Review of County Development Plan

I-LOFAR, Radio Astronomy and Radio Frequency Interference

A submission, dated 27th Sept. 2019, made on behalf of the I-LOFAR Consortium* to Offaly County Council in relation to the Offaly County Development plan 2021-2027.

*The I-LOFAR consortium comprises the following institutions:

- Trinity College Dublin
- NUI Galway
- Dublin Institute for Advanced Studies
- Dublin City University
- Armagh Observatory
- University College Cork
- University College Dublin
- Athlone Institute of Technology

Summary

The Irish Low Frequency Array (I-LOFAR; [1]) is a sensitive radio telescope located in Birr, Co Offaly. It is a designated "Radio Observatory" registered as an earth station with the International Telecommunication Union (ITU; [2]) to protect the service from interference [3, 4]. The telescope is used to measure radio waves in the frequency range of 10-270 MHz from faint astronomical objects that are at great distances from the Earth. Modern technologies, such as wind turbines and LED lights, can cause radio frequency interference. It is therefore important that future planning/development policy take into account the sensitive measurements that I-LOFAR is taking and the potentially damaging effects that Radio Frequency Interference (RFI) can have on the telescope. The I-LOFAR Consortium therefore request of Offaly County Council that spatial planning regulations be employed to ensure that developments with the potential to cause harmful interference to the telescope area considered in consultation with the I-LOFAR Consortium. We therefore request two coordination zones for the purposes of planning:

1. Protected Zone* (<5 km): We request special consideration within this zone to protect the radio telescope from inference that could significantly impact telescope operations.
2. Consultation Zone (<10 km): We request that developments within this zone be the subject of consultation and agreement with the I-LOFAR Consortium for future coexistence.

* In the context of this submission, the term 'zone' refers to an area inside which certain considerations are given to the vulnerability of a Radio Astronomy facility.

The LOFAR Radio Telescope

I-LOFAR is part of a €150 million network of radio telescopes that stretches from Birr through the Netherlands to Latvia (International LOFAR Telescope; [5]). The radio signals from cosmic objects (stars, galaxies, etc.) that radio astronomers observe are extremely weak because the objects are very distant, often millions or billions of light years away from us. Radio telescopes such as LOFAR are highly sensitive and routinely detect minute signals that have radio flux densities of the order of 10^{-29} $Wm^{-2}Hz^{-1}$, which corresponds to the signal received from a mobile phone radiating 1 W at a distance of 40 million km (i.e. at approximately a hundred times the Earth-Moon distance).

In order to detect distant cosmic radio sources, radio observatories require sufficient frequency bandwidth free of man-made radiation for a sufficiently long time (including weak and distant man-made sources). These requirements have led some countries, like the USA, Chile, Australia, and South Africa, to create large radio quiet zones around their current radio observatories, where human radio emissions are very strictly controlled. Large exclusion zones are not an option in densely populated European countries, however planning controls around certain types of development close to installations such as I-LOFAR would be of great benefit to the continued operation of what is currently a world class facility. Such planning controls should take into account the expected radio emissions (both intentional and possible unintentional emissions) from the proposed systems and take the vulnerability of the radio telescope into account.

Radio Frequency Interference (RFI)

Although it is possibly obvious that a radio transmission system broadcasting in the frequency ranges used by I-LOFAR has potential to cause harmful interference to the telescope, there are many other systems which are also potentially harmful [6, 7]. Such harmful interference is known as radio interference (RFI) or radio spectrum pollution. RFI can severely degrade the ability of I-LOFAR to make astronomical observations.

Sources of RFI

Clean Energy and Energy Efficiency

The drive for sustainability and the resultant shift from the use of fossil fuels has resulted in the development of many new systems for the generation and efficient use of energy. While acknowledging the need for this, it should be noted that, from the perspective of passive (receive only) users of the radio spectrum such as radio astronomy facilities (e.g., I-LOFAR), these systems can produce pollution in the form of radio interference.

