**Candidacy EMR-Einstein Telescope: factsheet**

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# Introduction

The Einstein Telescope is the initiative of more than 750 scientists to create a European research centre for gravitational wave research. It is a triangular infrastructure with 10x10x10 km tubes about 250 meters underground. The infrastructure is high-tech, safe and with clean techniques. With this infrastructure it is possible for the first time to see almost the entire visible universe even looking back into its dark ages, which are unobservable by other means. Thousands of scientists worldwide work together in this rapidly growing field of science.

The European consortium of scientists around the Einstein Telescope has submitted the project for the update of the European roadmap of large scientific infrastructures: the ESFRI roadmap 2021. The application is directly supported from 5 European countries (including Belgium and the Netherlands). As soon as the Einstein Telescope is included on this roadmap, a process will start that should eventually lead to the site selection in Q1 2025. Belgium, Germany and the Netherlands must present their bid book and candidacy by 2024 at the latest.

The Euregion Meuse-Rhine (EMR) is listed as one of the two possible locations for the Einstein Telescope. The geology of the region appears to be ideal. The techniques are clean and safe and the landscape will not be affected. The top technology region around the Meuse-Rhine Euregion also has a cross-border ecosystem with many strong top research institutes and clusters of innovative high-tech industry for the required key technologies. The international living and business climate is excellent. The total approach to a candidacy is led by cross-border partnership of 50 scientific institutes from Belgium, Germany and Netherlands that are jointly shaping the EMR candidacy.

The Einstein Telescope offers a great leap forward for science, technical innovation in the region and in cross-border cooperation. The best researchers and students come to the Euregion. Top talents create an attractive business climate with new high-tech start-ups and spin-offs.

Total investments:

* R&D: € 200 million (position now at € 65 million, see appendix A);
* Construction: € 1,700 million;
* Operation € 40 million / year

Employment: 34,000 man-years during construction; 1500 jobs structurally.

Each euro invested provides a total of 3.6 euros in the economy.

At the moment, the institutes in the Euregion are working on the basis of the MoU to realize the ambitious R&D that is needed to realize the Einstein Telescope. The institutes are tackling this challenge together, in partnership with industry and with the support of Belgian, German and Dutch governments (total subsidies of € 65 million). See the appendix A. With the upcoming European programs, the Euregion can strive to occupy a dominant position in the total European R&D program (estimated € 200 million). Important EU-regional projects include ETpathfinder, E-TEST and now also the ET2SME project.

See also: [www.etpathfinder.eu](http://www.etpathfinder.eu) and [www.etest-emr.eu](http://www.etest-emr.eu).

See also: [www.einsteintelescope.be](http://www.einsteintelescope.be), [www.einsteintelescope.de](http://www.einsteintelescope.de), [www.einsteintelescope.nl](http://www.einsteintelescope.nl).

# Scientific building blocks for a candidature-bidbook

Note in advance: the starting point is the European planning in the ESFRI application and assuming the ET-ESFRI status in 2021. We look here at the share that the institutes must take - under the umbrella of the 2018 MoU - to arrive at their share for a bid book to come to a fundament for consideration of a candidacy by the Belgian, German and Dutch governments before 2025 (see 3).

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| **What** | **Who** | **When** |
| Principle study of seismic suitability of EMR geology | Nikhef cs. | 2019 (delivered) |
| Principle study of economic impact for region B, D and NL | Technopolis;  HEC Liège | 2018 (delivered) |
| Complete geological exploration of the EMR soil | E-TEST consortium | 2020-2022 (ongoing) |
| Civil engineering design, costs and permits bases on geology | E-TEST consortium | 2020-2022 (ongoing) |
| ET R&D program on KETs together with industry | See appendix A | See appendix A (ongoing) |
| Site/ route, civil engineering, permits and business case | MoU-partners | 2021 - 2022 |
| Collaboration agreement between institutes for the preparation, construction and exploitation of ET infrastructure | Formation of consortium to build and operate the ET from the MoU-partnership (2018) | 2021 – 2024 |
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| Bidbook | Governments Belgium, Germany and Netherlands | 2021 - 2024 |

# Political steps and status

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|  | **Political support for the site-selection procedure including the EMR-region** | **Political support for the EMR-candidacy** | **Financing the EMR-candidacy** |
| **Euregion / NRW** | ESFRI-application support letter | ESFRI-application support letter | Cofunding R&D projects (Appendix A) |
| **Netherlands** | ESFRI-application support letter | Elections 2021 and ‘Nationaal Groeifonds’? | |
| **Belgium** | ESFRI-application support letter | Flemish ‘Relanceplan’, plan ‘Get up Wallonia’, elections 2024? | |
| **NRW** | NRW-Landtag petition > 2022 elections as new momentum? | | |
| **BRD** | Elections 2021 and FIS roadmap 2022/ 2023? | | |
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| **Agreement of support by the three countries** | Based on the collaboration agreement of the institutes and a bid book a joint declaration / agreement of support with financial commitments will be made for the candidacy (2024) | | |

