UNIVERSIDAD DE GUADALAJARA

Centro Universitario de los Valles

Master of Software Engineering

Intelligent Traffic Management System

Final Document

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Glossary

Software Configuration Management (SCM): It is the set of practices designed to systematically control, track, and manage software elements throughout their lifecycle.

Configuration Management Database (CMDB): Is a centralized database that contains information about the components within an IT infrastructure and their relationships.

Configuration Item Records (CIRs): Are records documenting specific details and characteristics of configuration items within a system or project.

Change Request (CR): Formal request to make modifications or alterations to an existing project, process, or system.

Intelligent Traffic Management System (ITMS): The central project aiming to optimize traffic flow, reduce congestion, and enhance urban mobility through real-time data collection and analysis.

Module: A functional and cohesive unit within the overall system, focused on specific tasks such as data acquisition, information processing, or traffic pattern prediction.

Functional Requirements: Detailed specifications of the capabilities and functions that the system must fulfill, such as real-time data collection or traffic light coordination.

Non-Functional Requirements: Specifications that define constraints and characteristics of the system, such as information update latency or compatibility with specific operating systems.

Baseline: A set of functional and non-functional requirements that establish the scope and expectations of the project.

User Interface: The part of the system that interacts with end-users, such as mobile applications displaying real-time traffic information.

Traffic Pattern Prediction: The system's ability to forecast future traffic conditions based on historical data and recurring events.

Traffic Light Coordination: The functionality that allows adjusting traffic lights at intersections to improve real-time traffic flow.

Integration with External Systems: The capability to connect and collaborate with other systems, such as navigation apps or external maps.

Security and Privacy: Protection of traffic data and user information, including encryption, authentication, and regulatory compliance.

Traffic Management: Configuration and monitoring of the system by administrators to optimize traffic flow.

API (Application Programming Interface): A set of rules and protocols that enable different components of the system to communicate with each other.

LFPDPPP (Federal Law for the Protection of Personal Data Held by Private Parties): The Mexican regulation for the protection of personal data.

Intelligent Traffic Management System: A software platform designed to collect, analyze, and present real-time traffic data with the goal of improving traffic flow and urban mobility.

Traffic Sensors: Electronic devices installed on roads and urban streets to collect data about vehicle flow, speed, and other relevant parameters.

Congestion: The state of traffic where there is a high density of vehicles on a road, resulting in reduced speed and delays.

Alternative Routes: Different paths that drivers can take to avoid congestion areas and improve travel time.

Traffic Signal Coordination: Synchronized adjustment of traffic signals at different intersections to improve traffic flow and reduce waiting times.

User Interface: Visual and functional space through which users interact with an application or system, including elements like buttons, menus, and informational panels.

Traffic Pattern Prediction Algorithm: Set of rules and mathematical calculations used to anticipate how traffic will develop based on historical data and current conditions.

Microservices Architecture: Software design approach where applications are developed as a set of small, independent, and highly specialized services that communicate with each other.

Data Privacy: Protection of users' personal information, including location data

and other sensitive information, to prevent unauthorized access or misuse.

Scalability: The ability of a system to handle an increase in workload, data, or users without degrading performance.

Availability: The percentage of time a system or service is available and operational, usually expressed as a decimal value.

Intuitive User Interface: Interface design that is easy to understand and use without requiring a significant learning curve for the user.

Traffic Safety Regulations: Standards and laws established by local or national authorities to ensure the safety of users on public roads.

GDPR (General Data Protection Regulation): European Union privacy regulation that sets rules for the protection of personal data and the privacy of European citizens.

Effort: The amount of work required to complete a task or project.

Time: The period during which an activity or project is carried out.

Costs: The expenses associated with the execution of a project.

Human Resources: The personnel or team needed to carry out a project or task.

1. Introduction

This final report represents the culmination of an ongoing process in the development and management of the Software Configuration Management (SCM) project. Throughout this period, several key documents have been generated, ranging from the initial definition of the project baseline to the evaluation and analysis of various Change Requests. Each version of these documents reflects a particular stage in the project lifecycle, documenting its evolution and adaptation.

This compilation presents the final versions of the generated documents, marking the progress and significant modifications over time. Additionally, explicit reference is made to the initial versions of each document to provide a clear and detailed view of the transformation experienced during the management process.

The primary objective of this final document is to provide a comprehensive overview of the project's development, highlighting changes, key decisions, and adopted processes to achieve the results obtained in the final versions of the SCM documents.

2. Software configuration management process

Software Configuration Management (SCM) stands as the pulsating heart of any software development project. It is the meticulous set of practices, tools, and procedures designed to systematically control, track, and manage software elements throughout their lifecycle. This process ensures the integrity, traceability, and quality of the final product, serving as a reliable compass for development teams in an ever-evolving technological landscape.

2.1 Software Configuration Identification

Software Configuration Identification is a foundational step in SCM that involves identifying, defining, and documenting all the components that constitute a software system. This includes software modules, documents, test scripts, databases, and other related artifacts. Each of these items is given a unique identifier, such as version numbers, tags, or labels, to distinguish and manage them effectively.

Key Aspects Covered in Software Configuration Identification:

- Configuration Item Definition: Describes the specific components that are considered configuration items. Establishes criteria for inclusion and defines the boundaries of each item.
- Baseline Creation: Establishes baselines or reference points for each configuration item at various stages of development. Baselines provide a snapshot of the configuration items at a particular point in time and act as a basis for future comparisons.
- Version Control and Change Management: Outlines version control techniques and practices, including branching, merging, and labeling strategies. Details how changes are tracked, evaluated, and approved, ensuring consistency and traceability.

2.2 Software Configuration Control

Software Configuration Control focuses on managing changes to configuration items throughout the software development lifecycle. It includes establishing change control boards or committees responsible for evaluating and approving proposed changes, ensuring that any modifications align with project requirements and objectives.

