Suppression Of underwater Noise Induced by Cavitation

FP7-314394-SONIC

SONIC –FINAL REPORT

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Document summary information

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Glossary

FP7	Seventh Framework Programme
RNL	Radiation Noise Level
MSFD	Marine Strategy Framework Directive
NFMT	Noise footprint and mapping tool
URN	Under Water Radiated Noise
SORIANT	TNO's Sound Risk Analysis Tool

PROJECT FINAL REPORT

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1. Executive Summary

The first goal of SONIC has been to enhance the understanding of underwater radiated noise from ships and shipping. The project aimed to improve computational and measurement techniques (full scale and model scale) to determine the underwater radiated noise extend to be used in ship design. Subsequently these methods were applied to potential noise mitigation measures to study the effect of these design and operational measures. The resulting knowledge has been summarised in a set of guidelines for underwater radiated noise, developed in close collaboration with the AQUO project.

A shipping noise footprint and mapping tool (NFMT) has been developed, implemented and tested for a number of benchmark scenario's. Vessel Noise Footprints and shipping noise maps have been generated to compare the effectiveness of different noise mitigation measures. The limited information available from AIS is, at this stage, a major uncertainty in the NMFT output.

Model scale experimental tools have been improved to measure the radiated propeller cavitation noise at partner test facilities. Techniques have been developed to remove the effects of background noise and reflections from the measurements. A suitable scale model test has been performed in each facility for various test conditions. Seven different approaches to the computational prediction of cavitation noise have been developed and applied to the suitable test case.

Measurements of radiated noise from a test ship at full scale have been carried out using on-board sensors and off-board hydrophone arrays. These data have been used to validate the experimental and computational results. The radiated noise from a variety of larger merchant ships have been measured near a shipping lane off the Dutch coast. The measurement data are published in the SONIC public database of ship radiated noise data.

The numerical and experimental techniques to determine radiated noise have been applied to investigate the effectiveness of a number of noise mitigation measures. Technical measures to reduce the cavitation and machinery noise have been studied as well as operational measures. For the operational measures it was shown that spatial planning can significantly reduce the underwater sound levels in specific marine areas.

2. Context and Objectives

2.1. Investigation of Radiated noise generated by Shipping

The Marine Strategy Framework Directive (MSFD) identifies underwater noise as a qualitative descriptor for achieving Good Environmental Status.
Computational and experimental techniques for investigating radiated noise at the design stage of ships using model scale facilities (model basins and cavitation tunnels) have been developed. These tools have been used to investigate design aspects to reduce cavitation noise from ships' propellers and hence assist with implementing the MSFD

2.2. Modelling of cavitation related noise

Cavitation of merchant ship propellers has been identified as a main source of background noise in the oceans. The EU requires member states to demonstrate that human caused underwater noise does not harm marine life.
Accurate tools have been developed and validated to predict underwater radiated noise levels of cavitating merchant ship propellers to allow early and efficient judgement of new builds with respect to their noise emission properties. By means of these tools design aspects and mitigation measures have been investigated in order to minimise the cavitation noise of ships without reducing the propulsion efficiency.
Existing experimental and computational tools had to be investigated and further developed to extend the underwater radiated prediction towards .

For the computational procedures different codes for wake prediction, propeller operation, propeller cavitation dynamics and noise radiation have been adapted and coupled in order to obtain an applicable tool for the prediction of underwater radiated noise.
Experimental and computational procedures have been validated by means of full scale measurements and finally applied to different test cases in order to investigate design changes and to serve as basis for mitigation studies.

2.3. Mitigation measures of cavitation noise, machinery noise and operational mitigation measures

The objectives set to meet this task in SONIC were as follows:

- To develop cavitation noise reduction measures without reducing fuel efficiency.

- To develop machinery noise reduction measures without reducing fuel efficiency.
- To assess effect on sound maps of spatial planning of ship traffic.

Mitigation of cavitation noise

The experimental and numerical techniques that have been developed in WP1 are applied to study the following mitigation measures for reducing cavitation noise:

- Optimisation of propeller design and selection
- Optimisation of control schemes for controllable pitch propeller installations
- Application of wake equalizing devices
- Air injection into the propeller plane

Mitigation of machinery noise

The contribution of noise emission by 4-stoke Diesel engines has been studied in a Source-Path-Receiver model, applying the sub-structuring breakdown of single steps contributing to the mechanical noise chain. Every single step in the chain has been analysed and modelled by means of the most advanced computer techniques. The main steps analysed are: engine combustion forces, engine structures, engine resilient mounts, ship foundation, ship hull and hull radiation efficiency.

Mitigation by spatial and operational planning

The NFMT sound mapping tool is used to study the effects of spatial and operational planning of ship traffic on the underwater noise distribution. Sound maps are calculated for different scenarios, to demonstrate the effects of operational measures like a speed limit or a limit to the noise footprint of individual vessels.

2.4. Developed of methodology to calculate the noise footprint of a vessel, and the development of noise and mapping tool for shipping

A methodology has been developed to assess the 'vessel noise footprint' of individual ships and of 'sound maps' representing the spatial distribution of underwater sound from shipping traffic for a specific part of the sea using AIS datasets. The methodology has been implemented in a Noise Footprint and Mapping Tool (NFMT) that is suitable for EU member states to support the implementation of the Marine Strategy Framework Directive (MSFD; 2008/56/EC). One of the MSFD descriptors of Good Environmental Status requires Member States to ensure that levels of underwater noise do not adversely affect the marine environment. In particular, Descriptor 11 requires Member States to monitor trends in underwater ambient noise, which requires a combination of measurements and modelling.

