RFID Implementation and Enterprise Management in the Healthcare Sector

Erick C. Jones[#1], Shalini Gupta[#2] LaTasha Taylor Starr[#3]
[#]Industrial and Manufacturing Systems Engineering Department,
University of Texas Arlington
420 Woolf Hall, Arlington, TX, 76079 USA
[1]ecjones@uta.edu
[2]shalini.gupta@mavs.uta.edu
[3]latasha.starr@mavs.uta.edu

Abstract- This article presents our method of applying radio frequency identification (RFID) technology within healthcare organizations, with the key concept of treating it as a supply chain enterprise. Past research relating to the pertinent elements is discussed, including RFID, supply chain reference model (SCOR model), healthcare supply chains. The authors then present their methodology for evaluating the supply chain, understanding where to possibly implement RFID, evaluate how it would impact the enterprise metrics and processes, evaluate the return on investment (ROI) of these, evaluate the cross-dependency, choose areas to proceed forward with implementation, and finally begin implementation. Additionally, researchers present the results of a recent company where this was implemented, which show significant cost savings and process improvement benefits due to the successful application of the SCOR model.

Keywords- "Enterprise management", "SCOR model", "RFID", healthcare, hospital.

1. Introduction

An approach to implementing RFID in healthcare organizations is presented from the perspective of treating the hospital as a supply chain enterprise. It is put forth before that hospitals actually function as an enterprise, but we believe the SCOR model to be applicable. [1]

The SCOR model itself will be presented as a template to base the organization upon. Then we present RFID before discussing various places in the healthcare enterprise where RFID can be implemented.

2. Literature Review

2.1 Supply Chain Operations Reference Model (SCOR Model)

The Supply-Chain Operations Reference model (SCOR) was advanced by (SCC) as the standard across all industries for management of supply chains. At the level 1 "process definitions", the SCOR model is centered on 5 "management processes". See Table 1 for a list of these processes and the respective definition. [2]

Table 1. SCOR model definitions for core processes [2]

PROCESS NAME	PROCESS DESCRIPTION
PLAN	"Processes that balance aggregate demand and supply to develop a course of action which best meets sourcing, production and delivery requirements" [2]
SOURCE	"Processes that procure goods and services to meet planned or actual demand" [2]
MAKE	"Processes that transform product to a finished state to meet planned or actual demand" [2]
DELIVERY	"Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management" [2]
RETURN	"Processes associated with returning or receiving returned products for any reason. These processes extend into post-delivery customer support" [2]

Linking to the model is the internal and external metrics. Internal metrics are relating to the performance of the company while external metrics are those that are

"customer facing". See table 2 for examples of internal versus external metrics. [3]

Table 2: SCOR model "level 1 performance metrics" from the SCC SCOR overview **document [2]**

METRIC NAME	EXT.	INT.
"Delivery performance"	X	
"Fill rate"	X	
"Perfect order fulfillment"	X	
"Order fulfillment lead time"	X	
"Supply-chain response time"	X	
"Production flexibility"	X	
"Supply chain management cost"		X
"Cost of goods sold"		X
"Value-added productivity"		X
"Warranty cost or returns processing cost"		X
"Cash-to-cash cycle time"		X
"Inventory days of supply"		X
"Asset turns"		X

1.2 The Hospital as an Enterprise

Stefanini discusses treating the hospital or healthcare organizations as an enterprise from the perspective of countries who may have a dysfunctional system, such as third world countries in Africa. See Table 3 for a list of activities that Stefanini suggests hospitals do that any enterprise would also perform. An interesting concept that he speaks of the "mystique of markets" it should not "be allowed to deprive public hospitals of the sense of social utility and of the caring ethos" [1]

It is worth mentioning, however, that Stefanini does not provide a methodology in the form of a specific list of steps to follow. Additionally, he presents that the hospitals that have tried to act as enterprises, including more independence from governmental control, as in centralized control, have not accomplished increased financial independence from the government. [1]

Table 3. Presented is a brief list of ways that a hospital or healthcare organization is similar to an enterprise. [1]

