Discovering the most urgent 5G services for the competitiveness of the port using an updated Analytic Hierarchic Process in the 5G-LOGINNOV project

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***Abstract*— The Analytic Hierarchic Process (AHP) is a type of analysis that allows finding - considering different criteria and given a certain objective - the best option among different choices [1]. Since it is not always possible and easy to collect proper data for AHP (especially if the context is complex and the stakeholders are complicated to contact), in this paper we want to propose a new methodology that allow to perform the AHP using data collected for other scopes. Following in the footsteps of the AHP proposed by Saaty [1], through a new methodology this paper identifies the most important 5G services for the competitiveness of the port. The research field is the 5G-LOGINNOV project and the research question that guided the work is: which 5G service best meets the most urgent needs of the ports? The aim of this paper is to propose a methodology for an AHP that can be re-used to understand which are the most urgent services needed in line with the defined objectives.**

Keywords*— *Evaluation methodology, data analysis, AHP, European projects, 5G services, 5G networks, maritime port, logistics, competitiveness.

I. Introduction

The AHP presented in this paper aims to understand which 5G applications and services in the 5G-LOGINNOV project [2] are considered more urgent and needed for port operation optimization. The importance of these applications and services will be evaluated considering the stakeholders' perception and the insights coming from workers of technological and operational companies involved in the port's processes.

5G-LOGINNOV is a European project that has the goal to use new innovative concepts, applications and devices supported by disruptive 5G technologies, Internet of Things (IoT), data analytics, Artificial Intelligence/Machine Learning (AI/ML), next generation traffic management and the Cooperative, Connected and Automated Mobility (CCAM).

Within these ambitions, the project will further develop and verify next generation ports & logistics hubs operation system architecture with integrated 5G networks in three European ports that are supporting deployment of innovative use cases (UC) in their living labs (LL): Athens (Greece), Hamburg (Germany) and Koper (Slovenia).

A. Living lab Athens with its use cases

[8] Use cases in Athens LL are exploiting several functions of 5G technology to address demanding logistics and Industry 4.0 scenarios in port operations. Optimizing real-time operations requires time constrained and precise updates over a set of participating assets (e.g., trucks, cranes, lifts), that address different phases of interconnected port operations. At Piraeus port, real-time traffic regulation and coordination over a fleet of 5G connected trucks were realized through low-latency transmissions and enhanced localization services, while also telemetry data from a set of diverse on-truck sensors were utilized. Such operations, illustrated by UC2/UC3, are exploiting the low latency 5G network to optimize in real-time the truck routes/selection (and potentially other dependent services) in port operations which have direct impact on several work chains at Piraeus port. To further facilitate automation in port operations, a MANO platform was developed to enable on the fly service orchestration and service life cycle management at scale, exploiting core 5G technologies and NFV, where pioneering 5G-IoT devices were designed and developed. Particularly, on average, a mother vessel at Piraeus needs 3000 stevedore moves for operations completion. Seal-presence check currently requires one person and about 30 seconds to complete. Reducing this time by e.g., 3 seconds per container, results to 9000 seconds (or 2.5 hours) reduction of vessel stay at the port and removes the need for human presence at an area with high safety risks. In this case, taking advantage of 5G technology and low latency transmissions (coupled with far-edge computing services on-board the proposed 5G-IoT device and MANO) will have a direct effect on the unloading (and other) processes for vessels in port operations. Additionally, eMBB service are exploited to provide greater data-bandwidth for consuming 4K surveillance video streams from several sites at port, and enhanced video analytics techniques based on Artificial Intelligence/Machine Learning (AI/ML) models at the far edge (incorporated into the proposed 5G-IoT device) were implemented, to meet the needs at the LL premises related to port control, logistics and remote automation (UC4, UC5). Finally, real-time asset monitoring (e.g., per truck CAN-Bus and other sensor data), coupled with analytics tools and ML for

predictive maintenance, were implemented through UC7, which are exploring 5G low latency transmissions to monitor in real time the performance/status of assets (e.g., trucks), in order to reduce operational costs, improve operational efficiency and extend the life cycle of port equipment.