Key Aspects Covered in Software Configuration Control:

- Change Request Handling: Describes the process for submitting, reviewing, and approving change requests. Emphasizes the importance of evaluating the impact of proposed changes on the software system.
- Change Implementation: Details the procedures for implementing approved changes, ensuring proper documentation, testing, and validation before incorporation into the software baseline.
- Version Management: Explores strategies for maintaining a well-organized versioning system, facilitating rollback options, and managing concurrent development efforts.

2.3 Software Configuration Auditing

Software Configuration Auditing involves systematic assessments and reviews of the configuration management process to verify compliance with established standards, policies, and procedures.

Key Aspects Covered in Software Configuration Auditing:

- Audit Planning and Execution: Outlines the planning phase for audits, including determining audit scope, objectives, and frequency. Details the execution phase, including data collection, examination, and reporting of findings.
- Adherence to Standards: Ensures that configuration management practices conform to industry standards, regulatory requirements, and organizational policies.
- Corrective Actions: Discusses the implementation of corrective actions in response to audit findings, emphasizing continuous improvement in configuration management processes.

2.4 Software Configuration Status Accounting

Software Configuration Status Accounting involves recording and reporting the status and changes of configuration items throughout the software development lifecycle.

Key Aspects Covered in Software Configuration Status Accounting:

- Recording Changes: Describes the methods for capturing and documenting changes made to configuration items, maintaining a comprehensive history of modifications.
- Reporting and Metrics: Explains the generation of reports and metrics to track the status of configurations, providing stakeholders with visibility into the software's current state and progress.

- Configuration Management Database (CMDB): Discusses the use of CMDBs or similar tools for storing and managing configuration-related information.

3. History of changes

Date	08/30/2023	Document	Baseline 1.0
Configuration items. Description	Summary	Initial release	
	Modules	Initial release	
	Requirements	Initial release	
Documented on the repository o the project			Yes
Previous document version		None	
Comments			
Add a presentation and implement the changes.			

Date	11/23/2023	Document	Baseline 1.1
Configuration items. Description	Presentation	Initial release	
	Architecture and design of the project	Initial release	
	Modules	Update	
	Requirements	Update	
	Risk management	Initial release	
	Schedule	Initial release	
Documented on the repository o the project			Yes
Previous document version		Baseline 1.0	
Comments			
No comments			

Date	09/20/2023	Document	Change Request Analysis 1
Configuration items. Description	Project context	Initial release	
	Decision	Initial release	
	Analysis before and after the change request	Initial release	
Documented on the repository o the project			Yes
Previous document version		None	
Comments			
The addition of 3 change requests.			

Date	09/27/2023	Document	Change Request Analysis 2.0
Configuration items. Description	Change request 1	Analyzed	
	Change request 2	Analyzed initial release	
	Change request 3	Analyzed initial release	
	Change request 4	Analyzed initial release	
Documented on the repository o the project			Yes
Previous document version		Change Request Analysis 1	
Comments			
Include the full text of the change request before each analysis to enhance comprehension.			

Date	10/01/2023	Document	Change Request Analysis 2.1
Configuration items. Description	Change request 1	Update	
	Change request 2	Update	
	Change request 3	Update	
	Change request 4	Update	
Documented on the repository o the project			Yes
Previous document version		Change Request Analysis 2.0	
Comments			
No comments			

Date	10/05/2023	Document	Committee board and policy for decision-making 1.0
Configuration items. Description	Committee board	Initial release	
	Policy and steps for decision-making	Initial release	
Documented on the repository o the project			Yes
Previous document version		none	
Comments			
Some of the steps in the process should be done concurrently to enhance execution time.			

Date	10/12/2023	Document	Committee board and policy for decision-making 1.1
Configuration items. Description	Policy and steps for decision-making	Update	
Documented on the repository o the project			Yes
Previous document version		none	
Comments			
No comments			

Date	11/17/2023	Document	Status Accounting 1.0
Configuration items. Description	Procedures	Initial release	
	Scales	Initial release	
Documented on the repository o the project			Yes
Previous document version		None	
Comments			
Add tables to improve the understanding of the procedures and refine the scales to be clearer, without bias.			

Date	11/20/2023	Document	Status Accounting 1.1
Configuration items. Description	Procedures	Update with tables	
	Scales	Update	
Documented on the repository o the project			Yes
Previous document version		Status Accounting 1.0	
Comments			
None			

Date	11/27/2023	Document	Audit Activities Report
Configuration items. Description	Summary	Initial release	
	Results and Conclusions	Initial release	
	Recommendations	Initial release	
Documented on the repository o the project			Yes
Previous document version		None	
Comments			
No comments			

4. Configuration identification and configuration control

The management of software configuration within the Intelligent Traffic Management System project is an essential aspect ensuring the integrity, traceability, and control of all project elements. This chapter focuses on the pivotal elements of Configuration Identification (CI) and Configuration Control (CC), encompassing various documents and processes vital for managing and maintaining the project's evolving components.

Baseline
The project's baseline stands as the foundation upon which all subsequent modifications and developments are based. It includes a comprehensive depiction of the project's initial requirements, specifications, and components, providing a reference point for change assessment and comparison throughout the project lifecycle.

Configuration Item (CIRs)
The Configuration Item Records encapsulate details about each element within the project's configuration. These records comprehensively document items such as software modules, hardware components, specifications, and associated documentation. Each CIR outlines the item's version, specifications, dependencies, and relationships with other project elements.

Change Request (CR) Documents
The Change Request documents detail proposed modifications or enhancements within the project. Each CR document outlines the Configuration Item affected, policies for implementation, and an analysis of the impact of the proposed change. Furthermore, it includes an assessment of the outcome post-implementation, whether accepted, rejected, or modified.

Policies for Change Requests
These policies set the guidelines and procedures for managing CRs, including submission, evaluation, approval, implementation, and documentation. They define the roles, responsibilities, and the decision-making process governing changes within the project's configuration.

