REGULATORY COMPLIANCE LEVERAGING PLATFORM

BTECH 451 Final Report

Karthik Padullaparty
Kpad470 | 2224454

Academic Supervisor
Lech Janczewski
Associate Professor – Information Systems
Yun-Sing Koh
Senior Lecturer – Computer Science
Industry Mentor
Gabriel Akindeju
Managing Director – Risks Consult Limited

RCL
Business Technology Risk Management

TABLE OF CONTENTS

Abstract 3
Key Words 3
1 Introduction 4
2 About RCL 5
3 People Involved 6
4 Business Problem 7
5 Background 8
5.1 Standards 8
5.1.1 Payment Card Industry Data Security Standard (PCI DSS) 8
5.1.2 SOX 9
5.1.3 ISO 27002 10
6 Related Works 13
6.1 Current research works – in this industry 13
6.2 Comparison of the research papers 17
6.3 Current technologies / platforms 18
6.4 Comparison of the technologies 20
7 Proposed Solution 21
7.1 Industry 21
7.2 Security Instruments 22
7.3 Methodology – 5 aspects of the platform. 22
7.4 Analysis of the methodology 24
8 Comparison Construct of the Standards 25
8.1 Controls grouping 25
8.2 Classification of Regulatory Instruments 26
8.3 Comparison Construct 29
9 Platform 31
9.1 Web-based vs App-based 31
9.2 Design 31
9.2.1 Frontend Design 32
9.2.2 Backend Design 37

9.3 Technologies....41
9.3.1 ASP.NET with SQL....41
9.3.2 HTML/CSS with AJAX....42
9.3.3 PHP with MySQL....43
9.3.4 Platform....44
10 What is next?....47
10.1 Timeline detailing my progress and future works....47
10.1.1 Timeline....47
10.1.2 Future Work....48
11 References....50

ABSTRACT

The aim of this research is to create a platform that will assist financial institutions comply with three main regulatory instruments while cutting their costs. In this research, the three main instruments in focus namely Sarbanes-Oxley, Payment Card Industry Data Security Service and ISO 27002 have been outlined and how they can be integrated into this platform has been explained along with the reasoning for the decisions made. Towards the end of the report, I have addressed different technologies that are possibilities for the back-end of this platform and the proposed technology with the reasoning behind my proposition. Testing in the future would need to be done to determine whether the changes I propose have any impact on the financial institutions and their compliance costs.

Key Words

Information Security, Regulatory Compliance, Platform, ISO 27002, PCIDSS, SOX, HTML, PHP, MySQL, Impact Zones, 11 Essential Controls.

1 INTRODUCTION

Information is the lifeblood of organisations — a vital business asset in today's Information Technology–enabled world. Access to high-quality, complete, accurate and up-to-date information is crucial in supporting managerial decision-making processes that lead to sound decisions. Therefore, having secure information system resources is extremely important to ensure that the company resources are well protected.

With the assistance of an information security management system (ISMS), organisations are able to apply a set of policies that will help them construct, develop and maintain security for their computer systems, both hardware and software. These policies will dictate the use of these resources in the protection of sensitive data.

Information security is not simply protecting your data with a username and password, but a lot more. Most organisations are obligated to impose various privacy and data protection policies and regulations, as they are continuously threatened by worms, viruses, bugs, hackers, and so on. A hacker, also known as an unidentified user, can cause huge losses for organisations by merely altering bits of information, stealing customer/employee data or even pilfering business strategies and selling them to competitors.

Banking and Financial Institutions also require such standards to protect their systems as they are the most at risk. They hold sensitive information not only about their employees, but also about their customers. Financial information is very important to everyone and once compromised it could cost a lot for an organisation.

The structure of this report is organised as follows. Section 2 presents a small background about the company RCL and their objectives. In Section 3, I list the people who are and have been an integral part of this project and its success. Section 4 outlines the business problem given by RCL, with a proposed solution in Section 5. A brief analysis of the current research in the field of compliance and the technologies that are available similar to the solution I am proposing in this report are mentioned in Section 6. I give a brief background into each of the regulatory instruments chosen in Section 7 and in Section 8 I complete a brief analysis and comparison of these instruments and how they tie into the platform. The penultimate section, Section 9, mentions briefly about the technologies I would like to use and implement in the platform. Finally to finish off, I wrap up this report with a timeline and what I plan to complete in the future.

2 ABOUT RCL

Risk Consult Limited is a Business Technology Risks Management Consulting Practice (RCL, 2014).

It consists of a team of professionals who are Certified Information Systems & Security Professionals (CRISC, CISM, CISSP, CISA, SCF, & PRInCE II) with backgrounds in Information Systems Management, Engineering, System Architecture, Business Process Engineering and Project Management. They have extensive Technology Risk Management & Information Systems Security governance, management and architecture experience from both private and public corporate environments.

They also have extensive experience in Financial and Business Audit Support, including but not limited to regulatory support, such as Sarbanes Oxley, BASEL I & II, HIPAA, Cloud Computing Standards, AIPAC SOCs, and so on, as well as industry standards such as ISO 2700x, and PCIDSS.

Their people are world-class industry thought leaders who have been part of the Big4 Professional Services environment. They have also had the privilege of pioneering and setting up Information Systems Security and Control teams both within New Zealand and internationally.

They have continued to work with a broad understanding that technologies are not only implemented in businesses for the sake of themselves, but also to drive and deliver values. They also understand that these technologies can lead to value leakage if risks are not optimised. They have developed the best-in-breed technology risks optimisation approaches and concepts, and have helped businesses achieve both of these objectives.

Having helped many corporates achieve these objectives, they can help with any business technologies-related risk management activities, including but not limited to:

- Business technology risk assessment along the entire lifecycle of business technology assets from concepts through to asset decommissioning
- Information asset protection strategies, implementation and operations
- Business technology risk management strategies and implementations
- Information security architectures and frameworks – design, implementation and operations

3 PEOPLE INVOLVED

There are several people involved with this project, from either RCL or the University of Auckland. Here are some of the key people that were important to the success of this project.

- **Industry mentor: Gabriel Akindeju**
  Gabriel is the Managing Consulting Director for RCL, who has been assisting me and supporting me throughout this project in terms of both moral support and resources provided.
- **Academic supervisor: Lech Janczewski**
  Lech is an Associate Professor at the University of Auckland specialising in Information Security. He has been key to my project in terms of the experience he possesses.
- **Academic supervisor: Yun Sing Koh**
  Yun Sing is a Senior Lecturer at the University of Auckland, who also is an expert in her field of data mining. I have kept in constant touch with her during the progress of the project. However, she is not available for the second half of my project.
- **BTech Coordinator: Sathiamoorthy Manoharan (Mano)**
  Mano is the BTech (IT) Coordinator and is the one who manages the BTech 451 project course. He was the one who validated my project.
- **My Parents: Ram and Madhavi Padullparty**
- **Special Thanks: Matthew Hicks** (For his assistance in my PHP coding)

4 BUSINESS PROBLEM

Regulatory and Industry Standards, including but not limited to Information Security Compliance, are a must for organisations wanting to operate above board to avoid contingent liabilities and to meet and satisfy customers' needs. However, compliance evidencing is a huge cost for businesses, especially when they have to provide evidence of compliance with multiple requirements and are policed by different authorities.

Information Security is very important for all organisations. There are multitudes of Information Security regulatory and industry standards that most organisations/businesses need to comply with. The costs of compliance audit and evidential proof of compliance could be daunting.

For example, Company X is a financial institution that wants to comply with three main regulatory instruments. Payment Card Industry Security Standards Council is enforcing Company X to comply with their PCI DSS standard due to their credit card transactions. Similarly, since the company has recently started their trading in the United States of America (USA), it was obligatory for them to make sure that they are regulated by the Sarbanes–Oxley Act. The company had already been following ISO 27002 standard to initiate, implement and maintain their information security management systems.

A typical compliance evidence process includes auditing and compliance reporting with typical associated cost profile. The table below lists the average associated costs for each of the standards Company X has to comply with.

The below figures are an estimate that have been retrieved from various websites and are not current costs. (Braintree, 2008), (Financial Executives, 2008), (PivotPoint Security, 2010)

	ISO 27002	***PCI DSS***	***Sarbanes-Oxley Act***	***Total***
Auditing Costs	$12,000	$362,500	$1,500,000	$1,874,500
Ongoing evidential costs	$10,000	$125,000	$250,000	$385,000
Total	**$22,000**	**$487,500**	**$1,750,000**	**$2,259,500**

With more than $2 million being spent on compliance, RCL has suggested a proposal of platform that will not only cut down the costs by more than 60%, but will also assist Company X to be compliant with all three of these instruments at once.

The estimated percentage value is a rough representation of the proposed savings suggested by RCL. This project is the development of a framework to help businesses optimise the value and minimise the cost of review and proofing compliance.

RCL Director Gabriel Akindeju has given me a project to create a platform that allows companies to select a set of regulatory instruments and the industry standards that impact

their business. This platform will then be able to perform minimal sets of walk-through reviews that will meet all of the requirements of the identified instruments.

Evidential proof of compliance can then be generated within the period of validity of the review and records to satisfy all of the business stakeholders.

5 BACKGROUND

5.1 STANDARDS

Standards are introduced to regulate the governance over the information security, which is very important to all organisations. Although there are many regulations and standards widely available, they are not adopted by most organisations for a variety of reasons. Mainly because of the cost involved. While evaluating the many options for network security solutions, it is essential to understand and consider the role of security standards. The growth in distributed computing and the ensuring increase in computer crime have led to legislation and regulations that establish legal requirements for network and data security (Kozlay, 2014).

Figure 1 - (Manske, 2007)

The three standards that are vital to this project are PCI DSS, ISO 27002 and Sarbanes-Oxley. In the following sections, there is a brief background on each of them, as well as the importance of each of their domains.

5.1.1 Payment Card Industry Data Security Standard (PCI DSS)

The Payment Card Industry Data Security Standard (PCI DSS) is a set of requirements for enhancing security of payment customer account data. It was developed by the founders of the PCI Security Standards Council, including American Express, Discover Financial Services, JCB International, MasterCard Worldwide and Visa to help facilitate global adoption of consistent data security measures. PCI DSS includes requirements for security management, policies, procedures, network architecture, software design and other critical protective measures.

There are 12 main controls areas, each with numerous controls within them. Although they are classified into 6 zones, the controls are not restricted to these specified zones, some of the internal controls address issues that are relevant in other zones.

1. Build and Maintain a Secure Network
    a. Install and maintain a firewall configuration to protect cardholder data

   b. Do not use vendor-supplied defaults for system passwords and other security parameters
2. Cardholder Data
   a. Protect stored cardholder data
   b. Encrypt transmission of cardholder data across open, public networks
3. Maintain a Vulnerability Management Program
   a. Use and regularly update anti-virus software or programs
   b. Develop and maintain secure systems and applications
4. Implement Strong Access Control Measures
   a. Restrict access to cardholder data by business need-to-know
   b. Assign a unique ID to each person with computer access
   c. Restrict physical access to cardholder data
5. Regularly Monitor and Test Networks
   a. Track and monitor all access to network resources and cardholder data
   b. Regularly test security systems and processes
6. Maintain an Information Security Policy
   a. Maintain a policy that addresses information security for employees and contractors

These controls will be compared and analysed alongside the other two instruments, for common zones, that may assist in addressing the business problem.

5.1.2 SOX

The Sarbanes-Oxley Act, 2002, is designed to protect investors and the public by increasing the accuracy and reliability of corporate disclosures. It was enacted after the high-profile Enron and WorldCom financial scandals of the early 2000's. It is administered by the Securities and Exchange Commission, which publishes SOX rules and requirements defining audit requirements, and the records that businesses should store and for how long (Seider, 2004). This standard can be used for multiple purposes but for this report, I will be referring to the general controls that overlook Information Technology.

There are two levels of controls that need to be considered when attempting to comply with SOX – the company level and the general level.

There are four main categories that need to be considered the company-level:

- Control Environment
  - The control environment creates the foundation for effective internal control, establishes the "tone at the top", and represents the apex of the corporate governance structure.
- Information and Communication
  - The identification, management and communication of relevant information represents an ever-increasing challenge to the IT department.
- Risk Assessment

  - Risk assessment involves the identification and analysis by management of relevant risks to achieve predetermined objectives, which form the basis for determining control activities.
- Monitoring
  - Monitoring, which covers the oversight of internal control by management through continuous and point-in-time assessment processes, is becoming increasingly important to IT management.

At the general level, the general controls are commonly defined as being the controls that are applicable across all IT systems and are essential to ensuring integrity, reliability and quality of the systems. These controls are standardised across the company and are centrally administered, controlled and repeatable (Seider, 2004).

