# Proposal for Implementation of a 5G Indoor Testbed with O-RAN and SDRs

**Course Title: AUT BCIS Research & Development Project**

**Course Code: COMP702/703**

**Date: March 5th, 2024**

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# Document Version(s)

|  |  |  |  |
| --- | --- | --- | --- |
| **Version** | **Date** | **Author(s)** | **Changes** |
| V0.0 | 19/03/2024 | Edward Keith | Provided Proposal Templates (ITPM) |
| V1.0 | 19/03/2024 | Chris Escandor | Created initial proposal document |
| V1.1 | 26/03/2024 | Chris Escandor | Compiled and established proposal layout |
| V1.2 | 28/03/2024 | Chris Escandor | Added Terms of Reference  Added Rationale for the Project  Added Objective and Scope  Added Skills and Analysis  Added Team Schedule for Part 1  Added Project Management Methodology or Approach  Added Risk and Issue Management  Added Project Plan  Added Estimated Costs  Added Appendix |
| V1.3 | 29/03/2024 | Chris Escandor | Updated Rationale for the Project |
| V1.4 | 31/03/2024 | Samuel Cathro | Added Table of Contents |
| V1.5 | 31/03/2024 | Chris Escandor | Updated Objective and Scope |
| V1.6 | 31/03/2024 | Kat Milicevic | Updated Problem, Need, or Opportunity and Skills Analysis |
| V1.7 | 01/04/2024 | Kat Milicevic | Added Team Roles |
| V1.8 | 01/04/2024 | Chris Escandor | Updated Objective and Scope |
| V1.9 | 01/04/2024 | William Bigley | Updated Risk and Issue Management |
| V2.0 | 02/04/2024 | Chris Escandor  Samuel Cathro  Kat Milicevic  Edward Keith  William Bigley | Team debriefs proposal progress  Proofreading context and updating team members for further work delegation |
| V2.1 | 02/04/2024 | Kat Milicevic | Updated Risk Register &  Team Schedule (Part 1) |
| V2.2 | 02/04/2024 | William Bigley | Added Relevant Tables to Risk Management |
| V2.3 | 03/04/2024 | Chris Escandor | Updated Skills List |
| V2.4 | 03/04/2024 | Kat Milicevic | Updated Skills Analysis  Updated Team Schedule (Part 2) |
| V2.5 | 04/04/2024 | Chris Escandor  Kat Milicevic  Edward Keith  William Bigley | Updated Skills List  Updated Skills Matrix  Added Hardware and Labour Costing  Functional Requirements + Hardware Spec  Updated Stakeholder Register  General editing/formatting |
| V2.6 | 04/04/2024 | Edward Keith | Updated Skills Matrix, Infrastructure |
| V2.7 | 04/04/2024 | Chris Escandor | Updated Skills Analysis  Updated SecSDLC Project Methodology |
| V2.8 | 05/04/2024 | Kat Milicevic  Chris Escandor | Updated Project Management Methodology or Approach |
| V2.9 | 05/04/2024 | Edward Keith  Samuel Cathro | Updated Skills Matrix and Team Roles, Cost Estimates, Project Methodology |
| V3.0 | 05/04/2024 | Edward Keith | Editing, formatting/alignment |
| V3.1 | 05/04/2024 | Edward Keith  Samuel Cathro | Implemented Gantt Chart, Revision of Cost Estimate Table, formatting |
| V3.2 | 05/04/2024 | Edward Keith | Semi-final edit |
| V3.3 | 05/04/2024 | Chris Escandor | Final edit |

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# Executive Summary

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Our proposed project aims to emulate the implementation of an open-source 5G small cell base-station, leveraging Software Defined Radios (SDRs) and off-the-shelf hardware. The objective is to replicate the functionality described in the paper T ARXIV.ORG: 2205.13178, utilizing a standard laptop/PC and National Instrument B-205-mini SDR (Software Defined Radios) module with appropriate antennas.

* Scope: The project scope encompasses the emulation of both RAN and mobile core network functionalities using open-source software and SDR technology. We will focus on developing software components that replicate the functions of proprietary hardware, ensuring compatibility with existing network infrastructures.
* Time: The project is scheduled to commence immediately upon approval, with a duration of 12 weeks. Weekly progress meetings will be held to track milestones and address any challenges encountered during the development process.
* Method: We will adopt the Security-oriented Software Development Life Cycle (SecSDLC) methodology, emphasising security-oriented practices throughout the development lifecycle. This approach ensures that security considerations are integrated from the initial planning stages to the final deployment phase.
* Risks: Potential risks associated with hardware handling, software compatibility issues, and SDR integration have been identified. Mitigation strategies include proactive risk management measures, regular communication with stakeholders, and contingency planning to address unforeseen challenges.
* Cost: Refer to estimated costs breakdown

# Terms of reference

## Context for the Project:

5G small cell (pico) base-stations can provide advanced features and standalone capabilities for private networks. There are two main parts of a mobile base-station – the radio access network (RAN) and the mobile core network. These parts are typically bundled and sold as proprietary hardware and software. However, the advance in virtualization technologies and commercial off-the-shelf (COTS) hardware has made it possible to implement such a base station using opensource software and Software Defined Radios (SDR).

## 

## Introduction to Client Organization:

The client for this project is **Auckland University of Technology**. The primary contact is Edmund Lai, who is serving as the touchpoint for client interaction.

## 

## Problem, Need, or Opportunity:

Although the technology described by the O-RAN Alliance specifications has been defined and implemented successfully within research and development environments, there does not seem to be straightforward and exhaustive documentation on the technical deployment of a network following the O-RAN architecture.

All existing published research appears to be written for the purpose of dissemination within academic circles, assuming a highly specialised technical knowledge of its reader. We propose that the creation of a freely available and comprehensible record of the implementation of a 5G testbed following O-RAN standards will allow other researchers to access and replicate our project, laying the foundation for further groundwork for flexible, interoperable, and non-proprietary mobile networks.

In addition, we believe that the synthesis of such documentation will allow for easier circulation of the O-RAN architecture and its highly promising applications within amateur or hobbyist communities who might otherwise feel intimidated by a perceived high barrier of entry into this subject matter.

