On Deploying Vehicular Communication at the Seaport and related Innovation Success Impediments

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Abstract

The paper develops the concept of deploying a vehicular communication network at seaport environments for traffic management and safety purposes. Both, traffic management and safety, can be arguably managed by a vehicular communication approach. Ultimately, the requirements for both scenarios, seaport and vehicular networks, are similar in terms of reliability and delay. For this purpose, a general scenario considering centralized and ad-hoc networks is analyzed. The main enhancement of our approach is to provide a communication-based cooperative scheme in order to increase situational safety. Simulations are performed in order to improve the safety of workers, while at the same time, optimize the management of on-port vehicles. Since the proposed vehicular communication analysis is realized over the container terminal of the developing Port of Bar, which functions in transitional economy, some of the corresponding innovation success infra- and supra-structural, institutional and interaction impediments are taken into consideration.
Keywords: vehicular communication, seaport safety, innovation (management)

1. Introduction

Fast development in information and communication technologies (ICT) leads to the emergence of cooperative systems, where vehicles and pedestrians equipped with on-board units can *talk* to each other and also with the infrastructure through road-side-units (RSU) or dedicated access sites. Such cooperative sensing and controlling systems may exhibit a more advanced behavior compared to vehicles, pedestrians and environments that do not communicate [1].

The large consortium projects such as Connected Vehicles, Cooperative Vehicle-Infrastructure Systems, Cooperative Systems for Road Safety, Strategic Platform for Intelligent Traffic Systems, Car-2-Car, etc., [2, 3] have showed the feasibility of Dedicated Short Range Communications (DSRC) technology, which is particularly important for vehicular communication. Namely, this technology enables safety and infotainment applications by IEEE 802.11p standard in 5.850 GHz to 5.925 GHz (75 MHz RF), which allows the devices to communicate up to 1000 m with 32 dBm transmit power [4].

The main motivation for the deployment of vehicular communication is to have safety-related applications. For example, by collecting up-to-date information about the status of the road, the driver or pedestrian assistance systems can quickly detect potential dangerous situations, and notify the driver and pedestrian about the approaching danger. A relatively small reduction in the driver's and pedestrian's reaction time may potentially avoid the occurrence of an accident [5]. In the seaport environment, e.g., driver can be a fork-lift driver, pedestrian can be an on-port worker or pedestrian, while the road is an internal road at the seaport transportation and operational area. Due to the best of our knowledge, some simulation experiments with vehicular communications at the seaport environment have been done up to now over Intelligent Autonomous Vehicles (IAV) at the container terminal [6], in addition to some indications that vehicular communications will enter Automated Guided Vehicles (AGV) market [7]. The idea of deploying vehicular communication for enhancing safety at the seaport environment has been proposed by [8, 9].

The seaport sector has progressively endorsed ICT based items (intranet, extranet, RFID, and different communication platforms), which primarily deliver benefits that include real time track and trace, visibility and reduced lead-time in the support of logistics [10]. Nevertheless researchers highlight the not so abundant seaports' field scientific literature, which gives opportunities to extend the current knowledge in this area in different directions. Hence, the remainder of the paper is organized in the following manner: Section 2 concerns some impediments in achieving innovation success while deploying vehicular communication safety system at the seaport that operates in transitional conditions (Port of Bar, Montenegro); Section 3 describes the vehicular communication system model and optimization problems; Section 4 gives the description of the simulation environment; Section 5 deals with the simulation analysis and discusses the obtained results; Section 6 gives some concluding remarks and the directions for further investigations.

2. Innovations in maritime sector

The transportation sector scores less than the average for the economy as a whole when it comes to innovation, including the countries with a good overall climate for innovation as Finland and Sweden, for instance [11]. Even though the transportation sector is the largest industrial research and development investor in Europe, there are considerable differences in the level of innovation activities carried out by the highly heterogeneous transport sub-sectors and their specific innovation capacities. The maritime sector in Europe is limited to mainly specialist products and military production, while the production of low-value vessels is undertaken outside Europe. In this regard, with the relatively small market of vessels production, the opportunities for the recovery of investments targeting innovations in maritime sector are rather limited [12]. Furthermore, research, innovations incubation and their diffusion impediments in waterborne transport and seaports, are much more emphasized in the so-called developing countries at South-East Europe, e.g., which have been functioning in transitional conductions, and which permanently suffer reproduction of economic crisis [13].

