Journal of Mechatronics, Electrical Power, and Vehicular Technology 12 (2021) 87-94

Journal of Mechatronics, Electrical Power, and Vehicular Technology

CrossMark

e-ISSN: 2088-6985
p-ISSN: 2087-3379

MEV

mev.lipi.go.id

Domestic component level analysis for multipurpose autonomous robot

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Received 27 August 2021; Accepted 22 October 2021; Published online 31 December 2021

Abstract

Multipurpose autonomous robot technology has been developed to assist transportation sectors or the current emergency as the Covid-19 pandemic. A practical issue in the robotic industry concerns the domestic content in commodities, services, and a combination of goods and services commonly determined as domestic component level (DCL). To be considered a standardized national product, a product's DCL must surpass a certain level of local content composition. This research aims to investigate the DCL of a developed multipurpose autonomous robot in Indonesia called ROM20. The research was initiated by interviewing specialists in DCL calculation and robotics research to perform DCL analysis on ROM20. The next step was breaking down the ROM20 components into a second layer component, in which the amount of domestic component and overseas components can be derived. Finally, the ROM20 DCL value was calculated by dividing the cost of domestic components by the total cost of domestic and overseas components. As a digital product, the ROM20 DCL calculation result showed that the manufacturing aspect is 70 %, and the development aspect is 30 %. The overall ROM20 DCL value has been calculated as 52.23 %, which surpasses the national standard threshold at 40 % DCL value. Therefore, ROM20 can be considered a high-value standardized national product, impacting the competitiveness of local products and the fast-growing medical device industry in Indonesia.

Keywords: domestic component level; modular system; multipurpose autonomous robot; ROM20.

I. Introduction

Indonesian government is determined to encourage optimization on the domestic component level (DCL) to increase the productivity and competitiveness of the national industry during world trade conditions that tend to be closed. DCL is the amount of content originating from within the country, particularly Indonesia, in goods, services, and combinations of both. The benefits of implementing DCL are creating new employment opportunities, adding income tax for products made in Indonesia, creating a supply chain with a good ecosystem, and creating equality between local and international brand players.

Each country will protect the results of its technological products from increasing the value of profits as a source of state income. On the other hand, the number of imported products will undoubtedly increase the dependence on other countries. Thus, protecting domestic products is such a nationalist act in Asia and Africa [1][2]. Moreover, nearly 90 % of countries with abundant natural resources have local content policies and requirements [3][4][5]. Therefore, local content policies in various countries will increase employment growth, incubation, upstream industry development, and sustainable economic growth towards higher levels of welfare [6][7][8]. In

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doi: https://dx.doi.org/10.14203/j.mev.2021.v12.87-94
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addition, the local content policy will also increase the superior human resources in the said country [9][10].

Indonesian domestic products continue to be developed to reduce the value of imported components. Domestic components used raw materials, design, and engineering that contain manufacturing, fabrication, assembly, and completion of work originating from and implementing in the country. The domestic component of services is using services up to the end of the workforce by utilizing manpower including experts, work tools including software, and supporting facilities originating from and implementing in the country. Determination of domestic components based on the following criteria 1) direct materials were based on their country of origin, 2) work tools/work facilities were based on their ownership and country of origin, and 3) workers were based on their nationality.

Several studies have been made on the calculation of DCL for Indonesian domestic products, as stated by Febijanto *et al.* [11], assessed the DCL of the salt industry. Increasing NaCl content was analyzed on a cost basis, while it is evaluated on a process basis for salt production. The analysis was carried out at the Indonesian salt center in two stages: pilot project and implementation. Other studies on domestic product DCL are also carried out on the planning and development of Geothermal Power Plants/PLTP [12], Biogas Power Plants/PLTBg [13], and the national shipping industry [14].

Robotic technology is not only in the industrial sector but also in daily life. Robotic technology has evolved so that robots can now have cognitive, manipulation, and interaction abilities. Electric vehicles or autonomous vehicles are an example of the development of robotic technology and autonomous systems.

Indonesia is still lagging behind other countries in robotic technology or autonomous vehicles. However, to support technological developments and take sides with domestic products, the government issued a policy that has been regulated in Presidential Regulation No. 55 of 2019 concerning the Acceleration of the Battery Electric Vehicle Program for Road Transportation [15]. The government hopes that the transportation in the new capital will use autonomous vehicles. ROM20 is one of the products that implement robotic technology and can also be called an unmanned vehicle because it can move independently.

Autonomous technology based on SAE International has six levels of self-mobility [16]. In Figure 1 [17], levels 0 and 1 do not have autonomous technology, where driver assistance has a significant role. While level 2 autonomous technology can move on its own, although partially, meaning that the car can run on its own while the driver still has to be ready if the vehicle faces certain road conditions. Level 3 autonomous technology described where the driver can let the car run alone and does not need to pay attention to road conditions. Level 4 autonomous technology, the driver, is much freer to let the car run independently. The last is level 5 autonomous technology, and the driver has the same ability at level 4. The difference is that there are no specific location restrictions and no intervention from the driver.

