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A Conceptual Concurrent Engineering Model of Service Quality

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Abstract

Concurrent Engineering (CE) concepts have been successfully inplemented in manufacturing organizations. There is reasonable consensus among researchers that CE is a useful and beneficial approach for reducing the development time and manufacturing costs while simultaneously improving the quality of a product. However, all reported instances of successful and unsuccessful CE practices lie within a manufacturing setting. However, these CE concepts and tools, originally developed in the manufacturing domain, can be altered to fit and benefit service organizations. This paper proposes a framework to improve the quality of services based on CE concepts and practices that proved beneficial in manufacturing organizations.

Keywords: Concurrent Engineering Model, Service Quality.

1. Introduction

There is reasonable consensus among researchers that Concurrent Engineering (CE) is a useful and beneficial approach for reducing the development time and manufacturing costs while simultaneously imporving the quality of a product [29]. Numerous organizations have reported time and cost saving due to CE parcties [17]. However, all reported instances of successful and unsuccessful CE practices lie within the manufacturing domain.

The service sector accounts for almost 70% of the US's GNP and 70 to 80% of its employment [10]. With the increasing volume of service organizations and their important role in all major industrialized economies, it was imperative for Service Operations Management (SOM) to evolve as a separate field addressing productivity and quality issues in service organizations. Consequently, a considerable body of research was built in SOM within the past decade; however, we could not trace any explicit link to CE

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parctices or programs. But, we were able to see several scattered quality improvement tools that can be listed under the general label of CE [1,2,4,18,20].

Researchers in SOM [3,9,22] realize that the challenges in service organizations are not necessary of the same nature as manufacturing organizations. Services cannot be treated as merely goods with some odd characteristics. As a matter of fact, the characteristics of most service firms differ widely from those of manufacturing firms. However, some concepts and tools developed in the manufacturing domain can be altered to fit and benefit service organizations. Behara and Chase [4] have adapted the concept of Qaulity Function Deployment (QFD) for service firm. Statistical Process Control (SPC) [1], Just-in-time [20], and quality circles [18] all originated in manufacturing and then were adopted by SOM researchers to fit service organizations [9]. This paper is built on the premise that the service sector can also benefit from CE philosophy. Our intent is to develop a conceptual C. E. model and a conceptual C. E. architectural framework. While the model will explain the relationship between C. E. practices and service quality, the framework will provide an architectural support for the service firms trying to implement C. E. practices to improve service quality.

2. Service Production Systems

A service is an economic activity that produces time, place, form, or psychological utility [3]. The main features of a service, which distinguishes it from a product, are intangibility, heterogeneity, and inseparability of production and consumption [25]. These features emphasize the essential uniqueness of service management and dispel the common belief that manufacturing management principles can be applied to services without recognition of the uniqueness of the service delivery system.

Service design is the determination of design specifications for a new service that fulfills the needs and desires of a customer. These needs and desries, customer wants, are usually captured through customer surveys or questionnaires performed by the marketing function of an organzation. Customer wants are then translated by management into performance specifications, which in turn will be translated by service designers into design specifications. These design specifications are fed to the delivery function of a service firm to implement during the delivery of the service. The process of service development and delivery, as described above, is depicted in Figure 1.

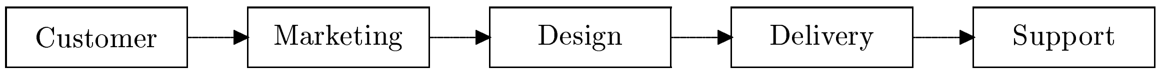

Figure 1 Service Development Process

3. Service Quality

Service quality can be defined as a measure of how well the service delivered matches the customer expectation of the service [19]. Parasuraman et al. [25] developed a service quality model shown in Figure 2 where service quality is labeled as gap 5, the discrepancy between the expected service and the perceived service. The model shows consumer's expectation of a service is influenced by communications with other consumers, personal needs, and past experiences. On the other hand, the consumer's perception of a service experience is influenced by four different types of gaps:

Gap 1: between consumer's expectations and management perception of those expectations.

Gap 2: between the management perceptions of customer expectations and service quality specifications.

Gap 3: between service quality specifications and the level of fulfillment of these specifications during service delivery.

Gap 4: discrepancy between service delivery and the external communications to the customer.

