

Competency Needs Assessment of High Angle Rescue Technique (HART) for Airport Rescue and Fire Fighting (ARFF) Personnel in Supporting Safety at Kualanamu International Airport

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Article Info	ABSTRACT
Article History: Submitted: July 28, 2025 Revised: August 30, 2025 Accepted: August 29, 2026	<i>Airport Rescue and Fire Fighting (ARFF) personnel must be prepared to respond to emergencies in complex airport environments, including elevated structures and steep terrain that may require specialized high-angle rescue capabilities. This study aims to assess the need for High Angle Rescue Technique (HART) competency among ARFF personnel at Kualanamu International Airport and to identify existing competency, training, and equipment gaps. A qualitative descriptive approach was employed through field observations, semi-structured interviews with key ARFF personnel, questionnaires involving 50 respondents, document review, and gap analysis against relevant national and international standards. The results indicate that HART competency is considered essential for rescue operations involving terminal buildings, the ATC tower, steep access-road areas, and other elevated locations. However, personnel readiness is constrained by irregular training, limited mastery of rope and knot techniques, inadequate rescue equipment, and the absence of standardized HART procedures and training modules. It is concluded that current HART preparedness remains insufficient to support optimal emergency response. Therefore, structured and continuous training, adequate standardized equipment, formalized HART procedures, competency certification, and collaboration with professional rescue organizations are recommended to strengthen ARFF operational readiness and airport safety.</i>
Keywords: High Angle Rescue Technique (HART), Airport Rescue and Fire Fighting (ARFF), high angle rescue, competency	

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INTRODUCTION

An airport is a designated area, encompassing both land and water, used for aircraft landing and take-off, passenger embarkation and disembarkation, cargo handling, and transportation transfers within and between modes[1]. It is equipped with facilities to ensure aviation safety and security, along with other supporting infrastructure. According to regulation[2], every airport must establish an Aviation Accident and Fire Fighting (PKP-PK) organization, commonly known as the Airport Rescue and Fire Fighting (ARFF) unit. This unit's purpose is to ensure safe airport operations according to set categories and to provide personnel with adequate qualifications and competencies. Furthermore, the decree by[3] defines the PKP-PK unit's responsibilities, including accident prevention, control, firefighting services, protection of people and property, and asset rescue during aircraft incidents or accidents within airport boundaries.

Kualanamu International Airport, one of the largest airports in Indonesia, features complex structures such as air traffic control towers and multi-story terminals. These infrastructures increase the risks associated with high-altitude operations like window cleaning and emergency evacuations. High Angle Rescue Technique (HART), a specialized rope rescue method employing technical equipment, is therefore crucial in such contexts. However, field observations and interviews indicate that most ARFF personnel lack adequate HART training and have limited experience in knot-tying, equipment handling, or formal drills. Moreover, current ARFF training programs do not include structured HART modules, indicating a significant competency gap.

Vertical or high-angle rescue is among the most hazardous rescue operations, requiring specialized skills, cohesive teamwork, and individual dedication. Not all rescuers achieve competence in these demanding techniques As highlighted by [4] in the ARFF Junior Course Batch II materials, HART refers to methods of evacuating disaster victims between elevated points and is an advancement of Basic Rope Access Techniques.

The strategic role of ARFF personnel necessitates proficiency in specialized rescue methods like HART, especially given the high-risk structures at Kualanamu International Airport, including towers and terminals. Current assessments reveal deficiencies in both training and equipment for HART, potentially compromising emergency response effectiveness and increasing risks for victims and rescuers. This study aims to evaluate competency levels, determine factors that facilitate or hinder HART mastery, and underscore the urgent need for targeted competency development among ARFF staff at Kualanamu.

Previous studies have identified similar competency gaps in ARFF units. For example, research by [5] reported low proficiency in Vehicle Accident Rescue (VAR) at Kualanamu, while [6] noted inadequate preparedness for maritime rescues. These findings reveal a broader issue of insufficient technical training within ARFF teams. Nevertheless, there is a lack of focused research on HART in airport settings, highlighting a clear area for investigation.

