

# Return on Investment Calculator for RFID Ecosystem of High Tech Company

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## Abstract

The use of RFID technology affords an opportunity for greater visibility in the supply chain and further supply chain automation, making the processes more streamlined, providing accurate and timely automatic data capture, thereby improving shipment reliability. This paper provides a case study of an RFID-enabled supply chain ecosystem focusing on a large high tech multi-national corporation based in Singapore. Specifically, the paper provides an implementation framework for the Return on Investment (ROI) calculator which trades off labor cost and productivity gains. The Supply Chain Operations Reference (SCOR) methodology is used to assess the operational level benefits of RFID implementation. We show how scalability is critical for RFID adoption.

**Keywords:** RFID adoption; SCOR; ROI analysis; RFID implementation

## 1. Introduction

Product proliferation in the supply chain, while advantageous to the consumer, logically leads to an increase in the effort to better manage cycle stock, stock-outs, and other product related information. Hence, there is a need for smart technology such as Radio

Frequency IDentification (RFID) to manage the flow of goods through the chain. There are good reasons for doing so. Indeed, RFID can help manufacturers to improve the linkage with upstream suppliers by tagging goods at the case level to ensure that the raw materials sourced are available, with automatic replenishment triggering, and for easy locating at the plant. This presents considerable production improvement in process and inventory control, and responsiveness through greater flow visibility. As RFID deployment proliferates across the shop floor, the information captured by RFID can be seamlessly integrated into the control, visualization, and information infrastructure, reducing the need to purchase new equipment, or invest in expensive, time consuming, and unproven IT integration projects [1].

RFID is a wireless communication technology that lets RFID readers ascertain the identity of the RFID tags from a distance in a contact-free manner. RFID tags can be active (requiring a power source) or passive. Passive tags are currently widely used due to their relatively lower cost.

Many companies running pilot systems on RFID adoption have been able to demonstrate some of the benefits that RFID promises. To the large global retailers such as Wal-Mart, RFID not only reduces its labor and inventory costs but also increases revenue by reducing the unnecessary out-of stock items [2]. RFID combined with EPC technology, which assigns unique ID numbers to product items, promises to provide timely and accurate data on products [3]. All the actors of the supply chain can now gain instant access to pertinent product information. Given the relative cost differential between the RFID tags and the barcode labels, any potential RFID adoption is therefore likely to be at the pallet and carton levels.

However, there is little by way of the literature or practice that describes an effective implementation framework, detailed elemental processes involved in moving over to the new RFID adoption, and more importantly the computation of the Return Of Investment (ROI) of the adoption of RFID. Hence, we seek to address this gap by presenting evidence from the field using the case of an established large multinational corporation in the high tech sector which has a global distribution hub in Singapore.

The rest of this paper is organized as follows. Section 2 reviews some applications of RFID. Section 3 presents the scope and methodology. Section 4 presents the RFID ecosystem for the case company. Section 5 details the RFID implementation framework for the case company using the SCOR model. Section 6 discusses the ROI calculator used to quantify the benefits of RFID adoption. Section 7 concludes.

## **2. Applications of RFID**

The extant literature is replete with RFID adoption. For instance, Finkenzeller [4] has discussed the diversity of RFID adoption from the smartcard to general household items. Bajaj [5] has proposed a techno-process model using RFID to create a lean supply chain and analyzed the business impact of RFID technology. RFID has also been applied successfully to increase container security [6]. Likewise, Pearson [7] has examined the use of RFID to prevent counterfeiting in the pharmaceutical and consumer products industry by embedding the RFID tags at the product item-level, making it easier to guarantee authenticity. There is a clear and increasingly important value proposition for RFID on product protection and brand integrity.

Thiesse et al. [8] have described a real-time identification and localization system using RFID and ultrasound sensor technologies to improve tracking visibility for inbound logistics in a wafer fabrication clean room. The results include fewer handling errors and reduced lead times, yielding lower manufacturing and inventory costs. Further, the fast and rich communication with operators enhanced the flexibility of transport and handling processes. RFID efforts aimed at inventory visibility across the supply chain are closely tied to the execution processes. Retooling assets, execution strategies, plant-level information systems, and integrating new RFID enabled manufacturing data to enterprise systems will be critical for synchronizing the plant floor with the RFID-enabled supply chain.

Elsewhere, RFID has been used to help manage the operations of large infrastructure facilities such as office buildings, industrial plants, and public utilities [9]. Legner and Thiesse [10] report that Frankfurt Airport's operating company integrated RFID and a mobile application with its asset management systems, leading to better planning, control, and documentation of the work as well as improved process quality. Hilders [11] has discussed the opportunity of using the visibility information to create a secure, efficient, flexible multi-purpose air cargo handling system to enhance flight safety in a cost effective way and sustain the required security level in the entire supply chain.