NO.	DESCRIPTION
1.	To provide service given a budget to manage within a district or a contracted district
2.	To negotiate on the cost of services [from others]
3.	To create income
4.	To purchase/acquire, have possession of, and dispose of assets
5.	To borrow money, subject to some annual limit
6.	To save surplus income assigned to operating budgets and creating monetary reserves
7.	To have an organizational structure for governmental body
8.	To employ as many and whomever staff the hospital deems essential
9.	To set salary or hourly pay rates and other employment conditions for employees and retainers; including having a manager

1.3 Radio Frequency Identification (RFID)

The RFID portion is made up of the following parts; the RFID tag itself, the tag scanner or reader, required software, and network to connect the necessary components. In regards to the RFID tags, the main types are passive tags and active tags, though variants of this do exist. [4]-[5].

2. Methodology

We hypothesize that RFID technology implementations will be more effective if linked to the wider activities of the enterprise, even the supply chain. To show this link, we suggest applying the SCOR model to a healthcare organization, including detailing processes, relevant metrics, establishing/linking best practices, and involving people. Only after doing this, can an implementation be truly understand. Using this pattern, we are confident that we can leverage the success of enterprise management to healthcare organizations namely hospitals.

To this end, we apply our experience and research to the five major kinds of hospitals, namely "general hospitals", "specialized hospitals", "isolation hospitals", "teaching hospitals", and "rural hospitals". It is typical to find many common functions such as out-patient and in-patient areas, a surgery unit, a pediatric ward, an emergency room, a department for medical records, and, typically, a pharmacy.

Our goal is to understand how we can provide RFID implementation services at these different stages in your healthcare organization. In pharmacy, we seek to use RFID tags to track medication concomitant to tracking of patient record, or emergency/operating/observation rooms, where, again, tracking of patients is related to other tracking (namely, asset and medicine). Additionally, RFID can be used to track medical devices and tools ("asset management") and also to track inventory supply rooms or warehouses ("inventory management"). [6]

We further hypothesize that supporting these processes from the start until the end in a turn-key mode will ensure that the lack of experience in RFID, SCOR model, or enterprise management does not hinder the organization moving forward. As the process continues, the organization will adopt the necessary knowledge and experience to enable them to continue on the path chosen.

In general, all of the savings and process efficiencies that could result from these implementations is one aspect, but there is also the seriousness of the quality and level of service requirements that does not exist in other industries. These have been some of the challenges in balancing improvement in the healthcare sector. [1]

3.1 Pharmaceutical Tracking

When linked with patient tracking, this implementation of RFID can result in lower incidences of patients being dosed with the wrong medicine, which could result in further complications, illness, or death. [7] This can also dramatically lower malpractice lawsuits and related insurance premiums. Past historical data from within the organization and externally can be used to base differences in annual premium costs.

3.2 Device/hardware Tracking

Although can be further linked to other types of RFID tracking (namely patient, doctor, and nurse tracking), device and hardware tracking by itself provides a return on investment due to being able to track utilization of equipment and prevent expensive medical tools from being needlessly thrown away. [4] Comparing purchase rates of tools, devices, and other hardware to their use and expected useful life can give an idea of savings by implementing RFID tracking here.

3.3 Patient Tracking

Useful when linked to other RFID tracking implementations such as pharmaceutical tracking, this can also be extended to tracking doctors, nurses, and other healthcare personnel. When looking at the big picture, one can couple the data from tracking a patient through the processes, including wait time, cycle time, etc. to nurse and practitioner availability. The immediate results are nothing compared to the long-term ability to collect data on all healthcare processes. This can be used for studies resulting in continuous improvement.

3.4 Inventory Tracking

Although many inventory models exist, any model that builds in extra inventory due to lead time will benefit from having real time and accurate stock inventory levels. Additionally, accurate levels can decrease costs associated with these (either from ordering product when you have it, or from not ordering product when you need it). These costs can be higher in healthcare than in other industries. Equation 1 illustrates some of the times associated with the "purchase-order cycle- time", which can be used for a comparison of lead time with and without accurate inventory levels and immediate stock re-order. The difference will be that PO creation, transmittal time, ship time, and receiving time will be significantly reduced with the use of RFID, some to a neglible amount of time.

