



D6.3

FINAL REPORT ON IMPACT AND DISSEMINATION

The 5G-SMART project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 857008.



DELIVERABLE D6.3 FINAL REPORT ON IMPACT AND DISSEMINATION

Grant agreement number:	857008
Project title:	5G Smart Manufacturing
Project acronym:	5G-SMART
Project website:	www.5gsmart.eu
Programme:	H2020-ICT-2018-3
Deliverable type:	Report (R)
Deliverable reference number:	D24
Contributing work packages:	WP6
Dissemination level:	Public (PU)
Due date:	31/05/2022
Actual submission date:	31/05/2022
Responsible organization:	Universitat Politècnica de València
Editor(s):	Jose F. Monserrat (UPV)
Version number:	1.0
Status:	Final
Short abstract:	This report summarises the synergy creation, and potential standardisation work in the project. It evaluates the outcome of the project dissemination plan. It also quantifies and lists the project prospective contributions to 5G-SMART manufacturing standards and regulation.
Keywords:	Communication, demonstration, dissemination, exploitation, impact, Industry 4.0, regulation, standardisation

Contributor(s):	Leefke Grosjean (ERICSSON AB) Dhruvin Patel (ERICSSON GMBH) Krister Landernäs (ABB AB) Ognjen Dobrijevic (ABB AB) Niels König (FRAUNHOFER IPT)
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	Berna Sayrac (ORANGE SA) Davit Harutyunyan (ROBERT BOSCH GMBH) Jose F. Monserrat (UNIVERSITAT POLITECNICA DE VALENCIA) Saúl Inca (UNIVERSITAT POLITECNICA DE VALENCIA) Roberto Padovani, Dirk Lange (MARPOSS)
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Executive summary

This deliverable has the objective to report the achievements of the project 5G-SMART for the dissemination, standardization and exploitation activities carried out during the three years of the activity, from June 2019 to May 2022.

5G-SMART prepared and attended a significant number of workshops, conferences and events, all based on the main technical objective of the performed research, i.e., the 5G system design for the industrial adoption of this technology. In doing so, 5G-SMART cooperated with the organizations in charge of the promotion of this technology, mainly 3GPP, ITU and 5G-ACIA. All the events and the dissemination activities were advertised through 5G-PPP channels and made available on the project site and through social media advanced exploitation.

Some of the achievements of 5G-SMART were also valuable input for the standardization bodies in this very challenging period that has seen the start of the actual use of the 5G into industry, surrounded by the convulsive period of the COVID-19 pandemic.

The 5G-SMART project has achieved the goals that were outlined at the start in the exploitation and dissemination plans of the consortium and all the partners. More than 25 papers, 13 press impacts, 30 contributions to standards, 3 keynotes in major conferences, the participation in 20 5G industrial events, 3 workshops, 5 demos and 8 webinars, show the high implication of the project in the dissemination of achieved results. A per partner-based report on the achievements of the ambitious plans stated at the project foundation is given in this deliverable as well as an impact analysis of the project.



Table of content

Disclaimer	3
Executive summary	4
1 Introduction	7
1.1 Objective of the document	7
1.2 Relation to other documents	7
1.3 Structure of the document	8
2 COVID-19 impact on the dissemination plan	8
3 Communication activities	9
3.1 Printed materials and press releases	10
3.2 Project website	12
3.3 Social media	13
3.3.1 Twitter	14
3.3.2 YouTube	14
3.3.3 LinkedIn	15
4 5G-SMART dissemination activities	16
4.1 Accepted papers/book chapters	17
4.2 White papers and technical reports	20
4.3 Panels, workshops, and events	21
4.4 5G Demos and validation events	22
4.4.1 Trial open days	23
4.4.2 Mobile World Congress 2021 and 2022	23
4.4.3 Hannover Messe 2021 and 2022	24
4.4.4 Smart Production Solutions Drive in Nuremberg	24
4.4.5 Control Fair in Stuttgart	24
4.4.6 Fraunhofer Solution Days	24
4.4.7 EuCNC	25
4.4.8 Other trade shows	25
4.5 Scientific publications	25
4.6 Workshops and presentations	25
4.6.1 5G-PPP events	26



4.6.2	5G-ACIA events	26
5	Standardization and regulation impact	27
5.1	Specific standardization and regulation synergies	27
5.2	5G Alliance for Connected Industries and Automation	28
5.3	Standard contributions	29
6	Achieved impact and exploitation goals	32
6.1	Industrial impact and exploitation	32
6.1.1	Ericsson	33
6.1.2	ABB	34
6.1.3	Marposs	35
6.1.4	Orange	36
6.1.5	Bosch	36
6.1.6	T-Systems	37
6.2	SME impact and exploitation	38
6.2.1	Cumucore	39
6.2.2	U-blox	39
6.3	Academic impact and exploitation	39
6.3.1	Budapest University of Technology and Economics	40
6.3.2	Fraunhofer IPT	40
6.3.3	Lund University	41
6.3.4	Universitat Politècnica de València	41
	Conclusions	43
	List of abbreviations	44
	References	45



1 Introduction

This deliverable summarises the main achievements of the 5G-SMART project in terms of dissemination and standardization activities performed along the timeframe during which 5G-SMART represented one of the most European-acknowledged research activities in the framework of industrial integration of 5G. The deliverable also includes a review of the industrial, academic and Small and Medium sized Enterprise (SME) exploitation plans prepared by the partners at the project start. The dissemination and exploitation plan was outlined at the beginning of the project in deliverable D6.1 [5GS19-D61].

Communication, dissemination, and exploitation have been tasks of high importance in 5G-SMART, as it is recognised that they are crucial elements to increase visibility and the impact of the project. With the outbreak of the Covid-19 pandemic, severe adjustments had to be made to the original plans of 5G-SMART for communication and dissemination. The quickly changing situation of decreasing possibilities to publicize the projects results through the usual channels such as conferences, trial open days, training activities, etc. during the pandemic outbreak, required a fast reaction of the project on finding alternative ways and creative solutions to continue to show the impact and benefits of the project. Therefore, it is true that due to the cancellation of several major events and conferences, 5G-SMART missed important opportunities to be exposed to a wider audience. Several events already planned were cancelled, while many others were organized online. However, our presence in keynotes and events from that moment on has been mostly in an online format, what at the end of the day seems not to have affected the impact of the project, since almost 125.000 entrances in google search mark the huge impact of the project in digital form. Section 2 reviews the actions done in the project to deal with the complications of COVID-19.

1.1 Objective of the document

The objective of this final report on the communication, dissemination, and exploitation activities is to provide a summary of the achievements made with respect to the communication from the start of the project until May 2022. This also includes a description of standardization activities and the impact on society and the involved players in the project.

1.2 Relation to other documents

This document builds on deliverable D6.1 [5GS19-D61] and D6.2 [5GS20-D62]. D6.1 provided a detailed overview of the project's dissemination, communication, and exploitation strategy at the project start. That plan was updated in D6.2, which at the same time included a report on the situation with respect to communication and dissemination from the project start until October 2020. D6.3 complements D6.2 in the report of activities and finalizes the plan described in D6.1.



1.3 Structure of the document

This document is structured as follows: Section 1 provides a general introduction to the deliverable and a detailed description of this report. Section 2 reviews the actuation of 5G-SMART with respect to the COVID-19 pandemic that affected the dissemination plans. Section 3 summarises the work done with respect to 5G-SMART's communication activities, while Section 4 focuses on 5G-SMART's dissemination activities. Section 5 presents the 5G-SMART activities with respect to the standardization and finally, Section 6 deals with the analysis of the initial exploitation plans at partner and at consortium level. Finally, in the last section, the deliverable is summarised, and conclusions are presented.

2 COVID-19 impact on the dissemination plan

5G-SMART realized early on the change that the dissemination in European projects was about to suffer, and the project immediately created an alternative plan to assure continued progress with respect to communication, dissemination, and exploitation. The following adjustments were made:

- In March 2020, some budget was shifted to reinforce communication activities. With this budget, filming activities were started, that documented the progress and results of the project at the trial sites. Until October 2020, professional photos and movies were taken from the 5G deployment and channel measurement activities at the Reutlingen trial site. Furthermore, photos and movies were taken at the Kista trial site. These photos and movies have been used during the project to better illustrate the project's results and activities, especially when trial site visits are not possible. The filming activities continued during the remaining project times, being an asset also when physical meetings are possible again.
- With tradeshow and fairs being cancelled, another emphasis of the project has been to organize live demos in connection with webinars and other activities. To reach a wide audience, all of these have been published on the project's YouTube channel. It is hard to estimate if this led to more attendees or fewer compared to physical meetings, but the good numbers confirmed that the research community was connected during this period of time.
- To compensate for the lower number of dissemination and communication activities, 5G-SMART has compiled a series of webinars that focuses both on research aspects as well as trial activities. These are listed below:
 - The "5G for smart manufacturing – Industry, and 3GPP RAN latest status" was the first webinar meeting held by 5G-SMART on 22 September 2020. Approximately 95 participants connected, coming mainly from the ICT field, and we received several requests for additional information through our social media with more than 250 views at the time of writing this deliverable. The recording is available via <https://youtu.be/5hatXCmMcPc>.
 - The "5G-SMART Webinar on 5G Process Monitoring in Manufacturing" was held on the 13th of October 2020. Approximately 82 attendees were online during the live stream and the recording is available via <https://youtu.be/puoFAayVpZk>.



