

DANTE CONSORTIUM AGREEMENT

----- IMPORTANT INFORMATION -----

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Purpose of the document: *This document is an agreement formalising the formation of a consortium for the DANTE (Development of an Advanced HBA Frontend) development project.*

Goal: *Following online discussion held between the Parties on 2022-05-18, this version is for further iteration by e-mail, towards a final version fixed on 7 June as input for the ILT Board on 14/15 June 2022, and subsequent signing by the Parties.*

Timeline for approval: *Approval of this document and signing by all parties in the Consortium is planned for the ILT Board meeting on June 14/15, 2022, followed by signing by all listed Parties that are ready to fulfil their obligations.*

DANTE CONSORTIUM AGREEMENT

DRAFT - 07 June 2022

1 - PARTIES

This Consortium Agreement has been prepared between

- i. the Stichting International LOFAR Telescope (ILT)¹, a foundation under Dutch law operating the network of LOFAR stations under a joint scientific policy, with the registered address at Oude Hoogeveensedijk 4 7991 PD Dwingeloo, the Netherlands,

and

- ii. ASTRON, the Netherlands Institute for Radio Astronomy, with the registered address at Oude Hoogeveensedijk 4 7991 PD Dwingeloo, the Netherlands,

and

- iii. The following ILT partners:

- a. Institute of Astronomy and National Astronomical Observatory (IANAO, Bulgaria) , on behalf of the LOFAR-BG consortium
- b. [The German LOng Wavelength (GLOW) consortium, represented by its chairperson M. Hoeft, OR [Universität Bielefeld (Germany), on behalf of the DE609 Norderstedt collaboration]
- c. Dublin Institute for Advanced Science (DIAS, Ireland), on behalf of the I-LOFAR consortium
- d. Istituto Nazionale di Astrofisica (INAF, Italy), on behalf of the LOFAR-IT consortium
- e. University of Warmia and Mazury in Olsztyn (UWM, Poland), on behalf of the POLFARO consortium
- f. Onsala Space Observatory (OSO, Sweden) on behalf of the LOFAR-SE consortium
- g. Science and Technology Facilities Council (STFC, UK), on behalf of the LOFAR-UK consortium

Hereafter referred to jointly as 'the Parties'.

¹ The ILT is in the process of becoming a European Research Infrastructure Consortium (ERIC), called LOFAR ERIC. LOFAR ERIC, set up as an ERIC under Council Regulation (EC) No. 723/2009, is the research infrastructure for the LOFAR telescope, and has the registered address at Oude Hoogeveensedijk 4 7991 PD Dwingeloo, the Netherlands. The role of the ILT will be transferred to LOFAR ERIC at the same time as the LOFAR2.0 development project, with the intention for LOFAR ERIC to incorporate this Consortium Agreement as an Optional Activity.

2 - BACKGROUND

A group of ILT partners has decided to join together to enable the DANTE (Development of an Advanced HBA Frontend) project, which will lead to the phased development of production-ready hardware designs for an upgraded LOFAR High Band Antenna Frontend (HBA-FE) board as well as a new HBA tile summator-beamformer.

This development project is motivated by several considerations:

- The current HBA-FE boards feature obsolete components which can no longer be produced. A solution is needed for future maintenance and the construction of new stations.
- The first-generation HBA-FE boards had several design shortcomings (mechanical resilience, operability in high humidity). The annual failure rate is higher than desirable.
- External radio-frequency interference (RFI) signals of human origin are increasing; a higher robustness of the HBA front-end signal chain is desirable.
- Large-area imaging surveys require a significant fraction of LOFAR's observing time, which competes with carrying out research projects requiring extensive targeted monitoring (even with selected LOFAR stations); two independent HBA beams can significantly extend the science productivity.

The EC Horizon2020 LOFAR4SW design project, completed in February 2022, has focused on investigating future ways to enable large-scale solar and space weather science, in parallel to regular LOFAR observations. Many ILT partners foresee equipping one or more LOFAR stations with hardware to produce two fully independent HBA beams, to enable unique science use cases with further data processing of the extended data on-station, and/or by using the resolving power by combined further processing of data from stations co-observing at various distances across the European LOFAR network.

