Gauging 5G Standalone Performance for Teleoperation Use Cases in 5G-enhanced Port Environments

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Abstract—**The International Transport Forum (ITF) predicts a significant increase in demand for transportation in the coming years, despite the shortage of drivers. To tackle this challenge, the Transport and Logistics (T&L) industry is increasingly relying on emerging technologies. While connected and autonomous driving offer promises of greater safety, efficiency, and environmental benefits, connected and autonomous driving face operational hurdles in complex environments. However, the existing limitations of autonomous vehicles, particularly in dense urban settings, highlight the need for complementary technologies, such as teleoperation. The European Horizon 2020 5G-Blueprint project aims to design and validate the technical architecture and business models for cross-border teleoperated transport, utilizing 5G technology. This study delves into the implementation of a real 5G Standalone (5G SA) network within a port environment, utilizing network slicing for teleoperation and Multi-Access Edge Computing (MEC) to enable real-time video processing at the network edge. Specifically focusing on Ultra-Reliable Low Latency Communications (URLLC) and enhanced Mobile Broadband (eMBB) slices, we conduct a comprehensive evaluation of a real-world 5G SA network. Our assessment examines key performance parameters such as Round-Trip Time(RTT) latency, Packet Delivery Rate (PDR), Reference Signals Received Power (RSRP), and corrupted frame rates, emphasizing the crucial role of 5G network slicing and MEC in enhancing operational reliability and efficiency in teleoperated transport systems.**

Index Terms—**5G Standalone, Transport and Logistics, Teleoperation, Network slicing.**

I. INTRODUCTION

According to the International Transport Forum (ITF), the demand for passenger and freight transportation is expected to increase in all regions of the world in the coming decades [1]. Addressing this challenge requires the Transport and Logistics (T&L) sector to confront the growing shortage of drivers in the market. Emerging technologies such as connected and autonomous driving promise to revolutionize the T&L sector by offering various advantages, such as improved road safety, traffic efficiency, enhanced comfort, and reduced emissions. However, it is crucial to consider the current limitations of autonomous vehicles, which often encounter difficulties in reliable and flawless operation, especially in complex urban environments [2][3]. To ensure reliability and safety, a supporting technology, such as teleoperation, is necessary. Teleoperation can serve as a transition phase towards autonomous driving [4]. By transforming truck drivers into teleoperators, Teleoperated Vehicles (ToVs) offer the potential to alleviate personnel shortages, reduce vehicle and equipment downtime, and eliminate the challenges associated with traditional driving professions [4].

In the realm of teleoperation, cameras are positioned in the ToVs to provide situational awareness to teleoperators located at the Teleoperation Center (ToC). These cameras rely on networks that provide both high bandwidth and minimal latency to transmit high-fidelity visuals in real time. The 5G technology is a strong candidate to enable teleoperation, offering extremely low latency (1-10 ms), nearly absolute reliability (99.999%), and impressive data transfer capacity (up to 20 Gbps) [5]. Moreover, 5G introduces an important feature called network slicing. Network slicing is a mechanism that subdivides the network infrastructure into multiple virtual and isolated networks, called slices, tailored to accommodate services with diverse network requirements, such as enhanced Mobile Broadband (eMBB) and Ultra-Reliable Low Latency Communications (URLLC). With network slicing, 5G guarantees that critical services, such as teleoperation, can perform without being affected by other services using the same network infrastructure.

