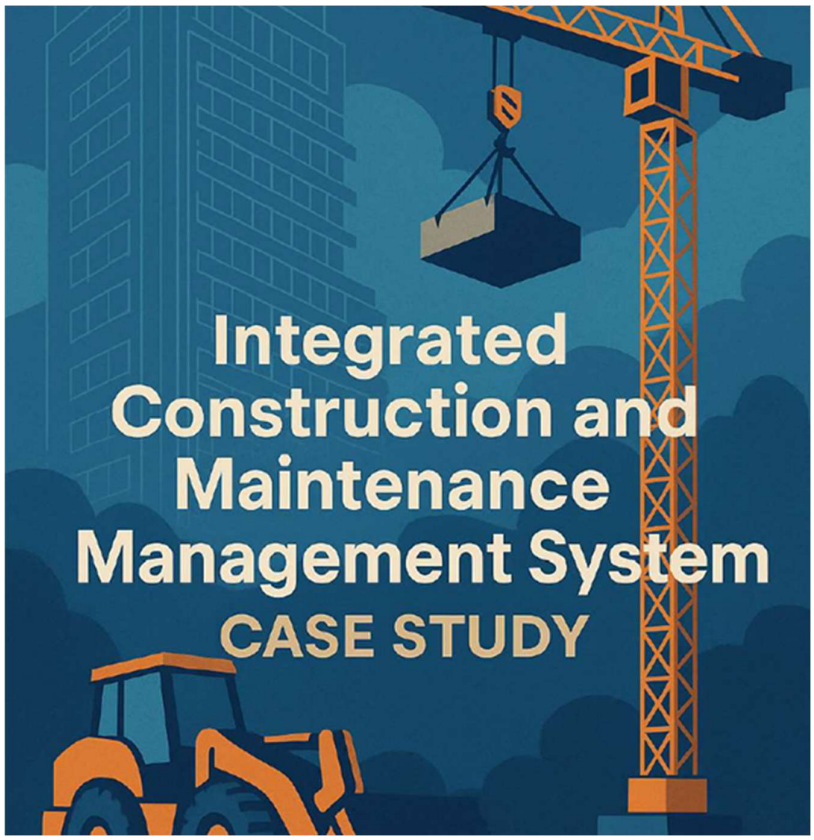
INSY7315 / WIL

Submission: Portfolio of Evidence (POE)

Date Created: 3rd November 2025

A team presents…



Group Name: a team

Project Name:

Integrated Construction Maintenance Management System (ICMMS) Development Project

Deployed App: https://icmms-taskit.co.za/
Backup Link: here

Brand: TASKIT

Scrum Agile Board URL: Trello: link
GitHub repository URL: link
Lucid Chart (all): link
YouTube Channel: link

Members:

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DIAGRAMS: NOTE TO VIEWER

The diagrams included in this report are highly detailed and complex, which affects their print quality when converted to PDF or image formats. While printed versions have been provided, they may appear unclear or difficult to read due to the level of detail and scale.

For optimal clarity and full visibility, we strongly recommend accessing the diagrams using the provided Lucidchart links.
Links to all charts: https://lucid.app/lucidchart/ebc85260-6801-4178-a378-dd99698ea8e7/edit?viewport_loc=-742%2C-1085%2C4866%2C2059%2Cc3KVyjod~nFq&invitationId=inv_7bf09684-d572-42df-9856-a59685633a67

Part 1 - Project Roadmap & Work Agreement

1.1. Introduction

1.1.1. Project problem:

Dr Majoko Projects is a property development company managing construction and maintenance projects across several provinces. At the moment, they rely on separate tools like spreadsheets, paper forms, email, and WhatsApp to coordinate tasks between clients, contractors, project managers, and admin staff. This scattered approach leads to delays, poor accountability, and difficulty keeping projects on schedule and within budget.

1.1.2. Proposed solution:

The solution is to create an integrated construction and maintenance management system that works on both web and mobile. This system will connect all user roles in one platform, allowing them to log issues, track progress, assign work, share documents, manage budgets, and communicate efficiently. Key features will include real-time dashboards, automated alerts, secure file storage, quotation and invoice workflows, and an AI assistant to help estimate costs from blueprints and identify risks early.

1.1.3. Project background/context:

Dr Majoko Projects specialises in residential and commercial property development. Their services cover the full project lifecycle which is inherently difficult to keep track of. As their client base and project portfolio grow across multiple provinces, managing these operations has become increasingly complex.

Without a centralised system, project managers and site coordinators struggle to enforce deadlines, track expenses, and maintain clear communication. Clients often experience frustration from delays and lack of updates, while internal teams spend time chasing information instead of making progress.

This project will deliver a responsive, AI-assisted web and mobile application that replaces manual processes with digital workflows. It will make project data accessible in real time, standardise communication between all parties, and provide tools to keep budgets, timelines, and quality in check. By integrating construction and maintenance functions into one platform, Dr Majoko Projects will be able to operate more efficiently, make informed decisions faster, and offer a better experience for both clients and contractors.

1.2. Work Agreement

1.2.1. Team meeting schedule:

The team will meet every Thursday until 1 November 2025. Meetings will follow a sprint review and sprint planning format to ensure all members are aligned on progress, blockers, and upcoming work. Sprints are planned to end on Thursdays so that completed tasks can be reviewed immediately, and new work can be assigned without delays. Additional ad-hoc meetings may be scheduled for urgent technical issues or decision-making.

1.2.2. Communication tools and response times:

All group communication will be managed through a dedicated WhatsApp group for quick updates, brainstorming, and support requests. Trello will serve as the official project management board, tracking tasks, deadlines, and responsible members. The Trello board will be kept up to date before and after each work session, and members are expected to check it regularly.

Responses to messages should be given within 24 hours for standard items. Low-priority items may take up to 72 hours, but sprint-critical issues should be addressed as soon as possible. For high-priority technical problems, the responsible member must acknowledge the issue within 12 hours to avoid blocking other tasks.

1.2.3. Conflict resolution process:

Conflicts should be addressed as soon as they arise. Members should first attempt to resolve issues directly and professionally between themselves. If this does not work, and the matter is between two members, a neutral third member will be asked to mediate and record the resolution steps. If the conflict remains unresolved or affects multiple members, the issue will be escalated to the lecturer for formal mediation.

1.2.4. Role clarity and accountability:

Each member has a defined role in the project (Scrum Master, Lead Developer, DevOps, Front-End Developer), and is expected to deliver tasks assigned in Trello according to the sprint plan. Missed deadlines must be communicated in advance with reasons and an updated completion date. Persistent failure to deliver without communication will be escalated to the lecturer.

1.2.5. Collaboration standards:

All code will be stored in the team GitHub repository, following branch naming conventions and using pull requests with mandatory peer review before merging. Documentation will be kept current in the shared collaboration folder. All members must contribute to maintaining code quality (SonarQube), security checks (Snyk), and testing according to the agreed plan.

1.2.6. Backlog Items

In Scrum, the product backlog is the single source of all work that the team will take on. It is updated as the project evolves, with items small enough for one sprint and detailed through refinement. The team sizes tasks, while the Product Owner helps clarify priorities and trade-offs (Schwaber & Sutherland, 2020).

1.3. Definition of Ready (DoR)

The DoR is a set of conditions a backlog item must meet before it can be added to a sprint. It ensures the item is clear, testable, and has all the information and resources the team needs to finish it within the sprint. This avoids starting work on poorly defined tasks or those blocked by unresolved dependencies (PremierAgile, 2023).

- **Clear description** : The task has a clear title and description in Trello, including acceptance criteria that define exactly what needs to be delivered.
- **Linked to a user story**: The task is tied to a user story in the backlog with business priority and story points already assigned.
- **Designs and references attached:** Any required mockups, diagrams, API documentation, or reference material are attached or linked.
- **Dependencies identified**: All technical or resource dependencies are listed, and blocking items are either resolved or scheduled to be resolved before work starts.
- **Team understanding**: The assigned member confirms they understand the task, the scope, and the expected outcome before it is moved to “In Progress”.

1.4. Definition of Done (DoD)

The DoD is a checklist that confirms the work is finished to an agreed standard. It includes both technical quality and meeting acceptance criteria so the outcome can be delivered to the user without further fixes (PremierAgile, 2023).

- **Meets acceptance criteria**: The work matches the agreed requirements and passes functionality checks.
- **Code quality verified**: The code passes automated quality scans (SonarQube) with no new critical or high-severity issues introduced.
- **Security checks complete:** Snyk scan is run with no unaddressed vulnerabilities.
- **Testing complete**: Unit and integration tests are written or updated, and the feature has been tested on all relevant devices (web and/or mobile).
- **Merged to main branch:** The feature has been merged into the main branch via pull request with at least one peer review approval.
- **No breaking changes:** The new work does not cause regressions in other parts of the system and passes the build pipeline.
- **Documentation updated**: Any related documentation, diagrams, or setup instructions have been updated to reflect changes.
- **Demo ready:** The feature can be demonstrated in a sprint review without additional setup or fixes.

1.5. High-Level Roadmap

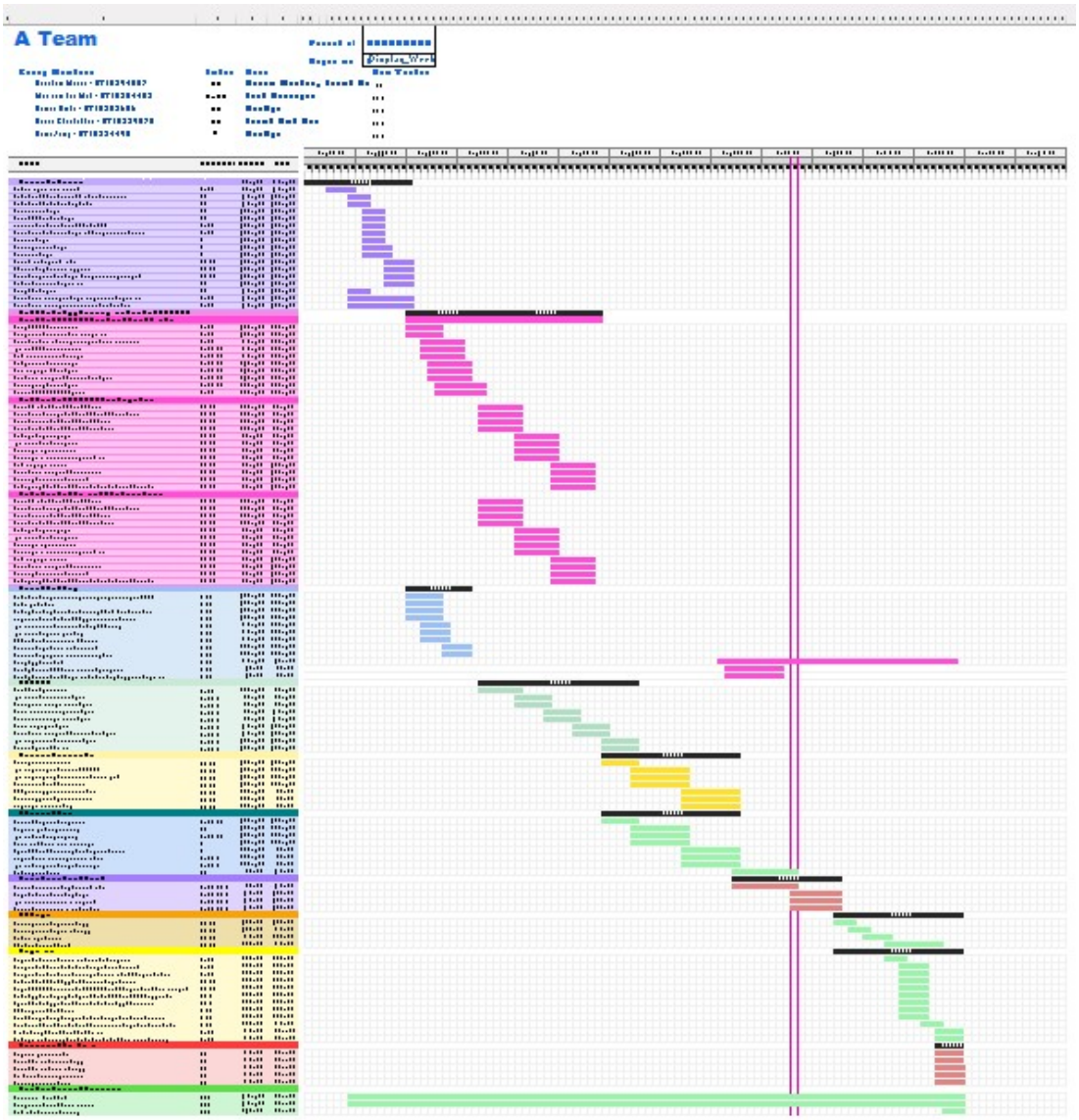


Figure 1.1 - Gantt Chart (Excerpt)

(Source: [Github] Docs/Part1/P1_01_GanttChart_ProjectRoadmap)

1.5.1. Sprint 1 - 4 Aug 2025 to 18 Aug 2025

Focus**: Complete Portfolio of Evidence.**
Deliverables:

- Full requirements capture, user roles, and user stories with backlog table.
- All system design diagrams (use case, ERD, bounded context, class, sequence, activity).
- UX assets including web/mobile mockups, journey maps, and navigation flows.
- Non-functional requirements documented.
- GitHub repository setup.
- Deployment, tech stack, and tools documentation.

1.5.2. Sprint 2 - 18 Aug 2025 to 28 Aug 2025

Focus: **Set up ASP.NET back-end, security, and API foundations.**
Deliverables:

- ASP.NET solution structure, authentication, role management, and database models.
- CRUD controllers, maintenance workflow, quotation/invoice logic, messaging, document, and reporting endpoints.
- API security (JWT, SSL, CORS).
- Test cases, bug tracking workflow, and SonarQube integration.
- Core security features including failed login tracking, role-based access control, and audit logs.

1.5.3. Sprint 3 - 28 Aug 2025 to 13 Sep 2025

Focus: **Develop Web and Mobile Front-End UIs**.
Deliverables:

- Role-specific dashboards (Admin, Project Manager, Contractor, Client) for web and mobile.
- Login/registration and role-based navigation.
- Forms for project creation and maintenance requests.
- Messaging system, document upload/view, quotation/invoice UI.
- Reporting and dashboard interfaces with visual charts (Gantt, Pie, Bar, Line).

1.5.4. Sprint 4 - 28 Aug 2025 to 18 Sep 2025

Focus: **Develop and test REST API.**
Deliverables:

- Planned API structure.
- Authentication, project management, maintenance request, and contractor assignment endpoints.
- Messaging and document management endpoints.
- Quotation and invoice endpoints.
- Postman testing of all endpoints.

1.5.5. Sprint 5 - 14 Sep 2025 to 2 Oct 2025

Focus: **Implement Quotation & Invoice System and begin AI Assistant.**
Deliverables:

- Quotation creation, plan upload, and basic plan parsing.
- Cost breakdown generation and quote approval/rejection.
- Invoice conversion and payment tracking.

- AI research for blueprint analysis, sample file preparation, and basic blueprint parsing.
- Manual cost estimation, exploration of AI APIs, integration into quotation module, and project delay prediction logic.

Initial AI testing and refinement

1.5.6. Sprint 6 - 2 Oct 2025 to 16 Oct 2025

Focus: **Add Voice Feedback feature and complete DevOps & Security.**
Deliverables:

- Research and design for web/mobile voice recording.
- Contractor voice memo upload with database storage/retrieval.
- Snyk security testing.
- CI/CD documentation and cloud deployment workflow.

1.5.7. Sprint 7 - 16 Oct 2025 to 2 Nov 2025

Focus: **Finalise UX Design.**
Deliverables:

- Responsive design finalised for web and mobile.
- UI testing on multiple devices.
- Adjustments based on feedback.
- Production Firebase environment configured (Hosting, Firestore, Storage, Authentication).
- API deployed to Firebase/Cloud Run with security settings (JWT, CORS, HTTPS).
- Final security review (Firestore/Storage rules, SSL, Snyk, SonarQube).
- Smoke testing on production environment.

1.5.8. Sprint 8 - 30 October 2025 to 2 Nov 2025

Focus: **Final Presentation and Collaboration Review.**
Deliverables:

- Presentation slides and combined web/mobile demo videos.
- Practice and delivery preparation.
- Commit history and branch documentation maintained.
- Submission of individual contribution logs.

1.6. Initial Risk Register:

This table shows the highest-priority risks to the project based on probability and impact.

Risk Description	% Prob	Impact	Mitigation Strategy
Delays in task completion due to academic workload or personal commitments	**High**	**High**	**Implement sprint buffer time in roadmap, redistribute tasks to available team members, enforce progress check-ins during standups.**
Version control issues on GitHub (conflicting changes, merge errors)	**Medium**	**Medium**	**Adopt strict branch naming conventions, use pull requests with mandatory peer review, schedule merge meetings before major pushes.**
Limited experience integrating AI functionalities	**High**	**Medium**	**Assign research responsibilities early (Max), use OpenAI documentation and GPT testing environment, start AI feature in earlier sprint (Sprint 4) to allow buffer.**
Poor coordination or communication among group members	**Medium**	**High**	**Use Trello for all task tracking, WhatsApp for updates, and enforce asynchronous standups every Thursday. Max will create and share the collaboration Word doc for updates.**
Technical setup challenges for code quality tools (e.g., SonarQube)	**Medium**	**Medium**	**Max will explore alternatives if setup fails (e.g., GitHub Actions). Pair programming or screen sharing if setup blockers occur.**
Security reporting tool (Snyk) not properly integrated	**Medium**	**Medium**	**Nicolas to set up Snyk and validate using dummy vulnerability, provide short guide or walkthrough for team if needed.**
Trello board or documentation not regularly updated	**Medium**	**Medium**	**Scrum Master (Braydon) to check-in twice weekly to ensure backlog and board reflect actual progress. Team encouraged to update cards before/after work sessions.**
Overreliance on GPT outputs without contextual editing	**High**	**Low**	**All GPT-generated outputs must be reviewed and customized (Daniel to revise Risk Register, Max to trim DoD). Assign reviewers for all content before submission.**

Figure 1.2 - Risk Register for ICMMS

1.7. Ethical & Privacy Considerations

The ICMMS platform processes operational and personal information from clients, contractors, and project managers. All structured data; including projects, quotations, invoices, and user records is stored in Firebase, while all uploaded documents and maintenance-related media files are stored in Supabase. Each file is referenced by a unique link (fileUrl or mediaUrl) for traceability and controlled access.

User information such as names, emails, phone numbers, company details, and license or insurance information is protected through role-based access control (RBAC). Administrators create and manage user accounts, and every login or system action is captured in the audit logs for accountability. All communication with cloud services is encrypted over HTTPS, and files are stored in private, restricted buckets.

The system's AI component uses the Gemini model to interpret uploaded blueprints for cost estimation. Blueprints are manually reviewed to remove any confidential or identifying information before processing. The team recognises that Gemini's internal data handling is outside their control, and all outputs are treated as temporary and non-persistent within ICMMS. A user-facing warning message will be added before AI processing to inform users of these conditions.

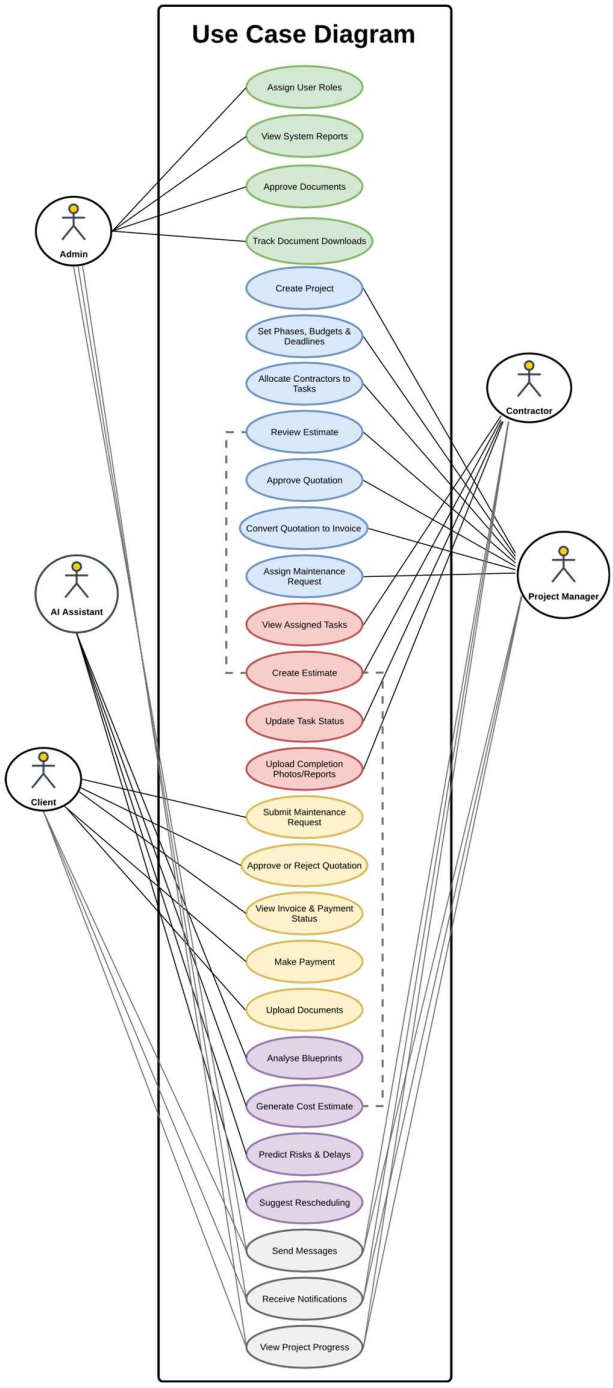
The system aligns with POPIA principles by collecting only essential information, maintaining secure storage, and supporting user rights to request data correction.

Part 2 - Requirements & UX Design

2.1. Introduction

This section defines the functional and user-experience foundations of the Integrated Construction & Maintenance Management System (ICMMS). It documents all user roles, workflows, and requirements that shaped the application's architecture and interface design. The artefacts presented here including use-case, user-flow, and journey-map diagrams establish how the platform meets operational needs of administrators, project managers, contractors, and clients within a single secure environment.

2.2. Use Case Diagram



The ICMMS Use Case Diagram provides a high-level overview of how the system's actors interact with its primary modules. It visualises every role's responsibilities, system-triggered processes, and shared interactions between components such as quotation approval, maintenance requests, and AI-based estimation.

Key interactions include:

- **Administrator:** Assign user roles, approve documents, and monitor reports and downloads.
- **Project Manager:** Create projects, define phases and budgets, allocate contractors, review estimates, and convert quotations to invoices.
- **Contractor:** View assigned tasks, update status, and upload completion reports and photos.
- **Client:** Submit maintenance requests, approve or reject quotations, and view invoices and payments.
- **AI Assistant:** Analyse blueprints, generate cost estimates, predict risks and delays, and suggest rescheduling.

Figure 2.1 – ICMMS Use Case Diagram.
Source: Lucid Chart*:* link here

2.3. User Roles, Stories, Data Flow, UX Journey Maps

ICMMS is designed around four main user roles. Each role has distinct permissions, CRUD capabilities, and interface access.

2.3.1.1. Administrator Roles:

Oversees the entire platform's operation, ensuring smooth workflows and system compliance.

Key CRUD Tasks:

- **Create:** User accounts, role permissions, system configurations.
- **Read:** All communication logs, reports, documents, project statuses.
- **Update:** User permissions, notifications, system settings.
- **Delete:** Remove outdated records, deactivated users, or invalid documents.

Notes:

- Has direct messaging ability with Project Managers when necessary.
- Oversees all communication logs and can initiate conversations if needed.
- Approves quotations in workflow; client must accept final quote before invoice generation.
- Monitors notifications and ensures SMS/email/app alerts reach the right stakeholders.

UI screens:

- Admin Dashboard
- Reports Panel
- Assignment Manager
- Messaging & Notification Panel

2.3.1.2. Administrator Stories:

- As an Admin, I want to create and manage user accounts so that each user has the correct role permissions.
- As an Admin, I want to view all communication logs so that I can oversee and ensure compliance.
- As an Admin, I want to approve quotations in the workflow so that the client can give final acceptance.
- As an Admin, I want to monitor system notifications so that alerts reach the correct stakeholders.

2.3.1.3. Admin User Flows

The administrator's flow begins at login and navigation to the User Management module, where all CRUD actions are performed. The system validates inputs for new users (email, password, role) before creating records in both Firebase Auth and Firestore.
Admins can create, view, edit, toggle status, or delete users.

Admin User flows

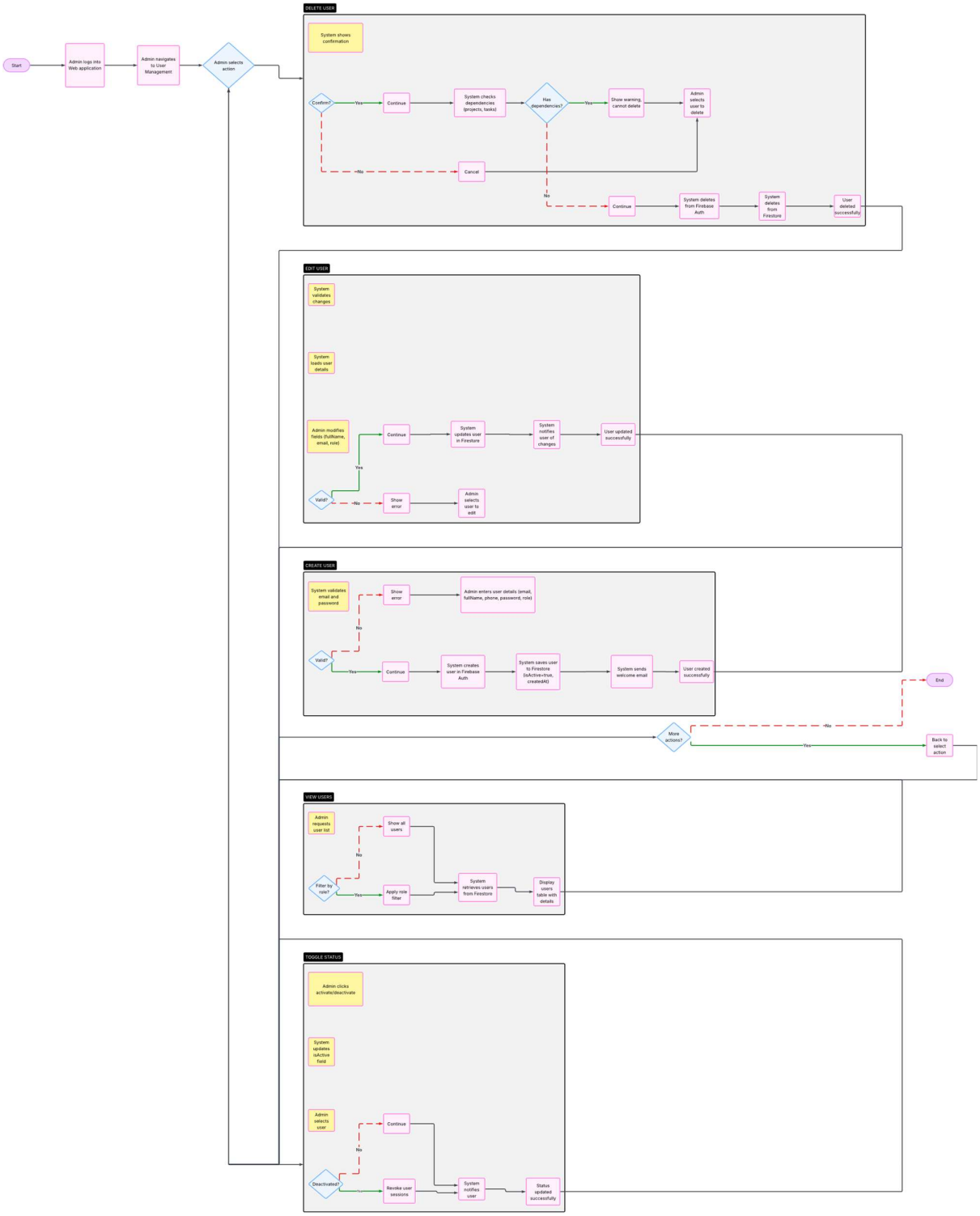


Figure 2.1.1 - Administrator User Flow (CRUD and Validation Process) Source: Lucid Chart: [link here]

2.3.1.4. Admin UX Journey Map

The Administrator journey covers six operational stages, from login to daily maintenance. It highlights how system control, configuration, and analytics are managed centrally. After login, the Admin accesses a system health dashboard showing uptime, performance metrics, and recent activity. The user then manages accounts, assigns roles, and configures integrations such as Firebase and Supabase. Monitoring, audit logging, and backup processes follow in the daily workflow, ending with support and scheduled maintenance tasks.Key pain points include complex configurations and alert overload, while positive moments include automated backups, role-based security, and comprehensive audit trails.

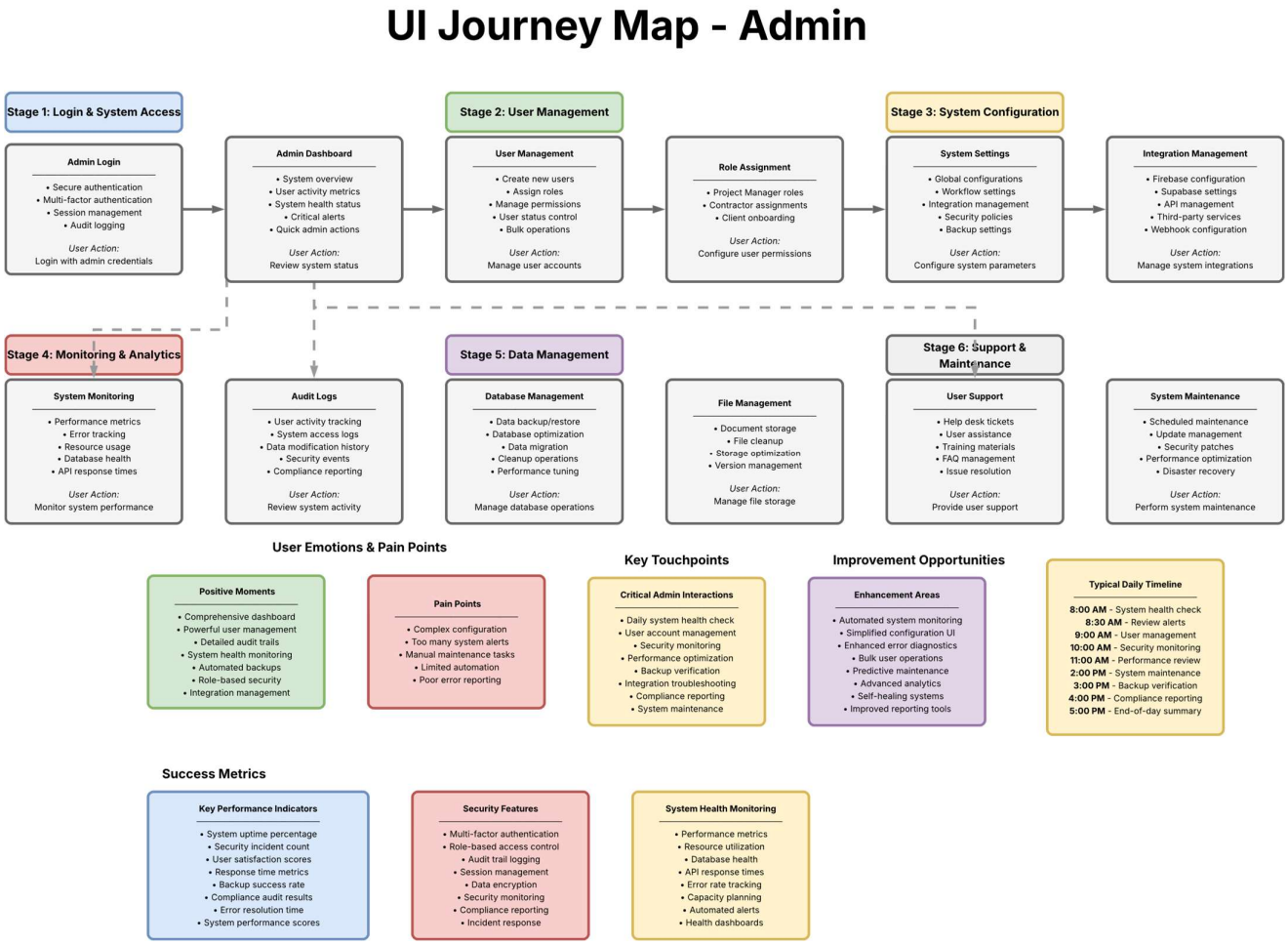


Figure 2.1.2 – Administrator UX Journey Map. Source: Lucid Chart: link here

2.3.2.1. Project Manager Roles:

Manages construction projects from creation to completion, ensuring delivery within budget and timelines.

Key CRUD Tasks:

- Create: New construction projects with quotes &invoice including budgets, phases, tasks per phase, deadlines,
- Read: Project status, budget vs actual reports, contractor updates.
- Update: Resource allocations, task assignments, document approvals, progress reports.
- Delete: Cancel projects or remove incorrect data.

Notes:

- Sole role that creates projects (admins do not).
- Assigns contractors to tasks and approves documents.
- Uses AI-generated quotes for cost planning but does not approve quotes.
- Communicates actively with contractors and clients for updates and clarifications.

UI Screens:

- PM Dashboard
- Quotes Creation & Invoice View
- Individual Tab Per Project's Page
- Review Screen
- Contractor Tracker
- Notification Panel

2.3.2.2. Project Manager Stories:

- As a Project Manager, I want to create construction projects, create quotes and get approvals with budgets, phases, tasks, and deadlines so that work is planned effectively.
- As a Project Manager, I want to assign contractors to specific tasks so that work is completed on time.
- As a Project Manager, I want to approve documents so that only verified files are used.
- As a Project Manager, I want to use AI-generated quotes for planning so that I can manage project costs.

2.3.2.3. Project Manager User Flows

The Project Manager workflow comprises three core streams:

1. **Project & Phase Management**: create, edit, or delete projects and phases after validation of dates and budgets. Each phase is stored with status tracking and linked to assigned contractors.
2. **Quotation & Invoice Management**: create & review draft quotations, approve or reject with reasons, and convert client-approved quotations to invoices.
3. **Task Assignment & Monitoring**: assign contractors, track progress, review completion, and verify deliverables. Overdue or unsatisfactory tasks trigger alerts and rework requests.

Every stage includes automated notifications to clients and contractors for status updates and invoice issues, ensuring accountability and project transparency

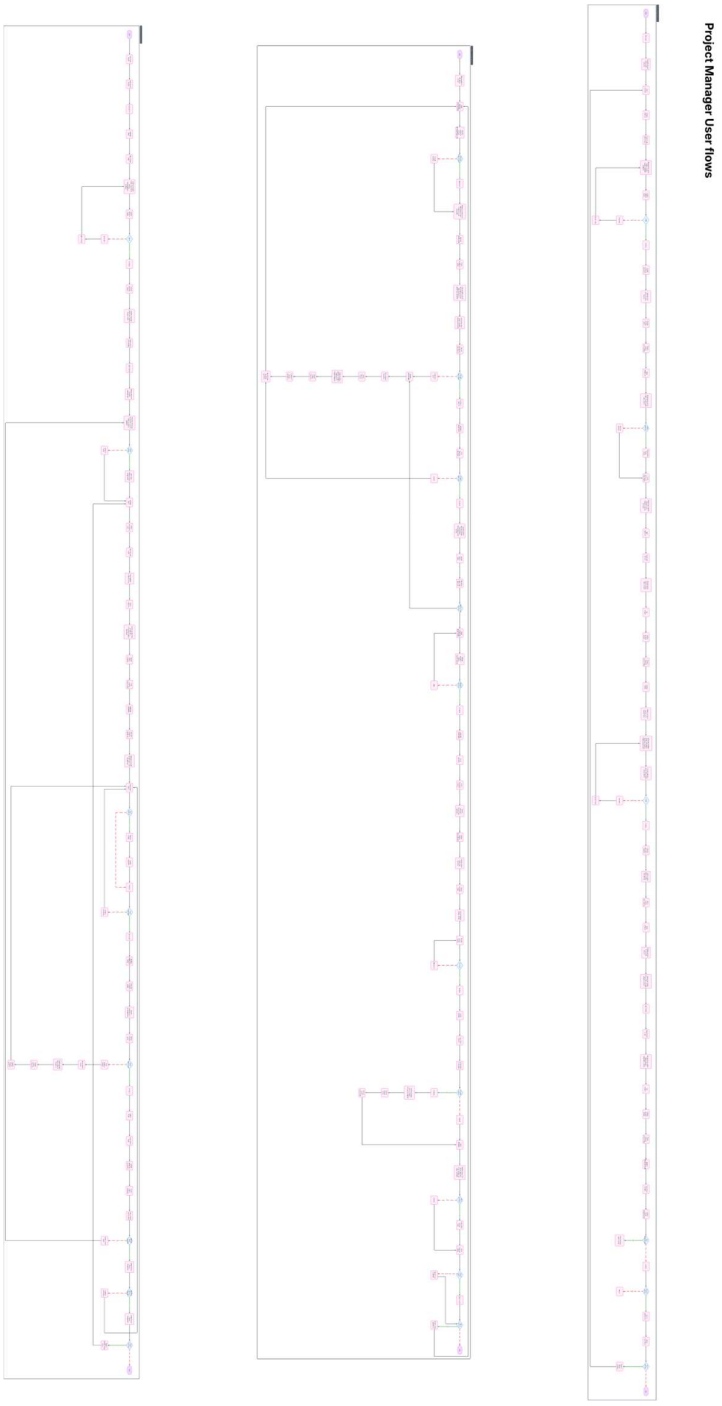


Figure 2.2.1 - Project Manager User Flow (End-to-End Lifecycle). Source: Lucid Chart*:* link here

2.3.2.4. Project Manager UX Journey Map

The Project Manager journey illustrates a full cycle of project oversight. Upon login, the PM dashboard displays all active projects, budgets, pending approvals, and maintenance requests. The user navigates between project creation, quotation approval, and contractor assignments through a unified interface. Daily touchpoints include quotation reviews, team communications, and analytics dashboards. Positive experiences include real-time notifications, clear project visualisation, and strong collaboration tools, while challenges arise from heavy data entry and long approval workflows.