# Project Rationale

The need for this project stems from several key factors within the telecommunications industry, as well as emerging trends in wireless technology and infrastructure.

## Cost Effectiveness:

Traditional 5G small cell base-stations rely heavily on proprietary hardware and software solutions, resulting in high deployment and maintenance costs for network operators. By developing an open-source emulation solution, the project aims to significantly reduce these costs, making 5G infrastructure more accessible and affordable for a wider range of organizations.

## 

## Scalability and Flexibility:

Proprietary solutions often lack the scalability and flexibility required to adapt to evolving network requirements. The open-source emulation approach allows for greater customization and adaptability, enabling network operators to tailor their infrastructure to specific needs and scale operations more efficiently.

## 

## Compatibility and Interoperability:

Existing proprietary systems may face compatibility issues with other network components or protocols, limiting interoperability and hindering seamless integration within larger network ecosystems. The open-source emulation solution aims to address these compatibility challenges by providing standardized interfaces and protocols, enhancing interoperability and facilitating smoother integration with existing network infrastructure.

## 

## Innovation and Collaboration:

Open-source projects foster innovation and collaboration within the industry, enabling developers and researchers to contribute to the advancement of 5G technology collectively. By embracing an open-source approach, the project encourages collaboration among industry stakeholders, driving innovation and accelerating the development of next-generation telecommunications solutions.

## Addressing Market Demand:

There is a growing demand for cost-effective and flexible 5G infrastructure solutions, particularly in sectors such as smart cities, IoT (Internet of Things), and industrial automation. The project aims to capitalize on this market demand by offering an open-source emulation solution that meets the needs of diverse industry verticals, opening new opportunities for deployment and expansion.

## 

## Overcoming Vendor Lock-In:

Vendor lock-in is a common challenge faced by network operators, limiting their ability to switch providers or upgrade equipment without significant cost and disruption. The open-source emulation solution provides an alternative to vendor lock-in, empowering network operators to retain control over their infrastructure and reduce dependency on single vendors.

The project addresses critical issues within the telecommunications industry by offering a cost-effective, scalable, and interoperable solution for implementing 5G small cell base-stations. By embracing open-source principles and fostering collaboration, the project aims to drive innovation, address market demand, and overcome barriers to adoption, ultimately enabling a more accessible and efficient 5G infrastructure landscape.

# Objective and Scope

Our project aims to develop a 5G Indoor Testbed utilising O-RAN and Software Defined Radios (SDRs) to showcase the feasibility of implementing a 5G base-station in indoor environments. By leveraging open-source software and the National Instruments B-205-mini SDR module provided, we seek to provide advanced features and standalone capabilities for private networks in indoor settings. This initiative aligns with our broader goals of advancing telecommunication infrastructure and fostering innovation in wireless network technologies.

Our endeavour is driven by the purpose of demonstrating capabilities of utilizing open-source software and SDRs to implement 5G base-stations. Through this project, we aim to contribute to the advancement of 5G network infrastructure, enabling experimentation and testing of new network functionalities and services in controlled indoor settings.

Throughout the project, we will undertake various tasks to achieve our objectives. This includes studying and understanding the specifications outlined in the provided paper (arxiv.org: 2205.13178), designing the architecture and components of the 5G Indoor Testbed, implementing the system using an open-source software; srsRAN and the provided SDR module, and testing the system’s performance under various scenarios in indoor environments. Additionally, we will document the implementation process, providing setup instructions, configuration details, and testing procedures, and develop a user guide for operating the system. Finally, we will demonstrate the system's capabilities, highlighting its performance and functionality in indoor environments.

Ultimately, our final product will encompass a fully implemented 5G Indoor Testbed, comprehensive documentation detailing the implementation process, a user guide for operating the system, and possibly a pre-install tool to streamline setup and configuration depending on the client’s demands. Through the deliverables of this project, we aim to validate our approach and provide a valuable resource for researchers, developers, and telecommunications professionals interested in advancing 5G network infrastructure.

## High-Level Requirements

Our project will involve the following high-level requirements:

* Implementing O-RAN functionalities for a 5G base-station.
* Integrating Software Defined Radios (SDRs) for radio access.
* Developing software components to control the SDR module and manage network functionalities.
* Testing the system’s performance under various scenarios in indoor environments, using various metrics such as throughput and latency

## Project Requirements:

For our project, we need to:

* Implement the system according to the specifications outlined in the provided paper (arxiv.org: 2205.13178)
* Ensure compatibility with the National Instruments B-205-mini SDR module and appropriate antennas provided.
* Document the implementation process, including setup instructions, configuration details, and testing procedures.
* Provide a user guide for operating the system and a demonstration of its functionalities.
* Demonstration of the system for the client.

## Out of Scope:

Our project will not address the following:

* Implementation of 5G base-station functionalities for outdoor environments.
* Integration with proprietary hardware or software solutions.
* Large-scale deployment or production-ready system setup.

## Functional Requirements:

Our functional requirements include:

* Providing connectivity for user(s) within the network
* Providing connectivity for multiple user devices simultaneously
* Ensuring compatibility with standard 5G protocols and interfaces

## Nonfunctional Requirements:

Our nonfunctional requirements encompass:

* Performance: Achieving high throughput and low latency for data transmission.
* Reliability: Ensuring system availability and stability under varying network conditions.
* Scalability
* Security

## Technical Infrastructure:

* Hardware:
  + Standard laptop/PC: A sufficient computer system that can be used for running the necessary software and tools – both for developing and testing the 5G Indoor Testbed. An Intel NUC would fit this criteria for example.