$$CT_{PO} = TIME_{CREATE\_PO} + TIME_{TRANSMIT\_PO} + TIME_{LEAD} + TIME_{SHIP} + TIME_{RECEIVE} \quad [1]$$

3.5 Final results

Finally, all the costs and savings can be tabulated to understand the ROI. Taken together with the change to the processes and metrics, the final decision can be based on the value of extra service and quality provided to the patient (through process, metric, and benchmark review), the return on process efficiency and the quality to the hospital (traditional ROI), and cost associated with making the change (all). From each of these, the traditional net present value of all proposed implementations can be calculated over the number of years the project is to be evaluated. [8]

After compiling all such returns, use an appropriate linear programming or nonlinear programming problem to decide on which projects are to be advanced first (or at all) due to budget constraints.

3. Proposed Theoretical Model

In general, we suggest that most prior attempts at RFID in healthcare assume that the organization continues functioning, management wise, as it has before. Implementations will be based on perceived ROI alone and less on the overall impact on company processes, metrics, and adherence to industry best practices.

See Figure 1 for an accompaniment to the section. NOTE: Figure 2 shows a larger view of this (full width of the page). We start with understanding the existing processes, known as the "as-is" state. Together with industry benchmarks and best practices relating to management and software, the "to-be" state is envisioned. To further this process and ensure that all processes, best-practices, and metrics are specific to the individual healthcare organization. Key to this is developing all the process descriptions and metrics at all associated levels of the SCOR scope. [2]

The next steps are to perform gap analysis relative to these processes and metrics. Where gaps are found, we relate them to where RFID implementations can occur. We investigate where there are linkages or whether the RFID can be implemented in independent stages. [4]

Upon investigating the linkages, an analysis of how the metrics will be effected in addition to the more traditional cost/benefit analysis. (3)Upon choosing areas to continue forward with, the formal project scoping phase begins. From here would be the typical project t management phase that is often present in RFID implementation literature.

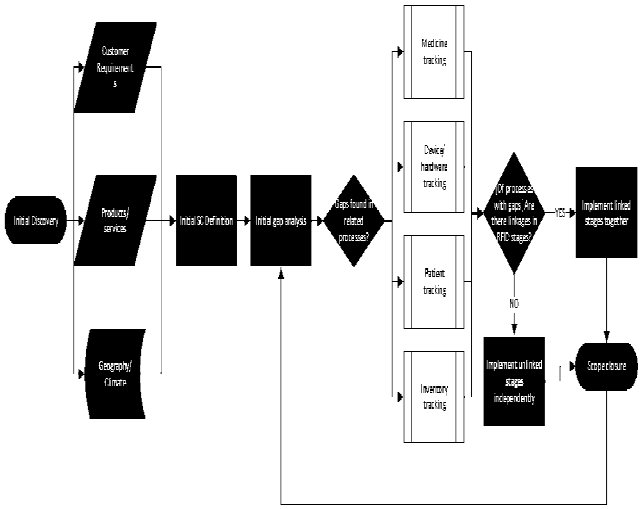

Figure 1. Process that is proposed for implementation of RFID in a healthcare enterprise. Note that the more technical implementation phases are in the "implement linked stages together". The key of this process is that it is a strategic methodology

4. Discussion/Results

As an example, this method was applied to a regional healthcare provider. Before going into the financial results, we will take a look at some examples of gaps found, enterprise-based solutions, and finally on the ROI of the actual RFID implementation and enterprise transformation project itself.

5.1 Gap Analysis

The following were lessons learned from the gap analysis.

5.1.1 Visibility of Assets

An internal metric was determining the utilization of assets, specifically medicines and hospital supplies. It was found that most departments were carrying excess inventory, sometimes past a shelf-life, hurting FIFO practices, and increasing holding/re-order costs. [3]

5.1.2 Patient Hand-off between Functions

After tracking the routing of patients in the hospital for different processes, it was found that these hand-offs were creating issues, including process failure, excess waiting time, lack of communication, and wasted efforts. [3]

5.1.3 Quality of Information Flow

A hold-out to a legacy process were the existence of multiple records (typically paper) that were often illegible. Notwithstanding this, this information had to be entered into multiple, disconnected systems. Beyond this difficulty, it also increased the "cash-to-cash cycle time".