An innovation is basically described as a historically irreversible change in the way of doing things [14]. A classic dictionary definition of innovation is the embodiment, combination, or synthesis of knowledge into a new idea, method, or device. Drucker [15] has defined innovation as a change that creates a new dimension of performance. Narayanan et al.[16] has used this description to define innovation as a new idea, method, process, or device that creates a high level of performance for the adopting user. Innovation includes efforts being made towards producing economic gain, either by reducing costs, or through increasing income [17]. Besides commercial innovations motivated by revenue generation or cost-reduction, there are also public (or political) innovations motivated by increasing socio-economic welfare. Although there are various additional categorizations with respect to innovation, one among them is relevant from the perspective of our study: product/service versus process; radical versus incremental; technological versus administrative; architectural versus modular; and disruptive versus sustaining innovation [18]. Although, the exact classification is rather vague, we consider deployment of vehicular communication at the seaport area, with the purpose of enhancing occupational safety as: service, technological, modular, and sustaining innovation. *Service innovation* is an intangible method of serving users with a new level of performance. It means in the context of our study that on-port workers and pedestrians will have a new vehicular communication based services for increasing their occupational safety at a harsh working environment. *Incremental innovation* is commonly defined as refinement or improvement of existing innovations. In the considered case, the innovation based on vehicular communication refines the existing personal protective equipment (helmets and vests); mirrors at the corners at the open storage and warehousing areas in the seaport; horns at hard transportation and manipulative devices, by adding them a new, more sophisticated dimension. *Technological innovation* reflects the application of science and engineering to develop technical applications, or to accomplish a specific technical task. In the examined case it is about developing a novel technical-engineering application based on vehicular communication for increasing safety and improving environmental management at the seaport. *Sustainable innovation* improves performance levels of established services and provides incumbent firm an opportunity to reinforce it competences. In the examined case it means a positive change in the direction of recognizing the seaport as a safe, *green* and sustainable one at the growing seaports' market. It is also important to mention within this context that the public policy, organization structure, managerial mindset, human resources, past experiences, tacit knowledge and much more, have strong impact on the success of innovation [19, 20].

In the following sub-section we shall put focus on the potential innovation success impediments vs. success conditions related to adopting vehicular communication for safety purposes at the developing seaport environment. As a base for our research, we have used [21], in which the authors have developed methodological framework for assessing success of the seaport-related innovations. They have analyzed three system innovation case studies related to development and implementation of: the indented berth capable of serving ships from both sides, deployed at the Cares Paragon Terminal in Amsterdam; port community value-added information system (PCS) in Thessaloniki Port, and cold ironing in European ports as a process that enables a ship to turn off its engines while berthed and plugged in to an onshore power source. We have adapted a similar methodology in assessing the potential success of introducing vehicular communication for increasing on-port workers' and pedestrians' safety.

2.1. Case Study

The initiation and adoption of vehicular communications for enhancing and upgrading the seaport safety management might be treated as a public innovation, motivated by increasing socio-economic welfare, or more precisely, on-port worker's and pedestrians' safety and wellbeing. In terms of the proposed innovation scale, it might be treated as a modular innovation, since it brings about a significant change in a concept within a component, i.e., the environmental seaport's safety management system. The links to the other components or systems remain unchanged and the impact is fairly low. In our case study related to the Port of Bar (South-East Adriatic Sea) there are some additional particularities: (i) besides safety personal protective equipment (helmets and vests), mirrors at corners and horns on transportation and manipulative equipment, there is no other safety system based on advanced info-communication systems; (ii) the port functions in transitional environment since decades, which is characterized by economic uncertainty, institutional fragility, lack of human capacities and social awareness about innovation, lack of public policy instruments for business support and management training, etc. [22]. All these and much more has to be taken into consideration while proposing state of the art technology, as vehicular communications are, for uprising safety management in the harsh and dynamic seaport conditions. Namely, seaports are dangerous places for on-port workers and pedestrians in terms of operational risks connected to loading and unloading operations, port transportation and manipulative equipment, manipulative activities, warehousing, etc. Additionally, seaports usually operate 7 days a week, 24 hours a day, in all weather conditions, with multiple employees and contractors carrying out different activities [23]. It is the duty of an employer to protect the health and safety of workers and to improve occupational safe systems, but unfortunately, the accidents in seaports are not rare [24, 25, 26]. The reason for the growing number of accidents is the increase in the seaports' turnover during the past three decades. On the other side, the relatively low turnover at developing seaports, including the Port of Bar, should be in favor of workers' and pedestrians' safety, even though due to the best of our knowledge, there is no official statistical data concerning this issue in the developing and transitional countries [27]. Regardless of all above stated, permanent improvement of safety measures, it is something that simply *must be done.*

