Information Products for Remanufacturing: Tracing the Repair of an Aircraft Fuel-Pump

Yang Lee
Northeastern University
y.lee@neu.edu

Thomas Allen
MIT Sloan School of Management
Tallen@mit.edu

Richard Wang
Boston University
rwang@bu.edu

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Abstract: This paper reports our initial study of the remanufacturing process of an organization, with a special focus on the role and nature of the information involved. As a first step, we trace a key physical aircraft component, an aircraft fuel pump, throughout the process of remanufacture. We apply an information product perspective to guide the tracing of information relevant to all physical parts, products, and work activities involved. Remanufacturing is a complex process, which involves repairing and refurbishing parts and products in the carcass. It has been a common practice for aircraft, railway locomotives, and heavy construction equipment. As landfill becomes a scarce resource, remanufacturing will undoubtedly be extended to other products and industries.

The quality of information is determined by characteristics of how the information integrates physical artifacts and activity process. Conversely, the quality of information can determine the performance quality of remanufacturing. An example of one aspect of this performance is the capacity to predict supply material effectively. The remanufacture process lends itself as a useful and comprehensive setting for studying the complex intricacies involved in role and nature of information. This study can be used to determine what should be required for information products for remanufacturing.

Upon completion of our research, we aim to show a clear picture of the entire remanufacture process of an aircraft fuel pump and the nature and various roles of information involved in the process. We will then be able to determine the required information products for this process. We believe that tracing one specific part through remanufacturing in one organization will pave the way for understanding the information needs in manufacture and remanufacture process.

1. Introduction

The process that we label "remanufacturing" has been a common practice for certain high investment capital products, such as aircraft, railway locomotives, and heavy construction equipment. Remanufacturing is a complex process, which involves repairing and refurbishing parts in the carcass of the product. The process also involves planning activities to supply these parts and products, and coordinating the necessary personnel involved in the process. Remanufacturing is also practiced in the automobile aftermarket, where reconditioned parts and re-machined engines are readily available. We will undoubtedly see remanufacturing extended to other products and industries as the availability of landfill space becomes scarcer.

This initial study attempts to understand the remanufacturing process with a special focus on the role and nature of the information involved. As a first step, we simultaneously trace a key physical aircraft component and the related information throughout the process of remanufacture.

We chose to trace a fuel pump, an essential part of every modern aircraft. The aircraft is not viable unless it has the pump; the pump is not viable unless it has the stator installed. A stator is a system of stationary airfoils in the compressor of an aircraft fuel pump. We studied a particular type of pump that is installed on many military aircraft. We also chose a specific organization, the United States Air Force, in which to trace the process. We refer to the information product perspective [15, 16] to guide tracing information relevant to all physical products, parts, and work activities involved.

Research on remanufacturing has been conducted to find solutions and strategies for operational problems at hand. The research conducted, particularly under the rubric of the Lean Sustainment Initiative at MIT, offers useful perspectives on understanding the complex processes involved and the various operational problems and solutions [4, 9, 12]. We have not found, however, any research that focuses on fundamental treaties of remanufacture, and in particular research that covers the importance of information.

Our particular purpose in mapping out the remanufacture process is to understand the characteristics of any discrepancies between the available information and information needs. We will then be able to determine the required characteristics of information that should be embedded in the information for remanufacturing. We focus in this study on the central importance of information. Far too often the information process necessitated in manufacture and remanufacture is treated in a secondary or subsidiary manner relative to the processing of the physical product itself. We believe this to be a serious mistake. The processing of information is central to the process of manufacture and is possibly even more critical to remanufacture. We show the importance of information in remanufacture by tracking and conceptualizing the hidden or missing links that information provides. Information, when designed and used properly, can link the movement of physical products and work activities involved in remanufacture.

Our research is at an initial stage and will require completing data collection and verifying conflicting data from the field interviews. Upon completion of our research, we aim to show a clear picture of the entire remanufacture process and the nature and various roles of information involved in the process. We will then be able to determine the required information products for the remanufacture process for an aircraft fuel-pump. We believe that tracing one specific part through remanufacturing in one organization will pave the way for understanding the information needs in manufacture and remanufacture process.

2. The View from the Field: Sources of "Dirty" Data

Based on our initial observations from field interviews, two related areas need further investigation in order to identify the sources of poor quality data. One is the area of obtaining quality data for effectively predicting the need for parts; and the other is the area of effectively providing and recording work activities performed on the parts and in other remanufacture processes.

