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Fundamental Prerequisites of Operational Readiness, Activation, and Transition: Case Study of Istanbul Grand Airport

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Abstract: Operational readiness, activation, and Transition (ORAT) is a series of processes that aims to convert an airport into an efficient business and make the personnel, processes, operations, and systems work in full harmony with each other. This paper aimed to determine the importance level of the fundamental prerequisites of the ORAT process. To fulfil this aim, the ORAT activities were first determined within a comprehensive literature review, and a descriptive case study was presented for illustrating the effects and the relations between the ORAT activities. Finally, the Pythagorean fuzzy analytical hierarchy process (PFAHP) method was used. "Management of airport systems", "Preparation of ORAT management and tracking systems", and "Providing process, and documentation requirements for operational transition of the facility" were found out as the three prominent ORAT activities. The study contributes to the body of knowledge with an empirical investigation of which of up-front activities in the ORAT process should be primarily focused. Thus, operational and risk management strategies can be developed by considering the fundamental prerequisites of ORAT on a preferential basis by practitioners. Additionally, the results of this study will also be an informative resource for the prevention of failures that are frequently encountered in ORAT experiences.

Keywords: airport management; case study; facility management; Pythagorean fuzzy analytic hierarchy process (PFAHP); operational readiness, activation, and transition (ORAT)

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1. Introduction

Increasing air transportation demand and changing needs of the aviation industry trigger the need for new or renovated airport facilities. According to the International Airport Transport Association (IATA)'s 2036 projection, the number of passengers using air transportation worldwide will increase to 7.8 billion, which will induce peaking problems due to insufficient space, gate, baggage capacity, and runway saturation, etc. [1]. Although it is assumed that the level of air transportation demands might decrease due to travel restrictions, accompanied with the change in the behavior of passengers following the COVID-19 crisis, air transportation demand will be at—or exceeding— pre-pandemic levels of demand by the end of 2023 [2].

Peaking problems in airports can be resolved through either expansion of the facility, scheduling of airline operations from peak times to more flexible times, surcharges on traffic movements, or construction of a new airport [3,4]. The construction of a new airport requires complex processes in all stages of its life cycle, starting with the development of the financial model for the contract of the construction till the operation of the facility. However, the operational transfer from an existing airport to the new constructed airport has more extensive difficulties, which requires extremely elaborate planning since the needs of the facility and the expectations of the passengers need to be fulfilled without any deficiency.

Operational readiness, activation, and transition (ORAT) processes are implemented to fulfill these expectations. However, when the ORAT implementations in aviation history were examined, it was seen that a vast number of ORAT practices were ended with failures, such as "delayed openings or cost increases", due to ill-conceived processes. Although numerous studies have mainly dealt with defining the core activities of ORAT [5–17], there is a lack of rigorous research available that present the ORAT prerequisites by prioritizing the importance of these ORAT activities. Additionally, studies that analyzed the importance of ORAT activities [13,14] are not inclusive, as they focused on the construction and operation of the new airport rather than the operational transfer from the existing airport to the newly built airport.

Prioritizing these ORAT activities is vital for airport openings, since operational readiness of the airports requires timely management and allocation of existing resources. At this point, it is believed that instead of spending limited resources on the management of all activities, it would be more logical to put efforts on the fundamental prerequisites of these ORAT activities. Thus, ORAT managers can develop operational and risk management strategies that give priority to these activities. Prioritizing the more important activities, developing strategies, and eliminating the risks associated with these activities will also prevent failures in operation. In the end, with a more successful ORAT process, costly failures for organizations, significant disruptions, and delayed openings, etc., are expected to less likely occur. Based upon this background, seeking answers to the question of "Which of up-front activities in the ORAT process should be primarily considered by the managers for successfully operating airports?" constitutes the research problem in this study. Although the prioritization of ORAT activities might be seen as a complex decision-making problem for practitioners, multi-criteria decision making (MCDM) methods constitute systematic analysis process to tackle complex decision problems, like the ORAT process [18]. Therefore, in this research, the below research hypothesis was tested with the use of the MCDM method (Pythagorean fuzzy analytical hierarchy process—PFAHP):

H_0: *The fundamental prerequisites of the ORAT process have an equal importance level.*

H_1: *The fundamental prerequisites of the ORAT process have different importance levels.*

In this regard, the ORAT activities were first determined within a literature review, following which the largest ORAT program and one of the best ORAT practices in civil aviation industry was presented as a descriptive case study to better illustrate the effects and the relations of the fundamental prerequisites of ORAT. Then, the PFAHP method was used to prioritize the ORAT activities for determining up-front activities that should be primarily considered by the managers in the ORAT process.

In line with the scope of the study, after the introduction section, Section 2 presents the term definitions of ORAT, previous ORAT experiences, and a literature review on previous ORAT studies to reveal the research gap and the novelty of the study associatively. Section 3 presents the research methodology that consists of the methodological details of how the ORAT activities were identified and validated and how the case study and PFAHP analysis were performed in terms of expert selection, data collection, and data processing. Findings derived from PFAHP analysis and sensitivity analysis are addressed in Section 4, while Section 5 presents a discussion of the findings. Finally, Section 6 concludes this study by stating practical and theoretical implications, and recommendations for further studies.

This study's results indicated that the "Management of airport systems", "Preparation of ORAT management and tracking systems", and "Providing process, and documentation requirements for operational transition of the facility" are the most three prominent ORAT activities. Therefore, strategies, such as establishing an airport operations control center to manage information systems, developing a detailed integration plan, developing contingency plans that includes alternative procedures, and communication protocols, should be considered on a preferential basis.

2. Operational Readiness, Activation, and Transition

Operational readiness, activation, and transition (ORAT) is defined as a process series, in which checks and balances are put into place to identify and mitigate risks in a project before operational impacts occur. The main objective of ORAT is to make the personnel, processes, operations, systems, interfaces, and business management work in full harmony with each other. The process of getting used to the new working environment and trainings of personnel are another critical issue. Along with the integration of personnel, systems, and the new working environment, testing is an important phase in ORAT. All systems, such as baggage management, fire alarm, and airport operation management, are tested in many different scenarios up to every detail before opening to enhance operational readiness. ORAT is basically incorporated into the project lifecycle in a way to ensure it overlaps with the execution phase towards its end and continue until reaching the point of handover. The opening of new airports requires following prerequisites: (i) comprehensive planning and organization, methodical execution, (ii) the capacity to evaluate issues globally as well as the ability to analyze all critical details, (iii) the ability to ensure the commitment of all stakeholders at the highest level, as the participation of many organizations will increase the difficulty and complexity of the project [8]. With the implementation of ORAT, airport managers can ensure minimal delays and zero rework post the airport opening day, along with troubleshooting "systems integration", "program integration", "people and operational readiness", risk factors, and end-users related risks [3,19].

The term "operational readiness" was defined as the list of activities which should be planned and executed by the project's stakeholders for the successful takeover and smooth operation of large infrastructure projects. Additionally, the term "transition" can be defined as the process or a period of change from one state or condition to another. In some sources, the abbreviation of "ORAT" stands for operational readiness and airport transfer, and this term lays down the procedures for preparing and testing various items of equipment at the airport, as well as guiding principles for the transfer of the airport [20]. Therefore, the typical scope of ORAT is engaged from the start of the airport project during the planning stage through opening and operation and, in such cases, includes the transfer of an existing airport facility to a newly built airport facility. However, in each approach, ORAT needs the same prerequisites and core process to implement.

2.1. Literature Review on Previous Operational Readiness, Activation, and Transition Studies

Numerous studies have dealt with various aspects of managing airport operation. Researchers have illustrated the challenges that operators face in airport management. Since the importance and prerequisites of airport ORAT have been well discussed in the literature, there are few studies presenting relations between the ORAT prerequisites in the body of knowledge. Additionally, there is a lack of rigorous research available that prioritize the importance of these ORAT activities.

As the summary of hitherto studies on ORAT, Martin and Martinez (2004) highlighted the importance of integrating the airport business, along with its inherent operational processes, which is a complicated matter, requiring careful design and planning, and examined the integration process of Madrid-Barajas airport [7]. Saounatsos (2009) also introduced the principles and methodologies used in the successful and timely opening of new airport facilities, as implemented at Larnaka International Airport and Pafos International Airport under an ORAT program [9]. Alnasseri et al. (2013) developed a theoretical framework for airport operators to cope with an airport environment and to enhance business operations [6]. Krauss (2014) emphasized the necessity of operational readiness and examined the compelling reasons affecting effective delivery and system start-up in the process of operational readiness [21]. Al-Mazrouie and Bajracharya (2013) developed a model that can portray the interaction between the workflows at the last stage of construction and the operational preparations [8]. Al-Mazrouie (2017) also developed an operational readiness framework for airports and listed confirmed items that can be used to support operational organizations to prepare for operating a new airport's facilities

within the UAE [22]. Al-Mazrouie et al. (2020) also focused on what readiness factors are commonly engaged to prevent disastrous openings at the transition between project completion and commencement of operations in complex multi-stakeholder settings and classified operation readiness factors [14]. Mc Elvaney (2020) highlighted the strategic benefits of early engagement in the planning of new facilities and the potential pitfalls of not incorporating an ORAT program into facility projects [23]. Angriani et al. (2020) aimed to identify the effects of good corporate governance and leadership on operational readiness using multiple linear regression analysis techniques [24]. On the other hand, Mota (2022) took unsuccessful opening cases as their starting point and developed an ORAT framework based on the lessons learned from failures [25]. Talbot (2022) investigated the contribution of ORAT activities to sustainability within the aspects of economy, society, and environment [26]. Jarvela and Nurminen (2023) reported how ORAT processes and integrated project delivery are combined to manage the extension at Helsinki Airport while the airport is functioning [27]. The ORAT pillars considered in the abovementioned studies are illustrated in Table 1. This table also shows the deficits of these studies.

