Development of an Improvement ATM service level model

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Submitted in partial fulfilment of the requirements for the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

In the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITY OF PRETORIA
PRETORIA

October 2012

Contents

List of Tables

List of Figures

Executive Summary

This report investigates ATM performance at a leading financial institution in South Africa, which for the purpose of this report is referred to as ABC Bank.

The objective of any bank is to provide customers with good ATM service at the lowest possible cost. However, in the financial services industry, good customer service is especially difficult to define and any form of cash handling and distribution is extremely costly. Therefore finding the balance between cost and service is a difficult task. ABC Bank places more emphasis on maintaining good customer service than reducing costs. It is company policy to stock *all* ATMs at a 98% service level. This means that each ATM is stocked with enough cash to be 98% confident that all customer demand will be satisfied.

This report first provides the results of research conducted into the ATM service industry, with respect to the cost components and risk factors associated with the ATM Cash Cycle, how ATM holdings are calculated using demand forecasts and finally, customer service in the ATM usage environment. Thereafter, the reasons why ABC Bank implements the 98% service level policy are discussed. Based on all of these aspects, the 98% service level is investigated and assessed in order to determine whether it is a good policy or not.

The investigation into the policy firstly proves that servicing all ATMs at a 98% service level is not in fact always necessary from a customer's perspective. This is because the results of the research conducted show that a customer's reaction in the event of a missed transaction at an ATM is directly related to the unique characteristics and location of the ATM itself. In other words, the willingness of a customer to *accept* a cash-shortage situation or the likelihood of the customer being highly *annoyed* varies from ATM to ATM. This implies that all ATMs are not the same and therefore should be treated differently from a service level perspective.

The next step of the investigation into the 98% service level policy proves that the policy significantly increases cost as well as risk. Since stocking all ATMs at a 98% service level is not always necessary, the high costs and risks incurred as a result of the policy are not justified.

This report therefore concludes that the 98% service level policy should be reviewed as it not a cost-efficient approach to satisfy customer demand. It is therefore proposed that ABC Bank utilises the ATM Service Level Model developed and discussed in this report and which has been built for the purpose of this project.

The ATM Service Level Model is able to calculate an optimal service level for each of the ATMs belonging to ABC Bank. The optimal service level is one which will provide the service level *actually required* by customers at each specific ATM while simultaneously minimising the costs and risks incurred. This is done by differentiating between ATMs based on their individual characteristics and location. Each ATM is assigned an "Importance Factor" and an optimal service level is calculated using historical *holdings-withdrawals* data pertaining to that specific ATM. Implementing the optimal service levels calculated by the ATM Service Level Model, will result in *substantial* savings for ABC Bank , while simultaneously maintaining the level of ATM Performance required for ABC Bank to be competitive in the financial services industry (exact figures have not been included in the report for confidentiality purposes).

Chapter 1: Introduction

1.1 Background

In the banking and financial services industry, automated teller machines (ATMs) enable banks to make cash easily and readily available to their customers. Despite the emergence of debit and credit cards, as well as internet and cellular banking, cash remains to be the preferred method of payment in concluding transactions. It is therefore still used for 65% of payments globally. (Straaten, 2009)

The objective of any bank is to provide customers with good ATM service at the lowest possible cost. In order to satisfy customer's demand for cash, cash needs to be provided at the right location in the correct quantities and at the right time. However, determining the quantity of cash with which to stock each ATM is a difficult task. This is because customer demand patterns relating to ATM usage are complex and dynamic in nature. (Straaten, 2009) In addition to this, getting cash to the ATM locations involves a high level of risk due to the occurrence of cash heists and ATM bombings. Due to the high risk nature of this industry, as well as the fact that cash is in itself an expensive commodity, (Kearney & Erasmus, 2011) any form of cash handling and distribution is extremely costly.

At a leading financial institution in South Africa, referred to as "ABC Bank" for purposes of this report, it is company policy to stock *all* ATMs at a 98% service level. (Cronje, 2012) This means that each ATM is stocked with enough cash to be 98% confident that all customer demand will be satisfied.

1.2 Problem Statement

As depicted in the figure below, stocking ATMs at a higher service level simply means that the chances of a cash-shortage occurring are reduced and better customer service is provided. This, however, results in higher costs and risks incurred because the amount of cash with which each ATM needs to be stocked is significantly increased. On the other hand, when lowering the service level, costs and risks are decreased. This is, however, at the detriment of customer service provided.

Figure 1: Conflicting objectives

Higher Service Level:	Better customer service
Increased cash stock:	Increased costs and risks

Lower Service Level:	Decreased customer service
Increased cash stock:	Decreased costs and risks

By implementing a 98% service level policy at all ATMs, ABC Bank places more emphasis on providing good customer service than keeping costs as low as possible. However, due to the competitive nature of the financial services industry, the need to satisfy customer demand at ATMs in a *cost-efficient* way is becoming more and more prominent. As a result, it is imperative that the 98% service level policy is assessed in terms of its effectiveness of meeting customer demand, as well as its impact on cost and risk.

1.3 Project Aim and Approach

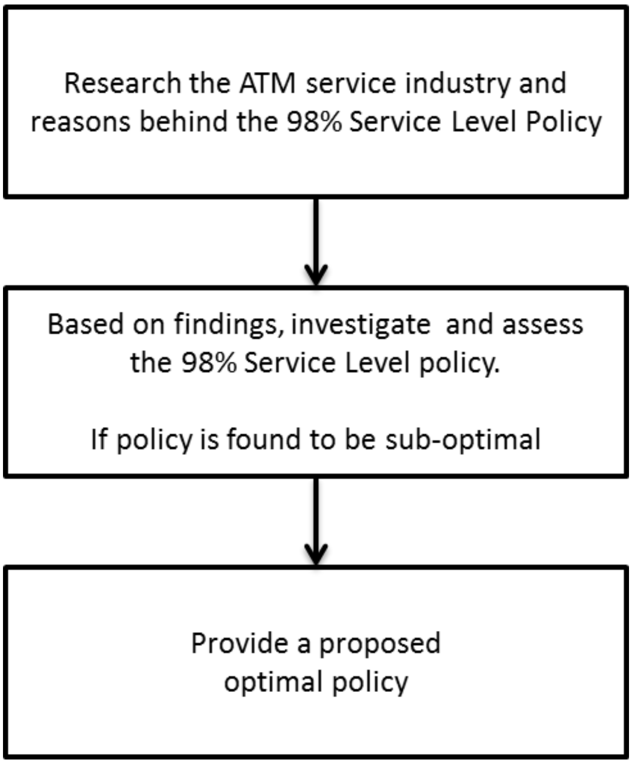
The aim of this project is to investigate and assess ABC Bank's 98% service level policy in order to determine whether it is an optimal policy or whether an improved policy should be developed and implemented. For the purpose of this report, an "optimal policy" is defined as one which:

- results in a level of customer service provided at ATMs which will ensure the continued, and preferably increased, loyalty and support of ABC's customers,
- while simultaneously minimising the costs and risks incurred by ABC Bank.

In the event that the policy is not found to be optimal, the aim of the project is to provide ABC Bank with an improved policy which will conform to the definition of an optimal policy described above.

The project is divided into three stages, as depicted the figure below.

Figure 2: Project stages



1.4. Deliverables

Based on the project aim, the deliverables of this report are as follows:

1. The main findings of the research conducted into the ATM service industry.
2. The reasons and motives behind the 98% service level policy.
3. An investigation into and assessment of the 98% service level policy.
4. An improved policy for ABC Bank if the outcome of the 98% policy investigation proves that it is sub-optimal.

Chapter 2: The ATM Service Industry

Based on extensive literature research, surveys and interviews conducted, the following topics pertaining to the ATM service industry are discussed in this section:

- Cash's resistance to substitution
- The ATM Cash Cycle
- Cost Components
- Risk Factors
- Demand Forecasts and ATM Holdings
- Customer Service

2.1 Cash's Resistance to Substitution

The emergence of debit and credit cards, as well as internet and cellular banking, led many to believe that the need for physical cash would disappear altogether. (Adendorff, 1999) However, cash remains to be the preferred method of payment in concluding transactions. (Straaten, 2009) The three main drivers behind the continued usage of cash and its resistance to substitution are as follows:

2.1.1 Anonymity

Unlike EFT and card payments, cash transactions cannot be traced. This makes cash the payment of choice for questionable services, illegal transactions and persons wanting to evade taxes. (Adendorff, 1999)

2.1.2 Convenience

Cash is the most widely accepted medium of payment making it not only convenient, but often necessary, to always carry cash. Using cash is also convenient since the transaction speed associated with a cash payment exceeds that of any other medium. (Adendorff, 1999)

2.1.3 Psychological Impact

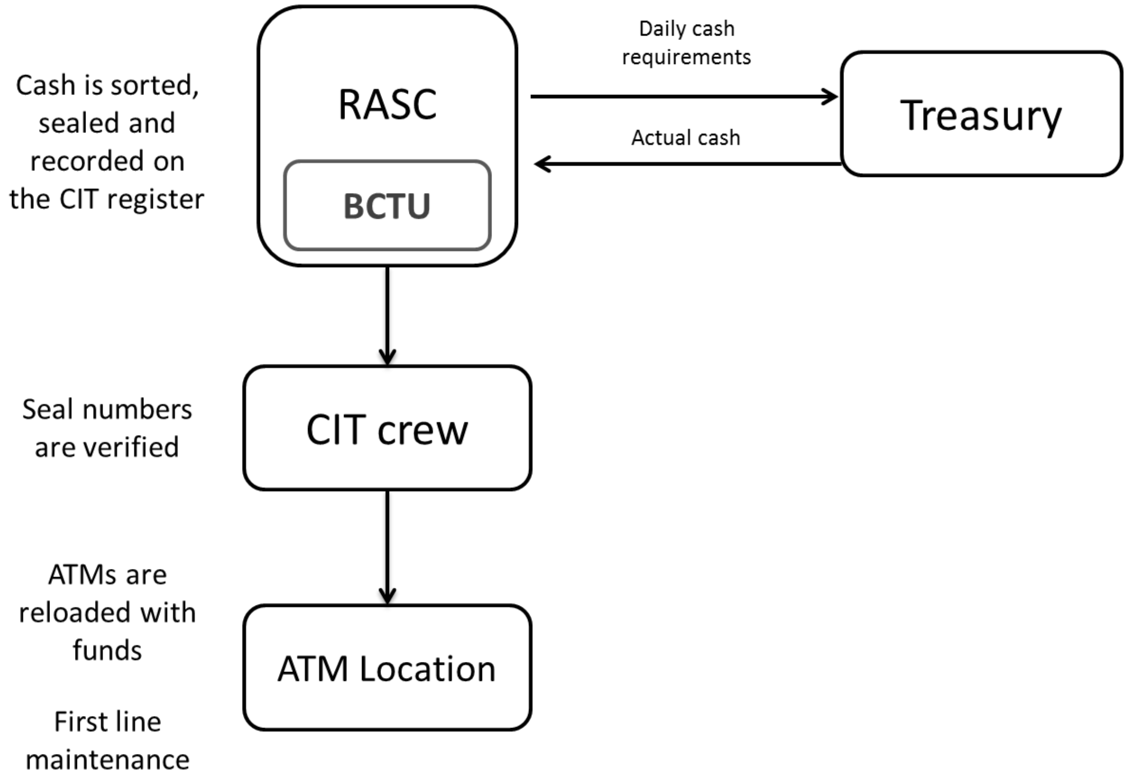
The general population still feel the need for physical cash because "*people hold a more personal opinion of the products they use close to their body*". (Adendorff, 1999) Since cash is carried on one's body, it falls under this category.

