Achieving "Reliability" Through an Operator Replaceable Component Strategy

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Abstract

This paper will present the opportunities that exist to improve "Reliability" in the Production printing environment using a strategy that includes Operator Replaceable Components (ORCs).

There are varied definitions of "Reliability". Availability is a commonly used operational measure of reliability performance of repairable systems.[1] In a Production environment where a higher volume of output sheets results in greater revenue and profit for the print producer, the preferred definition of reliability is uptime or availability. Alternatively, a definition of the inherent reliability of a system is based on sheets, time or image count between failures or service calls.

As we know, state-of-the-art technology selection, robust product design, and six-sigma quality components cannot totally prevent the physics and the mechanics of failure modes from having their effect on a tuned system.

Many attributes need to be considered in the identification, selection, and optimization of ORCs for an effective "Reliability" strategy. Examples of attributes that will be explored in this work include functional dependencies, component life, distribution of component life, ease of use and handling, fault isolation and diagnostics, unit manufacturing cost, trigger event, time to maintain or repair, tools, operator skills, and calibrations.

Introduction- The History of ORCs

ORCs are not a new concept. In the automotive world, any vehicle driver can enter a well-equipped auto parts dealer, and exit with just about any replacement part for repairing a vehicle after a failure. The next steps may require some specialized knowledge, tools, dexterity and patience in order to make the vehicle functional once again. After several attempts to do these repairs upon a variety of failures, it becomes obvious to most standard drivers that not all of those parts that can be purchased at the auto parts dealer were designed to be ORCs.

Figure 1 and Figure 2 show examples of ORCs that are already widely known in two segments of the NIP world. In the Small Office/Home Office (SOHO) environment, nearly everyone has become familiar with the inkjet replacement cartridge ORC for the PC printer. In the Corporate environment, laser printer cartridge replacement is also well accepted as a task to be performed by most everyday operators. In this Corporate environment example, the operator is replacing multiple items (charging element, photoconductor element, cleaning element…) clustered into one operator replaceable cartridge. In what is often less than one minute of downtime, the operator has the replenished toner supply along with replacing several critical imaging components targeted to prevent future downtime and to improve reliability.

Figure 1. SOHO ORC Example

Figure 2. Corporate ORC Example

Beyond the SOHO or Corporate environment, the Production oriented printing environment faces its own, unique reliability challenges. Even under the best of circumstances, failure events within the system will occur. These larger, more complex systems have more opportunities for failure. Murphy's Law reminds us that those events can occur while the overnight Pick-up carrier representative is waiting in the lobby for the job to come off the press.

Figure 3 shows the comparison in the flow of events for a traditional system without ORCs as contrasted to a system containing ORCs.

