Review of the doctoral dissertation entitled:
"Analysis and Assessment of The Quality of Wireless Information Transmission in Shipboard Measurement and Control Systems – Coexisting Perspective"
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The undersigned, University Professor Alexandru Salceanu, Director of the Council for Doctoral Studies, Technical University "Gheorghe Asachi" of Iasi, Romania, I have examined the scientific content and the form of presentation of the doctoral dissertation entitled "Analysis and Assessment of The Quality of Wireless Information Transmission in Shipboard Measurement and Control Systems – Coexisting Perspective".

I have concluded the following:

1. The relevance and necessity of the topic

This doctoral thesis examines the evolution and enhancement of shipboard measurement and control systems, which have traditionally been dominated by analog and on-off binary standards, with a particular focus on the 4-20 mA standard due to its noise immunity and reliability. Despite its robustness, environmental factors such as temperature, humidity, vibration, and salinity can adversely affect these systems in marine environments, leading to issues like ground loops and inaccurate readings.

The maritime industry's primary motivation is to reduce construction costs while maintaining profitability, a goal shared by both shipbuilders and owners. Conventional measurement systems, deemed cost-effective, are a short-term solution that overlooks long-term operational costs, impacting maintenance and quality. Addressing these challenges, the study proposes a shift towards integrating wireless technologies with classical standards and smart sensing protocols to improve system cost-effectiveness and performance.

Through simulations, experimental research, and real-time applications, this thesis evaluates the deployment of wireless technologies, specifically wireless HART and Wi-Fi, as efficient data transmission mediums. These technologies offer enhanced reliability and quality by mitigating the limitations posed by traditional cabling systems. The study highlights issues associated with cabling,

such as its vulnerability to extreme marine conditions. It examines modern protocols, including HART and Foundation Fieldbus, for improved operational efficiency in maritime settings.

The implementation of Wireless HART, particularly in harsh environments, is explored alongside the use of Wi-Fi as a general-purpose alternative, demonstrating their potential to work synergistically with cabling. Various case studies, including the deployment of smart sensors on bulk carriers and Wi-Fi data transactions on container ships, illustrate practical applications and provide cost analysis. By adopting wireless technologies as a cooperative rather than a replacement medium, the thesis proposes an enhanced measurement and control process, thereby driving the popularity of wireless systems in the maritime industry.

Overall, the work supports the adoption of wireless technology to enhance shipboard system efficiency, providing a comprehensive analysis of the coexistence concept. This concept is expected to gain traction among stakeholders due to its potential to deliver superior performance without entirely discarding traditional systems.

Undoubtedly, the topic addressed is current and arouses great interest.

2. The structure of the dissertation

The doctoral dissertation primarily focuses on evaluating the quality of using selected types of wireless technologies as a medium for measuring and controlling data management and transmission in shipboard systems. Such an evaluation is carried out through a perspective that takes into consideration the following key factors:

- Conventional measurement/control systems based on cabling in marine engineering applications are more vulnerable to the negative impact of harsh environmental conditions than land-based industrial automation systems.
- Using smart sensing techniques can enhance the performance (to a specific extent) of measurement/control tasks executed at shipboard systems.
- Increased levels of reliability and accuracy, easier fault detection and troubleshooting, and more efficient maintenance planning are the direct results of the collaborative coexistence between wireless technology, classical cabling-based measurement/control standards, and cabling-based smart sensing protocols.
- Wireless technologies are highly recommended for deployment as a cooperative data transmission medium in shipboard systems to achieve an optimal improvement in the quality of the conducted measurement /control processes.

, starting with a foundation in wired instrumentation, transitioning to wireless solutions, and then integrating both for enhanced shipboard systems. It combines theoretical discussions, simulations, experimental analyses, and practical applications. The flow is well-defined, providing a cohesive story arc focused on improved measurement and control in maritime settings. The dissertation appears to be thoroughly researched and well-organized, with a clear and practical focus on enhancing naval measurement and control systems through the integration of wireless technology.