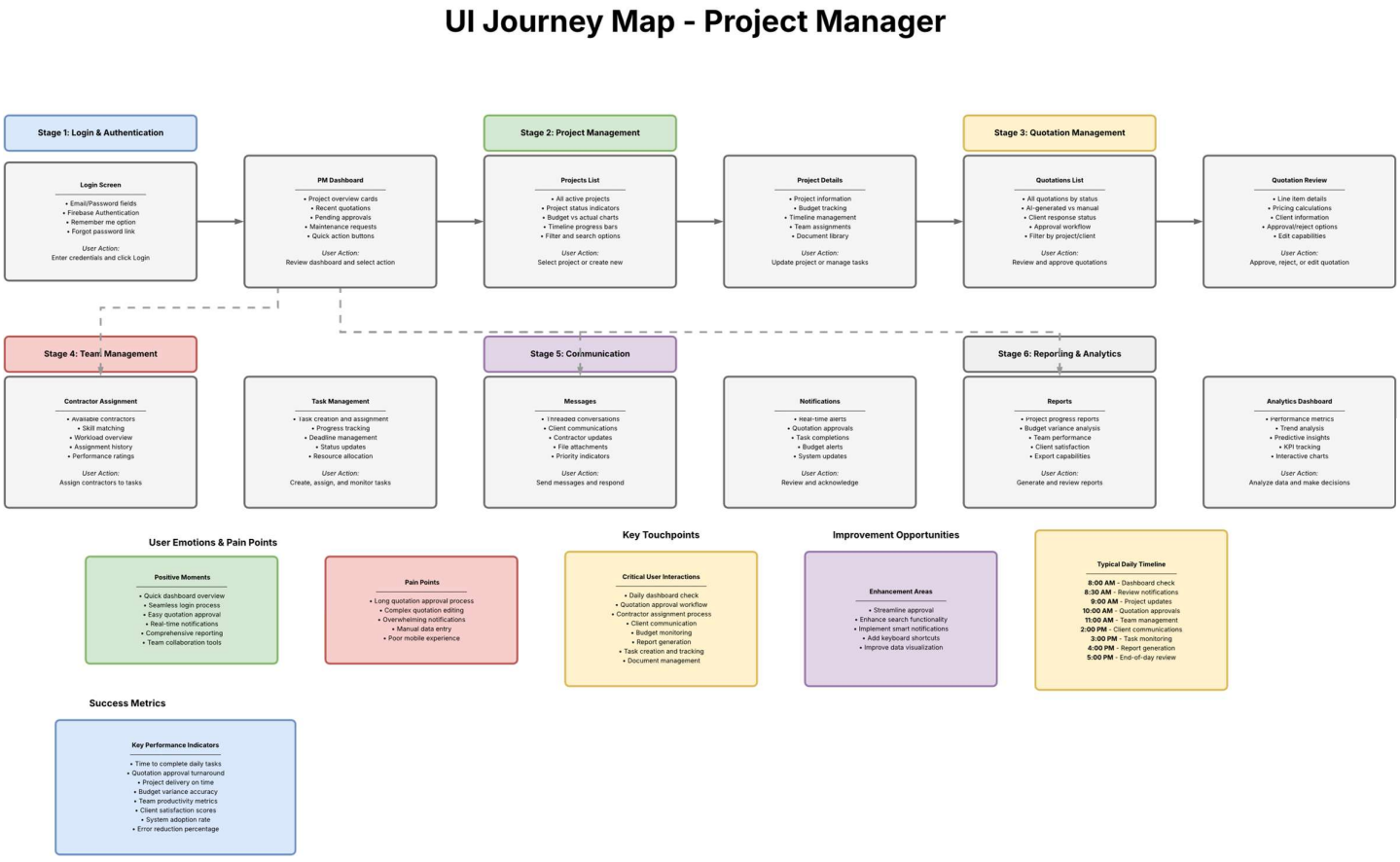


Figure 2.2.1 - Project Manager UX Journey Map. Source: Lucid Chart*:* link here

2.3.3.1. Contractor Roles:

The Contractor executes assigned tasks on projects or maintenance jobs.

Key CRUD Tasks:

- Create: Task completion updates, upload completion photos/reports.
- Read: Assigned tasks, deadlines, instructions.
- Update: Task progress, status changes (Pending → In Progress → Completed).
- Delete: Remove incorrect (their own) submissions before final approval.

Notes:

- Works only on tasks assigned by Project Managers.
- Communicates progress to Project Managers via messaging.
- Cannot approve quotes or create projects.

UI Screens

- Contractor Dashboard including Task List
- Individual Tab Per Project's Page (simplified)
- Completion Report Form
- Notification Panel

2.3.3.2. Contractor Stories:

- As a Contractor, I want to view assigned tasks so that I know my responsibilities.
- As a Contractor, I want to update task progress so that the Project Manager is informed.
- As a Contractor, I want to upload completion photos so that task verification is easier.

2.3.3.3. Contractor User Flows

The Contractor flows cover three processes:

1. **Task Management**: View assigned tasks, start work, log progress, and mark completion. System automatically notifies the Project Manager for verification.
2. **Document Management**: Upload reports and media files to Supabase Storage; metadata is recorded in Firestore with status tracking and version updates.
3. **Estimate & Quotation Creation**: Generate AI-assisted estimates from blueprints or manual entry, convert to quotations, and submit for PM approval.

The flows ensure work accuracy and speed by combining AI cost estimation with manual verification, supporting secure document handling and transparent communication with PMs and clients.

Figure 2.3.1 – Contractor User Flow (Task, Document & Quotation Process). Source: Lucid Chart*:* link here

2.3.3.4. Contractor UX Journey Map

The Contractor journey focuses on mobile-first usability, task execution, and communication. Starting with biometric login and offline access, contractors immediately see assigned jobs and maintenance requests on their dashboard. They can review details, track progress, upload before/after photos, and communicate with project managers.
The workflow concludes with task completion reports, performance tracking, and earnings summaries.
Positive aspects include intuitive mobile access and instant notifications, while major pain points involve weak connectivity, unclear instructions, and limited offline capability.

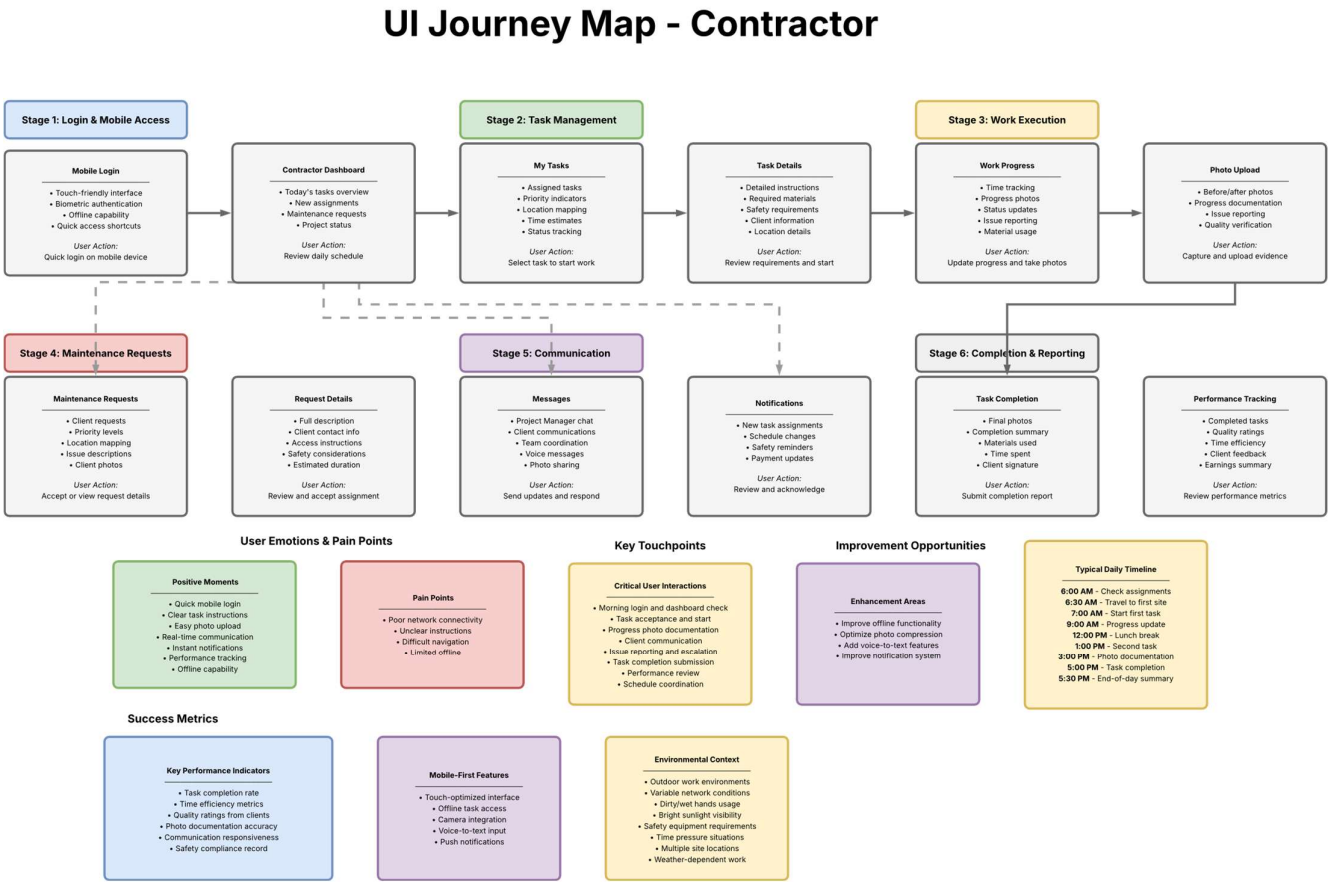


Figure 2.3.2 - Contractor UX Journey Map. Source: Lucid Chart***:*** link here

2.3.4.1. Client Roles:

Requests maintenance, receives project updates, and approves final quotations.

Key CRUD Tasks:

- Create: Maintenance requests with descriptions/images.
- Read: Progress tracking, quotations, invoices, reports.
- Update: Approve/reject quotations, confirm completion of maintenance.
- Delete: Cancel pending maintenance requests before work starts.

Notes:

- Only role that can approve/reject quotations before invoice generation.
- Communicates with Project Managers and Contractors for status and clarifications.
- Receives automated alerts for every project/maintenance stage.

UI Screens

- Client Dashboard
- Maintenance Request Form
- Notification Panel
- Individual Tab Per Project's Page (simplified)

2.3.4.2. Client Stories:

- As a Client, I want to submit maintenance requests with descriptions and images so that issues can be addressed
- As a Client, I want to track the status of my requests so that I know when they will be resolved.
- As a Client, I want to approve or reject quotations so that only agreed work is billed.

2.3.4.3. Client User Flows

The Client journey is divided into three operational flows:

1. **Maintenance Request Flow**: Clients submit requests with descriptions and media attachments; system validates fields and creates unique IDs, then notifies the assigned Project Manager.
2. **Quotation Review Flow** : Clients evaluate quotations sent by PMs, accept or decline with notes, and automatically trigger invoice creation upon acceptance.
3. **Payment Flow**: Clients pay via EFT or PayFast/PayPal gateways; Project Manager records transactions, updates invoice status to 'Paid,' and issues receipts to both client and PM.

These flows illustrate the client's entire experience from maintenance submission to payment confirmation, highlighting the system's automation and audit trail capabilities.

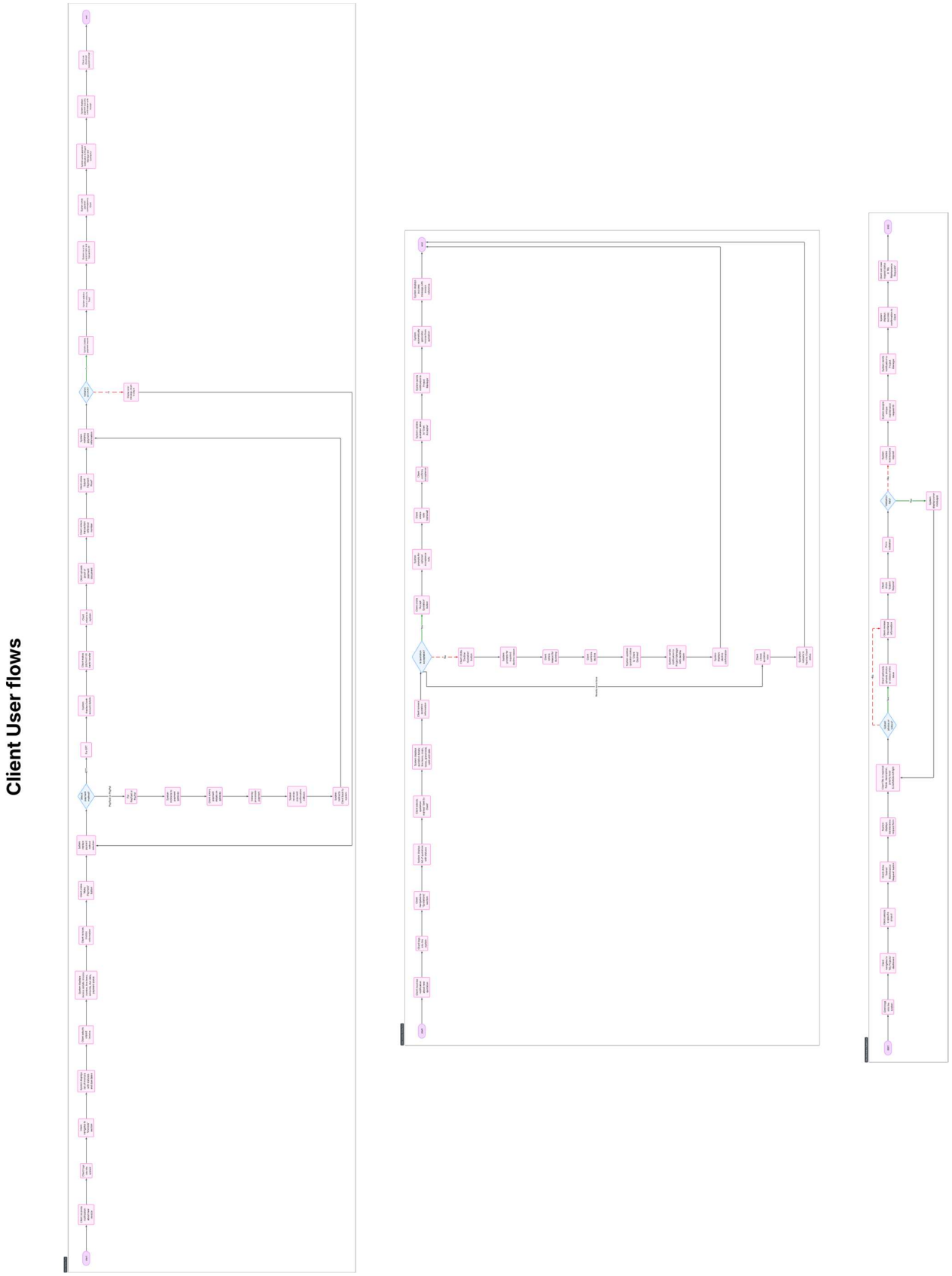


Figure 2.4.1 – Client User Flow (Maintenance, Quotation & Payment. Source: Lucid Chart*:* link here

2.3.4.4 Client UX Journey Map

The Client journey traces the customer experience from registration to project completion and payment. After onboarding, clients can view project timelines, monitor progress, and access quotations.

Key stages include quotation acceptance, maintenance request submission, and payment confirmation. The interface offers visibility into every project milestone, communication thread, and invoice record.Positive feedback centres on transparency and secure payments, while challenges include complex quotation details and occasional processing delays.

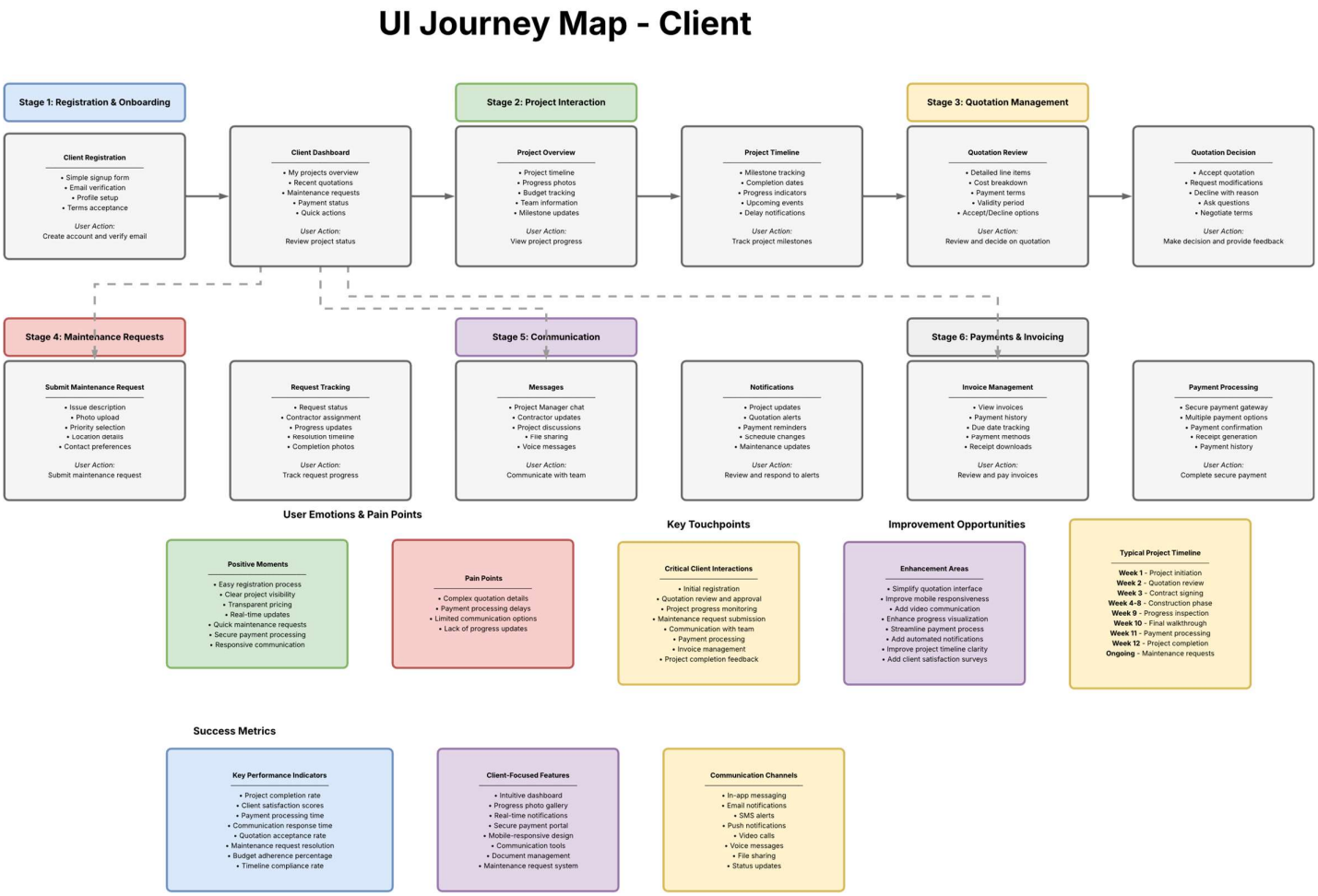


Figure 2.4.2 - Client UX Journey Map. Lucid Chart*:* link here

2.4. User Story Backlog Table

The user-story backlog consolidates all functional requirements defined during early sprints.
Each story links directly to a module in ICMMS.
Stories are prioritised by business impact and sprint allocation.

ID	User Story	Priority	Module/Feature
US-01	As an Admin, I want to create and manage user accounts so that each user has correct access.	High	User Management
US-02	As an Admin, I want to view all communication logs so that I can ensure compliance.	High	Communication & Notifications
US-03	As an Admin, I want to monitor system notifications so alerts reach correct stakeholders.	Medium	Communication & Notifications
US-04	As a Project Manager, I want to create construction projects with budgets and deadlines.	High	Project Management
US-05	As a Project Manager, I want to assign contractors to tasks so that work is completed on time.	High	Project Management
US-06	As a Project Manager, I want to approve documents so that only verified files are used.	High	Document Management
US-07	As a Project Manager, I want to use AI-generated quotes for planning so I can manage costs.	Medium	AI-Powered Estimation
US-08	As a Contractor, I want to view assigned tasks so that I know my responsibilities.	High	Contractor Portal
US-09	As a Contractor, I want to update task progress so that the Project Manager is informed.	High	Contractor Portal
US-10	As a Contractor, I want to upload completion photos so that task verification is easier.	Medium	Contractor Portal
US-11	As a Client, I want to submit maintenance requests so that issues can be addressed.	High	Maintenance Request Management
US-12	As a Client, I want to track the status of my requests so that I know when they'll be resolved.	High	Maintenance Request Management
US-13	As a Client, I want to approve or reject quotations so that only agreed work is billed.	High	Quotation Management

Table 2.1 - User Story Backlog Overview
(Source: docs/diagrams/Part2/P2_03_UserBacklogTable.pdf).
Each record specifies ID, story statement, priority level, and functional module to assist sprint planning and progress tracking.
This table also serves as the foundation for your Functional Requirements Matrix in Part 3.

2.5. UX Journey Map - All Roles (System Overview)

The consolidated UX Journey Map presents a holistic view of how the system interconnects across roles and modules. It visualises the entire ICMMS ecosystem from authentication to project delivery and reporting. It also illustrates how multi-role coordination supports real-time decision-making and communication.

The diagram maps each actor (Admin, Project Manager, Contractor, Client) against the system core modules, including Firebase Authentication, Firestore Database, Supabase Storage, and ASP.NET Core MVC interfaces.
It highlights major workflows such as:

- **Quotation Cycle:** Project Manager creates → Client reviews → Contractor executes → Admin monitors.
- **Maintenance Workflow:** Client submits request → Project Manager assigns → Contractor completes → Client approves.
- **Communication Flow:** Real-time messaging, push notifications, and email/SMS alerts keep all stakeholders in sync.

The consolidated journey map demonstrates how the ICMMS enables seamless collaboration across all stakeholders, improving communication and project transparency. By unifying user interactions within one integrated platform, it ensures faster decision-making, accurate information flow, and complete accountability from project creation to completion.

Figure 2.5 - UX Journey Map for All Roles (System Overview). Lucid Chart*:* link here

2.6. User Interface and Experience Reflection

The ICCMS interface was intentionally structured around the distinct journeys of its three primary roles, Project Manager, Contractor, and Client, each with unique functional depth but unified through a shared design language and consistent navigation logic. The earlier UX artefacts (journey maps and flow diagrams) guided the transition from conceptual pathways to testable interfaces. This reflection evaluates how those design decisions translated into user experience, focusing on usability, cognitive flow, and perceived system efficiency.

2.6.1. Visual Hierarchy and Task Orientation

Entities are displayed on each dashboard in a hierarchal format with clear separations. The Project Manager Dashboard serves as the system's control centre, presenting progress summaries, task cards, and quotation tool. The grid-based card system, supported by hover feedback and contextual icons, allows immediate comprehension of project states ("Draft", "Active", "Completed").

During informal evaluation sessions between colleagues in the group, each member consistently navigated toward the correct modals (Quotation Builder, Blueprint Picker, Completion Request) without additional guidance, indicating strong affordance and minimal cognitive friction.

2.6.2. Consistency and Reuse Across Roles

Modals for reporting, uploading, and reviewing follow an identical information structure (task info → action inputs → confirmation). This was intentional to reduce re-learning between the Contractor and Project Manager interfaces. For example, the Progress Report Modal (Contractor) and Progress Review Modal (Manager) use the same headings and form rhythm but differ only in available controls (submit vs approve/reject). This consistency was validated during peer testing. Such predictability supports faster onboarding and achieves several functional and non-functional requirements.

2.6.3. Blueprint Integration and Feedback Loops

Real-time feedback through animated icons, inline messages, and spinners ensured that users always understood the system state. This aligns directly with Nielsen's heuristic of visibility of system status (Nielsen, J., 1994).

2.6.4. Usability and Interaction Efficiency

Testing within a small user group (Project Manager and Contractor roles) revealed that modal-based interactions significantly reduced navigation time. Actions such as submitting progress, uploading evidence, or requesting completion could be completed without leaving the dashboard view.

This validated the low-friction principle captured in the UX flow diagrams, where all high-frequency actions were designed to occur within two clicks from the dashboard.

However, testing also exposed improvement areas; particularly the discoverability of hidden filters and the density of information on smaller screens. These insights informed later design recommendations, such as persistent filter visibility and simplified mobile card stacks.

2.6.5. Accessibility and Design Ethics

Attention was given to contrast and legibility through a dark-theme palette (--primary-bg: #1A1B25, --accent-yellow: #F7EC59), ensuring compliance with WCAG contrast ratios (webaim.org. (n.d.).). Form labels, icon support, and modal focus trapping contribute to accessibility and error prevention.

2.6.6. Reflection on User Feedback and Experience Testing

Although formal usability testing was limited due to project time constraints, ad-hoc trials with peer users highlighted strong learnability and interface coherence. Feedback centred on the system's professional polish and clear information grouping. Some users noted that the modal-based workflows created a sense of "contained workspaces"; supporting concentration and reducing navigation loss.

2.6.7. Concluding Reflection

The ICCMS interface demonstrates how role-centred design, visual consistency, and real-time feedback can convert complex construction workflows into approachable digital processes.

While future enhancements could include expanded accessibility testing and progressive disclosure for mobile devices, the current design delivers a clear, efficient, and trustworthy user experience. The reflection process underscores the value of iterative testing and empathic design reasoning in shaping systems that are not only functional but genuinely usable.

2.7. Functional and Non-Functional Requirements

The following sections formalize the operational scope of the Integrated Construction & Maintenance Management System (ICMMS). While the preceding diagrams and user stories describe how users interact with the platform, these requirement specifications define what the system must deliver and how it must perform.

Together, they ensure alignment between business needs, technical implementation, and evaluation criteria used during testing.

2.7.1. Functional Requirements

The functional requirements document defines all features and behaviours expected from the ICMMS, grouped into nine major modules.
It specifies the capabilities required to support each user role and provides the baseline for development, testing, and traceability through later phases.

FR 1.0: User Management

- **FR 1.1** User Onboarding and Role Management - Admins shall create, update, deactivate, and assign roles (Admin, Project Manager, Contractor, Client)
    - **FR 1.1.1** Admins shall be able to view all created users.
    - **FR 1.1.2** Admin shall be able to reassign roles.
- **FR 1.2** User Authentication and Access Control - The system shall authenticate users via Firebase Authentication and enforce role-based access rules.
    - **FR 1.2.1** Authentication shall require email and password.
    - **FR 1.2.2** Access rules shall restrict actions to permitted roles.
    - **FR 1.2.3** Login Attempt Tracking - The system shall track, and limit failed login attempts.
        - **FR 1.2.3.1** After 5 consecutive failed login attempts, the account shall be locked for 5 minutes.
        - **FR 1.2.3.2** Successful login shall reset the failed attempt counter.
        - **FR 1.2.3.3** Lockout timer shall display remaining time to user.

FR 2.0: Project Management

- **FR 2.1** Project Creation - Only Project Managers shall create projects with timelines, budgets, and phases
- **FR 2.2** Project Managers shall be able to allocate resources per phase.
- **FR 2.3** Project Tracking - Project Managers shall track actual progress vs planned milestones.
    - **FR 2.3.1** Progress tracking shall include percentage completion.
    - **FR 2.3.2** Milestone status updates shall be logged.

FR 3.0: Maintenance Management

- **FR 3.1** Maintenance Request Submission - Clients shall submit maintenance requests with descriptions, photos, and videos.
    - **FR 3.1.1** Priority Levels - Maintenance requests shall include priority designation (Low, Medium, High, Critical).
- **FR 3.2** Maintenance Request Tracking - Clients shall be able to track maintenance updates.

- **FR 3.3** Contractor Assignment - Project Managers shall assign contractors to maintenance requests or project tasks.
- **FR 3.4** Task Management - Contractors shall view assigned tasks, update progress, and upload completion evidence.
    - **FR 3.4.1** Evidence Upload – Contractors shall upload photos, videos, or documents as task completion evidence.
    - **FR 3.4.2** Evidence Storage 0 Evidence files shall be stored in Supabase and linked to specific tasks.
- **FR 3.5** Task Corrections - Contractors shall delete or correct their own submissions before final approval.

FR 4.0: Document Management

- **FR 4.1** Document Upload & Access – All users shall upload, access, and download project documents according to permissions.
- **FR 4.2** Document Upload Type – All users shall be able to upload PDF, DOCX, PNG or DWG files.
- **FR 4.3** Document Version Control – The system shall maintain version history for documents.
- **FR 4.4** Document Verification – Project Managers shall review and verify uploaded documents for accuracy and completeness.
- **FR 4.5** Document Approval – Admins shall approve verified documents to ensure all project stakeholders are working from approved and accurate files.
- **FR 4.6** Document Access Logging – The system shall log all document views, and modifications.
    - **FR 4.6.**1 Admins shall have full visibility of document access logs.
    - **FR 4.6.2** Project Managers shall have visibility of document access logs for projects they manage.

FR 5.0: Communication

- **FR 5.1 Messaging Infrastructure** - The system shall provide comprehensive messaging capabilities for all authenticated users.
    - **FR 5.1.1** All authenticated users (Admin, Project Manager, Contractor, Client) shall have access to the messaging system.
    - **FR 5.1.2** Messages shall be stored in Firebase Firestore with real-time synchronization.
- **FR 5.2 Message Types** - The system shall support multiple message communication patterns.
    - **FR 5.2.1** Direct Messages - Users shall send one-to-one messages to specific recipients.
    - **FR 5.2.2** Thread Messages - Users shall participate in multi-party threaded conversations.
    - **FR 5.2.3** Broadcast Messages - Admins shall broadcast messages to all active users in the system.
- **FR 5.3 Message Attachments** - Users shall attach files to messages for enhanced communication.
    - **FR 5.3.1** Attachment Storage - Files shall be stored in Supabase Storage with public URLs generated for authorized access.

    - **FR 5.3.2** Attachment Management - Users shall be able to view and download attachments and uploaders may delete their own attachments.
    - **FR 5.3.3** Attachment Status – Deleted attachments shall be marked as "deleted" rather than physically removed, preserving audit trail.
- **FR 5.4 Message Search and Filtering** - Users shall be able to search and filter messages efficiently.
    - **FR 5.4.1** Search by Content - Users shall search messages by text content in subject and body.
    - **FR 5.4.2** Filter by User - Users shall filter messages by sender or receiver.
    - **FR 5.4.3** Filter by Project - Users shall view all messages related to a specific project.
    - **FR 5.4.4** Read Status Filtering - Users shall filter messages by read/unread status.
- **FR 5.5 Message Status and Tracking -** The system shall track message delivery and read status.
    - **FR 5.5.1** Read Receipts - Messages shall track read status with ReadAt timestamp.
    - **FR 5.5.2** Unread Count - The system shall maintain unread message counts per user and per thread.
- **FR 5.6 Broadcast Messaging** - Admins shall broadcast messages to multiple users simultaneously.
    - **FR 5.6.1** Admin Broadcast - Only users with Admin role shall create broadcast messages.
    - **FR 5.6.2** Recipient Selection - Broadcast messages shall be sent to all active users in the system.
    - **FR 5.6.3** Individual Message Records - System shall create individual message records for each recipient to track read status independently.
- **FR 5.7 Message Validation** - The system shall validate message content before delivery.
    - **FR 5.7.1** Content Validation - Messages shall be validated for: Required fields (SenderId, ReceiverId, Content), Content length limits, Valid participant references
    - **FR 5.7.2** Validation Feedback 0 Validation errors shall be returned to sender with specific error messages.
    - **FR 5.7.3** Validation Warnings 0 Non-critical issues shall generate warnings without blocking message delivery.
- **FR 5.8 Workflow Messaging** - The system shall send automated messages for business process events.
    - **FR 5.8.1** Quotation Workflow Messages - System shall send automated notifications when: Quotation is submitted for approval, Quotation is approved by Project Manager, Quotation is rejected by Project Manager, Quotation is sent to client, Quotation is accepted or declined by client
    - **FR 5.8.2** Invoice Workflow Messages - System shall send automated notifications when: Invoice is generated from accepted quotation, Invoice is sent to client, Payment is received, Invoice becomes overdue
    - **FR 5.8.3** Project Update Messages - System shall send automated notifications for: Project milestone completions, Task assignments, Project status changes

    - **FR 5.8.4** System Alert Messages - Admins shall send system-wide alerts for critical notifications.
- **FR 5.9 Message Notifications** - Users shall receive real-time notifications for new messages.
    - **FR 5.9.1** Push Notifications - New messages shall trigger push notifications to recipient's registered devices via Firebase Cloud Messaging.
    - **FR 5.9.2** Notification Content - Push notifications shall include: Sender name, Message subject or preview, Message type indicator, Attachment indicator (if present)
    - **FR 5.9.3** Notification Data - Notifications shall include metadata for direct navigation to the message or thread.

FR 6.0: Notifications

- **FR 6.1** Real-Time Notifications - The system shall send real-time alerts for new assignments, updates, and overdue tasks.
    - **FR 6.1.1** Notifications shall be delivered via email and push notifications using Firebase Cloud Messaging (FCM).
    - **FR 6.1.2** Notifications shall be sent out to project shareholders regarding the completion of project milestones.
    - **FR 6.1.3** Users shall register device tokens for receiving push notifications.
    - **FR 6.1.4** Push notifications shall include rich data for direct navigation to relevant content (messages, tasks, quotations, invoices).

FR 7.0: Quotation and Invoice Management

- **FR 7.1 Estimate Generation -** The system shall generate cost estimates from uploaded blueprints using AI processing.
    - **FR 7.1.1 Blueprint Upload** - Contractors and Project Managers shall upload building plans (blueprints) for AI processing.
    - **FR 7.1.2 AI Blueprint Processing -** The AI system shall parse uploaded building plans using computer vision and natural language processing**.**
        - **FR 7.1.2.1** The AI shall identify rooms, dimensions, and construction elements from blueprints.
        - **FR 7.1.2.2** The AI shall extract construction line items including material types and quantities.
        - **FR 7.1.2.3** Each extracted line item shall include AI confidence score (0.0 to 1.0).
    - **FR 7.1.3 Material Database Integration -** The system shall maintain a construction materials pricing database.
        - **FR 7.1.3.1** Materials shall be categorized (Concrete, Masonry, Finishing, Steel, Electrical, Plumbing, etc.).
        - **FR 7.1.3.2** AI-extracted line items shall be matched against the material database for automatic pricing.
    - **FR 7.1.5 Estimate Calculation -** The system shall automatically calculate: Subtotal (sum of all line item totals), Tax Total (15% VAT on subtotal), Total Amount (subtotal + tax)
- **FR 7.2 Estimate Review and Conversion -** Project Managers shall review and convert estimates to quotations.

- **FR 7.2.1 Estimate Review -** Project Managers shall review AI-generated estimates for accuracy.
- **FR 7.2.2 Manual Pricing -** Items marked "REQUIRES MANUAL PRICING" shall be priced by Project Manager.
- **FR 7.2.3 Estimate Editing -** Project Managers may edit line items, quantities, and prices before conversion.
- **FR 7.2.4 Conversion to Quotation -** Project Managers shall convert approved estimates to quotations for client presentation.
  - **FR 7.2.4.1** All estimate line items shall be converted to quotation items.

- **FR 7.3 Quotation Workflow -** Quotations shall follow a defined approval and acceptance workflow.
  - **FR 7.3.1 Quotation Creation -** Project Managers shall create quotations for clients.
    - **FR 7.3.1.1** Quotations may be created from estimates or manually.
    - **FR 7.3.1.2** Each quotation shall be assigned to a specific ClientId.
    - **FR 7.3.1.3** Quotations may be associated with Projects or MaintenanceRequests.
  - **FR 7.3.4 Quotation Status Workflow -** Quotations shall transition through the following statuses:
    - **FR 7.3.4.1 Draft -** Initial creation state; quotation can be edited.
    - **FR 7.3.4.2 PendingPMApproval** - Submitted for Project Manager approval; requires PM review.
    - **FR 7.3.4.3 SentToClient -** Approved by PM and sent to client for decision.
    - **FR 7.3.4.4 ClientAccepted -** Client has accepted the quotation; ready for invoice generation.
    - **FR 7.3.4.5 ClientDeclined -** Client has rejected the quotation.
    - **FR 7.3.4.6 PMRejected -** Project Manager has rejected the quotation; requires revision.
- **FR 7.4 Quotation Approval Process -** Project Managers shall approve quotations before client presentation.
  - **FR 7.4.1 Submit for Approval -** Project Managers shall submit Draft quotations for approval.
    - **FR 7.4.1.1** Quotations must have at least one item and GrandTotal > 0 to submit.
    - **FR 7.4.1.2** Status shall change from Draft to PendingPMApproval.
  - **FR 7.4.2** PM Approval Project Managers shall approve PendingPMApproval quotations.
    - **FR 7.4.2.1** Approval shall change status to SentToClient.
    - **FR 7.4.2.2** Automated workflow message shall be sent to client.
  - **FR 7.4.3 PM Rejection -** Project Managers may reject quotations with reason.
    - **FR 7.4.3.1** Status shall change to PMRejected.
    - **FR 7.4.3.2** Rejection reason shall be stored.
  - **FR 7.4.4 PM Editing** - Project Managers may edit quotations in Draft or PMRejected status.
- **FR 7.5 Client Quotation Decision -** Clients shall accept or decline quotations sent to them.

    - **FR 7.5.1 Client Access -** Clients shall view only quotations where ClientId matches their UserId.
    - **FR 7.5.2 Quotation Validity -** Clients may only accept/decline quotations before a deadline.
    - **FR 7.5.3 Client Acceptance -** Clients shall accept quotations they wish to proceed with.
    - **FR 7.5.4 Client Rejection -** Clients shall decline quotations they do not wish to proceed with.
- **FR 7.6 Invoice Generation -** Invoices shall be automatically generated from accepted quotations.
- **FR 7.7 Payment Tracking -** The system shall log and track payments against invoices.
    - **FR 7.7.2 Mock Payment System -** The application shall use a mock non-functional payment system for all specified payment options during development and testing.
    - **FR 7.7.3 Payment Status -** The system shall update invoice status upon payment confirmation:
    - **FR 7.7.4 Payment History -** The system shall maintain complete payment history for all invoices.
- **FR 7.8 Multi-Currency Support -** Quotations and invoices shall support currency designation.
    - **FR 7.8.1 Default Currency -** Default currency shall be ZAR (South African Rand).
    - **FR 7.8.2 Currency Field -** All quotations and invoices shall include a Currency field.
    - **FR 7.8.3 Currency Consistency -** Currency shall remain consistent from estimate through quotation to invoice.
- **FR 7.9 Pricing Recalculation -** System shall automatically recalculate totals when items are modified.