5.2 Enterprise-based Solutions

The following were solutions implemented that were directly or indirectly tied to the treating the organization as an enterprise, using the SCOR model, or other industry best practices.

5.2.1 Cost per unit Calculation and Work-order Approach

Work was done to find the cost per unit for all processes in order to able to assign them to "work centers" and work orders. Understanding the cost of supplies, personnel, and additional administration related to patient care in that functional area is helpful for this. [3]

Each process becomes a "work order" and these work orders are collected to a patient. This process benefits from the SCOR model that allows for breakdown of related processes. The appropriate processes are used for the appropriate circumstance. Finally, this also helps create a "defensible invoice". [3]

5.2.2 Lean/Other Best Practices

To further simplify and improve, lean principles such as 5S and a Kanban system were used.

Since scheduling of activity to work centers allowed for better utilization of the equipment, where possible, excess equipment and supplies were sold to other healthcare organizations.

5.2.3 Automation of Patient Data

The automation of patient data entry and the use of a system that allows this data to integrate with all required functions allowed for the elimination of manual data entry and manual records.

5.3 ROI Results

After the initial 1 year consultation period, stages 1-3 were selected to implement based on budgetary restrictions $5,000,000 and interlinking. See table 4 to see the costs and savings associated with this project. Table 5 presents the summary of costs/benefits per project year plus other years project will be evaluated over and the net present value summary. A required rate of return of seven percent was used. Based on the positive net present value, the decision was made to move forward with the project.

Additionally, to truly understand the savings of this approach, the issue has to be evaluated in subsequent years to gauge the savings to other process improvements

and to the long-term profitability and stability of the healthcare organization in the long-term. As such, although the project is easily justified as-is, there are numerous other savings that are too difficult to evaluate within the scope of this study.

Table 4. Presented are details of all costs and benefits from project inception to end of evaluation period.

YEAR	AMOUNT	DESCRIPTION
1	$ (1,300,000.00)	Internal/External SC consulting hours (1yr)
2	$ (520,000.00)	Continuing consultant hours (6 months)
2	$ (2,300,000.00)	Implementation costs stages 1-3 (6 months)
2	$ (230,000.00)	Variables costs of implementation
2	$ (250,000.00)	Ongoing costs of RFID use
2	$ 1,260,000.00	Savings due to implementation (6 months)
3	$ (500,000.00)	Costs
3	$ 2,520,000.00	Savings
4	$ (500,000.00)	Costs
4	$ 2,520,000.00	Savings
5	$ (500,000.00)	Costs
5	$ 2,520,000.00	Savings

Table 5. Presented is a summary of costs/benefits for each year and results for net present value based on a required return of 7%. The NPV>0, so this project was deemed worthy.

YEAR	NET SAVINGS (COST)	
1	$ (1,300,000.00)	
2	$ (2,040,000.00)	
3	$ 2,020,000.00	
4	$ 2,020,000.00	
5	$ 2,020,000.00	
i = 7%	NPV(i) =	$1,633,433.85

5. Conclusion

Treating a healthcare organization as an enterprise with the SCOR model has proven to be a novel approach to RFID implementation. Instead of making half-way attempts to implement one methodology or another (such as lean, six sigma, etc.), all implementations are linked to processes, metrics, and benchmarks that are relevant to the healthcare organization, tying any future continuous improvement undertaking to the organization's enterprise management strategy. Absolutely key to this, for the continued success of the organization, is apply the SCOR model to the organization at all levels as specified, to understand the specific processes, the relationships thereof, and to set specific internal or external metrics. Despite all the benefits touted for RFID, both within healthcare and other industries, there are many detractors to its implementation. We will present these concerns in three categories: privacy/security, investment, and other long-term concerns.