Table 1. Previous ORAT studies and their deficits.

References	The Pillars of the ORAT Procedure	The Deficits of Studies
[6]	• Customs/security • Stakeholder management • Leadership • Documentation management • Communication management • Risk management • Team development and performance management • Training, planning, and monitoring	• Only focuses on the identification of priorities of ORAT activities • Consideration of the construction phase rather than ORAT processes • Qualitative study
[7]	• System integration • Airport management center • Integrated test center	• Only focuses on the identification of priorities of operational readiness activities • Not considering the transition process • Qualitative study
[8]	• Execution of operational trials • Training/familiarization planning and monitoring	• Identification of priorities of operational readiness activities • Not considering the transition process and leadership
[9]	• The airport opening and transfer strategies • Training/familiarization planning and monitoring • The operational readiness review and evaluation • The technical readiness assessment	• Only focuses on identification of priorities of ORAT activities • Not considering leadership and stakeholder management • Qualitative study
[13,14]	• Facility readiness • People readiness • System/technology readiness • Organizational/processes readiness	• Identification of priorities of operational readiness activities • Not considering the transition and logistic process
[21]	• Commissioning and start-up • Health, safety, security, environmental, and quality (HSSEQ) Policy • Organizational/processes/management readiness	• Identification of priorities of operational readiness activities • Not considering the transition process • Qualitative study

Table 1. *Cont.*

References	The Pillars of the ORAT Procedure	The Deficits of Studies
[23]	• System integration • Familiarization • Processes readiness	• Only focuses on identification of priorities of operational readiness activities • Not considering transition process and leadership • Qualitative study
[24]	• Leadership • Organizational readiness	• Identification of priorities of operational readiness activities • Not considering logistic, facility, and technology, nor system and information activities
[25]	• Core processes (schedule, scope, and resource definition, familiarization, trials, transition, opening support, and post-opening support) • Support processes (trainings, reviews, and operational handover) • Project management processes (master schedule, analysis and meetings, monitoring, risk management, budget control, reporting, and documenting)	• Identification of priorities of operational readiness activities • Qualitative study • Not considering leadership
[26]	• Program definition and strategy • Integration of needs into the preliminary design • Integration of needs into procurement documents • Adjustment or execution and migration • Transition • Post-transition review and support	• Identification of priorities of operational readiness activities • Qualitative study
[27]	• Stakeholder corporation/communication • Organization • ORAT process management • Systems and special procurements • Trainings • Tests	• Identification of priorities of operational readiness activities • Qualitative study • Not considering leadership

According to this literature review, the existing studies related to the ORAT body of knowledge have not considered all aspects of the ORAT processes. The majority of them only focus on the identification of operational readiness activities and do not consider the transition process. This literature review also showed that many studies investigated the ORAT procedure by interpreting successful and unsuccessful ORAT case studies (qualitative methods), and these case studies generally did not aim to discuss the ORAT process under well-detailed ORAT activities. Instead, they generally presented process information in terms of the airport project. The findings obtained from this literature review indicate that there is a high correlation between well-identified and managed ORAT activities and successful airport openings. However, a quantitative study to discover important ORAT activities has not been performed to date. In light of the limited number of quantitative studies available that will help decision makers to create operational strategies by focusing on the priority orders of ORAT activities, this study aims to fill these gaps.

2.2. Previous Operational Readiness, Activation, and Transition Experiences

To better understand the ORAT implementation framework and enhance isomorphic learning, ORAT practices in aviation history were investigated. Kuala Lumpur (Malaysia) airport's ORAT process, connection problems of passenger boarding bridges, baggage

system malfunction, and communication problems (radio etc.), caused lost baggage problems with expeditions and cancellations in flights. In addition, until 2007, even though all systems were changed, various similar problems continued to occur. Similar problems were also observed at Denver Airport (USA), which commenced operations in 1994 with an estimated cost of USD 5 billion, and Chek Lap Kok Airport (Hong Kong), which commenced operations in 1998 with an estimated cost of USD 20 billion [14]. In Cheklap Kok airport's ORAT process, baggage system, flight information display, and cargo system problems resulted in 20 thousand unboarded baggages and 40 days of downtime [11]. Heathrow T5 (England) faced similar problems, such as baggage system, security, and parking system problems, that led to both passengers and staff having trouble locating car parks, long waits for baggage due to clogged conveyor belts, and all check-ins at T5 being suspended. As a result, Heathrow Terminal 5 commenced operations in 2008 with an estimated cost of USD 6.4 billion [13]. In Suvarnabhumi (Thailand), baggage, apron, taxi, and runway issues similarly caused hours of baggage losses and international baggage tags not being read by the system. There were also errors in the check-in system and in the flight information screen. As a consequence, the government ordered to move all domestic flights to the old airport [13,16]. Likewise, Heathrow Terminal 5 and Suvarnabhumi Airport commenced operations in 2006, with an estimated cost of USD 3.9 billion. Similarly, non-readiness of fire extinction, traffic, security, check-in, and baggage systems caused delays in the open day of both Wichita (USA) and Brandenburg (Germany) airports [16].

As for the successful cases, in Madrid-Barajas airport, "Airport Systems Integration" was used to exchange information between systems with specific intentions for achieving integration. Thus, all the control and coordination centers were gathered under one roof. Additionally, an "Integrated Test Center facility" was specified, whereby testing can confirm that the implemented system's integration can indeed make the airport operate in a particular manner, under a given set of required circumstances [7]. In a similar context, operability review, trails, staff orientation, and familiarization provided preparedness for any errors that may occur and led to success in the cases of the Incheon International Airport (Republic of Korea), Dubai International Airport (UAE), and Rajiv Gandhi International Airport (India) ORAT processes. As another successful example, in New Larnaca Airport, the ORAT program itself was established eleven months earlier. ORAT program was operated by a core team comprising seven experts who have expertise in operational and technical readiness. The implementations consist of planning and monitoring of opening and transfer strategy, trainings, and familiarization. Emergency preparedness plans were also tested on a reduced scale to familiarize both the airport community and the external responding agencies [10].

3. Research Methodology

In this research, the research steps that were depicted in Figure 1 were followed. In this study, ORAT activities were determined within the literature review, and identified activities were then validated with a pilot study. Then, the largest ORAT program and one of the best ORAT practices in civil aviation industry were presented as a descriptive case study to better illustrate the effects and the relations of the fundamental prerequisites of ORAT. Finally, the Pythagorean fuzzy analytical hierarchy process (PFAHP) method was used to prioritize the ORAT activities for determining the fundamental prerequisites of ORAT. Herewith, professions can primarily focus the up-front activities that have a higher importance in coordinating the ORAT activities.

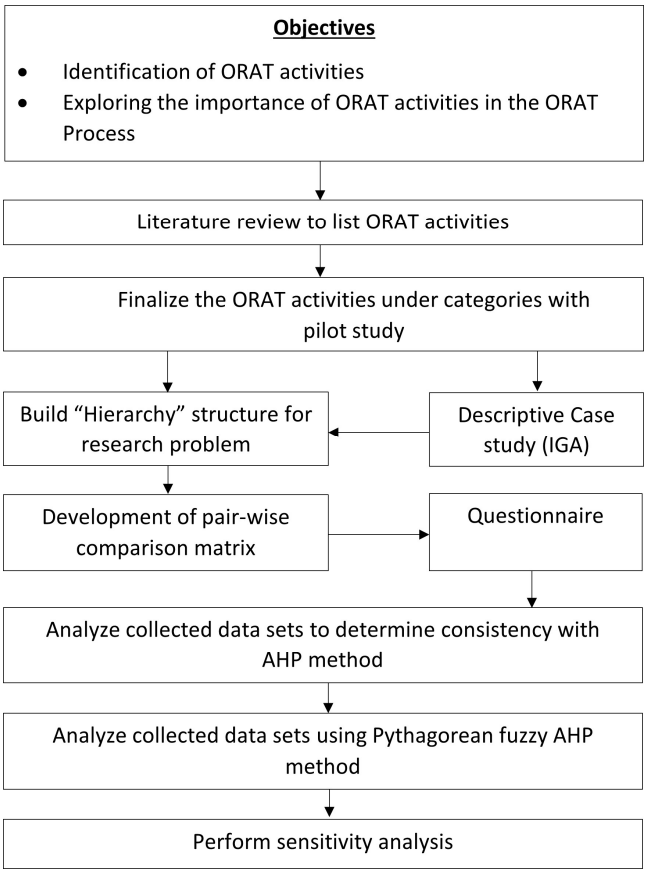

Figure 1. Research flow.

3.1. Literature Review for the Identification of Operational Readiness, Activation, and Transition Activities

The conversion of a newly constructed facility into a fully functioning facility necessitates meticulous planning and management processes. After performing conversion processes, the services in the facility must be equal to business requirements, which are performed in the previous facility. Therefore, ORAT is not an easy task since it is seen as a different project, in which operational issues are eliminated and requires different expertise, such as logistics [4,9]. In addition, countries give the utmost importance to these ORAT processes to increase or save their reputations against their international counterparts [8]. Therefore, modern airport owners have been signing up for ORAT programs and incorporating them into their project cycle to ensure a smooth transition from the construction phase to the operational phase. In tandem, lots of companies, such as ARUP, Fraport, Jacobs, Ineco and Aena, Malaysian Airport Holdings Berhad, etc., have given a service for ORAT processes and activities. An ORAT service which is given by companies comes up as a result of companies' horizontal strategy and reflects their experience from the facility management of airports to new airports to obtain extra revenue [28,29]. For instance, it was suggested that ORAT requires a master schedule and an implementation plan that defines the roadmap for how ORAT will be executed. It contains "stakeholder engagement plan", "operational concept, design integration and standard operating procedures", "risk identification, mitigation and contingency planning", "familiarization, induction, and training plan", "testing and commissioning assurance", "integrated operational trials", and "transition plan" [23]. Ineco and Aena projected "the airport management center" to follow transferring procedures in a real, timely manner. The role of this center is to bring supervision, coordination, management, and intervention in the areas of security, services, operations, maintenance, and IT maintenance so that risky situations are eliminated [30].

