A discrete simulation model for incorporating RFID technology into the Brazilian postal service

Jair Jairo Joris

SENAI CIMATEC,
Avenida Orlando Gomes,
1845 Piatã, Salvador, Bahia 41650-010, Brazil
Email: jairjairojoris@gmail.com

X. Lucas Travassos

Universidade Federal de Santa Catarina,
Rua Presidente Prudente de Moraes – até 1326 – lado par,
Santo Antônio, 89218000 – Joinville, SC, Brazil
Email: lucas.travassos@ufsc.br

Paulo S. Figueiredo*

SENAI CIMATEC,
Avenida Orlando Gomes,
1845 Piatã, Salvador, Bahia 41650-010, Brazil
Email: paulo_s_figueiredo@hotmail.com
*Corresponding author

Abstract: The market of logistic operators in the segment of parcel delivery in Brazil has grown considerably in the last few years. This growth is caused mainly by e-commerce transactions. Companies that excel in this business offer services that enable traceability of objects and near real-time availability of information to customers. This research aims to study the current process for receiving and handling mail pouches at the Brazilian Postal Service (ECT), with the objective of verifying the technical viability using RFID – *Radio Frequency Identification* technology. Discrete simulation analysis is used for this purpose. It was found that ECT currently does not offer full traceability of its products. The applicability of RFID technology is determined. Based on the results of the simulations, advantages of the use of RFID tags are discussed.

Keywords: simulations; RFID; tracing of postal objects; tracking; technology management; discrete-events simulation; postal service; post office; services operations.

Reference to this paper should be made as follows: Joris, J.J., Travassos, X.L. and Figueiredo, P.S. (2013) 'A discrete simulation model for incorporating RFID technology into the Brazilian postal service', *Int. J. Services Operations and Informatics*, Vol. 8, No. 1, pp.59–77.

Biographical notes: Jair Jairo Joris is currently working at the Brazilian Postal Office. He holds an MSc degree from SENAI CIMATEC.

X. Lucas Travassos is currently working at Universidade Federal de Santa Catarina (UFSC). He holds a PhD degree from École Centrale de Lyon – France.

Paulo S. Figueiredo is currently working at SENAI CIMATEC. He holds a DBA degree from Boston University.

1 Introduction

According to Whang (2010), Radio Frequency Identification (RFID) has been hailed as a major innovation to enhance the efficiency of inventory management (Gaukler et al. 2004) and logistics (Heinrich, 2005). The basic premise of RFID is that a radio frequency reader can read as many as 200 tags per second without the line-of-sight requirement. Near-real-time tracking and tracing capabilities, together with item-level identification through EPC (Electronic Product Code) standard, would allow a host of new chances for improvements (Whang, 2010). Among these improvements lies increased efficiency by making products available at the right time and in the right place, with a lower operational cost. As a result, numerous companies are adopting RFID technology for product tracking/tracing purposes, especially within sectors that move multiple parts through their facilities each day (Chow et al., 2006; Kach and Borzabad, 2011). RFID systems are rapidly replacing Universal Product Codes (barcodes) (Stambaugh and Carpenter, 2009).

It is possible to notice a global evolution in the Postal Logistics System, evidenced by the use of RFID. Zhang et al. (2006) identify many international postal services making use of RFID tags in postal objects and in pallets. This technology requires large investments, but has a series of advantages, including near real-time information about the place and condition of postal objects and their pallets.

According to technology research firm IDTechEx (IT Professional Magazine, 2005), postal and courier mail services are expected to become the second largest market for RFID item level tagging following the retail sector. Zhang et al. (2006) predict that the market of RFID tags for postal services will reach 3 billion dollars until 2016. Around 25% of the demand will be in the USA, 25% in Europe, and 50% in Eastern Asia. This demand will be even larger if tags become more accepted for use in individual objects. It is estimated that in due time (by 2020), more than a trillion postal objects will be using RFID tags.

In Brazil, barcodes are still used as the indexer for postal objects. Currently, different companies offer different kinds of information to customers. The basic service is to offer information about the flow of merchandise on the internet. The differences in performance among these companies are related to the set of information available to the customers and the time in which the information is released.

Considering the different modalities of services offered by ECT for the parcel segment (such as the SEDEX family, PAC and mail pouches), we have focused the study on the mail pouches service, since this service is very similar to the aforementioned ones. This research was authorised by the parcels processing centre (CTE/SDR) of the *Empresa Brasileira de Correios e Telégrafos* (ECT, 2007a; ECT, 2007b; ECT, 2007b; ECT, 1999; ECT, 2010) in Salvador-Bahia-Brazil.

ECT adopts the Objects Tracing System (SRO) as a tool to operationalise the process of receiving and distributing objects. The SRO indexes objects with barcodes, using barcode readers and data centres. This system also makes information available to the customer, through the data centres, via intranet (for internal customers) or internet (for external customers).

This study focuses on the process of posting of mail pouches at the Parcel Centre in Salvador-BA (CTE/SDR). It made it possible to identify the steps in which the tracing system failed, resulting in missed deadlines, misplacement of objects and compensations to customers.

