



H2020-ICT-25-2016-2017



HYbrid FLying rollIng with-snake-arm robot for contact inSpection

HYFLIERS

D7.4

HYFLIERS Dissemination and Exploitation Report P2, and Plan Update

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Abstract:

This deliverable reports about the dissemination and exploitation activities of the consortium partners during period P2, and the update of the dissemination and exploitation plans.

Keywords:

Conference. Dissemination. Exploitation. Horizon 2020. HYFLIERS. Innovation. IPR management. Journal. Magazine. Workshop. Risk mitigation.

Executive summary

This deliverable reports about the dissemination and exploitation activities of the consortium partners for the second reporting period P2 (from 1 July 2019 to 31 December 2020). The exploitation activities at this stage concentrate on risk mitigation for successful deployment in an operational scenario. An update of the dissemination and exploitation plans is also included in the deliverable.

Abbreviations and symbols

AEND	Spanish association for non-destructive testing (Asociación Española de Ensayos No Destructivos)
ATEX	atmosphères explosives
EAKR	Euroopan aluekehitysräho, same as ERDF
EC	European Commission
ECNDT	European Conference of Non-Destructive Testing
EMAT	electromagnetic acoustic transducer
ERDF	European Regional Development Fund
ERF	European Robotics Forum
HYFLIERS	Hybrid flying rolling with-snake-arm robot for contact inspection
ICRA	International Conference on Robotics and Automation
ICT	Information and Communications Technology
ICUAS	International Conference on Unmanned Aircraft Systems
IMU	inertial measurement unit
IROS	International Conference on Intelligent Robots and Systems
ISAR	International Symposium on Aerial Robotics
LIDAR	light detection and ranging
NDT	Non-Destructive Testing
RSS	Robotics, Science and Systems
SPE	Society of Petroleum Engineers
UAS	unmanned aerial systems
UT	ultrasound transducer, ultrasonic testing
WCNDT	World Conference of Non-Destructive Testing

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1. Dissemination

The HYFLIERS research results are targeted to reach:

- Scientific community,
- Industry and end users,
- Educational community,
- General public.

All HYFLIERS project outputs include a project acknowledgement statement, or otherwise suitable identification means, to help to identify them as originating from the project.

Publications are written on both the methods and technologies developed during the project and the applications. Scientific publications are made primarily through high-level international conferences and journals, favouring open-access models. Dissemination also exploits social networks (including LinkedIn, Twitter, etc.), national and local newspapers and television, as relevant. In addition to publications, the consortium also aims at organising international workshops on the research areas related to the project, summer schools, academic courses, seminars and events.

1.1. Dissemination Actions

The following contains the dissemination actions of each individual partner in the consortium.

1.1.1. Academic Partners

University of Oulu

During P2, University of Oulu disseminated HYFLIERS results at conferences as follows:

- Röning, Juha (2020) Combining aerial and ground robot to solve inspection tasks in refineries. European Robotics Forum (ERF). Malaga, Spain, 3 March. Presentation.
- Röning, Juha, et al. (2020) HYFLIERS: Hybrid flying-rolling with-snake-arm robot for contact inspection. European Robotics Forum (ERF). Malaga, Spain, March. Poster.
- Röning, Juha, et al. (2020) HYFLIERS: Project overview and current achievements. International Conference on Robotics and Automation (ICRA). Online, May-August. Video.

HYFLIERS project was also advertised during P2 at the following events:

- Röning, Juha (2020) AI & Robotics Business Event. Oulu, 13 March. Talk. (<https://www.oulu.fi/university/node/198199>)
- Röning, Juha (2020) EAKR Garbot Seminar. Oulu, 4 February. Talk. (<https://www.oulu.fi/bisg/node/60625>)

The project's web-site (<http://hyfliers-project.eu/>) is maintained up-to-date with the progress.

University of Seville

USE is disseminating HYFLIERS results through the publication of scientific papers in journals and at international conferences and workshops. In the second period, six papers in journals have been published (two of them in cooperation with CATEC), and another seven papers have been published in international conferences:

- S.R. Nekoo, J.Á. Acosta and A. Ollero, (2021) “Geometric control using the state-dependent Riccati equation: application to aerial-acrobatic maneuvers, *International Journal of Control*, DOI: 10.1080/00207179.2021.1881165
- A. Suarez, M. Perez, G. Heredia and A. Ollero, “Cartesian Aerial Manipulator with Compliant Arm”. *Applied Sciences*, 11(3):1001, 2021. <https://doi.org/10.3390/app11031001>.
- A. Caballero, P.J. Sanchez-Cuevas, M. Bejar, G. Heredia, M.A. Trujillo and A. Ollero, "An Aerodynamic Extension for Motion Planning with Dynamics Awareness in Aerial Long-Reach Manipulators", *International Journal of Aerospace Engineering*, vol. 2020, Article ID 6348035, 17 pages, 2020. <https://doi.org/10.1155/2020/6348035>.
- C.R. de Cos, M.J. Fernandez, P.J. Sanchez-Cuevas, J.Á. Acosta and A. Ollero, "High-Level Modular Autopilot Solution for Fast Prototyping of Unmanned Aerial Systems," *IEEE Access*, vol. 8, pp. 223827-223836, 2020, <https://doi.org/10.1109/ACCESS.2020.3044098>.
- A. Suarez, A. Caballero, A. Garofano, P. J. Sanchez-Cuevas, G. Heredia and A. Ollero, "Aerial Manipulator with Rolling Base for Inspection of Pipe Arrays," *IEEE Access*, vol. 8, pp. 162516-162532, 2020, <https://doi.org/10.1109/ACCESS.2020.3021126>.
- M. Faria, A.S. Ferreira, H. Pérez-Leon, I. Maza and A. Viguria, “Autonomous 3D Exploration of Large Structures Using an UAV Equipped with a 2D LIDAR”, *Sensors*, vol. 19:4849, 2019, <https://doi.org/10.3390/s19224849>.
- A. Lopez-Lora, P. J. Sanchez-Cuevas, A. Suarez, A. Garofano-Soldado, A. Ollero and G. Heredia, "MHYRO: Modular HYbrid RObot for contact inspection and maintenance in oil & gas plants," 2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Las Vegas, NV, USA, 2020, pp. 1268-1275, doi: 10.1109/IROS45743.2020.9341639.
- S.R. Nekoo, J.A. Acosta and A. Ollero, “Collision avoidance of SDRE controller using artificial potential field method: application to aerial robotics”, *International Conference on Unmanned Aircraft Systems (ICUAS)*, pp. 551-556, 2020.
- P.J. Sanchez-Cuevas, V. Martín, G. Heredia and A. Ollero (2020) Aerodynamic Effects in Multirotors Flying Close to Obstacles: Modelling and Mapping. In: Silva M., Luís Lima J., Reis L., Sanfeliu A., Tardioli D. (eds) *Robot 2019: Fourth Iberian Robotics Conference. ROBOT 2019. Advances in Intelligent Systems and Computing*, vol 1092. Springer, Cham. https://doi.org/10.1007/978-3-030-35990-4_6.
- S.R. Nekoo, J.A. Acosta and A. Ollero (2020) Fully Coupled Six-DoF Nonlinear Suboptimal Control of a Quadrotor: Application to Variable-Pitch Rotor Design. In: Silva M., Luís Lima J., Reis L., Sanfeliu A., Tardioli D. (eds) *Robot 2019: Fourth Iberian Robotics Conference. ROBOT 2019. Advances in Intelligent Systems and Computing*, vol 1093. Springer, Cham. https://doi.org/10.1007/978-3-030-36150-1_7.
- P. Ramon-Soria, A. E. Gomez-Tamm, F. J. Garcia-Rubiales, B. C. Arrue and A. Ollero, "Autonomous landing on pipes using soft gripper for inspection and maintenance in outdoor environments," 2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2019, pp. 5832-5839, doi: 10.1109/IROS40897.2019.8967850.
- S.R. Nekoo, J.Á. Acosta, A.E. Gomez-Tamm and A. Ollero, “Optimized Thrust Allocation of Variable-pitch Propellers Quadrotor Control: A Comparative Study on Flip Maneuver,” 2019 Workshop on Research, Education and Development of Unmanned Aerial Systems (RED UAS), Cranfield, UK, 2019, pp. 86-95, doi: 10.1109/REDUAS47371.2019.8999681.
- F.J. Garcia-Rubiales, P. Ramon-Soria, B.C. Arrue and A. Ollero, “Magnetic detaching system for Modular UAVs with perching capabilities in industrial environments,” *2019 Workshop on Research, Education and Development of Unmanned Aerial Systems (RED UAS)*, 2019, pp. 172-176, doi: 10.1109/REDUAS47371.2019.8999704.

HYFLIERS results have been presented in the following workshop organized at the European Robotics Forum in period P2 before the COVID lockdown:

- “New Aerial Robotics Technologies for Inspection and Maintenance”, workshop organized by A. Ollero at the European Robotics Forum (ERF). Malaga, Spain, 3 March 2020. Several presentations by USE, UOULU, CATEC, CHEVRON and CREATE.

Furthermore, USE had a stand at the European Robotics Forum, March 2020, Malaga, Spain, where HYFLIERS prototypes were on display. The project and the prototype were presented at the stand by A. Ollero to the Andalusian Minister of Economy, Knowledge, Business and University, Rogelio Velasco.