According to the studies in the literature, the fundamental prerequisites of ORAT are commonly categorized under facility (construction and equipment), information (procedures and manuals), system (IT systems, airport security system, and baggage/cargo management system), and human resource (organization, qualified people, and staff training), whereas the core process of ORAT are airport access, pax/crew handling, baggage handling, cargo handling, ground handling, aircraft control, administration and management, facility/system management, airport security, and customer service and environment [5–17,20–23,31–35].

Within the explanations above, different ORAT strategies can be followed by different authors and companies. Nevertheless, common features of an efficient ORAT program involve the planning and implementation of trainings according to the ORAT plan, informing the stakeholders for the trial operation, application of trial operations according to the prepared scenarios, and evaluating the problems of trial operations and planning studies for solving problems. The aggregate fundamental prerequisites of ORAT based on the above-mentioned strategies followed by authors, companies, and airports were categorized in this study under five headings, namely "Logistics, Leadership, Stakeholder, Facility and Technology/System and Information". The list of ORAT activities under the mentioned headings can be found in the "Supplemental Material" section.

3.2. Pilot Study for the Validation of Identified Activities

The aim of the pilot study was to validate the identified ORAT activities and to find out if there are any prerequisites that were not included in the literature review results. The pilot study consisted of the following steps: (1) introducing the aim of the study and the importance of identifying the prerequisites of ORAT, (2) collection of the descriptive statistics of respondents, and (3) evaluation of the sufficiency of the identified prerequisites based upon the literature review results by experts. In this pilot study, three respondents answered the developed questionnaire (two respondents with an ORAT and managerial experience and one academician with transportation and ORAT experience). According to the literature, this respondent number is acceptable in terms of its number and their experience level [36]. The profile of the pilot study participants is given in Table 2.

Table 2. The profile of the respondents for the pilot study.

Expert	Position	Experience (Years)
DM1	Manager (airport facility manager)	25
DM2	Manager (airport facility manager)	22
DM3	Academician	16

As a result of the pilot study, respondents reached a consensus about the sufficiency of identified ORAT activities. In other words, these participants did not add any new ORAT prerequisite. The validated ORAT activities via the pilot study was used as a base for the assessment of the İGA case (the questionnaire used in the pilot study can be found in the "Supplemental Material" section).

3.3. Case Study of İstanbul Grand Airport

Case studies aim to analyze specific issues within the boundaries of a specific environment, situation, or organization. According to its design, case studies in business research can be divided into three categories: explanatory, exploratory, and descriptive (illustrative) [37]. A descriptive case study is used to describe an intervention or phenomenon and the real-life context in which it occurred [38]. In other words, descriptive case studies aim to explain to the reader a situation and provide enough details on a given topic in a common language. In this research, descriptive case study methodology was used to illustrate both the main activities of ORAT and the relations between these activities. Therefore, the ORAT process of Istanbul Atatürk Airport (IST) to Istanbul Grand Airport (IGA) was chosen

as a case for the following reasons: (1) importance: this case study is considered as the largest ORAT program of the civil aviation industry and one of the largest BOT investment commitments for a mega transportation project in a host country, (2) observation possibility: the authors participated in the transfer part of the IGA ORAT process as a member of the observation team, and (3) implementation success: the IGA's ORAT process was completed without any failure in terms of integrating logistics, leadership, stakeholder, facility, technology, system, and information.

3.3.1. Information about the Descriptive Case Study

IST was the busiest airport in Turkey, and was the fifth busiest in Europe, while fifteenth in the world. However, the transmission decision from IST to IGA was made by the public authorities depending on increasing demand for air transportation and difficulties in new slots addition induced the idea of a new airport project [39]. The government has decided to commission the project to the private sector using a build-operate-transfer approach with the concession period of 25 years. The construction cost of this project has been estimated to be EUR 10.2 billion and a consortium of five national construction firms won the tender with a bid worth of EUR 22.152 billion and VAT. On 19 November 2013, the concessionaire signed the implementing agreement of the project with the General Directorate of State Airports Authority. The construction site was delivered to the consortium in 2015, and the first construction phase of the airport with a 42-month construction period began in 2016 and was completed in 2018 [40]. This airport consists of four phases, and all construction phases are going to be completed in the first half of 2025. When all phases are completed, IGA will provide flights to more than 300 destinations with an annual capacity of 200 million passengers. Within the ORAT milestones of IGA, studies related to the ORAT project plan were initiated in 2016 under the leadership of the General Directorate of State Airports Authority. The consortium and the General Directorate of State Airports Authority were both responsible for the ORAT program. ORAT consultants had started their full-time studies in 2017. Along with the ORAT consultants, IGA had developed important milestones for the ORAT process that would last 18 months. Generally, the ORAT process starts after the handover processes, corresponding to the completion of the facility construction, commencement with trainings, trials, completion of the required documents, and end with the airport transfer. However, in the case of IGA, ORAT and construction activities were simultaneously carried out that provided serious advantages in terms of the time. In this context, operational preparation scenarios, training, and moving plans were realized on October 2018, whereas field studies related to ORAT processes started in May 2018. According to the ORAT plan, the full transfer of IST to IGA was planned to finish within 48 h in 2019.

3.3.2. Data Collection for the Descriptive Case Study

Required data for case study analysis were gathered from: (1) documents and archival records that were provided by IGA, (2) field observations: the transfer part of the IGA ORAT process from IST to the new IGA was observed by the authors participating in the observation team at the IGA ORAT control center with the IGA ORAT team, and (3) interview with the airport operations control center (AOCC)/ORAT director: a half-day interview was carried out with the AOCC/ORAT director of IGA to better comprehend the post effects of the process.

The AOCC is the command, coordination, and control center for the whole airport, which integrates the diverse processes relating to the three major operational areas—passenger, baggage and cargo, and aircraft. The questionnaire that was used in the interview with the AOCC/ORAT director was designed based on the literature review and pilot study's findings. In the interview with the AOCC/ORAT director, the aim of the case study was first explained. Then, the AOCC/ORAT director was asked the following: (1) to discuss the suitability of the identified ORAT activities for İGA, (2) to eliminate or add new activities if it is required, and (3) to give information about the ORAT processes of

IGA in terms of the identified ORAT activities. The questions that were addressed to the AOCC/ORAT director of IGA can be found in the "Supplemental Material" section.

3.3.3. Data Analysis of the Descriptive Case Study

The assessment of the AOCC/ORAT director towards the ORAT activities related to IGA case were explained below:

LG1—development and implementation of transfer and transition management plan: After IGA's partial opening in October 2018, operations started with 8–10 flights per day that created an accustoming period for all stakeholders. Full-time operations started following to the opening day that realized on 6 April 2019. For the period between 29 October 2018 and 6 April 2019, the IGA ORAT team developed a transition management plan to efficiently carry out familiarization activities, especially for the ground handling and baggage handling companies. This accustoming period prevented system failures, such as the check-in and baggage system problems that were seen in the Heathrow T5 case. According to the transfer and transition management plan, the full transfer of IST to IGA, which was called the "Great Transfer", was planned to realize between 4–6 April 2019 with a 45 h transfer. However, the "Great Transfer" was completed in 33 h due to the detailed master plan that was prepared during a 6 month period. The "Great Transfer" was the first and largest logistic program of the civil aviation industry, with the features of moving a new airport approximately 42 km from Ataturk Airport in a lump. The "Great Transfer" only included the transfer of equipment and materials that are required for operations (for further details see explanations on LG4), and approximately 10,500 equipment tools were transported in 33 h. Before the transfer operation, a total of 1000 pocket booklets, including information about drop-off and pick-up areas, exit routes, emergency phones and instructions that should be followed on apron, were delivered to the truck drivers. In addition, a total of 9100 transport vehicle identification cards were delivered to the companies related to the transfer operation. Each truck driver and staff member were examined by a general information gathering system, and a personnel identification card was prepared for each truck driver and staff member. During the transfer, each truck was tracked with GPS by crisis management counters (for further details see explanations on LD2). In addition, cooperation with the municipalities, police, gendarmerie, highway regional directorate, and fire department was sustained to achieve risk avoidance related to transfer operations on the transfer route. With this aim, support stations were set up on the transfer routes. The IGA ORAT team identified a total number of 81 "Airport Activation List" with stakeholders within the transfer plan. The content of the airport transfer plan contains the airport transfer organization's structure, the determination of stakeholders' duties and responsibilities within the airport transfer, the airport transfer operation plan, the determination of the properties and numbers of each object to be transferred, the arrival and departure procedures of equipment, the cargo handling methodologies, the airport transfer training, the airport transfer security/contingency plans, the airport transfer operation trial, and the airport transfer schedule. Determination of the airport transfer security/contingency plans and related actions were also crucial for the completion of the transfer without delay. Therefore, determination of the security procedures related to the airport entrances and exits, occupational health and safety procedures, safety plans for logistics trucks, ground handling equipment and other items during transfer, emergency communication channel among stakeholders, emergency plan for vehicle accident and vehicle breakdown cases on route, emergency plan for breakdown of road facilities and airport facilities, and outbound routes when the main routes cannot be used were agenda topics within the transfer security/contingency plans. Tests were performed to decrease the transfer duration between two airports. Similarly, the loading durations of each equipment was measured and then optimized. On-site and classroom-based trainings, and familiarization programs related to the transfer operation, were also carried out by the logistics company for their own staff.