Illustration of the magnitudes of the local, regional and national flows of mail pouches is presented in Table 1. It represents a sample of average mail pouch postings at the postal service.

Table 1 Sample of the circulation of mail pouches.

Unit	*Mail pouches per day*	*Mail pouches per month*	*Mail pouches per year*
CTE City of Salvador	1699	37,380	448,562
State of Bahia	3385	74,470	893,640
ECT – Brazil	27,4405	6,036,928	74,443,136

Source: DW system of the Brazilian Postal Service, 2012

The specific objectives of this study are as follow:

- Diagnose the routines and the tracing performance of the mail pouch service of the Brazilian postal service, observing the phases of posting, handling, transporting and physical distribution of the objects;
- Verify the necessary or existing conditions for the use of RFID technology at the SRO.
- Study the RFID technology to estimate the operational and financial impacts of its use;
- Propose a model and procedures for the use of RFID technology in the tracing system of the Brazilian postal service.

This research aims to enable online tracing to all points of the mail pouch service. The use of the new technology will enable real-time verifications at all the stages of the process, from posting to handling to transporting. The study also aims to suggest a methodology to estimate the benefits of the RFID technology.

2 Literature review

The literature on financial analysis of RFID systems is very scarce. Some exceptions are from the work of Miragliotta et al. (2009), which focuses on activity-based cost and benefits for both the manufacturer and retailer in the fast moving consumer goods industry; Kinley (2004) reviews the RFID Return on Investment (ROI) for a specific application in a semiconductor environment. Balocco et al. (2011) developed an analytical profitability assessment model to evaluate the barriers preventing RFID

technology diffusion in the fast-moving consumer goods industry. Jones et al. (2007) demonstrated the cost effectiveness of using an RFID system to track calibrated tools throughout a production facility. Other studies in different environments are therefore needed.

The general impact of information technology on third party logistics (3PL), however, has been explored more. Evangelista and Sweeney (2006) focused on how information and communications technology (ICT) such as RFID has become an important element of 3PL competitive capability as it enables higher levels of supply chain integration. The results of the study provide a useful technological profile of the surveyed companies, as well as an analysis of the role of ICT in customising services and the factors influencing ICT adoption. The survey results indicate that the use of relatively advanced ICT is more prevalent in advanced providers. This is particularly the case in relation to the level of IS integration and the exchange of information with other supply chain participants. Despite the fact that current levels of expenditure on ICT in relation to overall company-based cost do not vary significantly across provider categories, there are significant differences with regard to future investment plans. This is particularly true in the area of integration with both customers and other 3PLs. This indicates that more advanced providers are adopting a long-term strategic view, making it more probable that less developed providers will be pushed further out of future competition.

Evangelista et al. (2012) went deeper into the analysis of the impact of use of information technology on the performance of 3PL. The results of the study indicate strong relationships among data-gathering technologies (including RFID), transactional capabilities and firm performance, in terms of both efficiency and effectiveness. Moreover, a positive correlation between enterprise information technologies and 3PL financial performance was found.

Other studies focused on design implications for RFID systems. Fosso Wamba et al. (2008) concluded that (1) the RFID–EPC network can improve the ‘‘shipping’, ‘receiving’, and ‘put-away’ processes, (2) these technologies can cancel, automate, or automatically trigger some business processes, (3) they foster a higher level of information sharing/ ynchronisation between supply chain members and (4) they require being integrated into a wider strategy.

Mogre et al. (2009) studied the introduction of RFID systems in healthcare services. The authors argue that RFID technology allows the healthcare service providers to re-engineer their processes in order to reduce costs, maintaining the same level of service to the patients. They identify the various operations in a hospital setting that have a potential to be streamlined by introducing RFID technology and propose an RFID-based service platform for hospitals, which is consistent with a service science-driven design approach.

Wagner and Sutter (2012) investigated contingency factors that are important in joint third-party logistics (3PL) provider–customer innovation project, and the project outcomes for 3PL providers and 3PL provider–customer relationships. This paper is based on multiple case studies. Case #2 addressed the introduction of RFID technology at DHL Exel Supply Chain, a division of DHL Logistics Switzerland, belonging to Deutsche Post DHL. The authors pointed out a series of benefits for both the provider and its clients: cost savings in internal processes, a positive marketing effect, lower investments by the customer, and strengthening of leadership position by the client, among others.

3 Methodology

In the field of simulation, a discrete-event simulation models the operation of a system as a discrete sequence of events in time. Each event occurs at a particular instant in time and marks a change of state in the system (Robinson, 2004). Between consecutive events, no change in the system is assumed to occur; therefore, the simulation can directly jump in time from one event to the next. Simulation approaches are particularly well equipped to help users diagnose issues in complex environments, such as the logistics of postal services. By accurately documenting the system inside a simulation model, it is possible to gain a broad view of the entire system. A working model of a system allows the understanding of performance drivers. A simulation can be built to include any number of performance indicators such as worker/machine utilisation, on-time delivery rate, scrap rate, and so on.