B. Living lab Hamburg with its use cases

[8] For Hamburg LL, use cases 8 and 9 are aimed at collecting Floating Truck & Emission data (FTED) by 5G IoT devices, on-board units, and nomadic devices, whereas use case 11 is using this data for sustainable traffic management purposes. Analyzing FTED data according to the ISO-23795 standard [2] leads to microscopic emission models per vehicle for the air pollutants CO2, NOx, PM, and noise, all directly linked to acceleration and energy performance index (API, EPI). But applying the ISO-23795 standard for carbon footprint monitoring, requires stable data transmission and precise positioning, even more when using ISO-23795 for NOx, PM, and noise where Newtonian Physics turned out to be non-linear relative to fuel consumption detection per floating car. Additionally, use cases 8, 9 and 11 include Real-Time Tracking & Enhanced Visibility features for traffic managers by monitoring FTED speed profiles and congested road segments, services which once again require stable data transmission and precise positioning (5G prerequisite).

Green Light Optimal Speed Advisory (GLOSA) helps drivers to avoid harsh braking, which is one of the main causes for increased fuel consumption and CO2 emissions. In 5G-LOGINNOV, GLOSA is used for truck platoons and to showcase a mid-term migration path for using GLOSA in Automated Truck Platoons based on 5G technology. From 5G projects and publication [3], it is well-known that Vehicle-to-Infrastructure (cellular V2X) for vehicle platooning has End-to-End (E2E) latency requirements of 20ms time frames and up to 350m minimum ranges, prerequisites, which can only be achieved with the URLLC functionalities of the 5G network. Performance requirements for advanced driving including collision avoidance (10ms E2E latency) and cooperative lane change (25ms E2E latency) have the same low latency communication characteristics and cannot implemented without 5G mobile networks. In 5G-LOGINNOV, GLOSA based Truck Platoons will demonstrate a migration path towards higher SAE levels of Automation starting with basic functionalities including 5G test cases and test runs foreseen in use case 10, GLOSA based Automated Truck Platoons.

C. Living lab Koper with its use cases

[8] To automate the process of 5G network and services deployment in LL Koper, NFV-MANO was selected as the orchestrator (showcased in UC1) as it provides means to efficiently provision, deploy and manage entire life cycle of 5G network infrastructure and Industrial IoT services. NFV-MANO supports OpenStack/Kubernetes and public cloud providers and can be used on private or public mobile network systems, as both are required for reliable port operation. Furthermore, NFV-MANO also supports network slicing, which is another requirement for efficient port logistic operation, as it can provide different network capabilities in terms of performance and QoS/QoE per different user segment (e.g., real-time communication, IoT, M2M, UHD video streaming in real-time). To enable more advanced port logistic services, such as automation control of container management system or real-time AI-powered video surveillance, 5G MEC components were established along with high-performance CCTV applications (as showcased in UC5/UC6). Such applications (e.g., body worn camera, drone-assisted video streaming) will significantly benefit from low-latency provided by 5G mobile network and its MEC enhancements while the complexity of the system is abstracted through the orchestration system powered by NFV-MANO.

Table 1 summarizes the usage of the 5G Services and applications within the context of the use cases that were developed and demonstrated in the 5G-LOGINNOV project.

TABLE 1: 5G SERVICES AND APPLICATION MATRIX

5G Services / Application	UC #1	UC #2	UC #3	UC #4	UC #5	UC #6	UC #7	UC #8	UC #9	UC #10	UC #11
Slicing	x										
MEC	x			x	x	x		x	x	x	x
NFV-MANO	x		x	x	x	x	x				
Positioning					x						
Traffic Management								x	x	x	x
HP CCTV Surveillance Application				x	x	x					
RT Tracking & Enhanced Visibility	x	x						x	x	x	x
Maintenance Support					x		x				

Due to the 5G system complexity and other non-technological factors (e.g., port size, supported logistic process) it is not directly visible which of the proposed 5G services and applications best meets the most urgent needs of the future ports. As such proposed AHP methodology will be used to support the decision process.