Minimum hardware requirements as per the research paper:

* 4G testing: 2-core CPU, 4GB RAM, USB3.0
* 5G testing: 8-core CPU, 16GB RAM, 10Gbps NIC
  + National Instruments B-205mini SDR module (supplied by Ettus Research): The primary hardware component for implementing the radio access network (RAN) functionalities of the 5G base-station.
  + Specific antenna and connectors for B-205mini SDR
  + Deliberate USB3.0 Cable for B-205mini SDR
* Software:
  + srsRAN
  + Ubuntu (Linux distribution)
  + Docker/Docker Compose
  + VS Code
  + GitHub
  + Kubernetes
  + Ansible

## Skills Required:

* Hardware Configuration and Integration
* Troubleshooting and Debugging
* Networking skills
* Analytical skills; problem solving, critical thinking and attention to detail
* Project Management
* Documentation and Communication
* Collaboration

## Deliverable Summary:

The deliverable summary for the project includes the following:

## 

## Project Management Deliverable:

* Client scope and objectives
* Team contract
* Project plan
* Project management plan
* Cost analysis
* Proposal
* Proposal presentation
* Meeting minutes
* Stakeholders register
* Gantt chart
* Skills analysis

## Final Product Deliverables:

1. Fully Implemented 5G Indoor Testbed: This includes the complete setup and configuration of the 5G Indoor Testbed using O-RAN principles and Software Defined Radios (SDRs).
2. Comprehensive Documentation: Detailed and comprehensible documentation covering the implementation process, setup instructions, configuration details, and testing procedures. The documentation will serve as a reference guide for users and stakeholders for future development.
3. User Guide: A user guide providing clear instructions on how to operate the 5G Indoor Testbed, including setup, configuration, usage, and troubleshooting tips. The user guide aims to ensure users can effectively utilize the system’s functionalities.
4. Demonstration of System: A demonstration showcasing the capabilities and functionalities of the 5G Indoor Testbed, highlighting its performance and usability in indoor environments. The demonstration will be tailored to meet the requirements and expectations of the project client and stakeholders.
5. Docker Image: A Docker image of the 5G Indoor Testbed, allowing for easy deployment and scalability across different environments. The Docker image ensures consistency and portability of the system’s configuration.
6. Pre-install Tool (potential deliverable based on client requirements): A pre-install tool designed to automate and streamline the setup and configuration process of the 5G Indoor Testbed. The tool aims to simplify the installation process for users and reduce the setup time.

## Milestones and Timeline:

It is key for our project that we have a set of solid milestones and a realistic timeline that the team can adhere to.

* Project kick-off and planning
* Research and Requirements Gathering:
* System Design and Architecture
* Upskilling
* Development and Configuration
* Hardware Configuration and Integration
* Testing and Validation
* Documentation and User Guide
* Demonstration and Client Review
* Finalization and Delivery

The project timeline spans one year, divided into two semesters. Semester one focuses on planning, research, design, upskilling, and initial setup. During this period, the team will initiate a project kick-off, planning, and initial research, followed by dedicated to in-depth research, requirements gathering, system design, and architecture. In weeks 9-12, a dedicated upskilling milestone is achieved, with training sessions and workshops conducted to enhance team members' skills. Initial hardware and software setup tasks are also initiated during this phase. Semester two, shifts focus to development, configuration, integration, testing, documentation, user guide creation, demonstration, and final delivery. Weeks 13-16 are allocated for software development, hardware configuration, integration, testing, and documentation efforts, while weeks 17-18 are dedicated to finalizing deliverables, conducting system demonstrations, and delivering the completed 5G Indoor Testbed to the project client.

## Project Success Criteria:

To ensure the successful delivery of a high-quality product, our team will prioritize effective communication and collaboration. We will hold weekly meetings as a group, often with our mentor and occasional client meetings to discuss progress, making sure we are on track and aligning priorities. During the research phase, we aim to share resources and insights to maximize coverage of relevant topics. Continuous learning will be key, so we plan to dedicate time to upskilling activities, enhancing our capabilities for project challenges.

We will be using secSDLC for our development approach, allowing for frequent feedback loops and adjustments based on stakeholder input. Our focus on quality assurance will involve conducting regular testing and validation to identify and address issues early on. Documenting project progress will facilitate knowledge sharing within the team, ensuring continuity and smooth transitions.

Furthermore, our collaborative relationship with the client will be vital, actively involving them particularly regarding technical feedback and guidance. For instance, the client’s clarity and specificity in outlining the approach to building the testbed, such as utilizing Docker and incorporating 4G LTE technology, will provide valuable direction for our team. Understanding the client’s expectation regarding deliverables ensures alignment with their vision. By actively involving the client in decision-making processes and seeking their input at key milestones, we aim to ensure that our project outcomes will meet or exceed all expectations.

## Constraints:

* Technical Constraints: Integration complexities between O-RAN, SDRs, and other technologies may pose challenges.
* Resource Constraints: Limited budget, time, and access to expertise may impact project progress.
* Scope Changes: Alterations in project requirements or scope could affect deliverables and timeframe.
* Regulatory Constraints: Compliance with radio frequency regulations may introduce obstacles.
* secSDLC Implementation: Strictly adhering to the secSDLC project management approach without flexibility may impact workflow and project execution.

## Assumptions:

* Hardware/Software Access: Assuming availability of required hardware and software for the project implementation.
* Technical Compatibility: Assuming compatibility between various technologies used in the project.
* Resource Constraints: Assuming availability of budget and time resources for project completion.
* Team Collaboration: Assuming effective collaboration among team members throughout the project.
* Team Roles and Deliverables: Assumed that assigned team roles and expectations of deliverables will be established; however, these assignments are subject to change as the project progresses.