Discrete-event simulation is particularly useful for modelling the logistics of the postal service, since each single processing activity of a postal object can be considered an event. There are no reinforcing or balancing loops in the structure of the model, making the use of a more complex and continuous simulation technique such as system dynamics (Sterman, 2000) unnecessary.

This study is based on field and documentary research, and involves action research, since the researchers actively participated in an organisational change situation whilst conducting the study. The research strategy consists of using two mathematical models calibrated to a single company. Simulations were run to estimate the gains with the new RFID system. Interviews were carried out with operators from the collecting and posting phases and observations were made of all the essential activities related to the mail pouching process.

The work presents developing an analysis between the current tracing system at ECT and a model that includes RFID technology. This model is based on the Park and Park's (2006) study and discrete-event simulation (Banks et al., 1996). In a public company such as ECT, projects of this kind are implemented over the long term. In this context, a proposal of migration from the current tracing model (SRO) to a model with the new RFID technology will also be analysed.

By studying the routines of the SRO operation, it was possible to determine that there are moments where objects are not being properly traced, such as during the collection of pouches, posting process, transportation between operational units, at the airport terminals and at the highway stations.

The Electronic and Telecommunications Research Institute (ETRI) presented a model for the use of RFID technology in managerial postal systems (Park and Park 2006). The model details how RFID technology is used for parcel processing such as registration, collection, sorting, distributing, sending, arriving, delivery, and real-time tracing and tracking of pallet management in postal logistics environments. Park and Park present four stages of operationalisation: (a) mailing office, (b) mail collection and distribution centre (c) delivery office and (d) monitoring centre. According to the authors, the architecture of the model can be used for tracing of objects in real time, as well as the management of pallets. The paper also deals with the adaptations necessary for the use of RFID technology in postal logistics environments. It considers factors such as tag recognition rate of parcels by tag mounting material, tag orientation and moving speed. The recognition rate of pallets and boxes by antenna type and tag position was also carried out.

The model developed by Park and Park (2006) uses RFID in all the postal agent's processes. Due to the high financial and administrative impact of the implementation of such a model, in this study we choose to focus on the mail pouch sector alone. In order to estimate the impacts of this technology, simulation techniques were used to represent the current and the future condition (with RFID). The software ProModel was used and two models were created to represent the two conditions.

Due to the nature and magnitude of the mail pouch service at ECT, the tracing events under study represent a significant sample, which can validate the study and enable projections for the other services that need traceability.

4 The models

The stage of model formulation will take into account the model of tracing already used by the ECT. This model generates tracing events by reading barcodes that are attached to the postal objects. These events are later transferred to a data centre, which makes the information available to all customers and employees via internet and intranet.

Another step of the process is data collection, carried out by observation, research and interviews with operators of the system. These data will be used to describe the current process and to calibrate the 'current model'.

The 'RFID model' presents a series of advantages that RFID technology can offer:

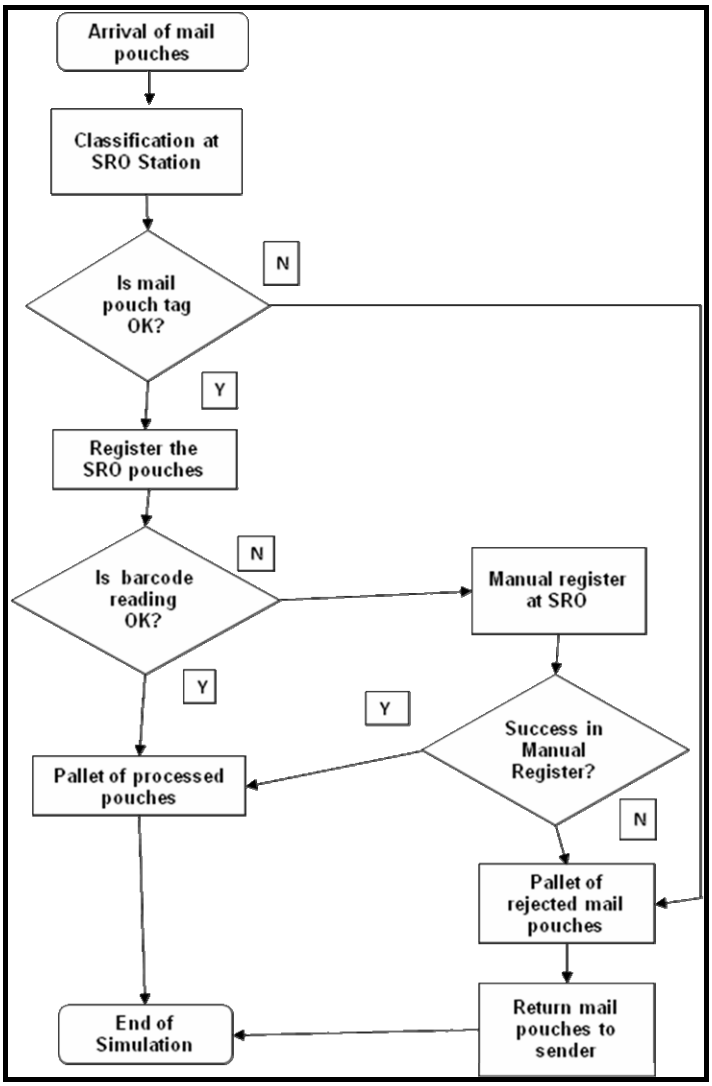
- A registered client can generate and attach an RFID tag to postal objects and request the collection of such items. However, he or she can transmit the tag information to the logistics operator data centre beforehand;
- The logistics operator, based on the information available, can initiate the procedures of collecting, classification, pallet programming, routing, and physical distribution. At the end of these procedures, information is again transmitted to the local data centre.
- Real-time monitoring of all the events of parcel processing and pallet management;
- Also allows the management of empty pallets, so that the deadlines for delivery and return are met and there is no lack of these materials.