Unlike initial manufacture where all of the parts needed to assemble a product are known well in advance, remanufacture has far less predictability. Instead, remanufacture involves many unscheduled, variable, and evolving activities. Much of the uncertainty in the process stems from the fact that there are two possible supply chains. One is similar to that found in the initial manufacture, in which new parts are fabricated and delivered by suppliers internal or external to the organization. Unlike initial manufacture, however, this is not the only source of parts. A second "supply line" delivers the parts that are contained in the "carcass," or product that is to be repaired. Particularly, the unpredictable quality of the parts contained in the carcass that is the

major source of uncertainty. Not knowing whether the parts delivered from the carcass are workable or not makes the need for additional parts through the normal supply chain unpredictable. It follows that a way to reduce this uncertainty is to find better ways to predict the state of the parts contained in the carcass. The predictive capability of these models is, of course, highly dependent upon the quality of the stored information. It is the interaction of the two supply chains that makes remanufacture the complex setting. This is where understanding the information process becomes critical.

Our interviews with those involved in the overhaul process lead us to believe that there is much that can be done to improve the prediction of parts that will be needed. The principal complaint voiced in interviews had to do with data quality. We were told that the current models were unable to accurately predict parts needs because the data on which they are based is faulty and questionable. To describe this, the term "dirty data" is used. Some data that is the input to the predictable model contains serious errors. The question then becomes, where and how do these errors enter into the information process? Some have suspicions about how past demands and future predictions are calculated, to state a few. These suspicions have never been tested to check their validity.

In our research, we chose to trace the fuel booster pump. The pump, as shown in Figure 1, plays a key role in the maintenance and improvement of mission capability and aircraft flying hours. In this research, we trace in detail the repair of the pump, in relation to the aircraft remanufacture managed by the airline.

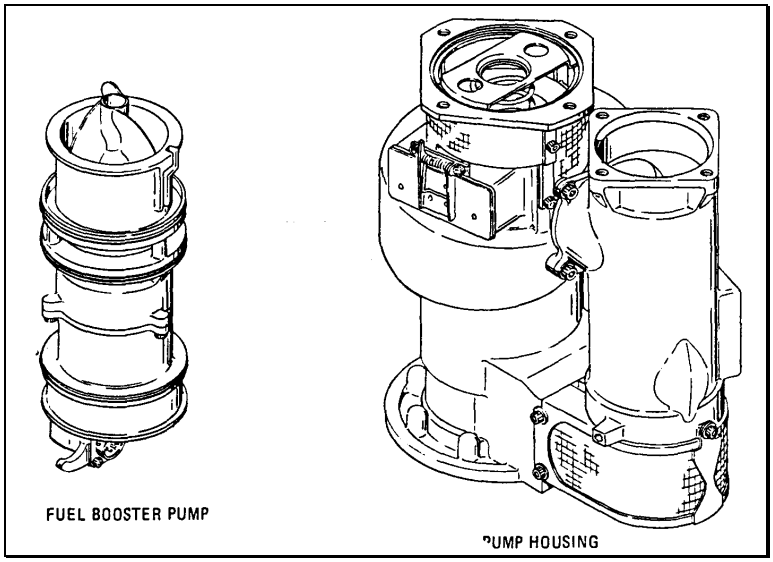

Figure 1: Fuel Booster Pump and Pump Housing

Based on our initial field interviews and document review, we hypothesized that the root cause of problems with the fuel pump is the stator. Therefore, we also traced the stator flow in detail. In so doing, we documented the work roles related to the pump and stator. An exploded view of the stator position in the fuel booster pump is shown in Figure 2.

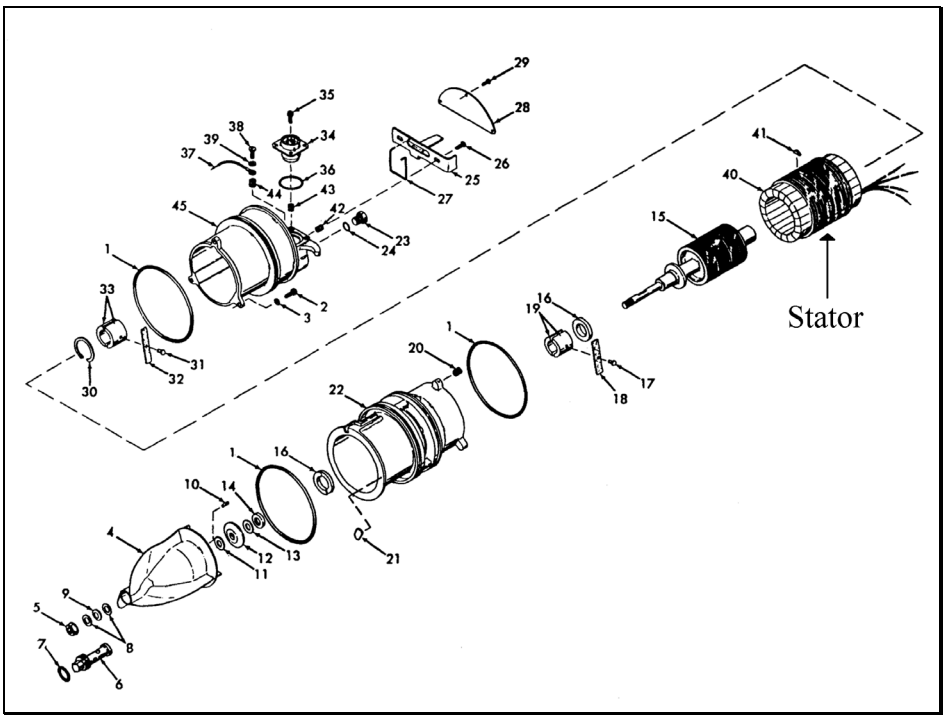

Figure 2: An Illustrative Stator position in the Fuel Booster Pump, Exploded View