According to the Project Report: *Comparison of Canister Replenishment and Custodian Cash Distribution Models,* the informal sector is another driver for cash usage. (Straaten, 2009) This is because most businesses in this category operate on a cash-only basis. The informal sector is often overlooked, but plays an important role in today's economy, contributing approximately 30% of the global GDP. (Straaten, 2009) Another factor is the 15 to 20 million food and beverage vending machines worldwide. Such coin-operated machines and other similar devices, such as coin-operated payphones, contribute significantly to cash demand. (Straaten, 2009)

2.2 The ATM Cash Cycle

The steps involved in the ATM Cash Cycle are depicted in the figure below.

Figure 3: ATM Cash Cycle



1. Based on demand forecasts the Regional ATM Service Centre (RASC) informs the bank's treasury of the daily cash requirements for ATM replenishment. The treasury then supplies the day's required cash to the RASC each morning. The cash is sorted per route, denomination and per ATM destination in stop-loss bags. The bags are closed with seals containing unique numbers which are recorded on a Cash-In-Transit or CIT register together with the corresponding ATM destination. (Straaten, 2009)
2. The sealed stop-loss bags are then taken to the Bulk Cash Transfer Unit (BCTU) and handed over to the cash-in-transit crew. The seal numbers are verified against the register and the seals are checked to be secure by the crew members. Once this is completed, the CIT crew then take custody of the bags and transport them to the ATM locations. (Straaten, 2009)
3. At the ATM location, the ATM is reloaded with funds. The replenishment process also includes first line maintenance duties where necessary. These duties include clearing of notes and cards that are stuck in the ATM, replacing receipt rolls and collecting deposits. (Straaten, 2009)

The management of ATMs includes ATM servicing and alarm testing. ATM servicing consists of first line maintenance (as discussed) and second line maintenance. Second line maintenance includes repairing faulty card readers, screens and keypads. ATM alarms are tested once a month at the controllers' discretion. It is done while the ATM is being replenished so that a separate trip is not necessary. (Straaten, 2009)

2.3 Cost Components

The cost components associated with the ATM Cash Cycle include the cost of inventory, downtime costs, transportation costs and CIT crew costs. It is important to note that for the purpose of this project, the main focus is on the cost of inventory and downtime costs. The remaining two cost components are discussed briefly for completeness sake, however they are not further considered in this report. All four cost components can be further divided into subcomponents as discussed below.

2.3.1 Cost of Inventory (I)

The cost of inventory in the banking environment is generally known as cost of funds (COFs). This is essentially the interest income a bank forfeits on cash in the system while it is in transit or in the cash centre vault or in ATMs. (Adendorff, 1999)

2.2.2 Transportation Costs (T)

Transportation costs refer to the cost of physically moving cash between the cash centres and ATMs. This cost can be charged in a number of different ways. For example, a fixed amount per vehicle per time unit (hour, day or month) could be charged. Another example is charging a fixed fee per kilometre or charging a fixed amount plus a specified amount per kilometre. (Adendorff, 1999)

2.2.3. Custodian Costs (C)

Custodian duties and responsibilities include safekeeping of ATM keys, first line maintenance, organising second line maintenance and alarm testing. The custodian costs are a function of the number of routes driven per day and the non-transport costs per custodian i.e. salaries. (Adendorff, 1999)

2.2.4 Downtime Costs (D)

When considering an ATM that is out-of-order and that cannot process a customer's transaction, the following adverse effects or "downtime costs" are prevalent.

- Since a fee is charged every time cash is withdrawn from an ATM, the bank loses this potential income when the ATM is out of order. (Straaten, 2009)
- It is annoying and inconvenient for customers and may result in long term consequences such as a reduced customer satisfaction or the loss of customers themselves. (Straaten, 2009)

The causes of ATM downtime are divided into the four categories listed in the table on the following page. According to Adendorff, a shortage at an ATM may occur from time to time and it is be tolerated by the customer, especially when the location is remote from a bank branch or cash centre. (Adendorff, 1999) The explanation behind this is that the customer is often unaware of the exact reason for the transaction not being processed and is therefore more willing to accept the shortage situation. (Adendorff, 1999)

Table 1: ATM downtime categories

Category	Explanation
Hard faults	Malfunctioning of ATM machines such as notes or cards stuck in the machine or faulty card readers, screens and keypads.
Cash outs	This includes situations when there is no cash in the ATM or when one of the denominations has run out and the machine is unable to provide the amount requested.
Communication	When Telkom lines are down and therefore ATMs cannot operate.
Supervisory	Downtime due to maintenance and servicing

Source: Straaten (2009)

Based on all of these costs components, a cost function can be set up as follows:

$$C = I + T + K + D$$

From ABC bank's perspective, it is desirable to keep costs as low as possible in order to maximise the amount of profit made by the financial institution.

2.4 Risk Factors

The alarming crime statistics in South Africa, regarding cash heists, ATM bombings, money laundering and fraud, makes the management and circulation of cash throughout the country an extremely high risk area. (Kearney & Erasmus, 2011) The weak security link in circulation and management of cash is the vulnerability of cash while in transit and also while in the retailer's possession. (Seldon, 2006) Other risks in the industry include operations, people, technology, financial reporting and regulatory risks. These risks are collectively termed "operational risks". (Straaten, 2009) In the South African context, the most prevalent operational risks are fraud and money laundering activities. (Adendorff, 1999)

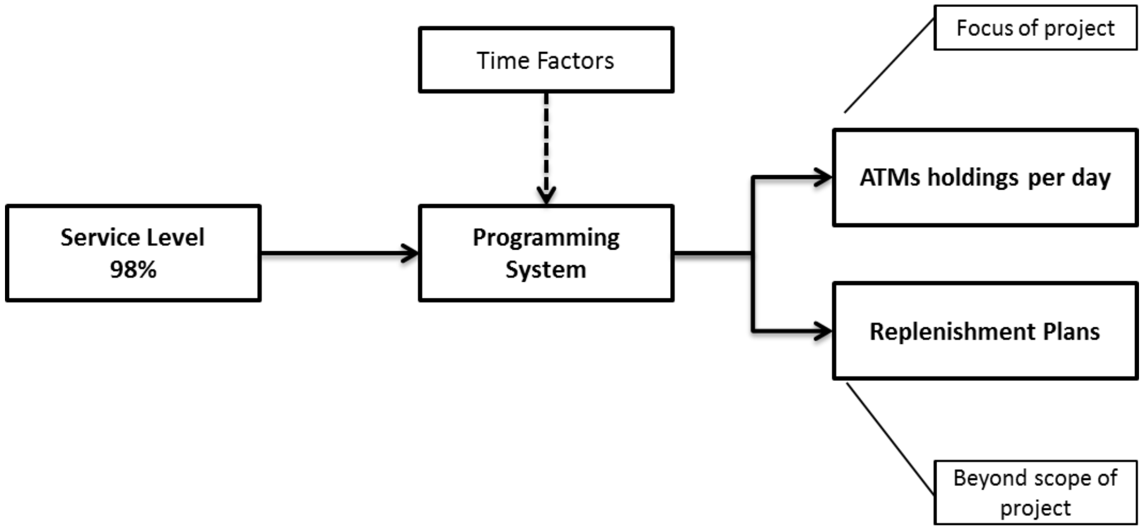
2. 5 Demand Forecasts and ATM Holdings

As previously stated, the RASC informs the bank's treasury of the daily cash requirements based on demand forecasts. ABC Bank uses a programming system to calculate the demand forecasts and develop the replenishment plans. Replenishment plans state *how often* and *when* ATMs are replenished. (Cronje, 2012) The method whereby the replenishment plans are developed falls beyond the scope of this project. Therefore only demand forecasts are discussed in detail.

The demand forecasts are calculated using time series analysis where historical data of withdrawals and deposits are used to predict future withdrawals. (Straaten, 2009) An input into the programming system, as depicted in the figure below, is the service level required for each ATM. At ABC Bank, the service level is currently set at 98%.

Since accounts are usually paid at the beginning of the month, spending increases during certain holidays such as Easter and Christmas and during weekends people do more shopping and therefore need more cash (Adendorff, 1999). A time factor is therefore taken into account by the programming system and the demand forecasts are adjusted accordingly[1].

Figure 4: Inputs and outputs of the programming system



ATM holdings refer to the volume of cash with which each ATM is stocked. The ATM holdings are a function of the demand forecast as well as the safety stock required at the specified service level. The ATM holdings and safety stock calculation are as follows, where the z value is depends on the service level.

$$\textbf{Ideal holdings} = \textbf{Demand forecast} + \textbf{Safety stock}$$

$$\textbf{Safety stock} = \textbf{z value} \times \sigma_{\text{DEMAND}} \times \textbf{sqrt(Lead time)} \times \textbf{Demand forecast}$$

2.6 Customer Service

Banking is to a large extent seen as a "convenience good". This implies that most people view banks to *all be alike* with the only differentiating factor being the level of customer service provided. (Adendorff, 1999) However, in the case of ATM usage, determining what the customers' real needs are, is not as straightforward as one might think. A user might be very displeased with a specific ATM which is out of order at a particular time, but his or her reaction might differ at another unavailable ATM at another time. (EMFA, 2012) In a study conducted by Earl M. Foster Associates[2] (known as "EMFA" and referred to as such hereinafter) on ATM Performance Measurement, the example below is given to illustrate this point:

[1] See Appendix A for Table of Time Factors

[2] Earl M Foster Associates is a financial investment advisory firm headquartered in Miami, Florida. The firm manages 95 accounts totalling an estimated $134 Million of assets under management. The results and findings of the ATM

Think about an ATM running out of money during the day in a busy shopping area and an ATM running empty at night in a quiet suburb. One might think the first example is worse, but more factors need to be considered to determine which event has more of a negative impact on ATM business.

Of course more customer transactions are missed in the same period of time in the shopping area at daytime, but what if, for example, many other ATMs are located within walking distance? Customers might just ignore the unavailable ATM and walk to the next operational ATM. However, if the ATM in the quiet suburb is the only cashpoint in the area and it runs out of cash, this event could be more critical for the continued performance of that ATM as compared to the shopping area ATM.

Source: (EMFA, 2012)

The example above suggests that all ATMs are not the same, but rather that a number of factors (for example the time of ATM usage, the location of the ATM itself and the proximity of other ATMs with respect to an ATM which is out-of-order) need to be considered in order to determine the impact of a missed transaction on the performance of the ATM in terms of customer service. The above example, however, only describes two ATM scenarios where a transaction cannot be processed. It goes without saying that a multitude of different scenarios can occur when considering all the different combinations of factors that exist. It is for this exact reason that EMFA conducted the *ATM Performance Measurement study*. Extensive market research was carried out by means of surveys and questionnaires across a broad, representative base of ATM users in order to conclusively establish the following, from the perspective of the customers themselves:

In the event that an ATM cannot process a transaction, which factors or combination of factors result in the missed transaction having a greater negative impact on the performance of the ATM in terms of customer service*?*

The study found that the moment of ATM usage, ATM characteristics and the location of the ATM affect the gravity of a missed transaction at an ATM. The elements relating to these factors are listed in the table on the following page. The study also found that not all the elements have the same impact on the gravity of a missed transaction. The third column in the table shows that a different "importance" can be applied to each element. The weights listed are the proposed weights for each element derived from the results of the study.