Figure 1: USE stand at ERF 2020 at Malaga (Spain), displaying a HYFLIERS prototype.

1.1.2. Research and Technological Centres

CREATE

CREATE is disseminating the achievements of the HYFLIERS project through scientific publications, workshops and exhibitions.

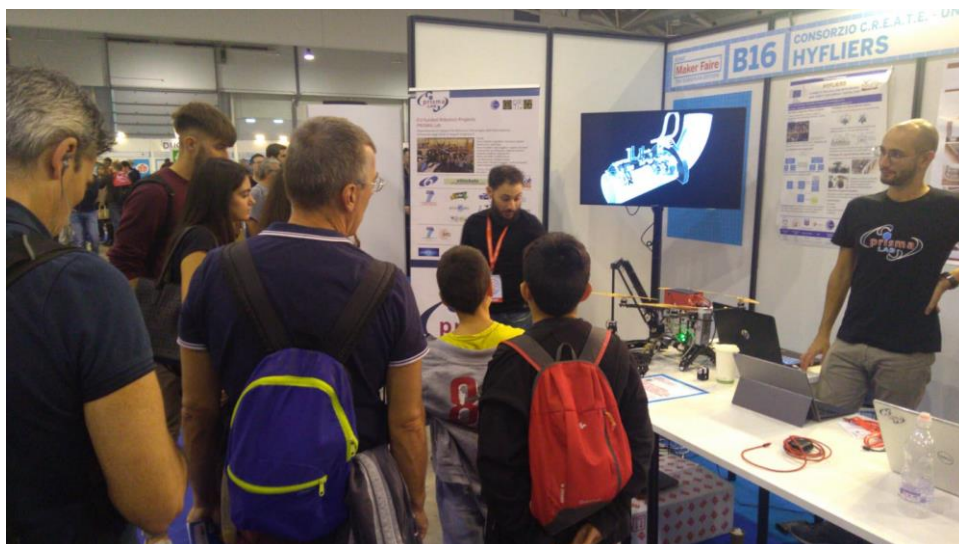


Figure 2: Maker Faire 2019 at Rome (Italy), HYFLIERS booth.

The HYFLIERS project has been disseminated at two editions of the **Maker Faire** (<https://makerfaire.com/>) from 17 to 19 May 2019 and from 18 to 19 April (Virtual) in Rome, Italy

through a dedicated booth and participation at a workshop. This international event is one of the most attended in Italy, with around 100.000 visitors and a large coverage of TV and newspapers (e.g., looking for “maker faire 2019” on Google gives 16.1M links, while looking for “maker faire 2020” gives 23.4M links).

In Figure 2, the HYFLIERS booth is shown. Several visitors have been attracted by the videos and live demos of preliminary prototypes that have been shown there.

Workshops

- Invited talk at a workshop “Aerial robotics for inspection and maintenance” for the School of Mechatronic Engineering, Beijing Institute of Technology, Virtual.
- Participation at the workshop: “Robotic inspection and maintenance in nuclear and other harsh environment” at the 2020 European Robotic Forum.
- Participation at the workshop: “Aerial Intelligent Robotics for Inspection and Maintenance” at the 2020 European Robotic Forum.

Press and social

- [MAKER FAIRE ROME & I-RIM KICK-OFF – OCTOBER 2019](#) – PRISMA Lab – 10.2019
- [PRISMA Lab e ICAROS center alla Maker Faire Rome 2019](#) – NewsUnina – 14.10.2019
 - 1 related post on Facebook – 14.10.2019
- [LA ROBOTICA CHE AMERAI È A MAKER FAIRE ROME 2020](#) – Maker Faire Rome.eu – 28.11.2020
 - 1 related post on Facebook and one on twitter 9.12.2020
- [Perché il digitale è un destino](#) – Infosfera – 29.11.2020
 - 1 related post on Facebook and 1 one on twitter 3.12.2020
- [Dal 10 al 13 dicembre 2020 torna “Maker Faire Rome – The European edition”](#) -- Maker Faire.eu -- 2.12.2020
- [Il PRISMA Lab federiciano alla Maker Faire Rome](#) – NewsUniNa – 9.12.2020
 - 1 related post on Facebook – 9.12.2020
- [PRISMA LAB AND ICAROS CENTER AT THE DIGITAL EDITION OF MAKER FAIRE ROME 2020 – 10–13 DECEMBER 2020](#) – PRISMA Lab – 12.2020
 - 1 related post on Facebook 9.12.2020