In view of the above considerations, and with the prospect of co-financing by many ILT partners, ASTRON has decided to initiate an integral development project, called DANTE, to deliver a tested and ready-for-manufacture design of an upgraded HBA-FE board, as well as a new HBA tile summator-beamformer that will be able to produce two independent HBA-tile beams.

- The DANTE HBA-FE board design will bring upgraded performance and robustness. This HBA-FE board design will function with the existing HBA tile summator hardware allowing 1 beam as output from each HBA tile. The DANTE HBA-FE board design will also function with the new HBA tile summator-beamformer, also designed within DANTE; the combination allows 2 independent HBA beams to be produced on a tile.
- The DANTE HBA tile summator-beamformer will be designed as an upgrade for the current HBA tile summator. It requires connection with the DANTE HBA-FE boards, and will be capable of generating 2 fully independent HBA beams on a tile.

ASTRON has decided to invest significantly from its own budget into carrying out DANTE, if other partners supply the remaining financing. ASTRON is prepared to manage the project

and will make available sufficient time from its engineers to assure efficient completion subject to funding. A detailed project budget and planning have been drawn up and are attached to this Consortium Agreement. DANTE incorporates preliminary design elements from the LOFAR4SW project. The integral project plan ensures that the phased design and delivery effort for both the HBA-FE board and the tile summator-beamformer proceeds in the most budget and time efficient way.

3 - PURPOSE OF THIS CONSORTIUM AGREEMENT

This Agreement is set up to formalise the Consortium between partners that:

- Aim to collectively fund the full HBA-FE board and HBA tile summator-beamformer design project
- Have an interest (but not an obligation *ab initio*) to participate in an initial joint procurement of the designed hardware and to operate it in their station(s)

The Agreement regulates the governance, and sets out the roles, as well as financial and other rights and obligations of ASTRON, the ILT / LOFAR ERIC, and the other partners.

4 - DANTE PROJECT SCOPE

The DANTE hardware is intended for building new stations, as well as for upgrading existing stations. Design differences preclude mixing old and DANTE HBA-FE boards within one station, hence HBA-FE boards on a station should all be upgraded at once. It is expected that current-generation HBA-FE boards will be recovered from upgraded stations in sufficient numbers that they can be used for the foreseeable future as spare components for one-on-one replacements in the maintenance of all non-upgraded LOFAR stations.

The DANTE hardware will be designed such that the data for 1 HBA beam can be connected on existing coaxial cables into the station backend (cabinet/container). For science use of both independent HBA beams from the DANTE summator-beamformer of each tile, it is essential to connect them simultaneously into the station backend. Potential solutions have been identified for upgrading existing and/or building new stations. However, at the start of DANTE, further exploratory research is required into the suitability, merits, risks, and costs of these solutions. After selection, further development will be required to technological readiness for production and installation. Development work beyond the tile hardware is not initially in scope of the DANTE project, and will at any rate require sufficient further partner funding and planning of development effort.

It is envisaged that, subsequent to the completion of the appropriate design phase, DANTE partners may opt to participate in the collective procurement and installation of the DANTE hardware at their individual LOFAR station(s). This procurement and rollout is not defined as part of the DANTE project, but the DANTE design will take into account specifications related to cost of purchase, and cost and ease of installation. Once there are near-final designs of the DANTE hardware, this will facilitate separate future planning and budgeting of procurement and installation.

A full LOFAR2.0 station backend (not a LOFAR1 station backend) is required in any mode of use of DANTE hardware. It is envisaged that DANTE partners will furthermore opt to procure and install in their station(s) an additional rack of LOFAR2.0 hardware for handling the second HBA tile beams that can be produced with the DANTE hardware. Operating the additional rack will require a future extension of the LOFAR2.0 station control software. LOFAR2.0 hardware design, procurement, and rollout are carried out and managed by ASTRON for the joint ILT partners, with appropriate funding contributions from each one. While the DANTE hardware designs will interface to LOFAR2.0 hardware, they are separate projects.

