CN6004

PROJECT MANAGEMENT

COURSEWORK

TFL STUDENT OYSTER

APP DEVELOPMENT

TEAM MEMBERS

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TFL

STUDENT OYSTER CARD

APP DEVELOPMENT PROJECT

1. Introduction:

Transport for London (TFL) is the integrated transport authority responsible for managing and operating most of London's transport network. Establishes in 2000, TFL oversees the London Underground, Buses, Docklands Light Railway (DLR), London Overground, and the Elizabeth Line, among other services. The organisation Is committed to ensuring efficient, reliable, and sustainable transport across the city, making it easier for millions of people to travel daily.

1.1 Mission of TfL:

Transport for London's (TFL) mission is to create a modern, efficient, and sustainable transport network that supports the growth and prosperity of London. They aim to improve the quality of life for all Londoners by providing reliable, accessible, and environmentally friendly transport options. TFL is committed to making every journey count, ensuring that the city's transport system meets the needs of its diverse population and contributes to a greener, healthier, urban environment.

1.2 Strategy of TfL :

TFL aims to make 80% of trips in London by walking, cycling, or public transport by 2041. Their Healthy Streets approach prioritizes health and well-being. TFL focuses on improving public transport, facilitating the development of new homes, and jobs, adapting to new technologies, and collaborating with various stakeholders for a unified approach.

1.3 Current Issue:

Transport for London (TfL) is currently addressing an ongoing cyber security incident that has compromised certain customer data, including names, contact details, and potentially bank information for around 5,000 customers. They are working with the National Crime Agency and Cyber Security Centre to investigate and secure their

systems. Applications for some Oyster photocards are suspended, while others are still being accepted. Customers may use expired Zip Oyster photocards until December 31, and refunds for additional travel costs will be issued due to website issues. Online journey history for contactless users is unavailable, and various payment and account services are affected. TfL is prioritizing customer support and communication during this incident.

1.4 Project Objectives:

As we work to address the challenges which TfL is facing and improve the customer experience, we have created a clear SMART objective for developing a secure, efficient, and user-friendly mobile application for student oyster cards. This objective will guide our project to ensure it has:

- **Specific:** To develop and implement an efficient, secure, easy-to-use mobile application for the TfL student Oyster card, encompassing secure features such as a strong firewall to secure customer details to avoid system compromise.
- **Measurable:** Achieve a rating of 95% end-user satisfaction; increase the mobile application security by 80% to avoid any cyber-attack by powerful firewalls.
- **Achievable:** The product will be entirely redesigned with professional developers to give the customer a new atmosphere with secure and friendly for the users.
- **Relevant:** Address the ongoing challenges of TfL's student oyster card, providing enhanced customer experience through an easy-to-use platform to apply for a new Student Oyster Card, buy travel services, and review transactions and travel history.
- **Time-**bound: The application be launched within 12 months and achieve the set targets related to user satisfaction, reduction of cyber-attack incidents within 6 months after launching the application.

1.5 Our Solutions:

As the current mobile application for Oyster cards is not functioning properly and doesn't support the Student Oyster Card, we are introducing a new application that will accommodate both the travel Oyster card and the Student Oyster Card. This new app will offer several fully functional features, including:

- Application Management: Users will be able to make new applications for Oyster cards directly through the app.
- Purchasing Options: The app will facilitate the purchase of travel cards and bus passes.
- Transaction Access: Customers will have easy access to their recent transactions.

- Travel History: Users can view their travel history for better tracking.

Additionally, we are planning to implement a strong firewall for the application to enhance security and prevent crashes or compromises of customer data. This new app is designed to provide a seamless experience for all Oyster cardholders while ensuring the protection of their information.

2. Cost, Resources, And Time:

Developing an App requires a significant investment in cost, resources, and time. It includes all of the costs of design, development, testing, and maintenance from planning to deployment. A group of talented engineers, designers, quality assurance testers, and security specialists, are needed to ensure the app is well-designed, safe, and easy to use. To guarantee a successful launch and the application's long-term viability, the full process usually takes several months to complete, containing steps like initial planning, detailed design, coding, extensive testing, and seamless deployment. Effective cost control and timely project completion depend on efficient project management and resource allocation.

2.1. Initial Cost Estimation:

The app development for the TFL student oyster card is expected to cost between £209,000 and £355,000. This covers every phase of the development process, including design, development, testing, deployment, security, and maintenance. Certain elements that add to the overall cost include transaction access, purchase options, application management, and travel history.

TFL Student Oyster Card App Development - Estimated Initial Cost			
Activity ID	**Activity**	**Initial Estimated Cost**	**Description**
1	Planning	£8,000 - £15,000	Covers the project kickoff, setting objectives, creating timelines, assigning resources and initial budgeting.
2	Requirement Gathering	£8,000 - £12,000	Involves meetings with stakeholders to collect requirements and define app features and scope
3	Market Analysis	£5,000 - £8,000	Researching competitors, understanding users need, analyzing trends to tailor the app.
4	Feasibilty Study	£6,000 - £10,000	Evaluating technical solutions, potential risks, and financial feasibility for the app
5	Wireframing	£3,000 - £6,000	Creating basic mockups or sketches to visualize the app's structure and navigations.
6	UX Design	£12,000 - £20,000	Designing the user experience to ensure easy navigation and intuitive interactions.
7	UI Design	£10,000 - £18,000	Crafting visually appealing and accessible designs for all platforms
8	Front - End Development	£35,000 - £60,000	Building the interactive elements of the app, such as screens, buttons and forms.
9	Back - End Development	£45,000 - £75,000	Developing server - side logic, APIs, and database interactions to handle app functionality.
10	Integration	£12,000 - £20,000	Connecting the front-end, back-end, external APIs (ex: TFL systems)

Activity ID	Activity	Initial Estimated Cost	Description
11	Data Encryption	£6,000 - £12,000	Implementing secure encryption protocols (ex: AES - Advanced Encryption Standard) to protect sensitive user data.
12	Authentication and Authorization	£10,000 - £18,000	Developing secure login system, including multi-factor authentication, and role-based access
13	Firewall Implementation	£5,000 - £8,000	Setting up firewalls and other network protections against unauthorised access.
14	Unit Testing	£5,000 - £8,000	Testing individual components of the App for bugs and functionality issues.
15	Integration Testing	£8,000 - £12,000	Ensuring all integrated components work together as intended.
16	User Acceptance Testing	£7,000 - £10,000	Gathering feedback from real users to validate the app usability and features.
17	Performance Testing	£8,000 - £15,000	Testing the App under heavy usage to ensure speed, stability and scalability.
18	App Store Submission	£2,000 - £4,000	Preparing documentation, creating an app store account, submitting the app for approval
19	Deployment to Servers	£5,000 - £8,000	Developing the app and its services to secure, scalable cloud services.
20	Monitoring Setup	£5,000 - £8,000	Setting up tools for real-time monitoring of performance, usage analytics, and error reporting.
21	Finalising	£4,000 - £8,000	Making final adjustments based on feedback, ensuring readiness for launch, and addressing minor issues.
TOTAL INITIAL COST ESTIMATION		**£209,000 - £355,000**	

Table 1Initial Cost Estimation

2.2. Feasibility Of Resources:

1. Technical Resources:
    - Development Team
    - Technology Stack
    - Infrastructure
2. Human Resources:

- Designers:
- Quality Assurance(QA) (Testers to ensure the app functions as expected and is free of bugs
- Project Management

3. Financial Resources:
    - Budget Allocation

2.3. Time Needed:

Developing a new app for TFL requires adequate time to ensure thorough planning, development, testing, and integration. This time ensures the app meets high functionality, security, and user experience standards while complying with regulations and incorporating user feedback. Proper time allocation is crucial for delivering a reliable and effective app.

TFL Student Oyster Card App Development Process		
Activity ID.	Activity	Duration(Weeks)
1	Planning	1
2	Requirement Gathering	2
3	Market Analysis	2
4	Feasibilty Study	2
5	Wireframing	2
6	UX Design	2
7	UI Design	2
8	Front - End Development	8
9	Back - End Development	8
10	Integration	4
11	Data Encryption	3
12	Authentication and Authorization	3
13	Firewall Implementation	3
14	Unit Testing	2
15	Integration Testing	2
16	User Acceptance Testing	2
17	Performance Testing	2
18	App Store Submission	2
19	Deployment to Servers	1
20	Monitoring Setup	2
21	Finalising	1
TOTAL DURATION		56

Table 2 Initial Time Plan

3. Project Scope:

Project	Project Team	Date
TFL Student Oyster Card App Development	**Lakshmi Mukundan Athul Harshakumar Jiyoosh Karayil Adithyan Sunil Kumar**	**15 - November - 2024**

Justification
Due to a recent cyber-attack on TFL's Oyster Card website, there is an urgent need to develop a new mobile application. This app will provide a secure and efficient way for students to manage their oyster cards, ensuring the data and transactions are protected. It will address the growing demands for digital solutions and enhance user experience by offering real-time travel updates, balance management, and seamless ticketing services.

Scope Description	
In Scope	**Must (M), Should (S), Could (C), Won't (W)***
User-friendly interface for managing Oyster Card	M
Integration with TfL's existing system for real-time updates and ticketing	M
Features for topping up the Oyster Card and viewing journey history	M
Secure login, registration, and payment processing capabilities	M
Compatibility with both iOS and Android platforms	M
User support and feedback mechanisms	S
Regular updates and improvements based on user feedback	S
Basic offline functionality for accessing travel history	C
Notifications for low balance and travel disruptions.	S
Out of Scope	**Must (M), Should (S), Could (C), Won't (W)**
Development of hardware components or physical devices	W
Support for non-student Oyster Cards	W
Integration with non-TfL transport services	W
Advanced features like AI-based travel recommendations	C
In-depth analytics and reporting features	C
Marketing and Promotional activities for the Applications	W

**Using MoSCoW prioritization to determine if:*
the functionality is essential to business values (M), important but can be deferred to the next version (S),
useful but can be deferred to the next version (C) or limited business value and can be indefinitely deferred (W)

Business Objectives
– **Specific:** To develop and implement an efficient, secure, easy-to-use mobile application for the TFL student oyster card, encompassing secure features such as a strong firewall to secure customer details to avoid system compromise. – **Measurable:** Achieve a rating of 95% end-user satisfaction; increase the mobile application security by 80% to avoid any cyber-attack by powerful firewalls. – **Achievable:** The product will be entirely redesigned with professional developers to give the customer a new atmosphere with secure and friendly for the users. – **Relevant:** Address the ongoing challenges of TfL's student oyster card, providing enhanced customer experience through an easy-to-use platform to apply for a new Student Oyster card, buy travel services, and review transactions and travel history. – **Time-bound:** The application be launched within 12 months and achieve the set targets related to user satisfaction, reduction of cyber-attack incidents, and the number of users within 6 months after launching the application.
Project Deliverables
- Functional mobile application for iOS and Android - Comprehensive user guide and support documentation - Secure integration with TfL's Back-end Systems - User feedback and monitoring tools
Project Exclusions
- Future updates for new Oyster Card features beyond the initial release - Development of separate applications for other types of oyster cards.
Requirements
- Availability of technical resources and skilled personnel - All necessary approvals and support from TfL management - Continuous access to required datasets and API endpoints - User acceptance and positive feedback during beta testing phases.