In December 2019, there was a Coronavirus Disease 19 (Covid-19) outbreak in Wuhan, China. And WHO declared it a global pandemic on March 11, 2020. The virus that causes Covid-19 is severe acute respiratory syndrome 2 (SARS-CoV-2) [18]. Coronavirus is a single-stranded RNA (ribonucleic acid) virus protected by a nucleocapsid protein [19]. The structure of the Coronavirus is composed of spike proteins and is surrounded by a membrane and glycoproteins. This spike protein is one of the main antigens and plays a role in attaching and entering viruses into the host (interaction of spike proteins with host cell receptors). Thus, this virus attacks the respiratory system. For mild cases, the symptoms are just like the flu. But there are some more severe cases such as pneumonia, Middle-East Respiratory Syndrome (MERS), Severe Acute Respiratory Syndrome (SARS), and even death. The spread of Covid-19 through droplets coughing or

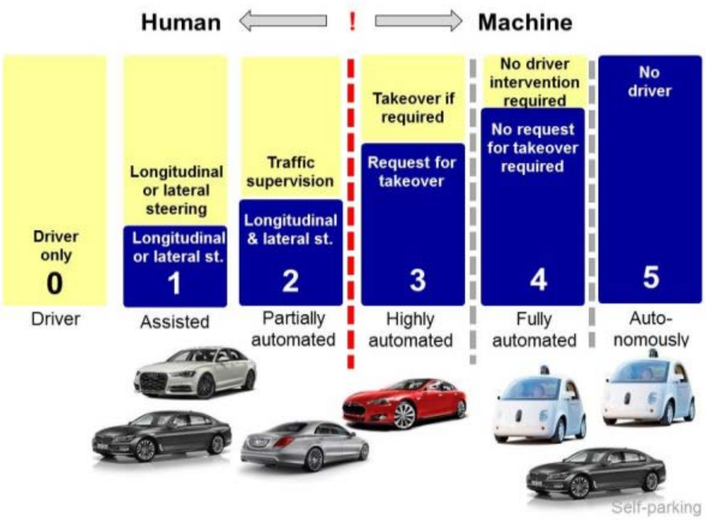

Figure 1. Level of autonomous driving [17]

sneezing with Covid-19 sufferers then spreads into the air and lands on surrounding objects. If a healthy person inhales air or touches an object affected by the droplet, then his hand accidentally touches his nose or mouth, the healthy person will be infected with Covid-19. Due to its massive spread, many Covid-19 patients with moderate and severe symptoms need to be hospitalized. Therefore, robots that can operate autonomously are required to assist and protect health workers from being infected with Covid-19 [20]. Several developed assisting robots such are disinfection robots using UVC, robots that spray disinfection liquids, and robots that deliver and warm food for Covid-19 patients.

UVC light with a 200 to 280 nm wavelength can inactivate various pathogens, including the SARS-CoV virus. Based on the research results Basin *et al.*, UVC with a wavelength of 254 nm can efficiently inactivate SARS-CoV-2 at a dose of 3.7 mJ/cm^2 without any signs of viral replication [21]. In addition to the UVC wavelength as given by David Welch *et al.* [22], the use of far-UVC with a wavelength of 207 to 222 nm can inactivate pathogens (H1N1 influenza virus) > 95 % present in aerosols at a very low dose of 2 mJ/m^2. This far-UVC wavelength is also safer because it is not carcinogenic. Furthermore, this light cannot penetrate the skin of mammals but can penetrate pathogens whose dimensions are microscopic and inactivate them [23]. Therefore, far-UVC 222 nm is a safe alternative to replace conventional UVC with a wavelength of 254 nm.

During the current pandemic, cleaning and disinfection steps are critical to reducing the spread of pathogens. These pathogens often stick in hidden places and are touched by many people, such as doorknobs, elevator buttons, electric buttons, etc. [24]. Based on several research results, disinfection of object surfaces with disinfectant spray using hydrochloride and hydrogen peroxide vapor has a significant impact on controlling the spread of pathogens [25][26]. Another research on sprayer robots by George Adamides *et al.* [27] discusses spraying robots controlled remotely through a reality-based interaction interface.

Another thing that needs to be considered during a pandemic is to reduce physical human interaction so that robots can assist in delivering goods and food. Calderon *et al.* [28] have researched health services by increasing the productivity of logistics activities in hospitals using a mobile robot platform. Putri *et al.* [29] have conducted research using a DHT22 temperature sensor and fuzzy logic algorithm to control food's warmth automatically to keep the food warm. Lucas Grasse *et al.* [30] have researched food delivery robots using voice recognition, mapping and navigation methods, and a depth camera to move according to predetermined coordinate points.

ROM20 is a multipurpose autonomous robot produced by the Indonesian Institute of Science (LIPI), as a researcher's contribution in dealing with the Covid-19 outbreak. This paper discusses the DCL calculation of ROM20 and briefly describes ROM20 technology, ROM20 components, and DCL calculation. In addition, several related regulations regarding DCL analysis are also discussed in this paper.

