

# Open-Source Prototyping of 5G-and-Beyond Wireless Systems

DESIGN DOCUMENT

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# Executive Summary

## Development Standards & Practices Used

- IEEE and SESC software development standards
- Continuous Integration/ Continuous Development

## Summary of Requirements

- Learn about 5g
- Implementation of 5g algorithm on:
  - srsLTE
  - USRP
  - Powder
  - COSMOS
  - AERPAW
- Refinement of algorithm

## Applicable Courses from Iowa State University Curriculum

- SE 329
- CPRE/EE 185

## New Skills/Knowledge acquired that was not taught in courses

- 5g infrastructure

List all new skills/knowledge that your team acquired which was not part of your Iowa State curriculum to complete this project.

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**List of figures/tables/symbols/definitions** (This should be the similar to the project plan)

# 1 Introduction

## 1.1 ACKNOWLEDGEMENT

We would like to acknowledge Professor Zhang for the research resources he has provided us as well as the advice he will be providing us with for the remainder of the project.

## 1.2 PROBLEM AND PROJECT STATEMENT

Problem statement: Advancements in 5G technology have led to an increase in demand for qualified engineers with the ability to develop and prototype advanced wireless solutions. 5G wireless networks are expected to enable not only Gbps mobile connectivity but also machine-type communications for smart agriculture, connected and automated vehicles, smart grid, Industry 4.0, and AR/VR. 5G wireless is projected to reach a market size of \$250 billion by 2025, and it has been attracting significant investment from industry and government worldwide.

Solution approach: Through this project, team members will get hands on experience with the development and implementation of advanced wireless 5G algorithms. As a part of the project, members will get to use platform technologies such as srsLTE, USRP software defined radios, and at scale wireless testbeds.

Project outputs: Experience with platform technologies and testbeds. Knowledge of advanced wireless 5G algorithms, and implementation of these algorithms through at scale wireless testbeds.

## 1.3 OPERATIONAL ENVIRONMENT

Our project will operate in a software environment. We will have an open-source software platform and a testbed in which it will exist.

## 1.4 REQUIREMENTS

### Functionality

- Ensures schedule efficiency and must utilize an efficient time allocation process
- RAN and Mobile core unity; ensures communication between base stations and the mobile core

User Interface: Users of our product must be able to access and use the modified algorithm for academic purposes.

## 1.5 INTENDED USERS AND USES

The product will be used for research purposes and other areas of academia. Therefore, the users will be primarily researchers, educators, and students.

## 1.6 ASSUMPTIONS AND LIMITATIONS

- Assumptions:
  - Our research will be used by other researchers in the 5G systems field.
  - Our test environment will apply to real life situations
  - As a team we have the required skills or the ability to obtain the required skills to complete the project.
- Limitations:
  - Lack of time (need to be done by December)
  - Lack of access to physical RAN
  - Lack of knowledge in the field of advanced wireless algorithms and technologies.
  - This technology is very new so there is not much information or infrastructure for it.

## 1.7 EXPECTED END PRODUCT AND DELIVERABLES

Deliverables: Wireless testbed setup, at scale testbed implementation of an advanced 5G wireless algorithm.

- The team will be implementing a simple wireless algorithm on an at scale wireless testbed to gain understanding of algorithm testing using at scale wireless testbeds. This will set the foundation for further analysis and testing of advanced wireless algorithms. To be implemented April 30, 2021
- With the testbed setup complete, the team will refine and test advanced dynamic algorithms. Expected implementation date, Nov 1, 2021.

## 2 Project Plan

### 2.1 TASK DECOMPOSITION

- Complete Research
  - Cover given reference materials on 5g
- Tools Setup
  - Set up GitLab
    - CI/CD setup
  - Website setup
  - Testbed setup
- Implement/refine algorithm using srsLTE
  - Begin with simple implementation of wireless algorithm
  - Begin implementation of advanced wireless algorithms
  - Analyze testbed results
  - Refine the algorithm
  - Retest
- Refine algorithm using Powder

### 2.2 RISKS AND RISK MANAGEMENT/MITIGATION

The nature of the project is purely/mostly software based as we are going to be developing algorithms. Therefore, our primary risk is code that does not work 100% of the time for all usage.

The probability of our code not fitting all scenarios is 1.00 as it is almost impossible for our algorithm to cover everything that 5g can be provided. An obvious mitigation of this is to include as much code testing as possible or at least till we deem it satisfactory.