The IT general controls are:

- Acquire or Develop Application Software
- Acquire Technology Infrastructure
- Develop and Maintain Policies and Procedures Install and Test Application Software and Technology Infrastructure
- Manage Changes
- Define and manage service levels
- Manage third-party services
- Ensure systems security
- Manage the configuration
- Manage problems and incidents
- Manage data
- Manage operations

Figure 2 - (Assuria, 2015)

The granularity of the expansion of general controls depends on how the company operates. As a result, a consumer soft goods manufacturer can be expected to have a number of significantly different controls than an internet service provider (Seider, 2004).

For this project, I will be using the above listed controls and comparing them to the other instruments and how they assist in addressing the business problem.

5.1.3 ISO 27002

ISO 27002, although it belongs to the same family of standards, varies slightly to ISO 27001. You cannot get certified with ISO 27002 because it is not a management standard, which means that it does not define how to run a system. Also, ISO 27001 defines the Information Security Management System (ISMS), unlike ISO 27002 (Kosutic, 2010).

Figure 3 - (Manske, 2007)

Although I mentioned that I am referring to ISO 27002 above, their controls listed are a derivative form of ISO 27001. The ISO 27002 standard describes a comprehensive set of information security control objectives and a set of generally accepted good practice security controls.

It contains 12 main control areas:

1. Risk assessment
2. Security policy
    a. Management direction for information security
3. Organization of information security
    a. Internal Organisation
    b. Mobile devices and teleworking
4. Asset management
    a. Responsibility of assets
    b. Information classification
    c. Media handling
5. Human resources security
    a. Prior to employment
    b. During employment
    c. Termination and change of employment
6. Physical and environmental security
    a. Secure areas
    b. Equipment security
7. Communications and operations management
    a. Operational procedures and responsibilities
    b. Protection of malware
    c. Backup
    d. Logging and monitoring
    e. Control of operational software
    f. Technical vulnerability management
    g. Information systems audit considerations
8. Access control
    a. Business requirements of access control
    b. User access management
    c. User responsibilities
    d. System and application access control
9. Information systems acquisition, development and maintenance
    a. Security requirements of information systems
    b. Security in development and support processes
    c. Test data
10. Information security incident management
    a. Management of information security incidents and improvements
11. Business continuity management
    a. Information security continuity
    b. Redundancies
12. Compliance

a. Compliance with legal and contractual requirements
b. Information security reviews

The controls listed above will be used in building a comparison construct, (See Section 8), and how they link together with the other two instruments. Although I have only listed the overall control zones each of the instruments are aimed at, we can already notice a few commonalities that appear. These commonalities will form the foundation for the platform, which I shall cover in more detail in Section 9.

6 RELATED WORKS

6.1 CURRENT RESEARCH WORKS – IN THIS INDUSTRY

Financial institutions and regulation compliance go hand in hand and there are multiple research papers and articles available, however they cover a variety of different aspects. There are two such reports that I have found are related to my project:

- Information Security Management System Standards: A Comparative Study of the Big Five
  Heru Susanto, Mohammad Nabil Almunawar and Yong Chee Tuan, 2011

- IT Audit Challenges for Small and Medium- Sized Financial Institutions
  Petter Lovaas and Suzanne Wagner, 2012

I have chosen these two research papers as they address different aspects of compliance in the financial and banking industry, and how the security of IT is dealt within each organisation. I will be referring to other reports and papers as well, but these are the main research I would like to focus on.

The Banking and Financial Sector (BFS) accounts for nearly eight percent of the US annual gross domestic product and is considered the backbone of the world economy in comparison to the other sectors. BFS are, according to regulations, required to develop an IT audit program to support its IT infrastructure in order to keep non-public customer information secure. Therefore, protecting the BFS means cooperation between financial regulators and private sector owners and operators. Furthermore, this coalition continuously improves these programs to include current and new threats to the banking and financial sector (Wagner, 2012).

Lovaas & Wagner continue to explain in their research the auditing challenges that small and medium-sized financial institutions (SMEs) face. This research paper is very relevant to my research as, even though they do not address the specific security standards, they address the importance of auditing. Similar to larger firms, SMEs need to perform risk-based IT audits on an ongoing basis. Having sound Internal IT audit examiners ensures that the time spent on regulatory compliance may be reduced (Wagner, 2012).

Information systems have a significant meaning to every organisation and the main purpose of auditing these systems is to review and provide feedback, assurance and suggestions to the organisation regarding the information security posture (Wagner, 2012). The topics that are covered within this review are grouped into the McCumber Cube's CIA. This basic model lists:

- **Confidentiality** – Critical information on any system can only be disclosed to authorize personnel.

- **Availability** – Critical business systems need to be available at all time when they are required. They also need to be well protected against all types of threats.
- **Integrity** – Information on the critical systems needs to always be accurate, reliable and timely. Controls need to be in place to prevent unauthorized modification to software, information or databases.

TRADITIONAL VS RISK-BASED AUDIT APPROACH

Traditional	Risk-Based
Audit focus	Business focus
Transaction-based	Process-based
Financial account focus	Customer focus
Compliance objective	Risk identification, process improvement objective
Policies and procedures focus	Risk management focus
Multi-year audit coverage	Continual risk-reassessment coverage
Policy adherence	Change facilitator
Budgeted cost center	Accountability for performance improvement results
Career auditors	Opportunities for other management positions
Methodology: Focus on policies, transactions and compliance	Methodology: Focus on goals, strategies, and risk management processes

Figure 4 - Traditional vs Risk-Based Auditing (Wagner, 2012)

The general issue that we understand from this paper is that, even though there are frameworks available for BFS, they have their limitations. For example, none of the models are customized to provide feedback for both adequacy and compliance, and there are none that include human factors of auditing, especially towards small and medium-sized BFS. Another key point raised in this paper was the difference between traditional auditing and risk-based auditing. Figure 4 outlines the main differences between the newer methodologies compared to the more traditional one. Lovaas and Wagner highlight the importance of risk-based auditing for financial institutions and define it as an approach that focuses on the response of the organisation to the risks they face when achieving their goals and objectives.

With a large shift towards technology, businesses need to make sure they follow risk-based auditing as this will ensure that they are volatile with their changes and do not have to spend large sums of money to change systems and other aspects of their business.

Haru Susanto suggests that most common security standards are ISO 27001, BS 7799, COBiT, ITIL and PCIDSS. Although the report does not detail the controls of each of the standards, it gives a brief overview of each and their usability level in the world. The comparative study determines their respective strengths, focus, main components and their adoption based on Information Security Management System (ISMS).

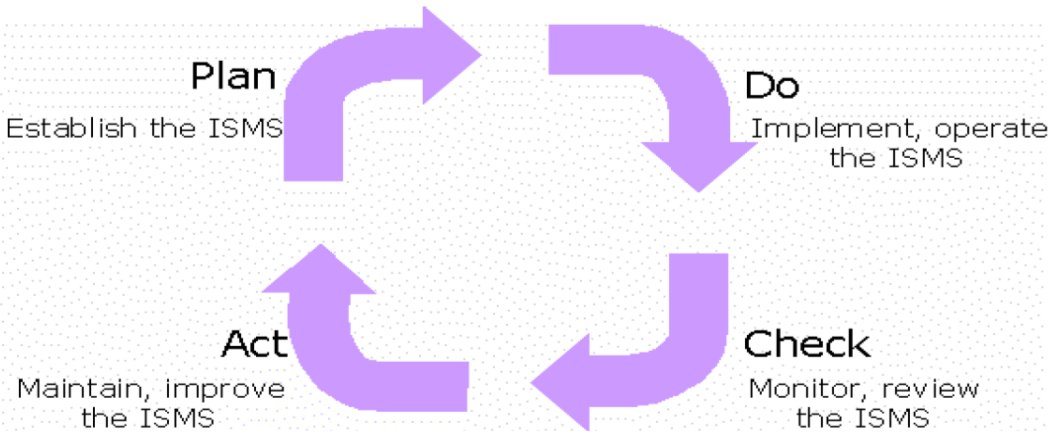


Figure 5 - PDCA Model (Allen, 2006)

ISO 27001 is the most used and well-known security standard available around the world with 163 countries using it. It is designed to protect the information assets and is applicable to all types of organisations, either private or public. BS 7799 is the predecessor to ISO 27001, ISO adopted their standards from BS 7799 and BS 7799-2. Both the standards implement the Plan-Do-Check-Act (PDCA), which aims to establish, implement, monitor and improve the effectiveness of an organisation's ISMS.

Julia Allen, states that the PDCA is a tried and trusted approach to security improvement that can be effectively used during deployment and operations. It is a set of minimum requirements for security hygiene and several security implementation frameworks that can be used in concert with the other articles in this content area (Allen, 2006).

Payment Card Industry Data Security Standard (PCIDSS) is also a security standard, but it is focused more towards helping organisations process card payments and to prevent credit card fraud through data compromise (Heru Susanto, 2011). Depending on the size of the organisation, they have to be assessed either by a Qualified Security Assessor (QSA) or by using a Self-Assessment Questionnaire (SAQ).

According Matthew Schwartz from Network Computing, 67% of companies that are PCI-regulated are still not in full compliance with the standard (Schwartz, 2011). He goes on to state that 50% of security professionals claim this to be a burden, which proves to me that due to the lack of clarity, professionals find that they are not too sure what they are complying with. This claim opens a loop hole — professionals may not find compliance a burden if they had a system that would investigate for them.

Figure 6- The ITIL components. (Heru Susanto, 2011)

The last two listed by Susanto are not standards, but instead are frameworks that assist organisations by giving them a guideline to follow so that their data can be secure. Information Technology Infrastructure Library (ITIL) is a set of concepts and practices for Information Technology Services Management (ITSM). Figure 4 illustrates the key components of ITIL. The listed components are a basic structure to achieving security for an organisation's complex systems. ITIL gets their motivation from the 11 essential controls specified below and has fashioned their structure based of that.

Control Objectives for Information and related Technology (COBIT), similar to ITIL, is also a framework that is a supporting toolset that allows managers to bridge the gap between control requirements, technical issues, business risks and security issues. Basically, no matter how many controls there are, without a sound framework they are rendered useless.

The five main governance areas that COBIT focuses on are:

- Strategic alignment
- Value delivery
- Resource management
- Risk management
- Performance management

All five focus on making sure that the security risks are mitigated by aligning these with the business plans.

Heru Susanto defined 11 essential control, called by 11EC, that should be implemented by an organization, as requirements and compliance of the information security criteria by the standard body of ISMS. Most organisations need to adhere to all these controls to ensure their information is secure and they can be compliant with the standards.

These 11 essential controls are:

1. Information Security Policy
2. Communications and Operations Management
3. Access Control
4. Information Systems Acquisition, Development and Maintenance
5. Organization of Information Security
6. Asset Management
7. Information Security Incident Management
8. Business Continuity Management
9. Human Resources Security
10. Physical and Environmental Security
11. Compliance

By understanding these 11EC, I am able to distinguish the criteria that are followed by the organisations to be secured against threat. These 11EC also tie very closely to the components of ITIL and is the backbone structure of ISO 27001, because the essence of these controls is

to integrate technology into a business without affecting its growth as depicted in Figure 4 and, as a whole, link in with the CIA triangle.

6.2 COMPARISON OF THE RESEARCH PAPERS

Both Lovaas & Wagner and Heru Susanto explain in detail the effect of compliance in IT. Although they both address the issue in different ways, the common point they make is for an organisation's data to be secure, they need to be compliant with security stands and follow certain standards and protocols. Lovaas & Wagner describe the effect of the major security standards on small and medium financial institutions, as well as suggest the best way to audit such institutions.

On the other hand, Heru Susanto explains the difference between the major security standards and frameworks that can be used in all industries, not just limited to financial institutions. If we understand the difference between a standard and framework, we can decide which is more important in an organisation. First, we need to understand the basic difference between the two. A dictionary definition for a standard is '*something used as a measure, norm, or model in comparative evaluations*'. By this definition, we can understand that organisations need to attain a certain level of quality and that level is defined by a standard. Similarly, when a methodology is adopted by an organisation then it is their standard (Ajim, 2013).

A framework, on the other hand, is defined as *'a basic structure underlying a system, concept or text'*. It is a general guideline that an organisation can adopt and it can consist of many components (Ajim, 2013). By this definition, we can understand that standards are accepted as the best practices or a perfect system, whereas a framework consists of practices that can be employed by an organisation in the real world. Susanto goes on to compare each of them using the 11EC of information security and how they tie into ISMS as a whole.

With both research papers claiming ISO series and PCIDSS to be major standards that organisations need to be compliant with, I believe my choice of comparing the two was not wrong. Another key thing to note was both paper used frameworks and standards together. However, my platform is solving the issue of being compliant with multiple security instruments without carrying out the same tasks multiple times.