Videos

- [HYFLIERS for Maker Faire Rome 2020 Main Channel – 11 Dec 2020](#) – PRISMA Lab YouTube channel
 - 3 related posts on Facebook and 3 on Twitter

Papers

- S. Zhao, F. Ruggiero, G. A. Fontanelli, V. Lippiello, Z. Zhu and B. Siciliano, "Nonlinear Model Predictive Control for the Stabilization of a Wheeled Unmanned Aerial Vehicle on a Pipe," in IEEE Robotics and Automation Letters, vol. 4, no. 4, pp. 4314-4321, Oct. 2019, doi: 10.1109/LRA.2019.2931821. [<https://zenodo.org/record/3659195/files/root.pdf>]

FADA-CATEC

- M. Faria, A.S. Ferreira, H. Pérez-Leon, I. Maza and A. Viguria, “Autonomous 3D Exploration of Large Structures Using an UAV Equipped with a 2D LIDAR”, *Sensors*, vol. 19:4849, 2019, <https://doi.org/10.3390/s19224849>.
- A. Caballero, P.J. Sanchez-Cuevas, M. Bejar, G. Heredia, M.A. Trujillo and A. Ollero, “An Aerodynamic Extension for Motion Planning with Dynamics Awareness in Aerial Long-Reach Manipulators”, *International Journal of Aerospace Engineering*, vol. 2020, Article ID 6348035, 17 pages, 2020. <https://doi.org/10.1155/2020/6348035>.

CATEC had a stand at the European Robotics Forum, March 2020, Malaga, Spain, where HYFLIERS achievements and information on the project were presented for 3 days.



Figure 3: CATEC stand at ERF 2020 at Malaga (Spain).

Furthermore, CATEC presented HYFLIERS project during a general robotic inspection presentation in which several projects were presented. The presentation was integrated in a workshop organized by the University of Seville at the European Robotics Forum (ERF) at Malaga, Spain, the 3rd of March called “New Aerial Robotics Technologies for Inspection and Maintenance”.



Figure 4: CATEC presentation of HYFLIERS project at ERF 2020.

1.1.3. Industrial Partners

Chevron Oronite

The results of the HYFLIERS project are disseminated on the following platforms:

- Chevron.com website and Chevron social media channels
- Workshops, posters and/or short papers at workshops and industrial conferences

- European Robotics Forum (ERF);
- SPE Offshore Europe;
- SPRINT Robotics Seminar;
- World Conference NDT;
- Innovation Events, fora and newsletters within Chevron.

A number of our in-house fora were postponed in 2020 and will now take place in 2021.

The results of the HYFLIERS project have to date been disseminated as follows:

- Unmanned Aerial Vehicles Industry Engagement Session, Oil & Gas Technology Centre, Aberdeen, UK, July 2019
 - Audience 30 persons.
- Chevron Unmanned Systems Virtual Seminar, December 2020
 - Audience 80 persons

Total

The results of the HYFLIERS project has to date been disseminated as follows:

- TOTAL Inspection & Corrosion Seminar – Biarritz, France – November 2019
 - Audience 100 persons;
- TOTAL Field Operations Seminar – Biarritz, France – December 2019
 - Presentation: innovation for inspection
 - Audience 100 persons;
- ORCA (Offshore Robotics for Certification of Assets) Hub / Industry Workshop, Edinburgh UK, January 2020
 - Audience 20 persons;
- TOTAL Annual R&D Technical Orientation Committee February 2020
 - Audience 20 persons;
- TOTAL Annual R&D meeting 2020 – Pau, France - March 2020
 - Audience 40 persons;
- TOTAL Annual R&D meeting 2021 – Pau, France - March 2021
 - Audience 40 persons.

WTR

The results of the HYFLIERS project are disseminated on the following platforms:

- Workshops, posters and/or short papers at workshops and industrial conferences;
- Workshops with lead customers;
- Innovation Events, platforms and newsletters within Waygate;
- Waygate internal innovation awards.

Dasel

The divulgation of the activities is carried out in the scope of congresses and events on NDT.

1.2. Dissemination plan update.

An updated dissemination plan of the project was presented in revised deliverable D7.3 (February 2020) [D7.3]. The dissemination plan includes actions targeted to the scientific, industrial/end users

and educational communities and the general public. The actions implemented by the consortium in the P2 period of the project have been presented in the previous section. The update of the dissemination plan for the rest of the duration of the project is presented in the following subsections for the four different target groups.

1.2.1. Dissemination to the Scientific Community

The dissemination of the HYFLIERS results is being done through publication of scientific and technical articles in journals and at international conferences and workshops. This task is being undertaken mostly by the research partners (Universities and Technology Centres) and the publications cover several areas of the work performed within the project.