The network requirements for teleoperation combine elements of both eMBB and URLLC slices simultaneously, also emphasizing uplink (UL) bandwidth consumption rather than downlink (DL). The European Horizon 2020 5G-Blueprint project aims to design and validate the technical architecture and business models for cross-border teleoperated transport, utilizing 5G technology. Since the specific combination of eMBB and URLLC might be challenging to achieve even for 5G technology, it is necessary to explore the ability of the 5G to provide strong connectivity for direct control of ToVs. Real-world 5G deployments are still not very common [6]. According to the records of Global mobile Suppliers Association (GSA) [7], only 17 operators have deployed 5G Standalone (5G SA) public networks. In this study, in Section IV we conduct a detailed assessment of a real 5G SA implementation provided by the 5G-Blueprint project in the port area of Vlissingen, Netherlands. Our first focus is on evaluating the performance of network slicing in a 5G SA network, specifically analyzing the capability of enhanced eMBB and URLLC slices to support teleoperation use cases. Moreover, in Section V we validate the network assessment, executing a series of experiments to validate network performance across various environments, including indoor, outdoor, and mixed (hybrid) settings, each with distinct environmental characteristics. The validation setup described in Section V uses a camera to emulate the operation of teleoperated skid steer loaders by streaming video to the Multi Access Edge Computing (MEC), so camera streams are analyzed. For proper execution of the software running on the MEC, the connection must be stable.

II. 5G-BLUEPRINT PROJECT

The 5G-Blueprint project, supported by the European Union, is dedicated to promoting the development and implementation of a comprehensive framework that integrates technical architecture and sustainable business and governance models for teleoperated transport [4]. This framework is designed to facilitate seamless and uninterrupted cross-border teleoperated transport, utilizing the advanced capabilities of 5G connectivity, as defined in the 3GPP Release 16 standards [8]. The technical mission of the project is to deploy a real prototype for a teleoperated transport system. This prototype aims to demonstrate end-to-end transportation of vehicles within real-life scenarios, including cross-border teleoperation. A key component of a teleoperated system is the integration of cameras that, together with the network slicing capabilities of 5G technology, ensure efficient and instantaneous remote driving operations [9].

In the 5G-Blueprint project, the teleoperated system is being tested and validated in real-life environments, such as pilot sites that involve busy port areas, such as Vlissingen (NL) and Antwerp (BE). To address the complexities of cross-border operations, which often involve coordination between different network operators, cross-border scenarios between Belgium and the Netherlands, Zelzate (BE-NL), have been deployed and tested within the 5G-Blueprint project. To demonstrate the practical applications of teleoperation in various vehicles, including trucks, vessels, and skid steers, the 5G-Blueprint project couples the 5G network and user case elements to create a fully-fledged teleoperation system, supported by enabling functions [10].

In this paper, we focus on the pilot site of the port of Vlissingen (NL), where we have deployed a 5G SA network configured with two slices, eMBB and URLLC.

A. Vlissingen pilot site

The Vlissingen pilot site is extensively used for piloting use cases like Automated driver-in-the-loop docking, Cooperative Adaptive Cruise Control-based platooning, and Remote takeover [11]. The pilot site of Vlissingen has a total of four 5G network deployment sites. In this paper, we will focus on the network deployment placed at the Verbrugge Scaldia Terminal since the 5G network deployed within the terminal is a 5G SA network with network slicing enabled.

The Verbrugge Scaldia Terminal houses large maritime vessels, truck loading stations, rail facilities, and container storage areas, as well as extensive warehouse buildings. The Verbrugge Scaldia Terminal covers a total area of 962,000 m², with a covered storage area of 323,000 m². These warehouses are mainly constructed of metal, affecting the performance of 5G networks and, thus consequently teleoperation scenarios.

The environment composition of the Verbrugge Scaldia Terminal makes the study of 5G network and network slicing very interesting in terms of radio signal propagation, due to the challenging environment.

The evaluation of the 5G SA network and network slicing, discussed in Section IV, is performed between the warehouses adjacent to the dock, respecting the maximum speed limit of 25km/h imposed by the terminal regulations. To validate the network assessment, in Section V we perform real experiments in three different locations. These locations are indoor warehouses and outdoor areas where we evaluate the quality of the 5G signals and the ability of the network to send video information e.g., relevant to cases such as the teleoperation of skid steer loaders. The gNB installed at the Verbrugge Scaldia Terminal is deployed in front of the docks where our network assessment and network validation take place. However, the full line of sight is limited to the docks in front, as shown in Figure 1, and many of the test locations do not have a clear line of sight with the gNB.