# SWOT-analysis candidature EMR on PESTO-dimensions

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| **Strengths** | **Weaknesses** |
| Political: support Belgium, Netherlands and NRW; local support of governments and EMR; combining complementary science efforts and dividing the costs between 3 countries; fresh open partnership.  Economical: high-tech industry environment; infrastructure;  Social: outreach potential and media coverage;  Technological: R&D lead (pathfinder, e-test, etc.); E-TEST will complete geological aspects for a bid;  Organisational: support institutes (MoU, R&D); forward GW-science movements in 3 countries. | Political: support Germany on federal level;  Economical: return on investment uncertainties;  Social: civil engineering impact uncertainties; uncertainties on legal and permits;  Technological: industrial involvement (is growing); geological siting (E-TEST ongoing)  Organisational: science community coordination B-G-NL; institute leadership bid/ incidental meetings; no anticipations on a preparatory phase plan; large infrastructure building plan; bidbook-management. |
| **Opportunities** | **Threats** |
| Political: Dutch cabinet agreement; BRD elections; Belgian momentum; Nortwest European partnership; one B-G-NL status-report for 3 governments.  Economical: Key Enabling Technologies in R&D; challenging industry; EU-programs; education; return on investment strategy/ plan;  Social: E-TEST studies on civil and legal/ permits;  Technological: more R&D programme coordination B-G-NL; RWTH-NRW-leadership R&D focus-points; leading noise mitigation, data analytics and computing;  Organisational: more German institutes joining; stronger partnership Helholz & Max Planck; broadening the science case and partnership (astronomy, applied science, etc.); working out a consortium of institutes based on R&D, exploitation and impact leadership; sourcing partners for civil engineering (investment); bidbook management. | Political: ESFRI-uncertainty; Site-selection-procedure uncertainty; Saxony-uncertainties; complex administrative challenge of 3 countries.  Economical: fixations on green and digital;  Social: unclear environmental impact management;  Technological: R&D leadership outside EMR;  Organisational: Italian leadership and funding. |