Analysis and Outcomes
This section presents a thorough evaluation and analysis of each CR's impact on the project's configuration. It details the reasons for change, assesses the implications, and documents the results post-implementation. The outcomes depict the changes accepted, rejected, or modified and their effects on the project's trajectory.

4.1 Baseline 1.1

Change Control

Revision	Description	Author	Date	Version
1.0	Initial version	Tomás Lugo	08/30/2023	Baseline 1.0
1.1	Presentation, architecture and design, risk management and schedule sections added CR 3 and 4 applied	Tomás Lugo	11/23/2023	Baseline 1.1

This is the final version with implemented changes. [1] contains the initial values; this document evolved to become [2]. We will be able to see the presentation of the project we worked on, its definitions, architecture and design of the project, modules, resources, risk management and schedule.

Presentation

Abstract

The project aims to develop an intelligent traffic management system for metropolitan areas with the goal of optimizing traffic flow, reducing congestion, and enhancing urban mobility. The system will collect and analyze real-time traffic data from traffic sensors to provide up-to-date information on traffic conditions, suggest alternative routes, and efficiently coordinate traffic lights.

Objective

The Intelligent Traffic Management System project aims to revolutionize traffic efficiency and safety in urban environments through the implementation of advanced technological solutions. This system aims to optimize traffic flow, improve road safety, and reduce travel times by integrating innovative technologies.

Project Scope

The Intelligent Traffic Management System will encompass a wide range of interconnected modules covering traffic monitoring, signal management, incident detection, and route optimization. This project will be divided into modular segments to facilitate development, implementation, and maintenance.

Key Technologies

The system will employ technologies such as IoT sensors, real-time data analytics, machine learning algorithms, and mobile applications to create an intelligent and adaptable ecosystem capable of dynamically responding to traffic conditions and user needs.

Expected Benefits

The successful implementation of the Intelligent Traffic Management System promises significant benefits, including congestion reduction, decreased accidents, improved public transportation efficiency, and optimized user experience.

Summary

The Intelligent Traffic Management System is an ambitious initiative designed to transform the way traffic is managed in urban environments. By incorporating advanced technologies, this project aims to address current challenges in urban traffic, enhancing road safety, optimizing mobility, and reducing travel times.

The modular approach of the project will enable the implementation of specific solutions in areas such as signal control, incident management, and route optimization. The use of IoT sensors, real-time data analytics, and machine learning algorithms will ensure the adaptability and effectiveness of the system, resulting in smoother, safer, and more efficient traffic flow.

The successful implementation of this project will bring about a significant change in urban traffic management, benefiting both individual drivers and overall road infrastructure.

Justification

Metropolitan areas face traffic congestion issues that lead to delays, stress, and unnecessary emissions. An intelligent traffic management system can address these issues by providing real-time information to drivers, optimizing traffic light coordination, and predicting traffic patterns. This can improve traffic flow, reduce travel time, and contribute to environmental sustainability.

Architecture and Design of the Project

The Intelligent Traffic Management System will consist of several interconnected modules to perform specific functions. The architecture will be divided into the following components.

Traffic Monitoring
Traffic sensors at key points in the city.
Interface for data collection and processing.

Data Analysis and Management
Data warehouse to store collected information.
Analysis and visualization tools to interpret traffic data.

User Information
Mobile application and web platform to provide real-time traffic information.
Notification systems and route recommendations based on real-time data.

Traffic Lights and Signals Control
Adaptive traffic light control based on traffic flow.
Variable signaling systems based on traffic events.

Modules

These modules changed after the acceptance of two change requests. If you wish to review the initial modules, please refer to [1].
To display the description changes in a more intuitive manner, they were enclosed in [brackets].
In the development of large-scale technological projects, efficient resource management and scalability are fundamental to success. To address these challenges and ensure agile and controlled development, we have adopted a core strategy: dividing the project's baseline into clearly defined modules. Each of these modules represents a functional and cohesive piece of the complete system, with specific objectives and requirements.

This modular structure enables us to develop, test, and maintain each component independently, streamlining the development process and facilitating resource and team management. Each module focuses on a particular set of functionalities and seamlessly integrates into the overall system.

Data Acquisition Module

Description: This module is responsible for collecting real-time data from traffic sensors located on roads and urban streets.
[Record user experience on the phone before uploading it to the database.]
[Capture and store additional information about user system usage.]
Key Functionalities: Sensor communication, raw data processing, filtering irrelevant data.

Requirements Analysis:

Requirement: The system must be capable of collecting real-time traffic sensor data.
Description: A data acquisition service will be implemented to connect to sensors through compatible hardware interfaces.

Requirement: It must be compatible with different types of traffic sensors, such as cameras, speed sensors, and flow sensors.
Description: A modular architecture will be developed to allow easy integration of new sensor types through specific adapters.

Requirement: It must provide mechanisms for sensor calibration and maintenance.
Description: Calibration and diagnostic functionality will be included, allowing operators to make adjustments and perform sensor maintenance remotely.

Requirement: The module must perform quality tests on acquired data and detect possible sensor errors or failures.
Description: A continuous monitoring system will be implemented to verify data quality and generate alerts in case of issues.

Real-Time Data Processing Module:

Description: This module processes real-time data to obtain information about the current traffic status.
[Process user experience data after it has been uploaded to the database.]
[Process and analyze user usage data for report generation.]
Key Functionalities: Real-time data processing, congestion detection, average speed calculation.

Requirements Analysis:

Requirement: The module must process real-time data to identify the current traffic status.
Description: Real-time processing algorithms will be developed to analyze incoming data and calculate traffic metrics.

Requirement: It must calculate average speeds, traffic densities, and estimated travel times.
Description: Real-time functions for speed, density, and travel time calculation will be implemented using sensor data.

Requirement: It must detect traffic congestions and notify other modules.
Description: A congestion detection system will be developed based on predefined thresholds, and notifications will be sent via an internal communication interface.