Table 3 Project Scope

The project scope outlines the project's key objectives, justifications, in-scope and out-of-scope functionalities, business objectives, deliverables, exclusions, and requirements. This comprehensive outline ensures all stakeholders have a clear understanding of what the project will achieve, the prioritization of features, and the

boundaries within which the project will operate. By clearly specifying these elements, the project scope provides a structured framework to guide the project's progress, manage expectations, and ensure alignment with business goals.

4. Organisational Structure:

The organisational structure is the method used in describing how certain activities are guided toward attaining organisational goals. Such activities include rules, roles, and responsibilities.

It forms the way information flows between different levels in the firm. it gives a company a visual idea of the shape it takes and in which direction it needs to move towards its objectives. Regarding organisation structures, there is a common practice being depicted in one form or another on a chart or diagram showing the hierarchical structure from top management to grassroots employees.

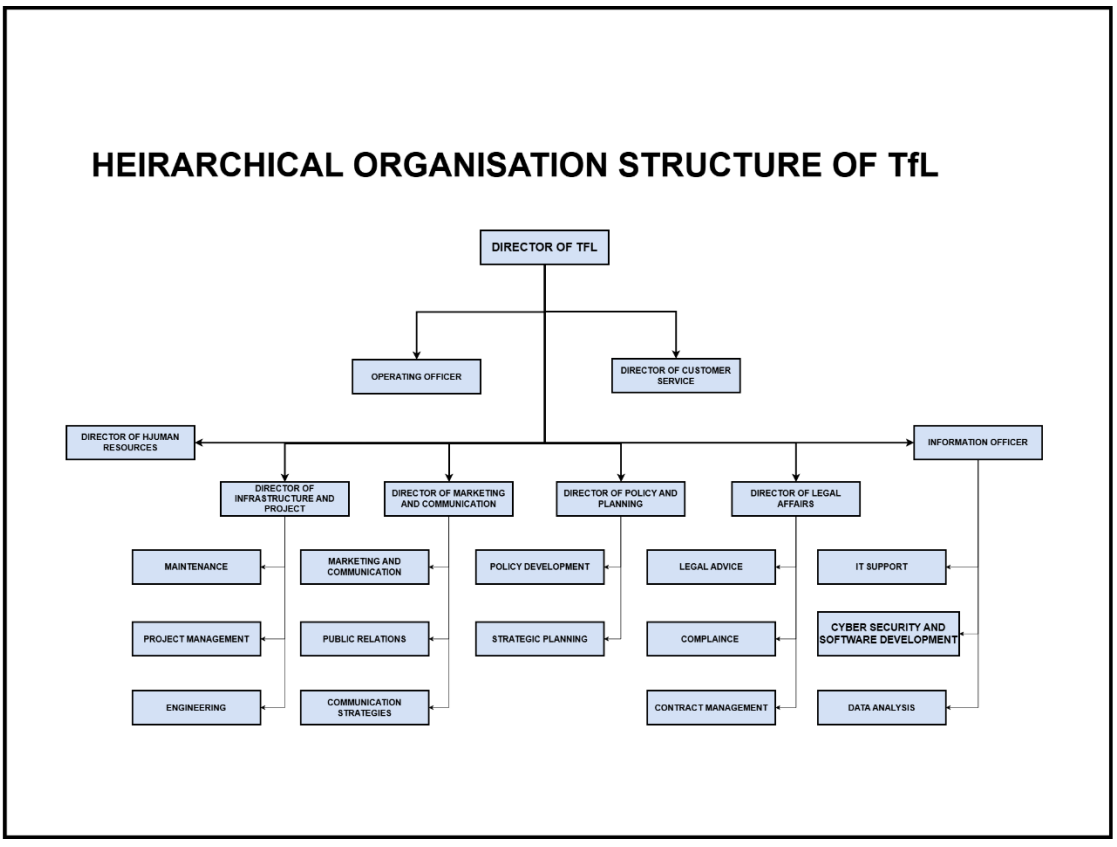


Figure 1TfL Organisation Structure

5. Responsibility Metrix

In a responsibility matrix diagram, **Responsibility** indicates the person assigned to complete significant tasks and ensure they meet the required standards. **Consultant** refers to those who provide expertise and advice related to the tasks without directly being involved in their execution. **Accountable** signifies the individual who has ultimate ownership of the task and is answerable for its completion, even if the work is delegated. **Informed** includes the team who need to be kept updated on the progress and decisions, ensuring they are aware of the project status.

TASK	PROJECT MANAGER	UI/UX DESINER	FRONT-END DEVELOPER	BACK-END DEVELOPER	QA TESTER	SECURITY EXPERTS	DEVELOPING ENGINEER	BUSINESS ANALYST
Planning	A	I	I	I	I	I	I	R
Requirement Gathering	A	C	I	I	I	I	I	R
Market Analysis	A	I	I	I	I	I	I	R
Feasibilty Study	A	I	I	I	I	I	I	R
Wireframing	I	R	I	I	I	I	I	C
UX Design	I	R	I	I	I	I	I	C
UI Design	I	R	I	I	I	I	I	C
Front - End Development	I	C	R	I	I	I	I	I
Back - End Development	I	I	I	R	I	I	I	I
Integration	I	I	C	C	I	I	R	I
Data Encryption	I	I	I	I	I	R	I	I
Authentication and Authorization	I	I	I	I	I	R	I	I
Firewall Implementation	I	I	I	I	I	R	I	I
Unit Testing	I	I	I	I	R	I	I	I
Integration Testing	I	I	I	I	R	I	I	I
User Acceptance Testing	A	I	I	I	C	I	I	R
Performance Testing	I	I	I	I	R	I	I	I
App Store Submission	I	I	I	I	I	I	R	I
Deployment to Servers	I	I	I	I	I	I	R	I
Monitoring Setup	I	I	I	I	I	I	R	I
Finalising	A	I	I	I	I	I	I	R

Table 4 Responsibility Matrix

R = Responsibility A = Accountable

C = Consultant I = Informed

6. Investigation of System

Investigate the project's processes and systems, from each step, in the interest of ensuring that the project process is efficient, at low risk, and objectives are met. This will enhance clarity and accountability in ensuring the successful execution of the project. The subsequent section will briefly outline each phase that the development process of the student Oyster card application for TfL.

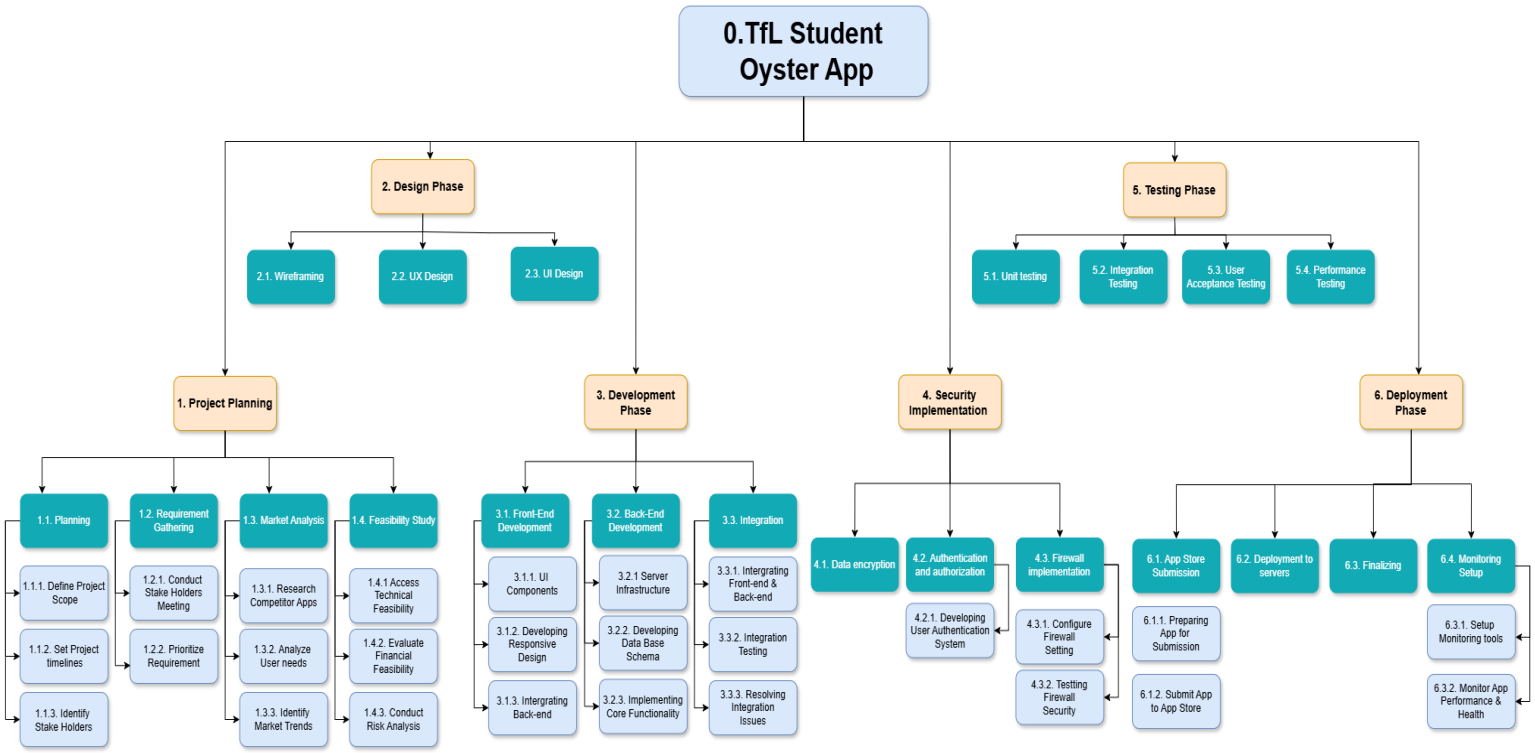
Some actions that fall under phases were grouped. where front-end and back-end development are in the development phase, and wireframing, UX, and UI are in the design phase. Lastly, the testing phases, include performance testing, UAT, integration testing, and unit testing.