As a first step, definitions are proposed for basic terminology of underwater acoustics, including shipping sound maps and vessel noise footprints, as geographical representations of the sound pressure level generated by ship(s) in a specified environment, and agreed with AQUO. The methodology to assess these distributions combines AIS data of the locations and characteristics of ships and their operation in the area, to model the sound sources, with environmental data (bathymetry, oceanographic, meteorological and geo-acoustic data), to model the sound propagation loss. Basin wide propagation modelling requires a trade-off between accuracy and computational speed. Various models are implemented and tested and the results compared in a joint SONIC-AQUO benchmark workshop. To be able to evaluate the sound as perceived by marine life, the noise footprint and mapping tool includes options for representing the sound pressure level distribution reflecting the hearing sensitivity (frequency weighting) and swimming behaviour (depth weighting) of different species of marine mammals and fish.

2.5. Develpoment of Guidelines for regulation of under water noise

The developed guidelines summarise the conclusions and recommendations of SONIC as advice to policy makers for the way ahead to develop good environmental status of European marine waters with respect to underwater noise pollution from commercial shipping. The guidelines are furthermore aimed to enhance international standardisation of underwater noise terminology, measurement methods and assessment criteria.

As a base line the guidelines describe how more knowledge on the present status and the future trends of underwater noise pollution and its impact on marine life can be gained. Noise emissions by individual vessels and commercial shipping as a whole is addressed. Furthermore, the guidelines describe solutions to reduce underwater noise. Mitigation measures applied in ship design in retrofit and in ship operation are considered, thus offering solutions from a designer's as well as an operator's perspective.

3. S&T Results / Foreground

3.1. Investigation of Radiated noise generated by Shipping

Experimental tools have been developed to improve the measurement of radiated noise from ships at model scale in various hydrodynamic testing facilities including cavitation tunnels, a depressurised wave basin and a towing tank.
At each facility a suitable model scale test vessel and set of test conditions was selected. Measurements were carried out to determine the level of underwater noise in the facility during model scale tests of a cavitating propeller.
Further measurements have also been undertaken to identify and characterise sources of unwanted noise such as facility background noise and reflections from surfaces such as the walls of the test facility and the water surface. Techniques have been investigated to remove or compensate for these unwanted sources of noise to allow better prediction of propeller cavitation noise.
Seven different approaches to the computational prediction of cavitation noise have been applied and developed in the SONIC project. These have each been applied to suitable test cases to allow the results to be compared and validated.

Measurements of radiated noise from a test ship at full scale have been carried out using on-board sensors and off-board hydrophone arrays. These data have been used to validate the experimental and computational procedures and to investigate the separation of noise generated by machinery and by a cavitating propeller.

The validation process has identified where agreement is good and also highlighted areas that require improvement. The process has therefore been a valuable step in assessing where current procedures provide reliable results and where future work needs to be concentrated.

Autonomous underwater noise recorders have been used to characterise the noise field (or noise footprint) around the trial ship. This trial used novel measurement techniques and also provided the data required to validate the noise footprint modelling tool developed for the SONIC project.

An autonomous recorder has also been deployed close to a shipping lane off the Dutch coast to measure underwater noise from a variety of larger merchant ships. The results of the full scale trials have been presented at a number of conferences.

The full scale measurement results are being added to a public database of ship radiated noise data measured during the SONIC project.

A mathematical model to predict the source level of different ship types has been developed. The model predicts a source level for a given ship based on ship speed, type and size using information from AIS. The source level model is being used for noise mapping and mitigation investigations in the SONIC project. The accuracy of the model is affected by the parameters available from AIS being too limited to adequately determine the properties of the ship, and by the lack of good quality published ship radiated noise data to validate the model.

Further Results expected

In order to further validate the experimental and computational procedures, each approach was applied to a number of specific vessel test cases. The SONIC project developed a publically accessible database of radiated noise information, allowing the dissemination of full scale and scale model results.

3.2. Modelling of cavitation related noise

Improved experimental and computational tools have been developed to predict the under-water radiated noise levels of cavitating merchant ship propeller down to the lower frequency range (typical of the blade rate and harmonics) that is important for marine fauna.
For the experimental procedures a low background noise has been established and corrections for the spatial limitations and the influence of the gas content in the different involved facilities have been determined.
For the computational procedures, different codes for wake prediction, propeller performance, propeller cavitation dynamics and the noise radiation had to be adapted and to be coupled in order to produce an applicable tool for the prediction of underwater radiated noise at the blade rate and up to 3rd harmonic. Both of the procedures were accordingly improved, validated by full scale data and applied to several test cases in order to study design changes and mitigation measures. The gathered full scale prediction data for selected ship types is to be included into the data base of noise levels. The results have been summarised in publicly available reports.

Further Results expected

Beside the direct dissemination of knowledge via public reports, it is expected, and in some case experienced, that model basins and ship design companies are inquiring and or ordering to predict the underwater noise emission of ships. With increasing awareness of the importance of this signature and the eventuality of regulation this new type of pollution may become a significant design aspect of a modern vessel.

3.3. Investigation, and mitigation measures of cavitation noise, machinery noise and operation

Mitigation of cavitation noise

The results of systematic model scale tests of the cavitation noise characteristics of a standard set of propeller designs has provided guidance for optimised propeller selection. Numerical and experimental techniques have been developed and tested for optimising propeller design against multiple requirements for efficiency and cavitation noise and for evaluating the effectiveness of technical mitigation measures. These have been applied for a number of specific examples: wake equalising devices, control schemes for controllable pitch propellers and air injection techniques. The latter two showed especially promising results.

Mitigation of machinery noise

The main result achieved has been the precise measurement of the transmitted force to the ship foundation by means of instrumented resilient mount with load cells. This measurement allows eliminating one of the remaining uncertainties in the methodology. Thanks to this information, it has been possible to confirm that the force is precisely correlated to the machinery vibrations and that phase information is maintained up to a certain frequency that depends on the mount characteristics. It has also been proven that calculation of transmitted power is possible, so that it may be utilised by ship builders to better design the ship structure. These results will provide added value to the Wärtsilä product manual, thereby given better integration of the engine into the ship design. Patents will be applied for the instrumented resilient mounts proposed.

