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Abstract	This deliverable presents the work executed in the first 15 months of the iNGENIOUS project with regards to dissemination, communication, standardization, exploitation, and innovation.
Keywords	

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Document Revision History

Version	Date	Description of change	List of contributor(s)
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Dissemination Level		
PU	Public, fully open, e.g. web	✓
CL	Classified, information as referred to in Commission Decision 2001/844/EC	
CO	Confidential to iNGENIOUS project and Commission Services	

** R: Document, report (excluding the periodic and final reports)*

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

OTHER: Software, technical diagram, etc.

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Executive Summary (NXW)

This deliverable presents the work executed in the first 15 months of the iNGENIOUS project with regards to dissemination, communication, standardization, exploitation, and innovation.

Chapter 1 covers dissemination and communication activities. These activities include contributions in the form of papers for journals and conferences, as well as participation in physical events to convey the preliminary results of technical deliverables and design, and digital dissemination for the iNGENIOUS vision and use cases through virtual mediums to approach the large professional communities of 5G stakeholders virtually. The chapter concludes with a reporting of the associated KPI metrics.

Chapter 2 reports the activities in targeted standardization bodies and industries for influencing the development of standards. The chapter then details the plans to maximise the technical and economic impact of iNGENIOUS project through exploitation intentions, increasing the project's competitive advantage and helping to improve products and services in new and existing IoT markets.

Finally, Chapter 3 gives a detailed look at the project's innovation management, including generated innovations tracking as well as a mapping of the relationship with the background and foreground intellectual property elements brought and developed by the various partners.

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Abbreviations

5G gNB	Next Generation Node B
AGV	Automated Guided Vehicle
AI/ML	Artificial Intelligence / Machine Learning
AIS	Automatic Identification System
API	Application Programming Interface
BIP	Background Intellectual Property
BLE	Bluetooth Low Energy
CIoT	Cellular IoT
CC	Component Carrier
CIR	Container Image Registry
CISM	Container Infrastructure Services Management
CRUD	Create, Read, Update, and Delete
DL	Down Link
DLT	Distributed Ledger Technology
DVL	Data Virtualisation Layer
E2E	End to End
eMBB	enhanced Mobile Broadband
FIP	Foreground Intellectual Property
FPGA	Field-Programmable Gate Array
FSS	Fixed-Satellite Service
GEO	Geostationary or Geosynchronous Orbit
GUI	Graphical User Interface
GW	Gateway
I/O	Input/Output
IE	Innovation Element
IIoT	Industrial Internet of Things
IoT	Internet of Things
ISG	Industry Specification Group
JDBC	Java Database Connectivity
KETI	Korea Electronics Technology Institute
KPI	Key Performance Indicator
LAN	Local Access Network
LoRa	Long Range
M2M	Machine to machine
MAC	Medium Access Control Layer of the Open Systems Interconnection model
MANO	Management and Orchestration
MEC	Multi-access Edge Computing
MEO	Medium Earth Orbit
mMTC	massive Machine Type Communications
MSS	Mobile-Satellite Service
NB-IoT	Narrowband IoT
NEF	5G Network Exposure Function

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NF	Network Function
NFV	Network Functions Virtualisation
NG-IoT	Next Generation Internet of Things
NoC	Network on Chip
NR	New Radio
NSMF	Network Slice Management Function
NTN	Non Terrestrial Networks
NWDAF	Network Data Analytics Function
O-RAN	Open Radio Access Network
OCEAN	Open allianCE for IoT stANdards)
OData	Open Data Protocol
ODBC	Open Database Connectivity
PDCP	Packet Data Convergence Protocol
PHY	Physical Layer of the Open Systems Interconnection Model
QoS	Quality of Service
RAN	Radio Access Network
RDSS	Radiodetermination-Satellite Service
REST	Representational state transfer
RLC	Radio Link Control
RoT	Root-of-Trust
SBA	Service Based Architecture
SDK	Software Development Kit
SPI	Serial Peripheral Interface
ST	Survival Time
SW	Software
TCU	Trusted Communication Unit
ToD	Tele-operation Driving
TLS	Transport Layer Security
TPCS	Tuscan Port Community System
TSG	Technical Specification Group
TT	Truck Turnaround
UC	Use Case
UC1	Automated Robots with Heterogeneous Networks
UC2	Improve Drivers' Safety with MR and Haptic Solutions
UC3	Transportation Platform Health Monitoring
UC4	Inter-modal Asset Tracking via IoT and Satellite
UC5	Situational Understanding and Predictive Models in Smart Logistics Scenarios
UC6	Supply Chain Ecosystem Integration
UE	User Equipment
UL	Up Link
URLLC	Ultra-Reliable Low Latency Communications
VNF	Virtualized Network Functions
VSMF	Virtual Session Management Function
WGs	Work Groups
ZSM	Zero touch network and Service

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1 Dissemination and Communication

1.1 Procedures and Methodologies

In line with the objectives set out at the beginning of the project, the iNGENIOUS Consortium has focused efforts towards two major lines of action:

1. Dissemination: contributions in the form of papers for journals and conferences, as well as participation in physical events to convey the preliminary results of technical deliverables and design;

2. Communication: digital dissemination for the iNGENIOUS vision and use cases through virtual medium to approach the large professional communities of 5G stakeholders virtually.

To facilitate the first line of action, the project identified target conferences, events and journals that focus on areas relevant to the project's goals and innovations (shown in Table 1 and Table 2). In addition, the project is actively involved with the EU-IoT and NG-IoT projects for supporting collaboration among relevant initiatives at a pan-European level.

The second line of action has been mapped into several tracks. A schedule for 22 blog posts, to be published periodically throughout the project timeline, was set at the beginning of the project, as reported in Table 3. Promotional material including videos and leaflets have been produced and planned. Social Media, in the form of Twitter and LinkedIn, is being utilised for the communication of research and innovation actions, as well as project results. The social channels are being handled by multiple partners, with a weekly target distribution activity. Finally, the project website is used as a hub for all distribution material of the project, including videos, leaflets, deliverables, blog posts, news, and press releases.

The following sections summarise the completed activities for dissemination executed in the first 15 months of the project. Metrics for each activity are first presented in Sections 1.2 and 1.3, then summarised in Section 1.4.

Target Conference/Event	Link
2022	
OSDI: USENIX Symposium on Operating Systems Design and Implementation	https://www.usenix.org/conference/osdi21
Naples Shipping Week	https://www.nsweek.com/
Asilomar: Conference on Signals, Systems, and Computers	https://www.asilomarsscconf.org/
ASPLOS: International Conference on Architectural Support for Programming Languages and Operating Systems	https://asplos-conference.org/
DAC: Design Automation Conference	https://www.dac.com/
DATE: Design, Automation, and Test in Europe	https://www.date-conference.com/
TOC Europe	https://www.tocevents-europe.com/en/Home.html
EuroSys: European Conference on Computer Systems	https://2021.eurosys.org/
IEEE Global Communications Conference (GLOBECOM)	https://www.comsoc.org/conferences-events/ieee-global-communications-conference-2022
IEEE Wireless Communications and Networking Conference	https://wcnc2022.ieee-wcnc.org/
IEEE International Conference on Industrial Technology (ICIT)	https://2022.ieee-icit.org/
International Conference on Future Internet of Things and Cloud (FiCloud)	http://www.ficloud.org/
ISCAS: International Symposium on Circuits and Systems	https://iscas2022.org/
Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit)	https://www.eucnc.eu/

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SAMOS: International Conference on Embedded Computer Systems: Architectures, Modeling and Simulation	https://samos-conference.com/wp/
TOC Europe	https://www.tocevents-europe.com/en/Home.html
USENIX ATC: USENIX Annual Technical Conference	https://www.usenix.org/conference/atc21
VLSI-SoC: International Conference on Very Large Scale Integration	https://sites.google.com/view/vlsi-soc-2022/
2023	
Genoa Shipping Week	https://www.gsweek.it/
Transport Logistics	https://www.transportlogistic.de/en/
Asilomar: Conference on Signals, Systems, and Computers	https://www.asilomarsscconf.org/
ASPLOS: International Conference on Architectural Support for Programming Languages and Operating Systems	https://asplos-conference.org/
DAC: Design Automation Conference	https://www.dac.com/
DATE: Design, Automation, and Test in Europe	https://www.date-conference.com/
EuroSys: European Conference on Computer Systems	-
IEEE Global Communications Conference (GLOBECOM)	-
IEEE Wireless Communications and Networking Conference	-
IEEE International Conference on Industrial Technology (ICIT)	-
International Conference on Future Internet of Things and Cloud (FiCloud)	http://www.ficloud.org/
ISCAS: International Symposium on Circuits and Systems	https://iscas2023.org/
Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit)	https://www.eucnc.eu/
OSDI: USENIX Symposium on Operating Systems Design and Implementation	https://www.usenix.org/conference/osdi21
SAMOS: International Conference on Embedded Computer Systems: Architectures, Modeling and Simulation	https://samos-conference.com/wp/
SOSP: ACM Symposium on Operating Systems and Principles	https://dl.acm.org/conference/sosp
USENIX ATC: USENIX Annual Technical Conference	https://www.usenix.org/conference/atc21
VLSI-SoC: International Conference on Very Large Scale Integration	https://sites.google.com/view/vlsi-soc-2022/

Table 1: Target conferences and events

Target Journal
IEEE Internet of Things Journal
IEEE Internet of Things Magazine
IEEE Communications Magazine
IEEE Communications Letters
IEEE Transactions on Broadcasting
IEEE/ACM Transactions on Networking
IEEE Transactions on Network and Service Management
IEEE Network
IEEE Network Letters
IEEE Communications Letters
IEEE Wireless Communications
IEEE transactions on communication
IEEE Transactions on Wireless Communications
IEEE open access journal
IEEE Communications Surveys and Tutorials
IEEE Journal on Selected Areas in Communications
EURASIP Journal on Wireless Communications and Networking
IEEE Global Communications Conference (GLOBECOM)
IEEE International Conference on Communications (ICC)
IEEE Wireless Communications and Networking Conference (WCNC)
IEEE Vehicular Technology Conference (VTC)
European Conference on Networks and Communications (EuCNC)
International Symposium on Wireless Communication Systems (ISWCS)
European Signal Processing Conference (EUSIPCO)
5G++ Summit Dresden
ACM TECS: Transactions on Embedded Computing Systems
Elsevier MICPRO: Microprocessors and Microsystems

Table 2: Target journals

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Subject/Title	Partner	Date
NG-IOT FOR THE NEXT- GENERATION SUPPLY CHAIN	UPV	M2
iNGENIOUS overall architecture	BI UPV	M4
Insight - the Smart Port	AdSP MTS	M5
Bitcoin on the iNGENIOUS Platform	PJATK	M6
Forthcoming IoT devices - bio-metric haptic devices	NED	M7
Insight - Predictive Analytics for Port Optimization	AWA	M8
Technology Insight - Use Case 1	TUD	M10
Technology Insight - Use Case 2	NOK	M12
Technology Insight - Use Case 3	NCG	M13
Technology Insight - Use Case 4	SES	M14
Technology Insight - Use Case 5	FV	M16
Technology Insight - Use Case 6	CNIT	M17
iNGENIOUS - IoT Solutions Over Satellite	iDR	M18
Insight - NG IoT for Intermodal E2E Asset Tracking	COSSP	M19
Insight - AI/ML Based Network Slice and Network Resource Optimization in iNGENIOUS	NXW	M20
Insight - Ultra Reliable Mobile Packet Core for Industrial Environments	CMC	M21
Technology Insight - PoC #1 Tactile AGV/arm robot	ASTI	M22
Technology Insight - PoC #2 Isolated Components Improving Security and Re-usability	BI	M24
Technology Insight - Cross-DLT in iNGENIOUS	TIOTBD	M25
iNGENIOUS Technology Achievements WP4	5CMM	M26
iNGENIOUS Technology Achievements WP3	SEQ	M28
iNGENIOUS Technology Achievements WP5	TEI	M29

Table 3: Blog contribution schedule

1.2 Dissemination Activities

The iNGENIOUS project has been participating in several dissemination activities in order to ensure the proper propagation of the knowledge developed within the consortium and the project context. These activities are grouped in the following subsections based on their category, which mainly include journal articles and other materials that have been presented.