In the retail sector, Byrne [12] has studied Wal-Mart's RFID application. Karkkainen [13], Chande et al. [14], Jones et al. [15&16], Ferreira and Ramachandra [17] have discussed efficiency improvement in the retail business. VeriSign [18] provides a more-than-description of the potential benefit areas and explores RFID application results at the item level, and presents an approach to planning and implementing item level tagging initiatives and explains how these projects can serve as a foundation for benefits and visibility that extend beyond the scope of one store. Prater et al. [19] examine the market drivers that lead to RFID

implementation in the grocery industry and provide a theoretical framework for future RFID implementation. Specifically, Prater et al. [18] developed a research framework that includes research using modeling techniques, RFID implementation and the impact of RFID on daily operational issues. Roussos [19] discusses the benefits of RFID vendor managed inventory and user profiling, concerns about consumer privacy protection are pointed out as possible obstacles of RFID adoption in the retail industry. Other successful retail applications include [20-26].

On warehouse operations, Vijayaraman and Osyk [27] report on RFID implementation and its benefits. Wang et al. [28] used model based (pull based) inventory replenishment analysis and cost turnover calculation with an application of warehousing. Apart from the traditional supply chain aspects, RFID is also applied in other fields. For example, Rangarajan et al. [29] suggested using the traceability of RFID tags to ensure food safety. Further, there is research considering the combination of RFID with other technologies. Kerr et al. [30] propose integrating voice with RFID. Lee et al. [31] discussed the application and impact of RFID in three different service sectors. Tzeng et al. [32] quantified the benefits of RFID from five healthcare centers in Taiwan. Ngai et al. [33] demonstrated the significance of RFID technology for a container depot and aircraft engineering company. They also studied a case to demonstrate the web and RFID technology in logistics operations to highlight the visualization effect.

Lee et al. [34&35] through simulation of a manufacturer-retailer environment, investigated how RFID can contribute to the performance of a supply chain with inventory reduction and service level improvement and hence to business value. Overby et al. [36] focused on a specific business process order-to-cash to uncover how RFID data can improve the process. Order capture, shipping, billing and payment receipt are the most obvious beneficiaries. The study also 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 other business processes. The literature on quantifying the benefits of RFID technology in a manufacturing-retail supply chain can be found in Leung et al. [37&38]. Others such as [39-43] discuss the challenges, security and privacy issues, problems and hidden costs of RFID adoption. To our knowledge, developing an RFID ecosystem consisting of the various business needs and levels focusing on a country as well as an industry are not well reported though there has been some mention by Bottani and Bertolini [44] and Bottani and Volpi [45], and albeit at the firm level. We aim to fill this research gap

with an implementation study involving a quantitative assessment of the cost-benefit analysis of RFID within a manufacturing environment.

### **3. Research scope and methodology**

This paper presents an RFID ecosystem of a global distribution hub for a high tech company based in Singapore, which is involved in the assembling and testing of equipment. For reasons of confidentiality, we refer to the company as XYZ. We first present the drivers applied to XYZ, to better understand the present RFID adoption in the supply chain across the geographical theatre of operations for XYZ. Then, we show how the delivery process is modelled as a detailed flow within the plant to enhance the process of distribution. Finally, we present the ROI calculator using the framework of the SCOR model. We limit the work in this paper to the study of the “Delivery” processes involved in the global distribution hub for finished goods. “Delivery” in the scope of SCOR encompasses activities such as the processing of order enquiries to the receipt of stocked items from the manufacturer and their outbound distribution.

### **4. RFID ecosystem for XYZ**

Figure 1 shows an RFID ecosystem comprising the various industry stakeholders. From the eco-system, three drivers are identified for RFID adoption, namely,

- a. Regulatory framework, standards and mandates: This is a key factor in the adoption of RFID technology in the supply chain. In Singapore, the Infocomm Development Authority (IDA) is the regulatory authority, while EPCglobal, ISO, SPRING are the agencies responsible for the standards and mandates for logistics and supply chain operations.
- b. Product solution driver: This driver consists of RFID vendors who hawk their technology and hardware to solve user problems. The eclectic mix of vendors is an asset in getting any RFID project into implementation. However, some potential users may be distracted by the cost of a 5-cent RFID tag rather than seeing RFID as part of a larger enterprise system solution.
- c. Service solution driver: This driver comprises system integrators who offer RFID technology as part of their solution to users. This total solutions approach helps to facilitate RFID adoption. When a total solution is offered, the RFID tag price becomes

less of an issue. In general, of the entire contract value for a solution, two-third goes to software and system integration cost while the remaining one-third is for hardware. Less than the cost of the servers, the remaining cost for RFID is only a small component of the entire system.

<Put Figure 1 about here>

## **5. Implementation framework for XYZ**

We apply the SCOR model on XYZ to organize the various business process activities and metrics, i.e. define the boundaries to demarcate the various modelling levels. The structure of the SCOR model is provided by five basic management processes (Plan, Source, Make, Deliver, and Return) as shown in Figure 2. As highlighted by Bottani and Volpi [45: pp.120], SCOR recognises any supply process to have four levels of resolution. Level 1 provides the overall definition of the plan, source, make, deliver and return processes. Level 2 defines the core process elements of the basic processes. Level 3 consists of the tasks, input measures, parameters and output metrics of the process elements. Level 4 represents the activities associated with task and focuses on its practical implementation.