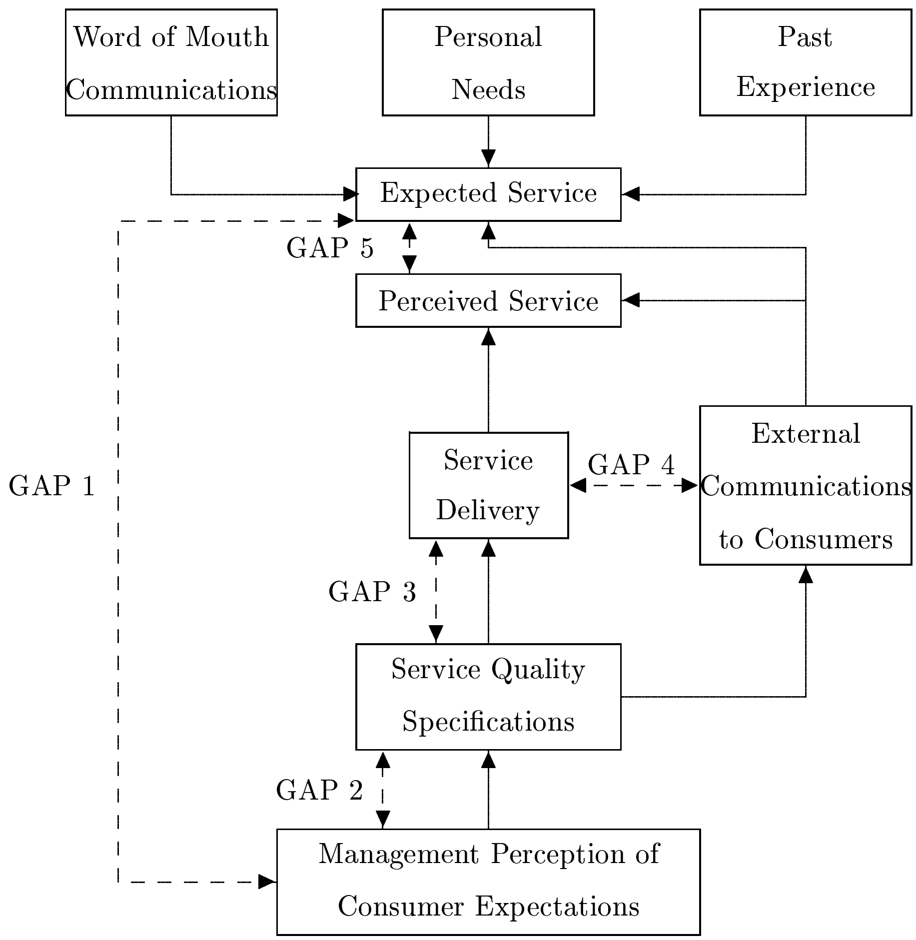

Figure 2 Service quality model

One of the major disadvantages of the above development process is that it is sequential (in the next sections, we will describe in more details what is meant by a sequential process). Being sequential in nature the voice of the customer passes through too many transformation procedures and filters before being actually translated into an actual service. Thus, with every transformation point the gap, between the customer and the delivery system grows bigger. Finally resulting in a great discrepancy between the customer's expectation of a service and their perception of the service experience.

4. Concurrent Engineering Background

The traditional approach to product development is sequential in nature where upstream functional experts perform their tasks and deliver final product related information to downstream activities. This is done with no or minimal interaction and cooperation between the different functional groups. Minimal interaction increases the probability of design conflicts between the functional groups. Resolving such conflicts require designers and engineers to iterate through trial designs until and agreement is reached. This iteration process results in an elongated product development time, increased development cost, and consequently loss of market share [30]. Figure 1 shows a schematic of a sequential design process where the flow of information is uni-directional.