Requirement: The module must provide an interface to access real-time processed data.
Description: An API will be implemented to allow other modules to access processed traffic data.

Traffic Pattern Prediction Module:

Description: This module uses machine learning algorithms to predict traffic patterns based on historical data and recurrent events.
Key Functionalities: Prediction model training, future congestion prediction.

Requirements Analysis:

Requirement: The module must train traffic prediction models based on historical data and recurrent events.
Description: A model training system will be implemented using historical data and machine learning algorithms to create prediction models.

Requirement: It must make predictions about traffic congestion within a specific time horizon.
Description: A prediction component will be developed, taking into account historical and real-time information to generate congestion forecasts.

Requirement: It must provide information about optimal alternative routes based on predictions.
Description: A route recommendation system will be implemented using congestion predictions to suggest alternative routes.

Requirement: It must be able to continuously adjust models as new data arrives.
Description: A continuous training process will be established to update models with recent data to maintain accuracy.

Traffic Signal Coordination Module:

Description: This module coordinates traffic signals at intersections to improve traffic flow based on real-time information and predictions.
Key Functionalities: Coordination of traffic signal cycles, adaptive adjustment based on current traffic.

Requirements Analysis:

Requirement: The module must coordinate traffic signals at intersections to optimize traffic flow in real-time.
Description: A traffic signal coordination system will be developed that receives real-time traffic data and adjusts signal cycles and phases adaptively.

Requirement: It must receive information about the current traffic status and predictions of congestion.
Description: A communication interface with the real-time data processing module will be established to receive updated data about traffic.

Requirement: It must adjust signal cycle times and phases based on received information.
Description: A control algorithm will be implemented to make decisions about signal coordination based on real-time information and predictions.

User Interface Module:

Description: This module provides user interfaces in mobile applications to display traffic information to users.
[Allow the recording of user experience before uploading it.]
[Allow users to view their own usage reports and may need new functionality to display this data.]
Key Functionalities: User interface design, real-time notifications, selection of alternative routes.

Requirements Analysis:

Requirement: The module must provide mobile applications for Android and iOS platforms that allow drivers to access real-time traffic information.
Description: Native mobile applications will be developed for Android and iOS using platform-specific languages and frameworks.

Requirement: It must display the current traffic status, including congestion and road conditions, clearly and legibly.
Description: An intuitive user interface will be designed to present real-time traffic information through interactive map applications and visual markers.

Requirement: It must provide real-time push notifications to drivers about congestion and available alternative routes.
Description: A push notification system will be implemented to alert drivers about relevant traffic events, such as congestion or accidents.

Requirement: Drivers must be able to select routes suggested by the system and receive step-by-step directions.
Description: Navigation functionality will be integrated to offer alternative routes and turn-by-turn directions using map and navigation services.

Administration Module:

Description: This module allows administrators to configure traffic management parameters and monitor the system. [include functionalities for the generation and distribution of monthly reports.]
Key Functionalities: Parameter configuration, administrator access, report generation.

Requirements Analysis:

Requirement: The module must allow administrators to configure traffic management parameters, such as signal cycle times and congestion thresholds.
Description: A secure administration interface will be developed to enable administrators to access and configure key system parameters.

Requirement: It must generate reports on system performance and collected traffic data.
Description: A report generation system will be implemented to collect relevant data and create periodic reports.

External Systems Integration Module:

Description: This module facilitates integration with external navigation systems and map applications.
Key Functionalities: Integration APIs, industry-standard compatibility.

Requirements Analysis:

Requirement: The module must offer integration APIs for external systems, such as navigation applications.
Description: Secure RESTful APIs will be developed to allow external systems to access processed traffic data and send control commands.

Requirement: It must efficiently provide processed traffic data to external systems.
Description: API performance will be optimized to ensure fast and efficient delivery of data to external systems.

Security and Privacy Module:

Description: This module ensures the security of traffic data and user privacy.
[Involves user experience data.]
[Involves user usage data.]
Key Functionalities: Data encryption, identity management, compliance with regulations.

Requirements Analysis:

Requirement: The module must encrypt traffic data and user data.
Description: End-to-end encryption will be implemented for both traffic and user data using secure algorithms and security protocols.

Requirement: It must manage user identity and ensure secure access to the system.
Description: A robust authentication system will be established, including measures like two-factor authentication (2FA) to ensure secure access.

Requirement: It must comply with road safety and data protection regulations, including LFPDPPP and local standards.
Description: Policies and procedures will be established to comply with local data protection and road safety regulations, and regular audits will be conducted to verify compliance.

Having each of these modules developed and tested independently facilitates project management and scalability. Furthermore, this modular structure allows you to assign specific tasks to teams or individual developers, which can expedite the development process.

Risk Management

Technical Risks
Failures in integrating system modules.
Interoperability issues between different technologies used.
Performance and scalability problems of the system.

Time Risks
Delays in developing critical system modules.
Frequent changes in client requirements or specifications.
Unforeseen issues during testing consuming more time than planned.

Resource Risks
Shortage of qualified personnel in certain technical areas.
Budget limitations that might impact the acquisition of necessary equipment or tools.
Problems with external vendors affecting the delivery or quality of key components.

Security and Privacy Risks
Security breaches in collecting or storing sensitive data.
Non-compliance with privacy regulations resulting in legal penalties.

Environmental Risks
Extreme weather conditions affecting detection devices or system operation.
Power outages disrupting the system's function in specific areas.

To manage these risks, it's essential to:

Identify and assess their likelihood of occurrence and potential impact.
Develop mitigation strategies and contingency plans for the most critical risks.
Continuously monitor risks throughout the project and adjust strategies as needed.

The risk management plan should be a dynamic document, subject to regular updates as new risks are discovered or project circumstances change.

Schedule

Phase of Planning (August 30 - September 15)

Definition of project objectives and scope.
Analysis of requirements and specifications.
Creation of project structure and team designation.