# Skills Analysis

* **Familiarity with O-RAN Architecture / Specifications**
  + MAC protocol
  + PHY (physical layer) protocol – modulation schemes, coding schemes, and multiple access techniques such as OFDMA
  + RLC (Radio Link Control) protocol – provides reliability and error correction over the radio interface
  + Interface protocols including E1, F1, and S1, all of which perform different connectivity and communication functions between different network components
  + Near-RT and non-RT Radio Interface Controller functions
* **4G/5G/LTE Technologies and Standards**
  + Deployment scenarios such as network slicing and network function virtualisation (NFV)
  + Knowledge of core network protocols such as NGAP and S1AP for communication between the RAN and core network
  + Proficiency in configuring and managing RAN elements such as base stations, radio units, distributed units, and central units
  + 5G functional splits including 7.2, 7.3, and 7.2x splits, all of which define how base station functions are accomplished by different elements of the network
  + Familiarity with wireless propagation models and radio frequencies
  + PDCP (Packet Data Convergence Protocol)
  + RRC (Radio Resource Control)
  + SCTP (Stream Control Transmission Protocol)
  + GTP-U (GPRS Tunnelling Protocol – User Plane)
* **Network Protocols and Networking Concepts**
  + TCP
  + UDP
  + IP
  + IP routing
  + VLANs
  + Subnetting
  + QoS
  + SSL/TLS
  + Ethernet
  + DHCP
  + DNS
  + SNMP
  + SFTP / FTP
  + TCP/IP and OSI Protocol Suite
  + IPsec
  + Advanced Encryption Protocols
  + Software defined networking
* **Operating System Knowledge**
  + Ubuntu 22.04/Linux familiarity
  + General: Windows/Linux
  + Knowledge of hypervisors
    - Setting up virtualisation support in UEFI/BIOS settings
  + Creation and management of Virtual Machines
    - Disk partitioning
    - Installation of guest OSes
  + Containerisation technologies
    - Creating, pushing, pulling images to/from repositories
    - Familiarity with writing Docker files (i.e. Docker syntax) to define dependencies and the build steps of a container image
    - Container lifecycle and image management
  + Dual boot configuration of a guest and native OS
  + IDE familiarity (VS Code, VIM, PyCharm etc)
  + Shell scripting
  + Automation Tools (Ansible, Kubernetes)
* **Soft skills**
  + Comprehensive documentation abilities
  + Technical writing skills
  + Document design/outlining
  + Ability to create and modify test plans
  + Collaboration/teamwork
  + Knowledge of IT project management principles

## Skills Analysis Rubric

To create the following chart the team compiled a list of relevant skills for our project, categorizing each one based-on expertise levels using the provided colour scheme below:

|  |  |  |  |
| --- | --- | --- | --- |
| **SKILL LEVEL** | **RUBRIC** | | |
| No experience |  | No awareness of concept or very little usage |
| Basic Understanding |  | Introductory or theoretical understanding of the concept |
| Intermediate Understanding |  | Used for university work or basic personal projects |
| Advanced Understanding |  | Paid work or deliberate use on advanced/multiple personal projects |

## Team specific skills

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SKILLS LIST** | **PROFICIENCY** | | | | |
|  | Chris | Edward | Katarina | Samuel | William |
| **O-RAN ARCHITECTURE AND SPECIFICATIONS** | | | | | |
| MAC protocol |  |  |  |  |  |
| PHY (Physical layer) protocol |  |  |  |  |  |
| RLC (Radio Link Control) |  |  |  |  |  |
| Interface Protocols |  |  |  |  |  |
| Near-RT and non-RT Radio |  |  |  |  |  |
| **4G/5G/LTE TECHNOLOGIES AND STANDARDS** | | | | | |
| Network Function Virtualization |  |  |  |  |  |
| NGAP and S1AP Protocols |  |  |  |  |  |
| Manage/configure RAN |  |  |  |  |  |
| 5G functional splits |  |  |  |  |  |
| Wireless propagation models |  |  |  |  |  |
| Packet Data Convergence |  |  |  |  |  |
| Radio Resource Control |  |  |  |  |  |
| Stream Control Transmission |  |  |  |  |  |
| GPRS Tunnelling Protocol |  |  |  |  |  |
| **NETWORK PROTOCOLS AND CONCEPTS** | | | | | |
| TCP |  |  |  |  |  |
| UDP |  |  |  |  |  |
| IP |  |  |  |  |  |
| IP routing |  |  |  |  |  |
| VLANs |  |  |  |  |  |
| Subnetting |  |  |  |  |  |
| QoS |  |  |  |  |  |
| SSL/TLS |  |  |  |  |  |
| Ethernet |  |  |  |  |  |
| DHCP |  |  |  |  |  |
| DNS |  |  |  |  |  |
| SNMP |  |  |  |  |  |
| SFTP/FTP |  |  |  |  |  |
| TCP/IP and OSI Protocol Suite |  |  |  |  |  |
| IPsec |  |  |  |  |  |
| Advanced Encryption Protocols |  |  |  |  |  |
| Software Defined Networking |  |  |  |  |  |
| **OPERATING SYSTEM KNOWLEDGE** | | | | | |
| Linux/Ubuntu 22.04 |  |  |  |  |  |
| Windows/OSX |  |  |  |  |  |
| Hypervisors |  |  |  |  |  |
| Virtual Machines |  |  |  |  |  |
| Containerization technologies |  |  |  |  |  |
| Dual boot configuration |  |  |  |  |  |
| IDE familiarity |  |  |  |  |  |
| Shell scripting |  |  |  |  |  |
| Automation Tools |  |  |  |  |  |
| **SOFT SKILLS** | | | | | |
| Comprehensive Documentation |  |  |  |  |  |
| Technical writing skills |  |  |  |  |  |
| Document design/outlining |  |  |  |  |  |
| Create and modify test plans |  |  |  |  |  |
| Collaboration/teamwork |  |  |  |  |  |
| Knowledge of ITPM principles |  |  |  |  |  |

It was crucial for our team to compile a comprehensive skills list and for each member to transparently indicate their proficiency levels for several reasons (particularly within the context of our project). Firstly, this process allows us to assess our collective strengths and weaknesses, facilitating better resource allocation and task delegation as we navigate the complexities of implementing a 5G Indoor Testbed with O-RAN and SDRs. For instance, by knowing that one team member has advanced knowledge in Docker containerization while another excels in 5G networking protocols, we can allocate tasks accordingly to leverage their individual expertise more effectively. Moreover, having a detailed skills inventory enables us to identify potential knowledge gaps and develop tailored training plans for each team member, ensuring that everyone has the necessary capabilities to contribute effectively to the project's success.

## Training Plan

In developing our training plan, we understand that it may not be highly detailed or exhaustive due to only having the broad strokes of what we need to learn. However, we recognize the necessity of identifying and acquiring specific skills essential for our project's success. This includes a comprehensive understanding of 5G technologies, O-RAN architecture, and Software Defined Radios (SDRs), which form the backbone of our project. Additionally, proficiency in containerization technologies such as Docker and knowledge of virtualization and virtual machine (VM) management are crucial for setting up our testbed environment efficiently and repeatedly. By focusing on these key areas, we will ensure that our team is equipped with the necessary expertise to tackle the project's challenges effectively. Through targeted learning and practical application of the skills mentioned above, we aim to build a strong knowledge foundation, enabling us to navigate the complexities of our project with confidence.

