A CONCEPTUAL FRAMEWORK FOR FACIAL RECOGNITION INTEGRATION IN ADNOC REFINING'S PHYSICAL SECURITY

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A thesis submitted
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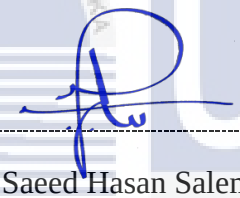
DECLARATION

I declare that this thesis entitled “A Conceptual Framework for Facial Recognition Integration in ADNOC Refining's Physical Security” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

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APPROVAL

I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature : .....

Supervisor Name : Dr. Ruzaidi bin Zamri

Date : 29/01/2024

DEDICATION

I humbly dedicate my dissertation work to my cherished family, with special gratitude to my beloved wife, whose unwavering compassion and understanding have been my constant support pillars. Throughout the countless hours I spent apart from them, she exhibited remarkable patience, even during those sleepless nights. I am truly blessed to have her by my side. Furthermore, I offer my heartfelt dedication to Almighty Allah, the infinite source of inspiration, knowledge, wisdom, understanding, and the unwavering courage that propelled me to embark on this academic journey and persevere through every challenge I encountered. It is by His grace that I am only able to overcome these challenges.

I extend my everlasting gratitude to my children, whose unwavering understanding and patience have been an immense source of strength. Their steadfast support and encouragement have kept me going during difficult times. I would also like to sincerely thank my parents for their boundless love, unending prayers, and unwavering support throughout my academic pursuits. Their guidance and belief in me have been instrumental in my success. Finally, I would like to extend my heartfelt thanks to all those who have supported, assisted, inspired, and believed in my abilities. Their efforts in encouraging me to pursue this journey have been invaluable, and I am genuinely grateful for the support and guidance I have received.

ABSTRACT

High-risk sectors, such as the oil and gas industry, demand optimal infrastructure to safeguard their valuable assets, given their substantial contribution to national economies. In recent years, the oil and gas industry in the United Arab Emirates (UAE) has experienced significant growth, solidifying its position as one of the top 10 oil producers globally. Security is an indispensable aspect of any business enterprise, regardless of size or industry, as it protects assets from various physical security threats, including unauthorized access, theft, espionage, vandalism, and other disruptive incidents that impede operations. Organizations have recognized the importance of enhancing their physical security systems, driven by technological advancements and external factors such as the Coronavirus Disease (COVID-19) pandemic. Multiple studies have suggested that integrating Facial Recognition Technology (FRT) with the existing physical security culture can create a holistic security system capable of effectively responding to physical security threats. Consequently, the main objective of this research was to investigate whether integrating FRT into the physical security measures of one of the Abu Dhabi National Oil Company (ADNOC) subsidiaries', ADNOC Refining, a prominent company in the UAE, would enhance its overall performance. The study also aimed to explore the relationship between physical security culture and performance, the efficiency of FRT, its integration with physical security, and the impact of external factors and physical security threats on physical security performance. A comprehensive review of physical security frameworks and models was conducted using deductive and inductive reasoning to accomplish these objectives, which provided meaningful information about key factors and concepts. Based on this knowledge, a conceptual framework was developed to test the research hypotheses. The study employed a quantitative research approach using a survey questionnaire to collect essential participant information. The sample size of 371 was determined using a simple random sampling method to ensure the validity and reliability of the research results. Inferential statistics were then conducted using SmartPLS software version 3.3.9, utilizing Structural Equation Modeling (SEM) to identify significant relationships between the research hypotheses and the conceptual framework. The study's results revealed a positive and statistically significant relationship between physical security culture and performance, FRT efficiency and its integration within the physical security system, physical security threats and performance, and external factors and performance. Furthermore, a positive and statistically significant relationship was observed between FRT integration and physical security performance. These findings provide valuable insights for organizations operating in the UAE oil and gas industry, enabling them to make informed decisions regarding investments in security technology. This study makes a notable contribution to the under-researched FRT integration with physical security in the oil and gas industry, particularly in the Middle East and North Africa (MENA) region. Its findings offer a foundation for further advancements in security practices within this sector, benefiting industry stakeholders and the broader community.