The findings of the EMFA study with respect to "if the ATM is located in a bank branch, the gravity of the missed transaction is greater" is supported by the fact that poor face-to-face customer service at a bank branch is deemed to be highly unacceptable. (Adendorff, 1999) This is due to *lasting* negative impression formed by the customer and the ripple effect it may have as a result of word of mouth.

Performance Management study conducted by EMFA are highly regarded and supported by ABC Bank as well as the financial services industry as a whole.

Table 2: Factors affecting the gravity of a missed transaction

Results of EMFA Study		
Factors	**Elements** **The gravity of a missed transaction is higher…**	**Proposed Weight**
Moment of ATM usage	• During holidays	1
	• During (local) events	1
ATM Characteristics	• If the ATM has a deposit function	1
	• If the denomination mix can be chosen	0.5
	• If the user can check his/her account balance	0.5
Location	• If not located next to other ATMs in walking distance	2
	• If the ATM is located in a bank branch	2

Source: EMFA 2012

2.6.1 Current Service Quality Trends

The service quality strategy of a financial institution needs to be adjusted as changes in the banking environment become evident. (Angur, et al., 1999) One such change which has had a significant impact on the financial industry is the emergence of electronic banking. As electronic banking has become more prevalent, the quality of a bank's service is now measured more in terms of personal support rather than technical support. (Angur, et al., 1999) In other words, as banks have become more and more ``high-tech'', their technical services have been standardized resulting in the reduced importance of such services. Therefore consumers are now evaluating banks based more on their ``high-touch'' factors than on their ``high-tech'' factors. (Angur, et al., 1999) These current service quality trends are summarised in figure 10.

Figure 10: Service quality trends

Technical services		**Personal services**
• No longer a differentiating factor because it is expected by the customer • REDUCED importance e.g. Internet banking, ATM services (where consumers interact with a machine)	**VS**	• Is now the main differentiating factor • INCREASED importance e.g. Face-to-face contact with employee at bank. If poor service is received it has a lasting negative impression.

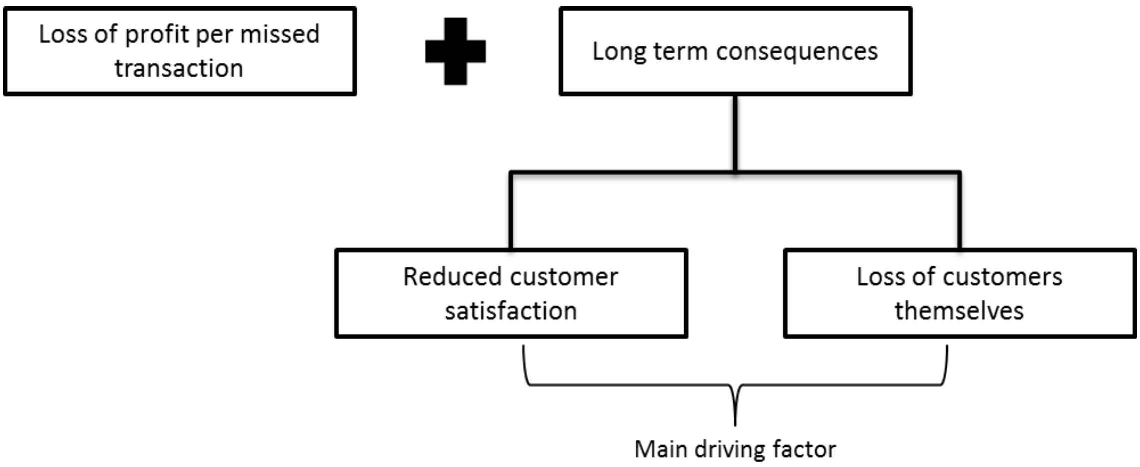
Chapter 3: Investigating the 98% Service Level Policy

3.1 Reasons for the 98% Service Level Policy

As previously stated, finding the balance between providing good customer service and keeping costs as low as possible is not an easy task. ABC Bank implements the 98% service level policy in order to avoid cash-out situations and maintain a high level of customer service. It is important to note that when the policy was decided upon, the results and findings of the ATM Performance Measurement study conducted by EMFA had not yet been published.

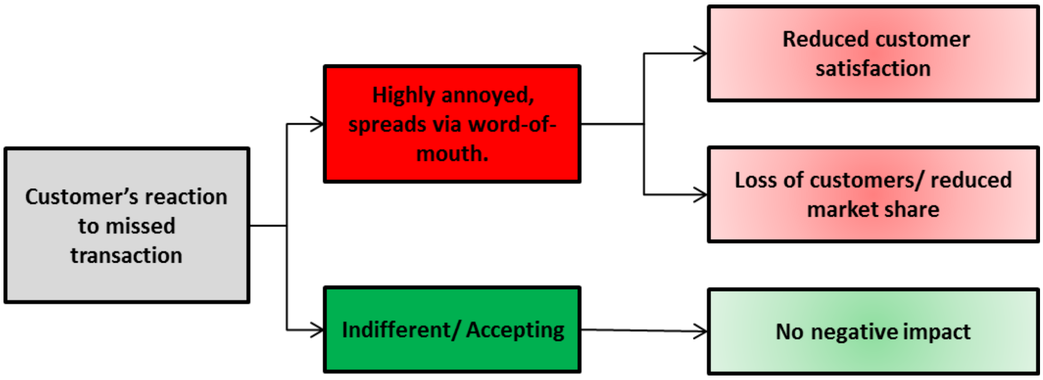
ABC Bank aims to meet 98% of customer demand because in the event of a cash-out, the profit which could have been made on missed transactions is lost. However, a more important concern is that an ATM which cannot process a transaction is annoying and inconvenient for customers and *may* result in long term consequences such as a reduced customer satisfaction or the loss of customers themselves. (Straaten, 2009) However, determining or quantifying these long term consequences poses a significant challenge and, as a result, it is the main driving factor behind ABC's decision to implement the 98% service level policy. The adverse effects of a cash-out situation are summarised in the Figure 5.

Figure 5: Adverse effects of a cash-out situation



Determining or quantifying the long term consequences of a missed transaction at an ATM poses a significant challenge for ABC Bank for a number of reasons. As depicted in Figure 6, a particular customer may be highly annoyed when a specific ATM cannot process a transaction, but his or her reaction might differ at another unavailable ATM at another time. (EMFA, 2012) Even though in some cases a missed transaction has no negative impact on the performance of ATM in terms of customer service, *when, where* and *why* these "accepting" situations occur was previously unknown to ABC Bank. The converse is also true for cases when customers *are* highly annoyed and the missed transaction does in fact have a large negative impact. ABC therefore overcompensates for this uncertainty by stocking all ATMs with enough safety stock, over and above the demand forecast, to be 98% confident that all customer demands will be satisfied. This is done in order to avoid the "highly annoyed" customer reaction in the event of a missed transaction and the associated negative consequences thereof, *no matter* the costs and risk involved.

Figure 6: Customer's reaction to a missed transaction



Due to this difficulty in determining or quantifying the long term consequences of a missed transaction at an ATM, the 98% policy can be seen as making provision for the worst customer behaviour scenarios as described below:

- Customers are *always* highly annoyed when a transaction cannot be processed at an ATM, irrespective of the time of ATM usage, the unique ATM characteristics or the location of the ATM.
- The ATM service provided by a financial institution has a large impact on how customers evaluate the quality of the financial institution's service. In other words, missed transactions at ATMs contribute significantly to the perceived level of customer service provided by a financial institution and result in diminished customer satisfaction and leads to the loss of customers themselves.
- Customers are always aware of the exact reason for the transaction not being processed. In the event that the ATM is out of cash, the customers view this to be the worst category of downtime.

When assuming the customer behaviour scenarios described above are true and taking into account the particular importance of customer service in the financial services industry, it is understandable why the 98% service level policy is implemented by ABC Bank at all ATMs, despite the increased costs and risks incurred. Now that it has been established *why* ABC Bank implements a 98% service level policy, the next step is to determine whether it is an optimal policy or whether a more policy should be developed and implemented.

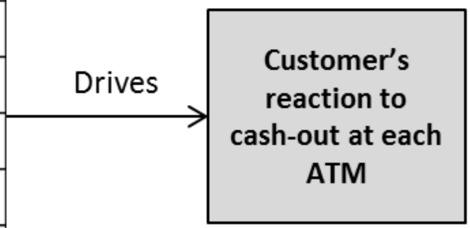
3.2 The 98% Service Level Policy and Customer Service

As previously stated, when the 98% service level policy was decided upon, the proven and comprehensive list of factors affecting the gravity of a missed transaction at an ATM were not yet published by EMFA. As concluded in *Section 6: Reasons behind the 98% service level policy,* the difficulty in determining or quantifying the negative consequences of a missed transaction on customer service was the main driving factor behind the 98% service level policy. However, due to the findings and results of the EMFA study, this is no longer the case.

The EMFA study ascertained that customers are not always highly annoyed when a transaction cannot be processed. Rather, as depicted in the figure below, the time of ATM usage, the unique characteristics of the ATM being utilised as well as the location of the ATM contributes *significantly* to a customer's reaction and the associated negative consequence of a missed transaction.

Figure 7: Factors which affect customers' reactions

Results of EMFA Study		
Factors	**Elements** **The gravity of a missed transaction is higher…**	**Proposed Weight**
Moment of ATM usage	• During holidays	1
	• During (local) events	1
ATM Characteristics	• If the ATM has a deposit function	1
	• If the denomination mix can be chosen	0.5
	• If the user can check his/her account balance	0.5
Location	• If not located next to other ATMs in walking distance	2
	• If the ATM is located in a bank branch	2

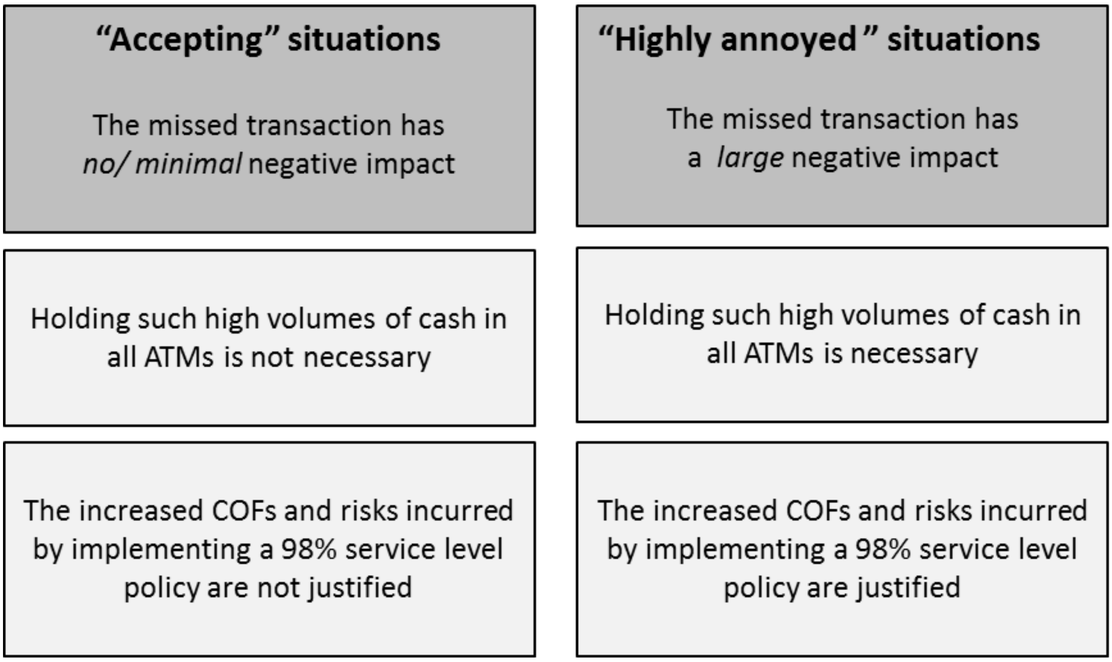


Source: EMFA (2012)

By means of these weighted elements affecting the gravity of a missed transaction, it is now possible to determine or and quantify ATM performance in terms of customer service. The main reason behind implementing the 98% service level policy at *all* ATMs is therefore no longer viable. It is thus not necessary to *always* make provision for the worst customer behaviour scenarios as described previously. On the contrary, in the event of an "accepting situation", as depicted in Figure 8,, holding such high volumes of cash in an ATM is actually not necessary and therefore the additional COFs and risks incurred are not justifiable.

