

# SCOR MODELLING OF AN RFID ENABLED SUPPLY CHAIN FOR ROI ANALYSIS

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## ABSTRACT

**Purpose** – To support the uptake of RFID (Radio Frequency Identification) technology amongst supply chain partners, a framework has been developed to quickly model positive business benefits arising from RFID adoption and to facilitate ROI (Return on Investment) analysis.

**Design/methodology/approach** – This paper describes a business process modelling tool that is based on the SCOR (Supply-Chain Operations Reference) model and IDEF0 (ICAM Definition language), which is extended to include time and cost weightings for ROI analysis. This is to provide a quantitative analysis of labour costs and productivity gains achieved through RFID data and process automation within business processes. The method described encompasses business process and data modelling concepts, as RFID implementation has an impact on the business operations and information architectures.

**Findings** – The business process modelling at SCOR model level 4 or higher levels provides an excellent start for process modelling and process re-engineering in order to perform ROI analysis. RFID implementation can increase data-entry accuracy so that mis-shipments, lost inventory and redundant data reads can be reduced.

**Practical implications** – The SCOR modelling tool and ROI calculator developed in this research can be applied to other cases where “as-is” and “to-be” scenarios can be constructed. While the SCOR concepts provide a perfect start point for process representation, the feature of allowing user customization of the tool enhances the flexibility of business process modelling.

**Originality/Value** – This research constructs a visual business process modelling tool based on the SCOR concept and provides a spreadsheet based ROI calculator for justification of adopting new technology and additional investment to projects.

## INTRODUCTION

Adoption of RFID technology is a significant business investment for most organizations, requiring a commitment to a particular solution and the dedication of resources and funding to implement the project. The use of a technology enhanced system offers advantages in terms of supply chain automation, making the processes efficient, providing accuracy of information and reliability in the handling of any shipment from make to delivery.

For any organization considering RFID implementation in their supply chain, a formal business case justification will help gain project implementation approval from management. Our intention is to provide a modelling tool for these “early adopters”, with an approach that can quickly identify whether the RFID project will generate positive business benefits and a tangible ROI. Our approach is to provide a quantitative analysis of labour costs and productivity gains achieved through RFID data and process automation, and better use of manpower resources within business processes.

RFID implementation involves an opportunity to critically examine business processes and re-engineered them with the goals of increased data-capture automation and data-entry error-reduction to reduce mis-shipments, lost inventory and redundant data reads. One of the many benefits is the reduction in manual processes through automated data capture to improve productivity, thus allowing manpower resources to be reallocated to higher value adding activities.

The approach described in this paper applies the SCOR model for business process modelling with the ability to capture the data elements used in the process. The use of SCOR as a reference model

provides an opportunity to model the related business processes across the whole supply chain in a panoramic way and enables business processes to be analyzed at different levels; moreover, it also offers an opportunity for business process re-engineering.

### **LITERATURE SURVEY**

There is no lack of articles and white papers appear in the literature reporting the qualitative benefits and potential applications of RFID, such as, Thiesse et al. (2006) describe a real-time identification and localization system uses RFID and ultrasound sensor technologies to improve tracking visibility for inbound logistics in a wafer fabrication cleanroom; Legner and Thiesse (2006) report that the Frankfurt Airport's operating company integrated RFID and a mobile application with its asset management systems; Prater et al. (2005) examine market drivers that are leading to RFID implementation in the grocery industry and Roussos (2006) discusses benefits of RFID at item-level; to name just a few. However, there is deficiency of literature regarding quantitative analysis of RFID benefits.

Lee et al. (2004) and Lee et al. (2005) investigate how RFID advantages can contribute to the performance of a supply chain and hence to business value. Simulation is used to model the impact of RFID in a manufacture-retailer supply chain. The studies provide a comprehensive view and a quantitative analysis on how to demonstrate the potential benefits of RFID in terms of inventory reduction and service level improvement. Lee and Özer (2005) argue that the value of RFID should be analyzed with detailed models and compare the cost benefits of visibility and prevention for models with and without RFID. Leung et al. (2006a) and Leung et al. (2006b) develop a tool set to show the business value of RFID to different parties in a manufacturing-retail supply chain. The tool set consists of two tools which are linked: a business value model and a business process model. The former consists of the benefit model, the cost model and the data sets and is implemented as an in-house application using spreadsheet. The latter is implemented through a commercial discrete-event simulation package and computes certain supply chain performance metrics.