- The 5G SMART webinar on “5G TSN deployment model and time synchronization aspects” counted with about 150 attendees in an online session organized on the 29th of January, 2021. The TSN model proposed in the project was analysed in depth. <https://youtu.be/j-IHbjKL8wI>
- On June 22nd of 2021 the webinar “5G and Industrial Robotics, Testbed Insights and Outlook” dug into the progresses on connected robotics, showing live demos about the performance of some of the proposals of 5G-SMART. 80 people connected to this webinar, that had up to 200 views considering the YouTube interactions. The recording is available at <https://youtu.be/yY1PcyuEI8>
- Another live demonstration took place on November the 18th 2021, in this case in a webinar entitled “5G SMART webinar on Demystifying 5G and industrial networks slicing, from theory to practice”. In this case the project showcased the 5G-SMART Network Slicing solution recorded at <https://youtu.be/6WaTMNc7IIQ> with more than one hundred live attendees and 215 views in YouTube at the time of writing this deliverable.
- Then, together with 5G-ACIA, on January the 26th 2022, the project demonstrated the trial site in Bosch, with again more than 200 people connecting to the live event online. The recording is available at <https://youtu.be/bIJHEhqGT3k>.
- On the 10th of February 2022, together with STL, 5G-SMART disseminated the results of A1.2 Analysis of business value creation enabled by 5G for manufacturing industries. Approximately 250 participants were reached in two sessions for the different time zones of the webinar entitled “Private 5G. What is the business case for the manufacturing sensor?”. The recording is available at https://youtu.be/E7V_7PM7ZxQ.
- Finally, in May 5th, the last webinar organized by the consortium took place, with the focus on edge computing services and entitled “Architecture Integration of 5G-enabled Industrial Networks with Edge Computing for Smart Manufacturing”. More than sixty people connected to this last webinar, whose recording is available at <https://youtu.be/O8BK6i1I1CI>.
- Due to the frequent cancellation of conferences during the pandemic outbreak, the project has encouraged partners to focus their dissemination from conference papers to journal papers. Furthermore, whenever possible, conference presentations were uploaded on the project's YouTube channel to increase the reached audience. Following this approach, several conference paper presentations given at PIMRC 2020 have been published on the project's YouTube channel: <https://www.youtube.com/channel/UCdhRYuUuSfT97tlivMGLRIg>.

3 Communication activities

The communications strategy of the 5G-SMART project aimed to share the goals, methods and results of the consortium's outreach activities with the target audience. The following goals were set in the communication strategy:

1. To communicate to our audience why 5G-SMART's results are relevant to them:



- To give visibility to the project vision, aims, activities and results at all levels.
 - To promote the exchange of knowledge regarding the introduction of 5G into the manufacturing industry.
 - To raise public awareness about the project key facts and findings while demonstrating the readiness of 5G in the manufacturing context.
2. To reach the specific target audience, where the project findings are most relevant, and can have the most impact:
- To identify the best channels of communication where these audience groups can be reached.
 - To build a project network that involves relevant stakeholders throughout Europe.
 - To attract the project's audience to our online platform for dissemination via webinars.
3. To reflect our project's goals and values:
- To facilitate the transferability and applicability of the project results for organizations and stakeholders outside of the project.
 - To promote transparency and accountability throughout the project.

In the following subsections, the status of the communication activities of the project from June 2019 until May 2022 are presented. It is worth mentioning the huge impact of the project at the time of writing this deliverable, that is present in more than 125.000 searches on the internet and more than 498 documents listed in google scholar, while interacting with more than 10.000 people in the world, according to the visits of the 5G-SMART project webpage. The target audience was reached, and the project created a huge reputation based on the quality of the research disseminated.

3.1 Printed materials and press releases

The project poster and leaflet were designed during the first five months of the 5G-SMART implementation and have been used at various occasions by all partners. All materials contain references to the online sources of 5G-SMART. Concerning the press, contacts were established with the relevant trade press (see Table 2-1 for the specific press sources) to extend the reach of the communications activities, and several press releases have been made by the project and partners. Two newsletters were published including information about the latest achievements of the project and links to recent public deliverables and forthcoming events. Newsletters are published on a yearly basis. The first newsletter is available online via the following URL: <https://5gsmart.eu/wp-content/uploads/2020-newsletter-5G-SMART-v1.0.pdf> while the second one is accessible at <https://5gsmart.eu/wp-content/uploads/2021-newsletter-5G-SMART-v1.0-2.pdf>.



Date	Title	Links
11/06/2019	EU-project 5G-SMART shows how 5G boosts smart manufacturing	https://www.marposs.com/eng/news/eu-project-5g-smart
12/05/2020	Elektronik online journal	http://www.elinor.se/borja-5g-resan-redan-idag-med-4g-lte.html/
20/05/2020	L'embarque	http://www.l embarque.com/lancez-vous-dans-la-5g-des-aujourd'hui-mais-avec-la-4g/lte_010009
18/06/2020	ETN journal	http://www.etn.fi/10897
22/06/2020	Enterprise IoT Insight	https://enterpriseiotinsights.com/20200806/channels/news/bosch-ericsson-hone-5g-for-manufacturing
26/06/2020	Seminet Korea	https://www.opensignal.com/reports/2020/06/southkorea/mobile-network-experience-5g
01/08/2020	5G PPP Progress Monitoring Report – 2019	https://5g-ppp.eu/wp-content/uploads/2020/10/5G-PPP-PMR2019v1-6.pdf
06/08/2020	Bosch launches 5G tests at Reutlingen	https://www.bosch-presse.de/pressportal/de/en/bosch-launches-5g-tests-at-reutlingen-wafer-fab-209216.html?fbclid=IwAR0swS5I7-jdEKchZ5Uv7DnoYw3p2Gydfh6knZ4xdwPSM3-ob5esDYaKRb0
17/08/2020	1 st year 5G-SMART newsletter	https://5gsmart.eu/wp-content/uploads/2020-newsletter-5G-SMART-v1.0.pdf
21/04/2021	5G-ACIA Testbed Endorsement	https://5g-acia.org/insight/endorsed-testbeds/
27/05/2021	European Annual Journal	https://5g-ppp.eu/the-5g-european-annual-journal-2021-is-out/
15/05/2021	2 nd year 5G-SMART newsletter	https://5gsmart.eu/wp-content/uploads/2021-newsletter-5G-SMART-v1.0-2.pdf



30/08/2021	Robotik Und Produktion	https://cdn.tedo.be/tedo-ecms/2/ROBOTIK_UND_PRODUKTION_4_(August)_2021.pdf
21/10/2021	Entscheidend in der Smart-Factory: Wie synchron ist die Zeit der smarten Systeme?	https://iot.telefonica.de/entscheidend-in-der-smart-factory-wie-synchron-ist-die-zeit-der-smarten-systeme/

Table 2-1: 5G-SMART press releases

3.2 Project website

The 5G-SMART public website is the central hub for communication with different parties, and is hosted behind the following URL: <https://5gsmart.eu/>. The public website presents the 5G-SMART project, including news, events, project description, consortium information and public deliverables of the project. Information about the project is provided on different levels of technical detail, thus addressing multiple groups of audiences at the same time. In compliance with the European Commission (EC) open access policy [EU19], open access to all scientific publications created in the project will be ensured through the website, and when publishers are involved, the submitted papers will be made available in compliance with the rules of the publisher.

The web design was structured to make it intuitive and easy to navigate. The current version is consistent with the project's graphical identity. The website was launched in August 2019 and was constantly expanding with news, links, events, communication materials, deliverables, and publications. After the first review, the project website was updated in its format to better fit the spreading desire of the consortium and in line with the comments received from the reviewers. The webpage will be maintained during five years after the finalization of the project, i.e., at least until May 2027. This will allow the research community to access the knowledge generated by the project.

A summary of the visitors to the 5G-SMART webpage is depicted below. Since mid-October 2019 statistics were collected, which allowed us to detect during the lifetime of the webpage an average of 13 visitors per day, mainly from the USA, followed by Germany and France. This statistic demonstrates that the project website represents a reference point for partners, stakeholders and public audience who want to get or give information on the project activities and is a well-accepted means of communication. More than 11,000 different persons had visited our webpage in May 2022 since the project started in October 2019.



Audience Overview



Figure 2-1: Summary of 5G-SMART website visitors

3.3 Social media

To ensure the largest possible exposure of the project to a wide audience, and to build a community, different social media and networking tools have been used in the project, including LinkedIn and Twitter. Considering the development of the Covid-19 pandemic, this early decision was quite beneficial and publishing on social media platforms has become even more important than anticipated. The project's



YouTube channel captures presentations from e.g., industry forum demonstrations, workshops, and test-bed trials. The chosen media and networking tools allow two-way interaction with the project and are, therefore, particularly interesting for 5G-SMART. Moreover, social media is considered of major relevance for the project to reach younger scientists who are in an early stage of their career. To improve the search engine ranking, all social media accounts are interconnected with the project website. The success of the social media presence of 5G-SMART was continuously monitored and regularly evaluated using both quantitative measures obtained through numbers, e.g., by Twitter Analytics, and qualitative measures, e.g., by evaluating the types of comments received.

The activity in 5G-SMART's social media platforms as of May 2022 is summarized in Table 2-2, where there are inputs, interactions, and impressions expressed in numbers. Inputs mean the number of posts, tweets or videos posted until May 2022 on the project's social media platforms. Social interactions measure the effectiveness of our social media campaigns. It represents communication (i.e.: comments, messages, etc.) between visitors of a 5G-SMART social media channel. Every platform has specific interactions such as 'mentions' on Twitter or 'likes', 'comments', and 'shares' on LinkedIn or YouTube. Impressions mean the total number of times the 5G-SMART content was displayed to people, regardless, whether it was clicked on or not.

	LinkedIn	Twitter	YouTube
Inputs	26	90	24
Interactions	3.1K	1203	83
Impressions	10.3K	19.8K	4.5K

Table 2-2: Activity on 5G-SMART social media channels

A further analysis per medium is given in the following sections. Note that these social media channels will be maintained in the next five years, but without new inputs.

