



Experimental FCC License Application
Exhibit 1: Description of Research and Experimentation

Collision Communications (the “Applicant”) is seeking a FCC Experimental License as part of its research, development, and testing efforts related to signal processing techniques to improve the transmission and reception of cellular (LTE & 5G) signals. In particular, an Experimental License will enable the Applicant to experiment with the processing of signal propagation effects that are not able to be accurately simulated as well as to provide confirmation with over-the-air testing of what it is able to simulate.

Research and Experimentation Program Description

Program

The Applicant’s research and experimentation program is focused on understanding channel effects on signal propagation at much higher levels of accuracy while developing and testing better PHY layer signal processing techniques to address interference issues and improve performance of wireless cellular communications networks. This research and experimentation applies to both TDD and FDD networks using MIMO and Massive-MIMO (M-MIMO) antennas configurations.

Proposed Experimentation

The proposed experimentation will consist of transmitting data signals from a software-defined radio MIMO antenna array system (of up to 64 tx / 64 rx antennas) to a software-defined radio MIMO antenna array system (of up to 64 tx / 64 rx antennas), collecting data about the received signals and the channel effects on those received signals, testing signal processing approaches on those received signals, and testing signal processing approaches that apply to the transmission of signals.

It is intended that signals be transmitted from one or more antennas at a time using one more transmitting radios in the array, whereby the multiple transmitted signals are transmitted in a coherent fashion. Though such experimental software-defined radio MIMO antenna array is intended to be as large as 64 transmitting radios/antennas, the majority of experimentation will be conducted only using a subset of the antennas or using an array with fewer radios/antennas in it. In some cases it may only be one transmitting antenna/radio.

Frequencies Requested

The Applicant requests authorization to operate within the following range of frequencies:

- 470 – 698 MHz
- 902 – 928 MHz
- 2,400 – 2,473 MHz

Operation in the 470 – 698 MHz Band: These frequencies correspond to the UHF Broadcast television frequency bands that have been made available for unlicensed use at locations where the spectrum is not being used by licensed services. The Applicant shall use accurate GPS coordinates and manual consultation of FCC-approved TV White Space Database(s) (e.g. Spectrum Bridge, LStelecom, Google, etc.) to ensure that no occupied channel will be transmitted on¹. It is recognized that some of these frequencies are undergoing reallocation in the coming months and years – the applicant is respectful of such reallocation activities and will only transmit on frequencies that available at that time, and as provided by the Whitespace Databases.

Operation in the 902 – 928 MHz and 2,400 – 2,473 MHz Bands: Applicants use of these frequencies shall follow the FCC's rules (47 CFR Part 15) for unlicensed operation in the 902-928 MHz Band and 2,400 – 2473 MHz Band

The above frequency bands are requested as they provide for experimentation with frequencies that are near some of the frequencies licensed to the cellular communications industry, and to which the Applicants experimentation is relevant to. The applicant has some flexibility in the frequencies that are experimented on – the above particular frequency bands were chosen as they are bands that permit unlicensed usage and with the intent that the experimental use of these frequencies (versus other frequencies) would minimize interference and coordination concern.

Transmit Power and ERP

The Applicant wishes to transmit emissions from both Fixed devices and Mobile devices that are either fixed in position while transmitting, or moving while transmitting. Note, so as to be granted the ability to move Fixed and Mobile devices within the requested area(s), the Applicant is treating all devices as mobile for the purpose of this application. It is requested that the Applicant be permitted to transmit emissions with power not greater than:

Peak² Transmit Power: 1 W
Peak EIRP = 4W (2.439W ERP)

With regards to operation in the 470 – 698 MHz Band, the Applicant requests that it receives authorization herein for transmitting on these frequencies at power levels consistent with Title 47 CFR

¹ Given the experimental nature of the Applicant's equipment, it is unable to *automatically* access White Space Spectrum Database information (this will be conducted manually), because it does not have a certification and FCC ID it is unable to register itself with the Spectrum Database, it is unable to accept PUSH notifications from the Spectrum Database, it is unable to transmit identifying information, it is unable to implement spectrum sensing, and power control will be administered in the interest of the experimentation being conducted.

² For the purposes of determining Peak Power/EIRP, the Applicant will follow the FCC's guidance and use Maximum Conducted Output Power as it is defined both in 47 CFR 15.709 and 47 CFR 15.247.

