Using reliability tools in service operations

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Abstract

Purpose – This paper aims to propose a service reliability framework for classifying technical reliability tools so that managers can better understand how to use them in practice.

Design/methodology/approach – Published research was examined to identify reliability tools that have been used in services. These tools were then categorized using a framework that considered subsystem reliability, system configuration and system reliability.

Findings – A number of traditional manufacturing reliability tools have been used in service companies. This paper has categorized those tools within a service reliability framework based on subsystem reliability, configuration and system reliability.

Research limitations/implications – Future research could address the issue of customer perception and customer feedback as part of the reliability appraisal process.

Practical implications – Service managers can use the proposed framework to examine the applicability of these technical tools in service operations and to guide reliability improvement efforts.

Originality/value – The proposed service reliability framework provides an integrated view of subsystems, systems and configuration that is lacking in the service management literature. The framework also emphasizes technical reliability tools that have not received sufficient attention in the service management literature.

Keywords Product reliability, Configuration management, Managers, Technical services

Paper type Conceptual paper

1. Introduction

No matter the type of service purchased, customers value service reliability. In a service context, reliability can be defined as the firm's ability to provide the service correctly the first time (Galetzka *et al.*, 2006; Van Raaij and Pruyn, 1998; Caruana and Pitt, 1997; Parasuraman *et al.*, 1985). Past research has not only characterized reliability as an essential component of service quality (Parasuraman *et al.*, 1988) but has also identified "reliability as a means of achieving total quality" (Madu, 1999, p. 692). Despite its importance, most papers link service reliability solely with customer perceptions while foregoing mathematical analysis of service system reliability (Gunes and Deveci, 2002). This situation is analogous to relying on customer satisfaction surveys alone to assess and improve service quality while neglecting the more mathematically rigorous tools of statistical process control.

This paper will argue that the use of technical tools for assessing and improving service reliability can offer service managers additional insight on delivering reliable services to customers. In addition, this paper will propose a service reliability framework for classifying these technical tools so that service managers can better understand how to use them in practice.

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The following section will introduce the major components of the proposed framework. Section 3 will discuss some of the key reliability tools that have been widely used in manufacturing and explain their classification within the framework. Section 3 will also describe how many of these tools have been used in actual service contexts. Section 4 will discuss the managerial implications of implementing the framework in service contexts. The final section will address possible approaches for future research in service reliability.

2. Service reliability framework

The service reliability framework proposed in this paper integrates three major themes from the literature on the reliability of manufacturing processes. These are:

(1) The effect of subsystem reliability on the reliability of the entire system.

(2) The role of system configuration in reliability analysis.

(3) The importance of a systemic view of reliability in analyzing and in preventing reliability problems (see Figure 1).

Previous research on reliability analysis in manufacturing has demonstrated the effect of subsystem/sub-process reliability on overall system performance. For instance, Kumar and Huang (1993) studied the reliability of a production system by applying a simulation program for identifying critical subsystems. Zakarian and Kusiak (1997) devised a methodology for predicting system availability by analyzing the reliability of machine subsets. Koren *et al.* (1998) investigated the link between system productivity and machine reliability and based productivity on system throughput estimates. In contrast to the manufacturing literature, the service management literature has not focused on mathematical analysis of subsystem reliability; however, some service quality researchers have argued that the decomposition of the service process into component stages plays a critical role in understanding the customers' service requirements and in controlling variability in process metrics (Sulek *et al.*, 2006; Sulek and Lind, 2005; Gunawardane, 2004; Souteriou and Hadjinicola, 1999; Armstrong, 1995). An increased research emphasis on the reliability of service subsystems could potentially extend the concept of service decomposition in the service management literature.

While subsystem reliability plays an important role in system performance, system configuration also makes a critical contribution. In a recent paper, Sun *et al.* (2008, p. 156) argued that "performance criteria of manufacturing systems, such as reliability, productivity and quality, are determined by different configurations". The two