1.1.1 MAGAZINES & WHITE PAPERS

iNGENIOUS has contributed to one magazine with one paper:

Magazine	Title	Submitted by	Submitted at	Audience
HiPEAC	iNGENIOUS: Next-GENeration IoT sOlutions for the Universal Supply chain	BI	06/2021	General

Table 4: Magazines & white papers

1.1.2 JOURNALS PAPERS

The project has contributed to five journal papers from its beginning:

Journal	Title	Submitted by	Submitted at	Audience
IEEE Communications Letters	A Robust and Low-Complexity Walsh-Hadamard Modulation for Doubly-Dispersive Channels	TUD	10/2020	Academia
IEEE Transaction on Wireless Communications	A Robust Baseband Transceiver Design for Doubly-Dispersive Channels	TUD	12/2020	Academia

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IEEE Transactions on Green Communications and Networking	Alternative Chirp Spread Spectrum Techniques for LPWANs	TUD	02/2021	Academia
EURASIP Journal on Wireless Communications and Networking	Machine type communications: key drivers and enablers towards the 6G era	UPV	06/2021	Academia
IEEE Open Journal of Communications Society (OJ-COMS), Low-Power Wide-Area Networks (LPWANs)	A Novel Approach for Cancellation of Non-Aligned Inter Spreading Factor Interference in LoRa Systems	TUD	11/10/2021	Academia

Table 5: Journal papers

1.1.3 CONFERENCE PAPERS

The project has contributed to five conferences from its beginning, as reported in the following table:

Conference	Title	Submitted by	Submitted at	Audience
ICC2021	Channel Estimation for MIMO Space Time Coded OTFS under Doubly Selective Channels	TUD	19/02/2021	Academia
2021 IEEE Globecom Workshops (GC Wkshps): Workshop on Human-Centric and Tactile IoT	Physical Layer Design Aspects to Meet the Requirements of Tactile Internet	TUD	15/07/2021	Academia
WCNC 2022: IEEE Wireless Communications & Networking Conference	Iterative Receiver for Power-Domain Non-Orthogonal Multiple Access with Mixed Waveforms	TUD	09/2021	Academia
WCNC 2022: IEEE Wireless Communications & Networking Conference	Implementation and Calibration of the 3GPP Industrial Channel Model for ns-3	5CMM	01/10/2021	Academia, Industry
CCNC 2022 WKSHPS: 6G: What to expect from 6G: visions, use cases and technologies	A Study on Iterative Equalization for DFTs-OFDM Waveform under sub-THz Channels	TUD	09/11/2021	Academia, Industry

Table 6: Conference papers

1.1.4 POSTERS

The project has generated one poster, that has been presented at the EuCNC event, as reported next:

Event	Title	Submitted by	Submitted at	Audience
EuCNC	iNGENIOUS: Next-Generation IoT Solutions for the Universal Supply Chain	UPV	12/03/2021	General

Table 7: Posters

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1.1.5 TALKS, PRESENTATIONS & PANELS

The project has contributed to dissemination with ten presentations in major events, including three keynotes:

Event	Title	Submitted by	Submitted at	Audience
Container Terminal Automation Conference 2020	5G in Maritime Ports and Terminals: An Unlocked Potential	José Luis Cárcel (FV)	02/12/2020	80
Global Maritime Week 2021	IoT, AI and 5G: Prediction in the Port of Valencia	Joan Meseguer (FV)	21/01/2021	>200
Shipbrokers Finland Webinar	Improving the efficiency of port operations using machine learning models	Jussi Poikonen (AWA)	18/02/2021	42
Microwave and Radio Electronics Week 2021 (MAREW 2021)	iNGENIOUS: Next Generation IoT for the Next-Generation Supply Chain	Eduardo Garro (UPV)	21/04/2021	32
Workshop of the H2020 EU-IoT Project on AIoT and Edge Machine Learning	Applications of Machine Learning and Edge Computing in Maritime Logistics	Jussi Poikonen (AWA)	21/05/2021	
EU-IoT 2nd Training Workshop: "Enabling the Tactile Internet with IoT"	Cross-layer framework for tactile applications	Ahmad Nimr (TUD)	08/07/2021	39
EU-IoT 2nd Training Workshop: "Enabling the Tactile Internet with IoT"	Enabling the Tactile Internet with IoT. 2nd Workshop	Cristina Escribano (NOK)	08/07/2021	
Wireless Networks in Ports 2021 (PORTCOMMS 2021)	5G In Next Generation IoT: A Key Enabler for Smart Ports	José Luis Cárcel (FV)	07/10/2021	60
Industrial 5G Uncovered: Spotlight on manufacturing and logistics	iNGENIOUS: Next Generation IoT for the Next-Generation Supply Chain	Nuria Molner (UPV)	16/11/2021	80
4th EU-IoT Training Workshop	iNGENIOUS: An IoT Architecture for the Universal Supply Chain	Carsten Weinhold (BI)	14/11/2021	45

Table 8: Talks, presentations & panels

1.1.6 ADVISORY BOARD MEETINGS

The advisory board of the project has been invited to the first day of plenary meetings in January 2021 and April 2021 in order to be updated with the main progress of the activities carried out in the different work packages of iNGENIOUS. In addition, a dedicated advisory board update meeting was held on June 15th 2021, including 20 minute presentations and Q&A on each of the use cases and 45 minute presentations and Q&A on the innovations and progress in the technical work packages.

1.1.7 MEETINGS WITH OTHER NGI/5G-PPP PROJECTS

iNGENIOUS in engaged in EU-IoT CSA project that gathers several NGI projects to establish contact and endorses cooperations and joint events as well as helps in the

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dissemination of all the involved projects. Monthly meetings ensure the commitment to the common goal.

1.1.8 BOOTHS & DEMOS

Event	Title	Partners	Date	Video/Photo
Valencia 5G Day	5G-enabled AGV control with haptic gloves	UPV, 5COMM, NED	11/06/2021	  
TRAFIC 2021 IFEMA	UC2 Tele-operation driving with immersive cockpit Demo and Poster	NOK	O2/11/2021	

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FEINDEF 2021 IFEMA	UC2 Telo-operation driving with immersive cockpit Demo	NOK	05/11/2021	

Table 9: Booths and Demos

1.1.9 WORKSHOPS

The project was involved in the planning of the IEEE GLOBECOM 2021 Workshop on Human-Centric and Tactile IoT, WS-12 [1]. This workshop was proposed in partnership with the ASSIST-IoT project and was accepted to be included in the 2021 IEEE GLOBECOM conference. Unfortunately, due to a lack of submitted papers, the workshop did not take place.

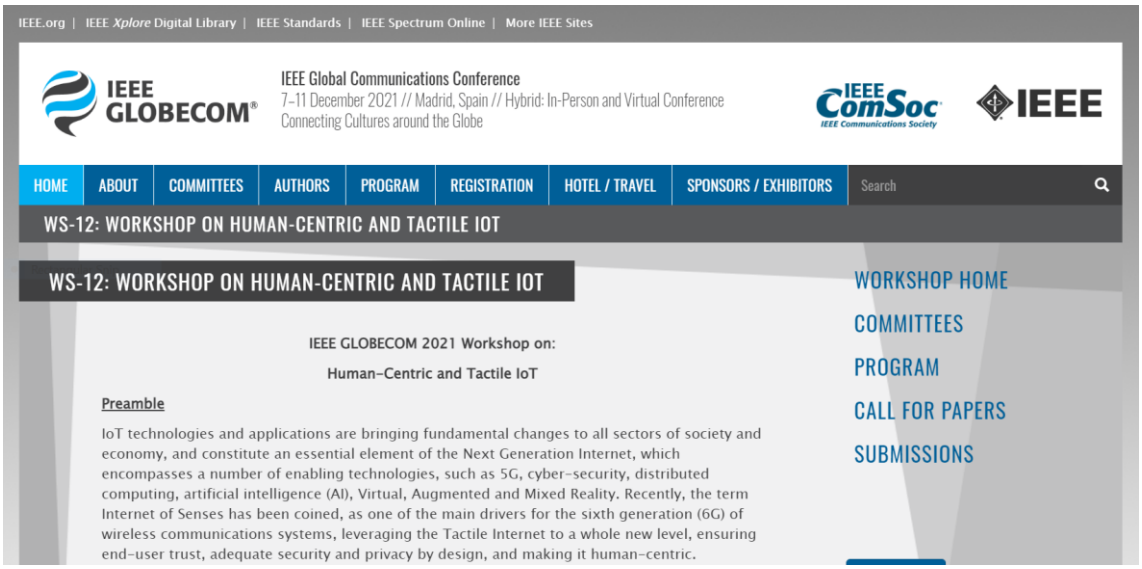

Figure 1: IEEE GLOBECOM Workshop

1.3 Communication Activities

This section reports on the results achieved with communication activities across the various channels which were configured at the beginning of the project (October 2020).

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1.3.1 WEBSITE

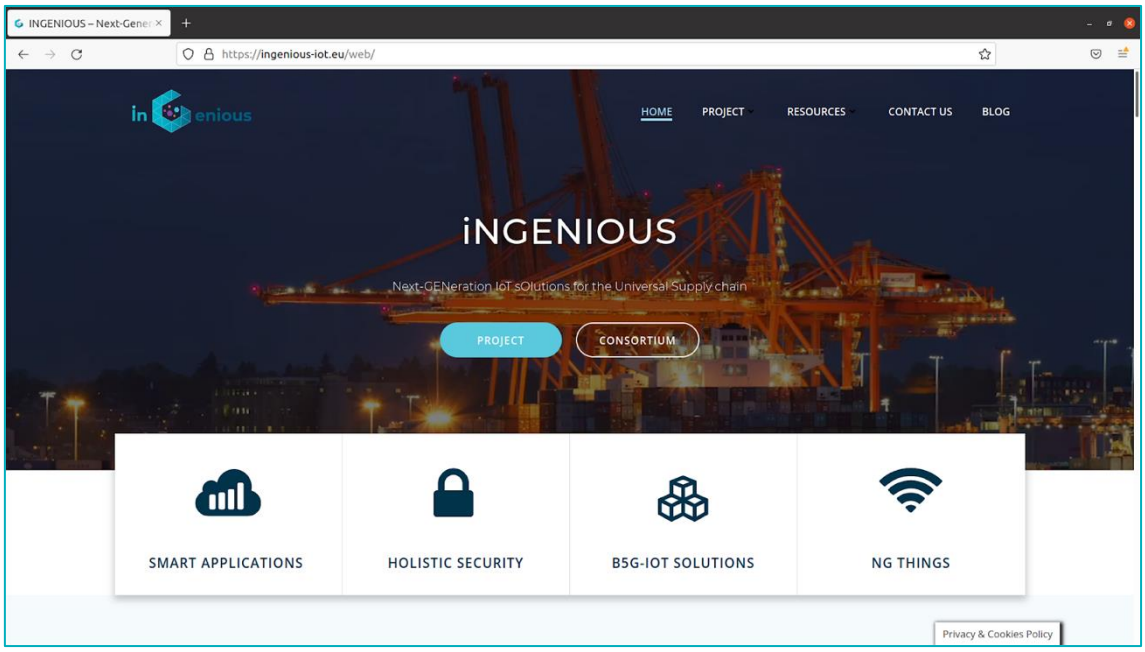

Figure 2: iNGENIOUS homepage

Since the beginning of the project, the project website [1] has been continuously populated with news, blog posts, press releases and the main results of the project (i.e., project deliverables). The website was used as the hub for all communication material which complemented and completed the communication campaigns on social networks.

To measure the impact of the website in terms of number of visitors and engagement metrics, Google Analytics was used and an overview of the analytics is shown in Figure 3.

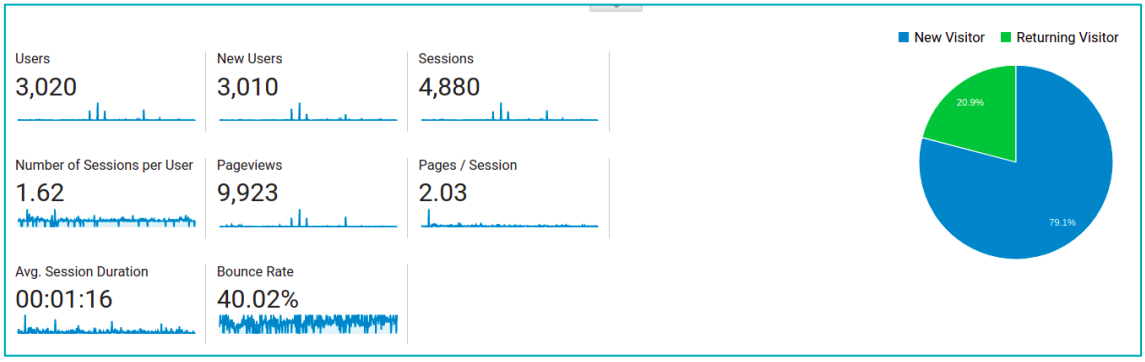

Figure 3: Metrics for www.ingenious-iot.eu

From October 2020 to December 2021, the number of new users recorded was 3,010, accounting for 79% of all visits, with an average of 1:16 minutes of visit duration This is a valuable indicator of project popularity, visibility, and promotion of its activities. Content will continue to be added to the website in the same mode as has been deployed in the first 12 months of the project.

1.3.2 SOCIAL MEDIA

The iNGENIOUS social media channels are particularly relevant to communication of research and innovation actions and have provided an effective communication and

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dissemination of project's results. The social media outlets, described in D7.1, include Twitter, LinkedIn, YouTube, Slideshare, the project Blog, and Zenodo.

Figure 4: Social channels used by the project

1.3.3 TWITTER

Twitter (@ingenious_iot) is the most immediate and effective tool to communicate project's news, events, and achievements. It serves to keep the iNGENIOUS partners, 5G community, EU institutions, media, and followers updated, informed, and involved in trending topics relevant to the project.

The iNGENIOUS Twitter account started in October 2020 in conjunction with the project's Kick-off meeting, and currently has 63 followers. The number of followers is expected to increase significantly following the first major event hosted by iNGENIOUS (TBD). Content is pushed on the iNGENIOUS twitter feed on average once per week as well as during events with iNGENIOUS participation. As of December, there have been 94 Tweets sent out from the iNGENIOUS account.

Figure 5: iNGENIOUS Twitter

1.3.4 LINKEDIN

The original communication strategy through LinkedIn was creating an iNGENIOUS group [2] to implement an accessible and direct link of followers to project activities. However, in the first year, the group had amassed only 76 followers. Therefore an alternative strategy has been adopted. An effective approach has been to reach out through the iNGENIOUS account [3] which currently stands with 189 connections and 193 followers.

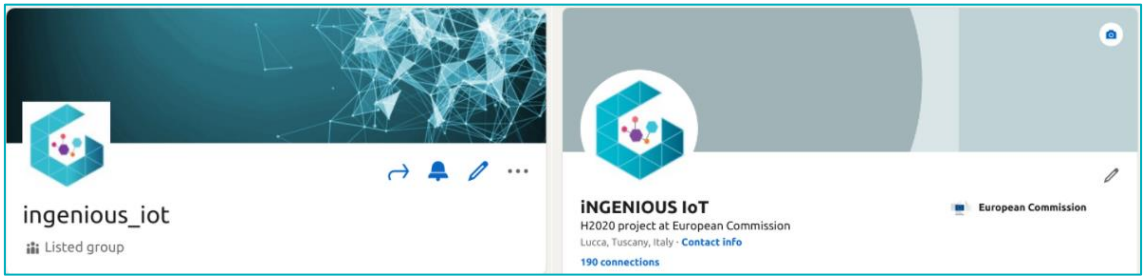

Figure 6: iNGENIOUS LinkedIn

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1.3.5 YOUTUBE

The project YouTube channel [4] was created to host relevant iNGENIOUS presentations, videos, tech talk, and interviews. The first video was created to illustrate the concept, goals, and use cases.

