Section A: Overview of the Research Project

1. Title of the research project: Statistically Optimized Antenna Arrays
2. Broad area of research (Engineering or Science): Engineering
3. Academic level of research project (Masters or Doctoral): Doctoral
4. Abstract of research project: Polynomial Choas Expansion (PCE) models will be used to model the yield of array antenna elements for the SKA MFAA. These models allow yield analysis to be performed on problems with many variables, using Computational Electromagnetic Analysis. Yield analysis and optimisation is crucial for systems using thousands of similar antenna elements, as it is directly related to cost.
5. Primary supervisor's details:

a. Full name of primary supervisor: Prof P Meyer
b. Primary supervisor's email address (please note that if this project is approved, this email address will be made available to students to contact the primary supervisor) pmeyer@sun.ac.za
c. University where primary supervisor is employed: Stellenbosch University

6. Co-supervisor/Research supervisor's details (if relevant):

a. Full name of co-supervisor/research supervisor:
b. University where co-supervisor/research supervisor is employed:

Section B: Details of Research Project

1. Scientific/Engineering merit: describe the objectives of the research project, placing them in the context of the current key questions and understanding of the field.

For antenna array systems using very high numbers of similar elements, such as the MFAA, manufacturing yield is of very high importance, as high volume elements are not adjusted after manufacturing. Currently, the only way to perform yield analysis, is with Monte Carlo analysis, which, for multi-variable problems, become fully intractable very quickly when each point requires a full 3D Electromagnetic analysis. The technique of Polynomial Chaos, recently applied to simple antenna problems, offers a solution to this problem, as it reduces the number of points required to calculate yield parameters, such as averages and standard deviations, by factors of 100-1000. This project aims to expand existing work on this technique at Stellenbosch University, to proposed MFAA elements, to predict yield, and also optimize some of these elements geometrically for yield.

2. Feasibility: outline the methods that will be used to achieve the objectives. Provide details on the availability of required data / access to required equipment / availability of research facilities and other resources required. Include any relevant expected intermediate milestones and associated timeframes towards attaining the overall objectives of the project.

The feasibility of the PCE technique has been verified by various authors. A current project at Stellenbosch University has already shown reductions in the required number of analysis points by more than two orders of magnitude, as compared to classical Monte Carlo. The project will require good computer infra-structure, state-of-the-art electromagnetic analysis tools, and antenna measurement facilities, all of which are available at Stellenbosch. The project will take place in three stages, each roughly 10 months in length, and a final 6 months to complete the PhD dissertation and papers. Stage 1 will be the extension of PCE to multivariable problems, stage 2 the application to existing proposed MFAA elements, and stage 3 the optimization of one of these elements for yield, manufacturing, and testing.

3. Link the proposed project to one or more of the SARAO research priority areas for 2021 (refer to Section 5 of the Application Guide), and explain in some detail how the proposed research will contribute to the priority area(s).

This project will link directly to the design of SKA MFAA antenna elements. By optimizing an element for yield, the cost of a total array can be reduced significantly, as yield is directly related to cost.

4. If relevant, describe any particular qualifications, academic abilities, skills and/or experience that a student should have in order to successfully deliver on the objectives of the research proposed.

Good mathematical skills.