Keywords: *physical security performance; oil and gas industry; physical security threats; physical security culture; physical security gaps; facial recognition technology*

RANGKA KERJA KONSEPTUAL PENGINTEGRASIAN PENGECAMAN MUKA UNTUK KESELAMATAN FIZIKAL DI PENAPISAN ADNOC

ABSTRAK

Sektor berisiko tinggi, seperti industri minyak dan gas, menuntut infrastruktur optimum untuk melindungi aset berharga mereka, memandangkan sumbangan besar mereka kepada ekonomi negara. Dalam beberapa tahun kebelakangan ini, industri minyak dan gas di Emiriah Arab Bersatu (UAE) telah mengalami pertumbuhan yang ketara, mengukuhkan kedudukannya sebagai salah satu daripada 10 pengeluar minyak teratas di dunia. Keselamatan ialah aspek yang amat diperlukan bagi mana-mana perusahaan perniagaan, tanpa mengira saiz atau industri, kerana ia melindungi aset daripada pelbagai ancaman keselamatan fizikal, termasuk akses tanpa kebenaran, kecurian, pengintipan, vandalisme dan insiden gangguan lain yang menghalang operasi. Organisasi telah menyedari kepentingan mempertingkatkan sistem keselamatan fizikal mereka, didorong oleh kemajuan teknologi dan faktor luaran seperti wabak Penyakit Koronavirus (COVID-19). Pelbagai kajian telah mencadangkan bahawa menyepadukan Teknologi Pengecaman Muka (FRT) dengan budaya keselamatan fizikal sedia ada boleh mewujudkan sistem keselamatan holistik yang mampu bertindak balas secara berkesan kepada ancaman keselamatan fizikal. Oleh itu, objektif utama penyelidikan ini adalah untuk menyiasat sama ada penyepaduan FRT ke dalam langkah keselamatan fizikal salah satu anak syarikat Syarikat Minyak Nasional Abu Dhabi (ADNOC), ADNOC Refining, sebuah syarikat terkemuka di UAE, akan meningkatkan prestasi keseluruhannya. Kajian ini juga bertujuan untuk meneroka hubungan antara budaya dan prestasi keselamatan fizikal, kecekapan FRT, integrasinya dengan keselamatan fizikal, dan kesan faktor luaran dan ancaman keselamatan fizikal terhadap prestasi keselamatan fizikal. Semakan menyeluruh tentang rangka kerja dan model keselamatan fizikal telah dijalankan menggunakan penaakulan deduktif dan induktif untuk mencapai objektif ini, yang memberikan maklumat bermakna tentang faktor dan konsep utama. Berdasarkan pengetahuan ini, satu rangka kerja konsep telah dibangunkan untuk menguji hipotesis kajian. Kajian ini menggunakan pendekatan kajian kuantitatif menggunakan soal selidik tinjauan untuk mengumpul maklumat penting peserta. Saiz sampel 371 ditentukan menggunakan kaedah persampelan rawak mudah untuk memastikan kesahan dan kebolehpercayaan hasil kajian. Statistik inferensi kemudiannya dijalankan menggunakan perisian SmartPLS versi 3.3.9, menggunakan Structural Equation Modelling (SEM) untuk mengenal pasti hubungan yang signifikan antara hipotesis penyelidikan dan rangka kerja konseptual. Keputusan kajian menunjukkan hubungan yang positif dan signifikan secara statistik antara budaya dan prestasi keselamatan fizikal, kecekapan FRT dan penyepaduannya dalam sistem keselamatan fizikal, ancaman dan prestasi keselamatan fizikal, serta faktor dan prestasi luaran. Tambahan pula, hubungan positif dan signifikan secara statistik diperhatikan antara penyepaduan FRT dan prestasi keselamatan fizikal. Penemuan ini memberikan pandangan yang berharga untuk organisasi yang beroperasi dalam industri minyak dan gas UAE, membolehkan mereka membuat keputusan termaklum mengenai pelaburan dalam teknologi keselamatan. Kajian ini memberi sumbangan ketara kepada integrasi FRT yang kurang diselidik dengan keselamatan fizikal dalam industri minyak dan gas, khususnya di rantau Timur Tengah dan Afrika Utara (MENA). Penemuannya menawarkan asas untuk kemajuan selanjutnya dalam amalan keselamatan dalam sektor ini, memberi manfaat kepada pihak berkepentingan industri dan komuniti yang lebih luas.

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LIST OF ABBREVIATIONS

ACS	-	Access Control System
ADNOC	-	Abu Dhabi National Oil Company
AI	-	Artificial Intelligence
AVE	-	Average Variance Extracted
CCTV	-	Closed-Circuit Television
CFA	-	Confirmatory Factor Analysis
CIP	-	Critical Infrastructure Protection
CMB	-	Common Method Bias
CMV	-	Common-Method Variance
COVID-19	-	Coronavirus Disease
CR	-	Composite Reliability
EFA	-	Exploratory Factor Analysis
FRT	-	Facial Recognition Technology
GASCO	-	ADNOC Gas Processing
GCC	-	Gulf Cooperation Council
HID	-	Human Interface Device
HTMT	-	Hetrotrait-Monotrait ratio of correlations
ICF	-	Integrative Conceptual Framework
ID	-	Identification
IPMA	-	Importance-Performance Map Analysis
IPPS	-	Integrated Physical Protection System
MENA	-	The Middle East and North Africa
PIN	-	Personal Identification Number
PLS	-	Partial Least Squares
RFID	-	Radio-Frequency Identification
SEM	-	Structural Equation Modeling
SPSS	-	Statistical Package for the Social Sciences
UAE	-	United Arab Emirates
VIFs	-	Variance Inflation Factors