Wind Turbines

I-LOFAR is currently in a moderately radio-quiet area. Because LOFAR's antennas are at ground level, their "radio horizon" for man-made interference (from, for example, household or industrial equipment)

is nearby. Building tall reflecting structures nearby would change that. Additionally, wind turbines generate their own potentially broadband radio interference. There are a number of ways in that wind turbines in the vicinity of a radio telescope can adversely affect a radio telescope:

- Signal blocking. In this case, a tall structure (the windmill) comes between the telescope and the signal of interest. It is not envisaged that this issue will be a significant problem in the case of I-LOFAR unless the windmill is very close to the telescope.
- Signal reflection. Radio signals can be reflected from structures. In the case of a wind turbine, the movement of the blades can cause variations in the levels of a reflected signal resulting in variations in the levels of these reflected signals being seen at the telescope. The variation in the rotation speed of the blades and the direction in which the blade points complicates the analysis greatly. Often, an unwanted man-made interfering signal which would otherwise not reach the telescope can be reflected into the view of the telescope depending on the angle of the blades. There are two types of reflected signals to be concerned about:
    - Reflections from a man-made transmission or radio spectrum pollution.
    - Unwanted cosmic signals from one part of the sky can be reflected into the field-of-view of the telescope even if the telescope is aimed in a different direction.
- Signal emission. There are several sources of RFI to be concerned with:
    - Aviation lights (LEDs) can emit RFI.
    - Radio telemetry from the individual turbines.
    - High-speed switching semiconductor circuits used to convert the voltage produced by the turbines to the voltage needed for the grid can also emit RFI.

Solar Farms (Photovoltaic installations)

Photovoltaic (PV) systems include high-speed switching semiconductor circuits to convert the voltage produced by the PV arrays to the voltage needed by the end user. Such switching power conversion circuits produce electromagnetic radiation at harmonics of the switching frequency.

LED Street Lighting

LED lights also include high-speed switching semiconductor circuits to control the current to the LEDs. Such switching power conversion circuits inherently produce electromagnetic radiation at harmonics of the switching frequency. Being elevated on a lamp post increases the exposure of the telescope to such unintentional transmissions.

Electric Fences

These act as large antennas radiating the electric pulse over a broad range of frequencies. When the fence discharges against an object (animals, grass etc.), the interference problem is more noticeable.

Other Electronic Equipment

Because radio telescopes routinely measure signal levels in the order of 10^{-29} $Wm^{-2}Hz^{-1}$, it is usually the case that electronic equipment, despite perhaps being properly CE compliant, can be detected at the telescope. Such detected levels are usually far in excess of the actual signal of interest.

Radio Broadcasts

I-LOFAR is sensitive to frequencies from 10 MHz to 270 MHz. The broadcast FM band from 90-110 MHz is not included in our observations due to the presence of so many existing radio stations. Digital Audio Broadcasting (DAB) has not yet become prevalent in Ireland, apart from major urban centres. Based on the experiences of other LOFAR station owners on the European continent, DAB is a threat to I-LOFAR in the higher frequency ranges we observe.

Although the Irish Commission for Communications Regulation (COMREG; [8]) has jurisdiction over which radio frequencies are used for a particular purpose, they have no power to stop a licenced operator using a particular frequency band for the purposes for which the band is licenced. We feel that this threat is therefore best addressed by the planning regulations as outlined below.

Spatial Planning Regulations to Protect I-LOFAR

The Dutch province of Drenthe, in which the main LOFAR core is located, has passed planning regulations offering protection from development which might adversely affect the telescope. This was done by defining two zones with different restrictions:

Zone I: All new developments which could cause electromagnetic radiation which could impact the telescope are prohibited.

Zone II: All proposed developments or changes to existing developments may only proceed if no electromagnetic radiation (RFI) that will impact the telescope will result. The telescope management should be contacted so that the risk to the telescope can be evaluated. This zone is sometimes referred to as a coordination or consultation zone.

For I-LOFAR, we propose the following two consultation zones as shown in the Appendix:

- Zone I (Protected Zone): A zone encompassing a radius 5 km.
- Zone II (Consultation Zone): A zone encompassing a radius 10 km.

I-LOFAR request that in the context of future planning decisions:

- Zone I (Protected Zone):
    - No further large wind farm/photo-voltaic installations are allowed within a radius of 5 km from I-LOFAR.
    - LED lighting installations to be subject to consultation with the I-LOFAR Consortium.

    - Consultation with the I-LOFAR Consortium on any other developments within a radius of 5 km (Zone I; Protected Zone) from I-LOFAR which require the use of large power inverters.
    - Consultation with the I-LOFAR Consortium on any proposed radio transmission systems in Zones I and II.
- Zone II (Consultation Zone):
    - Limitations on the turbine height for wind farms.
    - Consultation with I-LOFAR as to the turbine types and related equipment to be used. It has been determined that turbines from certain manufacturers are better than others from the point of view of radio interference/pollution.
    - Consultation with I-LOFAR as to equipment to be used on any photo-voltaic installations. Field tests on the equipment to determine the effects, if any, on the station should be carried out.
    - Equipment field tests to determine effects, if any, on the station should be carried out.