3.3.1 Twitter

The project was using Twitter as a key tool for communication. The Twitter channel can be accessed via:

https://twitter.com/5g_smart

Here, short comments, announcements, news, and other content relevant for a larger audience are shared. The engagement rate on the project's Twitter channel is relatively high (interactions/impressions are over 4%) with more than 574 followers, and 90 inputs which shows that the news, videos, and other contents uploaded to this platform are mostly reaching the relevant users.

3.3.2 YouTube

The project's YouTube channel called 5G-SMART is accessible via:



<https://www.youtube.com/channel/UCdhRYuUuSfT97tlivMGLRlg>

The channel has gained more than 25,000 page views and more than 400 hours of views, from the time it was started, which is a relatively high reach, considering the amount of content currently available, and relatively short time being in use. Since the YouTube channel of the project is used for sharing the presentations and raising project awareness in general, a relatively high 'New Visitor' number is desirable. The 68.2% bounce rate (meaning the average number of bounces across the entire site divided by the total number of visits on the site along the project) is considered an average ratio, which means that the 5G-SMART YouTube channel content is attracting mostly the audience, and provides interesting content to these users.

54.4% of the visitors were male, 45.6% female. 30.9% aged from 25-34 years old, 38.2% between 35-44 years. With respect to the nationality, the two most important communities came from Germany and Sweden. 13.5% of our visitors came from Germany, followed by Sweden with 5.1% of views.

3.3.3 LinkedIn

A business channel on LinkedIn has been created under the following URL:

<https://www.linkedin.com/company/5gsmart/>

Here, news, events, and relevant information were shared on a regular basis targeting a professional audience. Like the project's Twitter channel, the LinkedIn one also performed well in terms of engagement rate compared to a relatively low amount of content, which signals that the posts are relevant to the followers. More than 30 visits per month to our LinkedIn page were experienced, being 44.24% of them coming from the Information Technology and Services industry. Germany, Sweden, Austria, United Kingdom, Italy and Spain, were the location of most of our visitors.



4 5G-SMART dissemination activities

In this chapter the objectives based on the deliverable D6.1 are reviewed, and the current status of dissemination activities is presented. The main strategies highlighted from D6.1 are to:

- Cooperate with other 5G-PPP research projects and disseminate the project results through the 5G-PPP and 5G-ACIA associations.
- Create synergies with the OT players, putting together the telecommunications industry and the industrial communities. This is achieved by working with relevant industrial alliances and related standards development organisations, and through demonstrations at relevant trade events that are specialized in Industry 4.0.
- Communicate with the research community through scientific publications and presentations at scientific conferences and workshops.
- Communicate with the regulators and standardisation bodies to raise awareness of the project results.

To have a clear goal, these dissemination activities have been translated into target values, which are listed in Table 3-1.

Dissemination activities	Target values	Results
Journal papers, white papers and international conference papers	20	25
Contributions to standards and regulatory bodies	30	30
Keynotes and panels in major conferences	10	18
Participation in 5G for industry events and forums in Europe and worldwide	10	10
Workshops in major conferences	5	4
Training activities	5	5
5G demos and validations events	3	5
Webinars	-	8
Videos	-	5
Technical Talks	-	3
Online open days	-	2
Newsletters	2	2

Table 3-1: Planned dissemination activities with target and current values

Dissemination status shows that the project has fulfilled and even exceeded all the expected indicators, apart from participation in major conferences, for obvious reasons. Several training activities were held by 5G-SMART, to attain a thorough cross-domain knowledge and understanding of communications and operation management. Both academic and industrial partners contributed to these training activities, but some of the previous ideas such as the whole student community would have the chance to join an academic event, can come true only within a framework of an online platform.



Another aspect of the dissemination activities has included interacting with other projects within H2020 and beyond. Of course, all 5G-SMART partners were subscribed to cooperation in the framework of 5G-PPP and specific links of communication exist due to the interrelation among the topics with 5Gang, H2020 SERENA, H2020 PRIMO-5G, H2020 FORCE and ICT-17 projects on automation.

Tables 3-2 to 3-4 list all the dissemination work by 5G-SMART since the beginning of the project.

4.1 Accepted papers/book chapters

Authors	Title	Event	Status
Meriem Mhedhbi, Mira Morcos, Ana Galindo-Serrano , Salah Eddine Elayoubi	Performance Evaluation of 5G Radio Configurations for Industry 4.0	WiMob 2019	Published
Saúl Inca , Danaisy Prado, David Martín-Sacristán, Jose F. Monserrat	Channel Modelling based on Game Engines Light Physics for mmW in Indoor Scenarios	EuCAP 2020	Published
Gábor Soós , Dániel Ficzer, Sándor Veress , Pál Varga	Discussion on Private Campus Networks - Privát mobil hálózatok az iparban	Life and Science magazine	Published
Gábor Soós , Dániel Ficzer, Pál Varga	Investigating the network traffic of Industry 4.0 applications – methodology and initial	IEEE Conference of Network and Service Management , 2020	Published
Pierre Kehl , Dirk Lange , Felix Maurer, Gábor Németh , Daniel Overbeck, Sven Jung, Niels König , Robert Schmitt	Comparison of 5G Enabled Control Loops for Production	PIMRC'20, London, 31 August-3 September 2020, Virtual Conference	Published
Sarah S. Schmitt , Praveen Mohanram , Roberto Padovani , Niels König , Sven Jung , Robert Schmitt	Meeting the Requirements of Industrial Production with a Versatile Multi-Sensor Platform Based on 5G Communication	PIMRC'20, London, 31 August-3 September 2020	Published



Raphael Kiesel , Robert Schmitt	Requirements for Economic Analysis of 5G Technology Implementation in Smart Factories from End-User Perspective	PIMRC'20, London, 31 August-3 September 2020, Virtual Conference	Published
István Gódor , Michele Luvisotto , Stefano Ruffini , Kun Wang , Dhruvin Patel , Joachim Sachs , Ognjen Dobrijevic , Daniel P. Venmani , Olivier Le Mout , Jose Costa-Requena , Aapo Poutanen , Chris Marshall , and János Farkas	A Look Inside 5G Standards to Support Time Synchronization for Smart Manufacturing	IEEE Communications Standards Magazine	Published
Raphael Kiesel , Kirstin Stichling, Philipp Hemmers, Thomas Vollmer, Robert Schmitt	Quantification of Process Performance of Latency-Critical Applications in Production by Implementing 5G Technology	CIRP CMS 2021 - 54th CIRP Conference on Manufacturing Systems, Athens (12 - 14 May)	Published
Gábor Soós , Dániel Ficzere , Tamás Seres , István Németh and Sándor Veress	Business opportunities and evaluation of non-public 5G cellular networks -a survey	Infocommunications Journal, 2020, 3rd Issue	Published
Danaisy Prado, Saúl Inca , David Martín-Sacristán, Jose F. Monserrat	Millimeter-wave human blockage model enhancements for directional antennas	IEEE Communications Letters	Published



Robert Botez, Jose Costa-Requena, Iustin-Alexandru Ivanciu, Vlad Strautiu, Virgil Dobrota	SDN-based Network Slicing Mechanism for a Scalable 4G/5G Core Network: A Kubernetes Approach	MDPI sensors 2021	Published
Elizabeth Palacios, Pablo Picazo, Saúl Inca, Jose F. Monserrat	Open Source 5G-NSA Network for Industry 4.0 Applications	PIMRC 2021	Published
Kimmo Hiltunen, Yanpeng Yang, Fedor Chernogorov	Impact of network densification on the performance of a non-public URLLC factory network	PIMRC 2021	Published
Attila Vidacs, Norbert Reider, Gabor Feher, Marcell Balogh, Markosz Maliosz, Marton Aron Horvath, Sandor Racz	Cloud-Controlled Autonomous Mobile Robot Platform	PIMRC 2021	Published
Yanpeng Yang, Kimmo Hiltunen, Fedor Chernogorov	On the performance of co-existence between public eMBB and non-public URLLC networks	VTC 2021	Published
Joachim Sachs, Krister Landernäs	Review of 5G capabilities for smart manufacturing	ISWCS 2021	Published
R. Kiesel; F. Boehm; J. Pennekamp; R. H. Schmitt	Development of a Model to Evaluate the Potential of 5G Technology for Latency-critical Applications in Production	IEEM 2021	Published
János Harmatos, Markosz Maliosz	Architecture integration of 5G networks and Time Sensitive Networking with Edge Computing for Smart Manufacturing	MDPI Electronics Dec. 2021	Published



Ansari J, Andersson C, de Bruin P, Farkas J, Grosjean L, Sachs J, Torsner J, Varga B, Harutyunyan D, König N, Schmitt RH.	Performance of 5G Trials for Industrial Automation	MDPI Electronics Jan. 2022	Published
Kiesel R, Henke L, Mann A, Renneberg F, Stich V, Schmitt RH.	Techno-Economic Evaluation of 5G Technology for Automated Guided Vehicles in Production	MDPI Electronics Jan. 2022	Published
Praveen Mohanram, Alice Passarella, Elena Zattoni, Roberto Padovani, Niels König and Robert H. Schmitt	5G-Based Multi-Sensor Platform for Monitoring of Workpieces and Machines: Prototype Hardware Design and Firmware	MDPI Electronics May 2022	Published

Table 3-2: 5G-SMART published papers and book chapters. *In bold 5G-SMART project members*

4.2 White papers and technical reports

The white paper 5G E2E Technology to Support Verticals URLLC Requirements was published by NGMN on the 31st of October 2019. A second white paper on vertical industries was also published in conjunction with other projects from 5G-PPP in August 2020. In January 2021 5G-ACIA white paper reflected the views of 5G-SMART.