Mitigation by spatial and operational planning

Calculated sound maps for a generic shipping lane scenario (based on actual AIS data) demonstrated how the NFMT can be applied to study the effects of spatial planning in specific sea areas. The generic scenario studies indicated that the effectiveness of operational measures (a speed limit or a limit to the noise footprint of individual vessels) strongly depends on the local traffic characteristics (density and variety of ship types and their speed).

Further Results expected

The results of the mitigation studies will be implemented in the guideline document, together with the results of similar studies from the AQUO project

3.4. Development of methodology to calculate the noise footprint of a vessel, and the development of noise and mapping tool for shipping

A shipping noise footprint and mapping tool (NFMT) has been developed, implemented and tested. It is coupled to various external databases to define the environment and includes various acoustic propagation models, including the recently developed efficient hybrid model SOPRANO.

The tool is tested and compared with the models developed in AQUO for a number of benchmark scenario's in a joint workshop and experimentally validated against 'footprint' measurements on a small research vessel.

Marine mammals and fish are distinguished in ecological groups with characteristic hearing sensitivity and swimming depth, as input for species specific sound maps.

The NFMT development has been presented at several European conferences.
Footprints and sound maps have been generated to compare the effectiveness of different technical and operational noise mitigation solutions studied in SONIC.
The main uncertainties in the NFMT output are currently associated with the available AIS data, because not all ships are equipped with AIS transmitters, the AIS receivers do not cover the complete sea area, and the transmitted AIS information appears to be insufficient for reliable ship source level modelling on its own.

Further Results expected

In the final phase of the SONIC project, the NFMT has been applied to generate sound maps for the Dutch and German parts of the North Sea, based on historical AIS shipping density data for a single year, to demonstrate the capability and to illustrate the various maps that can be made as input for the MSFD monitoring and for studies of the impact of underwater sound on marine life.
The NFMT is developed such that it can be easily extended to model other anthropogenic underwater sound sources such as pile driving, air-guns and explosives and natural sound sources such as wind, rain and lightning.

3.5. Development of guidelines for regulation of under water noise

The developed guidelines represent a summary of the individual SONIC work packages condensed into recommendations for potential future regulation. The main topics are:

- Standardised and systematic measurement, monitoring and documentation of status and trends of underwater noise pollution by individual vessels, vessel types and commercial shipping as a whole and its impact on marine life.
- Relative effectiveness of technical underwater noise mitigation measures under consideration of the impact on fuel efficiency and building cost, and implications for practical realisation in ship design or retrofit.
- Relative effectiveness of operational underwater noise mitigation measures considering their impact on fuel efficiency, operating and maintenance cost.

The guidelines are jointly developed with the AQUO project. A dissemination event of the common draft guideline document to EU, IMO and interested stakeholders was held on the 21st September 2015, with the final guideline document to be finalised and published in November 2015.

Although the guidelines primarily aim at supporting policy makers in defining the way ahead, the findings and recommendations are also of interest for the ship building and shipping industry, since a variety of design and operational solutions for underwater noise mitigation are described and assessed.

Further Results expected

The guideline document may serve as a reference document for EU and IMO policy makers, national authorities, classification societies, ship designers ship yards and operators. Furthermore it provides a sound basis for further research on the impact of underwater noise on marine species.

4. Impact

4.1. Investigation of Radiated noise generated by Shipping

Experimental and computational techniques have been developed within SONIC and validated against full scale radiated noise data. These improved techniques can be used to predict the likely levels of radiated noise from new-build ships and hence investigate approaches to reducing noise levels at an early stage

4.2. Modelling of cavitation related noise

The developed procedures for prediction of the underwater radiated noise of cavitating merchant ship propellers enables ship owners, yards and ship operators to take into consideration the underwater noise emissions of an individual ship at the design stage. In this phase design changes and mitigation measures can be investigated most cost-efficient manner. In the end it is expected that merchant shipping will reduce noise emission while keeping the high propulsion efficiency.

4.3. Investigation, and mitigation measures of cavitation noise, machinery noise and operational measures

This study has provided an overview of the state of the art for mitigating shipping noise and of the tools and techniques available to quantify the effectiveness of the different available mitigation measures, both for the ship building industry and for regulators.

4.4. Development of methodology to calculate the noise footprint of a vessel, and the development of noise and mapping tool for shipping

An underwater noise footprint and mapping tool (NFMT) has been developed and tested, that can be used in the implementation of the monitoring for descriptor 11 of the European Marine Strategy Framework Directive.

4.5. Development of Guidelines for regulation of under water noise

In future the guideline document may serve as a reference document for EU and IMO policy makers, national authorities, classification societies, ship designers ship yards and operators. Further it provides a direction for further research on the impact of underwater noise on marine species.

5. Use and Dissemination of Foreground

5.1.A1 – List of Scientific (Peer Viewed) Publications

NO.	D.O.I Website	Title	Author(s)	Journal	Number, date or frequency	Publisher	Publication Location	Date of publication	Volume / Issue / Pages	Permanent identifiers (URL, if available)	Is/Will open access provided to this publication ?
1.		Experimental approaches for the diagnostics of hydroacoustic problems in naval propulsion	CNR-INSEAN M. Felli, M. Falchi, G. Dubbioso CNR-INSEAN	The Journal of Ocean engineering		Elsevier		2015	106/1-19		YES
2.		Propeller Cavitation Noise Investigations of a Research Vessel Using Medium Size	UNEW Batuhan Aktas, Serkan Turkmen,								

		Cavitation Tunnel Tests and Full-Scale Trials	Weichao Shi, Roderick Sampson, Emin Korkut, Patrick Fitzsimmons, Mehmet Atlar,								
3		Measurement of Radiated Underwater Noise from a Small Research Vessel in Shallow Water	SOTON Alex Brooker and, Victor Humphrey	The Journal of Ocean engineering		Elsevier		In Press			