<Put Figure 2 about here>

Set in the context of the global distribution ecosystem of XYZ, the delivery portion of the SCOR management process is the most relevant and likely to benefit most directly from the adoption of the RFID technology model. The focus will be on the delivery process for the finished goods and detailed models of the distribution management processes are developed using the IDEF0 methodology, which allows process decomposition in accordance with the prescribed SCOR process detail levels right down to Level 4, as shown in Figure 3. The development of this work using the SCOR framework will enable the portability of the resulting technology models.

<Place Figure 3 about here>

Figure 4 shows that for a particular Level 2 process, it can be decomposed into Level 3 processes at the process element level, as shown at the top of Figure 4. For instance, in the Plan process, the process “P1 Plan Supply Chain” is decomposed into four sub-processes -

P1.1, P1.2, P1.3, and P1.4. Each process can be further decomposed into the implementation level processes, as the lower part of Figure 4 indicates.

<Place Figure 4 about here>

The proposed framework is illustrated by a Graphical User Interface (GUI) to capture the process decomposition and data input. Figure 6 presents the process view of the model where each level 3 process can be associated with a dialog box so that the process can be edited using that dialog box. Figure 5 illustrates how a process can be modelled. The inputs, triggers, resources and outputs can be entered, reviewed and revised via the GUI. A major objective of modelling the activity is to identify points at which “production penalties” may be captured. A penalty may either be a cost of a time value consumed in carrying out the activity. The “As-Is” model is presented in the left panel and the “To-Be” model is presented in the right panel of Figure 5.

<Place Figure 5 about here>

## **6. ROI Calculator for RFID Implementation**

To calculate the ROI of the implemented RFID enabled SCOR model, we focus on the assembly and product testing lines, as well as the packaging and dispatch area for XYZ’s servers. For this paper, we exclude any specific mention of the particular server product for which the RFID tagging was introduced. The results have also been sanitised, as the actual numerical figures are confidential to XYZ.

### *6.1 “As-Is” Assembly-Despatch Scenario*

At the time of the study, XYZ had already piloted the RFID implementation and the information that describes the previous barcode process was gleaned from the discussions with company personnel rather than through a survey as was the case with Bottani and Volpi [45]. The general overview of what was likely to be the supply chain process of XYZ that was supported by barcode technology, is shown in Figure 6. The various stages associated with production are described as follows.

<Place Figure 6 about here>

### *6.1.1 Assembly, test and packaging*

In the “As-Is” scenario for the assembly, the test and packaging line was supported by barcode technology. Servers that were assembled to order undergo several stages of testing. The servers were packaged and barcode labels applied. The servers were sent to a dispatch area where they were consolidated into a shipment comprising a pallet of a number of servers. Figure 7 shows the various stages of the packaging process supported by barcode technology.

<Place Figure 7 about here>

The stages shown in Figure 7 provide sufficient detail to show the breakdown of the time and cost elements involved, e.g. having to pick up a barcode scanner, performing the actual scan, and replacement of the scanner handset. These are activities that will be replaced by the RFID implementation (see Figure 8).

<Place Figure 8 about here>

### *6.1.2 Handover to 3PL*

The shipment is consolidated following the packaging of the product and the pallet is physically handed over to the designated 3PL, who is located close by the packaging area, prior to moving the pallets to the loading and transport bay. At the handover, the barcodes are scanned. The pallets, along with the necessary, dispatch paperwork are given to the 3PL. The process of scanning the individual barcodes is a time consuming activity. Collectively, the amount of time used can be an hour each work day of 12 hours, involving at least one person. From the perspective of XYZ, one person was required to handover the consignment of pallets to the 3PL handlers. From the perspective of the 3PL, two handlers were required to accomplish the scanning and take over of the consignment.

### *6.1.3 Loading and Dispatch*

The loading and dispatch activity involves some consolidation of the orders and the shrink-wrapping of the pallets. This activity is carried out solely by the handlers from the 3PL. The pallets are loaded into the trucks and then dispatched.

## *6.2 “To-Be” Assembly-Despatch Scenario*

In the “To-Be” scenario for the assembly, test and packaging line, which involves RFID technology and its implementation. The pilot test was carried out on a single production line.

### *6.2.1 Assembly, test and packaging*

Servers that were assembled to order undergo several stages of testing. The servers were packaged and RFID tags are printed and applied. Similar to the previous situation, the servers were sent to a dispatch area where they were consolidated into a shipment comprising a pallet of a number of servers. These are loaded onto trolleys and taken by the 3PL to the loading bay. This process, as shown in Figure 8, demonstrates the simplification that is achieved by the adoption of RFID technology, where the parts are scanned without the need for a hand-held barcode scanner. This considerably reduces the manual handling activities and consequently accelerates the packaging rate. Further, the person who handles the packaging is alerted when a wrong component is included in the package, which the barcode technology is not smart enough to capture. Should a missed package occur, there is also a traceability to the source of the problem.

### *6.2.2 Handover to 3PL*

The shipment is consolidated following the packaging and each pallet (on trolleys) is physically handed over to the designated 3PL. In all, four RFID transponders were installed (two on each side) and these read the RFID tags as the pallets were pushed between them. From XYZ’s perspective, this was accomplished by the single handler and there was no reduction in headcount. From the 3PL’s perspective, there was a saving of one handler and this cost was passed to XYZ in terms of the cost per pallet handled.