In conclusion, the basic message that is presented by both Susanto and Lovaas & Wagner is that if a company is able to abide by the controls of specific security standards, then they will not be faced with data loss when breached.

6.3 CURRENT TECHNOLOGIES / PLATFORMS

Similar to the research papers, there are a few platforms that are available to organisations. These platforms provide data as a service and assist internal auditors with controls over financial reporting. There are many platforms and services available, but they all are for different purposes or regulatory compliance is incorporated into a bigger package.

Strevus is one of the few platforms that is very close to the platform I want to create. It provides a highly secure and scalable infrastructure for financial institutions to collect, validate, maintain and share their compliance data and documentation (Strevus, 2014). The platform helps customers navigate through the sea of regulatory compliance in today's shifting landscape and deploy an effective solution that meets the unique challenges of each of the organisations.

Strevus's main selling point is the Enhanced KYC/AML due diligence for Bitcoin. Bitcoin is a form of currency, created and held electronically. With many large companies accepting Bitcoin they need conduct KYC/AML due diligence along with existing global regulatory compliance.

Although the platform is important, it is essential to realise the dynamics behind the whole platform. Strevus claim that they are committed to ensuring the confidentiality, integrity and security of customers and system data. This ties in very well with what Lovaas & Wagner covered in their research paper. Strevus go on to state that by adhering to the highest standards for security they ensure organisations can rely on electronic-based compliance and confidence.

Table 1

Strevus	11 Essential Controls
Community Policing	Information Security Policy
Data Centre Security	Physical and Environmental Security
System Hardening	Asset Management
Comprehensive Network Protection	Organization of Information Security
Full Lifecycle Auditing and Reporting	Business Continuity Management
Data Encryption	Access Control
Security Policies and Configurations	Information Systems Acquisition, Development and Maintenance

The information security policies listed by Strevus are very close to the 11 essential controls listed above. I did a small comparative analysis of both Strevus and 11EC, (*Table 1*), and found although Strevus do not address all of them, they cover the main important controls when information security is concerned.

In the same way, MetricStream are a market-leading organisation that developed a cloud app for Governance, Risk and Compliance. They integrate GRC technologies and programs across businesses, IT and security functions. With their regulatory compliance app, they are very close to the product solution I have detailed. The only difference I have observed from my research is that their focus is on supporting compliance management through document control, compliance training, ongoing auditing and recording as well as reporting of exception events (MetricStream, 2015).

MetricStream have many services and applications, one of them that seemed relevant was their IT security and governance function. It ensures, establishes and enforces security policies, standards and procedures. Also, assisting managers continuously monitor all the components of the IT infrastructure for compliance and security threats, and take appropriate action.

IT-GRC solution by MetricStream provides a few of the following capabilities:

- Policy Management
    - All policies can be mapped to frameworks and regulations like COBIT, ISO, SOX, and PCI.
    - These policies can be broken down into sections and sub-sections, and mapped to controls.
- Risk Management
    - Provides a framework that simplifies the identification and analysis of all risks related to IT operations and information security.
    - Provides risk identification to mitigation and reporting.
- Compliance Management
    - Provides a common framework and an integrated approach to manage all IT compliance regulations and mandates.

I highlighted these capabilities, as they are common with my proposed solution. Policy management describes the use of the standards and regulations being mapped to policies. According to a Unified Compliance Framework, they have already grouped close to 9300+ controls from 1200+ regulations to make data retrieval easy (MetricStream, 2015). This is what MetricStream used to help them classify the regulations into a set of essential controls. Everything mentioned above about MetricStream links back to the 11 essential controls of information security.

MetricStream also follows the PDCA methodology closely, by mapping the policies to the controls they are able to plan well ahead of any risks. By having the app, they are able to both Do and Check the progress and threats affecting their systems and come up with a plan to mitigate them, which is the final step.

6.4 COMPARISON OF THE TECHNOLOGIES

My understanding of the entire process followed by both Strevus and MetricStream is that they followed the 11 essential controls closely and have based their platforms on them. Strevus covers compliance of the financial institutions but only a single aspect of it, by looking at the transactions of Bitcoins. MetricStream on the other hand looks at the variety of standards and regulations tailored to the organisation, which enables the companies to have flexibility.

The Strevus platform was explained as a basic overview of the platform itself. We saw that it was referring to the customer data model and ETL mapping that reads the customer data and writes to the ERP system. This is based on NoSQL that allows users to easily find and manage their assets in one place. A summary of the whole platform was integrating this platform into a company's existing ERP system.

Although my solution is tied in very closely with the output of the MetricStream platform, I will be focusing on providing guidelines for the company to make sure they are compliant with their chosen security standards. In the future, I might plan to implement a dashboard that gives the managers a visual representation of the key systems that need to be addressed to achieve the certification for certain regulations. It will be closely following the 11 essential controls as well as referring to the CIA triad.

7 PROPOSED SOLUTION

My main task is to analyse a few of these regulatory instruments and industry standards, and classify them. Using this analysis, I will create a foundation for a platform that can be used, maintained and updated in the future.

By comparing existing research and technologies, I will answer the business problem placed by Risk Consult Limited (RCL) and create a solution that will help organisations manage the security of their data. The solution will be presented as a platform that eliminates the recursive costs for a financial institution as well as provides guidelines on which part of their system is not compliant with a certain standard.

The prototype produced at the end of this project will be a web-based platform that will demonstrate the structure and functionality of the proposed platform. It can however be completely developed to assist organisations with their selected security standards by providing guidelines on improving sections of the business to be better compliant with multiple regulations with half the cost. In Section 7.3, I have highlighted the approach I propose to take to achieve a working prototype.

7.1 INDUSTRY

There are many types of instruments for information security as it is a part of all types of industries, ranging broadly from local requirements to industry specifics as well as international standards and regulations. An analysis of every industry and its specific instrument would be beyond the project scope and the proposed project time period.

We decided that financial industry would be more beneficial to focus on as this is where the data needs to be more secured. Since the introduction of online transactions and online banking, the exchange of physical cash is very limited. With the increase in online transactions there is an increased exposure to cyber threats. Instead of cash, with little or no information about the owner, we have been familiarised with plastic cards that hold almost all information about an individual. With all this information available, organisations need to take acute precautions to prevent it from falling into the wrong hands.

Most organisations assume their security is sufficient to protect this data from being breached. This may be true, but they will never know the ‘chinks in their armour’ unless they follow some standards and regulations. These standards and regulations assist organisations to keep their data secure, they do not guarantee that the systems would not be breached due to the volatility of security threats, however they will ensure some security.

7.2 SECURITY INSTRUMENTS

As previously discussed, certain organisations require to be compliant with certain instruments. The importance of these instruments varies with the organisation, and their business goals. Each of these instruments has many controls, which the organisation needs to follow to ensure they are compliant. Depending on the size of the company, their budget for the compliance varies. Obviously, the bigger the company the more they are willing to spend, but also due to the volume of information that they have to protect they need to be all the more secure. Even though there are over 1,200 regulations and standards (MetricStream, 2015), they all have the same objective of protecting information. For the sake of this project, I have chosen to focus on the three main regulations and standards that affect the majority of the financial institutions.

Here I have listed three of the standards/regulations that have some commonality:

✓ISO 27002

✓ Sarbanes-Oxley Act (SOX)

✓ Payment Card Industry Data Security Standard (PCI DSS)

I will be making references to the 11 essential controls and the CIA triad to assist me in creating a comparison construct that will be the foundation of the platform.

7.3 METHODOLOGY – 5 ASPECTS OF THE PLATFORM.

The approach that I propose to take to build a working prototype will be staged into two main stages, the analysis and the coding. Analysis involves finding the commonalties between the instruments based on each of the control zone.

My initial step is to classify the controls of each of the instruments into 15 impact zones, to form a very high level matrix to understand which control zones align with each other. Given this matrix I would have a clearer vision on how the controls align, then I can focus on three main zones to find the commonalties within each of the control zones.

The commonalities will be referred to as a base controls from this point on. This base control is either one control or a combination of controls from each of the instruments. Although each of the instruments has very similar controls, some of them do not address some of the issues raised by the others. This difference is what we call as an alignment; if an instrument has any controls that are very similar to the base control and address something other than that defined by the base control then it will be classified as alignments. These alignments will also be included in the comparison construct.

The second stage of this project is to code the platform, this process includes the creation of databases, connection to the platform, and the User Interface. To create a successful platform/system, there are 5 main aspects that need to be addressed. These aspects are as follows:

- Data Input
- Comparison construct
- Reporting
- Integrity/Audit trail
- Time based (period end) archiving.

Data Input

An important aspect that is required in this platform. The platform needs to have the capability of taking in the responses by the auditors. The responses could vary from a simple check in check box to a written comment, in regards to that specific base control or alignment. In the next section, I will explain further the importance of such data input.

Comparison Construct

This is the major focus of my project and the backbone of the platform. The comparison construct is a matrix that has base controls and alignments for each of the different zones encompassed within. The structure of the construct will be presented in Section 8.

Reporting

Reporting allows auditors to get an overview of the controls they are compliant with and those that they need to focus. It also allows the upper management to understand the situation without having to know the technical aspects of it.

Integrity/Audit Trail

The platform is solving the business issue where integrity of the data is being questioned, hence it is a necessity that we incorporate such a feature into this platform. To address this, we will be making sure that all entries are time-stamped.

Time-based (Period ending) Archiving

This aspect leads on from the previous, allowing the auditors to back up all the data input for a specific year, allowing the external auditors to audit the company and ensuring the integrity of the internal audits. This means, there would be no write access to the controls after the end of a financial period; and all that data is shifted to a read-only database.

With the above aspects in mind, the platform will incorporate each of them. In Section 9, I have outlined the frontend and backend design, giving a better perspective on the implementation of each of the aspects specified above.

In Section 6.3, I had mentioned the technologies in relevance to their instruments that they focused on how it would help me with my comparison construct, as the major focus of this project is on the analysis of the instruments and to find the commonalities between them.

7.4 ANALYSIS OF THE METHODOLOGY

The idea for my methodology was derived from a typical audit program for an internal audit. An internal audit is carried to ensure that all systems are compliant with each of the regulatory instruments and can give the auditors a fair idea of where they stand in each instrument. My proposed methodology would be very similar to an audit work program in terms of the structure, an example depicted in Figure 8.

1994 Clauses (Across)		4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11	4.12	4.13	4.14	4.15	4.16	4.17	4.18	4.19	4.20
ISO 9001:2000 Sections (Down)																					
8	Measurement, analysis and improvement																				
8.1	Planning																				
8.2	Measurement and monitoring																				
8.2.1	Customer Satisfaction																				
8.2.2	Internal Audit																				
8.2.3	Measurement and monitoring of processes																				
8.2.4	Measurement and monitoring of product																				
8.3	Control of nonconformity																				
8.4	Analysis of data																				
8.5	Improvement																				
8.5.1	Planning for continual improvement																				
8.5.2	Corrective action																				
8.5.3	Preventive action																				

Figure 7 - ISO Audit Program

In my proposed methodology, the platform will be web-based compared to a traditional excel-based program. The platform will allow the auditors to see the input made, thanks to reporting requirement, as well as help with data integrity by assigning each audit to a particular user. Unlike a traditional audit program, an external auditor will be able to run the platform and check the audit trail for all the instruments by generating reports, which will be a built-in function.

With all these added functionalities, the platform will be an immediate replacement to current work programs and will not require any additional training to the auditors. With a large initial investment, I predict a very quick return on investment as the companies would be saving a lot more money by not repeating the same process multiple times for each of the regulatory instruments.

8 COMPARISON CONSTRUCT OF THE STANDARDS

8.1 CONTROLS GROUPING

With 1200+ standards and more than 9600 controls, it is difficult to keep track of which control in one instrument aligns with a control in another instrument. However, I have found a way to classify them into 15 impact zones from a very high level. Each of these of impact zones deals with the one area of policies, standards and procedures technology acquisition, physical security, continuity, records management, etc.

The impact zones that I found apply to this solution and its potential growth in the future to cater to other industries and their regulations and standards (Unified Compliance Framework, 2015).

The impact zones are:

- Leadership and high level objectives
- Audits and risk managements
- Monitoring and measurement
- Technical security
- Physical and Environmental protection
- System continuity
- Human resources management
- Operational management
- System Hardening through configuration management
- Records management
- Systems design, build and management
- Acquisition or sale of facilities, technology, and services
- Privacy protection for information and data
- Compliance and Governance Manual of Style
- Third Party and supply chain oversight

Using this, I expanded further by focusing on three main domains with which I created a Comparison Construct (Section 8.3) that acts as a foundation for my prototype.