The use cases (and related services) considered in this paper are: UC1: Management and Network Orchestration platform, developed in Luka Koper; UC5: Automation for Ports: Port Control Logistics and Remote Automation, established in Luka Koper and Athens; UC6: Mission Critical Communications in ports, settled in Luka Koper; UC8: Floating Truck & Emission Data, grown in Hamburg; UC10: 5G GLOSA & automated truck platooning (ATP), developed in Hamburg; UC11: Dynamic control loop for environment sensitive traffic management actions established in Hamburg.

II. METHODOLOGY: INNOVATION TO USE THE AHP WITH NO STANDARD DATA

During the 5G-LOGINNOV project, an online survey was delivered to all stakeholders involved in the project, comprising all the experts working for businesses located in the three ports. Particularly, the respondents are employees of companies straightforwardly involved in daily operations and services aimed at supporting port activities [3].

For this paper we used the answers to two questions that were not set purely to perform the AHP as the Saaty Scale [1] was not used and no specific comparison questions were defined: a further step to proceed with the AHP was necessary.

The data that we used for this analysis came from the two following questions:

1. Can you order the importance of the evaluation criteria of the UCs from the 1st to the 15th place? This question had the goal to clarify the scale of importance that each interviewee assigned to the pre-defined criteria.

2. How much do you agree that a certain criterion is important for the relative UC? In this case, the scale used included 5 options: 1 = strongly disagree; 2 = disagree; = 3 = somehow agree; 4 = agree; 5 = strongly agree.

We had to adjust the data so that it could be used for the AHP: for the answers to the first question, we decided to give a score inversely proportional to the ranking: the criteria placed in the first place was assigned a score of 15, while to the criteria positioned in the last place was assigned a score of 1. Furthermore, within each use case, for each criterion, the average of the scores given by the individual interviewees was considered to have a single value for each criterion as shown in Table 2.

It was therefore possible to find the highest and the lowest score given to the criteria and for each UC. Then we found the relative differences (i.e., the highest score given to a criterion minus the lowest score given to a criteria). Once that we have found all the variances, the highest difference was divided by 5 (like the number of scores in the Saaty scale: 1, 3, 5, 7, 9). All these numbers and passages are summarized in Table 3.

Thanks to this procedure, it was possible to obtain the size of the sets of each value included in the Saaty Scale, defining five ranges to be matched with the Saaty scale value as follow: 0 – 2,2 = 1; 2,21 – 4,41 = 3; 4,42 – 6,62 = 5; 6,63 – 8,83 = 7; +8,84 = 9

The same procedure was followed to recalculate the AHP scores based on the answers to the second questions, arriving to define the range as shown in Table 4.