In the following sub-section, some infra- and supra-structural, institutional and interaction barriers vs. success conditions in initiation, potential development and implementation phases of a novel vehicular communication system for supporting safety measures within the seaport environment are considered in more detail.

2.1.1. Barriers and success conditions

The Port of Bar is a moderately developed seaport at the South-East Adriatic Sea, without strict orientation to a specific group of cargo. Currently, it consists of four organizational units: Port of Bar, Container terminal and general cargo operator, Maritime operations and IT operators. The port is under the direction of the Port Authority, which is located in Kotor. Also there is a private company, which performs a range of tasks related to the protection of the environment within the port and beyond. The port has seven technological units for cargo handling: container and general cargo terminal (which is used for the simulation experiments); wood terminal; terminal for grains; bulk cargo terminal; general cargo terminal; liquid cargo terminal, and passenger terminal. In addition to a very complex organizational structure, the port also has a specific ownership, in terms that the majority owner now-a-days is a foreign company.

In such a rather complex organizational and technological environment, we tried to make a communication matrix between different actors and environmental conditions in the initial, development and implementation phases concerning vehicular communication safety system (Fig. 1), in accordance to Arduino et al. [21] work. These communication channels are connected with certain barriers and success conditions. In the initial phase, we presume necessity of existing positive communication between the port authorities and knowledge institutes at supra-structural, institutional, interaction and human/administrative capacity levels. At this stage, the biggest problems are at the supra-structural and institutional levels. They can be treated as hard problems. Namely, it might be difficult to provide funds for road-side-units (RSU), tablets (for fork-lifts' drivers) and mobile hand-held devices (for on-port workers and pedestrians). Also establishing back-end info-communication support system might be a problem, since it commonly requires costly infrastructure. Developing the appropriate law regulations (standards) in the domain of port environmental management system and providing funds for the aforementioned supra-structural requirements are prerequisites for establishing positive effects in this initial phase. In the development phase, it should be established positive communication with third parties in the ports (lobbyists, consultants, agents, etc.), firstly at institutional and interrelation levels. Through regulation of institutional and interaction conditions, the third parties can be prevented from making obstructions, which is among success conditions [28]. In the implementation phase, support should be provided from the external cargo operators in a manner to convict them that these safety measures are in their favor, as well. In such case, external container cargo operators might provide financial support for the project implementation. We have set this matrix (Fig. 1), identifying the barriers and proposing general success conditions due to several in-depth interviews with the port managers, and due to our intuition and previously acquired experiences in the field.