Important to note that a final booklet was prepared by the project, summarizing all the outcomes from the trials and the lesson learnt. The text is under review for publication in the moment of finalization of this deliverable.

Date	Organization	Title
31/10/2019	NGMN	5G E2E Technology to Support Verticals URLLC Requirements
20/08/2020	5G PPP	Empowering Vertical Industries through 5G Networks - Current Status and Future Trends
28/01/2021	5G-ACIA	Integration of 5G with Time-Sensitive Networking for Industrial Communications

Table 3-3: 5G-SMART white papers



4.3 Panels, workshops, and events

Date of event	Name	Title
21/06/2019	EuCNC Valencia	5G-SMART
24/06/2019	Ericsson Innovation Day	Wireless Tool Wear Monitoring
30/09/2019	5G World Forum	5G-SMART and Industry 4.0
10/10/2019	2nd 5G World Summit, Barcelona	5G Deployment Panel
15/10/2019	Vocational Evening Stories at ELTE university	5G-SMART
23/10/2019	MWC Los Angeles	IoT in Manufacturing: Automation, Optimisation and Robots
05/11/2019	Hungarian Science Festival organized by Hungarian Academy of Sciences	5G SMART
05/11/2019	European Industry Partnerships - Lighthouses to Thrive in the New Digital Age	5G for Smart Manufacturing
28/11/2019	5G Techritory - Riga	The Role of 5G for the Manufacturing Industry
21/01/2020	5G-ACIA Plenary Meeting	5G-SMART
28/01/2020	IRACON Meeting	Quo Vadis, Wireless: An Industrial Automation Perspective
30/01/2020	5G-ACIA kick-off meeting on "5G integration with TSN for industrial automation"	5G-SMART 5G Time Synchronization
23/06/2020	IIC Meeting	Industrial internet
01/09/2020	5G World 2020 Summit	5G-SMART
20/01/2021	B2B Forum on SmartIndustry	5G-SMART overview
28/01/2021	Networld2020 workshop	5G-SMART
18/02/2021	IoT M2M Council, IoT Days - Winter 2021	Gaining from 5G Trials



24/03/2021	5G Briefing conference	5G-SMART overview
12/04/2021	Hannover Messe	Presentation of trial sites
01/06/2021	COST IRACON meeting	On ultra-reliability and channel characteristics in cluttered industrial environments
06/06/2021	OFC Conference	Low Latency Communications
08/06/2021	EuCNC & 6G Summit	IPT presentation: 5G NPN for Process Monitoring
11/06/2021	EuCNC Exhibition	Bosch demos
29/06/2021	VDI-Kongress Automation	5G-ACIA presentation
16/09/2021	NetSys Panel	5G-SMART overview
23/09/2021	Cambridge wireless IoT SIG event	5G-SMART overview
4/10/2021	EMO Fair	Marposs presentation
16/11/2021	Digital Catapult Industrial 5G uncovered webinar	5G-SMART overview
08/12/2021	Industrial applications in Sweden and internationally	5G-SMART testbeds
10/02/2022	Private 5G: What is the business case for the manufacturing sector?	IPT Presentation
30/05/2022	Hannover Messe	5G-SMART testbeds

Table 3-4: 5G-SMART participation in panels, workshops, and events

4.4 5G Demos and validation events

To accelerate the adoption of 5G into manufacturing processes, an essential part of the dissemination activities was 5G demos and validation events. However, due to the Covid-19 outbreak most of the demo and validation events were cancelled from March 2020 on, remaining a few of them in online or hybrid mode. As for 2022 some activities come back to normality. In this section, all targeted 5G demo and validation events are listed, commenting on in what way 5G-SMART has been able to participate in these events.



4.4.1 Trial open days

At the start of the project, 5G-SMART planned the organization of three trial open days targeting different communities, among these are standardisation organisations like 5G-ACIA, automation associations, and small and medium-sized enterprises (SMEs) across Europe within the manufacturing area. Trial open days are project events that include presentations of 5G-SMART results, workshops, and most importantly live demonstrations of 5G trial use cases. The trial open days are meant to strengthen the 5G-SMART impact on standardisation work. Moreover, they create greater awareness of 5G integration into manufacturing use cases, and thus contribute to a faster adoption of 5G in the European manufacturing sector. Two trial open days were originally planned to take place at the Aachen trial site, while one trial open day was planned to take place at the Kista trial site.

Due to the Covid-19 outbreak, the first trial open day, at the Aachen premises, was moved to an online event and held in the format of a webinar: "5G-SMART webinar on 5G process monitoring in manufacturing ", on the 13th of October 2020. There were over 80 participants in the webinar. The topic was the inclusion of 5G in a factory and the demonstration of two examples of relevant application, including a drilling machine sensor and a multi-purpose 5G communication hub. Several companies joined the event, and the Q&A slot stressed the huge interest of the industrial players to move forward with the incorporation of the 5G into their manufacturing processes. The recording of the open day can be found at <https://youtu.be/puoFAayVpZk>. While the organization of a physical form of the next two trial open days of 5G-SMART was preferred and planned for, the project had to wait until full COVID restrictions fall, which allowed only for the organization of a second open day, arranged in hybrid mode.

This second open day was organized in Kista, corresponding with the final demo from the project. At the event demos were shown from all three trials of 5G-SMART. To reach out as wide as possible with the final key results of the project, the event was arranged in hybrid mode in May 2022. Several key notes were provided ranging the overview of the 5G integration in smart manufacturing. The public presentation was followed by the online visit to Aachen and Reutlingen and the physical visit to the Kista smart factory, where several demos were shown involving the integration of ABB robots with the 5G network deployed by Ericsson. The full recording of the open day session can be found at https://www.ericsson.com/en/cases/2021/5g-smart?video-dialog=1_17p07pm9.

4.4.2 Mobile World Congress 2021 and 2022

The Mobile World Congress (MWC) is the largest exhibition for the mobile industry, featuring players from the end-to-end mobile ecosystem. Promotional material was provided for MWC 2020, although the event was finally cancelled. The edition of 2021 has been moved to June, and 5G-SMART participated indirectly in the event, through the stands of associated partners. The same happened with the 2022 edition, that was initially not planned but, due to project extension, count on the participation of 5G-SMART in the partners' booths.



4.4.3 Hannover Messe 2021 and 2022

Hannover trade fair is the largest industry trade show in the world. Since a few years back, digitalization aspects have gained importance for this trade show. 5G-SMART was given the opportunity to present at the EU booth in 2020, but the edition of 2020 was cancelled without any online replacement. The Hannover fair in 2021 was completely digital. Since the three trial sites of 5G-SMART were chosen as official 5G-ACIA trial sites, they were presented as part of the digital program of 5G-ACIA, while the Aachen trial site had appearances also in the Fraunhofer program and a live demonstration from the IPT shopfloor. The Hannover Messe 2022 corresponds with the last days of the project. Again, 5G-SMART used the opportunity to show all testbeds in the booth of 5G-ACIA.

4.4.4 Smart Production Solutions Drive in Nuremberg

Smart Production Solutions (SPS) is a major international trade show in the field of industrial automation, which is being held every year in Nuremberg. In 2018, the SPS hosted more than 1,600 exhibitors and attracted more than 65,000 visitors from around the world. The event covers the latest technological trends around industrial automation, including, for example, industrial real-time control, industrial PCs, programmable logic controllers (PLCs), industrial Ethernet, TSN, and real-time industrial OS and hypervisors, which are all relevant topics with respect to the scope of 5G-SMART. Accordingly, SPS can serve as an important platform, for the OT partners in the project, to disseminate the achievements of 5G-SMART. The SPS Drive was held online from 24-26th November 2020 in an online format in which 5G-SMART was present.

4.4.5 Control Fair in Stuttgart

Control Fair is the largest trade show dedicated towards metrology and quality assurance in Germany. Fraunhofer IPT, as a member of the Fraunhofer Alliance Vision, takes part as an exhibitor since 1998, showing its current developments in metrology. For 2021, Control was cancelled, for which it was planned to demonstrate 5G sensor prototypes developed within 5G-SMART. For 2022, control fair took place in the first days of May. IPT participated in the event showcasing the 5G-SMART demos.

4.4.6 Fraunhofer Solution Days

Due to the cancellation of many exhibition events, Fraunhofer decided to organize its own virtual conference and exhibition on 26-29th October 2020. Part of the program was a presentation about the 5G-Industry Campus Europe held by Fraunhofer IPT together with Ericsson in Germany as well as a virtual booth, which also offered the possibility for live demonstration of the sensor solutions developed within 5G-SMART. The latter was also mentioned during the presentation, had an exposed position directly after the keynote speech of the Fraunhofer President. A video on the event can be found at <https://www.youtube.com/watch?v=pb0j2Fib-R4>.



4.4.7 EuCNC

The European Conference on Networks and Communications (EuCNC) is one of the most prominent communications and networking conferences in Europe and is supported by the European Commission. 5G-SMART has been presented at EuCNC on 15-18th June 2020 (<https://www.youtube.com/watch?v=YaTTPi5axk4&t=66s>). In the 2021 edition 5G-SMART participated with a virtual booth in which the Bosch trial activities were the main attraction. We received a good number of interactions in a virtual manner, in which was the first fully online demonstration fair for 5G-SMART.