6.1 Privacy /Security Concerns

For example, Rosenbaum expresses his concerns regarding related "privacy and security", especially in regards to the data on the tag. [9] McGrady et al also warn of the integrity of data and its vulnerability to "electronic attacks". They speak of additional costs of safeguarding against these hazards. See table 6 for a list of privacy/security concerns that Rosenbaum shared when discussing radio frequency identification in the healthcare field. [10]

Table 6. Privacy/security concerns and key examples of relating to RFID implementation in the healthcare industry

Concern	Key Example
Price	That as a result of the high cost of the manufacture and implementation of RFID, that how much controls are integrated relative to privacy/security may be limited [10]
"Counterfeit or Decoy"	"RFID tags can be read and identical counterfeit tags created" [10]
"Service Denial"	"With a limit to the number of RFID tags that can be read simultaneously, a saboteur can overwhelm traffic with radio frequency signals or RFID tags" [10]
"Eaves-Dropping"	"listening to unencrypted data transfer" [10]
"Physical Attacks"	"Tampering with RFID tags may leave them invalid" [10]
"Spoofing"	"RFID tags with different data can be created and replace authentic tags" [10]
"Traffic analysis"	"data transfer can be analyzed to determine location" [10]

6.2 Investment and Other Long-term Concerns

Barut et al discuss investment related risks, namely the ongoing costs of maintenance and other service costs. Furthermore, they bring up costs that are less difficult to measure, such as training/acclimation costs. [11]

For example, they bring up the costs per tag of twenty-five to thirty cents, suggesting that one to five cents was a better target price for applying these tags to a single saleable unit, e.g., one each. Also, additional costs mentioned were the cost of readers and software. [11]

Beyond this, training on the use of the related hardware/software and learning to interpret the data that comes back is called an "implicit cost". [11]

6.3 Other Long-term Concerns

A topic not discussed here, but of potentially emerging importance as global economies integrate further, is the implementation of RFID for the purpose of preventing counterfeiting of pharmaceuticals. [12]