B. 5G SA Network setup

The deployment of the 5G SA network at the Verbrugge Scaldia Terminal includes a complete Radio Access Network (RAN) with the Core Network (CN) architecture. The RAN utilizes a singular 5G New Radio (NR) frequency band centered around the 3.5 GHz spectrum, with the Base Band Unit (BBU) and a Multi-Input Multi-Output (MiMo) antenna array comprising 64 elements. This configuration facilitates the formation of 16 distinct beams, optimizing coverage and throughput capabilities [12].

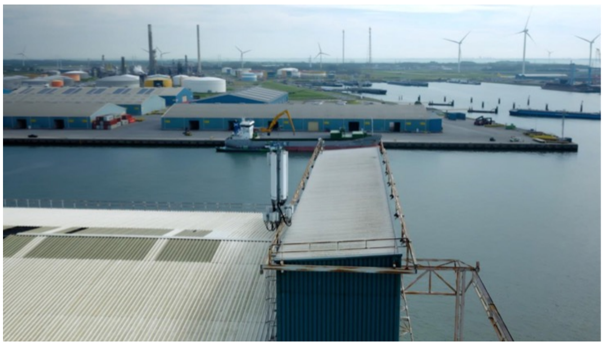
Fig. 1. Port environment overview and gNB location.

The CN infrastructure is distributed across multiple sites to optimize performance and reliability. The primary data center, located in Aachen (NL), manages a portion of the CN operations. The same data center hosts an edge node where MEC is implemented. In parallel, a metropolitan core facility provides localized core functions, which are crucial for the regional performance and resilience of the network [12].

This 5G deployment is configured with two separate slices, such as eMBB and URLLC, each of which is deployed to meet specific service requirements, described in Section III. Due to different requirements, the resource allocation for these slices is different. The URLLC slice receives a guaranteed minimum of 50% of the available Resource Blocks (RBs), a significant provision to meet its stringent quality of service requirements. In addition, the URLLC slice is configured with a 5G QoS Identifier (5QI) of 86, which guarantees priority traffic management for latency-sensitive applications [13]. The eMBB slice receives a guaranteed minimum of 25% of the available RBs.

III. NETWORK REQUIRMENTS

The purpose of the 5G-Blueprint project is to provide a blueprint for a 5G-based infrastructure that enables seamless teleoperated transport [4][11]. As part of the 5G-Blueprint project, the following network requirements have been defined to make teleoperation real and safety:

1) **Data Transmission and Data Reception**: Network bandwidth affects the response of the teleoperator. Remote operators depend heavily on the quality of video and data streams from sensors. Handling a high volume of data including control signals, commands, multiple video streams, and GPS data is crucial for teleoperations. This large data load requires a network with adequate bandwidth to provide the teleoperator with a sense of the area around the vehicle.
2) **Low Latency Communication**: For teleoperation and autodocking capabilities, low latency is critical. High latencies can complicate operations, particularly in constrained spaces like distribution centers where precise control is necessary. To facilitate real-time interaction and control, the network must provide low-latency communication between the ToC and the ToVs. Minimal delay in transmitting control commands and safety messages is a must to respond promptly to dynamic situations on the road.
3) **High Reliability**: The network should guarantee high reliability to prevent communication failures or data loss. This is critical for maintaining continuous communication between the ToC and the ToVs, especially in safety-critical scenarios.

4) **Network Slicing**: Implementing network slicing mechanisms is necessary to prioritize safety-critical messages over less critical data traffic. This prioritization guarantees that safety-related information always receives the highest level of attention from the network.
5) **Network Coverage**: To support teleoperation in diverse urban areas, the network must provide seamless coverage. This means minimizing connectivity gaps and ensuring reliable communication even in areas with varying signal strengths.

In the 5G-Blueprint project, teleoperation is demonstrated and tested with four selected use cases [10]. This analysis of the use cases, together with the enabled functions developed as part of the project, led to the identification of specific network requirements values, listed in Table I. This table provides a summary detailing these network requirements values, which are essential to ensure reliable teleoperation.