FR 8.0: Reporting and Analytics

- **FR 8.1** Reporting & Dashboards - The system shall provide project, task, and financial performance reports.
    - **FR 8.1.1** The dashboard shall display project status.
    - **FR 8.1.2** The dashboard shall display budget vs actual expenditures.
    - **FR 8.1.3** The dashboard shall display contractor ratings.
    - **FR 8.1.4** The dashboard shall make use of Gantt Chart, Pie Chart, Bar Graph and Line graph to display data.
    - **FR 8.1.5** Admins and Project Managers shall be able to view contractor ratings.
- **FR 8.2** AI Risk Analysis - AI shall identify potential project delays and risks.
- **FR 8.3** AI Maintenance Forecasting - AI shall predict future maintenance needs based on historical data.

FR 9.0: Security and Compliance

- **FR 9.1** Audit Logging - All critical actions shall be logged with timestamps.
    - **FR 9.1.2** Audit logs shall be immutable once created.
    - **FR 9.1.3** Admins shall be able to search and filter audit logs by date range, user, log type, and entity.

- **FR 9.2** Role-Based Data Visibility - Data visibility shall be restricted according to user roles.
- **FR 9.3** Escalation Handling - Admins shall intervene in stalled workflows or disputes.
- **FR 9.4** System Configuration - Admins shall configure global settings, notification templates, and retention policies.\

2.7.2. Non-Functional Requirements

The non-functional requirements (NFRs) define the quality attributes of the ICMM. While the functional requirements describe what the system should do, non-functional requirements define how the system should perform. These requirements ensure usability, security, scalability, and performance of the application.

NFR 1.0: Performance Requirements

- **NFR-1.1:** The system shall support a minimum of **500 concurrent users** without degradation in performance.
- **NFR-1.2:** Average page load time for the web application shall not exceed **5 seconds** under normal load.
- **NFR-1.3:** Mobile API responses shall return within **5 seconds** for 95% of requests.
- **NFR-1.4:** The AI-based blueprint analysis shall complete within **60 seconds** for plans up to 20MB in size.
- **NFR-1.5:** Database queries shall be optimised to execute within **2 seconds** for standard operations.
- **NFR-1.6**: Message delivery shall occur within 4 seconds for 95% of messages.

NFR 2.0: Reliability Requirements

- **NFR-2.1:** The system shall achieve **99.5% uptime** (excluding planned maintenance).
- **NFR-2.2:** All critical business transactions (quotations, invoices, payments, project updates) must be logged to prevent data loss.
- **NFR-2.3:** The system shall implement retry and logging mechanisms for failed notifications (SMS/Email).

NFR 3.0: Availability Requirements

- **NFR-3.1:** The web application shall be available 24/7 except during scheduled maintenance
- **NFR-3.2:** Planned downtime shall not exceed **4 hours per month** and must be communicated to stakeholders at least 24 hours in advance.

NFR 4.0: Security Requirements

- **NFR-4.1:** User authentication shall be implemented using **Firebase Authentication** with email and password.
- **NFR-4.2:** User passwords shall be managed by Firebase Authentication, which uses scrypt hashing algorithm with automatic salting.
- **NFR-4.3:** All communications between client and server shall be encrypted using **HTTPS/TLS 1.3**.
- **NFR-4.4:** Role-based access control (RBAC) shall enforce least-privilege principles.

- **NFR-4.5:** All sensitive actions (logins, document downloads, invoice updates) shall be recorded in an **audit log**.
- **NFR-4.6:** The system shall comply with **POPIA (Protection of Personal Information Act, South Africa)** and **GDPR (EU General Data Protection Regulation)**.
- **NFR-4.7**: Brute Force Protection – System shall implement login attempt tracking.

NFR 5.0: Usability Requirements

- **NFR-5.1:** The web interface shall be responsive and accessible on desktop, with a mobile app available for clients and contractors.
- **NFR-5.2:** The mobile app shall support Android version **9 (Pie)** and above.
- **NFR-5.3:** All role-specific dashboards shall be intuitive and require **no more than 4 clicks** to access key tasks.
- **NFR-5.4:** The system shall comply with **WCAG 2.1 accessibility standards** for visually impaired users.
- **NFR-5.5:** Online help and tooltips shall be provided for all complex workflows.

NFR 6.0: Maintainability Requirements

- **NFR-6.1:** The system shall follow a **modular architecture** (separation of concerns between project management, maintenance, documents, AI, etc.).
- **NFR-6.2:** The source code shall follow **SOLID principles** and industry-standard naming conventions.
- **NFR-6.3:** Automated unit tests shall cover at least **70% of core business logic**.
- **NFR-6.4:** New developers should be able to onboard and contribute within **1 day**, aided by documentation.

NFR 7.0: Scalability Requirements

- **NFR-7.1:** The system shall support up to **10,000 registered users** without redesign.
- **NFR-7.2:** The messaging and notifications module shall handle **up to 50 messages per second**.

NFR 8.0: Portability & Compatibility Requirements

- **NFR-8.1:** The web application shall be compatible with latest versions of Chrome, Edge, Firefox, and Safari.
- **NFR-8.2:** The mobile application shall run on both **emulators and real devices**.
- **NFR-8.3:** The system shall support migration to different cloud providers (AWS, Azure, GCP) with minimal changes.

NFR 9.0: Compliance Requirements

- **NFR-9.1:** The system shall comply with **South African ICT regulations**, **POPIA**, and where applicable, **GDPR**.
- **NFR-9.2:** Audit logs must be retained for **at least 5 years**.
- **NFR-9.3:** All financial data shall comply with **IFRS (International Financial Reporting Standards)**.

NFR 10.0: File Storage Requirements

- **NFR-10.1:** Document Storage - All files shall be stored in Supabase Cloud Storage.
- **NFR-10.2**: Storage Buckets - Files shall be organized in separate storage buckets
- **NFR-10.3:** Storage Retention - Deleted files shall only be soft-deleted and retained indefinitely or until otherwise permanently deleted.

NFR 11.0: Push Notification Requirements

- **NFR-11.1**: Delivery Platform - Push notifications shall be delivered via Firebase Cloud Messaging.
- **NFR-11.3**: Notification Delivery - Push notifications shall be sent within 5 seconds of triggering event.

NFR 12.0: Data Validation Requirements

- NFR-12.1: Input Validation - All user inputs shall be validated before processing.

The implementation of these requirements was executed through a structured, sprint-based approach, as detailed below.

2.8. Sprint Progress Per Requirements

Our development team maintained a consistent rhythm of bi-weekly Scrum meetings (every Monday and Thursday) from 4th August to 4th November 2025, documenting all progress through formal minutes and Trello updates. Each sprint built on the deliverables defined in the Part 1 Roadmap, with steady integration of backend logic, UI, and system testing.

2.8.1. Sprint 1 - 4 Aug 2025 to 18 Aug 2025

Focus**: Complete Initial Report.**

The first sprint focused on establishing the complete system foundation with a primary focus on documentation. User roles, stories, and backlog tables were finalised, all structural diagrams (ERD, Use Case, Sequence, Activity, Class) were completed, UX mock-ups for mobile were produced, and Firebase was selected for authentication and Firestore for data storage. GitHub and Trello were fully configured.

Completed: Initial Firebase and GitHub configurations completed, no code deliverables.

2.8.2. Sprint 2 - 18 Aug 2025 to 28 Aug 2025

Focus: **Set up ASP.NET back-end, security, and API foundations.**

This sprint delivered Firebase Authentication, role-based access, and audit logging. Passwords were managed by Firebase Auth, login-attempt tracking and lockout logic were implemented. GitHub branching standards and bug-tracking were introduced. Initial API controllers for all entities were created.

Completed: FR 1.1 (User Onboarding & Role Management), FR 1.2 (User Authentication & Access Control), FR 9.2 (Role-Based Data Visibility), NFR-4.1 (Firebase Authentication), NFR-4.2 (Password Encryption), NFR-4.3 (HTTPS/TLS 1.3), NFR-4.4 (RBAC Least Privilege).

2.8.3. Sprint 3 - 28 Aug 2025 to 13 Sep 2025

Focus: **Develop Web and Mobile Front-End UIs**.
Role-specific dashboards (Admin, PM, Contractor, Client) were built with real-time Firestore connections. Project creation, estimate-quote linkage, and task assignment logic were integrated. Audit-trail expansion and responsive layouts were completed.

Completed: FR 2.1 (Project Creation), FR 2.2 (Resource Allocation per Phase), FR 2.3 (Project Tracking), NFR-5.3 (Role-Specific Dashboards Usability), NFR-6.1 (Modular Architecture), NFR-6.2 (SOLID Coding Standards), NFR-12.1 (Input Validation).

2.8.4. Sprint 4 - 28 Aug 2025 to 18 Sep 2025

Focus: **Develop and test REST API.**

Quotation workflow, Quotation and invoice endpoints were implemented. The system could now generate, review, and approve quotations and send to the client. API Endpoints were fully developed. Security documentation and Firestore rule updates were finalised.

Completed**:** FR 4.1 – 4.6 (Document Management Suite), FR 7.3 (Quotation Workflow), FR 7.4 (Quotation Approval Process), FR 7.9 (Pricing Recalculation), NFR-10.1 (Document Storage in Supabase), NFR-10.2 (Storage Buckets), NFR-10.3 (Storage Retention and Soft Deletes).

2.8.5. Sprint 5 - 14 Sep 2025 to 2 Oct 2025

Focus: **Implement Quotation & Invoice System and begin AI Assistant.**

The Gemini-based AI parser was integrated for blueprint cost estimation. Data sanitisation prior to AI submission was implemented. Quotation-to-invoice conversion and automated tax calculations were completed. Client functionality was also implemented for approving quotes, receiving automatically generated invoices and also requesting maintenance for projects that are “Completed”.

Completed: FR 3.1 – 3.5 (Maintenance Module), FR 7.1 – 7.8 (Quotation, Invoice, and Payment Workflow), NFR-1.2 (Page Load ≤ 5 s), NFR-1.4 (AI Blueprint Processing ≤ 60 s for 20 MB Files).

2.8.6. Sprint 6 - 2 Oct 2025 to 16 Oct 2025

Focus: **Add Voice Feedback feature and complete DevOps & Security**.

This sprint concentrated on refining the system’s reliability, DevOps configuration, and accessibility. The Voice Feedback feature was designed for contractors to record and upload site audio notes through the mobile interface. Deployment pipelines were finalised with secure HTTPS connections and enforced authentication. Comprehensive penetration testing was completed using Snyk and SonarQube to assess vulnerabilities and code quality. Final environment variables, JWT configurations, and audit-log checks were validated.

Completed: FR 8.1 Reporting & Dashboards, FR 9.3 Escalation Handling, FR 9.4 System Configuration. NFR-1.1 – 1.6 (Performance), NFR-2.1 – 2.3 (Reliability), NFR-3.1 – 3.2 (Availability), NFR-4.5 – 4.7 (Security Auditing and Brute Force Protection), NFR-6.3 (Automated Unit Testing Coverage ≥ 70%), NFR-6.4 (Developer Onboarding within 1 Day), NFR-7.1 – 7.2 (Scalability), NFR-8.1 – 8.3 (Compatibility), NFR-12.1 (Input Validation).

2.8.7. Sprint 7 & 8 - 16 Oct 2025 to 4th Nov 2025

Focus: **Messaging Functionality, Ensuring Ethical Compliance, Ensuring completion of all Non-Functional Requirements.**

These sprints finalised all communication and ethical-compliance components. The internal messaging module was completed, enabling real-time notifications, threaded messages, and attachment uploads with Supabase Storage. The “Ethical & Privacy Considerations” section was formalised into the system documentation. A planned user-warning prompt was prepared to notify users before AI processing, ensuring transparency in Gemini blueprint handling.
Final reviews were conducted to confirm POPIA compliance, responsive UI performance, and accessibility standards before the final hand-off.

Completed: FR 5.1 – 5.9 (Communication and Notifications), FR 6.1 – 6.1.4 (Real-Time Notifications), FR8.1 Reporting & Dashboards, FR 8.2 AI Risk Analysis and FR 8.3 Maintenance Forecasting (finalised), FR 9.1 Audit Logging (final review), NFR-5.1 – 5.5 (Usability and Accessibility), NFR-9.1 – 9.3 (Compliance), NFR-11.1 – 11.3 (Push Notifications), NFR-10.1 – 10.5 (Storage Integrity).

2.9. System Testing and Verification

Every functional and non-functional requirement defined in the previous sections was validated through a structured, layered testing strategy. Testing began early in development and continued through each sprint to ensure that the ICMMS operated as specified and that performance, security, scalability, and reliability were demonstrably achieved.

Verification followed two complementary approaches:

1. ***In-App Testing Dashboards***
   The team developed internal testing interfaces accessible from the Admin and Tester Role Dashboards.

2. ***Automated Quality and Security Scanning***
   Continuous-integration pipelines on GitHub Actions executed automated analysis for every commit and pull request.

Together, these methods ensured that each requirement was not only implemented but verifiably tested within the live system.
Readers are referred to Part 5 – Testing and DevOps Plan (see Section 5.7) (Page 91) for detailed evidence of the implemented testing environments, SonarQube Cloud quality-gate summaries, and Snyk security-scan results.

2.10. Summary: Requirements & UX Design

The functional and non-functional requirements together form the backbone of the ICMMS specification. The functional requirements define how modules such as Project Management, Quotation Processing, Document Storage, and Communication will perform in practice. Each requirement directly traces back to one or more user stories from Part 2, ensuring that all critical business objectives are implemented through measurable system functions.

Complementing this, the non-functional requirements capture the quality benchmarks that guarantee stability, reliability, and security under operational stress. These include explicit thresholds for performance, availability, scalability, usability, and legal compliance. In doing so, they ensure that ICMMS is not only feature-complete but also robust, efficient, and maintainable within real-world conditions. Together, the FRs and NFRs create the technical rulebook that guides every design, coding, and testing activity in later stages.

The following section, **Part 3 - Analysis and System Design**, builds directly upon these specifications. It converts the documented requirements into structured system models, data architectures, and secure design components that represent the ICMMS in its complete technical form.

Part 3 - Analysis & System Design

3.1. Introduction

Part 3 translates the requirements foundation established in the previous section into a structured system design that defines how the Integrated Construction and Maintenance Management System (ICMMS) will operate in practice.
This stage focuses on the underlying logic, data architecture, and security infrastructure that enable those behaviours to function reliably in production.

The analysis phase begins by modelling the problem domain to identify key entities and their relationships within bounded business contexts. These models guide the design of the database schema and inform the logical architecture used to connect the web application, API services, Firebase / Firestore data layer, and authentication framework.

3.2. Domain Modelling

The ICMMS domain model defines the logical structure of the system and how all entities interact within bounded business contexts. It represents the static relationships between key objects such as Users, Projects, Phases, Tasks, Quotations, Invoices, Payments, and Documents, showing how data flows across the construction and maintenance lifecycle.

As shown in Figure 3.1, the central entity is Project, which links directly to Phase, Task, and Document classes; reflecting the hierarchical structure used in real construction workflows. Each *Project* is created by a ProjectManager, associated with a specific Client, and executed through assigned Contractors. The Quotation and Invoice entities connect the financial lifecycle, referencing the same ProjectId for full traceability from cost estimation to payment. Maintenance is designed as the final phase of every project. If only a Maintenance request is required, an account is first needed with a project setup.

The User superclass defines shared attributes (e.g., UserId, Email, Role) inherited by the system's four role types; *Administrator*, *Project Manager*, *Contractor*, and *Client*. This inheritance model simplifies authentication logic and enables role-based permissions through a unified data schema.

Other supporting entities include MaintenanceRequest, which originates from the Client and links to both the *ProjectManager* and *Contractor*, and AuditLog, which records system-wide actions for accountability and compliance. Together, these relationships outline the real-world dependencies between administrative control, operational execution, and client oversight, forming the technical foundation for database and architectural design that follows.

UML Class Diagram

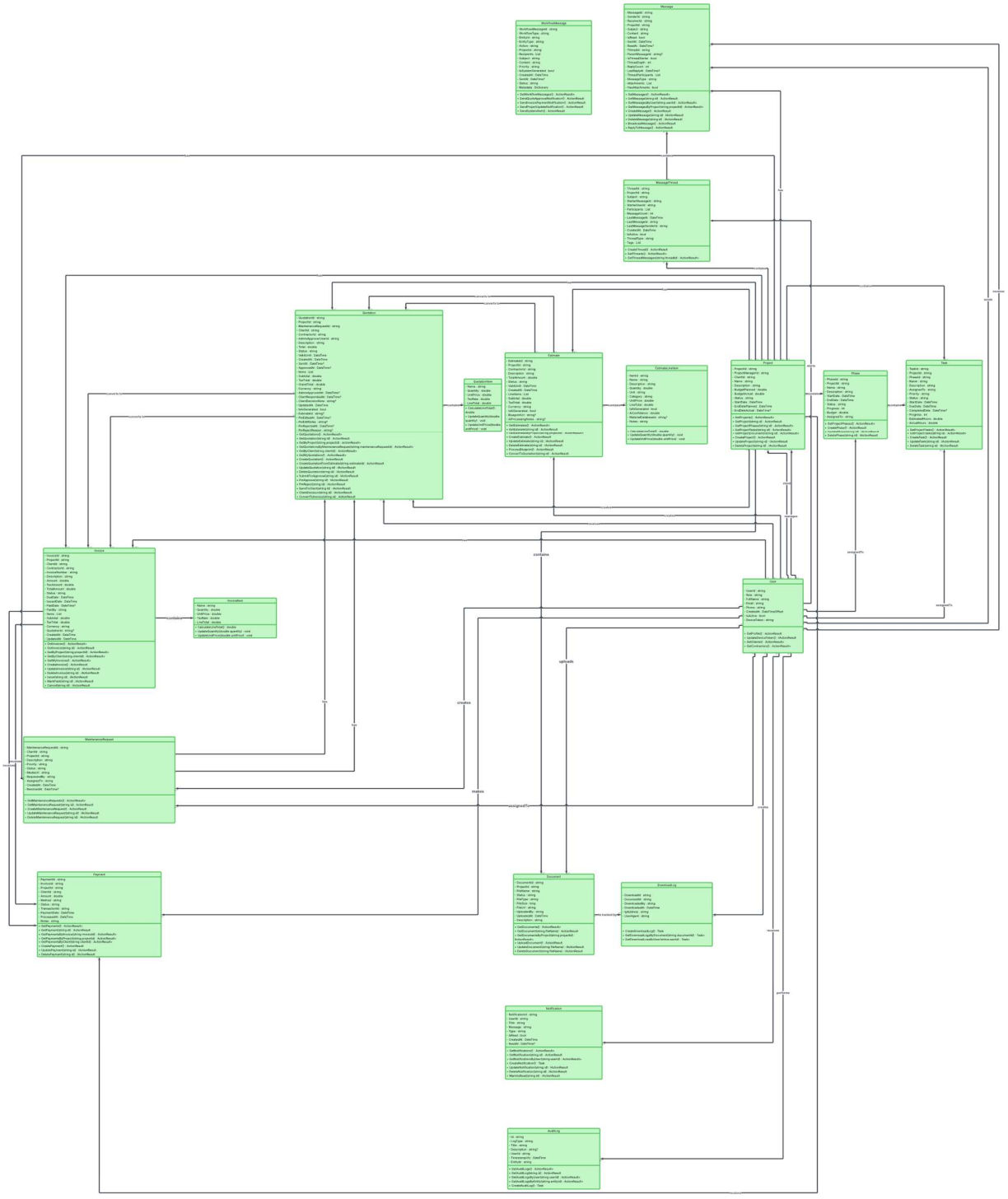


Figure 3.1 - UML Class and Domain Model. Source: Lucid Chart: link here

3.2.1. Bounded Context Diagram

The intention of this model is to separate the system's logic into clear business domains including preventing overlap, reducing data coupling, and improving maintainability across the full lifecycle of construction and maintenance operations. As shown in Figure 3.2, the architecture is divided into four main contexts:

- **User and Access Management Context:** Handles authentication, authorisation, and user configuration. This context governs all role-based access and security policies managed through Firebase Authentication and the Admin module.
- **Project Lifecycle Management Context:** Represents the core of the system where projects are created, divided into phases, and monitored through task assignments, document uploads, and progress tracking. It integrates tightly with the Contractor and Client contexts via shared ProjectId references.
- **Quotation and Billing Context:** Manages cost estimation, quotation approval, invoicing, and payment tracking. It interacts directly with the Project Lifecycle context and references both Project Managers and Clients to maintain a full financial audit trail.
- **Maintenance and Support Context:** Focuses on client-submitted service or maintenance requests. Each request triggers a workflow linking the responsible Project Manager and assigned Contractor to ensure accountability and timely completion.

Bounded Context Diagram

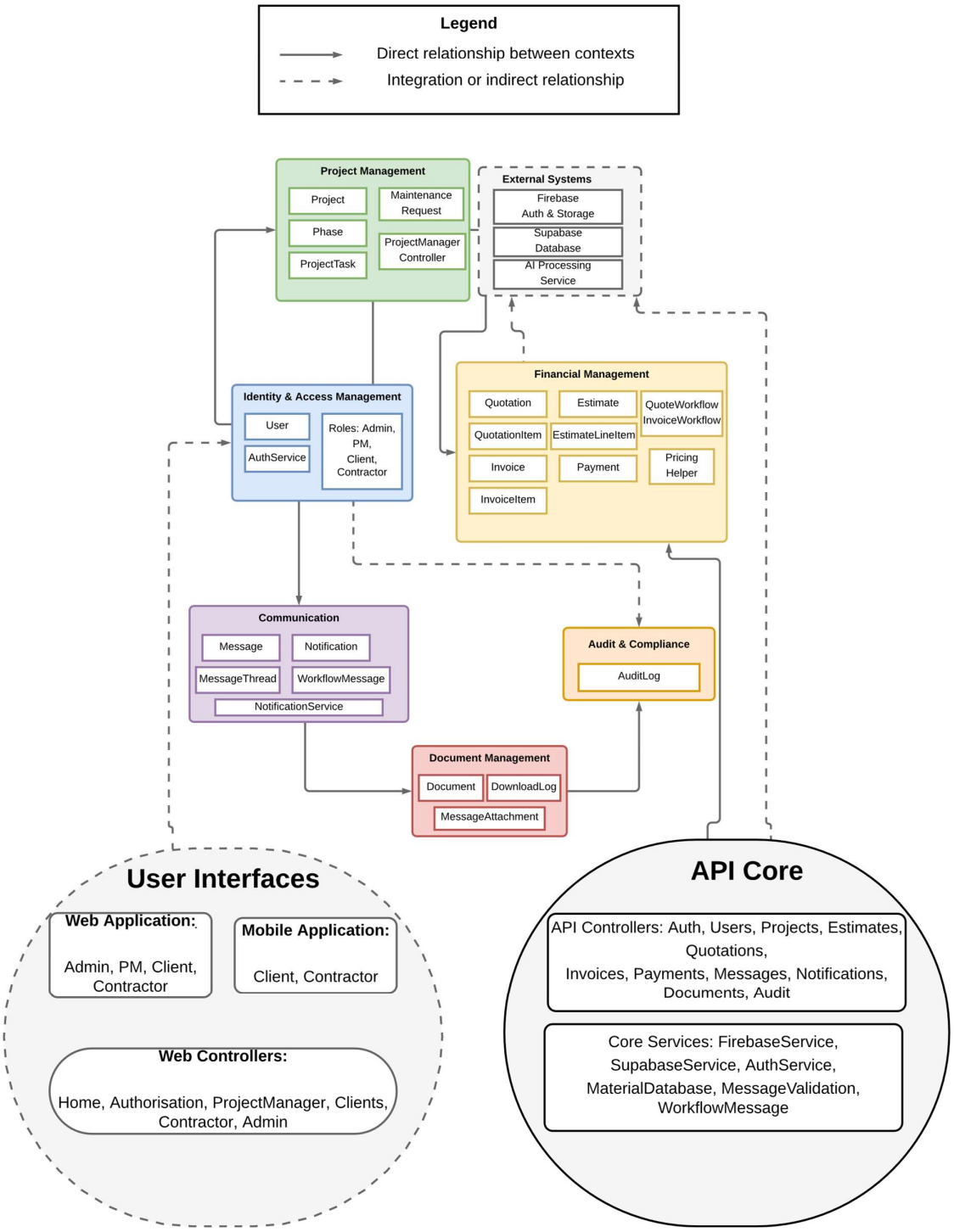


Figure 3.2 – Bounded Context Diagram*. *Source: Lucid Chart: link here

3.2.2. Connecting the UML and Bounded Context Models

The UML class diagram and bounded context model together illustrate how the ICMMS applies a domain-driven architecture. Connecting these diagrams ensures that technical components designed at entity level are logically grouped into functional areas that promote modularity, maintainability, and scalability. The mapping between UML entities and bounded contexts separates business logic boundaries while maintaining system-wide interconnectedness through shared identifiers such as ProjectId and UserId.

Each bounded context serves as a container for UML entities with a common purpose. The Identity & Access Management context covers authentication and user configuration handled by User and AuthService. The Project Lifecycle Management context includes operational entities like Project, Phase, Task, and MaintenanceRequest, which manage construction workflows. The Financial Management context isolates entities such as Estimate, Quotation, Invoice, and Payment to ensure financial integrity and encapsulation. Meanwhile, the Communication and Document contexts integrate with these layers through service-based APIs, using entities like Message, Notification, Document, and AuditLog to support traceability.

Bounded Context	**Associated UML Entities**
Identity & Access Management	User, AuthService
Project Lifecycle Management	Project, Phase, Task, MaintenanceRequest
Financial Management	Estimate, EstimateLineItem, Quotation, QuotationItem, Invoice, InvoiceItem, Payment
Communication	Message, MessageThread, Notification, WorkflowMessage
Document & Audit Management	Document, MessageAttachment, DownloadLog, AuditLog
External System Services	FirebaseService, SupabaseService, AI Processing Service

3.1. Entity–Relationship Model (ERD) and Database Schema

The Entity–Relationship Diagram (ERD) defines how project creation, task management, document control, and quotation processing interconnect to support all system operations

As illustrated in Figure 3.3, the core entities include User, Project, Phase, Task, Quotation, Invoice, Payment, and Document.

The *User* entity is associated with multiple *Projects* via the ProjectManagerId or ClientId foreign keys, while each *Project* cascades into multiple *Phases* and *Tasks*. This one-to-many relationship mirrors the practical structure of project execution workflows.

Financial processes are represented through *Quotation* and *Invoice*, both of which maintain direct references to their parent *Project* for traceability and reporting. The *Document* entity links to both *Project* and *Task*, capturing all uploaded reports, blueprints, and completion images. Additional utility entities; *Notification*, *AuditLog*, and *MaintenanceRequest*, support real-time communication, activity tracking, and maintenance scheduling within the system.

3.1.1. Entity–Relationship Model

ERD Class Diagram

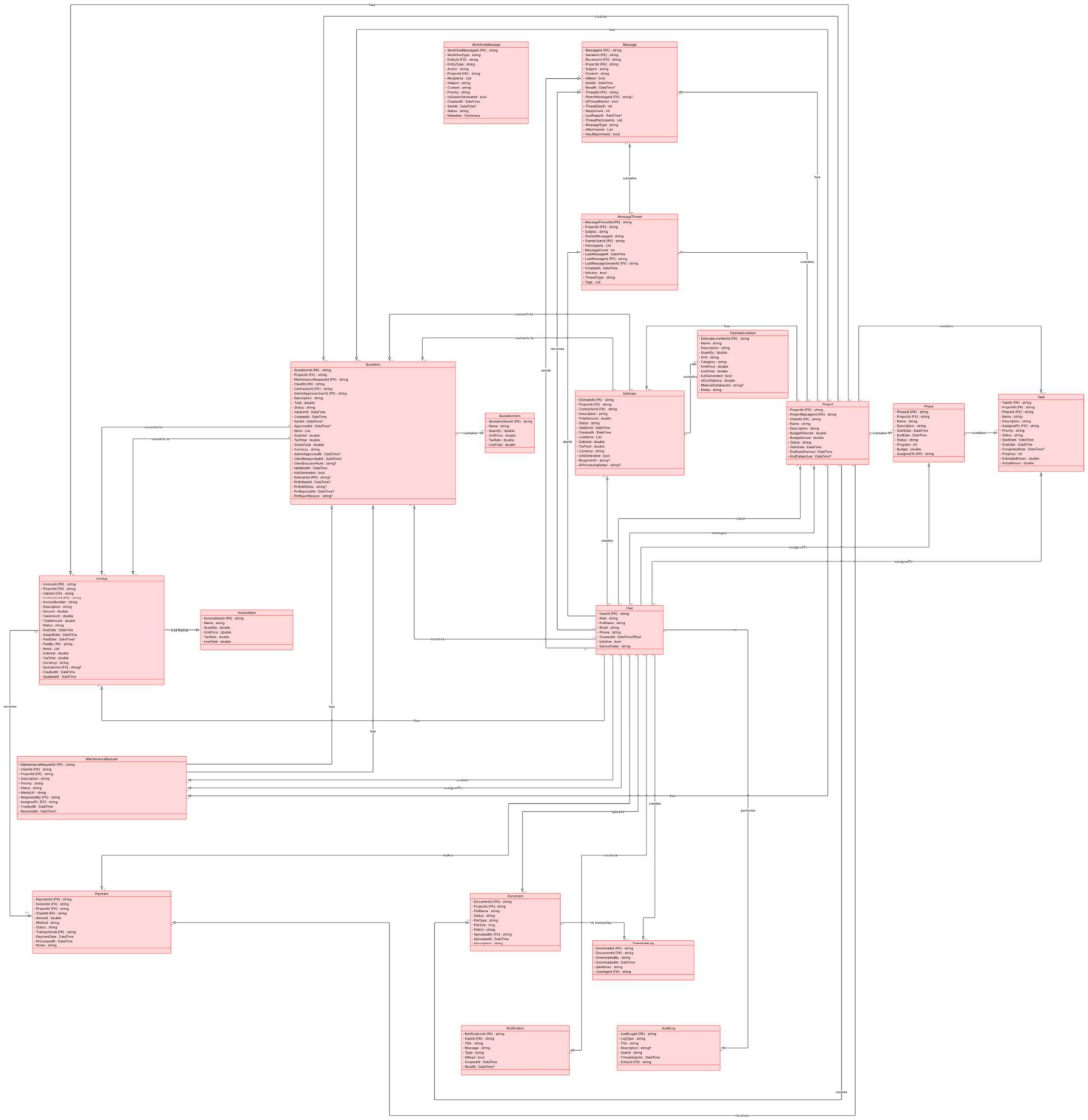


Figure 3.3 – Entity Relationship Diagram. Source: Lucid Chart*:* link here

3.1.2. Database Justification

During the design phase of the Integrated Construction and Maintenance Management System, we explored multiple database strategies, including a polyglot architecture combining SQL for structured, transactional data, and NoSQL for dynamic, operational data.
While the hybrid approach offers theoretical advantages in data integrity for financial records, our research identified several practical constraints that made this architecture less suitable for the scope and requirements of the project. Thus, the decision to go with only Firestore's NoSQL database was made.

Hosting and Cost Constraints:

Hosting a polyglot architecture solution would require additional infrastructure, configuration and maintenance. Additionally, many hosting solutions are catered for production grade SQL databases, which would incur recurring costs. (SQL, n.d.)

Complexity:

Hosting and maintaining two databases would result in complex backend logic to coordinate between the two databases and would pose synchronization challenges with additional security and access control layers.

Adequacy of Firestore:

While SQL naturally enforces schema and relational integrity (Teak, 2024), Firestore's flexibility allows us to model both structured and unstructured data into a single database. (Firebase, n.d.). We can enforce strict server-side data validation on our backend to ensure correctness without relying on a schema.

File Storage Strategy – Supabase Bucket

For storing and managing uploaded documents, we are using a Supabase Bucket. Supabase provides a scalable object storage that integrates seamlessly with our backend services. (Supabase, n.d.). This approach allows us to separate static file storage from dynamic application data in Firestore, ensuring efficient data retrieval and optimized bandwidth usage. Additionally, Supabase's authentication and control features align with our existing Firebase Authentication setup, mainting consistent security standard across both systems.

Seamless Integration into Tech Stack:

Firestore integrates natively with our current Tech Stack that already includes

- *Firebase Authentication*
- *Firebase Storage*
- *Supabase Bucket*
- *Kotlin*
- *ASP.NET (C#)*

Suitability

The system's goal is to demonstrate functionality and architectural principles, not to operate as a production-grade, compliance regulated financial system. A Firestore only architecture, complemented by Supabase for file storage, will allow us to focus on feature completeness, user experience, and maintainable code.

3.2. System Architecture Design

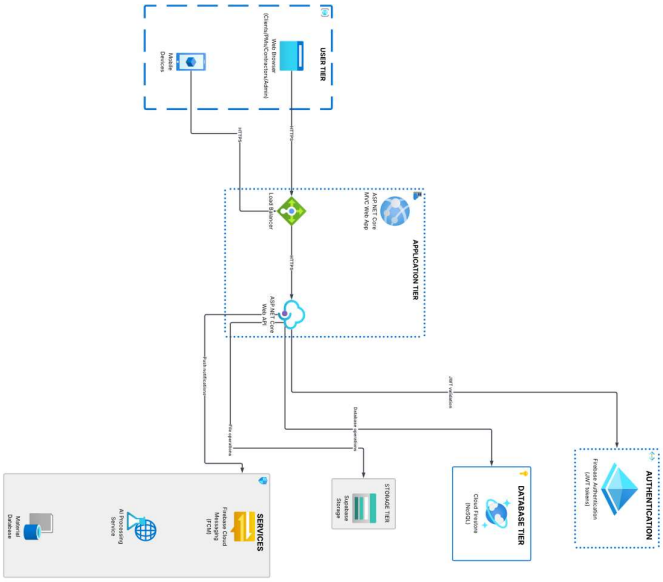
3.2.1. Logical Architecture

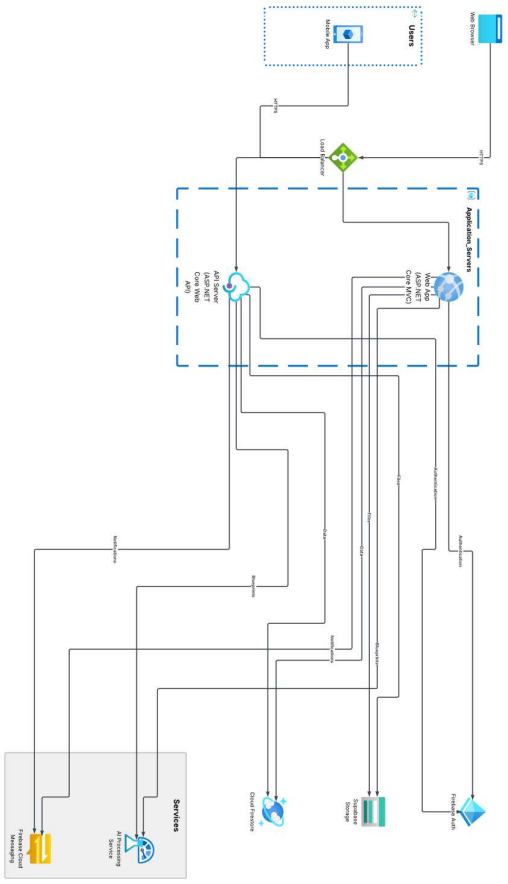
The logical architecture, illustrated in Figure 3.4, outlines the data and control flow across all major components. The core system comprises three primary layers:

- **Presentation Layer:** Web App (ASP.NET MVC) and Mobile App (Android Kotlin) provide role-specific dashboards and CRUD interfaces.
- **Application Layer (API):** The .NET 6 Web API exposes endpoints for Projects, Users, Quotations, and Documents. It enforces validation, authentication, and audit logging.
- **Data Layer:** Firestore (NoSQL) stores application data; Supabase Buckets handle static file storage; Firebase Auth secures login sessions; and Azure App Service hosts the backend and web frontend.

Data flows from the client layer to the API via HTTPS, authenticated by Firebase Auth tokens, then routed to Firestore for persistence.
This multi-tier approach isolates business logic, promotes scalability, and enables independent updates without downtime.

Additionally, the architecture enforces secure communication across all cloud layers. All traffic between the Web App, Mobile App, and .NET API is transmitted over HTTPS using TLS 1.3. Firebase Authentication issues signed ID tokens that are validated at the API gateway before any request reaches Firestore or Supabase. Both Firestore and Supabase use role-based access rules and encrypted connections, ensuring that no direct public access occurs between the client and database layers. This design provides a secure, fully isolated network path from user interface to data storage.