ACTIVITY	OBJECTIVE	PROCESSES	TOOLS
Planning	Establish project goals,scope, timeline, and resources	Project Kick-off meetings, defining objective, resource allocation and timeline setup	Project Management software, meeting rooms
Requirement Gathering	Collect and Document all the functional and non-functional requirements	conduct workshops, interviews, surveys, and create requirement specifications	Collaboration tools, documentation software
Market Analysis	Understand market needs, and user expectations	conduct market research, analyze user data, and competitive analysis.	Market research tools, Data analysis software.
Feasibility Study	Access the feasiblity of the project in terms of technology , cost, and time.	Evaluate technological options, cost benefit anlaysis, risk assessment	Project management software, financial analysis tools.
Designing Phase (Wireframing, UX, UI)	Create design prototype and ensure user-centric design	Develpop wireframes, create UX/UI designs, conduct design reviews.	Design Software(e.g, Adobe XD, Sketch)
Development Phase(Front-end, Back-end)	Develop the application's Front-end and Back-end components.	Write code, conduct code reviews, performs unit tests.	Development environment(IDEs, code editors, version control system
Integration	Integrate various components and ensure seamless operation	Conduct integration test, resolve integration issues	Integration testing tools, continuous integration software.
Security Implementation	Ensure the application is secure and the user data is protected	Implement data encryption, authentication, autherization mechanisms, firewall setup	Security tools, development environment
Testing Phases(Unit Testing, Integration Testing, UAT Performance Testing)	Validate the functionality, performance, and security of the application	Conduct various tests, log and fix defects, validate with end-users	Testing environment, testing tools
Development and monitoring	Deploy the application and setup monitoring for ongoing performance	Deploy of production servers, set up monitoring, perform post-deployment checks	Deployment tools, monitoring tools
Finalizing	Ensure all project deliverables are met and application is ready for use	Final project review, stakeholder approval, documentation	Collaboration tools, meeting rooms

Table 5 Investigation of Processes

7. Work Breakdown Structure (WBS)

The WBS is a graphical, hierarchical, and deliverable-oriented decomposition of a project. It is a helpful diagram for project managers, as it allows them to break their project scope down to visualize just how many different tasks it will take to complete their projects.



LAKSHMI MUKUNDAN	1.1.	1.1.2.	1.2.1.	1.3.1.	2.1.	3.2.	3.2.3.	4.2.	4.2.1.	6.1.1.	6.3.2.
ATHUL HARSHAKUMAR	1.2.	1.1.1.	1.4.1.	1.3.2.	2.2.	3.1.1.	3.3.	4.3.	5.1.	6.1.2.	6.4.
JIYOOSH KARAYIL	1.4.	1.2.1.	1.3.	1.4.3.	2.3.	3.2.1.	3.3.3.	4.3.1.	5.2.	6.3.	6.4.
ADITHYAN SUNIL KUMAR	1.1.3.	1.2.2.	1.3.1.	1.4.2.	3.1.	3.2.2.	4.1.	4.3.2	5.2.	6.3.	6.3.1.

Figure 2 Work Breakdown Structure

Work breakdown Structures levels:

- Level 1 of the WBS is the product, here it is TfL Student Oyster App
- Level 2 of WBS includes,
    1. Project planning
    2. Design phase
    3. Development phase
    4. Security phase
    5. Testing phase
    6. Deployment phase
- Level 3 – The Sub Deliverables,
    - 1.1. Planning
    - 1.2. Requirement gathering
    - 1.3. Market analysis
    - 1.4. Feasibility study
    - 2.1. Wireframing
    - 2.2. UX Design
    - 2.3. UI Design
    - 3.1. Front-end development
    - 3.2. Back-end development
    - 3.3. Integration
    - 4.1. Data encryption
    - 4.2. Authentication and Authorization
    - 4.3. Firewall implementation
    - 5.1. Integration Testing
    - 5.2. Unit testing
    - 5.3. Performance testing
    - 5.4. User acceptance testing
    - 6.1. Appstore submission
    - 6.2. Development of servers
    - 6.3. Finalizing
    - 6.4. Monitoring setup

8. Project Organisation Structure

There are primarily three types of project organisation structures:

Functional organisational structure: This structure is based on a hierarchy of departments that have historically operated. In each department, a functional manager will be in charge and respond to the executives. Usually, one person who works in each department to assist with the project serves as the functional manager; there are no external staff members (Eby, 2021).

Matrix organisational structure: Team members in a matrix organisation report to both a project manager and a department lead, which sets it apart from a typical structure. In essence, team members from different departments are required to collaborate on a certain project (Asana, 2024).

Dedicated organisational structure: A contract between a client and a service provider whereby the latter offers the client software development experts on an ongoing basis. These experts are selected based on the client's requirements regarding their backgrounds and skillsets.

Here, A dedicated team structure is ideal for developing a student oyster card application for TfL. This approach ensures focused effort, specialized expertise, agility in responding to changes, and clear accountability. These benefits make it the best choice for this urgent and security-focused project.

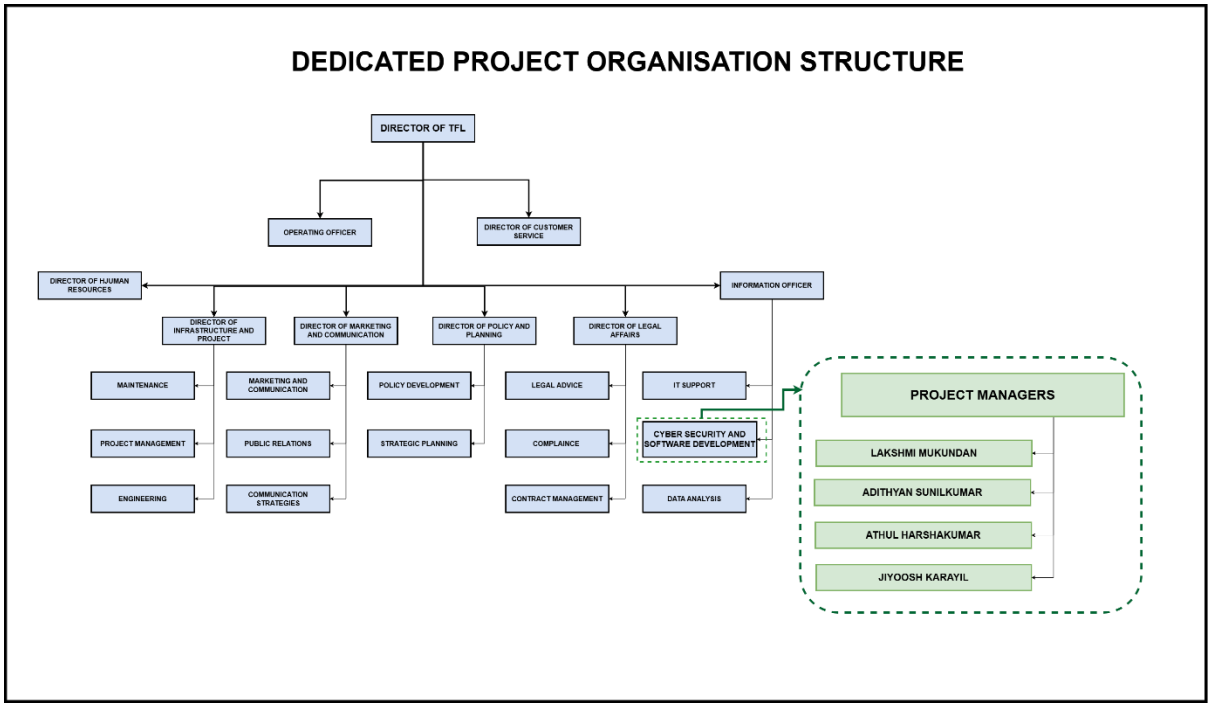


Figure 3 Dedicated Project Organisation Structure

9. Resource Analysis

Resource Analysis is the act of determining and assessing every resource that can be used to accomplish a goal or complete a project. It's a critical phase in any project, but it is especially important when estimating the duration and figuring out the costs.

9.1 Resources and Equipment

The resources for the app development include:

1. Project Manager
2. Business Analyst
3. Market Analyst
4. UX/UI designer
5. Front-End Developer
6. Back-End Developer
7. QA Tester
8. Security Expert
9. Develops Engineer
10. System Administrator
11. End-Users (UAT)

The Equipment for the app development will include:

1. Meeting room
2. Project Management Software
3. Collaboration Tools
4. Market Research Tools
5. Design Software
6. Development Environment
7. Testing Environment
8. Performance Testing Tools
9. Security Tools
10. App Store Accounts
11. Servers
12. Monitoring Tools

Equipment	Cost per Week (GBP)	Explanation	Resource	Cost per Week (GBP)	Explanation
Meeting Room	500	Includes office space, utilities, and standard facilities for meetings.	Project Manager	2000	Oversees project execution, planning, and stakeholder management.
Project Management Software	400	Tools like Jira, Trello, or MS Project on a team subscription basis.	Business Analyst	1800	Gathers and analyzes business requirements for the project.
Collaboration Tools	300	Tools like Slack, Microsoft Teams, or Google Workspace for team communication.	Market Analyst	1700	Conducts market research and competitive analysis.
Market Research Tools	500	Includes survey tools, data analysis software, and research platforms.	UX Designer	1800	Designs user experience workflows, wireframes, and prototypes.
Design Software	300	Tools like Figma, Adobe XD, or Sketch for UI/UX design work.	UI Designer	1800	Creates visual designs and interfaces for the application.
Development Environment	400	Includes IDEs, version control systems, and other programming tools.	Front-End Developer	1900	Develops the client-side (UI) functionality of the application.
Testing Environment	500	QA tools like Selenium, Appium, or a custom test environment.	Back-End Developer	2000	Builds server-side logic, APIs, and database interactions.
Performance Testing Tools	700	Load testing tools like JMeter, LoadRunner, or similar.	QA Tester	1700	Conducts testing to ensure software meets functional and performance requirements.
Security Tools	600	Includes encryption tools, vulnerability scanners, and firewall software.	Security Expert	2200	Implements and reviews data encryption, security protocols, and firewalls.
App Store Accounts	150	Cost divided weekly for annual Apple and Google developer accounts.	DevOps Engineer	2000	Handles deployment, server setup, and monitoring configurations.
Servers	800	Hosting platforms or physical servers for deployment.	System Administrator	1800	Manages infrastructure and ensures system reliability and availability.
Monitoring Tools	500	Tools like New Relic, Datadog, or other analytics platforms.	End-Users (UAT)	1500	Stakeholders or external testers providing feedback during UAT.