5.1.A2 - SONIC Dissemination Activities

Nº	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
1	Web sites/Applications	ARTTIC	SONIC Public Website	19/02/2013	SONIC Public Website	Scientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias		International
2	Articles published in the popular press	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	SONIC - Surface Transport Research Synopsis	30/05/2013	Volume 2 - FP7 Transport Research Synopsis	Scientific community (higher education, Research) - Industry - Policy makers		European
3	Oral presentation to a scientific event	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	Noise and Vibration Conference - London	20/06/2013	2nd IMarEST Ship Noise and Vibration Conference - London	Scientific community (higher education, Research) - Industry		International
4	Oral presentation to a scientific event	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	EU FP7 SONIC PROJECT	17/09/2013	AMT'13	Scientific community (higher education, Research) - Industry		International
5	Posters	ARTTIC	SONIC Dissemination Material - Banner to be utilised during conferences	18/11/2013	N/A	Scientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias		International
6	Web sites/Applications	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	Submission of SONIC P1 Periodic Report to SONIC Advisory board	12/06/2014	SONIC Advisory Board	Scientific community (higher education, Research) - Industry - Policy makers		European
7	Oral presentation to a scientific event	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO	SHIP NOISE MAPPING IN THE NORTH SEA	22/06/2014	Underwater Acoustics 2014 Conference	Scientific community (higher education, Research) - Industry - Policy makers		International
8	Oral presentation to a scientific event	DNV GL SE	Sound Of Silence	16/10/2014	Ship Owner Forum of Schiffbautechnische	Scientific community (higher education,		International

Nº	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
					Gesellschaft	Research) - Industry		
9	Articles published in the popular press	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	Not So Loud	02/03/2015	Maritime by Holland Magazine	Scientific community (higher education, Research) - Industry - Medias		International
10	Web sites/Applications	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	EU FP7 SONIC PROJECT	31/03/2015	Review of CORDIS Result in Brief - EC	Scientific community (higher education, Research) - Industry - Policy makers		European
11	Articles published in the popular press	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO	Interview and Article	01/04/2015	New Scientist: www.newscientist.com	Scientific community (higher education, Research) - Industry		International
12	Oral presentation to a scientific event	CETENA S.p.A. Centro per gli Studi di Tecnica Navale	A method to predict underwater noise from cavitating propellers	21/05/2015	IEEE OCEANS'15 Conference	Scientific community (higher education, Research) - Industry - Medias		International
13	Oral presentation to a scientific event	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO	Experimental assessment of underwater radiated noise levels of different ship types	21/05/2015	IEEE OCEANS'15 Conference	Scientific community (higher education, Research) - Industry - Policy makers		International
14	Oral presentation to a scientific event	CONSIGLIO NAZIONALE DELLE RICERCHE	Advanced experimental methodologies for the diagnostics of hydroacoustic noise sources in naval engineering	21/05/2015	IEEE OCEANS'15 Conference	Scientific community (higher education, Research) - Industry - Policy makers		International
15	Oral presentation to a scientific event	NEDERLANDSE ORGANISATIE VOOR	Definition and results of test cases for	21/05/2015	IEEE OCEANS'15 Conference	Scientific community (higher education,		International

Nº	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
		TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO	shipping sound maps			Research) - Industry - Policy makers		
17	Oral presentation to a scientific event	UNIVERSITY OF SOUTHAMPTON	VARIABILITY OF UNDERWATER RADIATED SHIP NOISE MEASURED USING TWO HYDROPHONE ARRAYS	21/05/2015	IEEE OCEANS'15 Conference	Scientific community (higher education, Research) - Industry - Medias		International
18	Oral presentation to a scientific event	UNIVERSITY OF SOUTHAMPTON	An assessment of the variability associated with the measurement of radiated noise from vessels	15/05/2015	OCEANOISE conference 2015	Scientific community (higher education, Research) - Policy makers - Medias		International
19	Oral presentation to a scientific event	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO	SONIC model generated, sound maps and footprints of ships	15/05/2015	OCEANOISE conference 2015	Scientific community (higher education, Research) - Industry - Policy makers		International
20	Oral presentation to a scientific event	UNIVERSITY OF NEWCASTLE UPON TYNE	Underwater radiated noise investigations of cavitating propellers using medium size cavitation tunnel tests and full-scale trials	04/06/2015	4th International Symposium on Marine Propulsion & 2nd Workshop on Cavitating Propeller Performance	Scientific community (higher education, Research) - Industry - Policy makers		International
21	Oral presentation to a scientific event	UNIVERSITY OF NEWCASTLE UPON TYNE	The Princess Royal Cavitation Tests in Emerson Cavitation Tunnel & Full Scale Noise Trial Comparison	04/06/2015	4th International Symposium on Marine Propulsion & 2nd Workshop on Cavitating Propeller Performance	Scientific community (higher education, Research) - Industry - Policy makers		International