LG2—development and implementation of the logistic risk management plan: Inefficient management of the transfer days was defined as one of the most important risk

factors. Through a risk assessment, logistic plans were found as being sensitive to any interventions, such as a terrorist attack or protests. Considering their effects, such as postponing the opening day of a new airport, tarnishing image, and creating financial losses for airlines and ground handling service manufacturers, related risk mitigation measures were identified. Staying in dialogue with responsible security agencies and following the necessary security procedures on time were some examples of exemplary risk mitigation measures to reduce the effects of risk factors within logistic management.

LG3—determination and organization of logistic process assets: Determination and organization of logistic process assets covers several topics, such as contracts, competency documents, legal certificates, etc. For instance, in the IGA ORAT case, IGA did not have a contractual relation with the transporter company. Logistic management was under the responsibility of Turkish Airlines (THY) and Turkish Ground Services (TGS). However, in planning the ORAT process, the transporter company was included to all planning processes by the ORAT team. The ORAT team established regulations related to logistic management (such as tire control, GBT control of drivers, preparation of vehicle identification cards, tracking vehicles, etc.) and declared THY to follow these regulations in the management of their relations with the transporter company.

LG4—development and implementation of the support and transfer strategy for both the opening and post-opening days: Supporting strategies embracing coordination and control for both the opening and post-opening days were handled in three sections: before, during, and after the transfer. Before the transfer, office furniture and equipment that was not used or needed at Ataturk airport (due to reduced flights) was moved prior. During the "Great Transfer" (realized during 4–6 April), that was the largest logistics operation of aviation history, the main equipment required for the airport operations was transferred from IST to IGA in a lump. Commercial transfer (i.e., duty-free shops' equipment, etc.) was not included in the "Great Transfer". After the transfer, equipment and materials that are required for the office workspace but not have a direct interaction with the operation were transferred. The transfer work that was not related to the operation were slotted according to their exigence and scheduled to take place before or after the "Great Transfer". While slotting non-operational works, all stakeholders were also informed, meaning that each stakeholder knew when their equipment was going to be transferred.

LD1—determination and control of the ORAT success indicators: The ORAT program of IGA aims to ensure participation and acceptance of all stakeholders, solution of operational communication problems, successful trials, opening without any time delay, efficiency from day one, and transformation of a new airport building into an airport business. In this context, the IGA ORAT process was implemented in four main steps: (1) operational preparation (ORAT plan and program and the planning of ORAT organization and trial scenarios); (2) airport training program (certifications, manuals and procedures, trainings, and familiarization); (3) operational trials (tests and commissioning of each airport system, trial scenarios, correction of erroneous results, verification testing, and control lists), and (4) airport transfer (airport transfer committee, airport transfer plan, and establishment and operation of the transfer observation and management center, opening and post-opening).

LD2—generating the organizational structure and governance to manage ORAT: Governance of ORAT management was addressed under three main topics: organizing the ORAT team, the airport coordination and control center (AOCC) for all operations of the airport, and organizing the crisis management center for relocation in terms of transporting all the equipment from IST to IGA. A total number of three crisis management counter were only created for the transfer. One of them was created at Atatürk Airport for tracking vehicles. Since it was not possible for all vehicles to move from one point, three different exits were planned, and this crisis management counter was responsible for tracking these exits. The second crisis management counter consists of representatives of all public institutions, organizations, and authorized representatives. This crisis management counter was working as a disaster coordination center to generate solutions in case of any accident, terrorist attack, adverse weather condition, etc., during the transfer period. The

third and the most important one was set at the AOCC. In these crisis centers, 44 personnel were employed in total.

LD3—leadership in ORAT stakeholder management: The ORAT team leads the entirety of the ORAT process. However, the participation and the leadership of important stakeholders, such as the General Directorate of State Airports Authority, THY, HAVAS, TGS, and Çelebi Aviation Holding, etc., was also very essential for the success of ORAT operations, along with the leadership of the IGA ORAT team.

LD4—leading trial scenarios in operational readiness process: The purpose of trial operations was the testing of operation scenarios (operational, technical, and IT-integrated validation tests, such as BHS and EDS system operation, check-in counter facilities usability, communication equipment availability, static signage usability, FIDS information display, etc.) to prepare the new airport before the opening day with the intent of determining technical faults. Procedures were gathered from all stakeholders tested and developed during these test runs. Considering any technical faults due to untested systems on the opening day, which may cause financial losses and tarnish the image of airport management, trial scenarios were vital for the success of the ORAT operations. Therefore, the IGA ORAT team had developed a list with more than a hundred trial scenarios and had set up 63 trial event days. Trials were categorized as basic trials, functional trials, contingency trials, advanced trials, integrated trials, and emergency trials. Basic trials were used to determine the functionality of a single system and a total number of 79 basic trials were planned for IGA. Functional trials (tram operation and cargo operations) were similar to basic trials and were a combination of simple processes that did not involve volunteer passengers. A total number of 17 functional trials were planned for IGA. On the other hand, a logistic trial verifies the entrance and exit routes for material and equipment. A total number of six logistics trials were planned for IGA. Contingency trials are also known as undo attempts; they test the implementation and validity of the undo process. The IGA ORAT team had planned 42 independent contingency trials. Within advanced trials, multiple processes and multi-system functionality were tested in one trail. Twenty-seven advanced trials were planned for IGA. In the cases where airplanes were included in the advanced trials, these trials were named as integrated Trials. The IGA ORAT team had also planned three integrated trials with 1000, 3000, and 5000 fake passengers. Emergency trials included fires, complete evacuations, safety issues, and plane crashes. A total number of 15 emergency trials were planned for Istanbul Airport. The IGA ORAT team also determined milestones for trial scenarios, including the preparation of trial scenarios, trial checklists, trial briefings, trial executions, trial de-briefings, collection of trial lists, trial open topic lists, and trial reports. All trials were tracked from checklists that included milestones, test suite, status, % success, and assigns.

LD5—leadership in risk management: Risk management of ORAT was considered on a basis of *The Project Management Body of Knowledge* (PMBOK) guide. As the first step of the risk management process, all risk factors were identified related to all milestones of the ORAT program. As the second step, all identified risk factors were evaluated in detail, according to their impact and probability. According to the impact–probability assessment matrix, the top 15 risk factors specific to IGA ORAT were determined. Among these 15 risk factors construction works, strikes, preparation of stakeholder facilities, and construction handover problems were identified as the most important risk factors, whereas protests of the society and operational readiness issues were identified as the least important risk factors, according to the impact–probability assessment matrix. As the third step of the risk management process, risk mitigation measures were identified for each risk factor to reduce their effect on the operations. Risk monitoring and control was the fourth and final step of IGA ORAT risk management. It includes the continuous monitoring of residual risks, considering the effectiveness of the control/mitigation mechanisms. The IGA ORAT team also monitors and evaluates all risks that could jeopardize the success of the opening with this four-step approach monthly, and if an unforeseen event occurs risk assessments and mitigation measures are updated and then presented to the ORAT Board of Directors.

LD6—Leadership in communication management: The overall objective of the communication management is to promote the success of the project by meeting the information needs of the project stakeholders. False assumptions can be made for the opening date if stakeholders do not receive sufficient information during the preparatory phase. The shortcomings in the preparatory phase of airport operations will result in shortages of procedures, resources, and equipment, and will directly affect operations and cause high costs due to instant corrections. Thus, the lack of information in terms of the roles and responsibilities by stakeholders due to inefficient communication management was addressed in the specific top 15 project risks for IGA ORAT. In this context, to increase stakeholder awareness and provide information about the operational concept of IGA, workshops were organized separately for each stakeholder as a risk mitigation measure. In these workshops, all FISH (facility, information, system, and human) elements of the new airport were revealed to the stakeholders. Additionally, the IGA ORAT team identified the related stakeholders who will be notified from specified communication channels, for example, when a crisis occurs during an operation, or who will be informed if any events occur during the transfer. In addition, in the context of communication management, over 250 meetings were held with all stakeholders, including public institutions and organizations, in the specified topics to move the airport smoothly and to make it ready for operation.

S1—management of airport and ORAT stakeholder engagement: In IGA ORAT, the General Directorate of State Airports Authority, airport operator, airlines, ground service companies, police/customs/gendarme, and catering company were the main stakeholders. Apart from the main stakeholders, approximately 1000 companies and 80,000 personnel took part in IGA ORAT. Even if all the IGA facilities were ready, the lack of preparedness of all stakeholders would prevent the start of ORAT operations or affect them significantly. Thus, the management of all stakeholders and sustaining engagement of all stakeholders were important matters.

S2—management of ORAT human resources: The success of ORAT highly depends on the success of the developing team. Thus, all personnel that would be placed in ORAT were selected among those with experience in aviation operations. Gathering people who had expertise in aviation operations leads to success in managing the ORAT process due to understanding the required business manner that ORAT needs or sensing consequences of possible problems in a proactive way. Also, one of the most important factors leading success within human resources was the strong commitment of staff to the project, along with high level of expertise of the team members. Considering the national importance of this project, personnel motivation and team performances were extremely interrelated. Within the context of managing human resources, calculation of staff numbers and recruitment of airport personnel were determined as critical risk factors affecting ORAT performance. If sufficient airport personnel were not available, this process would result in a lower quality of service, safety, and quality standards. Thus, close collaboration with ground services, organizing operational seminars, discussing operational procedures, and tracking HR recruit status were set as risk mitigation measures.