Table 6 Resources and Equipment

The above table indicates the equipment and resources that will be used to finish the app development process and the cost it will take per week with an explanation of what each term represents.

9.2 Task, Time, Cost, Resource and Equipment Allocation

The table() indicates the approximate activity cost according to the duration it takes, the explanation, and the total cost with indirect cost. The whole project will take an estimated ~ **56 weeks** to finish and as per our calculations, the total cost for resources will be **~£203,000**. The total cost for equipment will be ~ **£27,800**. The actual cost which will be the sum of resources and equipment (excluding the indirect costs) is ~ **£230,800**. The total cost including the indirect cost will be ~ **£290,800**. That is ~ **£60,000** more than the actual cost.

The indirect cost will include the additional cost which is not specifically allocated to a single task and it could be the cost of unforeseen events, administration fees, etc.,

Task	Duration (Weeks)	Resources	Resources Cost (£)	Equipment	Equipment Cost (£)	Actual total cost (£)	Total Cost with Indirect cost (£)	Explanation
Planning	1	Project Manager, Business Analyst, Developers	7600	Meeting room, project management software	900	8500	11500	Resources include Project Manager, Business Analyst, and 2 Developers. Overheads add up to £11,500.
Requirement Gathering	2	Business Analyst, Developers	12200	Meeting room, collaboration tools	1600	13800	14800	Resources include a Business Analyst and 2 Developers. Equipment includes Meeting Room and collaboration tools.
Market Analysis	2	Market Analyst, Business Analyst	4400	Market research tools, data analysis software	1000	5400	6500	Resources include a Market Analyst and Business Analyst. Equipment includes market research tools.
Feasibility Study	2	Project Manager, Business Analyst, Developers	12200	Meeting room, project management software	1600	13800	8000	Resources include Project Manager, Business Analyst, and 2 Developers. Equipment includes Meeting Room.
Wireframing	2	UX Designer, Developers	5700	Design software (e.g., Figma, Sketch)	600	6300	7000	Resources include UX Designer and 2 Developers. Equipment includes design software.
UX Design	2	UX Designer, Developers	11200	Design software (e.g., Figma, Sketch)	600	11800	16000	Resources include UX Designer and 2 Developers. Equipment includes design software.
UI Design	2	UI Designer, Developers	10600	Design software (e.g., Adobe XD, Sketch)	600	11200	14000	Resources include UI Designer and 2 Developers. Equipment includes design software.
Front-End Development	8	Front-End Developers	30400	Development environment (e.g., IDE, code editor)	3200	33600	47500	Resources include 4 Front-End Developers. Equipment includes development tools.

Back-End Development	8	Back-End Developers	32000	Development environment (e.g., IDE, code editor)	3200	35200	60000	Resources include 4 Back-End Developers. Equipment includes development tools.
Integration	4	Developers, QA Testers	12800	Development environment, testing environment	2000	14800	16000	Resources include Developers and QA Testers. Equipment includes testing environment.
Data Encryption	3	Security Experts, Developers	6600	Development environment, security tools	1800	8400	9000	Resources include Security Experts and Developers. Equipment includes security tools.
Authentication & Authorization	3	Security Experts, Developers	10200	Development environment, security tools	1800	12000	14000	Resources include Security Experts and Developers. Equipment includes security tools.
Firewall Implementation	3	Security Experts, Network Engineers	5100	Network devices, security tools	1500	6600	8000	Resources include Security Experts and Network Engineers. Equipment includes firewall tools.
Unit Testing	2	QA Testers, Developers	4400	Testing environment, testing tools	1000	5400	6500	Resources include QA Testers and Developers. Equipment includes testing tools.
Integration Testing	2	QA Testers, Developers	7000	Testing environment, testing tools	1000	8000	10000	Resources include QA Testers and Developers. Equipment includes testing tools.
User Acceptance Testing	2	QA Testers, End-Users	5900	Testing environment, testing tools	1000	6900	8500	Resources include QA Testers and End-Users. Equipment includes testing tools.
Performance Testing	2	Performance Engineers, QA Testers	8050	Performance testing tools	1400	9450	11500	Resources include Performance Engineers and QA Testers. Equipment includes performance tools.
App Store Submission	2	Project Manager, Developers	2100	App store accounts, submission tools	300	2400	3000	Resources include Project Manager and Developers. Equipment includes app store accounts.
Deployment to Servers	1	DevOps Engineers, System Administrators	5200	Servers, deployment tools	800	6000	6500	Resources include DevOps Engineers and System Administrators. Equipment includes servers.
Monitoring Setup	2	DevOps Engineers, System Administrators	4550	Monitoring tools	1000	5550	6500	Resources include DevOps Engineers and System Administrators. Equipment includes monitoring tools.
Finalizing	1	Project Manager, Stake Holders	4800	Meeting room, collaboration tools	900	5700	6000	Resources include Project Manager and Stakeholders. Equipment includes meeting room facilities.
	56		**£20,3000**		**£27,800**	**£230,800**	**£290,800**	

Note: The indirect costs are additional costs not directly attributed to resources or equipment, such as administrative fees, indirect operational costs, contingency (additional cost) for unexpected issues, or licensing and subscription fees that are not specifically allocated to a single task. These are necessary to ensure smooth project execution and often vary depending on the taks's complexity and duration.

Table 7 Project Cost Estimation

10. Communication Plan

Phase	Participants	Communication Method	Frequency	Explanation
Planning	Project Manager, Business Analyst, Developers	Meetings, project management tools	Weekly	Outline goals, tasks, resources, and schedules for the project.
Requirement Gathering	Business Analyst, Developers	Workshops, collaboration tools	As needed	Document the app requirements and understand user needs.
Market Analysis	Market Analyst, Business Analyst	Reports, meetings	Bi-weekly	Evaluate market trends and ensure the app meets market demand.
Feasibility Study	Project Manager, Business Analyst, Developers	Meetings, project management tools	Weekly	Assess project feasibility in terms of technology, budget, and timelines.
Design Phases	UX Designer, UI Designer, Developers	Design reviews, collaboration tools	Bi-weekly	Create and finalize app wireframes and prototypes.
Development Phases	Front-End & Back-End Developers	Daily stand-ups, development tools	Daily	Code and build the app's components in line with the design and requirements.
Integration	Developers, QA Testers	Integration sessions, testing tools	Daily	Combine components and verify their seamless functioning.
Security Implementation	Security Experts, Developers	Security briefings, collaboration tools	Weekly	Ensure robust security measures like data encryption and firewall implementation.
Testing Phases	QA Testers, Developers, End-Users	Testing reports, meetings	Bi-weekly	Perform various app tests (unit, integration, UAT, performance) for quality.
Deployment & Monitoring	DevOps Engineers, System Administrators	Deployment meetings, monitoring tools	Bi-weekly	Deploy the app and set up monitoring for performance and stability.
Finalizing	Project Manager, Stakeholders	Final review meetings, collaboration tools	At completion	Review project deliverables and ensure all objectives have been achieved.

Note:
Weekly: *For planning, feasibility study, and security implementation. Regular meetings maintain momentum and ensure continuous evaluation and security updates.*
As needed: *For requirement gathering. Allows for flexibility to gather and clarify requirements when necessary.*
Bi-weekly: *For market analysis, design phases, testing phases, and deployment/monitoring. Provides time to gather data, analyze trends, and ensure quality and performance.*
Daily: *For development phases and integration. Keeps the team synchronized and addresses issues promptly.*
At project completion: *For finalizing. Ensures all deliverables are reviewed and signed off.*

Table 8 Communication Plan

11. Risk Assessment and Risk Severity Matrix

No	Risk Event	Description	Likelihood	Impact
1	Integration Failures	Issues connecting the app with existing TfL systems.	3	E
2	System Downtime	Unexpected server outages affecting app functionality.	1	E
3	Data Security Breaches	Unauthorized access to sensitive user data.	3	E
4	Scalability Issues	App performance may degrade under high traffic.	3	C
5	Budget Overruns	Development costs exceeding the allocated budget.	3	E
6	Cost of Maintenance	Unanticipated costs in maintaining the app.	3	C
7	Non-Compliance with Regulations	Failure to comply with GDPR or app store policies.	1	E
8	Intellectual Property Disputes	Risk of using third-party content or code without proper licenses.	1	E
9	Project Delays	Development timelines may slip due to unforeseen challenges.	3	C
10	Inadequate Testing	Insufficient testing can lead to app malfunctions post-launch.	3	E
11	Low User Adoption	Students may not adopt the app due to poor user experience or lack of awareness.	3	E
12	User Data Misuse Concerns	Students might be wary of how their personal data is used.	1	C
13	Technological Changes	Rapid changes in technology may render parts of the app outdated.	3	C
14	Third-Party Dependency Failures	Downtime or changes in third-party services impacting app functionality.	3	E

Table 9 Risk assessment plan

Severity matrix:

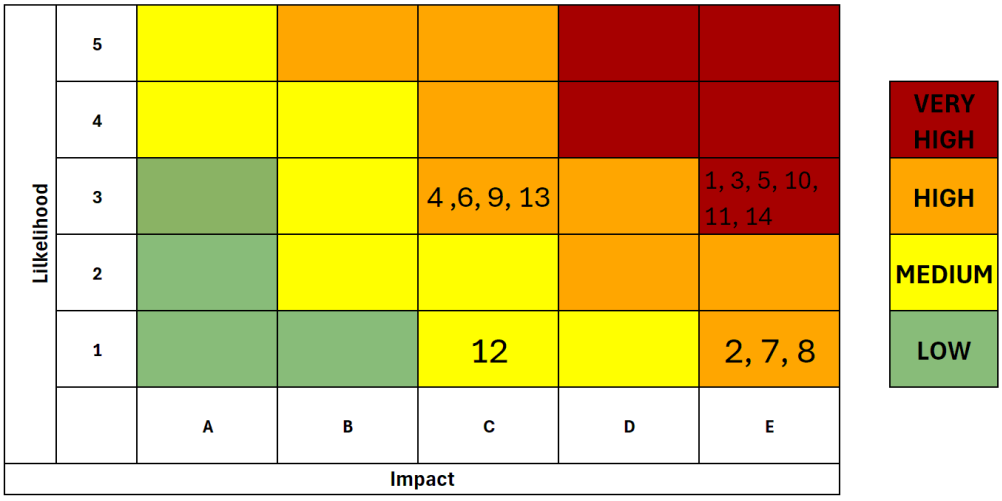


Figure 4 Risk Severity Metrix

11.1 Risk Event and Mitigation Strategy:

Risk Event	Mitigation Strategy
Integration Failures	Conduct feasibility studies, use experienced developers, collaborate with TfL teams.
System Downtime	Deploy on reliable cloud platforms, implement real-time monitoring.
Data Security Breaches	Employ strong encryption, secure authentication, regular security audits.
Scalability Issues	Conduct performance testing, use scalable infrastructure, implement caching.
Budget Overruns	Define clear scope, regular budget reviews, allocate contingency funds.
Cost of Maintenance	Plan maintenance costs, negotiate maintenance contracts.
Non-Compliance with Regulations	Consult legal experts, review app store guidelines.
Intellectual Property Disputes	Use licensed content, vet third-party components.
Project Delays	Use agile practices, monitor progress, address bottlenecks quickly.
Inadequate Testing	Allocate time for testing phases, use automated tools.
Low User Adoption	Conduct user research, implement intuitive UX/UI, launch a marketing campaign.
User Data Misuse Concerns	Clearly communicate privacy policies, ensure transparency about data usage.
Technological Changes	Use modern frameworks, plan regular updates.
Third-Party Dependency Failures	Establish SLAs, monitor APIs, implement fallback mechanisms.