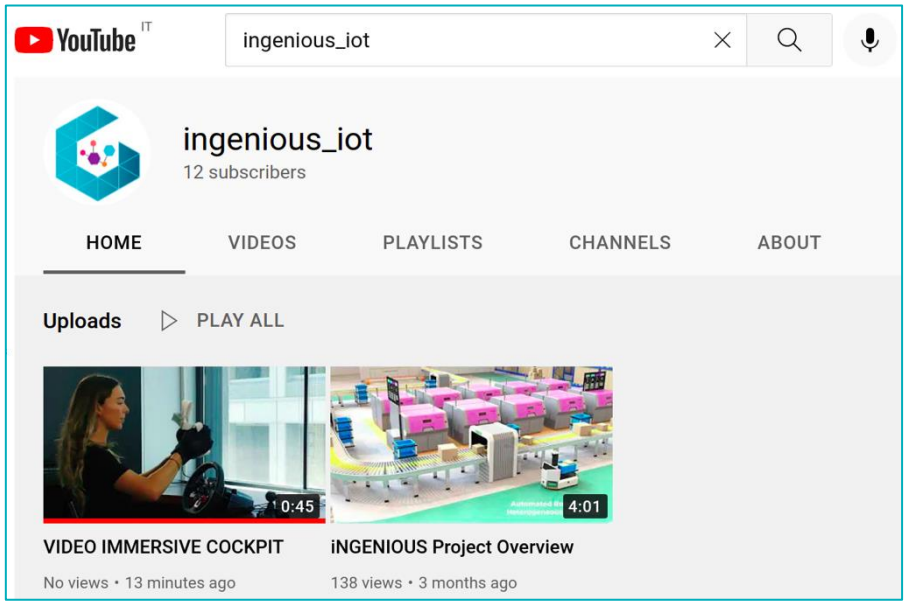

Figure 7: iNGENIOUS YouTube channel

At the moment, 2 videos have been published in the channel as described below:

- iNGENIOUS Project Overview - 4'01" published 03/08/2021
- Video Immersive Cockpit - 0'45" published 30/12/2021

More videos are planned, as described in Section 1.3.7.

1.3.6 BLOG POSTS

To better stoke interest in the project, highlight partners, and engage the online community, the Consortium has been producing blog posts on specific topics on the project research.

Since November 2020, 7 blog posts have been published in the website dedicated section [5].

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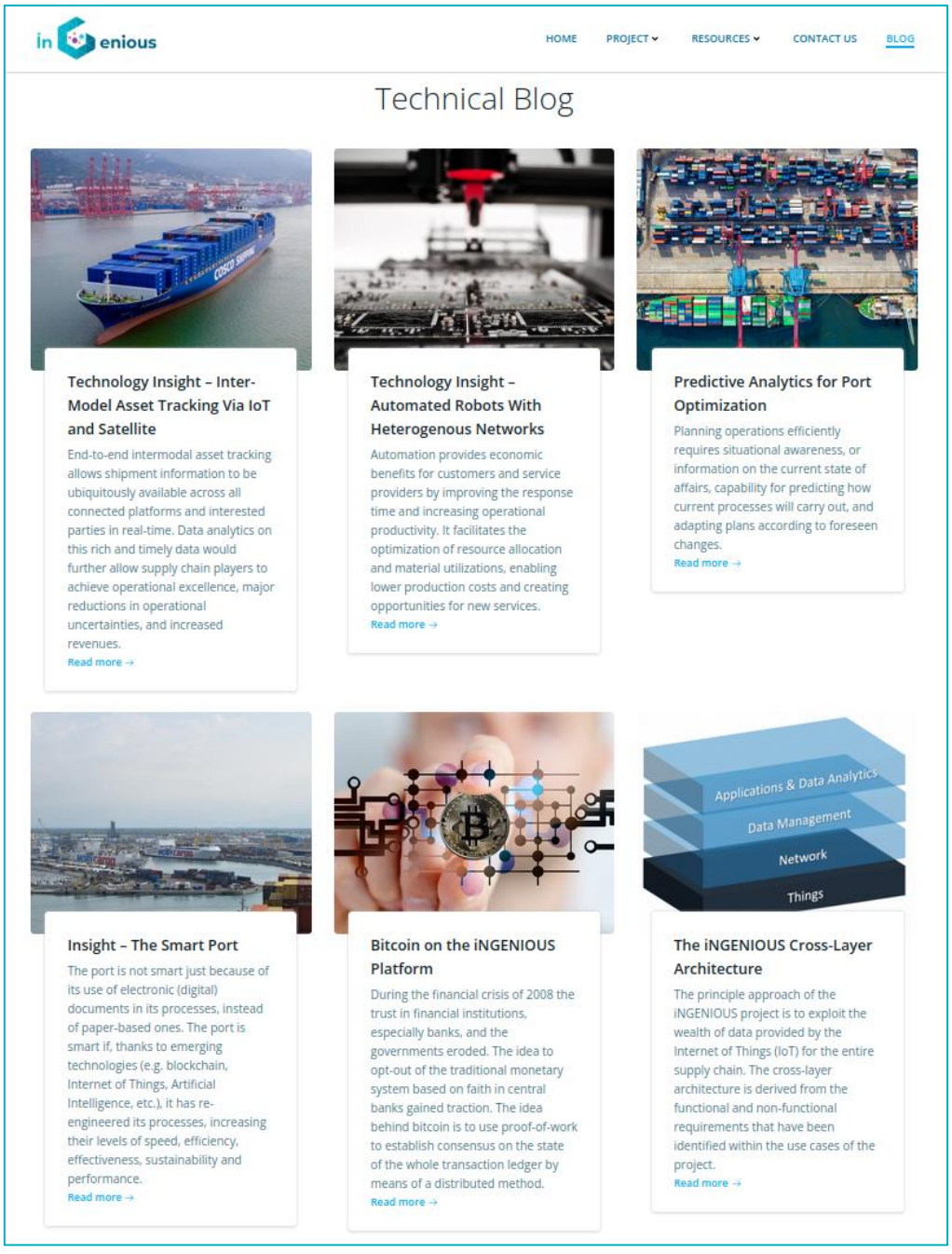

Figure 8: iNGENIOUS Blog

1.3.7 PROMOTIONAL VIDEO

To follow a dynamic communication approach, the Consortium created a 4 minute video describing the iNGENIOUS overall concept and use cases. This video was meant to be an introduction to the innovations and applied use cases of the project. The video can be found at [6].

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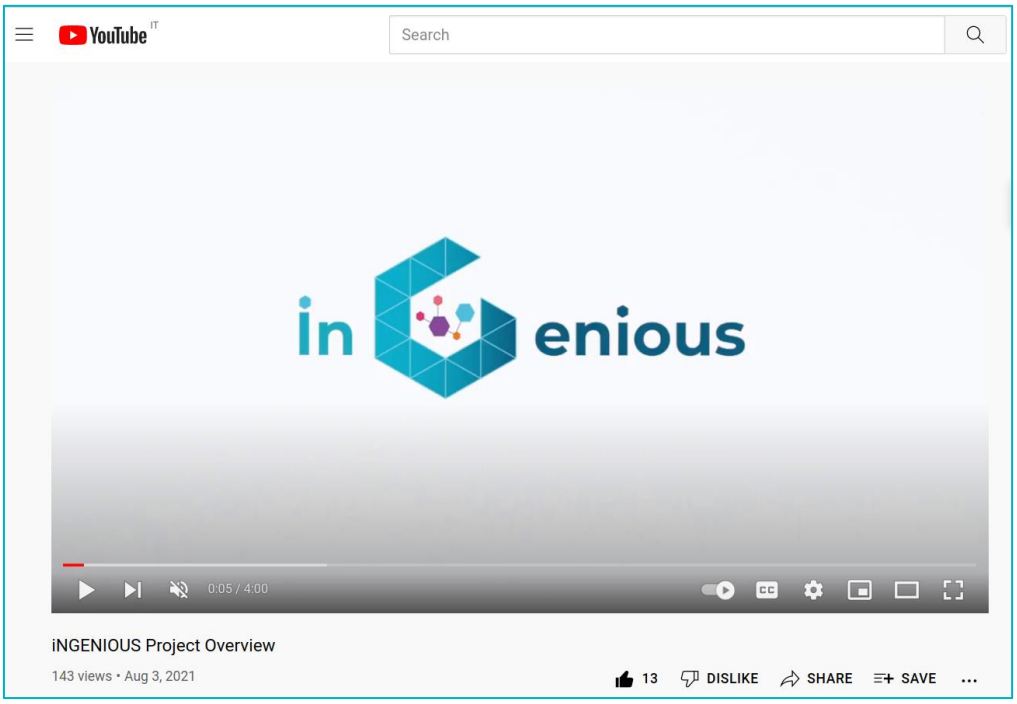

Figure 9: iNGENIOUS promotional video

Additional videos, such as shown in Figure 10, are actively being produced as well as planned in the upcoming months to show the progress and outcomes of Use Cases and reinforce iNGENIOUS as a reference in applying emerging technologies.

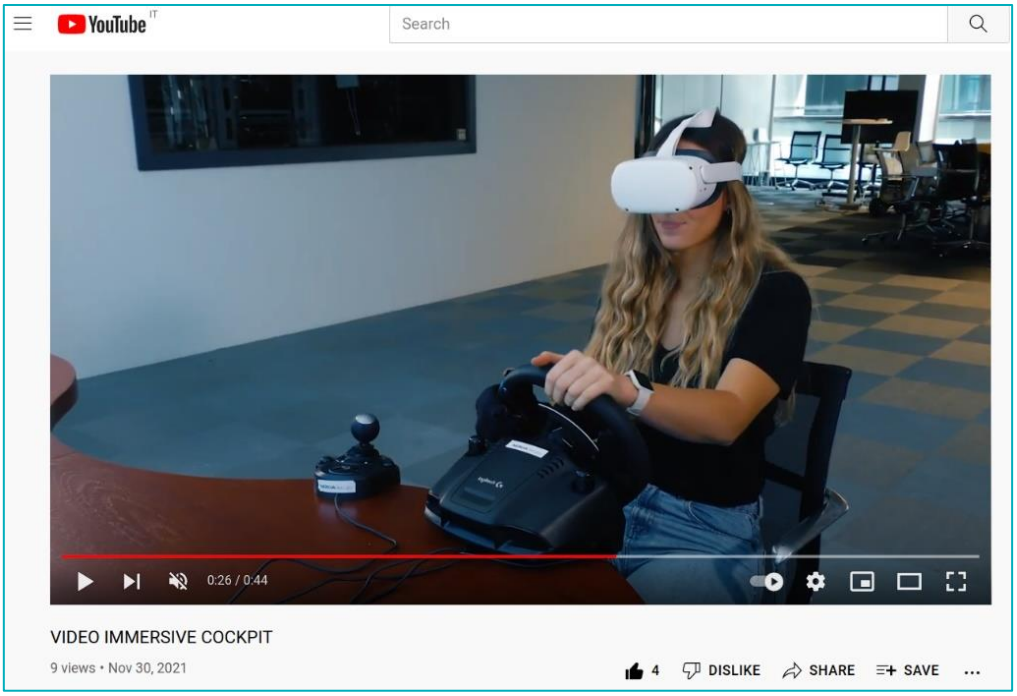

Figure 10: Use Case video [7]

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1.3.8 PROMOTIONAL FLYER

A project flyer was recently prepared for publication and distribution. It describes the iNGENIOUS vision, use cases, and expected outcomes. In addition to physical events, the flyer will be published online through the website and social media.

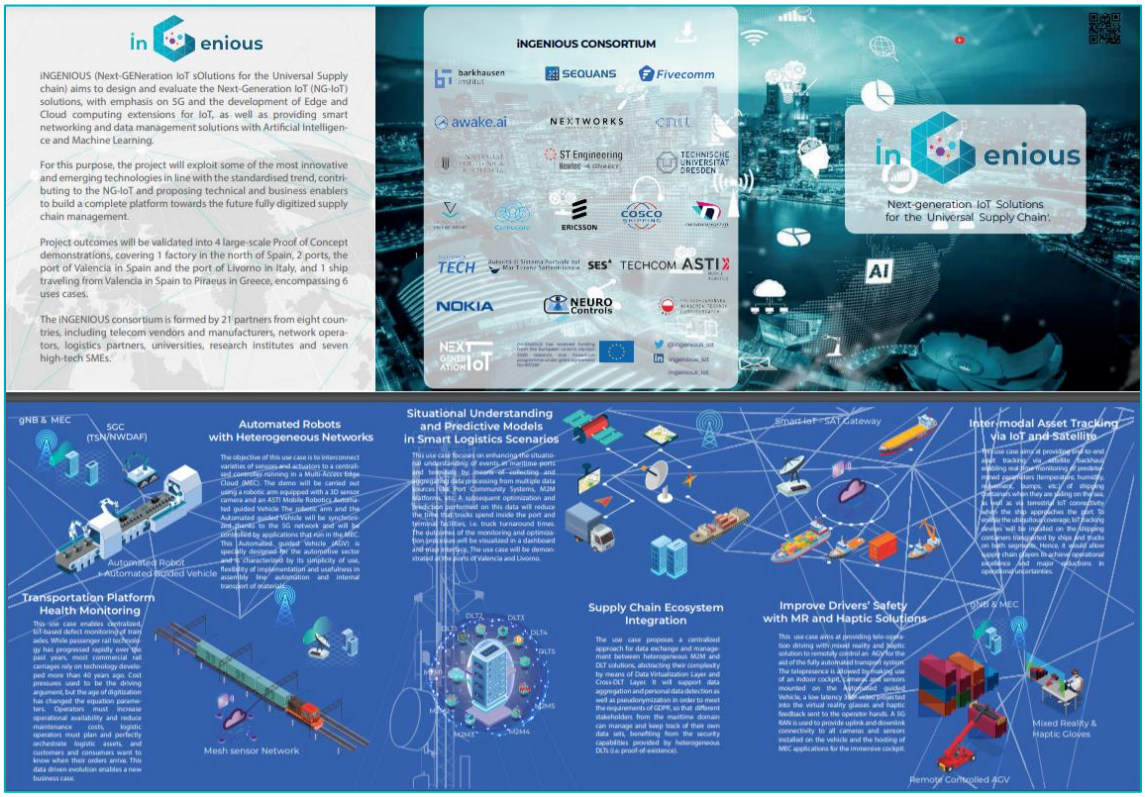

Figure 11: iNGENIOUS project flyer

1.3.9 PRESS RELEASES & NEWS

The 8 partner news and press releases done in the past 15 months of the project are presented in the figures below.