Development Phase (September 16 - April 30 of the following year)

Development of system modules: traffic light control, traffic monitoring, etc.
Implementation of detection technologies and data collection.
System integration and user interface development.

Testing Phase (May 1 - June 15)

Functionality and system performance testing.
Identification and resolution of issues.
Optimization and final adjustments.

Implementation Phase (June 16 - July 15)

System implementation in pilot areas.
Staff and user training.
Initial monitoring of system effectiveness.

Evaluation and Adjustment Phase (July 16 - July 30)

Data collection on system performance in pilot areas.
Evaluation of results and necessary adjustments.

Full Deployment Phase (August 1 - August 15)

Complete deployment of the system in all planned areas.
Final evaluation and approval for general use.

4.2 Change Request Analysis 2.1

Revision	Description	Author	Date	Version
1.0	Initial version	Tomás Lugo	09/20/2023	Change Request Analysis 1
1.1	Change request 2, 3 and 4 added	Tomás Lugo	09/27/2023	Change Request Analysis 2.0
1.2	Change request 1, 2, 3 and 4 update	Tomás Lugo	10/01/2023	Change Request Analysis 2.1

Project Context

The client requests 4 changes to the system:

- CR1 The client requests that the system records the places where transit police are imposing fines on car drivers to avoid punishments for DUI (driving under impairment). The system is expected to help alcoholics and drug users prevent jail time and provide massive profit due to the alcoholism and drug addiction of users.
- CR2 For marketing purposes, the client requests incorporating a recommendation system that pinpoints the marketed places when traveling nearby.
- CR3 The client requests that the user experience should be recorded first on the phone and later uploaded into the system database.
- CR4 Due to a government law, a report of usage by each should be generated monthly, including used days, hours, and travels.

Before delving into the details of our project, "Intelligent Traffic Management System," it is essential to understand the framework that shapes this endeavor. In this section, we present an analysis of the effort, time, costs, and human resources originally estimated for the project.

CR Analysis

Before the Change Request

Effort: Originally, the project was estimated to require approximately 12 months of development with a full-time development team of 10 software engineers.
Time: The initial project schedule included 12 months for development and an additional 2 months for testing and deployment.
Costs: The initial project budget was estimated at $1 million, which included team salaries, infrastructure costs, and software licenses.
Human Resources: The development team consisted of 10 software engineers, 1 project manager, and 1 traffic expert.

Decision

The decision will depend on factors such as available resources: human resources, budget, time and effort, as well as the level of automation desired and the willingness of users to participate in the process. This CR have their pros and cons, and the final decision must take these aspects into account.

After the first Change Request

CR1 The client requests that the system records the places where transit police are imposing fines on car drivers to avoid punishments for DUI (driving under impairment). The system is expected to help alcoholics and drug users prevent jail time and provide massive profit due to the alcoholism and drug addiction of users.

Effort: The addition of the new feature for recording DUI fine locations is estimated to require an additional effort of 2 months of development.
Time: Implementing this additional feature will extend the schedule by an additional 2 months, bringing the total project time to 16 months.
Costs: The additional cost of the Change Request is estimated at $200,000, which includes the additional team salaries and costs associated with adding this feature.
Human Resources: The development team will expand to 12 software engineers, and 1 data privacy specialist will be hired to ensure compliance with regulations.

CR1 Affected modules

Data Acquisition Module: It will need new functionalities to receive and manage the location data of DUI fines registered by users.
Real-Time Data Processing Module: It will need to include logic to process and analyze this new location data in real-time and possibly adjust traffic predictions.

Traffic Pattern Prediction Module: It might require adjustments to its prediction algorithms to account for the new location data registered by users.
User Interface Module: It will need to provide users with a way to manually register locations of DUI fines, so changes to the user interface are likely.
Security and Privacy Module: Since this Change Request involves the collection of location data by users, additional measures must be taken to ensure the privacy and security of this data.

After the second Change Request

CR2 For marketing purposes, the client requests incorporating a recommendation system that pinpoints the marketed places when traveling nearby.

Effort: The implementation of the recommendation system to highlight points of interest will require additional effort. Let's assume that this additional effort would be 2 months. It would be necessary to add 2 extra software engineers to the team, including a specialist in recommendation systems.
Time: Implementing the recommendation system will extend the project timeline by an additional 2 months, bringing the total project duration to 16 months.
Costs: After the Second Change Request: The estimated additional cost for the second Change Request is $200,000, which includes additional salaries and expenses associated with the implementation of the recommendation system.
Human Resources: The development team will expand to 12 software engineers, and a recommendation system specialist will be hired.

CR2 Affected modules

Data Acquisition Module: It may require the implementation of data collection about nearby locations for the recommendation function.
Real-Time Data Processing Module: To process and calculate recommendations based on the user's location.
User Interface Module: It will need to display and provide recommendations of nearby places to the user.
External Systems Integration Module: If external location data is used for recommendations, this module will need to integrate with these services.
New modules: Add a module of recommendation system to highlight points of interest

Percentages in which the CR2 would affect the project

CR2
Budget:20%
Time:14.28%
HR:2

Work effort:18%

After the third Change Request

CR3 The client requests that the user experience should be recorded first on the phone and later uploaded into the system database.

Effort: Implementing user experience recording and loading into the database will require an additional effort of approximately 2 months of development with a team of 2 software engineers and 1 data storage specialist.
Time: The project schedule will be extended by an additional 2 months, bringing the total project duration to 16 months.
Costs: The estimated additional cost of the third Change Request is $70,000, which includes additional team salaries and expenses associated with user experience recording and loading.
Human Resources: The development team will expand to 12 software engineers, and 1 data storage specialist will join the team to ensure efficient management of user experience data.

CR3 Affected modules

Data Acquisition Module: It may require the implementation of functionality to record user experience on the phone before uploading it to the database.
Real-Time Data Processing Module: It might need adjustments to process user experience data after it has been uploaded to the database.
User Interface Module: The user interface is likely to be adapted to allow the recording of user experience before uploading it.
Security and Privacy Module: Since it involves user experience data, it may require adjustments in privacy and security management.

