Attachment 1

Title: Low-cost Gaussian Process-based RFI Source Predictor

Section A: Overview of the Research Project Proposal

1. **Academic level of research project:** Masters
2. **Broad field of research:** Engineering
3. **Title of the research project:** Low-cost Gaussian Process-based RFI Source Predictor
4. **Full names of supervisor and co-supervisor:** Dr Simon Winberg
   (availability of co-supervisor expected)
5. **University where postgraduate student would be registered:** University of Cape Town

Section B: Research Project Proposal

Research project abstract/summary:

This project related to the Engineering Focus Aspect #3, "Hardware and data analysis systems for detecting, monitoring and identifying RFI", and particularly the development of skills in this area together with development of hardware and software tools. This project also connects with aspects of Armature Radio Astronomy, and inspiring both more professionals members, as well as novice members (e.g. high school kids interested in STEM), to pursue careers in STEM disciplines. This connects directly with our group's current "Hobby RA" initiative, which we started in response to interest in this area and the large amount of cheaply, or entirely freely, available equipment left over after upgrading or replacing satellite television systems. This project involves the development of a low-cost RFI source prediction system, one that will use a low-cost RF front-end with low-cost or repurposed aerials (possibly terrestrial TV aerial or satellite dishes, among other antenna possibilities, depending on the frequency of focus). The project is a partly Software Defined Radio (SDR) approach. The brief in terms of the front-end is towards low-cost and establishing a suitable down-converter that can then be fed into an embedded platform (e.g. Raspberry Pi, or just a laptop for prototyping) connected via a low-cost sampling solution (e.g. usbStick PC Oscilloscope).
The RFI identification aspect of this work will build upon research completed by Dr Chez's, in terms of techniques he has established and tested for RFI identification; these methods could be ported to C for use on the embedded side for distinguishing the source of RFI that may be interfering with a Hobby RA installation. It is further proposed, upon evaluation of the performance of these existing techniques, the implementation of an Gausian Processes mechanism, to work separately or concurrently (alternating with these other methods) to generate a report on the levels or types of sources of RFI predictions over a time period (i.e. over a few hours at a time that the Hobby RA is likely used). Ideally, if a laptop with good GPU is used for the RFI Predictor system, these C RFI source prediction routines can be reworked as a GPU solution. The HobbyRA is designed for frequencies from 50MHz up to 2.5GHz (it is by default an analogue system but allows adaptation for digital, a future project). For the *initial* version of this RFI predictor, it is suggested to use frequency ranges below 200MHz (even though this frequency range is much more restrictive than SKA's range, many of the principles used for this project will help improve the preparedness of the student towards these more complex contexts).

1. Scientific merit:
This project aims to develop and deepen the student's skills in the following areas that relate both to radio signal acquisition and analysis methods. This will ensure the student in well-skilled in these fundamental aspects of understating radio and radio astronomy technologies, which would provide the student a good foundation to pursue further research and development in this area. Moreover, it is aimed that through this project, the student will also have opportunity (and be encouraged) to

participate in outreach activities, and collaborate with organizations such as the US-based ARRL and the local SARL (SA Radio League). The student will also be encouraged to attend the RFI Work Group meetings, to learn about RFI sensing and mitigating techniques from this team of experts. Specific training and skills that the student will learn include:

a) Radio electronics and system design (for the low-cost front-end and backend)
b) Apply SDR techniques (initial prototyping e.g. with GNURadio and/or MATLAB suggested)
c) Understanding machine learning techniques (including Neural Nets, GP and other, more signal pattern matching, methods)

Note: Although the student is recommend to develop the RF front-end for this project, we do already have a backup front-end that can be slotted in to the project – however, for the educational value, it is suggested that the student make an attempt at their own solution (this could even be prototyped with mini-circuit components, as a proof-of-concept, even though these are not cheap).

2. Feasibility:
As mentioned earlier, there are backup plans, e.g. pre-existing RF front-end, and in the group we have a variety of DAQ systems that the student could fall back on to get real-time sampled data. The RFI source predictor is not expected to run in real-time – at best it would be able to run at the same time as the HobbyRA, which the researcher can utilize for flagging time periods of the HobbyRA observations. Neverthless, what this project does hinge strongly upon is the student understanding, or being able to quickly develop, a good understanding of radio signal sampling and signal processing. For both of these aspects, support in the form of formally thought Masters level courses are provided at UCT, which the student can attend if they need to build their initial understanding of these areas. Furthermore, in the EE department, we have many postgraduate students who are working on radio and radar projects, it is planned that the student doing this project will not only be encouraged to collaborate with the student working on HobbyRA, but, if needed, may be allocated a more senior (PhD or MSc) postgraduate to provide him additional, in-person, coaching should it be needed. Accordingly, it is anticipated that that this project, and graduation of the student, has a good chance of succeeding.

3. Link the proposed project to one or more of the SARAO research priority areas for 2020

This project connects with Engineering aspect #3: "Hardware and data analysis systems for detecting, monitoring and identifying Radio Frequency Interference (RFI),"

4. Particular qualifications, academic abilities, skills and/or experience that a student should have.
It is very important that the student has a good understanding of radio theory and systems, as well as a understanding signal processing methods. They should be good at programming (particularly in C and ideally CUDA / GPU programming).