The three main domains are:

- Policy Management
- Incident Response Management
- Back-ups

Being three of the main domains that are very vital when conducting auditing. Policy management is important to make sure that the entire organisation is aware of the rules and policies in regards to security and there are systems in place that are complying with such policies. With the increase in cybersecurity crimes, companies need to ensure that they know

what to do when they have been attacked, Incident Response management plays a crucial role during this time, so we need to ensure that companies can comply with certain rules and regulations. This leads on to the final choice, Back-Ups, after an incident, we need to have measures in place so that the company has backup of their daily transactions. The existence of backups is not important, but their compliance with the instruments is really important.

Although the three standards I have chosen do not fit into all of the 15 impact zones, they fit into a few of them. With the assistance of the 11 essential controls to help me demarcate the controls grouping, I have classified each of the controls into each of the 15 impact zones.

In Section 5, I had outlined the main sections of each of the regulatory instruments, but these are not the main controls that the company has to adhere to. However, in Section 8.2 I classified the controls into the 15 impact zones and how they can be combined to form one big instrument that companies can comply with. Following that section, in 8.3, the three domains I have chosen to focus have been classified using their controls and their sub-controls.

8.2 CLASSIFICATION OF REGULATORY INSTRUMENTS

Table 2 – Classification Matrix

Impact Zones	*PCI DSS*	*SOX*	*ISO 27002*
Leadership and high level objectives		- Define and manage service levels (16)	
Audits and risk managements	Maintain a policy that addresses information security for all personnel (12)	- Develop and maintain policies and procedures (13) - Manage problems and incidents (20)	Security Policy (5) Information Security incident management (13)
Monitoring and measurement	Track and monitor all access to network resources and cardholder data (10) Regularly test security systems and processes (11)	- Manage Changes (15)	Organisation of Information Security (6.1)

Technical security	Firewall Configuration (1)	- Ensure systems security (18)	Asset Management (7)[1]
Physical and Environmental protection	Restrict physical access to data (9)		Asset Management (7) Physical and Environmental Security (9)
System continuity			Business Continuity management (14)
Human resources management			Human Resources Security (8)
Operational management		- Manage operations (22)	Communications and Operations Management (10)
System Hardening through configuration management	Use of anti-virus (5)	- Install and test application software and technology infrastructure (14) - Manage the configuration (19)	
Records management	Assign a unique ID to each person with computer access (8)		
Systems design, build and management	Develop and maintain secure systems and applications (6)	- Acquire or Develop -Application Software (11)	
Acquisition or sale of facilities, technology, and services		- Acquire Technology Infrastructure (12)	Information System acquisition, development and maintenance (12)
Privacy protection for information and data	Not using vendor-supplied defaults for system passwords (2) Protect stored cardholder data (3)	- Manage data (21)	Access Control (11)

[1] Different sub-controls apply.

	Encrypt transmissions of data across open, public networks (4) Restrict access to cardholder data by business need to know (7)		
Compliance and Governance Manual of Style			Compliance (15)
Third Party and supply chain oversight	Shared hosting providers must protect the cardholder data environment (A.1)	- Manage third-party (17) services	Organisation of Information Security (6.2) Communications and Operations Management (10.2)

As we can notice from the main sections of each of the three regulatory instruments, we can see that they cover almost all the 15 impact zones, and some of the zones have controls from each of the instruments. This suggests that there are a few commonalities in the controls and what they cover. Obviously the financial institutions are spending a lot of money on checks that are duplicated in each of these specified controls. However, my platform will be incorporating a more detailed matrix that will be embedded in the back end database.

This matrix will assist me in creating a more detailed comparison construct in the following section. The construct will be providing a more detailed analysis of the three main domains from each of the instruments with which the institutions have to comply with.

8.3 COMPARISON CONSTRUCT

Error! Not a valid link.

The following points are a commentary for each of the rows in the above table. Each paragraph is a representation of a single row, starting from the second row and refers to the number in the first column. The base control is common for the two instruments, the varying aspects of the controls are what form the alignments. If only one of the instruments has something different then, the alignment for the other will be blank.

(1, 2) In Policy Management, we discuss the importance of policies in an organisation and the three instruments refer to various aspects of the policies. PCI and SOX do not mention the establishment of the policies; rather they focus on the importance of regular reviews and ensuring the systems comply with the documented policies. ISO, on the other hand, addresses the above to a certain extent, and also has a control that is specific to the establishment of the controls.

(3) Policy management between these introduces the commonalities between HR, Access Control and Segregation of Duties

(4) They cover policies, but in terms of data storage. Although it comes under Managing Data and Protecting Cardholder Data, it still has controls for policies.

(5) ISO - has different controls pertaining to the establishment of policies. They all form alignments of this base control.

(6) The procedures and controls that are required for managing incident responses. Both in terms of the programs used as well as the approach itself. All need to be tuned to achieve the best outcome, with very minimal loss.

(7) Problem management system is required, and needs to be effective and consistently applied to all incidents. They need to be reviewed. The problem here is that all three talk about the system or approach, but only PCI discuss the implications that it might have on the rest of the business. Therefore, it forms an alignment for the base control, which is 'it exists and management has documented how to use it'.

(8) Ensure procedures are there for effective handling of the situations. They need to be tested annually.

(9) Employ people who are aware of the procedures to handle incidents and respond to them accordingly.

(10) Here we are addressing the issue of how to improve our plans to better respond to the incidents.

(11) Integrity of the reports can only be verified by collecting the evidence and keep it as an audit trail.

(12) Data management is split into two main aspects, one of which is storage of data, and back up policies, and the other is access control to the data itself. I will be filling in the details for only back up data. Access control will be left for future works. I have listed the control numbers, in this row however, they will not be used for this project.

(13) The most common aspect for all the three instruments refers to the Policies and procedures in regards to the management of data back up and retrieval.

(14) Backing up the data is only part of the process, we need to have controls in place for restoration of that data.

(15) Retention of sensitive data needs to have secured policies and controls to ensure that there is no breach in data as well as no data leaks. The alignment might have almost everything that is specified in the base control, however, there are a few details that needed to be addressed for each of the controls. Due to the vagueness of the base control.

In Section 9.2.2, I discuss the importance of this construct in the construction of the backend database.

9 PLATFORM

9.1 WEB-BASED VS APP-BASED

The best way of presenting this solution is using a web-based platform, which enables organisations to track their systems and check the compliance without having to install any software as such. Below are few benefits and limitations of having such platform.

We can list a few benefits that are common knowledge like the lack of upgrades, security, uptime, backups and 'IT guys' stuff. With cloud computing taking over the technological world currently, quite a few businesses are shifting towards it. Companies prefer to have information on a centralized location that will allow them to access this information from any geographical location. These are few of the benefits that RCL sees in potentially employing a more traditional web-based system.

Although app-based platforms are preferred, I will be creating a web-based platform as it is more robust and modular. Also, the platform does not need to be used while on the move, so an app-based platform is not required.

9.2 DESIGN

Design is plays a key role when it comes to creating a front end for customers as their opinions are based on the usability of the system. Similarly, the backend of the system needs to be very robust, so it may handle database transactions at high pace, without affect the work of an auditor. In the following sections, we shall discuss the frontend and backend design of the platform, their importance and what are the decisions and assumptions made to create the platform.

9.2.1 Frontend Design

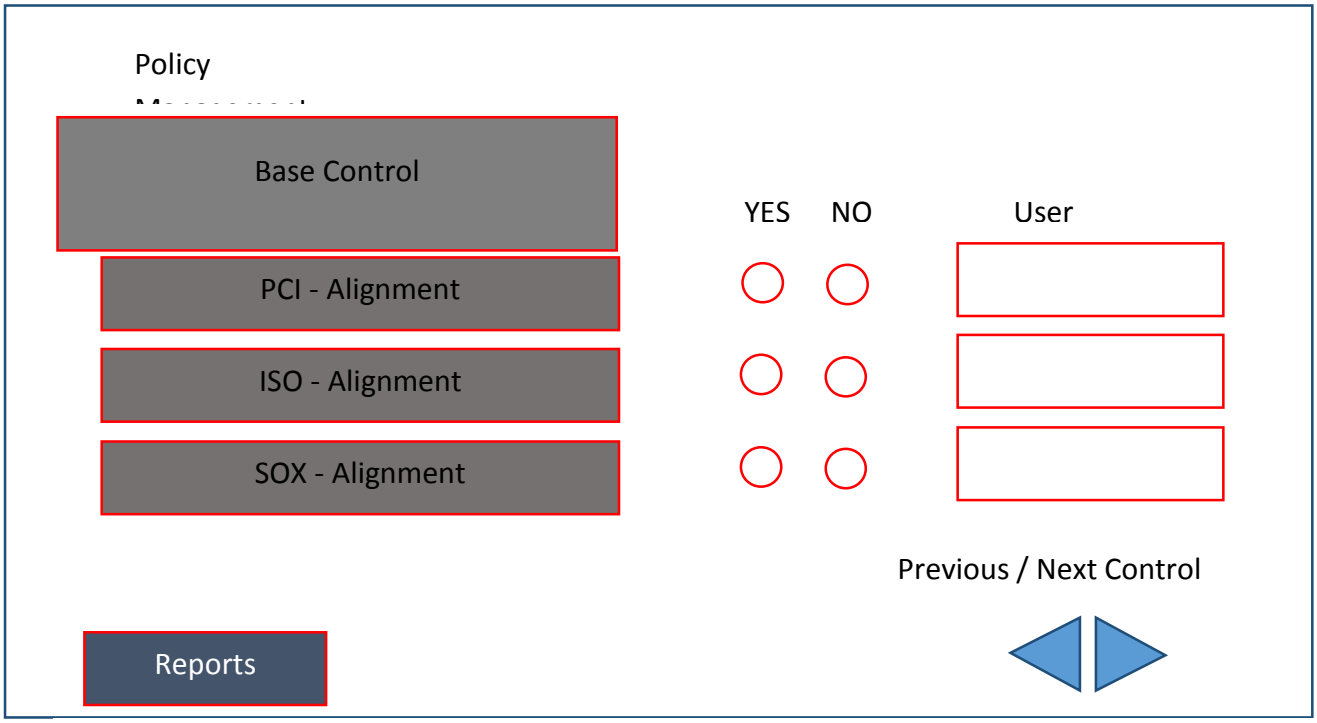


Figure 8- Proposed frontend design.

Current audit work program requires auditors to select "Yes/No" if the system meets the control's requirements. With majority of the work done on paper it makes for a very tedious job. The proposed layout follows the same structure as the paper audit program where the auditor is able to select the response for each of the alignments as well as leave a comment. These responses and comments will be used to develop reports, making it easier for external auditors to perform compliance checks for a particular regulatory instrument.

The page would be split into three main sections, the first zone is Base Control and the three alignments. The next section is the data input followed by the buttons for controlling the movement between the base controls. Rather than making static pages where the data is hardcoded into each page, I will be looking at making a dynamic form that will grab data from a backend database structure populating each of the grey boxes as per Figure 8.

The 'Reports' button will have to ask the auditor for parameters and generate reports on the fly, allowing them to export them to a PDF making their compliance checklist easier. The reports will have the responses and response comments for each alignment as well as detailing the user who wrote those comments and the date time.

All these tie back to the five requirements mentioned in Section 7.3. For the purpose of this project, we will not be focusing too much on the usability however it should be taken into consideration when developing this project further.

Login Page

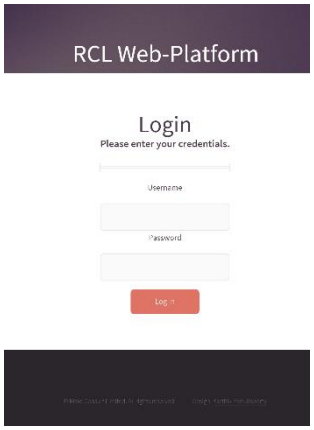


Figure 9 - Login Page

The simple login page was designed as level of defence as well as a method of authenticating the user. We would like to have a user associated with each of the responses to maintain integrity within the platform.

In Figure 9, we can see two text boxes for user's to input their credentials. Additionally we have 'Login' button to submit the inputs and cross check with the username and password entered in the database.