Numerous design improvement strategies and techniques have evolved to solve the problems inherent in a sequential design environment. Design for Manufacturing (DFM), Design for Assembly (DFA), Quality Function Deployment (QFD), Taguchi's robust design, Continuous Process Improvement (CPI), and Total Quality Management (TQM), to name a few. All of the above mentioned techniques offered a partial improvement to the development process; however, the industry felt the need for a more comprehensive approach that can tie all their concerns together. Finally, the extensive research in product development resulted in the creation of a conceptual framework that acts as an umbrella to all design improvement tools and techniques and was called Concurrent Engineering. Smith [28] argues that CE can be visualized as a summary of best practice in product development, rather than the adoption of a radically new set of ideas. Formally, CE is defined as a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support [26]. Simply stated, CE is the incorporation of downstream factors and concerns in problem solving during the upstream phase. The basic factors underlying CE include complete visibility of design parameters, mutual consideration of all downstream decisions, overlapping problem solving, partial/incomplete information transfer, collaboration to resolve conflicts, teamwork, and continuous improvement [11]. From an information perspective, CE is concerned with the availability and timing of information to all design participants. The ability to act on this information by the process participants is yet another important dimension of CE. Therefore, CE requires the maximization of design information at all stages of the design process and the ability to share and communicate useful information on timely basis. Figure 3 shows a representation of a design process integrated through a common information system that facilitates CE activities.

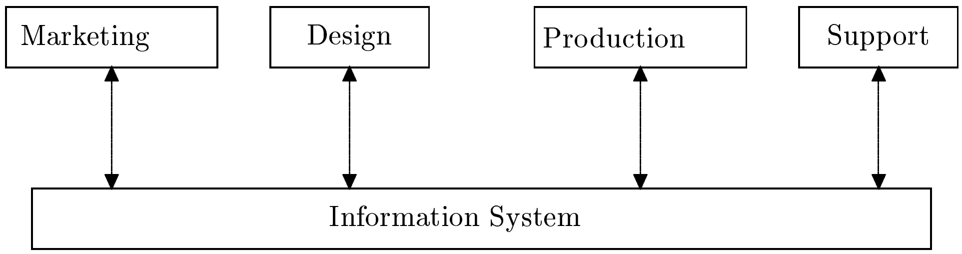

Figure 3 Concurrent engineering model

In a survey by Lawson and Karandikar [17] of what constitutes a CE program, in the manufacturing sector, teamwork was rated as the number one component. The second major component in the list was DFM practice. Quality tools such as QFD and SPC came in the third place, while process improvement initiatives was ranked fourth. Less than half of the respondents considered information technology deployment as part of their CE program. Finally, business re-engineering, benchmarking, and CAD/CAM integration came in last according to the survey.

In another study of US manufacturing companies, Hull et al. [13] found that there are three core sets of CE practices that lead to the improvement of product development performance. These three core sets are:

1. Early Simultaneous Influence (ESI): refers to the level of participation and the extent of influence of manufacturing engineering in the product design process.
2. In-process Design Controls (IDC): refers to the extent to which firms have adopted standardized design practices, emphasized design documentation, and conduct systematic design reviews.
3. Computer and Information Technologies (CIT): this set refers to three different subsets: the use of electronic datebases, extent to which CAD and CAM is coupled, and the level of programmable automation.

Smith [28], in a recent study, traced the roots of CE in early engineering literature and outlined its principles as follows:

1. Increased role of manufacturing process design in product design decisions - design - manufacturing integration.
2. Consideration of customer prefrences during the design process - design marketing integration.
3. Formation of cross - functional teams to accomplish the development process - integration of design with all other functions.

4. Adoption of computer tools or mechanisms for accomplishing integration: QFD, DFM and DFA.
5. The use of lead time as a source of competitive advantage.

Another important CE dimension that is discussed extensively in the literature is the concept of overlapping. In overlapping, we determine what fraction of the predecessor task must be completed before the follower task can begin. For overlapping to be effective, upstream (predecessor) information availability and downstream (successor) information needs must be understood [15]. In many design situations, the official release time of design information does not coincide with the time this information is really available. Finding when this information is really available and whether it can be released right away to subsequent tasks is critical for overlapping [16]. The critical step in overlapping is identifying a point within the predecessor task duration where preliminary (i.e. partial) design information is sufficiently evolved to be utilized by the successor task.

5. The CE Service Model

This part of the paper examines the impact of using CE practices on service quality. The extent to which concurrent engineering is practiced in a service firm is measured along the proposed four dimensions, as shown in Figure 4. These dimensions collectively measure the degree of concurrency in any service organization and consequently the level of service quality.