In both zones, we suggest there should be a condition be attached to any planning permission granted for new developments, or modification to existing developments, to ensure effective mitigation measures (filtering etc.) for the purpose of eliminating any potential interference to the telescope.

It would be of great benefit to the I-LOFAR station and Irish research therefore if the next iteration of the Offaly County development plan were to take into account the need to protect the radio spectrum in general from increased radio pollution and for coordination of clean energy initiatives (solar photovoltaic installations, wind farms, LED (street) lighting) and I-LOFAR.

References

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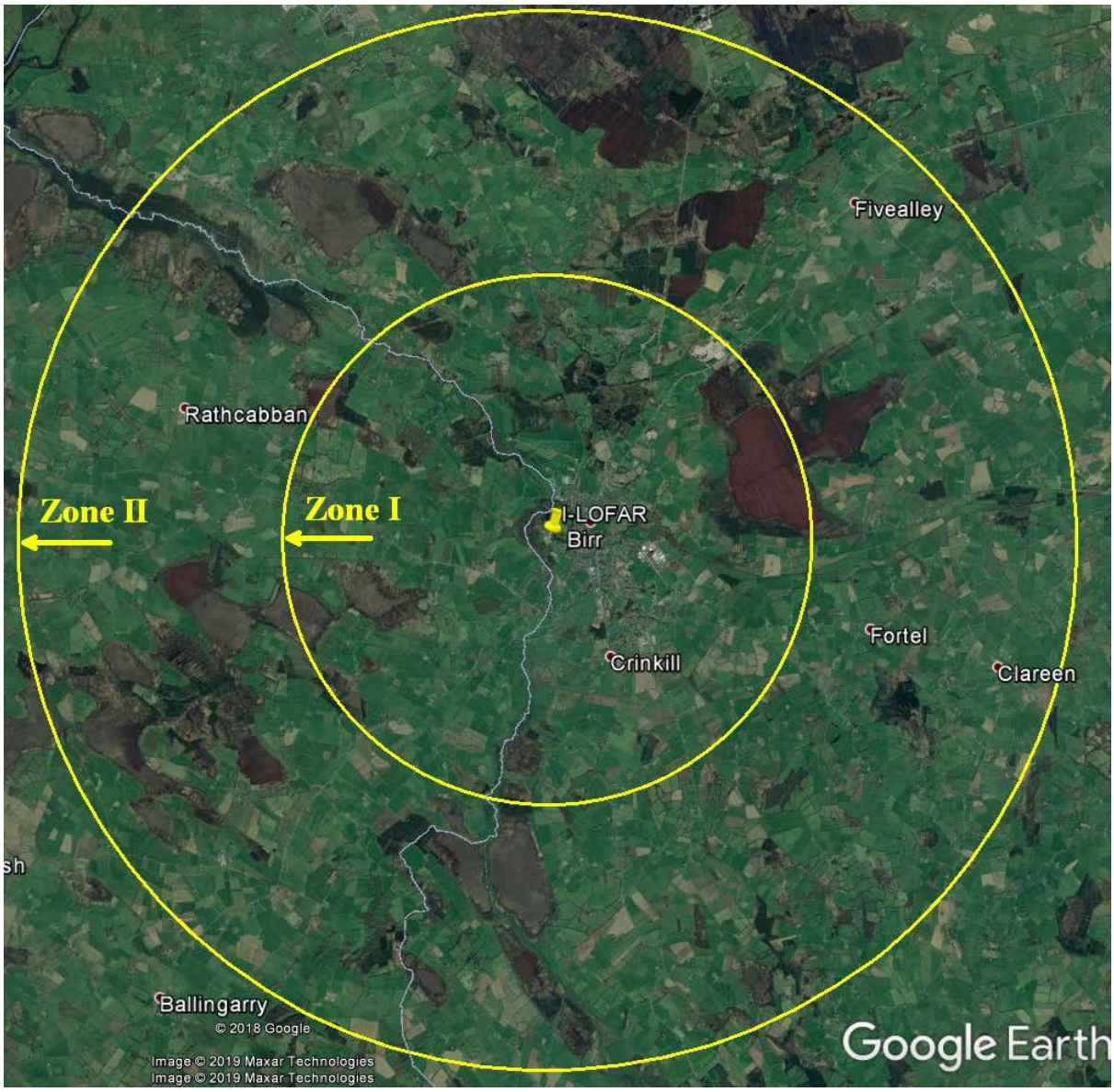
Contact

I-LOFAR Consortium,
c/o Birr Castle,
Co. Offaly,
Ireland.
Email: consultation@lofar.ie
URL: www.lofar.ie

Appendix



The proposed Zones I & II consultation zones for I-LOFAR