Therefore, there are many possibilities for tracing objects and pallets with RFID technology, with the advantage of real-time information about the events. Operational benefits are also attained, such as in quality and in lead-time, allowing all users to check the flow of their objects on the postal logistics system.

4.1 The model

Based on the information collected during the first part of the research, two models were built to represent the current and future configurations (with and without the use of RFID technology) of the mail pouch service at ECT. The current configuration is presented in Figure 1.

Figure 1 Process flow of the current mail pouch posting service at the SRO

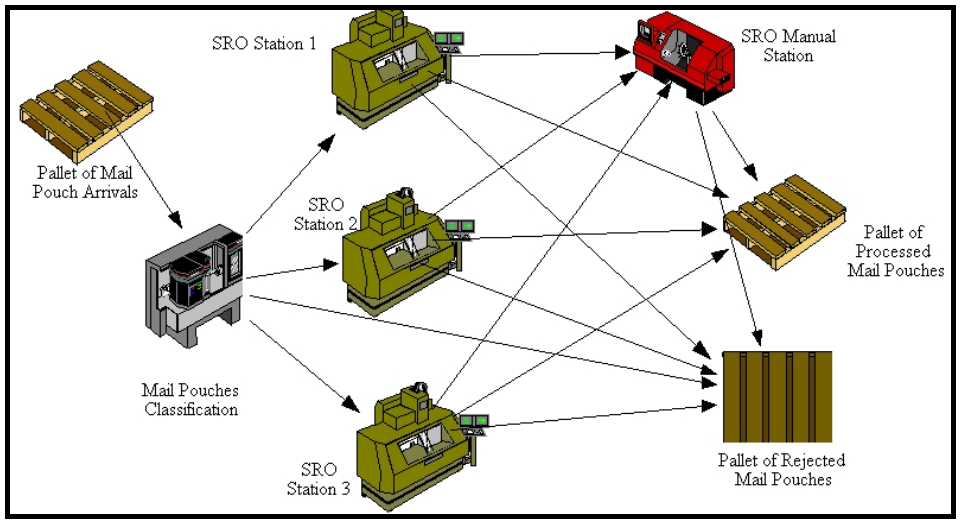


According to the process flow represented in Figure 1, the process of posting of mail pouches at the CTE/SDR happens daily from Mondays to Saturdays. However, the processing activities happen only during weekdays. All activities are important, but the following ones are decisive for the performance of the system:

- Necessity of a tag/card identifying the addressee;
- Need to have a readable barcode in the mail pouch tag;
- Need to release the product for posting, taking into account the billing and contractual situation;
- For the barcode tags that cannot be read, it is necessary to input the data manually.

Based on the process flow of the mail pouch service, a mathematical model is created to represent the current posting of mail pouches at CTE/SDR, as shown in Figure 2.

Figure 2 Simulation model of the current process of mail pouch posting at CTE/SDR (see online version for colours)



Source: ProModel software

This simulation model is structured as follows: the mail pouches arrive at CTE/SDR (on a pallet containing the pouches) and then these objects are taken to the three stations at the SRO. Some of these objects fail the process and are sent to the pallet of rejected mail pouches. From the SRO stations, the objects follow the flow to the pallet of processed mail pouches (end of process) or go to the manual processing station (then being taken to the pallet of processed mail pouches or being rejected in case they cannot be read/registered). At the SRO stations, some of the objects also follow the flow to the pallet of rejected mail pouches.

Figure 3 shows the process flow for the future operation of the mail pouch service. This process flow includes the use of RFID technology.

The simulation model of the new system is structured as follows: the process initiates with the arrival of mail pouches, which are then transported through the RFID portal to be read. The data are transmitted to the data centre. Then a supervisor analyses the readings to check for inconsistencies, which are taken to the manual processing station. The valid objects are taken to the end of the process (pallet of processed mail pouches).

The new process suggested for the company enables the simultaneous reading of many objects, in contrast to the old system, which required a manual reader and one reading operation for every object. The RFID portal would be located at the CTE, providing efficiency in the process of posting and optimising resource usage. A representation of such a process can be found in Figure 4.