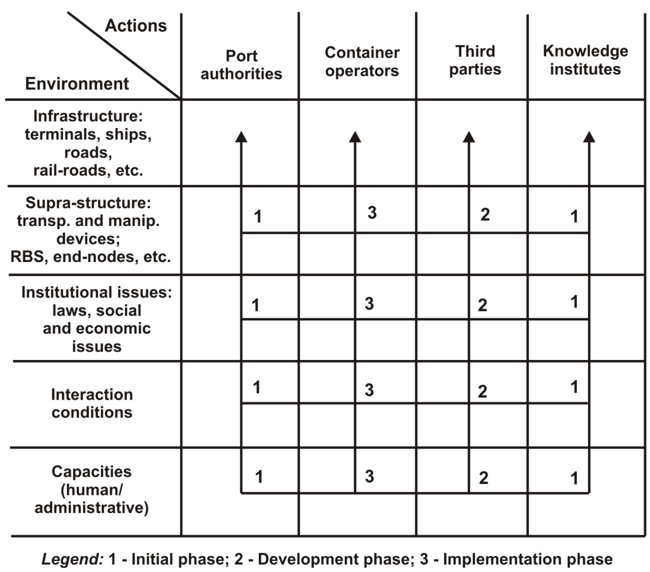


Figure 1: Actors-environment communication matrix in providing innovation success (Source: Adapted from [21], p.99)

It is to be noted that in the case of the Port of Bar there is a general orientation towards economic gain, rather than to the socio-economic welfare. The communication between the port authorities, research institutes and universities exist, but it is rather week, since the investments at governmental level for science and education are insufficient, and the research community consequently has a weak influence on firms' innovation incubation and implementation actions. Currently, a trend of orientation towards foreign investors and relying on their development politics is prevailing. The last stated is not in favor of innovation success and should be overcome through uprising the responsible people awareness of the socio-economic wellbeing and environmental protection importance, and through establishing much more closer and effective communication between research institutions and maritime (seaport) industry and business sectors. So far, it has been shown that involvement of foreign investors does not support the economic gain neither the socio-economic welfare of the employees and wider local/regional community. All afore stated should be kept in mind for both the inventors (research institutes and universities) and the users (seaport actors and stakeholders) regarding the provision of the *fertile soil* for innovation, economic growth and social welfare.

2.1.2. An innovation success model

Vehicular communication innovative approach for enhancing on port occupational safety at the transitional environment, might be treated rather as a supply-side innovation. Namely, in the considered case, the researchers' propose the innovation to the seaport's managers, while there is a risk of the managers' misreading the market and its demand for safe and *green* ports with zero accidents. Moreover, a good example of a supply-side approach is Sony's portable cassette player (the Sony Walkman) on the basis that Sony does not serve markets, it creates them [29]. In this case, the researchers have to create a market. In fact, in the initial phase of the innovation success, the researchers have to take the rule of the *marketing managers* and recognize uncover latent demand. They have to identify and exploit the opportunities (Fig. 2). More precisely, they have to offer port authorities a novel safety solution based on advanced vehicular communication system as a complement to existing personal protective equipment garments, mirrors and horns. Under the assumption of researchers' success in this first step, then, during the time, new opportunities should appear. For instance, on-port workers, pedestrians and forklifts' drivers will most probably prefer their new protective equipment, and they might ask for its refinement during time. In such way, the researchers can blend into implementation phase supply- and demand-side approaches. After the innovation adoption, the customers will likely treat the port as a safer and *green* environment. This shall raise customers' confidence in the port services in terms of environmental management, and they might also like to adopt the same or similar vehicular communication system for occupational safety and production purposes within their industry or business. Afore listed should cause a vivid interplay between demand- and supply-sides within the seaport environment as a primer market place in this case, and beyond. We suppose that the port is proactive, so we did not take into consideration its potential reactive behavior connected with misreading opportunities and status quo (crossed fields in Fig. 2).

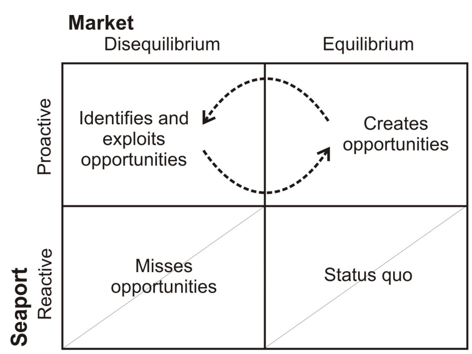


Figure 2: A dynamic model of market creation
(Source: adapted from [30], p.101)

In the direction of innovation success, we can also assume that the innovation initiation, implementation, routinization and development will cause (positive) repositioning of the port at the ports' market and customers' perception map. Also, the concerned port might be used as a model to other ports in the region and wider. Afore presented dynamic model of the innovation deployment should undoubtedly lead to innovation success. Of course, it assumes resolving previously identified impediments. It means that the researchers have to persuade the port managers and stakeholders that they need safety and environmental management system improvements and that vehicular communication is a sound and promising path of doing so.