HYFLIERS honours the H2020 Mandate on open access to publications, and therefore provides ‘green’ or ‘gold’ open access to peer-reviewed journal and conference publications. The open access will be provided through the Zenodo repository when possible, and linked to OpenAIRE.

In the P2 period, the consortium has published papers in the following *journals*:

- IEEE Robotics and Automation Letters;
- International Journal of Control;
- IEEE Access;
- International Journal of Aerospace Engineering;
- Sensors;
- Applied Sciences.

In the final period, we expect that the number of publications in journals will be incremented. The updated list of recommended journals is presented in Table 1.

Table 1: Updated list of recommended journal and magazines

No	Journal / Magazine
1	IEEE Transactions on Robotics
2	IEEE Robotics and Automation Magazine
3	IEEE Access
4	IEEE Robotics and Automation Letters
5	Sensors
6	IEEE Multimedia
7	IEEE Transactions on Knowledge and Data Engineering

In the P2 period, the consortium has published research papers and delivered project presentations at these *international conferences*:

- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) – 2020;
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) – 2019 (publication);
- International Conference on Robotics and Automation (ICRA) -2020;
- International Conference on Unmanned Aircraft Systems (ICUAS) – 2020;
- International Conference on Unmanned Aircraft Systems (ICUAS) – 2019 (publication);
- Iberian Robotics Conference (ROBOT 2019) (publication);

- Workshop on Research, Education and Development of Unmanned Aerial Systems (RED-UAS) – 2019 (publication).

In the final period, the number of publications and presentations in international conferences will be incremented given the expected availability of final results and experimental tests. The updated list of recommended conferences is presented in Table 2.

Table 2: Updated list of recommended conferences

No	Conference
1	IEEE International Conference on Robotics and Automation (ICRA)
2	IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
3	International Conference on Unmanned Aircraft Systems (ICUAS)
4	IEEE International Conference on Mechatronics and Automation (ICMA)
5	IEEE International Conference on Automation Science and Engineering (CASE)
6	International Conference on Advanced Robotics (ICAR)
7	Robotics: Science and Systems (RSS)
8	Iberian Robotics Conference (ROBOT)

The P2 period has been marked by the mobility restrictions due to COVID starting March 2020. The consortium members only had the opportunity of presenting HYFLIERS results in the following workshop before the lockdown:

- European Robotics Forum (ERF) 2020.

In the final period the expectations are that the mobility restrictions will be gradually lifted, and the consortium expect to significantly increase the public presentations of the HYFLIERS results in workshops and symposiums. The updated list of planned and recommended venues is presented in Table 3.

Table 3: Updated list of recommended venues for public presentations

No	Venues for public presentations (keynotes, workshops, ...)
1	European Robotics Forum (ERF)
2	Workshops in IEEE International Conference on Robotics and Automation (ICRA)
3	Workshops in IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
4	Workshops in Robotics: Science and Systems (RSS)
5	International Conference on Unmanned Aircraft Systems (ICUAS)
6	International Symposium on Aerial Robotics (ISAR)

1.2.2. Dissemination to the Industry and End Users

Dissemination of HYFLIERS to the Industry and End-Users is being done through public presentations at industrial conferences and workshops, and industrial seminars. This task is being undertaken mostly by the industrial partners, and also by the other partners.

In the P2 period, the consortium has delivered the following public presentations in industrial seminars, workshops and conferences:

- European Robotic Forum (ERF), 2020, project presentations and HYFLIERS prototypes displayed at stands;

- AI & Robotics Business Event, 2020;
- EAKR Garbot Seminar, 2020;
- Unmanned Aerial Vehicles Industry Engagement Session, Oil & Gas Technology Centre, Aberdeen, UK, July 2019;
- Chevron Unmanned Systems Virtual Seminar, December 2020;
- TOTAL Inspection & Corrosion Seminar – Biarritz, France – November 2019;
- TOTAL Field Operations Seminar – Biarritz, France – December 2019;
- ORCA (Offshore Robotics for Certification of Assets) Hub / Industry Workshop, Edinburgh UK, January 2020;
- TOTAL Annual R&D Technical Orientation Committee February 2020;
- TOTAL Annual R&D meeting 2020 – Pau, France - March 2020.

In the final period, the consortium expects to increase the public presentations of the HYFLIERS results at industrial conferences, workshops and seminars. The updated list of planned venues is presented in Table 4.