Nº	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
22	Oral presentation to a scientific event	UNIVERSITY OF NEWCASTLE UPON TYNE	Full scale and model scale cavitation comparisons of a Deep-V catamaran research vessel	04/06/2015	4th International Symposium on Marine Propulsion & 2nd Workshop on Cavitating Propeller Performance	Scientific community (higher education, Research) - Industry - Policy makers		International
23	Oral presentation to a scientific event	UNIVERSITY OF NEWCASTLE UPON TYNE	Cavitation Noise Prediction of Marine Propellers	11/06/2015	RINA London Branch Evening Lecture http://www.rina.org.uk/london_branch.html	Scientific community (higher education, Research)		UK
24	Oral presentation to a scientific event	CHALMERS TEKNISKA HOEGSKOLA AB	Numerical prediction of cavitation and radiated underwater noise of a research vessel	17/06/2015	Eccomas MARINE2015 Conference	Scientific community (higher education, Research) - Industry - Policy makers		International
25	Articles published in the popular press	UNIVERSITY OF NEWCASTLE UPON TYNE	Propeller Cavitation Noise Investigations of a Research Vessel Using Medium Size Cavitation Tunnel Tests and Full-Scale Trials	01/07/2015	The Journal of Ocean engineering: http://www.journals.elsevier.com/ocean-engineering/	Scientific community (higher education, Research) - Industry		European
26	Articles published in the popular press	CONSIGLIO NAZIONALE DELLE RICERCHE	Experimental approaches for the diagnostics of hydroacoustic problems in naval propulsion	01/07/2015	The Journal of Ocean engineering: http://www.journals.elsevier.com/ocean-engineering/	Scientific community (higher education, Research) - Industry - Medias		European
27	Oral presentation to a scientific event	CETENA S.p.A. Centro per gli Studi di Tecnica Navale	Underwater Radiated Noise of a Small Vessel	16/07/2015	22nd International Conference on Sound and Vibration: http://icsv22.org/	Scientific community (higher education, Research) - Industry - Policy makers		International
28	Web sites/Applications	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	SONIC - EC Oceans of Tomorrow Annex 1 and Annex 2	31/07/2015	Oceans of Tomorrow: http://ec.europa.eu/research/bioeconomy/pdf/ocean-of-tomorrow-2014_en.pdf	Scientific community (higher education, Research) - Industry - Policy makers		European

Nº	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
29	Videos	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	MARIN and TNO Utilisation of footage taken during the towing tank tests conducted on the Princess Royal.	19/08/2015	SAIL Amsterdam: https://www.sail.nl/en	Scientific community (higher education, Research) - Industry - Policy makers - Medias		International
30	Oral presentation to a scientific event	CONSIGLIO NAZIONALE DELLE RICERCHE	NOVEL EXPERIMENTAL APPROACHES FOR NOISE SOURCE DIAGNOSTICS IN NAVAL AND MARINE APPLICATIONS	28/09/2015	AMT15: http://conferences.ncl.ac.uk/amt15/	Scientific community (higher education, Research) - Industry - Policy makers		International
31	Oral presentation to a scientific event	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	Submission of Abstract: Acoustic reverberation measurements in the Depressurized Wave Basin	28/09/2015	AMT15 conference	Scientific community (higher education, Research) - Industry - Policy makers		International
32	Oral presentation to a scientific event	STICHTING MARITIEM RESEARCH INSTITUUT NEDERLAND	Submission of Abstract: Suppression Of underwater Noise Induced by Cavitation: SONIC	21/04/2016	TRA 2016 conference: http://www.traconference.eu/	Scientific community (higher education, Research) - Industry - Policy makers		International
33	Oral presentation to a scientific event	UNIVERSITY OF NEWCASTLE UPON TYNE	Systematic Cavitation Tunnel Tests for Cavitation Noise Prediction of Commercial Ships using a Standard Series Approach	29/09/2015	AMT15: http://conferences.ncl.ac.uk/amt15/	Scientific community (higher education, Research) - Industry		International
34	Web sites/Applications	DNV GL SE	UNDERWATER NOISE FROM COMMERCIAL	24/09/2015	leaflet on current R&D activities of DNVGL - Website Home Page	Scientific community (higher education, Research) - Industry - Civil society - Policy		International

Nº	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
						makers - Medias		
35	Oral presentation to a scientific event	UNIVERSITY OF NEWCASTLE UPON TYNE	On-Board Measurement Techniques to Quantify Underwater Radiated Noise Level	29/09/2015	AMT15: http://conferences.ncl.ac.uk/amt15/	Scientific community (higher education, Research) - Industry		International
36	Oral Presentation	WI	SONIC Project	27/3/2014	Vibro-Acoustics Marine Interest Group	Scientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias		International
37	Oral presentation to a scientific event	CNR INSEAN	Direct and Indirect Experimental Methodologies for the Hydro-Acoustic Analysis of Marine Propellers	05/11/2014	30th Symposium on Naval Hydrodynamics Hobart, Australia, 2-7 November 2014	Scientific community (higher education, Research) - Industry		International
38	Oral presentation to a scientific event	University of Southampton	SONIC Project	20/06/2013	2nd IMarEST Ship Noise and Vibration Conference - London	Scientific community (higher education, Research) - Industry		International
39	Oral presentation to a scientific event	University of Southampton	SONIC Project	27/5/2014	Lloyd's Register, London	Scientific community (higher education, Research) - Industry		International
40	Oral presentation to a scientific event	NAVANTIA	Study of cavitating vortex on pressure side of a controllable pitch propeller by means of Star-CCM+	09/11/2015	Workshop CFD Simulation for the Naval Industry (CD-adapco)	Scientific community (higher education, Research) - Industry		Spain
41	Oral presentation to a scientific event	NAVANTIA	Estudio de la mitigación de ruido de banda ancha radiado por una hélice mediante modelización matemática	12-13/11/2015	III Jornadas de Seguridad, Defensa, Tecnologías Matemáticas y Computacionales (ITMATI)	Scientific community (higher education, Research) - Industry		Spain

5.2.B1 – List of Application for Patents Trademarks, Registered designs (Confidential or Public: confidential information must be marked clearly)

Type of IP Rights	Application reference(s) (e.g. EP123456)	Intellectual Property Organisation	Subject of Application	Confidential YES / NO	Foreseen Embargo Date dd/mm/yy	Applicant(s) (as on application	URL of application (Mandatory for Patents)
Patents	Pending; not yet available	www.wipo.int	Engine Power Transmission sensor	YES	31/12/2035	**WÄRTSILÄ FINLAND OY** [FI/FI]; Tarhaajantie 2 FI-65380 Vaasa (FI)	www.wipo.int