Percentages in which the CR3 would affect the project

CR3
Budget:7%
Time:14.28%
HR:2
Work effort:11%

After the fourth Change Request

Effort: The monthly generation of usage reports, including days, hours, and trips used, will require an additional effort of approximately 1 month of development with a team of 2 software engineers to implement the monthly report generation.

Time: An additional 1 month for the implementation of report generation, bringing the project to a total of 15 months.
Costs: The estimated additional cost of the fourth Change Request is $50,000, which includes the salaries of two software engineers and the resources needed to develop the monthly report functionality.
Human Resources: 2 software engineers will be added to the development team to carry out this addition.

CR4 Affected modules

CR4 Due to a government law, a report of usage by each should be generated monthly, including used days, hours, and travels.

Data Acquisition Module: It may need to capture and store additional information about user system usage.
Real-Time Data Processing Module: Additional functionality may be required to process and analyze user usage data for report generation.
User Interface Module: It should allow users to view their own usage reports and may need new functionality to display this data.
Security and Privacy Module: Since it involves user usage data, it may require adjustments in privacy and security management.
Management Module: This module is likely to include functionalities for the generation and distribution of monthly reports.

Percentages in which the CR4 would affect the project

CR4
Budget:5%
Time:7.14%
HR:2
Work effort:8%

Table of acceptance percentages

Tolerance
Budget-32%
Time-20%
Hr-2
Work effort-20%

Results

	Budget	Time	HR	W.E	Risk Exp	Law Mandatory	First Approval	Ranking	Final decision
CR1	20%	14.28%	3	20%	High	No	Rejected	4	Rejected
CR2	20%	14.28%	2	18%	Medium	No	Approved	3	Rejected
CR3	7%	14.28%	2	11%	Low	No	Approved	2	Approved
CR4	5%	7.14%	2	8%	None	Yes	Approved	1	Approved
	52%	50%	9	57%	Medium/ low	1			

Executive Summary

This report is presented to provide an overview of the analysis of the Change Requests (CRs) submitted to the Intelligent Traffic Management System project and to justify the decisions made regarding their acceptance or rejection. During this initial analysis phase, four CRs were evaluated in terms of effort, time, costs, and human resources. The results of this analysis are detailed below.

Change Request 1 (CR1):
Description: This CR proposed the incorporation of a manual user registration system for DUI fine locations.
Reason for Rejection: The analysis revealed that implementing this change would involve a significant increase in project costs and effort, as well as an extension in development time. These changes exceed the desired percentages for costs, time, and effort, which could compromise the project's feasibility.

Change Request 2 (CR2):
Description: The second CR requested the addition of a recommendation system for nearby places.
Reason for Rejection: Analysis demonstrated that implementing this feature would also result in a substantial increase in costs, effort, and an extension of development

time. These increases do not meet the desired percentages and could jeopardize the timely project delivery.

Change Request 3 (CR3):
Description: CR3 required user experience to be recorded on mobile devices before being uploaded to the system's database.
Reason for Acceptance: CR3 was accepted as the increases in costs, effort, and time remained within desired limits. Additionally, the implementation of this feature provides substantial benefits to users.

Change Request 4 (CR4):
Description: This CR originated from a government law requiring the monthly generation of a usage report.
Reason for Acceptance: CR4 was accepted as a legal requirement. Despite this, the increases in costs, effort, and time are relatively low and manageable.

Final Summary:
CR1 and CR2 were rejected as they exceed the desired percentages in costs, time, and effort, which could negatively impact the project. On the other hand, CR3 and CR4 were accepted because they meet the established criteria, and CR4 is required to comply with government regulations. These decisions were made considering the project's interests and defined constraints.

4.3 Committee board and policy for decision-making 1.1

Revision	Description	Author	Date	Version
1.0	Initial version	Tomás Lugo	10/05/2023	Committee board and policy or decision-making 1.0
1.1	Steps or decision-making update	Tomás Lugo	10/12/2023	Committee board and policy or decision-making 1.1

Committee board

Director: Lead and ultimate vote in case of a tie.
Development Manager: Overseas technical feasibility of the change.
Cost Analyst and Company Financial Representative: Assesses financial and budgetary impact.
Legal Representative: Verifies the legal compliance of the change.
Human Resources: Analyze and manage the need as human resources.

Policy and Steps for Decision-Making

Step 1: Change Request Submission

Submission of Change Request. The request should include a detailed description of the proposed change, its justification, and can have the expected impact on the project.

Step 2: Initial Evaluation

The Project Director and Development Manager conduct an initial evaluation of the request to determine if it meets basic criteria, such as technical feasibility and alignment with project objectives. If the request does not meet these criteria, it is rejected at this stage.

The following steps will be carried out simultaneously with the intention of reducing time and streamlining the process:

Step 3: Detailed Analysis

If the request passes the initial evaluation, the Cost Analyst and Company Financial Representative perform a detailed analysis of the costs associated with the Change Request and its financial impact on the project.

Step 4: Legal Review

The Legal Representative reviews the request to ensure it complies with relevant regulations and legal requirements. Possible legal implications of the proposed change are also assessed.

Step 5: Technical Assessment

The Technical Specialist analyzes the technical feasibility of the change, including its compatibility with the existing architecture and any impact on system quality.

After these steps, we proceed with decision-making and communication.

Step 6: Presentation to the Board

If the request successfully passes through all the previous stages, it is presented to the Board for final review. The board discusses the Change Request based on expert reports and makes a decision.

Step 6: Decision-Making
Each board member expresses their opinion and vote on whether to accept or reject the Change Request.

If there is consensus, and all members agree, the decision is made by majority vote.

In case of a tie or lack of consensus, the Project Director has the ultimate vote and makes the final decision.

This approach ensures that the Project Director bears the responsibility of making the final decision in situations where there is no agreement within the board. However, all board members are encouraged to voice their opinions and votes for a more informed decision-making process.