TABLE I
NETWORK REQUIRMENT

KPI	Camera stream	Vehicle control interface
Service Type	Uplink	E2E
Network Latency	< 50 ms	< 35 ms
Network Service Interruption	< 150 ms	< 150 ms
Bandwidth Requirement	> 5 Mbps < 25 Mbps	< 2 Mbps
Slice Type	eMBB	URLLC

IV. ASSESMENT OF THE 5G STANDALONE NETWORK

To assess the performance of the 5G network deployment at the Verbugge Scadia Terminal, several network Key Performance Indicators (KPIs) have been defined to evaluate if the network requirements are matched. The KPIs, listed in Table II, are used to evaluate the 5G SA network across i) eMBB slice ii) URLLC slice iii) eMBB slice considering background traffic and iv) URLLC slice considering background traffic.

To perform the measurements and evaluate the list of network KPIs in Table II, we used open-source measurement tools and in-house tools. Regarding open-source tools, we used ping[1] to measure Round-Trip Time (RTT) latency and Iperf[2] to generate Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) traffic in both directions, UL and DL. With TCP traffic, we intend to emulate the traffic generated by the sensors in the ToVs and sent to ToC i.e., UL, and traffic from the ToC to ToVs i.e., DL. With UDP traffic we intend to emulate the video traffic emitted from the cameras, installed in the ToVs, to the ToC. On the other hand, in-house tools were used to measure the Packet Delivery Rate (PDR) and reliability. Furthermore, to evaluate the coverage of the 5G SA network we decide to consider the Reference Signals Received Power (RSRP) value. The RSRP value is obtained using the come to ATtention (AT)[3] serial commands from the 5G modem.

A. Experiment setup

Since we are evaluating network performance to perform teleoperation use cases, we conduct dynamic tests along the Verbrugge Scaldia Terminal using a test car [14]. The test car is equipped with an Intel NUC embedded PC, a 5G User Equipment (UE) i.e., the Fibocom FM150 5G modem[4] with two SIM cards, one dedicated to the eMBB slice and the other to the URLLC slice. In addition, the test car incorporates the Netgear 5G Nighthawk router[5], complemented by essential peripherals such as a USB GNSS receiver with Pulse per Second (PPS) functionality for precise time synchronization and positioning. To ensure complete network coverage and accuracy of our measurements, the test car is also equipped with MobileMark 5G Magmount vehicular antennas and a separate battery, which ensures an uninterrupted power supply during the test scenarios. Furthermore, we used a remote data center located in Antwerp (BE) provided with a GNSS receiver with PPS to support accurate time syncing, as an end user to send the traffic generated by Iperf and ping. Last but not least, we use a mobile device, the OnePlus Pro 10, to generate background traffic to evaluate the impact the background traffic causes on the slices e.g., traffic generated by other UEs in the same area of the ToVs.

B. Methodology

To evaluate the network KPIs listed in Table II we follow the trajectory outlined using the green color in Figure 2. The signal strength, quantified by the RSRP, is a key parameter in identifying network behaviors. To evaluate the RSRP values we follow the 3GPP technical specification [15]. According to [15], the RSRP value can be classified as excellent, good, mid cell or cell edge.

As illustrated in Table I, the eMBB slice is attributed to the upstream of the data from the cameras in the ToVs to the ToC. We evaluate the eMBB slice for both UL and DL traffic using the UDP protocol. UDP is suited for real-time data transmission like video streaming, due to its emphasis on speed and efficiency. The URLLC slice is dedicated to critical commands propagating from the teleoperator to the ToVs, or feedbacks from the sensor in the ToVs to the ToC e.g., GPS data. Hence we evaluate the RTT latency, the PDR, and the UL throughput of the URLLC slice, using TCP protocol. Since the URLLC slice is dedicated to messages with higher priority than the eMBB slice [16], the slices have different configurations. In our network setup, described in Section II-B, the URLLC slice has 50% of RBs assigned, while eMBB has 25% RBs assigned.