In the introductory section, the state of the art is presented by outlining the challenges associated with conventional shipboard systems. The PhD student notes that existing wired systems are susceptible to environmental conditions and frequently lack long-term cost-effectiveness. Arguments are presented in support of integrating wireless technologies (Wireless HART, Wi-Fi) as a means to enhance measurement and control while reducing costs. There are highlighted wireless solutions that coexist and collaborate with traditional systems.

The **first chapter is entitled ”Wired Instrumentation in Maritime Engineering.”**
The content focuses on cable properties and environmental effects, including humidity and temperature, on (4-20 mA) Analogue Standard, a traditional industry standard, and its typical applications. The Smart Sensors (HART, FF) are presented, and modern smart sensor protocols operating via cabling are being explored. The limitations are discussed by simulating noise, interference, and specific setups.
We can appreciate that this chapter builds a foundation by dissecting traditional system vulnerabilities and potential improvements with smart sensors, before moving to wireless solutions.

The **second chapter, entitled ”Wireless HART Protocol in Maritime Engineering,”** demonstrates a thorough treatment of Wireless HART's suitability for maritime applications, addressing environmental limitations and suggesting reinforcement techniques.
Common concerns are addressed: RFI, EMI, signal strength, and power. A Wireless HART mathematical model for network reinforcement is detailed. Application Examples illustrate how to implement Wireless HART on various ship types for specific tasks.

The **third chapter, entitled ”General Use Wireless Technologies (Wi-Fi) in Maritime Engineering,**” discusses a lab setup to analyze authenticated Wi-Fi data, analyzes Wi-Fi performance, and discusses limitations based on range. It also introduces Wi-Fi Enhancements, highlighting solutions based on the ESP-NOW protocol for improved range.
Implementations are explored, demonstrating potential Wi-Fi applications through example deployments.

Solutions on Safety and Predictive Maintenance are presented, incorporating functional safety and predictive maintenance components for a marine cargo crane system.

Ultimately, an expanded **discussion** synthesizes the research and findings from all preceding sections, formulating the core concept of coexistence between wired and wireless technologies for maritime measurement and control systems.

The **last chapter of Conclusions** summarizes key results and validates the dissertation's theses.

Overall, the dissertation appears to be thoroughly researched and well-organized, with a clear and practical focus on enhancing maritime measurement and control systems through the integration of wireless technology.

3. On the literature referenced in the dissertation

The literature appears to be well-researched and representative of the key areas in the dissertation. The references come from diverse sources, both theoretical and practical.

The list contains both research papers directly related to the topic (primary sources) and foundational or general works (secondary sources). This indicates a well-rounded understanding of the field. I appreciate that the list relies on relatively recent publications, which is essential given the rapidly evolving nature of wireless and automation technologies.

There are several references to IEEE publications, respected journals, and standards from organizations such as ISA, CENELEC, and IEC, which indicate credibility.

The variety of reference types (e.g., empirical research, standardization documents) is broad, providing a balance between theoretical background and practical application. Several sources are particularly relevant to maritime engineering, indicating focused study and consideration of the specific context.

A special appreciation for the 7 articles included in the Bibliography of 113 titles, which have Mr. Abotaleb as the first author, 2 of which are in the prestigious journal Sensors, and another 2 in the Bulletin of the Polytechnic Institute of Iași.

4. Identification and assessment of the candidate's research objectives

The candidate's objectives demonstrate a balance between theoretical exploration and practical application, aligning with the goals of enhancing reliability, safety, and cost efficiency in maritime

engineering. The identified goals appear comprehensive, achievable, and impactful. The main research objectives are the following:

- Address Environmental Vulnerabilities: Investigate the negative impact of maritime environments (temperature, humidity, vibration, salinity) on the reliability and stability of existing wired shipboard measurement/control systems.
- Improve System Reliability: Explore and propose techniques to enhance the reliability and stability of shipboard systems through integration of wireless technologies, smart sensors, and advanced communication protocols.
- Coexistence Approach: Develop a comprehensive strategy and guidelines for the effective coexistence and collaboration between wired (classical + smart sensors) and wireless technologies (Wireless HART + Wi-Fi) in shipboard systems, rather than solely focusing on wireless as a replacement.
- Practical Application and Cost-Effectiveness: Ensure that any proposed changes or modifications can be effectively deployed while also demonstrating enhanced cost-effectiveness compared to traditionally deployed systems.
- Network Reinforcement: Dedicate efforts to reinforce wireless HART networks, overcoming limitations by developing a mathematical model to optimize the placement of repeaters and addressing the challenges posed by the high density of metallic infrastructure obstructing radio frequency propagation.
- Real-time Monitoring: Design, implement, and test a small-scale wireless system, dedicated to marine cargo cranes on a container ship, to demonstrate improved safety and performance.