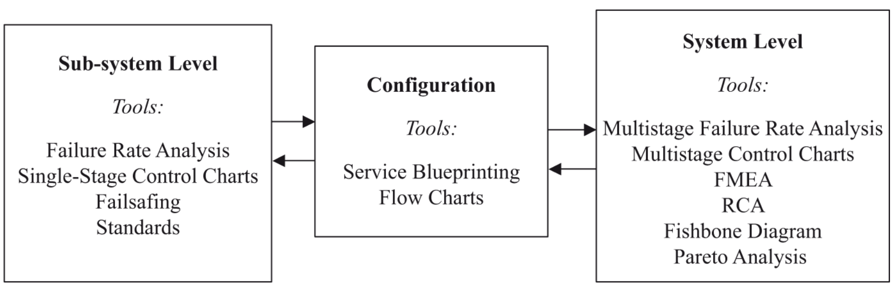
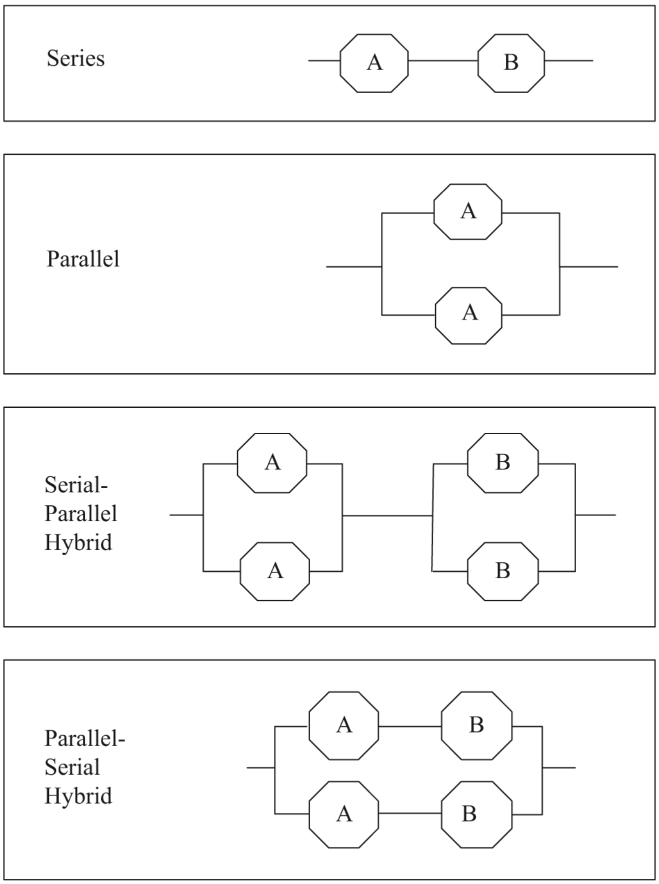


Figure 1.
Service reliability framework

fundamental configurations are the series design and the parallel design (see Figure 2). Sun *et al.* (2008, p. 156) noted, that these two configurations "form the basis for the reliability modeling and analysis of other more complicated configurations". These more complex designs often involve hybrid configurations such as the parallel-serial hybrid and the serial parallel-hybrid configurations (Levitin and Meizin, 2001). All of these configurations are characterized by linear process flow; however, arbitrary configurations, which reflect varied flow paths, are also used in practice, typically in job shop environments (Sun *et al.*, 2008). While some service management research has emphasized process flow in service operations (Bitner *et al.*, 2008; Sulek, 2004; Shostack, 1984), the role of configuration in reliability analysis has received very little attention in the service management literature compared to the manufacturing literature. Consequently, more emphasis should be placed on configuration in a service context.

The third framework component, a systems view of reliability, is receiving increased attention in the manufacturing literature. Gorkemli and Ulusoy (2010) have



Source: Adapted from Sun *et al.* (2008)

Figure 2.
Service configurations

noted that while many papers have investigated the reliability of production system components, fewer studies have focused on system reliability as a whole. They argued that a systems view of reliability is essential for production planning and control, particularly when unmet due dates result in high costs for the manufacturer (Gorkemli and Ulusoy, 2010). Madu (2005, p. 317) also supported a systems approach and observed that "a company cannot adopt a rapid response strategy if its system is unreliable and unavailable." Kuei and Madu (2003) identified a lack of system thinking as a source of process errors. In addition, Madu (1999, p. 696) has suggested that "managers adopt a systemic view in reviewing an unreliable system". In a similar fashion, some service management researchers have underscored the need for a systems approach to service quality (Lusch *et al.*, 2007; Sulek and Hensley, 2010; Stewart, 2003; Chase and Bowen, 1991). Since reliability is intertwined with quality and has even been defined by Sun *et al.* (2008, p. 152) as "quality over time", a system wide view of service reliability should be further developed in the service literature.

The three themes – subsystem reliability, configuration and overall system reliability – suggest the three major components in the service reliability framework shown in Figure 1. In the next section, the proposed framework will be applied to a set of well-known reliability tools. While these tools are common to manufacturing contexts, they may also be successfully applied in service settings.