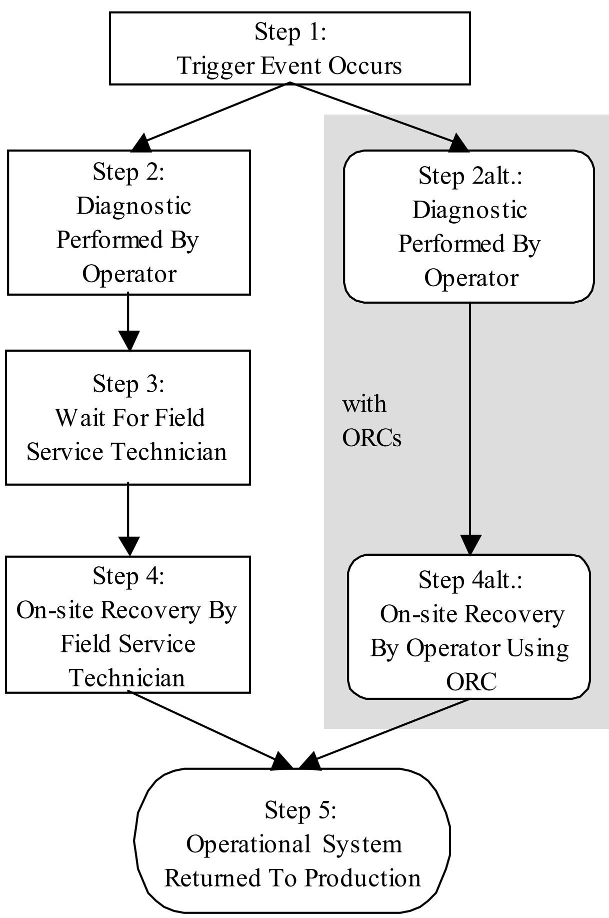

Figure 3. Event Flow: without and with ORCs

The key to optimize availability as a reliability measure is to enable the operator to have the capability to act as a field service technician without complexity and expense of having an actual field service technician standing ready at each system waiting for the next failure event to occur.

Primary ORC Considerations

Listed in Table 1 are factors that can be readily used in determination of ORCs.

Table 1. ORC Determination Factors

Primary	Frequency-of-Occurrence Time-To-Restore-System
Secondary	Trigger Event Diagnostic Certainty Clustering & Nesting Tooling Usability Post-Replacement Calibrations Operator Skills Unit Cost

The Frequency-of-Occurrence of an ORC event needs to be quantified using traditional reliability engineering methods and data. As with any analysis of this type, the underlying hazard rate of the failure modes leading to the ORC event also needs to be included as part of this reliability analysis. Clustering and nesting of ORCs are secondary factors that will complicate such analysis since the components can no longer be treated as independent.

The Time-to-Restore-System (TTRS) certainly needs to include the standard replacement time for the ORC. However, it also should include or exclude, as needed, the time required for the field service technician to arrive on site, access and climb a fault isolation tree, obtain the proper parts or tools, and perform any subsequent recalibrations of the system[2]. Each one of these sub-elements of TTRS may need to be re-balanced during the concurrent design process.

Figure 4 shows the effects of the primary factors, and their relationship to the secondary factors in the initial considerations for which elements are to become ORCs.

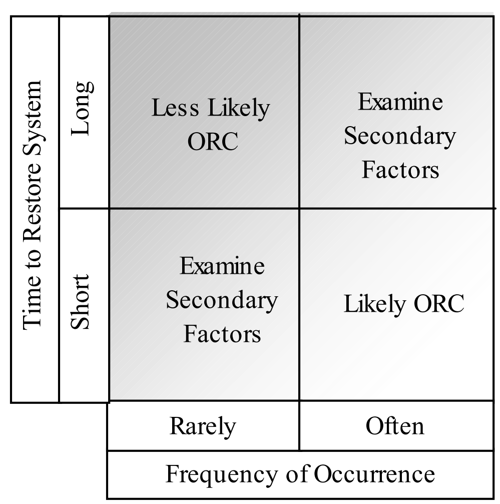

Figure 4. Primary Factors to Determine ORCs

Optimization

Triggers events that initiate an ORC activity fall into three main categories;

1) Sensor activated; based on a sensor designed into the system.
2) Meter activated; based on typical metering functions available with in the system such as time, sheet count, or image count.
3) Customer initiated; based on operator observable attributes of the system output, such as print quality artifacts.

The selection of the trigger will drive many of the resulting design, diagnostic, and cost parameters of the final system.

How, and when to deliver the right information at the right time to the operator is an important secondary factor to consider in ORC optimization. It is critical, particularly in the case of the customer initiated trigger event, to perform the proper diagnostic. The knowledge transfer from the designer of the system to the operator can be through many modes. A mix of modes, ranging from classroom style training to web-enabled, interactive video from a central support site can all be applied to improve the diagnostic certainty. Offline material presented to the operator asynchronously to the ORC event trigger can be used for some ORC diagnostics. The more complex the diagnostic, however, the more a synchronous knowledge transfer is required. An ORC replacement that is performed at an interval of only once per year may require a different approach than one that is done once per day. Regardless of the methods of knowledge transfer used, if the diagnostic is unsuccessful to point the operator to the correct ORC, additional downtime for the system, frustration for the operator, and an eventual visit from the field service technician can all result.

