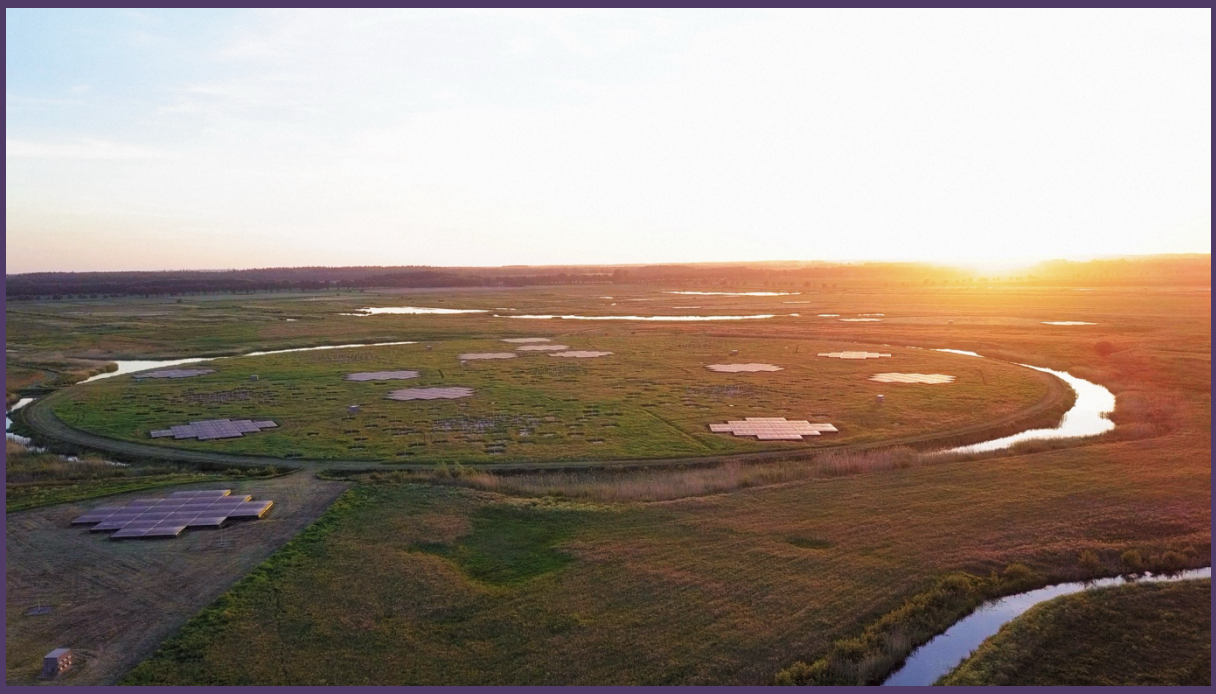

LOFAR ERIC

Activity Report 2024

LOFAR ERIC

LOFAR ERIC Activity Report 2024

Table of Contents

1. Introduction 2
2. Establishment of the LOFAR ERIC 3
3. LOFAR ERIC Membership and Governance 4
4. Features of the LOFAR telescope 5
5. Highlights and developments in 2024 7
   - 5.1 LOFAR ERIC Establishment and ILT to ERIC transfer 7
   - 5.2 LOFAR 2.0 8
   - 5.3 LOFAR Science Operations 11
6. Expectations for the future 14
7. LOFAR ERIC Financial Report 15

1. Introduction

The year 2024 marked a pivotal chapter in the evolution of LOFAR ERIC, as the organisation completed the transition from the ILT Foundation. Following its formal establishment by the European Commission on 20 December 2023, LOFAR ERIC has taken shape as a robust and collaborative European Research Infrastructure Consortium, dedicated to advancing the frontiers of low-frequency radio astronomy.

This inaugural year has been characterised by significant organisational developments, strategic planning, and technical progress. The LOFAR ERIC Council convened for the first time in January 2024, setting in motion the governance structures and leadership appointments that will guide the consortium in the years ahead.

A major focus of 2024 has been the continued implementation of the LOFAR 2.0 upgrade programme. Building on years of design and development, the project entered its integration and validation phase, with the successful deployment of pre-production and final hardware across several test stations. These efforts have laid the groundwork for the full-scale roll-out of the upgraded system, scheduled for 2025 and 2026. The enhancements introduced by LOFAR 2.0 will significantly expand the scientific potential of the telescope and ensure its relevance well into the next decade.

In parallel, the formal transition from the International LOFAR Telescope (ILT) Foundation to LOFAR ERIC was completed in July 2024, resulting in the legal transfer of assets, projects, and responsibilities. This milestone marks the successful conclusion of years of careful preparation and reflects the shared commitment of the member countries and partner institutions to the long-term success of the LOFAR enterprise.