3. Classification of reliability tools

The service reliability framework discussed in the previous section can be used to classify reliability tools that have been widely used in the manufacturing sector. As this section will illustrate, the application of these tools in service settings can furnish a manager with useful information about reliability at both the subsystem level and at the system level.

The first block in Figure 1 lists tools that are especially appropriate at the subsystem level. The tools that are listed in this block can help a service manager address three important aspects of reliability:

(1) Failure rate.

(2) Consistency.

(3) Error prevention.

In a manufacturing context, the failure rate for a product – denoted by λ – can be defined as the ratio of the number of failures to the total unit operating hours. Gunes and Deveci (2002) adapted this ratio to study the error rate in reporting examination scores at a university office. They used the formula: [total count of weighted failures]/[total number of questions on all examination forms] to compute λ and defined the reliability of the score reporting process as (1-λ). Their study revealed that the failure rate for the reporting process during the spring semester was smaller than the failure rate for the previous semester, with fewer errors involving late announcements and fewer reports issued by mistake.

While a failure rate represents a summary measure of reliability at a point in time, statistical process control (SPC) charts such as the widely used Shewhart charts, allow the service manager to continuously track performance metrics. When an SPC chart is in control, the performance metric is predictable within limits; this indicates performance consistency on that measure. In contrast, an out of control SPC chart signals the presence of special causes of variation and a lack of service consistency, which the manager must address. Shewhart charts are applicable to a variety of service subsystems. For instance, Apte and Reynolds (1995) used the range chart to monitor wait time variation at a drive-through window at a quick service restaurant. Restaurant managers used the charts to identify changes in performance and gauge improvement over time. Likewise, Sulek *et al.* (2006) used Shewhart charts to track productivity in individual departments of grocery stores. In the health care sector, Woodall (2006) recommended control charts for monitoring infection rates, fall rates, and patient waits in hospital settings.

Also shown in Figure 1 are two additional tools for ensuring the service reliability at the subsystem level. The first of these involves poke-yoke or failsafe procedures. Failsafe techniques consist of devices and control mechanisms designed to help workers and/or customers avoid or immediately correct mistakes that could lead to reliability problems (Chase and Stewart, 1994). For instance, in a rural paratransit system studied by Sulek and Lind (2005), the number of rider no-shows and riders not ready for pickup at the scheduled time was reduced when the dispatcher phoned each rider the night before the scheduled trip to remind him or her to be ready at the scheduled time. This was an important failsafe solution to the problem of schedule creep, which can lead to greater delays in rider pickup and delivery as the day progresses.

The second technique involves standards. Just as operating standards can help ensure service quality, so can they also help maintain, and even enhance service reliability. For example, KFC (Kentucky Fried Chicken) radically reduced the standard for wait time at drive-through windows to 60 seconds to remain competitive with other quick service restaurants with drive-through service. Despite the fact that the new standard was not advertised, drive-through business increased substantially (Apte and Reynolds, 1995). Similarly, Wyckoff (1984) delineated operating standards used by Rusty Pelican restaurants; these included a four-minute standard for making a request for orders once beverages are served, a 16-minute standard for serving the entrée after the order is placed and a four-minute standard for presenting the check after dessert is served. Boeing Aerospace Support sets a number of standards and uses these to measure its performance. For instance, the tele-services area has a standard of answering calls in less than 30 seconds (Boeing Aerospace Support, 2003). DynMcDermott Petroleum Operations Company sets standards for a number of operational measures, including Mean Time Between Failure, and uses a formal failure analysis system to identify help in identifying corrective actions (DynMcDermott Petroleum Operations Company, 2005).

The second block of the service reliability framework in Figure 1 involves configuration. Sun *et al.* (2008, p. 156) have observed that "configuration defines flow paths of material through the manufacturing process." Likewise, in a service operation, configuration can affect both the flow of customers and work products through the system and ultimately the performance of the entire system. Past research in the service quality literature has stressed the importance of understanding process flow paths to assess current performance and to identify possible failure points (Bitner *et al.*, 2008; Sulek, 2004). For instance, Shostack (1984) applied flowchart techniques to service operations; her approach is known as service blueprinting. Shostack (1984, p. 139) argued that many problems with service delivery can be anticipated and that service blueprints allow "a company to test its assumptions on paper and thoroughly work out the bugs" before they materialize in practice. Since a service blueprint can be as detailed as necessary for problem solution, blueprinting is a technique that is applicable at the system level and the subsystem level (Bitner *et al.*, 2008). Wyckoff (1984) also advocated the use of step-by-step flow charts as a starting point for controlling quality in his restaurant study. Wyckoff (1984) expanded a summary flow chart to detailed examination of each step with corresponding performance specifications.