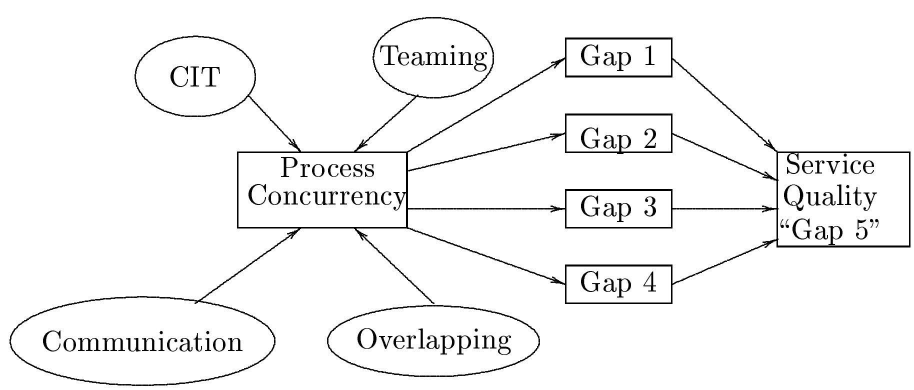

Figure 4 Model and main variables of process concurrency and service quality in CE

1. Utilization of multi-disciplinary or cross-functional teams (or CE teams)

Cross-functional teaming is an organizational technique for accomplishing functional integratioin. Under this approach the team is composed of experts from design, production, marketing, and any other functional area in the organization. The team is formed to work on a specific project and stays together throughout the development of the service.

Bursic [7] conducted a study to determine what factors contribute to successful team programs in manufacturing organizations and what are the benefits to be expected from such programs. The study concluded that if a manufacturing organization utilized cross-functional teams as an integral part of its organization design, appointments a facilitator for the team program, provide proper training for team members, leverage senior management support, and establish clear objectives for the team, then increased quality and productivity should result. The team concept proved to be a useful and powerful organizational technique for manufacturing organizations involved in successful concurrent engineering implementations. The concept proved useful also for service organizations as documented by Apte and Reynolds [1] as Kentucky Fried Chicken utilized a cross-functional team to reduce the service time at drive-through windows from over two minutes to 60 seconds.

2. Overlapping practices

The main goal of overlapping is to reduce the product development lead-time of manufactured products. In the service industry the lead-time is paralleled by the service time (i.e. the time a customer has to spend waiting before receiving a service plus the time consumed when receiving the service).

Overlapping can be used during the delivery phase where service providers can benefit from the possibility of overlapping some activities comprising the service. This will reduce service delivery time and ultimately increase customer satisfaction. For example, consider two sequential tasks, A and B, where task B is dependent on task A. Traditionally, the dependent task is performed after the predecessor task is completely finished. Utilizing the overlapping strategy, the service delivery time can be reduced by allowing parts of task B to be started before the completion of task A. Apte and Reynolds [1] describe the use of headsets by all drive-through window employees (at a fast food restaurant) to perform their jobs while simultaneously listening to customer orders; thus, converting serial activities into parallel ones.

3. Communication and information sharing

Integrated and overlapped problem solving requires frequent bi-directional information exchanges between all functional areas of an organization. In a manufacturing context, the frequency of communication between design and manufacturing is an important determinant of the organization's success in implementing CE [8,11]. In the service industry, Zeithaml et al. [31], conjectured that upward and horizontal communications tend to reduce Gap 1 and Gap 4 respectively (gaps as shown in Figure 2). While upward communication provides information to upper management about the activities of the organization, horizontal communication is meant to exist within and between departments.

Preliminary (i.e. partial or tentative) information sharing and usage has been proved to be a source of competitive advantage in manufacturing organizations and it can also be utilized to improve service organizations performance as well. For example, partial design information on a certain service to be delivered can be released to the process designers to comment on the design from their own perspective or even to make some tentative decisions on equipment required for the production (or delivery) of the service. As such, both designers might benefit from sharing partial information. However, attitudes towards partial information release and usage play an important role in its success. Traditionally, employees tend to withhold partial information from others, because of their belief that they might be releasing wrong information. Similarly, employees receiving this kind of information are skeptical about its usage.

4. Computer and information technologies (CIT)

There are two major classes of CIT: tools that facilitate communication and tools that facilitate analysis. The computer-based tools that facilitate communication include integrated databases, electronic communication tools, and others. They enable rapid information exchanges and the application of a range of analytical frameworks that are necessary in cross-functional design work.