Figure 12: iNGENIOUS news [8]

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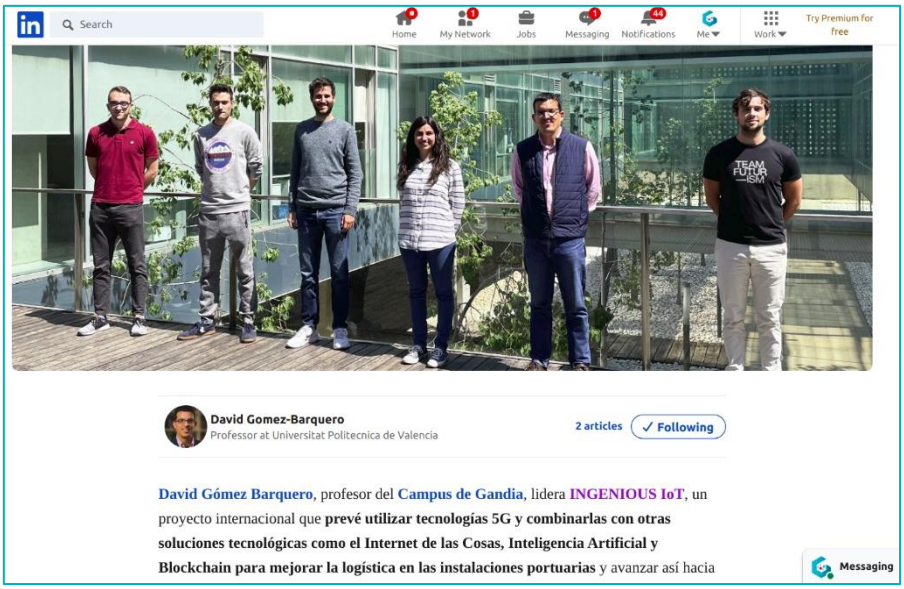

Figure 13: iNGENIOUS news [9]

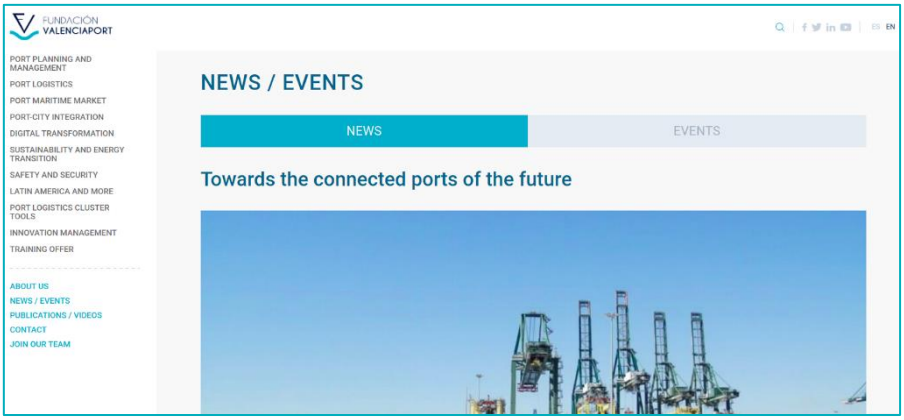

Figure 14: iNGENIOUS news [10]

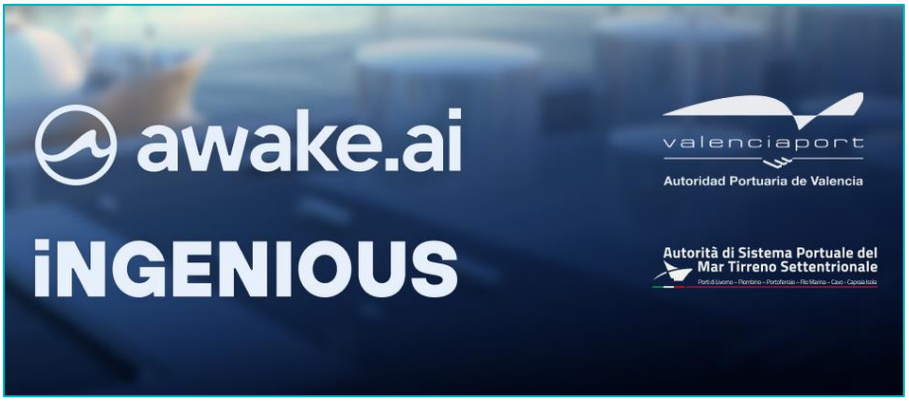

Figure 15: iNGENIOUS news [11]

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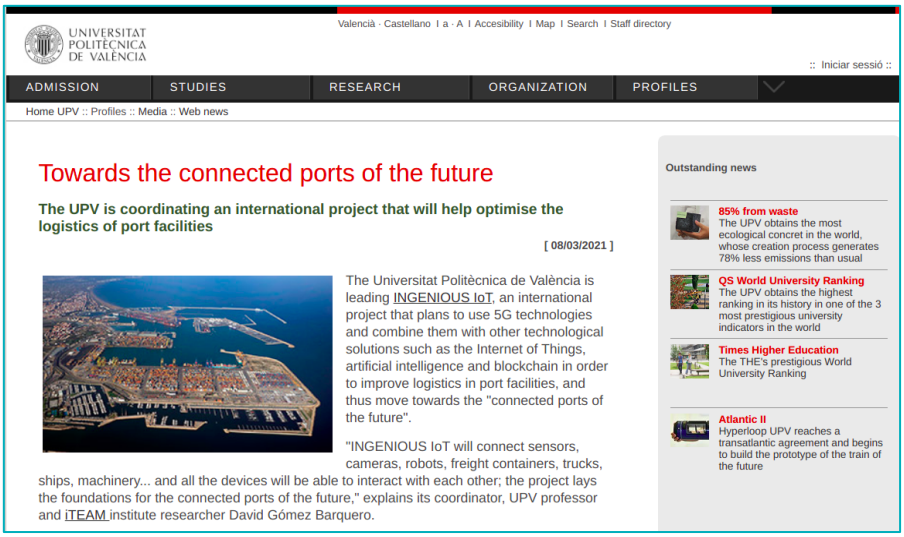

Figure 16: iNGENIOUS news [12]

Figure 17: iNGENIOUS news [13]

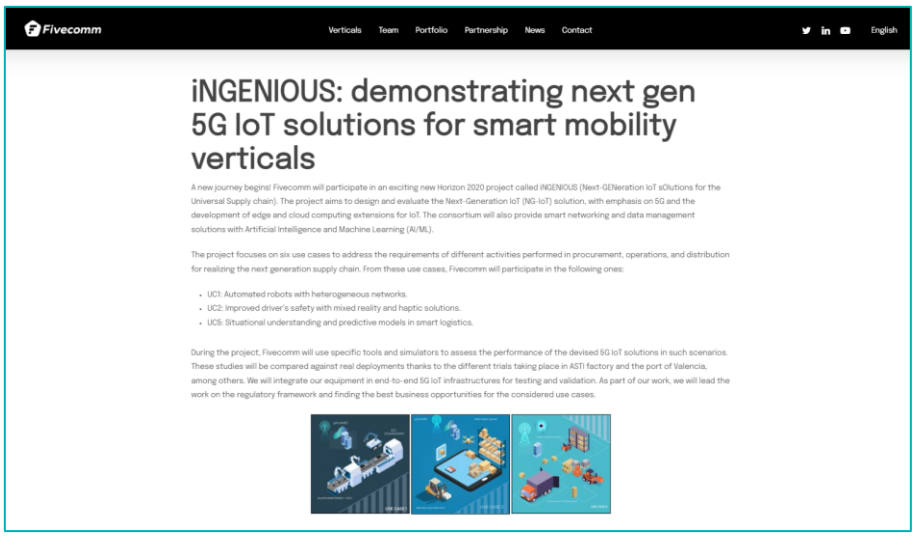

Figure 18: iNGENIOUS news [14]

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Figure 19: iNGENIOUS news [15]

1.4 KPIs

KPIs and target values for the dissemination and communication activities in iNGENIOUS are stated in the project's DOA. A summary of these KPIs, as well as the current KPI measurements are presented in Table 10.

The consortium has been very active in presenting project innovations and results in online workshops and webinars (4 and 9 events, respectively). The project is currently mapping opportunities to take a more active role in the organization of these events, as well as in the presentation of results.

Unique website visits and media coverage have also exceeded 50% of the target values during the first half of the project. Posts to social media have fallen short of the initial estimated values, and steps are being taken to increase output, including involvement of more partners in these forms of communication. Posts, as well as online community size, are expected to increase with the planned increase in involvement in the planning and organization of public webinars and workshops.

Finally, publications in the form of journal articles, white papers, success stories, and press releases, are all on-track for meeting the target values by the end of the project.

KPI	DOA Targets	Current
Number of workshops	6	4
Number of webinars / showcasing events	4	9
Number of webinar and workshop participants	250	>275
Number of attendees in information campaigns, webinars, peer networking events	>1.000	>500
Size of community (Twitter followers, mailing list subscribers, bloggers)	>1.000	334
Media coverage (editorials and clippings)	50	64
Press releases	>10	6
Blog posts, tweets including editorial and clippings	>2.500	141
Unique Website visits	>4.000	3,010
Journal and conference scientific papers	>20	10
White papers, newsletters, success stories, factsheets	>10	5 + 1 in progress
Public deliverables	18	6
Keynotes in major European and worldwide conferences events	10	1
Summer schools, tutorials, online training modules	1	0

Table 10: Dissemination and communication KPIs

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2 Standardization and Open-Source Activities

The objective of these activities is to promote the project outcomes to targeted standardization bodies and industry for a influencing the development of standards. iNGENIOUS partners have been contributing as members of various standardisation bodies to promote the insights and results of the project.

The Table below provides an overview of iNGENIOUS standards activity while the following subsections give more detail on this activity.

SDO	Current Activity
3GPP	Active participation to RAN, RAN1, RAN2
5GAA	Active participation at Tele-operation Driving rate and reliability communication requirements.
ETSI	Monitoring of ETSI NFV, ETSI ZSM and ETSI SES SCN
SSIG	Active member of Satellite Standardisation Interest Group (SSIG) group

Table 11 . Overview of iNGENIOUS Activity on Standardization.

2.1 3GPP

iNGENIOUS partners have been actively participating in Technical Specification Group (TSG) Radio Access Network (RAN) and its affiliated Work Groups (WGs) on several topics relevant to the project.

The topics of current contributions include the following:

- NR RedCap: 3GPP efforts within Release 17 for emerging cellular IoT (CIoT) solutions included the study and specification of reduced capability (RedCap) New Radio (NR) devices. This work targeted to enable devices of low cost and complexity, compared to legacy NR devices. NR RedCap can be viewed as NR-based C-IoT devices targeting use cases with requirements not adequately addressed by the LTE-based C-IoT solutions which are of particular interest to iNGENIOUS (e.g., Factory use case). iNGENIOUS contributed specifically to NR RedCap study item with views and proposals on the various PHY topics of the study to ensure that only necessary features with good trade-off between low-complexity and performance loss were scoped for specification.

- NR NTN and IoT NTN: 3GPP Release 17 work also included adaption of NR features to support Non-terrestrial Network (NTN). At the same time with NR NTN specification, feasibility of ensuring NTN connectivity of LTE-based C-IoT devices was studied and respective specification work started; which heavily inherited insights and features from NR NTN. This whole NTN work is of particular interest to iNGENIOUS which includes use cases expected to rely on satellite-based connectivity (e.g., Port use case). iNGENIOUS contributions include several suggestions for keeping the various proposed NTN PHY features beneficial and of low complexity for end devices. It also includes an ongoing push of proposals for efficient higher-layer techniques to improve delays and power consumption of NTN-based devices in scenarios with bursty small data traffic which can be typical in IoT applications of interest.

- NR IIoT: The Release 17 standardization work on NR Industrial Internet of Things (NR IIoT) enables a new communication class aiming to cover industrial applications of high interest to iNGENIOUS. They are related to factory automation (i.e., logistics, sensor networks, robotics, and augmented reality) where both eMBB and URLLC features become vital elements to support high transmission reliability and performance. Within this scope, 3GPP is

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investigating RAN enhancements for handling IIoT use cases based on new defined QoS parameters, including the so-called Survival Time parameter. iNGENIOUS started analysing other proposed solutions and provided a suggestion of how to efficiently use this information.

- Release 18 scoping: It should also be mentioned that Release 18 scoping discussions started in 3GPP RAN within second semester of 2021 and iNGENIOUS partners have been following closely the IoT-related proposals within these scoping activities in order to provide suggestions (e.g., for NR RedCap evolution) but to also plan for future proposals and solutions relevant to the project.

The contributions that have been submitted to 3GPP are listed in the Table below. Resubmissions or minor revisions of a contribution target are collected together in a single row.

N.	Partner	SDO, Group	Title of Contribution	Reference	Date
1	SEQ	3GPP, RAN1	Complexity reduction features for RedCap UE	R1-2008738	10-2020
2	SEQ	3GPP, RAN1	Coverage recovery for RedCap UE	R1-2008740	10-2020
3	SEQ	3GPP, RAN1	Reduced PDCCH monitoring for RedCap UE	R1-2008739	10-2020
4	SEQ	3GPP, RAN1	Framework and principles for RedCap UE	R1-2008741	10-2020
5	SEQ support (Thales lead)	3GPP, RAN1	Considerations on UL timing and frequency synchronization	R1-2009298	10-2020
6	SEQ	3GPP, RAN2	Additional RLC and PDCP aspects for NTN	R2-2010170 R2-2101532	11-2020 01-2020
7	SEQ	3GPP, RAN2	On RLC t-Reassembly for NTN	R2-2101518 R2-2103964 R2-2106055 R2-2108460	01-2021 04-2021 05-2021 08-2021
8	SEQ	3GPP, RAN1	On UL time and frequency synchronization enhancements for NR NTN	R1-2103687	04-2021
9	SEQ	3GPP, RAN2	ST handling with alternating CC allocations	R2-2108457	08-2021
10	SEQ (views within)	3GPP, RAN	Moderator's summary for discussion [RAN94e-R18Prep-05] RedCap (Reduced Capability) Evolution	RP-212665	12-2021

Table 12 . Summary of contributions to 3GPP RAN WGs.