In a service operation, even a single carefully chosen change in configuration – such as adding a critical backup – can reduce the possibility of service failure. For instance, Kworthnik (2005) reported that only 48 percent of hotels in his study maintained emergency power during the 2003 blackout on the Eastern seaboard. The consequences of inadequate backup power systems were numerous and included:

- lack of air conditioning;
- lighting problems;
- unreliable elevator service;
- inability to make new keys for guest rooms;
- unavailability of computer systems;
- frozen automatic exit doors; and
- disabled communications systems.

Boeing Aerospace Support utilizes backup systems to ensure reliability of its operations (Boeing Aerospace Support, 2003).

The third block of the service reliability framework consists of techniques which are especially well suited to reliability analysis at the system level. The first two techniques, multistage failure rate analysis and multistage control charts, are extensions of Gunes and Deveci's (2002) work on failure rates and single stage SPC charts, respectively.

Gunawardane (2004, p. 581) extended Gunes and Deveci's (2002) work on failure rates to a multistage service process. Gunawardane (2004) applied his approach to a multi-stage claims processing system. Analysis revealed that errors occurring at the data entry stage compounded the problem of inaccurate verification at the pre-authorization stage. The reliability of the entire process failed to meet customer expected reliability. He noted that "multi-stage service processes where customers or paperwork pass through several sub-processes are very common in practice". Gunawardane (2004) cautioned that that the use of a single failure rate to assess service reliability is appropriate only for a single stage or sub-process since a single rate cannot by itself capture the complexity of multistage configurations. Similarly, traditional Shewhart charts can supply misleading information if they are applied to complex service configurations, which incorporate cascade processes or result from the confluence of multiple service flows. Such system configurations can create a natural hierarchy in the reliability metrics for each stage, since the output for a preceding stage or stages constitutes the input for a subsequent stage or stages. In such cases, Mandel's (1969) regression control chart and Zhang's (1985, 1989) cause-selecting control charts can help to determine if variation in reliability metrics is predictable within limits or if unnatural variation is occurring in the reliability metric (Lowry and Montgomery, 1995).

The Failure Modes and Effect Analysis (FMEA) technique also incorporates configuration in reliability analysis. A key feature of this technique is the system block diagram which shows all component subsystems, identifies the series and parallel relationships among the sub-processes and describes the inputs and outputs of each sub-process (Dhillon, 2003). The block diagram can be used together with statistical data from each sub-process to determine why the overall system is unable to meet a reliability goal (Madu, 2005). Dhillon (2003) has delineated potential benefits of FMEA. These include:

- an organized methodology for studying service failures;
- improved communication about service design;
- improved customer satisfaction; and
- a potential source of safeguards against future mistakes that lead to service failures.

In his study of hypermarkets Chuang (2007) utilized FMEA to identify possible failure points in back office and front office operations. He identified random inventory shortages, air conditioning problems and mis-shelved items as the top three failure modes requiring preventive actions.

The third block of the service reliability framework contains three other techniques, which can help a manager study system reliability. The first is root cause analysis (RCA), which can be used to determine why a particular service failure has occurred. Root cause analysis investigates the event sequence that led to the failure. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has recommended the use of RCA by health care facilities responding to sentinel events (Dhillon, 2003). Dhillon (2003) notes that JCAHO requires that the RCA analysis must begin with an investigation of special causes in clinical operations and proceed to common causes in organizational processes.

The Ishikawa diagram (or fishbone diagram) can also be used to determine causes of service failure. This approach traces problems to four possible sources:

(1) Manpower.

(2) Method.

(3) Machine.

(4) Material.

Wyckoff (1984) illustrated the use of the Ishikawa diagram to trace the causes of delays in pushback (moving an aircraft away from the gate) at Midway Airlines.