A risk event and mitigation strategy table is something we have created as part of our project management approach for the TfL Student Oyster Card App Development Project. A full overview of potential risk and the associated mitigation techniques is

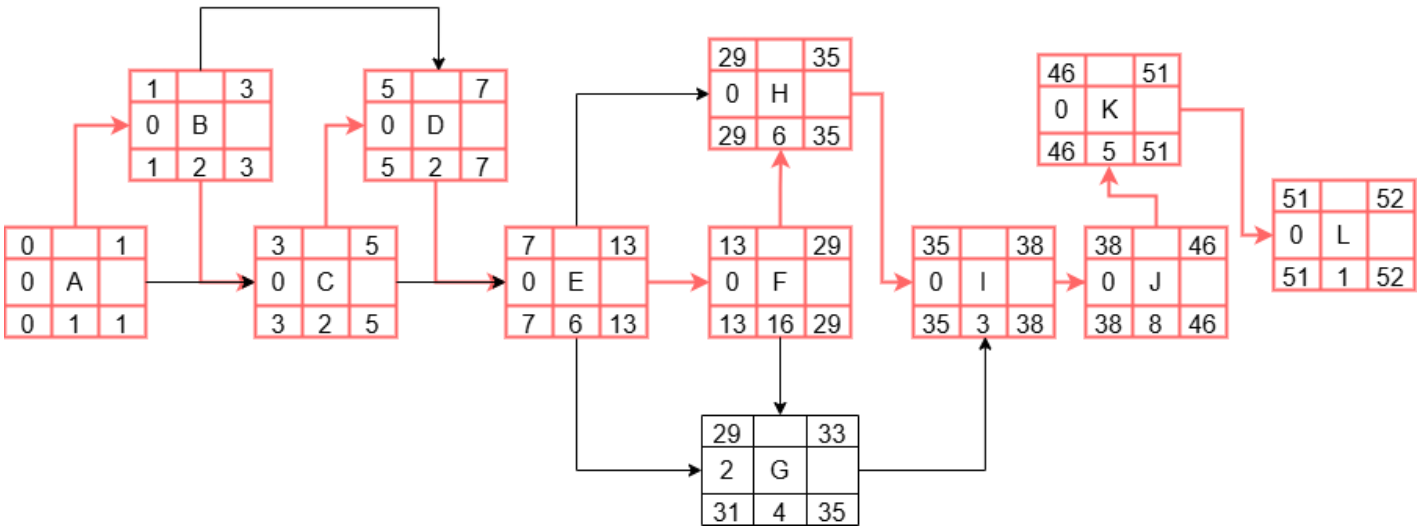
given in the above table. These risks may be reduced in impact and the project's success can be guaranteed by carefully recognizing and resolving them.

12. Project Network

A project network diagram is an organisational tool that shows the sequences of activities, their dependencies, and the workflow required to complete a project. For the TfL Student Oyster card app development, it focuses on the task interdependencies, and critical paths, ensuring all stakeholders are aligned and the project stays on schedule and within budget.

Activity ID	Activity	Duration (Week)	Predecessors
A	Planning	1	None
B	Requirement Gathering	**2**	**A**
C	Market Analysis	**2**	**A, B**
D	Feasibility Study	**2**	**B, C**
E	Design Phases	**6**	**C, D**
F	Development Phases	**16**	**E**
G	Integration	**4**	**E, F**
H	Security	**6**	**E,F**
I	Implementation	**3**	**G, H**
J	Testing Phases	**8**	**I**
K	Deployment & Monitoring	**5**	**J**
L	Finalizing	**1**	**K**

Table 10 Project Network Table



LEGEND

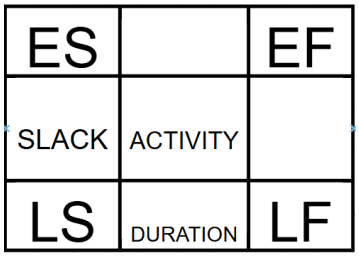


Figure 5 Project Network Diagram

ES – Early Start – This is the earliest time an activity can start without delaying any other activity
EF – Early Finish – This is the earliest time an activity can finish, based on its earliest start time and duration
LS – Late Start – This is the latest time an activity can start without delaying the overall project.
LF – Late Finish - This is the latest time an activity can finish without delaying the overall project.
These all are used to find the Critical Path in which the sequence of activities directly impacts the overall project duration.

13. Resources Allocation

Resource allocation using Project Network Diagram. The total duration of the Project is 52 Weeks. We have a slack of 2 days for the activity Integration (G) which will take 4 weeks to complete, but with the slack, it will take 6 weeks.

ID	Activity	Resources	Duration	Predecessor	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
A	Planning	3	1	None	3X												
B	Requirement Gathering	2	2	A		2X	2X										
C	Market Analysis	2	2	A, B				2X	2X								
D	Feasibility Study	3	2	B, C						2X	2X						
E	Design Phases	3	6	C, D								3X	3X	3X	3X	3X	3X
F	Development Phases	2	16	E													
G	Integration	2	4	E, F													
H	Security	2	6	E,F													
I	Implementation	2	3	G, H													
J	Testing Phases	3	8	I													
K	Deployment & Monitoring	2	5	J													
L	Finalizing	2	1	K													
Total Resources					3X	2X	2X	2X	2X	2X	2X	3X	3X	3X	3X	3X	3X

ID	Activity	Resources	Duration	Predecessor	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26
A	Planning	3	1	None													
B	Requirement Gathering	2	2	A													
C	Market Analysis	2	2	A, B													
D	Feasibility Study	3	2	B, C													
E	Design Phases	3	6	C, D													
F	Development Phases	2	16	E	2X	2X	2X	2X	2X	2X	2X	2X	2X	2X	2X	2X	2X
G	Integration	2	4	E, F													
H	Security	2	6	E,F													
I	Implementation	2	3	G, H													
J	Testing Phases	3	8	I													
K	Deployment & Monitoring	2	5	J													
L	Finalizing	2	1	K													
Total Resources					2X	2X	2X	2X	2X	2X	2X	2X	2X	2X	2X	2X	2X

ID	Activity	Resources	Duration	Predecessor	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36	Week 37	Week 38	Week 39
A	Planning	3	1	None													
B	Requirement Gathering	2	2	A													
C	Market Analysis	2	2	A, B													
D	Feasibility Study	3	2	B, C													
E	Design Phases	3	6	C, D													
F	Development Phases	2	16	E	2X	2X	2X										
G	Integration	2	4	E, F				2X	2X								
H	Security	2	6	E,F				2X	2X	2X	2X	2X	2X				
I	Implementation	2	3	G, H										2X	2X	2X	
J	Testing Phases	3	8	I													3X
K	Deployment & Monitoring	2	5	J													
L	Finalizing	2	1	K													
Total Resources					2X	2X	2X	4X	4X	2X	2X	2X	2X	2X	2X	2X	3X

ID	Activity	Resources	Duration	Predecessor	Week 40	Week 41	Week 42	Week 43	Week 44	Week 45	Week 46	Week 47	Week 48	Week 49	Week 50	Week 51	Week 52
A	Planning	3	1	None													
B	Requirement Gathering	2	2	A													
C	Market Analysis	2	2	A, B													
D	Feasibility Study	3	2	B, C													
E	Design Phases	3	6	C, D													
F	Development Phases	2	16	E													
G	Integration	2	4	E, F													
H	Security	2	6	E,F													
I	Implementation	2	3	G, H													
J	Testing Phases	3	8	I	3X	3X	3X	3X	3X	3X	3X						
K	Deployment & Monitoring	2	5	J								2X	2X	2X	2X	2X	
L	Finalizing	2	1	K													2X
Total Resources					3X	3X	3X	3X	3X	3X	3X	2X	2X	2X	2X	2X	2X

Suppose we have a problem of having only 3 workers maximum coming every day starting from Week 25, the Resource allocation table will change into the below one:

BEFORE:

ID	Activity	Resources	Duration	Predecessor	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36	Week 37	Week 38	Week 39
A	Planning	3	1	None													
B	Requirement Gathering	2	2	A													
C	Market Analysis	2	2	A, B													
D	Feasibility Study	3	2	B, C													
E	Design Phases	3	6	C, D													
F	Development Phases	2	16	E	2X	2X	2X										
G	Integration	2	4	E, F				2X	2X	2X	2X						
H	Security	2	6	E,F				2X	2X	2X	2X	2X	2X				
I	Implementation	2	3	G, H										2X	2X	2X	
J	Testing Phases	3	8	I													3X
K	Deployment & Monitoring	2	5	J													
L	Finalizing	2	1	K													
Total Resources					2X	2X	2X	4X	4X	2X	2X	2X	2X	2X	2X	2X	3X

AFTER:

ID	Activity	Resources	Duration	Predecessor	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36	Week 37	Week 38	Week 39	
A	Planning	3	1	None														
B	Requirement Gathering	2	2	A														
C	Market Analysis	2	2	A, B														
D	Feasibility Study	3	2	B, C														
E	Design Phases	3	6	C, D														
F	Development Phases	2	16	E	2X	2X	2X											
G	Integration	2	4	E, F				1X	1X	1X	1X	1X	1X					SLACK = 2
H	Security	2	6	E,F				2X	2X	2X	2X	2X	2X					
I	Implementation	2	3	G, H										2X	2X	2X		
J	Testing Phases	3	8	I													3X	
K	Deployment & Monitoring	2	5	J														
L	Finalizing	2	1	K														
Total Resources					2X	2X	2X	3X	3X	3X	3X	3X	3X	2X	2X	2X	3X	

14. Top-Down and Bottom-Up Cost Estimation

These are two common methods used to estimate the cost of a project.