This study's objectives are to:

1. Assess current HART competency levels among ARFF personnel,
2. Identify obstacles to acquiring HART skills,
3. Propose improvements to integrate HART training into airport emergency preparedness protocols.

METHODS

The research method refers to a systematic scientific approach used to collect, analyze, and interpret data to solve problems or answer research questions. It is a crucial element in the research process, providing structure and ensuring the validity of the findings. By applying proper research methods, researchers can conduct their work logically and in an academically accountable manner [7].

This study employed a qualitative descriptive design, utilizing multiple data collection techniques, including direct observation, semi-structured interviews, questionnaires (distributed to 50 respondents), and literature review. Key informants, such as the ARFF Chief, ARFF Team Leader and Building Rescue & Fire Fighting Team Leader were interviewed due to their operational roles and thorough knowledge of emergency procedures.

To enhance the validity of the data, triangulation was applied by comparing information gathered from interviews, observations, and document analysis. Ethical considerations were strictly

maintained throughout the research, including obtaining informed consent from participants and ensuring their confidentiality.

Data analysis was performed using a Gap Analysis approach, comparing current HART competency levels against applicable regulatory standards, including:

1. PR 30 of 2022 (Technical and Operational Standards for Civil Aviation Safety),
2. NFPA 1983 (Life Safety Rope & Rescue Equipment Standards),
3. UU No. 1 of 2009 (Aviation Law),
4. PERMENAKER No. 9 of 2016 (Safety and Health in High-Altitude Work).

Table 1 GAP Analysis

Current Condition	Desired Condition	Gap	Impact	Regulations
Rescue equipment availability is inadequate	Complete, standard-compliant rescue gear available	Equipment shortfall such as harnesses, pulleys	Inability to perform technical rescues safely, higher risk to rescuers and victims	NFPA 1983[8]
Personnel lack proficiency in knot techniques and equipment use	Personnel fully skilled in rope techniques and equipment	Low technical proficiency	Longer rescue times, higher chance of failure or accidents during rescue ops	PR 30 of 2022 [3]
HART training is unstructured and irregular	Regular, structural training embedded in regulations	Absence of official SOP and certification	Lack of standardized procedures, unclear competency benchmarks, variable readiness	PERMENAKER REPUBLIC OF INDONESIA number 09 of 2016 concerning Occupational Safety and Health in Work at Heights [9]

Instrument validation involved expert review (ARFF trainers and academic supervisors) of interview protocols and pre-testing questionnaires with five ARFF personnel outside the study sample to ensure clarity and relevance. The sample size of 50 ARFF personnel represents a significant portion of the operational unit at Kualanamu, covering various roles such as ARFF exercise and facility personnel, ARFF Chief, Team Leaders, prevention specialists, building staff, and watchroom guards. Purposive sampling was used to include participants directly involved in ARFF operations. In summary, this study integrated qualitative descriptive methods with data collection tools and analytical frameworks to thoroughly assess HART competencies among ARFF staff at Kualanamu International Airport.

RESULT AND DISCUSSION

Current Condition and Competency Need

The assessment of the operational environment at Kualanamu International Airport indicates that ARFF personnel are responsible for responding to emergencies across areas with varying physical characteristics and rescue challenges. As illustrated in Figure 1, the Area of Responsibility of the Kualanamu ARFF Unit covers not only the airside area but also several airport facilities, including the terminal building, administrative buildings, the Air Traffic Control (ATC) tower, and the airport access road. Several of these facilities involve elevated structures and locations with differences in ground elevation. These characteristics indicate that emergency response activities within the ARFF area of responsibility may require rescue operations beyond conventional firefighting and ground-level evacuation. Therefore, the ability to perform rescue operations in elevated or difficult-to-access areas

becomes an important consideration in determining the competency requirements of ARFF personnel.