3. Proposed System Model

Let a set of $\mathcal{N} = \{1, \dots, N\}$ port-workers and $\mathcal{M} = \{1, \dots, M\}$ fork-lifts, all of them equipped with mobile devices, enabling GPS signaling and communication. In addition, we consider a set of $\mathcal{K} = \{1, \dots, K\}$ interconnected road-side-units (RSU) covering the entire port area. It is noteworthy that for the sake of generality, we do not consider any particular communication technology in our proposed scheme. Due to the particularities of port areas, we consider concentration areas, denoted as $\mathcal{L} = \{1, \dots, L\}$, where the density of on-port workers and fork-lifts is higher. Moreover, the environmental information is known by the RSU, i.e., container positions, railway infrastructure and load and unload areas, allowing prediction and optimization of traffic and communication load.

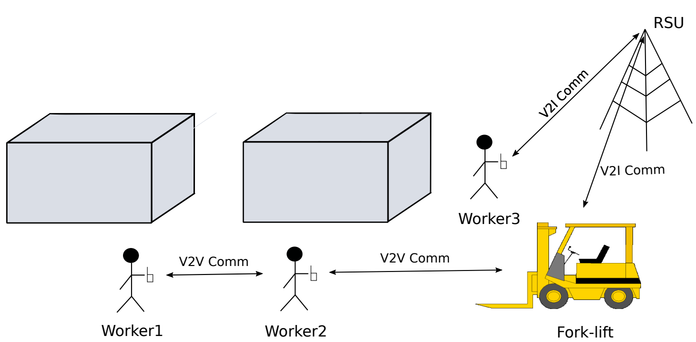


Figure 3: Communication network overview

Both the on-port workers and the fork-lifts can communicate among each other (V2V) and with a given infrastructure (V2I) due to their communication equipment as shown in Fig. 3. Due to the restrictive requirements for safety applications in vehicular communications, i.e., high reliability and low latency, the main objective of our simulation is the study of these parameters. Ultimately, the final goal of this proposed framework is to enable the use of autonomous robots to perform the job of human workers. In order to obtain this goal, the co-operative scheme based on communication is of vital importance. Furthermore, our proposed system model includes the idea of concentration areas $\mathcal{L}$. These areas have a higher probability of being occupied by fork-lifts or workers, since these are areas of load and unload. Hence, each worker, n, in a concentration area l can be defined as n_k^l, being k the RSU at which the worker is connected to. Analogously, the fork-lifts are denoted as m_k^l.

As discussed in previous section, the port under investigation has no infrastructure deployed to enable vehicular communications, hence, the first step consists on obtaining the optimal placement of the RSUs. In order to provide a suitable network for safety applications, the area covered by the RSUs has to be the totality of the port area. For this matter, we use the following radio channel model for multi-path environments [31]:

$$h(t,\tau) = \sum_{n=1}^{N} A_n(t) e^{j\beta_n(t)} \delta(t-\tau)\delta(\phi-\phi_n)\delta(\theta-\theta_n) \tag{1}$$

where A_n is the amplitude for each received path n. Moreover, β_n denotes the phase of the received ray and θ and ϕ are the angle of arrival in azimuth and elevation plane, respectively. In order to plan the deployment of the RSUs, we define a constraint:

$$P_{rec}(t) \geq P_{th} \tag{2a}$$

$$\text{s.t.} \qquad P_{rec}(t) = |h(t,\tau)|^2. \tag{2b}$$

By using this constraint, it is guaranteed that the entire port area is covered within a certain received power threshold for all time instant t. Moreover, in an environment with several users sharing the same resources and infrastructure, the problem of interference arises. Hence, we define the signal-to-noise ratio (SINR) as follows, in order to model the interference and the impact in the communication:

$$\text{SINR} = \frac{P_{rec_n} G_n}{\sum_{j \in U} P_j G_j + \sum_{i \in V} P_{i,n} G_{i,n} I_{i,n} + \mathcal{N}} \tag{3}$$

where P_{rec_n} is the received power and G_n is the signal gain for each user n. The first term in the denominator defines the interference created by collisions, i.e., two users using the same resource block, while the second term is the in-band emission interference (IBEI) produced by the leakage between sub-bands and $\mathcal{N}$ is the noise power. The set U contains all the workers under the coverage of the same infrastructure sharing the same resources and V defines the set of workers located under the coverage of the infrastructure k but connected to a different infrastructure. Moreover, since the concentration areas are known in our scenario, we want to maximize the received power in these areas, P_l, by means of an optimal beam-forming as follows:

$$\begin{aligned}
\underset{\theta_i,\phi_i}{\text{maximize}} \quad & P_l = |h(t,\tau)^H \mathbf{w}(\theta_i,\phi_i)|^2 && \text{(4a)}\\
\text{s.t.} \quad & \theta_i = \alpha_l && \text{(4b)}\\
& \phi_i = \gamma_l && \text{(4c)}
\end{aligned}$$

where α_l and γ_l are defined in order to cover the desired concentration area $l \in \mathcal{L}$ and $\mathbf{w}$ is the antenna beam-forming based on the channel state information (CSI) which depends of both angles θ_i and ϕ_i. The proposed concept of concentration areas $\mathcal{L}$ has a double advantage. It enhances the communication signal in the areas with a higher density of users, while at the same time, decreases the interference produced by adjacent cells, since the power in these areas is smaller.

4. Simulation Setup

The simulation experiments related to emerging vehicular communication are done over the container and general cargo terminal at the Port of Bar. This terminal has a quadrilateral form, which can be approximated by a rectangle with dimensions 650 x 350 m (Fig. 4). The container terminal is located at the pier I of the port and it covers an area of 60,000 m^2. Wharf length is 330 m and the depth of the sea is 11 m. The surface of the terminal is divided into zones, and the connections for refrigerated containers are also provided. The terminal has an area for disposal of 2,635 TEU in the range of the container crane. It has also 13 modular fields with capacity of 2,320 TEU per field. Additionally, the terminal has 6 modular fields for transportation and manipulation operations with 6,320 TEU per field. The containers handling is realized in direct manipulation with railway wagons or other means of transportation. The general cargo terminal is located at the piers I and II of the Port of Bar, and it is equipped with necessary devices for loading, unloading and manipulating cargo (including fork-lifts). The length of the operational waterside line is 1,370 m. The terminal is equipped with 15 portal cranes with capacity of 15 t per crane. The number of workers at the port depends on the workload and daily operational plans, and it varies from several workers to 20-25 per terminal/shift. Similar simulations have been conducted deploying three base stations and 10 mobile users, i.e., workers and fork-lifts in total [8, 9] without taking into consideration the interference between adjacent cells and users.

Table 1: Simulation parameters

Parameter	**Value**
Bandwidth	10 MHz
Frequency Base Station	2.4 GHz
Frequency Workers/FL	5.9 GHz
Transmission Power	23 dBm

As described in Section 3, the communication scheme has a hybrid nature, therefore, the communication frequency is adapted accordingly to the requirements, i.e., for V2I the used frequency is 2.4 GHz, while for V2V the used one is 5.9 GHz. Moreover, the rest of relevant parameters are defined in Table 1. In order to simulate the radio channel model, a combination of a deterministic ray-tracer algorithm (PIROPA) [32] and a stochastic radio channel model (WINNER II) is used [33]. This approach has been applied successfully in several scenarios [34], obtaining similar values compared with the real measurements. The simulation has been performed using a 2.6 GHz Intel Core i5 with 16 Gb of RAM, while the obtained results are presented within the next section.

5. Simulation Results

The simulation scenario is depicted in Fig. 4. The workers paths are simulated with a speed in the range of 1.4 m/s to 2.5 m/s (blue lines in Fig. 4), while the fork-lifts move at a maximum speed of 6 m/s (red lines in Fig. 4).