5.3.B2 - SONIC OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND

Type of Exploitable Foreground	Description of Exploitable Foreground	Confidential	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable for commercial use or any other use	Patents or other IPR exploitation (licences)	Owner and Other Beneficiary(s) involved
General advancement of knowledge	Further development of knowledge of the HYKAT	Yes	31/12/2025	Exploitable product(s) or measure(s)?Noise measurements in the HYKAT	Maritime Hydrodynamics in Research and Consulting	On actual request	N/A	HSVA
Commercial exploitation of R&D results	Further development of knowledge of the LCT	Yes	31/12/2025	Noise measurements in the Large Cavitation Tunnel	Maritime Fluid Dynamics in Research and Consulting	On actual request	N/A	CNR-INSEAN
Commercial exploitation of R&D results	Further development of knowledge of the DWB	Yes	31/12/2025	Noise measurements in the Depressurised Wave Basin	Maritime Fluid Dynamics in Research and Consulting	On actual request	N/A	MARIN
Commercial exploitation of R&D results	Further development of knowledge of the Free Surface Cavitation Tunnel	Yes	31/12/2025	Summary of Noise Test Results in the Free Surface Cavitation Tunnel	Maritime Fluid Dynamics in Research and Consulting	On actual request	N/A	ROLLS ROYCE AB
Commercial exploitation of R&D results	Further development of own methodology to predict propeller radiated noise, tonal and broadband.	Yes	31/12/2025	Computational chain to predict propeller radiated noise	Maritime Fluid Dynamics in Research and Consulting	Upon Request	N/A	CETENA
Commercial exploitation of R&D results	Development and implementation of an acoustic propagation model in OpenFOAM	Yes	31/12/2020	Computational tool to propagate and predict radiated noise	Maritime Fluid Dynamics in Research and Consulting	Direct use in other research projects	N/A	CHALMERS
Commercial exploitation of R&D results	Prediction of cavitation pattern on propeller blades / hull pressure fluctuation assessment and extrapolation of	No		Source definition for full scale propeller noise assessment	Environmental friendly shipping	HSVA will Start usage within next 2 years; No restriction on access	N/A	HSVA

Type of Exploitable Foreground	Description of Exploitable Foreground	Confidential	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable for commercial use or any other use	Patents or other IPR exploitation (licences)	Owner and Other Beneficiary(s) involved
	experimental hydro-acoustic sound levels to unlimited domain							
General advancement of knowledge	Advancement in computational tools PROINS, NAVIS, KAA	Yes		Porous formulation in the FWH solver	Maritime Fluid Dynamics in Research and Consulting	Within SONIC, industrial project and other EC projects CNR-INSEAN are involved with.	PRO-INS is a Registered Trade Mark	CNR INSEAN
Commercial exploitation of R&D results	Further development of ETV-model and MATUSIAK-model, knowledge on applicability and limitations of the models	No		ETV-model and MATUSIAK-model	Maritime Fluid Dynamics in Research and Consulting	Utilisation in EC and Commercial projects	N/A	MARIN
General advancement of knowledge	Development of a computational procedure to predict the radiated noise by a cavitating propeller	Yes	31/12/2025	Computational procedure to predict propeller radiated noise	Naval construction	Utilisation in EC and Commercial projects	N/A	NAVANTIA
General advancement of knowledge	Development of Computational Procedures: computational tool ANSYS FLUENT	Yes	31/12/2025	Prediction of radiated noise from propellers	Maritime Fluid Dynamics in Research and Consulting	Utilisation in EC and Commercial projects	N/A	RRAB
General advancement of knowledge	Further development of own methodology to predict propeller radiated noise, tonal and broadband.	Yes	31/12/2025	Computational chain to predict propeller radiated noise	Maritime Fluid Dynamics in Research and Consulting	Utilisation in EC and Commercial projects	N/A	CETENA
General advancement of knowledge	Improved understanding and techniques for radiated noise measurements in model scale and extrapolation to full-scale	No	31/12/2020	Model measurement techniques and data on a particular vessel	Maritime Hydro-acoustics and Underwater	On request	N/A	UNEW

Type of Exploitable Foreground	Description of Exploitable Foreground	Confidential	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable for commercial use or any other use	Patents or other IPR exploitation (licences)	Owner and Other Beneficiary(s) involved
	Improved understanding and techniques for radiated noise measurements on full-scale vessels. Development systematic propeller noise database using experimental techniques			Full-scale measurements techniques and data on a particular vessel. Systematic propeller noise database for major commercial ship types	Environmental Noise			
General advancement of knowledge	Improved understanding and techniques for radiated noise measurements on vessels. On-board measurement of ultrasound radiated by cavitation activity.	No		Radiated noise and on-board ultrasonic noise measurements	Maritime Hydro-acoustics and Underwater Environmental Noise	On request	N/A	SOTON
General advancement of knowledge	WP 2.3 and WP 2.5 Improved understanding and techniques for cavitation observations and	No		On-board cavitation observations and hull vibration measurements as well as relationship between these and the	Ship design, manufacturing and testing establishments; Class societies; Regulatory	Upon Request	No	UNEW

Type of Exploitable Foreground	Description of Exploitable Foreground	Confidential	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable for commercial use or any other use	Patents or other IPR exploitation (licences)	Owner and Other Beneficiary(s) involved
	on-board vibration measurements On-board cavitation observations and hull vibration measurements			URN	bodies;			

5.3.1. B2a - Exploitation Plan

1. MARIN

The experimental methods developed in SONIC to determine the underwater radiated noise on model scale will be applied in commercial projects assisting ship designers in reducing the radiated noise of new ship designs. The improved methods to filter out background noise in the model basin will increase the accuracy of the measurement of the actual cavitation noise, this increasing the accuracy of the design. These methods can be applied to any commercial or non-commercial project in the model basin.

With the numerical methods to determine the cavitation extent and resulting noise radiation MARIN will be able to assist clients in determining the underwater radiated noise in an early design stage. Combing these methods with the experimental methods will result in a further increased accuracy and can also be applied to any commercial or non-commercial project.

Numerical methods to determine the wake field of a ship can also be utilised to calculated the potential energy saving of energy saving devices. This is outside the scope of the SONIC project but can have a big impact on ship energy saving.

