ANNUAL REPORT

2015

Wireless Communications Laboratory of CNIT

A Year in Review

WILAB a CNIT lab

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01 Director's Address

After (almost) six years, it is time for WiLab to take advantage of new blood: my mandate as WiLab Director is over, and by the start of 2026 a new Director will take my place. It was an incredible journey, which has signed my professional and personal life. Most of the considerations I want to leave, and my vision of the future for the Laboratory, have been included in the speech I offered few weeks ago to the researchers and academics that met for the 2025 WiLab Gathering. The text is reported below (in Italian).

The WiLab Founding Director

Cari e care,

è giunto per me il momento di passare il testimone e quindi di fare il punto su quanto abbiamo costruito insieme nei primi sei anni di questa avventura. Mi rivolgerò soprattutto al futuro, proponendo la mia visione di come possa e debba evolvere il WiLab; come sempre, per prendere una direzione, bisogna però prima partire da un'analisi di ciò che abbiamo alle spalle, per individuare i punti di forza sui cui contare, che hanno originato la nostra storia di successo.

IL PASSATO

Le nostre radici affondano nel terreno reso fertile da più di quarant'anni di attività del Prof. Andrisano, dei suoi allievi, insieme cui mi pregio di appartenere, e dei loro allievi. Una Scuola che ha fatto dell'interazione tra teoria e sperimentazione una filosofia, perpetuata dal WiLab. Sono trascorsi esattamente sei anni (era novembre 2019) da quando trenta persone dall'Università di Bologna, Ferrara e dallo IEIIT del CNR, hanno firmato la proposta di costituzione del WiLab, il Laboratorio Nazionale di Comunicazioni Wireless del CNIT. Di cosa disponevamo? Di una storia di attività scientifica sviluppata a livelli di eccellenza e di una grandissima credibilità (che è una ben cosa diversa, è anche un fatto di comunicazione) in Italia e nel mondo. Un patrimonio che mi permise di preparare il campo per l'accettazione della nostra proposta da parte degli Organi del CNIT.

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Ma c'era di più. Quando pochi mesi prima proposi a quegli amici e colleghi di incontrarci periodicamente, per raccontarci in pillole le attività e le opportunità condivisibili, avvertii subito un desiderio che ci accomunava: di costruire un luogo che raccogliesse l'enorme patrimonio di competenze sul wireless di cui disponevamo. Quel desiderio, quell'entusiasmo, quel fuoco, ha illuminato la mia azione durante questi sei anni di Direzione. Come dirò in seguito, è stato un enorme privilegio guidarvi alla luce di quella fiamma. Però non bastano eccellenza scientifica, entusiasmo e credibilità per costruire una storia di successo come la nostra, in un contesto mal finanziato e ad elevatissima competizione. Occorre anche impegno quotidiano, inteso nel senso di attenzione, dedizione alla causa. Benché il termine successo sia grammaticalmente un participio passato, la storia di successo del WiLab è in realtà succedente: si perpetua solo se c'è dedizione quotidiana. La nostra storia di successo si protrarrà solo se la fiamma che ha originato il WiLab continuerà a bruciare, come fuoco imperituro, illuminando la via ogni giorno, del Direttore e di tutti noi.

Mi soffermo ulteriormente sul tema della competizione. Le comunità scientifiche da cui originiamo sono caratterizzate da persone che lavorano molto più del dovuto o richiesto contrattualmente. È certamente vero nel nostro Paese, ma è drammaticamente ancor più vero quando il confronto è a livello internazionale ed in particolare con i Paesi che in questi anni sono diventati tecnologicamente dominanti. In Europa da qualche tempo si colgono spinte politiche (in vari Paesi) volte a recuperare il terreno perduto da questo punto di vista; la sopravvivenza in contesti competitivi (come il nostro) impone lavoro duro. Molti di noi hanno sacrificato momenti di vita personale per l'attività al WiLab. Non è un fatto prescindibile. Infine, un ultimo ingrediente del nostro successo: il collante; una forza in grado di attrarre attorno a quel fuoco le competenze, le capacità e l'entusiasmo, che faciliti l'aggregazione, in un contesto, quello della ricerca, che spesso invece predispone all'individualismo. Se c'è un merito che mi son sempre attribuito in questi anni, ed è il solo, è proprio quello di aver saputo svolgere questa funzione di forza federatrice, che ci ha permesso di diventare quello che siamo. Queste devono esser le stelle polari del Direttore entrante; questi sono i nostri punti di forza.

IL PRESENTE.

I co-fondatori del WiLab, come detto, erano trenta, da tre diverse istituzioni. Oggi gli afferenti, associati e collaboratori a vario titolo coinvolti nei nostri progetti sono novantuno, da undici diverse sedi. Sedici sono i dipendenti, con la previsione di assumerne ulteriori tre nei primi mesi del 2026 (ma, ahimé, lasciarne andare qualcuno). Abbiamo ragionato a lungo nell'ultimo anno, per convenire che ciò conferisce la massa critica necessaria per rispondere a opportunità e progetti di ampio respiro senza dipendere dalla disponibilità di personale accademico. Ma la forza del WiLab consiste nell'ecosistema che avvolge i dipendenti: l'insieme di professori Universitari, ricercatori, dottorandi e studenti che alimentano il WiLab con competenze scientifiche, ulteriore disponibilità di massa critica, opportunità, esperienza; una peculiarità che porta in dote il CNIT. Come ogni ecosistema, si basa su equilibri e meccanismi fragili, delicati. Che vanno, appunto, rimessi in discussione ogni giorno, stretti tra il desiderio del WiLab di divenire un ente indipendente e l'opportunità di avvalersi del grande apporto delle Università. Un equilibrio da ribadire e riconquistare, da reinterpretare ogni momento. È, forse, questo il compito più difficile del Direttore, che si coniuga in mille azioni quotidiane.

Due anni fa, al primo WiLab Gathering, ci siamo chiesti: "perché WiLab?". Le risposte diedero spazio a quell'entusiasmo che citavo poco fa. Una che mi piace molto ricordare: per creare una opportunità in Italia per chi vuole fare ricerca nel nostro settore. Risposte in parte dettate dall'emotività e dal sentimento. Oggi, è giunto il tempo della ragione, della prova dei

fatti; mi pare più importante domandarsi invece: "cosa è e cosa vuol diventare il WiLab?" Abbiamo già discusso in passato le missioni del WiLab. Il WiLab però non è (solo) un ente che fa ricerca, non è (solo) una istituzione che fa innovazione, non fa (solo) formazione. Fa un po' tutto questo, ma ambisce anche ad altro: ad esempio sviluppare propri servizi e prodotti da proporre al mercato, un obiettivo non ancora messo a terra. Non ho mai trovato la giusta definizione, un semplice termine che ci rappresenti. Certamente il WiLab è un luogo dove il sapere prende forma e diviene concretezza, superando l'astratta teoria. Con questa definizione, ChatGPT suggerisce di usare il termine "fucina".

Personalmente ho sempre concepito il WiLab come una startup: una impresa che, dalle radici di una fortissima competenza, sviluppasse una solida ossatura e si ergesse via via più alta, con un processo di continua crescita. Come ogni startup, dopo una prima fase di consolidamento della struttura portante segue quella detta di scale-up, in cui le attività si moltiplicano e ramificano. Quella in cui, alle radici, si aggiungono le ali. Passare alla fase di scale-up significa ambire a maggiori margini, più remunerativtà, minor precarietà. Significa dimostrare che si è raggiunto un livello di maturità che permette di rendere scalabile il proprio business. La fase di scale-up del WiLab non è ancora iniziata. Questo passaggio di consegne tra il Direttore fondatore e quello del prossimo triennio è l'occasione per chiedersi come e se si voglia affrontarla. Il tempo della startup deve cessare.

Il WiLab però non può fare o divenire quel che vuole: è una emanazione del CNIT e deve osservarne le regole, scritte e non scritte, che a volte ci appaiono troppo rigide, a volte incerte. Il CNIT è un ente con trent'anni di storia, guidato dalle Università. Negli ultimi tempi ha cominciato ad evolversi. Vi sono forze interne che spingono verso un controllo più accentrato, altre che insistono per conferire ai Laboratori maggiore libertà di azione. È presto per dire quali saranno vincenti. La scelta avrà impatto sulla capacità di crescita del WiLab. Dobbiamo quindi contribuire al dibattito interno al CNIT con costruttività e determinazione. Per farlo, bisogna però avere chiaro ciò che vogliamo essere.

IL FUTURO.

Il mio WiLab vorrei spiccasse il volo, che continuasse a crescere, numericamente e di prestigio. Oggi è una realtà importante nel contesto scientifico Italiano del settore telecomunicazioni, ma ancora molto piccola perché giochi un ruolo nei tavoli dove si decidono le politiche tecnologiche del territorio, Regionale e Nazionale. Chiedo ai dipendenti: qual è la vostra ambizione per il WiLab? La mia è che divenga una realtà interpellata ogni volta che sono richieste competenze sul wireless nel Paese. Che produca progresso, che abbia impatto. Non c'è, tra i Laboratori Nazionali del CNIT, una realtà con le dimensioni che permettano di svolgere un tale ruolo di leadership. Da questo punto di vista non vedo vincoli posti dal regolamento CNIT. È una nostra scelta se nutrire tale ambizione o no. È nelle nostre mani guadagnarsi tale traguardo o meno.

Perché il WiLab continui a crescere, non basta però che si perpetuino le condizioni dei primi sei anni; occorre che si moltiplichino le opportunità di finanziamento, pubblico e privato. Il che richiede un numero maggiore di progetti. Servono più portatori di opportunità (PO): professori, ricercatori e dipendenti che si propongano ed impegnino per ottenere finanziamenti, ed abbiano successo. Sottoponendo proposte di progetti Europei o Nazionali, tessendo rapporti con aziende per la stipula di contratti, partecipando ad eventi con la finalità di creare nuove relazioni. A tal fine servono capacità, volontà ed un ambiente che stimoli tale iniziativa. I portatori di opportunità devono disporre di visione strategica e tecnica, saper comprendere quando vale la pena investire il proprio tempo in una idea. Non è una capacità

innata. Si acquisisce col tempo. Mi rivolgo ai più giovani, dipendenti o accademici: è nella natura di ogni ricercatore desiderare di divenire, un giorno, fautori diretti del proprio lavoro, procurandosi le opportunità di finanziamento. È un processo per passi. Il primo consiste nell'assumersi la responsabilità di un progetto, svolgere il ruolo di principal investigator (PI), o supportare un PI. L'assunzione di una responsabilità modifica il punto di vista: lo stesso progetto viene percepito non più solo come un insieme di attività volte ad un obiettivo, ma come una occasione di crescita personale, una sfida che, se superata, incrementa l'autostima ed attiva un circolo virtuoso. Le responsabilità fanno crescere. Il WiLab crescerà se cresceranno i propri dipendenti. E viceversa. Ci sono nel WiLab molti giovani, sia tra i dipendenti sia tra gli accademici, che sottovalutano la loro capacità di leadership, che non significa dover guidare gli altri, ma saper guidare le attività. Carissimi e carissime, fatevi avanti, assumetevi responsabilità. Non abbiate timore di fallire. Le persone esperte devono esser caute perché ci si aspetta conoscano i propri limiti. Un giovane che osa, invece, è coraggioso, a prescindere dall'esito dell'iniziativa; il coraggio viene sempre plaudito. E va remunerato. È giusto proporre incentivi in tal senso e che si premi maggiormente chi si sforza in tale direzione; giovane o no. Di incentivi tratterò più tardi.

Illustrerò a breve, in sintesi, il bilancio previsionale del 2026. Ogni anno, a novembre, il WiLab si dota di un prospetto che include gli incassi previsti come ragionevolmente certi e le spese pianificate; normalmente in corso d'anno il bilancio cresce poi significativamente con ulteriori contratti e progetti. Il documento ha la funzione di controllo delle spese, ma è anche uno strumento di pianificazione strategica. Fino ad oggi il bilancio era determinato dal Direttore. Credo sia opportuno che per il futuro, ora che un certo numero di dipendenti ha raggiunto un buon livello di maturità, sia condiviso maggiormente con loro nella sua fase di definizione. Anche perché tra le spese previste vi sono i compensi stipendiali e occasionali, così come le indennità ed i premi. Il bilancio tocca corde care ai dipendenti e conferisce contezza e certezza del futuro.

IL TRATTAMENTO ECONOMICO DEI DIPENDENTI.

Finora i dipendenti del WiLab hanno goduto dello stipendio stabilito dai rispettivi livelli contrattuali, così come previsti dal Contratto Collettivo Nazionale del Lavoro (il CCNL) per il nostro settore, che non è generoso. Questo, per tre motivi: primo, perché nella fase di startup si investe sulla struttura, a scapito delle remunerazioni individuali; secondo, perché questo ha permesso di misurare la reale motivazione dei dipendenti; terzo, perché qualche anno fa il nostro settore era caratterizzato da livelli stipendiali non superiori alla media. Ora qualcosa sta cambiando (per fortuna, mi permetto di dire): i nostri dipendenti sono dotati di grandi competenze e meritano una remunerazione superiore. Non suggerisco di inseguire l'incremento delle remunerazioni esterne; lavorare al WiLab deve esser visto come un privilegio, un valore di per se, ma certamente ritengo occorra inserire meccanismi, premiali e non, che permettano di confrontarsi con maggior tranquillità.

Il CNIT permette di farlo. Tra i paradigmi applicati negli ultimi mesi, c'è il principio dello svincolo tra livello contrattuale e remunerazione. Il Laboratorio può dotarsi di criteri interni. Mi spetta quindi avanzare una proposta al nuovo Direttore. Si noti che se questo è un vantaggio, c'è un rovescio della medaglia: il passaggio da un livello all'altro verrà certamente normalizzato dall'ente per una equa applicazione in tutti i Laboratori; sarà necessario contribuire alla salvaguardia dei principi espressi dal CCNL, non del tutto rispettati al momento.

Ho redatto un documento, che metto nelle mani del nuovo Direttore ed in quelle dei dipendenti, che ipotizza un meccanismo di incremento annuale dello stipendio dei dipendenti su base anzianità di servizio,

per qualsiasi livello, sin dal primo anno di assunzione, fino al raggiungimento dello stipendio previsto dal livello successivo; fissando l'incremento al 3%, ciò avviene in quattro anni. Ovviamente, potrà esser erogato solo se il bilancio lo permetterà. A questo incremento annuale si possono poi sommare le indennità di responsabilità ed i premi. Le prime sono definite ex ante, in funzione delle responsabilità assunte, i secondi ex post sulla base di eventi inattesi. Un principio di fondo ha animato questi miei ultimi mesi trascorsi a ragionare su che indirizzo proporre alla gestione del Laboratorio: si conferiscono indennità e premi quando un dipendente accetta responsabilità o realizza azioni che vanno oltre il ruolo che gli/le spetta. Ogni ruolo prevede specifiche funzioni, che dipendono dall'area (ricerca, tecnica, gestionale o amministrativa) ed il livello contrattuale; lo svolgimento con livelli di qualità di tali funzioni rappresenta l'elemento necessario per contribuire alla crescita del WiLab. Tale svolgimento è remunerato mediante lo stipendio, aggiornato sulla base dell'anzianità. Indennità e premi vanno conferiti laddove si espletino funzioni aggiuntive.