C. Results and Discussion

The measurement of the RSRP values along the Verbrugge Scadia Terminal is depicted in the heat map in Figure 3. In Figure 2 between points A and B, we observe a good RSRP [15], explainable to a clear line of sight with the gNB. In contrast, the trajectory from B to C experiences a decrease in signal quality due to the unclear line of sight posed by the warehouses, where the metal structure further degrades signal reception. The trajectory from C to D has a full line of sight with the gNB; however, the presence of a large maritime vessel involved in unloading containers along the dock during the test introduces further signal attenuation. Figure 4 show the throughput and RTT latency metrics for the eMBB and URLLC slices. Table IV-C gives a more accurate analysis of the measured values. The analysis of the result related to the eMBB slice under ideal conditions, e.g., a single device connected to the network, reveals an average throughput of 360 Mbps in DL and 25 Mbps in UL with an average latency of 15 ms and a PDR of 100%. The URLLC slice performs a latency of 13ms with a PDR of 100% and a throughput of 38 Mbps for TCP under ideal conditions. These results were expected since we tested the network in ideal conditions. In more realistic conditions e.g., more devices connected to the network, we observe an impact on

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[1] Ping: https://linux.die.net/man/8/ping

[2] Iperf: https://iperf.fr/

[3] AT commands: https://www.maritex.com.pl/product/attachment/40451/15b4db6d1a10eada42700f7293353776

[4] Fibocom FM150: https://www.fibocom.com/en/products/5G-FM150-NA.html

[5] Netgear 5G Nighthawk : https://www.downloads.netgear.com/files/GDC/MR5000/MR5000_UM_EN.pdf

TABLE II
KEY PERFORMANCE INDICATORS FOR THE NETWORK EVALUATION

KPI	Protocol	Direction	Description	Measurement Method	Tool Used
Throughput	TCP	Uplink	The capacity of the network to handle TCP traffic from the device to the network.	Measured using iperf3 by generating TCP traffic from the device to the network and assessing the bandwidth.	iperf3
		Downlink	The capacity of the network to handle TCP traffic from the network to the device.	Measured using iperf3 by generating TCP traffic from the network to the device and assessing the bandwidth.	iperf3
	UDP	Uplink	The capacity of the network to handle UDP traffic from the device to the network.	Measured using iperf3 by generating UDP traffic from the device to the network and assessing the bandwidth.	iperf3
		Downlink	Measures the capacity of the network to handle UDP traffic from the network to the device.	Measured using iperf3 by generating UDP traffic from the network to the device and assessing the bandwidth.	iperf3
Latency	RTT	N/A	Measures the round-trip time for packets from the source to the destination and back, indicating network responsiveness.	Measured using ping to calculate the time it takes for packets to travel to the destination and back to the source.	ping
Reliability	TCP	Uplink	Thehe ability of the netwrok to deliver TCP packets successfully from the device to the network.	Measured with an in-house tool evaluating TCP traffic's success rate from the device to the network.	In-house tool
		Downlink	The network's ability to deliver TCP packets successfully from the network to the device.	Measured with an in-house tool evaluating TCP traffic's success rate from the network to the device.	In-house tool
	UDP	Uplink	The network's ability to deliver UDP packets successfully from the device to the network.	Measured with an in-house tool evaluating UDP traffic's success rate from the device to the network.	In-house tool
		Downlink	The network's ability to deliver UDP packets successfully from the network to the device.	Measured with an in-house tool evaluating UDP traffic's success rate from the network to the device.	In-house tool
Signal Strength (RSRP)	N/A	N/A	The strength of the signal received by the device, influencing connection quality.	Measured as RSRP using a tool from the modem chipset, assessing the coverage and signal quality available to the device.	UE chipset tool