Another important finding from the literature review conducted is that in today's society, a bank's service is measured more in terms of personal support rather than technical support. (Angur, et al., 1999) Since ATMs fall into the technical service category, placing *so much* emphasis on maintaining a 98% service level at all ATMs does not make strategic sense. This is not to say that quality ATM service is no longer important, however, when *compared* to high-touch factors such as face-to-face interaction with a bank employee, it contributes less and less to the perceived level of customer service provided by a financial institution as a whole. This definitely undermines the validity of the 98% service level policy.

Figure 8: When is the 98% service level necessary?



3.3 The 98% Service Level Policy in Practice

As previously stated, increasing the service level provided at ATMs results in higher costs and risks incurred. The extent to which this occurs in practice at a 98% service level is now illustrated by means on an example:

Recall that the ideal holdings are calculated per ATM per day as follows:

$$\textbf{Ideal holdings} = \textbf{Demand forecast} + \textbf{Safety stock}$$

$$\textbf{Safety stock} = \textbf{z value} \times \sigma_{DEMAND} \times \textbf{sqrt(Lead time)} \times \textbf{Demand forecast}$$

For illustrative purposes, assume the following for an ATM:

- $\sigma_{DEMAND} \times \text{sqrt(lead time)} = 0.5$
- $\text{Demand Forecast} = \text{R}250\ 000,00$

Therefore $\sigma_{DEMAND} \times \text{sqrt(Lead time)} \times \text{Demand Forecast} = \text{R}\ 125\ 000,00$

Table 3 shows the safety stock and corresponding ATM holdings at various service levels between 80% and 98%. The percentage increase between the safety stock required at an 80% service level and each service level increment as well as the percentage increase in safety stock required between each consecutive service level increment is also shown.

Table 3: Safety stock and ideal holdings at different service levels

Service level	**z value**	**Safety Stock** R 125 000 × z value	**Percentage Increase** Between 80% and each service level increment	**Percentage Increase** Between each consecutive service level increment	**ATM holdings** (Demand Forecast + Safety Stock)
80%	0.841621	R 105 202.65			R 355 202.65
81%	0.877896	R 109 737.04	4.31%	4.31%	R 359 737.04
82%	0.915365	R 114 420.64	8.76%	4.27%	R 364 420.64
83%	0.954165	R 119 270.66	13.37%	4.24%	R 369 270.66
84%	0.994458	R 124 307.24	18.16%	4.22%	R 374 307.24
85%	1.036433	R 129 554.17	23.15%	4.22%	R 379 554.17
86%	1.080319	R 135 039.92	28.36%	4.23%	R 385 039.92
87%	1.126391	R 140 798.89	33.84%	4.26%	R 390 798.89
88%	1.174987	R 146 873.35	39.61%	4.31%	R 396 873.35
89%	1.226528	R 153 316.02	45.73%	4.39%	R 403 316.02
90%	1.281552	R 160 193.95	52.27%	4.49%	R 410 193.95
91%	1.340755	R 167 594.38	59.31%	4.62%	R 417 594.38
92%	1.405072	R 175 633.95	66.95%	4.80%	R 425 633.95
93%	1.475791	R 184 473.88	75.35%	5.03%	R 434 473.88
94%	1.554774	R 194 346.70	84.74%	5.35%	R 444 346.70
95%	1.644854	R 205 606.70	95.44%	5.79%	R 455 606.70
96%	1.750686	R 218 835.76	108.01%	6.43%	R 468 835.76
97%	1.880794	R 235 099.20	123.47%	7.43%	R 485 099.20
98%	2.053749	R 256 718.61	144.02%	9.20%	R 506 718.61

This table shows that as the service level increases, the amount of safety stock required becomes *exponentially* larger. There is a staggering 144% increase in the amount of safety stock required between an 80% service level and a 98% service level. Therefore it can be concluded that at the stipulated service level of 98%, the amount of cash with which each ATM is replenished, is *extremely* inflated.

The following sections discuss the impact of holding such high cash inventory in all ATMs on cost, ATM Cash cycle activities and risk.

3.3.1 Impact on Cost

The cost of inventory in the banking environment is generally known as cost of funds (COFs). This is the interest income a bank forfeits on cash while it is in transit or in the cash centre vault or in ATMs. (Straaten, 2009) The COFs incurred per year for the fictional ATM, introduced in section 7.1, when holding cash inventory at various service levels between 80% and 98% is shown in Table 4 below. The percentage increase between the COFs incurred at an 80% service level and each service level increment as well as the percentage increase in the COFs incurred between each consecutive service level increment is also shown.

Table 4: COFs incurred at different service levels

Service level	**COFs incurred** per year per ATM	**Percentage Increase** Between 80% and each service level increment	**Percentage Increase** Between each consecutive service level increment
80%	R 31 968.24		
81%	R 32 376.33	1.28%	1.28%
82%	R 32 797.86	2.60%	1.30%
83%	R 33 234.36	3.96%	1.33%
84%	R 33 687.65	5.38%	1.36%
85%	R 34 159.88	6.86%	1.40%
86%	R 34 653.59	8.40%	1.45%
87%	R 35 171.90	10.02%	1.50%
88%	R 35 718.60	11.73%	1.55%
89%	R 36 298.44	13.55%	1.62%
90%	R 36 917.46	15.48%	1.71%
91%	R 37 583.49	17.57%	1.80%
92%	R 38 307.06	19.83%	1.93%
93%	R 39 102.65	22.32%	2.08%
94%	R 39 991.20	25.10%	2.27%
95%	R 41 004.60	28.27%	2.53%
96%	R 42 195.22	31.99%	2.90%
97%	R 43 658.93	36.57%	3.47%
98%	R 45 604.68	42.66%	4.46%

The COFs incurred shown in the table are calculated, assuming an interest rate of 9%, as follows:

$$\textbf{COFs incurred} = \sum_{i=1}^{365} (\textbf{Holdings on day}_i \times \textbf{interest rate})$$

It is clear that the service level has a significant influence on the COFs incurred. With reference to the example, there is a R 13 636.44[3] difference in the yearly COFs incurred for this *single* ATM between implementing a 98% service level and an 80% service level. Assume that all ATMs in an average network consist of 400 ATMs that are replenished with the same amount. There is an overwhelming R 5 454 576. 00[4] difference in COFs between stocking all ATMs in one network at a 98% service level rather than at an 80% service level. (Please note

[3] R 45 604.68 - R 31 968.24 = R 31 968.24

[4] R 13 636.44/ ATM-year × 400 ATMs/ year-network = R 5 454 576.00/ network. This is not the case in reality and is only done for illustrative purposes

that this assumption is purely for illustrative purposes) It is important to remember that this is only for *one* network of ATMs. The COFs incurred at a 98% service level would be even greater if all ATM networks across the country were to be considered.

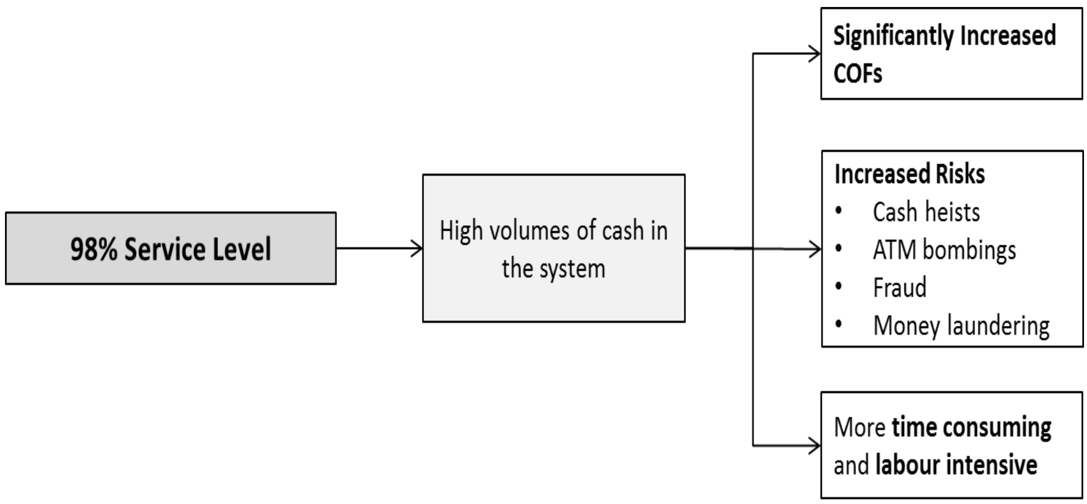
3.3.2 Impact on the ATM Cash Cycle and Risk Factors

As previously discussed, cash is sorted, sealed and recorded on the CIT register on a daily basis. Thereafter, the stop-loss bags are verified by the CIT crew, transported to the ATM destinations and reloaded into the ATMs. (Straaten, 2009) With such inflated volumes of cash in the system as a result of the 98% policy, these activities are much more time consuming, labour intensive and costly[5]. The figure below summarises the impact of the 98% service level on ATM Cash Cycle activities.

As discussed in *Section 5.4 Risk Factors,* the weak security link in the ATM Cash Cycle is the vulnerability of cash while in transit and in the ATMs themselves. (Seldon, 2006) Fraud and money laundering activities also pose a significant operational risk, especially in South Africa. (Adendorff, 1999) With such large volumes of cash in the system, the amount of money that could be stolen in the event of a cash heist, ATM-bombing or money laundering scheme is significantly larger. As a result, the amount of money spent by ABC Bank on security measures is significantly higher.

Figure 9 summarises the impact of the 98% service level policy on cost, risk and operations.