4.4.8 Other trade shows

EMO (European trade show for manufacturing in Hannover), BI-MU (Biennale della Macchina Utensile in Milan), IMTS (International Manufacturing Technology Show) and JIMTOF (Japan International Machine Tool Fair) are the most important trade shows for machine tools and production equipment in Europe, Italy, USA, and Asia, respectively. 5G as an enabler for manufacturing is well suited to be showcased in connection with machine tool companies, e.g., Georg Fischer (GF), Makino, and DMG Mori. Apart from BI-MU, the exhibitions initially planned for 2020 were postponed to 2021. BI-MU was held in Milan, Italy, from the 14th to 17th of October 2020. 5G-SMART's poster was shown, and leaflets have been distributed. For the 2021 EMO fair, 5G-SMART showed sensors in live machining operation in a machine tool, as a guest exhibition at the booth of a machine tool supplier. Marposs was the one participating in the event on behalf of 5G-SMART.

4.5 Scientific publications

The 5G-SMART partners maximized the scientific visibility of the results obtained within 5G-SMART by publishing papers at major conferences organised by IEEE, as well as other relevant conferences, and in high impact journals. Depending on the targeted society, different conferences and journals were used for dissemination of the results. The list of journals specific for vertical industries and conferences of interests specified in D6.1 was not changed.

All accepted papers/book chapters and white papers/technical reports made by 5G-SMART during the project lifetime are listed in Table 3-2 and Table 3-3.

4.6 Workshops and presentations

Workshops and presentations are an important part of 5G-SMART's dissemination activities. The original plans on 5G-SMART's strategy have not been changed since the beginning of the project. A workshop on 5G Mobile Communication System for Smart Factories (5G Smart Factories) was organized by 5G-SMART, collocated with PIMRC 2020 (see 5G-SMART YouTube channel for an extract of some of the presentations at the event). The project continued participating in other workshops like ISWCS 2021, 5G-PPP and 5G-ACIA events, as well as training and teaching activities.



Table 3-4 lists all panels, workshops, and event participations of 5G-SMART along the project.

4.6.1 5G-PPP events

The 5G Infrastructure Public Private Partnership (5G-PPP) is a joint initiative between the European Commission and European ICT industry. 5G-SMART is part of the technical board, steering board and represented in relevant working groups ("Trials" WG, "Pre-Standardization" WG, "Vision and Societal Challenges" WG, "5G Architecture" WG, "Test, Measurement and KPIs Validation" WG). Physical workshops and 5G-PPP events have been limited along 2020 and 2021, but 5G-SMART participated in all suitable online events. For instance, 5G-SMART has been presented in two online workshop organized via 5G-PPP entitled "5G Experimentation Facilities and Vertical Trials" on the 14th of October 2020 (see <https://www.youtube.com/watch?v=yCpf8GH7Kxl> for more details) and on the 10th of December 2020 in an online workshop (see <https://5g-ppp.eu/tb-eworkshop-dec-2020/>).

4.6.2 5G-ACIA events

The 5G Alliance for Connected Industries and Automation (5G-ACIA) is a global forum, which brings ICT and OT players together, to ensure best possible applicability of 5G technology for connected industries, in particular the manufacturing and process industries. 5G-SMART is represented in the alliance with several project partners who are also board members. The project as a whole and all three trial sites have been presented in 5G-ACIA plenary meetings. Online events of 5G-ACIA were held on November 3-5 (15th Plenary Meeting), November 11-12 (5G Techritory 2020) and on November 24-26 (5G-ACIA at the SPS connect - The digital automation hub). The project also joined the 5G-ACIA events in 2021 and 2022. Of particular relevance are the webinars on testbeds that were jointly organized by 5G-ACIA and 5G-SMART. Note that in 2020 the three 5G-SMART testbeds were formally appointed as official 5G-ACIA testbeds for all the association.



5 Standardization and regulation impact

5.1 Specific standardization and regulation synergies

The consortium has identified a list of relevant standardisation and regulatory bodies where 5G-SMART findings and key results are expected to have significant impact. The 5G-SMART consortium monitors the outlined list of relevant standardisation bodies to align its technical work, 5G-SMART use cases and 5G features beyond the trials, with standardisation and to prepare relevant contributions to working groups. The bodies of interest remain the same since the project start, and more details can be found in deliverable D6.1 [5GS19-D61]. The below list states the activities done for the different bodies.

- 3GPP
 - Several contributions have been made towards 3GPP by 5G-SMART members related to their activity in the project (see Table 4-2). The project had a great impact on the TSN topic that was specified in the standard, as well as in the definitions of industrial use cases.
- 5G-ACIA
 - 5G-SMART has made several important contributions to 5G-ACIA since the project start. Due to its relevance, next section details such contribution.
- ETSI
 - This standardization body is being monitored with activity from 5G-SMART partners.
- ITU-R
 - Several contributions have been made towards ITU-R by 5G-SMART (see Table 4-2). Special attention has been paid to synchronization signals.
- CEPT
 - This standardization body is being monitored with activity from 5G-SMART partners.
- NGMN
 - 5G-SMART partners have contributed to relevant NGMN reports (see Table 3-3). Ericsson has been the editor of the NGMN report on "5G E2E technology to support verticals URLLC requirements".



5.2 5G Alliance for Connected Industries and Automation

5G-ACIA is the central global forum for shaping 5G in the industrial domain [5G-ACIA]. On one platform, various industries from all over the world jointly create a new ICT and OT ecosystem and set the frameworks for a highly attractive emerging market. In total, 5G-SMART has four members representing 5G-SMART companies, being two of them members of the board of governors, the General Chair, Dr. Andreas Müller from Bosch, and the General Vice-Chair, Dr. Afif Osseiran from Ericsson. The contribution of 5G-SMART to 5G-ACIA is of significant relevance, and the project has been actively contributing to the working items as described in Table 4-1. Furthermore, the 5G-SMART document on a common terminology between OT and ICT partners has proven to be a valuable document outside 5G-SMART and it has been provided to 5G-ACIA and other communities on request (please refer to <https://5gsmart.eu/wp-content/uploads/5G-SMART-common-terminology.pdf>). Moreover, in 2020 the three 5G-SMART testbeds were formally appointed as official 5G-ACIA testbeds for all the association.

Working item	Working group	Title	Contributors from 5G-SMART	Status
052	1	Clarification of communication parameters and concepts	Orange, ABB, Fraunhofer IPT, ERI-SE	Ongoing
053	3	Industrial 5G Devices – Architecture and Capabilities5G	ERI-SE, Fraunhofer IPT	Ongoing
055	1	Edge Computing Use cases and Requirements	Fraunhofer IPT	Ongoing
058	1	Use Cases and Requirements focusing on 5G-enabled Devices for Industrial Applications	Fraunhofer IPT	Ongoing
067	4	Response LS to ITU R WP5D [IMT.INDUSTRY]	Fraunhofer IPT	Ongoing
068	3	Analysis of DetNet-based deterministic IP communication over 5G for industrial IoT	ERI-SE, Fraunhofer IPT	Ongoing

Table 4-1: List of work-items in which 5G-SMART contributed and its status by the end of the project

5.3 Standard contributions

Date	ID	Body	Title	Area	Contributors	Status
17/06/2019	[C1250]	ITU-T	Proposal for G.8271.2	Time sync	Orange, Huawei Technologies Co., Ltd.	Private
17/06/2019	[C1253]	ITU-T	Proposal for the scope of G.8275.1, G.8273.2 and G.8275.2	Time sync	Orange, Huawei Technologies Co., Ltd.	Private
18/06/2019	[C1500]	ITU-T	G.8271.1 Appendix: Generalized HRMs for fronthaul cluster synchronization	Time sync	Orange	Private
18/06/2019	[C1501]	ITU-T	G.8271.1 Appendix XII.5: Relative Time error allocation	Time sync	Orange	Private
18/06/2019	[C1503]	ITU-T	Recommendation to use of UTC time scale in ITU-T Q13 documents	Time sync	Orange, Deutsche Telekom AG	Private
02/10/2019	[WD13-15]	ITU-T	Noise accumulation of Cascaded media converters - G.8273.2 Appendix V	Time sync	Orange, Microsemi, Deutsche Telekom, A1 Telekom Austria, China Mobile Communications Corporation	Private
02/10/2019	[WD13-16]	ITU-T	WD-GNSS edits	Time sync	u-blox, Orange, Microsemi, Nokia	Private
02/10/2019	[WD13-33]	ITU-T	Fiber wander reduction [G.8261]	Time sync	Orange, Huawei Technologies Co. Ltd., Ministry of Industry, and Information Technology (MIIT)	Private



02/10/2019	[WD13-78]	ITU-T	Inter-operator TDD synchronization - G.8271, Appendix VI	Time sync	Orange, Deutsche Telekom	Private
02/10/2019	[WD13-79]	ITU-T	Synchronization Accuracy for OTDOA	Time sync	Orange	Private
24/02/2020	S2-2002604	3GPP	MBDV mapping and configuration for TSC QoS Flow	Time sync	Ericsson	Public
17/03/2020	SP-200094	3GPP	Study on enhanced support of Non-Public Networks	Time sync	Ericsson	Public
20/04/2020	S2-2003228	3GPP	Alignment of traffic forwarding information	Time sync	Ericsson	Public
01/06/2020	S2-2004639	3GPP	UE-UE communication based on generalized Ethernet model	5G-TSN integration	Ericsson	Public
17/08/2020	Tdoc R1-2005517	3GPP	Propagation Delay Compensation Enhancements for Time Synchronization	Time sync	Ericsson	Public
17/08/2020	Tdoc R2-2006701	3GPP	Enhancements for support of time synchronization	Time sync	Ericsson	Public
19/08/2020	S2-2005884	3GPP	PSFP clarifications including IEEE LS response on TSN support	5G-TSN integration	Ericsson	Public
19/08/2020	S2-2006004	3GPP	TSN stream information provisioning from CNC to 5GS	5G-TSN integration	Ericsson	Public
25/01/2021	Tdoc R1-2100272	3GPP	Propagation Delay Compensation Enhancements for Time Synchronization	Time sync	Ericsson	Public
25/01/2021	Tdoc R2-2100232	3GPP	Propagation Delay Compensation Enhancements	Time sync	Ericsson	Public