TABLE 2: SCORE FOR THE CRITERIA ACCORDING TO THE RESPONDENTS OF UC1 AND THEIR AVERAGE

	RESPONDENTS	20	21	24	26	Total	Average
	USE CASE	1	1	1	1		
CRITERIA	PROVIDE ACCURATE COMMUNICATIONS AND RECOMMENDATIONS FOR OPERATIONS	15	6	15	8	44	11
	INCREASE SAFETY WITHIN PORT	2	10	11	11	34	8,5
	INCREASE SECURITY IN PORT AREAS	3	9	14	12	38	9,5
	INCREASE EFFICIENCY OF THE OPERATIONS	14	15	13	15	57	14,25
	DECREASE COSTS FOR OPERATION	13	3	12	14	42	10,5
	DECREASE TRAFFIC AND INCIDENTS	5	11	10	13	39	9,75
	IMPROVE CONNECTIONS INSIDE AND OUTSIDE THE PORT	6	8	5	3	22	5,5
	INCREASE NUMBER OF ITC SERVICES	4	14	4	2	24	6
	DEGREE OF CENTRALIZATION OF DATA AND INFORMATION SOURCES	11	13	2	1	27	6,75
	DEGREE OF DATA-DRIVEN AND DIGITALLY AUTOMATED PROCESSES	12	12	3	4	31	7,75
	IMPROVE QUALITY OF WORKING ENVIRONMENT	7	7	6	10	30	7,5
	INCREASE ECONOMIC WEALTH	10	2	8	7	27	6,75
	INCREASE BUSINESS COOPERATION	9	1	7	9	26	6,5
	DECREASE HEALTH RISKS FOR WORKERS	1	5	9	6	21	5,25
	INCREASE RESILIENCY TO CLIMATE CHANGE	8	4	1	5	18	4,5

TABLE 3: DIFFERENCES AMONG THE HIGHEST SCORE AND THE LOWEST SCORE GIVEN TO A CRITERION FROM THE RESPONDENTS

	Highest score given to a criteria	Lowest score given to a criteria	Difference (highest score given to a criteria - lowest score given to a criteria)	Size of the sets of each value included in the Saaty Scale
UC1	14,25	4,5	9,75	
UC 5	14,5	3,75	10,75	
UC 6	13,83	2,83	**11**	= 11/5 = **2,2**
UC 8	12,55	4,45	8,1	
UC 10	12,09	4	8,09	
UC 11	13	4,17	8,83	

TABLE 4: DEFINITION OF RANGES AND THEIR CORRESPONDENT SAATY SCALE VALUE FOR THE CHOICES

Range of difference when comparing different criteria	**Saaty Scale (values to be used to perform the AHP)**
0 → 0,50	1
0,51 → 1,01	3
1,02 → 1,52	5
1,53 → 2,03	7
+ 2,04	9

III. THE AHP IMPLEMENTATION

After having obtained the right data format to proceed performing the AHP, the steps proposed by Saaty [1] were followed.

A. Clarify the objective of the analysis

This analysis aims to provide a specific answer to the question: "what is the impact of the use cases, based on different evaluation criteria and the different weights that the respondents have assigned to these criteria?".

B. Identify the data representing the choices and the criteria for the AHP

To perform the two-level AHP included in this analysis, the methodology followed was the one proposed by [4], inspired by [1]. The idea behind this analysis is to assess how much a choice (the six use cases, in our analysis) is better than the other ones according to our established 15 criteria, which were: provide accurate communications and recommendations for operations, increase safety within the port, increase security in port areas, increase the efficiency of the operations, decrease costs for operation, decrease traffic and incidents, improve connections inside and outside the port, increase the number of ITC services, degree of centralization of data and information sources, degree of data-driven and digitally automated processes, improve quality of the working environment, increase economic wealth, increase businesses cooperation, decrease health risks for workers, increase resiliency to climate change.

According to the methodology of the two levels AHP, the steps to be performed to obtain a ranking of UCs based on their importance involves a double AHP: one in which all the criteria were compared with each other; one in which all the use cases were compared with each other, based on each criterion. The

AHP foresees a pairwise comparison of use cases by assigning to them a specific assessment based on the Saaty scale, as reported in Table 4.

The total number of pairwise comparisons is related to the number of elements to be compared and it is equal to n (n-1) / 2, where "n" is the number of elements to compare. In our analysis: for the criteria, the total number of pairwise comparisons were: 15(15-1)/2 = 105; for the choices (the UCs) the total number of pairwise comparisons for each criterion are: 6(6-1)/2 = 15.