DANTE partners may also, at some time, opt to participate in further development, procurement, and installation of dedicated on-station and off-station data acquisition, transport, storage, and processing facilities, and associated algorithms and software. Any such supplementary endeavours are outside the scope of the DANTE project.

5 - GOVERNANCE: PROJECT STEERING AND PARTNER OBLIGATIONS

- 5.1 The Parties shall jointly act as a Consortium of partners for the governance of their collaboration and top-level steering of the project.
- 5.2 To this end, there is a Consortium Steering Board (CSB), consisting of 1 representative per partner. The CSB shall set and modify the overall project budget and planning, top-level deliverables and design specifications, upon proposals by ASTRON. The CSB will, in particular, confirm advancing with the execution of the work in stages tailored to sufficient total funding having been committed. The CSB decides on memberships of the Consortium.
- 5.3 The CSB will have a progress meeting (by any accepted means/medium) twice per year, facilitated by ILT / LOFAR ERIC; additional meetings may be called by ASTRON, ILT / LOFAR ERIC, or any combination of 3 partners. The CSB shall aim to operate by consensus, and otherwise shall make decisions by simple majority voting (>50% of the votes cast must be in favour), where each partner has 1 vote; decisions cannot, however, impose a mandatory increase in the financial obligations (whether cash, effort, or other in-kind) of a partner without its consent.
- 5.4 ASTRON shall bear the responsibility for the overall project management, including financial and effort bookkeeping, and tracking of progress. ASTRON in principle provides the engineering effort to carry out the project efficiently, subject to total available funding from the combined consortium partners.
- 5.5 The other partners shall co-fund the development effort, in accordance with the Funding Model below, that stipulates minimum participation levels to the core budget and further acquisition targets. In return, the partners have specific rights, stipulated below. For partners other than ASTRON, contribution of effort or other in-kind contributions, instead of or in addition to cash, may be considered by the CSB when

expedient for the completion of the project goals, upon the recommendation of ASTRON.

6 - PROJECT BUDGET

- 6.1 At the start of the project, the core budget covering the planned development of the HBA-FE board and the HBA tile summator-beamformer is set to 600,000 €, plus a contingency of 400,000 €, in view of significant planning uncertainties in several design stages. The total target for fundraising is thus 1,000,000 €. The detailed initial budget is in the appended project plan.
- 6.2 The Funding Model, below, assumes the full core budget of 600,000 € will be committed at the start from the combination of the initial Consortium members; their payments may be made in stages. Covering the contingency funding of 400,000 € is set as a best-efforts fundraising target for all partners at the start of the project.
- 6.3 The CSB may decide, as a fall-back, that development will progress stepwise, should there be only partial core project funding committed; this would carry a significant risk of non-completion for the partners that initially invest. In that case, if and when further funding becomes available, it will first be used to reach the full core budget.
- 6.4 Should it become clear that the full core budget will be depleted before the end of the design effort, the CSB may, likewise, decide to progress stepwise by drawing on contingency funding if and when that becomes available.
- 6.5 In order to facilitate later reconciliation of contributions not made in proportion to the shares of the Funding Model (either between the partners, or for hardware purchases; see Section 7), the partners except ASTRON will make their contributions through the ILT / LOFAR ERIC, which reconciles these with ASTRON.

7 - FUNDING MODEL; FINANCIAL OBLIGATIONS

The information worded below is summarised in Table 1.

- 7.1 In order to start a viable end-to-end project without undue risks, the Funding Model has been designed to cover the full core budget by firm commitments from the expected initially joining partners. Payment time scales (spending profiles) may, however, be individually arranged, within the boundaries of project progress. The Funding Model allows the contingency budget to be covered from any combination of initially committed funding supplemented by pledges for best-efforts fundraising.
- 7.2 At the start of the project, ASTRON has committed 200,000 € to the core budget, and is prepared to take on a best-efforts fundraising commitment of 100,000 € towards the contingency. ASTRON is considering the eventual upgrade of 2 Dutch stations to dual-beam HBA-FE.