Step 7: Decision Communication

Once a decision is reached, it is communicated to all stakeholders, including the requester of the Change Request, and appropriate action is taken accordingly. If approved, the change is implemented. If rejected, clear reasons for the decision are provided.

This policy keeps the board without the inclusion of technical experts as permanent members. Technical experts can still be consulted as needed during the evaluation process.

5. Status Accounting

Within the framework of the Intelligent Traffic Management System project, Status Accounting holds a critical role in monitoring, recording, and maintaining an up-to-date record of the project's evolution. This chapter is dedicated to elucidating the significance of Status Accounting and how it ensures transparency, accountability, and effective management of project changes and progress.

Tracking Project Progress
Status Accounting serves as a mechanism to systematically track and document the evolution of the project. It encompasses a detailed record of modifications, updates, and enhancements made to the project's configuration items and associated documentation.

Documentation and Reporting
Comprehensive documentation is maintained, reflecting the current state of the project, including any changes implemented as a result of approved Change Requests (CRs). This documentation involves the status of configuration items, updated specifications, and alterations made throughout the project lifecycle.

Change Implementation Records
Status Accounting maintains records of the implementation of approved CRs. These records detail the changes made, the time of implementation, the affected components, and any associated impact on the project.

Versioning and Revision History
Version control and revision history are integral parts of Status Accounting. It encompasses maintaining a clear and accessible versioning system for all project elements, ensuring traceability and enabling the retrieval of specific versions as needed.

Progress Reporting
Regular reporting on project status, changes, and progress is a core component of Status Accounting. This reporting mechanism facilitates informed decision-making and ensures stakeholders remain updated on the project's trajectory.

Auditing and Verification
Periodic audits and verification of the project's current status against established baselines and requirements are conducted to ensure alignment and compliance.

5.1 Status Accounting 1.1

Revision	Description	Author	Date	Version
1.0	Initial version	Tomás Lugo	11/17/2023	Status Accounting 1.0
1.1	Procedure tables added. Scales update.	Tomás Lugo	11/20/2023	Status Accounting 1.1

Define the scales and the criteria to measure changes in the baseline.

Policies

Scales and Procedures for timing, money, effort, team skills, timing.

Timing:

Timing	
Evaluation of existing schedule	
	Review the current project planning in detail to identify phases or tasks affected by the change.
Identification of additional required duration	
	Accurately determine how much additional time is needed to implement the change.
Quantification of change	
	Calculate in percentage terms the impact of the change on the total project time. This involves determining whether the estimated time extends or shortens.
	It is done using the initial estimation's 100% as a reference.

Scale: 0-100%

0-4% +- than was estimated-> Excellent

5-9% +- than was estimated-> Good

10-15% +- than was estimated-> Acceptable

>15% +- than was estimated-> BAD

Money:

Money	
Analysis of current budget	
	Thoroughly assess the project's existing budget, considering personnel costs, resources, and software licenses.
Estimation of additional costs	
	Precisely determine how much costs will increase due to the requested change.
Assignment of percentage increase:	
	Quantify the increase in the total budget in relation to the initial budget. This quantification allows for a more precise evaluation of the financial impact.
	It is done using the initial estimation's 100% as a reference.

- Analysis of current budget: Thoroughly assess the project's existing budget, considering personnel costs, resources, and software licenses.
- Estimation of additional costs: Precisely determine how much costs will increase due to the requested change.
- Assignment of percentage increase: Quantify the increase in the total budget in relation to the initial budget. This quantification allows for a more precise evaluation of the financial impact.

Scale: 0-100%

0-4% +- than was estimated-> Excellent

5-9% +- than was estimated-> Good

10-15% +- than was estimated-> Acceptable

>15% +- than was estimated-> BAD

Effort:

Effort	
Detailed evaluation of current work:	
	Analyze existing tasks
	Analyze the current workload of the team in depth.
	Are we capable of supporting more workload?
Calculation of additional necessary hours	
	Estimate the number of work hours required to carry out the change.
Assignment of increase in percentages	
	This is taken as a reference: ((|time|+|money|)/2) + HR and evaluated based on experience.
	Quantify the increase in the project's total effort due to the requested change. This provides a clear assessment of the additional workload involved.

Scale: 0-100%

0-3% +- than was estimated-> Excellent

4-8% +- than was estimated-> Good

9-12% +- than was estimated-> Acceptable

12-16% +- than was estimated-> Bad

>16% +- than was estimated-> Unacceptable

Team:

Team	
Identification of current team skills	
	Evaluate the technical competencies of the work team and understand their current level of expertise.
	Use tests and assessment tools
	Give each employee a level: jr, medium, or senior
Comparison with necessary skills	
	Determine the specific skills required for implementing the change and compare them with existing skills.
Assignment of necessary skill level	
	Classify the required skill level to implement the change as Junior, Medium, or Senior, providing a clear understanding of the necessary competencies.

Skills scale: jr, medium, or senior

Scale: Number of people

1+- than was estimated-> Excellent

2+- than was estimated-> Good

3+- than was estimated-> Acceptable

4+- than was estimated-> BAD

These procedures enable a thorough and structured assessment of each aspect affected by a change in the project, providing an objective basis for the analysis.