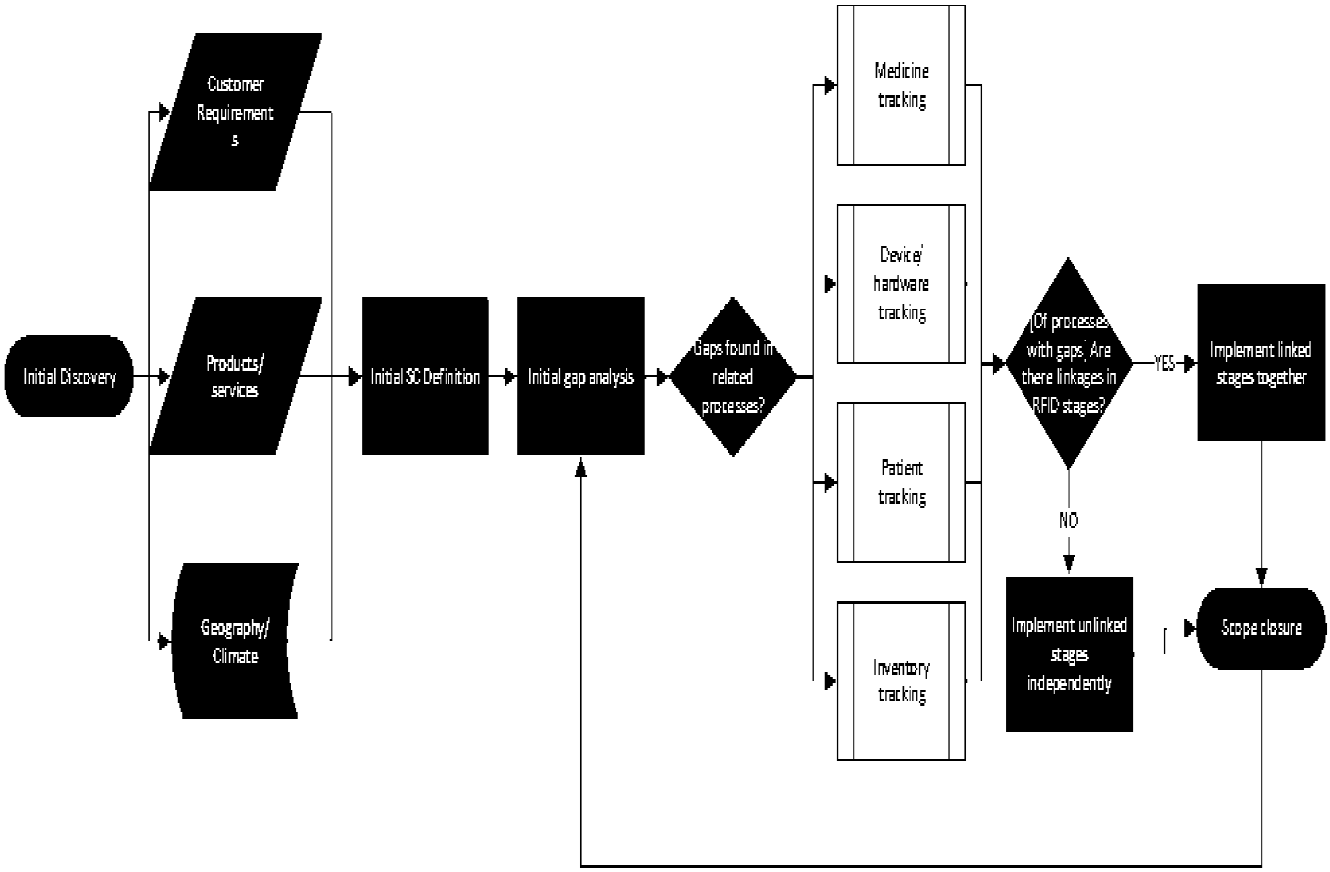

Figure 2. Larger view of process that is proposed for implementation of RFID in a healthcare enterprise. Note that the more technical implementation phases are in the "implement linked stages together". The key of this process is that it is a strategic methodology

References

[1] The hospital as an enterprise: management strategies. Stefanini, Angelo. 3, 1997,Tropical Medicine and International Health,Vol. 2, pp. 278-283.

[2] Supply Chain Council. Supply-Chain Operations Reference-model. Pittsburgh: Supply-Chain Council, 2003. Organization publication.

[3] Knowing the SCOR: using business metrics to gain measurable improvements. Malin, Jane. July 2006, healthcare financial management, pp. 54-59.

[4] Stage implementation of RFID in hospitals. Kumar, Sameer, Livermont, Gregory and McKewan, Gregory. 2010, Technology and Health Care, Vol. 18, pp. 31-46.

[5] Fish, Lynn and Forrest, Wayne. A Worldwide Look at RFID. s.l. : Dow Jones / Factiva.

[6] RFID in the healthcare supply chain: usage and application. Kumar, Sameer, Swanson, Eric and Tran, Thuy. 1, 2009, International Journal of Health Care Quality Assurance, Vol. 22, pp. 67-81.

[7] RFID MEDICINE MANAGEMENT SYSTEM. Shieh, Horng-Lin, Lin, Shih- Fong and Chang, Wen-Sheng. Xian: s.n., 2012. 2012 International Conference on Machine Learning and Cybernetics. pp. 15- 17.

[8] Measuring the Value of RFID Investment: Focusing on RFID Budget Allocation. Lee, In and Lee, Byoung-Chan. 4, 2012, IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, Vol. 59, pp. 551-559.

[9] Radio Frequency Identification (RFID) in Health Care: Privacy and Security Concerns Limiting Adoption. Rosenbaum, Benjamin. 19, 2014, Journal of Medical Systems, Vol. 38.

[10] Emerging Technologies in Healthcare: Navigating Risks, Evaluating Rewards. McGrady, Elizabeth, et al. 5, 2010, Journal of Healthcare Management, Vol. 55, pp. 353-365.

[11] RFID and Corporate Responsibility: Hidden Costs in RFID Implementation. Barut, Mehmet, et al. 3, 2006, Business and Society Review, Vol. 111, pp. 287-303.

[12] RFID in the Pharmaceutical Industry: Addressing Counterfeits with Technology. Taylor, Douglas. 141, 2014, Journal of Medical Systems, Vol. 38.

[13] Ayre, Lori. RFID in Libraries: A Step toward Interoperability. 2012.

[14] RFID systems implementation: a comprehensive framework and a case study. Ngai, E.W.T., et al. 9, 2010, International Journal of Production Research, Vol. 48, pp. 2583-2612.

[15] Supply chain replenishment: before-and -after EDI implementation. Leonard, Lori and Davis, Christine. 3, 2006, Supply Chain Management: An International Journal, Vol. 11, pp. 225-232.