24/02/2021	S2-2100216	3GPP	KI#5-1: Impact due to Survival Time	Time sync	Ericsson	Public
24/02/2021	S2-2102017	3GPP	KI#2-1: Capturing the FS_IIoT conclusions on static filtering entries	IIoT	Ericsson	Public
12/04/2021	Tdoc R1-2102748	3GPP	Propagation Delay Compensation Enhancements for Time Synchronization	Time sync	Ericsson	Public
12/04/2021	SG15-C2532	ITU	Performance requirements for G. 8273.2 when SyncE is lost and PTP continues: Further discussion	Time sync	Orange, Huawei	Private
12/04/2021	SG15-C2534	ITU	Clock synchronisation service performance requirements for 5G Systems	Time sync	Orange	Private
12/04/2021	SG15-C2536	ITU	The role of "end application" in the context of 5G Industrial IIoT Systems	IIoT	Orange	Private
17/05/2021	S2-2103968	3GPP	Extensions to the TSC Framework to support DetNet	Time sync	Ericsson	Public
19/05/2021	Tdoc R2-2105674	3GPP	Determining per Uu Interface Time Sync Error Budget	Time sync	Ericsson	Public
06/12/2021	SG15-C2784	ITU	G.8271: 900 ns for end-to-end 5G Systems	IIoT	Orange, Huawei	Public
06/12/2021	SG15-C2787	ITU	Reply to 3GPP Liaison	IIoT	Orange, Huawei	Public

Table 4-2: 5G-SMART standard contributions



6 Achieved impact and exploitation goals

The 5G-SMART exploitation strategy consists of both an exploitation plan for the project as well as individual exploitation plans per partner. Different types of exploitable results are identified. Their direct value, indirect value and impact for different stakeholders will be considered to boost the actions of interested partners in the exploitation of them.

The exploitation plans both on consortium level as well as individual partner level have been described in D6.1 and have been achieved by all partners as will be described along this section. It is assumed that the reader is familiar with the overall project goals but still the structure of the project is summarized in the following table.

Work package number	Work Package Title	Lead Participant Name
WP1	Use cases, Business Models, Network Design	ORANGE
WP2	Testbed and Validation Trials for 5G-Enhanced Industrial Robotics	ABB
WP3	5G for Enhanced Industrial Manufacturing Processes	Fraunhofer IPT
WP4	Trials and Validation in Semiconductor Factory	BOSCH
WP5	5G Optimization for Manufacturing	Ericsson Germany
WP6	Impact and Dissemination	Polytechnic University of Valencia
WP7	Project and Technical Management	Ericsson Sweden and ABB

Table 5-1: List of Work Packages

6.1 Industrial impact and exploitation

The 5G-SMART project is an eminently industrial project, where the contribution of the large industry of the European region is perfectly represented, as shown below in the analysis of the impact of the participating companies. Note that this section captures the impact of the project at the moment of writing this deliverable, but even more future impact and exploitation of the projects' results is expected.



6.1.1 Ericsson

Ericsson has designed and deployed the 5G networks at all 5G-SMART trial sites. The learnings gained from the deployments, e.g., on the specific requirements in the industrial context, such as clean-room compliance, security zones, certifications, operational requirements, etc., have been fed back internally to be taken into consideration for improved product development, but these learnings have also been published in 5G-SMART deliverables, thereby contributing to the overall knowledge increase in the area. The coexistence studies performed by Ericsson are interesting for e.g., questions related to spectrum allocation, and how to deploy private networks in areas with existing public networks. An uptake and interest of the results has for instance been observed, by a request for a deep-dive session by Ofcom on this topic. Ericsson has designed the test setup for conducting Electromagnetic Compatibility (EMC) tests, which Bosch has performed the EMC measurements in the factory. These tests have created insights into the 5G deployment suitability in factories. Bosch has expressed their interest in continuing the tests also outside the 5G-SMART project. By publishing one of the first papers about latency measurements in an industrial environment and context, Ericsson has contributed to the general understanding of 5G technology and its expected performance.

Ericsson has contributed to the development of the [common terminology](#) document developed by 5G-SMART, for which a high interest has been seen, as it helps in facilitating the interaction and communication between partners in the ecosystem, for instance communication infrastructure vendors, device vendors, OT vendors, system integrators, MNOs, etc.

Interaction with and contributions towards 5G-ACIA have been cornerstones of 5G-SMART's path towards a successful dissemination and exploitation of the project's results. Ericsson has together with ABB, Fraunhofer and Bosch driven the application of all 5G-SMART testbeds to become endorsed by 5G-ACIA. Three of the four first [endorsed 5G-ACIA testbeds](#) are the 5G-SMART testbeds. This created a momentum, encouraging other players to show what industrial 5G can do and how it performs in real environments. Once the testbeds were endorsed by 5G-ACIA, Ericsson has presented the 5G-SMART testbeds at various 5G-ACIA internal meetings (working group levels, plenaries), provided testbed reports to 5G-ACIA and promoted them at various [webinars](#) and international fairs, e.g., [Hanover fair 2021](#) and 2022.

Apart from the endorsed testbeds, Ericsson has contributed with 5G-SMART results in various activities of 5G-ACIA. For instance, four 5G-ACIA whitepapers have contributions from 5G-SMART, either by knowledge sharing or direct references to 5G-SMART (e.g., ["Integration of 5G with Time-Sensitive Networking for Industrial Communications"](#), ["5G-QoS-for-Industrial-Automation"](#) and ["5G-for-Industrial-Internet-of-Things"](#)). In addition, Ericsson has contributed to several 5G-ACIA internal studies and activities in the areas of industrial edge computing with 5G, integration of 5G with industrial systems based on OPC-UA, exposure of 5G capabilities to industrial application, performance evaluations of 5G for industrial applications, suitability of different spectrum bands for industrial applications, DetNet communication over 5G.

On several occasions, Ericsson has presented results towards policy makers, political purpose authorities. For instance, the AGV demo from the Reutlingen trial has been presented live to a delegation including Hungarian politicians (such as the Ministry of Foreign Affairs), policy makers and authorities. There, the



benefits of 5G for industrial use cases were expressed, so that they could be considered when related decisions had to be taken. A short summary and a video of the event can be found [here](#) together with the [video](#). The research activity related to the robot HW and SW architectures developed in WP4 during the project has been taken up in further research activities outside the action already. For instance, Ericsson has continued the activity in form of an approved university collaboration to extend the implementation with advanced use cases such as camera-based real-time and highly accurate self-positioning and adding social layer information to the common map from camera to categorize obstacles as humans or objects.

The work by Ericsson on cloud-controlled mobile robots has an impact on the efficiency of the robot operation. Efficiency can be increased by optimizing AGV routes in real factories when cloud-based control is realized over the 5G network. Ericsson has quantified the gain in terms of mission execution time in real environment with obstacles and multiple paths, which can be directly exploited when the use case is applied in the real production flow. Important learnings and insights from the development and validation of the AGV use cases have been acknowledged by robot servo manufacturers. Future discussions on further enhancements are planned.

The results of WP5 on the feature development led by Ericsson are serving as a baseline for proof-of-concepts and feature realization of future 5G testbeds, as an example the 5G-COMET ([5G-Comet - Fraunhofer IPT](#)) project is developing an end-to-end real-time capable communication infrastructure based on 5G and TSN. 5G-SMART's investigations of advanced features such as TSN, positioning and time synchronization provide understanding on how such features can be introduced in products and solutions. The work has moreover resulted in 8 contributions to 3GPP by Ericsson, thereby contributing to driving the industry standards. The output on the network architecture assessment was fed into the NGMN report on URLLC. Other research collaborations to continue the different workstreams of WP5 are under development by Ericsson.

Following the activities in WP1 on network deployment options, Ericsson has extended its simulation capacities to cover a wide variety of use cases and requirements, including the ones considered in the project.

By developing short easy understandable videos of the trials and publishing them on the 5G-SMART website and YouTube channel, as well as on an [Ericsson site](#), Ericsson has contributed to informing the general public about the project.

6.1.2 ABB

Work on developing and evaluating novel industrial robotics use cases in the project has increased the level of understanding in 5G capabilities. This has improved the confidence in 5G technology as a wireless connectivity enabler. Learnings on capabilities of mobile robotics are utilized as ABB continues to explore cloudification of robotics software and services. ABB involvement in the 5G community has increased and the project has on several occasions participated in 5G-ACIA webinars including a presentation at Hannover Messe. In addition, the project has shared insights from the project by organizing webinars, participated in journals, and invited talks.



Work in the project speeded up the implementation and deployment of a private 5G at ABB premises. The network has been and will continue to be an important asset for 5G evaluations across all ABB business units. Furthermore, the collaboration between ABB and Ericsson has been strengthened.

Exploitation of results:

- The Knowledge and understanding of 5G capabilities gained in the project has influenced ABB Robotics technology roadmap
- ABB have collected ideas for new offerings and services over wireless connectivity
- Results from the project have regularly been shared on an ABB group level where valuable learnings on 5G are shared across the four business areas of ABB.