System Overview Diagram

Figure 3.4 – System Overview Diagram. Source: Lucid Chart*:* link here

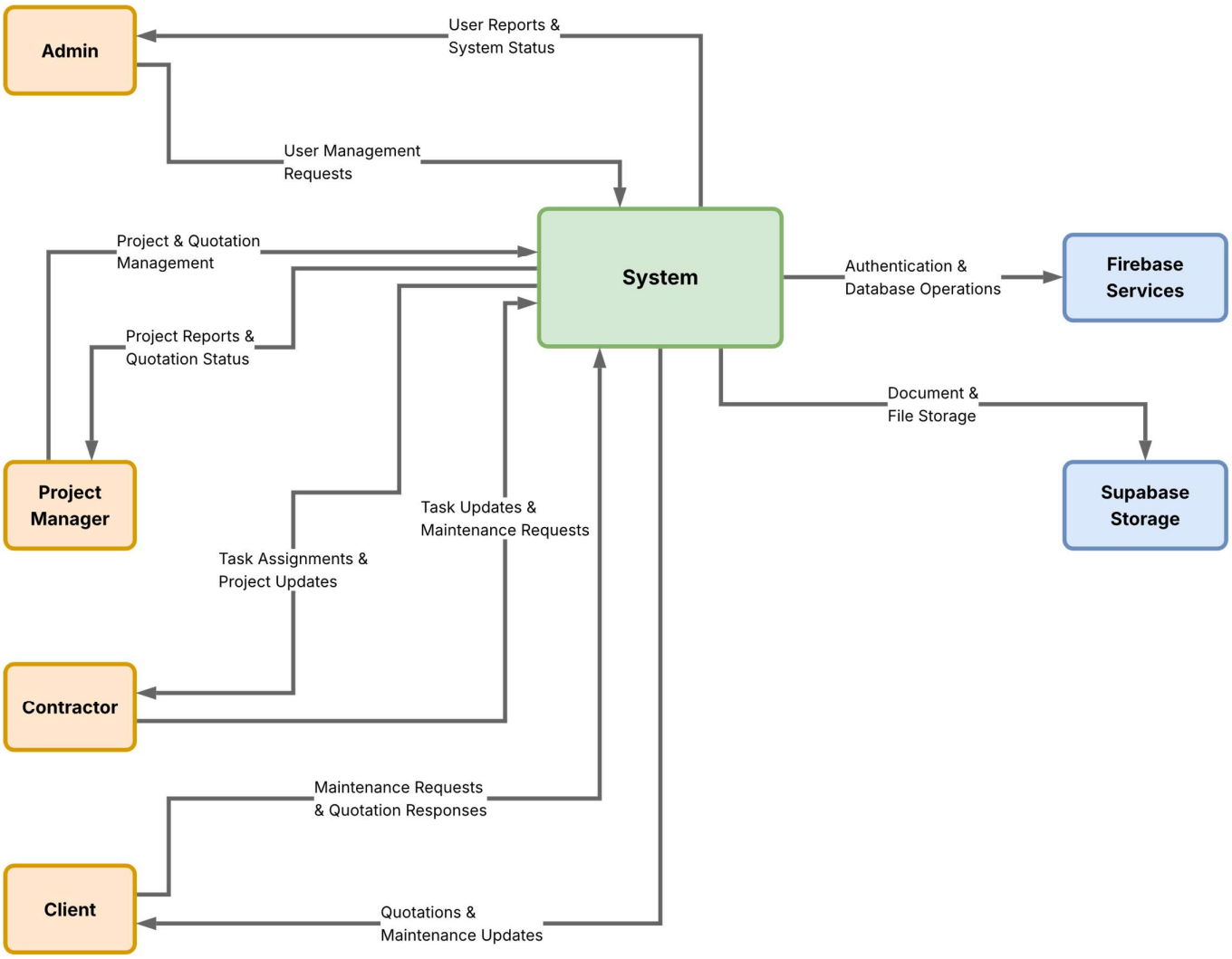
3.2.2. Data Flow Architecture

The supporting data-flow models expand the logical architecture into granular process views:

- **Level 0:** Context Data Flow Diagram (Figure 3.5) shows external entities (Admin, Project Manager, Contractor, Client) interacting with the system through secure API requests.
- **Level 1:** Authentication and User Management DFD (Figure 3.6) details credential validation via Firebase Auth and user-role retrieval from Firestore.
- **Level 1:** Quotation and Invoice Management DFD (Figure 3.7) models quote creation, approval, and invoice generation between Project Manager, Admin, and Client roles.

These flows ensure clear traceability of data movement and process responsibilities across all system components.

Context Level Data Flow Diagram (Level 0)



Notes:
- ISystem includes Web App, API, and Mobile App components
- Firebase handles authentication and Firestore database
- Supabase provides document and file storage services
- All data flows are bidirectional with appropriate security controls

Figure 3.5 – Context Level Data Flow Diagram Source: ***Lucid Chart***: ***link here***

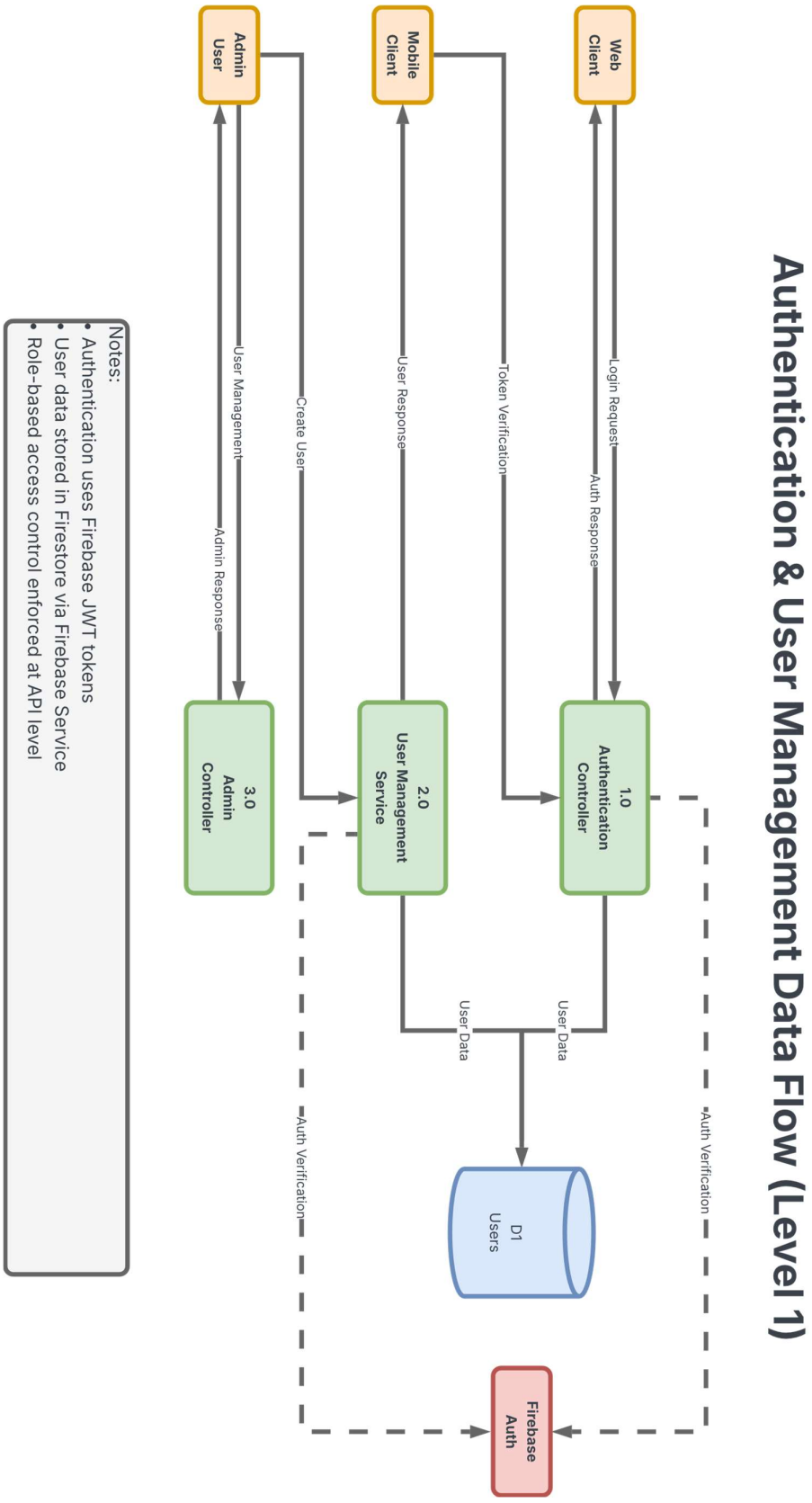


Figure 3.6 – Authentication and User Management Data Flow (Level 1) Source: ***Lucid Chart***: ***link here***

Quotation & Invoice Management Data Flow (Level 1)

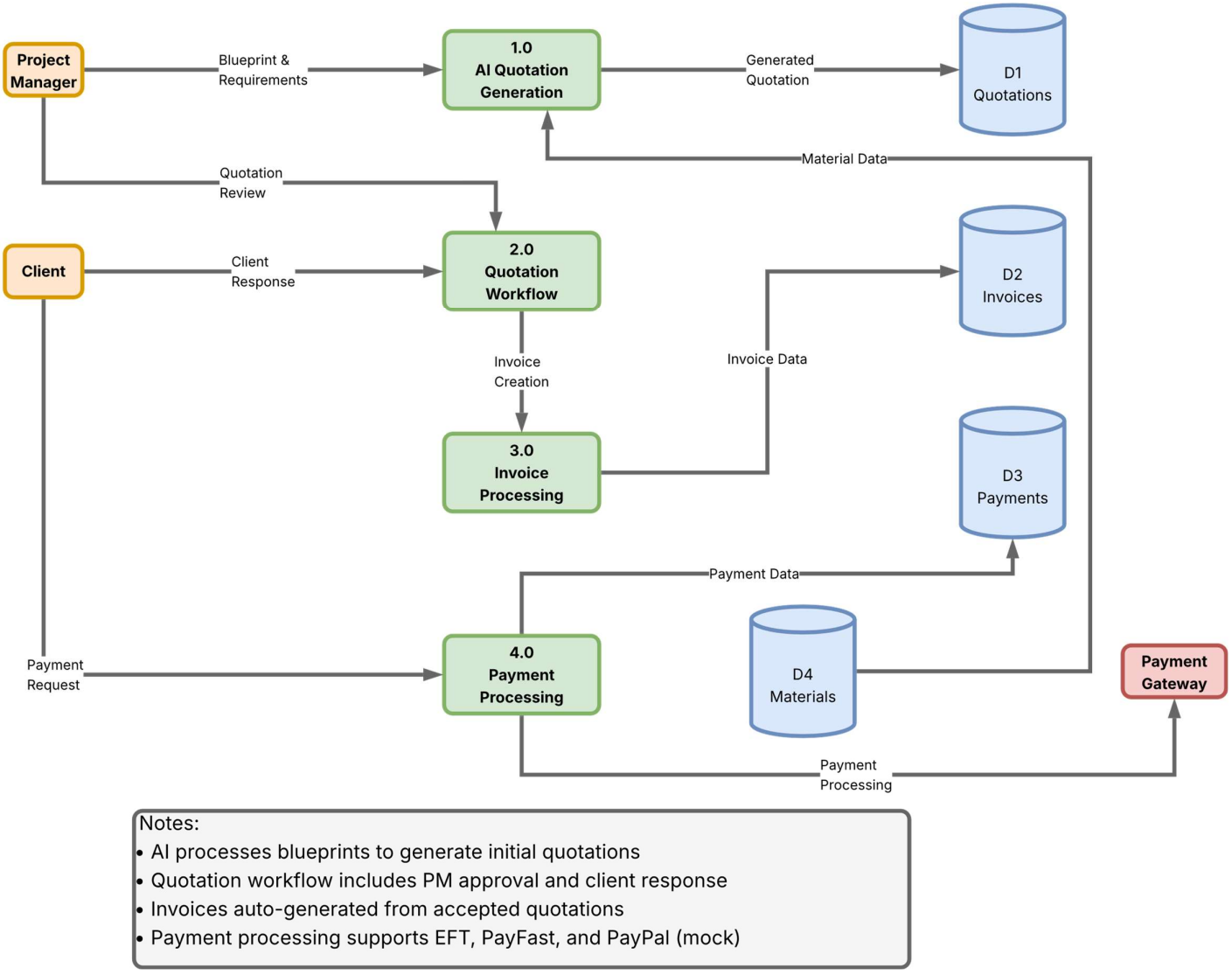


Figure 3.7 – Quotation and Invoice Management Data Flow (Level 1) Source: ***Lucid Chart***: ***link here***

3.2.3. Physical Deployment Architecture

Prerequisites

Azure Account

- Azure subscription
- Resource Group
- App Service Plan
- App Service
- Web App

Firebase Setup

- Create a Firebase project
- Link Google Cloud project
- Enable the following services
  1. Authentication: Go to Authentication -> sign-in method -> enable Email/Password & Google
  2. Firestore: Go to Firestore Database -> Create Database -> Start in test mode
  3. App Check: Go to App Check -> Register apps
- Generate Configuration Files
  1. Go to Project Settings -> General -> Your apps
  2. Add Android app -> download 'google-services.json' and place in app directory.
  3. Add Web app -> copy config object -> use in web app.

Development Environment

Required downloads

- .NET SDK 6.0+
- Azure CLI
- Git
- Visual Studio / VS Code
- Android Studio

3.2.4. Deployment Processes

Backend API Deployment

1. Build and Deploy
   - Navigate to API project
     `cd API/ICCMS-API`
   - Build the application
     `dotnet publish --configuration Release --output ./publish`
   - # Create deployment package
     `Compress-Archive -Path "./publish/*" -DestinationPath "./publish.zip" -Force`
   - Deploy to Azure
     `az webapp deployment source config-zip --name ICCMS-API --resource-group abcretailers_group --src ./publish.zip`
2. Restart App Service
   - Restart to apply runtime changes
     `az webapp restart --name ICCMS-API --resource-group abcretailers_group`

Alternative:
Run ./deployAPI bat script from project root

Web Frontend Deployment

- Navigate to Web project
  ` cd Web\ICCMS-Web`
- Build the application
  ` dotnet publish --configuration Release --output ./publish`
- # Create deployment package
  `Compress-Archive -Path "./publish/*" -DestinationPath "./publish.zip" -Force`
- Deploy to Azure
  ` az webapp deployment source config-zip --name icmms --resource-group abcretailers_group --src ./publish.zip`

Alternative:

Run ./deployWeb bat script from project root

Mobile App Build Process

Requirements:

- Android Studio
- ‘google-services.json’ file in app directory
- Proper API endpoint configuration pointing to Cloud Run API

Build steps:

```
# Generate debug APK for testing
cd Mobile
./gradlew assembleDebug
# APK location: app/build/outputs/apk/debug/app-debug.apk

# Generate release APK for distribution
./gradlew assembleRelease
# APK location: app/build/outputs/apk/release/app-release.apk
```

Installation:

- Transfer APK to Android device
- Enable “Install from unknown sources”
- Install APK directly
  OR
- Can install directly if device is connected using

```
adb install app-debug.apk
```

3.3. Wireframes and UI Mockups

The following wireframes visualise the Contractor Mobile Interface of the Integrated Construction and Maintenance Management System (ICMMS). They illustrate the user experience from a functional perspective. How daily tasks, project updates, and communication are delivered through a responsive and intuitive design.

The Contractor role was chosen for detailed mock-ups because it represents the most active operational user within the platform. Contractors interact with multiple system modules: task tracking, schedule management, document uploads, and real-time notifications. The mobile layout ensures accessibility on-site, where field workers require fast status updates and minimal navigation overhead.

Each screen maintains consistent design language, using standard spacing, high-contrast typography, and a clear bottom navigation bar to reinforce familiarity across views. Visual feedback (progress bars, task chips, and colour states) provides at-a-glance understanding of project progress.

3.5.1 Home Screen

The Home Screen displays an overview of active projects, upcoming tasks, and progress metrics. Dynamic widgets summarise deadlines, completion percentages, and task priorities. The top search bar enables quick access to specific jobs or clients.

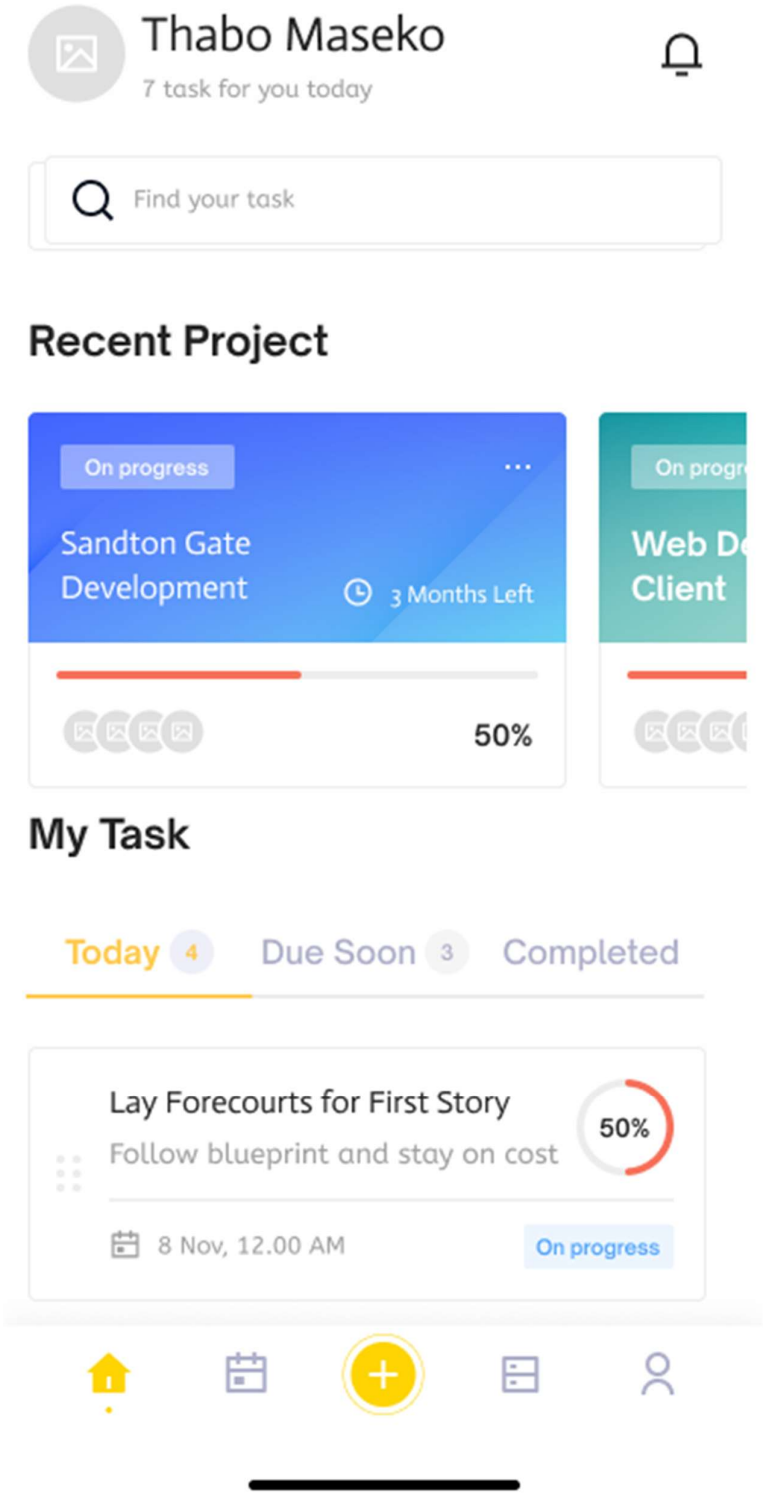
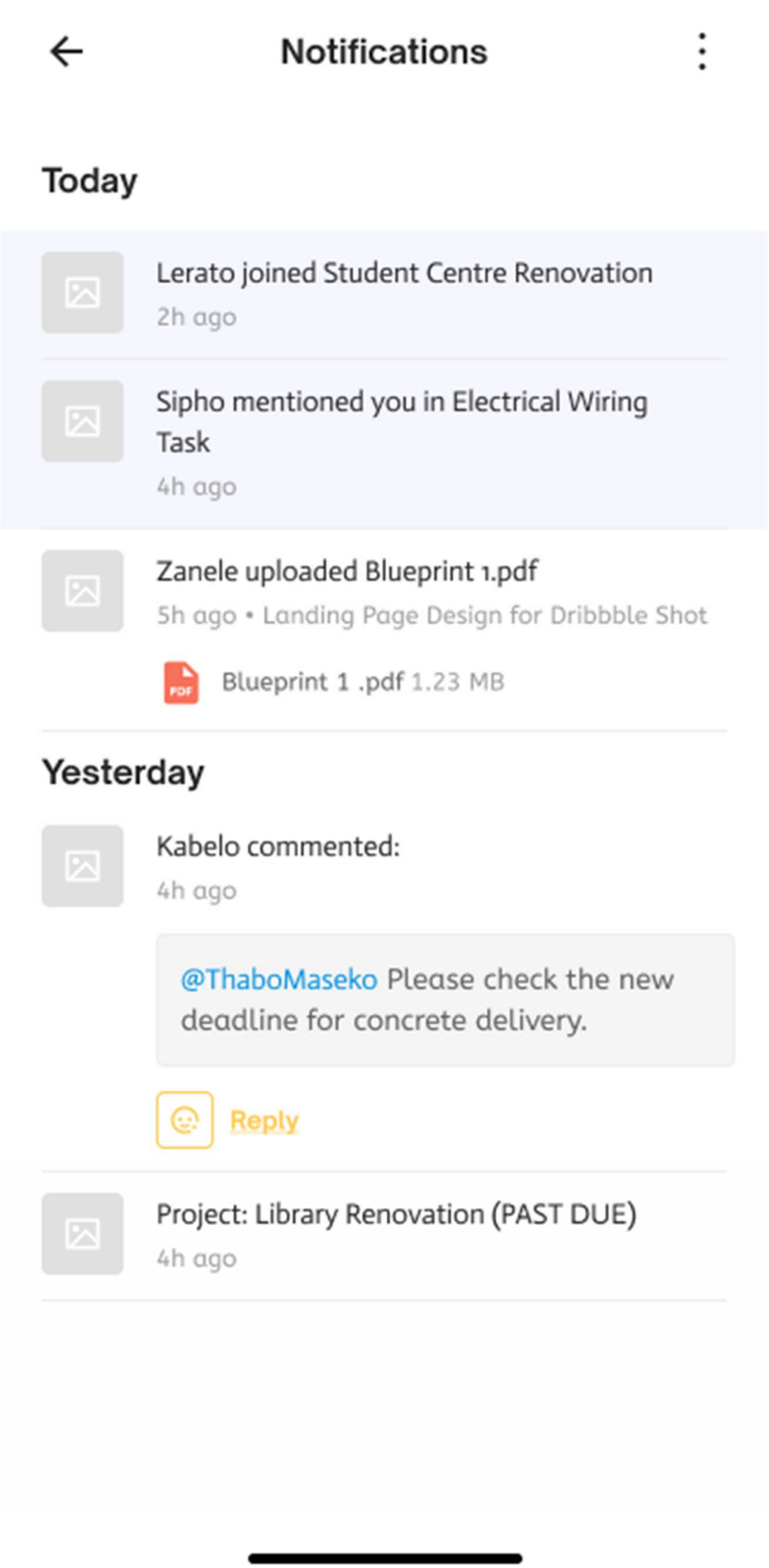


Figure 3.8 – Contractor Home Page Mock-up

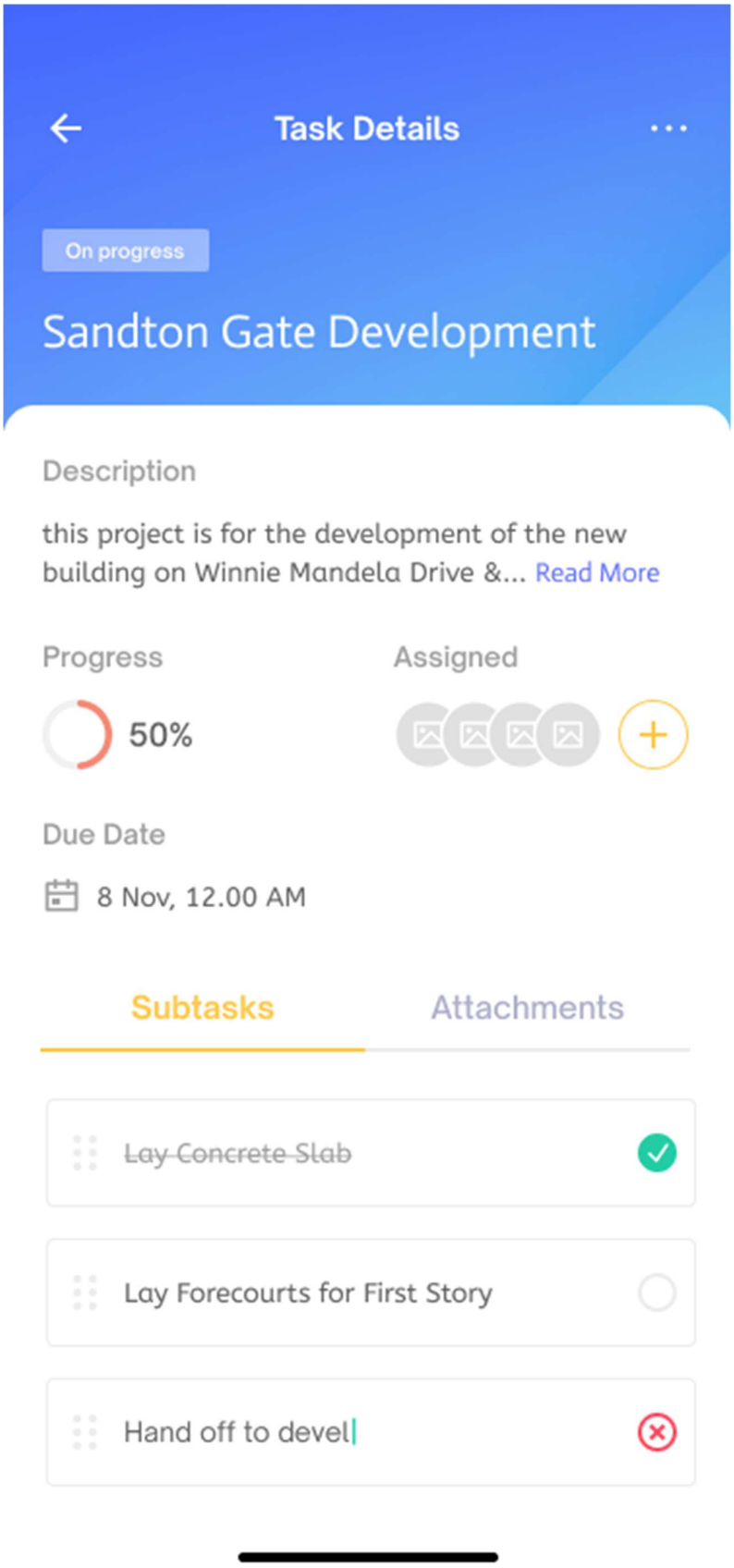
3.5.2 Notifications Screen



The Notifications interface aggregates all real-time system alerts; new task assignments, document uploads, and project mentions. Grouped by “Today” and “Yesterday,” it helps contractors respond immediately to time-critical updates while maintaining a chronological activity log.

Figure 3.9 – Contractor Notifications Page Mock-up

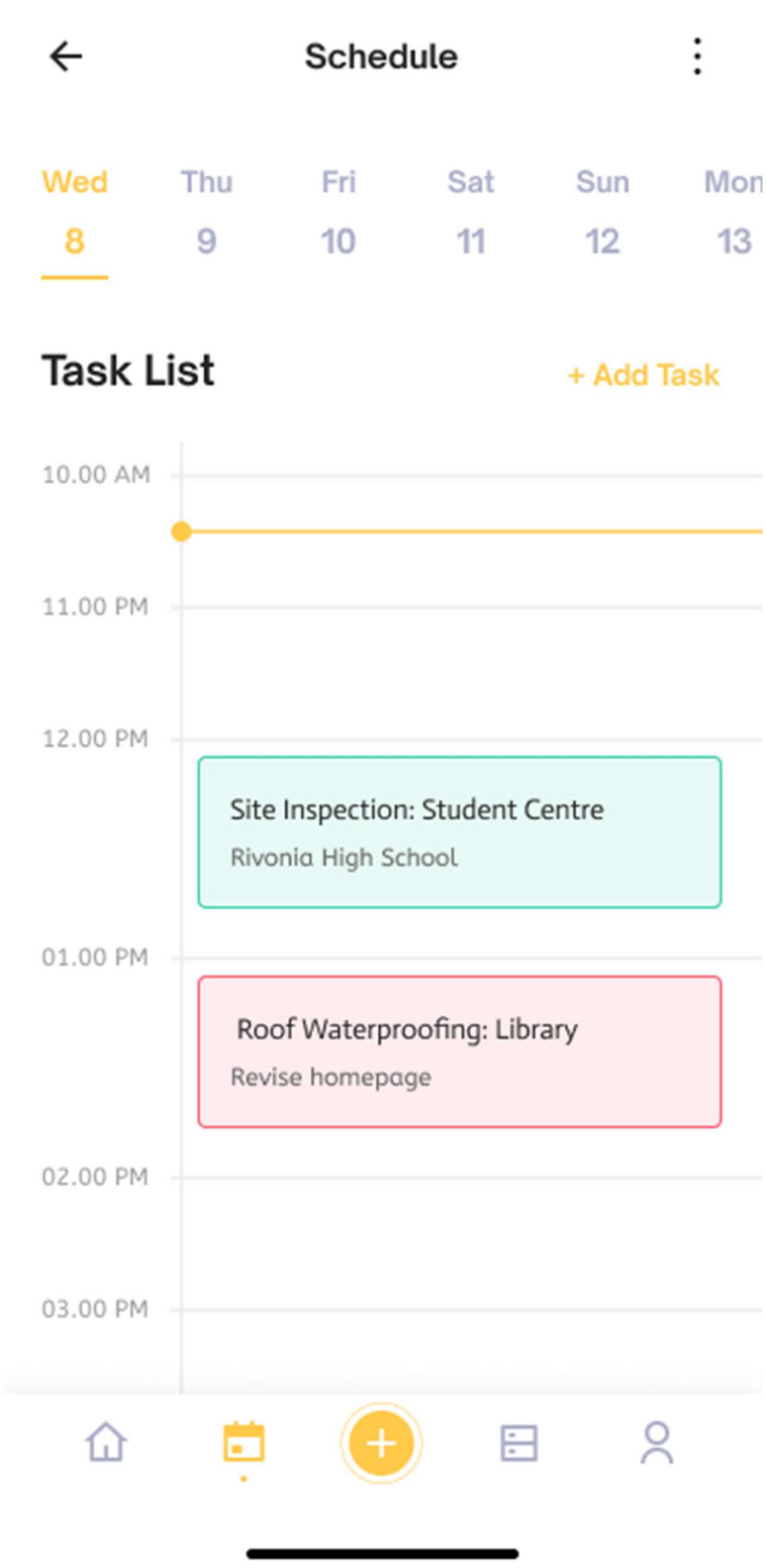
3.5.3 Task Details Screen



The Task Details view provides comprehensive insight into a specific job, including description, due date, progress, and subtasks. Users can mark individual subtasks as complete and attach photos or PDFs directly from the mobile interface; feeding data to Firestore in real time.

Figure 3.10 – Contractor Task Details Page Mock-up

3.5.4 Schedule Screen



The Schedule view integrates all assigned activities into a daily calendar timeline. Colour-coded tasks differentiate project categories (e.g., inspections vs. waterproofing). This interface supports intuitive drag-and-drop rescheduling and integrates with push notifications for reminders.

Figure 3.11 – Contractor Schedule Page Mock-up

3.5.5 Profile Screen

The Profile screen consolidates performance metrics; total projects, ongoing work, and completed tasks. It also serves as an entry point to manage user credentials, privacy preferences, and quick navigation to assigned projects.

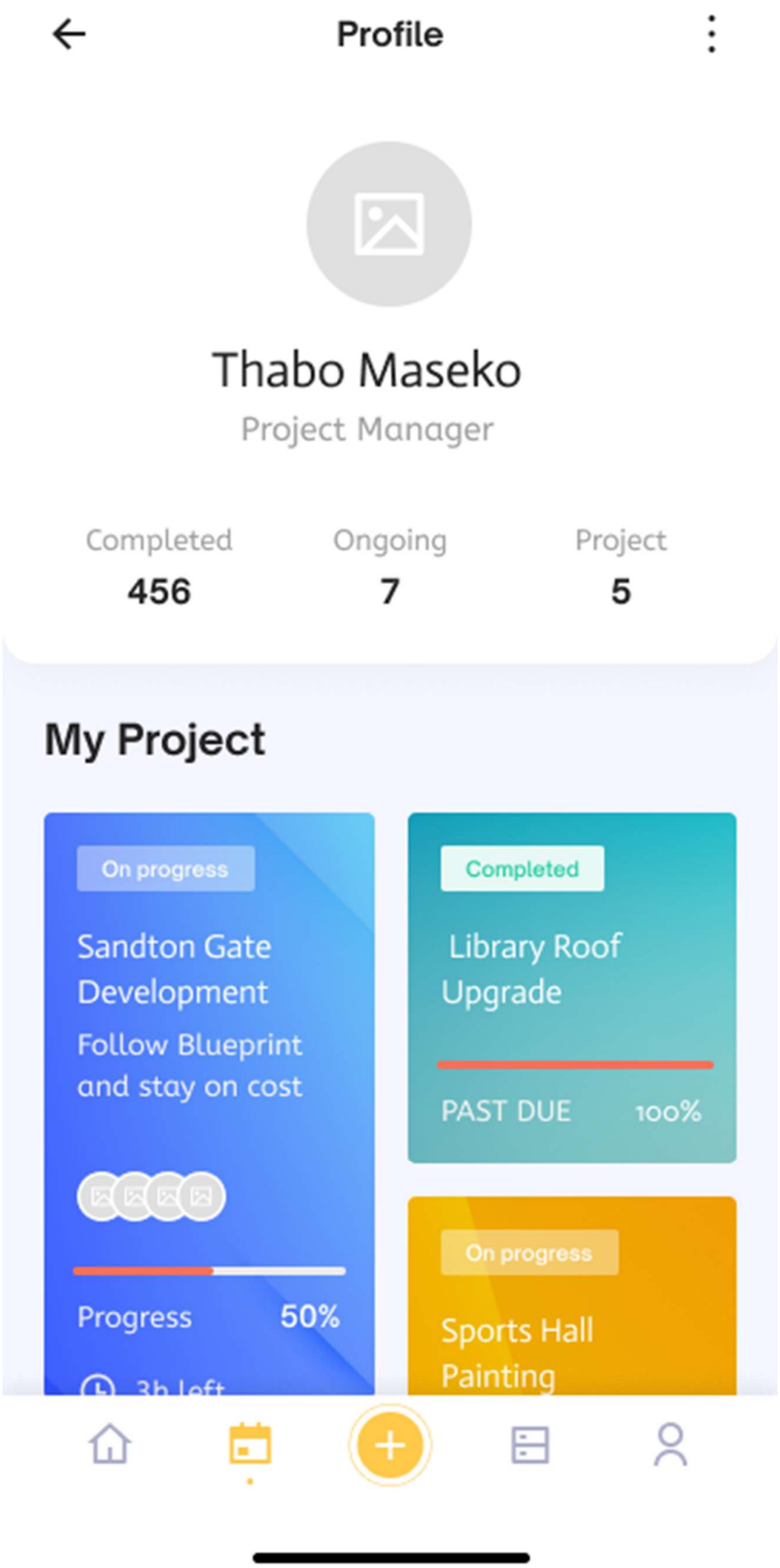


Figure 3.12 – Contractor Profile Page Mock-up

3.4. Security Design

The ICMMS implements a multi-layered security architecture that protects data integrity, enforces role-based access, and ensures full accountability across the application stack. Security is embedded from authentication through data transmission and storage, using industry-standard protocols and cloud-native controls from Firebase, Firestore, and Azure.

3.6.1 Authentication & Authorisation

User authentication and authorisation are handled through Firebase Authentication, which validates credentials, generates secure ID tokens, and maps each login session to its corresponding role within the Firestore user document.
As shown in Figure 3.6 – Authentication and User Management Data Flow (Level 1) each login request from the web or mobile client is transmitted via HTTPS to the backend API. The API verifies the token with Firebase, retrieves the user's Role, and enforces access rules at the controller level.
Only verified tokens can access endpoints; unauthorised or expired sessions are immediately rejected. This guarantees that Administrators, Project Managers, Contractors, and Clients operate strictly within their assigned permissions, preventing privilege escalation or unauthorised CRUD actions.

3.6.2 Secure Data Flow & Transmission

Data movement within the system follows tightly controlled pathways illustrated in Figure 3.5 – Context Level Data Flow Diagram. All communication between the front-end, API, and Firestore occurs over TLS-encrypted channels. Requests are validated by the API gateway before being routed to the corresponding microservice.
Document uploads and large media files are offloaded to Supabase Buckets, ensuring that static file storage remains isolated from dynamic Firestore data collections. This reduces exposure to injection or data-tampering risks while maintaining efficient retrieval performance.

3.6.3 Transaction and Workflow Integrity

Financial and operational workflows rely on multiple verification points to maintain transactional integrity. As detailed in Figure 3.7 – Quotation and Invoice Management Data Flow (Level 1), quotation approvals and invoice generations are authenticated through both Project Manager and Client sessions.
All approval actions generate immutable entries in the AuditLog collection, which captures UserId, ActionType, and Timestamp. These logs form a complete, non-repudiable trail of every modification made within the system, reinforcing transparency and compliance.

3.6.4 Threat Mitigation & Data Protection

The ICMMS applies proactive defences against common attack vectors:

- Injection prevention: Input validation and parameterised queries on all API endpoints.
- Cross-site request forgery (CSRF): Token-based session verification in client-server communications.
- Access control enforcement: Role-based middleware ensures least-privilege operations.
- Audit logging and monitoring: Every data change and login attempt is logged for anomaly detection.
- Secure storage: Firestore documents and Supabase files are encrypted at rest and transmitted over SSL.

This layered strategy minimises breach probability while maintaining system performance and user experience.

3.5. Summary: Analysis & System Design

Part 3 established the complete technical foundation of the Integrated Construction and Maintenance Management System (ICMMS). It transformed the project's requirements into a practical, scalable design through structured modelling, architecture definition, and secure data management. The domain model and bounded context diagrams clarified system boundaries and relationships between entities such as Users, Projects, Tasks, and Quotations, while the ERD and database justification confirmed the choice of Firestore's NoSQL architecture supported by Supabase for document storage.

The logical and physical architecture diagrams demonstrated how the web, mobile, and API layers integrate through Firebase Authentication and Azure cloud services to deliver a unified operational platform. Data-flow diagrams traced secure interactions between modules, ensuring consistent communication and traceability. Wireframes and mobile mock-ups then translated these technical designs into functional user interfaces that prioritise clarity, responsiveness, and role-specific efficiency. The section concluded with a robust security design that defined authentication, authorisation, and threat-mitigation strategies.

Part 4 - Implementation Documentation

4.1. Introduction

Part 4 demonstrates how the Integrated Construction and Maintenance Management System (ICMMS) was implemented, deployed, and maintained through structured coding, automation, and documentation practices.

4.2. UML Sequence Diagrams

The sequence diagrams illustrate how each major feature of ICMMS executes end-to-end through coordinated service calls between users, the web application, the API layer, and the database.