UI – Layout

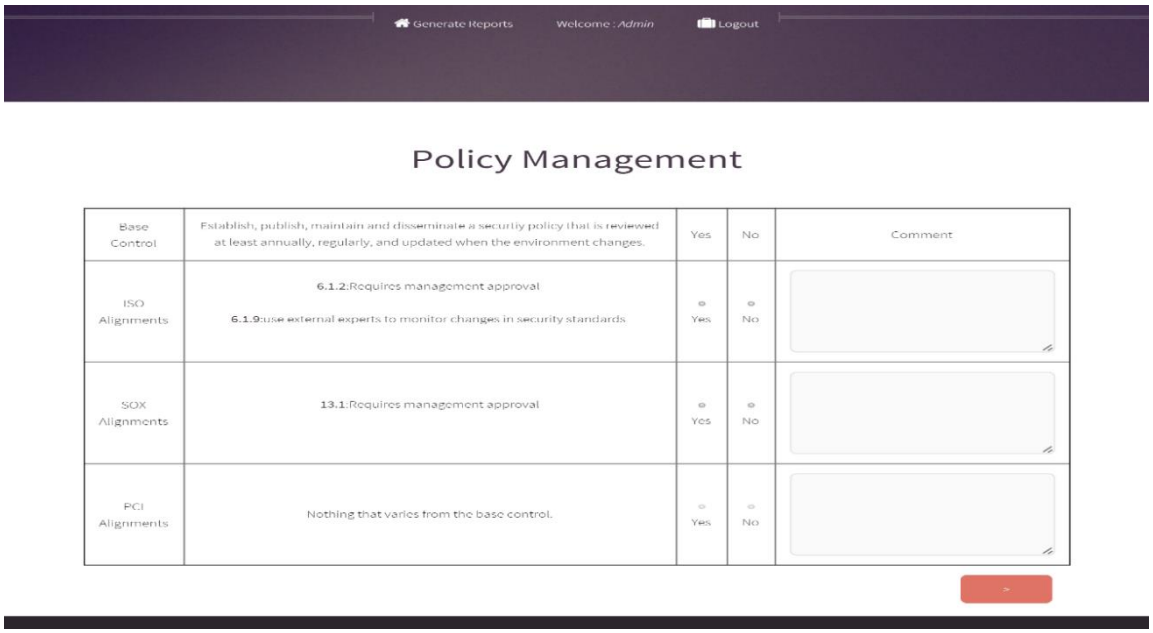


Figure 10 - User Interface

Figure 10 depicts a prototype of the web-based platform. It was coded in the same format at the proposed design. An added functionality is the introduction of users. The frontend has been programmed using PHP, hence the page is created as a form. Adding in variables that represent the number of base controls, we circulate through that many dynamic pages. In this project, although we only covered a few of the domains, I did not want this to limit the scalability aspect of the platform.

The title has been created using a query that retrieves the Zone name from the Zone table. Using this information all the control objectives that belong to that zone are looped through in each form. Each form page is restricted to one base control objective for simplicity purposes. Based on the base control objective, all the alignments for each of the types are

listed below. By referring to Figure 10, the values in front of the alignments correlate to the control in that regulatory instrument.

On the top left, we have feedback to the user indicating who has logged into the system currently. The top right, has two buttons; one to generate reports for the auditors and the other for a user to logout of the system. The Yes/No responses have been configured as radio buttons and response comment is a comment text box. The button at the bottom of the screen allows for navigation between the different base controls objectives.

Reporting

For the scope of this project the reporting page has been coded to give an example of how the data is retrieved and displayed. The reports return 3 main aspects; the date and time of when the data was written to the database, the user who ran the checklist and finally the alignments and responses for each of the regulatory instruments.

Response at 2015-10-20 03:28:47 by admin

SOX

Base Control	Alignment	Response	Response Comment
1	Requires management approval	No	adfasd
4	Review incident reports, to ensure they were recorded, analysed and resolved in a timely manner.	No	fasdf
8	Provide adequate audit trail facilities.	N/A	
8	Process for proper disposition.	N/A	
6	Verify that all incidents are responded in a timely fashion.	No	asdfasdf
3	Same for reporting output. | timely distribution of all the correct financial reports (including electronic reports) to appropriate personal.	No	fasdf
9	Periodically test the effectiveness of the restoration process and the quality of backup media.	No	asdfasd

Figure 11 - Reporting view

The most efficient way to generate such reports is to use stored procedures, which are defined in the database allowing for easy retrieval. However for this project the query was written inside a PHP file. Figure 11, 12 and 13 show the structure of the reports based on the data type.

PCI

Base Control	Alignment	Response	Response Comment
3	deals with card holder data | limiting storage amount and retention time to meet legal, regulatory and business requirements. | Process for secure deletion of data | specific retention requirements for cardholder data | deletion of data after retention period has passed.	No	fasdf
10	Render all authentication data as irretrievable.	N/A	
10	Full contents from a magnetic strip not stored.	N/A	
10	Verification code used for validating the card online.	N/A	
10	PIN or encrypted PIN block not stored.	N/A	
10	Render PAN unreadable anywhere it is stored (including on portable digital media, backup media, and in logs) by hashes, truncating, tokens, cryptography.	N/A	
2	Identify the critical assets, threats and vulnerabilities. Perform risk assessments.	No	fasdfsa
4	Plan addresses: - Roles, responsibilities, and communication and contact strategies in the event of a compromise including notification of the payment brands, at a minimum. | specific incident response procedures | business continuity procedures| data back up | legal requirements for reporting compromises | coverage of all critical system components.	No	fasdf
5	Test the plan annually	N/A	
6	People available 24/7	No	asdfasdf
6	appropriate training to staff who are responsible for security breaches.	No	asdfasdf
8	Alerts from Intrusion Detection/Prevention and file monitoring systems.	N/A	
7	Modify and evolve incident plans according to lessons learnt and industry developments	N/A	

Figure 13 - PCI reporting

ISO

Base Control	Alignment	Response	Response Comment
1	Requires management approval	No	adfasd
1	use external experts to monitor changes in security standards	No	adfasd
3	Implement backup policy and strategy.	No	fasdf
9	restoration activites are rehearsed.	No	asdfasd
4	Incident approach is both effective and consistently applied.	No	fasdf
6	Once it has been reported.	No	asdfasdf
2	Audit the systems and technical platforms on how well they comply with the security policies and requirements.	No	fasdfsa

Figure 12 - ISO Reporting

```
$sql = mysqli_query($link, "SELECT * FROM tbl_response");
while($rl = mysqli_fetch_assoc($sql))
{
    echo "<h1>Response at " . $rl['Date'] . " by " . $rl['User'] . "</h1>";
    $query2 = mysqli_query($link, "SELECT type_id, type_desc FROM tbl_type");
    while($res2 = mysqli_fetch_assoc($query2))
    {
        echo "<h2>" . $res2['type_desc'] . "</h2><table border='1'><thead><tr><td>Base Control</td><td>Alignment</td><td>Response</td><td>Response Comment</td></tr></thead>";
        $queryx = mysqli_query($link, "SELECT * FROM tbl_compdata WHERE DataType = {$res2['type_id']}");
        //$queryx = mysqli_query($link, "SELECT * ")
        while($resx = mysqli_fetch_assoc($queryx))
        {
            $query3 = mysqli_query($link, "SELECT * FROM tbl_responsemeasure WHERE ResponseID = {$rl['ResponseID']} AND Controls_ID = {$resx['Controls_ID']}");
            $res3 = mysqli_fetch_assoc($query3);
            echo "<tr><td>{$resx['Controls_ID']}</td><td>{$resx['Alignments']}</td><td>{$res3['Response']}</td><td>{$res3['ResponseComment']}</td></tr>";
        }
        echo "</table>";
    }
    echo "<br /><br /><hr><br />";
}
```

Figure 14 - Reporting query

Figure 14 illustrates a SQL query that queries a database to get the information about each of the regulatory instruments. Firstly I perform a query to find the User and Date of the response, using this information for the next query we find the Type (ISO, PCI or SOX). While performing a while loop, we go through all the alignments under each of these types and tabularise the responses along with the alignments.

User Input and Feedback

The user input section of the platform is very straight forward. There are two radio buttons to make sure that their system meets the controls and the auditor may leave a comment to assist the external auditors. To ensure there are no mismatches with the data in terms of only half the checklist being carried out and then the user logs out; I have coded that the input is only submitted to the database once all the controls have been visited. The last base control also has a 'next page' button and this button submits the data into the database. Figure 15 shows an example of the data input.

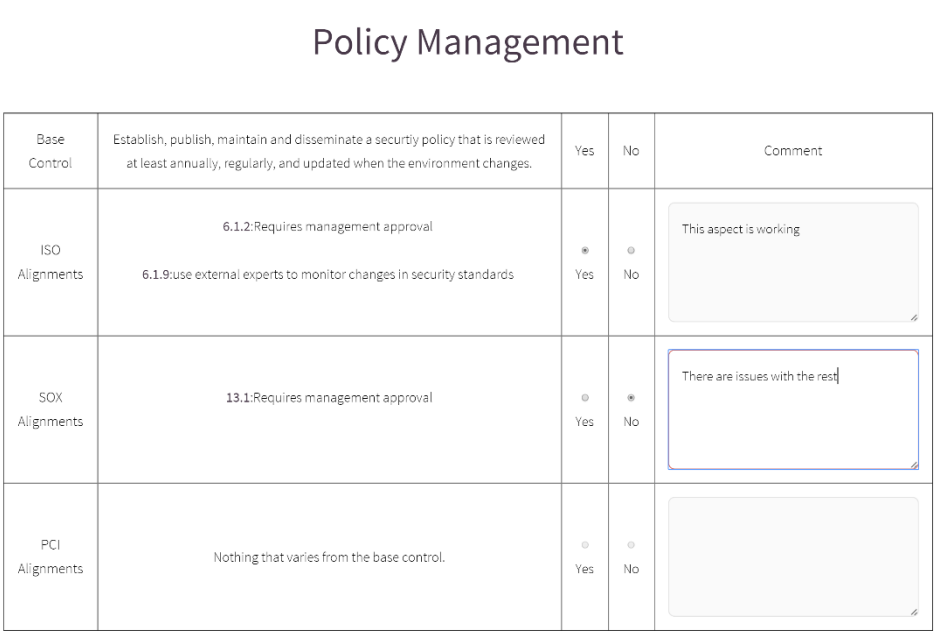


Figure 15 - Data input example

9.2.2 Backend Design

ERD Structure

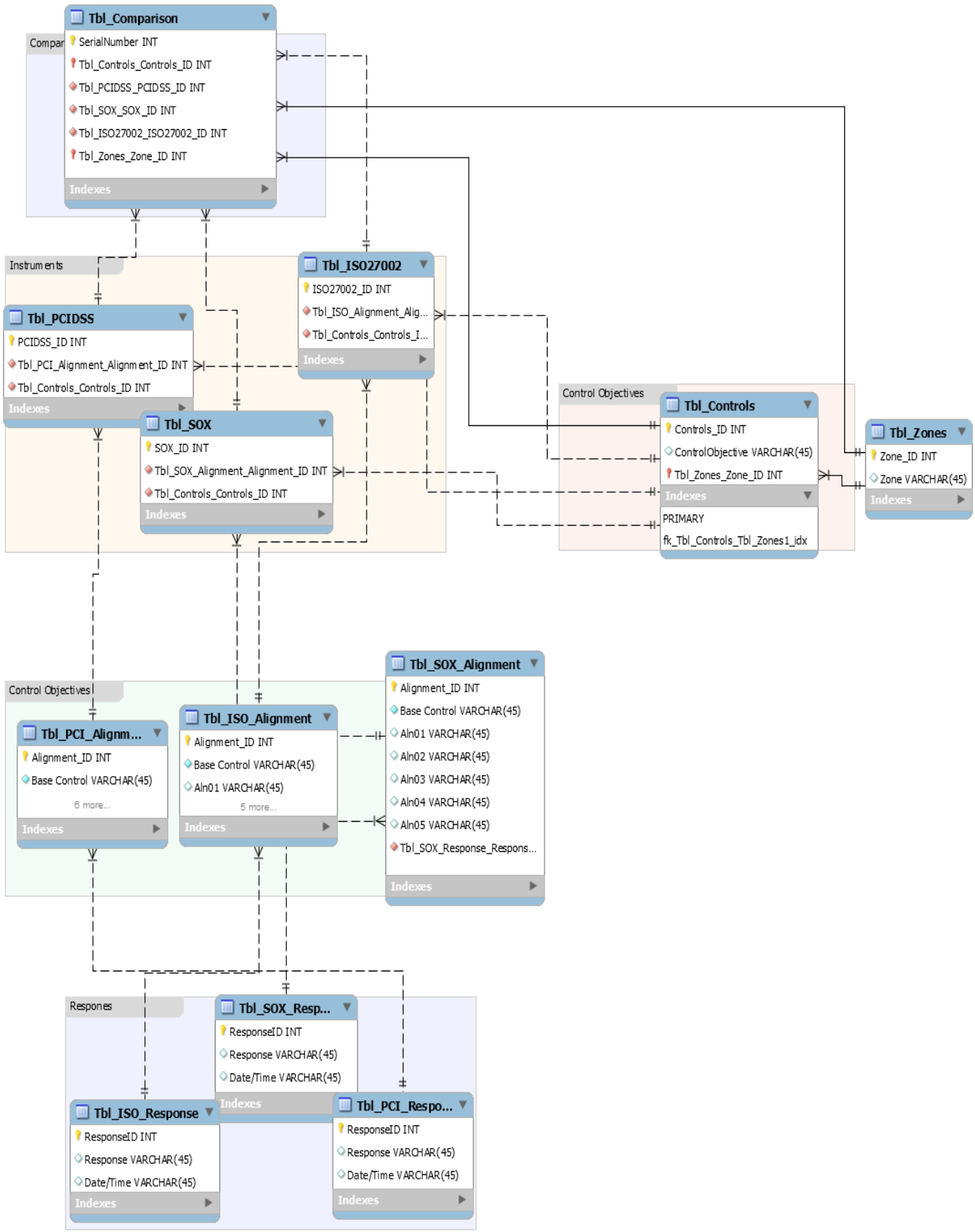


Figure 16 – Proposed Backend ERD design

This is the proposed design of the backend system. The tables required to create a functional platform, are detailed in the image above. However, after the creation of the Comparison Construct in the previous section, the design had a few flaws that caused duplication and redundancy of data.