Pump repair is performed in two geographically dispersed places: depots and fields. Depots conduct regular scheduled overhaul, whereas fields handle surprises, the immediate problems at hand. Throughout the repair process, information about the work process and the physical products or parts are isolated from each other by operational procedures. The direct impact is that it becomes difficult to connect the two kinds of information. One needs the ability to retrieve and understand the physical parts as well as the work information. For example, when a repairperson sees a pump needing repair, the repair history is not easily accessible. As such, the repair history, the supply information, and the conformance-testing information is stored and used separately. Most of the relevant information is stored and categorized meticulously, but without consideration of cross-area retrieval and access. The connection between physical parts and process information part is missing. Currently, one has to contact multiple agents and places over phone and email to track down the information needed to make this connection. We view that this observation can be an input for designing certain information products for remanufacture.

We observe yet another area for improvement. A supply vendor initially produced the engineering specification of the stator, for the pump. We encountered some opinions that the engineering specifications were not consistent with the stators manufactured and delivered to the Air Force. After going through revisions, the updated specification document and drawings were not stored most effectively by AF and the vendor. In the process, different people could develop different understandings of what the official engineering specifications for a stator should be. Meanwhile, the aircraft has to fly. Some work-arounds might have been performed to meet the demand using parts of questionable quality. In short, the lack of management of data products (in this case, the blue prints of the stator) led to a possible lack of quality in physical products. We hypothesize that changes in engineering specifications over time have been poorly communicated between the Air Force and vendors in terms of specific design problems and resolutions.

3. Information Products for Aircraft Fuel-Pump Remanufacturing

Viewing information as a product implies two essential information management requirements. For historical and future use requirements, information must be stored and protected against undesired change. For current use, information must be kept as current as possible. Information stored in databases is typically safeguarded to preserve these two aspects of quality among others.

As a first step toward solving the problem of dirty data, we have traced the process of remanufacturing fuel pumps from the time that they are removed from an aircraft, from inspection, repair and remanufacture through to re-installation. We fully recognize that every part is unique, as is every organization in the remanufacture business. Different parts in different organizations will not undergo the same process. Nevertheless, we believe that there will be some common elements across both parts and organizations. A thorough understanding of how one part in one organization is handled will enable us to ask the right questions as we extend the study to other parts and other organizations.

Based on our preliminary work. We identify four types of information managed in the remanufacture process of the fuel pump: 1) Blueprints for manufacturing parts and products involved, 2) Conformance lists for testing performance of new and reconditioned parts and products, 3) Plans for supply schedules, and 4) Work records such as repair activities on parts and components. All of these types of information have various life cycles and transfer routes. This variety of information is represented in different forms, processed by different agents, and interfaced with different computer systems. In short, remanufacture demands managing information that resembles what archeologists wish to have when they investigate an archeological site: perfect visibility with all historical integrity attached.

4. Discussion and Conclusion

We believe that information product integrates necessary physical products and work processes. Other research shaped our views on information products for remanufacture. The research and our interpretations are summarized below.

Mead's [8] classical premise of a disjunction between human actions and human grasp of actions raises the question of quality of data that can be the representation and manifestation of reconstructed human actions. Von Hipple [13] conceptualized a reason for costly transfer of certain information, useful for innovation, as "sticky" information. Allen [1] demonstrated that "gatekeepers" can play an important role in the transfer of technical information and thus impacting the technology acquisition and dissemination. Rein and Schon [10] also emphasized the criticality of problem framing that can make a considerable consequences for the nature and type of searching for solution information. Wand and Wang [14] explained the difference between real-world situation and stored information as data quality problems, using an ontological perspective. Madnick [5-7] identified a stream of data quality problems that arise from transferring data from one context and using it in another (different) context. He suggested their reconciliation with "Context Interchange" technology. Strong, Lee, and Wang [11] explored how specific characteristics of data quality problems are changed as data are transferred from one locale to another. Huang, Lee, and Wang [3] suggested examples of information products such as eye-glass prescriptions. Davidson [2] reported a preliminary methods for mapping information products.

Characteristics of how information integrates physical artifacts and activity process determine the kinds and quality of information product. The quality of information reveals how

effectively and efficiently planning and implementation of such integration is performed. We believe that remanufacture process lends itself as useful setting for studying the complex and detailed intricacies involved in information product and its performance.

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