6.1.3 Marposs

Marposs as a multinational corporation co-operates in 5G-SMART through the two companies Marposs SpA (headquarters) and Marposs Monitoring Solutions (MMS). The exploitation plan is necessarily coordinated into a single plan described herein. Marposs is actively developing the electronics systems, which are used in the WP3 (5G for Enhanced Industrial Manufacturing Processes) trials at the Fraunhofer Institute premises, also its applicative knowledge was shared and used in the initial trial specifications. In the second part of the project, this work was brought forward until completion, and it led to the real experimentation, from which results we gained insights useful both to the IT partner's perspective and to our OT point of view.

To verify the usage of process sensors in 5G MMS developed an acoustic emission electronic with a signal processor module. This electronic was connected on one hand to an industrial acoustic emission sensor and on the other hand to a 5G device to communicate the pre-processed AE-signal. This device was integrated in a test bench at IPT and a DMG Mori machine tool to demonstrate the capabilities of 5G. The test bench was presented by IPT at several events and webinars.

To evaluate the latency and reaction time of the 5G based electronic in the DMG Mori machine a second industrial cable based Acoustic Emission acquisition system was integrated. The outputs of both systems were transmitted via an industrial fieldbus to a GEM process monitoring main module connect to the machine. The delay of the 5G signals of a real milling process were around 10 ms, so acceptable for a lot of use cases in process monitoring.

A control loop with a machine integrated vibration sensor was setup in the machine test field of the MMS division with transmission of the process data via mobile network. There a vibration sensor transmitted the signals via the mobile network back to GEM main module to monitor and control the machine tool (Chiron FZ08). This was tested and presented with a live demonstration during the 5G Webinar. Even if 5G was not available in the MMS test field and 4G was used it showed the functionality of using mobile network to control machine tools. MMS gained knowledge how to connect machine tools to the 5G network and transmit data via the mobile network.



A lot of use cases for 5G applications were evaluated and deeply discussed with the MMS product management. The identified use cases are workpiece contact detection, collision monitoring, remote process diagnosis, 5G Sensors in machine tools, 5G Tool holders. For some applications like collision monitoring or contact detection 5G is currently too slow because reaction times of less than 1ms are required. Beside technical solutions infrastructural advantages can be seen for reduction of installation effort, fast setup, installation and communication across different plants and Installation in case of missing or not usable missing IT infrastructure.

A similar test bench is also being developed at the IPT site, integrating a Multi-sensor Platform which was developed to demonstrate the potential of integration and flexibility of sensors and 5G together. In Marposs SpA the product development management is evaluating the technical and commercial feasibility of a new generation of hand-held gauging equipment, in which the currently adopted Bluetooth is replaced by 5G. Such a solution would guarantee an unprecedented level of flexibility in the production process.

MMS and Marposs published 4 papers together with IPT and other partners.

6.1.4 Orange

Orange has driven the work on MNO business value creation in WP1 (Use cases, Business Models, Network Design) and investigated the Total Cost of Ownership of a 5G industrial network. This work, carried out in a collaborative manner, fed important information into the business development of Orange and Orange Business Services. On the other hand, the forward-looking technical work in WP5 (5G Optimization for Manufacturing), where Orange is leading the activity on network architecture, allowed Orange to gain insights on future technological features and contribute to standards. Orange has done a significant number of contributions (15 contributions to ITU-T SG15 in 2020 so far and 4 contributions to 3GPP SA1 co-signed with Ericsson) showing the relevance of the project for the standardization taking place by the company.

6.1.5 Bosch

Bosch has performed Electromagnetic Compatibility (EMC) tests to analyze the impact of the 5G signal onto the running production of various types of semiconductor product at the Bosch factory in Reutlingen. The outcome of these EMC tests represents a valuable input for Bosch when adopting the 5G network technology for productive use since the EMC tests have been performed in the area of wafer test, which is one of the relevant areas for ensuring a high-quality level.

Wireless channel measurements have been performed both in a mid-band frequency centered around 3.71 GHz and also in a higher frequency centered around 27 GHz in the production area of the Bosch semiconductor factory. These measurements provide useful insights into this quite challenging radio propagation environment and will be taken into consideration when planning a 5G network deployment in the factory for productive use. Since the channel measurements have been performed in area of wafer



processing above, the obtained results are excellent base for further activities in semiconductor production e.g., for clean room space extension.

As a central activity of 5G-SMART, Ericsson and Bosch have deployed a temporary 5G-infrastructure for wafer processing. This activity leads to significant learnings about implementation and integration of a 5G-net to the existing Bosch-network in fulfilling requirements of IT-security.

Bosch has gained more hands-on experience with testing and evaluating the applicability of 5G network industrial applications (e.g., controller-to-controller communication, control of mobile robots). Specifically, Bosch has evaluated the 5G network as well as the performance of the applications considered in the Cloud-based mobile robotics and TSN/I-LAN over 5G use cases. This allows Bosch to better understand the advantages and limitation of the 5G network for industrial applications, which in turn helps Bosch with the evaluation of the overall 5G performance for productive use.

6.1.6 T-Systems

T-Systems has continued to contribute, by investigating the possible use cases, MNO engagement options, their requirements and related KPIs, as well as evaluating different network design options considering the technical use cases and business-related KPIs. In the beginning of 2021, T-Systems submitted a paper entitled "Performance of a PROFINET based industrial service over mobile operator's 5G network" to PIMRC 2021. T-SYS also contributed to writing detailed 5G-NSA RAN Coverage Measurement description for a customer project. The main investigated points were to compare the simulation and the real-life coverage. Therefore, T-Systems specified multiple customer use-cases, simulation environment based on real-life environment and specified PNI-NPN coverage requirement. T-SYS worked and shared the review of D5.4 Second Report on 5G network architecture options and assessments. Furthermore, T-SYS contributed to the evaluation and further research work of 5G public network integration for a real-life PROFINET application topic which presents insights into the early adoption of a 5G Public Network Integration Non-Public Network (PNI-NPN) for industrial automation applications with observed network performance. T-Systems contributed in the following ways:

1. Presented network design concepts to overcome the challenges of industrial use-cases and mobile network limitations.
2. Proposed network architecture over 5G non-Standalone architecture (NSA).
3. Performed validation measurements with PROFINET and PROFIsafe communication. The results – at a real industrial 5G setting – indicate that the proposed architecture is very promising for the future 5G industrial deployments. In addition, T-Systems worked on the manuscripts of the rejected papers with improved measurement methods and using better/different statistical algorithms to avoid sampling issues. T-Systems has also continued to support the ongoing dissemination activities in the project.
4. Furthermore, T-Systems worked on the manuscripts of the rejected papers with improved measurement methods and using better/different statistical algorithms to avoid sampling issues. The new publications are submitted to NOMS 2022, which will be held in Budapest.



Regarding the exploitation of results:

- As working further on the Topic, there are connecting research item about V2X and 5G-PN connection. Based on the results of the 5G-Smart the research work continues to the direction to investigate the 5G V2X dynamic traffic characteristics.
- Cooperating in the creation of the D1.3 document, T-Systems has had the opportunity to better understand the main challenges posed by the cooperation of various parties (i.e: industrial, MNO, third parties) to fulfill the needs of the end users more successfully.
- Through the research work done on the project publications, T-Systems was able to carry out the analysis of the Technology Economics Analysis of the Campus -Non-Public Industry Cellular Network for instance, which provides the company with valuable information regarding this technology.
- T-Systems was able to gain insights to mitigate the risk of spectrum allocation issues. To understand the main values and aspects of spectrum trading. The evaluation was done from MNO perspective.
- Gained valuable understanding of the possible business opportunities and the evaluation of non-public 5G cellular networks.
- Was able to better identify and understand the roles of the key players within the new industrial ecosystem.
- T-Systems also had the opportunity to examine the difference between various network infrastructures in terms of cost and usability, through a tech-eco analysis.
- Through the work conducted in WP5, T-Systems gained insights into the network traffic implications within Industry4.0 applications.
- Participated in the work connected to the investigation of how 5G non-public and industrial networks for smart manufacturing can be integrated.
- Evaluated the user authentication possibilities of Non-Public Networks, based on existing 4G solutions.

Altogether, the work conducted within these work packages and tasks has provided T-Systems with valuable insights, and specific knowledge in the above-mentioned topics, which in the future can be the basis for industrial exploitation through the better understanding of the underlying technological infrastructures, the business and economic implications, and the roles and needs of the various stakeholders.

6.2 SME impact and exploitation

The 5G-SMART project has been supported by the presence of two small to medium sized enterprises, Cumucore and U-blox. Both covered some essential aspects in the technical activities performed in the consortium: the virtualization of the system for network slicing purpose and the synchronization and localization approach.



6.2.1 Cumucore

Cumucore has completed the design and implementation of network slice manager (NSM) to deploy dedicated slices for different traffic requirements within a factory floor. The 5GLAN components have been integrated on top of network slices to enable connectivity between wireless and wired devices connected to fixed industry LAN. The NSM is now integral part of Cumucore product portfolio and will be first deployed commercially by network operator that will demonstrate network slicing to offer slices for their customers requiring private network as a service.

6.2.2 U-blox

u-blox has been supporting the partners in following areas. Technically, u-blox provided connectivity components for the multi-sensor platform, provided technical know-how and recommendations on hardware prototyping and configurations. u-blox contributed to the configuration of hardware and services for the communication components with precision timing function and the theoretical analysis of time synchronisation. The above capabilities have been endorsed in one of the 5G-ACIA testbeds with Fraunhofer and Ericsson.

u-blox contributed with insights on positioning and timing from standards perspective, on the state of art and gap analysis, co-signed a contribution with Orange to ITU-T SG15. u-blox has also developed a ray tracing model in WP5 and evaluated the performance of 5G indoor positioning in a real factory environment. The results are disseminated in couple of IEEE papers. The learnings gained from the evaluation have also been fed back internally to be taken in consideration for improved and future product development.

u-blox is serving as the 5G-ACIA WG4 (Industry Liaison and Marketing) Chair and has been creating opportunities and facilitating the dissemination of 5G-SMART activities and results at various international events, MWC and Hannover Messe 2021.