The area highlighted as Instruments, seems to be a redundant step, which may increase the computation of the queries as more tables need to be properly indexed. After a few modifications, we removed that area and noticed that results were retrieved a lot quicker than with the initial configuration.

The modified (current) structure shows a cleaner view of the entire design.

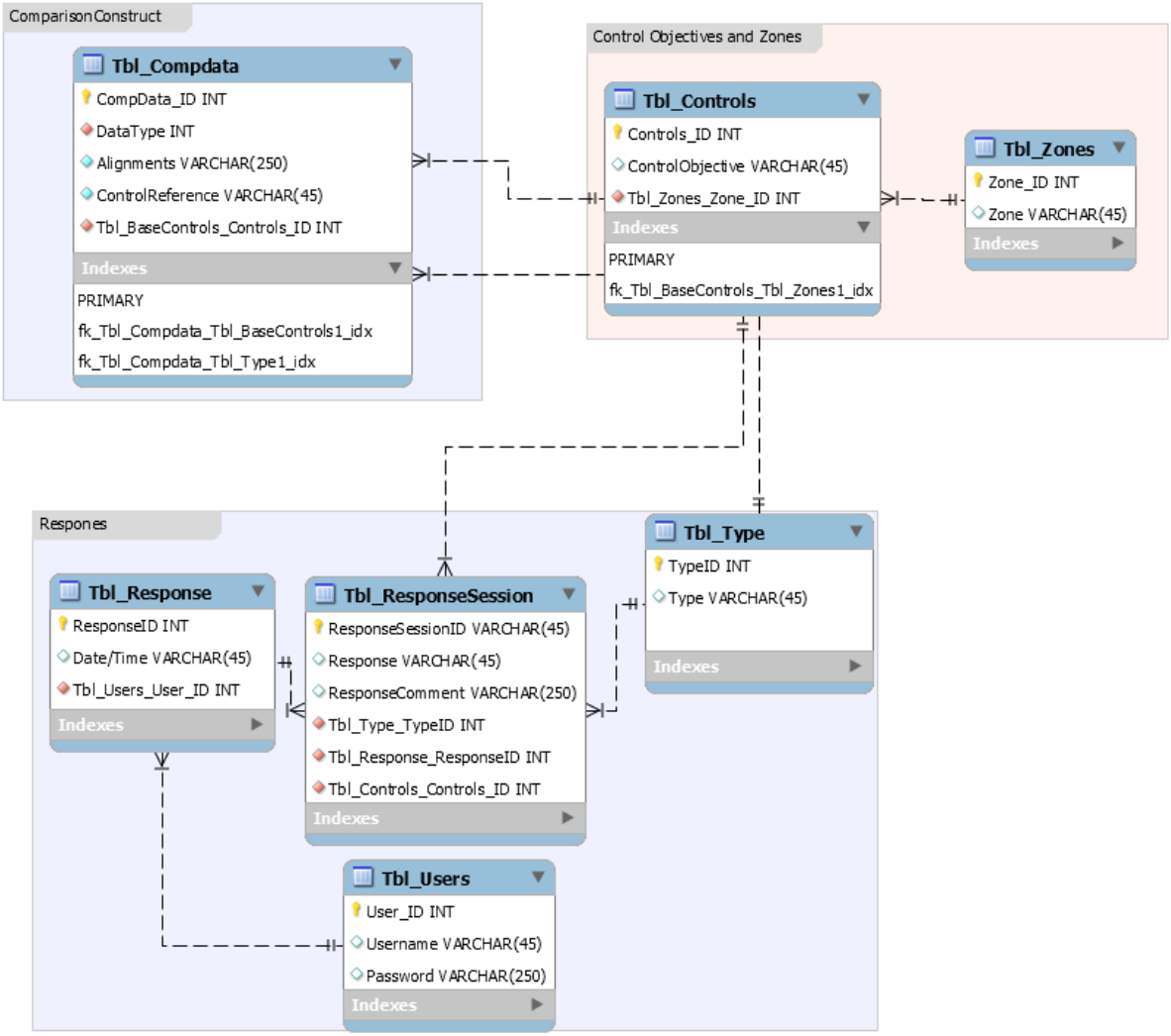


Figure 17 - Current Backend ERD design

In this design, I normalised the structure to allow for ease of retrieval of data. Database Normalisation is very key when creating databases, as this is the process of organising the columns and tables in a relational database to minimise data redundancy. I have made my design follow a simple normal form (SNF), allowing addition of the entries into the table to not affect the relations and other entries. Depending on the tables, I have either used second normal form or third normal form.

Tables

As shown in the above ERD design, there are a total of 8 tables. The comparison construct, even though it is included in the design, it is a fact table. That will be drawing information from each of these base tables.

The tables have been classified into three main layers, these layers will remain consistent. The only addition required for future works, would be to add the tables into each of the sections. The three sections and their tables are:

- Control Objectives and Zones
  - Tbl_Controls
  - Tbl_Zones
- Comparison Construct
  - Tbl_CompData
- Responses
  - Tbl_Response
  - Tbl_ResponseSession
  - Tbl_Type
  - Tbl_User

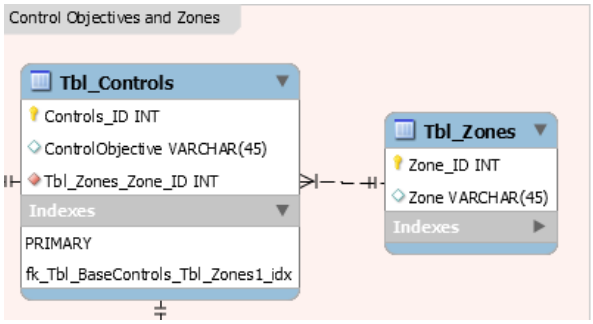


Figure 18 - Controls Objectives and Zones Tables

Control Objectives and Zones, has two main tables (figure 11), the `Tbl_Controls` and `Tbl_Zones` each in Second Normal Form. `Tbl_Controls` is a table for all the common controls. It contains the `Controls_ID` which is an auto numbering primary key, and corresponds to a `ControlObjective` which is a VARCHAR with a maximum of 45 characters. During the database creation, I had modified the VARCHAR to have a max of 255 characters, as I was having issues with some of the controls being too long. We have a non_identifying (See Appendix A for definition) one-to-many relationship with `Tbl_Zones`, which is a table that contains the different zones each of the controls belong to.

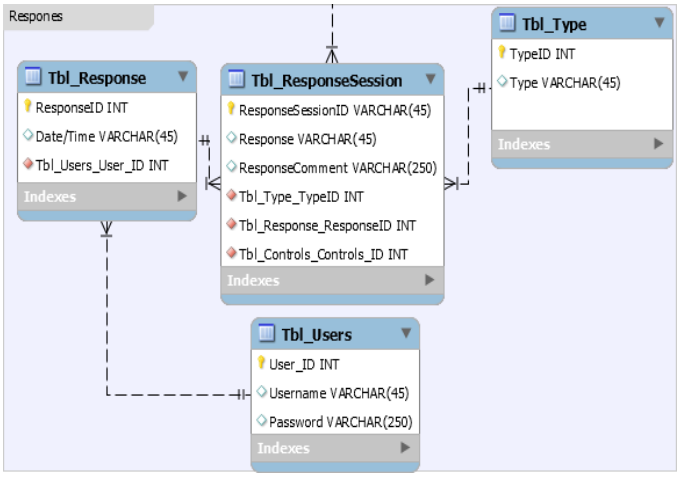


Figure 19- Responses Tables

The Response zone contains four tables, each table normalised to make scalability easier. `Tbl_Response` is a table which records a `ResponseID` and its `Date/Time` as well as `UserID` which is a foreign key. The purpose of a `UserID` is to associate each response to a particular user, which makes it easier during reporting at the end of the financial year. A `ResponseID`, which is an INT, is defined as the number of responses that have been submitted. It is an auto-incrementing primary key that accepts no null values. Only when all the controls have been addressed will the form submit the

responses, otherwise they are discarded. Each time a response is submitted a Date/Time is attached for auditing purposes.

A Tbl_ResponseSession is another table where we have multiple attributes. The main attributes are ResponseSessionID that is a primary key that auto-increments and allows for no null values. A Response attribute stores a Yes/No input that is stored as a VARCHAR (45) and a ResponseComment stores any comments left by the auditors for future reference, due to the response being limitless it is stored as a VARCHAR(250). There are three foreign key constraints in this table, a TypeID which maps to the type of instrument the response belong to. Secondly, a ResponseID so we have a record of the date/time and user associated with each response. Finally, a ControlsID that supplements to the correct ControlObjective.

Tbl_Users is used to record the different users that will have access to this platform, the three attributes in this table are: UserID which is an auto-incrementing primary key that does nOt accept any nulls, a username which is a unique name and is stored as a VARCHAR(45) and finally a password that is stored using SHA-1 hashing algorithm for security reasons and to accommodate for such a long string the data type is a VARCHAR(250).

The last table in that section is Tbl_Types, this table lists the different regulatory instruments that are being compared in this platform. Currently I have three instruments, so the two main attributes in this table are: TypeID again another auto-incrementing primary key which doesn't allow for null values and Type which is VARCHAR(45).

The final zone is Comparison Construct, which contains only one table Tbl_Compdata. The table name had changed from Tbl_Alignments to Tbl_Compdata because of a mismatch in my database. The Tbl_Compdata, as depicted in Figure 14, has three attributes with two foreign key constraints, one with Tbl_Controls and the other with Tbl_Types. Both tables are connected using a non-identifying one to many relationships with this table.

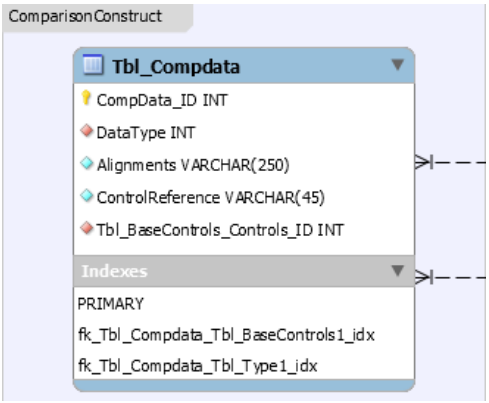


Figure 20 - Comparison Construct

CompData_ID is another auto-incrementing primary key that does not accept null values. All data that varies from the ControlObjective but aligns with the same zone is classified as an Alignment. These alignments can be of various lengths hence I have decided to make it VARCHAR (250), so no data gets truncated. Finally we have ControlReference, this is a number however it varies and there is no set format. To accommodate for such a volatile attribute, I have made the data type VARCHAR(45).

The two foreign keys are `DataType`, which is the `TypeID` from `Tbl_Types`, and `Controls_ID` from `Tbl_Controls`. These two attributes are used to map the alignments correctly and assists with the reporting once all the responses are recorded.

9.3 TECHNOLOGIES

The technologies that are available for web-based platforms are:

- ASP.NET with SQL
- HTML/CSS with AJAX
- PHP with MYSQL (incorporating HTML and CSS)

By investigating further into each of these technologies, I would be able to better decide which option is better suited for my project. In this project, the use of a database is very important as I need to store the controls for each of the regulatory instruments. Hence, I have included some sort of database engine in all my options. Although currently I am only focused on solving the issue of three regulatory compliances, I would be considering expanding this to integrate other instruments that are required for other major industries like Health, Tourism and so on.