ECO Magazine

Article about the SONIC project in U.S. based ECO Magazine (Environmental, Coastal & Offhore). October issue, covering International Shipping Regulations:
www.ecomagazine.com

TRA'16

SONIC Papers published and presented during TRA'16: http://www.traconference.eu/

2. CNR-INSEAN

The unconventional techniques developed by CNR INSEAN (i.e. direct "far field" pressure fluctuation measurements combined with detailed flow/pressure measurements in the proximity of the noise source through correlation and conditional techniques) are successfully applied for the experimental identification of the underlying mechanism of noise generation and propagation in the hydrodynamic facilities of CNR INSEA and represent effective approaches for the diagnostics and the design. Examples are documented in Felli et al. (2015) on Journal of Ocean engineering. Further developments will include the implementation of effective techniques to filter out the facility background noise and the self-induced noise.

3. HSVA

The project and results were published on international conferences (e.g. Internoise 2013, 15. – 18. September 2013, Innsbruck, Austria) and disseminated in workshops and discussions with customers interested in the underwater radiated noise signature of their vessels (MY's, RV's).

The computational and experimental tools developed by HSVA within the project will replace the current procedures and will be used for actual and future projects to increase the prediction accuracy as well as the frequency range.

The results will be used in consulting activities to convince customers that mitigation of underwater radiated noise is **not** contradictory to high propulsive efficiency.

4. NAVANTIA

The computational procedure developed by NAVANTIA within the SONIC Project aim to substitute the current procedure used by the shipyard to calculate the noise radiated by a cavitating propeller. Although more research is still needed, the work carried is considered to be a very good starting point that allows the application of this procedure to new ship and propeller designs in the near future.

5. RRAB

General focus areas:

- Focus on the noise footprint of individual ships and mitigation of noise such as the experimental work aimed to support the overall knowledge of setting up measurement standards in the area of noise measuring technology in a laboratory environment, versus real conditions.
- A specific hull and propeller design will be measured with an air injecting method of noise mitigation
- Give input to the Noise Footprint and Mapping Tool (NFMT) of the level of noise mitigation of the solution by injecting air in the vicinity of the propeller/hull.

Outcomes and intentions for further research projects:

- Contribute by publishing the results in this study at a suitable conference (to be decided)
- Be a pro-active partner in research and technology development of reducing the underwater ecological impact of marine systems.

- Be part in, as a larger marine product supplier, setting standards and develop future design of products to meet the new environmental requirements.
- Understand and be a consultancy of noise mitigation and low noise design for our customers and other collaborating parties such as research institutes

6. SOTON

The comprehensive measurement programme of full scale measurements on a single vessel has led to an improved understanding of the uncertainties associated with the measurement of radiated noise levels and vessel source levels. These results will be presented at international conferences and written up for publication in international peer reviewed journals. The experience and knowledge will also be used to inform the development of international standards for the measurement the source level of vessels, particularly in shallow water, under ISO. Opportunities will be sought to extend this measurement programme. The vessel noise footprint has also been measured, providing a unique data set that has not normally been obtained, and illustrating the radiated noise directionality. These results will be consolidated and disseminated by a variety of means. The unique Vessel Underwater Radiated Noise Database will continue and will be publicised in order to increase its content and use; the data contained will help develop improved models of the source level for use in conjunction with noise mapping software. This together, with other data obtained, will also be further analysed by a variety of student projects.

7. UNEW

The purpose of the foreground knowledge developed by UNEW threefold:

1. Further development on model based underwater radiated noise (URN) measurements and their extrapolation to full-scale using a benchmark vessel and associated model;
2. Full-scale URN measurements with the benchmark vessel and methods to relate them to on-board data;
3. Development of systematic URN data for major commercial ship types based on model test data.

The advancement in (1) & (2) have been achieved by conducting model tests and trials with a dedicated benchmark vessel in a collaborative campaign and producing an invaluable benchmark database. In (3) a unique database, which is non-existent, has been produced for the first time for commercial ship types. The produced knowledge and data can be disseminated through publication in journals, conferences and lectures immediately.

Knowledge in (3) is also part of a PhD research and hence will be disseminated through further publications. The potential impact of the knowledge provided on the wider community is significant since the produced benchmark data is rare, transparent and comparative due to its collaborative nature. Further research is required to generalise the measurement methods and benchmark data to cover for other ship types

8. WI

Within the SONIC project Wartsila have developed the prediction methodology of vibration transmission from the machinery to the ship foundation. The aim was to break down the chain of vibration transmission from the source to the receiver, thereby reducing the approximation at each propagation step, if compared to the commonly used methodology, using state of the art available tools. There is a Patent pending on the special innovative sensor that has been developed; “Engine Power Transmission sensor”. This will be an integrated sensor into the engine resilient mounting and will measure both the force and vibrations in order to compute the power flow as a direct computation. This will then be fed back into future resilient mounting design and installation.

9. TNO

The NFMT has been integrated in the TNO risk assessment tool SORIANT for the effects of underwater noise on marine life. SORIANT is being used in environmental impact assessment studies for offshore projects (e.g. wind farm development, oil and gas exploration) and is proposed as one of the tools for the underwater noise monitoring in the framework of the EU MFSD. Future developments will include an improvement of the current ship source level modelling, when more data become available, and an extension of the model to other anthropogenic noise sources.

11. CHALMERS

The computational noise assessment tools developed in the project, and the verification and validation studies are in the process of being consolidated into a range of publications, both journals and relevant conferences, to document and disseminate the work performed in SONIC. Several research proposals have already been developed and submitted, awaiting funding decisions. Efforts are made to continue to develop international and national cooperation' and research proposals beyond SONIC, building on the experiences and results from the project. These efforts concern both applications within ship propulsion and marine renewable energy, as well as more basic research investigations. The tools and methodologies will further be developed within our established collaboration with Rolls-Royce AB (through the Rolls-Royce University Technology Centre at Chalmers, outside the SONIC project), and future commercial use will be investigated in this context.