Figure 3 Process flow of the mail pouch posting service, using RFID technology

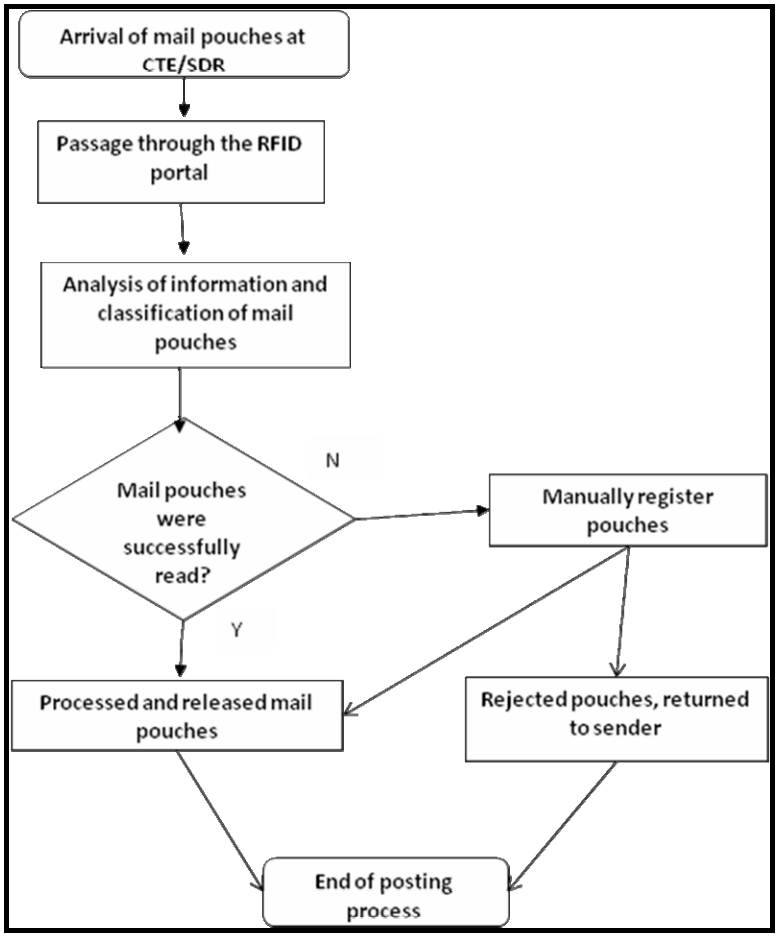
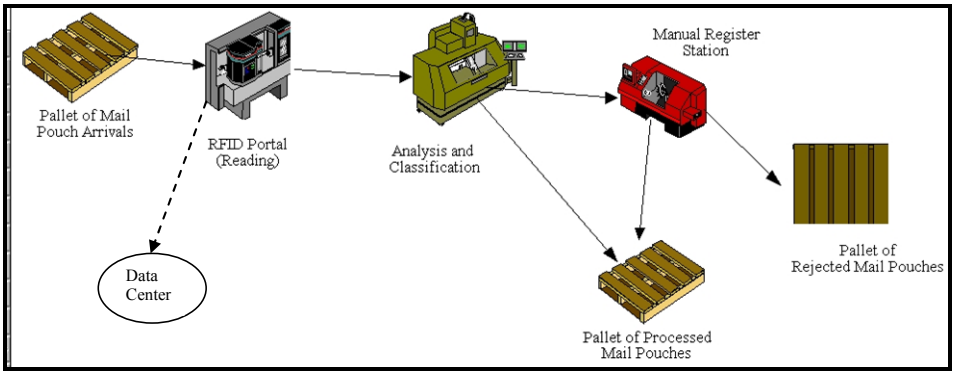


Figure 4 Simulation model of the future process of mail pouch posting at CTE/SDR (see online version for colours)



Source: ProModel software

4.2 Data collection

The data collection was based on managerial reports, on the analysis of SRO indicators published by the operations department, on interviews with workers who operate and manage the service of mail pouches and on observations of the flow of pouches at the CTE/ SDR. A data collection form is developed (see Appendix 1). The results of the data collection are presented in Tables 2–4.

Table 2 Daily arrivals of mail pouches at CTE/SDR. A day corresponds to a two-hour period

Day	*Daily Arrivals*
1	1626
2	1625
3	1916
4	2156
5	1954
6	2056
7	1644
8	2305
9	2189
10	1888
11	1703
12	2161
13	2075
14	1948
15	2316
16	1712
17	1683
18	1796
19	2312

Table 3 Square errors of different probability distributions (Kolmogorov–Smirnov test), corresponding to the month of September 2012

Distribution	*Square Error*
Uniform	0.0244
Beta	0.0297
Exponential	0.0503
Erlang	0.0503
Gamma	0.055
Weibull	0.0554
Normal	0.0601
Triangular	0.0808
Lognormal	0.0918

Table 4 Average fractions of mail pouches processed per day at CTE/SDR. Data collected at CTE/SDR