We have already initiated knowledge-sharing efforts within our team and are committed to continuing this practice throughout the project. By facilitating knowledge transfer and sharing resources through various means such as documentation, crash courses, related articles, videos, and workshops, we ensure that everyone has access to relevant information and learning materials. This proactive approach to information sharing is crucial, especially for a project as technical as ours, where staying updated on the latest developments and acquiring new skills will be essential for success.

# Team Roles

|  |  |  |
| --- | --- | --- |
| **Role** | **Responsibilities** | **Team Member** |
| Team Leader | Leads decision making, role assignment and task delegation | Will |
| Client/Mentor Touchpoint | Communicating and coordinating meetings and equipment handover between the team and client/mentor/stakeholders | Chris/Edward |
| SDR Engineering | Configuring and operating the physical USRP B-205mini unit and the accompanying srsRAN control software | Sam/Chris |
| Container Engineering | Container setup and automation for the testbed. Dockerfiles, Ansible playbooks and Kubernetes testing. Hardware compatibility and OS imaging. | Edward/Sam |
| Network Engineering | Configuring and setting up network, troubleshooting 5G testbed network infrastructure, logging faults and network performance testing. | Kat/Sam |
| Documentation (Specialised) | Documenting the setup process, including all configuration, diagnosing and debugging issues | Will/Kat |
| Documentation (Deliverables) | Document preparation for proposal, pitch decks, meeting minutes, client deliverables | All |

# Team Schedule for Part 1

Sprint 1: Weeks 1 – 4 : Upskilling and research

Sprint 2: Weeks 5 – 6: Startup; initial configuration

Sprint 3: Weeks 7 – 8: System & Architecture Design

**Mid-semester Break**

Sprint 4: Weeks 9 – 10: Hardware Configuration

Sprint 5: Weeks 11- 12 : Planning of Documentation & User Guide

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sprint** | **Weeks** | **Name** | **Description** | **Relevant Milestones** |
| **1** | 1 – 4 | Upskilling | This period will be dedicated to upskilling and researching. This includes familiarising ourselves with srsRAN, the O-RAN architecture, and any relevant operating systems and hardware which will be used in the project. | Kick-off meetings: mentor/team, client/team, and team only |
| **2** | 5 - 6 | Startup & Initial Configuration | This sprint will see the initial configuration of all hardware components of the 5G testbed. | Installation of srsRAN software on properly configured systems.  Basic configuration of the SDR module for compatibility with srsRAN. |
| **3** | 7 - 8 | System & Architecture Design | Within this sprint, the project focus will shift to the design of the system architecture before its implementation. | Creation of system architecture which will reflect the configuration of the network testbed and be included in documentation/deliverables. |
| **4** | 9 – 10 | Hardware Configuration | This sprint will focus on the configuration and optimisation of the hardware components. It will involve enhancing performance of the SDR module and srsRAN software and fine-tuning radio frequency parameters. | Verification of communication between the SDR module and the srsRAN controller.  Comprehensive configuration of the USRP SDR module |
| **5** | 11 – 12 | Planning of Documentation & User Guide | This phase involves the planning of the documentation which describes the configuration of our network and serve as the final deliverable for the project. | Creation of an easily legible and well-structured outline for the documentation deliverable. |

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# Project Management Methodology/Approach

We have chosen to use the **secSDLC** project management methodology, with risk management practices at the forefront of our decision. This method involves identifying specific threats and risks to the project, and the subsequent design and implementation of specific controls to counter threats and manage potential risks. SDLC defines the general methodology for design and implementation of an information system in an organisation.   
  
Our project's role as a proof-of-concept for a research paper underscores the need to ensure the integrity and reliability of our system. While our project may not involve proprietary information or require non-disclosure agreements (NDAs), prioritizing security measures remains crucial.

## secSDLC Project Application Phases

## Initiation

* + **Agenda(s)**:
  + Identifying the scope of the project and hold kick-off meetings with stakeholders.

**secSDLC Integration:** Include security considerations in defining project scope and objectives to ensure that security requirements are established from the beginning.

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## Planning/Analysis

* + **Agenda(s):**
  + Identifying requirements and objectives for the 5G network testbed based on directives from mentor/client.
  + Gathering relevant resources, familiarizing ourselves with relevant technologies, and identifying risks.
  + Establish a team plan.
  + Create a comprehensive project proposal

**secSDLC Integration:** Risk assessment, identifying potential security threats and vulnerabilities. Defining security procedures and tools necessary for the project and incorporating them into the team plan and proposal.

## Development: Logical design

* + **Agenda(s):**
  + Determining design specifications based on functional requirements defined in the planning/analysis phase including tools needed for the project.

**secSDLC Integration:** Requirement analysis, threat/risk modelling, implementing “on-the-go" documentation would provide immediate references, real-time updates for the whole team, risk mitigation and the emphasized knowledge transfer.

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## Development: Physical design

* + **Agenda(s):**
  + Evaluating the necessary tools and technology that is needed to support the security blueprint. Further research will be done to explore the various solutions as well as generate alternative solutions. Once assessed, the team will come together and agree upon a final decision.
  + Designing the physical network topology, incorporating and prioritising security concerns revealed during the logical design phase

**secSDLC Integration:** Design implications with the physical network topology would be considered, ensuring that security measures are implemented in the layout and connectivity of the network.

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## Implementation/Deployment

* + **Agenda(s):**
  + Compiling and putting the project infrastructure together
  + Comprehensive documentation.
  + Creating user guides, and any other deliverables we come up with.

**secSDLC Integration:** Implementing security controls during the deployment such as proper configurations, secure deployment practices, continuous documentation.

# Risk and Issue Management

Risks associated with hardware handling, software compatibility issues, and SDR integration will be identified and mitigated by the team, through proactive risk management strategies (in line with our secSDLC methodology) and general troubleshooting.