1. **Bottom-up estimation** starts with breaking down the project into the smallest tasks and estimating the cost of each task. These individual costs are then added up to get the total project cost. This method is more accurate but takes longer.

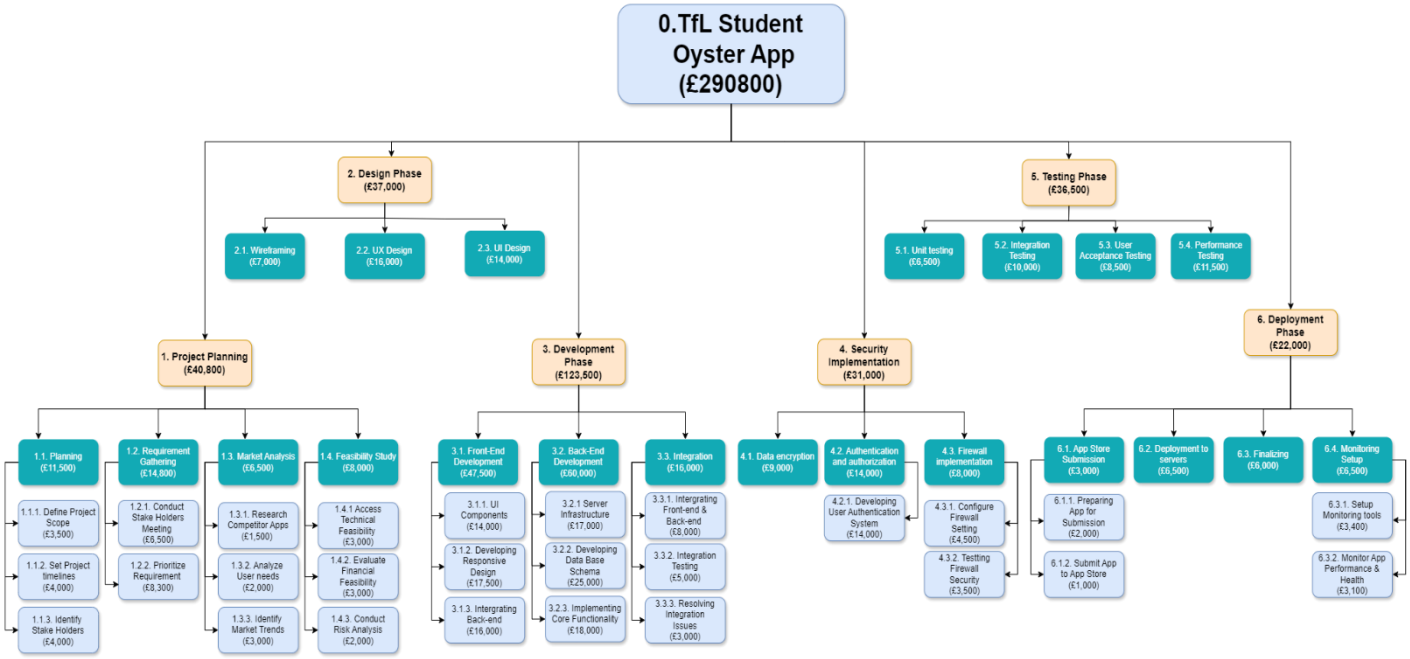


Figure 6 Bottom-up approach for cost estimation

2. **Top-down estimation** starts with a high-level view of the project and breaks it down into smaller components. This method is often used early in the project lifecycle when there's limited detail it's faster but less accurate.

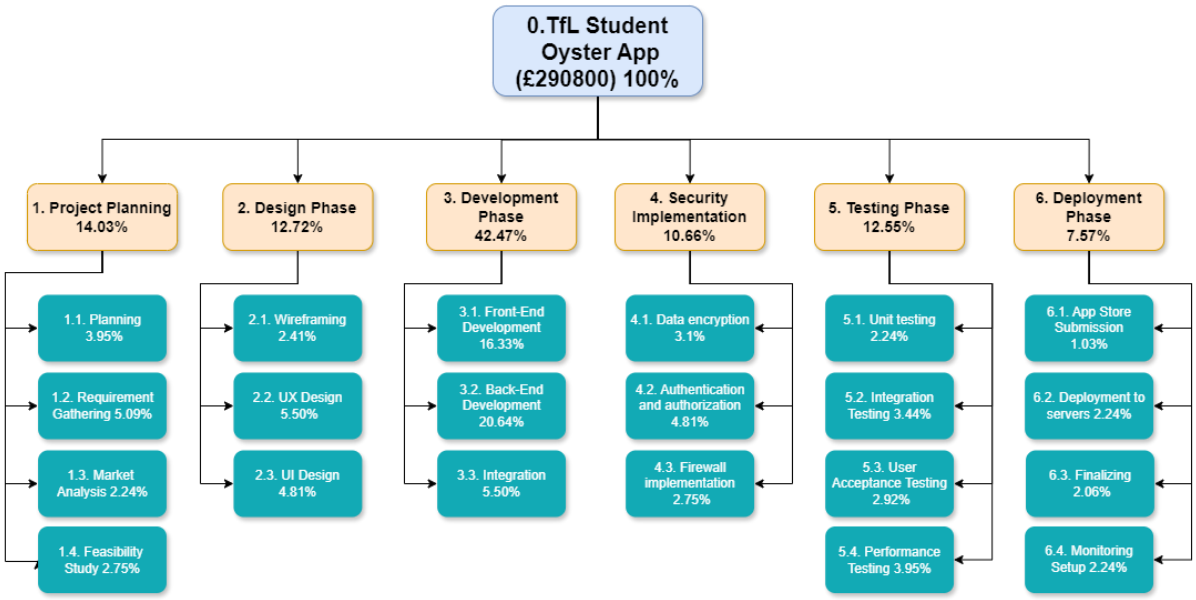


Figure 7 Top-down approach for cost estimation

15. Delphi Approach

To conduct a cost Analysis for the TfL Student oyster card App development using the Delphi approach, first, we have to select a Panel of Experts, then Develop an Initial Questionnaire and ensure the Anonymity and Distribution of the Initial Questionnaire. Collect and Compile Responses and feedback, Iterate the process, and at last, Finalize the Cost estimates.

Step 1: Selecting the Panel Experts

Choosing a diverse group of experts relevant to the project:

1. Project Managers
2. UX/UI Designers
3. Software Developers(Front-end & Back-end)
4. Security Specialists
5. QA Testers
6. Business Analysts
7. Infrastructure Specialists

Step 2: Develop Initial Questionnaire

A set of Questions to gather cost estimates and insights from each expert.

For example:

1.	**Project planning**
	What is the estimated cost for project planning activities, including requirement gathering, market analysis, and feasibility studies?
2.	**Design Phase**
	What are the estimated costs for wireframing, UX design, and UI design?
3.	**Development Phase**
	What are the estimated costs for front-end development, back-end development, and integration?
4.	**Security Phase**
	What are the estimated costs for data encryption, authentication and authorization, and firewall implementation?
5.	**Testing Phase**
	What are the estimated costs for integration testing, unit testing, performance testing, and user acceptance testing?
6.	**Deployment Phase**
	What are the estimated costs for app store submission, server development, finalizing, and monitoring setup?

Step 3: Anonymity and Distribution

- Ensuring the anonymity of each expert to encourage unbiased feedback.
- Distributing the initial questionnaire to each expert.

Step 4: Collect and Compile Responses

- Gather responses from the experts
- Compile the responses, summarizing key points and cost estimates.

Step 5: Feedback and Iteration Process

- Provide the compiled summary to the experts.
- Ask them to review the summary and refine their estimates based on collective feedback.
- Repeating this process for several rounds until the consensus is reached.

Step 6: Finalize Cost Estimates

- Analyse the final round of responses to identify the consensus or key conclusions on cost estimates.
- Preparing a detailed report summarizing the findings and the final estimated costs for each phase and sub-deliverables.

ROUND 1 – DELPHI APPROACH

1.	**Project planning**	**Experts Response**
	What is the estimated cost for project planning activities, including requirement gathering, market analysis, and feasibility studies?	Total Estimated Cost: GBP 15,000 Breakdown: • Planning: GBP 10,000 • Requirement Gathering: GBP 5,000
2.	**Design Phase**	
	What is the estimated cost for the design phase, including wireframing, UX design, and UI design?	Total Estimated Cost: GBP 20,000 Breakdown: • Wireframing: GBP 10,000 • UX Design: GBP 5,000 • UI Design: GBP 5,000
3.	**Development Phase**	
	What are the estimated costs for front-end development, back-end development, and integration?	Total Estimated Cost: GBP 50,000 Breakdown: • Front-end Development: GBP 20,000 • Back-end Development: GBP 20,000 • Integration: GBP 10,000
4.	**Security Phase**	
	What are the estimated costs for implementing security measures, such as data encryption, authentication and authorization, and firewall implementation?	Total Estimated Cost: GBP 15,000 Breakdown: • Data Encryption: GBP 5,000 • Authentication and Authorization: GBP 5,000 • Firewall Implementation: GBP 5,000
5.	**Testing Phase**	
	What are the estimated costs for integration testing, unit testing, performance testing, and user acceptance testing?	Total Estimated Cost: GBP 31,500 Breakdown: • Integration Testing: GBP 7,875 • Unit Testing: GBP 7.875 • Performance Testing: GBP 7.875 • User Acceptance Testing: GBP 7.875
6.	**Deployment Phase**	
	What are the estimated costs for app store submission, server development, finalizing, and monitoring setup?	Total Estimated Cost: GBP 10,000 Breakdown: • Appstore Submission: GBP 5,000 • Development of Servers: GBP 3,000 • Finalizing: GBP 1,500 • Monitoring Setup: GBP 500
7.	**Unforeseen Costs and Risks**	
	What potential risks and unforeseen costs should be accounted for in the overall budget?	Total Estimated Cost: GBP 7,500 Breakdown: • Contingency Budget: GBP 7,500

8.	**Software Licenses and Tools**	
	What are the estimated costs for software licenses, tools and third-party services needed for the project?	Total Estimated Cost: GBP 5,000 Breakdown: • Licenses and Tool Costs: GBP 5,000
9.	**Additional Cost Factors**	
	Are there any other cost factors that have not been covered in the above questions but are essential for the project's success?	Total Estimated Cost: GBP 5,000 Breakdown: • Other Essential Costs: GBP 5,000

ROUND 1 Feedback for Experts

1.	**Project planning**	**Expert's Response (ROUND 1)**	**Feedback (ROUND 1)**
	What is the estimated cost for project planning activities, including requirement gathering, market analysis, and feasibility studies?	Total Estimated Cost: GBP 15,000 Breakdown: • Planning: GBP 10,000 • Requirement Gathering: GBP 5,000	Suggest an increase in initial planning due to detailed requirement analysis needs.
2.	**Design Phase**		
	What is the estimated cost for the design phase, including wireframing, UX design, and UI design?	Total Estimated Cost: GBP 20,000 Breakdown: • Wireframing: GBP 10,000 • UX Design: GBP 5,000 • UI Design: GBP 5,000	Suggested allocation for additional prototyping and user testing sessions
3.	**Development Phase**		
	What are the estimated costs for front-end development, back-end development, and integration?	Total Estimated Cost: GBP 50,000 Breakdown: • Front-end Development: GBP 20,000 • Back-end Development: GBP 20,000 • Integration: GBP 10,000	Increase needed for more complex integration and additional features.