The computer-based tools that facilitate analysis include, but not limited to, the use of QFD, SOC, DFD, expert systems, shared datebases, and decision support systems. Design for Delivery (DFD) is analogous to Design for Assembly (DFA) [6], DFD can be envisioned as a design improvement strategy that encompasses a number of sepcific design rules, if followed can make the service delivery process simpler. These rules should primarily involve reducing the number of steps in service delivery. Further, the service designer should build into the service serveral "foolproof" devices [27] that do not let the server make mistakes. Expert systems help employees in making decisions faster resulting in a faster service delivery. American Express (AMEX) [9] utilizes an expert system that draws from several databases to help their credit authorization employees in making a wise and quick decision over the phone. OTIS also utilized a similar approach to help their repairmen in providing a faster service [9]. Federal Express developed COSMOS (Customer Operations Service Master On-line System) that keeps track of the movement of a package from pickup until delivery. The system allows them to give their customers instantaneous location information on their packages [9].

6. Testing the Proposed Model

The theoretical model of service quality proposed in the previous section was derived based on the literature reviews in the areas of service quality and concurrent engineering. However, it was not empirically tested using actual data from service organizations to statistically test the influence of concurrent engineering on service firms. Therefore, in this section we develop a research methodology to perform such a task.

First, an instrument was devised to measure the degree of concurrency in service organizations similar to the one developed by Hauptman and Hirji [11]. The dimensions of coucurrency were measured by a set of straightforward questions based on five-point ordinal scale item (see Appendix A for details of questions). The concurrency scale measures the extent to which CE is practiced in service organizations along five distinct dimensions: teaming, information sharing, overlapping, and computer and information technology utilization. Second, the service quality as perceived by consumers (gap 5 in Figure 2) can be measured using the SERVQUAL instrument [24]. SERVQUAL is a multiple-item scale for measuring consumer perceptions of service quality. It measures service quality along five dimensions: tangibles, reliability, responsiveness, assurance, and empathy.

The model can be tested by collecting data on the four indicators of concurrent engineering and gap five through a cross-sectional study of service organizations. The data can be analyzed with statistical techniques such as regression where the four dimensions of CE are the independent variables and the service quality (gap 5) is the dependent variable. Factor analysis [23] can also be employed in analyzing the data if we are interested in finding the top "X" factors or dimensions potentially affecting the service quality.

7. The C. E. Architectural Framework

This section provides a C. E. architecture to support the implementation of C. E. initiatives in service organizations. The framework consists of four layers as shown in Figure 5. Each layer is responsible for achieving specific objectives of a C. E. environment.

The first layer necessary for the implementation of the CE model is the service management layer. It addresses service process flow issues and manages the flow of information among the constituent activities. It is responsible for maintating a map or a network for the whole service experience. This will include activities name, person/group responsibility, and coordination/dependency relationships.

The second layer, is the tools layer which contains a collection of communication and analysis tools useful at any stage in the service design or delivery process. This layer can contain communication tools that support the interaction and coordination required for CE teams such as e-mail and shared databases. Other analysis tools can be contained in this layer such as QFD, SPC, and expert systems. This layer should also accommodate for a customer feedback and comments mechanism such as a web site where customers can preview service features and be able to e-mail their comments.

The modeling layer should contain a service model and a process model. The service model describes and design features of the service in a format that is understandable to the entire process participants including customers. A process model describes the process required to produce the service. The product model can be simply a verbal model (i.e. describing the service in sentences or words) or a pictorial representation of the service such a flowchart. Process models can be Standard Operating Procedures (SOP) or a service blueprint.

The last layer is the communication layer that establishes the physical connection between all the different participants in the service system. This layer is simply a local area network (LAN).

8. Conclusion

The paper presented a C. E. model and framework for service organizations. The model is used to predict the influence of C. E. practices on service quality. The framework can be utilized to provede C. E. architectural support for service organizations. Implementing such a framework in service organizations should, in theory, lead to service quality improvements.

CE can play an interesting and meaningful way in reducing the magnitude of the service quality gaps (see Figure 2) through the re-structuring and realignment of these gaps according to the CE framework as shown in Figure 5. It could be argued that what is new about the CE framework application in the service industry is not the adoption of any individual element of the framework; however, the integrated, systems approach provided by the framework is ite biggest value. The CE framework establishes an integrated communication and computation environment supporting team activities and enhancing bi-directional information sharing.