Table 4: Updated list of planned actions for dissemination to the Industry and End-Users

No	Venues for dissemination to the Industry and End-Users
1	European Robotics Forum (ERF)
2	SPRINT Robotics “World Conference for Inspection and Maintenance Robotics”
3	Presentations in Total worldwide meetings: Total E&P Inspection & Corrosion Seminar, 2021 Total E&P EXP Field Operations Seminar, 2021 Total Annual Technical Orientation Committee, 2021
4	Chevron worldwide meetings
5	Internal presentation to end-users
6	ORCA Hub Industry Workshop 2021

1.2.3. Dissemination to the Educational Community

The dissemination actions intended for the educational community consist of presentations to MSc and PhD students of robotics-related topics linked to HYFLIERS results, and also in summer schools. Actions in school and youth outreach programs are also included in this section. These actions are mostly accomplished by the academic partners, and also the rest of the partners for the outreach actions.

In this second period, HYFLIERS partners have done the following actions to disseminate the project to the educational community:

- Invited talk at a workshop “Aerial robotics for inspection and maintenance” for the School of Mechatronic Engineering, Beijing Institute of Technology, Virtual, 2020;
- Presentation to students of the Electrical Engineering MSc program (U. Seville) 2020, 2021;
- Presentation to students of the Automation, Electronics and Telecommunication Engineering PhD program (U. Seville) 2020, 2021.

In the next period, the consortium will continue the dissemination actions targeted to the educational community. The updated list of planned actions is presented in Table 6.

Table 5: Updated list of planned action for dissemination to the educational community

No	Planned actions for dissemination to the educational community
1	Participation in aerial robotics summer schools
2	Presentations to MSc and PhD students (University of Seville, University of Oulu)
3	Participation in outreach programs (WTR)

1.2.4. Dissemination to the General Public

Dissemination of HYFLIERS results to the general public is done through the project website (<https://hyfliers.eu>) and the partners' own websites, the social media, appearance in the media, and presentations and presence in events intended for the general public.

In the P2 period, HYFLIERS partners have done the following actions to disseminate the project to the general public:

- Maker Faire Rome 2020. Stand and presentations to the public. Youtube channel, social media and web entries;
- Project website (<https://hyfliers.eu>);
- Individual partners' websites;
- Twitter accounts;
- LinkedIn accounts.

In the final period, the consortium will continue the dissemination actions targeted to the general public. The updated list of planned actions is presented in Table 6.

Table 6: Updated list of planned activities for dissemination to the general public

No	Dissemination to the general public
1	Articles/interviews in newspapers and magazines
2	Participation in general public events
3	Project website
4	Individual partners' websites
5	Twitter accounts
6	LinkedIn accounts

2. Exploitation

With the aim to strengthen the position of Europe in the field, the HYFLIERS exploitation priorities are the following:

- Provision of HYFLIERS technology to the project's end user;
- Direct commercial exploitation and licensing of HYFLIERS technology to third parties;
- Generation of spin-off companies;
- Inspiration of new research in robotics;
- Further improvement of academic teaching offer in the field.

A strong focus on the end user needs has been kept throughout P2 to continue strengthen the exploitation of the HYFLIERS project.

2.1. Exploitation activities

2.1.1. Industrial Partners

Total / Chevron

The end users identified early in the project that the two proposed prototypes were too complex to certify for use in a potentially explosive atmosphere (ATEX). Instead, the approach decided for successful deployment of the HYFLIERS prototypes in an industrial oil and gas environment is to mitigate risk to a level that is as low as reasonably practicable.

To achieve this, Total and Chevron stated that a gas sensor must be included in the sensor payload of each prototype. Switching the power off is not enough as a residual current will exist in the batteries which are not designed to contain an ignition source (because of the non ATEX design). In this way, upon confirmed gas, each prototype is able to detect and fly away before reaching critical explosive limits.

The main issue that remains is in the event of a gas release once each prototype has landed, stabilised on a pipe and is clamped by some means, how to achieve the prototypes disconnecting from the pipe and taking off quickly enough.

To this end, USE has developed a mechanical bridge for the HRA prototype which acts as a quick release mechanism modular in design for various clamping methods. See Section 2.1.2.

WTR

The exploitation goal of WTR in HYFLIERS is to expand its product and technology portfolio as an inspection systems provider. And by extension the exploitation of inspection service solutions in cooperation with Waygate Technologies Advanced Inspection Services.

The following technologies developed during HYFLIERS are being actively pursued with the aim for commercial exploitation:

- The ultrasonic testing solution using a Rollerprobe has been implemented on the BIKE platform to perform B-Scans in vessel confined spaces.
- A software algorithm has been developed for the BIKE platform using the Rollerprobe to drive a raster path enabling the combination of multiple parallel B-Scans to a full C-Scan, offering a novel solution for C-Scan mapping without the use of an additional scan axis.
- Integration of the satellite into the WTR inspection software suite.
- Implementation of a localization system based on IMU, odometry and geometry data, without the use of a LIDAR.
- A patent application for 'VEHICLE SUSPENSION WITH COUPLED, PIVOTING, OPPOSING SUPPORT LEGS' has been approved, covering the kinematics of the HMR satellite.
- Presentation of the HMR to interested companies in the petrochemical field.
- Review of the satellite for use in additional use-cases beyond pipe inspection
 - Inspection of the lower dome of vertical storage vessels with limited direct access
 - Heat-recovery steam generator (HSRG) header inspection where a small robot (satellite) is used to guide a borescope for visual inspection to each pipe joining the header.