9.3.1 ASP.NET with SQL

When creating a web application with ASP.NET, we are introduced to a framework known as MVC (Model, View and Controller). This framework makes it easier to manage the complexity by dividing the application into a model, view and controller.

- The **Model** is the part of the application that handles the logic for the application data. Often model objects retrieve data, and store data, from a database.
- The **View** is the part of the application that handles the display of the data. Most often the views are created from the model data.
- The **Controller** is the part of the application that handles user interaction. Typically controllers read data from a view, control user input, and send input data to the model.

Below I have listed some of the advantages and disadvantages of using ASP.NET MVC:

Table 3 - (Anand, 2011)

Advantages	Disadvantages
Separation of Concerns - The MVC framework provides a clean separation of the UI , Business Logic , Model or Data	**Large data in the view state:** Frustrating site visitors with slower response times and increasing the bandwidth demands of the server.

More Control - provides more control over the HTML, JavaScript and CSS than the traditional Web Forms.	**Limited control over HTML:** HTML output usually failed to comply with web standards or make good use of CSS, and server controls generated unpredictable and complex ID values that are hard to access using JavaScript.
Testability - provides better testability of the Web Application and good support for the test driven development too.	**Leaky abstraction:** Web Forms tries to hide away HTML and HTTP wherever possible. As you try to implement custom behaviours, you frequently fall out of the abstraction, which forces you to user to use the traditional post back mechanism to generate the desired html
Lightweight - does not use View State and thus reduces the bandwidth of the requests to an extent.	

For this project, I will not be considering this technology as it does not meet the requirements of the solution.

9.3.2 HTML/CSS with AJAX

Hypertext Mark-up Language (HTML) is a mark-up language that is useful for describing web documents. It is a set of mark-up tags that describes different document content. HTML is preferred by many developers due to its flexibility and its wide usage, established on almost all websites. However, there are a few drawbacks to this language. When another language replaces the original work of the tag, it becomes deprecated tag, common when used in conjunction with Cascading Style Sheets (CSS).

AJAX (Asynchronous Javascript and XML) is a collection of old technologies with slight deviations to each of these technologies. These groups of technologies comprise of the following aspects, namely:

- HTML and CSS
- Javascript
- XML and XSLT
- XMLHttpRequest

AJAX allows displaying web pages with interactive, efficient and quick interfaces. Web giants like Google effectively utilize AJAX in their web applications like Gmail and Google Maps (JScripters, 2011).

Table 4 - (JScripters, 2011)

Advantages	Disadvantages
Better interactivity AJAX allows easier and quicker interaction	**The back and refresh button are rendered useless**

between user and website as pages are not reloaded for content to be displayed.	With AJAX, as all functions are loaded on a dynamic page without the page being reloaded or more importantly a URL being changed (except for a hash symbol maybe), clicking the back or refresh button would take you to an entirely different web page or to the beginning of what your dynamic web page was processing. This is the main drawback behind AJAX but fortunately with good programming skills this issue can be fixed
Easier navigation AJAX applications on websites can be built to allow easier navigation to users in comparison to using the traditional back and forward button on a browser.	
Compact With AJAX, several multi-purpose applications and features can be handled using a single web page, avoiding the need for clutter with several web pages.	**It is built on JavaScript** While JavaScript is secure and has been heavily used by websites for a long period of time, a percentage of website surfers prefer to turn JavaScript functionality off on their browser rendering the AJAX application useless, a work around to this con is present as well, where the developer will need to code a parallel non-JavaScript version of the dynamic web page to cater to these users.
Backed by reputed brands Several complex web applications are handled using AJAX, Google Maps is the most impressive and obvious example.	

Although I have mentioned the advantages and disadvantages of Ajax, I will not be considering it for this project.

9.3.3 PHP with MySQL

Hypertext PreProcessor (PHP) is a widely-used open source general-purpose scripting language that is especially suited for web development and can be embedded into HTML. Rather than the use of HTML code, PHP allows the programmer to create a more dynamic system. What distinguishes PHP from something like client-side JavaScript is that the code is executed on the server, generating HTML which is then sent to the client. The client would receive the results of running that script, but would not know what the underlying code was. You can even configure your web server to process all your HTML files with PHP, and then there is really no way that users can tell what you have up your sleeve.

Below I have listed some of the pros and cons of using PHP:

Table 5 - (PHP-Tutorial, 2015)

Advantages	Disadvantages
Open source: It is developed and maintained by a large group of PHP developers, this will	Security : Since it is open sourced, so all people can see the source code, if there are

helps in creating a support community, abundant extension library.	bugs in the source code, it can be used by people to explore the weakness of PHP
Speed: It is relative fast since it uses much system resource.	Not suitable for large applications: Hard to maintain since it is not very modular.
Easy to use: It uses C like syntax, so for those who are familiar with C, it's very easy for them to pick up and it is very easy to create website scripts.	Weak type: Implicit conversion may surprise unwary programmers and lead to unexpected bugs. For example, the strings "1000" and "1e3" compare equal because they are implicitly cast to floating point numbers.
Stable: Since it is maintained by many developers, so when bugs are found, it can be quickly fixed	
Built-in database connection modules: You can connect to database easily using PHP, since many websites are data/content driven, so we will use database frequently, this will largely reduce the development time of web apps.	

9.3.4 Platform

After researching the advantages and disadvantages of the technologies listed above, I have decided to use PHP due to its ability to have Built-In database connection modules. The other two listed technologies required a much longer process to establish such connection. A database is very crucial for my project, as I will need to be able to group the internal controls based on each of the impact zones.

To assist me in creating a potential working prototype I have used the following software:

- XAMPP
- MySQL Workbench

XAMPP

To host my MySQL server and Apache server to host my web-based application, I had used XAMPP. XAMPP (Cross Platform, Apache, MySQL, PHP, Perl) is an open-source web-server solution pack, with the capabilities of hosting an Apache HTTPS sever, a MySQL database server as well as Perl and PHP programming interpreters (Friends, 2015).

Upon installation of the XAMPP control panel I had to ensure, due to my laptop ports specifications, that the Apache server and the MySQL server where both running. So I modified the `httpd.conf` (apache) and the `my.ini` (mysql) configuration file for both

servers to ports that were active. Figure 21 shows both the servers on and the ports that they are using; Apache server was listening on port 81 and 444, whereas MySQL server was listening on port 3306.

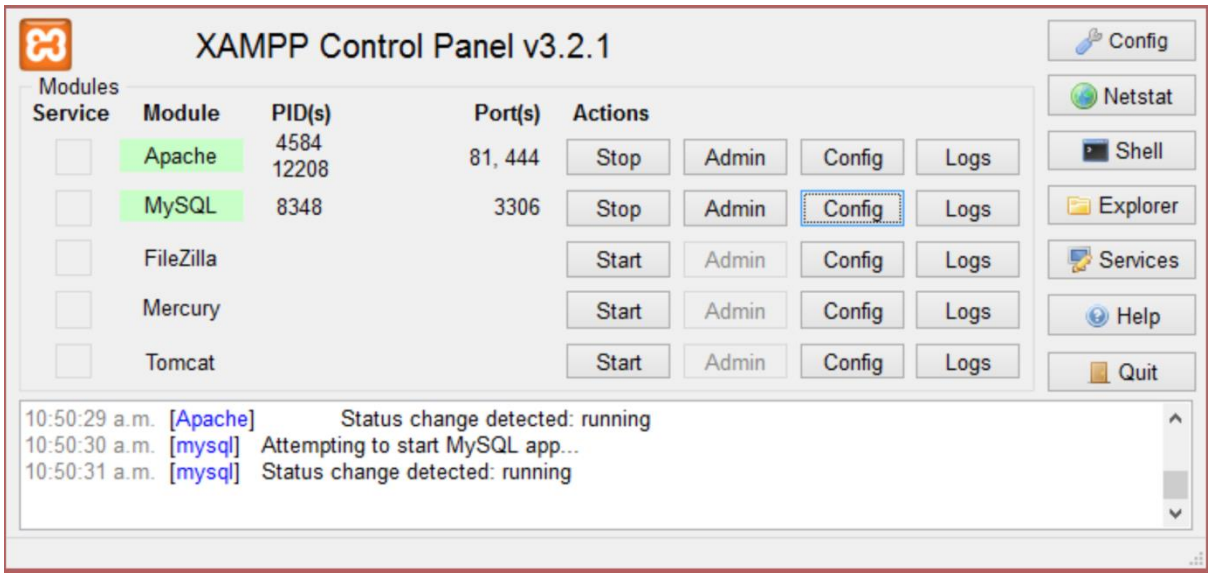


Figure 21 - XAMPP Control Panel

MySQL Workbench

For database management, I have used MySQL Workbench, which is a unified tool for database management. It provides services like data modelling, SQL development, and comprehensive administration tools for server configuration, user administration, backup and many more (MySQL, 2015).

The main components for the MySQL are the ERD Design, which allows you to add in entities and attributes for each of the tables you want to use and it automatically maps them to the correct tables and structures. In my project, I had mainly used the ERD to give me an outline of how my structure will work and what are the limitations I might face when coding the frontend.

Figure 16 is an example of my ERD, designed using the MySQL Workbench. A model overview illustrates the ERD structure as well the schema with the tables used, depicted in Figure 22. Finally Figure 23 shows the layout of my Database Management System (DBMS) provided by MySQL Workbench, with tables listed on the left and the query designer in the middle which can be used for stored procedures.

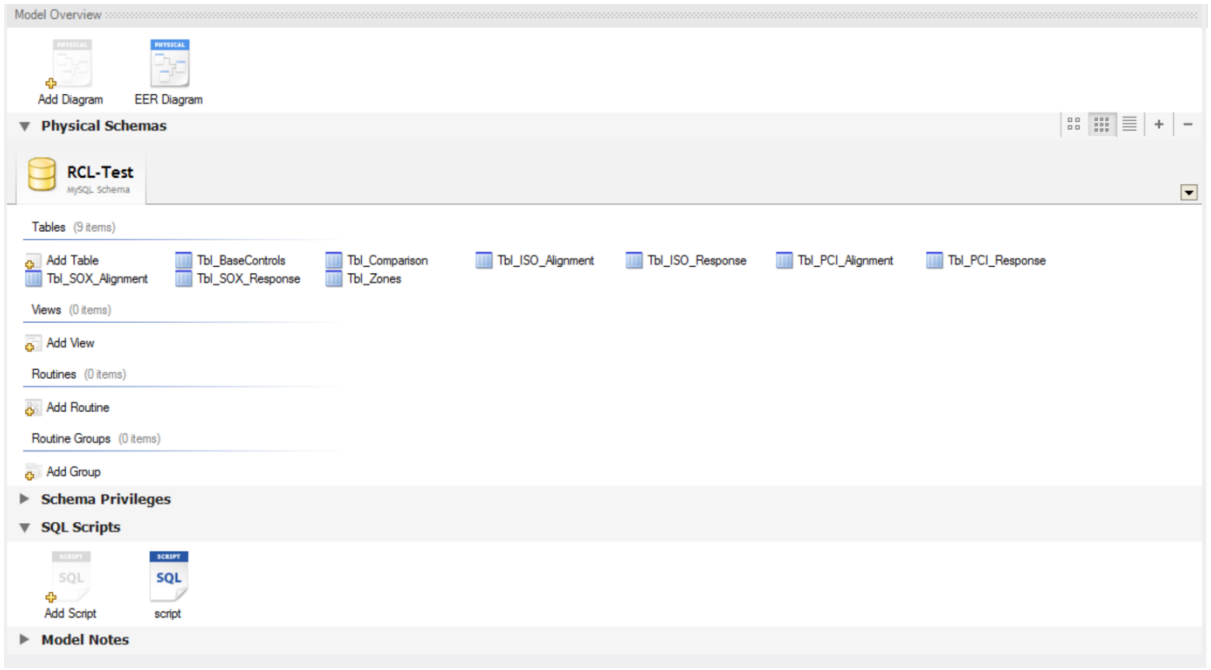


Figure 22 - MySQL Workbench (Model Overview)