Figure 9: Summary of implications of 98% policy



Taking all of these factors into account, it is clearly advantageous from cost, risk and operational viewpoints to *minimise* the amount of cash in circulation. Servicing ATMs at a 98% service level however does the exact opposite by exponentially inflating the volumes of cash in the system. The fact that holding such high volumes of cash in an ATM is in actual

[5] The operational expenses are beyond the scope of this project. As stated in *Section 2.3 Cost Components*, only COFs are focused on in this report.

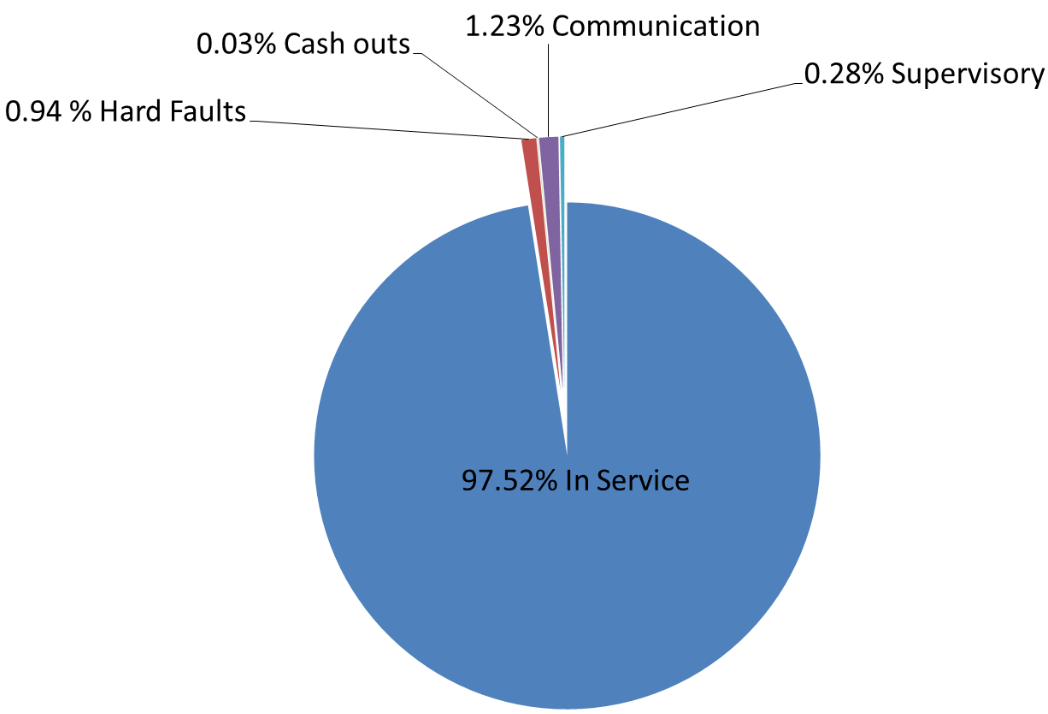
fact not always necessary, coupled with the exceptionally high costs and risks associated with the 98% service level policy, the following conclusion can be drawn:

The 98% service level policy is not optimal and an improved policy which will reduce cost and risk and also improve operational efficiency is necessary.

3.4 The 98% Service Level Policy and ATM downtime

The pie chart in Figure 5 illustrates the percentage of downtime caused by each downtime category i.e. cash-outs, hard faults, communication downtime and supervisory downtime for ATMs belonging to ABC Bank.

Figure 5: ATM downtime



Based on this pie-chart the following points are raised:

1. Why is so much emphasis placed on avoiding a cash-out, when ATMs are down for various reasons? Especially since communication problems are out of management's control and supervisory downtime is a necessary part of ATM management. The pie chart above indicates that hard faults are responsible for approximately 0.94% of downtime, whereas cash outs only result in 0.03% downtime. This implies that for every one cash-out there are 31.3 hard fault occurrences. Placing so much emphasis on avoiding a cash-out specifically seems futile when the ATM could be down for hours due to something as simple as a faulty card-reader.

2. From the pie chart it is evident that the ATM network is in an actual fact operating at a 99.97% service level[6] from a cash holdings perspective and not at the 98% service level

[6] 100% - 0.03% Cash Outs = 99.97% Service Level

specified. The explanation behind this is that the actual service level provided at an ATM must take into account the number of ATMs located next to it. The actual service level is calculated by the equation below: (Cronje, 2012)

$$\textbf{Actual service level provided} = 1 - (\textbf{failure level})^{\wedge \text{Number of ATMs}}$$

$$\text{Where failure level} = 1 - \text{service level}$$

$$= 1 - 0.98$$

$$= 0.02$$

Table 5 shows the implication of this.

Table 5: Actual service level provided

Number of ATMs next to an ATM	Actual Service level provided
1	98.00000%
2	99.96000%
3	99.99920%
4	99.99998%
5	100.00000%

It is evident that servicing *each* individual ATM at a 98% service level is in actual fact unnecessary in order to maintain a 98% service level, which has already proven to be a sub-optimal policy. Therefore, the conclusion that 98% service level policy needs to be replaced by an improved policy is reinforced.

Another factor relating to ATM downtime which supports the notion that the 98% service level policy is not optimal is as follows:

As stated in *Section 2.6 Customer Service,* a shortage at an ATM may occur from time to time and it would be tolerated by the customer, especially when the location is remote from a bank branch or cash centre. (Adendorff, 1999) The explanation behind this is that *the customer is often unaware of the exact reason for the transaction not being processed* and is therefore more willing to accept the shortage situation. (Adendorff, 1999) When considering that the reason behind implementing the 98% policy makes provision for the worst customer behaviour as described below, the necessity for the 98% service level policy is immediately questioned. Therefore, the necessity for an improved policy is once again reaffirmed.

3.5 Conclusion on the Investigation of a 98% Service Level

Taking all of the factors covered in this investigation into account, the following conclusion is drawn:

The implementation of the 98% service level policy at all ATMs is not an optimal policy from various perspectives. These include customer service, cost, risk, current service quality trends and downtime. There is a definite need to provide ABC Bank with an improved policy which will reduce cost and risk.

Figure 10 summarises the findings of this investigation.

Figure 10: Summary of findings

98% Service Level Policy for *all* ATMS is not optimal because..

ATMs are **not all the same** from a **customer's perspective** and in "accepting situations" holding such high volumes of cash in an ATM is in actual fact not necessary

Significantly increased COFs

Increased Risks
Cash heists
ATM bombings
Fraud and money laundering

More **time consuming** and **labour intensive**

ATMs are **down** for various reasons, not only as a result of cash-outs

Service Quality Trend:
"High Touch" service >> "High Tech" service

The question must now be asked: what is the optimal service level for each ATM and how does one go about determining it?

Chapter 4: ATM Service Level Model

The objective of the ATM Service Model is to provide ABC Bank with an optimal service level for each *individual* ATM. The potential savings per ATM, which would result if the optimal service level specified is implemented, is also an output of the model. In order to determine the optimal service level for each ATM, two factors are considered, namely cost and service level. The optimal service level is the service level which provides the highest customer service at the lowest cost.

From a service perspective, the results of the ATM Performance Measurement study conducted by EMFA showed that a user might be very displeased in the event of a missed transaction at one ATM but his or her reaction might differ at another ATM. Therefore, the first step in building the model was to differentiate between ATMs with respect to the factors affecting the gravity of a missed transaction. As the results of the EMFA study are generic in nature, it was first necessary to determine the elements affecting the gravity of a missed transaction that are relevant to ABC Bank specifically. Table 6 shows the elements that are not applicable ABC Bank. These elements are typed in red. In the cases where an element is not applicable, column three in the table provides a reason why this is so.

Table 6: Relevant elements for ABC's ATMs

Factors	Elements: The gravity of a missed transaction is higher…	Reason the element is not relevant
Moment of ATM usage	• During holidays	Already taken into account by TACTIX
	• During (local) events	
ATM characteristics	• **If the ATM has a deposit function**	**Is relevant**
	• If the denomination mix can be chosen	Denomination mix cannot be chosen at any ATMs
	• If the user can check his/her account balance	Users can check account balances at all ATMs
Location	• **If not located next to other ATMs in walking distance**	**Is relevant**
	• **If the ATM is located in a bank branch**	**Is relevant**

Therefore, the elements that differentiate ATMs belonging to ABC Bank include:

- If the ATM has a deposit function,
- If the ATM is isolated (i.e. not located next to another ATM in walking distance),
- If the ATM is in a bank branch,

These relevant elements, as well as each element's weight, are summarised in the Figure 11. It is important to note that the location element ("If the ATM is not located next to another ATM in walking distance") is not deemed to be in sufficient detail for ABC Bank. The location element has therefore been expanded into greater detail, as discussed in Section 8.3, and is implemented as such in the ATM Service Level Model. However, for the purpose of explaining how the ATM model works, only the three elements stated above are utilised.

Figure 11: Differentiating elements and associated weights

Element	If the ATM has a DEPOSIT FUNCTION	If the ATM is or is not located NEXT TO other ATMs in walking distance	If the ATM is located in a BANK BRANCH
Weight	1	2	2

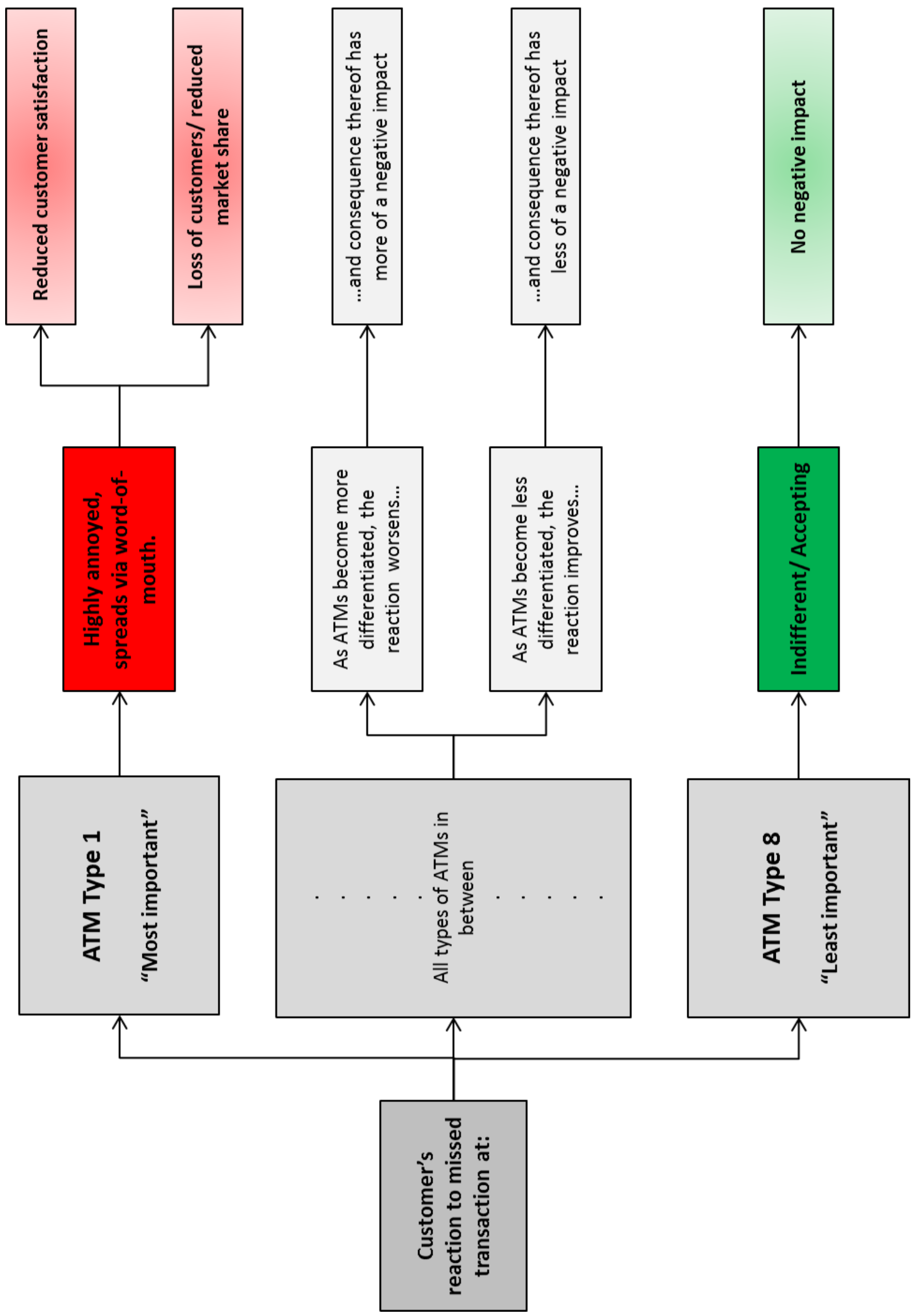
The next step in building the model was to determine which elements apply to each ATM. The associated weights were then summated, as depicted in the Figure 12. The overall weight of each ATM is called the "importance factor" for the purpose of this report.