2.2 5GAA

iNGENIOUS partners have been actively participating in the 5G Automotive Association (5GAA) in the field of Tele-operation Driving (ToD).

Tele-operated Driving technology assists, complements, and accelerates semi and fully automated driving in various scenarios. The 5GAA studies system requirements and corresponding enabler technologies for ToD services.

NOK has contributed to the discussions of the data rate and reliability requirements of communication networks to support ToD services. The basis of the study that has been used are the Service Level Requirements (SLR) on information and reliability for ToD use cases.

The topics of current contributions include the following:

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- Information Requested/Generated data and service level reliability data about UL and DL of direct control ToD, indirect control ToD for max speed of 20 km/h, indirect control ToD for max speed of 30 km/h
- Information Requested/Generated data and service level reliability data about infrastructure-based Tele-Operated Driving. Focusing on KPI for RADAR, cameras, and LiDAR.
- Information flows for ToD service, specifically actuators/control DL information flow, biometric sensor DL information flow, vehicle actuators/telemetry UL information flow, and video & audio UL information flow.

2.3 ETSI

The iNGENIOUS consortium is actively monitoring several ETSI standardization activities that relate with network and service management aspects. In particular, iNGENIOUS is carefully following the progress in the ETSI NFV, ETSI ZSM and ETSI SES SCN specifications. It is worth to mention that these monitoring activities aim at aligning the iNGENIOUS research and development activities with these relevant standards in the area of network slice management and orchestration, 5G network functions virtualization, and edge infrastructures management. On the other, direct contributions to the ETSI NFV, ETSI ZSM and ETSI SES SCN are not planned at the time of writing.

2.3.1 ETSI NFV

The ETSI NFV Industry Specification Group (ISG) has been the driver of the network transformation activities in ETSI, being at the core of the NFV technology definition and standardization, starting from the NFV term itself. The NFV scope is focused on the lifecycle of the Virtualized Network Functions (VNFs) and the services built by composing them. With NFV, network functions are implemented in software and can run on homogeneous, industry-standard commodity infrastructures. Up to now, the ISG has released specifications related to the initial NFV framework and continued in the following phases working on interfaces, information models, and testing procedures. Detailed specifications for NFV workflows, data models and APIs are now under consolidation in the close-to-finished Release 3. The available NFV standards are already used in the industry to implement NFV products and can be considered as a necessary component for next-generation networks, and in particular for 5G.

These ETSI NFV specifications are the core of the design and development of the iNGENIOUS network slice orchestration framework and in general to the Management and Orchestration (MANO) functionalities in WP4. Beyond the existing standard specifications, iNGENIOUS is actively monitoring the ongoing work on NFV in the context of the Release 4, which is bringing new fundamental capabilities and new relevant functionalities into the NFV MANO for what concerns its applicability in 5G and cloud-native environments. In particular, iNGENIOUS is following the progress of the ETSI NFV in these specific areas, with the intent of applying the related outcomes and new specifications in the WP4 work:

- Cloud-native VNFs and Container Infrastructure management: it enhances the NFV architectural framework to support VNFs which follow "cloud-native" design principles and the NFV MANO to support capabilities for container and container infrastructure management and orchestration. Regarding the container management and orchestration, new NFV MANO functions, the Container Infrastructure Services Management (CISM) and Container Image Registry (CIR), are defined, exposing a new set of service interfaces.

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- NFV enhancements for 5G: to enable automated deployment of 5G networks, supporting the various 5G capabilities and associated requirements for the various user and control plane network functions, at both RAN and core.
- SBA for NFV-MANO: it enables service exposure for 3rd party access to selected NFV MANO services following an SBA approach, through service independence, modularization, data separation/split, exposure, dynamic registration, and discovery of services
- NFV-MANO automation and autonomous networks: it enables NFV MANO support for managing autonomous networks, with higher level of automation in the internal logic, exploring intent-based principles for external exposure of network services management

2.3.2 ETSI ZSM

The ETSI Zero touch network and Service Management (ZSM) ISG aims at defining a new framework enabling agile, efficient, and qualitative management and automation of emerging and future networks and services. ZSM targets a network and service management architecture where all operational processes and tasks (e.g., delivery, deployment, configuration, assurance, and optimization) are executed with full automation in multi-vendor environments.

ZSM aims at making easier the integration of the various management aspects (from data collection to orchestration and analysis) enabling the closure of the control loop through network and service optimization processes. In practice, with ZSM, management services are grouped according to the functionality offered (such as data collection, analytics, intelligence, orchestration, control) and dynamically interact through an integration fabric that, following the SBA approach, provides registry, discovery, and data exchange mechanisms.

Based on all of the above, the ZSM approach and principles fit with the iNGENIOUS requirements and needs for what concerns an agile framework for composing different services and slices under a common flexible architecture, with high cooperation of orchestration, data collection and storage, and analytics services with decoupled functions. Up to now, ZSM has released specifications for defining use cases and requirements, a first version of the reference architecture for zero-touch network and service management, end-to-end multi-domain management services, as well as initial drivers for automation. iNGENIOUS is actively monitoring the current progress of ZSM work, mostly in the area of closed-loop automation and integration of AI techniques. In particular, iNGENIOUS is following the progress of the ETSI ZSM in these specific areas, with the intent of applying the related outcomes and new specifications in the WP4 work:

- Closed-Loop Automation: to investigate advanced topics related to closed-loop operations such as learning and cognitive capabilities (e.g., based on different degrees of use and integration of artificial intelligence technologies). This includes problem statements and technical challenges, potential requirements, and evaluation of potential solution options.
- Enablers for Artificial Intelligence-based Network and Service Automation: to support automation of management functionalities and operations based on AI, including data handling and analytics, interoperation, governance and execution environment, and related deployment aspects.
- Cross-domain end-to-end services lifecycle management: to investigate the management of end-to-end services across management domains (e.g.,

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orchestration, data collection and analytics, assurance, etc), with identification of procedures and models to enable the automation of lifecycle management

2.3.3 ETSI SES SCN

The ETSI Satellite Earth Stations and Systems (SES) ISG group within ETSI is responsible for all aspects related to satellite earth stations and systems. Within ETSI SES is the **Satellite Communications and Navigation (SCN)** working group is responsible for radio and transmission aspects related to Fixed, Mobile and Global Navigation Satellite Systems operating in any bands allocated to FSS, MSS or RDSS.

In particular:

- to produce and maintain harmonised standards for satellite earth stations;
- to produce and maintain technical specifications for satellite radio interfaces;
- to encourage spectral efficiency on satellite links and harmonisation of satellite radio interfaces;
- to produce specifications that promote integration and inter-working between satellite and terrestrial networks.

The SCN working group produces architecture and service requirements, interfaces (user, control and management planes), transport and network protocols, service enablers. The SCN working group also encourages the development of network, transport and service layers compatible with various fixed and mobile satellite access networks.

2.4 SSIG

The Satellite Standardisation Interest Group (SSIG) was created under the ESA ALIX project and serves as a platform where a broad range of stakeholders can exchange information about satellite-related standards activities for the integration of satellite into the 5G ecosystem, with the aim of improving mutual understanding and collective effectiveness in pursuing the vision. The SSIG may also provide a platform/forum for garnering support by individual participating organizations for specific actions they wish to pursue. Current areas of Focus for SSIG include

- Release 17 NTN standardisation
- Release 17 NB-IoT NTN study
  Release 18 NR NTN and NB-IoT enhancements and new feature scoping and planning

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3 Exploitation and Innovation

3.1 Exploitation

To maximise the technical and economic impact of iNGENIOUS project, partners designed from the proposal stage exploitation intentions and activities as part of the exploitation planning strategy. The objective of this task is to increase iNGENIOUS project competitive advantage, helping to improve products and services in new and existing IoT markets.

In this section we provide an update of these exploitation plans as well as the completed and ongoing activities within the project. Specifically, the individual and joint exploitation plans of iNGENIOUS partners are reported, upgraded based on the progress during the first phase of project's life, subdividing partners on the base of their role in the project ecosystem: supply chain stakeholder, technology solutions, network providers, chipset manufacturers, and academia. Then, the different synergies between partners, focusing on the creation of new business models for the NG-IoT solutions for the universal supply chain, are described. Finally, the exploitation database table presents the details of partner's actual activities on exploitation.

3.1.1 SUPPLY CHAIN STAKEHOLDERS

Partner	Plans
ASTI	ASTI is exploiting the project results by following a strategic plan to maximise the impact: i) develop the technology at prototype level under the project; ii) integrate the developed technology into ASTI vehicle range; iii) create pilot projects with internationally well-known customers; iv) define the marketing actions and the necessary documentation to market the new technologies; v) introduce the technology to potential customers in professional events; and vi) implement progressively the technology in AGV systems for the markets and the geographic areas currently targeted by ASTI.
COSSP	Assess tracking technologies that contribute to optimise E2E supply chain service, real-time data exchange and customer satisfaction.
AdSPMTS	The Livorno Port Authority is responsible for addressing, programming, coordinating, promoting and controlling port operations as well as other commercial and industrial activities, by means of its regulatory powers. As the main contact point between different stakeholders from the port community (e.g., terminal operators, maritime agencies, freight forwarders, ship forwarders, shippers, carriers, institutional bodies, etc.), AdSPMTS expects to exploit the main outcomes coming from relevant use cases demonstrations of iNGENIOUS project (Port Entrance and DVL/DLT use cases) in the following way: -promote NG-IoT solutions according to the current needs and requirements from the stakeholders so that relevant feedback can be used to assess prototypes' functionalities in a relevant environment. -improve and upgrade the current digital infrastructure of the Port of Livorno by integrating new functionalities for the maritime domain (e.g., assets tracking, predictive models, secure data management, etc.). -involve major seaports of the network (Northern Tyrrhenian Sea including the Port of Piombino, the Port of Capraia, the Port of Portoferraio and the Port of Rio Marina) into EU R&D activities so that potential benefits of the iNGENIOUS prototypes can be exploited in other local seaports.
FV	As R&D centre of the Port of Valencia, FV will leverage iNGENIOUS for assessing the potential application of NG-IoT technologies in maritime and logistics use cases. In particular, FV will leverage iNGENIOUS demonstrations to test the use of 5G mmW connectivity at the Port of Valencia facilities for enabling AGV remote driving. Additionally, FV will test NB-IoT connectivity inside the Port of Valencia by performing IoT tracking field measurements. The tracking of containers through LoRa, NB-IoT and satellite connectivity will also be tested by building iNGENIOUS smart container. On the other hand, FV will also use the project use cases to define a common data framework where different data sources will provide data to model and optimize truck turnaround times. Finally, the project will also be used for testing the exchange of data between PI System OSIsoft and other M2M platforms, and between Hyperledger Fabric and other blockchain technologies.
AWA	Work performed by Awake.AI in iNGENIOUS on data analysis and development of predictive models regarding vehicle schedules and operations at ports of Valencia and Livorno supports the development of similar services to be offered globally as part of the Awake.AI smart port platform. Collaboration with the iNGENIOUS partners enables evaluation of which new predictive models are viable for deployment as scalable services globally, and what kind of datasets are required for their implementation.

Table 13 Individual exploitation plans of supply chain stakeholder partners.

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3.1.2 TECHNOLOGY SOLUTIONS

Partner	Plans
TEI	TEI intends to exploit project results in the development and extension of future Ericsson telecom infrastructure products and to further validate and evolve its 5G portfolio and IoT solutions by leveraging the research results from iNGENIOUS, not least the experiences gained in the field-trials foreseen in the Port Entrance and DVL/DLT use cases implementation. Considering that both the data pseudonymization and the Identity and Access Management functions implemented in iNGENIOUS provide innovative techniques, suitable to enrich the security functionalities to be included in the Ericsson products, a showcasing of the preliminary research results has been started towards TEI colleagues; in addition it is planned to prepare demos based on the implemented prototypes to be proposed at Ericsson R&D Italy Innovation Day, an in-house exhibition where customers and employees could take the opportunity to get a focused look at the latest solutions.
NXW	Nextworks, as technology provider and software SME active in the ICT and telecommunication sectors, participates to the project aiming at identifying and developing innovative solutions and application scenarios in the area of 5G and IoT, to be then turned into company assets and knowledge services for its ICT market. In particular, in iNGENIOUS Nextworks is actively developing a 5G network slice and service orchestration platform to automate the deployment and operation of network slices in industrial IoT and smart port logistic scenarios. This substantially contribute to the consolidation and improvement of the existing company research-oriented network and service management portfolio, helping in building a comprehensive inventory of integrated software tools bound with specific 5G, industrial IoT and smart port use cases. On the other hand, Nextworks actively develops and markets a distributed and decomposed IoT platform called Symphony, which is continuously evolving towards cloud-native system that integrate thousands of interconnected devices with advanced services for automation and communications. In this sense, in iNGENIOUS Nextworks plans to enhance the Symphony platform to enable its deployment and use for smart port use cases, leveraging on the integration with the project data interoperability layer. This aims at combining the company system integration and solution provider offers in a unique and very specialized service portfolio ready to access new markets, such as the smart port one.
5CMM	Contribute to the technical analysis of 5G-IoT systems for the next-generation iNGENIOUS IoT use cases, by developing a system-level simulator. Collaborate with partners on the technological integration and validation of the trials carried out in Valencia. Developed a 5G modem to be integrated in several use cases. Expand 5CMM IoT portfolio helping its customers to select the optimum solution for their needs, thanks to the aforementioned activities, as well as by leading the iNGENIOUS regulatory framework and business models task, 5CMM will expand its IoT portfolio helping its customers to select the optimum solution for their needs.
TIOTBD	Telefónica IoT&BigData contribute to the development of Distributed Ledger Technologies (DLT) within the DVL/DLT use case to develop a CrossDLT layer. Regarding the CrossDLT layer, Telefónica has focused on the Ethereum development to enhance its product TrustOS. Also, it has focused on the definition of a common API for every DLT to implement, so the communication with different ledgers is easier and in order to integrate all the ledger with the CrossDLT layer. All these activities are part of the task 5.2 which Telefónica is leading regarding the part of the CrossDLT. These new functionalities, once tested, will be considered to be included in the TrustOS platform.