Partiamo dunque dalle indennità di responsabilità. Un ulteriore documento che offro al nuovo Direttore illustra la lista di ruoli di cui a mio parere si può dotare il WiLab, con le relative funzioni. Il regolamento CNIT ne propone alcuni (pochi): oltre al responsabile (quello che chiamiamo usualmente Direttore), c'è il responsabile scientifico (un ruolo che non ho mai assegnato), il responsabile di area e di settore. La gestione del Laboratorio, a mio modo di vedere, ne richiede di ulteriori, in qualche modo già implementati negli anni passati. Ho identificato una decina di ruoli e specificato in sintesi le funzioni assegnate. Per ciascuno, ho ipotizzato una forbice di livelli economici di indennità, lasciando ovviamente una parte di discrezionalità al Direttore. Come per l'incremento stipendiale connesso alla anzianità, l'erogazione delle indennità dipende dalla disponibilità di bilancio a consuntivo.nIl Direttore, ad inizio anno, deve stabilire a chi assegnare i ruoli che posson dar luogo ad indennità. Il processo deve partire dai dipendenti che si devono fare avanti, proporsi.

L'ORGANIGRAMMA.

L'organigramma del Laboratorio è un fatto formale: è pubblicato sul sito web del CNIT ed è un elemento che il CdA richiede nel momento in cui si propongono nuove assunzioni a tempo indeterminato. Comprende la definizione delle aree scientifiche ed i ruoli e le responsabilità assegnate. Oggi mi spingo a suggerire quali ruoli sia bene assegnare fin dall'inizio del prossimo triennio, per alimentare efficacemente la fase di scale-up del WiLab mantenendo tuttavia un organigramma snello. Comincio l'analisi con quello di responsabile scientifico, definito dal regolamento CNIT: si tratta di una figura dalle funzioni molto diversificate, che spaziano dal coordinamento delle attività scientifiche allo sviluppo strategico e di business. Non sono a favore dell'assegnamento di tale ruolo, che si sovrappone eccessivamente con quello del Direttore. Eventualmente, un sottoinsieme delle funzioni che il regolamento attribuisce a tale figura potrebbe esser assegnato ad a altri ruoli.

Riguardo il coordinamento progettuale, ci siamo dotati da tempo delle figure dei responsabili di area; ruoli certamente da confermare, magari con una rinnovata identificazione delle aree scientifiche. Tre anni fa le definimmo vincolandoci alla disponibilità di alcune persone. Questa volta lo farei con l'obiettivo di meglio chiarire gli indirizzi e le competenze rappresentate chiedendosi successivamente chi possa assumersi il ruolo di area leader. Il regolamento CNIT suggerisce una organizzazione tecnico-scientifica a due livelli, con aree e settori. I settori richiedono una dimensione numerica del Laboratorio non ancora raggiunta. Tuttavia, potremmo esercitarci da subito a identificare aree che si prestino ad un successivo raggruppamento in settori, magari non attivi da subito. Senza entrare nel merito della definizione delle aree, mi pare che per rappresentare plasticamente verso l'esterno il desiderio di crescita del Laboratorio nel lungo termine si potrebbe iniziare a

ragionare su una suddivisione in due settori, con almeno due aree ciascuno. Ogni area comprenderà un sottoinsieme di progetti. Non attribuirei necessariamente i dipendenti alle aree. I responsabili di area del WiLab (quanto meno due di loro) hanno svolto negli anni passati un compito straordinario e molto, troppo ampio; credo che in futuro dovrebbero concentrarsi solo sul coordinamento delle attività scientifiche e progettuali. Tra i compiti onerosi di cui si son fatti carico vi è stata la gestione della crescita degli altri dipendenti, di pochissimo più giovani di loro. Ritengo sia stato estremamente utile per la loro stessa maturazione. Ma ora è opportuno attribuire tale funzione ad altri ruoli: quello del responsabile delle risorse umane in primis; una persona che si preoccupi della crescita dei dipendenti, dal punto di vista prima di tutto tecnico, ma anche contrattuale, nell'organigramma. Che sappia consigliarli, motivarli, sostenerli. Si tratta di un ruolo chiave per uno sviluppo sereno del lavoro.

È opportuno poi assegnare esplicitamente anche altri ruoli operativi, quali il responsabile dei fondi, dei servizi IT, degli acquisti e della strumentazione. Infine, trovo necessario che si identifichi un/una responsabile gestionale, che coordini il reparto ed il rapporto con l'Amministrazione, per garantire il miglior funzionamento delle attività di gestione; non fondamentale nel passato, in un momento di discontinuità è certamente utile. Tutti questi ruoli potrebbero esser assegnati in linea di principio a dipendenti o accademici. Per quanto riguarda quelli operativi, mi pare più che opportuno che siano rivestiti da dipendenti. Suggerisco, per alimentare il circolo virtuoso dell'ecosistema, che le responsabilità del coordinamento tecnico - progettuale, ancora più che nel passato, siano invece condivise tra dipendenti e accademici.

LE COPERTURE ECONOMICHE.

Il WiLab riceve dal CNIT un finanziamento ordinario di 11.000 EUR l'anno. Più del 99% del nostro bilancio è coperto dai finanziamenti che ci accreditiamo sul mercato. Esistiamo solo se incassiamo. Applichiamo da sempre un prelievo del 6% su tutti i progetti, aggiuntivo rispetto a quello imposto dall'Amministrazione centrale CNIT. Con quel prelievo costituiamo un fondo di funzionamento che utilizziamo per tutte le esigenze trasversali rispetto ai progetti; paghiamo gli affitti e i servizi annessi ad esempio. Come vedremo, i costi di funzionamento del WiLab fissi (ovvero, che non dipendono dalla presenza di più o meno progetti) ammontano a circa 74.000 EUR, riducibili se necessario rinunciando a qualche iniziativa. Un bilancio annuale di 1 MEUR non è sufficiente per coprirli, generando un accantonamento di 60.000 EUR.

Le coperture economiche per la remunerazione dell'anzianità di servizio e le indennità di responsabilità che sto proponendo vanno ricercate, anch'esse, nel fondo di funzionamento del Laboratorio. Non si può imputarle ai progetti, soprattutto se soggetti a rendicontazione. Certamente non le seconde. Un bilancio di 2 MEUR permette, oltre alla copertura dei costi fissi, di erogare complessivamente 46.000 EUR di compensi per anzianità ed indennità, un ammontare sufficiente per il 2026, non per il 2027 quando i compensi per anzianità raddoppierebbero secondo la mia proposta. Bilanci maggiori potrebbero permettere di abbassare il prelievo sui progetti di qualche unità percentuale, oppure pagare maggiori indennità. Una scelta che spetta al Direttore. Gli incassi previsti dal bilancio previsionale del 2026, redatto sulla base delle informazioni disponibili al primo novembre, ammontano a circa 1.300.000 EUR. Si tratta di un bilancio che permette di coprire i costi di funzionamento fisso senza margini. Insomma, il WiLab deve crescere. Strettamente connesso al tema delle coperture economiche vi è quello dei premi, legato agli incentivi.

L'incentivo è una linea guida, che va discussa e condivisa con i dipendenti a priori e definisce la visione strategica del Direttore a riguardo di quale direzione debba prendere l'impegno del Laboratorio. L'incentivo è la promessa di una remunerazione a fronte di un risultato ottenuto, o ambito. La mia proposta per gli anni a venire, solo parzialmente condivisa dai dipendenti, è di definire l'incentivo in termini

di capacità di attrarre finanziamenti. Quel che è certo è che il WiLab potrà avviare la fase di scale-up solo quando avrà costruito una maggiore capacità di attrazione di finanziamenti. Si tratta di un passaggio obbligato; è giusto proporre incentivi in tal senso e che si premi maggiormente chi si sforza in tale direzione.

I premi, essendo connessi alle attività progettuali, ragionevolmente saranno finanziati dalle risorse economiche a disposizione dei progetti, non dal fondo di funzionamento. Siccome i fondi sono utilizzati sulla base delle indicazioni dei PO e dei PI, spetta a loro individuare i destinatari del compenso. I premi prenderanno la forma di contratti per gli accademici e di premi di fine anno per i dipendenti. Prima di presentare per sommi capi il bilancio, atto dovuto nel momento di un passaggio di testimone, è opportuno però menzionare un principio che ho sempre applicato in seno al WiLab e che suggerisco di perpetuare. Le interfacce tra i capitoli di spesa relativi a diversi progetti sono porose. In altri termini, ho sempre utilizzato i fondi dei progetti prima pagando le risorse necessarie al progetto, poi altre, come se si trattasse di un unico capitolo di spesa. In questo modo ogni dipendente deve sentirsi ed è parte di un corpo unico, indipendente dal suo ruolo in un progetto meglio o peggio finanziato. Il bilancio va visto cumulativamente, sommando tutte le spese e tutti gli incassi, senza distinguere il progetto che li ha originati. Si tratta di un principio ovvio, che peraltro è necessario osservare nel momento in cui fanno parte di quel corpo anche gestionali, amministrativi, tecnici.

IL BILANCIO.

Il bilancio previsionale del 2026, redatto sulla base delle disponibilità al primo novembre, prevede i seguenti elementi:

- Fondi residui del 2025 disponibili: 610.000 EUR

- Incassi ragionevolmente certi fino al 31 dicembre 2026*, al netto dei prelievi: 1.031.595 EUR

- Disponibilità del Direttore: 966.243 EUR

- di cui il fondo di funzionamento ammonta a: 75.522 EUR

- Disponibilità dei PO: 675.352 EUR

- Costi fissi (affitti, servizi, premi, eventi periodici) 74.000 EUR

- Compensi per i dipendenti: 903.420 EUR

- Indennità e premi: 19.000 EUR

- Margine: 9.823 EUR

* escludendo l'anticipo che riceveremo da Huawei a novembre 2026 per il 2027

In passato il bilancio del WiLab è stato più ricco. Quest'anno le nostre risorse economiche risentono della sfortuna che ha caratterizzato la proposta di tre progetti di ricerca Europei nel 2024. Mi consente di assegnare minime quantità di premi ed indennità. Vale la pena tuttavia osservare alcuni dati: 1) I compensi ammontano a circa 900.000 EUR. L'adozione del meccanismo dell'incremento per anzianità potrebbe far aumentare la voce, ogni anno, di circa 15.000-20.000 EUR a seconda del numero di dipendenti. Un bilancio preventivo la cui dimensione complessiva ammonti a circa un milione e mezzo è strettamente sufficiente a coprire i costi del personale, senza tener conto delle auspicate crescite del WiLab.2) I PO dispongono di una quantità di risorse cospicue: più di 600.000 EUR. Queste posson esser utilizzate per alimentare il meccanismo dei premi, a discrezione dei PO.

Complessivamente, benché il bilancio che vi ho presentato sia inferiore a quello di due anni fa, lo stato di salute delle nostre finanze è buono. Il JIC con Huawei paga ogni anno in anticipo il 100% dell'ammontare contrattuale per l'anno successivo. Questo ci mette nelle condizioni, stabilmente (almeno per i prossimi cinque anni), di disporre sempre di notevoli risorse di cassa; queste sono molto utili nel momento in cui occorre stipulare contratti di assunzione o se si propongono passaggi a tempo indeterminato, che impongono anticipi di circa 100.000 EUR.

Alla voce "compensi" in realtà ho addebitato, oltre alle spese per garantire la

copertura economica degli stipendi di tutti i dipendenti, compresi quelli che ci accingiamo ad assumere, anche gli anticipi necessari per il passaggio a tempo indeterminato pianificato da tempo per tre dei nostri dipendenti pe il primo trimestre 2026. Non ho invece tenuto conto degli anticipi che saranno dovuti a dicembre 2026 per tre ulteriori passaggi a tempo indeterminato pianificati; le risorse (circa 300.000 EUR) andranno recuperate durante il corso dell'anno. Il nuovo Direttore ha ricevuto da me il bilancio previsionale con il dettaglio progetto per progetto. Tuttavia, come ho già avuto modo di dire, il bilancio va visto in forma integrale. C'è un dato che non emerge da quel bilancio e che rappresenta una eredità spiacevole che, purtroppo, conferisco al nuovo Direttore. Come ricorderete, due anni fa abbiamo scelto di investire, partecipando al progetto CTE CoBo, che ci ha imposto un cofinanziamento del 30% su un ammontare complessivo di spesa di 1.400.000 EUR circa. Per sostenere il quale ho applicato un prelievo aggiuntivo a molti progetti, con la promessa di una restituzione, quando le condizioni lo permetteranno. Complessivamente, è un debito nei confronti dei PO di circa 110.000 EUR. Un fatto da ricordare, perché prima o poi quel debito andrà sanato.

INCENTIVI E PREMI.

La natura del CNIT e quindi del WiLab impone di approfondire l'argomento degli incentivi rivolgendomi a dipendenti e accademici separatamente. I dipendenti attuali del WiLab sono molto giovani e naturalmente non hanno ancora l'esperienza o la rete di contatti per proporsi come portatori di opportunità. Ciò non ostante qualcuno di loro ci sta provando, con l'incertezza dei neofiti e magari qualche errore, ma soprattutto con primi risultati positivi. Sono fermamente convinto che ciascuno dei dipendenti del WiLab possa divenire portatore d'opportunità: chi prima, chi dopo. Come per tante attività umane, si impara dai modelli: affiancando ed osservando chi ha esperienza. Daniel Kahneman sostiene che la competenza più importante per una vita ed una carriera di successo è l'apertura mentale attiva: ovvero, la propensione ad osservare, imparare da chi e da ciò che ci circonda, sempre pronti a metter in discussione le proprie certezze ed uscire dalla propria comfort zone.

Per uscire dalla quale occorre forte motivazione. Un modello accreditato nella psicologia del lavoro, il modello di Vroom, stabilisce che la motivazione a compiere una azione sia data dal prodotto di tre fattori: l'aspettativa, ovvero la percezione che ad uno sforzo impresso possa seguire un effetto positivo; la strumentalità, cioè l'idea che l'effetto si possa tradurre in un compenso; la valenza, che rappresenta il valore, soggettivo, che l'individuo conferisce al compenso. Cari ragazzi e ragazze, riguardo all'aspettativa, fidatevi di me: le competenze attirano naturalmente le opportunità di finanziamento; costruendo una competenza, quello che state facendo ogni giorno con il vostro lavoro al WiLab, si generano opportunità. Si tratta di tenere occhi ed orecchie aperte e non tirarsi indietro quando una opportunità si palesa. L'esigenza di strumentalità è quella che mi ha spinto a proporvi incentivi economici, di cui parleremo più tardi, per chi si propone come portatore di opportunità; la ragionevole garanzia di un compenso a fronte dell'opportunità generata. Per quanto riguarda la valenza, spetta a voi indicare al Direttore quanto tali incentivi possano contribuire a migliorare le vostre condizioni economiche, il vostro benessere e quindi avere, per voi, valore.

(omissis: la restante parte della memoria è riservata ad uso dei dipendenti)

CONSIDERAZIONI CONCLUSIVE.

Formulo gli auguri più sentiti al nuovo Direttore, che sono certo opererà con continuità rispetto allo spirito con cui il WiLab è stato costituito, con la capacità di portare il Laboratorio oltre i successi già conseguiti.


WILAB


Andrea Conti

02 WiLab in a NUTSHELL

Research Areas

Frontiers of Wireless Communications
Area Leader: Andrea Conti
Theoretical research activities with a long-term perspective or transversal to several application domains.

Large-Scale Wireless Networks
Area Leader: Riccardo Marini
Theoretical and experimental research activities on technologies typical of large-scale scenarios.

Small-Scale Wireless Networks
Area Leader: Giampaolo Cuozzo
Theoretical and experimental research activities on technologies typical of small-scale scenarios.