6.3 Academic impact and exploitation

Academia has been widely represented in the 5G-SMART project with some of the most influential Universities in the field of industrial 5G research community in Europe, and worldwide. Budapest University of Technology and Economics, Fraunhofer IPT, Lund University, and Universitat Politècnica de València have represented a very significant academic support in a project that has been quite industry oriented by choice.

The 5G-SMART environment has been helpful for universities to increase the level of expertise in the 5G topics, to train the young professionals and PhD students and to increase the business opportunities and



further collaboration, as well as for the important exchange of knowledge with the industrial partners. More details of the relevance impact for each academic partner are given below.

6.3.1 Budapest University of Technology and Economics

The Budapest University of Technology and Economics has completed the WP4 (Trials and Validation in Semiconductor Factory) AGV use case implementation. One commercial AGV (type MIR 100) and a custom-built model (built from HEBI smart servos) by Ericsson Hungary were deployed and tested in real industrial environment. The AGVs can cooperate in the sense that both share a common map. This common map can be used to share information on the working environment gathered by the sensory systems (lidars, cameras) of the robots. The mapping, localization and navigation tasks are performed on the network side in the cloud, removing all control logic from the devices, making it possible to cloud-control the AGV fleet. The same scenario was implemented in a simulation environment using the ROS/Gazebo physical simulator.

The Cloud Robotics research group at BME has just recruited a PhD student on agile robotics focusing on the communication aspects of networked robotic systems. More than half a dozen MSc students carried or are carrying on their project work on 5G and cloud robotics topics. A Students Scientific Conference paper was also presented based on experiences and results gained from 5G-SMART implementation.

At the Faculty of Electrical Engineering and Informatics a new course material entitled "5G Mobile Systems: Architecture and Services" was prepared and audited for the MSc curriculum. The course heavily relies on the experiences gained from industrial use cases and applications, among the the one from 5G-SMART factory trial.

Throughout the work, BME's strategic cooperation with Ericsson Hungary was further deepened and strengthened having achieved all work results in close cooperation within 5G-SMART.

6.3.2 Fraunhofer IPT

Fraunhofer IPT was driving the research activities in WP3 (5G for Enhanced Industrial Manufacturing Processes). All findings were actively disseminated among the many industrial partners of Fraunhofer IPT, including the International Community for Networked Adaptive Production (ICNAP) and its working group "Interfaces and Connectivity." Dissemination activities of Fraunhofer IPT also contained numerous live demonstrations of the results achieved in WP3. This has had its premiere in a tutorial session of PIMRC, where IPT has demonstrated two use cases on the Fraunhofer IPT shopfloor-based 5G-Area, followed by a Webinar on 5G for Process Monitoring, which involved several presentations as well as live demonstrations. Furthermore, Fraunhofer IPT also contributed with publications in journals and conferences, a guest editorship for a special issue of the MDPI journal Electronics. Regarding standardization, Fraunhofer IPT has contributed to many 5G-ACIA working items, including one on TSN over 5G together with other 5G-SMART partners of WP5 (5G Optimization for Manufacturing).



Technically, Fraunhofer IPT gained much experience in electronics design, programming of embedded systems for the sensor systems, edge-cloud integration, orchestration of virtual machines, and industrial communication. IPT has increased its knowledge in the performance and applicability of wireless sensor systems and the overall setting up of 5G networks. IPT benefits from 5G-SMART and can offer 5G sensor solutions with Marposs after the project.

Fraunhofer IPT was the initiator and leader in modeling the business perspective for industrial 5G manufacturing. 5G-SMART was fundamental to drive these activities, which ultimately resulted in a tool to calculate the return-on-invest. IPT is following this research even after the project ends to commercialize the tool and make it a valuable support for sales teams of mobile network operators and equipment vendors to use it for their customer engagements.

6.3.3 Lund University

Lund University has built up a local standalone 5G network together with Ericsson that now is used for further research along the lines of the project, especially focusing on cloud and edge control over 5G for industrial application. This lab is now engaging two post docs and a couple of PhD students, and the goal is to have this setup as a part of our open-door initiative, where local industry can join us in our lab to further investigate and characterize their own use cases.

The measurements in Reutlingen have convinced us that spatial diversity is a very promising way forward for the ultra-reliable low latency use cases. Based on the results we see that it should be possible to avoid retransmissions completely, and to rethink coding strategies as the fading channel can be made very flat by proper pre-coding. This could open very interesting possibilities in a 6G context. We are currently working on one journal paper from the measurements in Reutlingen, and the work will be an important part of one PhD student's thesis, planned to be defended in December 2022.

In November 2021 we also hosted 30 participants in the EU Innovative training network MINTS, European Training Network on Millimeter-wave NeTworking and Sensing for Beyond 5G. It was one week of training for the 15 PhD students in the network, and a two-day meeting for all seniors. Half a day was devoted to High-resolution dynamic characterization and modelling of mmWave channels, and half a day to cell free and distributed massive MIMO for mmW. Here we really exploited latest findings based on the experience and results from 5G-SMART and disseminated results to a group of next generation European researchers.

6.3.4 Universitat Politècnica de València

Universitat Politècnica de València (UPV) has published three conference paper and one journal paper directly related to its activity in 5G-SMART. Apart from the more academic part, the development of this project has increased the business opportunities and further collaboration of the UPV. Moreover, UPV considers that some of the ideas identified along the project (mainly on the electromagnetic isolation based on joint planning and codebook selection) could disrupt the current technological limitations in



industrial 5G systems and beyond and will be considered as patent candidates in the coming months by the UPV. The dissemination through training events is also relevant, and in this direction, they have participated in three events, one academic, another one with the agri-food industry of Valencia region, to motivate the inclusion of the 5G for industry boost, and finally with two SMEs in the region dedicated to the manufacturing of industrial communication devices.

Regarding exploitation of results:

- The simulation platform capabilities have been extended, thus giving more added value for future licensing to this important tool. One of the current consultancy contracts of the UPV depends on the outputs generated in 5G-SMART. The automatic planning algorithm could be a nice topic to exploit, and we are currently exploring this alternative together with another company.
- UPV has increased the level of expertise in the field of evaluation of beyond 5G systems, which could result in further opportunities for consultancy on the design, testing and evaluation of similar solutions. UPV is further looking for identifying potential interested institutions to cooperate with for the development of this expertise.
- UPV personnel has gained expertise, which allows us to be ready and in an excellent position for preparing courses and other education activities. In general, the participation in the project has been used as a means for training Ph.D. students (two PhD have collaborated in the project, Danaisy Prado and Andrea Ramos) as preparation of future European mobile communication experts.
- Visualization capabilities have been extended, thanks to the activity performed in 5G-SMART, to the use of a virtual reality approach. Together with Lund University and Bosch, the Reutlingen factory was recreated, and significant improvement was made to the ray tracing tools to make an accurate characterization of the mmW air propagation in an industrial environment. These capacities are expected to result in new ideas for products and means for exploitation. In particular, we are currently planning to go for a totally mobile virtual reality experience, aspect that could be of interest for many companies.



Conclusions

The overall aim of this document has been to provide information on the 5G-SMART project's dissemination and exploitation activities implemented during the project lifetime. 5G-SMART's communication, dissemination and exploitation plans were described in D6.1. This report reflects that the project successfully conveys the message to the society with respect to the need for the introduction of the 5G into society. The tasks of communication, dissemination, and exploitation have been considered as of utmost importance to 5G-SMART, as it is recognised that they are crucial elements to increase the impact of the project.

To tackle with the unprecedented situation of the pandemic 5G-SMART conducted always a safe approach, following the recommendation of the WHO [WHO20]. Any decision to restrict, modify, postpone, cancel, or proceed with holding the scheduled events has been based on a rigorous risk assessment exercise, tailored to the specific event. The risk assessment has guaranteed no incurrence into any tragic situation along our activities.

Fortunately, as it is visible from the results of the project, most of the activities (i.e., workshops, presentations) as well as the outputs (i.e., white papers, publications) were properly executed reaching the fixed targets. More than 24 papers, 30 contributions to standards, 18 keynotes, the participation in 10 5G industrial events, 4 workshops and 5 demos, show the high implication of the project in the dissemination of achieved results.

Therefore, the aim to create synergies with the operational technologies players, communicating with the research community through scientific publications and presentations at scientific conferences and workshops, and communicating with the regulators and standardisation bodies in order to raise awareness of the project results were successfully implemented.



List of abbreviations

3GPP - 3rd Generation Partnership Project

5G – fifth generation cellular network technology

5G-ACIA – 5G Alliance for Connected Industries and Automation

5G-PPP – 5G Infrastructure Public Private Partnership

AGV – Autonomous Guided Vehicle

BI-MU – Biennale della Macchina Utensile in Milan

EC – European Commission

eMBB – enhanced Mobile Broadband

EMC – Electromagnetic Compatibility

EMO – Exposition Mondiale de la Machine-Outil

HW – Hardware

ICT – Information and Communication Technology

IMTS – International Manufacturing Technology Show

IoT – Internet of Things

IPR – Intellectual Property Rights

ITU – International Telecommunications Union

JIMTOF – Japan International Machine Tool Fair

KPI – Key Performance Indicator

LAN – Local Area Network

MNO – Mobile Network Operator

NGMN – Next Generation Mobile Networks

OT – Operational Technology

SME – Small and Medium-sized Enterprise

SW – Software

TSN – Time-Sensitive Networking

URLLC – Ultra-Reliable Low-Latency Communication

WP – Work Package



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