the behavior of the 5G SA network. The eMBB slice exhibits an average latency of around 25 ms, a UL throughput of 23 Mbps, and a median PDR of 80%. These results indicate a performance degradation of approximately 50% (in terms of throughput and latency). The URLLC slice, under realistic conditions, demonstrates a latency of approximately 15ms and a UL throughput of 32 Mbps, with the PDR consistently at 100%. According to Table I and target values, our measurements demonstrate the ability of the 5G SA network to support teleoperation in both ideal and realistic conditions. The realistic condition is more relevant due to the coexistence of multiple traffic flows managed simultaneously within the same network. The obtained outcomes from the realistic conditions show the resilience of URLLC slice, which, despite the presence of background traffic, guarantees low-latency performance, around 15 ms. These results underscore not only the versatility and efficiency of URLLC slices within the 5G SA network but also their critical importance in enabling teleoperation applications that require reliability and fast response times, even in congested and complex network environments. Deliverable D5.4 [14] produced by the 5G-Blueprint project, contains a more complete analysis of our measurements. Due to space constraints within this manuscript, readers are invited to point to [14] for more details.

V. VALIDATION OF THE 5G STANDALONE NETWORK

To validate the effectiveness of the 5G SA network (evaluated in Section IV) for teleoperation use cases, we perform an experiment using a video camera. The main intent of this experiment is to validate the use of teleoperation e.g., teleoperated skid steer, in different contexts, such as indoor, outdoor, and mixed environments. We stream video data from a camera placed between different locations within the Verbrugge Scadia Terminal to the edge node. In addition, through this experiment, we aim to understand how various environmental conditions affect the 5G SA network performance. We collected data related to RSRP, bitrate, and corrupted frames through large periods e.g., four weeks for location 1, 24/7. The corrupted frames are the number of frames that cannot be reconstructed on the edge node through the software running in the MEC infrastructure. In the case of teleoperation, the corrupted frame has a large impact on the end-to-end performance e.g., the teleoperator loses view

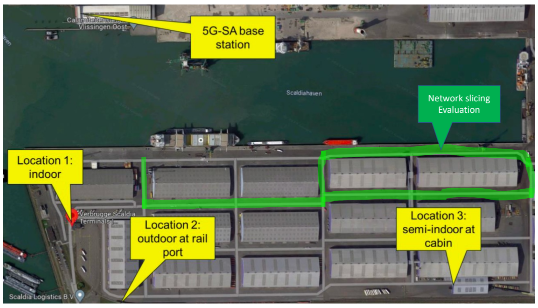

Fig. 2. Verbrugge Scaldia Terminal.

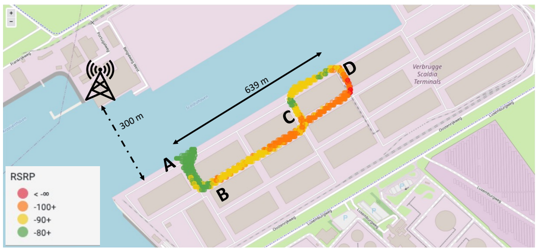

Fig. 3. Heat map of the RSRP value in the Verbrugge Scadia Terminal.

TABLE III
ANALYSIS OF 5G SA NETWORK EVALUATION

KPI	**Min**	**5th perc**	**Median**	**95th perc**	**Max**	**Average**
RSRP (dBm) - Fibocom	-101	-96	-84	-66	-62	-82.3
TCP DL (Mbps) - eMBB without background	185	252	338	433	556	343
TCP DL (Mbps) - eMBB with background	6.58	48.8	128	197	246	127
TCP UL (Mbps) - eMBB without background	1.79	37.1	53.1	61.8	114	52.8
TCP UL (Mbps) - URLLC without background	5.73	10.5	37	60.6	114	38.3
TCP UL (Mbps) - eMBB with background	3.40	16	23.2	30.3	45.7	23.3
TCP UL (Mbps) - URLLC with background	3.32	6.06	34.6	52.2	66	31.9
UDP DL (Mbps) - eMBB without background	145	241	344	503	660	360
UDP DL (Mbps) - eMBB with background	86.1	121	180	248	369	185
UDP UL (Mbps) - eMBB without background	32.2	41	54.7	63.1	65.5	54.3
UDP UL (Mbps) - URLLC without background	9.79	13.2	45	61.6	63.9	42.8
UDP UL (Mbps) - eMBB with background	3.44	19.3	25	30.8	31.9	25.2
UDP UL (Mbps) - URLLC with background	5.42	8.93	34.6	50.9	54.2	32.2
RTT (ms) - eMBB without background	10.6	11.7	14.4	20.9	41.2	15.0
RTT (ms) - eMBB with background	11.5	12.6	23.8	37.6	48.8	24.6
RTT (ms) - URRLC without background	11.1	11.6	12.6	17.8	26.6	13.1
RTT (ms) - URRLC with background	10.8	11.5	14.1	18.7	26.7	14.7