Part 15.709 for Fixed devices. Though Part 15.709 specifies lower power limits for Personable/Portable devices, which transmit/receive at “unspecified locations”, The Applicant respectfully requests that it receive authorization herein to transmit emissions at the power limits specified in Part 15.709 for Fixed devices for Applicant’s Fixed and Mobile devices, with the understanding that the emissions are only being transmitted in a very limited geographical area (and where the Whitespace Database will be consulted for any transmit points within that area) and for very short periods of time, as indicated herein. Due to the nature of the desired experimentation, where diverse channels with high scattering hope to be realized, having the ability to transmit up to this power limit has significant value for carrying out the experimentation effectively.

With regards to operation in the 902 – 928 MHz and 2,400 – 2,473 MHz bands, the Applicant shall conform to the FCC’s 47 CFR Part 15.

Modulation and Emissions

The Applicant proposes to operate with OFDM modulation, in a manner that resembles transmissions for LTE.

It is intended that emissions will be transmitted relatively infrequently – in most cases with transmissions occurring on the order of seconds to tens-of-minutes at a time per hour. There may be an occasional longer period of transmission. Lastly, there may be long periods of time (e.g. weeks) where there won’t be any transmissions.

Both 5 MHz and 10 MHz bandwidths are requested herein. Though 5 MHz is more practical due to channel availability in the 470-698 MHz band, as well as less prone to interference in the 2.4 GHz band, 10 MHz bandwidth provides much better time-resolution which would be beneficial to the Applicant’s experimentation.

Antenna Locations

It is proposed that the experimentation occur in the following locations/areas:

- Applicant’s Lab Space
 - o 42° 44’ 20.832” N, 71° 29’ 8.6748” W
 - o 1 km radius
- Nashua, NH -- 14 Elm St, Nashua, NH 03060
 - o 42°45’43.1460” N, 71°27’46.7784” W
 - o 1 km radius

Though the Antenna Locations specified are specified as ‘Mobile’, in almost all scenarios the transmitters will be acting as though they are fixed. The specification for ‘Mobile’, versus ‘Fixed’, is as a result of the nature of our experimentation and the desire to be able to reposition transmitters within a small geographical area so as to create diversity in the channels realized. There are a few test cases intended to be conducted where the transmitters will be moving within the limited designated area, but such activity will be limited.

It is requested and intended that the placement of the transmitters shall be moveable within the area defined in the associated Form 442 Application – 1km radius.

Equipment and its Operation

The Applicant's software-defined radio MIMO antenna array system, from a transmission-side perspective, consists of the following:

- A bank of off-the-shelf Software-Define Radios with off-the-shelf daughterboards:
 - Ettus USRP X300 (each capable of two transmission channels / daughterboards) – Quantity per array: up to 32
 - Ettus UBX 160 USRP Daughterboard – Quantity per array: up to 64
- Off-the-shelf antennas with omni-direction radiation pattern (e.g. dipoles) coupled to each transmission channel/daughterboard – Quantity per array: up to 64 Tx and 64 Rx
- Associated stand and mechanical/structural hardware to assemble the system on

It is requested that two such arrays be used in this experimentation.

It is intended that such arrays be assembled with up to 64 transmitting radios/antennas and 64 receiving antennas/radios, but the majority of experimentation will occur while only using a subset of the transmitting and receiving radios/antennas or the arrays will be assembled with a smaller number of antennas and radios.

The need for up to 64 Tx and 64 Rx antennas/radio per array is a result of the experimentation being related to developing and testing Massive MIMO technologies, which require up to large antenna arrays. Though in most cases, the Applicant will be using far fewer than those requested, there are instances where the Applicant will desire to test arrays of up to 64 antennas, which is also a common array size found in industry.

These antennas and/or antenna arrays will be mounted on stands, whereby the top of the antenna(s) will not extend above 6 meters above ground or 6 meters above the top of a building. The stands will be non-permanent and moveable.

Objectives

The primary objectives of this research and experimentation are to:

- Test the Applicant's existing signal processing techniques over-the-air.
- Experiment to create a more accurate understanding and data-sets related to wireless transmissions relevant for cellular communications, and the channel effects incurred through transmission and reception.
- Apply this research to the further development and advancement of physical layer signal processing to improve network performances using a variety of antenna configurations.
- Compare and Confirm testing results with those obtained through simulation.

Research and Experimentation Contribution to the Development of the Radio Art

The research and experimentation proposed here is aimed at advancing PHY layer technology, in new ways and beyond what industry has achieved, to improve performance of the often over-loaded cellular networks and to enable some of the visions of 5G communications.

Contact Information

For questions about this application, please contact:

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In the unlikely event that interference concerns present themselves, please contact the following person who shall service as the designated point of contact (stop buzzer) to terminate transmissions if interference occurs:

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