WiLab Numbers

No. of Employees: **16**

No. of Affiliates: **65**

No. of Active Projects: **20**

No. of WiLab Sites: **14**

No. of Foreign WiLab Sites: **1**

PH Giovanni Bortolani

HEADQUARTERS

VIA NANNI COSTA 20
BOLOGNA, ITALY

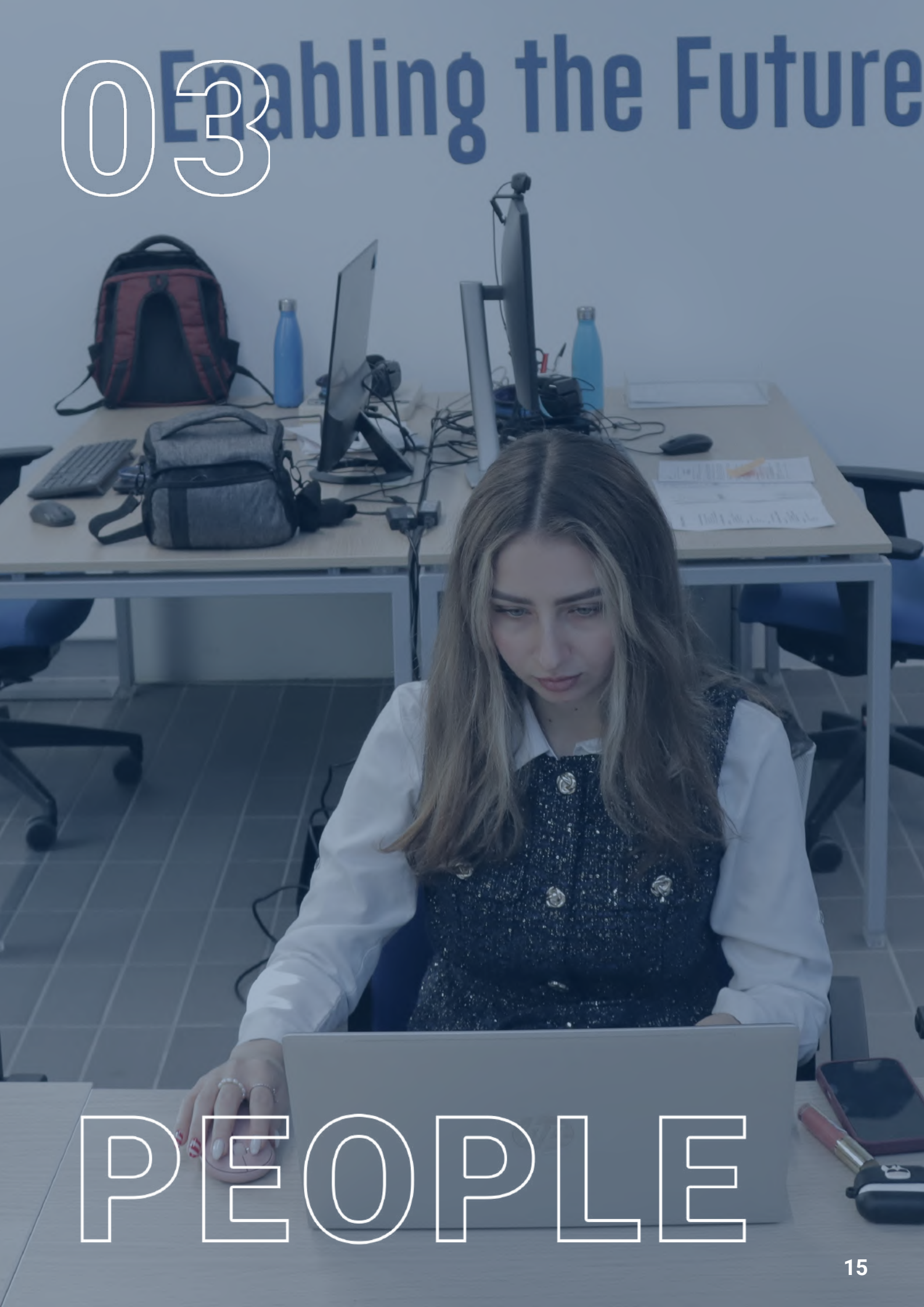
WiLab Sites

Administration Office: CNIT, Viale G.P. Usberti, 181/A Pal.3, 43124 Parma

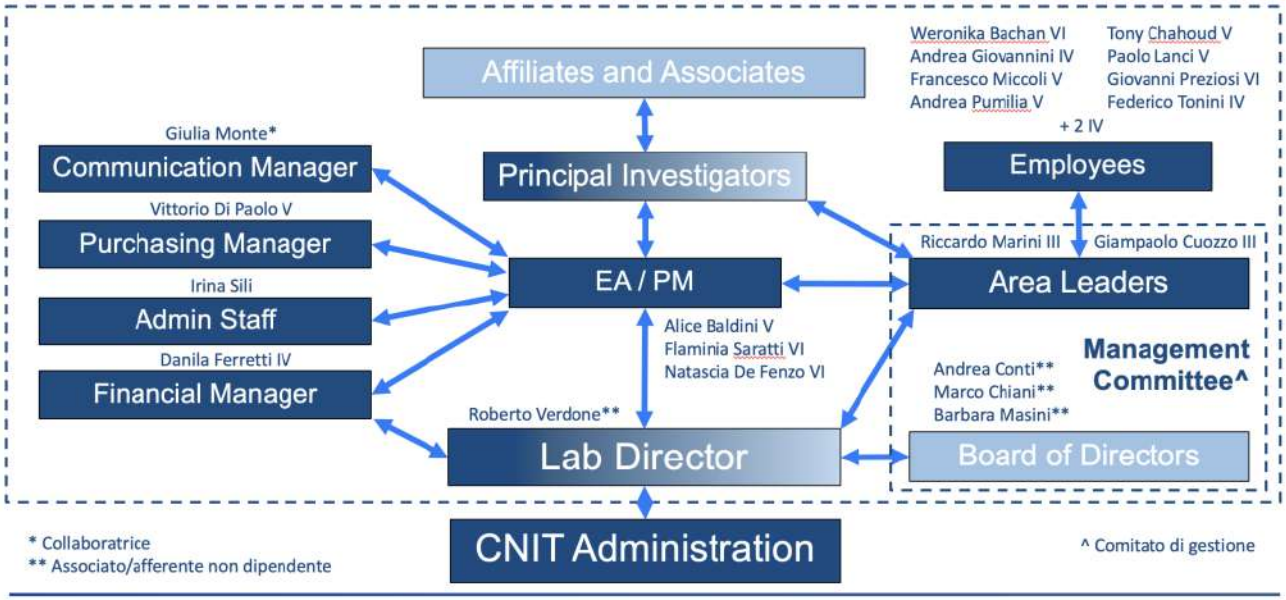
Headquarters: Via Paolo Nanni Costa 20, 40133 Bologna

Founding sites: University of Bologna, University of Bologna – Cesena Campus, University of Ferrara, CNR/IEIIT-Bologna

Other sites: University of Padua, University of Genoa, University of Siena, University of Pisa, La Sapienza University of Rome (UniRoma1), Rome Tor Vergata (UniRoma2), University of Cassino and Southern Lazio, University of Pavia, University of Malaga (ES)



03 PEOPLE



Board of Directors

Marco Chiani

Andrea Conti

Barbara Masini

Roberto Verdone

Associate Emeritus

WiLab inherits scientific competencies and technical background gathered along the past forty years through the work of its founder, Prof. **Oreste Andrisano** of the University of Bologna.

EMPLOYEES

Weronika Bachan

Alice Baldini

Tony Chahoud

Sara Cavallero

Giampaolo Cuozzo

Natascia De Fenzo

Vittorio Di Paolo

Yulia Fedchyshyna

Danila Ferretti

Andrea Giovannini

Riccardo Marini

Francesco Miccoli

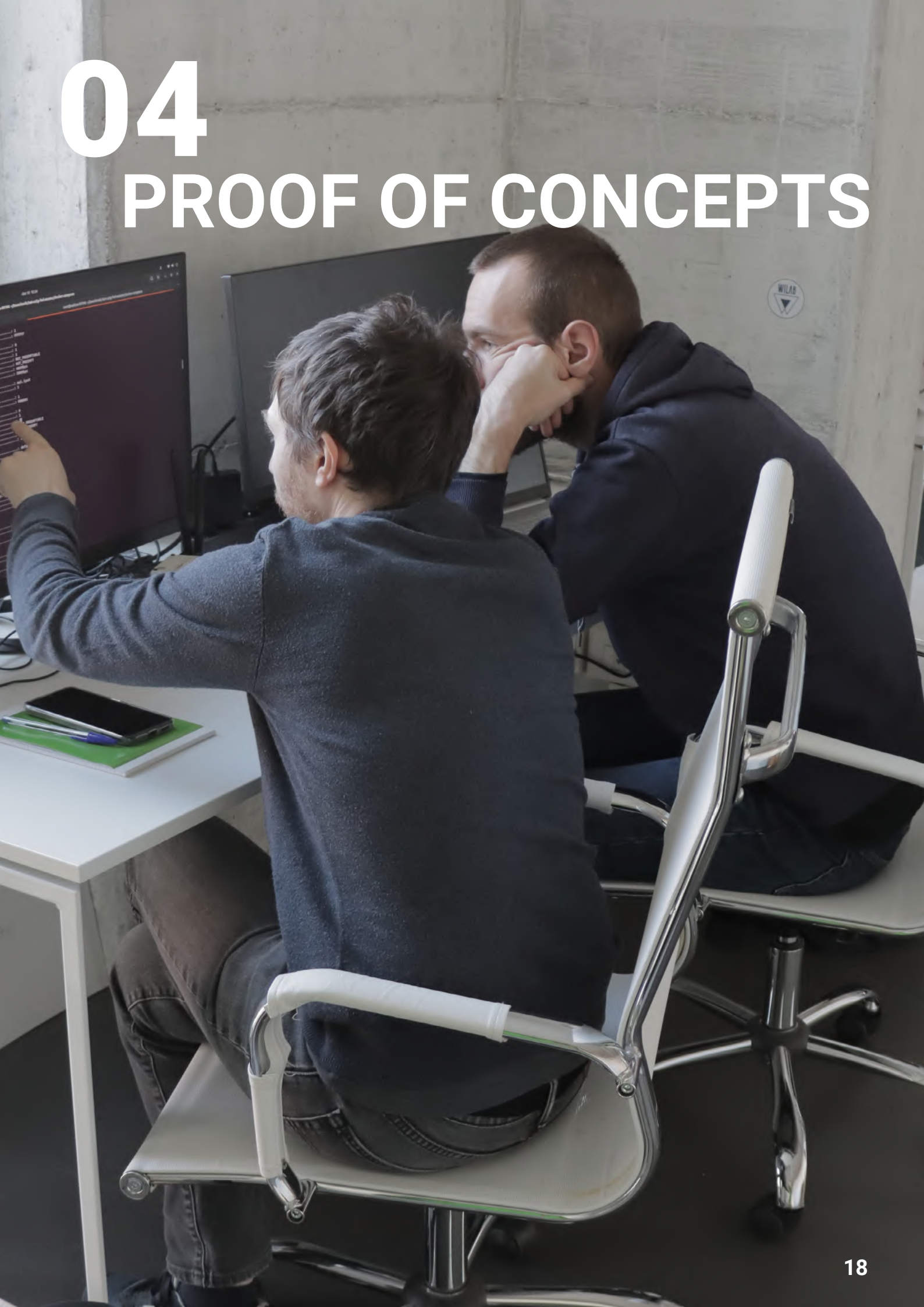
Claudio Nappi

Flaminia Saratti

Irina Sili

Federico Tonini

04
PROOF OF CONCEPTS



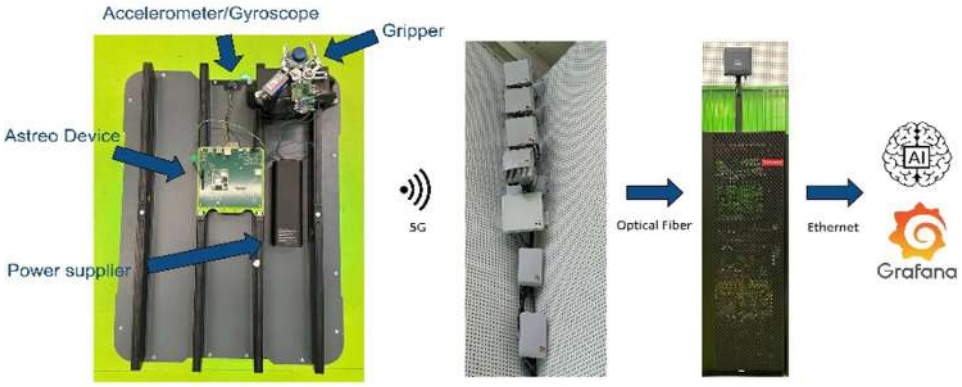
Detection and Prevention of Hazardous Liquid Drop Using 5G and AI

Responsible
Giampaolo Cuozzo

Partners
BI-REX,
University of Bologna

Use-case
Autonomous Mobile Robots carries dangerous liquids in industry plant without mechanical support

Solution
Collect real-time movements data via 5G and utilize AI to predict and avoid liquid spills by means of an ad-hoc gripper mounted on the AMR of the BI-REX pilot line



Block scheme

A screenshot of the output

A photo of the experiments

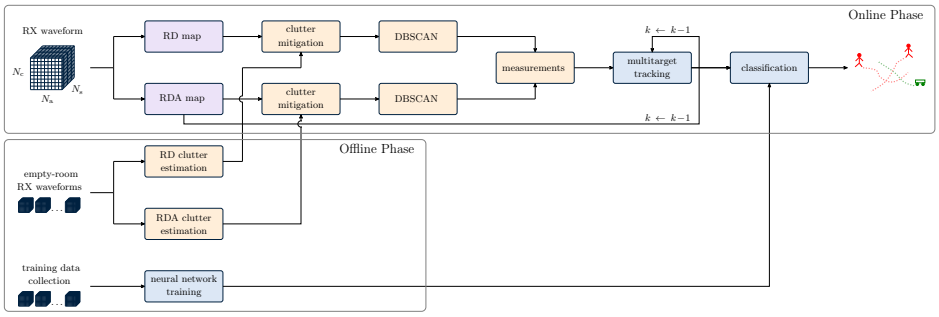
Tracking and Identification of Multiple Targets Via mmWave MIMO Radar

Responsible
Andrea Conti

Partners
BI-REX,
University of Ferrara

Use-case
Perform high-accuracy identification and tracking of multiple device-free targets

Solution
Use a single MIMO radar operating at mmWaves to perform sensing based on the analysis of the backs-cattered electromagnetic waves



Block scheme

A screenshot of the output

A photo of the experiments

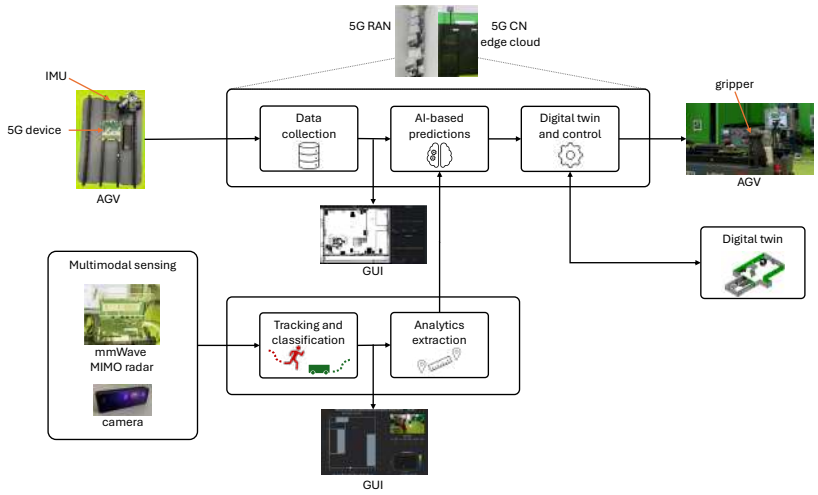
AI-based integrated sensing, communication, and control in industrial environment

Responsible
Andrea Conti, Giampaolo Cuozzo, Riccardo Marini

Partners
BI-REX , University of Ferrara

Use-case
Safety in industrial environments

Solution
The integration of sensing, communication, and control is essential to enable new applications and to provide efficient resource management in next-generation networks. This work developed a framework to integrate and process situational data (including tracking and classification) of objects moving in an industrial environment. Multimodal sensing using a single mmWave radar together with a camera, AI-based predictions derived from real-time motion data, and control of movement for industrial AGV are demonstrated at BI-REX premises. The outcomes of sensing and prediction are provided as input of a network digital twin for enhanced digital representation of the wireless environment and efficient networked task management. In particular, real-time statistical weighting of situational-awareness information obtained from multimodal sensing combined with AI-based predictions of BI-REX AMR motion, in order to enhance the reliability of the commands sent by the dedicated 5G network to control with low-latency the custom on-board gripper mounted on the AMR through a microservice-based architecture. The system feeds an operational digital twin of the AMR that fuses realtime sensing with AI-based predictions, thus enabling validation, diagnosis, and optimization of 5G control commands before execution on the robot.