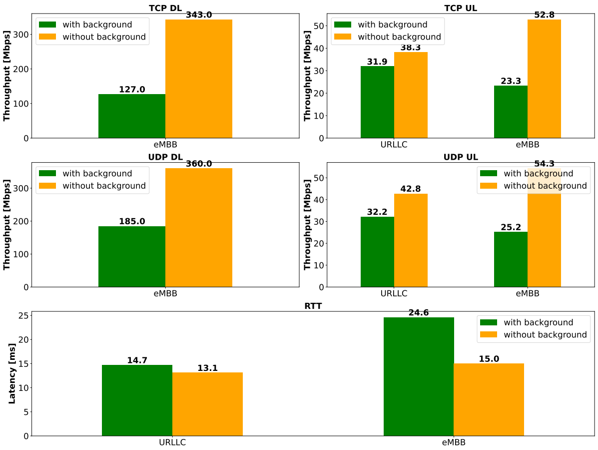

Fig. 4. Summary of 5G SA network evaluation.

from the teleoperated forklift.

A. Experiment setup

The experiment setup involves one camera that streams video data at a rate of 30 frames per second, a Fibocom FM160 5G modem, one switch, one mini-computer, and a remote Virtual Machine (VM) to process the incoming video frames. The VM is the edge node where the MEC application is executed. We use in-house software for real-time processing and metadata detection e.g., frames per second from the live camera feed.

B. Results and discussion

Figure 5 shows the results of our experiment for the different locations illustrated in Figure 2. In Figure 5 the a) column shows the RSRP values, column b) shows the data rate, and column c) shows the number of corrupted frames per day. According to [15], from the RSRP values, we classify location 1 as "Cell edge" with an average of -116 dBm, location 2 as " Good" with an average of -85 dBm, and location 3 as "Cell edge" with an average of -125 dBm. The bit rate in location 2 is higher than in the other two locations. These results are expected since location 2 is outdoors, and it has a higher RSRP value. The graphs related to the corrupted frames show the number of corrupted frames per day. From the graphs related to the corrupted frame, we can see the trend follows the same tendency. For location 1 we registered 0.006% of the corrupted frame (284 out of 4.821.176), for location 2 we obtained 0.009% corrupted frame (1324 out of 13.618.941), and for location 3 we registered 0.004% of corrupted frames (4 out of 88.599). Therefore, 99.99% of the video frames sent by the camera e.g., from the skid steers, arrive correctly at the remote VM e.g., teleoperator located at the ToC. Therefore, the measured percentage of corrupted frames is statistically negligible. Those results confirm the evaluation from the network assessment in Section IV, highlighting the robustness of the 5G SA network.

VI. CONCLUSION

In this study, we evaluate a real-world 5G Standalone network with network slicing in port environments, focusing on the performance of different network slices, specifically uRLLC and eMBB, for teleoperation use cases. We validate 5G SA network measurements through real experiments conducted in various locations whitin the port environment. this work thoroughly evaluates the capabilities of each slice, highlighting the critical role of network slicing in ensuring efficient and reliable teleoperation. Through detailed experimentation, we demonstrate the robustness of the network and its ability to support complex teleoperation scenarios, highlighting the significant contribution of 5G Standalone technology to the advancement of teleoperated transport systems in challenging operational environments. Key performance indicators such as Round-Trip Time latency, Reference Signal Received Power, Packet Delivery Ratio, and corrupted frame rates were evaluated to highlight the technological advances and operational efficiencies enabled by 5G.