Gaukler (2005) investigates the impact of RFID on supply chain management in strategic, tactical and operational dimensions in his PhD thesis. Mathematical frameworks are proposed for evaluating some of the pertinent issues that have arisen with the availability of RFID technology in the broad field of supply chain management. Extracting value for supply chain with the traceability characteristic of RFID is also discussed. Gaukler et al. (2007) consider a supply chain with one manufacturer and one retailer and present analytic models of the benefits of item-level RFID to both supply chain partners within the context. Situations of a dominant manufacturer and a dominant retailer are examined respectively and the results indicate an introduction of item-level RFID to such a supply chain depending on partners' market power characteristics. How the cost of item-level RFID should be allocated among partners is also analyzed so that supply chain profit can be optimized under different scenarios.

Overby et al. (2005) focus on a specific business process — order-to-cash to uncover how RFID data significantly improves the process. Order capture, shipping, billing and payment receipt are the most obvious beneficiaries out the improvement over order-to-cash process. The study suggests two basic questions (whether the process can benefit from automated data capture and whether the process can benefit from serialization) for RFID adopters to analyze their business processes.

### **SCOR MODEL**

The Supply-Chain Operations Reference-model (SCOR) is a process reference model that has been developed and endorsed by the Supply-Chain Council. As it has gained acceptability, the supply chain models developed in this paper were based on the SCOR model in order to provide a common language for disseminating the results among supply-chain partners. The Model itself contains several sections and is organized around the five primary management processes of Plan, Source, Make, Deliver, and Return as defined in SCOR (Supply-Chain Council, 2008). SCOR is a hierarchical model with specific boundaries in regard to the supply chain management processes.

In terms of process decomposition, it contains three levels of process detail. The hierarchical decomposition, using the Deliver management process as an example is illustrated in Figure 1.

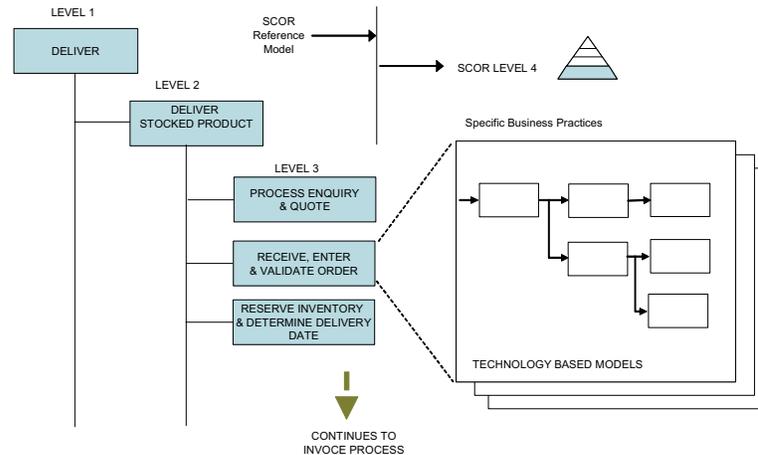


Figure 1: Modelling of specific business processes at SCOR Level 4

The primary management processes are defined at Level 1. Within the Deliver process, there are other Level 2 processes such as “Deliver Stocked Product” and “Deliver Make to Order”, etc. Each Level 2 process is further decomposed into “Configuration Processes”, which are at Level 3. This research, implemented supply chain improvements using the SCOR-model, by extended the Model, at least to Level 4, using specific processes to reflect how the supply chain costs and savings would be affected with the incorporation of RFID technology. The definition of the reference model to Level 3 provided a reusable framework of supply chain processes, which avoids the wastage of re-invention.

**ROI ANALYSIS OF AN RFID ENABLED SUPPLY CHAIN**

Many organizations that produce, distribute, handle or sell goods are researching what RFID can do to improve operating efficiency, reduce business risk and drive additional revenue opportunities. The proposed framework for this research is illustrated in Figure 2. The SCOR model is used as the foundation which also enables portability of the resulting technology models. Business processes are mapped based on the SCOR Level 3 processes and from there, the resources, inputs, outputs and triggers of each process are identified, collected and output to a spreadsheet. The ROI calculator is embedded in the spreadsheet and computes based on the data provided. In modelling SCOR activities, particular attention was given to factors such as the costs and time that are consumed by individual activities. Certain investment in technology allows business process re-design and improvements; the inclusion of cost and time factors enabled ROI analysis to be propagated across the process chain.

