CSD provides a language for describing the goals on an organization (FRs) and the means of reaching those goals (PSs). The approach enables organizations to clearly communicate organizational goals and describes the solutions that will meet them. This paper offered five recommendations for managers to apply the CSD approach effectively at their workplace.

One important aspect in future research is the process by which organizations engage in CSD. We should ask, "Who needs to be at the table during the initial building step? Should it be system engineers, managers, and/or workers? How should decisions to finalize FRs be made?" Research can examine how the design and decision-making process can impact engagement from employees at all levels of an organization, as well as the quality of decisions made.

Better understanding is also needed as to how managers and other organizational leaders can act to both motivate workers and to help build worker understanding of organizational FRs with the Collective System Design methodology. CSD offers a clearer means for leaders to determine organizational goals with the workforce.

Leaders are a significant part of successful lean implementation and other enterprise transformations (Bhasin, 2011; Scherrer-Rathje et al., 2009; Worley & Doolan, 2006; Womack & Roos, 1996). Research should examine in more detail the role leaders' play in CSD. Future research should also include how leaders can develop line-of-sight related to the goals of lean and how workers implement those goals. Goal setting research has suggested some goals are more effective than others (Locke & Latham, 1990; Locke & Latham, 2002) and researchers may want to more directly examine CSD derived-goals as to how they fit into traditional goal conceptualization models. This could help managers to give the best goals to motivate workers to work hard in implementing current physical solutions as well as suggest potential valuable modifications that help functional requirement attainment.

A key difficulty addressed by CSD is lack of a shared purpose among the people involved in the development of a product or service and its delivery by a value stream. Management, engineering,

production, finance and other groups may have completely different viewpoints on how to meet customer needs. Thus, it is important to develop a shared mental model of the Enterprise Design that starts with Functional Requirements of the enterprise (Cochran & Barnes, 2013).

CSD provides a logical way to identify Functional Requirements for each value stream that has been identified within the system boundary, thereby defining what the system must achieve to satisfy the needs of customers. The MSDD provides a methodical way to communicate design relationships from highest-level to lowest-level of implementation as well as to understanding path dependency. These relationships provide a roadmap to move forward in enterprise transformation, allowing organizations to easily identify the most critical areas in which to focus. Furthermore, the MSDD highlights system inter-dependencies, and may be used to justify resource allocation and investment to achieve deficient Functional Requirements.

In summary, CSD defines the business strategy – including requirements and solutions, the performance measures, a continuous improvement loop through Plan, Do, Check, Act (PDCA) and a prioritized resource allocation plan that leads to a sustainable system. Value Stream Mapping is a critical tool used in CSD to identify customer needs and Functional Requirements and provides an excellent launch into enterprise transformation.

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