S3—Development of stakeholder (staff, etc.) training, orientation, and familiarization programs related to the airport operation: Since construction activities were simultaneously carried out with the ORAT implementation process, familiarization featured as a prominent factor. If the operation had been transferred to IGA after the airport construction was finished, employees' adaptation to the facility would be easier. Therefore, not only classroom-based trainings and on-site trainings were planned, but also 3D-driven simulations were added to familiarization activities, as field visits were not possible due to the ongoing construction work. In this way, even though the airport was not ready, it was ensured that employees fully understood the airport at least formalistically. In addition, along with simulation videos, special materials had been designed for the ORAT training and familiarization program, such as pocket maps, which are guide maps, including information, graphics, and user-friendly maps for airport employees, brochures, identification cards, and checklists. On the other hand, lack of training, orientation, and familiarization

of an important stakeholder was another crucial risk factor. End-user preparation should be guaranteed through training, orientation, and familiarization programs. Systems will be useless if end users do not know how to use these systems. Therefore, a qualified education coordination team was established within the ORAT team to monitor and control the readiness of employees.

S4—implementation of stakeholder (staff, etc.) training, orientation, and familiarization programs related to the airport operation: Classroom trainings given within the scope of ORAT familiarization, which started on 5 March 2018 and ended on 1 June 2018, were completed in 88 days. A total number of 27,783 trainings were completed within the training, orientation, and familiarization programs. The ORAT training workflow includes the coordination of the following training activities: aviation training required by the aviation regulations, operational execution training, IGA in-company behavior training, customer service training, personal development training, and system training to be provided by İGA construction and subcontractors. Trainings were also planned to be flexible, considering the out of working hours of each stakeholder staff member. However, the integration of staff program and trainings' program was a key issue that requires detailed planning. Within the familiarization, plotted routes for baggage transfer from apron to airport and transportation from the parking lot to the airport were tracked in terms of the transformation duration. In these monitoring activities, game-cards that included directions and instructions were used by the end-users who had a limited level of knowledge about the airport facility. Another important issue in the implementation of familiarization was the adaptation of valid conditions and rules in IST to IGA. There were significant differences in the execution rules and processes between IGA and IST due to the fact that they did not have identical operational processes as an airport. Accordingly, trainings were provided for 693 experts from relevant stakeholders in terms of process familiarization of the airport.

S5–implementation of operational trial scenarios with relevant stakeholders: Within IGA ORAT, a total number of two trials were executed. A total of a 1000 fake passengers, 2000 baggages, 800 personnel from operational stakeholders and public institutions, 2 real airplanes, and 50 ground service equipment took place in the first trial, whereas 3000 fake passengers, 6000 fake baggages, 2000 personnel from operational stakeholders and public institutions, 3 real airplanes, and 150 ground service equipment took place in the second trial. In the context of trial execution, pre-trial activities and post-trials activities were determined. Pre-trial activities can be summarized as follows: monitoring the readiness of the site, monitoring the readiness of the systems to be used in the trial scenarios and determining the deficiencies, ensuring coordination for the elimination/completion of the identified deficiencies, finalizing the trial scenario date according to the completion (readiness) of the detected deficiencies, informing IGA personnel who will participate in trial scenario, controlling the tools and equipment to be used in the trial scenarios, identifying and contacting external stakeholder trial representatives, conducting meetings with internal and external stakeholders (separately) on a weekly basis before the trial, tracking and coordination of the trainings that should be taken within the scope of the relevant trial scenarios, and informing the personnel who will participate in the trial scenario via e-mail (reminder). Post-trial activities can be summarized as follows: preparing the final trial scenario report within 3 days and sending to the respective departments and senior managers, determining the corrective and preventive actions if any deficiencies were detected during the trials, evaluation of trial performance with the relevant İGA departments, and follow-up of updates due to evaluations and retesting if deemed necessary.

F1—completing the construction processes of the facility before the operation: Generally, the ORAT process starts after the handover processes, corresponding to the completion of the facility construction. However, in the IGA case, ORAT and construction activities were simultaneously carried out that provided serious advantages in terms of the time; on the other hand, it brought some challenges within familiarization. If the operation had been transferred to IGA after the airport construction was finished, employees' adaptation to the

facility would be shorter. There had been some problems related to showing employees their work areas, entrance doors, and routes to their office, as the construction works were still going on while the familiarization process continued. The first construction phase of the airport, including the construction process of the facility, was identified as 42 months, in line with the ORAT master plan. On the other hand, the progress in the construction period was directly affecting the ORAT master plan, depending on the concurrence of ORAT operations and construction works. For this reason, the ORAT team had to repress and control construction teams and suppliers that were not under their responsibilities within the master plan. The completion of the construction processes of the facility was also of vital importance, according to the ORAT risk assessment, because delays in the completion of construction works would significantly affect the opening day of the new airport. If delays were crucial and had a significant impact on the use of essential airport facilities or functions, the airport opening day should be rescheduled. Therefore, the ORAT team always requested construction progress information from IGA construction and made field visits to monitor real progress. Another important issue related to the construction processes of the facility was construction delivery problems that arose from design features, T and C issues, O and M issues, and uncertainty in transfer dates. To compensate for these construction delivery-related collaboration gaps, senior- and mid-level managers of IGA construction and IGA had listed all the details of their transfer transactions. Thus, all related process became clear and recorded for both sides.

F2—providing process and documentation requirements for the operational transition of the facility: IGA is subjected to a wide range of Turkish and international aviation regulations in terms of the passenger, baggage safety, and airport operation processes. Therefore, the documentation process within ORAT was developed to be compatible with national and international civil aviation institutions' legislation, procedures, instructions, and handbooks. In this process, collaboration with users is established to develop or improve standard operating procedures (SOPs) and irregular operating procedures (IOPs). Within the scope of the ORAT process, which can also be seen as an opportunity for airlines to improve their procedures, systems, and skills, it is therefore important to have the necessary personnel and resources available for the above activities. Thus, the new airport checklist—one of the International Air Transport Association (IATA) *Airport Development Reference Manual* support documents—was used to conduct onsite reviews of new facilities. Within IGA ORAT, operational documents, such as handbooks, procedures, operation and maintenance plans, human resources planning documents, and education planning documents, were developed. To set an example in numbers, a total number of four manuals (aerodrome operational manual, safety management manual, airport emergency response plan, and AOCC manual) and a total number of 380 instruction and procedures were developed by the ORAT team. Among these four main manuals, the airport emergency response plan had a top priority because some of the previous ORAT failures occurred related to problems in baggage handling, check-in system, or flight information systems. Therefore, a total number of 54 emergency response plans were developed in concern with the evacuation plan, network failure, turnstile failure, security system failure, trunk radio system failure, cyber-attacks, parking system failure, self-check-in failure, X-ray failure, door detector malfunction, boarding gate malfunction, explosive trace detector failure, body scanner malfunction, etc.

F3—integrated facility management: Operational processes are different from facility management; however, ORAT usually covers operational and facility management aspects in one program. In the context of integrated facility management, transition plans of new infrastructure related to maintenance were reviewed; FM-related standard procedures and contingency procedures for a proper integration were developed, and operational interfaces between facilities, systems, procedures, and human resources were tested in the context of commissioning tests.

TSI1—management of airport systems: There were innumerous systems related to several stakeholders that should be considered within ORAT. These systems can be cate-

gorized as airport systems (facility management systems, wireless network, ERP systems, resource management systems, flight information systems, check-in and boarding systems, baggage handling system, departure control system, signalization, etc.), airline systems, ground services systems, security systems (police and customs systems), etc. The main consideration within ORAT was to ensure that these systems can work problem-free one by one, and if they work, to integrate all systems with each other to prevent major failures. For example, when a flight is delayed 20 min, the airplane company uploads this information to its own information system. However, if this information cannot be tracked from the flight information systems of IGA simultaneously, any delay in the response time would cause a financial loss. Thus, this issue was also addressed in the specific top 15 project risks for IGA ORAT due to their high possibility and effect. Considering the case where crucial systems, such as baggage handling, departure control, or resource management systems, were not properly integrated, the entire airport operation would be affected due to this non-functionality. Therefore, trials, along with installation and integration tests of systems and on-site visits of ORAT team members for monitoring these integration tests were implemented as risk mitigation measures. For example, basic trials were used to determine the functionality of a single system and 79 basic trials were performed in total. Similarly, advanced trails were used to test multiple processes and multi-system functionality. A total number of 27 advanced trials were planned for IGA.

TSI2—preparation of ORAT management and tracking systems: To track and operate a whole airport's operations, there is a big need for information management systems. These systems are needed to track aviation operations rather similarly to manage facility operations. Any power or water shortage, accidents, flight cancellation or delays, meteorological data, such as fog and wind increase, number of flights, number of passengers, parking plans of airplanes, timely departure rates, ventilation systems, heating and cooling systems, camera systems, barcode reading systems, etc., are monitored from dashboards either by the ORAT director or duty managers 24/7. Due to the necessity of controlling, coordinating, and reporting these systems from a centralized structure, the AOCC was established. The AOCC aims to increase the efficiency in the operational management performance, predictability, and general awareness by bringing the airport operational departments together in a single center, taking the necessary measures, and continuously interacting with the stakeholders.