Table 7: Allocation of importance factors

ATM Type	Differentiating Elements			Importance Factor
	Bank branch?	Another ATM/s in walking distance?	Deposit function?	
	Weight			
	2	2	1	
1	Yes	Yes	Yes	5
	2	2	1	
2	Yes	Yes	No	4
	2	2	0	
3	Yes	No	Yes	3
	2	0	1	
4	No	Yes	Yes	3
	0	2	1	
5	Yes	No	No	2
	2	0	0	
6	No	Yes	No	2
	0	2	0	
7	No	No	Yes	1
	0	0	1	
8	No	No	No	0
	0	0	0	

With reference to Table 6 on the previous page, ATM Type 1 can be viewed as the "most important" ATM. As depicted in the Figure 12, a missed transaction at this ATM will most likely result in a highly annoyed customer. ATM Type 8, on the other hand, can be viewed as the "least important" ATM. A missed transaction at this ATM will most likely result in an "accepting or indifferent customer". For ATM Types 2 to 7, as the ATM becomes more differentiated, the expected reaction of a customer in the event of a missed transaction worsens.

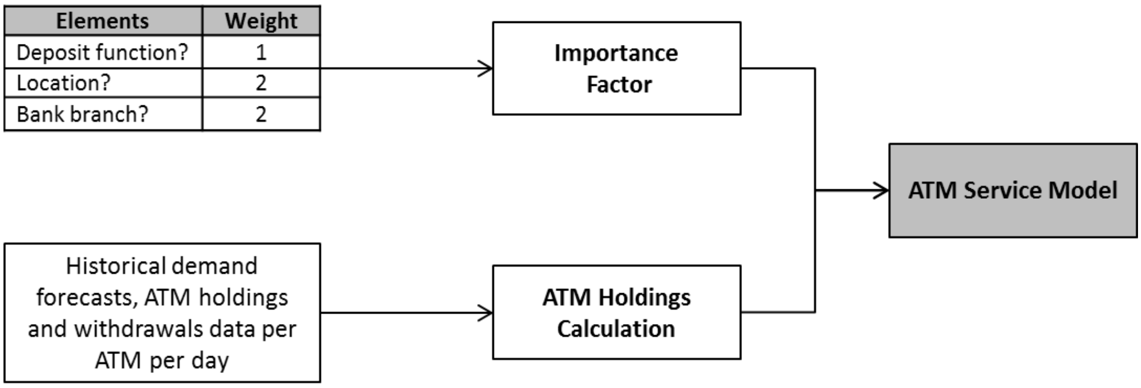
Figure 12: Customer reactions at different ATM types



4.1 How the ATM Service Level Model Works

As illustrated in the Figure 13, the inputs into the ATM Service Level Model include the importance factors linked to each ATM as well as historical data in terms of demand forecasts, ATM holdings and withdrawals per ATM per day.

Figure 13: ATM Service Level Model inputs



The ATM Service Level Model uses the historical demand forecast data and the ATM holdings calculation to calculate what the ATM holdings would have been at service levels starting at 80% and ending at 97%. If the ATM holdings calculated at a specific service level are less than the withdrawals made on that day, then a cash-shortage would have occurred and a certain number of transactions would have been missed. The calculation of the "number of transactions missed" is included in Appendix B.

To illustrate this, assume the following:

Actual ATM Holdings using 98% service level:	R100
Actual withdrawals on day *x*:	R80
Number of withdrawals on day *x*:	5
Average amount withdrawn on day *x*:	R16/ withdrawal

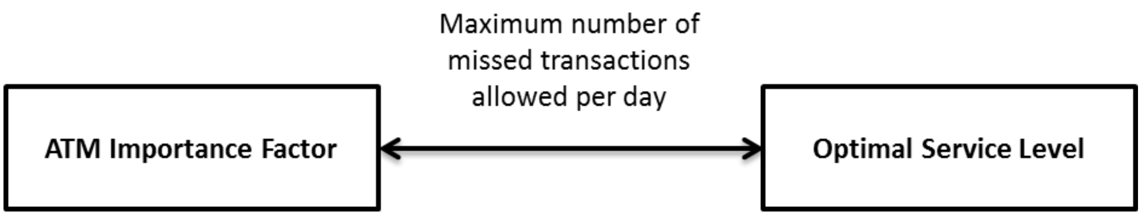
Table 15 shows how the ATM Model works, using the data assumed above. From the table, it is evident that missed transactions only occur at a service level from 82% downwards.

Figure 14: ATM Service Level Model calculations

Service Level	ATM Holdings	Withdrawals	Holdings - Withdrawals	Missed Transactions
98%	R 100.00	R80.00	R 20.00	0
97%	R 96.00	R80.00	R 16.00	0
96%	R 93.00	R80.00	R 13.00	0
95%	R 91.00	R80.00	R 9.00	0
. .	. .	. .	. .	. .
90%	R80.00	R80.00	R 0.00	0
. .	. .	. .	. .	. .
82%	R 78.00	R80.00	-R 2.00	0.125
81%	R 76.50	R80.00	-R 4.50	0.28125
80%	R 75.00	R80.00	-R 5.00	0.3125

The question can now be raised: what number of missed transactions per day is deemed acceptable? In order to answer this question, the importance factor of each ATM comes into effect. The importance factor determines what the optimal service level for an ATM is by means of the maximum number of missed transactions allowed per day, as illustrated in the figure below.

Figure 15: The number of missed transactions allowed per day



Each importance factor is linked to a maximum number of missed transactions allowed per day. The logic behind allocating the number of missed transactions allowed per day for each importance factor, and the effect thereof, is discussed below:

- The *higher* the Importance Factor is, the *more* imperative it is for an ATM to be sufficiently stocked to meet customer demand and therefore the number of missed transactions allowed per day is *lower*. This will result in a higher optimal service level to be allocated to the ATM. However due to the importance of the ATM, a high service level is actually necessary from a customer perspective. Therefore, the increased costs and risks of inflated ATM holdings would be justified.
- The *lower* the Importance Factor is, the *less* imperative it is for an ATM to be sufficiently stocked to meet customer demand and therefore the number of missed transactions allowed per day is *higher*. This will result in a lower optimal service level to be allocated. A high service level is fact not necessary from a customer

service perspective and the increased costs and risks that would be incurred are not justified.

Table 8 shows the number of missed transactions allowed for each Importance Factor[7].

Table 8: Number of missed transactions allowed for each Importance Factor

Importance Factor	Maximum number of missed transactions allowed per day
5	0
4	1
3	2
2	3
1	4
0	5

Continuing with the 8 Example Types of ATMs discussed previously, Table 10 on the following page represents how the optimal service level is determined per ATM per day.

The green blocks indicate that the service level is acceptable. A red block indicates that at the corresponding service level, the number of transactions that would have been missed, exceed the number of transactions allowed for the importance factor linked to that ATM. Therefore the red block indicates that the service level is not acceptable. The optimal daily service level is the lowest service level which is deemed to be acceptable i.e. the last green block is the optimal service level for that ATM.

It is important to note that process depicted in Table 10 is carried out for every single day of historical data that the model is based on. As a result, the daily optimal service levels differ from one another for the same ATM. The overall optimal service level which the model determines for the ATM once the model has run to completion is the *maximum* daily optimal service level over all of the days. This is depicted in Table 9 (100 days are assumed for illustrative purposes). This ensures that there are no days during which the number of missed transactions allowed for the specific ATM is exceeded. This is done to always maintain a high level of customer service required for the ATM.

[7] It is important to note that the model is built in such a way so that *the maximum number of missed transactions allowed per importance factor* as well as the *weights allocated to each element* can be easily changed and adjusted at management's discretion. This is done because the values allocated to these variables have a significant impact on the optimal service levels determined for each ATM.

Table 9: Overall optimal service level

Day	1	2	3	.	.	.	98	99	100
Optimal Service Level	94%	89%	91%	.	.	.	82%	86%	89%
Overall Optimal service level = Max(optimal service level for all days) = 94%									

Table 10: How the daily optimal service level is determined

Service level	Number of missed transactions per day	ATM Type							
		1	2	3	4	5	6	7	8
		Importance Factor							
		5	4	3	3	2	2	1	0
		Corresponding number of missed transactions allowed per day							
		0	1	2	2	3	3	4	5
98%	0.00								
97%	0.08								
96%	0.12								
95%	0.58								
94%	0.92								
93%	1.05								
92%	1.35								
91%	2.07								
90%	2.42								
89%	2.99								
88%	3.40								
87%	4.05								
86%	5.28								
85%	6.65								
84%	7.50								
83%	910								
82%	11.00								
81%	14.40								
80%	18.80								
Optimal Service Level		**98%**	**95%**	**92%**	**92%**	**89%**	**89%**	**88%**	**87%**

4.2 Calculation of Potential Savings

The second output of the ATM Service Model is the potential savings per ATM, which would result if the optimal service level specified is implemented. The calculation of potential savings for each service level is shown below:

Potential savings per year =

COFs saved on reduced holdings – Profit lost on missed transactions

This is demonstrated by way of the same example data used previously. To recap, assume the following:

Actual ATM Holdings using 98% service level:	R100
Actual withdrawals on day *x*:	R80
Number of withdrawals on day *x*:	5
Average amount withdrawn on day *x*:	R16/ withdrawal
Profit made per transaction	R2.00
Interest rate at which COFs is charged	9% pa

Table 11 illustrates how the potential savings, at service levels ranging between 80% and 97%, are calculated.