- 7.3 The parts of the core budget and contingency budget not covered by ASTRON are to be equitably divided over the other participating partners. The key for sharing is the total number of so-called Participation Units (PU). Contribution requirements are set as follows:
- a. 1 PU for each station that is considered for upgrade
 - b. 2 PU for each new station to be built
- 7.4 The Funding Model has been prepared in the expectation of obtaining 8 PU from initially joining partners other than ASTRON, as tabulated below.
- a. The part of the core budget not covered by ASTRON is 400,000 €. Each PU is therefore fixed to requiring a confirmed commitment to contribute 50,000 €.
 - b. The part of the contingency budget not initially available and not pledged for best-efforts fundraising by ASTRON, is 300,000 €. Each PU therefore initially requires any combination of a confirmed contribution amount plus a best-efforts additional fundraising pledge, to a total 37,500 €. (QUI INKIND INAF)
- 7.5 The fixed minimum contribution commitment of 50,000 € per PU will be applied to the initially joining partners as well as to any partner that enters at any later time, or when a partner increases its ambition (i.e., its PU level); payment time scales (spending profiles) may be individually arranged, within the boundaries of project progress.
- 7.6 All initial and subsequent contribution commitments (including those of partners entering later) will be first applied to covering the core budget, then the contingency budget.
- 7.7 The CSB, advised by ASTRON, will decide on the progress of the project when this requires release of available or prospective contingency funding. The CSB will, likewise, adjust targets for further fundraising based on advice by ASTRON, and consider an equitable distribution in accordance with individual partner PU obligations and funding already committed.
- 7.8 At the completion of the project, the total amount spent is used as the basis to recompute, *a posteriori*, the fair contributions to the total by each partner, in proportion to their fixed *a priori* minimum shares of 200,000 € for ASTRON, and 50,000 € per PU for all other partners (except ILT). Reconciliation will take place through the ILT, with the primary aim to be applied to the amounts that will be due by individual partners within a collective purchase of the designed hardware; partners that eventually elect to participate, may discuss at that time with the ILT / LOFAR ERIC alternative forms of reconciliation, including but not limited to a cash reconciliation (i.e., additional payment by the partner, or cash return to the partner).

Table 1. Budget of the DANTE project.

CORE BUDGET Commitments required		CONTINGENCY BUDGET Contribution targets	
ASTRON	Interested	ASTRON	Interested

	ILT/LOFAR ERIC partners		ILT/LOFAR ERIC partners
200,000 €	400,000 € 50,000 € per PU	100,000 €	300,000 € 37,500 € per PU
600,000 €		400,000 €	

8 - BENEFITS OF THE PARTIES

- 8.1 Partners contributing to the DANTE development project according to Article 7 are fully eligible to actively participate in and make use of data obtained by the IDOLS project. IDOLS has long-term exclusive use, granted by the ILT Board, to a single LOFAR Core station and additional LOFAR array filler time, for solar and space weather science demonstrations that emulate near-continuous availability of a dedicated beam/data stream, as will become available with HBA dual-beam tiles. IDOLS will engage in associated pipeline and software development and testing; use of the IDOLS station as a testbed when developing DANTE hardware is being considered. However, IDOLS has its own collaboration and project management structure; detailed rights for IDOLS to access ILT / LOFAR ERIC infrastructure and interaction with ILT / LOFAR ERIC operations are separately regulated by the ILT Board, are not part of the DANTE project, and are not covered in this Consortium Agreement.
- 8.2 Partners contributing to the DANTE development project shall further benefit from the option to participate in joint procurement and installation of the designed hardware at the best price, if possible, through LOFAR ERIC (see Article 9).

9 - HARDWARE PROCUREMENT

The aim is that LOFAR ERIC shall conduct joint procurement of the DANTE designed hardware for station conversion, station building, and station maintenance; this is foreseen as part of an Optional Activity, in which the DANTE partners may elect to participate as long as they have fulfilled their financial obligations (Article 7).

