

Hardware Conceptual Design of Tsunhan-14 Multimodal Robot Observer in Support of TNI Tasks

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Abstract

The development of technology in the military field has changed from time to time. This dynamic must be taken seriously because they are a challenge, and pose a potential threat to the sovereignty of the Unitary State of the Republic of Indonesia (NKRI), As well as the trend of the technology-based warfare today. So it has become a necessity for the Indonesian National Army (TNI) to accept it. One of the popular technologies today, war robot technology (warbo), and including multimodal robots with a variety of basic missions. Furthermore, developing a multimodal robot concept design that can fulfil TNI surveillance needs. The methodology used is in the form of interview, observations, comparison, and literature studies by applying system engineering theory and life cycle models. This research has successfully formulated user requirement objectives which are then elaborated into robot design concepts including characteristic design, and architecture design of multimodal monitoring robots. The hardware on the robot is design differently from others because it has the ability to fly and walk on the ground. The robot is also conceptualised to have advantages in terms of durability with agility, silence, and operate with various terrain conditions. Equipped with sensors to see, hear, measure ambient temperature, and read surrounding conditions using camera sensors, where the robot moves autonomously equipped with GPS and Lidar can send data in the form of audio visual directly to the Ground Control System (command centre). The concept design of the multimodal monitoring robot called Tsunhan-14 is expected to be the basis for determining technical requirement and further developed into a national innovation that is utilized as part of the TNI's war strategy.

Keywords: *Surveillance, Multimodal, Durability, Agility, Autonomous, Camera, Temperature, GPS, Lidar*

INTRODUCTION

According to the 2015 Indonesian Defence White Paper, national defence is essentially a universal defence effort. Its implementation is based on an awareness of the rights and obligations of all citizens and a belief in one's own strength to defend the survival of an independent and sovereign Indonesian nation and state. Related to the rights and obligations of state defence is also contained in Article 30 paragraph 1 of the 1945 Constitution, which reads: every citizen has the right and obligation to participate in the defence and security of the state. Observing the contents of the regulation above, the effort to defend the nation's sovereignty is a joint task of the nation's components, but specifically this task is the main task of the Indonesian National Army (TNI) where the TNI is placed as the main component of defence equipment specially trained in facing military and non-military threats. Based on Law number 34 of 2004 concerning TNI article 7 paragraph, the main tasks of the TNI are carried out: first military operations for war, second military operations other than war including operations to overcome armed separatist movements, overcome armed rebellions, overcome acts of terrorism, secure border areas, and secure strategic national vital objects.

Regarding military operations, the TNI has a special unit with special operations, one of which is *Special Reconnaissance* where the presence of advanced technology and equipment is needed, because with the help of technology-based defence tools it can help and accelerate the movement of military personnel in controlling and controlling the battle area. *Special Reconnaissance* (SR) monitoring / *reconnaissance* activities, the role of information and intelligence is decisive in the success of the operation. The information related to special

operations (SR) and also part of combat tactics is related to weather conditions, terrain, and enemies (Cumemu). Weather includes information about the state of wind, temperature, humidity, and light. While the terrain is generally related to environmental conditions such as hills, steepness, valleys, rivers, jungles, land contours and so on. Regarding the enemy, the information that needs to be obtained is in the form of its weaknesses and strengths. So that by mastering the overall information about Cumemu monitoring, the chances of success in completing the mission are very large.

To obtain accurate information about Cumemu in military operations (Headquarters Department of the Army, 2011) is not easy if done by military personnel serving as combat intel. The factor of limited physical condition due to the exploitation of enormous energy, draining time to be able to reach the target, limited access to logistics distribution (munitions, medicines, food, etc.), high operational costs, and the risk of casualties if hit by firing targets and captured by the enemy. History records the number of TNI personnel killed in various military operations such as in Aceh to suppress GAM, and finally the ongoing operation to suppress the Papuan separatist rebellion. Of course, it is a factor inhibiting the successful completion of a mission and causing losses to the TNI. By including technological aspects in TNI tasks, these inhibiting factors can be minimized

Nowadays, Science and Technology (Science and Technology) is developing rapidly in various fields of life, including economics, agriculture, health, and defence and security (Hankam). Such as robot technology where robots have the ability to do daily work known as *human robot interaction* (Pitowarna, 2011). For example, robots are involved in military missions such as: Black Hornet robots, MQ-9B Reapers, Snakers, SPUR robots capable of shooting bullets as far as 1.2km with thermal camera sensors that can zoom 30 times (sindonews.com), Big Dog, and Daksh robots. The presence of robot technology for the application of the military field is very helpful for TNI tasks. Examples of case studies related to the role of robot technology in assisting TNI tasks such as interception operations carried out by the Mobile Border Security Task Force of the 411th Infantry Battalion Mechanised Raider TNI Kostrad. Where the TNI can quickly capture logistics couriers for the Papuan Terrorist Separatist Group (KST) led by Egius Kogoya (source: viva.co.id31/10/2023).