Table 11: Calculation of potential savings

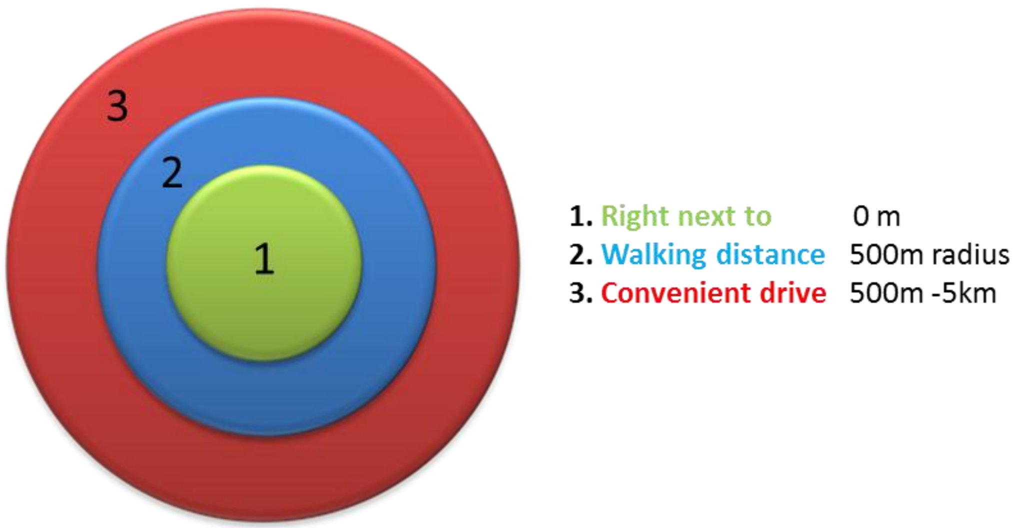
Service Level	ATM Holdings per year	Reduced ATM holdings per year	COFs saved on reduced holdings	Profit lost on missed transactions	Potential Savings
98%	R 36 500.00	R 0.00	R 0.00	R 0.00	R 0.00
97%	R 35 040.00	R 1 460.00	R 131.40	R 0.00	R 131.40
96%	R 33 945.00	R 2 555.00	R 229.95	R 0.00	R 229.95
95%	R 33 215.00	R 3 285.00	R 295.65	R 0.00	R 295.65
.	.	.	.	.	.
.	.	.	.	.	.
90%	R 29 200.00	R 7 300.00	R 657.00	R 0.00	R 657.00
.	.	.	.	.	.
.	.	.	.	.	.
82%	R 28 470.00	R 8 030.00	R 722.70	R 182.50	R 540.20
81%	R 27 922.50	R 8 577.50	R 771.98	R 204.40	R 567.58
80%	R 27 375.00	R 9 125.00	R 821.25	R 229.95	R 591.30

From the figures in the table above it is evident that as the service level decreases, the potential for savings increases. It is important to note that the savings illustrated in the table above are only fictional values relating to the example. When considering the actual ATM holdings and withdrawals data, (which have not been included for confidentiality reasons) the savings which could be made by ABC bank are *exponentially* larger.

4.3 The Location Factor

As previously stated, the "if not located next to other ATMs in walking distance" factor was not deemed to be in sufficient detail. The reason behind this is that a completely isolated ATM in a rural area should be treated differently to an ATM that, for example, has three ATMs right next to it. Therefore, for the purpose of this model, the location factor was further divided into the following categories:

Figure 16: Location categories



Another factor to consider is that an ATM situated in a developed urban area could, for example, have as many 20 ATMs within a 500m radius. Therefore if this ATM were to run out of cash, a consumer could *easily* make use of one the many surrounding ATMs. When comparing this situation to an ATM that only has one other ATM within a 500m radius, it is clear that there is a large difference between the two scenarios. Therefore another factor, namely "number of ATMs within a location category" is introduced.

When taking these two factors into account, all of the elements and allocated weights that are utilised to determine the importance factors of the ATMs belonging to ABC Bank are summarised in the table on the following page. The logic behind the allocation of the weights to the different location categories is explained in detail in Appendix C.

It is again important to note that the model is built in such a way so that the weights allocated to each element, as depicted in the Table 12, can be easily changed and adjusted at management's discretion. This is done because the value allocated to these variables have a significant impact on the optimal service levels reached for each ATM.

Table 12: Factors and allocated weights

Factors	Elements: The gravity of a missed transaction is higher…		Weight
ATM characteristics	If the ATM has a deposit function		1
Location	If the ATM is located in a bank branch		2
	Category	**Number of ATMs**	
	0m Right next to	0	**5**
		1 - 2	4
		3 - 4	3
		5 - 11	1
		12 - 26	0
	500m radius Walking distance	0	**4**
		1	3
		2 - 3	2
		4 - 12	1
		13 - 34	0
	500m-5km Convenient drive	0	**3**
		1 - 23	2
		24 - 31	1
		32 - 57	0.5
		58 - 102	0
Maximum weight possible			**15**

4.4 Model Validation

The model is validated in terms of how it addresses the reasons behind implementing the 98% service level policy in the first place.

To recap, ABC implements the policy for the following two reasons:

Reason 1: To avoid the lost transaction fee associated with a missed transaction

Reason 2: Most importantly, to maintain good ATM performance in terms of customer service provided. The policy makes provision for the worst customer behaviour, since the factors affecting the gravity of a missed transaction were previously unknown.

With respect to the first reason listed above, from the potential savings per day calculation (i.e. Potential savings per year = COFs saved on reduced holdings – *Profit lost on missed transactions*) it is clear that the model takes the lost transactional fees into account. The COFs saved on reduced holdings however, outweigh the lost profit made on the transaction. Therefore, losing potential profit is not a valid reason for implementing the 98% service level policy. On the contrary, ABC Bank could generate *massive* savings if the ATMs are stocked at optimal service levels prescribed by the ATM Model.

In terms of Reason 2, the "worst customer behaviours" assumed when implementing the 98% Service level policy, are not a true reflection of reality. The "worst customer behaviour" assumed are listed below. The reason why the assumption is invalid is discussed after each point.

- Customers are *always* highly annoyed when a transaction cannot be processed at an ATM, irrespective of the time of ATM usage, the unique ATM characteristics or the location of the ATM.

    - The study conducted by EMFA showed that customers are *not* always highly annoyed when a transaction cannot be processed and that the reaction of the customer is *significantly* affected by the time of ATM usage, the unique ATM characteristics or the location of the ATM. (EMFA, 2012) Therefore this assumption is null and void.

- The ATM service provided by a financial institution has a large impact on how customers evaluate the quality of the financial institution's service. In other words, missed transactions at ATMs contribute significantly to the perceived level of customer service provided by a financial institution and result in diminished customer satisfaction and leads to the loss of customers themselves.

    - In today's society, customers are evaluating banks based more and more on their personal support rather than their technical support. (Angur, et al., 1999) With this in mind, as well as the EMFA results, the "worst customer behaviour" described above is not a true reflection of reality and is therefore not a good enough reason to implement the 98% policy.

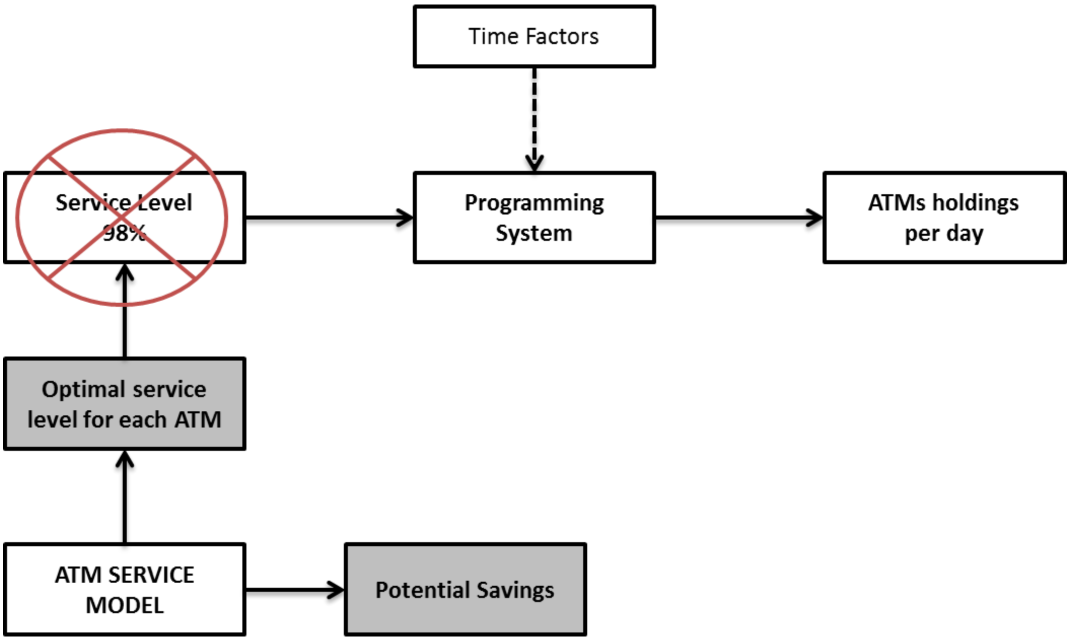
- Customers are always aware of the exact reason for the transaction not being processed. In the event that the ATM is out of cash, the customers view this to be the worst category of downtime.

    - Studies show that customers are not always aware of the exact reason for the transaction not being processes and are therefore more willing to accept a shortage situation. (Adendorff, 1999) Therefore the above "worst customer behaviour" is inaccurate and cannot be used as a valid reason to implement the 98% service level policy.

It can be concluded that both Reason 1 and 2 are not valid and therefore do not justify implementing the 98% service level. Always providing a 98% service level is not actually necessary from a customer's perspective and therefore the increased costs and risks incurred as a result are not warranted. By means of an Importance Factor linked to each ATM, the ATM model ensures that each and every ATM provides the service level *actually required* by the customers themselves. Therefore, good ATM performance *will be* maintained, however this will be done in a more *cost-efficient* way. From this perspective, the ATM Service Level Model can be seen as an improved and valid replacement for the 98% service level policy.

As depicted in Figure 17, it is proposed that ABC Bank no longer implement the 98% service level policy but rather makes use of the ATM Service Model, as described in this section.

Figure 17: ATM Service Level Model in context



5. Conclusion

This report substantively proves that ABC Bank should no longer implement a blanket 98% service level policy. Servicing each ATM, irrespective of whether the ATM has a deposit function or *where* it is located relative to a bank branch as well as other ATMs, does not make strategic sense. This, coupled with the fact that the policy is not efficient from a cost, risk or operational perspective, fully undermines its validity.

Therefore, it is proposed that ABC Bank replace the policy with the ATM Service Level Model, built for the purpose of this project. The ATM Service Level Model ensures that each ATM will provide the appropriate service level *required* by the customers at that specific ATM. This is done by using the individual characteristics of each ATM, as well as ATM specific historical withdrawal-holdings data, to find the optimal balance between service and cost. As proven in this report using fictional data, implementing the ATM Service Level Model would result in significant savings for ABC Bank, while simultaneously maintaining the level of ATM Performance required for ABC Bank to be competitive in the financial services industry.