- The procurement and installation Optional Activity will take place through contributions by the partners, for their station construction or upgrading.
- The intention is to follow the LOFAR ERIC Uniform Station Condition policies on contributions, ownership, and placement of station hardware; this may also lead to procurement without requirement to pay VAT.
- The ILT / LOFAR ERIC intends to secure, at its expense, DANTE HBA-FE boards as spare components for future maintenance in accordance with ILT Station Contracts and LOFAR ERIC Uniform Station Condition policies.
- As part of the procurement and installation Optional Activity, the ILT / LOFAR ERIC intends to reach an agreement with partners that upgrade their stations on the re-use

of their current-generation HBA-FE Board, for the long-term maintenance of stations not (yet) upgraded.

- The ILT / LOFAR ERIC endorses use one of the LOFAR stations and further filler time use for the IDOLS project goals, and if needed at a later stage for on-station testing and commissioning of the HBA-FE boards under design in DANTE

10 - OPERATIONAL INTEGRATION

The ILT Board endorses and will promote that under the Optional Activity Agreement with LOFAR ERIC:

- 10.1 One beam of the dual-beam HBA data stream shall be immediately implemented and operated as part of the standard single-beam LOFAR2.0 array by the relevant station owners. An estimate of costs of implementation and operation will be provided by the DANTE project design in due time.
- 10.2 Partners contributing to the development project will have the opportunity to operate the second HBA beam for 3 years for their exclusive use, at their own cost. LOFAR ERIC and the partners of the Optional Activity Agreement aim to decide in consultation on a transition project to common-user mode after the exclusive use period, in order to gradually implement standard operation of the dual-beam instrumentation, with time allocation under general access policies and data in the LTA.

11 - DELAYED PARTICIPATION

The CSB decides on the admission of new partners. The Funding Model (Article 7) prescribes the financial contributions due from partners joining after the initial approval of this Consortium Agreement; these will be equal to those of the initial members. Other modalities of delayed participation are decided as needed by the CSB.

12 - ENTRY INTO FORCE AND DURATION

- 12.1 This Consortium Agreement will enter into force when a total of € 600,000 in committed contributions, covering the core budget, is reached. The Agreement is intended to remain in force until full completion of the development project. Development work beyond the HBA-FE board and summator-beamformer tile hardware is not initially in scope of the DANTE project. Incorporation of related further work is not precluded, but will require a decision by the CSB, and is at any rate subject to the availability of sufficient additional funding and development effort.
- 12.2 The ILT and all other partners in the DANTE Consortium shall endeavour to anchor this Collaboration Agreement as a LOFAR ERIC Optional Activity (as defined in the

LOFAR ERIC Financial Model), at the same time as the transfer of the LOFAR2.0 Joint Investment Project from ILT to LOFAR ERIC.

- 12.3 After successful completion of the development project, all financially contributing Parties in the Consortium will be offered the opportunity (but not the obligation) to jointly procure (if possible, under the LOFAR ERIC umbrella) an initial batch of newly designed DANTE hardware, at the best possible price level.

13 - AMENDMENTS

Amendments and additions to this Consortium Agreement require the unanimous agreement of all Parties.

14 - IPR

Foreground IPR generated from the DANTE development project is available to all partners, including ILT / LOFAR ERIC. When using it elsewhere, the Parties shall ensure an appropriate licence.

15 - RESOLUTION OF CONFLICTS

- 15.1 The Parties shall make all possible efforts to resolve any disputes arising out of or in connection with this Consortium Agreement through amicable negotiations in the CSB and by non-recourse to legal action.
- 15.2 If a conflict that cannot be settled through amicable negotiations, the Parties may take the issue to court. Any legal action under this Consortium Agreement shall be brought in the court of Assen, the Netherlands.

[Annexes: Prospective partner contributions, Project Plan DANTE]

ANNEX I - PROSPECTIVE PARTNER CONTRIBUTIONS

PARTNER	# OF PARTICIPATION UNITS (PU)	CONTRIBUTION	
		Core budget	Contingency budget
ASTRON (NL)		200,000 €	100,000 €
IANA0 (BG)	2	100,000 €	75,000 €
GLOW (DE)	1	50,000 €	37,500 €
DIAS (IE)	1	50,000 €	37,500 €
INAF (IT)	2	100,000 €	75,000 €
UWM (PL)	2	100,000 €	75,000 €
OSO (SE)	1	50,000 €	37,500 €
STFC (UK)	1	50,000 €	37,500 €