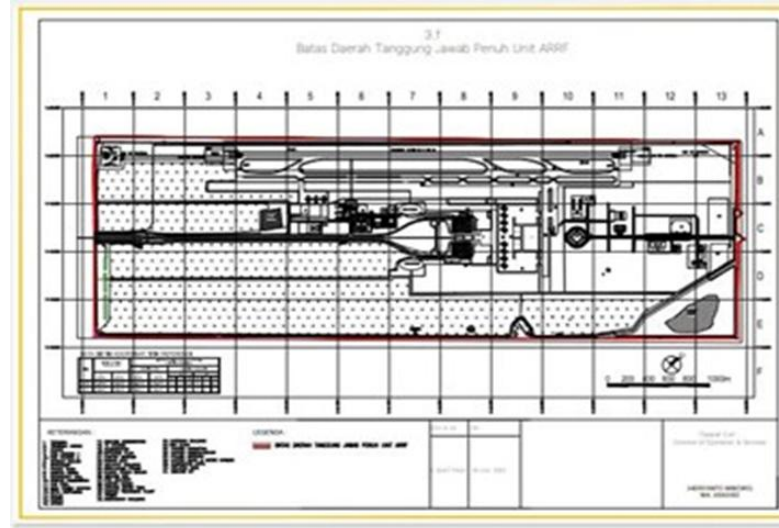


Figure 1 Regional Boundary Grid Map Full Responsibility
Kualanamu ARFF Unit

In addition to elevated airport structures, terrain conditions around the airport may also increase the complexity of emergency response operations. Figure 2 shows several steep sections along the access road to Kualanamu International Airport. Such terrain may increase the potential consequences of vehicle incidents, particularly when a vehicle loses control, leaves the roadway, or becomes positioned on a slope that cannot be safely accessed using conventional rescue procedures. Under these circumstances, rescuers may be required to operate on inclined surfaces or use rope-based access and evacuation systems. Thus, the terrain characteristics presented in Figure 2 further demonstrate the potential relevance of High Angle Rescue Technique (HART) competency for ARFF personnel.



Figure 2 The area of Kualanamu Airport Access Road
that has steep terrain

Another potential rescue scenario is associated with work-at-height activities conducted within airport facilities. As shown in Figure 3, glass-cleaning activities are performed on elevated sections of the terminal building. During field inspection, a glass-cleaning worker was observed carrying out the activity at height without direct supervision. Regardless of the specific occupational safety measures applied by the service provider, activities performed at height inherently present the possibility of incidents in locations that may be difficult to access using conventional rescue equipment. In the event of a fall, suspension incident, or worker incapacitation at height, rapid and technically appropriate evacuation would be required. The condition illustrated in Figure 3 therefore demonstrates a realistic operational scenario in which ARFF personnel may be required to provide assistance using specialized high-angle rescue procedures.

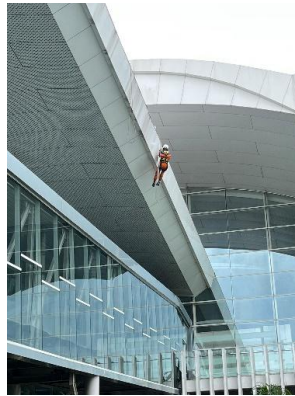


Figure 3 Glass cleaning process at the terminal building

The need for HART competency identified through field observations is also supported by the interview findings presented in Table 2. The interviewed personnel, consisting of the ARFF Chief, ARFF Team Leader, and Building Rescue and Fire Fighting Team Leader, consistently considered HART competency important for emergency response operations at Kualanamu International Airport. Although each respondent emphasized different operational aspects, their responses demonstrate a common concern regarding the ability of ARFF personnel to conduct safe and effective rescue operations in elevated locations. The ARFF Chief highlighted the presence of high-rise airport facilities and emphasized that personnel without adequate HART competency may experience difficulties during evacuation operations. Similarly, the ARFF Team Leader emphasized that competency in high-angle rescue is necessary not only for technical effectiveness but also for ensuring rapid and accurate emergency response, particularly because rescue operations are highly time-sensitive.

The response of the Building Rescue and Fire Fighting Team Leader further reinforces this finding. As summarized in Table 2, airport facilities such as the terminal building and ATC tower were specifically identified as locations where emergencies may occur at height. These facilities may require rescue personnel to reach victims in areas that cannot be accessed safely through conventional ground-based evacuation methods. Consequently, the absence of adequate HART training may limit the capability of ARFF personnel to perform technically appropriate rescue operations in such environments. The interview findings also identified insufficient formal HART training and limitations in specialized rescue equipment as constraints that may affect operational readiness.