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Appendix A: Time Factors

Table 13: List of Time Factors

Event	Event Description	Event Type
D_1	Day - Sunday	Day of Week
D_2	Day - Monday	Day of Week
D_3	Day - Tuesday	Day of Week
D_4	Day - Wednesday	Day of Week
D_5	Day - Thursday	Day of Week
D_6	Day - Friday	Day of Week
D_7	Day - Saturday	Day of Week
W_1	Week - 1	Week of Month
W_2	Week - 2	Week of Month
W_3	Week - 3	Week of Month
W_4	Week - 4	Week of Month
M_01	Month - January	Month of Year
M_02	Month - February	Month of Year
M_03	Month - March	Month of Year
M_04	Month - April	Month of Year
M_05	Month - May	Month of Year
M_06	Month - June	Month of Year
M_07	Month - July	Month of Year
M_08	Month - August	Month of Year
M_09	Month - September	Month of Year
M_10	Month - October	Month of Year
M_11	Month - November	Month of Year
M_12	Month - December	Month of Year
PD_01st	Payday - 01st	Payday
PD_15th	Payday - 15th	Payday
PD_20th	Payday - 20th	Payday
PD_22nd	Payday - 22nd	Payday
PD_23rd	Payday - 23rd	Payday
PD_25th	Payday - 25th	Payday
PD_27th	Payday - 27th	Payday
PD_Pension	Payday - Pension	Payday
PD_MonthEnd	Payday_MonthEnd	Payday
PH_NewYears	Public Holiday - New Years Day	Public Holiday
PH_HumanRights	Public Holiday - Human Rights Day	Public Holiday
PH_GoodFriday	Public Holiday - Good Friday	Public Holiday
PH_EasterMonday	Public Holiday - Easter Monday	Public Holiday
PH_FreedomDay	Public Holiday - Freedom Day	Public Holiday
PH_WorkersDay	Public Holiday - Workers Day	Public Holiday
PH_YouthDay	Public Holiday - Youth Day	Public Holiday
PH_WomansDay	Public Holiday - Womans Day	Public Holiday
PH_HeritageDay	Public Holiday - Heritage Day	Public Holiday
PH_ReconciliationDay	Public Holiday - Reconciliation Day	Public Holiday
PH_ChristmasDay	Public Holiday - Christmas Day	Public Holiday

PH_DayOfGoodwill	Public Holiday - Day of Goodwill	Public Holiday
PH_Other	Public Holiday - Other	Public Holiday
SH_Apr	School Holiday - April	School Holiday
SH_Jun	School Holiday - June	School Holiday
SH_Sep	School Holiday - September	School Holiday
SH_Dec	School Holiday - December	School Holiday
SP_Vote	Special - National Voting Day	Special
SP_2nd	Special - 2nd day of month	Special
SP_PreEasterWeekend	Special - Pre-Easter Weekend	Special
SP_PreLongWeekend	Special - Pre-Longweekend	Special
SP_ChristmasShopping	Special - Christmas Shopping	Special
PD_Christmas15thPayday	Payday - Christmas 15th Payday	Payday
SP_NovLast6Days	Special - November Last 6 Days	Special
SP_ELWeek1Nov	Special - East London Week 1 November	Special
SP_HolidayTravel	Special - Holiday Travel	Special
SP_GovBackPay	Back pay issued for government employees	Special

Appendix B: Number of Missed Transactions Calculation

The average amount of cash withdrawn per transaction per day is calculated as follows:

$$\frac{\textbf{Rand}}{\textbf{transaction}} = \frac{\textbf{Total amount withdrawn per day}}{\textbf{number of transactions recorded per day day}}$$

If the number of transactions that would be missed if the holdings calculated using a lower service level (between 80% - 97%) is less than the actual amount of cash withdrawn on that specific day then:

$$\textbf{Number of missed transactions} = \frac{\textbf{New holdings} - \textbf{Actual withdrawals}}{\frac{\textbf{Rand}}{\textbf{transaction}}}$$

Appendix C: The Location Factor Expanded

For the ATM benign to ABC Bank, the following population characteristics are evident for each of the decided upon location categories.

Table 14: Population Characteristics of ATM Network

Population Characteristics	Number of ATMs within		
	0m	**500m radius**	**500m-5km radius**
Minimum value	0	0	0
Standard deviation	5.2	5.5	24.8
Mean	4	3	31
Maximum value	26	34	102
Median	1	0	22

These population characteristics are used to determine the appropriate intervals for "number of ATMs within a certain distance" factor.

Table 15: Intervals for Location Categories

Characteristic Driver	Intervals for Number of ATMs within		
	0m	**500m radius**	**500m-5km radius**
Minimum value	0	0	0
Median + 1	1 - 2	1	1 - 23
Mean	3 - 4	2 - 3	24 - 31
Mean + Roundup(Max/4)	5 - 11	4 - 12	32 - 57
Maximum value	12 - 26	13 - 34	58 - 102

The logic behind the allocation of weights to the location categories are discussed in more detail below:

- **The fewer ATMs that are within a given location category, the higher the weighting is**

Consider the 500m category. The EMFA study showed that when an ATM has other ATM(s) within *walking distance*, the effect of a cash-out is negligible since the customer can simply walk to another operational ATM. The converse is also true: when an ATM does not have other ATMs within walking distance, it is more inconvenient for a consumer since he or she needs to drive to find another ATM. Therefore the fewer ATMs that are within walking distance, the higher the allocated weight is.

- **The further the distance from the ATM, the lower the weighting is**

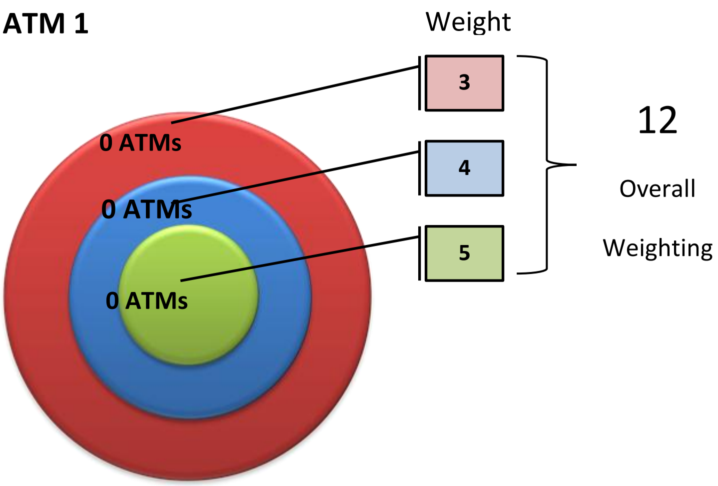
Category	Number of ATMs	Weight
0m	0	**5**
500m radius	0	**4**
500m -5km radius	0	**3**

Since walking to another operational ATM is more convenient than having to drive to another ATM, as the location intervals increase, the weightings decrease.

The remaining weights within each location category are incrementally decreased so that the last "number of ATMs within a location category" interval is allocated a weight of 0. The scenarios on the following pages illustrate and explain the logic behind the weights allocated to the different location categories and intervals by means of comparative examples.

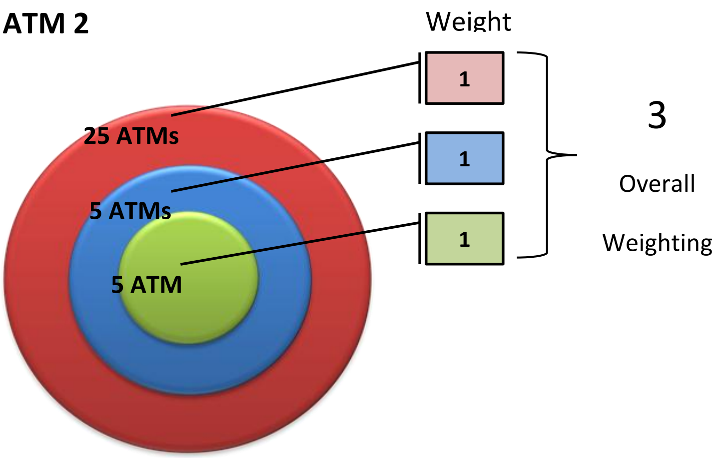
Scenario 1

ATM 1



ATM 1 has the highest importance because it is completely isolated. In other words, if ATM 1 is down then the customer needs to drive 5km or further to find another ATM. This would be inconvenient for the customer and have larger negative impact on that customer's perspective of the bank than in the case of ATM 2.

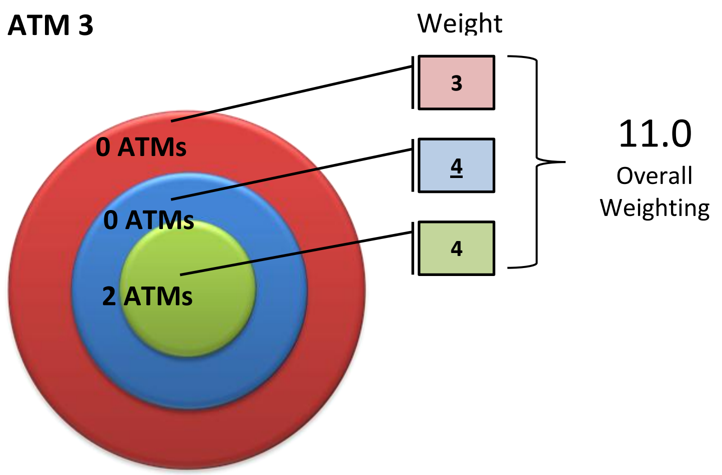
ATM 2



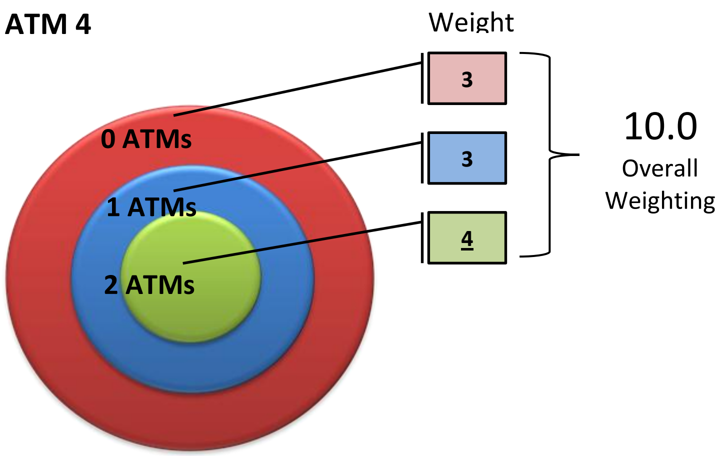
ATM 2 has 5 other ATMs right next to it as well as another 5 within walking distance. Therefore in the event that ATM 2 cannot fulfil the required transaction, it is *far* more convenient for the customer to make use of another ATM, and therefore the overall weighting is less.

Scenario 2

In the case of the two ATMs below, it is important to note that the "blue weighting" of 4 and the "green weighting" of 4 does not suggest that having 2 ATMs in a 0m radius is equivalent to having no ATMs within a 500m radius. This is because the weights are "cascaded on top of one another" in order to determine the overall importance of the ATM from a location perspective. Therefore the weights should not be compared across categories but rather within the same category to determine relevant importance.



The customer is completely dependent on the 2 ATMs right next to it. However, in the event that *both* of these ATMs are out of order, the customer needs to drive for +5km to find another ATM.



The customer is not completely dependent on the 2 ATMs right next to it. However, in the event that *both* of these ATMs are out of order, the customer has the option to walk 500m to the next ATM. Therefore ATM 4 has a lower overall weighting than ATM 3.