- As a satellite placed on a larger crawler platform for use in pipe inspections where smaller branching pipes can be explored.
- Implementation of multi-segmented manipulator arms on crawler platforms
- Technologies developed by other partners:
 - lightweight arm, circular arm;
 - lightweight UT instrument for onboard integration;
 - EMAT technology;
 - small and lightweight EMAT instrument suitable for placement on robots.

DASEL

Dasel will focus on the development of ultrasound technology. Its main objective is to develop the necessary elements to have a small UT unit.

DASEL continues advancing in the integration of ultra-low weight ultrasound systems, concentrated in the following technologies:

- EMAT
- Roller probes
- Guided wave technology
- Multichannel system > 4 channels.

Dasel has a particular interest in using this type of technology in the field of aerospace inspection. The objective of DASEL is not to exploit the complete solution of HYFLIERS, but to market UT's software and electronics.

2.1.2. Academic Partners

University of Oulu

As a consequence of the participation to the HYFLIERS project, UOULU targets at

- Widening their knowledge base;
- Strengthening and expanding their teaching offer in specialised courses;
- Activating related academic thesis topics;
- Raising UOULU academic profile;
- Sparkling new research in the field.

Academic theses work on HYFLIERS research topics is also progressing. The staff of UOULU research team is active in strategic planning at the University.

Moreover, UOULU will disseminate and promote results in euRobotics and SPARC, and thus feed them to the EC for possible use in future framework programmes.

University of Seville

The University of Seville is developing a modular concept for a hybrid robot that can fly, land on the pipe, and move over it to reach the different points that need inspection. This concept, which is presented in detail in deliverable D2.1 [D2.1], has an aerial platform, a magnetic linkage module and a landing gear add-on module which can have different designs with different specifications. The arm, developed by CREATE and described in deliverable D3.1 [D3.1], is attached directly to the magnetic linkage module.

The magnetic linkage module is designed so that in event of confirmed gas detection the lower part with the landing gear, the arm and the ultrasonic sensor can be detached, and the aerial platform with the upper part of the linkage and the batteries can take-off and move away from the dangerous area very fast. The different add-ons, the roller, the soft clamp and the crawler clamp are designed for different pipe configurations, i.e., isolated pipes, groups of pipes with a minimum lateral clearance, pipe racks with small or no lateral clearance, etc. These designs are included in two Spanish patents that are being filed by the University of Seville.

University of Seville presented a patent application covering the HRA modular design during the first period. The patent has been published officially (patent with reference [ES2823073A1](#)), and USE has applied for the PCT extension, published with reference [WO2021089896A1](#).

2.1.3. Research and Technological Centres

CREATE

The NEABOTICS spin-off, which has been founded by prof. Vincenzo Lippiello to exploit the outputs of the HYFLIERS project, under the stipulated scientific collaboration agreement with CREATE and a specific agreement signed for the exploitation of the results of the HYFLIERS project, has deposited further two national patent requests (other two patents have been requested during the first period), which are extendable at European/World level in one year after the formal acceptance by the patent office:

- number 102019000016133 (12/09/2019): Accepted
- number 102020000020644 (31/08/2020): Under review (II round)

Exploitation workshops:

- Presentation of the achievements of the HYFLIERS project to interested companies for exploitation purposes: EQUINOR, AKER SOLUTION, 2019, Bergen, Norway.
- Presentation of the achievements of the HYFLIERS project to interested companies for exploitation purposes: ENI SpA, 2020, Milan, Italy.

FADA-CATEC

The main objective of FADA-CATEC is transferring technology to companies that will market them. Therefore, it is expected that some of the technologies developed in this project, and that will be demonstrated in a realistic scenario, will be of interest of the UAS/robotics industry. Then, the exploitation scheme is based on licensing the technology for its industrialization and production.

Furthermore, CATEC has also sent a patent application (request number P202130238) to the Spanish office of patents and trademarks. The patent is related to the landing gear developed in HYFLYERS for landing on top of pipes. This novel mechanism gives to any aerial robot the capability of safely land on metallic pipes without any active equilibrium system needed. In this way, the landing gear adapts to a wide range of pipe diameters and is attached to the pipe using permanent electromagnets that can be deactivated applying current. Moreover, a previous study was performed by a specialized company to ensure that the patent is viable, so it is expected that it will be accepted during the next period of the project.