Block scheme

A photo of the experiments

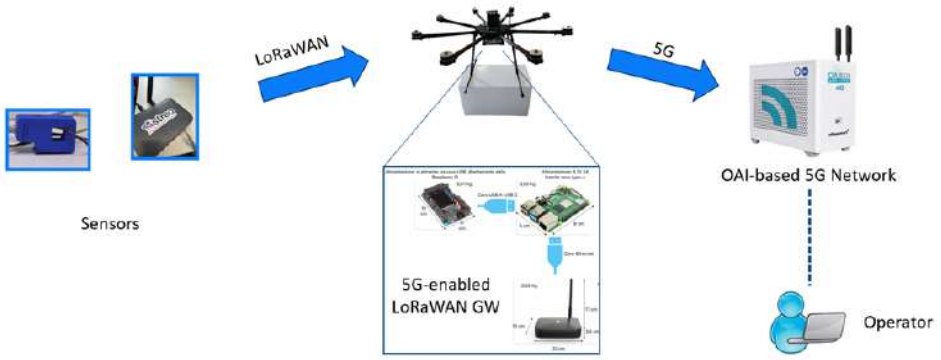
A screenshot of the output

UAV-based Coverage Extension

Responsible
Riccardo Marini

Use-case
Extended wireless connectivity in coverage-limited or capacity -limited areas

Solution
Exploit drones with on-board radio equipment to cooperate with terrestrial network to offer service



Block scheme

A photo of the experiments

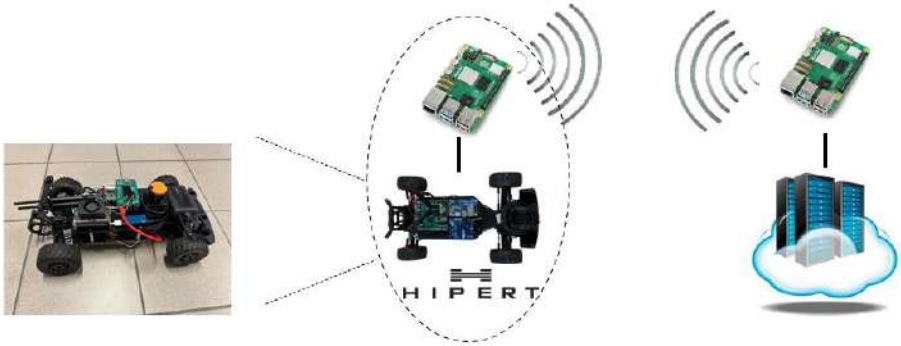
Vehicle-to-Infrastructure communications for seamless mobility

Responsible
Alessandro Bazzi

Partners
UNIBO, CNR, GSSI, HIPERT, POLITO, RADIO-LABS, UNIAQ, UNIMORE, UNIPD, WIND3

Use-Case
Autonomous driving

Solution
F1Tenth minicars exchange data using ETSI C-ITS–compliant vehicle-to-infrastructure wireless communications, enabling them to move autonomously without the need to stop along an 8-shaped track.



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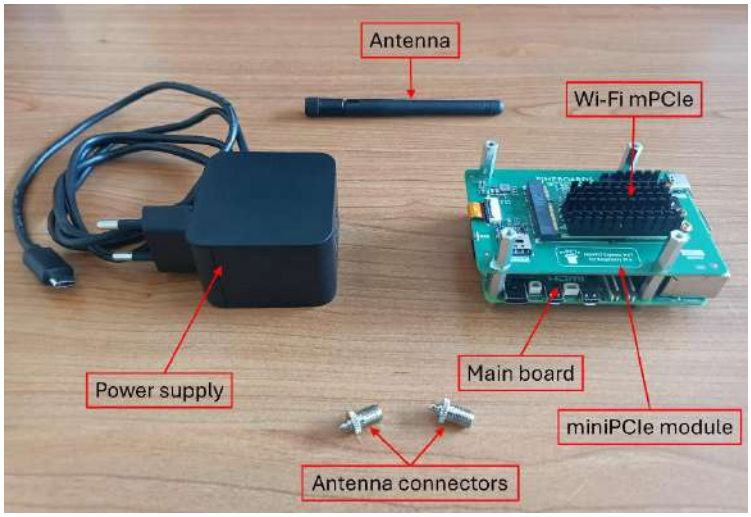


A photo of the experiments

05

CURRENT ACTIVITIES

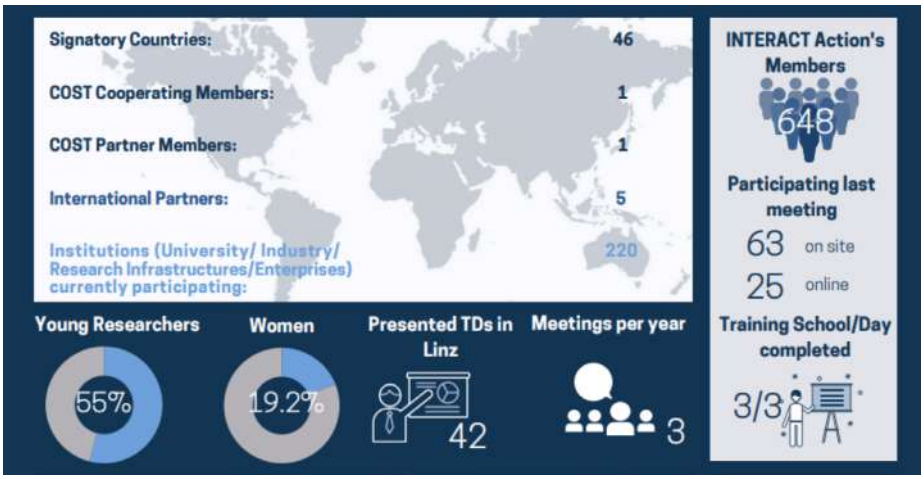
COST - INTERACT international meeting in Lille

The Action aims to achieve scientific breakthroughs by introducing novel design and analysis methods for making future radio communication networks intelligent, meaning aware, adaptive and parsimonious, and contributing to the creation of intelligent environments.

Involved countries

Albania, Algeria, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, China, Colombia, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Kosovo, Lithuania, Luxembourg, Macedonia, Malta, Montenegro, Netherlands, Norway, Pakistan, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Tunisia, Turkey, Ukraine, United Kingdom, United States of America

COST - INTERACT international meeting in Lille



PI
Prof. Laurent Clavier,
University of Lille, France

Funding Institution
COST Association, EU

Project Duration
2021-2025

6G SHort range extreme communication IN Entities (6G-SHINE)

6G-SHINE is a European Smart Networks and Services Joint Undertaking (SNS JU) project (stream B) which is led by the Aalborg university and foresees a consortium of both academia and industries from all over Europe.
The 6G-SHINE project develops in-X wireless subnetworks, short-range, low-power radio cells to support extreme communication needs in areas like robotics, vehicles, production, and classrooms. The in-X concept is summarized in Figure 1.
6G-SHINE pursues its targeted breakthrough by focusing on eight constituent objectives:

1.Define relevant application scenarios, use cases and architectures for in-X subnetworks, and analyze related performance requirements.
2.Characterize the radio propagation channel in the short range scenarios and frequency bands of interest.
3.Design new physical layer enablers for scalable requirements in terms of latency, reliability or throughput, tailored to resource-constrained devices.
4.Develop new effective Medium Access Control (MAC) solutions for efficient multiplexing of diverse traffic types in a subnetwork, including deterministic traffic.
5.Develop cost effective centralized, distributed or hybrid radio resource management techniques in hyper-dense dynamic subnetwork deployments.
6.Develop new methods for integration of subnetworks in the 6G architecture and efficient orchestration of radio and computational resources among subnetworks and wider network.
7.Validate the most promising technology components via Proof-of-Concepts (PoCs) in laboratory facilities.
8.Generate a substantial portfolio for pre-standardization, publications, workshops, and intellectual property filings.

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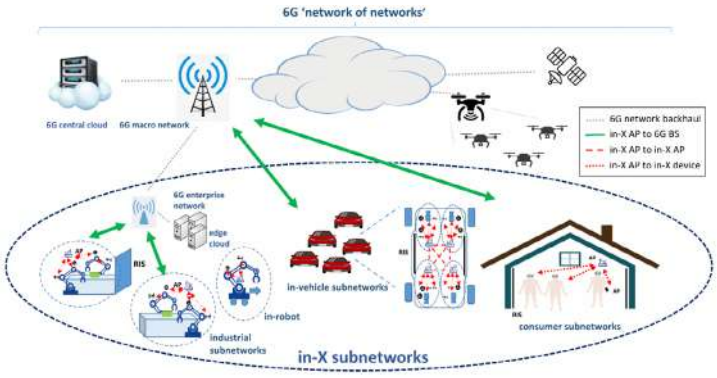
In this project, WiLab actively works on fulfilling objectives **2**, **3, 4, 7** and **8**. In this project, WiLab actively worked on fulfilling objectives 2, 3, 4, 7 and 8. In particular, WiLAB has: i) conceived novel antenna arrays based on self-conjugating metasurfaces, which can automatically retrodirect the impinging signals in the same direction and modulate it at the same time, reducing beam alignment delays down to <20 microseconds, and reducing digital signal processing complexity and energy consumption; ii) introduced the concept of dynamic scattering arrays (DSA), where the signal processing tasks required to implement beamforming and precoding in multiple-antenna multiple-node scenarios are moved from the digital to the electromagnetic domain. Compared to current MIMO digital and hybrid technology adopted in 5G systems, a power reduction > x10 has been achieved with near-zero latency without sacrificing the processing flexibility; iii) Designed coded random access techniques ensuring low latency constraints and low packet error probabilities; iv) experimentally characterized and modeled the wireless propagation in sub-networks (e.g., inside-outdoor cars) at mmWave and sub-Thz bands; iv) measured and modeled reconfigurable intelligent surfaces (RIS) for implementation in ray-tracying tools (e.g. NVIDIA Sionna); vi) Studied a new multiport network approach exploiting only statistical CSI and ensuring near-optimal performance while minimizing reconfiguration complexity and control overhead in a RIS-enabled scenarios



Schematic representation of main concept of the 6G-SHINE project.

PI
Prof. Gilberto Berardinelli, Aalborg Universitet, Denmark, WiLAB coordinator: prof. Davide Dardari

Funding Institution
European Smart Networks and Services Joint Undertaking / European Commission

Project Partners
AAU, APPLE, BOSCH, COGN, CNIT/WILAB, FHG, IDE, IMEC, KEYSIGHT, NOKIA, SONY, UMH.

Project Duration
2023 – 2025

Involved Countries
Belgium, Denmark, Finland, Germany, Greece, Italy, Spain, Sweden, United Kingdom

Large-scale simulations of wireless technologies supporting collective perception (Car2Car)

The project focuses on a scenario where all vehicles are connected and cooperative, and they share the information obtained by their sensors using direct V2X communications. This information sharing is called collective perception and will enable future cars and roadside units to share their local view of the surrounding objects and people. This will in turn increase the horizon of the perception of the vehicles beyond their own sensors, as in the example shown in Figure 1. In this context, an open issue is how to trade-off the possibly large number of objects to be shared, which may imply many sizeable packets, and the limited spectrum available. The project aims at using real datasets to infer the information that could be generated and use it in the network simulator WiLabV2Xsim to assess the performance of the two radio technologies that are today being considered for direct V2X communications, namely the WiFi-based ITS-G5 and the cellular sidelink (in the 5G NR-V2X version).

An example of the collective perception service, where a car and a camera mounted over an intersection detect a pedestrian crossing the road and alert another car approaching with low visibility.

PI
Prof. Alessandro Bazzi, University of Bologna

Funding Institution
Car2Car Communication Consortium

Project Partners
University of Modena and Reggio Emilia

Project Duration
2025

Involved Countries
Italy

Cellular IoT and DALI Standard for Smart-Cities Lighting Control Systems (CIDS)

Modern smart-city infrastructures require robust, scalable lighting control systems (LCS) that can adapt to rapidly changing environmental and traffic conditions. This project focuses on creating a point-to-point lighting control solution with integrated Cellular IoT capabilities, designed global and reliable communication. The aim is to enable seamless telecontrol of individual lighting units, achieving greater efficiency and flexibility in urban lighting management. This solution is developed to meet the Digital Addressable Lighting Interface (DALI) standard, a key requirement in the lighting industry that ensures interoperability and standardized control mechanisms. Key project activities are:

- **Adherence to DALI Standards:** Ensuring all components of the software protocol stack is fully DALI-compliant, to support integration with existing lighting systems in urban infrastructure.

- **Exploration of Cellular IoT Technologies**: Detailed analysis and testing of SoM and SoC manufactured by industry-leading companies, assessing performance, energy consumption, and ability to be customized to the project purpose considering also future optimization for Scalability and Cost-Efficiency. .

Project Scenario

PI
Dr. Riccardo Marini, WiLab, CNIT

Funding Institution
Trailslight Srl

Involved Countries
Italy

Development of standards for direct V2X Radio Resource Management (V2X-RRM)

Over the past decade, ETSI has developed a comprehensive set of standards for Cooperative Intelligent Transport Systems (C-ITS), aimed at enabling vehicles and roadside devices to exchange information to enhance road safety and traffic efficiency. While deployment in Europe has begun based on the Release 1 C-ITS standards, work is now progressing towards Release 2. This new phase introduces a significant expansion of shared information and supported services, making efficient use of radio resources increasingly critical. Within this project, carried out by a Specialist Task Force funded by ETSI, new standards are being designed to manage multiple available channels, prevent congestions in them, and optimize traffic distribution across them.