Table 14 Individual exploitation plans of technology solution partners

3.1.3 NETWORK PROVIDERS

Partner	Plans
CMC	Productize the Network Slice Manager and commercialize as part of CMC product offering. Complete the 5GLAN functionality for IOT device to device communications and include in CMC product.
iDR	ST Engineering iDirect will leverage iNGENIOUS to research and develop use cases for indirect and direct access to IoT devices over a satellite network. Indirect access use cases are where the satellite network is used to backhaul and optimise the traffic from IoT devices connected to the satellite edge node. The Transport and Ship use cases include satellite backhaul as part of the end-to-end solutions. Direct access is where IoT devices are connected directly to the satellite network. For direct access, iDirect plan to investigate the deployment of new and existing waveforms over satellite to support ubiquitous coverage. iDirect will target commercialization of project findings and outcomes to improve their IoT product and service offering. iDirect will also use the project to engage with satellite and terrestrial network operators to enhance the role of satellite in next generation ubiquitous networks.
NOK	Provide edge, radio and core infrastructure to enable low latency communications in control and video protocols for IOT devices and sensors.
SES	SES owns and operates the world largest commercial satellite fleet with over 70 satellites, covering 99% of the globe and world population. SES is strategically positioned as the unique satellite operator

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	to offer combined GEO-MEO, multi band (C/X/Ku/Ka) services capabilities, to support future network infrastructure. Leveraging on keys satellite features as ubiquity, mobility broadcast and security, currently SES services' portfolio covers several categories such backhaul, tower-feed, communication on the move and hybrid multi-play, providing an outstanding integration with the terrestrial networks. iNGENIOUS developments will conduct to increase and customisation in SES service offering, for commercially attractive mMTC use cases. The demonstration of the envisaged end-to-end assets tracking use case and the outcomes in area of efficient communications architectures developed for next generation IoT devices and optimised for satellite communication, will support SES in developing advanced integration interfaces with external service providers to increase the network acceleration of the later ones. In addition, SES will continue the partnership with terrestrial mobile industry in commercial endeavours and standardisation activities, to promote the role of satellite in next generation network and their adaptation to increasing needs in M2M communications.

Table 15 Individual exploitation plans of network providing partners.

3.1.4 CHIPSET MANUFACTURERS

Partner	Plans
NCG	General Vision Neuromorphic Chipset development and manufacturing via ASML
NED	Creation of multiplatform SDKs for Windows / Android / Linux. Use of BLE 5.0 wireless communication standard to provide cross-platform connectivity. Remote monitoring and control platform for multiplayer experiences.
SEQ	Strengthen internal awareness and know-how in 5G IoT space and accelerate the time to market of related SEQ products by better meeting requirements from concrete use case of verticals. Exploit the iNGENIOUS outcomes to anticipate and consolidate SEQ knowledge of standard evolutions in context of 3GPP Rel-17, Rel-18, and beyond, and transfer these results to product definition and development. Be visible in research or industrial fora thanks to publications or other dissemination actions.

Table 16 Individual exploitation plans of chipset manufacturing partners.

3.1.5 ACADEMIA

Partner	Plans
TUD	TUD will incorporate results from the project to its teaching program within the Communications Laboratory of TUD, contributing to maintain a competitive academic offer. The fundamental work obtained within iNGENIOUS is expected to stimulate follow-up projects with industry partners, focusing on utilization and implementation of the developed approaches. Considering TUD's members activity as founders of spin-offs companies during the past, a new opportunity for a spin-off might arise based on the project results.
UPV	iNGENIOUS will increase the business opportunities of Universitat Politècnica de València for further industrial and research collaboration on private IoT networks and platforms. The project will impact UPV activities by i) increasing the level of expertise in the field of network design for 5G-IoT systems, and ii) bringing worldwide visibility by publishing in the main journals of the field. UPV will introduce the project outcomes into the teaching and research syllabus at undergraduate and postgraduate levels. 2 Bachelor-level theses involving iNGENIOUS innovations have been written [15] [16].
BI	iNGENIOUS allows BI to apply its research to practical industry applications and to bridge the gap between research activities and industry requirements. Research and development results in iNGENIOUS will be the basis for future activities and innovation in BI's research area of the "trustworthy IoT". BI will transfer its knowledge to European industries through bilateral contracted R&D, licensing of intellectual property or to foster the creation of start-ups if applicable. BI also collaborates with Technische Universität Dresden (TUD) in teaching of national and international students, who learn about the latest research results from projects, including iNGENIOUS, and write theses on project-related topics.
CNIT	As a research institute, the CNIT expects to exploit the main outcomes of the iNGENIOUS by considering the following aspects: -validate the DVL component as an intermediate layer for data access and data lake management in relevant industrial scenarios (e.g., UC4, UC5 and UC6). -enhance the current level of the collaboration with industrial providers of telecommunication equipment, embedded systems, and digital platforms. -update the existing set of prototyping applications in Livorno seaport thus fulfilling the mission of technological transfer. -enforce the current know-how in terms of machine-to-machine communications in maritime domain. -assess the iNGENIOUS telecommunication infrastructure model in terms of transferability to other industrial scenarios. -perform submission of the research results in highly ranked journals and/or conferences.

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PJATK	Activities of PJATK within iNGENIOUS concentrate on the development of blockchain technology and research in the supply chain area. To enhance stance in industrial and research collaboration in both fields the PJATK team will submit the results to major journals and engage in promotional activities. The results and expertise gained will also be incorporated in the teaching program in effort to increase competitiveness of teaching offer.

Table 17 Individual exploitation plans of academic partners.

3.1.6 JOINT ACTIVITIES / SYNERGIES FOR CREATION OF NEW BUSINESS MODELS

Partners	Plans
SES, iDR	Through a close collaboration, SES and iDR will exploit the iNGENIOUS outcomes to develop and optimise the space segment and the associated ground networks in order to enhance the support of Massive IoT use cases over satellite.
CNIT, TEI, AdSPMTS	A joint collaboration between CNIT, TEI and AdSPMTS is expected to increase the current digital offer of the Port of Livorno according to the main outcomes of the iNGENIOUS project. CNIT and AdSPMTS, as a joint R&D national laboratory, will explore different connectivity configurations foreseen by the NG-IoT scenarios of the project in order to create a model for the local telecommunication infrastructure supporting new digital services (e.g., mission critical applications). According to current and past experiences in the Port of Livorno, TEI will increase its knowledge of the maritime domain in terms of processes and operations so that new 5G and IoT networks services and applications can be developed and delivered to end-users, based on emerging needs and requirements from the maritime sector.
BI, NCG, TUD	BI and NCG jointly exploit the developed FPGA prototypes to increase their knowledge on the measurement quantification of different indicators related to data traffic and energy consumption of neuromorphic sensors, as well securing IoT devices. TUD exploits the possibility of the SDR connection to run flexible PHY/MAC baseband processing on BI's simulator and FPGA-based prototype of a tiled-hardware architecture, including updating of critical components and evaluation of the impact of the underlying hardware platform on various real use case scenarios.
CNIT, FV, SES, NXW	CNIT expects to take advantage of the main developments and integration activities related to DVL to improve the current capabilities of such solution for data access and management by integrating different data sources as well as M2M platforms. FV, SES and NXW will exploit cross-M2M interoperability layer capabilities to assess different M2M configurations as well as deployments as far as iNGENIOUS supply chain scenarios are concerned.
AWA, FV	AWA and FV will jointly develop AI-based models for optimizing truck turnaround times at the Port of Valencia and the Port of Livorno. This joint action will be performed in different steps including the exchange of data sets, exploratory data analysis, definition of the modelling and optimization strategy and the subsequent application of the models for the optimization of TT.
CNIT, TID, PJATK	CNIT, TID and PJATK will exploit the benefits of the interoperable layer, based on TrustOS solution, by assessing the possibility to simultaneously use different DLTs in other relevant industrial scenarios such as the automated dispute resolution between stakeholders in the maritime domain. The main outcomes of the above-mentioned assessment are then expected to be used for the publication of the results in relevant journals and/or conferences.

Table 18 Individual exploitation plans of technology solution partners.

3.1.7 EXPLOITATION DATABASE

Description of Exploitable Element	Exploitable Service where Element will be used	Sector of application	Time-plan for use	Relevant iNGENIOUS deliverables	Owner, other involved beneficiaries	Relevant IP (if any)	Achievement status
Know-how in 5G IoT space	CIoT modem/chipset solutions	Verticals' vendors (factory, ship/port, train/station, etc.)	2024+	D3.2	SEQ	N/A	Ongoing
3GPP standards knowledge	Research, Product development	Vendors, operators	3GPP Rel-17/18 timeline and beyond	D3.2	SEQ	N/A	Ongoing
Visibility in 3GPP	Collaborative research /	Industry forum	3GPP Rel-17/18 timeline	D7.2, D7.3	SEQ		Ongoing

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	specification activity						
Network Slice Manager	Product development	Vendors, operators	2022	D2.1	CMC		Ongoing
5GLAN Group Management	Product development	Vendors, operators	2022	D2.1	CMC		Ongoing
TSN Application Function	Product development	Vendors, operators	2023	D2.1	CMC		Ongoing
5G modem	Product	Verticals, vendors	2021 onwards	D2.2, D3.1, D3.2	5CMM	N/A	First prototype complete
System-level simulator	Research activity	Verticals, such as factories or ports	2022	D3.2	5CMM	N/A	Ongoing
Immersive cockpit	Products and services integration	Vertical stakeholders	2021 onwards	D2.1, D2.2, D6.1	5CMM	N/A	Ongoing
Smart container	Product and research activities	Maritime port stakeholders	2022 onwards	D2.1, D6.1, D6.2, D6.3	FV, COSSP, SES, iDR	N/A	Ongoing
IoT tracking application	Product and research activities	Maritime port stakeholders	2022-2023	D2.1, D6.1, D6.2, D6.3	UPV, FV, SES COSSP, iDR		Ongoing
TT application	Product and research activities	Maritime port stakeholders	2022-2023	D2.1, D6.1, D6.2, D6.3	FV, AWA, CNIT	N/A	Ongoing
TTT application	Research activity	Port stakeholders	2022-2023	D2.1, D6.1, D6.2, D6.3	AdSPMTS, CNIT, AWA	N/A	Ongoing
Smart IoT Gateway	Product and research activities	Verticals (Maritime, Agriculture, Transportation, PPDR, etc.)	2022+	D2.2, D4.1, D4.2, D5.1, D5.2, D6.2	SES	N/A	Ongoing
RoT and Remote Attestation (M^3 platform)	Research activity	IoT device architecture	2022+	D2.1, D2.2, D3.3, D5.3, D6.1, D6.2	BI	N/A	Ongoing

Table 19 Database of iNGENIOUS partners' exploitation activities.

3.2 Innovation

3.2.1 INNOVATION MANAGEMENT METHODOLOGY

The main purpose of the Innovation Management activity is to track the innovations generated in the project, analysing and formalizing their relationship with the Background and Foreground Intellectual Property (IP) elements brought and developed by the various partners.

3.2.1.1 Innovation and Intellectual property entity relationships

The starting assumption is that a given Foreground Intellectual Property element (FIP) is made by one or more "Innovation Elements" (in the form of ideas, concepts, design patterns, or pieces of hardware/software). Therefore, innovation elements (IEs) do not have, by themselves, the "legal" independence to be regarded as IP elements. They are just the fundamental bricks of a Foreground IP element. This is represented in Figure 20 by the 1:N relationship.

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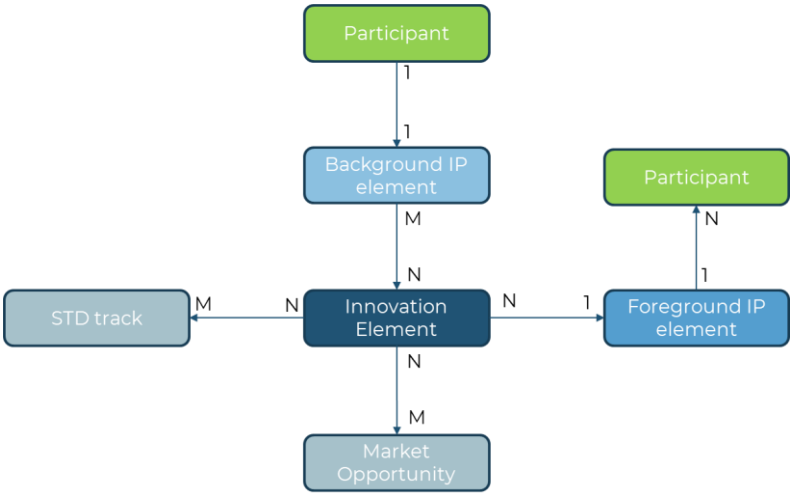

Figure 20: Entity Relationship diagram for innovations and IP elements

In all IP management framework, Foreground IP elements might depend (or be based on) one or more Background IP elements (BIPs). In our Entity Relationship diagram, the focus is moved on the relationship between Background IP elements and Innovation Elements: an IE can depend on one or more BIPs, and one BIP can contribute to one or more IEs. This is represented by the M:N relationship between BIPs and IEs, and leads to the usual M:N relationship between BIPs and FIPs.

Each Background IP elements is brought to the project by one single participant (except for very specific cases where two or more participants already co-own a BIP). Each Foreground IP element is then owned by one or more participants (1:N relationship).

Finally, each Innovation Element can be considered the door to one or more market or standardization opportunity, and each market or standardization opportunity can involve the exploitation or one or more IE. This is represented by the N:M relationships between IEs, standardization tracks and possibly market opportunities, and is the fundamental link between the Innovation Management activity and the other activities in WP7.

3.2.1.2 Innovation Management work methodology

Based on the presented ER diagram assumption, the following work methodology has been set out in Task7.2/IM.

Firstly, the Innovation Manager reports to the PMT, just like any other managerial figure. Then, the IM establishes a close interaction with the Technical Manager, in order to gather continuous information about potential inventions in the project. Finally, the IM has a direct interaction with WP7 and WP8 Leaders, in order to manage the usage and impact of IEs within these work packages; the interaction within WP7 is expected to be more frequent and direct with Task leaders, for all the issues related to IEs and dissemination, exploitation, standardization and communication.