The final technique listed in the third block is Pareto Analysis. This technique is based on the premise that most reliability problems stem from a small set of causes (Madu, 2005). A frequency distribution or Pareto Diagram is constructed by totaling the number of service errors that result from each of the possible causes of reliability problems. The diagram can help the service manager identify those few causes that led to the greatest number of errors. By monitoring these causes, a service should be able to maintain or even improve reliability (Madu, 2005). Wyckoff (1984) applied Pareto analysis in his study of service problems at Midway Airlines. He found that nearly 90 percent of late departures stemmed from only four causes. BI, a Malcolm Baldrige Quality Award winner in the service category, uses Pareto Analysis as a tool for identifying process performance improvement targets (BI, 1999). Similarly, the Ritz-Carlton Hotel Company, the only two-time recipient of the Malcolm Baldrige Quality Award, measures and reports averages for categories of service quality failures (The Ritz-Carlton Hotel Company, L.L.C., 1999). The most serious categories of service failure were identified as unresolved guest difficulties and missing/damaged guest property/accidents (The Ritz-Carlton Hotel Company, L.L.C., 1999).

The framework discussed in this section can provide insight on reliability in a service setting; however, several managerial implications are associated with its use in service contexts. These are discussed in the following section.

4. Discussion

Several managerial implications stem from the framework discussed in the previous section. These implications involve several potential advantages of the framework as well as some possible barriers to implementing the framework in service contexts.

The advantages of the proposed approach include its flexibility, its emphasis on rigorous analytical methods and the importance it places on configuration. The first advantage, flexibility, manifests in two ways. First, the framework can be used to prevent failures or it can be used to investigate the causes of actual reliability failures. Second, the framework generates two natural progressions in reliability analysis:

- A bottom-up approach, which reflects a progression from left to right in Figure 1.
- A top-down approach, which corresponds to a progression from right to left in Figure 1.

The case studies discussed in the previous section reveal that both the bottom-up approach – such as Gunawardane's multistage failure rate model (2004) – and the top-down method – such as Chuang's (2007) use of FMEA to analyze a hypermarket service system – can lead to greater insight on service reliability.

In addition to its flexibility, the proposed framework also offers the manager an array of technical tools that can increase analytical rigor. The ability to mathematically analyze service reliability is especially useful for services that are increasing their dependency on technology. In such services equipment and machine reliability can profoundly affect overall service performance as well as customer satisfaction (Madu, 1999). Many of the technical methods that comprise the framework are well suited to analyzing reliability of service technology.

A final advantage of the proposed framework is its emphasis on the role of configuration in ensuring reliable service operations. As Kworthnik's (2005) study demonstrated, overlooking a weakness in configuration can lead to catastrophic consequences for the service and its customers. Furthermore, exact specification of system configuration facilitates both bottom-up reliability analysis and top down analysis since both depend of knowledge of system architecture.

Despite the advantages of the proposed framework, some difficulties may arise when it is used in practice. In particular, some managers may be uncomfortable with the technical content of the framework. A manager that lacks a strong background in quantitative analysis may hesitate to implement some of the more mathematically rigorous tools. This sort of implementation barrier may diminish with training programs that clearly demonstrate the value of technical reliability analysis and that develop the mathematical competency needed for effective tool use. In general, one of the easiest ways to encourage workers in the implementation of reliability techniques may be through the introduction of the failsafing technique. The failsafing process can be intuitively appealing to workers because it allows them to draw on their own experiences with service failures when devising failsafe solutions (Sulek and Lind, 2005).

Another potential problem with the framework is that some managers may decide that its technical content obscures the importance of customers' perceptions of service delivery. In actuality, a number of the tools contained in the framework can be exploited to enhance the customer's service experience. For example, improved failsafe techniques can help customers feel more secure navigating the service environment and can help them feel more like co-creators of the service rather than simply service recipients (Chase and Stewart, 1994).

5. Conclusion

This paper presented a service reliability framework that focused on three key components:

(1) Subsystems.

(2) Configuration.

(3) System level analysis.

This framework served as a basis for classifying reliability tools and supports their application in either a bottom-up approach or a top-down approach to service reliability. Such a framework has been missing in the service management literature despite the growing recognition of the critical role of reliability in service quality. Using the proposed framework as a point of departure, future research could investigate the two natural progressions associated with its use. In particular, field studies comparing the effectiveness of the two progressions could be conducted.

As noted in the previous section, the proposed framework can address the role of the customer in service performance even though it does not highlight this role. Thus future research could extend the framework to more fully integrate customer perceptions and customer feedback in reliability analysis. Such an extension would parallel the work on quality improvement, which combines statistical analysis of operating data with perceptual data obtained from customer input. A combined approach may lead to a better understanding of what reliability improvement means in service operations. However, as the framework in this paper has illustrated, the reliability tools that originated in the manufacturing sector provide a useful starting point for improving service reliability.

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