2.2. Exploitation Plan

An initial exploitation plan for each partner was presented in deliverable D7.2. The full value chain and each partners role were identified in D7.3 as shown in Figure 5. The actions implemented based

on this by each partner in P2 have been presented in the previous section. Following an update of the exploitation activities and plans of the partners in HYFLIERS.

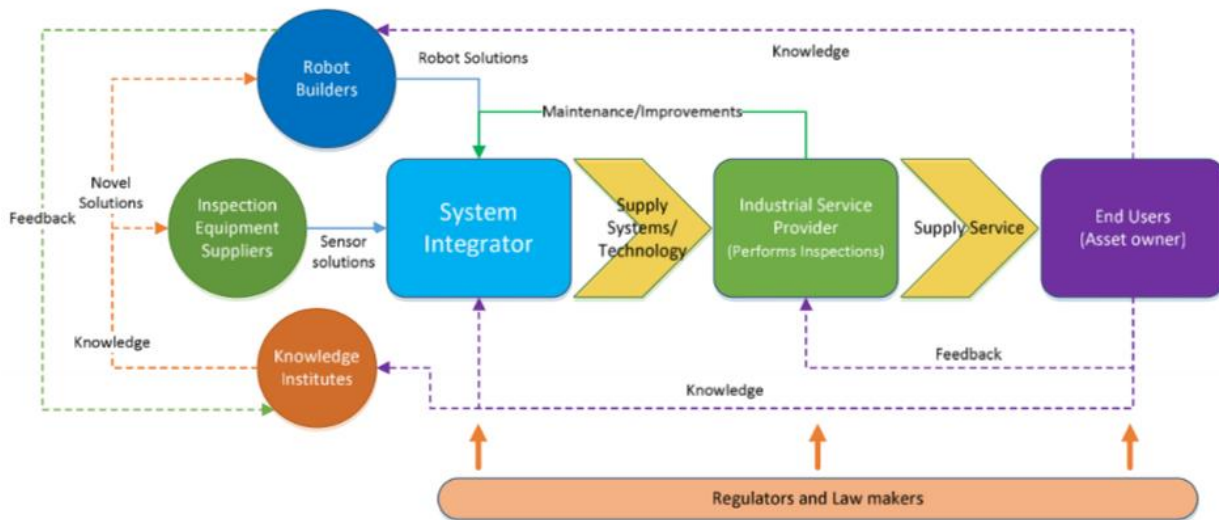


Figure 5: Value chain and stakeholder in robotics in the maintenance & inspection industry domain (see SPRINT Robotics Strategic Roadmap [ROADMAP2018]).

Roles of each consortium partner in the value chain:

- Asset Owner: Chevron, Total
- Industrial Service Provider: Waygate Technologies Robotics, Waygate Advanced Inspection Services
- System Integrator: FADA-CATEC, Waygate Technologies Robotics, Dasel
- Inspection Equipment Suppliers: Waygate Technologies Robotics, Dasel
- Robot Builders: Waygate Technologies Robotics
- Knowledge & Research Institutes: FADA-CATEC, University of Oulu, CREATE, University of Seville.

In addition to the spin-off set up to exploit the HYFLIERS solution, several partners have been pursuing exploitation activities using HYFLIERS development results both for inspection of assets at elevated heights or in other applications. Multiple partners have held workshops with potential customers outside the consortium to pursue further exploitations opportunities. A total of five patent applications have been submitted or approved, representing a very strong position for exploitation.

Each partner is continuing to pursue the plan by itself and the coverage of the full value chain ensures that opportunities for collaboration between partners can be exploited in different relationships (customer – supplier relationship, joint industrialization and exploitation set up etc.).

References

- D2.1 Rönig J, ed. (2018) Project presentation. HYFLIERS project deliverable D8.1. 31 Jan.
- D3.1 Rönig J, ed. (2018) Data management plan. ORDP. HYFLIERS project deliverable D8.2. 29 Jun.
- D7.2 Ollero A, ed. (2018) HYFLIERS Dissemination and Exploitation Plan. HYFLIERS project deliverable D7.2. 31 Jan.

D7.3	Kydd K, ed. (2019) HYFLIERS Dissemination and Exploitation Report P1 30 Jun.
HPI2012	Hydrocarbon Processing Industry Market Data (2012)
ROADMAP2018	Wim van Hoorn et al. (2018). SPRINT Robotics Roadmap. https://www.sprintrobotics.org/media-downloads/sprint-robotics-strategic-roadmap/