3.4. Pythagorean Fuzzy Analytic Hierarchy Process

In the literature, analytic hierarchy process (AHP) methodology has been followed to evaluate subjective and categorical parameters for multi-criteria, decision-making problem solving. However, the evaluation scale (linguistic terms) and the implementation process of the AHP method is criticized, since the AHP method does not consider the vagueness and impreciseness of subjective evaluations. Within this context, fuzzy AHP is presented by combining AHP with fuzzy logic to overcome these issues [41]. Since classical AHP is not fully suitable for decision making under uncertainty, fuzzy AHP is presented by combining AHP with fuzzy logic [42]. The Pythagorean fuzzy analytic hierarchy process (PFAHP) was developed with the aim of improving fuzzy AHP for obtaining more consistent results. The PFAHP is one of the favored methods evaluations in multi-criteria decision-making methods: (1) it considers vagueness and impreciseness of subjective evaluations, (2) experts can make clearer decisions over a wider area and express their assessment of the problem being addressed, and (3) the Pythagorean fuzzy set theory can handle not only incomplete information, but also vague information and inconsistent information commonly found in real situations [43,44]. The PFAHP method was employed in this study according to its advantages on giving opportunities to experts to express their thoughts by considering their thoughts' vagueness and impreciseness, which will result in obtaining more reliable and accurate data with less uncertainty, and the common use in the project management literature [41,45–48].

3.4.1. Data Collection

With the aim of exploring the weights of the fundamental prerequisites of ORAT process using the PFAHP, a questionnaire was prepared to first collect data from experts. This questionnaire was created based on four sections. In the first section, the aim of the study was explained and the descriptions of the ORAT prerequisites were introduced. In the second section, the questions related to descriptive information about the experts were asked. In the third section, the guide for responding to the questionnaire was provided. In the last section, six comparison matrices were asked to reveal the importance level of the ORAT prerequisites. These data were collected from five experts who have expertise in the ORAT process, airport management, and aviation (the questionnaire can be found in the "Supplemental Material" section). In this field, there are limited experts due to the availability of limited airport projects containing the ORAT process. Moreover, there are limited experts who take a responsibility in a project's lifecycle from the feasibility phase to the commissioning phase. The literature review showed that data collection from four experts to five experts is reliable [42,47,49]. The descriptive information about experts is given in Table 3.

Table 3. The descriptive information about experts.

Expert	Position	Experience (Years)
DM1	Manager (airport facility manager)	28
DM2	Manager (airport facility manager)	27
DM3	Manager (airport facility manager)	22
DM4	Industrial engineer (airport facility manager)	8
DM5	Engineer (manager in airline company)	14

3.4.2. Data Analysis of the Pythagorean Fuzzy Analytical Hierarchy Process

Data gathered from experts were analyzed according to the main steps of the PFAHP. The PFAHP method has six main steps, which comprise the following: (1) development of pairwise comparison matrices, (2) creation of the differences matrix (D) using the lower and upper values of membership and non-membership degrees, (3) creation of the interval multiplicative matrixes (S), (4) calculation of the determinacy value (τ), (5) calculation of the matrix of weights, and (6) the normalization. The mathematical operations that are used in Pythagorean fuzzy sets, the linguistic terms for the PFAHP, and the equations that were used in each step of the PFAHP can be found in the "Supplemental Material" section [50,51].

Before applying the PFAHP method, the consistency ratio (CR) needs to be calculated to find out the consistency issues that arise from expert judgements. To calculate the CR, the classical AHP that was proposed by Saaty (1977) was followed [52]. The CR value should be between 0–0.1. As a result of CR analysis, all pairwise comparison matrices were found in acceptable limits. CR analysis for pairwise comparison matrices, an aggregated pairwise comparison matrix of the main criteria, and aggregated pairwise comparison matrices of logistic, leadership, stakeholder, facility, technology, system, and information activities can be found in the "Supplemental Material" section.

After control of the CR value, pairwise comparison matrices that were evaluated according to the linguistic terms for the PFAHP were aggregated according to the geometric mean operation [49]. After obtaining the aggregated matrices, the steps of the PFAHP were implemented.

4. Findings of The Study

The findings of this study are presented below with two sub-headings, namely findings derived from "PFAHP analysis" and findings derived from "sensitivity analysis".

4.1. Findings of Pythagorean Fuzzy Analytical Hierarchy Process Analysis

According to the six-staged PFAHP-solving procedure, ranks of all ORAT activities and main criteria were calculated using the gathered data from experts. As a result of the calculations of the weights of all ORAT activities in each category, the global weights of all ORAT activities are given in Table 4.

Table 4. Global ranks of all ORAT activities.

Criterion	Weight	Rank	Sub-Criterion	Weight	Rank	Global Weight	Global Rank
LG	0.178	4	LG1	0.383	1	0.068	4
			LG2	0.230	2	0.041	14
			LG3	0.182	4	0.032	18
			LG4	0.204	3	0.036	16
LD	0.260	1	LD1	0.187	2	0.049	7
			LD2	0.190	1	0.049	6
			LD3	0.162	4	0.042	11
			LD4	0.158	5	0.041	13
			LD5	0.170	3	0.044	9
			LD6	0.132	6	0.034	17
ST	0.153	5	ST1	0.252	3	0.039	15
			ST2	0.180	4	0.027	19
			ST3	0.274	2	0.042	12
			ST4	0.294	1	0.045	8
F	0.180	3	F1	0.325	2	0.059	5
			F2	0.439	1	0.079	3
			F3	0.235	3	0.042	10
TSI	0.229	2	TSI1	0.542	1	0.124	1
			TSI2	0.458	2	0.105	2

The analysis results revealed that the "leadership" category is the most important category in the ORAT process. The "Technology, system, and information" category follows the leadership category. In logistic activities, "LG1-Development and implementation of Transfer and Transition Management Plan" was found out as the most important activity, whereas in leadership activities, "LD2-Generating the organizational structure and governance to manage ORAT" activity was seen as the most important activity. Facility-related activities were found as the third-most important category. In the facility category, "F2-Providing process, and documentation requirements for operational transition of the facility" activity was found out the most important activity. As a result of this analysis, the stakeholder category was found to be the least important category. In the stakeholder category, "ST4-Implementation of stakeholder (staff etc.) training, orientation and familiarization programs related to the airport operation" activity was found out as the most important activity.

Although the "Leadership" criterion was found to be the most important criterion among the main criteria, two sub-criteria found under the "Technology, System and Information" criterion were found as the most important criteria. The underlying reasons under this analysis results depend on two main facts. The first fact is related to the closeness of the weight scores of the main criteria between leadership (0.26) and technology, system, and information (0.226). The second fact is that the total sub-criteria weight scores must equal one. This means that if the number of sub-criteria is less than other main criteria, the

weight score of the sub-criteria will be higher than the weights of other sub criteria found under the main criteria. In the technology, system, and information criterion, there were two sub-criteria, while six sub-criteria were found under the leadership criterion. Therefore, the weight scores of the TSI sub-criteria were found to be higher than the LD sub-criteria.

The analysis results also showed that the fundamental prerequisites of the ORAT process do not have an equal importance level. Therefore, the null hypothesis is rejected.

4.2. Findings of Sensitivity Analysis

For validation of the PFAHP analysis results, a sensitivity analysis was performed. Sensitivity analysis is performed to find out the robustness and applicability of the analysis [45], and to validate any decision-making analysis [53–55]. In this study, sensitivity analysis was made based on the study by Shete et al. (2020) [41]. In this analysis, the weights of the leadership category were changed, since the analysis results indicated that the most important criterion is leadership activity. In the sensitivity analysis, the weight of the leadership category was multiplied with coefficients (1, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, and 0.1). According to the sensitivity analysis, the evaluation change in the leadership category was sensitive, and the decision maker ought to give an importance to the leadership category (Figure 2).

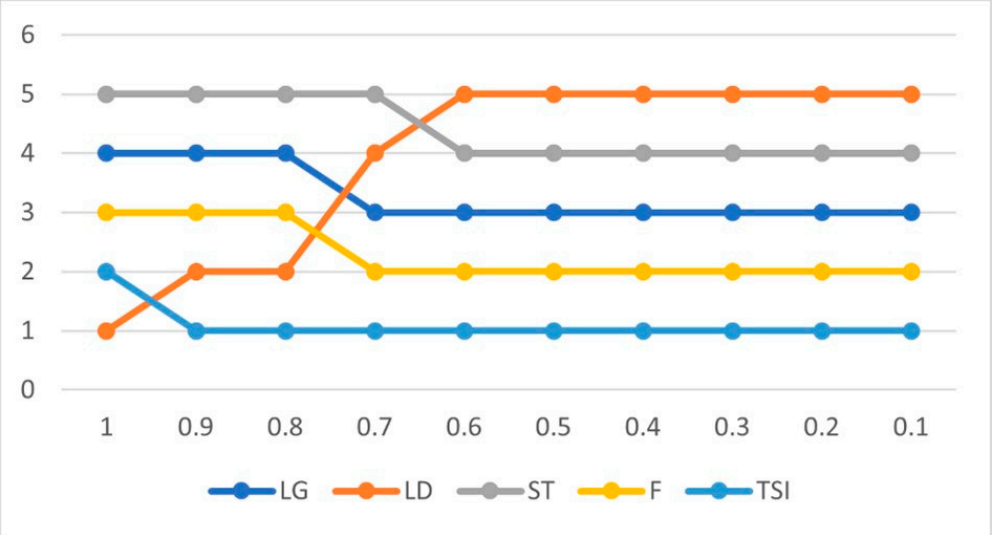

Figure 2. Rank changes in the process of sensitivity analysis (criteria).

