THE LOFAR GLOBAL CITIZENSHIP RADIO ARRAY "GLORAY"

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This is a summary of a proposal to be submitted to ASTRON and the Board of the International LOFAR Telescope Board later in 2022 to carry out a design study for a project that would transform LOFAR into a multidisciplinary facility that would span 3 continents. Countries in North Africa would be crucial partners of GLORAY, a facility that could eventually link with SKA-Africa. The project would impact astrophysics, geophysics and capacity building in Africa is therefore relevant for ASFAP.

The International LOFAR Telescope (ILT) is the world's largest, most sensitive high-resolution radio telescope at low frequencies (<300 MHz) and a pathfinder for the ESFRI Landmark SKA (Square Kilometre Array). It is a pan-European facility, with a network of ***mutually dependent*** antenna stations that stretch across Europe, from Ireland to Latvia. A dense sensitive `core' is located in the Netherlands and additional ILT antenna stations are located in 9 European partner countries.

The GLORAY vision builds on the ILT by increasing the number of antenna stations, thereby adding substantially to the antenna collecting area at strategically located parts of the array and ***extending the array to North Africa*** and the Middle East. The resultant baseline coverage would improve the sensitivity and resolution of the ILT by large factors and provide observational capabilities for observing the Sun and the ionosphere at lower latitudes. GLORAY would probe hitherto unexplored discovery space in astrophysics, ionospheric physics, space weather and solar physics. Because GLORAY will operate at the lowest frequencies of the electromagnetic spectrum observable from earth, it will access many ***unique physical diagnostics*** that are crucial for understanding our own planet and the Universe in which we live. GLORAY discovery space will complement that of the Square Kilometre Array (SKA). It will probe a lower relatively ***unexplored frequency band below 50 MHz,*** and because of its much ***longer baselines (factor ~ 50 compared with SKA-low),*** it will produce pictures of the low-frequency sky with ***unprecedented clarity and depth.*** GLORAY will also complement SKA-low by providing low-frequency access to the ***northern sky*** and its plethora of exotic and unique astrophysical objects.

The diagnostics observable with GLORAY will complement those from much more expensive ground and space facilities, resulting in a whole that is greater than the sum of the parts. The low-frequency high-resolution capabilities of GLORAY will produce important new information about fundamental issues, such as our cosmic history, the extreme physics of stars, galaxies and clusters of galaxies and new types of exotic exoplanets. GLORAY will also contribute to the solution of practical problems on our planet, by monitoring the propagation of ionospheric perturbations and storms throughout Europe, North Africa and the Middle East, by studying space and solar weather from an intercontinental perspective and by investigating differences in the characteristics of lightning strikes between diverse climates. An important feature of GLORAY is that its ***individual stations can be used separately by local scientists*** for local climate-related monitoring of the ionosphere, lightning etc., ***as well as*** participating in pan-GLORAY observations with ***the array as a whole***.

However, the most important and ground-breaking aspect of the GLORAY vision is the transformation of the ILT from its present main function as a world-leading tool for astronomical discovery, into a multidisciplinary intercontinental facility that will be a unique ***engine for capacity building and development within all GLORAY countries, in Europe, North Africa and the Middle East.*** Radio interferometry is a particularly effective technique for stimulating international partnerships because it requires simultaneous operation of antenna stations in all the partner countries and a combination of their data, using advanced ICT techniques, to produce beautiful high-resolution pictures of the radio sky. This creates ***interdependence between partner countries to produce a whole that is greater than the sum of the parts.*** The interdependence, inspirational science mission and cutting-edge technological expertise make GLORAY an ideal platform for initiating multidisciplinary and interdisciplinary partnerships, that will ***advance the SDGs and stimulate a sense of global citizenship and respect*** throughout the partner countries and the 3 GLORAY regions. This aspect of the GLORAY mission would be carried out in close consultation or collaboration with UNESCO and following the precepts of UNESCO's Education Sustainable Development ESD for 2030.

In accomplishing its globalist international development mission, GLORAY will exploit:

- the mutual interdependence between the partner countries that will equip the array for multidisciplinary bridge-building and a potentially important role in ***science diplomacy***;
- the technological ICT expertise and skills needed to develop and operate the array that will stimulate advances in image processing, ***distributed sensor fields, GRID and Exabyte computing***, with societal applications, including ***medical imaging and precision agriculture;***
- an SDG-based educational programme that will use the cosmic perspective and innovative high-tech aspects of the array to target citizens with the ***message of global citizenship*** "from the cradle to the grave".

This unique combination of assets will be used to pursue a strategically focused programme of capacity building, in collaboration with the International Astronomical Union Office of Astronomy for Development in Cape Town and its relevant regional offices. The GLORAY capacity building programme will focus on advancing the United Nations Sustainable Development Goals, particularly that of stimulating global citizenship (SDG4.7) in GLORAY partner countries and associated regions. This is reflected in the naming of the new facility as the "LOFAR Global Citizenship Radio Array". GLORAY will build on the pioneering work in the development of Africa by the Meerkat and SKA-Africa radio telescopes. It would be a ***model for a new generation of scientific infrastructures,*** in which cutting edge curiosity-driven ***scientific discovery is combined with*** highly ***practical societal relevance,*** to establish ***visible scientific, educational and diplomatic bridges of mutual respect between partner countries.***

Like many large new astronomical infrastructure projects, GLORAY is a long-term venture that can take decades to realise. As a first step, I will propose setting up a ***multidisciplinary design study*** by scientists from Europe, North Africa and the Middle Easy that will consider the ***scientific, technological, educational, diplomatic and organisational issues*** in realising the facility and its mission. The design will place ***equal weight on the requirements of***

astronomy, applied science and capacity building in determining the optimum parameters for such an intercontinental low-frequency array. The study would result in a management plan for the development, construction and operation of GLORAY, optimised to its breakthrough pure and applied scientific goals and its mission for advancing the SDGs, emphasising the task of stimulating global citizenship among the citizens of GLORAY partner countries.