## Risk Register

|  |  |
| --- | --- |
| **Risk Name** | **Risk Management Plan** |
| Lack of Resources (Hardware) | All hardware required for the project will be provided by the client or mentor. If difficulty procuring hardware occurs, the team will collectively liaise with the client/mentor and set a meeting to obtain necessary hardware. |
| Incompatibility between hardware, software, or other components | The team will collaborate to troubleshoot and debug any incompatibility that should arise between hardware, software, and operating systems used. |
| Lack of software support | This issue can arise when using srsRAN software which may not have adequate support documentation for its use in our specific purposes. In these cases, the team will combine efforts to synthesize all online resources and leverage our own expertise and knowledge to attempt to troubleshoot the necessary configurations. |
| Inability to communicate regularly with mentor/client | The team will combine efforts to set up meetings and establish communication with the client/mentor, however, this may prove difficult due to busy schedules on both sides. The team will put forth their best effort to make the most of all mentor/client meetings, no matter how infrequent, preparing an agenda and adhering to it during meetings. |
| Lack of contact between group members | The team will schedule regular meetings between each other and keep in contact via Teams, ensuring that all members are present whenever possible. If a member is unable to make a meeting, another team member will take diligent meeting minutes which will be made available in the team documents. |

## 

## 1. Monitor and Control Process

A proactive approach will be used to monitor and control risks and issues that present themselves throughout the development of this project. This process will include risk assessments, communication withing the team and appropriate mitigation actions.

## 2. Risk Management Plan

**2.1 Identification of Risks**

Risks will be identified through brainstorming, documentation review and continuous monitoring of the project. Any potential for risks or issues identified by a team member should bring it up with the rest of the team during our weekly meetings. An example of this would be software compatibility with the products we are using.

**2.2 Analysis of Risks**

Once a risk is identified, it will be analysed based on its potential impact and likelihood of occurrence. The risks will be categorised into low, medium and high severity based on their potential likelihood and consequences.

**2.3 Mitigation Strategies**

For each of the identified risks, mitigation strategies will be made to reduce the impact of the risk or reduce the likelihood of occurrence. These mitigation strategies will include preventative measures, contingency plans and risk transfer strategies.

**2.4 Risk Response Plan**

A risk response plan will be developed and will outline the specific actions to be taken in response to each identified risk. It will also include triggers for implementing the mitigation actions, escalation procedures and criteria for revaluation of risks over the course of the project.

## 3. Measure of Consequence

The consequences of the identified risks will be measured based on their impact on project objectives, schedule, budget and quality. These consequences will be assessed to prioritise the risk response efforts.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Level | Description |  |
| Catastrophe | 1 | Significant impact on the project. Loss of software functionality and irreparable damage to hardware. Will put the project to a halt. |  |
| Major | 2 | Major impact on the project. Loss of software/hardware functionality. Will delay the project while the response is undertaken. |  |
| Moderate | 3 | Will have an impact on the project and can be handled by mitigation processes already in place. |  |
| Minor | 4 | Minor impact on the project. Can cause loss of functionality but entirely manageable and preventable. |  |
| Insignificant | 5 | Insignificant impact on the project. Not worth worrying about |  |

## 4. Measure of Likelihood

The likelihood of risks occurring will be assessed based on current project conditions, historical data and overall judgement of the risk. Risks with higher likelihood will be given priority and greater attention in the risk management process.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Almost Certain | Likely | Possible | Unlikely | Rare |
| Description | Is expected to occur during the project. | Will probably occur during the project. | Might occur during the project. | Small chance of occurring during project. | Is not expected to occur during the project. |

## 5. Overall Risk Classification

The risks for this project will be classified based on their overall severity, which is based on their consequences and likelihood. This classification will ensure prioritisation of risk response efforts and resources directed towards these risk management activities.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Consequence | | | | |
| Likelihood | Catastrophe | Major | Moderate | Minor | Insignificant |
| Almost Certain | Extreme | Extreme | High | Medium | Low |
| Likely | Extreme | Extreme | High | Medium | Low |
| Possible | High | High | Medium | Low | Low |
| Unlikely | Medium | Medium | Low | Low | Low |
| Rare | Low | Low | Low | Low | Low |

## 6. Issue Management

**6.1 Issue Identification**

Issues will be identified through regular meetings, reports and communication within the team. Any deviation from the project plan, unforeseen challenges/roadblocks will be documented for further investigation and resolution.

**6.2 Issue Analysis**

Once issues are identified, they will be analysed to determine their cause, how they impact the project's objective and any potential solutions. Our team will collaborate and assess each issue and determine its severity and prioritise them based on urgency and impact.

**6.3 Issue Resolution Plan**

An issue resolution plan will be developed to address each identified issue. This plan will include specific actions to be taken, timelines for each resolution and the criteria for evaluating the effectiveness of the proposed solutions to each issue.

## 7. Constraints and Assumptions

Constraints and assumptions related to the risk and issue management will be documented to provide context for decision-making and risk response planning. Constraints will include things such as budget, resource limitations and requirements, whereas assumptions will include things such as the project timeline, stakeholder expectations and other dependencies.