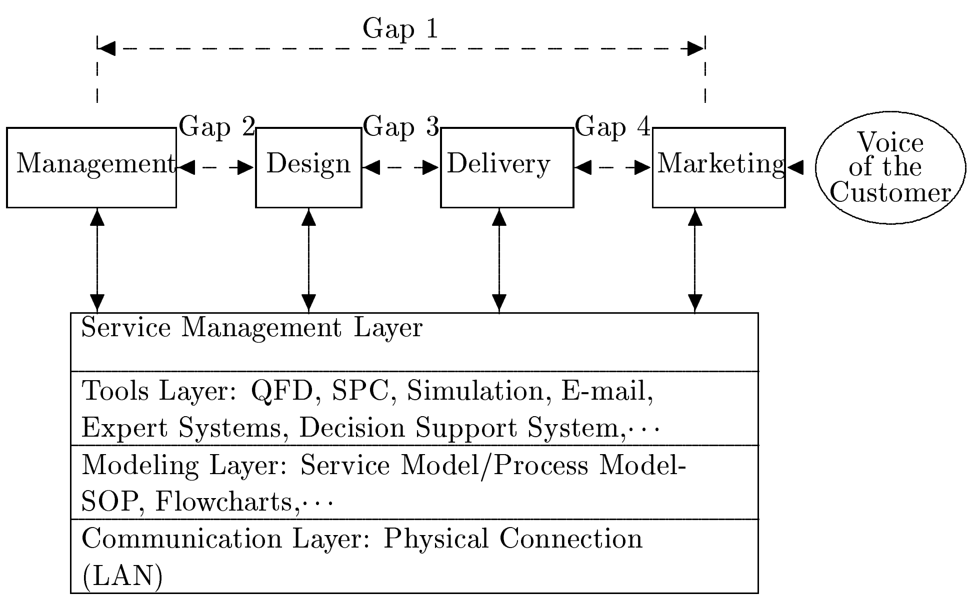

Figure 5 CE serviice quality model

Finally, the paper did not include any empirical evidence for the impact of C. E. aproach on service quality; however, we have outlined a research methodology for accomplishing this task. Concurrency data can be collected using the sample questionnaire provided in Appendix A and service quality data can be collected using the SERVQUAL model.

Appendix A

Proposed questionnaire items to measure the degree of concurrency in service organizations:

1) Communication between service design and service delivery is bi-directional.

strongly disagree Neutral strongly Agree

1 2 3 4 5

2) Communication between service design and service delivery is frequent.

strongly disagree Neutral strongly Agree

1 2 3 4 5

3) How complete was the service design when production (service delivery) started their involviment.

0% complete 50%complete 100% complete

1 2 3 4 5

4) How complete was the process design when service design started their involvement.

0% complete 50%complete 100% complete

1 2 3 4 5

5) How willing were service designers to share information with service delivery during the service development phase.

not at all moderate extreme

1 2 3 4 5

6) How willing were service designers to share incomplete and uncertain information with service delivery during the service development phase.

not at all moderate extreme

1 2 3 4 5

7) What means of information sharing are available.

mouth-to-mouth formal meetings computerized

1 2 3 4 5

8) Availability of computer-based analysis tools such as QFD, SQC, expert systems, shared data bases, and decision support systems.

None all

1 2 3 4 5

9) Availability of service models such as flowcharts or SOPs.

None all

1 2 3 4 5

10) Existence of team spirit or culture.

non-existent		sometimes		always
1	2	3	4	5

11) Formation of teams to tackle design or delivery problems.

non-existent		sometimes		always
1	2	3	4	5

12) Exitence of formal tools or methodologies to support communication and feedback between the consumer and the marketing function of the organization

non-existent		sometimes		always
1	2	3	4	5

13) Existence of formal tools or methodologies to support communication and feedback between marketing and service design:

non-existent		sometimes		always
1	2	3	4	5

14) Existence of formal tools or methodologies to support communication and feedback between marketing and delivery:

non-existent		sometimes		always
1	2	3	4	5

15) Existence of formal tools or methodologies to support communication and feedback between service design and delivery:

non-existent		sometimes		always
1	2	3	4	5

16) Existence of formal tools or methodologies to support implementation of customer wants and demands (such as DFD).

non-existent		sometimes		always
1	2	3	4	5

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