Additionally, this condition was compared with the study by Shete et al. (2020) [41], and it was seen that the changes can be seen on the ranks of the criteria and alternatives. Moreover, the changes in the weights of the leadership category were reflected to the ORAT activities. As a result of this operation, the global weights of the criteria were calculated. After that, the ranks were determined using the global weights. Details related to the sensitivity analysis procedure and the tabulated results can be seen in Table 5.

Table 5. Global ranks of the ORAT activities.

LD	0.26	0.23	0.21	0.18	0.16	0.13	0.10	0.08	0.05	0.05
LG1	4	4	4	4	4	4	4	4	4	4
LG2	14	11	9	9	9	9	9	9	9	9
LG3	18	17	15	12	12	12	12	12	12	12
LG4	16	15	12	11	11	11	11	11	11	11
LD1	7	9	13	14	15	15	15	15	15	15
LD2	6	7	11	13	14	14	14	14	14	14
LD3	11	14	16	17	17	17	17	17	17	17
LD4	13	16	17	18	18	18	18	18	18	18
LD5	9	13	14	16	16	16	16	16	16	16
LD6	17	18	19	19	19	19	19	19	19	19
ST1	15	12	10	10	10	10	10	10	10	10
ST2	19	19	18	15	13	13	13	13	13	13
ST3	12	10	7	7	7	7	7	7	7	7
ST4	8	6	6	6	6	6	6	6	6	6
F1	5	5	5	5	5	5	5	5	5	5
F2	3	3	3	3	3	3	3	3	3	3
F3	10	8	8	8	8	8	8	8	8	8
TSI1	1	1	1	1	1	1	1	1	1	1
TSI2	2	2	2	2	2	2	2	2	2	2

Against to changes in the rank of the criteria, the sensitivity analysis results showed that global ranks change too much. In other words, TSI1, TSI2, F2, LG1, and F1 do not change, or are not sensitive.

5. Discussion of the Findings

A variety of people, project stakeholders, tools, and techniques are used to deliver airport projects. Within this context, management of these items and elimination risks related to these activities require effective and efficient tools and techniques to achieve success [6,14]. Furthermore, the airport facilities give a service to a large mass of the public as soon as they open. Any faulty and dysfunctional elements cause delays and interruptions during the operation phase. Moreover, this type of issue can negatively affect the reputation of the project. Thus, ORAT is the most important step to ensure the operability of the constructed facility.

PFAHP analysis results revealed that "leadership" is the most important criterion to perform successful ORAT process for airport projects to solve complex ORAT issues, convince employees, and enable successful management. ORAT activities can be considered as fourth in the success criteria (in addition to timely completion, on budget, and required quality): operational readiness, which requires system, technology, and people integration. In other words, users must be comfortable with the operating mode. This situation requires not only focus on the consideration of construction execution, but also focus on project delivery through the ORAT process. As it is known, in the construction phase, effective leadership is essential in any project for the smooth running of project activities and stakeholder engagement [56]. Likewise, leadership is considered as vital in ORAT processes since the primary responsibility of a manager is to ensure that the systems of an environment work in harmony with one another. Additionally, ORAT processes require adaptation of organization members into deliberate organizational changes. Also, convincing employees to achieve the common goals is an important task for leaders [24]. Moreover,

leadership is vital, since guidance in ORAT stakeholder management, risk management, communication management, and leading trial scenarios in operational readiness process is a part of the ORAT manager's responsibility. Moreover, data analysis and interpretation of data, understanding the interactions, adaptation into change, and choosing the changed model according to the company's structure and targets are other important requirements for successful leadership [24].

Due to the high level of segmentation, complexity, and uncertainty in airport project management, it is more effective for the leadership structure to be demonstrated as shared leadership style rather than individual leadership in these projects [6]. Shared leadership describes the collective performance of all project activities by certain individuals, rather than a single leader or manager performing all leadership functions. This leads to the importance of the appropriate selection of the manager and managerial team for ORAT processes to achieve project success.

The factors of "LD2-Generating the organizational structure and governance to manage ORAT" and "LD1-Determination and control of ORAT success indicators" were found to be the two most important factors under the leadership criterion. LD2 was not considered in the study by Al-Mazrouie et al. (2020) [14]. However, the authors used "Necessity of checklist/reporting mechanism for the operational readiness program", "Ensuring all roles and responsibilities documentation is signed off by relevant stakeholders", and "Establishing joint control room with all the stakeholders for the move sequence and new operations indicators" in their SEM analysis. Additionally, these indicators were among the most important indicators for organizational/process readiness [14]. This result showed that LD2 needs to be meticulously developed, since ORAT processes are intertwined and consist of complex and coordination-intensive tasks. Moreover, some activities can be subcontracted depending on the project's size. Therefore, generating the organizational structure and its governance by understanding project reality are vital for accomplishment [24]. Furthermore, the duration of the transfer process is limited compared to other project phases. Therefore, all roles and responsibilities need to be defined without causing any misunderstandings. "LD1-Determination and control of ORAT success indicator" was found as the second-most important leadership activity. Countries try to attract more passengers to obtain more financial resources from the aviation industry. Therefore, the project requirements are designed on the determination of clear objectives about passenger satisfaction, such as friendly staff, short distance, easy accessibility to services, passenger guidance, etc. In addition to these expectations, the timely and on budget commissioning of operations are considered as key success indicators to enable successful opening [27]. Within this context, the ORAT process should be measured, and objectives and performance outcomes should be also documented [14]. The literature attribute importance to tracking the whole airport's operation performance with identified indicators, and dashboards are suggested to observe the determined indicators [24]. Similarly, this issue is of significance for the case study of IGA since success indicators were observed from the dashboard in a real and timely manner.

"Technology, system, and information criteria" was found to be the second most important criteria in PFAHP analysis. In airport projects, a variety of technologies and systems are needed to work synchronously. If the expansion is made on the existing facility, these systems and technologies need to be coherent with the existing area [6]. Talbot (2022) stated that the equipment-, system-, and infrastructure-related issues are one of the most important users' dissatisfaction reason [26]. The flight process of the passengers at the airport includes security-related technologies (computed tomography and centralized security control screening point), check-ins, self-service bag drops, baggage handling, emigration, security, gates, immigration, baggage reclaim, and customs [25,27]. A malfunction in any of these systems or any disconnection in the integration with each other will affect the level of satisfaction of the passengers, which might lead failure recursions, like the ORAT practices of Kuala Lumpur Airport, Chek Lap Kok Airport, Heathrow Airport, and Suvarnabhumi Airport.

Furthermore, in the near future, the automation and services without staff members will increase due to the lack of experienced professionals in the airport services. As a result of this process, the tasks under technology, system, and information will be more complicated. Moreover, the use of technology and its issues directly reflects on the customers. Therefore, possible issues related to technology, system, and information cause reputational and financial damage [14].

"TSI1-Management of airport systems" and "TSI2-Preparation of ORAT management and tracking systems" were found to be the most important factors under the technology, system, and information criterion. For example, the root issue-related disastrous openings of Heathrow Terminal 5 were found out as a number of system integration problems [13]. The analysis results showed that system integration, tests, and trials need to be carefully conducted. During this process, ORAT professionals need to plan this process with the participation of stakeholders. As an informative resource for the prevention of failures that are frequently encountered in ORAT experiences, it may be beneficial for ORAT managers to adopt strategies, such as "Cross-functional collaboration", for fostering collaboration among airlines, ground handlers, security, and maintenance teams to assess readiness and identify areas for improvement, and "Developing contingency plans" that includes alternative procedures, and communication protocols in case of emergencies or unexpected events to address potential issues or disruptions during the ORAT process. As it is pointed out in the İGA case, not only systems working problem-free one by one are not enough, but also integrating all systems with each other to prevent major failures is crucial. Therefore, developing a detailed integration plan that outlines the sequence of activities, dependencies, and timelines, with a focus system on compatibility, data migration, testing, and commissioning should be taken into consideration by the ORAT managers. Additionally, throughout this integration process, robust data migration strategies should also be developed to ensure that data integrity and security measures (data backup and recovery procedures, etc.) are in place throughout the integration process. Another important finding from the İGA case in terms of the "management of airport systems" was the importance of testing and commissioning all airport systems. Therefore, basic and advanced trials should be planned to monitor and evaluate the performance of the integrated systems, as was conducted in the İGA case. This will reduce the failure risk in the integration of these systems, as well as ensure a seamless operation. To enhance the success of the ORAT process, trials should also include various types of testing, such as functional testing, interoperability testing, performance testing, and user acceptance testing.

This study's results also draw attention to the importance of ORAT management and tracking systems (TSI2). This includes setting up the infrastructure of systems by identifying the requirements of the ORAT system and infrastructure. As the authors of [7] suggest, an airport management center should be one of the pillars of the ORAT procedure; IGA interiorized this pillar by establishing the AOCC to manage and track the information management systems to track aviation operations rather like to manage facility operations. For future ORAT operations, establishing an airport operations control center to manage information system before, during, and after ORAT relocation is highly suggested.