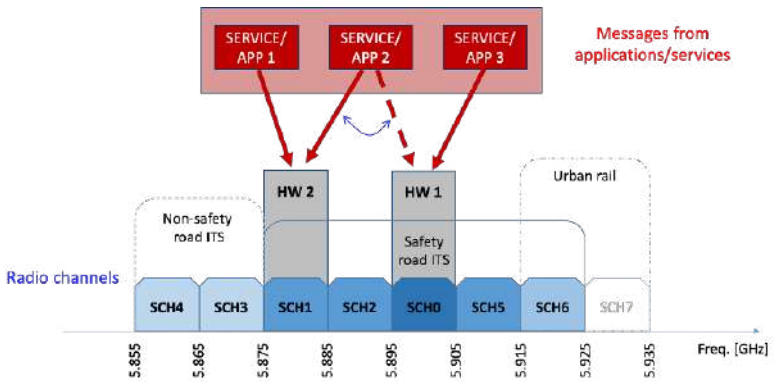


Image representing the dynamic allocation of messages to the different radio channels.

PI
Prof. Alessandro Bazzi, University of Bologna

Funding Institution
ETSI

Project Partner
Innomo, FBConsulting SARL, Università di Bologna, Universitad Miguel Hernandez de Elche, Kapsch, Technische Hochschule Ingolstadt

Project duration
2023 – 2026

Involved Countries
Hungary, Germany, Italy, Spain, Austria

Casa delle Tecnologie Emergenti (CTE)

CTE is an Italian initiative aimed at establishing a distributed center for the development of emerging technologies and fostering innovative entrepreneurship by supporting startups and Small to Medium-sized Enterprises (SMEs) through dedicated funding opportunities. The program is divided into various projects, and WiLab is actively participating in the CTE COBO project, which focuses on the Emilia-Romagna region and is led by the Metropolitan City of Bologna.

The objective of CTE COBO is to demonstrate the benefits of integrating Information and Communication Technologies (ICT) across the three primary application domains illustrated in Figure 1. Specifically, the technologies envisioned by CTE COBO include 5G/6G, Artificial Intelligence (AI), the Internet of Things (IoT), edge-cloud computing, blockchain, augmented/virtual reality, quantum technology, and high-performance computing.

- **Industry 4.0**

  1.An emergency system that enhances the safety of human workers by preventing the spillage of hazardous liquids from an Autonomous Mobile Robot (AMR) of BIREX, using AI-based predictions applied to real-time data collected via 5G.
  2.Remote control of a machine controller through an open-source 5G network.
  3.Real-time localization and tracking of multiple targets using various technologies (5G, UWB, radar).
  4.Evaluation of 5G coverage and quality of service within the BIREX pilot line to optimize device placement.

- **Urban Services**

  1.Utilization of an Unmanned Aerial Vehicle (UAV) for automated monitoring of marine signaling buoys using LoRaWAN and 5G.

- **Cultural and Creative Industry**

  1.Monitoring and assessments of artists' and athletes' performances through Bluetooth and 5G

Besides the research and development activities, WiLab is also involved in the following Work Packages:
WP1: Kick-off and Strategic Design of the CTE
WP2: Setup and Management of Spaces
WP4: Technology Transfer and Services for SMEs
WP7: Activation and Animation of Spaces
WP8: Project Management 8.

The three applications domains for PoC developments in the CTE project.

PI
Metropolitan city of Bologna

Funding Institution
Ministry of Enterprises and Made in Italy

Project Partners
ALMACUBE, ART-ER, BIREX, CINECA, CITY OF BOLOGNA, CITY OF RAVENNA, CREATIVE HUB, G-FACTOR, GELLIFY, MEDIA GROUP, METROPOLITAN CITY OF BOLOGNA, SEARCH ON, START 4.0, TIM, UNIBO.

Project Duration
2023 – 2025

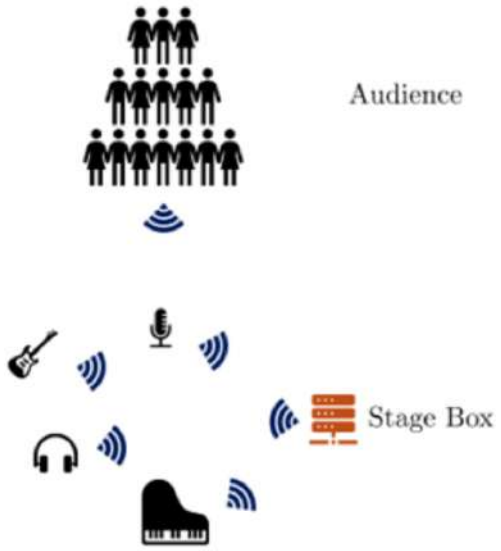
Involved Countries
Italy

Short-range Wireless Communications for Live Concerts (WCLC)

The **WCLC** project is funded by EnverAudio, a Small-to-Medium Enterprise (SME) participating in the Lazioinnova initiative. As part of the latter, EnverAudio proposes a wireless system designed to eliminate all audio cables on a stage for live musical events. This is a hardware and software system composed of a network of wireless sensors, with a central node known as the "Stage Box." Its role is to orchestrate and manage the wireless audio signals coming from the sensors. The sensors are placed on any object on the stage that sends or receives audio signals (for instance, a musical instrument or speaker, respectively). The Stage Box receives signals from input sensors and sends them to output sensors. The signal routing can be configured by the sound engineer according to stage requirements.

In this framework, the WCLC project aims to perform the following activities:

- Technology scouting of leading wireless solutions (e.g., Wi-Fi, Ultrawideband, Bluetooth) for short-range communications, taking into account the main system requirements characterizing the "Stage Box" ecosystem (e.g., stage layout, number of nodes, communication flows, power consumption, latency).
- Study of primary models for channel characterization for wireless communications on stage.
- Model-based evaluation of area coverage for wireless communications on stage.
- Model-based evaluation of interference effects and coexistence for wireless communications on stage.
- Definition of radio network requirements for live event applications.
- Identification of radio network protocols for wireless stage communications.
- Development of a radio network simulator for performance estimation of wireless stage communications.



Reference conceptual scheme of the WCLC project.

PI
Prof. Marco Chiani,
University of Bologna

Funding Institution
EnverAudio

Project duration
2024 – 2025

Involved Countries
Italy

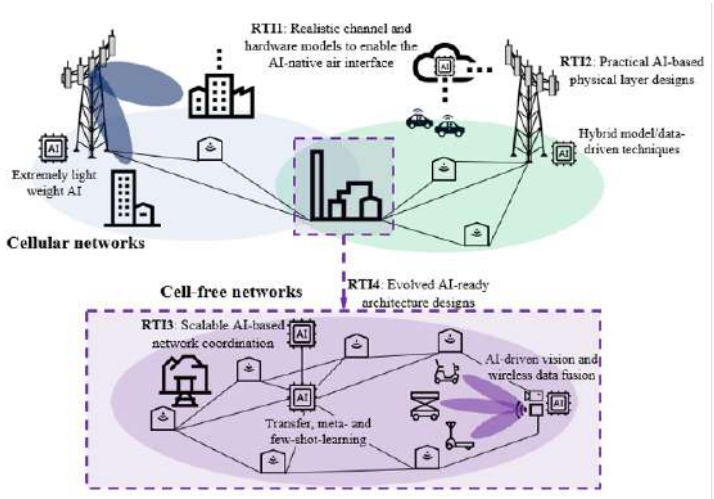
Machine Intelligence Based Radio Access Infrastructure (6G-MIRAI-HARMONY)

Wireless communication systems face mounting demands for higher data rates, reduced latency, and improved reliability. These challenges are intensified by the increasing range of applications such as collaborative robotics, full industrial automation, real-time digital twinning, and immersive virtual reality, all while ensuring economic and ecological sustainability.

To meet these demands, **6G-MIRAI** aims to:
- Develop advanced multi-antenna technologies like user-centric cell-free massive **MIMO**.
- Address the practical limitations of **AI/ML** implementation in wireless communications.
- Enable scalable, energy-efficient network solutions.

The project represents a collaborative effort between leading European and Japanese academic institutions and industry experts. WiLab contributes by developing innovative distributed and centralized solutions to support the deployment and operation of user-centric, cell-free massive MIMO networks.

Reference industrial scenario and key technological enables of the TIMES project. The following figure visualizes the three main innovation pillars of TIMES: The 6G-MIRAI-HARMONY project is structured around five Research and Technology Items (RTIs) to achieve its objectives:
1. **RTI1**: Develop realistic models and datasets to serve as the foundation for innovative technological solutions.
2. **RTI2**: Focus on enabling AI/ML techniques for key physical layer components, ensuring reliability, robustness, and scalability.
3. **RTI3**: Explore AI-driven solutions for efficient coordination of physical layer components, higher-layer functions, and control planes, especially in cell-free networks.
4. **RTI4**: Provide design guidelines for AI-ready 6G-RAN architectures, leveraging the solutions from RTI2 and RTI3.
5. **RTI5**: Investigate methodologies for data management, testing, and validation, integrating inputs from RTI1, RTI2, and RTI3.



PI
Prof. Luca Sanguinetti, University of Pisa

Funding Institution
European Smart Networks and Services Joint Undertaking / European Commission

Project Partner
Ericsson France, Fraunhofer HHI, Apple, Telefonica, Sequans, ISWireless, University of Pisa, KULeuven

Project Duration
2025 – 2028

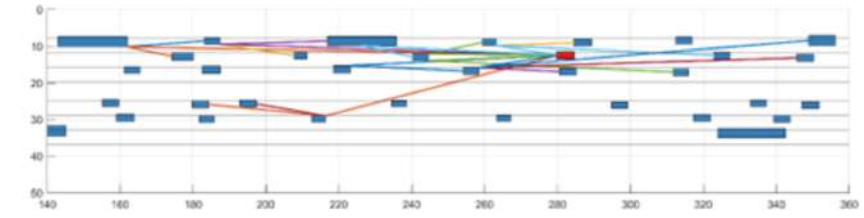
Involved Countries
France, Germany, Italy, Spain, Belgium, Poland

Next-generation Automotive Radar (NAR)

Vehicles are increasingly equipped with advanced driver-assistance systems (ADAS) sensors that help reduce road risks and accidents. Among them, radar sensors play a key role due to their affordable cost and high effectiveness in object detection and tracking. However, with increasing penetration, radar signals generated by different vehicles can create interference and this may have a detrimental impact on the functionality. This observation is leading to a discussion about the need for new bands and mitigation rules.

The Project, which is in its third year of activity, aims at investigating the impact of interference between radars in realistic dense scenarios with high penetration of radar systems and to analyze possible mitigation methods. The focus includes the use of new bands at 140 GHz and both Frequency Modulated Continuous Waveform (FMCW) and Orthogonal Frequency Division Multiple access (OFDM). The first point was to create realistic mobility scenarios generated using the traffic simulator SUMO; an example snapshot is reported in Figure 1, where vehicles in a highway with three lanes per direction all mount a front radar; in the figure, the radar of the red vehicle suffers from the interference from a large number of sources (directly or after a reflection), which are indicated by the colored lines.

During the Project, two types of studies were conducted, one concentrating on a network level using FMCW and the other deepening the effects at the receiver with both types of signals. The network level investigation compared, from a statistical point of view, the effectiveness of some of the possible mitigation methods, with analytical models and a dynamic simulator, for the moment limited to FMCW and correlated interference. The second one concentrated on specific worst-case situations and compared the performance of FMCW or OFDM, with or without basic mitigation methods.



An exemplary snapshot of the inter-vehicle interference assessment within the ADAS scenario tackled in the NXP project.

PI
Prof. Alessandro Bazzi, University of Bologna

Funding Institution
NXP

Project Partners
CNIT/RaSS

Project duration
2023– 2026

Involved Countries
Italy, France

ML-based RAN Performance Optimization (MLRAN)

The project advanced latency modelling and prediction in the 5G RAN downlink. The goal was to create an AI-driven predictive framework providing latency-reliability estimates by leveraging cell-level KPIs, enabling proactive latency management for the mobile network operator (MNO) with the ultimate aim of optimizing RAN performance.

Key Outcomes:

Full-Stack Analysis: Identified critical RAN delay phases through a detailed study of the 5G QoS architecture at the user-plane level, offering insights for latency mitigation.

Statistical Latency Modelling: Applied queuing theory to characterize latency distribution, revealing further criticalities affecting RAN-level latency.

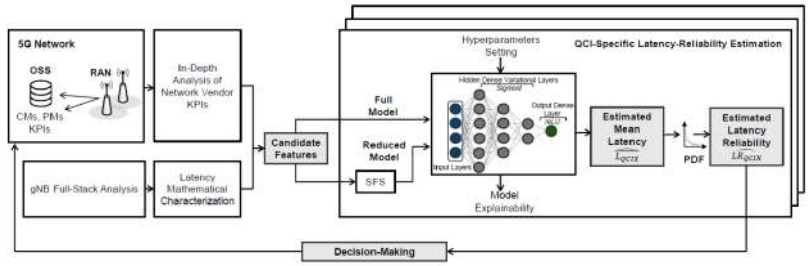
KPI Mapping: Mapped RAN delay stages to vendor-monitored KPIs, defining candidate input features for the ML-based framework to estimate latency and enabling targeted MNO interventions.

Service-Specific Models: Correlation analysis highlighted the need for distinct models per service class, improving prediction accuracy.

Latency-Reliability Framework: Developed a service-specific, data-driven framework to estimate mean latency and leverage the latency distribution knowledge to derive latency-reliability estimates.

SHAP Analysis: Highlighted KPI relevance during the prediction process and uncovered unexpected feature relationships. As SHAP assumes feature independence, issues like multicollinearity must be further investigated. Future work will explore interpretability analyses that do not assume feature independence.

In parallel, within TIM's Open SMO Framework, a standardization procedure for KPI nomenclature across vendors was carried out. Conducted in TIMatom's sandbox, this initiative ensured data consistency, streamlined analytics, and optimized network operations across TIM's multi-vendor infrastructure.



System Model

PI
Prof. Alessandro Bazzi, University of Bologna

Funding Institution
NXP

Project Partners
CNIT/RaSS

Project duration
2023– 2026

Involved Countries
Italy, France

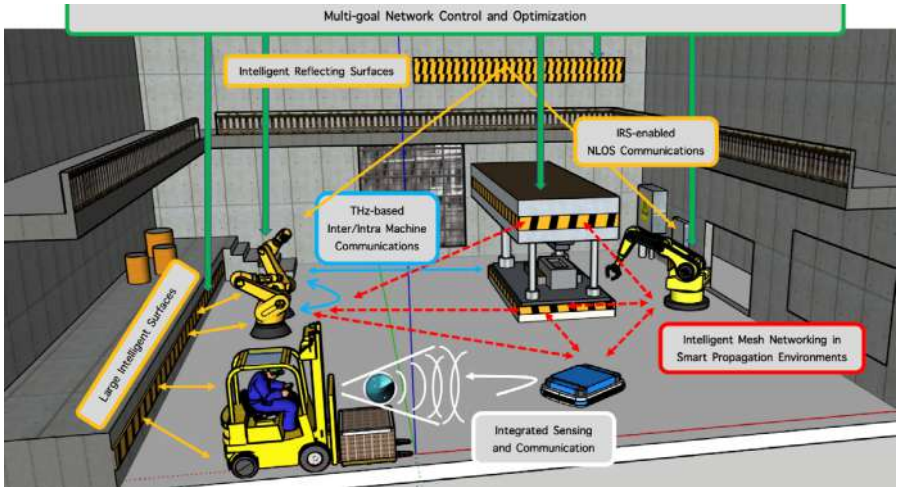
THz Industrial Mesh Networks in Smart Sensing and Propagation Environments (TIMES)

TIMES is a European Smart Networks and Services Joint Undertaking (SNS JU) project (stream B) which is led by WiLab and foresees a consortium of both academia and industries from all over Europe.