TABLE 5: SAATY SCALE [1]

Assessment	Reciprocal value	Meaning
1	1	Equal
3	1/3	Slightly better / slightly worse
5	1/5	Strongly Better / Strongly worse
7	1/7	Very strongly better / very strongly worse
9	1/9	Extremely better / extremely worse

C. Procees with the AHP for both choices and criteria

This third step has been divided in 3 sub steps**.**

Compute criteria priority vectors for each use case (AHP level 1): Table 6 shows the AHP process: in yellow there are the diagonal elements that are always equal to 1 because they compare the same element in the row-column, in blue the judgments of the comparison in pairs row-columns are highlighted and in orange there are corresponding elements that complete the matrix with reciprocal values. For each comparison matrix, we calculated the normalized relative weight, dividing each element of the matrix with the sum of its column. Then it was necessary to calculate the priority vector by averaging across the rows. The results are shown in the Table 6.

Select relevant criteria: in Table 7 we show the results deriving from all the comparison matrices, displaying the priority weight of each criterion, considering each UC and on average. The priority vectors show different weights for different use cases. This means that each UC has shown to have dissimilar significant criteria. In addition, the average values of the weights for each one of the 15 criteria shows that some have greater values than others and their average values range from 2,2 to 17,95. Assumed the wide range, it was fundamental to privilege only the sensitive criteria to be passed on to level 2 of the AHP where they are used to compute the rank among different choices. To select the criteria, we used the mean value as an estimator of the importance at the project level and the standard deviation as an expression of the accordance among priority weights of different use cases. Figure 1 shows a plot of the two statistics, and it presents two different behaviors. One on the top right quadrant characterized by high mean and standard deviation, and another one in the bottom left with low mean and standard deviation. By setting the threshold at criteria with values greater than 6 and 3 respectively for the mean and the standard, 7 relevant criteria were identified. These will be weighted in to compute the ranking in the AHP level 2.

Compute ranking of choices/use case (AHP level 2): this final step foresees the ranking of choices per use case: Table 8 shows the priority weight for each UC according to the different considered criteria.

TABLE 6: COMPARISON OF THE DIFFERENT USE CASES CONSIDERING THE INCREASED SECURITY IN PORT AREAS

	UC 1	UC 5	UC 6	UC 8	UC 10	UC 11
UC 1	1,00	1,00	0,33	5,00	5,00	5,00
UC 5	1,00	1,00	0,33	3,00	3,00	5,00
UC 6	3,00	3,00	1,00	7,00	7,00	9,00
UC 8	0,20	0,33	0,14	1,00	1,00	1,00
UC 10	0,20	0,33	0,14	1,00	1,00	1,00
UC 11	0,20	0,20	0,11	1,00	1,00	1,00

TABLE 7: COMPARISON MATRIX, NORMALIZED RELATIVE WEIGHT, PRIORITY WEIGHT

	UC 1	UC 5	UC 6	UC 8	UC 10	UC 11	normalized relative weight	priority weight
UC 1	0,18	0,17	0,16	0,28	0,28	0,23	0,22	**21,56**
UC 5	0,18	0,17	0,16	0,17	0,17	0,23	0,18	**17,85**
UC 6	0,54	0,51	0,48	0,39	0,39	0,41	0,45	**45,31**
UC 8	0,04	0,06	0,07	0,06	0,06	0,05	0,05	**5,31**
UC 10	0,04	0,06	0,07	0,06	0,06	0,05	0,05	**5,31**
UC 11	0,04	0,03	0,05	0,06	0,06	0,05	0,05	**4,67**