"F2-Providing process, and documentation requirements for operational transition of the facility" was found out as the third prominent ORAT activity, according to the PFAHP analysis. In contrast with the findings of Mazrouie et al.'s (2020) study [14], this study attributes importance to F2 based upon the need for data related to the changes performed during the transition period to be stored in the computerized maintenance management systems, since these documents are important in understanding how to operate the hardware [21]. Furthermore, it was stated that the "lack of supporting documentation or inability to locate relevant documentation" is one of the value erosions [21]. F2 is crucial, not only for ensuring a smooth, well-coordinated, and compliant transition, but it is also crucial for minimizing risks in airport operations. In the aviation industry, there are often strict compliance and regulatory requirements that need to be met during the operational transition of an airport facility. Having well-defined processes and documentation helps

ensure that these requirements are met, reducing the risk of non-compliance. As was conducted in the IGA case, it would be beneficial to develop a documentation process that will be compatible with national and international civil aviation institutions' legislation, procedures, instructions, and handbooks. Along with this, to clarify process and documentation requirements for the operational transition of the facility, operational documents, such as handbooks, procedures, operation and maintenance plans, human resources planning documents, and education planning documents, should be developed. These documents will not only ensure a clarity on who is responsible for each aspect of the transition, they will also serve as a communication tool by enabling a common language and understanding of the steps and requirements for operational transition. Additionally, well-defined processes and documentation requirements help identify and mitigate risks associated with the operational transition. By following a structured approach and capturing important information, potential risks can be proactively identified, assessed, and addressed.

6. Conclusions

An airport facility must operate as designed from the first day it opens. A failed or delayed opening can result in significant disruptions and losses for airlines. Additionally, implementation of ORAT requires methodical preparation, expert involvement, close cooperation with end users, and huge amount of investment. Therefore, the ORAT program should be engaged earlier to as a larger project plan for preventing failures in operating airport facilities.

Many studies have investigated the ORAT procedure by interpreting successful and unsuccessful ORAT case studies, and they have mainly dealt with defining the core activities of ORAT. However, a quantitative study to discover the important ORAT activities has not been performed to date. In this regard, this study adopts a descriptive case study methodology to better illustrate the effects and the relations of the fundamental prerequisites of ORAT, following which PFAHP methodology was implemented to prioritize the ORAT activities for determining the up-front activities.

The study findings showed the importance of the "Management of airport systems", "Preparation of ORAT management and tracking systems", and "Providing process, and documentation requirements for operational transition of the facility".

6.1. Practical Implication of the Study

The prioritization of ORAT activities provides implementational contribution for practitioners by revealing which of the up-front activities in the ORAT process should be primarily considered by the project managers. Therefore, operational and risk management strategies can be developed by considering these primary activities to prevent failures that have been frequently encountered in prior ORAT experiences. Since ORAT is conducted as a series of processes in an airport, which proactively identify and mitigate operational risks, revealing the possible role and effects of the fundamental prerequisites of ORAT is important for helping practical implementations and better illustrate the prominent risks related to ORAT. Therefore, operational and risk management strategies can be developed by considering these primary activities to prevent failures that have been frequently encountered in prior ORAT experiences. In addition, the added value of prioritizing ORAT activities is to form a basis for allocating resources and to prevent time, energy, and attention on tasks that are not as urgent as others. In this sense, this paper is a first step towards a better understanding of the relations between the fundamental prerequisites of ORAT, along with addressing important issues that would be useful for decision-making authorities. Additionally, the ORAT process requires high levels of expertise in the fields of construction, logistic, electronics, and mechanics. In this sense, the results of this study provide important insights for airport managers, facility managers, etc., working on any ORAT process.

This study's results revealed that the "Management of airport systems", "Preparation of ORAT management and tracking systems", and "Providing process, and documentation

requirements for operational transition of the facility" are the most severe ORAT activities, and they should be first addressed in the ORAT process for achieving successful airport openings in terms of planning trails, familiarization, and stakeholder management for integrating facility, process, systems, and people. In this respect, this study's results might shed light for ORAT managers to develop operational and risk management strategies by considering the fundamental prerequisites of ORAT on a preferential basis. Some strategies include, but are not limited to:

- Cross-functional collaboration for fostering collaboration among all airport systems: As stated above, there are lots of connected information technologies and systems in the airports. However, these technologies and systems are designed to serve different stakeholders, such as ground services, check-in, security, etc. Therefore, the collaboration should be fundamentally performed by meeting the demands of stakeholders. The management of stakeholders can be the challenging part of this strategy. Stakeholder management and regular meetings will be the key to implement this strategy successfully.
- Implementing regular drills and simulations to assess readiness and identify areas for improvement: Performing drills and simulations are one of the costliest parts of ORAT activities. It requires intensive resource allocation, such as time, personnel, and equipment. Also, while drills are performed, some part of the construction activities is executed in the facility. Therefore, the management of drills is complex and risky. However, simulations and drills will be useful to prevent failures during the operation phase of the facility.
- Developing contingency plans that includes alternative procedures, and communication protocols in case of emergencies or unexpected events to address potential issues or disruptions during the ORAT process: ORAT is a dynamic and complex process. Therefore, as being in every project phase, it contains risks and requires the wise allocation of limited resources. To handle risks and unexpected events, the development of ORAT contingency plans requires intensive collaborations with stakeholders to consider possible scenarios. Communication and stakeholder engagement will be important to implement this strategy. Within this context, the employment of an experienced ORAT team can be the facilitator for this strategy.
- Developing a detailed integration plan that outlines the sequence of activities, dependencies, and timelines "developing a robust data migration strategy" to ensure data integrity and security measures: The information technologies and systems found in the airports requires databases that are managed securely. Moreover, when the operations are transferred to a newly constructed facility, data migrating, and the integration of old and new systems, can be challenging. However, if the ORAT activities involving data mapping and documentation, quality assessment, and trials are performed carefully, this process can be error-free.
- Implementation of basic and advanced trials, including functional testing, interoperability testing, performance testing, and user acceptance testing: The most challenging part of trials/tests will be interoperability issues. However, this issue can be overcome with the use of interoperable systems that are currently used at operating airports.
- Establishing an airport operations control center (AOCC) to manage information systems before, during, and after ORAT relocation: Resource allocation (financial, human, and technological), data integration and monitoring, trainings, hiring experienced personnel, coordination, and communication will be important to establish a successful airport operations control center. Especially, setting up and operating an AOCC can require significant financial resources in terms of acquiring the necessary technology, infrastructure, and personnel. Limited budgets or competing priorities may hinder the establishment of a fully functional AOCC. On the other hand, ensuring regulatory compliance can be another challenge, since an AOCC must comply with various regulations and standards related to data privacy, security, and operational procedures.

- Having well-defined processes and documentation (handbooks, procedures, operation and maintenance plans, human resources planning documents, and education planning documents) that will be compatible with national and international civil aviation institutions' legislation, procedures, instructions, and handbooks for enhancing success in the ORAT process: Different civil aviation institutions may have various national and international regulations, standards, and guidelines. Complying with these requirements and ensuring compatibility with them can be challenging, as they may involve multiple layers of regulations and frequent updates. However, ensuring effective communication, collaboration, and consensus among regulatory bodies, airport authorities, airlines, and other relevant entities might help to break through this obstacle.

6.2. Theoretical Implication of the Study

The main implication of this study is that, to the best of our knowledge, this is one of the pioneer studies contributing to the state-of-the-art ORAT studies today. When the studies related to operational readiness of airports were examined, there were few studies presenting relations between ORAT prerequisites in the body of knowledge. In this sense, the novelty of this study stands, as its focus is on presenting the relations between ORAT prerequisites in the body of knowledge, since there is a lack of rigorous research available that prioritize the importance of these ORAT activities.

6.3. Limitations and Directions for Future Studies

While this study offers insights into the up-front activities that should be considered on a preferential basis by ORAT managers, it is essential to recognize its limitations. These limitations are in two-fold. First, this study performs its analysis using the PFAHP method, which is a combined method of AHP with Pythagorean fuzzy sets. It generally consists of quantifying the weights criteria through pairwise comparisons without considering the cause-and-effect relationships of the criteria. Neglecting these cause-and-effect relationships might cause misleading interpretations for the importance levels of the identified ORAT prerequisites. Secondly, this study only has a focus on the operational readiness of airport facilities. Importance of the level of ORAT prerequisites for a variety of projects and industries, such as stadiums and venues, hospitals, etc., where the facility needs to be prepared for efficient and successful operations, might vary.

Further studies can be focused on developing a structured and comprehensive investigation of airports' ORAT process by developing a framework that maps the flow-oriented representations of the important ORAT activities. While developing these frameworks, researchers can benefit from the descriptive case study that highlighted crucial practical implementations as one of the best ORAT practices in the industry. Knowing these best practices can help an organization to evolve by nurturing a learning culture, filling knowledge gaps, generating creative and innovative ideas, and enabling better decision making. Hence, "lessons learnt" with an associated case study will also provide meaningful contribution for engineering managers and researchers. In addition, reveling the impacts of implementational difficulties can be another subject of future studies, since different expectations of stakeholders, different legislations in a host country, and differentiation in organizational cultures may generate different implementational difficulties.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/systems11090468/s1, Figure S1: comparison of membership and non-membership degrees for Pythagorean and intuitionistic, Figure S2: rank changes in the process of sensitivity analysis (criteria), Figure S3: rank changes in the process of sensitivity analysis (factors); Table S1: logistics activities; Table S2: leadership activities, Table S3: stakeholder activities, Table S4: facility activities, Table S5: technology, system, and information activities, Table S6: ORAT activities, Table S7: comparison scale, Table S8: the linguistic terms for Pythagorean fuzzy AHP, Table S9: CR analysis for pair-wise comparison matrices, Table S10: aggregated pairwise comparison matrix of main criteria, Table S11: aggregated pairwise comparison matrix of logistic activities, Table S12:

Aggregated pairwise comparison matrix of leadership activities, Table S13: aggregated pairwise comparison matrix of stakeholder activities, Table S14: aggregated pairwise comparison matrix of facility activities, Table S15: aggregated pairwise comparison matrix of technology, system, and information activities, Table S16: global ranks of all ORAT activities, Table S17: sensitivity analysis for leadership categories, Table S18: global ranks of ORAT activities.

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