4.	**Security Phase**		
	What are the estimated costs for implementing security measures, such as data encryption, authentication and authorization, and firewall implementation?	Total Estimated Cost: GBP 15,000 Breakdown: • Data Encryption: GBP 5,000 • Authentication and Authorization: GBP 5,000 • Firewall Implementation: GBP 5,000	Additional costs suggested for advanced security protocols and compliance checks.
5.	**Testing Phase**		
	What are the estimated costs for integration testing, unit testing, performance testing, and user acceptance testing?	Total Estimated Cost: GBP 31,500 Breakdown: • Integration Testing: GBP 7,875 • Unit Testing: GBP 7.875 • Performance Testing: GBP 7.875 • User Acceptance Testing: GBP 7.875	Feedback indicated need for more rigorous testing and multiple testing and multiple user acceptance cycles.
6.	**Deployment Phase**		
	What are the estimated costs for app store submission, server development, finalizing, and monitoring setup?	Total Estimated Cost: GBP 10,000 Breakdown: • Appstore Submission: GBP 5,000 • Development of Servers: GBP 3,000 • Finalizing: GBP 1,500 • Monitoring Setup: GBP 500	Increase suggested for comprehensive monitoring setup and scaling infrastructure.
7.	**Unforeseen Costs and Risks**		
	What potential risks and unforeseen costs should be accounted for in the overall budget?	Total Estimated Cost: GBP 7,500 Breakdown: • Contingency Budget: GBP 7,500	Increase recommended for contingency to cover potential risks
8.	**Software Licenses and Tools**		
	What are the estimated costs for software licenses, tools	Total Estimated Cost: GBP 5,000	Additional tools and software

	and third-party services needed for the project?	Breakdown: • Licenses and Tool Costs: GBP 5,000	licenses required for enhanced functionality.
9.	**Additional Cost Factors**		
	Are there any other cost factors that have not been covered in the above questions but are essential for the project's success?	Total Estimated Cost: GBP 5,000 Breakdown: • Other Essential Costs: GBP 5,000	Suggest an additional budget for unforeseen essential costs and enhancements.

ROUND 2 Questions for Experts

	ROUND 2 Question	Expert's Response
1.	**Project Planning**	
	Considering the feedback, do you have any adjustments to your initial estimate for project planning?	Total Estimated Cost: GBP 25,000 Breakdown: • Initial Planning: GBP 15,000 • Requirement Gathering: GBP 10,000
2.	**Design Phase**	
	In light of Feedback, do you suggest any update to the estimated costs for the design phase?	Total Estimated Cost: GBP 30,000 Breakdown: • Wireframing: GBP 12,000 • UX Design: GBP 9,000 • UI Design: GBP 9,000
3.	**Development phase**	
	Based on the feedback, what changes, if any, do you recommend for the estimated costs for front-end and back-end development?	Total Estimated Cost: GBP 70,000 Breakdown: • Front-end Development: GBP 30,000 • Back-end Development: GBP 30,000 • Integration: GBP 10,000
4.	**Security Phase**	
	Considering the feedback, do you recommend any changes to the estimated costs for implementing security measures?	Total Estimated Cost: GBP 25,000 Breakdown: • Data Encryption: GBP 10,000 • Authentication and Authorization: GBP 7,500 • Firewall Implementation: GBP 7,500
5.	**Testing Phase**	
	Based on the feedback, how should the estimated costs for testing be adjusted?	Total Estimated Cost: GBP 40,000 Breakdown: • Integration Testing: GBP 10,000

		• Performance Testing: GBP 10,000 • User Acceptance Testing: GBP 10,000
6.	**Deployment Phase**	
	Considering the feedback, what adjustments , If any, should be made to the estimated costs for the deployment phase?	Total Estimated Cost: GBP 15,000 Breakdown: • App Store Submission: GBP 6,000 • Finalizing: GBP 2,000 • Monitoring Setup: GBP 2,000
7.	**Unforeseen Costs and Risks**	
	Based on the feedback, what additional risks and unforeseen costs should be accounted for in the overall budget?	Total Estimated Cost: GBP 17,500 Breakdown: • Contingency Plan: GBP 17,500
8.	**Software Licenses and Tools**	
	In light of the feedback, do you recommend any changes to the estimated costs for software licenses and tools?	Total Estimated Cost: GBP 10,000 Breakdown: • Licenses and Tools Costs: GBP 10,000
9.	**Additional Cost Factors**	
	Are there any other cost factors that have not been covered in the above questions but essential for the project's success?	Total Estimated Cost: GBP 17,500 Breakdown: • Other Essential Costs: GBP 17,500

ROUND 2 – Feedback for Experts

	ROUND 2 Question	Expert's Response	Feedback (ROUND 2)
1.	**Project Planning**		
	Considering the feedback, do you have any adjustments to your initial estimate for project planning?	Total Estimated Cost: GBP 25,000 Breakdown: • Initial Planning: GBP 15,000 • Requirement Gathering: GBP 10,000	Suggest adding contingency for planning risks and extended analysis.
2.	**Design Phase**		

	In light of Feedback, do you suggest any update to the estimated costs for the design phase?	Total Estimated Cost: GBP 30,000 Breakdown: • Wireframing: GBP 12,000 • UX Design: GBP 9,000 • UI Design: GBP 9,000	Suggest additional funding for extensive user feedback iterations and re-designing.
3.	**Development phase**		
	Based on the feedback, what changes, if any, do you recommend for the estimated costs for front-end and back-end development?	Total Estimated Cost: GBP 70,000 Breakdown: • Front-end Development: GBP 30,000 • Back-end Development: GBP 30,000 • Integration: GBP 10,000	Suggest more resources for handling increased feature complexity and integration with other systems.
4.	**Security Phase**		
	Considering the feedback, do you recommend any changes to the estimated costs for implementing security measures?	Total Estimated Cost: GBP 25,000 Breakdown: • Data Encryption: GBP 10,000 • Authentication and Authorization: GBP 7,500 • Firewall Implementation: GBP 7,500	Need to budget for security assessments and updates beyond initial implementation.
5.	**Testing Phase**		
	Based on the feedback, how should the estimated costs for testing be adjusted?	Total Estimated Cost: GBP 40,000 Breakdown: • Integration Testing: GBP 10,000 • Performance Testing: GBP 10,000 • User Acceptance Testing: GBP 10,000	Suggest increased budget for extensive testing cycles and additional test environments.
6.	**Deployment Phase**		
	Considering the feedback, what adjustments , If any,	Total Estimated Cost: GBP 15,000 Breakdown:	Suggest adding resources for post-

	should be made to the estimated costs for the deployment phase?	• App Store Submission: GBP 6,000 • Finalizing: GBP 2,000 • Monitoring Setup: GBP 2,000	deployment support and monitoring
7.	**Unforeseen Costs and Risks**		
	Based on the feedback, what additional risks and unforeseen costs should be accounted for in the overall budget?	Total Estimated Cost: GBP 17,500 Breakdown: • Contingency Plan: GBP 17,500	Recommend higher contingency budget to mitigate risks identified during planning.
8.	**Software Licenses and Tools**		
	In light of the feedback, do you recommend any changes to the estimated costs for software licenses and tools?	Total Estimated Cost: GBP 10,000 Breakdown: • Licenses and Tools Costs: GBP 10,000	Suggest additional licenses for new tools needed for enhanced functionality.
9.	**Additional Cost Factors**		
	Are there any other cost factors that have not been covered in the above questions but essential for the project's success?	Total Estimated Cost: GBP 17,500 Breakdown: • Other Essential Costs: GBP 17,500	Suggest additional budget for unforeseen essential costs and future enhancements.

ROUND 3 – Questions for Experts

	ROUND 3 Questions	**Expert's Response**
1.	**Project Planning**	
	In the light of the feedback, do you recommend any further adjustments to the project planning costs?	Total Estimated Costs: GBP 30,000 Breakdown: • Initial Planning: GBP 20,000 • Requirement Gathering: GBP 10,000
2.	**Design Phase**	
	Based on the Feedback, what further adjustments should be made to the design phase costs?	Total Estimated Costs: GBP 35,000 Breakdown: • Wireframing: GBP 15,000 • UX Design: GBP 10,000 • UI Design: GBP 10,000
3.	**Development Phase**	

	Considering the feedback, do you recommend further adjustments to the development costs?	Total Estimated Costs: GP 75,000 Breakdown: • Front-end Development: GBP 30,000 • Back-end Development: GBP 35,000 • Integration: GBP 10,000
4.	**Security Phase**	
	Based on the feedback, what further adjustments should be made to the security measures costs?	Total Estimated Costs: GBP 30,000 Breakdown: • Data Encryption: GBP 10,000 • Authentication and Authorization: GBP 10,000 • Firewall Implementation: GBP 10,000
5.	**Testing Phase**	
	Considering the feedback, do you recommend further adjustments to the testing phase costs?	Total Estimated Costs: GBP 42,500 Breakdown: • Integration Testing: GBP 11,000 • Unit Testing: GBP 11,000 • Performance Testing: GBP 10,500 • User Acceptance Testing: GBP 10,000
6.	**Deployment Phase**	
	Based on the feedback, what further adjustments should be made to the deployment phase costs?	Total Estimated Costs: GBP 15,000 Breakdown: • App Store Submission: GBP 6,000 • Server Development: GBP 5,000 • Finalizing: GBP 2,000 • Monitoring Setup: GBP 2,000
7.	**Unforeseen Costs and Risks**	
	In light of the feedback, what further adjustments should be made to the contingency budget?	Total Estimated Costs: GBP 20,500 Breakdown: • Contingency Budget: GBP 20,500
8.	**Software Licenses and Tools**	
	Based on the feedback, do you recommend further adjustments to the software licenses and tools costs?	Total Estimated Costs: GBP 10,000 Breakdown: • Licenses and Tools Costs: GBP 10,000
9.	**Additional Cost Factors**	
	Based on the feedback, what further adjustments should be made to the additional cost factors?	Total Estimated Costs: GBP 5,000 Breakdown: • Other Essential Costs: GBP 5,000

From Round 3, The Experts came up with a total estimate of GBP 258,000, which is GBP 32,800 less than the initial cost estimations.