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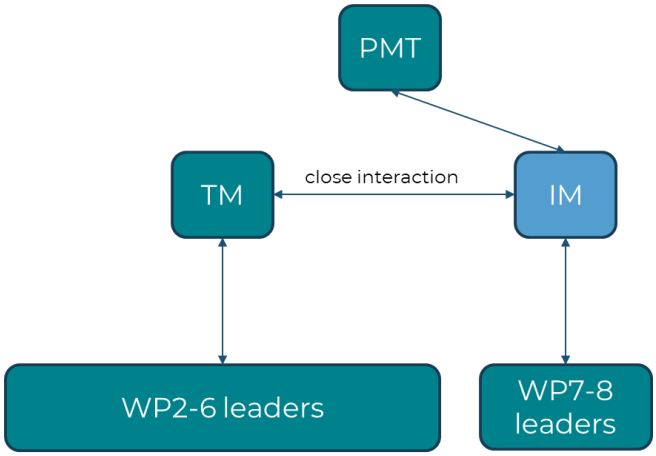

Figure 21: Innovation Manager work interactions

Based on these interactions, the work of the Innovation Manager goes through the following steps:

1. Define, with the collaboration of all partners, a table template for the collection of the IEs and their related FIPs (ref. Section 3.2.4).
2. Define, with the collaboration of all partners, a table template for the collection of the BIPs (ref. Section 3.2.3).
3. Set these tables as working documents on the project's collaborative space.
4. Identify, with the help of the TM, the most promising technical areas of the project for the generation of IEs.
5. Establish a procedure for the regular update of these tables (by the TM or by specific partners, directly).
6. Derive and analyse the relationship diagrams that emerge from the BIP and IE tables.
7. Analyse (with the help of WP7 task leaders) the interconnection with and impact on the various IEs identified and the market and standardization opportunities.

Points 5 and 6 in the list will be iterated several times during the project.

3.2.1.3 Innovation Management Tables

The main table of the innovation management activity is the Innovation Element (IE) plus Foreground Intellectual Property (FIP) table (Table 20). This serves as the table for the identification and definition of both IEs and FIPs, because:

- Each row defines two identifiers: IE id and FIP id;
- The assumption is that each FIP will be defined by the IEs that are composing it.

Field	Example	Explanation
IE id	IE-01	An id which will unambiguously identify the IE within the project.
IE description	....	A brief description, which should be sufficient to clearly define the IE.

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IE type	hw / sw / design / know-how	The type of IE (i.e. its tangible form).
Work item(s)	Tx.y, Tw.z	The tasks (or work packages, if specific tasks cannot be identified) where the IE has been generated.
Background IP elements (by partner)	BIP-x (Pn), BIP-y (Pm)	The BIPs (and, for each BIP, the project partner contributing it, in case multiple BIP owners are present) which are feeding into this IE.
Foreground IP element associated	FIP01	The FIP which this IE is feeding into; the identifier used here will also define the FIP id.
Partners involved	Pn, Pm	The partners involved in the generation of this IE.
Patent(s)		Some reference (text or ids) to the patents planned for this IE (optional).
Ownership	Pn	The planned owner(s) for this IE; not necessarily all the partners generating the IE will also plan to apply as owners (other conditions might be agreed).
Access conditions	Pm, Pq, Ps	Access conditions for the various partners which are not owners of this IE; both those contributing to its generation, and those who will need this IE after the project.

Table 20. Innovation Element and Foreground IP table

The BIP table (Table 21) will then identify and define the BIP information needed for the IE plus FIP table.

Field	Example	Explanation
BIP id	BIP-01	An id which will unambiguously identify the BIP within the project.
Background IP element description	....	A brief description, which should be sufficient to clearly define the BIP.
Background IP element type	hw / sw / design / know-how	The type of BIP (i.e. its tangible form).
Owner partner(s)	Pn, Pm	The actual owner(s) of this BIP.
Access conditions		Access conditions for the various project partners which are not owners of this BIP, after the project.

Table 21. Background IP elements table properties

3.2.2 MAIN INNOVATION TECHNICAL AREAS

For the time being, the Innovation Elements have been mostly identified as outcomes of specific activities in the iNGENIOUS technical WPs. This is because the main project ideas, concepts, design patterns, hardware and software products are indeed conceived and implemented as part of the technical work.

¡Error! No se encuentra el origen de la referencia. shows the main innovation t echnical areas that up to now have generated Innovation Elements in the project. It is worth to mention that is an initial set of technical areas, that is expected to grow when the technical work in the project will be mature enough to generate new innovations. As shown in the picture (and the innovation table in section 3.2.4), at the moment the main innovation technical areas cover a subset of the WP3, WP4 and WP5 technical tasks.

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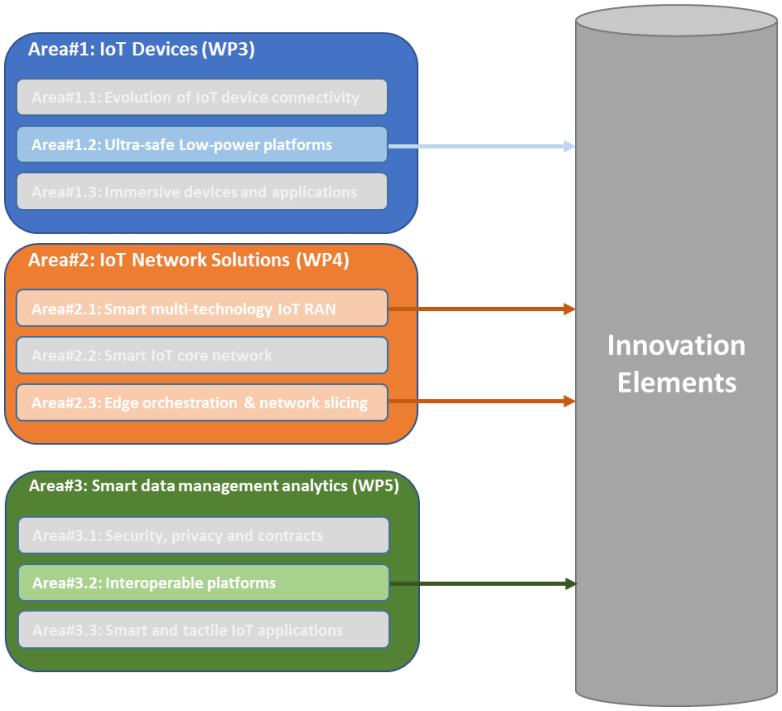

Figure 22: iNGENIOUS main innovation technical areas

3.2.3 BACKGROUND IP ELEMENTS

The BIP elements that build the reference baseline and building blocks for the implementation and realization of the iNGENIOUS Innovation Elements are listed in Table 22.

The following subsections provide a brief description for each Innovation Element listed in the table.

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BIP id	BIP name	BIP element type	Ownership	Access conditions
BIP-01.1	Symphony	SW (Source Code)	NXW	Reserved to NXW for foreground development.
BIP-01.2	Symphony	SW (Installed Platform)	NXW	Available to partners requesting it for the development of their foreground (e.g. in the context of project Use Cases). Free of charge during the project.
BIP-02	NXW slicer	SW (Source Code)	NXW	Opensource (GitHub - nextworks-it/slicer: Network slice manager).
BIP-03.1	Data Virtualization Layer – Teiid	SW (Source Code)	CNIT	Apache Software License (ASL) v2.0 (Teiid - Data Virtualization Layer).
BIP-03.2	Data Virtualization Layer – Teiid	SW (Installed Platform)	CNIT	Available to partners requesting it in the context of project Use Cases (Ship, Port Entrance and DVL/DLT use cases).
BIP-04	PI System OSIsoft	SW	FV	Reserved to FV for foreground development. Access to PI data after NDA signature.
BIP-05	Data Sources - Port of Valencia	Datasets	FV	Access granted to AWA under NDA signature.
BIP-06	Data Sources - Port of Livorno	Datasets	AdSPMTS	Access granted to AWA under NDA signature.
BIP-07	M3 hardware/software co-design	SW (source code)	BI	Open Source licensed under GPLv2 (GitHub - TUD-OS/M3: Microkernel-based system for heterogeneous manycores). Access to upcoming, but not yet public new release granted to TUD.
BIP-08.1	Mobius OneM2M Server Platform	SW (source code)	CNIT	Opensource (https://github.com/IoTKETI/Mobius).
BIP-08.2	Mobius OneM2M Server Platform	SW (installed platform)	AdSPMTS	Access granted to CNIT for foreground development (e.g., integration with DVL).

Table 22 . Background IP elements

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3.2.3.1 BIP-01 Symphony

Symphony is a service-oriented generalized IoT platform capable of integrating thousands of interconnected devices in support of multiple vertical needs and services. It integrates several functionalities (e.g., interfacing with field bus protocols, data acquisition and actuators control, data storage and processing, rule-based engines, application logic and GUIs) into a unified fully decomposed and distributed IP-based platform.

In practice, Symphony is a complete IoT platform characterized by a modular architecture which allows to interact with a variety of hardware devices, IoT sensors or actuators in a seamless and unified manner. Internally, Symphony integrates a number of services for notifications, event management, analytics and automated reactions which can be applied to a variety of applications, like access control, technical systems monitoring, automation, energy management, etc. At its southbound, Symphony implements a Hardware Abstraction Layer (HAL), which provides protocol-specific plugins to enable the interconnection with heterogeneous protocol gateways and devices deployed on field. The “low level” data received from the field are translated into the concept of “plain objects” (i.e., generalized items expressed in unified format). Such objects are then further processed on the basis of device-specific information models to generate “objects with semantics”, that constitute “meaningful” inputs for the applications’ data elaboration in the upper layers and components of the platform.

3.2.3.2 BIP-02 NXW slicer

The NXW slicer is a service-driven management and orchestration tool for modelling and instantiation of vertical-driven services across 5G network slices. It is available as an opensource tool and implements network slice orchestration functionalities aligned with 3GPP Release 15 and ETSI NFV specifications. The NXW slicer provides a common entry point for all the verticals to request the provisioning and management of vertical services through a simplified and vertical-oriented interface. It implements, in a monolithic solution, different functionalities identified by the 3GPP network slice management architecture, and includes a Vertical Service Management Function (similar to the Communication Service Management Function (CSMF) defined by 3GPP) and a Network Slice Management Function aligned to 3GPP Release 15 information models. These two functionalities are highly cooperative, and take care of the lifecycle management of vertical services and network slices, including the translation of vertical services into end-to-end slices, and of each end-to-end slice into a set of subnet slices implemented through NFV Network Services.

3.2.3.3 BIP-03 Data Virtualization Layer – Teiid

The Data Virtualization Layer (based on Teiid) is a cloud-native data virtualization platform, allowing applications to use data from multiple and heterogeneous data sources. It provides a SQL client, OData or REST access to a wide variety of sources regardless of specific underlying technology.

In the scope of the iNGENIOUS project, we relied on Teiid (v16.0) platform, an open-source implementation of data virtualization concept. Teiid is a flexible Java-based component that provides integrated access to multiple data sources through a single and uniform API so that applications can access information using standard interfaces such as JDBC, ODBC, OData or REST, even if that information resides in more than one source or in sources that do not understand standard queries. It is not a database management system: it does not store any data and it acts as a data gateway for accessing data in an optimal manner.

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In order to come up with a commercially standardized way to define maritime events such as gate-in, gate-out, vessel-arrival, vessel-departure and container's seal removal, it has been adopted a data model for the events that is compliant with the one used by Tradelens platform. According to this data model, DVL implements a limited set of procedures to be remotely invoked by data consumers (e.g., cross-DLT layer, pseudonymization module and external platforms) in order to retrieve data related to above-mentioned events.

3.2.3.4 BIP-04 PI System OSIsoft

PI System OSIsoft is a M2M platform owned by the Port of Valencia and used for storing data related to gate-in and gate-out events at the port accesses. REST API access will be made available for enabling the exchange of data with external platforms (e.g., DVL).

3.2.3.5 BIP-05 Data Sources - Port of Valencia

PCS port calls, summary declarations, meteorological data and AIS data are owned by the Port of Valencia and made available for developing prediction and optimization AI-based algorithms in Situational Understanding use case.

3.2.3.6 BIP-06 Data Sources - Port of Livorno

TPCS (Tuscan Port Community System) port calls, summary declaration and AIS data are owned by the Port of Livorno and made available for developing prediction and optimization AI-based algorithms in Situational Understanding use case as well as in Supply Chain Ecosystem Integration use case.

TPCS (Tuscan Port Community System) is the Port Community System of the Port of Livorno. It has been identified by the port operators as the focal point for the digitalisation of processes and services addressed to the Port Community. TPCS is currently used by freight forwarders, terminal operators, maritime agencies, control bodies, hauler, shippers and so on. By means of TPCS, maritime carriers and their representatives can download, in various steps, data related to departing goods, so that they can correctly present the Inward and the Outward Cargo Manifest in a completely automatic way, intervening only when it is necessary to correct errors or cargo refusal message.

One of the founding principles of the system architecture is the complete decoupling between the data level and the application level, with the aim of facilitating a granular access control and perfectly sewn on the different needs and peculiarities of the assets in play (e.g. data, processes, services, interfaces, etc.).

The new architectural framework is based on a micro-service architecture, kept as autonomous as possible within its application domain, thanks to a communication based on asynchronous messages, conveyed by means of a high-performance queue.

3.2.3.7 BIP-07 M3 hardware/software co-design

M3 is an isolation-by-default and secure-by-design microkernel-based operating system and a tile-based system-on-chip hardware architecture that has been specifically tailored to enforce data access/communication security policies at the hardware level. It is particularly suited for building highly-secure and efficient computing components of IoT devices.

The hardware uses a tile-based design, where processors are located on tiles that are connected to a network-on-chip (NoC). Every tile is isolated in hardware an cannot

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access the NoC unless explicitly allowed to interact with other parts of the system. The access-control policy that describes what is allowed or disallowed is configured through the M3 kernel and enforced by a hardware component called Trusted Communication Unit (TCU). There is one TCU per tile that is located between the tile and the NoC. It acts as a gatekeeper that either blocks or lets pass communication to/from the tile. Thus, software running on a processor tile can only communicate or exchange data with another tile, if an access-control policy allows it to do so, resulting in a secure-by-default approach following the principle of least privilege.