As the author has explained about the tasks of the TNI and based on the case study above, it is necessary to conduct research on the conceptual design of robots, in this case the author calls it Tsunhan-14, which is a combination of the word weapons technology with the University of Defence, as well as giving an implicit message that the author is equipped with an educational background in the weapons technology study program. While the number fourteen in the name of the robot symbolises the number of the author's study batch. The application of the *multimodal* concept considers that if the robot can only walk on land, it will be difficult to negotiate extreme terrain conditions such as steep slopes, down valleys, muddy roads, rivers, and other extreme conditions (Eric Sihite, Arash Kalantari, & Alireza K, 2023). Research Nir Meiri and David Zarrouk in 2019 from the Mechanical Engineering Department of Ben Gurion University Negev Izrael. With the title Flying STAR, a Hybrid Crawling and Flying Sprawl Tuned Robot. This research designed a hybrid robot, which can walk on land, and can fly. Where to fly like a regular quadcopter, and walk on the ground at a speed of 2.6m / s. Using a sprawl mechanism to change from flying to crawling. Using a sprawl mechanism to change from flying quadcopter to walking on the ground. It has a total weight of 900 grams, with a width of 37.1cm in flight mode.

Tsunhan-14 robot is *multimodal* in its hardware design can operate in urban areas through tunnel alleys, and climb into high-rise buildings by flying with the concept of *Vertical Take Off Landing* (VTOL) the robot does not need a runway either *take off* or when *landing*. Duration of walking on the ground and flying (*durability*), silent, camouflaged, aesthetics, safety, moving autonomously, and *agility*. As a guideline and comparison in the conceptual design of the

multimodal Tsunhan-14 robot based on previous research, namely the M4 Caltech robot research, Flying Star Zarrouk lab, Syma X9, Balck hornet, DJI Mavic, Smart Surveillance Robot, Surveillance Mobile Robot, SPUR, Flying robot maintenance. IP Camera Surveillance Robot.

RESEARCH METHODS

The method that the author uses in this thesis research is to use a *mixed* method approach. By definition according to Sugiyono (2011) *mixed method* is a research method that combines or combines qualitative methods with quantitative methods to be used together in a research activity. The type of *mixed method is sequential exploratory*, according to Creswell (2010) said that the *sequential exploratory* method in the initial *stage* is to collect and analyse qualitative data and then collect and analyse quantitative data. So that it can produce a concept in the form of an engineering system. Qualitative methods are used to obtain *user requirement* design data based on operating system *requirements*. The quantitative stage is used to formulate the results of *user requirements* in a conceptual design of the Tsunhan-14 *multimodal* robot hardware.

RESULT AND DISCUSSION

By knowing the data about user needs in this case the TNI, through the interview method, as a supporting instrument using a questionnaire, from 14 populations the researcher took a sample of 8. As secondary data in the form of documents on the Decree of the Head of the Army Research and Development Service (Dislitbangad) regarding the requirements of the type of monitoring robot number 58/III/2011. As for the concept design of the surveillance robot, it is a reference for the author to formulate the robot concept design. So that the expectations of the user can be achieved with the design results. To see the level of importance of the needs, the authors processed primary data from the results of *the* questionnaire as outlined in the *List of Requirement*) LOR) as follows:

Table 1. List Of Requirement

No	User Requirement	Urgency	Instrument
1	<i>Durability</i>	5	Motors, battery, fixedwing + quadcopter combination
2	<i>endurance</i> ≥ 60 menit	5	battery
3	Stable in use	4	wing + propeller+whell
4	Smooth communication between robot and operator (<i>Ground Control Station</i>)	5	telemetry
5	<i>agile on land and in the air (agility)</i>	4	whell, Propeller, control system
6	Secret movement	4	ANC & PNC
7	Detection capabilities	4	Sensors

8	has system autopilot capabilities	4	Sensors telemetry
9	Applying system VTOL	4	Quadcopter

Source: Author, 2024 questionnaire results

Description:

Value 1: not important Score 2: less important

Score 3: moderately important

Score 4: high importance

Score 5: very high importance

Based on data analysis in Table.1 List Of Requirement (LOR) table that the level of user requirements can be explained. Based on the results of *user requirements*, the *importance rating* (level of importance) is analysed with nine *lists of* user requirements. Where the results of data analysis obtained from sources and for reinforcement are supported by instruments in the form of questionnaires from fourteen populations taken nine samples to represent. With the results of data processing that there is a very high level of importance with a value of 5, namely having *durability* against environmental conditions, duration of operation (*endurance*) ≥ 60 minutes, and smooth communication between the robot and the operator (GCS). For a high level of importance worth 4 consists of: stable in operation, movement on land and air *agility*, silent movement, detection capabilities, having an *autopilot system*, and implementing a VTOL system.