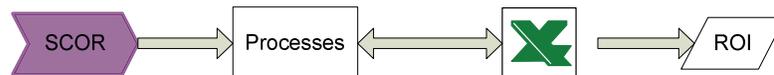


Figure 2: The approach to modelling ROI

RFID technology enhances visibility and accuracy of information throughout the supply chain via the automated data collection, as well as data associated with product movement. The study of the supply chain therefore progressed from the business process layer into the data layer. This was to focus on the modelling of data elements that could benefit from RFID automation and quantifying the associated cost and time weightings for subsequent ROI analysis.

IDEF0 is a descriptive method that shows the activities of a process. It is a notation for specifying the input, control, output, and mechanisms (ICOM) associated with each activity. Figure 3 is an abstract view of the IDEF0 notation. In addition to the activity, arrows represent the “data” associated with the ICOMs. Inputs are the typical artifacts such as resources consumed or transformed by a process. Output(s) are the results of the transformations of the inputs by the process. Controls are the standards, policies, guidelines, etc., that guide the process. Mechanisms are the resources (people, manual tools, automated tools, etc.) that accomplish the actions delineated within the process.

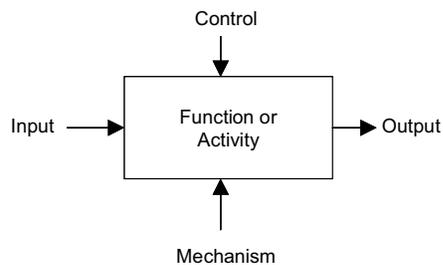


Figure 3: The IDEF0 Notation for Function or Activity Modelling

The concept of cost penalties is introduced at the stage where the activities are analysed and where the artifacts are identified. The transition from process modelling to data analysis was made by examining the process artifacts. At this stage, the authors were concerned with associating a “penalty” against the artifact, such as the time or cost taken to populate the element of data. This approach was taken with a view to weighting the overheads of data redundancy in systems.

In relation to the global supply chain, in addition to the approach of collecting cost and time weightings to measure ROI at the data-element level, it is likely that inefficiencies will exist in its operations. Examining the process in terms of the business process chains should be done in anticipation of achieving savings in labour, operational efficiencies. Significant opportunities for improvement are likely to exist in these areas and major improvements can be achieved prior to applying RFID through business process re-engineering. Cost and time implications also exist at the data level, when RFID technology is used to automate data entry, e.g. product location as opposed to collecting the data via bar-code technology, or even manually with pen and paper. Automated collection of data enables a smoother throughput of shipments by reducing manual operations and the accuracy of information is improved.

### **SCOR MODELLING TOOL**

To benefit a cross section of the industry and to make the SCOR model readily usable, a visual modelling tool was developed. The tool was based on the SCOR process hierarchy and incorporated the IDEF0 modelling method for describing the individual activity. The modelling tool can be distributed to supply chain partners as a means to increase the uptake of SCOR. The tool provides two instances of the SCOR hierarchy in terms of the “as-is” and “to-be” models.

The software perspective of the tool is shown in Figure 4, which presents the UML model that the logic of the tool was based on.

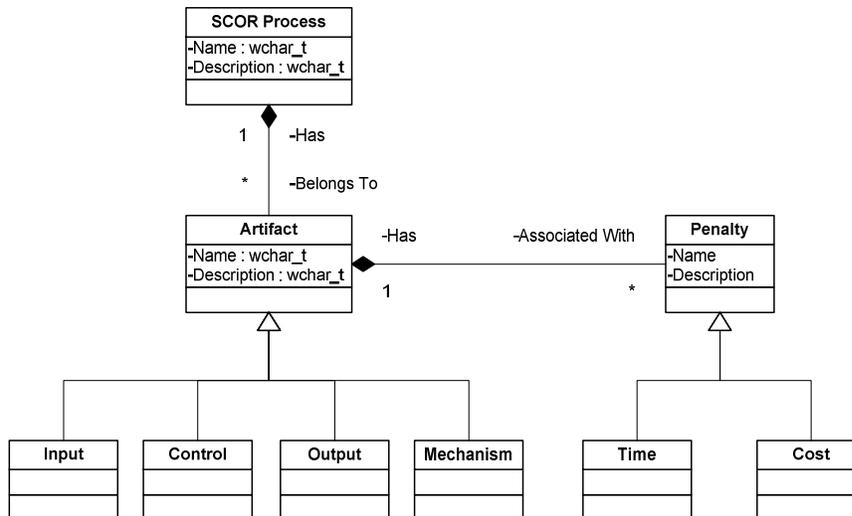


Figure 4: UML representation of the SCOR activity model

The model implements the IDEF0 constructs and extends the modelling notation to capture cost and time overheads. The SCOR process hierarchy is implemented using a tree-control (Figure 5), which is a type of control that provides the ability to show the hierarchical relationships of the SCOR processes, indenting the child processes and showing the sibling processes at the same level.