TIMES focuses on a THz-based smart radio ecosystem designed for industrial environments, as illustrated in Figure 1. This framework incorporates a large number of heterogeneous wireless devices capable of delivering data rates in the terabits-per-second (Tbps) range, along with ultra-low latency, advanced sensing, and high reliability—achieving performance comparable to wired networks and surpassing the capabilities of current wireless technologies. These advancements facilitate the implementation of demanding, co-located industrial use cases such as digital twinning, real-time robotic management, and predictive maintenance.
TIMES pursues its targeted breakthrough by focusing on eight constituent objectives:

1. Derivation of new THz channel models based on measurements in industrial scenarios
2. Design of novel solutions at the physical (PHY) and medium access control (MAC) layers
3. Design and implementation of THz front-ends and antennas
4. Design of a multi-goal mesh-based radio access network (RAN) composed of active nodes and intelligent reflecting surfaces (IRSs)
5. Design and fabrication of IRSs operating at THz frequencies
6. Integration of sensing and communications functionalities
7. Definition of use cases and requirements for future industrial applications
8. Realization and validation of a PoC in real industrial environments

WiLab is deeply involved in achieving most of these objectives, excluding those focused on hardware manufacturing and measurement activities. The innovations of TIMES are not only scientific; they improve THz device fabrication, create business opportunities, and promote safer, more efficient industrial environments.



Reference industrial scenario and key technological enables of the TIMES project.

PI
Prof. Luca Sanguinetti, University of Pisa

Funding Institution
European Smart Networks and Services Joint Undertaking

Project Partners
AETNA, ANT, BIREX, CNRS, FRAUNHOFER, HWDU, TNOR, TUBS, USTUTT

Project duration
2023– 2025

Involved Countries
France, Germany, Italy, Norway, Spain

Advanced Industrial Use-Case Analysis and 5G Connectivity Assessment (AURA-5G)

The **AURA-5G** project aims to explore the potential of 5G technology in industrial environments by analyzing innovative use cases, evaluating their technical requirements and associated benefits, and assessing the real-world implementation of 5G-based industrial applications both in Europe and Italy. WiLab, commissioned by BI-REX to conduct this study as part of a broader initiative led by Qualcomm and TIM, has carried out a feasibility analysis addressing the following points:

- Identification and classification of innovative industrial use cases;

- Definition of the corresponding technical performance requirements;

- Assessment of the benefits of 5G compared to other radio connectivity solutions;

- Examples of 5G trials and experimentation in Europe;

- Examples of 5G trials and experimentation in Italy.

Most important Key Performance Indicators (KPIs) of 5G for Industrial Applications. .

PI
Dr. Giampaolo Cuozzo, WiLab, CNIT

Funding Institution
BI-REX

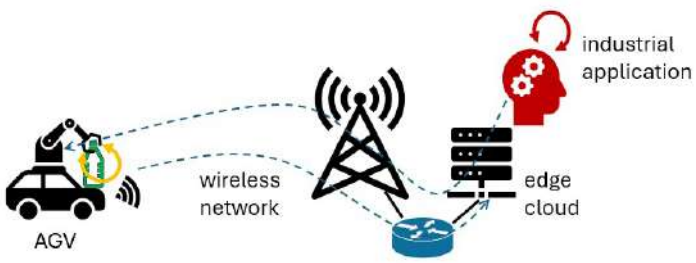
Project duration
2025

Involved Countries
Italy

Edge Cloud Applications in Industrial Networks (EDGE)

Industrial networks enable communication between machines, sensors, and remote control systems, enabling automation in modern industrial environments. Thanks to this connectivity, widespread data collection is possible across the production floor. Digital twins further extend these capabilities by creating virtual representations of the environment, including the physical assets and networks. This, in turn, can lead to a better optimization of industrial operations. This project aims to evaluate the role of edge computing in industrial applications, providing practical insight into expected benefits, operational constraints, and suitable architectural approaches. The outcomes will support future deployments, enabling advanced digital services aligned with modern Industry 4.0 frameworks.

The work conducted this year includes an analysis of the main industrial use cases and their requirements and constraints. A performance analysis of different edge-cloud architectures for industrial networks has been performed to understand their applicability. Numerical measurements have been combined with theoretical models to develop a model for estimating the performance achievable in various edge-cloud scenarios. The activities also explored the key factors for integrating network digital twins with edge-computing capabilities



Example of a robotic application leveraging an industrial network.

PI
Dr. Federico Tonini,
WiLab, CNIT

Funding Institution
FiberCop Spa

Project Partners
University of Bologna

Project duration
4 months

Involved Countries
Italy

JOINT INNOVATION CENTRE

The WiLab-Huawei Joint Innovation Centre on “6G for IoT” started its activities in March 2021, based on a five-year contract. While approaching the end of this first phase, it is already agreed that the goals and activities of the JIC will be extended for five more years. This testifies the excellent results achieved so far, an accomplishment made possible by the enthusiasm and excellence of WiLab researchers and the great collaboration spirit set by the two institutions. The JIC activities in the past years have been mostly of theoretical nature. However, some experimental Proof-of Concepts have also been developed; among them, the pictures below show the first demonstration of a pre-6G joint communications and sensing platform, used to measure the incline of the Garisenda tower, performed in Bologna (September 2025).

Endorsed by

HUAWEI

3D Networks (3DN)

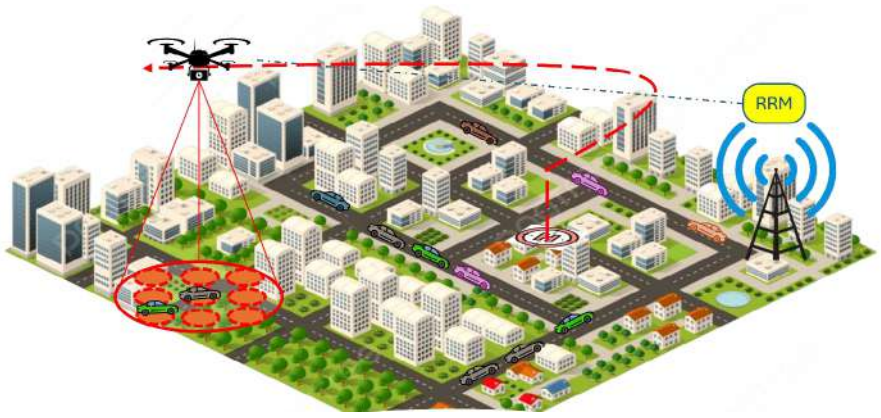
Future mobile networks require a degree of flexibility that will be achieved through a number of technologies, including the use of UAVs (Unmanned Aerial Vehicle) carrying Base Stations (UABS). This project focuses on applications where UABS are used to serve vehicles roaming in the city, which might benefit from highly reliable link toward the UABS. In these scenarios, the UABS trajectory design problem becomes particularly important, as the dynamism of the users in a particularly complex scenario requires readily adapting to network conditions, and the mobility of a swarm of drones requires coordination. At the same time, UABSs must cooperate with the already deployed terrestrial network to maximize performance, both in terms of coverage and capacity. To do this, the project developed techniques based on reinforcement learning and optimization algorithms.

This project is the continuation of the previous JIC projects on 3D Networks, and it exploits all results achieved in the previous three years. The activity in 2024 mainly focused on:

- Study distributed multi-agent reinforcement learning algorithms for trajectory design and radio resource management

- Design of novel meta learning tools for faster adaptation of the multi-agent model to different scenarios, represented by changes in the service areas considered.

- Introduction of the concept of ISAC in UABSs scenarios.



A UABS moves in a urban environment and cooperates with the terrestrial base station to provide service to vehicular users.

PI
Dr. Riccardo Marini,
WiLab, CNIT

Funding Institution
Huawei

Project Partners
University of Bologna

Project Duration
2024 - 2026

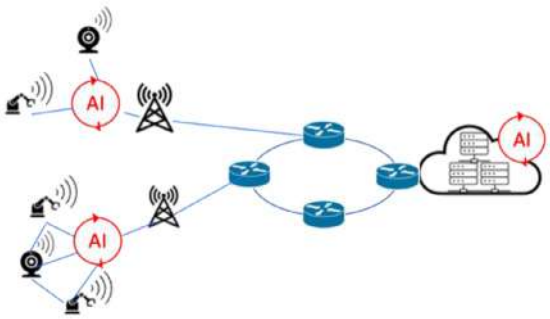
Involved Countries
Italy

Intelligent IoT Service Orchestration (CTN)

In a conventional IoT service, IoT devices communicate over a network (e.g., 5G) with centralized data processing which often results in significant energy consumption due to continuous data transmission. In contrast, 6G is expected to enable **"Intelligent IoT Services"** where devices incorporate artificial intelligence (AI) to send only the most relevant data over the network, a method known as goal-oriented communication, thereby minimizing energy consumption by reducing unnecessary data flow. However, in cases where IoT devices face operational challenges or anomalies, they may need to transmit more comprehensive data to a central processor for in-depth analysis.

An example of a network supporting such services is shown in Figure 1. Intelligent IoT Services can dynamically adapt configurations, such as switching between centralized and distributed processing or adjusting data quality to suit varying requirements. This can be achieved by leveraging the knowledge of the service needs over time. Adaptive (re)configurations require the network to adjust automatically, meeting specific requirements for each state. An AI-based orchestration system is essential to manage these dynamic transitions and ensure the network supports the evolving needs of Intelligent IoT Services. Therefore, this project aims to model Intelligent IoT Services and to develop optimization strategies that maximize energy efficiency by using only as many resources as needed at a specific time while ensuring the required level of performance.

The activity in 2025 mainly focused on:
• Development of an optimization framework for Intelligent IoT service deployment to ensure proper resources are allocated when needed, while maintaining required performance levels.
• Design of a Proof-of-Concept to demonstrate AI-based orchestration for autonomous deployment of Intelligent IoT Service on a real network.



Example of a network supporting Intelligent IoT Services.

PI
Dr. Federico Tonini, WiLab, CNIT

Funding Institution
Huawei

Project Partners
University of Bologna

Project Duration
2024- 2026

Involved Countries
Italy

Topological Information Theory: Explore GENEO for Topological information Processing in Wireless System (GENEO)

The upcoming **6G generation** will be the first to incorporate AI as an embedded feature. In the current state of the art, most AI implementations applied to wireless scenarios—such as resource scheduling—are based on neural networks. Neural networks are known to be highly effective for solving complex problems, but they often require substantial structural complexity. This complexity results in a high number of parameters (the weights of connections between neurons) and consequently a large amount of data needed for training (learning phase).

The introduction of AI tools based on alternative types of networks, such as those employing group-equivariant non-expansive operators (GENEOs) instead of neurons, can help address this issue by reducing the number of parameters by several orders of magnitude.

In this project, GENEOs are applied to address a specific challenge in the mobile radio domain: reconstructing cellular coverage of a city from sparse spatial data points. By using only a small set of data points collected from users, this approach reduces radio resource consumption compared to gathering all available data. Unlike other methods, GENEOs are based on geometric mathematical theory, which enables a more interpretable and efficient model.

In our research to date, we have explored the use of GENEOs to reconstruct distributed signals within a city from extremely sparse signal samplings. We initially used a single linear GENEO, then progressed to a configuration with two concatenated linear GENEOs. More recently, we introduced a combination of a nonlinear GENEO with an equivariant (potentially expansive) operator. This progression has steadily improved results, leading us to a mathematical model that we consider highly promising.

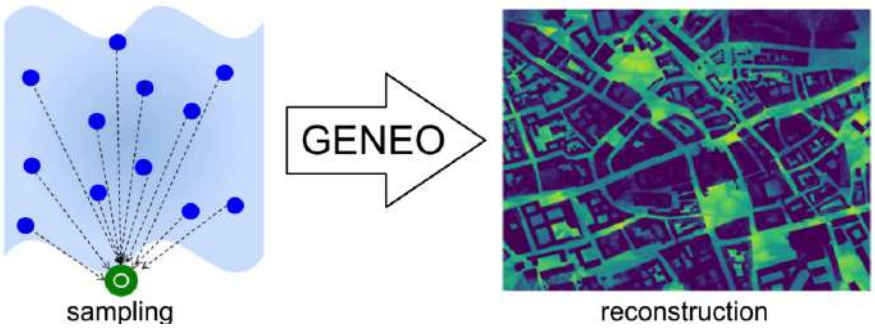


Image reconstruction via GENEO

PI
Prof. Patrizio Frosini, University of Pisa

Funding Institution
Huawei

Project Partners
University of Bologna, University of Pisa

Project duration
2023 – 2025

Involved Countries
Italy

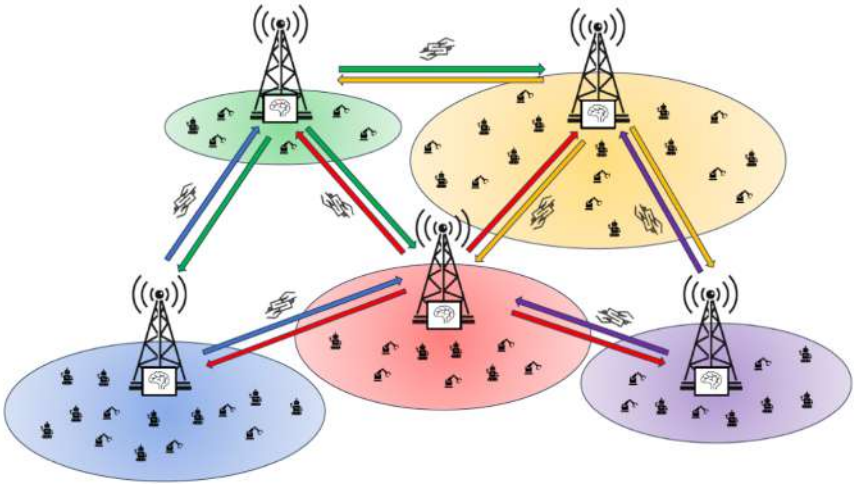
Graph Neural Network Optimization of IoT Networks (GNN)

Machine Learning (ML) methods, in particular, Deep Neural Networks (DNNs) are increasingly being used for the design and optimization of communication systems, from channel estimation to coding, modulation, semantic-based communication, and protocol design. While most of these works focus on point-to-point systems, and aim at using advanced DNN architectures to extract the most relevant features from data for the underlying function, when we consider tasks involving many nodes in a wireless network such as resource allocation, scheduling, hand-over, or access-point (AP) selection, these architectures do not scale well. A promising direction for the solution of such large-scale problems is to deploy neural network architectures that are better suited for the topology and the physics of wireless networks. In this project, we employ goal-oriented Graph Neural Networks (GNNs): they are designed not only to learn a mapping from network data, but to produce policies explicitly conditioned on a given objective, such as line-of-sight blockage prediction in industrial environment. Consequently, the GNN needs to adapt its behaviour to different performance targets and network conditions.

The primary objectives are mainly related to:

- Develop GNNs that, given a specific optimization goal, jointly output feasible power-allocation decisions under local constraints and perform a predictive downstream task.

- Support distributed execution: ensure each node's GNN inference requires only local and neighborhood information, exploiting over-the-air computation.