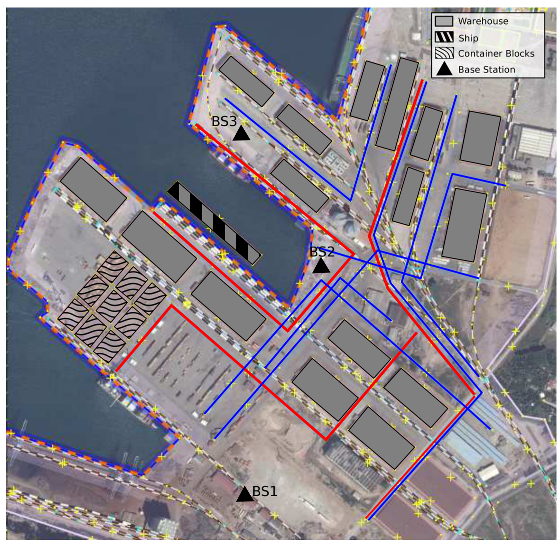
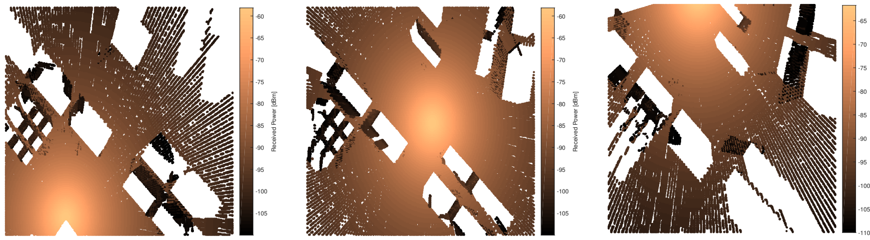


Figure 4: Deployed network and routes at the Port of Bar

The routes of the workers and the fork-lifts are predefined and known by the infrastructure and authorities, respectively. Moreover, since the proposed radio channel model has a environment-based component, it is important to know at any time the environment information, i.e., the number and location of all the containers. The situation of the containers shown in Fig. 4 is the usual one. Therefore, the complete port area has a deterministic behavior, i.e., the ship arrivals and working areas are planned beforehand, making our approach suitable for this situation. In Fig. 5, the received power at any port location



(a) BS1 (b) BS2 (c) BS3

Figure 5: Heat map for three base stations at the Port of Bar

is shown. In this situation, three base stations are deployed, at the positions shown in Fig. 4 denoted as BS1, BS2 and BS3, covering the entire port area with the power constraint defined in Eq. 2. It is noteworthy that there are areas which are shadowed by the containers causing a lower received power. Due to this obstruction, created by the different environment elements, the already mentioned idea of concentration areas is useful. The concentration areas are defined next to the container locations as it is displayed in Fig. 6 for BS2.

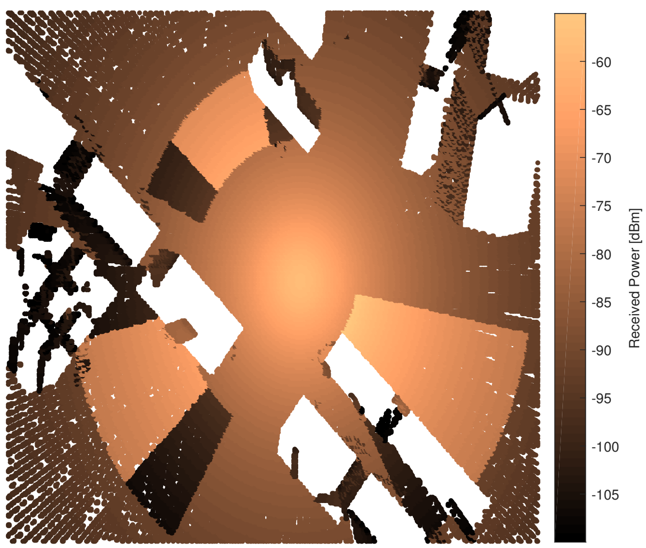


Figure 6: Tri-sector antenna pattern for concentration areas

Due to this concept of concentration areas, a double goal is achieved: the areas with a lower received power are reduced and the areas next to the containers have a higher received power, increasing the reliability of communications. The final parameter to analyze is the communication between workers and fork-lifts (V2V). For this purpose, we simulate workers and fork-lifts in their predefined routes as shown in Fig. 4. The results of this simulation are depicted in Fig. 7