**See page 15 for more specifics.**

# Project Plan - a schedule for the entire project

Sprint 1: Weeks 1 – 4: Upskilling and research

Sprint 2: Weeks 5 – 6: Startup; initial configuration

Sprint 3: Weeks 7 – 8: System & Architecture Design

**Mid-semester Break**

Sprint 4: Weeks 9 – 10: Hardware Configuration

Sprint 5: Weeks 11- 12: Planning of Documentation & User Guide

**Winter Holiday Break**

Sprint 6: Weeks 13 – 14: Software Installation & Setup

Sprint 7: Weeks 15 – 16: First round of testing and integration

Sprint 8: Weeks 17 – 18: Network Configuration

**Mid-semester Break**

Sprint 9: Weeks 19 – 20: Functional Testing and Validation

Sprint 10: Weeks 21 – 22: Performance Evaluation, Benchmarking, and Optimisation

Sprint 11: Weeks 23 – 24: Documentation Finalisation and Client Approval

# GANTT Chart

|  |  |  |  |
| --- | --- | --- | --- |
| **Task Name** | **Duration** | **Start** | **Finish** |
| **Pre-Project Initiation** | **7 days** | **Fri 1/03/24** | **Tue 12/03/24** |
| **Team Forming** | **7 days** | **Fri 1/03/24** | **Tue 12/03/24** |
| Kick-off Meeting | 1 day | Fri 1/03/24 | Mon 4/03/24 |
| Create Team Contract | 4 days | Fri 1/03/24 | Thu 7/03/24 |
| Create Team Availability Sheet | 5 days | Fri 1/03/24 | Fri 8/03/24 |
| Start Skill Analysis | 6 days | Fri 1/03/24 | Mon 11/03/24 |
| Assign team roles | 7 days | Fri 1/03/24 | Tue 12/03/24 |
| **Project Initiating** | **10 days** | **Fri 1/03/24** | **Fri 15/03/24** |
| First Mentor Meeting | 1 day | Fri 1/03/24 | Mon 4/03/24 |
| Update team availability sheet | 1 day | Fri 1/03/24 | Mon 4/03/24 |
| Create Project Charter | 2 days | Mon 4/03/24 | Wed 6/03/24 |
| **Set up first meeting with Client** | **6 days** | **Wed 6/03/24** | **Thu 14/03/24** |
| Research and Prepare for client meeting | 5 days | Wed 6/03/24 | Wed 13/03/24 |
| Create meeting agenda | 1 day | Wed 13/03/24 | Thu 14/03/24 |
| First Client Meeting | 1 day | Thu 14/03/24 | Fri 15/03/24 |
| Understand the project brief and research solutions | 5 days | Fri 1/03/24 | Fri 8/03/24 |
| **Project Planning** | **24.41 days** | **Fri 1/03/24** | **Fri 5/04/24** |
| Prepare Project Proposal and assign proposal tasks | 1 day | Fri 1/03/24 | Mon 4/03/24 |
| Create Terms of reference and Rationale of project | 1 day | Fri 1/03/24 | Mon 4/03/24 |
| **Detailed project objective and scope** | **1 day** | **Fri 15/03/24** | **Mon 18/03/24** |
| Define project objective and success criteria | 1 day | Fri 15/03/24 | Mon 18/03/24 |
| Identify functional requirement and non-functional requirements | 1 day | Fri 15/03/24 | Mon 18/03/24 |
| Identify technical infrastructure and skill requirement | 1 day | Fri 15/03/24 | Mon 18/03/24 |
| Skill analysis is created | 1 day | Fri 15/03/24 | Mon 18/03/24 |
| Finalise project team roles | 1 day | Fri 15/03/24 | Mon 18/03/24 |
| **Project management methodology** | **2.76 days** | **Mon 18/03/24** | **Wed 20/03/24** |
| Identify the best suited project management methodology for the project | 1 day | Mon 18/03/24 | Tue 19/03/24 |
| Create a Work breakdown Structure (WBS) | 1 day | Mon 18/03/24 | Tue 19/03/24 |
| Create a Quality Assurance Plan (QA) | 1 day | Tue 19/03/24 | Wed 20/03/24 |
| **Stakeholder Identification** | **2.88 days** | **Thu 21/03/24** | **Tue 26/03/24** |
| Create a Stakeholder Register | 1 day | Thu 21/03/24 | Fri 22/03/24 |
| Create a Stakeholder management Strategy | 1 day | Mon 25/03/24 | Tue 26/03/24 |
| **Risk and issues management Plan** | **2.76 days** | **Wed 27/03/24** | **Fri 29/03/24** |
| Create a Risk Register | 2 days | Wed 27/03/24 | Fri 29/03/24 |
| Create a issue log | 2 days | Wed 27/03/24 | Fri 29/03/24 |
| **Project Plan** | **3 days** | **Mon 1/04/24** | **Thu 4/04/24** |
| Create a Gant Diagram | 3 days | Mon 1/04/24 | Thu 4/04/24 |
| Project Costs Estimate | 1 day | Wed 3/04/24 | Thu 4/04/24 |
| Finalise project proposal | 1 day | Thu 4/04/24 | Fri 5/04/24 |
| Prepare Project Proposal Presentation | 4 days | Fri 1/03/24 | Thu 7/03/24 |
| **Project Execution** | **133 days** | **Mon 8/04/24** | **Tue 22/10/24** |
| **Setup Developer Environment** | **9.71 days** | **Mon 8/04/24** | **Mon 22/04/24** |
| Understand use of Docker | 5 days | Mon 8/04/24 | Mon 15/04/24 |
| Understand use of SDR toolsets | 5 days | Mon 15/04/24 | Mon 22/04/24 |
| **Setup Hardware Physical Environment** | **1.94 days** | **Mon 22/04/24** | **Wed 24/04/24** |
| Setup Workstation | 1 day | Mon 22/04/24 | Tue 23/04/24 |
| Setup Ettus Research B205 Mini | 1 day | Tue 23/04/24 | Wed 24/04/24 |
| Configure Device | 88 days | Wed 24/04/24 | Mon 2/09/24 |
| Create Documentation and User Guide | 10 days | Tue 3/09/24 | Tue 17/09/24 |
| Software installation and Setup | 3 days | Tue 17/09/24 | Fri 20/09/24 |
| Begin testing and integration | 15 days | Mon 23/09/24 | Mon 14/10/24 |
| Network Configuration | 5 days | Tue 15/10/24 | Tue 22/10/24 |
| **Project Closure and Handover** | **12.24 days** | **Tue 22/10/24** | **Fri 8/11/24** |
| **Final documentation and reflective reports** | **12.24 days** | **Tue 22/10/24** | **Fri 8/11/24** |
| Prepare final portfolios | 5 days | Tue 22/10/24 | Tue 29/10/24 |
| prepare reflective report | 2 days | Wed 30/10/24 | Fri 1/11/24 |
| Prepare project portfolio poster | 3 days | Mon 4/11/24 | Thu 7/11/24 |
| Conduct project presentation and conduct a closure meeting | 0 days | Fri 8/11/24 | Fri 8/11/24 |
| **Project Handover** | **0 days** | **Fri 8/11/24** | **Fri 8/11/24** |