Origin	*Destination*	*Fraction of the Flow*
Pallet of Mail Pouch Arrivals	Mail Pouch Classification	100%
Mail Pouch Classification	SRO Station 1	40.923%
Mail Pouch Classification	SRO Station 2	37.436%
Mail Pouch Classification	SRO Station 3	19.641%
Mail Pouch Classification	Pallet of Rejected Mail Pouches	2%
SRO Station 1	SRO Manual Station	2.506%
SRO Station 1	Pallet of Processed Mail Pouches	96.617%
SRO Station 1	Pallet of Rejected Mail Pouches	0.877%
SRO Station 2	SRO Manual Station	2.328%
SRO Station 2	Pallet of Processed Mail Pouches	96.851%
SRO Station 2	Pallet of Rejected Mail Pouches	0.821%
SRO Station 3	SRO Manual Station	2.35%
SRO Station 3	Pallet of Processed Mail Pouches	96.606%
SRO Station 3	Pallet of Rejected Mail Pouches	1.044%
SRO Manual Station	Pallet of Processed Mail Pouches	97.83%
SRO Manual Station	Pallet of Rejected Mail Pouches	2.17%

The arrivals of mail pouches vary significantly over the days of a month. Seasonal effects, on the other hand, are quite small. The mail pouch service is by nature restricted to exchange of documents/materials between organisations and does not exhibit seasonality. Other services such Express Mail (SEDEX) and parcels have a significant oscillation of the demand during the year, with a peak during the end-of-the-year holidays and other commemorative dates, exhibiting an increase of 20–30% on these occasions. Therefore, it was decided not to model the variation in the long term, and focus on monthly variation. This makes even more sense once one considers that the time unit of the model is hours.

A sample was collected for the month of September 2012 (see Table 3) and the Kolmogorov–Smirnov test was carried out in order to find the best random probability distribution to represent the rate of arrivals. There were only 19 working days in September; therefore there are only 19 data points. The normal, uniform, Erlang, beta, gamma, exponential, Weibull, triangular and lognormal distributions were tested. The distribution with lowest square error was the uniform distribution (see Table 3). Therefore, a random uniform distribution was utilised in both models, with minimum and maximum hourly values of 810 and 1160 (based on empirical data, collected on-site for every hour –data not shown here for brevity). The Kolmogorov test achieved a p-value of 0.15. Higher p-values are desirable for this test, meaning that there was a good fit.

4.3 Analysis of the outputs

In the simulation of the current posting process, the following data were generated. Forty hours or 20 days were simulated, in order to represent a month of operations. Twenty

replications (simulations) were run and averaged, since there is uncertainty in one of the variables. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter.

In this simulation of the current mail pouch posting process at CTE/SDR, which occurs daily in a two-hour shift, it is possible to make a few observations based on Table 5:

- The daily arrivals of mail pouches reached 1715 units;
- 39.23 mail pouches are processed manually due to problems with the barcode tags, representing 2.288% of errors in the sample;
- 1615.5 mail pouches were successfully posted, representing 94.20% of the sample;
- 48.8 mail pouches were rejected and returned to the sender due to problems with the display, seal, label or contract, representing 2.85% of the sample.

Table 5 Results of the simulations with the 'current process' model

Processing Unit	*Time (HR)*	*Capacity per day*	*Avg. Entries/ Day*	*Conf. Interval*
Arrival of mail pouches	40	2000	1715	±85.81
Mail Pouch Classification	40	1950	1664.37	±88.06
SRO Station 1	40	850	682	±36.48
SRO Station 2	40	800	622.75	±32.47
SRO Station 3	40	400	326.05	±17.84
Manual SRO Station	40	100	39.23	±2.08
Station of processed mail pouches	40	2000	1615.50	±85.63
Station of rejected mail pouches	40	500	48.8	±2.50

Source: ProModel simulation report

In the simulation of the new process, using RFID technology, there is a change in the process of data collection; according to Park and Park (2006), a portable collector would be used for reading the RFID tags, validating the postings and immediately transmitting the data to the local data centre. This procedure would result in no more identification errors in the display, no more contractual errors (billing) and no errors in the barcode reading process.

In the simulation of the mailing process with the use of RFID technology, a reduction in the number of mail pouches returned to senders can be observed. The number of manually processed mail pouches, due to problems in the tags, was reduced. All these improvements are the result of the new process of identification using RFID technology. In this new condition, a small number of administrative errors (0.1881%) are caused by contractual impediments (blocked contracts due to delinquency) and there is always the rare possibility of a reading error (estimated at 0.017% based on experiments by Araújo Filho et al., 2012), so around 0.2051% of the total flow of pouches is returned to senders. Only 1282% of the total flow of mail pouches goes to the manual register station. Of these, 16% go to the rejected mail pouch pallet, due to the above-mentioned reasons. The number of contractual impediments was based on actual numbers from CTE/SDR.

Table 6 Average fractions of mail pouches processed per day in the new condition

Origin	*Destination*	*Fraction of the Flow*
Mail Pouch Arrivals	RFID Portal	100%
RFID Portal	Analysis and Classification	100%
Analysis and Classification	Manual Register Station	1.282%
Analysis and Classification	Pallet of Processed Mail Pouches	98.718%
Manual Register Station	Pallet of Processed Mail Pouches	84%
Manual Register Station	Pallet of Rejected Mail Pouches	16%

Taking into account this new condition, the numbers are obtained from the simulations with the 'RFID model (Table 7).