LIST OF APPENDICES

LIST OF PUBLICATIONS

The following is the list of publications related to the work of this thesis:

Al Zaabi, S.H., Zamri, R., 2022. Managing Security Threats through Touchless Security Technologies: An Overview of the Integration of Facial Recognition Technology in the UAE Oil and Gas Industry. *Sustainability* 14. https://doi.org/10.3390/su142214915

Zaabi, S.A., Zamri, R., 2023. Enhancing Physical Security Performance in the Oil and Gas Industries through the Integration of Facial Recognition Technology. *J. Eng. Technol. JET* 13, 45–72.

Al Zaabi, S. and Zamri, R., 2021 'Review of Scoping Studies on Improving Physical Security Performance and Integrating Facial Recognition Technology,' *Indian Journal of Economics and Business*, 20(4), pp. 21–63.

Al Zaabi, S.H., Zamri, R. and Yassin, S.W.M.S. (2023) 'Developing a Conceptual Model for Integrating FRT in Oil and Gas Company Physical Security: A Comparative Study of Security Models.', *Res Militaris*, 13(2), pp. 4528–4546.

CHAPTER 1

INTRODUCTION

1.1 Background

1.1.1 The Global Oil and Gas Industry

The global oil and gas industry is mainly associated with fossil fuels, especially natural gas and oil. Exploration, extraction, transport, storage, and promotion of petroleum products constitute the oil and gas sector's activities (Canfield, n.d.). The significance of fossil fuels emanates from the prevalence of the products in the global supply and demand chain for energy. Indeed, "to meet demand, 2014 knew a staggering production of 32.365 billion barrels of oil, 3460.6 billion cubic meters of gas, and 3933.5 million tons oil equivalent of coal" (Scholten, 2018). Interestingly, despite the increasing demand, the reserves for oil and gas are depleting, and this trend is common for all fossil fuels. As a result, oil and gas have an important role in the world economy, and their importance cannot be overstated (Li *et al.*, 2015). Thus, the global market is preoccupied with energy geopolitics, mainly founded on the inherent technical and geographic attributes of oil and gas industries, which have defined an intricate interstate energy network in contemporary society. Therefore, the global oil and gas industry outlook shows intricate scenery involving increasing demand, geopolitics, and resource availability.

In recent years, the oil and gas sector has changed due to the challenges and opportunities of commodity prices. Globally, this sector is undergoing significant change by utilizing new business models and marketing strategies. Furthermore, the oil and gas sector strives for effective performance because disruptions can lead to poor businesses. According

to Wilson (2014), many factors have contributed to the escalating incidences of vandalism and thefts across various oil and gas fields, encompassing lapses in security protocols, negligence on the part of the government, the organization's culture, and deliberate acts of crime. As oil and gas play an increasingly important role in global economic growth, security needs are also evolving. Therefore, the oil and gas sector faces inevitable security challenges that require governments and organizations to adjust accordingly (Canfield, n.d.).

1.1.1.1 Physical Security Performance in the Global Oil and Gas Industry

From a broad perspective, physical security can be defined as the comprehensive system and set of processes aimed at safeguarding physical assets, restricted areas, and personnel within an organization against potential physical events and actions that could result in damage or losses to an agency, institution, or enterprise (Al-Fedaghi and Alsumait, 2019). As the core of any assets protection program and often the most visible defense, physical security has existed longer than any other security function (Kovacich and Halibozek, 2005). According to (Al-Fedaghi and Alsumait, 2019) and Nelson (2020), physical security relies on strong physical controls, such as access control systems and monitoring, detection, and auditing devices, which prevent unauthorized access to protected spaces by restricting and verifying entry. However, the priority given to physical security in the overall information and other security systems is typically low, according to Hutter (2016). In addition, organizations and their employees may be exposed to security risks and significant financial loss without effective physical security measures (Tajali, 2021). Similarly, it is common for stakeholders to focus on technology-based breaches of security rather than physical threats (Goldstein, 2016). As a result, many organizations have low resilience toward physical security threats.