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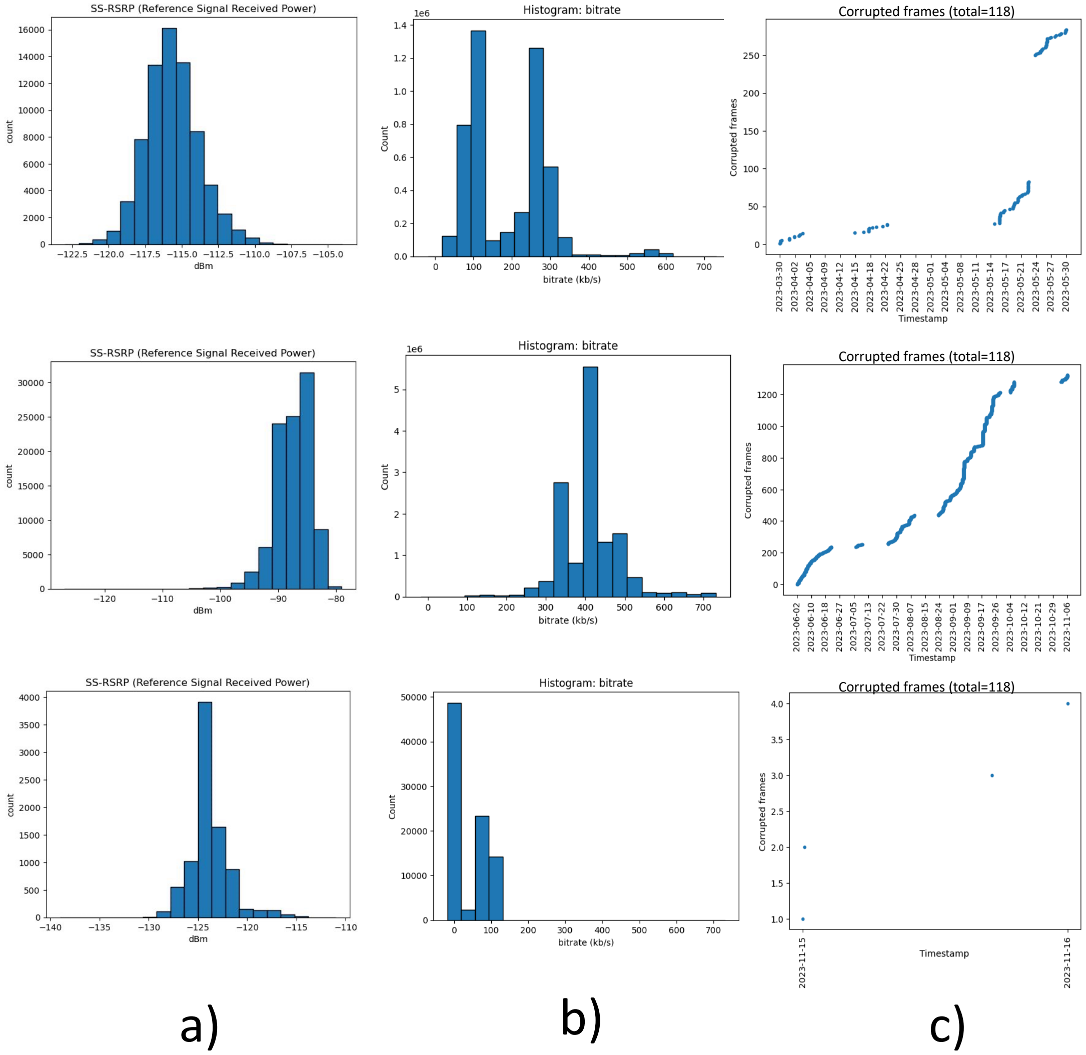

Fig. 5. Summary of the network validation. a) column shows the RSRP values, column b) shows the data rate, and column c) shows the number of corrupted frames per day.

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