# Cost Estimate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Implementation of a 5G Indoor Testbed with O-RAN and SDRs** | | | | | |
| **Project Management** | Hours | $ Cost p/h  (Excl GST) | $ Subtotal (Excl GST) | $ Subtotal (Incl GST) | Source |
| *Project Manager* | 360 | 350.00 | 126,000.00 | 144,900.00 |  |
| *Project Team Members* | 1440 | 120.00 | 172,800.00 | 198,720.00 | *(15 hours Per Week Per Member)* |
| *Mentor* | 26 | 142.00 | 3,692.00 | 4,245.80 | Information provided by AUT |
| Total Team Cost |  |  | 302,492.00 | 347,865.80 |  |
| **Hardware** | Item Qty | $ Cost Per (Excl GST) | $ Subtotal (Excl GST) | $ Subtotal (Incl GST) |  |
| *Ettus Research B205mini SDR Kit* | 1 | 2,555.70 | 2,555.70 | 2,939.06 | (1) |
| *VERT900 VERTICAL ANTENNA* | 2 | 184.83 | 369.66 | 425.11 | (2) |
| *SMA Plug to Reverse SMA Socket Adaptor* | 2 | 9.13 | 18.26 | 21.00 | (3) |
| *Intel Nuc* | 1 | 599.00 | 599.00 | 688.85 | (4) |
| *LG 24MR400-B 24" FHD Monitor* | 1 | 149.00 | 149.00 | 171.35 | (5) |
| *Keyboard and Mouse* | 1 | 26.08 | 26.08 | 29.99 | (6) |
| Total Hardware Cost |  |  | 3,717.70 | 4,275.36 |  |
| **Software** | Item Qty | $ Cost Per (Excl GST) | $ Subtotal (Excl GST) | $ Subtotal (Incl GST) |  |
| *Ubuntu 22.04.4 LTS* | 1 | - | - | - | (7) |
| *Docker Student Ed.* | 1 | - | - | - | (8) |
| Total Software Cost |  |  | - | - |  |
| **Testing Costs** |  |  | $ Subtotal (Excl GST) | $ Subtotal (Incl GST) | *10% of Hardware and Software* |
|  |  |  | 371.77 | 427.54 |  |
| **Cash Reserve** |  |  | $ Subtotal (Excl GST) | $ Subtotal (Incl GST) | *20% of Total Project Cost* |
|  |  |  | 367,897.76 | 423,082.43 |  |
|  | | | | | |
| **Total Project Cost Estimate** |  |  | 674,479.23 | 775,651.12 |  |

1. <https://www.digikey.co.nz/en/products/detail/digilent-inc/6002-410-021/13282612>
2. <https://www.digikey.co.nz/en/products/detail/ni/782773-01/16818596?s=N4IgTCBcDaIG4FMBOAXAnABgyAugXyA>
3. <https://www.jaycar.co.nz/sma-plug-to-reverse-sma-socket-adaptor/p/PA0630?pos=1&queryId=07aad81ba347a97d17a099924c06b808&sort=relevance&searchText=PA0630>
4. <https://www.pbtech.co.nz/product/BPCINT92501/Intel-NUC11-Tiger-Canyon-Pro-Kit-i5-1135G7-Mini-PC>
5. <https://www.pbtech.co.nz/product/MONLGL124240/LG-24MR400-B-24-FHD-Monitor-1920x1080---IPS---HDMI>
6. <https://www.pbtech.co.nz/product/KEYJ5C1002/J5create-USB-Wired-Keyboard-and-Mouse-Combo>
7. <https://ubuntu.com/desktop>
8. <https://www.docker.com/pricing>

# Stakeholder Register

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Position** | **Context** | **Project Role** | **Contact Information** |
| **Edmund Lai** | Project Client | Internal | Provide project scope and feedback | <edmund.lai@aut.ac.nz> |
| **Bobby Yang** | Project Mentor | Internal | Provide project guidance and feedback | <bobby.yang@aut.ac.nz> |
| **Nurul Sakar** | Project Moderator | Internal | Provide project feedback and assessment marking | <nurul.sarkar@aut.ac.nz> |
| **Chris Escandor** | Student | Internal | Communicate / coordinate meetings and equipment handover between the team and stakeholders | [tpy2351@autuni.ac.nz](mailto:tpy2351@autuni.ac.nz) |
| **Edward Keith** | Student | Internal | Configure network, troubleshoot 5G testbed network infrastructure, container setup and automation | [rkh0526@autuni.ac.nz](mailto:rkh0526@autuni.ac.nz) |
| **Katarina Milicevic** | Student | Internal | Document setup process, include all configuration, diagnosing and debugging | [ksy5103@autuni.ac.nz](mailto:ksy5103@autuni.ac.nz) |
| **Samuel Cathro** | Student | Internal | Configure/operate USRP B-205mini unit and accompanying srsRAN control software | [zjq6910@autuni.ac.nz](mailto:zjq6910@autuni.ac.nz) |
| **William Bigley** | Student | Internal | Lead decision making, role assignment and task delegation | [nhh8869@autuni.ac.nz](mailto:nhh8869@autuni.ac.nz) |
| **AUT** | Client & Sourcing | Internal | Provides resources and environment for project | [https://aut.ac.nz](https://aut.ac.nz/) |

# Appendix

## AUT BCIS R&D Disclaimer

**Appendix I**

**Auckland University of Technology**  
**Bachelor of Computer & Information Sciences**  
**Research & Development Project**

**Disclaimer:**

**Clients should note the general basis upon which the Auckland University of Technology undertakes its student projects on behalf of external sponsors:**

*While all due care and diligence will be expected to be taken by the students, (acting in software*  
*development, research or other IT professional capacities), and the Auckland University of*  
*Technology, and student efforts will be supervised by experienced AUT lecturers, it must be*  
*recognised that these projects are undertaken in the course of student instruction. There is*  
*therefore no guarantee that students will succeed in their efforts.*

*This inherently means that the client assumes a degree of risk. This is part of an arrangement,*  
*which is intended to be of mutual benefit. On completion of the project it is hoped that the client*  
*will receive a professionally documented and soundly constructed working software application,*  
*some part thereof, or other appropriate set of IT artefacts, while the students are exposed to live*  
*external environments and problems, in a realistic project and customer context.*

*In consequence of the above, the students, acting in their assigned professional capacities and*  
*the Auckland University of Technology, disclaim responsibility and offer no warranty in respect*  
*of the “technology solution” or services delivered, (e.g. a “software application” and its*  
*associated documentation),both in relation to their use and results from their use.*