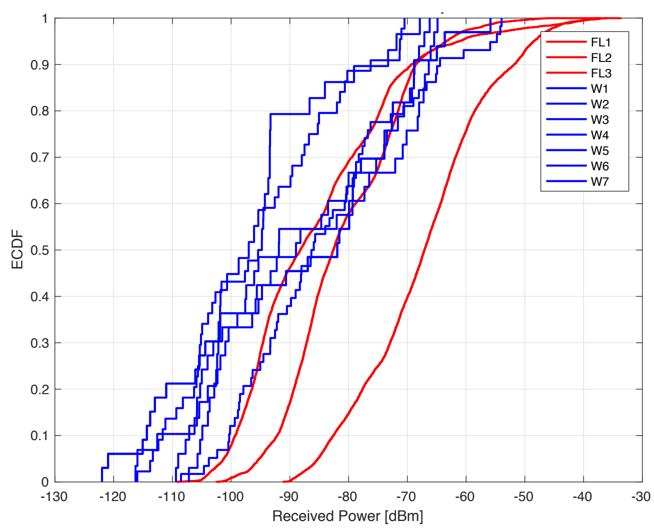


Figure 7: ECDF for vehicle-to-vehicle communication

The study of the received power is performed using a Empirical Cumulative Distribution Function (ECDF) in order to show the coverage profile for each path. Since our study works with the obtained samples from the proposed radio channel model, using the ECDF is the most suitable way of representation The simulation shows that the received power lies in the range of -130 dBm up to -30 dBm, which creates a feasible and reliable communication scheme. It is noteworthy to mention the higher received power by the fork-lifts due to the higher altitude of their antennas, creating LoS situations. Moreover, the simulation also takes into consideration the interference defined in Eq.3, due to the adjacent cells and the shared resources by several user at the same time.

Moreover, due to the focus of our approach on safety, it is critical to investigate the reliability of the communications. For this purpose, the delay, Doppler and

Table 2: Delay, Doppler and angular parameters

	Max	**Mean**	**Stand. Dev.**
Delay Spread	37.358 μs	11.1350 μs	5.637 μs
Doppler Spread	5.345 Hz	-4.8491 Hz	1.871 Hz
Angular Spread	-	181.512°	109.245°

angular spread are detailed in Table 2. It is shown that the delay for the overall communication scheme is in the order of dozens of μs which is acceptable for safety applications. In addition, both angular and Doppler parameters are useful for the design of the receiver equipment in order to maximize the reliability of the communications.

6. Conclusion

This paper proposes a vehicular communication network to increase the on-port safety of workers and machinery. The vehicular scheme here proposed prioritizes the communication reliability which is the main aspect in safety applications. The idea of using vehicular communications for on-port safety comes from the similar requirements of both fields, i.e., vehicle-to-vehicle and worker-to-worker communications, and also due to the great efforts done in the research of vehicular networks in the scope of 5G technology. Our simulations show a feasible network scenario involving communication equipment for on-port workers and machinery, along with the deployment of communication infrastructures. Moreover, the concept of concentration areas, creating a heterogeneous network, is introduced enhancing the communication scheme and reducing the interferences.

Undoubtedly, the technology works, but one can not negligible the problem of innovation impenitence vs. success factors considered in the first part of the paper. Through the forthcoming work in the field, the researches should have in mind among other issues the following statements [35]: (i) The innovation cannot be restricted to the adoption of new technologies, instead it is to be conceived as a creative use of technology in order to interpret the market or integrate the knowledge; (ii) A culture of innovation can be nurtured on a continuing basis by promoting the creation of dedicated innovation networks around specific development challenges of the port that involve exchange of knowledge, technologies and resources among port operators, industrial, technology, and research and development (R&D) partners.

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