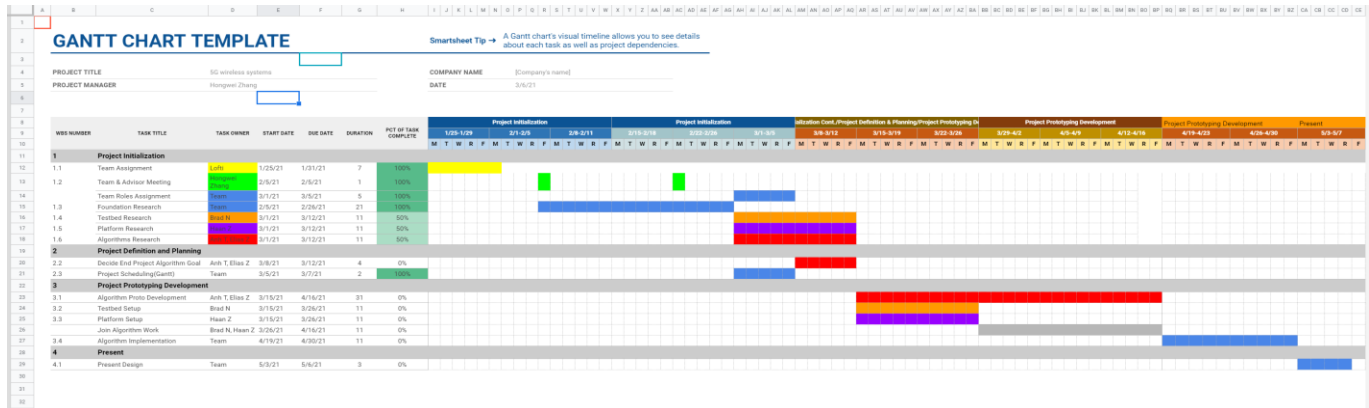
### 2.3 PROJECT PROPOSED MILESTONES, METRICS, AND EVALUATION CRITERIA

Milestones:

1. Complete research
2. Finish tools setup
3. Implement simple code on platform
4. Prototype of algorithm
5. Finished algorithm

Progress metric will be time spent on the given task.

## 2.4 PROJECT TIMELINE/SCHEDULE



## 2.5 PROJECT TRACKING PROCEDURES

Github, MS Team, Gantt Chart(Google Excel)

## 2.6 PERSONNEL EFFORT REQUIREMENTS

Members	Anh To	Brad Norman	Hann Zilmer	Elias Zougmore
Time (Coding)	9hr	9hr	9hr	9hr
Hours/Week				

## 2.7 OTHER RESOURCE REQUIREMENTS

- Internet access
- Personal computers
- SrsLTE
- Reference Materials
- At scale wireless testbeds

## 2.8 FINANCIAL REQUIREMENTS

NA



## 3 Design

### 3.1 PREVIOUS WORK AND LITERATURE

Include relevant background/literature review for the project

- If similar products exist in the market, describe what has already been done
- If you are following previous work, cite that and discuss the **advantages/shortcomings**
- Note that while you are not expected to “compete” with other existing products / research groups, you should be able to differentiate your project from what is available

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

### 3.2 DESIGN THINKING

Detail any design thinking driven design “define” aspects that shape your design. Enumerate some of the other design choices that came up in your design thinking “ideate” phase.

### 3.3 PROPOSED DESIGN

Include any/all possible methods of approach to solving the problem:

- Discuss what you have done so far – what have you tried/implemented/tested?
- Some discussion of how this design satisfies the **functional and non-functional requirements** of the project.
- If any **standards** are relevant to your project (e.g. IEEE standards, NIST standards) discuss the applicability of those standards here
- This design description should be in **sufficient detail** that another team of engineers can look through it and implement it.

### 3.4 TECHNOLOGY CONSIDERATIONS

Highlight the strengths, weakness, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

### 3.5 DESIGN ANALYSIS

- Did your proposed design from 3.3 work? Why or why not?
- What are your observations, thoughts, and ideas to modify or iterate over the design?

### 3.6 DEVELOPMENT PROCESS

Discuss what development process you are following with a rationale for it – Waterfall, TDD, Agile. Note that this is not necessarily only for software projects. Development processes are applicable for all design projects.

### 3.7 DESIGN PLAN

Describe a design plan with respect to use-cases within the context of requirements, modules in your design (dependency/concurrency of modules through a module diagram, interfaces, architectural overview), module constraints tied to requirements.

## 4 Testing

Testing is an **extremely** important component of most projects, whether it involves a circuit, a process, or software.

1. Define the needed types of tests (unit testing for modules, integrity testing for interfaces, user-study or acceptance testing for functional and non-functional requirements).
2. Define/identify the individual items/units and interfaces to be tested.
3. Define, design, and develop the actual test cases.
4. Determine the anticipated test results for each test case
5. Perform the actual tests.
6. Evaluate the actual test results.
7. Make the necessary changes to the product being tested
8. Perform any necessary retesting
9. Document the entire testing process and its results

Include Functional and Non-Functional Testing, Modeling and Simulations, challenges you have determined.

### 4.1 UNIT TESTING

– Discuss any hardware/software units being tested in isolation

## 4.2 INTERFACE TESTING

- Discuss how the composition of two or more units (interfaces) are to be tested. Enumerate all the relevant interfaces in your design.

## 4.3 ACCEPTANCE TESTING

How will you demonstrate that the design requirements, both functional and non-functional are being met? How would you involve your client in the acceptance testing?

## 4.4 RESULTS

- List and explain any and all results obtained so far during the testing phase
  - Include failures and successes
  - Explain what you learned and how you are planning to change the design iteratively as you progress with your project
  - If you are including figures, please include captions and cite it in the text

# 5 Implementation

Describe any (preliminary) implementation plan for the next semester for your proposed design in 3-3.

# 6 Closing Material

## 6.1 CONCLUSION

Summarize the work you have done so far. Briefly re-iterate your goals. Then, re-iterate the best plan of action (or solution) to achieving your goals and indicate why this surpasses all other possible solutions tested.

## 6.2 REFERENCES

List technical references and related work / market survey references. Do professional citation style (ex. IEEE).

### 6.3 APPENDICES

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc., PCB testing issues etc., Software bugs etc.