The Delphi Approach will serve as the foundation for the cost analysis. This thorough cost analysis will be used for resource allocation, planning, and budgeting later for the project.

16. Reducing Environmental Impact & Ethical Considerations of the TfL Student

16.1 Reducing Environmental Impact

1. **Minimizing Paper Waste:** Transitioning to a digital app reduces the need for physical Oyster cards and paper-based receipts, contributing to decreased paper waste. Encouraging students to use digital tickets helps eliminate the environmental footprint associated with printing and distribution.
2. **Energy-Efficient Design:** Optimize the app to consume minimal device resources such as battery and processing power. This can help extend the device lifespan and reduce the energy demands of user's phones.
3. **Promoting Sustainable Travel**: The app can include features encouraging environmentally friendly travel behaviours, such as highlighting off-peak travel times or routes with lower carbon footprints.

16.2 Ethical Consideration

1. **Data Privacy and Security:** The app must prioritize the secure handling of personal data, such as travel history, payment information, and personal identifiers. Adhering to GDPR and other privacy laws is crucial to protect user trust and prevent misuse of data.
2. **Accessibility and Inclusion:** Ensure the app is accessible to all users, including those with disabilities. Features like screen-reader compatibility, customizability text sizes, and intuitive navigation should be implemented to promote digital inclusivity.
3. **Avoid Discrimination:** The app should not inadvertently exclude any group based on socioeconomic or technological barriers. For example, ensuring offline functionality for users without consistent internet access can help mitigate the digital divide.
4. **Transparency in Data Usage:** Provide clear and detailed policies regarding how user data is collected, stored, and shared. Students should have the ability to view and manage their data easily and opt-out of non-essential data sharing.

16.3 Social Issues:

1. **Accessibility Concerns**: Ensuring the app is accessible to all students, including those with disabilities, to provide equal opportunities for travel.
2. **Privacy Concerns**: Addressing how student data is collected, stored, and used to ensure privacy and prevent misuse.

16.4 Legal Issues:

1. **Data Protection Compliance:** Ensuring the app complies with data protection laws such as GDPR, to protect student information.
2. **Cybersecurity Measures:** Implementing Robust cybersecurity measures to prevent data breaches and protect against cyber-attacks.

17. Project Closure

Project closure is the final phase of the project. Completing deliverables, recording lessons learned, archiving project documents, and evaluating project performance. Project closure is an important step in the project management process. It ensures the project is completed successfully and all stakeholders are satisfied. This is a normal Project Closure type.

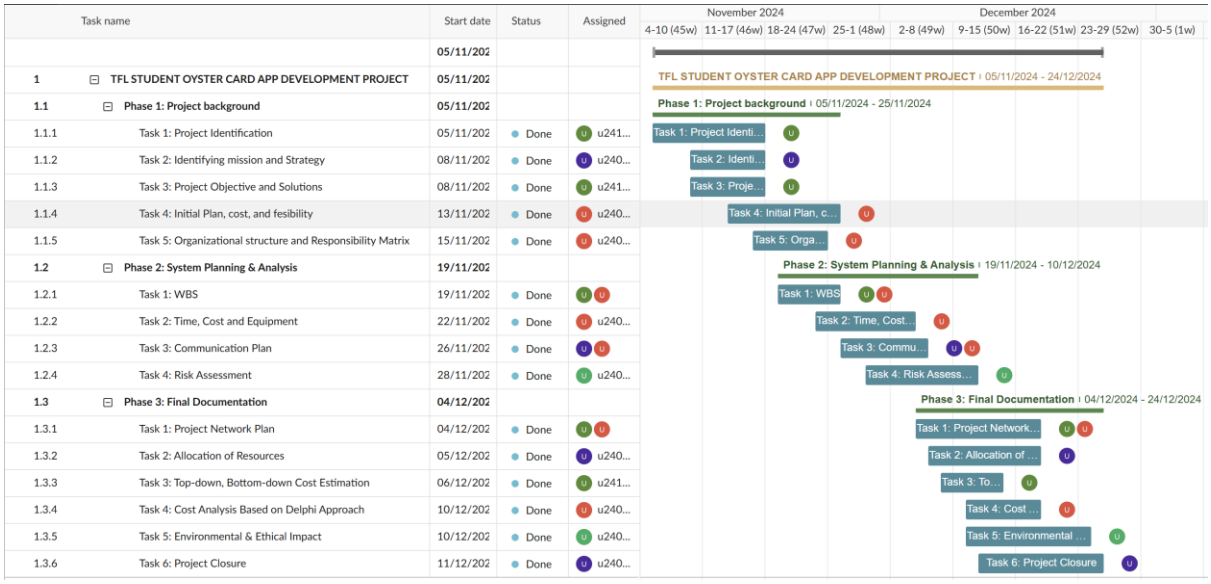
Checklist for Project Closure:

PROJECT : TfL: Student Oyster App Development				**CUSTOMER: Students**
PROJECT MANAGER: ATHUL HARSHAKUMAR				**COMPLETION DATE : 15 Dec 2025**
	Due Date (MM/DD/YYYY)	**Person responsible**	**Notes**	**Yes / No**
Document TFL acceptance	12/20/2025	JIYOOSH KARAYIL	Obtain final sign-off from TFL stakeholders.	YES
Staff training on the app	12/21/2025	ATHUL HARSHAKUMAR	Train operations staff on app functionality.	YES
Archive project deliverables	12/22/2025	ADITHYAN SUNIL KUMAR	Source Code: Final version archived in repository. Designs: Stored in central documentation system. Testing reports: Archived in QA database.	YES
Close all vendor accounts	12/23/2025	ADITHYAN SUNIL KUMAR	Ensure final payment are processed and contracts are closed	YES
Conduct team debriefing	12/24/2025	JIYOOSH KARAYIL	Summarize project outcomes and challenges.	YES
Final evolution	12/25/2025	LAKSHMI MUKUNDAN	Use post-project evaluation form: •Vendors: assess quality and timelines. •Team member: evaluate performance and contributions.	YES
Transition app to TFL IT team	12/26/2025	ATHUL HARSHAKUMAR	Provide final documentation an conduct handover meeting with TFL IT.	YES
Final report and lessons learned	12/27/2025	LAKSHMI MUKUNDAN	Distribute report and hold meeting with key stakeholders.	YES
Lessons learned archived	12/28/2025	JIYOOSH KARAYIL	Store in TFL project database.	YES
Celebrate project completion	12/29/2025	ADITHYAN SUNIL KUMAR	Organize a team event and distribute recognition awards	YES

The development phase of TfL's Student Oyster Card Application is completed now, and the set objective has been achieved, which means the application is now ready to

go live. During the project closure process, the deliverables were completed to specifications, lessons learned were held with team members and stakeholders to obtain valuable insights, and such lessons were documented and analysed to arrive at improvements for future projects.

18. Gantt Chart



	Task name	Start date	Status	Assigned
		05/11/202		
1	TFL STUDENT OYSTER CARD APP DEVELOPMENT PROJECT	05/11/202		
1.1	Phase 1: Project background	05/11/202		
1.1.1	Task 1: Project Identification	05/11/202	Done	u241...
1.1.2	Task 2: Identifying mission and Strategy	08/11/202	Done	u240...
1.1.3	Task 3: Project Objective and Solutions	08/11/202	Done	u241...
1.1.4	Task 4: Initial Plan, cost, and fesibility	13/11/202	Done	u240...
1.1.5	Task 5: Organizational structure and Responsibility Matrix	15/11/202	Done	u240...
1.2	Phase 2: System Planning & Analysis	19/11/202		
1.2.1	Task 1: WBS	19/11/202	Done	
1.2.2	Task 2: Time, Cost and Equipment	22/11/202	Done	u240...
1.2.3	Task 3: Communication Plan	26/11/202	Done	
1.2.4	Task 4: Risk Assessment	28/11/202	Done	u240...
1.3	Phase 3: Final Documentation	04/12/202		
1.3.1	Task 1: Project Network Plan	04/12/202	Done	
1.3.2	Task 2: Allocation of Resources	05/12/202	Done	u240...
1.3.3	Task 3: Top-down, Bottom-down Cost Estimation	06/12/202	Done	u241...
1.3.4	Task 4: Cost Analysis Based on Delphi Approach	10/12/202	Done	u240...
1.3.5	Task 5: Environmental & Ethical Impact	10/12/202	Done	u240...
1.3.6	Task 6: Project Closure	11/12/202	Done	u240...

19. Conclusion

The TfL Student Oyster Card app's development marks a major step forward in improving student's travel experience around London. To ensure thorough and strategic execution, we have carefully addressed every stage of this project, from planning and design to deployment and maintenance.

Important Achievement:

- **Alignment of Mission and Strategy:** The project follows TfL's mission and strategic goals by targeting present problems and achieving specific objectives through creative solutions.
- **Time, Cost, and Resources:** By using time management plans, resource feasibility studies, and initial cost estimates, we have effectively distributed resources and met the project schedule.
- **Detailed Project Scope:** Task management and execution have been made easier by well-defined organisational structures and project scope.
- **Detailed Investigation of Project and WBS:** A Strong basis for project operations has been established through system investigations and a well-organised Work Breakdown Structure (WBS)

- **Allocation of Resources and Equipment:** Thorough evaluation, and distribution of tasks, equipment, and resources have guaranteed smooth project operations.
- **Effective Communication and Risk Management:** The project's advancement and stakeholder alignment have been protected by a strong communication plan in combined with comprehensive risk assessment and mitigation techniques.
- **Cost estimation and Delphi Approach:** Consensus-driven budgeting has been guaranteed by precise cost estimates made using top-down, bottom-up, and Delphi approaches.
- **Social and Legal Considerations:** The project's implementation has placed a high priority on addressing social and legal concerns including privacy and accessibility and adhering to the data protection regulations.
- **Environmental Impact and Ethical Considerations:** In keeping with TfL's dedication to sustainability and social responsibility, the project has strongly emphasized minimizing environmental impact and maintaining ethical standards.

In conclusion, the structured approach and detailed analysis guarantee the successful delivery of a safe, usable, and accessible app, greatly advancing TfL's objectives of offering all students effective and safe transportation.

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