### *6.2.3 Loading and Dispatch*

The loading and dispatch activity involves some consolidation of the orders and the shrink-wrapping of the pallets. This activity is carried out solely by the handlers from the 3PL. The pallets are loaded into the trucks and despatched. For the benefit of the 3PL, a further RFID transponder was installed in the loading bay as the 3PL had a separate operation to scan the RFID tags prior to shrink wrapping and loading onto the trucks.

### 6.3 Process Analysis

#### 6.3.1 Cost components and process modelling

The relevant cost information as communicated by the finance department of XYZ is given in Table 1, including the individual items as well as their quantities. This is divided into two categories, namely Material and Maintenance.

<Place Table 1 about here>

The cost of the RFID tags, given the quantity for a single assembly line is relatively high. No doubt, this contributes to the overall negative ROI. The second category relates to the maintenance cost for the software applications. This is also a high cost component and this was borne by a single assembly line. In view of the RFID installation, the 3PL was willing to offer a price reduction as the new system required only one handler as opposed to two. Table 2 indicates the cost savings to XYZ as a result of the RFID implementation. The RFID process modeller was used to capture the various activities involved in the RFID enabled process. The values were modelled in the “To-Be” model as a negative figure to indicate the cost saving. The “As-Is” and “To-Be” scenarios were modelled and the corresponding costs were captured as penalties (shown in Figure 9). In the case of the cost savings that were passed to XYZ from the 3PL. The cost savings are given in terms of the cost per pallet, i.e. where the 3PL was able to reduce the manual handler. However, from the perspective of XYZ, this was not accounted for in terms of the reduced personnel, but a reduction in the cost of handling per pallet.

<Place Table 2 and Figure 9 about here>

#### 6.3.2 Output from RFID Process Modeller

Figure **Error! Reference source not found.**10 illustrates the output from the RFID Process Modeller for XYZ. In the As-Is scenario, all costs are assumed to be 0. The cost savings in the To-Be scenario are reflected as negative numbers. Figure 10 shows that the process “D1.10.1 Add RFID Tag” incurs a total cost of \$24,366.30, which is the total cost of the RFID tags and XYZ’s printer toners. Apart from this cost, there are cost savings of \$9,300 for “D1.11.1 Handover Shipment to 3PL”, and \$300 for “D1.11.2 Take over shipment from XYZ”. These numbers yield a cost of \$14,766.30 to XYZ.

<Put Figure 10 about here>

### *6.3.3 Considerations on time savings*

In Figure 10, the time components are zero for two reasons. First, in XYZ, only the packaging operation, which is the last step of the whole production line, is modelled. Second, across the production line, the time savings from RFID is quite small and does not lead to any financial savings from the reduction in headcount for XYZ. Also in XYZ's internal study on ROI, the time saved is not considered. As such, we exclude the time savings so as to make a fair comparison. The output shows that applying the RFID technology is a good opportunity for improving productivity. A quick check of the number of processes reveals that the number of processes has been reduced significantly in the RFID enabled packaging process. The simulation runs for the case study show that the total production time can be reduced by 21.6% using RFID technology compared to the barcode enabled process.

## *6.4 ROI calculator*

### *6.4.1 Current ROI*

The outputs from the RFID Process Modeller were read by the ROI engine and the results are shown in Table 3. The total annual cost increase of \$14,766.30 is the result of moving from the As-Is scenario to the To-Be scenario. This amount is attributed to the \$24,000 on the RFID tags, \$366.30 on RFID printer toners less \$300 on the 3PL taking over and the \$9,300 on shrink wrapping cost savings. Based on the annual maintenance cost of \$12,772 for the respective software and hardware, the ROI is thus negative.

<Place Table 3 about here>

### *6.4.2 Achieving Positive ROI*

While the ROI in the case study is negative, XYZ was keen to pursue the RFID adoption as the RFID enabled packaging process (Figure 8) is much simplified compared to the bar code supported packaging process (Figure 7). Further, XYZ realised that there were other benefits to be had from the RFID implementation, other than the assembly and dispatch functions at the shop floor. Also, with more production lines being RFID enabled, for the purpose of demonstrating the use of the ROI calculator, the figures given will be used to demonstrate how a positive ROI may be achieved, with more production lines using RFID (see Table 4). In the case of 4 production lines being RFID enabled, the annual cost to XYZ is only

\$3,233.70, which was acceptable to XYZ for three reasons. First, the numbers suggest the need for scalability when relying on RFID implementation. Second, it provides management with a stronger case to push for a wider adoption of RFID within the global distribution hub. Third, with more lines using RFID, the RFID tags would realise a cost reduction too.