Table 2 Interview questions about the condition and level of need

Position in the unit	Interview Results
ARFF Chief	Mastery of the High Angle Rescue Technique (HART) is very important for us at Kualanamu Airport, considering the many areas with heights such as tower buildings, terminal buildings, and various other facilities that have the risk of accidents from height. Without this competency, personnel in charge of evacuation in emergency conditions will face significant difficulties in carrying out their duties effectively and safely.
ARFF Team Leader	Mastery of the High Angle Rescue Technique (HART) is very important, considering the many high altitude areas around us, such as office buildings, towers, terminal buildings, and other facilities that have the risk of accidents from height. If personnel are not equipped with this competency, they will face difficulties in evacuating and assisting in emergency situations. Moreover, in an emergency situation, we must work quickly and precisely as time is of the essence in determining the success of the rescue.
Building Rescue & Fire Fighting Team Leader	Regarding the High Angle Rescue Technique (HART), this is very important. If we look at our work environment, especially at Kualanamu Airport, there are many tall buildings, not only in the terminal, but also in tower buildings such as the control tower (ATC). Therefore, without HART training, we will not be able to provide effective assistance in the event of an emergency, especially in areas that are at high altitude.

Factors Supporting and Restricting HART Mastery

International manuals state that most incidents in high-altitude rescue occur due to equipment failure or lack of regular training and discipline in standard operating procedures [10]. Key barriers include insufficient frequency and intensity of training, limited specialized rescue equipment such as full body harnesses, pulleys, and rescue stretchers, and inadequate personnel skill in rope techniques and knot tying. The interview about inhibiting factor shown in Table 3.

Table 3 Interview questions about the inhibiting factors

Position in the unit	Interview Results
ARFF Chief	The obstacles we face include a lack of adequate training and knowledge, as well as limited specialized equipment such as full body harnesses, pulleys, rescue stretchers, and others. With minimal equipment and insufficiently intensive training, we experienced difficulties in performing rescues in high altitude areas. Therefore, more intensive and continuous training is needed, especially regarding rescue techniques in high altitude terrain as well as mastering the use of rescue equipment proficiently.
ARFF Team Leader	The main obstacles we face in carrying out operations are the lack of routine training and the limitations of specialized equipment, such as full body harnesses, pulley equipment, rescue stretchers, and others. In addition, not all personnel are well versed in knot-making techniques, even though this technique is very important in High Angle Rescue Technique (HART) activities. The current training is still considered inadequate, so intensive training is needed for each personnel, especially those related to rescue techniques in high altitude terrain and mastery of the use of rescue equipment proficiently.
Building Rescue & Fire Fighting Team Leader	The obstacle we faced was the lack of training, which made us less familiar with the equipment, how to use it, and knot-making techniques. In addition, the tools currently available are not sufficient in their entirety, such as the lack of stretchers and pulley equipment. The training we currently undergo is still inadequate because it has not been carried out intensively and specifically. As a result, we still experience limitations in the implementation of our assistance, both in terms of mastery of equipment and a thorough understanding of the material.

Recommendations and Training Needs

Personnel expressed a strong desire for a structured and continuous HART training program supported by adequate facilities and professional collaboration, especially with Vertical Rescue Indonesia (VRI). Recommendations included holding regular drills, increasing equipment availability, and formalizing HART competency requirements as a standard specific to each personnel. Interview about the wishes and expectation of personnel shown in Table 4.