This brief Activity Report provides an overview of the key activities, achievements, and strategic directions of LOFAR ERIC during 2024. It highlights the dedication of the scientific, technical, and administrative teams across Europe who continue to advance the mission of LOFAR – delivering world-class science and strengthening international collaboration in the field of radio astronomy.

2. Establishment of the LOFAR ERIC

The LOFAR ERIC has its registered office in Dwingeloo (municipality of Westerveld) in the Netherlands. LOFAR ERIC was established on 20 December 2023 by the European Commission implementing decision (EU) 2023/2881.

The principal task of LOFAR ERIC is to assure coordinated exploitation of the LOFAR infrastructure, to produce world class scientific research and to pursue further development, with the aim to maximise productivity and impact for the Members and the international scientific community, positioning LOFAR ERIC as a world-leading distributed research infrastructure with a long-term perspective. LOFAR ERIC is the legal successor of the International LOFAR Telescope Foundation (ILT).

3. LOFAR ERIC Membership and Governance

The Founding Members of the LOFAR ERIC are the following:

- The Republic of Bulgaria represented by the Institute of Astronomy and National Astronomical Observatory (IANAO) of the Bulgarian Academy of Sciences,
- The Federal Republic of Germany represented by the Thüringer Landessternwarte (TLS),
- The Republic of Ireland, represented by Dublin Insititute for Advanced Studies (DIAS),
- The Italian Republic, represented by the Istituto Nazionale di Astrofisica (INAF),
- The Netherlands, represented by Stichting Nederlandse Wetenschappelijk Onderzoek Instituten (NWO-I),
- The Republic of Poland, represented by the Ministry of Education and Science.

LOFAR ERIC has agreements in place with the following Collaborating Organisations:

- Centre National de Recherche Scientifique (CNRS) in France,
- Ventspils International Radio Astronomy Centre (VIRAC) in Latvia,
- Onsala Space Observatory (OSO) in Sweden, and
- Science and Technology Facilities Council - UK Research and Innovation (STFC-UKRI) in the United Kingdom

It is expected that these countries will apply to join LOFAR ERIC in the near future.

Each of the Members and Collaborating Organisations hosts one or more LOFAR stations that form part of the International LOFAR Telescope or have agreed to host a station in the next few years. The latter is the case for Bulgaria and Italy – these stations are expected to be completed in 2026. Each member commits to a contribution per station set by the Council at a rate of € 95,000 (in 2024 unchanged from previous years). These contributions can be provided partially in-kind, typically in the form of personnel or as compute and data storage resources.

LOFAR ERIC Members are represented on the Council by up to two delegates. Collaborating Organisations can also appoint up to two (non-voting) representatives. The Council elects a Chair and Vice-Chair from among the delegates for a two year term, renewable twice. The Council is advised by two committees, one responsible for financial and the other responsible for scientific and technical aspects of the LOFAR ERIC activities. Members of these two committees are appointed by Council upon recommendation by the Members and Collaborating Organisations. A third committee, the Scientific Advisory Committee, is also foreseen but has not yet been installed.

The LOFAR ERIC Council convened five times in 2024: on 22 January (online), 27 February (online), 11 June (hybrid meeting in Dwingeloo and online), 1 October (in person), and 10 December (online). Key matters addressed by the Council included the transition from the ILT Foundation to LOFAR ERIC, the appointment and establishment of various governance and advisory committees, and the oversight of LOFAR ERIC's principal investment initiative – the LOFAR 2.0 upgrade programme.

Figure 1: Map showing the distribution of LOFAR stations. The Netherlands hosts a total of 38 stations, while the other points on the map each host a single station. LOFAR stations in Medicina (Italy) and Rozhen (Bulgaria) will be constructed in 2026.

4. Features of the LOFAR telescope

The LOFAR telescope comprises radio-astronomical antenna stations with receivers located in the Netherlands and other member countries (see Figure 1). The Netherlands hosts 38 stations, Germany 6, Poland 3, while France, Ireland, Latvia, Sweden and United Kingdom host a single station. These antenna stations are owned by different organisations, each is responsible for local maintenance, local operating costs and for the national part of their network connection. Two further stations will be built in Italy and Bulgaria in 2026.

All stations are connected via a dedicated fibre-optic network to the central data processing facilities, which are hosted at the Centre for Information Technology of the University of Groningen in the Netherlands. This central processing facility includes networking and computing equipment, along with the necessary software to conduct observations and perform the initial processing of incoming data.

LOFAR data are archived at three main sites: SURF, the IT cooperative for Dutch education and research institutions in Amsterdam; the Jülich Supercomputing Centre in Germany; and the Poznań Supercomputing and Networking Center in Poland. Over the years, LOFAR has amassed what is arguably the world's largest astronomical data archive, exceeding 50 petabytes.