Table 7 Results of the simulations with the 'RFID model'

Processing Unit	*Time (HR)*	*Capacity per day*	*Average Entries per Day*	*Confidence Interval*
Arrival of mail pouches	40	2000	1739.75	±75.31
RFID Portal for reading the tags	40	2000	1702.01	±71.60
Validation of the RFID reading	40	2000	1702.01	±71.60
Manual processing station	40	500	21.93	±0.92
Station of processed mail pouches	40	2000	1698.43	±71.48
Station of rejected mail pouches	40	500	3.58	±0.21

Source: ProModel simulation report

Comparing Tables 4 and 7, there is a small difference in the number of mail pouch arrivals between models; since both models have the same distributions for arrivals; this small discrepancy (1715 versus 1739.75) can be explained by the random nature of the distributions.

5 Model validation

Forrester and Senge (1980) suggest three types of tests of system dynamics models: (a) structural similarity to the actual system, i.e. the main structures and processes are faithfully reproduced; (b) reasonable behaviour over a wide range of input values; and (c) behaviour similarity to actual systems. The coding of the model takes into account all the data collected during the study. The model was tested under extreme conditions (the arrivals of pouches covered a wide range of inputs) and it behaved well. Model behaviour remains reasonable through these tests. By basing the model on the RFID literature and on supply chain management, the model's structural similarity to RFID-enabled processes in the postal system supply chain as practiced is improved. The data on actual postal service operations allowed detailed model calibration and behaviour comparison. The model behaved well in all studies.

Adding to these considerations, the model's behaviour is consistent with the logic of mail pouch posting as found in the literature. The results of the model mimic those of the actual mail pouch posting at CTE/SDR as determined by our data collection process. Based on the above tests, the model is considered useful for analysis of the product pipeline.

6 Results

Considering the data collected from the current process of mail pouch posting, as represented in Table 4, a simulation was performed, with the following results (on average):

- Mail pouch arrivals: 1715 = 100%
- Processed mail pouches: 1615.5 = 94.20%
- Manually processed pouches: 39.23 = 2.29%
- Rejected pouches (returned to sender): 48.8 = 2.85%.

The simulation of the new process (with RFID technology) takes into account the same data (delays, flows) of the current posting of mail pouches, but with an increased rate of reading and a longer MTBF for the RFID collector. The following results were obtained, on average:

- Mail pouch arrivals: 1739.75 = 100%
- Processed mail pouches: 1698.43 = 97.62%
- Manually processed pouches: 21.93 = 1.26%
- Rejected pouches (returned to sender): 3.58 = 0.21%.

Applying the fractions of rejected pouches to ECT's regional and national markets, the following values are obtained. The number of arrivals was averaged for the two conditions.

Table 8 Mail pouches returned to sender due to errors. Values are rounded to the nearest integer

Unit	*Flow of mail pouches per Day (DW/ECT)*	*Mail pouches rejected in the current model (Day) (2.85%)*	*Mail pouches rejected in the new model (day) (0.21%)*
CTE/SDR	1727 (average)	49	4
State of Bahia	3385	96	7
Brazilian Postal Service	274,405	7821	576

It is possible to estimate the financial impact of the process of returning pouches to senders, based on the values charged for the service. This estimate is presented in Table 9, considering the price for a mail pouch with the average weight of 2 kg. Different rates were used for different destinations. Forty percent of the pouches are sent to the

same state (Bahia) and 60% are sent to other states in the country. An estimate was made for the price of sending pouches to other states. Since most of the inter-state pouches are sent to the state of São Paulo (SP), that rate was used.

Table 9 Financial impact of mail pouch rejection (1 U$ = 2.02 R$)

Daily Demand for pouches CTE/SDR (current)	*Intra-state (Bahia) = 60% of avg. rate up to 2 kg = U$ 4.60*	*Inter-State (Sao Paulo) = 40% of avg. rate up to 2 kg = U$ 16.93*
Arrivals = 1727 pouches	1036 × 4.60 = U$ 4765.6/day	691 × 16.93 = U$ 11,698.63/day
Returned to sender = 49 pouches	29 × 4.60 = U$ 133.40/day	20 × 16.93 = 338.6/day

Source: Rates used by ECT (2012) converted from Reals to Dollars in October 2012

Therefore, the daily demand for mail pouch posting at CTE/SDR represents the total revenue of U$ 16,464.23 including national and regional postings. The rejection of pouches represents U$ 472, resulting in daily net revenue of U$ 15992.23. Using the same analysis for the new process (with RFID technology), the daily net revenue would be U$ 16,030.36, representing an increase in net revenue of U$ 38.13 per day.

Based on interviews with managers at the CTE/SDR, it was possible to estimate other savings that would occur with the new process. Resources are used with more efficiency, eliminating the need for equipment and workforce, as shown in Table 10.