Example of a graph representation of a wireless network

PI
Dr. Lorenzo Mario Amorosa, University of Bologna

Funding Institution
Huawei

Project Partners
University of Bologna

Project duration
2024 – 2026

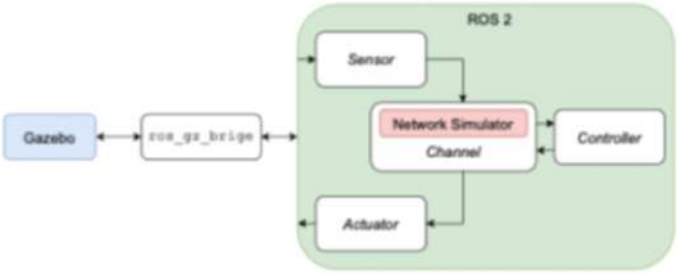
Involved Countries
Italy

AI-Enabled URLLC for Robotic IIoT Applications (IMI)

The grand objective of this project is to design, develop, implement, and evaluate new communication and radio control algorithms, as well as machine control design principles, to support URLLC (and 6G URLLC+) in dynamic Industrial Internet of Things (IIoT) networks, and develop a new platform for 6G IIoT based on simulation and demonstration levels. Special attention will be given to the paradigm of Joint Communication and Control (JCC), which allows robots/machines equipped with sensors to operate as sensing networks with both communication and control capabilities.

In the current phase of the project, we considered a scenario where an Automated Guided Vehicle (AGV), i.e., a mobile robot, transports goods within a smart factory. The AGV integrates advanced sensors (e.g., LiDARs) to drive autonomously via an onboard control system on very simple tracks (e.g., following a line on the floor). However, in case the track is lost, the AGV must be controlled remotely via driving commands received from an external control unit using the 5G wireless network. This is an example of JCC, since communication and control are tightly correlated: communication errors between the AGV and the controller may delay driving instructions, and deteriorate the performance of the controller. First, we designed a new fully-integrated simulation platform based on Gazebo and ROS 2 for the simulation and control of the AGV, respectively, and a 5G network simulator. Using this software tool, we evaluated the impact of the network performance (especially the delay and the packet loss) on the underlying control system, measured in terms of the control error, i.e., the gap between the robot's planned trajectory and its actual trajectory. We proved that the performance of the control system depends on the interaction with the Radio Access Network (RAN), especially the type of scheduler. Specifically, in normal conditions (e.g., small packets and sporadic traffic) grant-free scheduling (GFS) shows superior performance than grant-based scheduling (GBS) under all metrics, while in critical conditions (e.g., in congested networks) it is the opposite. In light of these conclusions, we proposed a new scheduling algorithm, based on two Reinforcement Learning (RL) agents, able to switch between GBS and GFS based on the status of the network and the requirements of the underlying control process.

Finally, we formalized the structure of the Proof-of-Concept (PoC) that will be formally implemented in the next phase of the project. Our objective is to demonstrate our simulation results via real-world experiments, i.e., evaluate the effects of 5G communication errors on the control system guiding the AGV along a trajectory. The 5G network (gNB and Core) will be emulated using the OAIBOX platform, the AGV will be represented by a physical Avular Origin One robot, and the control architecture will be developed in ROS 2. t.



Block scheme of the JCC paradigm considered in the IMI project.

PI
Prof. Michele Zorzi,
University of Padua

Funding Institution
Huawei

Project Partners
University of Bologna

Project duration
2024 – 2026

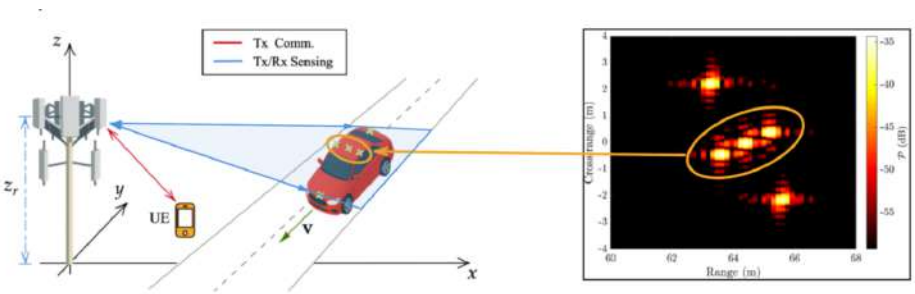
Involved Countries
Italy

Towards Ubiquitous Future Wireless Systems – Integrated Sensing and Communication (ISAC)

The project investigates advanced techniques for integrated sensing and communication (ISAC), focusing on multiband sensing and inverse synthetic/virtual aperture imaging.

1_Multiband sensing:
The goal is to understand how sensing performance can be improved by exploiting multiple frequency bands, either coherently or non-coherently. The project studies both single sensors capable of operating across several bands and cooperative sensing among multiple sensors at different frequencies. Since targets exhibit different electromagnetic responses depending on the band and propagation conditions vary with frequency, fusing multiband information can significantly improve target visibility and detection. The objective is to design novel techniques for coherent fusion of separated bands within a single channel and non-coherent fusion of information across wider ranges such as FR1 and FR2.

2_Inverse synthetic/virtual aperture imaging:
The second direction investigates advanced inverse synthetic (or virtual) aperture methods for imaging extended moving targets, such as vehicles or UAVs, whose trajectories are known or estimable. By synthesizing a large virtual aperture from motion, these methods can achieve high-resolution imaging even at lower frequencies (e.g., sub-6 GHz), where only small physical arrays are available. By combining multiband sensing and motion-based virtual aperture synthesis, the project aims to advance ISAC systems toward more accurate and robust sensing and imaging capabilities.



Schematic representation of an ISAC inverse virtual aperture setup with a base station using part of the physical-layer resources to perform imaging of a moving vehicle.

PI
Prof. Andrea Giorgetti, University of Bologna

Funding Institution
Huawei

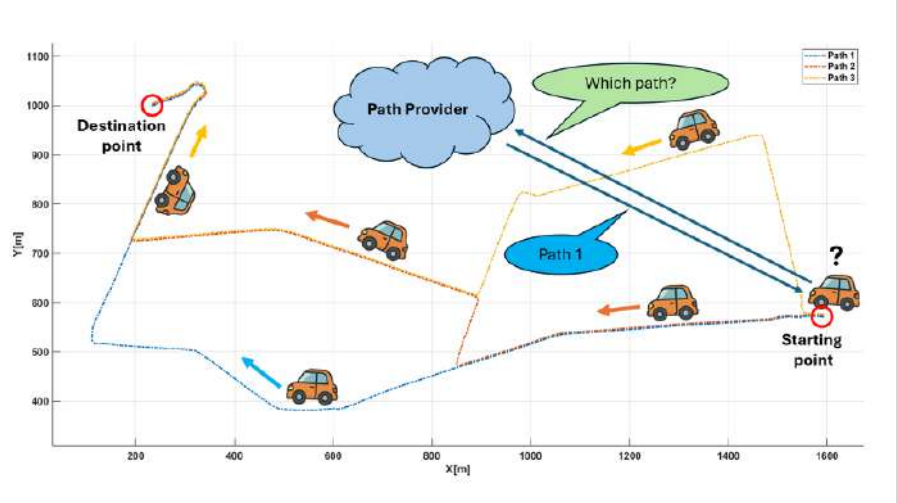
Project duration
2025 – 2026

Involved Countries
Italy

6G C-V2X for Wide Area High Data Rate URLLC (V2X)

The project focuses on a scenario where Cooperative Connected and Automated Vehicles (CCAVs) need to be reliably served by the network to receive real-time contextual information. This requires high data rate with Ultra-Reliable Low Latency Communication (URLLC) across multiple cells in a wide area. To this aim, the activity considers and investigates two types of quality predictions which take into account the vehicle mobility, channel quality, and multi-cell interference: the first type is a long-term quality prediction that is used, as exemplified in Figure 1, to define the best route to the destination by an entity called path provider; the second type is a short-term quality prediction used to optimize the resources allocation and minimize the intervals when the service level agreement between users and network is not respected. The overall objective is to jointly optimize the route followed by CCAVs and the settings of the network.

This two-year project focuses on the downlink and builds on the knowledge gained over three years of the previous JIC project on sidelink communications for vehicles (V2X). The first year of the project was dedicated to the detailing of the use case and to the design of a simulation framework that integrates different tools reproducing realistic mobility of the vehicles, the network behavior with handovers and resource management, and realistic channel modeling using advanced raytracing. The second year is concentrated on optimization solutions for both the short-term and long-term quality prediction.



An exemplary figure depicting the route optimization problem tackled in the JIC-V2X project.

PI
Prof. Alessandro Bazzi, University of Bologna

Funding Institution
Huawei

Project Partner
UNIRC

Project duration
2024 – 2026

Involved Countries
Italy

RESTART

With 116 million euros and a duration of 3 years, starting from January 2023, the research and development program **RESTART (RESearch and innovation on future Telecommunications systems and networks, to make Italy more smart)** is the most important public R&D program ever implemented in the Telecommunications sector in Italy.

It is funded by the **NRRP (National Recovery and Resilience Plan)** as part of the **Next Generation EU (NGEU)** programme that the European Union negotiated in response to the pandemic crisis.

RESTART has the ambitious goal of contributing to shaping the evolution of Telecommunications in Italy, restarting a sector that possesses world-class expertise and experience. It focuses on the main topics of Telecommunications science and technology, including all types of related systems and networks for both human and non-human users.

The activities of the program are structured into 7 Missions: 1) Research; 2) Laboratories, Proof of Concept, and Demonstrators; 3) Innovation and Technology Transfer; 4) Support for Start-ups and Spin-offs; 5) Education and Training; 6) Research Doctorates; 7) Communication, Standardization, and Open-Source Solutions.

RESTART involves **more than 100 partners** and is organized in a **Hub** and **Spokes** structure, where the Hub manages and coordinates the Spokes that carry out the activities to achieve the project goals. The Hub represented by the *RESTART Foundation* manages 8 spokes related to eight major scientific themes. The whole organization will collaborate on the implementation of 32 research projects.

In addition to this, a number of Cascade Calls are implemented. This funding mechanism organises the distribution of funds into several stages, facilitating access to resources for SMEs, startups, and other smaller entities. In other words, the main funding body allocates significant resources to intermediary entities (the winning Consortia) which, in turn, are responsible for redistributing part of them to additional, final beneficiaries, through simplified administrative procedures.

It also includes Grand Challenges, adressing the main research problems of future telecommunications from the point of view of new technologies and systems.

Industrial Networks (IN)

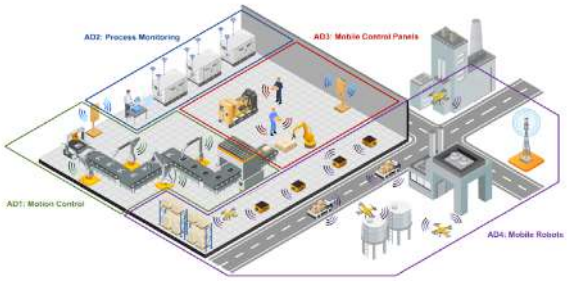
IN is the unique structural project of Spoke 9 of the RESTART program, titled "Industrial and Digital Transition Networks." Although led by the University of Bologna, WiLab plays a crucial role in both coordination and scientific efforts within the project.

The objective of IN is to support the Italian automation industry by pursuing interdisciplinary theoretical and applied research for communication networks in industrial environments, with both a medium and long-term vision. This is achieved by exploring both legacy and new technologies supporting the stringent requirements characterizing industrial use-cases and that sometimes cannot be fulfilled by 5G but need to follow the 6G standardization.

The IN project has identified five reference Industrial Application Domains (ADs) shaping the research framework and established procedures for potential future UC inclusion. These ADs, shown in Figure 1, are derived from industry discussions and standard documentation analysis.
Based on the above framework, the IN project covers a broad range of topics within the field of Industrial Internet of Things (IIoT), including but not limited to:

- Architectures and optimizations for mobile radio networks
- Radio and network planning
- Communications techniques and protocols
- Heterogenous localization and sensing algorithms
- Applications of artificial intelligence in wireless communications
- Data analysis
- Network of digital twins
- Design of radio frequency components, frontends and antennas
- Design of radio-over-fiber solutions
- Development of 7 Proof of Concepts (PoCs) that demonstrated key theoretical concepts through real-world applications within the identified set of industrial ADs

WiLab is directly involved in most of the research topics outlined above, leveraging its expertise in wireless communications to produce generate scientific outputs such as publications, patents, and demonstrators, thereby affirming the telecommunication's role in industrial settings.



Reference Application Domains (ADs) of the IN project.

PI
Prof. Roberto Verdone, University of Bologna

Funding Institution
National Recovery and Resilience Plan

Project Partners
AC2, CNR, EBW, FIBERCOP, NIVA, TIM, UNIBO, UNICT, UNIFE, UNIFI, UNIPR, UNIROMA1, UNITR, WEWIT

Project duration
2023 – 2025

Involved Countries
Italy

Technologies, Algorithms, and Protocols for use cases of Industrial Networks (TAP-IN)

TAP-IN is a cascade project of Spoke 5 “Industrial and Digital Transition Networks” of the RESTART program. The project complemented and supported the activities of the RESTART IN structural project (S9), in which WiLab has a crucial role. The TAP-IN project was led by the University of Ferrara, which collaborates closely with WiLab. The TAP-IN project aimed to develop and demonstrate technologies, algorithms, and protocols for use cases of industrial networks toward supporting the digitalization process of the Italian manufacturing industry and promoting the Made in Italy excellence. In addition to studying theoretical aspects and developing new algorithms and methods exploiting machine learning (ML) and artificial intelligence (AI), TAP-IN had a strong focus on the development of proofs of concepts (PoCs) demonstrating its solutions in a functional industrial environment.

In synergy with IN, the TAP-IN project developed or contributed to the development of PoCs for: multimodal rainfall estimation; indoor localization with UWB and 5G; radio links at mmWave and sub-THz; detection and prevention of hazardous liquid drop from mobile robots using 5G and AI; tracking and classification of multiple targets via multimodal wireless sensing; and multi-interface gateway for industrial networks. The PoCs with higher readiness level were combined into an integrated demonstrator with sensing, communication, and control functionalities. Field trials and demonstrations were performed at the BI-REX Pilot Line to validate the developments. The TAP-IN project also contributed actively to the RESTART Grand Challenge #4 “Expose network infrastructure to services through digital twins” by developing digital twin components ranging from 3D modeling to data exposure. The key functionalities developed jointly by the TAP-IN and IN projects are shown in the figure.

The WiLab was involved in most of the activities within the IN/TAP-IN synergy. This synergy leveraged the expertise of the WiLab on the broad area of wireless communications and its experience in developing PoCs and experimental demonstrators. In particular, the WiLab Research Unit of the University of Ferrara had a key role in both TAP-IN and IN projects, leading the development of PoCs.

WiLab also contributed to the organization of the dissemination workshop “Research and innovation for industry: Wireless technologies on the field” held at Confindustria Lecce, where the IN/TAP-IN PoCs and key outcomes were presented to stakeholders. Such a workshop included a visit to end-user companies that tested solutions developed by NIVA within the TAP-IN project. The demonstrators were also shown at the RESTART Spoke 5 Final Workshop organized jointly by the University of Bologna and WiLab.

PI
Prof. Andrea Conti, University of Ferrara

Funding Institution
National Recovery and Resilience Plan

Project Partners
AC2, EBW, NIVA, UNIFE, UNIPR, UNITR, WEWIT

Project duration
2024 – 2025

Involved Countries
Italy

Grand challenge 4: Making teleportation virtually possible with digital twins

WiLab coordinates the Grand Challenge related to Network Digital Twins (NDTs) within the RESTART framework.