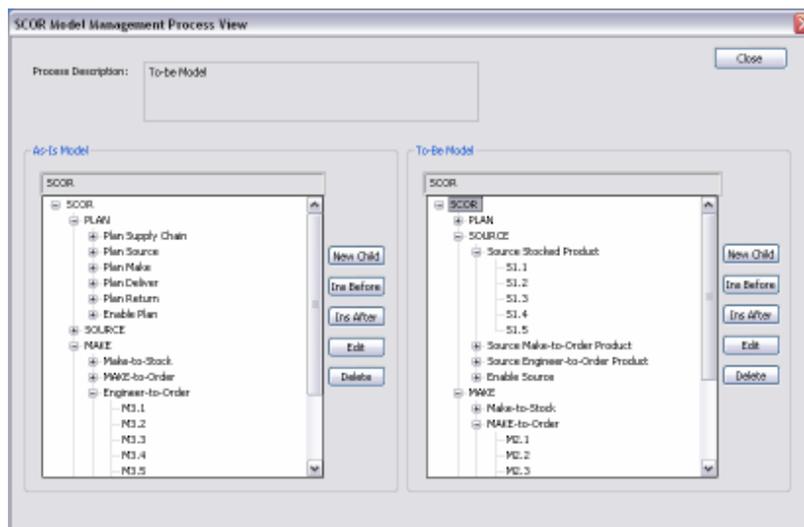


Figure 5: Using the SCOR process hierarchy

The “as-is” model is presented in the left pane and the “to-be” model is presented in the right pane. The SCOR model is fully implemented, providing end-users with a suitable basis for tailoring their models. End users may insert or delete new processes as appropriate, in order to create the configuration of specific business processes at SCOR Level 4. A particular study tends to be focused on specific processes, for example, the Make-to-Order branch. It is possible therefore, for other branches of the hierarchy to be deleted where appropriate. The most important feature is the ability to create two models (“as-is” and “to-be”) for comparative studies. The time and cost data associated with each process can be captured through the constructs of the IDEF0 notation.

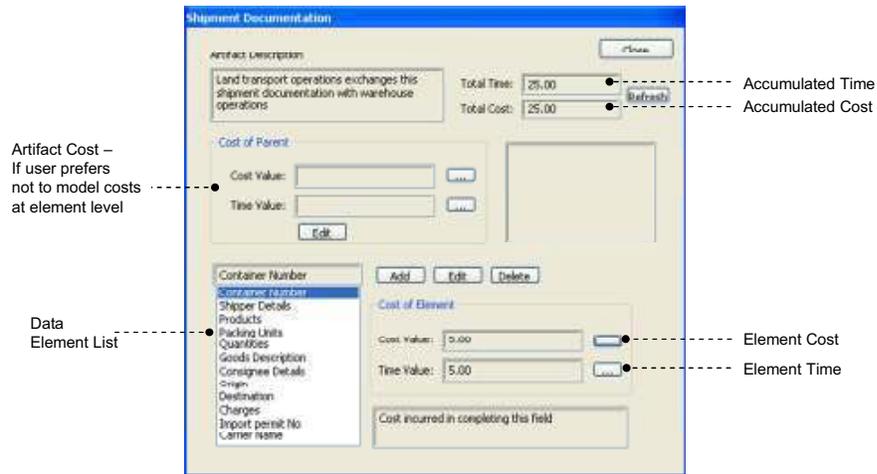


Figure 6: View of a process artifact

Cost and time are accumulated and displayed for individual ICOM(s), and accumulated in terms of a total cost and time for the activity itself. The user may view either the cost or time. The view into an individual artifact may be expanded to show the overheads and further data elements if relevant. This is achieved by the modelling tool using the detailed view of the process artifact, shown in Figure 6. The expansion of the artifact view demonstrates how an item is modelled using the extended SCOR concept.