Table 10 Estimation of costs eliminated by the RFID process (1 US$ = 2.02 R$)

Resource/Equipment	*Quantity*	*Unit Value (US$)*	*Total (US$)*
Computer with SRO Station	03	1975	5925
PLS 2100 Scanner	03	225	675
Toledo Prix4 Scale	03	850	2550
Epson Lx300 Printer	03	650	1950
SMS 115V Energy Stabiliser	03	120	360
Maintenance (estimated cost per station)	03	250	750
Worker (monthly cost)	03	7250	21,750
Total			*33,960*

Source: Values provided by ECT

It is also worth noticing the reduction in approximately 50% of the lead time from 4 h in the current process to 2 h. Part of this time could be used to increase the period of posting to clients, who would be able to deliver the objects closer to the deadline. The post office has already received information from customers, who declared that they would like to deliver their mail pouches later in the day.

In order to enable the use of RFID technology, it is necessary to use new equipment, develop software and train the workforce. For the purposes of this study, an estimate was made for the implementation of the new process at CTE/SDR, based on the Araújo Filho et al.'s (2012) study. Araújo Filho et al. carried out an experiment by implementing an RFID system in a microcomputer assembly company. The processes at ECT are similar to the ones performed in the supply chain of the assembly company; therefore, the following costs were estimated (Table 11).

Table 11 Estimate of investments with RFID technology (1 US$ = 2.02 R$)

Resource/Equipment	*Quantity*	*Unit Value (US$)*	*Total (US$)*
Symbol XR450 Reader	01	2362.09	2362.09
Motorola AN400 Antenna	02	616.12	1232.24
Aluminum RFID Portal	01	742.57	742.57
Symbol MC9090-G Collector	02	5795.74	11591.49
Zebra 110Xi4 Thermal Printer	01	6445.02	6445.02
Software Development	01	3960.40	3960.40
Training of Workers	01	2970.30	2970.30
Total			*29,304.10*

Source: Araújo Filho et al. (2012)

It is worth noticing that with the current mailing process, 2.85% of the demand is returned to senders. With the new condition, the simulation indicates a fraction of rejected objects of 0.21%.

If we take into consideration that identical procedures can be applied to other postal services, such as Express Mail (SEDEX), Registered Mail and other services that require traceability, these operational gains become even more relevant. It is worth noticing that other gains can be earned:

- Real-time locating of objects and traceability of activities.
- Traceability at places that currently does not offer this service, such as air cargo terminals, during the activities of cross docking.
- Reduction in the number of registrations and data exchanges, which in turn would reduce the workforce and the equipment needed for the operation.
- Reduction in the payment of compensations (due to loss of postal objects and lack of traceability).

The model for RFID technology utilisation created by Park and Park (2006) is already used by the Korean postal services and in other countries. By analysing such a model, it is possible to understand the possibility of using RFID technology for other procedures that were not included in this study, such as:

- Identification and tracking of empty pallets, which are key pieces for the postal process;
- Carry out more preparatory work such as a delivery list based on the information coming from the RFID tags at the data centre (local platform). Currently, these lists are created only when the objects reach their units;
- Postal handling and classification based on the data transmitted to the data centre at the local platform.

7 Conclusion

In this paper, it is evident that the methodology for implementation of RFID technology on the mail pouch posting service is viable.

The results of the simulations that are carried out for the new process brought about significant gains, especially:

- Important reduction in the number of mail pouches returned to sender. In the current process, 2.85% of mail pouches are rejected, on average. In the new process, this number is reduced to 0.21%.
- Table 6 presents the losses incurred every day due to the mail pouches that are rejected.
- Table 7 presents the estimate of gains that can be brought about by the new system by eliminating costs currently incurred.

It is easy to predict that similar procedures can be implemented for other postal services, such as express mail (SEDEX), parcels and registered mail. These operational gains would be even more important due to advantages listed in the previous section.

In terms of suggestions for future studies, we recommend a focus on other activities similar to the mail pouch posting service. There is a need to conduct further research on RFID applications in the postal service sector as this area holds a great potential for performance improvements. Additionally, there is a need to conduct more in-depth research into the isolated impact of RFID technology in comparison to the change in management and process redesign that it generates.

One key limitation of this research is the case study approach based on a single case. This paper, however, provides direction for practitioners on how to assess RFID's potential impact on the postal service process, from the receipt of mail pouches to the final processing of the pouches. This research contributes to our understanding of RFID's potential in intra-organisational processes. Hopefully, the experience and lessons learned from this case study can be shared with the readers, and they will be beneficial to those organisations that are contemplating the implementation of RFID systems.

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Appendix

Field Research Form.

Date of collection: ___/____/2012.

Step of the Process:_____

Unit: _____

Name of interviewee: _____

Questions:

1 How do the procedures of mail pouch posting happen? How long does it take to carry out each procedure?

2 What fractions of the mail pouches follow each destination in the stream shown to you?

3 What are the main types of errors that happen at this stage? What is the relative magnitude (fractions) of these errors?

4 What are the procedures for dealing with these errors?

5 How long does it take to fix the errors?

6 Are there errors that cannot be solved? What kind of procedure is adopted in these situations?

7 Is there anything else that you want to say about the mail pouch posting service that could contribute to our study about the process?