This Grand Challenge aims at exploring the integration of Network Digital Twins into existing telecommunications infrastructure, leveraging advanced modeling, simulations, and analytics techniques to enable automatic processes to enhance operational efficiency, resilience, and decision-making procedures. The data measured from the network (the observed real system) can include geographical/geometric data, channel models, network node characteristics, Key Performance Indicators (KPIs), MDT (Minimization of Drive Tests) data, Key Value Indicators (KVIs), and other.

The activity focuses on developing a comprehensive framework for creating and managing NDTs, encompassing aspects such as data acquisition, model construction, synchronization, and visualization. The NDTs will provide an accurate representation of the network, enabling features such as proactive monitoring, predictive maintenance, and optimization strategies.

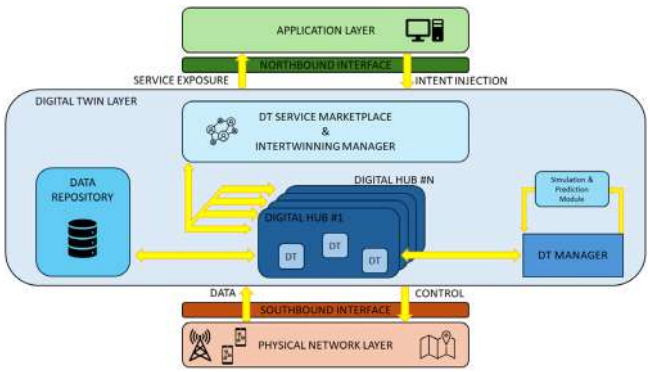
The activity has lead to the publication of a White Paper, which includes:

- A comprehensive analysis of the technological enablers required for effective NDTs deployment, ranging from data acquisition and AI-driven orchestration to edge-cloud infrastructure.

- A focused analysis of the standardization landscape, covering 3GPP, ETSI ZSM, ITU-T, and TM Forum

- A novel architecture featuring the concepts of Digital Hat and Digital Hub, which support the composition, federation, and dynamic lifecycle management of collaborative NDTs.

- A strategic call for harmonized and actionable standardization efforts, stressing that NDTs can only scale if supported by shared models, open interfaces, and governance frameworks.



Example of Digital Twin Architecture

PI
Dr. Riccardo Marini,
WiLab, CNIT

Project duration
2023 – 2025

06
Education & Training

IoT Academy. Città e industria del futuro: le reti e l'intelligenza artificiale per applicazioni e servizi IoT
9 September - 15 December 2025, Bologna

The course is designed for professionals who want to develop technical, specialized, and innovative skills in the field of IoT, particularly Industrial IoT and Smart City. The course is structured into online lesson modules and testbed lesson modules, where hands-on exercises are performed..

3o workshop RESTART sulle Soft Skill per Universitari
20-21 January 2025, Bologna

The RESTART program, as part of the Education & Training mission, aims to enhance university professors' public speaking skills. The event, designed for professors and researchers, focuses on both effective science communication (in a TED-style format) and the clear presentation of technical content in academic or conference settings.

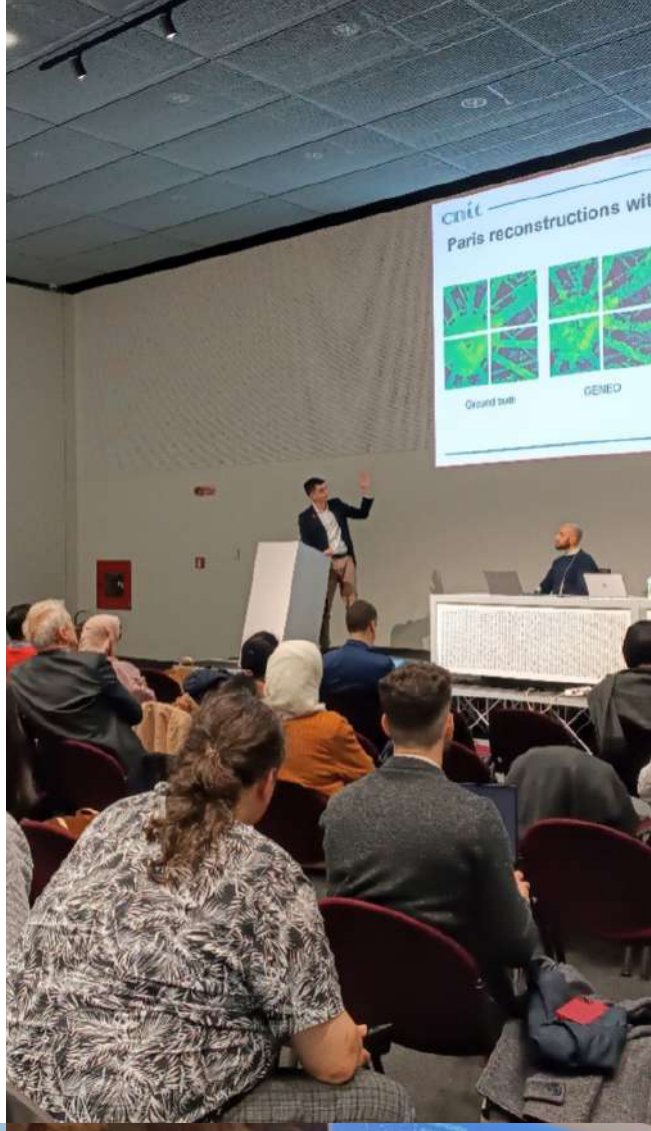
4o workshop RESTART sulle Soft Skill per Universitari
15-16 September 2025, Bologna

The RESTART program, as part of the Education & Training mission, aims to enhance university professors' public speaking skills. The event, designed for professors and researchers, focuses on both effective science communication (in a TED-style format) and the clear presentation of technical content in academic or conference settings.

07 Events

Joint WiLab-Huawei JIC Workshop and Steering Committee on “Intelligent IoT and Networks for 6G”
25 - 26 March 2025, Milan

WiLab and Huawei held a workshop on March 24 in Milan during IEEE WCNC 2025 to present JIC results and their 6G vision. On March 26, the Steering Committee met in Bologna, where project results were reviewed and approved.The activities concluded with a guided tour of the DAMA Tecnopolo and the Leonardo supercomputer.



Riunione annuale GTTI – Gruppo Telecomunicazioni e Tecnologie dell’Informazione
15-17 September 2025, Bologna

Annual event that gathers all the members of the Association. It represents for the community an opportunity for discussing, updating and networking.

Orizzonte 2030: l'Italia tra 5G e 6G
17 September 2025, Bologna

The event marked the inaugural annual meeting of the Orizzonte6G initiative, held under the patronage of RESTART. Its purpose was to monitor ongoing standardization activities toward 6G and to support the identification of future business opportunities for Italian companies. The program included an update on the 3GPP roadmap toward 5G Advanced and 6G, followed by discussions with industry representatives on the role that 6G technologies are expected to play in Italy as a driver of investment, innovation, and market growth. The event also featured a joint session with IEEE CSCN.

One6G Summit 2025. 6G Innovation: Setting the Standards for Tomorrow

18-19 September 2025, Bologna

A premier platform for expert discussions on the future of connectivity. The 2025 Summit focused on 6G innovation and standardization, bringing together international researchers, industry leaders, and policymakers to discuss how the next generation of connectivity will transform our world.

NanniCosta_x – La x sulla mappa dell'innovazione

22 November 2025

The second edition of the event took place on November 22, 2025, at Opificio Golinelli (Via Paolo Nanni Costa, 14, 40133 Bologna (BO)). Attendance was free and open to all, with prior registration. The event focused on innovation and scientific research, highlighting their crucial role in improving the quality of life and promoting social progress. The program featured dialogues with experts, inspirational talks by special guests, and music and dance performances interspersed.

RESTART all'università di Bologna: 3 anni di Progetti

11 November 2025

RESTART all'università di Bologna: 3 anni di Progetti 11 November 2025 WiLab organized the final event of Spoke 5, "Industrial and Digital Transition Networks," of the RESTART program at the Opificio Golinelli in Bologna. The event featured technical presentations from the Principal Investigators (PIs) regarding the main achievements of the structural project IN ("Industrial Networks") and from the four focused projects: INCHNET ("INnovative CHannel coding for modern and green NETworks"), MOSS ("Macroscopic modeling of scattering from static and reconfigurable smart skins"), MoveOver ("Wireless communications for seamless mobility in connected vehicles for day-3 and beyond"), and TeleSmEg ("Telecom as a service in the next SMart Energy Grid"). A total of nine Proofs of Concept (PoCs) were showcased, including real-time demonstrations of integrated localization, communication and learning techniques realized by WiLab within the BIREX pilot line as well as offline exhibits with videos and prototype hardware. The event concluded with a visit to the Ducati Museum and Factory, providing an opportunity to compare the technological innovations developed within RESTART with those consolidated in the automotive sector of the Emilia–Romagna region.

08 WiLab Gathering

A Week of Innovation, Collaboration, and Growth

24-26 November 2025 | Borgo San Luigi, Monteriggioni

The WiLab Gathering is an annual event that brings together researchers from the WiLab ecosystem, including both employees and associates. Its purpose is to foster team spirit, exchange scientific ideas, showcase recent research achievements, and engage with external audiences. The gathering combines presentations, panels from invited experts, and networking opportunities with outdoor and team-building activities, creating a dynamic environment for collaboration and reflection.

This year's WiLab Gathering took place in Moteriggioni (Siena, Italy) from November 24 to 26, 2025, at the Borgo San Luigi. The program featured:

Scientific sessions: Internal presentations on the latest theoretical and experimental WiLab achievements from employees and associates working in different sites (Bologna, Ferrara, Cesena, Rome), including discussions on cutting-edge topics such as situational awareness, intelligent reflective surfaces, joint sensing, communication and learning, non-terrestrial networks, and next-generation massive multiple access.

Internal brainstorming: Discussion on the evolution of the laboratory in terms of structure, projects and long-term objectives.

Leadership transition sessions:
Leadership transition: A session in which the outgoing director, Prof. Roberto Verdone, formally greeted the laboratory community and reflected on the accomplishments of his six-year mandate. This was followed by another session to discuss the future of WiLab, outlining new strategic priorities, opportunities for growth, and plans for strengthening the laboratory's national and international role.

Team-building moments: Group activities, from wine tasting to collaborative workshops, promoting cohesion and innovation.

The WiLab Gathering is not just an event but a reflection of the lab's commitment to excellence, growth, and community. It is a space where researchers inspire and learn from one another while strengthening the vision of WiLab as a leading force in wireless communication research. .


Il WiLab del triennio 2026-2028:
prospettive dal Direttore uscente
Roberto Verdone
Borgo San Luigi (SI), 24 novembre 2025

09 ONGOING PARTNERSHIPS

Other than the actual projects listed in the previous pages, WiLab has also established partnerships with prominent institutions such as Universities, Companies, Research and Competence Centres.
The purpose is pooling resources to more effectively promote technological innovation and the dissemination of scientific culture, the exchange of know-how and best practices, as well as joint projects, events and education initiatives, and any other opportunities that may arise.

In 2025 WiLab held partnerships with the following institutions:

- **Bi-Rex: Big Data Innovation & Research Excellence**
- **Lepida**
- **Huawei Joint Innovation Center**
- **TIM**
- **Fondazione Golinelli**
- **CNR – IEIIT**
- **Fibercop**
- **Astreo**

WiLab, Bi-Rex and Fondazione Golinelli on the same stage for the second edition of NanniCosta_x in November

10 PUBLICATIONS

Journals (34 in 2025)

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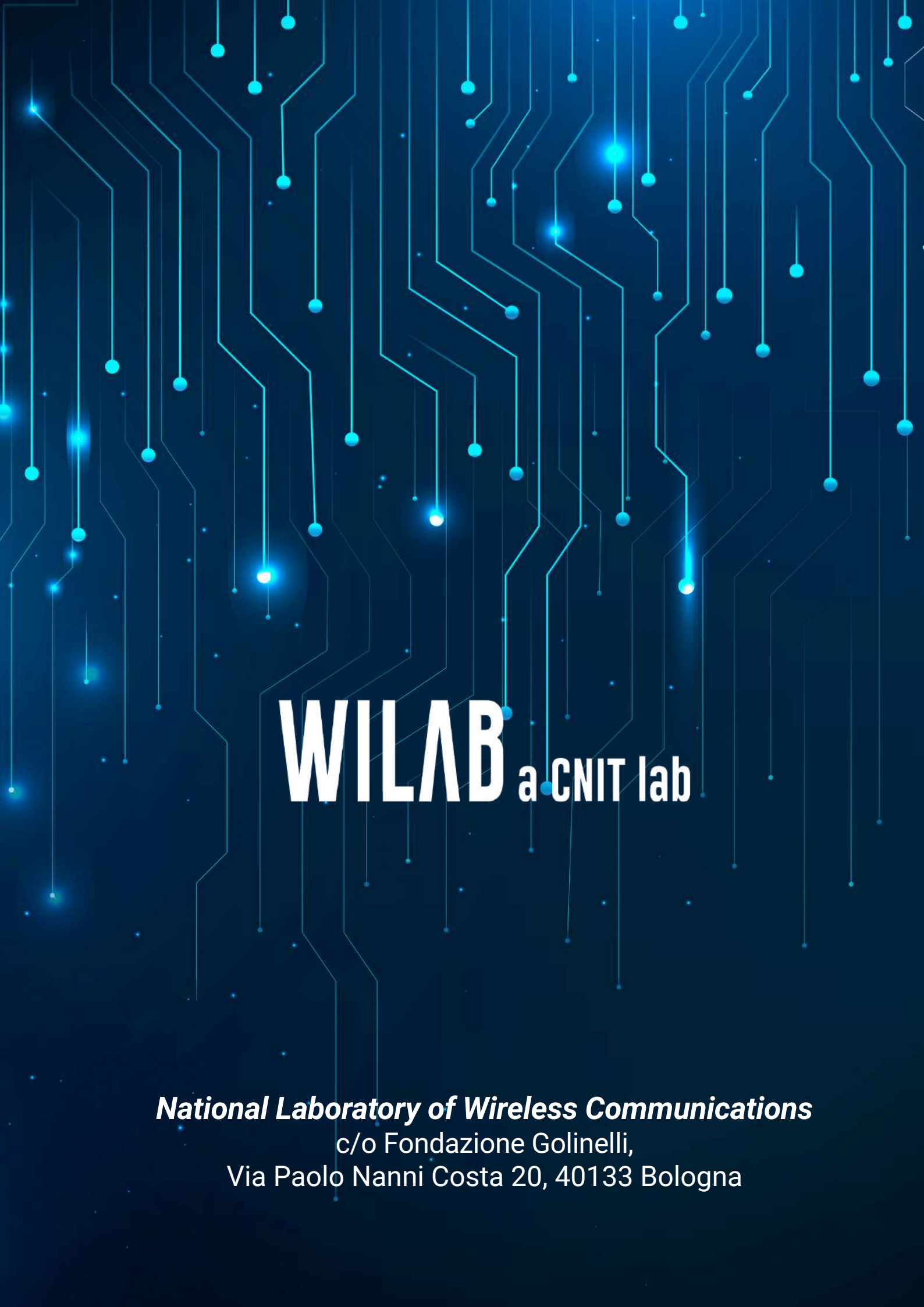

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