The tile-based hardware architecture also allows system designers to integrate I/O devices such as communication modems, as well as special-purpose accelerators for cryptographic operations or machine learning (ML). There is a TCU in front of those tiles, too. Therefore, I/O devices and accelerators benefit from highly efficient data transfer capabilities provided by the NoC and TCU. More importantly, access control to and by these tiles can be configured and enforced in the same way as for software running on processor-based tiles, resulting in a single, unified, TCU-enforced security regime for all hardware and software components.

3.2.3.8 BIP-08 Mobius OneM2M Server Platform

Mobius OneM2M Server Platform is an open source server platform implementing oneM2M standards available in the OCEAN (Open allianCE for IoT stANdards), an open source based global partnership project for IoT (CNIT is a developer partner). One advantage of using the public IoT server (from KETI - Korea Electronics Technology Institute) is that it is possible to use a web-based oneM2M resource monitoring application that makes it easy to monitor sensing values and actuation commands for the IoT devices in real-time.

The Port Authority of Livorno in collaboration with CNIT, has employed the public Mobius-based IoT server provided by KETI in order to perform smart-objects and IoT devices management at seaport.

Currently, the Mobius platform allows to manage and interact with meteorological stations, parking sensors, seaside surveillance and bathymetric services by means of a web-based interface. Moreover, a REST interface from OData is currently used to retrieve meteorological data by means of DVL component.

3.2.4 INNOVATION AND FOREGROUND IP ELEMENTS

Table 23 lists the initial set of Innovation Elements identified so far by the iNGENIOUS consortium. This has to be considered as a preliminary list of Innovation Elements produced in iNGENIOUS. Indeed, the Innovation Management activities will be continuing in the second half of the project, and will aim at identifying further Innovation Elements as result of activities carried out in the technical WPs.

The following subsections provide a brief description for each Innovation Element listed in the table.

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IE id	IE description	IE type	Work item(s)	BIPs (by partner)	FIP associated	Partners involved	Patent(s)	Ownership	Access conditions
IE-01	Orchestration and data collection from 5G Core.	SW (source code)	T4.3	BIP-02	FIP-01	NXW	None	NXW	Opensource
IE-02	AI-assisted network-data based slice optimization	SW (source code)	T4.3	BIP-02	FIP-01	NXW	None	NXW	Opensource
IE-03	Interoperability among heterogeneous Machine-to-Machine platforms and external data sources.	SW (Installed Platform)	T5.2	BIP-03.1 BIP-03.2 BIP-04 BIP-08.1 BIP-08.2	FIP-02	NXW, FV, SES, AWA, TEI, TIOTBD, AdSPMTS, PJATK	None	CNIT	On request
IE-04	Remote attestation for secure cross-device communication and secure software updates.	Hw/SW (source code)	T3.2	BIP-07	FIP-03	BI	None	BI	Access to upcoming, but not yet public open-source release granted to TUD
Ie-05	Smart IoT Gateway.	Hw/SW (source code)	T4.1 T5.2	-	FIP-04	SES	None	SES	On request

Table 23. IEs and FIPs

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3.2.4.1 IE-01 Orchestration and data collection from 5G Core

The iNGENIOUS network slice orchestration solution is based on the NXW slicer BIP-02, and enhances it for aligning it to the main relevant 3GPP Release 17 specifications in the area of network slice management. In particular, the monolithic NXW slicer approach is evolved towards a cross-layer solution where three highly cooperative but independent orchestration functionalities are taking care of service orchestration, network slice and slice subnet orchestration, and resource orchestration. In particular an end-to-end network slice management function coordinates a set of network slice subnet management functionalities defined and implemented for each domain (e.g., RAN, Core Network, Transport Network). Specifically, for the 5G Core such solution envisage a dedicated network slice subnet management function to enable the automated deployment, configuration and operation of 5G Core NFs part of end-to-end network slices, allowing to provision multiple slices in the same 5G Core instance. This innovative network slice orchestration solution also includes embedded monitoring functionalities that are able interact with the 5G Core NDWADF for slice, NFs and UEs related data collection. Similarly, for the RAN, dedicated network slice subnet management functions allow to coordinate resource provisioning and allocation for specific technologies and solutions (e.g. 5G gNB, O-RAN, iNGENIOUS flexible PHY/MAC RAN, etc.).

3.2.4.2 IE-02 AI-assisted network-data based slice optimization

An AI/ML engine has been conceived to assist the service, slice and slice-subnet management functions within the iNGENIOUS network slice orchestration solution in their decision logics. This approach leverages on external ML algorithms that are able to analyse and process network slice related data collected from various network sources. This results into an AI-assisted network-data based slice optimization solution that significantly improve the automation capabilities of the overall slice management functionalities. Given the cross-layer nature of the iNGENIOUS network slice orchestration solution, the ML algorithms outputs can assist decisions at different levels, including mapping of services into slices, arbitration of slice resources, optimized slice resource and network functions allocation, slice resource and network functions scaling. In practice, this approach is enabled by dedicated interfaces and workflows supported by the network slice management functions and the AI/ML engine for data acquisition and processing from the 5G Core Network Data Analytics Function (NWDAF) and the 5G infrastructure in general, and enforcement of ML-based decisions.

3.2.4.3 IE-03 Interoperability among heterogeneous Machine-to-Machine platforms and external data sources

The interoperability among heterogeneous Machine-to-Machine platforms and external data sources provides data aggregation functionalities based on custom implementation of the virtual databases, views and procedures in order to enable data flows to feed consumers (e.g., Awake.AI Platform, Trust-OS, etc.). The functionalities include also a role-based access rights (CRUD model) as well as personal data management policies based on pseudonymization techniques.

The Data Virtualization Layer is the core component for such interoperability. According to project use cases, DVL aggregates data from disparate data sources as well as heterogeneous M2M platforms. The main purpose of data aggregation is to define maritime events like gate-in, gate-out, vessel-arrival and vessel-departure for both Port of Livorno and Port of Valencia by extracting relevant attributes as required by the data model currently adopted in Tradelens Platform.

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In the scope of iNGENIOUS project, DVL will support different data consumers that will exploit aggregated data in supply chain scenarios. On one side data are expected to be used by cross-DLT layer in order to guarantee data immutability and on the other side historical ones will be used for predictive analysis. Moreover, in order to meet data privacy requirements according to EU regulations, pseudonymization functionality will be part of the DVL component so that sensitive data can be properly pseudonymized before being used by expected applications.

3.2.4.4 IE-04 Remote attestation for secure cross-device communication and secure software updates

Th remote attestation for secure cross-device communication and secure software updates consists in a simulated and FPGA-based hardware implementation of a Root-of-Trust (RoT) for the M3 hardware/software co-design platform and associated system-software integration to enable remote attestation together with Transport Layer Security (TLS) and secure software updates.

A minimal hardware Root-of-Trust (RoT) is the key development activity carried out by BI in iNGENIOUS to enable secure communication between IoT devices and (edge) cloud servers. The core feature of the RoT is a secret and unique device identity key embedded in the hardware. This secret key is used to create digital signatures that certify, using operating-system support, which software has been loaded. Such a certificate provides a cryptographic attestation proof of the current state of the execution environment, which enforced by the tile-based hardware/software co-design and the currently-in-place access control policy. This proof can be verified remotely to establish whether an M3-based IoT device is in the expected and secure state (i.e., whether it is trustworthy). The RoT is the foundational building block for this remote attestation, which will be integrated with Transport Layer Security (TLS) protocol. However, RoT-based attestation can also be utilized to implement secure software updates with automatic cross-device compatibility checking.

3.2.4.5 IE-05 Smart IoT Gateway

The Smart IoT Gateway (GW) is the system/hardware element responsible for the appropriate routing and sorting of sensors data, coming from one or more sensor networks to higher layer data consolidation services and machine-to-machine (M2M) platforms. In order to perform these operations, the Smart IoT GW is able to interconnect multiple physical interfaces, extracting and transforming messages as data goes from one side to the other.

The Smart IoT GW will expose several physical and data-link interfaces to receive sensor data. Sensors can send messages to the Smart IoT GW either wirelessly (with technologies such as IEEE 802.11, LoRa or Sigfox), or directly connected to the device (via Ethernet, I2C or SPI). The Smart IoT GW will be smart enough to manage the routing of the received messages to the right output interface in the right timing. Several factors will be taken in consideration in this operation:

- Context: such as the current geographical localization of the Smart IoT GW or its situation relative to potential recipients of messages;
- Message prioritization: due to urgent messages that need to be forwarded immediately over other messages that can be grouped together for channel usage optimization;
- Channel availability: in cases where constrained communications impose a specific interface linked to a channel, such as a satellite link in situations where satellite networks provide the only means of ubiquitous connectivity.

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Physical interfaces are added to the Smart IoT GW as plug-in modules, that allow to abstract most of the device functionality from the number and type of the interfaces installed in the Smart IoT GW.

3.2.5 INNOVATION MAPS

The BIP and IE plus FIP tables allow to derive a number of innovation maps, where each IE, FIP and BIP will be cross-linked among themselves, and with the partners owning them.

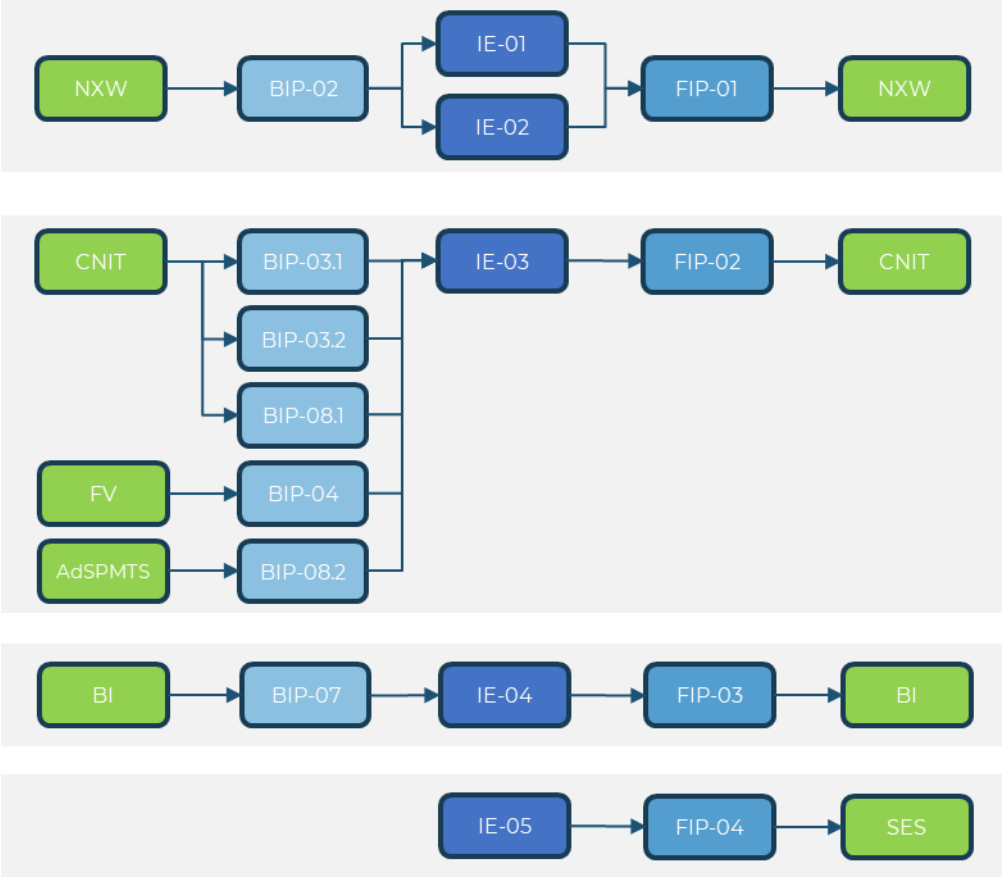

Figure 23: Innovation maps

These maps will constitute the basic information to analyse intellectual property interdependencies among the various IP elements entering the project, and being generated during the project. As such, these maps are also the basic information needed for the potential legal and commercial agreements among the partners, after the end of the project.

As an example, let's analyse IE-03. The generation of this IE depends on a number of BIPs, contributed by three different partners. The IE alone feeds and maps into FIP-02, which will then owned by CNIT. The map means that, in order to fully exercise their rights and use FIP-02, CNIT will have to establish some agreements with the other owners of the BIPs that FIP-02 depends on (i.e. FV and AdSPMTS).

3.2.6 NEXT STEPS

The results of the Innovation Management work reported in this Section 3.2 provide a preliminary mid-term overview of the Innovation Elements and Foreground IP envisaged and generated in iNGENIOUS so far. The methodology described in Section

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3.2.1.2 will be further implemented during the second half of the project with the aim of fostering and assisting the identification of additional project innovations, with special focus on those main technical areas listed in Section 3.2.2.

Moreover, as part of the Innovation Management duties, iNGENIOUS will consider contributing to the EC Innovation Radar initiative [17]. In this context, relevant project Innovation Elements will be selected to be part of the Innovation Radar platform, and thus ease greater access to the iNGENIOUS innovations information, facilitating their potential introduction in the market through its dynamic ecosystem of incubators, entrepreneurs, funding agencies and investors.

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4 Conclusions

This deliverable has presented the work completed in dissemination, communication, standardization, exploitation and innovation executed in the first 14 months of the iNGENIOUS project.

In Chapter 1, dissemination and communication activities have been reported alongside KPI metrics. These activities include contributions in the form of papers for journals and conferences, as well as participation in physical events to convey the preliminary results of technical deliverables and design, and digital dissemination for the iNGENIOUS vision and use cases through virtual mediums such as webinars and social media to approach the large professional communities of 5G stakeholders virtually.

Chapter 2 covered the activities to promote the project outcomes to targeted standardization bodies and industry for influencing the development of standards, and the plans to maximise the technical and economic impact of the iNGENIOUS project through exploitation intentions.

Finally, Chapter 3 covered the innovation management, tracking the innovations generated in the project, as well as presenting their relationship with the background and foreground Intellectual Property elements brought and developed by the various partners.

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