I appreciate that the objectives are relevant, feasible, support innovation, and cover a broad range of aspects, from theory to practical applications, indicating a significant contribution to the existing literature and providing practical solutions for the industry.

5. Assessment of the research methods

Unlike most of the existing literature, which discussed the various aspects of adopting wireless technology in industrial automation systems, this dissertation is more focused on formulating the outlines of a general strategy based on which the ships' owners, as well as the ships' building facilities, can acquire the adequate knowledge required for decision-making process during ships' construction early phases to determine the selected techniques (at particular shipboard systems) through which the selected analyzed wireless technologies can be effectively deployed most efficiently. The dissertation concentrates on using two specific wireless technologies in marine engineering applications. The first technology is the wireless HART protocol, which is specifically designed for industrial applications. In

contrast, Wi-Fi is a general-use technology. The dissertation's analysis aims to explore the most efficient way to deploy both technologies in shipboard systems. However, the dissertation will initially dedicate a considerable section to analyzing the negative influence of extreme marine environmental/operational conditions on conventional measurement/control cabling-based systems. Additionally, the dissertation dedicates a significant part to describing the analysis conducted and its connection to the expected improvement from using smart sensing technologies, such as the HART protocol and Foundation Fieldbus, in shipboard systems. Conclusively, the dissertation presents the results of the conducted research related to the aforementioned concepts from the perspective of efficient, cost-saving, and collaborative coexistence of wireless technologies with other classical and smart sensing technologies.

- Conventional shipboard systems based on classical binary/analog standards are subjected to considerably low to high temperature, humidity, corrosion, salinity, and vibration levels. The general condition of marine measurement/control systems tends to deteriorate gradually due to the influence of various operational and environmental factors. Such deterioration can be primarily manifested in the formation of ground loops and higher levels of capacitive coupling currents, leading to lower accuracy and reliability levels. Such drawbacks can be overcome to a certain extent by using smart sensors based on communication protocols such as HART and Foundation Fieldbus, which provide additional parametric and diagnostic information.
- In many cases, the use of wireless technology as a coexistent data transaction medium can provide solutions for such problems. The improved security of measurement data transactions and facilitated deployment in intrinsically safe applications in explosive hazardous areas are the most significant advantages of deploying different types of wireless technologies (including solely dedicated industrial automation and general-use wireless technologies) in marine engineering measurement/control systems.
- The high density of metallic infrastructure on commercial ships can obstruct radio frequency RF wave propagation. The proposed techniques in this study offer methods dedicated to improving range capabilities through collaboration between two protocols (WebSerial and ESP-NOW) in Wi-Fi-based applications, as well as the use of adapters and repeaters in the wireless HART protocol.
- Based on the proposed techniques, wireless technologies such as Wi-Fi and wireless HART will coexist with cabling-based shipboard systems to implement essential principles such as functional safety and predictive maintenance PdM through adopting economically efficient plans.

These approaches have been validated to a specific extent through a systematic strategy to deploy the selected wireless technologies as integrative, cooperative data transaction mediums with cabling.

6 Research findings, novelty, and their practical applicability

I appreciate that the findings of this doctoral research enhance the cost-effectiveness and reliability of ship and cargo cranes. The integration of wireless technologies (Wireless HART and Wi-Fi) in shipboard measurement/control systems offers a more cost-effective and reliable alternative to traditional cabling solutions.

As a result, shipbuilders and owners could adopt wireless technologies to reduce cabling needs, leading to lower construction costs and decreased maintenance.

Another finding is that such specific setups enable accurate monitoring despite varying environmental conditions, which implies increased reliability compared to cabled devices, resulting in lower downtimes and more predictive power.