Previous Estimation of CRs

CR3 (The client requests that the user experience should be recorded first on the phone and later uploaded into the system database):

- Timing: +14.28% (Additional 2 months)
- Money: +7% ($70,000)
- Effort: +11% (Moderate workload)
- Team and Skills: +2 Medium – Mobile implementation knowledge

CR4 (Due to a government law, a report of usage by each should be generated monthly, including used days, hours, and travels):

- Timing: +7.14% (Additional 1 month)
- Money: +5% ($50,000)
- Effort: +8% (Moderate workload)
- Team and Skills: +2 Medium – Experience in monthly report generation

100% Total Project Estimation after CRs Acceptance

- Timing: 100% (17 months)
- Money: 100% ($1,120,000)
- Effort: (Moderate workload)
- Team and Skills: Medium
    - 2 Software engineers (medium and senior)
    - 8 Developers (2 jr, 3 medium, 3 seniors)
    - 1 Security expert (senior)
    - 1 project manager (senior)
    - 1 traffic expert (senior)
    - 1 data storage specialist (senior)

Final Results compared to Initial Estimation

100% Total Project Estimation after CRs Acceptance

- Timing: 100% (17 months)
- Money: 100% ($1,120,000)

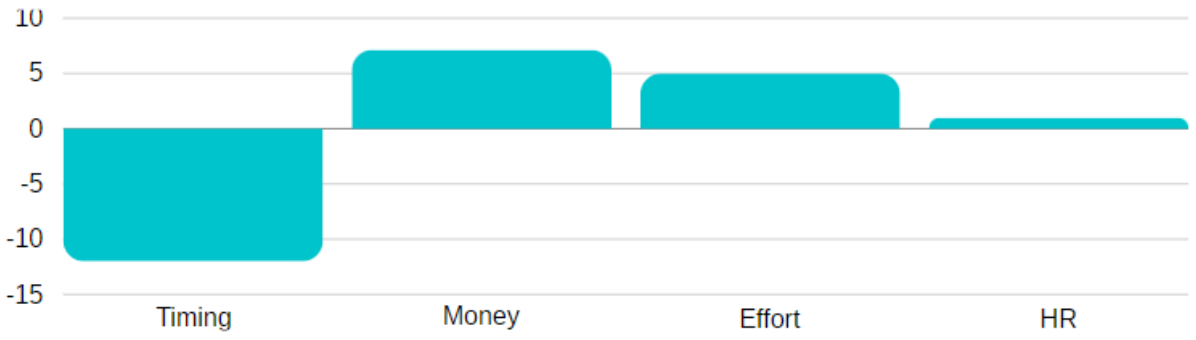
- Effort: (Moderate workload)
- Team and Skills: Medium
    - 2 Software engineers (medium and senior)
    - 8 Developers (2 jr, 3 medium, 3 seniors)
    - 1 Security expert (senior)
    - 1 project manager (senior)
    - 1 traffic expert (senior)
    - 1 data storage specialist (senior)

Final Results compared to Initial Estimation

- Timing: 88% (15 months)
- Money: 107.14% ($1,200,000)
- Effort: 105% (Moderate workload)
- Team and Skills: +1 Medium
    - 2 Software engineers (medium and senior)
    - 8 Developers (2 jr, 4 medium, 2 seniors)
    - 1 Security expert (senior)
    - 1 project manager (senior)
    - 1 traffic expert (senior)
    - 2 data storage specialist (medium and senior)

These results demonstrate how each CR impacts the project's baseline in terms of time, costs, effort, and team skill requirements, based on the defined scales and procedures.

Comparative Chart



Comparative Chart of Estimated vs Final Outcome

Conclusion

Considering the previous results, the conclusion could be positive with nuances. Although the project time has been calculated with a slight margin and has slightly exceeded in terms of HR, budget, and required a bit more team effort, the difference hasn't been hugely significant.

The adjustments in the team and skills have provided an improvement in the project's adaptability and capability, which is a positive point. Even though the reference values in terms of money and effort were exceeded, the gained experience and the proximity of the results to the initial estimates can be considered positive in terms of learning and team adjustment for future projects.

In summary, despite the adjustments, the project has managed to remain relatively close to the initial expectations. The acquired experience and the improvement in the team's skills can be seen as a positive aspect for future projects, allowing better planning and execution in similar situations.

6. Auditing

The auditing process within the framework of software development and project management serves as a critical component ensuring compliance, accuracy, and efficiency in the execution of tasks. This chapter delves into the pivotal role of auditing in the Intelligent Traffic Management project. It explores the methodologies, assessments, and findings involved in various auditing activities conducted throughout the project lifecycle.

Auditing plays a fundamental role in verifying the adherence of project activities to established standards, guidelines, and regulatory requirements. It encompasses a range of activities, including configuration audits, control audits, compliance assessments, and status accounting. Each of these aspects contributes to maintaining the integrity and coherence of the project's configuration items, ensuring proper version control, tracking changes, and upholding compliance with relevant policies and regulations.

This chapter will provide an in-depth exploration of the auditing activities undertaken, the objectives pursued, the methodologies employed, the findings derived, and the subsequent recommendations made to optimize the project's configuration management processes. It aims to elucidate the significance of auditing in assuring the quality, accuracy, and regulatory compliance of the Intelligent Traffic Management project.

6.1 Audit Activities Report 1.0

Revision	Description	Author	Date	Version
1.0	Initial version	Tomás Lugo	11/27/2023	Audit Activities Report 1.0

Report Date: 11/27/2023

Objective

The purpose of this report is to document the audit activities carried out within the framework of the Intelligent Traffic Management project.

Summary of Activities

Configuration Audit

- A comprehensive review of the configuration elements identified in the project was conducted.
- The accuracy and consistency of the baseline documentation and changes made throughout the project were verified.
- Configuration Items (CIs) were identified and their current status was verified.

Control Audit

- An assessment of version control and change control processes was performed to ensure their effectiveness and alignment with established policies.
- Change management was evaluated, and the correct application of defined procedures was verified.

Compliance Audit

- A review was conducted to ensure that the activities performed align with standards, regulations, and defined requirements.
- Alignment with data privacy and security policies was verified.

Results and Conclusions

- Areas for improvement were identified in the documentation of certain configuration elements.
- Control processes were found to be well-established and aligned with defined policies.
- Some minor corrective actions were identified to ensure full compliance with regulations.

Recommendations

- Strengthen documentation of configuration elements to maintain a complete and accurate record.
- Conduct training sessions for the development team on best practices in change management and version control.

This report is a summary of conducted activities and does not represent a comprehensive system assessment.

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