<Place Table 4 about here>

## **7. Conclusion**

This paper describes the use of the SCOR framework as the RFID Process Modeller for the implementation of RFID on the assembling and testing line of a large multinational company in the high tech sector, which is using Singapore as a global distribution hub. The proposed framework provides an understanding of the RFID implementation given the existing regulatory standards and mandates. We used the SCOR based approach to assess the various operational processes (including task, activities and metrics) in a supply chain through the RFID Process Modeller and the ROI analysis were tested through an implementation with a case company XYZ. It is recognized that the cost of the RFID tags may not decrease to the same level as that of a barcode. Nevertheless, this study provides an indication of how the RFID Process Modeller and ROI calculator engine may be used to simplify the tasks and activities, and to analyze the impact of the various cost parameters on the feasibility of a project contemplating large scale RFID adoption at a distribution hub where economies of scale in distribution are possible. Moreover, we show through the case of XYZ, that to gain maximum benefit from the RFID adoption, it is necessary to focus beyond the factory and realise that RFID can provide with the needed timely and accurate information to enable real-time visibility across the supply chain, leading to improved lot tracking, streamlined shipping and receiving, and process automation. In short, RFID technology not only provides quick information access across the whole supply chain, but also is beneficial at the operational level and can benefit other actors in the supply chain (in the case of XYZ, it is the 3PL). Future work can directed at quantifying the cost of RFID implementation for other industries.

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Table 1: Breakdown of operational cost for RFID enabled line

Item	Description of Artifact	Unit Price	Quantity	Cost (USD)
1	Material			
	RFID case tags	0.2	120000	24000
	Printer toner	183.15	2	366.3
2	Maintenance			
	OAT Software	30000	20%	6000
	Hardware	12120	30%	3636
	GDIS			3136

Table 2: Cost savings of RFID implementation

Benefits	unit price	quantity	cost (\$)
SWC handling cost (\$/pallet)	0.31	30,000	9,300
Production (handover)	0.01	30,000	300
Total Benefits (B)			9,600

Table 3: ROI results for XYZ

<b>Input</b>					
Salary (\$/hour)		0			
Interest Rate		15%			
Fixed Costs (\$)		0			
Maintenance Cost (\$/year)		12772			
	<b>Cost</b>	<b>Time</b>			
AS-IS	0	0			
TO-BE	14766.3	0			
<b>Total Cost Yearly</b>	-14766.3	0			
	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
Fixed Costs	0				
Maintenance Costs	12772	12772	12772	12772	12772
<b>Total Costs</b>	12772	12772	12772	12772	12772
	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
Total Cost Savings	-14766.3	-14766.3	-14766.3	-14766.3	-14766.3
Total Time Savings in \$	0	0	0	0	0
<b>Total Savings</b>	-14766.3	-14766.3	-14766.3	-14766.3	-14766.3

Delta	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
<b>Net Inflow</b>	-27538.3	-27538.3	-27538.3	-27538.3	-27538.3
<b>Output</b>					
<b>NPV</b>	<b>(\$92,313)</b>				
NPV (Costs)	\$42,814		(Cash Outflow)		
NPV (Benefits)	<b>(\$49,499)</b>		(Cash Inflow)		
Ratio Benefits to Costs	-116%				

Table 4: Positive ROI by a reduction in RFID tags and amortization over 4 assembly lines

<b>Input</b>						
Salary (\$/hour)		0				
Interest Rate		15%				
Fixed Costs (\$)		0				
Maintenance Cost (\$/year)		3193				
		<b>Cost</b>	<b>Time</b>			
AS-IS		0	0			
TO-BE		-3233.7	0			
<b>Total Cost Yearly</b>		3233.7	0			
		<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
Fixed Costs		0				
Maintenance Costs		3193	3193	3193	3193	3193
<b>Total Costs</b>		3193	3193	3193	3193	3193
		<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
Total Cost Savings		3233.7	3233.7	3233.7	3233.7	3233.7
Total Time Savings in \$		0	0	0	0	0
<b>Total Savings</b>		3233.7	3233.7	3233.7	3233.7	3233.7
Delta		<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>
<b>Net Inflow</b>		40.7	40.7	40.7	40.7	40.7
<b>Output</b>						
<b>NPV</b>		<b>\$136</b>				
NPV (Costs)		\$10,703		(Cash Outflow)		
NPV (Benefits)		\$10,840		(Cash Inflow)		
Ratio Benefits to Costs		101%				