As Yasseri (2019) asserts, physical security occupies an integral position within the systems engineering framework of the oil and gas sector, encompassing various domains such as operations, information, network, communications, administrative, computer, personnel, and emanation security. Facilities in this sector encounter several physical security threats, such as operator errors; as Vásquez et al. (2021) noted, during the inspection of people entering their facilities, companies face numerous security challenges; consequently, the personnel who are responsible for this control make errors that can have an adverse impact on the level of security. Considering the extensive scope of their operations and their vital role in national economies, neglecting a physical security threat can lead to substantial losses of significant magnitude (Green, 2022). Therefore, it seems evident that physical security is essential for various oil and gas sector facilities. As a result, oil and gas industries must address with the greatest urgency the need to increase physical security significantly, implementing objective, performance-based methods for verifying the adequate resources available to defend against impending physical security threats (Landucci, Khakzad and Reniers, 2020b). Accordingly, adequate physical security measures should be essential to any system security engineering strategy in the oil and gas sector.

Existing evidence suggests that relying solely on uncomplicated locks or the presence of security officers may not be adequate to ensure an optimal level of physical security within the oil and gas industry (Lee, 2020). Analyzing the existing security technologies utilized in the physical security systems seems necessary to better understand this sector's physical security performance. The physical security systems in facilities should display high performance to protect assets from physical security events. Nevertheless, the decision of a company to adopt protective measures is contingent upon various factors, including the

perceived practicality of the solution, a positive attitude toward security, and a sense of responsibility for safeguarding its assets (Jansen *et al.*, 2016).

While the existing physical security control systems can be helpful, multiple control measures must be integrated into security zones that are highly restricted; just as Kruegle (2007) emphasized, “For maximum effectiveness, all parts of the security system must work together synergistically.” A fence around a perimeter protects the property from security threats such as trespassing, vandalism, and espionage. Security gates, doors, and barriers are necessary to allow traffic through fences, while doors and windows are vulnerable areas along a perimeter (Purpura, 2017b). According to Shaikh (2018), many physical security methods could injure animals and intruders. However, sometimes perpetrators escape injury by tossing a sheet or jacket over the fence top before jumping over it (Purpura, 2017b). Despite multiple defense layers, determined offenders often find ways to breach security systems.

In light of the criticality of their assets, organizations within the oil and gas industry allocate substantial resources toward establishing a highly effective physical security system. Such a system typically integrates a range of security measures aimed at deterring, detecting, and delaying physical security threats, thereby allowing the security team ample time to respond effectively. According to Triantafyllou (2021), as part of designing a physical security system, it is essential to identify the objectives and then begin to design the system, integrating people, procedures, and security technology as necessary to accomplish the objectives. Furthermore, Reniers et al. (2018) emphasized that securing oil and gas facilities poses an elevated challenge due to the dynamic nature of threats, necessitating the ongoing refinement and updating of counter-management strategies. Therefore, an oil and gas organization should implement an adequate physical security system to protect its assets

utilizing new technologies. While numerous studies have examined the implications of physical security gaps resulting from the inefficiency of specific security elements (Alhussain and Drew, 2009; Yang *et al.*, 2019), the design and implementation of an effective physical security framework present notable challenges.

1.1.2 Oil and Gas Industry in the UAE and the MENA Region

The UAE is an active member of the Gulf Cooperation Council alongside Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia, comprising the seven emirates of Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al-Quwain, Fujairah, and Ras Al Khaimah with Abu Dhabi as its capital, primarily relies on oil revenues except for Dubai (Cherian *et al.*, 2021). The UAE is prominent among the world's leading oil and gas producers (The International Trade Administration, 2023). Although located in a desert region, historically neglecting its prosperity, the country has proven oil reserves of 97.8 billion barrels, representing close to 10% of the global oil reserves (Ayish and Kruckeberg, 2004; The U.S.-U.A.E. Business Council, 2019; U.S. Energy Information Administration, 2020). Since crude oil and petroleum have emerged as the predominant fuel sources for vital industries and facilities, the oil and gas sector is pivotal in significantly bolstering the world economy (Ali, Kasim and Adaji, 2020). Therefore, global value chains have become the focal point of production activities in the UAE (Shqairat and Sundarakani, 2018). Furthermore, ensuring uninterrupted operations in these sectors has become a significant concern to ensure the oil and gas facilities' security. Indeed, since the dramatic explosion at the ADNOC Refining on January 15, 2017, safety, health, and security have been topics of concern for the sector (Rahman, 2017; Al Mazrouei *et al.*, 2019). Lambrechts and Blomquist (2017) pointed out that oil and gas organizations have multiple threats that need to be considered in any investment