Table 4 Interview questions about the wishes and expectations of personnel

Position in the unit	Interview Results
ARFF Chief	We hope that HART training can be carried out regularly and structured. In addition, there is a need for additional HART support facilities at the airport to be more complete and adequate. We also propose to increase cooperation with professional organizations engaged in improving HART competencies. For example, the cooperation that has been carried out with Vertical Rescue Indonesia is very useful, but due to limited training time, the absorption of HART competencies is still not optimal. We also hope that the mastery of HART competencies can be officially regulated in regulations so that it becomes an obligation for every personnel. This is important to support the safety of victims in high-altitude rescue situations.
ARFF Team Leader	We hope that in the future High Angle Rescue Technique (HART) training can be carried out routinely and structured, meaning that the training is carried out on an ongoing basis and not just seasonally. In addition, additional training facilities that meet the standards are needed, because currently some of the equipment we have is not in accordance with the established standards. We also propose increased cooperation with professional training institutions in the field of vertical rescue, such as Vertical Rescue Indonesia, SAR, and other related institutions.

<i>Building Rescue & Fire Fighting Team Leader</i>	Our suggestions and hopes are that High Angle Rescue Technique (HART) training should be carried out routinely and structured to facilitate the implementation of tasks during emergencies. The training also needs to be supported by adequate facilities, not only in terms of material, but also competent human resources (HR).
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The HART training program should be structured, sustainable, and in line with international standards as recommended in the Australian Emergency Manual [10] and ARFF's benchmarking evaluation in the United States which emphasizes the importance of periodic training and rotation of personnel [11]. The following authors attach a curriculum based on PERMENNAKER Number 09 of 2016 concerning Occupational Safety and Health at Work at Height which can be used as a reference to create a learning syllabus in vertical rescue in the ARFF unit shown in Table 4-6.

Table 4. Labor Curriculum at Altitude Level 1

No.	Training Material	Total (Training Hours)
I BASIC GROUP		
1.	Occupational Safety and Health (OSH) Regulations for Working at Height	2
II CORE GROUP		
1.	Hazard Identification in Rope Access Activities	1
2.	Knowledge of Suspension Intolerance and Its Management	1
3.	Application of Fall Factor Principles in Rope Access	1
4.	Selection, Inspection, and Use of Appropriate Rope Access Equipment	1
5.	Basic Knots and Anchors	2
6.	Rope Maneuvering Techniques	10
7.	Structural Climbing Techniques	3
III SUPPORTING GROUP		
1.	Self-Rescue and Victim Rescue Techniques for Downward Evacuation Using Descending Devices	2
IV EVALUATION		
1.	Theoretical Evaluation	2
2.	Practical Evaluation	5
TOTAL		30

Table 5. Labor Curriculum at Altitude Level 2

No.	Training Material	Total (Training Hours)
I BASIC GROUP		
1.	Basic Occupational Safety and Health (OSH) Principles and Regulations Related to Working at Height	3
II CORE GROUP		
1.	Rope Rescue Techniques for Victims	12
2.	Advanced Anchor Line Systems	10
3.	Advanced Structural Climbing Techniques	2
III SUPPORTING GROUP		
1.	Determination of an "Exclusion Zone" and Protection of Third Parties	1
IV EVALUATION		
1.	Theoretical Evaluation	2
2.	Practical Evaluation	5
TOTAL		35

Table 6 Labor Curriculum at Altitude Level 3

No.	Training Material	Total (Training Hours)
I BASIC GROUP		
1.	Occupational Safety and Health (OSH) Policies and Regulations Related to Working at Height	3
2.	Introduction to the Occupational Safety and Health Management System (SMK3)	1
II CORE GROUP		
1.	Planning and Implementing Rope Access Equipment Management Systems	2
2.	Selection of Appropriate Anchors	2
3.	Selection of Appropriate Methods for Accessing Work Areas	2
4.	Advanced Rope Rescue Techniques for Victims	15
III SUPPORTING GROUP		
1.	Conducting and Implementing Risk Assessments at the Workplace	2
IV EVALUATION		
1.	Theoretical Evaluation	3
2.	Practical Evaluation	5
TOTAL		35

According to the Minister of Manpower Regulation of the Republic of Indonesia Number 9 of 2016 concerning Occupational Safety and Health in Work at Heights, safety requirements are set for workers performing activities at elevated locations. Workers at height are classified into different levels, namely Level 1, Level 2, and Level 3, each with distinct responsibilities related to the use of fall protection equipment and emergency response measures. Level 1 workers primarily assist in anchoring tasks under supervision and are responsible for self-rescue efforts. Specifically, their duties include creating anchors under the guidance of Level 2 or Level 3 workers, and performing self-help actions to ensure personal safety during high-altitude operations.