Figure 1: RFID Eco-System

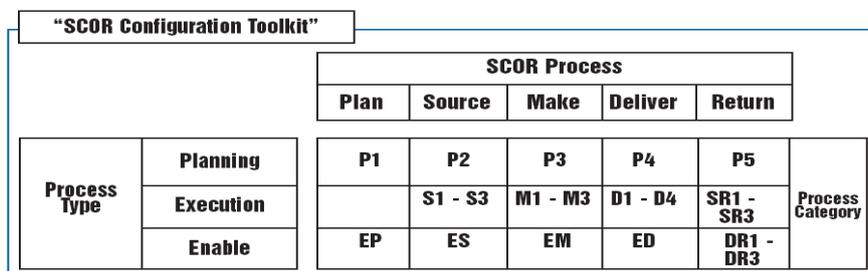
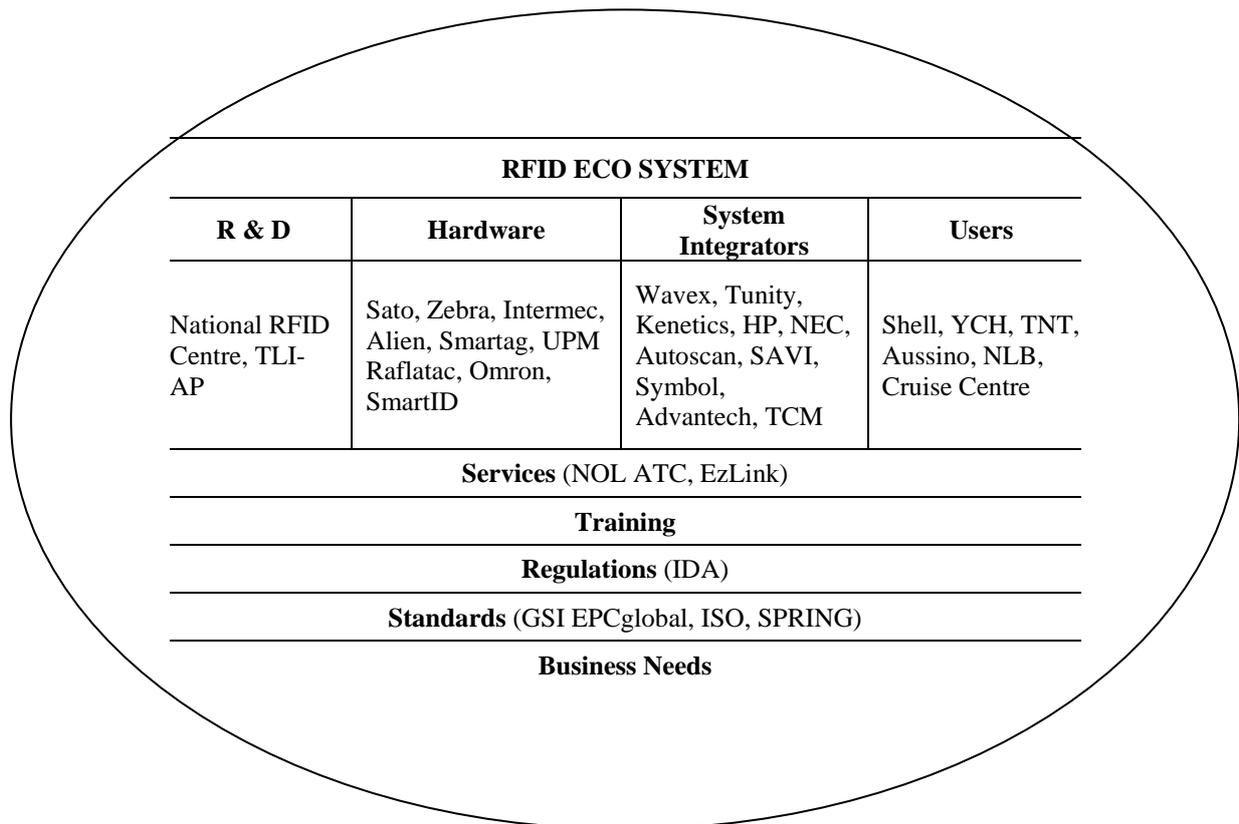