- **Figure 4.1- Project and Task Assignment Flow: (Figure 4.1)** This diagram visualises how a Project Manager creates a project, assigns tasks to contractors, and how acknowledgments are relayed via the API and Firebase event triggers. It highlights asynchronous notifications and secure role-based data exchange.
- **Figure 4.2 - Quote-to-Cash Workflow: (Figure 4.2)** Demonstrates the quotation approval lifecycle, from AI-generated estimates to invoice creation and payment confirmation. It captures how financial logic synchronises across Firestore and Supabase storage.
- **Figure 4.3 - Document Control and Access: (Figure 4.3)** Outlines secure file handling between Admin, Project Managers, and Clients. Access tokens and metadata validation ensure role-based file visibility.
- **Figure 4.4 - Maintenance Request Sequence: (Figure 4.4)** Shows the Client–PM–Contractor workflow where requests move through statuses (Pending → In Progress → Completed), automatically updating the project dashboard and notification system.
- **Figure 4.5 - Invoice Reminder and Dunning: (Figure 4.5)** Describes automated notification triggers for overdue invoices, integrating Firestore scheduling with email alerting.
- **Figure 4.6 - Contractor Task Sequence Diagram**: **(Figure 4.6)** visualises how task data is retrieved, updated, and synchronised across the platform in real time. The sequence begins when a Contractor logs into the mobile interface and retrieves a list of assigned tasks from Firestore through the API. Each task entry includes key metadata such as project ID, deadline, priority level, and linked documentation.

Together, these artefacts confirm that the implemented workflows mirror the functional intentions set out in the requirements phase.

Project & Task Assignment Sequence Diagram

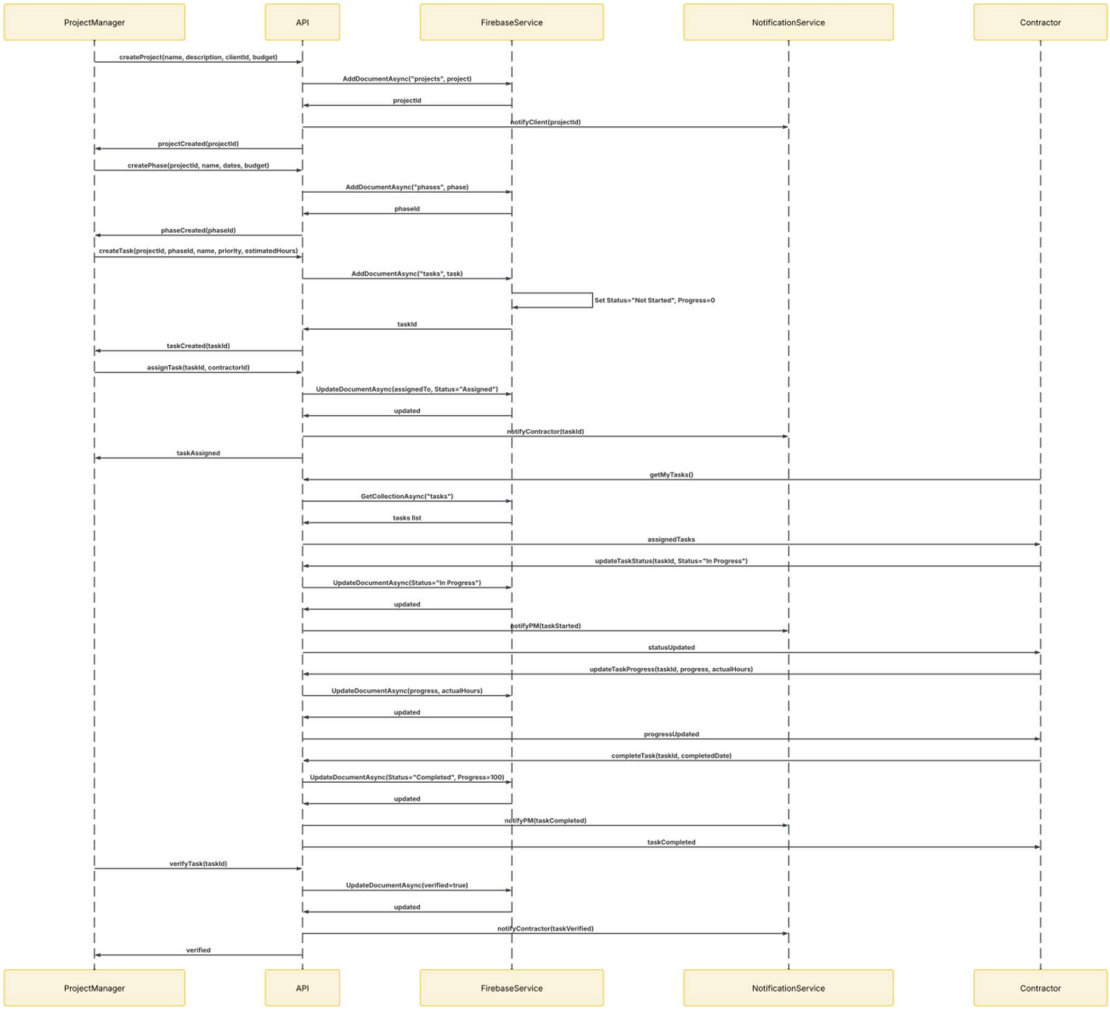


Figure 4.1 – Project & Task Assignment Sequence Diagram Source: link here

Quote to Cash Sequence Diagram

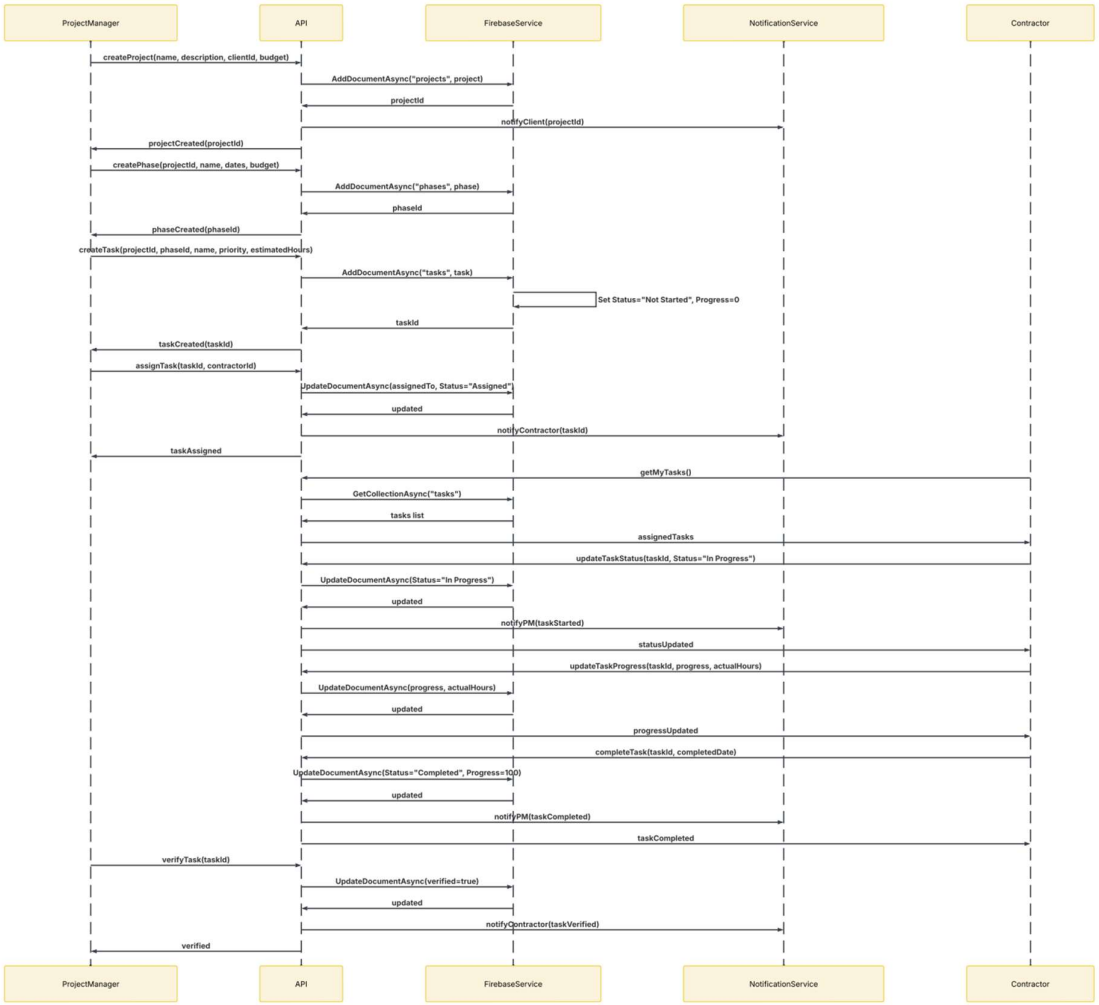
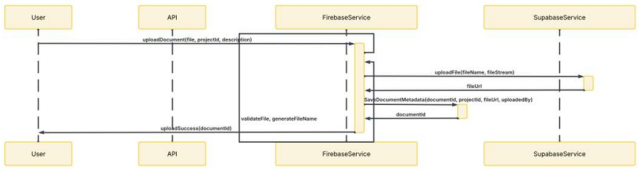


Figure 4.2 – Quote to Cash Sequence Diagram. Source: link here

Document Control & Access Sequence Diagram

Upload Sequence Diagram



Download Sequence Diagram

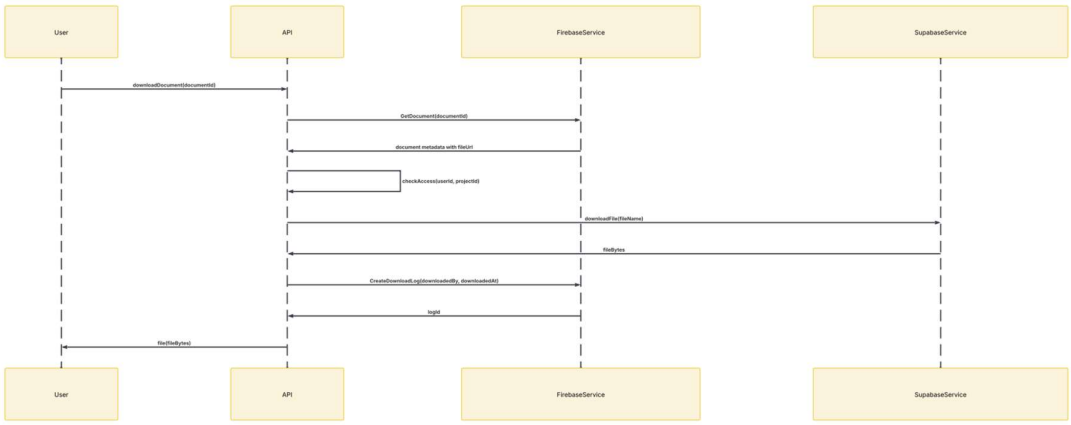


Figure 4.3 – Document Control & Access Sequence Diagram. Source: link here

Maintenance Request Sequence Diagram

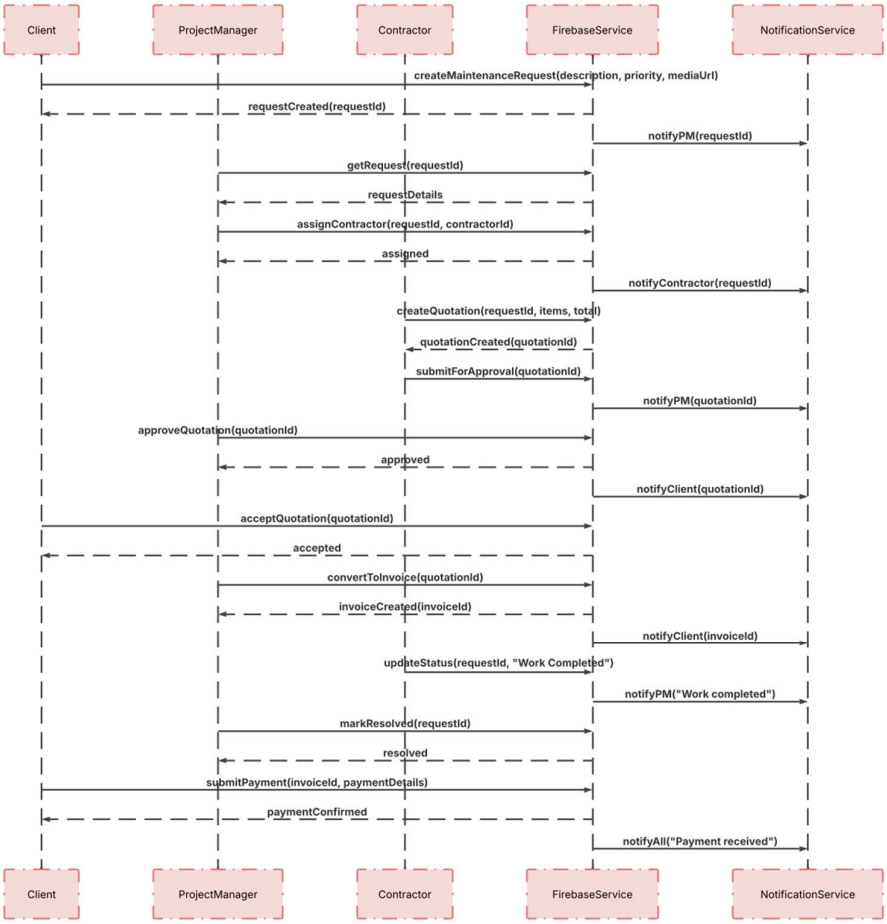


Figure 4.4 – Maintenance Request Sequence Diagram. Source: link here

Invoice Reminder & Dunning Sequence Diagram

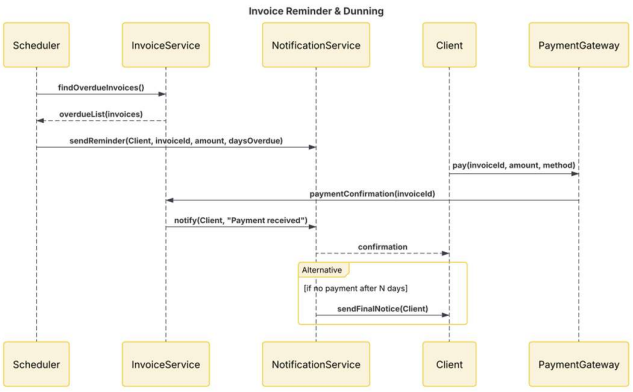


Figure 4.5 – Invoice Reminder & Dunner Sequence Diagram. Source: link here

Contractor Task Sequence Diagram

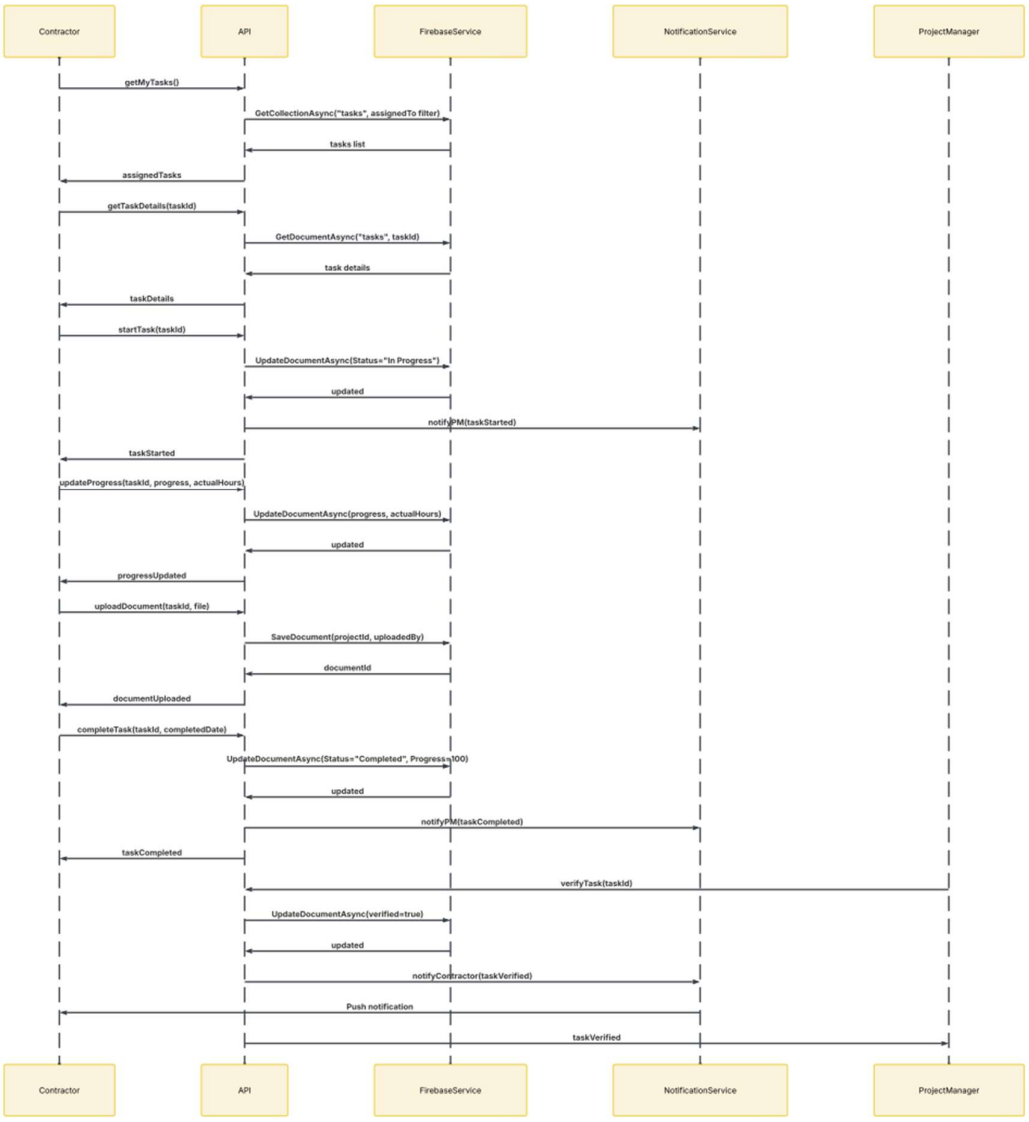


Figure 4.6 – Contractor Task Sequence Diagram. Source link here

4.3. Deployment Documentation

4.3.1 Prerequisites

Azure Account

- Azure subscription
- Resource Group
- App Service Plan
- App Service
- Web App

Firebase Setup

- Create a Firebase project
- Link Google Cloud project
- Enable the following services
    - Authentication: Go to Authentication -> sign-in method -> enable Email/Password C Google
    - Firestore: Go to Firestore Database -> Create Database -> Start in test mode
    - App Check: Go to App Check -> Register apps
- Generate Configuration Files
    - Go to Project Settings -> General -> Your apps
    - Add Android app -> download ‘google-services.json’ and place in app directory.
    - Add Web app -> copy config object -> use in web app.

4.3.2 Development Environment

Required downloads

- .NET SDK 6.0+
- Azure CLI
- Git
- Visual Studio / VS Code
- Android Studio

4.3.3 Deployment Processes

Backend API Deployment

1. **Build and Deploy**
    - Navigate to API project

    `cd API/ICCMS-API`

    - Build the application

    `dotnet publish --configuration Release --output ./publish`

    - # Create deployment package

    `Compress-Archive -Path "./publish/*" -DestinationPath "./publish.zip" -

    Force`

    - Deploy to Azure

    `az webapp deployment source config-zip --name ICCMS-API --resource- group abcretailers_group --src ./publish.zip`

2. **Restart App Service**
    - Restart to apply runtime changes

    `az webapp restart --name ICCMS-API --resource-group abcretailers_group`

    Alternative:

    Run ./deployAPI bat script from project root

    Web Frontend Deployment

    - Navigate to Web project

    ` cd Web\ICCMS-Web`

    - Build the application

    ` dotnet publish --configuration Release --output ./publish`

    - # Create deployment package

    `Compress-Archive -Path "./publish/*" -DestinationPath "./publish.zip" -

    Force`

    - Deploy to Azure

    ` az webapp deployment source config-zip --name icmms --resource- group abcretailers_group --src ./publish.zip`

Alternative

Run ./deployWeb bat script from project root

Mobile App Build Process

Requirements:

- Android Studio
- ‘google-services.json’ file in app directory
- Proper API endpoint configuration pointing to Cloud Run API

Build steps:

```
# Generate debug APK for testing cd
Mobile
./gradlew assembleDebug
# APK location: app/build/outputs/apk/debug/app-debug.apk


# Generate release APK for distribution
./gradlew assembleRelease
# APK location: app/build/outputs/apk/release/app-release.apk
```

Installation:

- Transfer APK to Android device
- Enable “Install from unknown sources”
- Install APK directly OR
- Can install directly if device is connected using

adb **install** app-debug.apk

4.4. GitHub Actions Pipeline

The GitHub Actions CI/CD Pipeline automates every phase of the ICMMS development lifecycle ensuring consistency and traceability.

Figure 4.7 – GitHub Actions CI/CD Pipeline demonstrates how each commit triggers a workflow that sequentially builds, tests, and deploys both the web and API layers. When a developer pushes code to the repository, the pipeline automatically runs syntax validation, executes unit tests, and checks dependencies against predefined security gates. Only successful builds progress to the deployment stage.

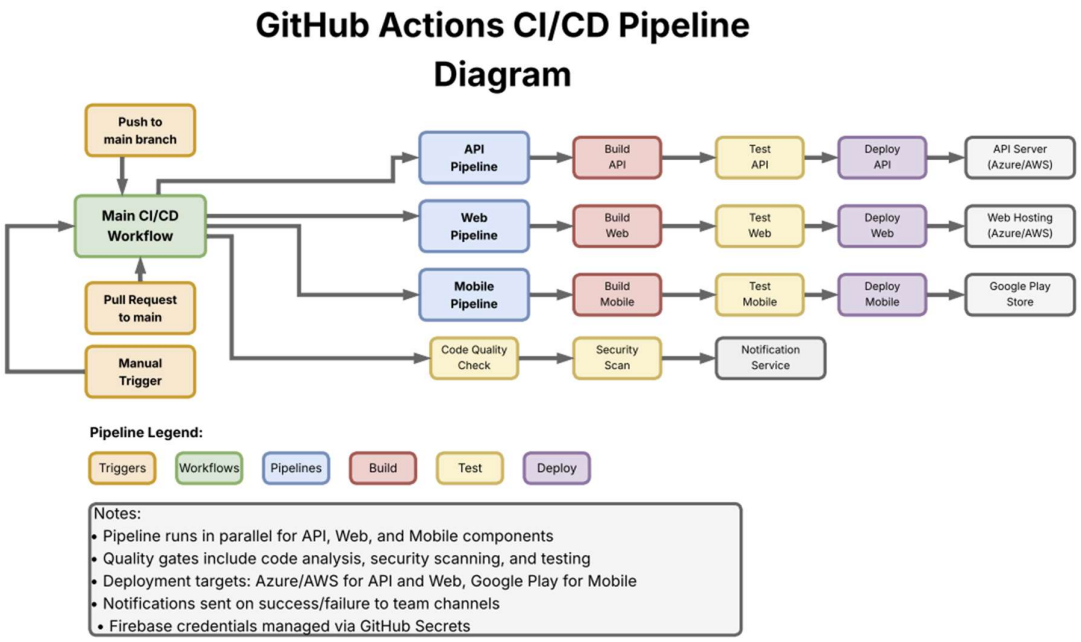


Figure 4.6 – GitHub Actions CI/CD Pipeline Diagram. Source link here

The process integrates with Azure and Firebase using secured environment variables stored within GitHub Secrets. Upon successful validation, the pipeline compresses the project files, transfers them to the Azure App Service, and triggers a post-deployment verification script that confirms endpoint availability and API connectivity. Failed jobs automatically roll back to the last stable build and notify the team via email and Trello webhook.

4.5. Scrum Evidence and Team Progress Documentation

Throughout the ICMMS development lifecycle, the team maintained consistent and transparent documentation of its collaboration and sprint activities through structured meeting minutes. These artefacts, compiled in the “ICMMS Meeting Minutes.zip” folder, capture all key discussions, decisions, and iterations from Sprint 2 through Sprint 9, ensuring that every development milestone is verifiable and traceable.

The recorded meetings began with the early planning and setup sessions held in July and August 2025, where foundational elements such as role assignment, version control, Firebase integration, and database strategy were finalised. Early documents such as *[02 Meeting – Physical Meeting with Junior INSY7135 WIL]* and *[03 Meeting – Group Discussion during Sprint 1]* reflect the team’s initial establishment of development priorities and the agreement to align all components under the ICCMS architecture. These discussions provided the groundwork for sprint-based delivery.

By the end of Sprint 1, the team conducted a review (*[04 Meeting – End of Sprint 1]*) to evaluate the completion of the initial dashboard, quotation flow, and project setup modules. Constructive feedback from this session shaped the improved UI flow and prompted early attention to security and validation measures. Subsequent meetings, such as *[05 Meeting – During Sprint 2]* and *[06 Meeting – End of Sprint 2, Start of 3 and 4]*, documented more advanced backend integration, including AI quotation logic, role-based authentication, and document management enhancements.

The mid-project meetings (Sprints 4–5) recorded detailed discussions on contractor task assignment, messaging implementation, and database refactoring for performance. These discussions, particularly in *[07 Meeting – Sprint Discussions (4,5)]* and *[08 Meeting – Sprint Discussions (4,5)]*, reveal strong inter-role collaboration between backend and frontend contributors.

Finally, *[09 Meeting – Preparing for POE Submission]* and *[11 September Meeting – Project Refinement]* illustrate the consolidation phase, where diagrams were finalised, documentation aligned, and final debugging tasks delegated. The team demonstrated full Scrum adherence, conducting retrospectives after each sprint, verifying deliverables against sprint goals, and maintaining accountability through Trello and GitHub task tracking.

4.6. Summary: Implementation Documentation

Part 4 consolidated the transition from design to full-scale implementation of the Integrated Construction and Maintenance Management System (ICMMS). It demonstrated how conceptual models evolved into the current program.

Implementation focused on structured coordination between roles, data layers, and services, verified through detailed UML sequence diagrams. Each workflow was modelled to confirm the correct order of system interactions and data persistence. These diagrams validated that the live implementation accurately mirrors the intended system behaviour defined in the earlier design phase.

Overall, Part 4 confirmed that ICMMS is not only functional but production-ready, built on traceable, automated, and secure practices. The next section, Part 5 - Testing & DevOps Plan, expands on how these systems were validated under controlled conditions to ensure stability, security, and long-term scalability.

Part 5 - Testing & DevOps Plan

5.1. Introduction

Part 5 outlines the approach used to validate, secure, and continuously deploy the Integrated Construction and Maintenance Management System (ICMMS). The goal was not only to confirm functionality but also to ensure long-term reliability, scalability, and security through disciplined testing and automation practices.

Principles:

Developers test their own code first using unit tests and manual checks.

Known bugs: issues that are expected or recognised will be logged in Trello and resolved as part of the sprint.

Unknown bugs: defects found during app usage, integration, or UAT will also be logged and tracked until resolved.

Major testing rounds will happen after Sprint 3 (Front-End UIs) and at the end of the application (Sprint 7/8).

In between, smaller integration and feature tests will happen after Sprint 4, 5, and 6.

5.2. Test Plan

Testing Levels

1. Unit Testing

- **Focus**: Backend services, database models, and UI components.
- **Responsibility**: Each developer tests their own code before merging.
- **Tools**: NUnit (ASP.NET), JUnit (Kotlin), built-in test frameworks.
- **Expected Outcome**: Modules work in isolation without errors.

2. Integration Testing

- **Focus**: How modules talk to each other e.g., project creation ↔ contractor assignment, AI quote ↔ invoice generation, document upload ↔ access logs.
- **Responsibility**: Team pairs (frontend ↔ backend) test connected features.
- **Tools**: Postman for API, Firebase staging environment, CI/CD pipelines.
- **Expected Outcome**: Data flows smoothly between modules with no breakage.

3. User Acceptance Testing (UAT)

- **Focus**: Real workflows from the perspective of Admin, Project Manager, Contractor, and Client.
- **Responsibility**: Full team, coordinated by Braydon.
- **Method**: Execute Sample Test Cases (to be written separately) in staging.

- **Expected Outcome**: Features align with user stories, critical workflows succeed, and
- major bugs are resolved.

Test Schedule (by Sprint)

- **Sprint 3 (28 Aug - 13 Sep 2025)**
    - First major testing round.
    - Test dashboards, login/registration, forms, messaging, document upload, quotation UI, reporting dashboards.
    - Goal: confirm frontend works and links correctly to backend stubs.
- **Sprint 4 (28 Aug - 18 Sep 2025)**
    - Postman API testing for all endpoints.
    - Verify role-based authentication and access control.
- **Sprint 5 (14 Sep - 2 Oct 2025)**
    - Test quotation workflow, invoice generation, and AI estimation logic.
    - Goal: confirm cost breakdowns and approval/rejection work as expected.
- **Sprint 6 (2 Oct - 16 Oct 2025)**
    - Test new voice memo features and storage.
    - Run security tests with Snyk.
- **Sprint 7 (16 Oct - 2 Nov 2025)**
    - **Final major testing round**.
    - Full UAT across all roles.
    - Test responsive design across devices.
    - Smoke testing on Firebase production.
- **Sprint 8 (5 - 10 Nov 2025)**
    - Demo prep: retest critical workflows.

Deliverables

- Unit test results (from GitHub Actions).
- Postman collections for API integration tests.
- UAT execution logs (Trello board + test cases).
- Final test summary report before submission.

Risks & Mitigation

- **Time pressure during UAT** → Mitigation: Prioritise quotation, maintenance, and project workflows.
- **AI module unpredictability** → Mitigation: Provide fallback manual cost estimation.

- **Integration issues between web/mobile and backend** → Mitigation: Test staging builds after Sprint 4.

5.3. Sample Test (Approach):

All test cases followed a standard template: Test ID, Module, Role, Preconditions, Steps, Expected Result, Actual Result, and Outcome. Testing covered authentication, CRUD operations, workflow logic, and error handling. Each sprint introduced at least one regression round to confirm no prior functionality was compromised.

Format:
ID | Module | Role | Precondition | Steps | Expected Result | Actual Result | Outcome

Access & Security

TC-001 | Auth | Any
Pre: User exists with role
Steps: Login with correct email/password
Expected: Login succeeds; redirected to role-aware dashboard
When: Sprint 3, UAT

TC-002 | Auth | Any
Pre: Existing user
Steps: Attempt login with wrong password 3×
Expected: Account temporarily locked or warning; failed-attempt logged
When: Sprint 3, Security pass in Sprint 7

TC-003 | RBAC | Admin/PM/Contractor/Client
Pre: Logged in as each role
Steps: Try to access a screen outside permissions (e.g., Client → User Management)
Expected: Access denied (UI hidden + API 403)
When: Sprint 4, UAT

TC-004 | HTTPS/CORS | Any
Pre: Deployed staging
Steps: Hit API from web and mobile builds
Expected: Only HTTPS allowed; CORS allows app origins; others blocked
When: Sprint 7

Project Management

TC-010 | Create Project | PM
Pre: PM logged in
Steps: Create project with name, budget, phases, deadlines
Expected: Project saved; appears in PM dashboard; audit entry created
When: Sprint 3 (UI), Sprint 4 (API)

TC-011 | Assign Contractor | PM
Pre: Project exists; contractor exists
Steps: Assign contractor to phase/task
Expected: Assignment saved; contractor sees task; notification sent
When: Sprint 4-5

TC-012 | Budget vs Actual | PM
Pre: Project has tasks with costs/time logged

Steps: Open project dashboard
Expected: Budget vs Actual chart renders with correct totals
When: Sprint 5-7

Maintenance Requests

TC-020 | Create Request | Client
Pre: Client logged in
Steps: Submit maintenance request with description + image
Expected: Request saved; status = Pending; PM notified
When: Sprint 3–4

TC-021 | Assign & Progress | PM/Contractor
Pre: Request exists (Pending)
Steps: PM assigns contractor → Contractor marks In Progress → Completed with photos
Expected: Status transitions tracked; timestamps stored; client sees updates
When: Sprint 4–5

TC-022 | Client Edit Before Assignment | Client
Pre: Request Pending (not assigned)
Steps: Edit description or cancel request
Expected: Edits allowed; cancel sets status = Cancelled; audit stored
When: Sprint 3–4

Document Management

TC-030 | Upload Blueprint | PM/Client
Pre: Logged in as PM or Client; project exists
Steps: Upload PDF/DWG/image
Expected: File stored; metadata saved; role-based access set
When: Sprint 3-4

TC-031 | Download Logs | Admin/PM
Pre: At least one download done by any role
Steps: Admin/PM opens document logs
Expected: Who/when/file recorded correctly
When: Sprint 4-5

TC-032 | Access Control | Contractor
Pre: Contractor not assigned to project
Steps: Try to open project document URL
Expected: Access denied (UI + API 403)
When: Sprint 4-5

Communication & Notifications

TC-040 | Messaging Flow | PM ↔ Contractor
Pre: PM and Contractor assigned on same project
Steps: PM sends message; Contractor replies
Expected: Messages appear in thread for both; timestamps correct
When: Sprint 3-4

TC-041 | Alerts | Any
Pre: Project milestone or status change
Steps: Trigger event (assignment, quote ready, overdue)

Expected: In-app notification + email/SMS (if configured) to correct role(s)
When: Sprint 5-7

Quotation & Invoices (AI Workflow)

TC-050 | AI Quote from Blueprint | PM
Pre: Project exists; blueprint uploaded
Steps: Request AI quote generation
Expected: Cost breakdown generated; includes materials + labour; status = Draft
When: Sprint 5

TC-051 | Quote Review | Admin/PM
Pre: Draft quote exists
Steps: Open quote; review line items; adjust allowed fields; send to Client → status = Sent
Expected: Client receives notification; quote visible to Client
When: Sprint 5

TC-052 | Client Approval/Reject | Client
Pre: Quote = Sent
Steps: Approve → or Reject
Expected: Approve → status = Accepted; Reject → status = Rejected; audit logged
When: Sprint 5

TC-053 | Invoice Generation | System
Pre: Quote = Accepted
Steps: System converts to invoice
Expected: Invoice created with correct amounts; payment status = Unpaid
When: Sprint 5

Reporting & Dashboards

TC-060 | KPIs Render | Admin
Pre: Seeded data for projects, maintenance, quotes, invoices
Steps: Open admin dashboard
Expected: KPIs show totals; charts (Gantt, Pie, Bar, Line) render without errors
When: Sprint 3-7

TC-061 | Contractor Ratings | Admin/PM
Pre: Some completed tasks with ratings
Steps: View contractor performance report
Expected: Accurate averages and counts
When: Sprint 5-7

Voice Feature

TC-070 | Voice Memo Upload | Contractor
Pre: Assigned task
Steps: Record/upload voice memo
Expected: File saved; linked to task; playable by PM/Admin
When: Sprint 6

Security & Quality Gates

TC-080 | Snyk Scan | Repo
Pre: Pipeline configured
Steps: Run Snyk on dependencies

Expected: No high/critical issues, or documented exceptions
When: Sprint 6-7

TC-081 | SonarQube Quality Gate | Repo
Pre: Pipeline configured
Steps: Run analysis on PR
Expected: Passes gate; coverage thresholds met on changed code
When: Sprint 7

UAT Packs (Major Rounds)

UAT-1 (post Sprint 3):

- TC-001, 003, 010, 020, 030, 040, 060

UAT-2 (final, Sprint 7/8):

- Full flow: 001–004, 010–014 (if added), 020–022, 030–032, 040–041, 050–054, 060–061, 070, 080–081

Every test case was peer-reviewed and revalidated following code merges or bug fixes to maintain consistent quality control.

5.4. Bug Tracking and Resolution Workflow

Defect management followed a clear workflow that ensured full visibility from discovery to resolution. Each bug was logged with a severity level (Critical, High, Medium, Low), a reproducibility indicator, and a version reference.

The resolution lifecycle followed this sequence:
New → Assigned → In Progress → Code Review → Testing → Verified → Closed.

5.4.1. Bug Tracking Process

Tool

- Trello Board will serve as the single source of truth for all bugs.
- All defects, discussions, and tracking will take place inside Trello or WhatsApp, or if needed Google Meet.
- GitHub will only be used for code management, pull requests, and linking fixes.

Roles (for bug management)

Triage Owners (Handle & Delegate Errors): Braydon (Scrum Master) or Max (Lead Developer) who are responsible for triaging, labelling, and prioritising bugs.

- Max - Architecture / Overall system health
- Denzel - Backend & Security (lead)
- Daniel - Backend support & documentation
- Nico & Braydon - Web & Mobile UI

Workflow (States)

1. **New** → Bug is created in Trello (and/ or WhatsAp) by any team member.
2. **Triage** → Bug is labelled (severity, priority, area) and assigned by Braydon or Max.
3. **In Progress** → Assigned developer begins work on a fix and calls other members if needed.
4. **In Review** → Fix is committed to GitHub, code is reviewed by a peer.
5. **Ready for Test** → Fix is deployed to staging for verification.
6. **Verified** → Bug is resolved, Trello card is moved to “Done.”
7. **Reopen** → If issue persists, Trello card is returned to “In Progress.”

SLA Targets (Time Expectations)

- **Critical (S1)** → triage within 4 hours, fix within 24 hours.
- **High (S2)** → triage within 24 hours, fix within 3 days.
- **Medium (S3)** → fix in next sprint.
- **Low (S4)** → fix when time allows.

Labels (Consistent Usage in Trello)

- **Type**: bug, regression, security, ui/ux, performance, docs
- **Severity**: S1-critical, S2-high, S3-medium, S4-low
- **Priority**: P1, P2, P3
- **Area**: backend, api, web-frontend, mobile-frontend, auth, storage, ci-cd, security
- **Module**: projects, maintenance, contractor, documents, messaging, quotation, invoice, reporting, ai, voice
- **Status**: triage, in-progress, in-review, ready-for-test, verified, reopen

Bug Card Template (Trello)

Each bug card must include the following:

Summary
Short, one-line description of the problem.

Steps to Reproduce
1., 2., 3.

Expected Result
What should happen.

Actual Result
What actually happens.

Scope / Area / Module
Area: [backend|api|web-frontend|mobile-frontend|auth|storage|ci-cd|security]
Module:
[projects|maintenance|contractor|documents|messaging|quotation|invoice|reporting|ai|voice]

Environment
Development / Staging / Production, commit ID, device/browser.