Engineering textbooks contain principles for designers to follow when making both strategic and tactical design decisions. It is important to maintain the functional independence in the design of an assembly or component.[3] Components must be separate if separate components would minimize costs.[4] When a single physical component can implement several functional elements of the product, these functional elements are best clustered together.[5]

Any clustering of components into one ORC will complicate the data analysis of independent competing risks that would normally be associated with a traditional series system. When one component of the ORC fails, the whole ORC may be considered failed.

Figure 5 shows it is conceivable to nest ORCs within one another, however. The corona wire is an ORC, and the entire corona charging assembly containing the corona wire is also an ORC. For maximum availability, the operator replaces the ORC at the assembly level with a complete assembly selected from the on-site inventory. Subsequently, during idle time while another job is on the press, the wire from the removed corona charger assembly can be replaced, and the entire corona charging assembly is put back into inventory for the next occurrence.

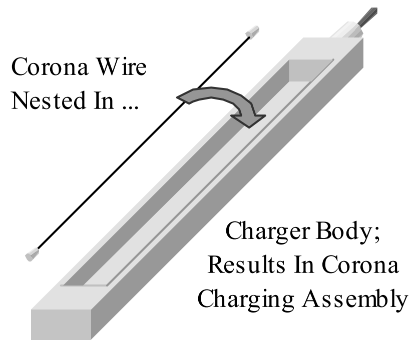

Figure 5. Nested ORC Example

The use of tools for the operator maintenance and repair of a system should be limited. A simple tool that can be used to enable a likely ORC, versus the alternative of not having the ORC in that application should be considered, however.

Universal design principles leading to improved usability also apply to ORCs. Visual cues for ORC identification, ergonomic design features for access and movement, and locating features and detents for ORC placement all need to be emphasized for the operator acceptance of the successful ORC strategy. Of course, if an item has been designed for ease of use from the operator perspective, if later decided that not an ORC, then the field service technician will enjoy the benefit of this design-for-service approach.

Recalibration of a sub-function and/or of the entire system can be required for ORCs that are critical functional elements. As in the diagnostic steps and the actual replacements steps, recalibration of the system needs to be designed with the ORC strategy in mind. The required operator skills and tools need to be specified and considered for such recalibration.

Unit cost of the product and of the initial investment in product development is affected with the ORC strategy. The ORC-to-product interface increases cost in the design details that would otherwise not be required if the ORC element were to only be replaced by the field service technician. Creating and implementing expanded operator level documentation required to support the ORC is a business investment. Given these financial considerations, the business opportunity of using the ORC strategy goes beyond the traditional reliability or availability analysis. It is necessary to weigh the incremental unit cost and up-front investment cost, versus the benefits of having the ORC available to the operator and press owner. Balancing these factors should include all stakeholders of the business model, and to the extent possible, it should welcome direct customer participation as well.

Conclusion

The use of ORCs is both a product and a business architecture decision. Frequency-of-Occurrence and Time-to-Restore-System are the primary factors in determining

ORCs for a Production printing system. Through the concurrent design process, these primary factors, and the secondary factors should be iteratively examined and quantified to create a final configuration on which replaceable item will result in effective ORCs.

Successful ORC approaches require the strategic and tactical inputs of the all members of a multi-functional project team, not just the R&D function. Many "Design-for-x" philosophies apply directly to the ORC strategy. Usability, serviceability, supply chain logistics, diagnostics, cost, all play relevant roles in the offering that the customer experiences. Without holistic attention to these relevant factors, the ORC approach may appear attractive, but may not be a practical success.

References

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Biography

David Bettiol received his B.S. degree in Mechanical Engineering from Rensselaer Polytechnic Institute in 1982 and an M.S. in Applied and Mathematical Statistics from Rochester Institute of Technology in 1989. From 1982 to 1997 he worked in the Office Imaging Division of Eastman Kodak in Rochester, N.Y, and since 1997 at NexPress Solutions LLC in Rochester, N.Y. His work has primarily focused on Systems Engineering, Program Management, and Reliability Engineering. He is an ASQ and IS&T member.