TABLE 8: PRIORITY WEIGHT FOR EACH CRITERION AS DEFINED FROM THE UCS AND ON AVERAGE

	UC1	UC5	UC6	UC8	UC10	UC11	**Average among Ucs**
Provide accurate communications and reccommendations for operations	11,10	9,95	6,17	7,92	11,08	16,83	**10,51**
Increase safety within port	5,21	6,58	20,80	2,85	3,78	2,04	**6,88**
Increase security in port areas	7,57	6,94	14,83	2,96	3,53	2,11	**6,32**
Increase efficiency of the operations	24,52	25,45	14,83	14,25	13,62	15,01	**17,95**
Decrease costs for operation	12,80	14,02	6,17	3,76	11,08	7,48	**9,22**
Decrease traffic and incidents	8,40	4,17	10,37	15,45	14,10	12,08	**10,76**
Improve connections inside and outside the port	2,54	1,66	3,69	10,22	5,51	5,19	**4,80**
Increase number of ITC services	2,75	2,51	4,23	2,61	2,60	2,18	**2,81**
Degree of centralization of data and information sources	3,41	6,94	2,87	4,67	4,47	7,19	**4,93**
Degree of data-driven and digitally automated processes	4,79	6,94	2,95	6,75	4,02	4,71	**5,03**
Improve quality of working environment	4,04	4,07	3,96	2,96	3,90	3,04	**3,66**
Increase economic wealth	3,41	2,87	2,87	3,76	3,78	3,15	**3,31**
Increase businesses cooperation	3,08	2,51	2,03	2,13	1,86	1,76	**2,23**
Decrease health risks for workers	4,48	2,80	2,95	2,08	1,72	2,22	**2,71**
Increase resiliency to climate changee considered successful?	1,89	2,57	1,27	17,64	14,94	15,01	**8,89**

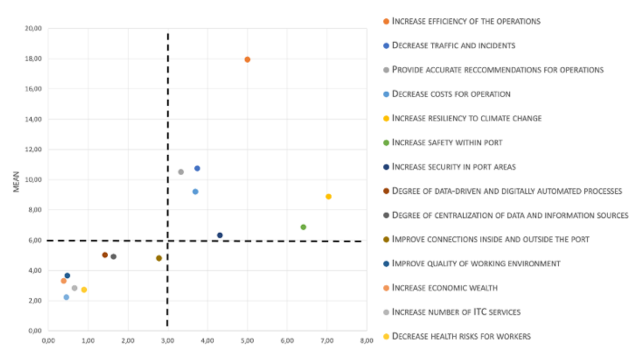

Figure 1: Standard deviation to find the most relevant criteria

TABLE 9: PRIORITY WEIGHT FOR EACH UC ACCORDING TO THE CONSIDERED CRITERIA

	USE CASE 1	USE CASE 5	USE CASE 6	USE CASE 8	USE CASE 10	USE CASE 11
PROVIDE ACCURATE COMMUNICATIONS AND RECOMMENDATIONS FOR OPERATIONS	16,07	13,69	13,69	16,07	16,07	24,4
INCREASE SAFETY WITHIN PORT	17,1	19,55	48,56	6,72	4,48	3,59
INCREASE SECURITY IN PORT AREAS	21,56	17,85	45,31	5,31	5,31	4,67
INCREASE EFFICIENCY OF THE OPERATIONS	20,49	16,32	14,24	16,32	16,32	16,32
DECREASE COSTS FOR OPERATION	15,97	28,47	13,19	13,19	13,19	15,97
DECREASE TRAFFIC AND INCIDENTS	7,52	7,52	10,5	21,01	29,11	24,35
IMPROVE CONNECTIONS INSIDE AND OUTSIDE THE PORT	39,84	4,83	13,83	13,83	13,83	13,83
INCREASE NUMBER OF ITC SERVICES	34,03	12,5	18,75	12,5	9,72	12,5
DEGREE OF CENTRALIZATION OF DATA AND INFORMATION SOURCES	22,21	22,21	11,34	9,26	16,1	18,88
DEGREE OF DATA-DRIVEN AND DIGITALLY AUTOMATED PROCESSES	16,67	16,67	16,67	16,67	16,67	16,67
IMPROVE QUALITY OF WORKING ENVIRONMENT	14,24	16,32	20,49	16,32	16,32	16,32
INCREASE ECONOMIC WEALTH	12,78	32,78	16,11	12,78	12,78	12,78
INCREASE BUSINESS COOPERATION	26,28	18,78	22,11	13,22	10,84	8,76
DECREASE HEALTH RISKS FOR WORKERS	10,55	14,31	44,03	9,03	10,55	29,32
INCREASE RESILIENCY TO CLIMATE CHANGE	3,77	7,19	4,76	29,32	29,32	25,63