It should also be emphasized that the study develops a mathematical model for enhancing wireless HART networks through techniques such as repeater optimization. A model that could assist network planners in creating robust and reliable wireless networks, especially in environments with high levels of metallic infrastructure that obstruct RF waves.

Another valuable achievement is the successful implementation of a wireless safety and performance monitoring system for marine cargo cranes using a laboratory setup enhanced with ESP32-based Wi-Fi. The development of this monitoring system enables early detection of potential failures, reduces downtime, and extends the lifespan of critical crane equipment, resulting in increased economic efficiency and improved safety.

The analyzed research provides a novel approach to wireless instrumentation. This is not purely about replacing cabling with wireless links, but rather about implementing and demonstrating the concept of **coexistence.**

The authenticity of data is enhanced by developing a secure means for exchanging data with the ESP32, and validating any data through analysis is essential for protecting systems that provide stability and reliability.

Proposed solutions for improving wireless range include devising methods that emphasize integrating different protocols to enhance signal quality and connectivity.

Another approach with elements of novelty is to incorporate the IoT into existing systems by implementing these principles in a system that can integrate more devices through improved communication lines. A predictive technique is incorporated to provide efficient functionality in various cases.

The supporting pillars of such a strategy are the most essential results procured from the executed experimental, simulation-based, and real-time analysis, which included:

- Discuss the effects of high temperature, humidity, and salinity levels on cabling-based measurement/control systems.
- Analyzing the simulated impact of combined humidity and vibration on the smart HART 4-20 mA measurement current loop.
- Developing the necessary techniques to avoid the effect of AWGN in the Foundation Fieldbus protocol.
- Comparison of the possibilities of deploying the FF protocol in a shipboard system, such as a tank level measurement system (simulation-based case study), in safe and explosive hazardous areas.
- Implementation of a mathematical model dedicated to wireless HART network reinforcement.
- Introducing two planning examples for the wireless HART protocol, possible deployment in the engine room and on deck on commercial ships.
- Introducing improved range capabilities of Wi-Fi as a data transaction medium through proposed verified and real-time tested techniques based on the conjunction operation of the WebSerial remote serial monitor and ESP-NOW protocol.
- Highlighting the advantages of adopting the presented strategy to deploy Wireless HART and Wi-Fi at shipboard systems. Such a strategy can be briefly described as a cost-effective and functionally safe approach, leading to longer service lifetimes for shipboard equipment through the adoption of maintenance plans based on predictive maintenance, rather than just preventive maintenance.

Based on the extensive outline, referenced works, and research objectives presented in this dissertation, the candidate demonstrates a solid foundation in the relevant domains of maritime engineering, wireless communication, and control systems. Their familiarity with established wired and wireless standards, protocols, safety regulations, and methods for data analysis showcases a firm theoretical grasp. Furthermore, the dissertation's structured approach, innovative model development, and plans for real-world implementation indicate a capacity for independent scientific inquiry and problem-solving. This suggests that the candidate is well-prepared to make significant contributions to the field through future research endeavors.

I can confidently state that the theoretical and experimental studies, which have utility and newly added value, carried out by Mr. Eng. Mostafa Abotaleb under the highly competent scientific coordination provided by Prof. Dr. H.C. Janusz Mindykowski, are convincingly synthesized in the currently analyzed doctoral thesis.

After carefully reviewing the entire material, I appreciate that the doctoral thesis developed by Eng. Mostafa Abotaleb presents a solid and helpful work with applicability value.

As a corollary to all that has been stated, I appreciate that the results of the doctoral research carried out by Eng. Mostafa Abotaleb satisfies the conditions of rigor, novelty, and potential applicability, which are mandatory for completing doctoral research and thesis.

All these conclusions, reinforced by the two articles published by Mr. Abotaleb as first author in Sensors (IF=3.5, Journal Rank: JCR - Q2), along with five other articles as first author in well-rated international journals, are the main arguments that lead me to appreciate that the dissertation that crowns the research activity of Mr. Abotaleb, under the masterful coordination of Prof. Janusz Mindykowski, deserves distinction.

Iasi, Romania, the 4th of September 2025

Prof.dr eng. Alexandru Salceanu

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