LOFAR ERIC itself is supported by a small office team, comprising the Executive Director, Finance Officer, and Office Support staff. The operational coordination of LOFAR – and thus the majority of the workforce involved in the telescope's exploitation – is provided as an in-kind contribution to LOFAR ERIC by ASTRON, the Netherlands Institute for Radio Astronomy.

Observing opportunities are made available to researchers from the global scientific community, based on submitted research proposals. These proposals are evaluated by an independent Programme Committee, with observing time and computing resources allocated primarily on the basis of scientific merit.

5. Highlights and developments in 2024

5.1 LOFAR ERIC Establishment and ILT to ERIC transfer

As noted in Section 2 of this report, LOFAR ERIC was officially established by the European Commission on 20 December 2023. The Council convened for the first time on 22 January 2024, during which Drs Jacqueline Mout (NL) was elected as Council Chair. At the second meeting, held on 27 February, Professor Gianfranco Brunetti was elected Vice-Chair of the Council.

On 1 March, Dr René Vermeulen, the Founding Director of LOFAR ERIC and former Director of the International LOFAR Telescope (ILT), stepped down. He was succeeded by Wim van Cappellen, who assumed the role of Interim Director. A search for a permanent successor was launched shortly thereafter, resulting in the appointment of Dr Michiel van Haarlem as Executive Director of LOFAR ERIC on 1 August. Dr van Haarlem has a long-standing association with LOFAR, having been involved in its design and development since its inception in 1997, and serving as Managing Director of the LOFAR Foundation during the original construction phase from 2007 to 2011.

The establishment of LOFAR ERIC also marked the formal transition from the ILT Foundation to LOFAR ERIC, following years of meticulous preparation. This process was completed in just over six months. On 10 July, the Deed of Transfer was signed and notarised in Dwingeloo (NL), effecting the transfer of all assets and liabilities – including ongoing projects and activities – from the ILT Foundation to LOFAR ERIC. The ILT Foundation was officially deregistered by the Chamber of Commerce on 8 August 2024.

Figure 2: (left) Guests touring the LOFAR core area, observing the antenna stations up close. (right) Group photo of attendees at the LOFAR ERIC inauguration celebration.

On 10 June 2024, the establishment of LOFAR ERIC was formally celebrated with a special event attended by representatives from all member countries and contributing organisations. The gathering marked the milestone in the evolution of LOFAR, recognising the collaborative efforts that led to the formation of the European Research Infrastructure Consortium. The day featured speeches, reflections on LOFAR's journey, and a visit to the LOFAR core area.

5.2 LOFAR 2.0

The LOFAR telescope has been in continuous operation since 2011. The system comprises numerous components, each with varying lifespans and maintenance requirements. While much of the physical infrastructure – such as antennas, cables, fibres, cabinets, and buildings – has a relatively long operational life, certain critical elements of the original system require replacement after approximately 15 years of use. This is particularly true for the station electronics, including receivers, digitisers, and control and monitoring systems.

Around eight years ago, initial plans were developed for an upgrade to the LOFAR telescope to ensure its continued operation well into the 2030s. This upgrade, known as LOFAR 2.0, will replace virtually all station-based signal processing hardware and introduce new, enhanced software systems. Additionally, the upgrade will involve the replacement of much of the central signal processing infrastructure in Groningen, including a new correlator/beamformer (COBALT3), a new central processing cluster (CEP6), and an upgraded network infrastructure.

LOFAR 2.0 builds upon existing investments and leverages advances in enabling technologies. The increased integration of electronics will enable three times more powerful real-time processing within the same LOFAR station cabinets. Further improvements include:

- Higher dynamic range digitisation (upgrading from 12-bit to 14-bit analogue-to-digital converters)
- Enhanced thermal design
- Centralised clock distribution to all Dutch stations using White Rabbit technology
- A modernised monitoring and control system based on TANGO and OPC-UA

These upgrades will deliver several highly anticipated new capabilities for the astronomical user community:

- Access to all LOFAR antenna data all the time, supporting simultaneous observations using both the LBA (10–80 MHz) and HBA (120–240 MHz) antennas
- Synchronised antennas to within nanosecond precision
- Concurrent imaging and beamformed observations
- Improved system linearity
- A new correlator that integrates the NenuFAR station in Nançay, France, into the LOFAR array
- A doubling of the field-of-view for more efficient surveys
- A new proposal tool designed to simplify and streamline the preparation, validation, and submission of observing proposals

The LOFAR 2.0 project has been funded by LOFAR ERIC members and collaborating organisations. In 2024, the project successfully concluded its design and testing phase. The full deployment of the LOFAR 2.0 hardware and software systems is scheduled to take place in 2025 and 2026, with preparatory work continuing steadily throughout the year.