12. CETENA

The CETENA exploitable foreground is an improved methodology to predict propeller radiated noise, both tonal and broadband contributions.

This methodology will be used in consulting activities to support ship design and assessment projects.

Further development will include an improvement of the broadband models and an extensive validation on different ship types.

13. DNV-GL

DNV GL will present the guideline document on its web-site to strengthen its reputation as a knowledge leader in the field of underwater acoustics and to attract parties potentially interested into voluntary certification of compliance with underwater noise radiation limits.

The knowledge gained on the effectiveness of technical and operational mitigation solutions and the related implications on ship design and operation will be used to consult designers, yards and ship owners in newbuilding or retrofit projects.

6. Report on Societal Implications

A General Information *(Completed automatically when Grant Agreement Number is entered)*	
Grant Agreement Number	314394
Title of Project	SONIC
Name and Title of Coordinator	Dr. Henk Prins (MARIN) Tel: +31 317 49 34 56 E-mail: H.J.Prins@marin.nl

B Ethics	
1. Did you project undergo an Ethics Review (and / or Screening)? **If Yes:** have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports?	**No**
2. Please indicate whether your project involved any of the following issues (tick box 'X')	
RESEARCH ON HUMANS	**No**
Did the project involve children?	**No**
Did the project involve patients?	**No**
Did the project involve persons not able to give consent?	**No**
Did the project involve adult healthy volunteers?	**No**
Did the project involve Human geneti9c material?	**No**
Did the project involve Human biological samples?	**No**
Did the project involve Human data collection?	**No**
RESEARCH ON HUMAN EMBRTYO / FOETUS	
Did the project involve Human Embryos?	**No**
Did the project involve Human Foetal Tissue / Cells?	**No**
Did the project involve Human Embryonic Stem Calls (hESCs)?	**No**
Did the project on Human Embryonic Cells involve cells in culture?	**No**
Did the project on Human Embryonic Cells involve the derivation of cells from Embryos?	**No**
PRIVACY	
Did the project involve processing of genetic information or personal data (e.g. health, sexual, lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	**No**

Did the project involve tracking the location or observation of people?	**No**
RESEARCH ON ANIMALS	
Did the project involve research on animals?	**No**
Were those animals transgenic small laboratory animals?	**No**
Were those animals transgenic farm animals?	**No**
Were those animals closed farm animals?	**No**
Were those animals non-human primates?	**No**
RESEARCH INVOLVING DEVELOPING COUNTRIES	
Did the project involve the use of local resources (genetic, animal, plant etc?)	**No**
Was the project of benefit to the local community (capacity building access to healthcare, education, etc?)	**No**
DUAL USE	
Research having direct military use	**No**
Research having the potential for terrorist abuse	**No**

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Types of Position	Number of Women	Number of Men
Scientific Coordinator	0	2
Work Package Leader	0	4
Experienced Researchers (i.e. PhD holders)	5	44
PhD Students	0	2
Other		

4. How many additional researchers (in companies and universities) were recruited specifically for this project?

Of which, indicate the number of men:	0

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project? No

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective				Very effective
❑ Design and implement an equal opportunity policy	○	○	☑	○	○
❑ Set targets to achieve a gender balance in the workforce	○	○	☑	○	○
❑ Organise conferences and workshops on gender	○	○	☑	○	○
❑ Actions to improve work-life balance	○	○	☑	○	○

○ Other:

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ If Yes- please specify

☑ **No**

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ If Yes- please specify

☑ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

○ If Yes- please specify

☑ No

F Interdisciplinary

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[1]: Transport

○ Associated discipline1: Environment

○ Associated discipline1: Fisheries and Maritime

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	**No**

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

- ○ No
- ○ Yes- in determining what research should be performed
- ○ Yes - in implementing the research
- ○ Yes, in communicating /disseminating / using the results of the project

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ○ Yes - in implementing the research agenda
- ○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- ○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture		Energy		Human rights	
Audio-visual and Media		Enlargement		Information Society	
Budget		Enterprise		Institutional affairs	
Competition		Environment		Internal Market	
Consumers		External Relations		Justice, freedom and security	
Culture		External Trade		Public Health	
Customs		Fisheries and Maritime Affairs		Regional Policy	
Development Economic and Monetary Affairs		Food Safety		Research and Innovation	
Education, Training, Youth		Foreign and Security Policy		Space	
Employment and Social Affairs		Fraud		Taxation	
		Humanitarian aid		Transport	

13c If Yes, at which level? ○ Local / regional levels ○ National level ○ European level ○ International level	

H Use and dissemination

14. How many Articles were published / accepted for publication in peer-reviewed journals?		**2**
To how many of these is open access provided?		**2**
How many of these are published in open access journals?		**2**
How many of these are published in open repositories?		
To how many of these is open access not provided?		
Please check all applicable reasons for not providing open access: ❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ Other[2]: ……		
15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**1**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	
	Registered design	
	Other	
17. How many spin-off companies were created / are planned as a direct result of the project?		**0**
Indicate the approximate number of additional jobs in these companies:		

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	❑	In small & medium-sized enterprises
❑	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	❑	None of the above / not relevant to the project
☑	Difficult to estimate / not possible to quantify		

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs: *Indicate figure:*

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes ☑ No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes ☑ No

22. Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

☑	Press Release	☑	Coverage in specialist press
❑	Media briefing	☑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
☑	Brochures /posters / flyers	☑	Website for the general public / internet
❑	DVD /Film /Multimedia	❑	Event targeting general public (festival, conference, exhibition, science café)

23. In which languages are the information products for the general public produced?

❑	Language of the coordinator	☑	English
❑	Other language(s)		

Question F-10: Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. **NATURAL SCIENCES**

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, volcanology, paleoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 **ENGINEERING AND TECHNOLOGY**

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. **MEDICAL SCIENCES**

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. **AGRICULTURAL SCIENCES**

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. **SOCIAL SCIENCES**

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. **HUMANITIES**

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]