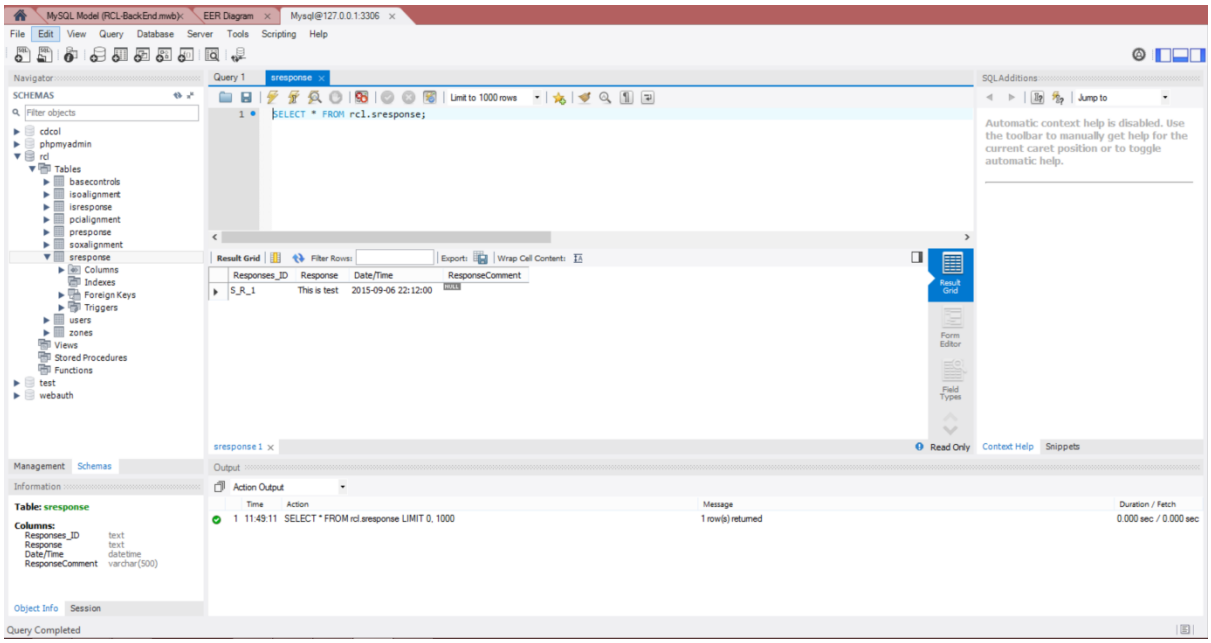
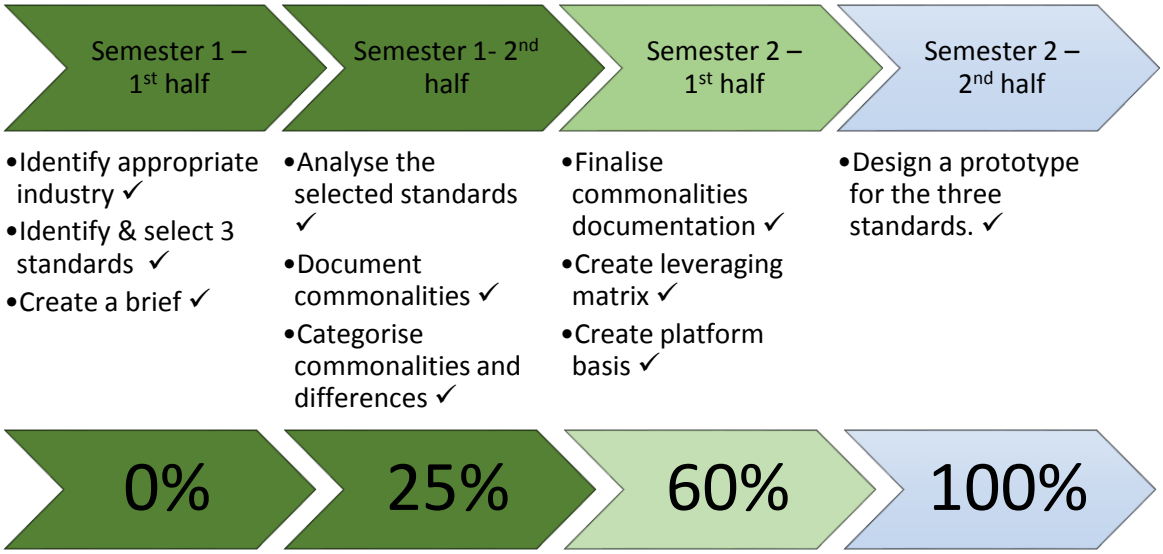


Figure 23 - DBMS View

10 WHAT IS NEXT?

10.1 TIMELINE DETAILING MY PROGRESS AND FUTURE WORKS.

10.1.1 Timeline



I have achieved 100% of the project that I had planned to complete. The most time consuming part of this project was the research and literature review as well as the classification of the controls into base controls. I had issues with finding research that is somewhat related to the topics I was covering in this report.

I have covered some of the technologies that are currently available in the market as well as researching the correct language required to create this platform. I have chosen to program the platform using the PHP language and with MySQL as the back end of the database.

After analysing the multiple regulatory instruments I had chosen to focus on three main domains. Each of the domains had a set number of controls under each instrument. The challenge was to find the commonalities between each of the controls. Once the controls were classified into base controls, then I had to compare and contrast to write up the alignments. Once I had perfected the matrix, I was able to get started on the database creation.

The database structure changed multiple times as the initial proposed design was too complex to program a working prototype. After redesigning the ERD, I managed to export the data from an Excel worksheet and import it into the MySQL workbench. With the data ready, the frontend programming was a simple task.

I faced a couple of issues during my data retrieval and data insertion stages. The issues were simple enough to solve; firstly wrong data was being populated into my title query and secondly 'Yes' response choices were not being recorded into the database. The first issue was due to the use of the wrong table and the second issue was caused due to case sensitivity, I had used a capital 'Y' instead of a small 'y'.

10.1.2 Future Work

The scope of the project exceeds the time allocated for this project. Due to this time constraint, I will not be able to create a complete working prototype by the end of this project.

After completing a basic prototype, I believe I have completed the scope of the project within the given time frame. This project is not complete until the working prototype is not developed into a large scale platform. I had only focused on three of the twelve domains, so the next step is to classify the rest of the domains into base controls and form their alignments.

The foundation of this project has been laid out. Upon completion of the base controls and alignments, importing the data into the database will not be too difficult. Programming the frontend is the second major aspect. My working prototype has merely suggested a framework however a web platform needs to be robust and security has to be introduced from the beginning.

The future scope of the platform is to incorporate multiple standards not just for the financial industry but also for other major industries. To aid this I understand that reporting is another key aspect where a dashboard is introduced allowing auditors to select the parameters and exporting the report as a PDF. If the project is carried on with the use of PHP then I would suggest the use of `fpdf` PHP plugin. The dashboard should allow the auditors to select the standard they would like to see i.e SOX and then generate a report of the current audit review. An added option would be to also report the edit history, which would enable the external auditors to check the history of responses. This will assist them when they are conducting their reviews at the end of the financial year.

The platform will need to include some aspect of security to make sure, that the information is not available to everyone and to only to the parties that have subscribed for this platform. Some of the security suggestions is the use of groups and policies for users who can edit the controls. With data being the main concept in this platform, there need to be security measures in place for both the database and the front end. We would like to ensure there is no SQL injection, Cross site scripting or any other attacks that could cause damage to the data.

In terms of the credentials entered, a future work would be to include two factor authentication to authenticate the user or other methods like OAuth or OpenID. I understand that passwords are a weak type of authentication especially as they are at risk of shoulder-surfing or brute force attacks.

With the current implementation, the database server and web server are both hosted on my local machine. However when the platform is completely functional it would be extremely difficult to make changes to the standards if they were updated at some point. A suggestion would be to deploy the web-platform on the local server of the company and have it link to a database in a remote location. This database will provide the company with the requirements based on their subscriptions as well as access to the controls. If this implementation was further researched, an optional possibility would be to have all companies and external auditors to subscribe to this service. That way the auditors can review their systems online without hindering the companies' day to day transactions.

Another suggestion that could be addressed when developing this platform is to make it more responsive, depending on the device it is accessed on. The platform would be more flexible if it could be accessed from any handheld device allowing auditors to work from any location.

11 REFERENCES

37 Signals. (n.d.). *Web-based software is better than your regular software.* Retrieved from https://37signals.com/webbased

Ajim, M. (2013, January 14). *Redefining Project Management*. Retrieved from What are the differences between standard, framework, and methodology?: http://blog.sukad.com/20130114/differences-between-standard-framework-methodology/

Allen, J. H. (2006). *Plan, Do, Check, Act.*

Anand, B. (2011, October 19). *Disadvantages of ASP.NET Web Forms*. Retrieved from ASP.NET Rocks World of Web Development: http://aspnet-rocks.blogspot.co.nz/2011/10/disadvantages-of-aspnet-web-forms.html

Assuria. (2015). *Assuria helps secure the integrity of reporting for Sarbanes–Oxley (SOX)*. Retrieved from http://www.assuria.com/compliance/sox.html

Basel Committee on Banking Supervision. (2005). *Compliance and the compliance function in banks.*

Braintree. (2008, June 25). *What does it cost to become PCI Compliant?* Retrieved from Braintree: https://www.braintreepayments.com/blog/what-does-it-cost-to-become-pci-compliant

CBSS. (2011). *CBSS*. Retrieved from CBSS Web Site: http://2cbss.com/

Dalling, T. (2009, May 31). *Model View Controller Explained*. Retrieved from http://www.tomdalling.com/blog/software-design/model-view-controller-explained/

Financial Executives. (2008, April 4). *FEI Survey: Average 2007 SOX Compliance Cost $1.7 Million*. Retrieved from FEI : http://www.financialexecutives.org/KenticoCMS/News---Publications/Press-Room/2008-press-releases/FEI-Survey--Average-2007-SOX-Compliance-Cost-$1-7-.aspx

Friends, A. (2015). *XAMPP*. Retrieved from Apache Friends: https://www.apachefriends.org/index.html

Heru Susanto, M. N. (2011). *Information Security Management System Standards: A Comparative Study of the Big Five.*

JScripters. (2011). *AJAX PROS AND CONS*. Retrieved from Jscripters: http://www.jscripters.com/ajax-disadvantages-and-advantages/

JScripters. (2011). *WHAT IS AJAX?* Retrieved from JScripters: http://www.jscripters.com/what-is-ajax/

Kosutic, D. (2010, September 13). *ISO 27001 vs. ISO 27002*. Retrieved from 27001 Academy: http://www.iso27001standard.com/blog/2010/09/13/iso-27001-vs-iso-27002/

Kozlay, D. (2014). *The Importance of Security Standards.*

Lovrić, Z. (2012). *Model of Simplified Implementation of PCI DSS by Using ISO 27001 Standard.*

Manske, M. (2007, September 7). *International_Organization_for_Standardization*. Retrieved from http://en.wikipedia.org/wiki/International_Organization_for_Standardization#/media/File:ISO_english_logo.svg

McMeley, R. G. (2013, December 13). *PaymentLawAdvisor*. Retrieved from PCI DSS 3.0: Business as Usual?: http://www.paymentlawadvisor.com/2013/12/16/pci-dss-3-0-business-as-usual/

MetricStream. (2015). *MetricStream Regualtory Compliance Management Software Solution*. Retrieved from www.metricstream.com/solutions/regulatory_compliance.htm

MySQL. (2015). *MySQL Workbench*. Retrieved from MySQL: https://www.mysql.com/products/workbench/

PHP-Tutorial. (2015, March 9). *PHP Introduction*. Retrieved from https://phptutorialpoints.wordpress.com/2015/03/09/php-introduction/

PivotPoint Security. (2010, July 26). *ISO-27001 Cost Estimate: $48,000 Information Security Confidence: Priceless*. Retrieved from http://www.pivotpointsecurity.com/risky-business/iso-27001-cost-estimate-48000-information-security-confidence-priceless

RCL. (2014). *Risks Consult Limited*. Retrieved from Risks Consult Limited: http://www.risksconsult.com/about-us/

Schwartz, M. (2011, April 20). *Network Computing*. Retrieved from http://www.networkcomputing.com/networking/67--of-companies-fail-credit-card-security-compliance/d/d-id/1097292?

Seider, D. (2004). *Sarbanes-Oxley Information Technology.* Las Vegas: SANS Institute.

Strevus. (2014). *Strevus*. Retrieved from www.strevus.com

Unified Compliance Framework. (2015). Retrieved from https://www.unifiedcompliance.com/

W3Schools. (n.d.). *PHP 5 Introduction*. Retrieved from http://www.w3schools.com/php/php_intro.asp

Wagner, P. L. (2012). *IT Audit Challenges for Small and Medium- Sized Financial Institutions.*

Weistein, E. (n.d.). *PHP in Action* . Retrieved from Codecademy: http://www.codecademy.com/en/tracks/php

Appendix A

Identifying relationships exist when the primary key of the parent entity is included in the primary key of the child entity. On the other hand, a non-identifying relationship exists when the primary key of the parent entity is included in the child entity but not as part of the child entity's primary key.