Figure 2: SCOR processes

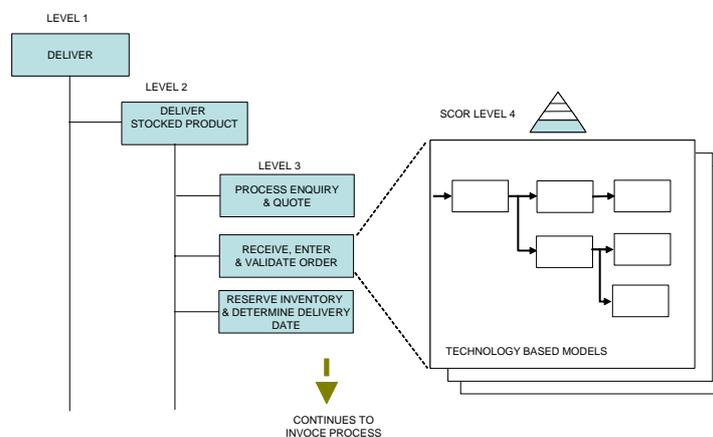


Figure 3: Development of technology based models at Level 4 of Deliver process

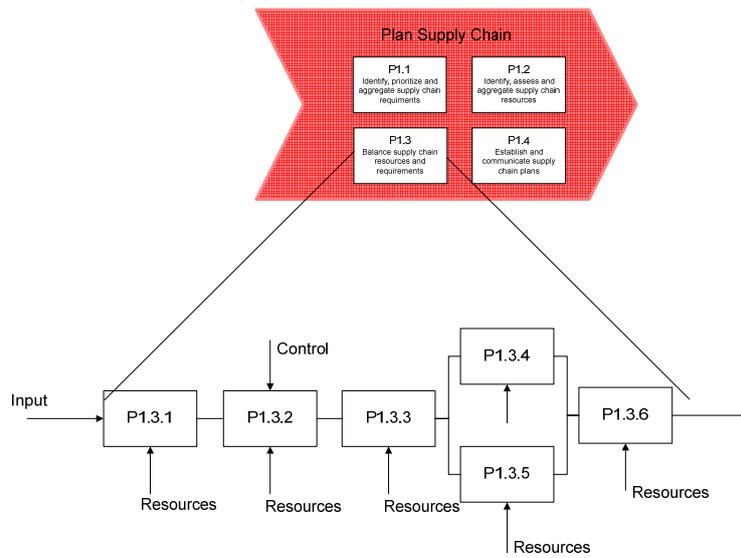


Figure 4: Decomposition of process

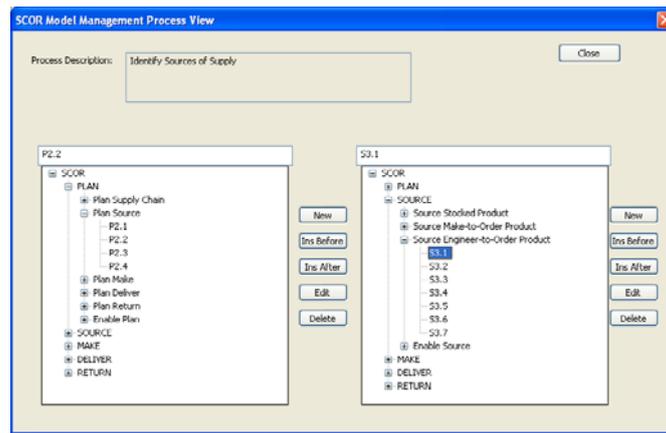


Figure 5: Hierarchical process view showing “As Is” & “To-Be” models

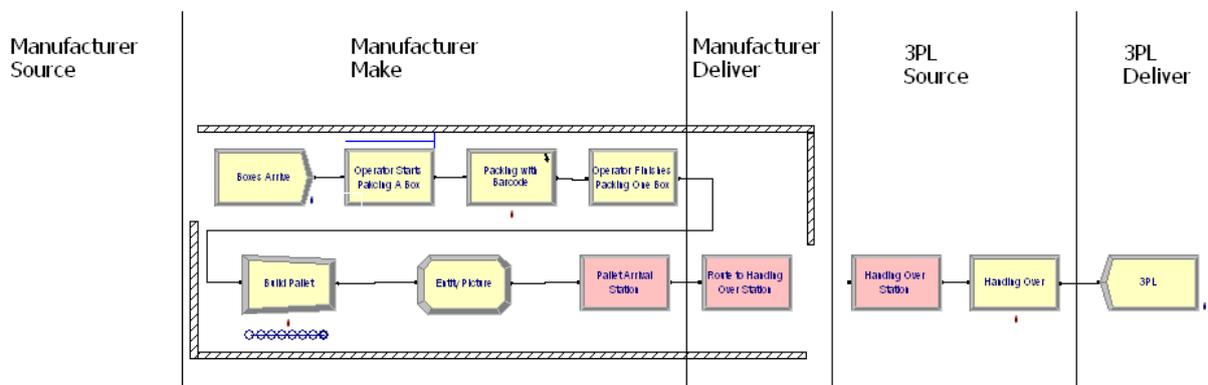


Figure 6: Assembly, packaging and dispatch line

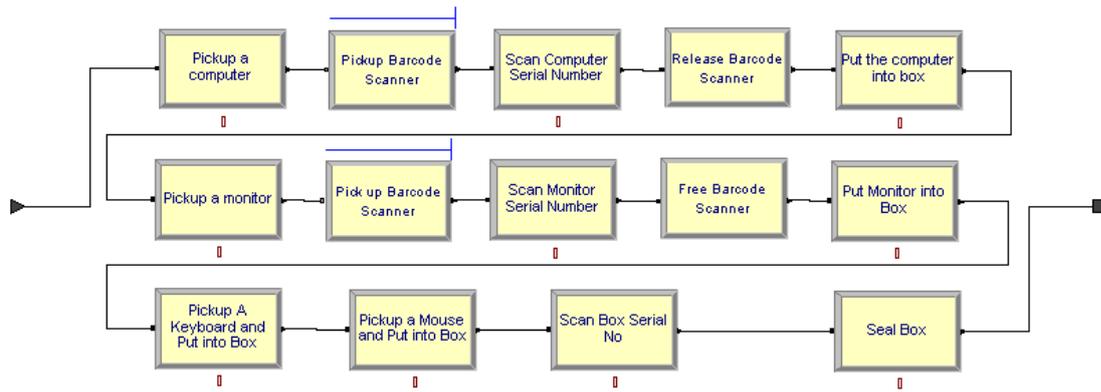


Figure 7: Packaging process supported by barcode technology



Figure 8: RFID enabled packaging process

Figure 9: Modelling cost of RFID Tags

To-Be Output from SCOR Modeller	Cost	Time
DELIVER	0.00	0.0
Deliver Stocked Product	0.00	0.0
D1.10	0.00	0.0
D1.10.1 Add RFID Tag	24366.30	0.0
D1.11	0.00	0.0
D1.11.1 Handover shipment to 3PL	-9300.00	0.0
D1.11.2 Take over shipment from XYZ	-300.00	0.0
As-Is Output from SCOR Modeller	Cost	Time
DELIVER	0.00	0.0
Deliver Stocked Product	0.00	0.0
D1.10	0.00	0.0
D1.10.1 Production (Handover)	0.00	0.0
D1.11	0.00	0.0
D1.11.1 Handover shipment to 3PL	0.00	0.0
D1.11.2 Take over shipment from HP	0.00	0.0