Attachments
Screenshots, logs, Postman exports, console output.

Severity & Priority
Severity: S1|S2|S3|S4
Priority: P1|P2|P3

Definition of Done (for a bug)

- Bug can be reproduced and confirmed.
- Fix has been implemented and pushed to GitHub.
- Peer review completed.
- Tests (manual and automated if available) pass successfully.
- Fix is verified on staging environment.
- Trello card is moved to **Done/Closed** with commit ID linked.

Weekly triage meetings reviewed all open defects and linked each resolution to a sprint deliverable, ensuring accountability and transparency throughout the process.

5.5. Security and Quality Testing

Security and quality testing were embedded into every stage of the development process to ensure that the Integrated Construction and Maintenance Management System (ICMMS) not only functioned correctly but also maintained strict protection of sensitive data. From the earliest sprints, the team used a combination of manual verification via the in-app Testing Dashboards and automated analysis through GitHub Actions pipelines. This dual approach ensured that authentication, data validation, and dependency integrity were continuously tested across both the Web and API layers.

5.5.1. Authentication and Access Control Testing:

Authentication and authorization mechanisms were verified repeatedly through Firebase Authentication and the internal API Testing Dashboard. Each request validated token integrity, expiration, and claim accuracy before allowing access to protected endpoints.
The team also conducted role-based access tests to confirm that restricted actions (such as Admin user management or Project Manager approvals) could not be performed by unauthorized roles like Contractors or Clients. These validations directly supported FR 1.2 (User Authentication and Access Control) and NFR 4.0 (Security).

5.5.2. Data Validation and Input Handling:

All user input was tested using both client-side and server-side checks to prevent injection or malformed data. The API Testing Dashboard allowed developers to manually submit simulated payloads with invalid data to verify backend schema enforcement.
Model binding, data type validation, and sanitization processes were validated through these dashboards to ensure strict adherence to data integrity and eliminate common vulnerabilities such as XSS or parameter injection.

5.5.3. Encryption and Transmission Testing:

Security testing confirmed full HTTPS/TLS 1.3 coverage across the web and API layers. Sensitive data such as authentication tokens, quotations, and project documents were validated to remain encrypted in transit and securely stored in Firebase Firestore and Supabase Storage.File uploads and downloads were tested using the Document Upload API within the Testing Dashboard to confirm correct token validation and secure bucket-level access.

5.5.4. Automated Quality Scans:

Automated scans ran continuously through GitHub Actions, integrating both SonarQube and Snyk:

- SonarQube Cloud analyzed every commit for maintainability, code duplication, null-safety compliance, and architectural consistency. Warnings were generated for complex or unreachable code, promoting early refactoring.
- Snyk CLI integration scanned all NuGet dependencies and flagged known vulnerabilities within transitive packages such as cryptography, HTTP, and compression libraries. Although full reports require a premium license, real-time dashboard results allowed developers to prioritize fixes.

Together, these tools ensured that each build passed automated quality gates, aligning with NFR 6.2 (Maintainability) and NFR 9.0 (Regulatory Compliance).

5.5.5. Load and Performance Validation:

Using the Message Testing Dashboard, concurrent message simulations and workflow triggers were executed to monitor latency and system throughput under load. Results confirmed consistent API responsiveness and stable system performance during simulated multi-user activity.
This validated compliance with NFR 1.0 (Performance) and NFR 7.0 (Scalability).

5.6. Threats & Mitigation

The table below outlines the primary threats considered during development and the mitigation strategies implemented through both technical controls and DevOps discipline.

Threat	Impact / Risk Description	Mitigation Strategy
1. Injection Attacks (SQL / NoSQL / Script)	Malicious input through form fields or API payloads could modify database queries or inject code into Firestore documents.	Strict model binding and Firestore data validation rules reject unknown fields. All parameters are sanitised on both client and server. No direct query strings are used.
2. Broken Authentication or Session Hijacking	Compromised credentials or intercepted tokens could allow unauthorised access to protected endpoints.	Firebase Authentication issues short-lived JWT tokens verified at the API gateway before every request. Token expiry, IP tracking, and refresh policies prevent reuse.
3. Insecure Direct Object Reference (IDOR)	Users attempting to access project, quotation, or maintenance URLs outside their assigned scope could expose data belonging to others.	Role-based access control (RBAC) enforced across controllers and repository methods. Every entity query validates UserId and role context before returning results.
4. Cross-Site Scripting (XSS) and Input Injection	Unfiltered input in chat messages, task comments, or text fields could execute malicious scripts in user browsers.	All user input is HTML-escaped, sanitised, and validated on the backend. Razor pages and Kotlin UIs render content with safe encoding by default.
5. Insecure Data Transmission	Sensitive data (login details, invoices, payment amounts) intercepted over insecure channels.	Enforced HTTPS/TLS 1.3 for all web, API, and Firebase communications. Azure App Service blocks plain HTTP and injects automatic HSTS headers.
6. Privilege Escalation or Role Abuse	Malicious users attempting to change roles or gain elevated permissions through API manipulation.	Role verification occurs on every token validation. The system cross-checks Role claims against the Firestore user profile. Audit logs capture all role changes.

7. Denial of Service (DoS)	Excessive or repeated API calls could overwhelm hosting resources and cause downtime.	Logs flag recurring request patterns for analysis. Message endpoints also include per-user rate limiting to prevent spam and flooding.
8. Data Leakage through Misconfigured Storage	Files uploaded to Supabase buckets could be publicly accessible without restriction.	Supabase bucket policies restrict access by signed URL only. File references are tied to project and role context, with access validation before retrieval.
9. Dependency Vulnerabilities	Outdated or insecure libraries introducing exploitable code paths.	Automated Snyk scans run within the CI/CD pipeline. Critical findings block builds until patched. SonarQube monitors for insecure dependencies and code smells.
10. Insider Threats and Untracked Changes	Privileged users modifying or deleting data without oversight.	Every sensitive action (delete, update, role change) logged in the AuditLog table with timestamps and actor identity. Weekly reviews cross-check audit trails.

5.7. DevOps and Continuous Integration

5.7.1. Branching and Version Control:

The GitHub repository followed a disciplined branching structure; feature branches were created for each new functionality, merged into a central dev branch after peer review, and then into a protected main branch for deployment. Each merge triggered automated build and test sequences within GitHub Actions, ensuring that no untested code reached the live environment.

5.7.2. Collaboration and Review Workflow:

All commits required at least one peer review before merging. Build and test results were automatically posted to the team's communication platform, ensuring visibility and accountability for each change. The entire process was fully traceable through GitHub Actions logs and Azure deployment histories.

This DevOps model ensured rapid delivery without sacrificing quality or stability. The automated testing, security validation, and deployment processes established a reliable development rhythm and positioned ICMMS for long-term scalability and maintenance efficiency.

5.7.3. System Testing and Verification

To verify that each functional and non-functional requirement of the ICMMS performs as intended, the development team integrated testing at three levels: in-app testing and automated quality assurance.

1. In-App Testing Dashboards

The ICMMS includes two internal testing environments accessible from the Admin Panel:

- **API Testing Dashboard** (see Figure 5.1) provides live, manual testing for over 100 endpoints across all modules (Users, Projects, Maintenance, Quotations, etc.). It allows testers to execute requests, validate responses, inspect payloads, and verify role-based authorization in real time.

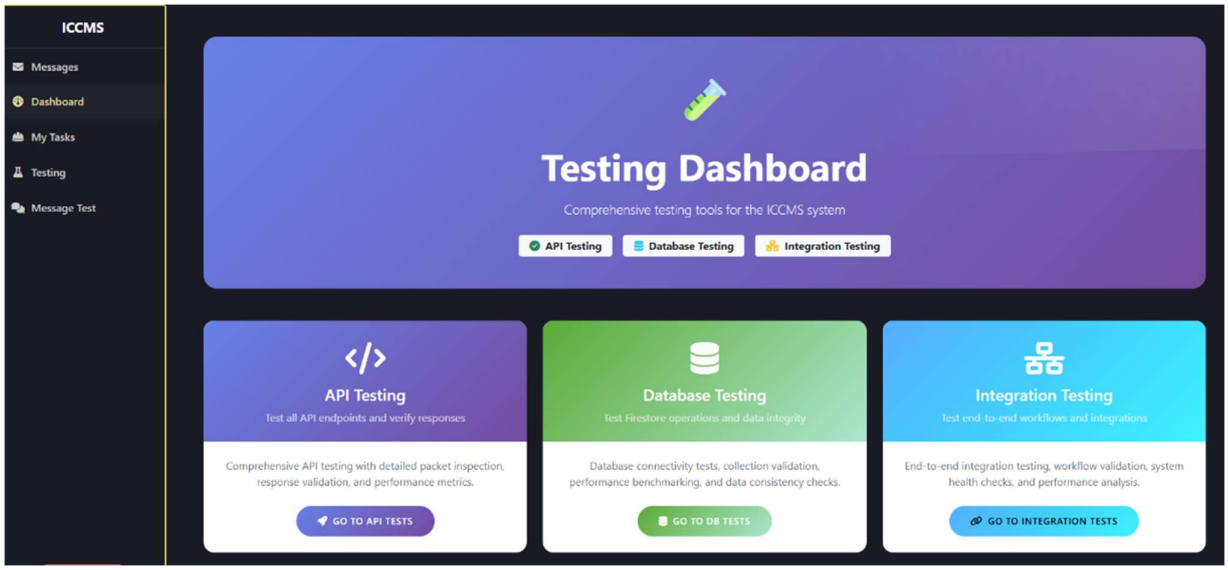


Figure 5.1 – screenshot of Testing Dashboard Available to Admin Users *(Web\ICCMS-Web\Views\Testing\Index.cshtml)*

- **Message System Testing Dashboard** (see Figure 5.2) automates scenario testing of the messaging and notification modules. Test suites cover message validation, workflow triggers (quotation/invoice alerts), error handling, rate-limiting, and performance benchmarking. Results display in real-time logs and can be exported for audit purposes.

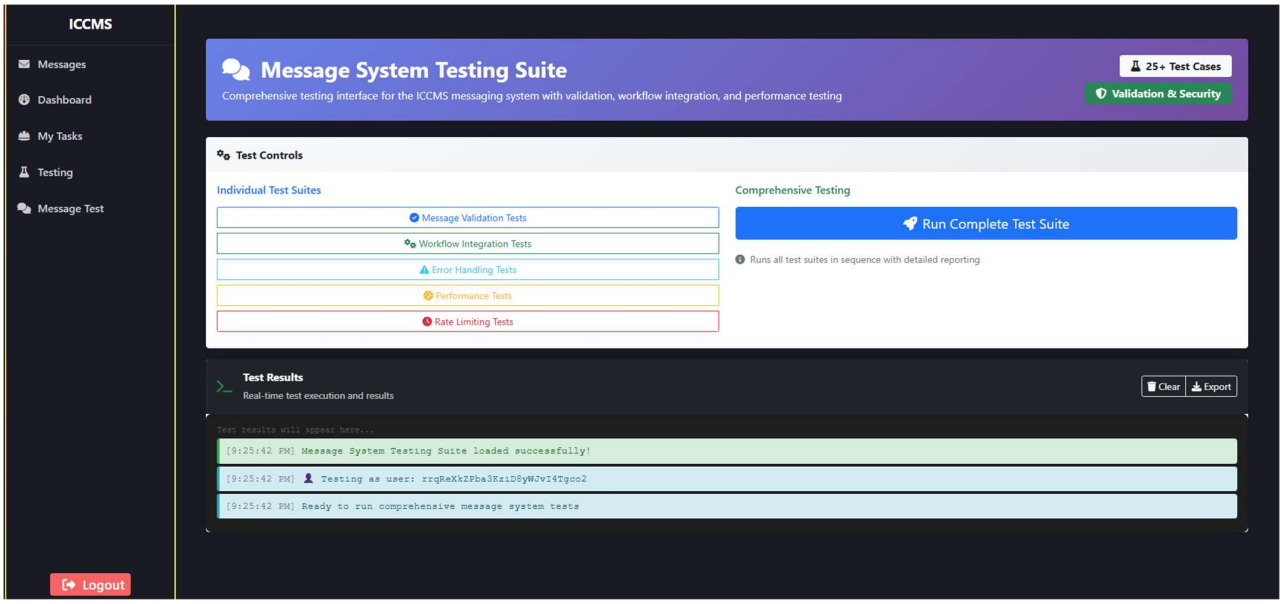


Figure 5.2 – screenshot of Message Testing Dashboard Available to Admin Users *(Web\ICCMS-Web\Views\MessagesTest\Index.cshtml)*

These in-app tools ensure functional requirements such as FR 5.7 (Message Validation), FR 6.0 (Notifications), and FR 9.1 (Audit Logging) are tested continuously within the deployed system.

2. Automated Quality and Security Scanning

Automated quality and security verification is integrated directly into the project's GitHub Actions pipelines. SonarQube Cloud and Snyk perform continuous static analysis and dependency auditing whenever changes are committed to the repository.

SonarQube Cloud (Figure 5.3) executed static analysis on both the Web and API layers, measuring maintainability, code duplication, complexity, and null-safety compliance. Each scan generated quantified scores per project, and passing all Quality Gates confirmed compliance with NFR 6.2 (Maintainability) and NFR 7.0 (Performance).

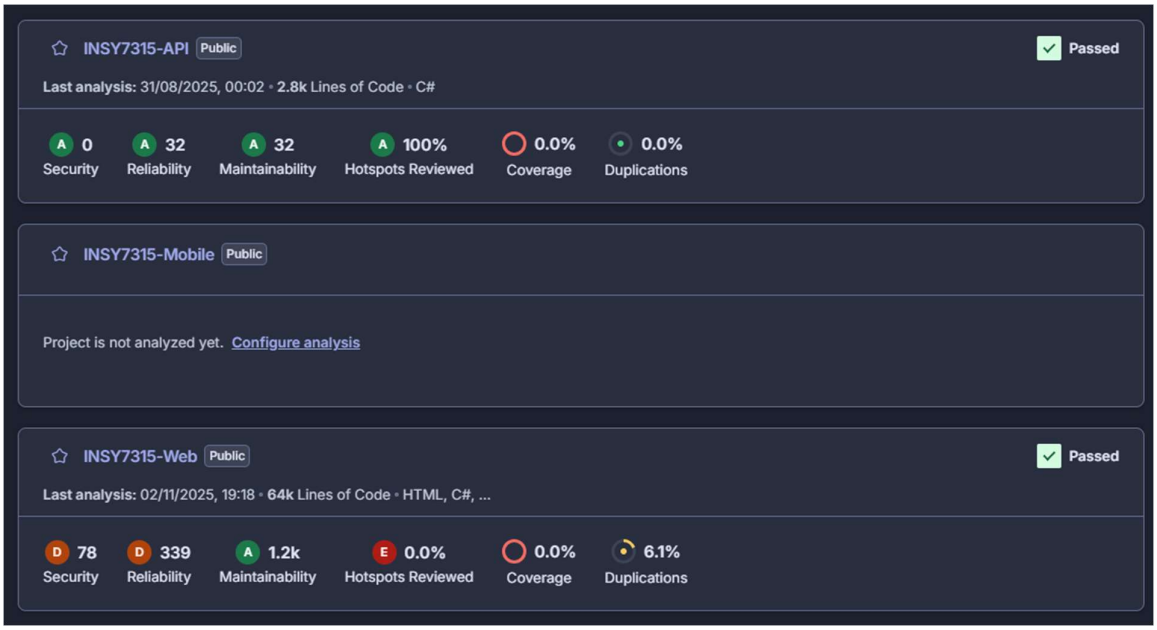


Figure 5.3 – SonarQube Cloud Analysis: Quality Gates for API and Web Projects

Snyk (Figure 5.3) audited every NuGet dependency for known vulnerabilities. Detected issues such as outdated cryptographic or HTTP libraries were prioritised by severity (Critical, High, Medium) and linked to their remediation paths.
While full report export requires a premium subscription, live dashboard visibility provided immediate feedback for every pipeline run, reinforcing NFR 4.0 (Security) and NFR 9.0 (Regulatory Compliance).

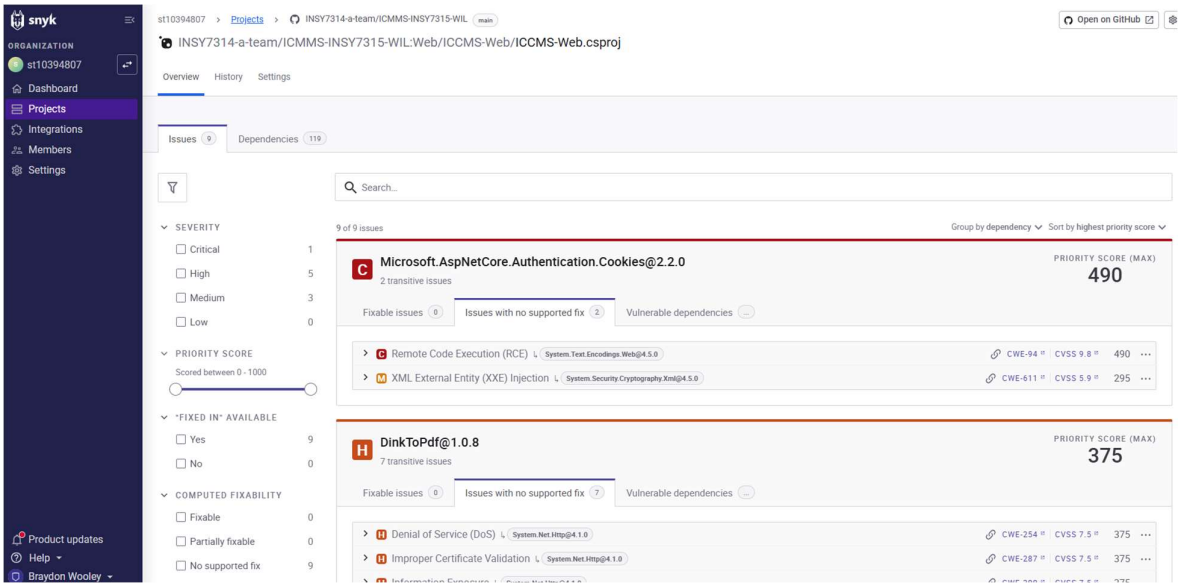


Figure 2.9 – Snyk Vulnerability Dashboard: Dependency Risks for ICCMS-Web.csproj

Together, these integrated pipelines form a self-governing verification layer that automatically detects structural flaws, insecure dependencies, and performance inefficiencies before code reaches production.

5.8. Summary: Testing & DevOps Plan

Part 5 outlined how the ICMMS team embedded testing, quality assurance, and DevOps automation throughout every development phase to ensure a secure and reliable system. Testing was not treated as a final step but as a continuous process integrated into the project's lifecycle from the first sprint.

Bugs, quality issues, and task progress were tracked transparently on Trello and Whatsapp, where each issue was categorised by severity and assigned a turnaround target. This allowed the team to maintain accountability and consistency across all sprints.

Security and quality validation occurred through two complementary layers: the in-app Testing Dashboards, which verified live functional behaviour across all modules, and the automated pipelines in GitHub Actions, which enforced static analysis, dependency scanning, and build verification through SonarQube and Snyk. Together, these tools ensured that every code change was tested, reviewed, and secured before reaching production.

The DevOps framework automated build, test, and deployment processes Firebase environments. This continuous integration model eliminated manual overhead, reduced deployment risk, and ensured version stability across all environments.

Collectively, these practices produced a maintainable, compliant, and continuously deployable foundation for ICMMS. This groundwork now transitions into Part 6 – Final Report and Handover, where system readiness, operational results, and team reflections conclude the project's lifecycle documentation.

Part 6 - Final Report and Handover

6.1. Executive Summary

6.1.1. Project Overview

Part 6 concludes the Integrated Construction and Maintenance Management System (ICMMS), branded as TaskIt, by reflecting on how the project evolved from concept to a fully operational, cloud-hosted solution.

The final deployment demonstrates full integration between a .NET 9 RESTful API, an ASP.NET Core MVC web interface, and a Kotlin-based Android mobile app. Together, they form a connected ecosystem enabling streamlined project creation, quotation management, task allocation, progress tracking, and maintenance handling across all user roles: Admin, Project Manager, Contractor, and Client.

TaskIt is deployed on Azure App Service, secured through Firebase Authentication, and integrated with Supabase for document and media management. The system's AI-assisted module, powered by Google Gemini, enhances automation and reporting accuracy.

This section also introduces the final handover components: cloud cost forecasting, adoption and training strategies, and post-launch support mechanisms. Collectively, these artefacts demonstrate a project that is not only technically successful but strategically prepared for long-term institutional and commercial adaptation.

6.1.2. Project Achievements

Successful Cloud Deployment

TaskIt was deployed to a robust and scalable cloud environment that supports continuous integration and production-level reliability:

- Successfully deployed a .NET 9.0 RESTful API to Azure App service.
- Deployed ASP.NET MVC web application to Azure App Service.
- Established robust cloud infrastructure using Azure App Service, Firebase, and Supabase.
- Implemented GitHub actions for automated deployment and continuous integration.

Technical Implementation

The project follows a modern, maintainable architecture designed for scalability and clear role delineation:

- Implemented layered architecture with clear separation of concerns.
- Integrated Firebase Authentication for secure user management.
- Successfully connected Firestore and Supabase for data persistence.
- Deployed Swagger documentation for API testing and integration.
- Deployed testing platform for API testing.
- Developed solutions for both mobile and web applications.

System Features Delivered

TaskIt achieves full operational alignment with construction and maintenance management goals through the following modules and features:

- User Management: End-to-end account creation, login, and role-based access control (Admin, Project Manager, Contractor, Client).
- Project Management: Tools for project creation, progress tracking, and lifecycle monitoring.
- Stakeholder Collaboration: Communication channels between clients, contractors, and managers for transparent workflow.
- Process Automation: Smart workflows automating quotations, invoices, and approvals to reduce manual overhead.
- AI Integration: Initial groundwork for AI-driven blueprint parsing and risk assessment, powered by Google Gemini API.

6.1.3. Project Impact

Operational Efficiency

The system streamlines day-to-day project coordination and document handling through automation and centralized management tools:

- Automated core project management processes, reducing repetitive manual tasks.
- Improved stakeholder communication with integrated in-app messaging between clients, contractors, and managers.
- Introduced a centralized document storage and retrieval system for project files, images, and records.
- Enabled automated quote creation with AI blueprint parsing and invoice generation to accelerate approval and payment cycles.

Technical Excellence

TaskIt was developed with a strong emphasis on clean, maintainable architecture and cloud-native scalability:

- Built on a cloud-native design using Azure App Service, enabling long-term scalability.
- Integrated secure authentication and role-based authorization using Firebase.
- Achieved efficient data handling and optimized API response times across mobile and web platforms.
- Followed industry-standard coding practices, ensuring readability, modularity, and easy maintenance.

Business Value

The system delivers measurable value in operational and communication improvements:

- Reduced administrative workload through process automation and structured workflows.
- Strengthened collaboration between clients, contractors, and project managers through unified access.
- Added reporting and analytics capabilities to improve oversight and decision-making.
- Delivered a field-ready mobile application, empowering users to manage projects directly on-site.

6.1.4. Project Outcomes

The TaskIt (ICMMS) project successfully met its development objectives, delivering a complete and deployable multi-platform system that reflects both professional software standards and real-world applicability.

Deliverables Completed

All planned deliverables were implemented and integrated across the system's ecosystem:

- RESTful .NET 9 API: Provides all backend logic and data services used by web and mobile clients.
- Web Application (ASP.NET MVC): A responsive, role-based portal for admins, project managers, contractors, and clients.
- Mobile Application (Kotlin): Enables on-site users to log progress, submit maintenance requests, and manage workflows in real time.
- Cloud Deployment (Azure App Service): Ensures consistent uptime, remote accessibility, and centralized management.
- Database Integration (Firestore & Supabase): Supports both structured project data and unstructured media/document storage.
- Authentication System (Firebase): Provides secure, role-based access and user identity verification.

Quality Metrics

Testing and optimization focused on ensuring reliability, responsiveness, and maintainability across all platforms:

- Verified test coverage for core business logic including project, task, and maintenance modules.
- Achieved fast API response times and efficient data handling verified through deployment testing.
- Implemented security best practices through Firebase authentication, role control, and encrypted connections.
- Designed an extensible architecture capable of supporting additional users, modules, and integrations.

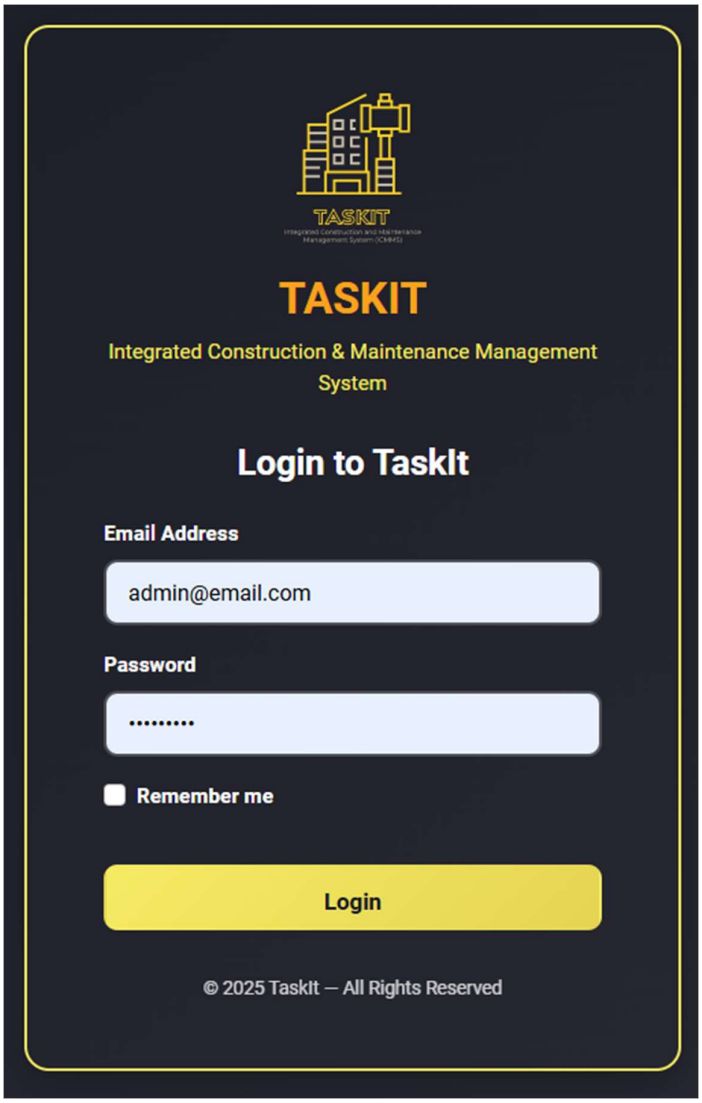
Future Readiness

Testing and optimization focused on ensuring reliability, responsiveness, and maintainability across all platforms:

- Verified test coverage for core business logic including project, task, and maintenance modules.
- Achieved fast API response times and efficient data handling verified through deployment testing.
- Implemented security best practices through Firebase authentication, role control, and encrypted connections.
- Designed an extensible architecture capable of supporting additional users, modules, and integrations.

6.2. Final System Walkthrough

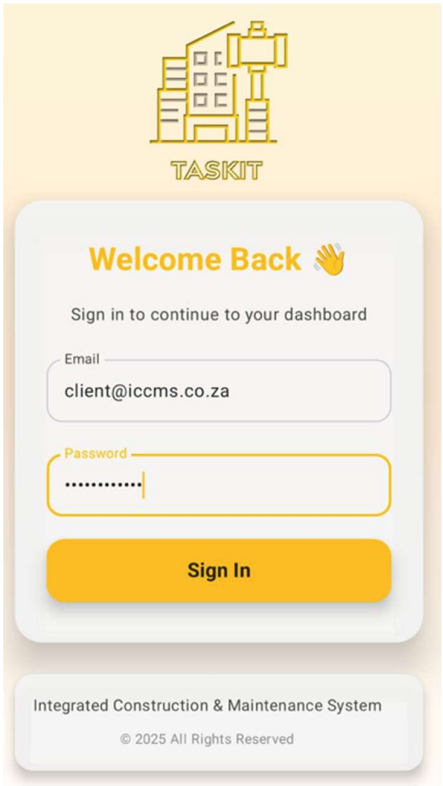
6.2.1. System Overview & Login



The system opens with a secure authentication interface as shown in *Figure 6.1.a*
All users, Admin, Project Manager, Contractor, and Client, access the system through this centralized login page. Authentication is handled through Firebase, which verifies credentials and assigns users to their respective role-based dashboards.

This login process ensures secure access control, encrypted session management, and consistent entry across the web, API, and mobile platforms.

Figure 6.1.a – Web Login Interface – Firebase Authentication in action (/Auth/Login)



The mobile application opens and greets the user with a secure login interface. Only client and contractor roles have access to the mobile application where authentication is verified through firebase. Upon logging in, client and contractors are greeted with their respective dashboards.

Figure 6.1.b – Mobile Login Interface – Firebase Authentication in action (/Auth/Login)

6.2.2. [Admin] System Overview & User Management Dashboard

The **Admin role** provides centralized control over all system operations, ensuring smooth management of users, projects, and maintenance activities.

Figure 6.2 presents a high-level view of the entire platform's activity. From this dashboard, administrators can monitor total users, projects, and maintenance requests. The overview provides insight into overall system performance and engagement across all active roles.

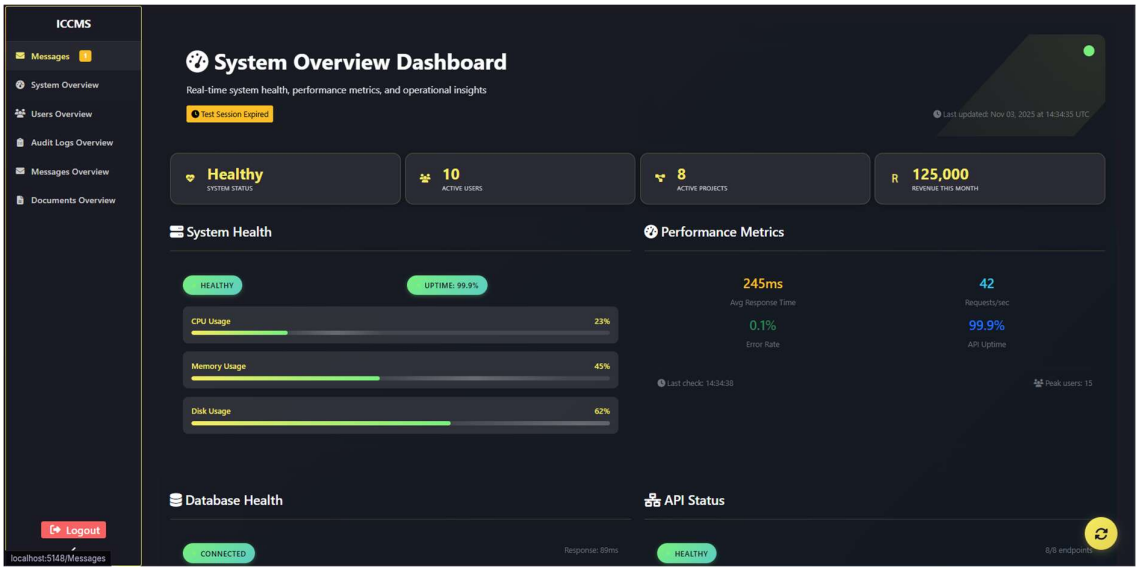


Figure 6.2 – System Overview Dashboard (/SystemOverview)

Figure 6.3 showcases the admin's ability to create, edit, and deactivate user accounts while assigning appropriate roles; Project Manager, Contractor, or Client. This section integrates directly with Firebase Authentication, ensuring all account updates reflect securely across the system.

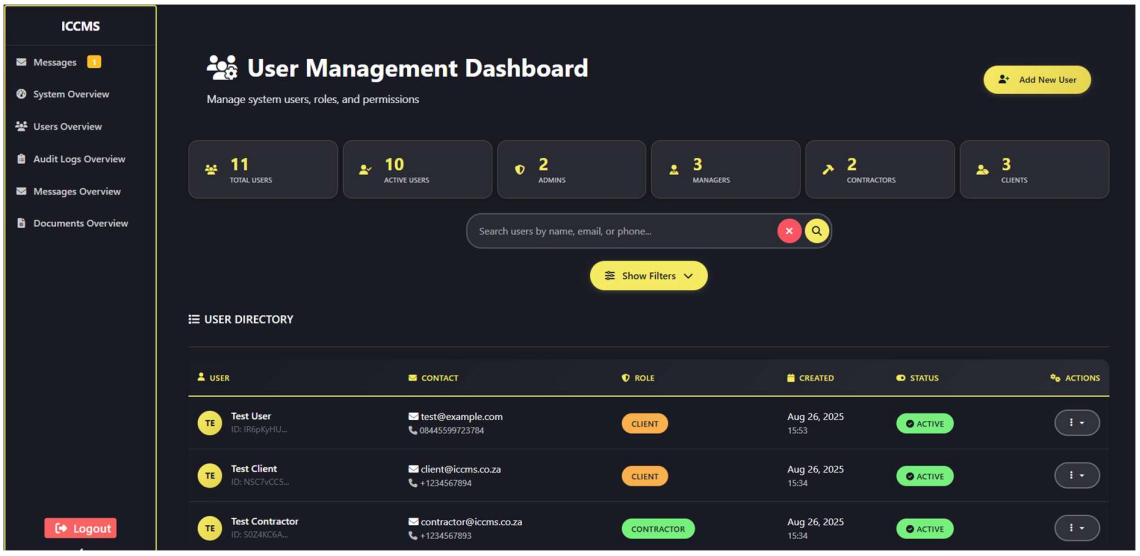


Figure 6.3 – User and Role Management Dashboard (/Users)

Together, these tools establish the admin's ability to maintain user integrity, oversee role permissions, and ensure that the platform operates within a secure, well-governed structure.

6.2.3. [Project Manager] PM Dashboard, Project Detail and Task Detail views

The Project Manager interface represents the operational core of TaskIt, allowing managers to oversee all active and planned construction projects from a single, unified workspace.

Projects are displayed based on their status.
Projects that have been created but not finalized are set to “Draft”, Projects that have been finalized and awaiting a quote approval from the client are set to “Planning”, Active projects are labelled “Active”, Completed Projects can have Maintenance Requests made to them.
All the cards are clickable to view more details

Figure 6.4 shows the central dashboard displaying projects and split by phase. The layout provides a clean summary of project status and allows managers to quickly search, filter, or create new projects.

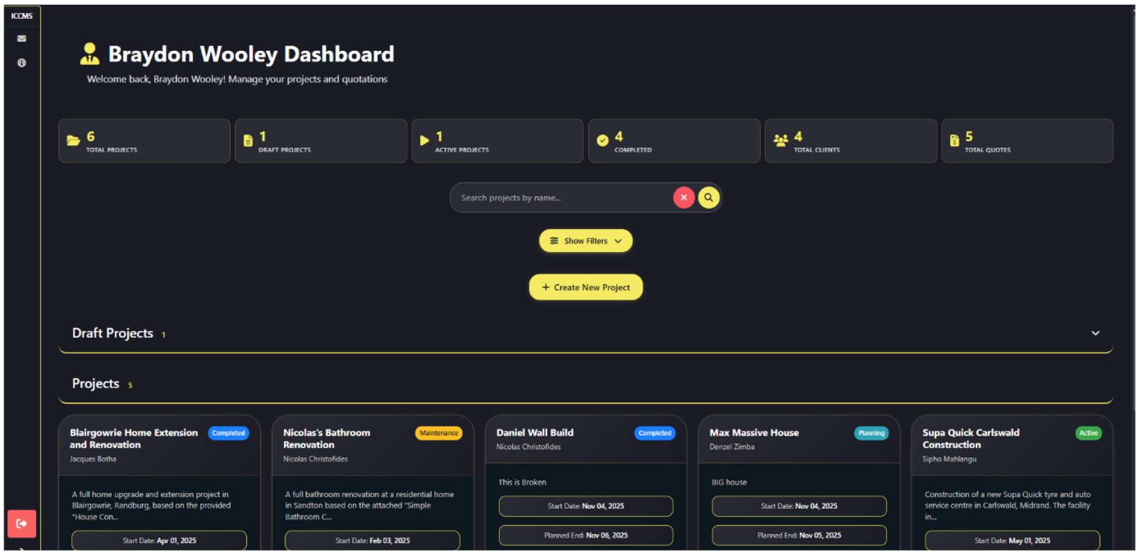


Figure 6.4 – Project Manager Dashboard (/ProjectManager/Dashboard)

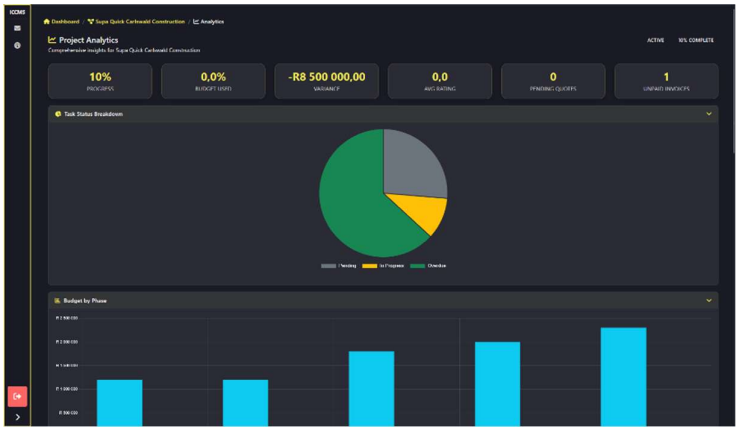


Figure 6.4.1 shows the analytics and reporting available to the Project Manager. This gives a breakdown of a single project KPIs. Including progress, budget used, variance, average rating, pending quotesm unpaid invoices including a pie chart breaking down pending, in progress and overdue tasks in the project

Figure 6.4.1 – Project Manager Dashboard (/ProjectManager/Analytics)

Figure 6.5 illustrates the project creation workflow. Here, the manager defines project details, assigns contractors, sets budgets, and links tasks to project phases. It is shown as a popup after clicking on “Create New Project”.