Characteristic Design

In principle, robots have basic characteristics, so that they become differentiated from other objects (Suprianto, 2015). So in this study, the author determines the character design based on the needs of the user. As listed in table 1. The character design consists of: power supply, seeing objects from a certain distance (seeker), moving land and air, weather detection, light detection, low *noise*, able to adapt to urban, hilly mountain, and forest environments, operational intelligence (programming) / ROS, *waterproof*, *processing device*, and *receiver device*.

Table 2 User requirements and design characteristics

No	User Requirement	No	Characteristic Design
1	durability	1	Power supply
2	<i>Endurance</i> ≥ 60 minute	2	seeker
3	Stable in use	3	Stable ground and air movement
4	Smooth communication between robot and operator (<i>Ground Control Station</i>)	4	Weather detection
5	<i>agile on land and in the air (agility)</i>	5	light detection
6	Secret movement	6	Walks nimbly on land and flies in the air
7	has system autopilot capabilities	7	low noise
8	Applying system VTOL	8	Able to adapt to urban environments, hilly mountains and forests

9	Detection capabilities	9	robot operational system (ROS)
		10	waterproof
		11	Processing device
		12	Receiver device

By obtaining data on the level of importance of *user requirements* as user needs. Furthermore, researchers need to analyse the level of relationship between user requirements in terms of *importance rating*. With characteristic design, using the *Quality Function Deployment (QFD)* method so that engineering targets and *benchmark performance (BP)* can be known.

$$BP = \sum_{category\ 1}^{category\ 9} (importance\ rating \times relation\ value) \quad (1)$$

Table 3. Relation importance rating with method characteristics
Quality Function Deployment

No.	Customer Requirement	importance Rating 1-5	Characteristic Design									
			Power supply	seeker	Weather detection	light detection	Robot Operational System (ROS)	Transmitter device	Processing Device	low noise	waterproof	receiver device
1	durability	5	9	3	3	1	1	3	3	3	9	3
2	Endurance ≥ 60 minute	5	9	3	3	3	3	3	3	1	3	1
3	Stable in use	4	9	3	1	1	1	1	1	1	1	1
4	Smooth communication between robot and operator (Ground Control Station)	5	1	1	1	3	9	9	9	3	3	9
5	agile on land and in the air (agility)	4	9	9	3	3	9	3	3	1	1	1
6	Secret movement	4	3	3	3	3	9	3	9	9	3	9
7	Detection capabilities	4	3	9	9	9	9	3	9	1	1	3
8	has system autopilot capabilities	4	3	3	3	3	9	9	9	3	1	3
9	Applying system VTOL	4	9	1	1	1	9	9	3	3	3	9
engineering targets (n)			239	147	115	115	249	187	211	107	115	169
Benchmark Performance % (n/351)			68,09%	41,88%	32,76%	32,76%	70,94%	53,27%	66,11%	30,48%	32,76%	48,14%
information: priority scale			2	6	7	9	1	4	3	10	8	5

- a. Value 0 : No relationship
 - b. Grade 1 : Weak Relationship
 - c. Grade 3 : Medium Relationship
 - d. Value 9 : High rapport
- Source : Franceschini, 2002

Based on table 3, it can be seen the engineering target, benchmark performance and priority scale in the conceptual design of multimodal robots.

Architectural Design

In the design of the monitoring robot hardware concept, one of them is related to the concept of architecture born from the basic idea of the author after conducting research on user needs. Architectural design part of the concept of technical specifications includes the concept of energy supply sourced from batteries, seekers, weather detection, light detection, low noise,

waterproof, robot operational system (ROS), agile movement, processing device, receiver device. Environment adaptability

CONCLUSION

By looking at the level of relationship between *user requirements* as part of the needs with design characteristics. The author analyses using the *Quality Fuction Deployment (QFD)* method so that from table 4.5 the *benchmark* performance can be known. With a percentage value for the Robot Operating System (ROS) of 70.94% as the first priority scale, power supply (power supply) 68.09% as the second priority scale, *Processing Device* of 66.11% third priority scale, adaptability of 53.27% fourth priority scale, receiver device of 48.14% fifth priority scale, ability to see 41.88% seventh priority scale, waterproof 32.76% eighth priority scale, light detection of 32.76% ninth priority scale, and low *noise* 30.48% tenth priority scale on the concept design made.

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