## ROI ANALYSIS

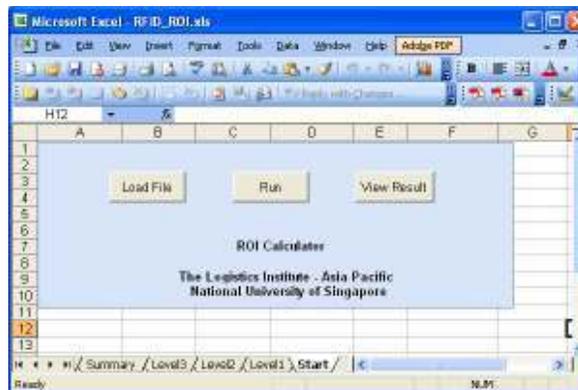


Figure 7: Interface of the ROI Calculator

ROI analysis is important for investment justification where the investment is evaluated by comparing the magnitude and timing of expected gains to the costs. To involve a wider number of stake-holders, the details of the Cost and Time data collected by the SCOR modelling tool are exported into a spreadsheet for subsequent analysis. The ROI calculator developed in this research bases on Excel spreadsheet and uses VBA to aggregate and analyse all data collected. Figure 7 shows the interface of the ROI calculator. The "Load File" button is used to import the data file. The "Run" button initiates the aggregation of data and calculates the summations at SCOR Level 1, 2 and 3 and put the overall cost and time into the "Summary" worksheet. The aggregation of cost

and time is made in a way that all cost and time happen at a particular level and all subordinate levels are summarized up to that level. Therefore, comparison can be made for different processes at different level.

### **CASE STUDY**

The case study investigates an IT product assembly line, where the RFID technology is used for assembling and handing over to a 3PL provider. The assembly process needs to associate part A and part B serial numbers with the box which they are packed into so that tracking of products can be achieved. The "As-Is" scenario is supported by barcode technology; while the "To-Be" scenario is supported by RFID technology. Parts are assembled to order and dispatched to the 3PL after assembly and testing.

In the "As-Is" scenario, the operator needs to switch operations between packing equipment and scanning barcodes to associate part serial numbers with box serial number. Following the final packaging, the shipment of several cartons is consolidated into a pallet and physically handed over to the designated 3PL. At the hand-over, the barcodes of the several cartons on a pallet are scanned to generate the hand-over document. From the perspective of the manufacturer, one person is required to hand-over the consignment of pallets; from the perspective of the 3PL, one handler is required to accomplish the confirmation scanning and take over of the pallet consignment.

In the "To-Be" scenario, RFID tags are printed and applied to the carton instead of using barcodes. Therefore, all serial number association can be done automatically through the RFID technology. The operator only needs to concentrate on the packing activities. This considerably reduces the manual handling activities and consequently speeds up the packaging rate. Furthermore, the person who handles the packaging is alerted when a wrong part is packed. The shipment is consolidated following the packaging and each pallet (on a pallet truck) is physically handed over to the designated 3PL. A total of four RFID antennas are installed (facing two opposite sides of the pallet) and these read the RFID tags as the pallets are pushed between them. The whole process of handing-over and consignment document generation can be finished after the pallet truck is pushed pass the RFID tag readers. Although in the case study this is still processed by the handlers, the process can actually be automated.

The whole process is recorded using the SCOR modelling tool, the output is processed by the ROI Calculator. The results of this cast study, which is a pilot implementation of RFID, show a negative ROI; however, this is acceptable by the manufacturer, as they realized other benefits in areas beyond the limits of the assembly line and that with full-scale implementation, the economy of scale spread the hardware and software cost, thus much reducing the cost per unit associated with this RFID implementation.

### **CONCLUSIONS**

To increase the uptake of RFID technology in the supply chain, "early adopters" need an approach that can quickly identify positive business benefits and a tangible ROI. The use of the SCOR model has provided the framework of business processes for modelling supply chain scenarios for ROI analysis. The SCOR model is applicable across the supply chain industry and avoids re-invention of process models. The use of the SCOR model to underpin a modelling tool is to provide a method for ROI analysis that can be readily used, in this case, for studies involving RFID enabled supply chains. Specific business processes may be modelled in detail at SCOR Level 4 through process decomposition and a number of candidate "to-be" processes can be evaluated.

The constructs of the SCOR process framework has been extended, where cost and time penalties are included in the model via process artifacts. Invariably, RFID implementation also has an impact on the information system architecture in terms of data and application integration. The SCOR modelling tool involves the first step of data analysis by introducing activity artifacts and their data elements into the SCOR model. Associated costs and time are captured and accumulated to enable a comparison between the "as-is" and the RFID enabled ("to-be") models. This enables the ROI to

be calculated on the basis of the running costs and technology investment. The development of a visual based interface to represent the SCOR and IDEF0 constructs offers a tangible and intuitive method for end-users to specify process artifacts and associated cost and time weightings.

The SCOR modelling tool and ROI calculator developed in this research can be applied to other cases where "as-is" and "to-be" scenarios can be constructed to justify adoption of new technology or additional investment in projects. While the SCOR concepts provide a good start point for process representation, the feature of allowing user customization of the tool enhances the flexibility of business process modelling.

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