D. Check the consistency of the data

Before proceeding further, we had to calculate the consistency index and the consistency ratio, using the Random Consistency Index [5]. All values analyzed passed the consistency test which means that all the considered values resulted <0.1.

E. Calculate the composite weight to answer the starting questions

Through this analysis, it was possible to arrive to the final calculation that allows answering the question that guided the whole analysis and the Table 9 shows the results of the AHP analysis, demonstrating that UC6 is the best choice, followed by UC1 and UC 11. This last calculation foresees that the overall weight of each UC is the normalization of a linear combination of multiplication between weight and priority vector as follow:

UCX = (adjusted weight for criteria A) (priority vector of UCx for criteria A) + (adjusted weight for criteria B) (priority vector of UCx for criteria B) ...

Through a quantitative method, this analysis allowed to reduce the subjectivity in the choice of criteria. Consequently, the selected criteria equipped the evaluation to better understand which use case best responds to the objective of the project.

TABLE 9: FINAL RESULTS

Use Cases	Composite Weight
Use Case 1	17,14
Use Case 4	15,92
Use Case 6	18,52
Use Case 8	15,37
Use Case 10	16,33
Use Case 11	16,72

IV. CONCLUSION

The AHP is an important decision-making technique that has revealed to be a significant strategy to resolve conflicts and incertitude. Even if the AHP can clearly help in providing an overall ranking of specific alternatives – as shown in the analysis proposed in this paper - the ranking produced can be very sensitive: the smallest change in the priority weights can completely alter the final order of the alternatives [6]. However, the results of the AHP allow, during the project lifetime, to cyclically check if the objectives and criteria used are still coherent and to clarify the strengths of the use cases, prioritizing certain services, allowing a better dissemination and exploitation of the results.

Within the methodology here presented we aimed to propose a new precious path for European projects that can perform different analysis using a single data set format, avoiding overloading the stakeholders involved in the project.

The AHP presented in this paper has given a result: considering the 15 criteria, the best 5G services and application are the ones developed within the use case 6: Mission Critical Communications in ports, established in Luka Koper. Future research should discover if different criteria and/or if a different sample should be considered.

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REFERENCES

[1] Saaty, T. L. (1990). An exposition of the AHP in reply to the paper "remarks on the analytic hierarchy process". Management science, 36(3), 259-268.

[2] 5G-LOGINNOV Consortium, 5G-LOGINNOV Home Page, https://5g-loginnov.eu/, 2021, last access: 04/01/2022.

[3] Porelli, A., Hadjidimitriou, N. S., Rosano, M., & Musso, S. (2021). Enhancing port's competitiveness thanks to 5G enabled applications and services. In 2021 IEEE 45th Annual Computers, Software, and Applications Conference (COMPSAC) (pp. 1950-1955). IEEE.

[4] Teknomo, K. (2006). Analytic hierarchy process (AHP) tutorial. Revoledu. com, 1-20.

[5] Saaty, T. L. (2000). Fundamentals of decision making and priority theory with the analytic hierarchy process (Vol. 6). RWS publications.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] Zhu, L., Aurum, A., Gorton, I., & Jeffery, R. (2005). Tradeoff and sensitivity analysis in software architecture evaluation using analytic hierarchy process. Software Quality Journal, 13(4), 357-375.

[8] Marco G., Ralf W., Johannes C., Pavlos B., Janez S., Luka K., Dejan Š., Jurij K., 5G-enabled logistics use cases, D1.1, 5G-LOGINNOV, 28/01/2021.