Figure 10: Output from RFID Process Modeller

## **Authors Biography:**

### **Dr Robert de Souza**



Dr Robert de Souza is the Executive Director of The Logistics Institute – Asia Pacific. Prior to joining TLI – Asia Pacific, Dr de Souza was Executive Vice President for V3 Systems in the Asia Pacific. His extensive tenure in the industry also includes serving as the Corporate Senior Vice President and Global Chief Knowledge Officer at Viewlocity Inc. In November 1998, Dr. de Souza co-founded SC21 Pte, Ltd., a Singapore-based supply chain software firm and served as its Vice Chairman and CEO up to its acquisition by Viewlocity Inc. As an educator and researcher, Dr de Souza is an Adjunct Professor at the School of Industrial and Systems Engineering at Georgia Institute of Technology in the USA and a Senior Fellow at the Department of Industrial and Systems Engineering at the National University of Singapore.

### **Dr. Mark Goh**



Dr. Mark Goh is a faculty of the Business School, National University of Singapore and he holds the appointments of Director (Industry Research) at TLI - Asia Pacific, a joint venture with Georgia Tech, USA; and a Principal Researcher at the Centre for Transportation Research. He was a Program Director of the Penn-State NUS Logistics Management Program. He was also Director of Supply Chain Solutions for Asia/Middle East with APL Logistics, responsible for crafting logistics engineering solutions for major MNCs in this part of the world He has been involved in executive training and a consultant for organizations both in Singapore and overseas, such as PSA Corp, Siemens Nixdorf, CAAS, Fuji-Xerox AP, Hewlett-Packard Far East, DHL, and Cleanaway (China). He is currently on the editorial boards of the Journal of Supply Chain Management, Q3 Quarterly, Journal for Inventory Research, International Journal of Supply Chain Management and Advances in Management Research.

### **Dr. Balan Sundarakani**



Dr. Balan Sundarakani is an Assistant Professor in the Faculty of Business and Management at the University of Wollongong in Dubai. He has 8 years of teaching and research experience in the area of across the various universities including the National Institute of Technology Tiruchirappalli, IIT Roorkee, Hindustan University Chennai and the National University of Singapore, Singapore. As a Program Manager and Senior Fellow with The Logistics Institute – Asia Pacific, Dr.Sundarakani has completed research and consulting projects for the Economic Development Board, Singapore, IBM, DHL and the Ministry of Defence, Singapore. The total worth of his research and consulting projects are around S\$2 Million. Dr. Sundarakani has published 40 research papers in refereed International Journals, National Journals and Conference Proceedings. His research outcomes have appeared in international Journals such as *International Journal of Production Economics*, *Omega*, *International Journal of Technology Management* etc., and which are frequently cited worldwide.

### **Mr. Wong Tack Wai**



Mr.Wong Tack Wai is the Director of GS1 Corporation, Singapore. Tack Wai joined GS1 Singapore in July 2009. He is working towards bringing more value to GS1 Singapore registered users through various activities such as export development programs. He continues his work to develop and roll out GS1 standards on barcodes (1D, Databar & 2D), GSDN data pool, MobileCom, and e-commerce to enable efficient trade. From January 2006 to July 2007, Tack Wai was with The Logistics Institute – Asia Pacific in National University of Singapore (NUS). Here, he worked on RFID E-Seal testing based on ISO 18185 with the sea port and co-authored articles on RFID activities around the world for a the book *RFID Applied* published by John Wiley & Sons in 2007. From August 2007 to June 2009, Tack Wai was with the National RFID Centre where he was responsible for promoting the adoption of RFID in the industry.

### **Dr.Keith Toh**



Dr.Keith Toh is a research fellow in the areas of bushfire, community resilience and communication. Previously, Keith worked as an analyst with the Institute for Logistics and Supply Chain Management in the area of port clusters. Prior to immigrating to Australia, his professional experience was in software design and development with major project lifecycle experience whilst working at Fujitsu Services (UK). Major projects have included the UK Department of Constitutional Affairs, the Automobile Association and the UK Post Office. With a background in manufacturing engineering with a trade certificate in metal machining, he is very versatile with a very broad understanding of both the IT and manufacturing industries. He retains a keen interest in systems modelling architectures and methodologies such as UML, Zachman Framework, TOGAF, SSADM, Rational Unified Process and RM-OD.

### **Dr.Wu Yong**



Dr Yong Wu is currently a Lecturer at the Department of International Business and Asian Studies, Griffith University, Australia. He holds a PhD in Operations Research and an MEng in Mechanical Engineering and have worked for The Logistics Institute - Asia Pacific, a joint venture between National University of Singapore and Georgia Institute of Technology (2005-2008), and the Institute for Logistics and Supply Chain Management, Victoria University, Australia (2008-2010). He teaches in the area of logistics and supply chain management and his research interests are in logistics and supply chain management, operations research and engineering optimization.