**Appendix A:**

**Einstein Telescope funded projects by third parties in Belgium, Germany and Netherlands**

#### Granted/ ongoing/ finished:

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| **Funder** | **Project** | **Total amount** | **Period** | **Notes** |
| *Interreg Flanders-Netherlands*  *+ co-funding by partners* | *ETpathfinder* | *14,5 MEuro* | *June 2019 –June 2022* | *R&D laboratory for laserinterferometry in Maastricht. Project concerns 100% capital investment. Partners provide human capital. Housing acquired by University of Maastricht. Conceptual Design Report available January 2020. Cleanroom finished in 2021. First tenders for vacuum installation in summer 2020. End of 2022 operational interferometer. Focus on cryogenic silicon mirrors and modern controls.*  *Consortium of:* ***Partners:*** *Nikhef (NL), Eindhoven (NL), Maastricht (NL), Antwerpen (B), Brussel (B), Leuven (B), Gent (B)*  ***Satelite partners:*** *Tilburg (NL), TNO (NL), VITO (B), RWTH Aachen (G), Fraunhofer ILT Aachen (G), UCLouvain (B), Liege (B), Hasselt (B)*  ***Ongoing*** |
| *Interreg Euregio Meuse-Rhine (EMR)*  *+ co-funding by additional partners* | *E-TEST* | *15 MEuro* | *Feb/2020-Dec/2022* | *Two main topics:*   1. *Large cryogenic silicon mirrors (Centre Spatial de Liege, CSL);* 2. *Detailed geological studies.*   *Project includes capital investment and human capital.*  *Consortium:* ***Partners:*** *Liege (B), UCLouvain (B), RWTH Aachen (G), Nikhef (NL), Maastricht (NL), KNMI, Hasselt (B), Leuven (B), Fraunhofer ILT (G), VITO (B)*  ***Satelite partners:*** *TNO (NL), Antwerpen (B), Brussel (B), Gent (B)*  ***Ongoing*** |
| *Interreg*  *Euregio Meuse-Rhine (EMR)*  *+ co-funding by additional partners* | *ET2SME* | *~2 MEuro* | *2021-2022* | *Mapping industry in the Euregion around R&D tenders for ET (ETpathfinder, E-TEST) and facilitating cooperation and innovation with vouchers.*  ***Started*** |
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| *Province of Limburg & University of Maastricht* | *Start of Gravitational Waves research group at University of Maastricht* | *7,5 MEuro* |  | *Group Hild:*  *5 (Stefan, Jo, Stefan, Sebastian & Jessica) +1 (Gideon Koekoek) staff physicist (tenure)*  *3-4 PhD*  *Master students*  *Housing*  **Ongoing** |
| *Province of Limburg/Nikhef (50/50)* | *Boring Terziet* | *1,6 MEuro* | *2017-2019* | *Drilling for first Seismic measurements for Einstein Telescope in South Limburg*  ***Finished***  ***(sensor part of Dutch seismic sensor network)*** |
| *Province of Limburg/Nikhef/Univeristy of Maastricht/AEI (D), Birmingham (UK)* | *Cost pilot study civil engineering Einstein Telescope* | *42 kEuro* | *2019* | *Study of civil engineering costs for Einstein Telecope (tunnels, caverns etc.) By Implenia (Swiss tunnelbuilder).*  ***Finished*** |
| *Province of Limburg/Nikhef/Ministry of Economic Affairs* | *Socio-economic impactstudie* | *~40 kEuro* | *2018* | *Technopolis study socio-economic impact ETpathfinder & Einstein Telescope.*  ***Finished*** |
| *Ministry of Economic Affairs* | *Samenwerking industrie* | *200 kEuro* | *1 June 2018 – end of 2021* | *Stimulating cooperation with Industry*  ***Ongoing*** |
| *Dutch Science Council (NWO/NWA)* | *Zwaartekracht - een nieuwe ontdekkingsreis* | *2,5 MEuro* | *2018-2020* | *PR/Communication, seismic sensors and fte*  ***Ongoing*** |
| *Dutch Science Council (NWO-Groot)* | *Gravitational waves: The new cosmic messengers* | *3,5 MEuro* | *2019-2023* | *Upgrades Virgo and porotypes of large mirrors for ET*  ***Ongoing*** |
| *Dutch Science Council (NWO-Physics)* | *Gravitational waves: a new road to fundamental physics, astrophysics, and cosmology* | *2,5 MEuro* | *2019-2025* | *PhD’s, Post-Docs for exploitation Virgo and development ETpathfinder and geology for studies for Einstein Telescope*  *Partners: Nikhef, VU, UvA, RUN, UU, UM, TU/e*  ***Ongoing*** |
| *Dutch Science Council (NWO/NWA)* | *Dutch Black Hole consortium* | *4,9 MEuro* | *2021>* | *Broad consortium (theory, instrument development, physisiscts & astronomers TNO, KNMI, HBO, …). Co-financing Province of Limburg, Innoseis, museum Boerhave and probably Continium discovery centre (Kerkrade) possibly Shell.*  ***Granted (PI: Stefan Vandoren/University of Utrecht)*** |
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| *German Federal Ministry of Education and Research* | Third Generation Gravitational Wave Telescope | *2.3 MEuro* | *2020-2023* | *This includes physical and geophysical research. These include, for example, laser techniques, cooling, seismic measurements and the development of crystalline fibers for suspending the mirrors related to ETpathfinder.*  *Partners are fourteen German universities and non-university research institutions led by RWTH Aachen.*  ***Granted*** |
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| *Vlaamse Interuniversitaire Raad (VLIR), iBOF funding* | *Verkenning van het donkere heelal met gravitatiegolven: van kwantum optica tot kwantum gravitatie* | *2,48 MEuro* | *2021-2024* | *Subsidy for GW university positions (PhD, postdoc, …)*  ***Granted*** |
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| *European Research Council* | *ERC Consolidator: SILENT* | *2M€* | *2020-2025* | *Seismic isolation of Einstein Telescope. Host: Universite de Liege, with Universite Libre de Bruxelles.*  ***Granted*** |
| *Wallonie Recherche SPW* | *BEWARE grant: SUNRISE* | *208 k€* | *2021-2023* | *SUperconducting Niobium actuatoRs for gravItational-wave Sensors and sEismic isolation*  ***Granted*** |
| *Institut Interuniversitaire pour la Recherche Nucleaire (IISN) du Fonds National de Recherche Scientifique (Belgium)* | *Virgo: physics with gravitational waves* | *850 k€* | *2019-2025* | ***Granted*** *to UCLouvain, ULiege and ULB: budget for 2 postdoctoral positions, 2 PhD grants, instrumentation and running budget (travel, etc). Dark matter and primordial black holes*  *-Stochastic background*  *-Binary coalescences, unmodeled signals*  *--Applications of machine learning*  *- Mode mismatch mitigation*  ***Granted*** |
| *Action de Recherche Concertée de la Communauté Francaise de Belgique (Belgium)* | *Gravitational Wave Science* | *950 k€* | *2019-2024* | ***Granted*** *to UCLouvain and ULiege. PhD and postdoctoral positions in gw data analysis and instrumentation. Budget for computing* |
| *China Research Council* | *Visiting postdoctoral researchers* | *100 k€* | *2021-2023* | ***Granted.*** *One postdoctoral researcher at UCLouvain* |
| *Fonds National de Recherche Scientifique (Belgium)* | *FRIA* | *150 k€* | *2021-2024* | ***Granted :*** *one PhD grant at UCLouvain* |
| *UCLouvain* | *Assistantship* | *150 k€* | *2019-2022* | ***Granted :*** *one PhD grant associated with teaching duties* |