Level 2 workers hold more advanced responsibilities, including the independent creation of anchors, supervising Level 1 workers during anchoring work, and overseeing their overall safety at height. Additionally, Level 2 personnel are authorized to perform emergency rescue actions for the work team in elevated environments. This supervisory and operational role places Level 2 workers at the frontline for maintaining safe working conditions and ensuring immediate response capability should incidents occur during high-altitude tasks.

Level 3 workers carry the highest level of responsibility and oversight in managing work-at-height safety systems. Their duties involve designing and planning comprehensive safety systems for work at height, conducting internal inspections of anchors, and supervising both Level 1 and Level 2 workers to ensure compliance with safety standards. Moreover, Level 3 personnel are tasked with leading emergency rescue efforts in high-altitude situations, ensuring preparedness and coordination in crisis scenarios.

Given these regulatory requirements, the Airport Rescue and Fire Fighting (ARFF) unit, as the safety and emergency response team at the airport, must possess adequate competencies in work-at-height safety. At minimum, ARFF personnel should hold a Level 2 Work at Height License, focusing on rope access techniques. Regular training and certification in work-at-height safety, aligned with the regulations, should be integrated into ARFF personnel capacity-building programs to ensure effective and safe emergency response operations.

High Angle Rescue Technique (HART) implications

Based on references from [12] Improving the competence of ARFF personnel, in accordance with national standards PR 30 Year 2022, plays a crucial role in ensuring the readiness and effectiveness of airport accident response. These competencies include knowledge, skills, and experience gained through basic education, training, as well as a clear division of tasks according to the results of training. With increased competence, the performance of ARFF personnel will be better, which contributes to

improving flight safety and reducing the risk of accidents. In addition, human resource planning also becomes more structured by ensuring each personnel has the ability according to their duties, so that ARFF operations can run optimally and coordinated.

In particular, increasing the competency of High Angle Rescue Technique (HART) has significant positive implications for the effectiveness of accident management at the airport. Competent personnel will be better prepared to deal with various emergency situations, ranging from administration, preparedness, rescue, prevention, to fire fighting. The division of tasks becomes more focused and efficient according to their respective expertise, so that accident handling becomes faster and more organized. In addition, proper training and certification enable ARFF personnel to optimally identify and control risks, minimize the impact of accidents, and make quick decisions when incidents occur. This increased competency also strengthens the safety culture in the airport environment, having a positive impact on overall flight operations and services, both in prevention, handling, and post-incident recovery.

Potential Impacts of ARFF Personnel Lacking HART Competency

The lack of High Angle Rescue Technique (HART) competency among ARFF personnel can have severe consequences, including delayed evacuation that jeopardizes victim safety by prolonging rescue times and increasing the risk of fatal injuries. Additionally, rescuers themselves face heightened dangers due to improper techniques and inadequate handling of essential equipment such as ropes and harnesses, which can lead to injury. Beyond individual safety concerns, airport operations may also suffer reputational damage as ineffective emergency responses undermine public trust, while non-compliance with critical international aviation safety standards, like ICAO Annex 14, could expose the airport to regulatory violations and operational setbacks.

CONCLUSIONS

This study concludes that the current High Angle Rescue Technique (HART) competency among ARFF personnel at Kualanamu International Airport is inadequate, thereby posing considerable risks to operational safety. To address this deficiency, it is imperative to implement structured and recurring training programs, ensure the availability of comprehensive rescue equipment, and integrate HART procedures into standard operating protocols. The research, however, is limited by its focus on a single airport unit and constrained by time during on-the-job training, which limited repeated field observations. Future studies should expand to multiple airports with varying topographies, develop and assess HART-specific SOPs and national training standards, and explore the incorporation of emerging rescue technologies such as drones and AI-based simulations. Crucially, collaboration with specialized organizations like Vertical Rescue Indonesia is recommended to expedite competency development. By resolving these gaps, ARFF units can significantly improve emergency response effectiveness in high-risk airport environments, ultimately safeguarding lives.

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