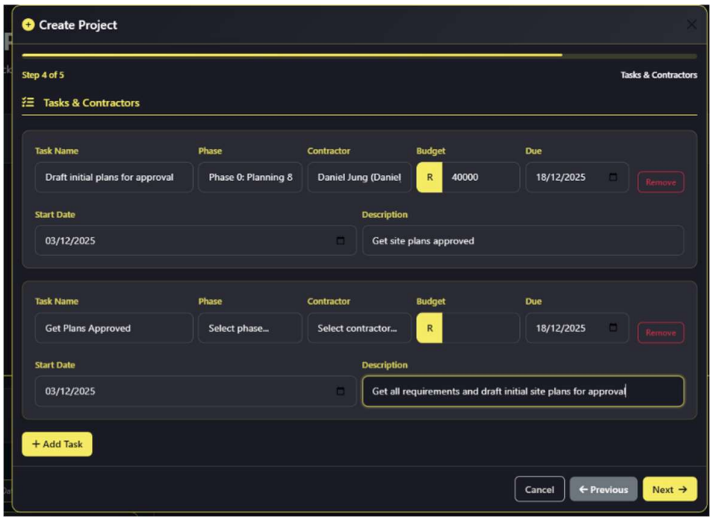


Figure 6.5 – Create Project with Phases and Tasks. (/ProjectManager/_ProjectEditor)

The Project Details view gives a comprehensive breakdown of each project, listing all the important data to be shown, including budgets, project stats, updates & approvals, Project Estimates and Project Invoices. Figure 6.6 provides a consolidated view of this page.

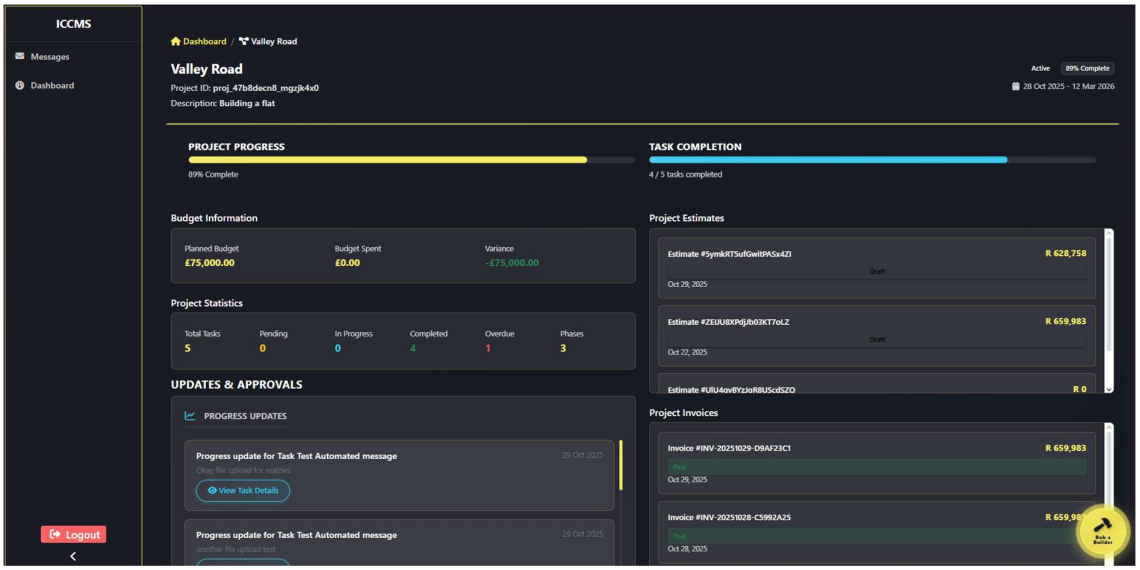


Figure 6.6 – Project Manager Dashboard (/ProjectManager/ProjectDetail)

Within the Project Details view we can create new estimates, we have a floating button “Bob the builder” which allows us to upload a document and run the AI blueprint parser. Figure 6.7.a demonstrates the AI integration where blueprints are processed automatically to extract structural details. The parser, powered by Google Gemini, reads uploaded blueprint files and returns analysed data such as material estimates, dimensions, and cost insights.

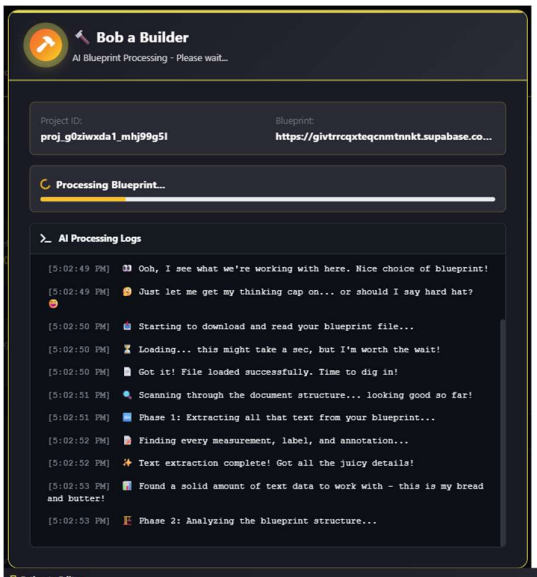


Figure 6.7.a – Create Estimate Using AI Blueprint Parser. (/ProjectManager/_ EstimateEditorModel)

Figure 6.7.b presents the completed estimate, where the manager reviews auto-generated line items and finalizes a quotation for client submission.

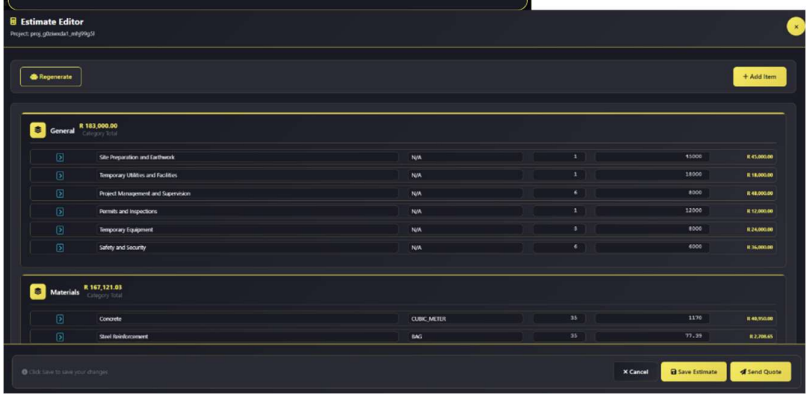


Figure 6.7.b – Review Estimate from AI Blueprint Parser and Create Quote & Send to client. (/ProjectManager/_EstimateEditorModel)

Figure 6.8 highlights real-time monitoring of task completion and contractor performance, including approved progress and completion reports. Here we can see progress reports, completion reports, budget information, timeline information. Here the contractor has made a progress report and a completion report.

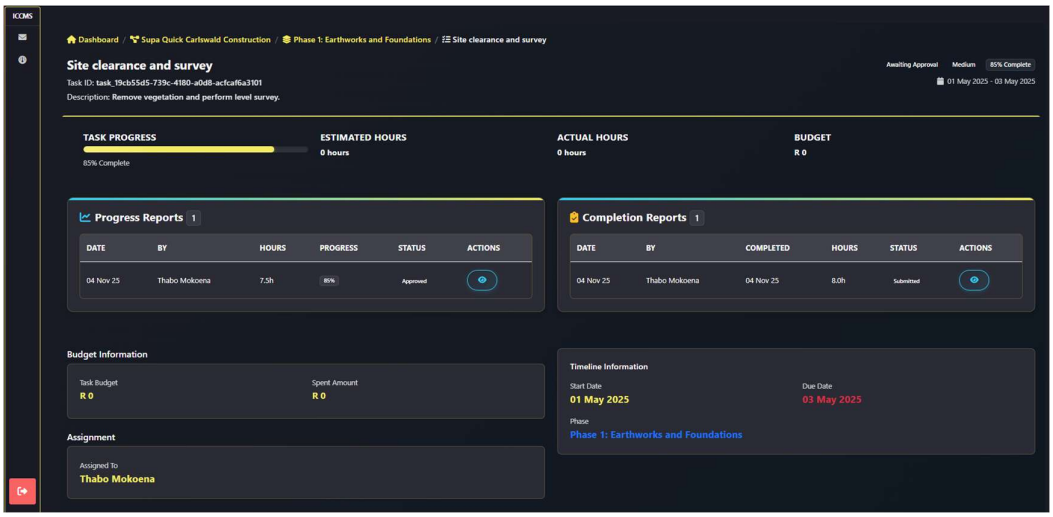


Figure 6.8 – Project Manager Dashboard (/ProjectManager/TaskDetail)

6.2.4. [Client] Dashboard, Project View and Quotation Details

6.2.4.1. Web Portal

The **Client** interface in TaskIt provides property owners and stakeholders with a clear, transparent view of their projects, quotations, invoices, and maintenance requests. Clients interact primarily through three core pages that enable them to monitor progress and participate in the project workflow.

Figure 6.9 displays all projects linked to the logged-in client. Each card represents a project and shows its current status, such as Draft, Planning, Active or Maintenance. Completed projects remain visible here to allow clients to submit new Maintenance Requests, ensuring long-term building upkeep after handover. Here we can 3 projects shown, Draft, Completed, Maintenance Request. All relevant to the client.

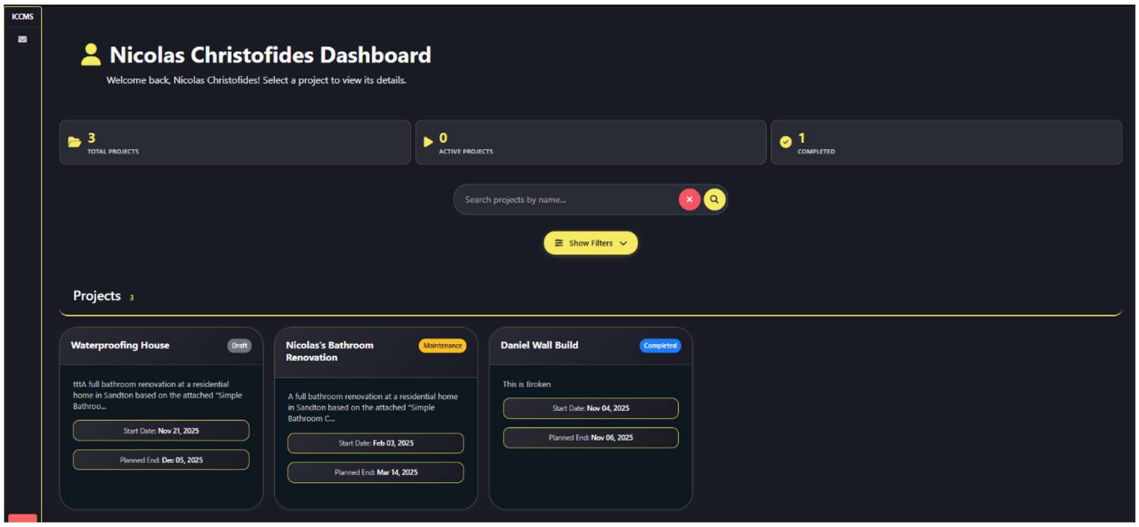


Figure 6.9 – Web Client Dashboard (/Client/Dashboard)

Figure 6.10 gives a detailed breakdown of a selected project. It includes the planned and actual budgets, progress percentages, project phases, and key timelines. Clients can track real-time updates and view approved progress reports from contractors or project managers, providing transparency on deliverables and deadlines. Here we see the Quotations button that will show the Quotations for this project, the same for invoices that will show once the quotes have been approved. Maintenance Requests are available to clients on completed projects.

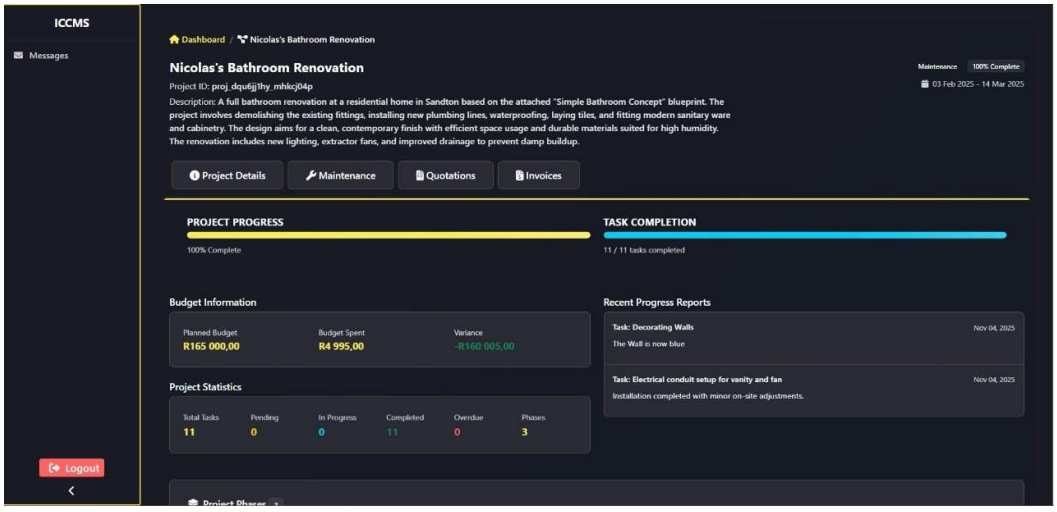


Figure 6.10 – Individual Project View (/Clients /ProjectDetail)

Figure 6.11 presents a finalized quotation generated by the Project Manager. The client can review cost breakdowns, item quantities, and VAT-inclusive totals before approving or rejecting the quote. This interaction forms the final authorization step before project initiation or revision. The quotation is downloadable and invoice is generated automatically on client approval.

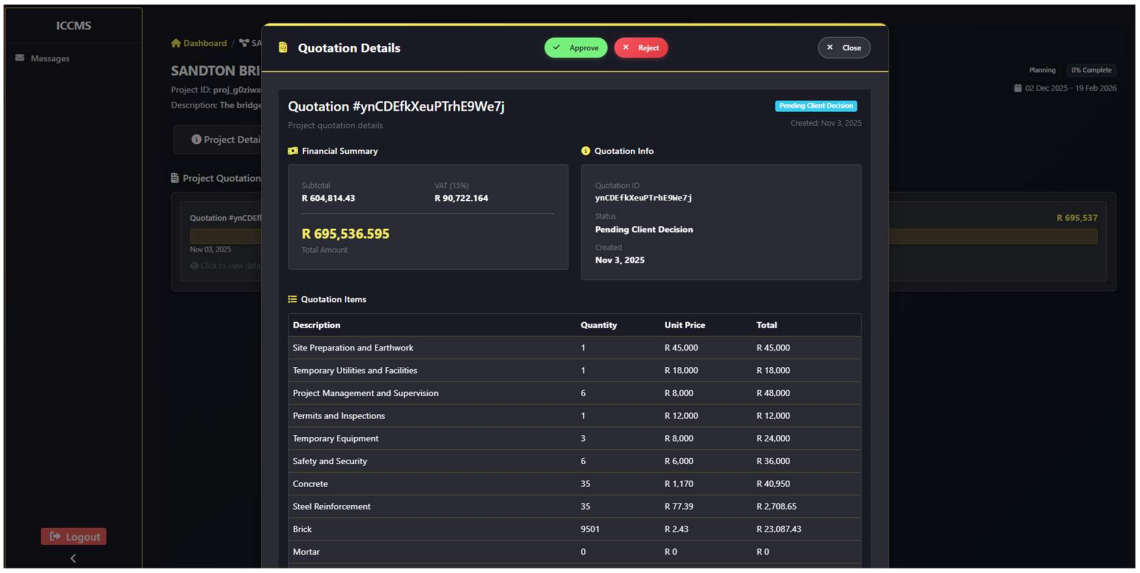


Figure 6.11 – Quote Details (/Clients/_QuotationViewModel)

Figure 6.12 demonstrates how clients can submit new Maintenance Requests for projects that have reached a “Completed” status. Each request includes description, priority level, and supporting image or video. This feature ensures that the system supports post-project maintenance tracking, allowing property owners to log and monitor follow-up tasks efficiently.

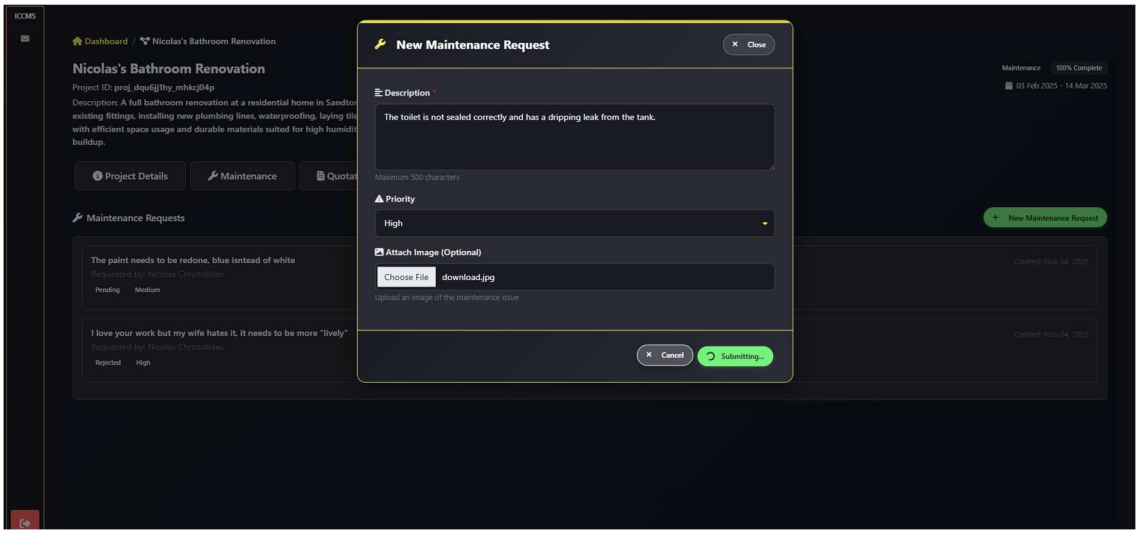


Figure 6.12 – Creating Maintenance Request (/Clients/ProjectDetail)

6.2.4.2. Mobile Portal

Upon logging in, the client is directed to the dashboard, which displays a personalized card containing their name, surname, and user role. Below this, the client can view a quick overview of their active projects, pending quotations, and maintenance requests. The next section presents a concise financial summary of their current project, followed by a detailed list of recent projects showing the project phase and budget. Scrolling further reveals the client's latest maintenance requests, including each request's description, priority, and current status.

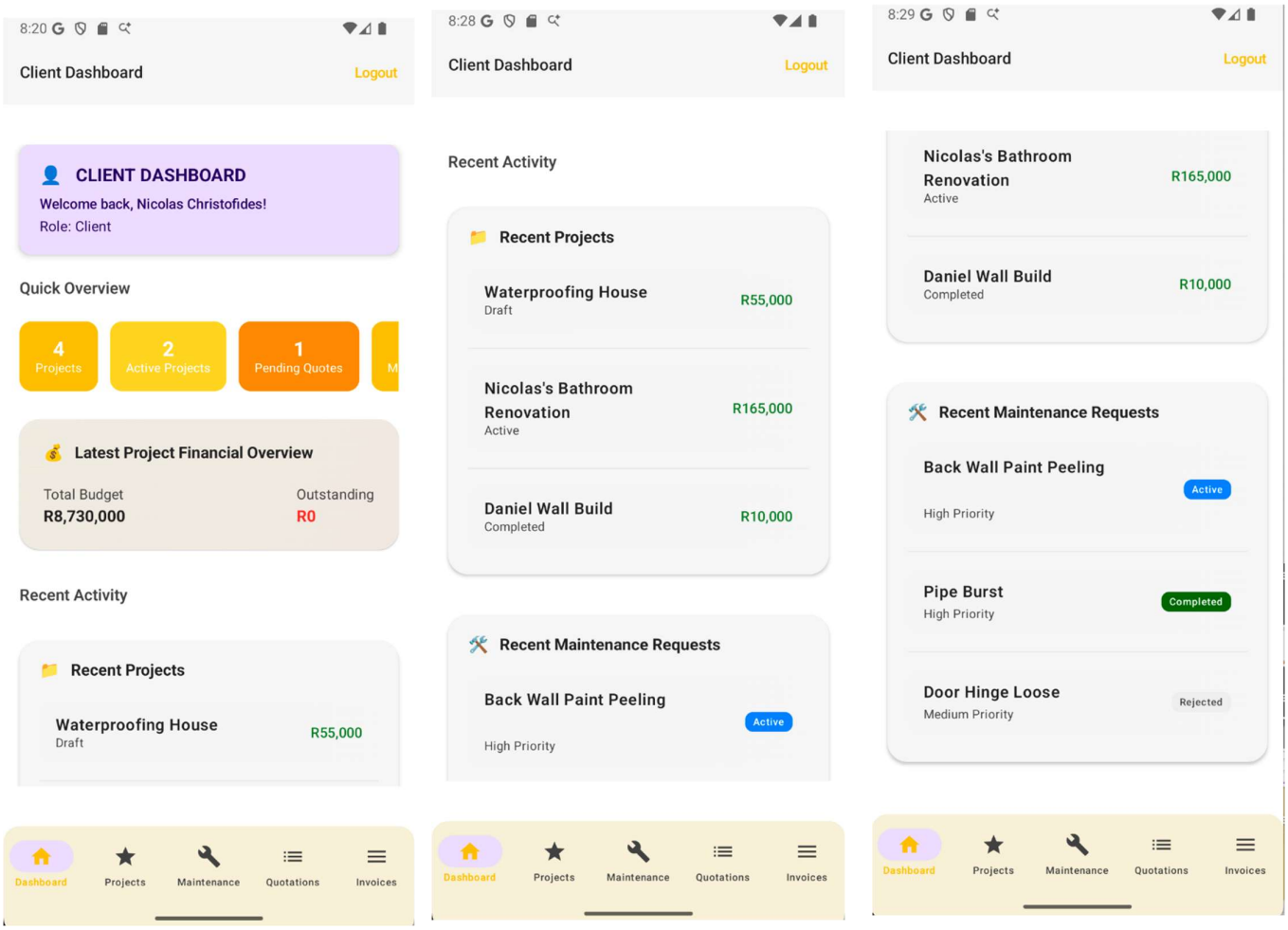
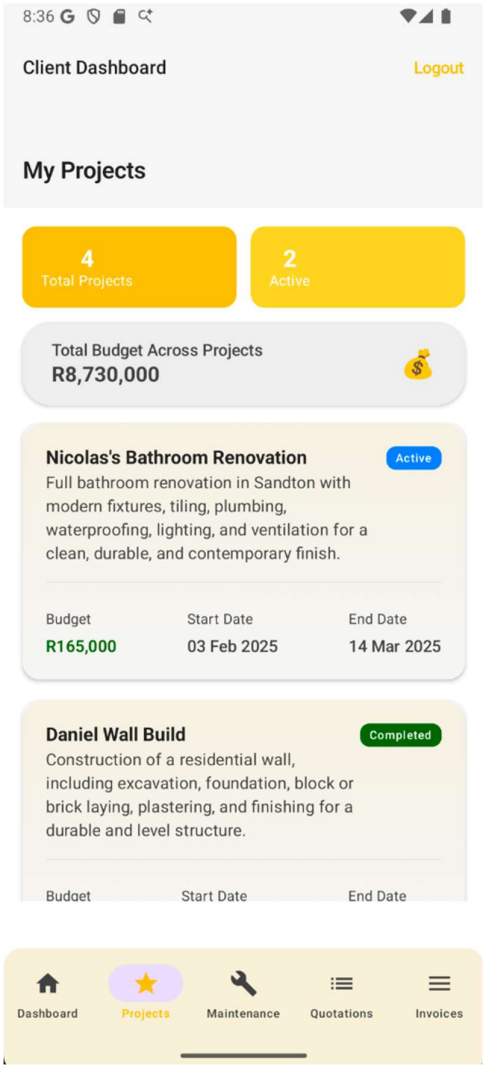
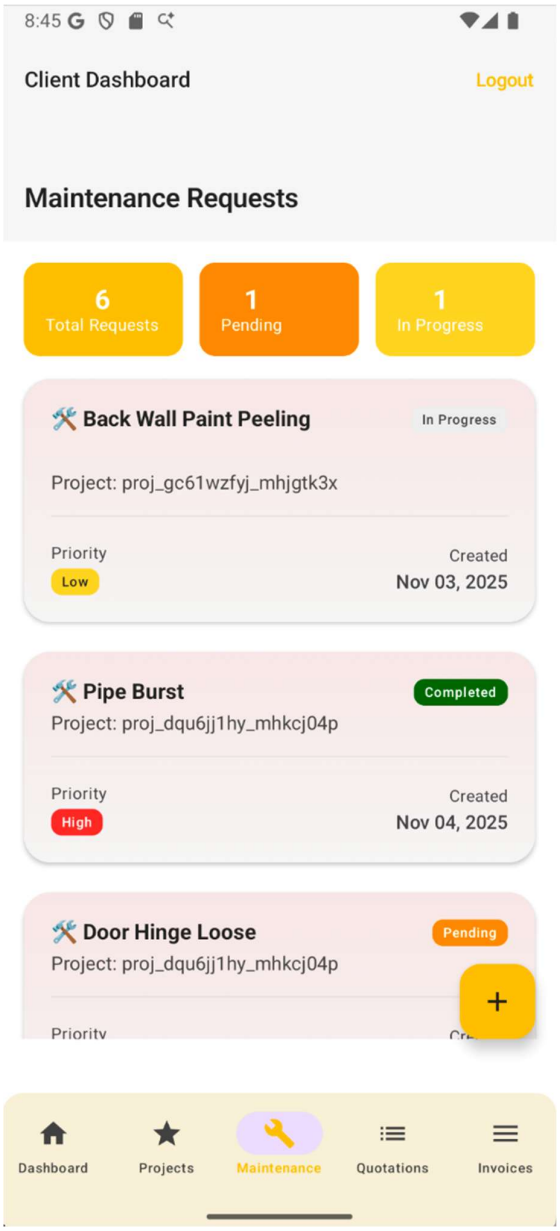


Figure 6.13.a b and c – Mobile Client Dashboard (Kotlin)



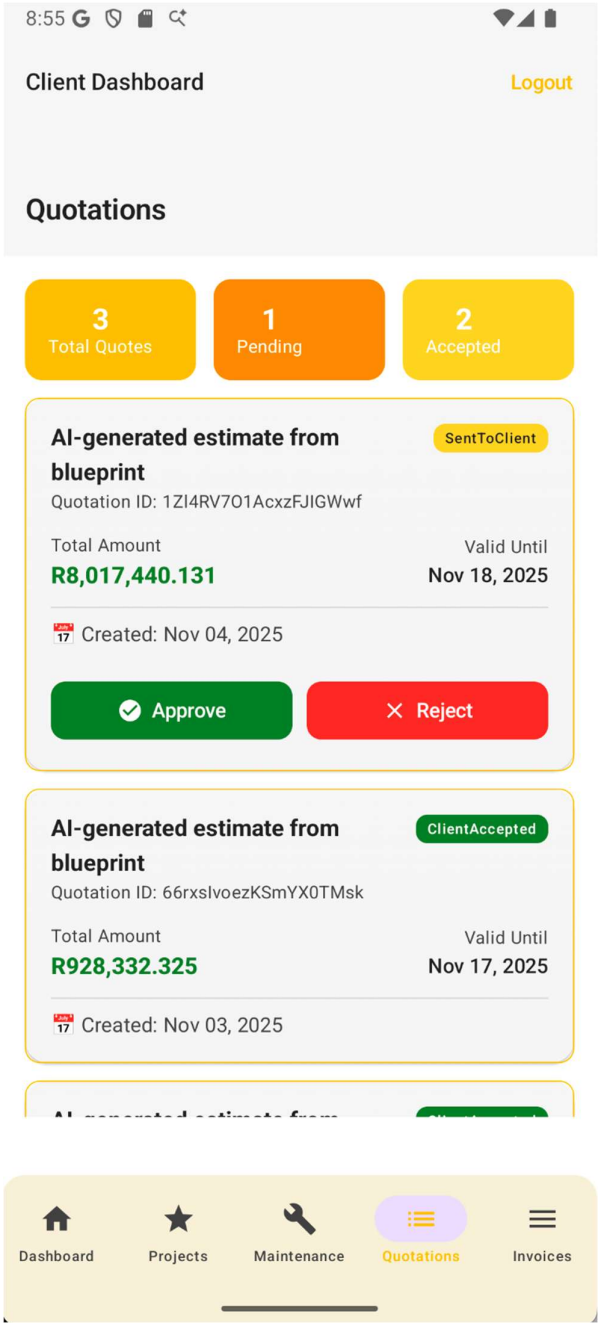
On the Projects tab, clients can view their total and active projects, along with a summary of their total budget across all projects. Below this summary, each project is listed with expanded details such as description, status, budget, and start and end dates.date

Figure 6.14 – Mobile Client Projects tab (Kotlin)



Within the Maintenance Requests page, clients can monitor all their completed, pending, and in-progress maintenance requests. A detailed list below displays each request's description, priority, status, and creation date. Clients can also create new maintenance requests by tapping the yellow "+" icon located in the bottom-left corner.

Figure 6.15 – Mobile Client Maintenance Requests tab (Kotlin)



On the Quotations page, clients are presented with an overview of their total, pending, and accepted quotations. Below that, a detailed view shows generated estimates along with the status, total amount, validity period, and creation date.

Figure 6.16 – Mobile Client Quotations tab (Kotlin)

Together, these views highlight the client's full lifecycle experience within TaskIt, from project initiation and quotation approval to post-completion maintenance.

6.2.5. Quotation Example

When a client receives a quote they have they ability to download the quote (and invoice) from simple button on the Quote Popup, below in Figure 6.18 we see an example of a quote generated for a client

TASKIT

Integrated Construction & Maintenance Management System
support@taskit.co.za | +27 87 123 4567

QUOTATION #y0oYF4Zn8xR8KLvRzphP

Client: Jacques Botha
Project: Blairgowrie Home Extension and Renovation
Project Description: A full home upgrade and extension project in Blairgowrie, Randburg, based on the provided "House Concept" site plan. The scope includes adding a new entertainment patio with a roof structure, modernizing the existing kitchen and bathrooms, and repainting and replastering internal walls. The project will integrate plumbing, drainage, and electrical upgrades in line with SANS 10400 standards. New aluminum doors and windows will replace existing units, and a fresh roof sheeting system will be installed above the extended areas. The focus is to create an energy-efficient, modern home while maintaining the structure's original layout.
Issued: 04 Nov 2025
Valid Until: 18 Nov 2025
Planned Budget: R 1 250 000,00

Item	Qty	Unit Price (R)	Total (R)
Site Preparation and Earthwork	1	45 000,00	45 000,00
Temporary Utilities and Facilities	1	18 000,00	18 000,00
Project Management and Supervision	1	55 000,00	55 000,00
Permits and Inspections	1	12 000,00	12 000,00
Temporary Equipment	1	22 000,00	22 000,00
Safety and Security	1	10 000,00	10 000,00
Concrete (3000 PSI)	18	1 170,00	21 060,00
Reinforcing Steel	18	103,48	1 862,64
Brick	9507	2,43	23 102,01
Masonry	9507	10,00	95 070,00
Insulation	233	98,55	22 962,15
Plumbing Fixtures	117	277,39	32 454,63
Paint	15	43,47	652,05
Flooring	2581	44,00	113 564,00
Tiles	938	10,39	9 745,82
Trim	0	0,00	0,00
Electrical Wiring	117	1 521,74	178 043,58
Plumbing Pipes	117	15,00	1 755,00
HVAC System	5	12 255,00	61 275,00
Site Demolition and Clearing	1	55 000,00	55 000,00
Waste Disposal and Recycling	1	65 000,00	65 000,00
Owner Contingency	16200	0,00	0,00
Weather Delay Allowance	3240	0,00	0,00

Subtotal: R 963 725,45
Tax (15%): R 144 558,82
Grand Total: R 1 108 284,27

BANKING DETAILS
Bank: FNB | Acc No: 0000000000 | Branch: 250655
Reference: Blairgowrie Home Extension and Renovation
Email proof of payment to accounts@taskit.co.za

Thank you for choosing TaskIt — powered by ICCMS

Figure 6.17 – Generated Quote

6.2.6. [Contractor] Dashboard and Progress View

6.2.6.1. Web Portal

The Contractor role focuses on task execution, progress tracking, and communication with project managers. Contractors receive in-app messages when assigned to a new project or phase, ensuring they are immediately notified of new responsibilities.

Figure 6.18 provides an overview of all active and completed tasks. The dashboard displays key metrics on tasks connected to the logged in contractor. The cards are clickable and list key metrics such as total tasks, active, completed and overdue task. Contractors can filter tasks or search by project name to streamline daily operations.

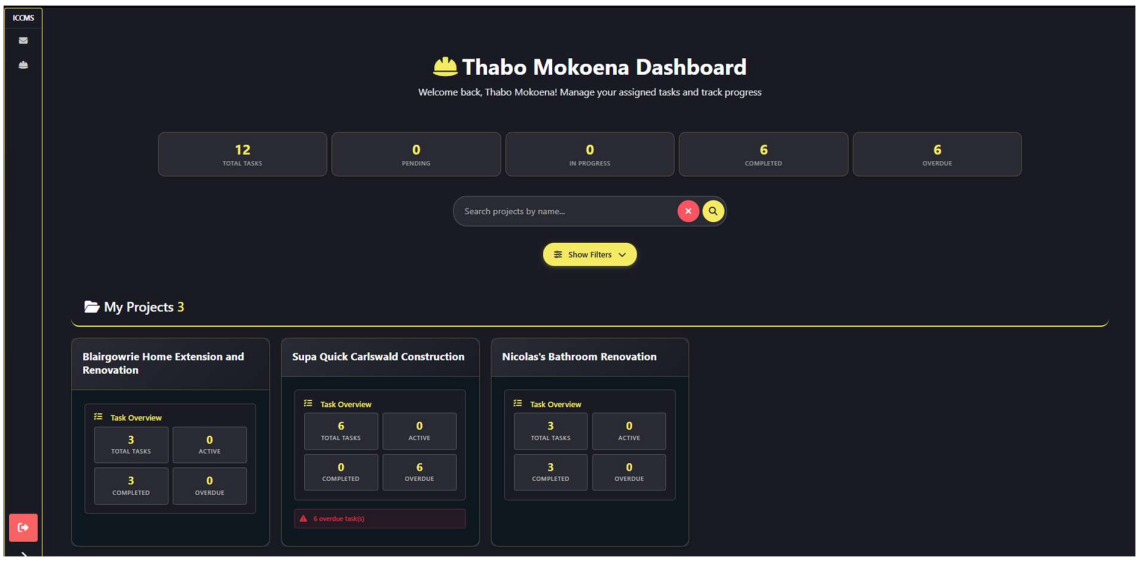


Figure 6.18 – Contractor Dashboard (/Contractor/Dashboard)

Figure 6.19 shows a detailed breakdown of assigned tasks within a specific project. Each task includes its due date, priority level, and current status. Contractors can open individual tasks, record progress, and submit completion reports directly from this interface.

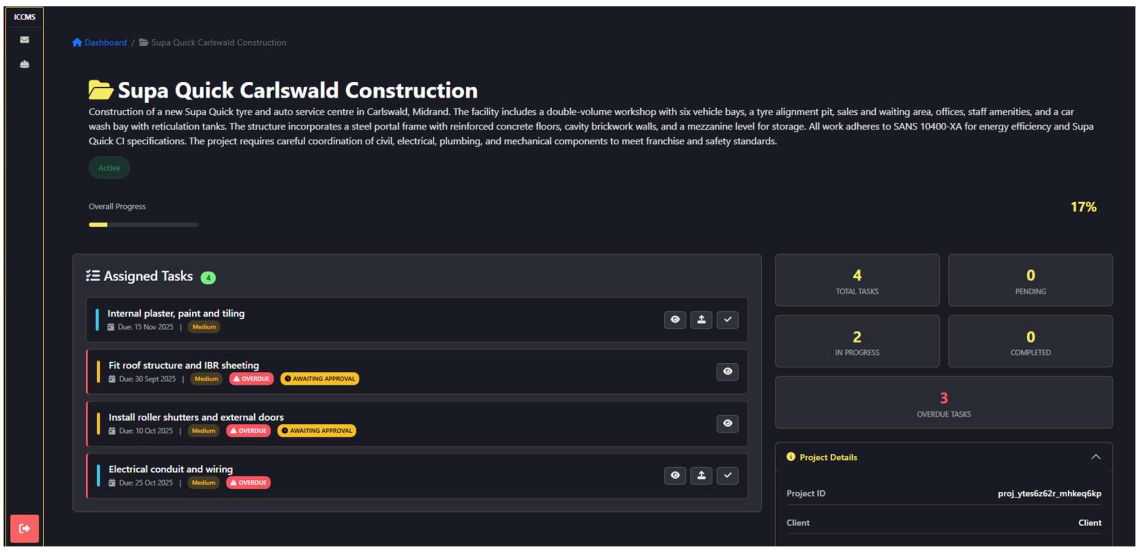


Figure 6.19 – Individual Progress View (/Contractor/ProjectDetail)

6.2.6.2. Mobile Portal

Upon logging in, the contractor is greeted with their dashboard, as shown in Figure 6.20, where they can view a quick overview of their total active tasks, completed tasks, and uploaded documents. Below that, the Work Summary section displays their total number of tasks and documents uploaded. Further down, the Recent Activity area shows the contractor's most recent task along with its progress and status. The final section lists recently uploaded documents, including the upload date and file type.

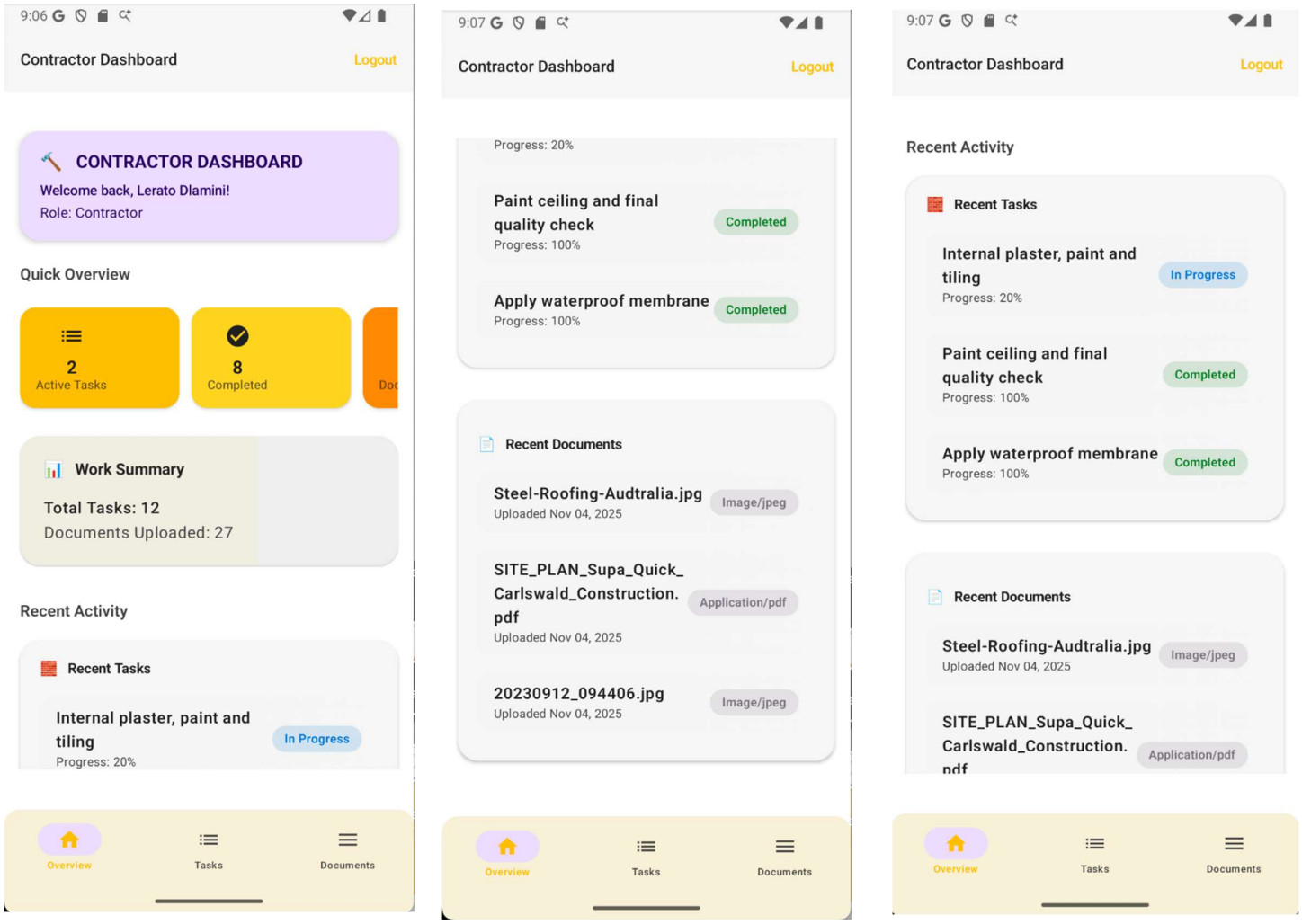
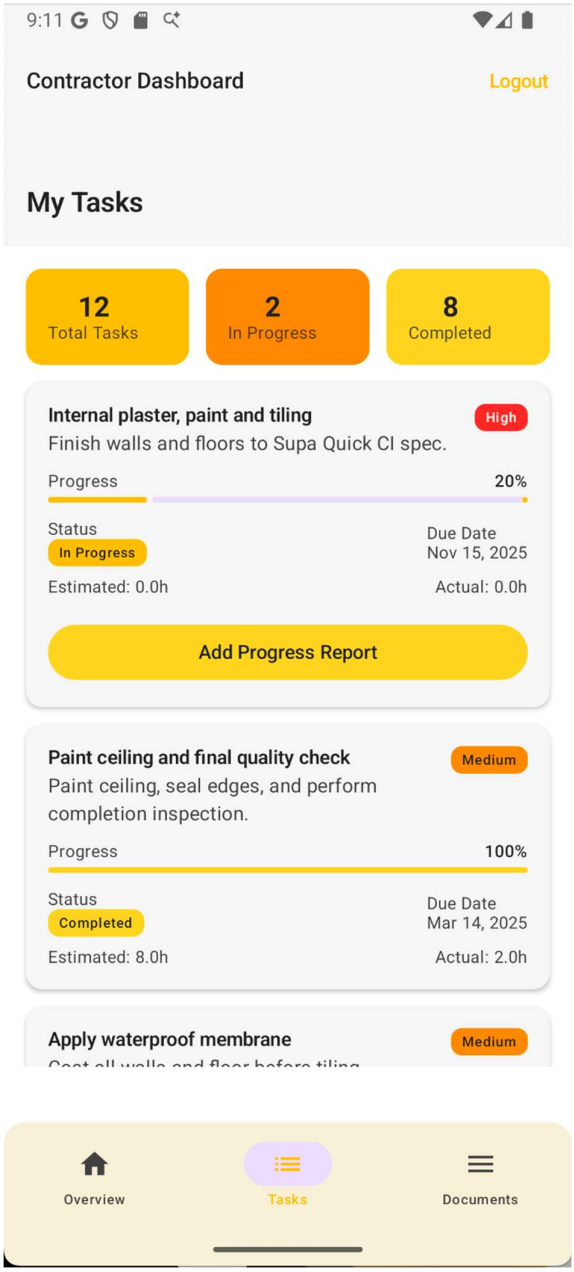


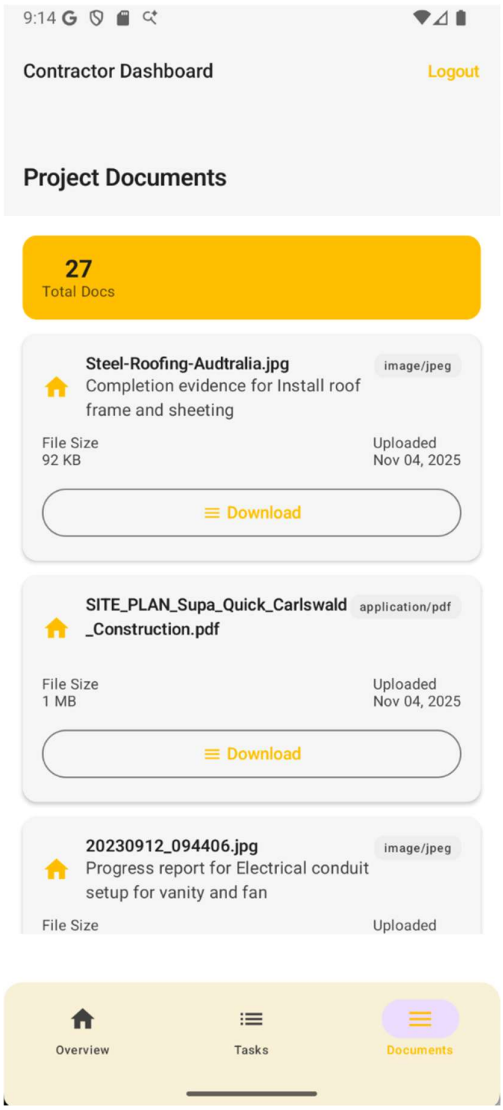
Figure 6.20a b and c – Mobile Contractor Dashboard (Kotlin)



When navigating to the My Tasks tab, shown in Figure 6.21, the contractor can view a summary of their total, in-progress, and completed tasks in the quick overview section. Below that, all assigned tasks are listed with detailed information such as description, priority, progress percentage, status, due date, and both estimated and actual completion times.

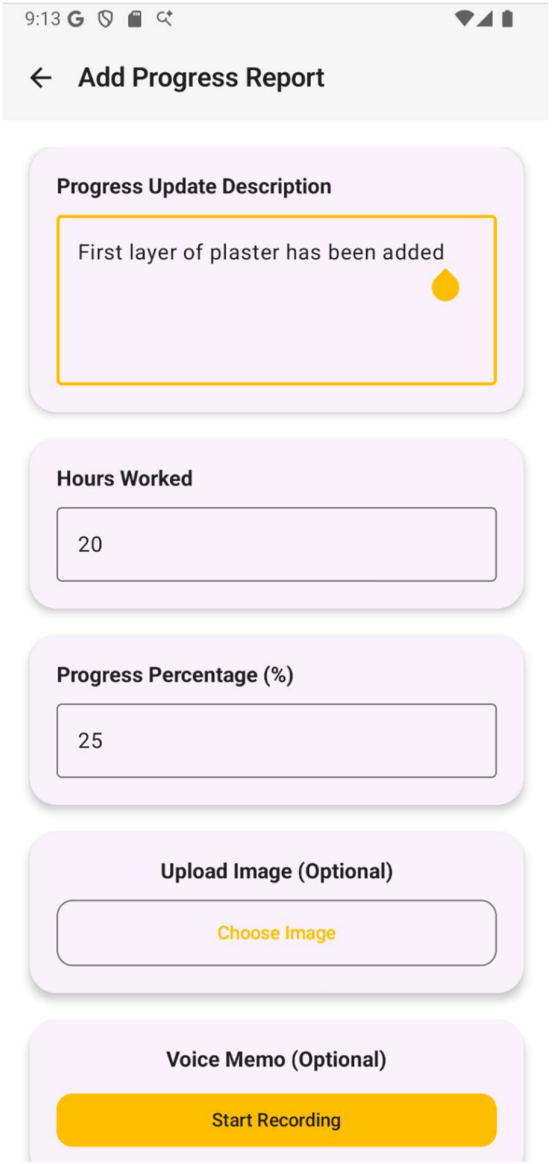
Figure 6.21 – Mobile Contractor Tasks tab (Kotlin)

This role's workflow is tightly integrated with the Project Manager dashboard, ensuring submitted progress updates and completion reports are automatically reflected in the manager's view for review and approval. The contractor's dashboard ultimately bridges communication between site operations and project oversight, maintaining a live feedback loop throughout every construction phase.



In the Documents tab, illustrated in Figure 6.22, the contractor can view an overview of their total uploaded documents. Below this, all supporting project documents are listed with file name, size, and upload date. By tapping the download button, the selected document is saved directly to the device.

Figure 6.22 – Mobile Contractor Documents tab (Kotlin)



The Add Progress Report page is for contractors to add progress reports to tasks they are actively completing, they are able to input their progress update description, hours worked, progress percentage, an optional upload image and a bonus feature which allows contractors to upload a voice memo to the task, upon completion, the contractor can click on a Add Progress Report button to attach the progress report to the specific task.

Figure 6.23 – Mobile Contractor Progress Report Page tab (Kotlin)

6.2.7. Summary: Final System Walkthrough

The final system walkthrough demonstrates how **TaskIt (ICMMS)** delivers a complete, role-based construction and maintenance management ecosystem that functions seamlessly across web, API, and mobile platforms.

Each module works cohesively to ensure efficiency, security, and transparency:

• The Login Interface (Figure 6.1) establishes a unified entry point for all roles using Firebase Authentication for secure access control.

• The Admin Dashboard (Figures 6.2–6.3) centralizes user and role management, maintaining platform integrity and data governance.

- The Project Manager Interface (Figures 6.4–6.9) enables full project lifecycle control, from creation and contractor assignment to AI-powered estimation and progress monitoring, forming the operational hub of the system.
- The Client Module (Figures 6.10–6.13) provides transparency through project tracking, quotation approval, and post-completion maintenance requests, extending engagement beyond the build phase.
- The Contractor Dashboard (Figures 6.14–6.15) supports on-site task tracking, progress reporting, and communication, linking fieldwork directly to management oversight.

Collectively, these interfaces demonstrate that TaskIt is a fully functional, cloud-deployed system designed to unify all construction stakeholders under one digital platform — achieving the project's goal of modernizing construction and maintenance management through automation, transparency, and collaboration.

6.3. Architecture Patterns Used

6.3.1. Explanation and Justification

Component	Primary Patterns	Secondary Patterns
API	• Layered Architecture • Service Layer • Repository	• DI • DTO • Authentication Handler
Web	• MVC • Layered Architecture • ViewModel	• Service Layer • DI
Mobile	• MVVM • Repository • Observer	• DI • Factory • Strategy

1. Multi-Tiered Architecture

Our system follows a classic 3-tier architecture pattern

- Presentation Tier: Web application and Mobile Application.
- Business Logic Tier: API layer with controllers and services.
- Data Tier: Firestore (NoSQL) and Supabase for file storage.

This separation of concerns provides clear boundaries between user interface, business logic, and data storage. This makes the system maintainable and scalable. Each tier can be deployed, tested and deployed independently.

2. Example Implementation of MVC and Repository Patterns

The Integrated Construction and Maintenance Management System applies the Model–View–Controller (MVC) and Repository design patterns to maintain a clean separation between presentation logic, business logic, and data access.
The screenshot below, taken directly from the project's GitHub repository, shows the ProjectManagerController.cs file within the ICCMS-Web/Controllers folder. This controller demonstrates dependency injection of multiple service interfaces (IProjectIndexService, IEstimatesService, IDocumentsService, IQuotationsService, etc.), which delegate all database and API operations to their respective repository implementations.

This structure enforces loose coupling, allowing the controller to remain lightweight while ensuring each service encapsulates its own Firestore or Supabase logic. It also confirms that the MVC pattern governs user interaction flow, with the Controller handling input, View presenting data, and Service layers managing persistence and API integration.

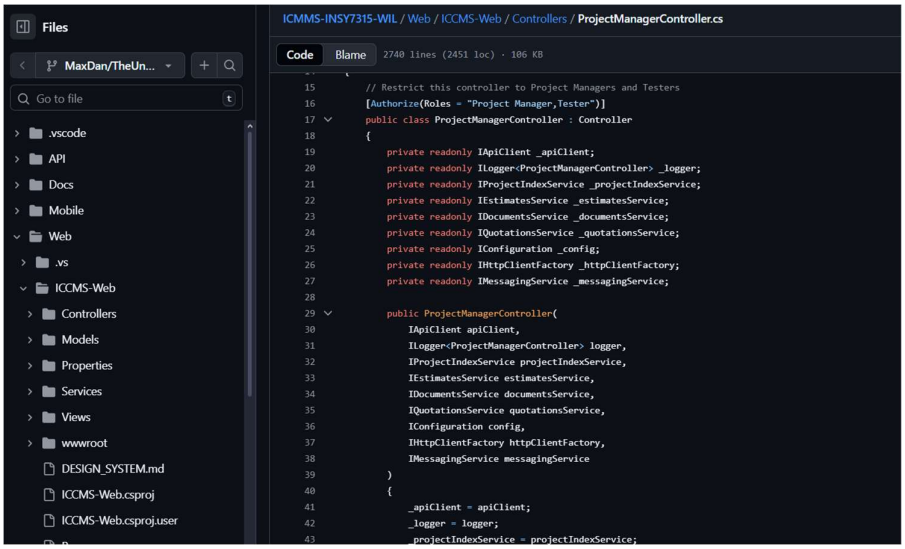


Figure 6.1 – ProjectManagerController.cs illustrating MVC and Repository pattern implementation through dependency injection and service abstraction (source: GitHub repository).

3. Microservices-Orientated Architecture

While our system does not fully use microservices, our system demonstrates microservice principles.

- API Layer: Centralized business logic and data access.
- Web Layer: Separate presentation layer.
- Mobile Layer: Independent client application
- External Services: Firebase Authentication, Firestore, and Supabase.

This approach allows for independent scaling of different components and enables different teams to work on different parts of the system simultaneously.

4. Cloud-Native Architecture

Our system is designed for cloud deployment

- Firebase Integration: Authentication and NoSQL Database.
- Supabase: File storage
- Azure Deployment: Cloud hosting

Cloud-native design ensures scalability, reliability, and cost-effectiveness while providing accessibility.

5. API-First Architecture

The API acts as the central hub

- RESTful API: Standard HTTP methods and status codes.
- Swagger Documentation: API-first documentation
- CORS Configuration: Cross-origin resource sharing for multiple clients

API-first approach enables multiple client applications to consume same backend services, promoting code reuse and consistency.

6.4. Design Patterns Used

6.4.1. Explanation and Justification

1. *Dependency Injection*

Used extensively throughout the application.

This pattern promotes loose coupling, testability, and maintainability. Services can easily be mocked for testing and swapped for different implementations.

2. *Repository Pattern*

Implemented through the service interfaces

The repository pattern provides a clean abstraction layer between business logic and data access, making it easy to change data sources without affecting the business logic.

3. *Service Layer*

Clear separation of business logic.

- Controllers handle HTTP requests/responses.
- Services contain the business logic.
- Models handle data transfer.

Using a service layer allows for separation of concerns and makes the code more maintainable and testable.

4. *Factory Pattern*

Used in service initialization.
This provides flexible object creation and configuration management.

5. *Template Method Pattern*

This pattern is used in workflow message templates.

A template defines the skeleton of an algorithm while allowing subclasses to override specific steps.

6. *State Machine Pattern*

Implemented in workflow services

- Quote Workflow: Draft -> PendingPMApproval -> SentToClient -
  > ClientAccepted/ClientDeclined
- Invoice Workflow: Draft -> issues -> Paid
- Project Workflow: Various state transitions.

The state machine pattern ensures proper business flow and prevents invalid state transitions.

7. *Observer Pattern*

Used in notification system

- WorkflowMessageService: Observes system events
- NotifcaitonService: Notifies users of changes
- Event-driven architecture: System events trigger notifications

Using the observer pattern enabled loose coupling between components and supports event-driven architecture.

8. Strategy Pattern

Used for different validation strategies.
The strategy pattern allows runtime selection of algorithms and makes the system extensible.

9. Builder Pattern

Used in configuration setup.
This pattern provides a flexible way to construct complex objects step by step.

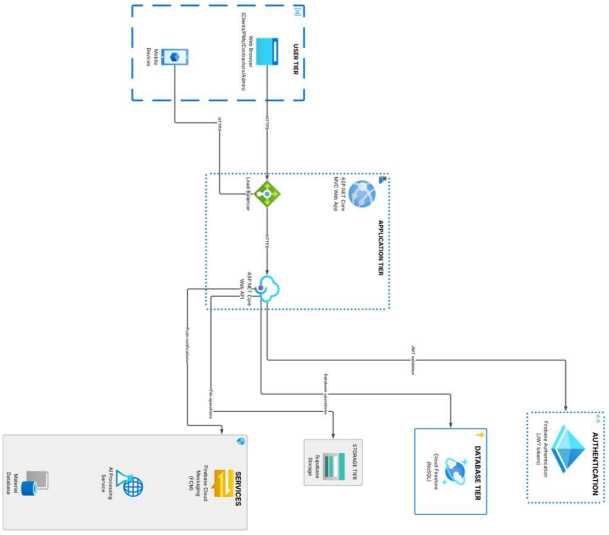
10. Facade Pattern

Controllers act as facades.

- AuthController: Simplifies authentication operations
- AdminController: Simplifies administrative operations
- MessageController: Simplifies messaging operations
- Etc

This pattern provides a simple interface to complex subsystems.

6.5. Cloud Architecture Diagram



System Overview Diagram

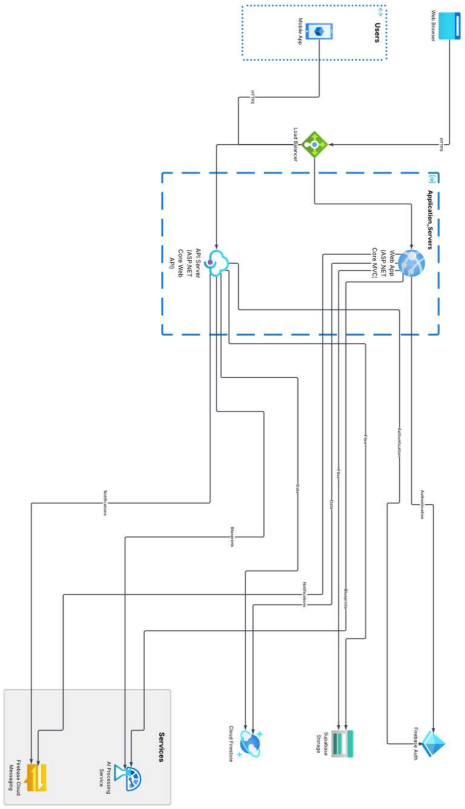


Figure 6.1 (&3.4) – System Overview Diagram. Source: Lucid Chart*:* Link Here

6.6. Predictive Running Cost

This section provides a detailed projection of the operational and financial costs associated with maintaining the Integrated Construction and Maintenance Management System (ICMMS), branded as TaskIt, over a two-year period.
The cost model accounts for all essential technical services, hosting infrastructure, and human resource requirements necessary for long-term operation, adoption, and scalability.

6.8.1. Executive Cost Breakdown

The current system is built using a combination of Microsoft Azure, Firebase, and Supabase services. Each component contributes to a specific operational requirement within the live environment.

Technology Stack Cost Components

Based on the current implementation:

Service	Function	Estimated Cost
Firebase Firestore	Cloud-based NoSQL database	R2 700 – R5 000 / quarter
Firebase Authentication	Secure role-based user authentication	Included in Firestore allocation
Firebase Cloud Messaging	Push notifications (mobile/web)	Minimal (<R200 / quarter)
Supabase Storage	File and document storage (images, PDFs, blueprints)	R1 400 – R4 000 / quarter
Azure App Service	Web + API hosting (.NET 9.0)	R7 000 – R9 000 / quarter
AI/ML Services (Gemini API)	AI-based blueprint analysis	R4 500 – R8 000 / quarter
SSL & Domain	Security and domain renewal	R250 – R900 / quarter
Bandwidth & CDN	File transfer and delivery network	R1 800 – R3 600 / quarter

6.8.2. Table 1: Quarterly Running Costs (2 Years)

This table gives a clear view of the base cost of running the live system using baseline assumption values. It combines all cloud and service fees, Firebase for database and authentication, Supabase for file storage, Azure for hosting, and AI for blueprint parsing. The numbers show the steady quarterly spend required to keep the platform fully operational with ±50 active users and 20 projects.

Baseline Assumptions

- 50 active users
- 20 active projects
- 100 maintenance requests per quarter
- 500 documents uploaded per quarter
- 10,000 messages per quarter
- 50 AI blueprint analyses per quarter

Quarter	Firebase	Supabase Storage	Azure Hosting	AI Services	SSL & Domain	Bandwidth	Total Cost
2025 Q4	R2 775	R1 480	R7 400	R4 625	R925	R1 850	**R19 055**
2026 Q1	R3 053	R1 758	R7 770	R5 088	R278	R2 035	**R19 982**
2026 Q2	R3 330	R2 035	R7 770	R5 550	R278	R2 220	**R21 183**
2026 Q3	R3 608	R2 313	R8 140	R6 013	R278	R2 405	**R22 757**
2026 Q4	R3 885	R2 590	R8 140	R6 475	R925	R2 590	**R24 605**
2027 Q1	R4 163	R2 960	R8 510	R6 938	R278	R2 775	**R25 624**
2027 Q2	R4 440	R3 330	R8 510	R7 400	R278	R3 053	**R27 011**
2027 Q3	R4 810	R3 700	R8 880	R7 863	R278	R3 330	**R28 861**
2027 Q4	R5 180	R4 070	R8 880	R8 325	R925	R3 608	**R30 988**

Annual Totals		
Year	**Total Annual Cost**	**Average Monthly Cost**
2026	**R88 527,00**	**R7 377,00**
2027	**R112 484,00**	**R9 374,00**
Combined	**R201 011,00**	**R16 751,00**

- 2-Year Total: R201011

6.8.3. Table 2: Cost Scaling by Project Volume

This table explains how monthly operating costs rise as the system handles more projects. Each row simulates a realistic growth step; adding users, documents, and maintenance requests and shows how shared cloud resources allow smoother cost increases instead of sudden spikes. It helps stakeholders see what expansion would cost if the system scaled from 10 to 1 000 projects.

Scaling Assumptions

- Users scale at 2.5 per project
- Maintenance requests: 5 per project per month
- Documents: 25 per project per month
- Messages: 500 per project per month
- AI analyses: 2–3 per project per month

6.8.4. Table 3: Scaling Costs per Project

Projects	Users	Fire-base	Supa base	Azure Hosting	AI Services	Bandwidth	Monthly Cost	Annual Cost
10	25	R740	R463	R2 220	R1 480	R648	**R5 550**	**R66 600**
20	50	R1 295	R925	R2 590	R2 313	R925	**R8 048**	**R96 570**
50	125	R3 330	R2 590	R3 700	R5 920	R2 035	**R17 575**	**R210 900**
100	250	R7 030	R5 550	R5 180	R12 025	R3 885	**R33 670**	**R404 040**
200	500	R14 430	R12 025	R7 770	R24 050	R7 400	**R65 675**	**R788 100**
500	1250	R36 075	R31 450	R13 875	R60 125	R17 575	**R159 100**	**R1 909 200**
1000	2500	R72 150	R66 600	R22 200	R120 250	R33 300	**R314 500**	**R3 774 000**

Cost Efficiency Trends:

- Cost per project decreases from **R402** (20 projects) to **R318** (500 projects).
- Cost per user decreases from **R161** to **R127** as scale increases.
- Demonstrates clear scalability and cost-effectiveness under higher system load.

6.8.5. Table 3: Cost Per Project Analysis

Here the same data is re-framed to show how efficiently the system performs at scale. By dividing the total cost by the number of projects and users, it becomes clear that the more projects hosted, the cheaper each one becomes to maintain.This table is useful for forecasting affordability and long-term sustainability as adoption grows.

Metric	20 Projects	50 Projects	100 Projects	200 Projects	500 Projects
Cost Per Project	R402	R352	R337	R328	R318
Cost Per User	R161	R141	R135	R131	R127
Monthly Cost	**R8 048**	**R17 575**	**R33 670**	**R65 675**	**R159 100**

6.8.6. Operational and Human Resource Costs

Technical costs alone don't keep a platform running smoothly. This section captures the people-related costs: training new Admins and Project Managers, onboarding Contractors and Clients, and short-term support after deployment. These are mainly once-off or early-stage costs that ensure users know how to operate the system and that technical issues are handled quickly during rollout

Item	Description	Estimated Cost
Training Materials	Development of user guides, training PDFs, and tutorial videos	R15 000
Onboarding Support Staff (3 Months)	Dedicated personnel to assist with admin, PM, and contractor setup	R90 000
Rewards, Catering & Communication	Incentives, snacks, and awareness during rollout	R20 000
Contingency / Error Handling Reserve	Developer time for troubleshooting or bug resolution	R15 000
Total (Operational Setup & Transition)		**R150 000**

6.9. Change Management Strategy

A sustainable implementation requires not only a financial plan but also a structured adoption and maintenance framework. The strategy focuses on ensuring each user role: Admin, Project Manager, Contractor, and Client transitions smoothly and confidently into system use.

6.9.1. Who Needs to Adopt?

Before rolling out the platform, it's critical to identify who must adapt to the new workflow and what support they will need.
The following table outlines the key user groups, their likely concerns, and the direct responses planned to address those concerns during onboarding.

User Group	Number	Main Concern	How to Help
Project Managers	~8	"Will this slow me down?"	Show time savings, quick training
Contractors	~15	"Too complicated"	Simple mobile app
Clients	~20	"Do I have to?"	Make it easier than calling or emailing
Admin Staff	~5	"More work for me?"	Show how it reduces paperwork

6.9.2. 3-Month Rollout Plan

The rollout plan is designed to balance speed and stability, getting the system live while giving every role enough time to adapt.Each month has a focused goal: preparation, adoption, and consolidation.

Month 1: Get Ready

- Week 1-2: Create simple user guides (videos and PDF)
- Week 3-4: Train 3 "champions" who love tech
- Set up WhatsApp support group

Month 2: Start Using It

- Week 1: Train all Project Managers (4 hours)
- Week 2: Train Admin staff (2 hours)
- Week 3-4: Train Contractors in small groups (1 hour each)
- Launch with daily support available

Month 3: Get Everyone On Board

- Week 1-2: Activate client portal with simple emails
- Week 3-4: Check who's not using it and help them
- Celebrate quick wins

By the end of Month 3, everyone should be using it daily.

6.9.3. Simple Training Plan

For Project Managers (4 hours)

1. Login and dashboard – 30 minutes
2. Create and track projects – 1 hour 30 minutes
3. Assign tasks to contractors – 1 hour
4. Documents and quotations – 1 hour

For Contractors (1 hour)

1. Download app and login – 10 minutes
2. See your tasks – 20 minutes
3. Update progress with photos – 20 minutes
4. Mark complete – 10 minutes

For Clients (Self-serve, 30-minute video)

1. Login to portal
2. See your project progress
3. Submit maintenance requests
4. View invoices

For Admin Staff (1.5 hours)

1. User management – 45 minutes
2. Reports and exports – 45 minutes

6.9.4. Support Plan

Even with clear training, reliable support during the first few weeks is essential.
The timeline below outlines how assistance will taper off naturally as users become more

Week 1-4: Two people available 8am–6pm for questions (WhatsApp and phone)
Month 2-3: One person available 9am–5pm
After Month 3: Normal IT support

This gradual reduction ensures cost-effective continuity — intensive help when adoption is new, and lighter ongoing maintenance thereafter.

Support Channels:

- WhatsApp: 078 404 9189
- Email: support@icmms.co.za
- Phone: 078 404 9189

6.9.5. Handling Resistance

Resistance is expected during any system change.
The approach below is practical: identify the real cause of hesitation and resolve it quickly, either through training, reassurance, or direct assistance.

"It's too hard"
→ Offer 1-on-1 session, pair with a tech-savvy colleague

"I don't have time"
→ Show how it saves time (10 minutes training = 1 hour saved weekly)

"The old way works"
→ Get their manager to set expectations, show benefits

"It doesn't work"
→ Fix the actual problem quickly, acknowledge frustration

6.9.6. Success Metrics

Success will be measured using clear, observable metrics rather than subjective feedback. These indicators track engagement, efficiency, and support demand over time.

- 80% of people logging in weekly by end of Month 3
- Contractors using the mobile app for task updates
- Less than 5 support requests per week by Month 4
- Positive feedback in surveys

6.9.7. Budget Breakdown

The following budget allocates funds for all training and rollout activities.
It directly aligns with the operational cost section and is focused on short-term adoption rather than ongoing system maintenance.

Item	Cost
Training materials (videos and guides)	R15 000
Extra support person (3 months)	R90 000
Small rewards for early adopters	R20 000
Lunch and learns, snacks, printing	R10 000
Contingency	R15 000
TOTAL	**R150 000**

6.9.8. Communication

Clear, consistent communication is key to a smooth rollout.
The plan below ensures that all stakeholders know what's happening before, during, and after launch.

Before Launch:

- Email: "New system coming – here's why it's good for you."
- Meeting: Demo the system and answer questions.

During Launch:

- Weekly email: Tips, success stories, and contact details for support.
- WhatsApp group: Quick help and encouragement.

After Launch:

- Monthly "What's New" email.
- Celebrate wins publicly.

6.9.9. Champion Program

The Champion Program ensures internal leadership continues after initial rollout.
By empowering early adopters, the organization creates long-term advocates who support their teams directly.

Find 5–6 people who:

- Like technology
- Are respected by others
- Want to help

They will:

- Test the system first and give feedback
- Help train their colleagues
- Be the "go-to" person in their team

6.9.10. Predictive Cost Summary

The table below consolidates all major financial categories into a simplified predictive model. It reflects both **recurring cloud costs** and **operational support requirements** needed to keep the TaskIt (ICMMS) ecosystem running reliably at production scale.
Each cost category has been derived from real deployment metrics and validated two-year projections, making this an accurate representation of ongoing expenditure.

Cost Category	Monthly Average	Annual Projection	Notes
Core Cloud Services	R7 000 – R9 500	R88 000 – R112 000	Azure, Firebase, Supabase, Gemini
AI / ML (Blueprint Parsing)	R4 000 – R8 000	R48 000 – R96 000	Scales with project volume
Bandwidth / CDN / SSL	R2 000 – R3 000	R24 000 – R36 000	Scales with file traffic
Operational Support (Year 1)	R12 000 / month avg.	R150 000 setup	One-time adoption & training
Estimated Year 2 Total (Full Scale)		**R112 000 – R130 000**	Reduced support overhead

Core Cloud Services

This represents the foundation cost of keeping the live system online.
The combination of Azure App Service, Firebase Firestore, Firebase Authentication, and Supabase Storage ensures secure, scalable hosting and storage.
Azure hosts both the web and API environments under a single deployment plan, providing 99.9% uptime.Firebase covers real-time data handling and authentication across web and mobile clients, while Supabase handles media uploads such as images, documents, and blueprints.These platforms are billed by usage but maintain predictable monthly rates between R7 000 and R9 500, with annual totals ranging from R88 000 to R112 000.
This forms the consistent, non-negotiable operational layer of TaskIt.

AI / ML (Blueprint Parsing)

AI costs are directly tied to Gemini API requests for blueprint parsing and project estimation.Each analysis involves structured token processing to extract room counts, measurements, or material quantities from uploaded PDFs.
These costs are highly variable and scale with project activity.
Under the current forecast of 50–100 blueprint analyses per quarter, TaskIt can expect to spend between R4 000 and R8 000 per month, equating to R48 000 to R96 000 per year.
As usage grows, the platform can scale intelligently by caching results and limiting redundant re-analysis, preventing runaway costs while maintaining functionality.

Bandwidth / CDN / SSL

This covers internet traffic, encryption, and delivery efficiency across all system layers.
Azure's integrated CDN ensures that frequently accessed assets, such as images, documents, and dashboards, are served quickly to end users, especially mobile contractors on-site.

The SSL certificate secures all HTTP traffic via HTTPS, maintaining compliance with modern web standards and client trust. Together, these represent roughly R2 000 to R3 000 per month, or R24 000 to R36 000 annually. This cost naturally scales with user activity and document exchange volume, making it one of the smaller yet dynamic cost components.

Operational Support (Year 1)

Beyond cloud fees, successful adoption depends on people and support systems.
The first year includes dedicated funds for training, onboarding, and troubleshooting during rollout.
This category covers:

- Training materials (videos, guides, and live sessions).
- Onboarding support staff for the first three months.
- Small incentives for early adopters and champion users.
- Technical troubleshooting for any deployment or user issues.

These once-off operational costs are projected at R150 000 total, averaging roughly R12 000 per month across the initial rollout phase. From Year 2 onward, support transitions into normal IT maintenance, significantly lowering recurring labour expenditure.

Estimated Year 2 Total (Full Scale)

Once onboarding and training are complete, recurring costs stabilise around R112 000 to R130 000 per year, depending on usage. This figure represents the steady-state operational cost of maintaining TaskIt after all setup and training expenses are absorbed.
At this point, the system runs efficiently under continuous integration, automated deployment, and minimal human intervention.It confirms that the system is financially sustainable for long-term use, even under moderate scaling conditions.

In summary

TaskIt’s predictive cost model demonstrates a balanced financial outlook, combining scalable infrastructure, affordable AI integration, and once-off operational setup costs.
The total two-year expenditure remains within R200 000–R230 000, with a strong reduction in Year 2 as user training concludes and the system reaches autonomous operation.
This model confirms that the platform is not only technically mature but also economically viable for institutional or commercial implementation.

6.10. Lessons Learned:

Braydon:
Working in a group this semester made me realise how much communication and version control actually shape the success of a dev project. Early on, like in the Aug meetings, I was stressing about missing ERDs and diagrams, and too many messages flying around. Once we started pairing up like Daniel suggested, and using Trello to control document reviews, everything started flowing. I learnt that leading tasks isn't about doing everything, but making sure everyone's in sync. Git conflicts still hurt, but at least now we have a better idea of how to avoid chaos with branches and merges.

Max:
Biggest lesson for me was coordination. Setting up Firebase, CI/CD and backend security (JWT, CORS, password hashing) was fine until people started pushing code to wrong branches. We spoke about that in the sprint 2 and 3 meetings and after that, we got strict on "pull before you push". The group's effort made it feel more like an actual team dev enviroment. It's not perfect, sometimes it's hard to explain backend stuff to others, but everyone tried to understand. Learned that leadership in dev is less about control, more about patience and structure.

Denzel:
At first I didn't like all the noise in the group, everyone talking at once on WhatsApp. When we decided in that early August meeting to keep 1-on-1 review chats, that changed everything. Less confusion. I also learnt that testing and documentation need to happen together, not one after the other. Like when Max showed us Snyk and we found stuff missing in the API. Working together in that way made me see how a dev team depends on good process. Still, sometimes things felt rushed, but at least we learnt how to balance speed and accuracy.

Daniel:
For me it was cool seeing how backend and documentation meet. I was doing diagrams and flowcharts, while others coded, but in the end it all had to make sense together. In the sprint 2 and 3 meetings I suggested internal review before uploading to Trello, and that really saved us from mixing old versions. I learnt how important naming, file structure and feedback loops are in team work. Even small things like JSON test files Max made helped us debug faster. Not everything went smooth but the team actually grew more professional through the chaos.

Nicolas:
The main thing I learnt was around UI and waiting on backend guys. Many times in September meetings I couldn't progress cause database wasn't done. I used that time to improve design stuff like colour schemes and dashboard layouts. Working with Max on endpoints and Braydon on visuals helped me understand API calls better. GitHub workflow was a pain sometimes but once we started doing branches for each task, it became better. I think collaborative development taught us patience more than anything. When everyone's parts connect at the end, it's worth all the stress.

6.11. Summary: Final Report & Handover

Part 6 represents the culmination of the ICMMS development lifecycle, uniting the project's engineering depth with its business rollout readiness. Across the subsections, the documentation provides evidence of complete system delivery.

The executive summary outlined the successful integration of Azure App Services, Firebase, and Supabase into a cohesive, cloud-native architecture. The architecture and design pattern analysis proved that maintainability and scalability were achieved through layered and event-driven design, while the predictive cost model translated technical success into measurable financial sustainability over a two-year horizon. The change management plan demonstrated pragmatic rollout sequencing; balancing user resistance, training accessibility, and ongoing support through WhatsApp-based communication and internal champions.

8. Appendices

8.1. Declaration of Authenticity

We, the undersigned members of this project team, collectively declare that this Integrated Construction and Maintenance Management System represents our original collaborative work. AI-assisted tools including Cursor and ChatGPT were utilized to assist with code boiler plating and development efficiency, while all core logic, architecture decisions, and implementations remain our original work. Each team member's contributions have been genuine and appropriately documented. We confirm that this system was developed for our academic coursework and has not been submitted elsewhere for assessment. We acknowledge that we have adhered to all institutional academic integrity policies and ethical guidelines throughout this project. We take collective responsibility for the authenticity and originality of this work.

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Date: 2025/10/10

8.2. Scrum Artifacts

Attached Scrum Meeting Minutes

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