II. Methods

The method used in this study is as shown in Figure 2, where the data used is secondary data. The data were obtained from government regulations, journals, and proceedings concerning DCL, autonomous robot development, and medical robots. In addition to the literature review, the data were also combined with the interviews with specialists in management and calculation, notable consultants from Surveyor Indonesia and researchers from the Research Centre for Electrical Power and Mechatronics, who built a prototype of the multipurpose autonomous robot (ROM20).

In this study, the DCL of the multipurpose autonomous robot (ROM20) has been calculated so that the component data obtained from the researchers are then derived and analyzed. Equation (1) [11] were used to perform the DCL calculation.

$$\% \, DCL = \frac{DC \ cost}{DC \ cost + OC \ cost} \ x \ 100 \ \% \qquad (1)$$

Domestic components (DC) are goods/services produced domestically, and overseas components (OC) are goods/services manufactured abroad. Therefore, using equation (1), the percentage of DCL ROM20 can be determined.

The process to calculate DCL is shown in Figure 3. The first thing that needs to be done is breaking down all components for each subsystem and then

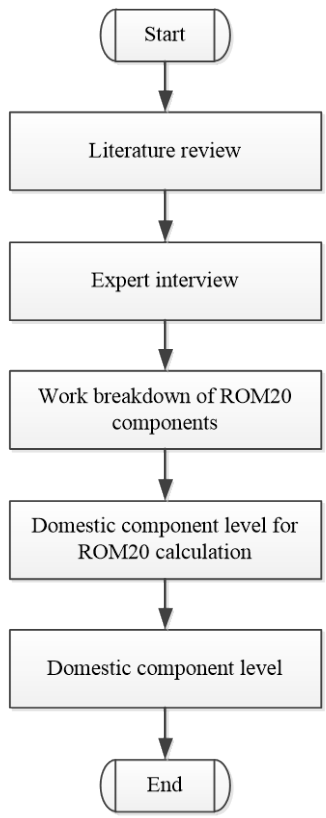

Figure 2. Research methodology flowchart

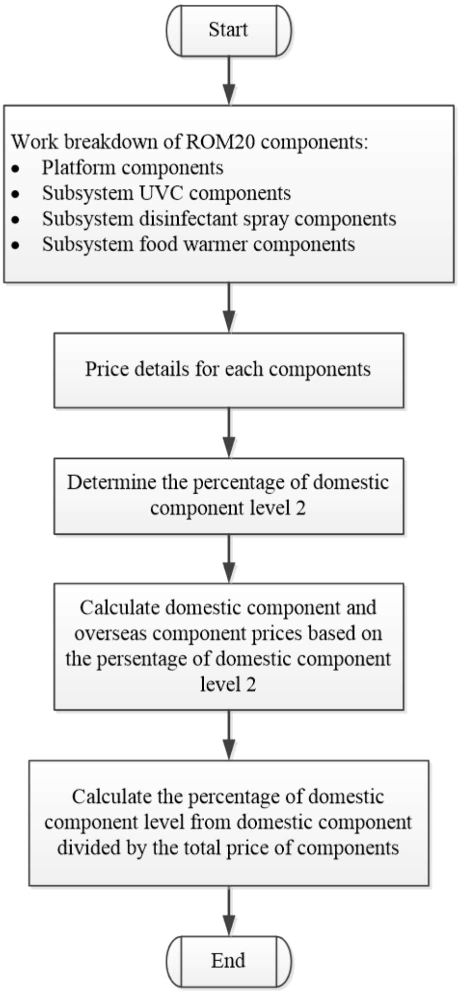

Figure 3. DCL calculation flowchart

set a price for each component. If ROM20 is the first layer, its components are the second layer. The next step is to determine the percentage for each component's second DCL layer (DCL 2) that make up ROM20. Each component in DCL 2 must be verified by referring to the domestic goods and services inventory book issued by the Indonesian Ministry of Industry. For example, one of the mechanical components on the platform is a metal produced by Krakatau Steel, an Indonesian steel factory. It means that this product is domestically produced to determine the DCL 2 weight of 60 %. At the same time, the determination for components made abroad has a DCL 2 weight of 0 %.

After determining the percentage of DCL 2 for each component, the cost of the domestic and foreign components can be calculated. Henceforth, the calculation of DCL for ROM20 refers to equation (1). The fundamental difference between this paper and the previous one is that this one will break down all of the ROM20 second layer. Furthermore, because the ROM20 is a digital product, the DCL calculation is split into 70 % manufacturing and 30 % development.

III. Results and Discussions

Multipurpose autonomous robot (ROM20) consists of three modular subsystems that can be removed as needed, where this modular subsystem is placed on a mobile robot platform. Figure 4 shows the modular concept of the mobile robot platform (A), if the platform is combined with a UVC lamp modular (B), it will become a UV robot subsystem (RUV). Furthermore, if combined with a disinfectant spraying modular (C), it will become a disinfectant spraying robot subsystem (RPC). Finally, when combined with a food warmer modular (D), it will become a food warmer robot (RPM) [31].

The mobile robot platform consists of a frame, motor, wheels connected to the driver, and the driver is connected to the control panel. The platform frame is closed with the body and chassis, and clamps are attached to the body to

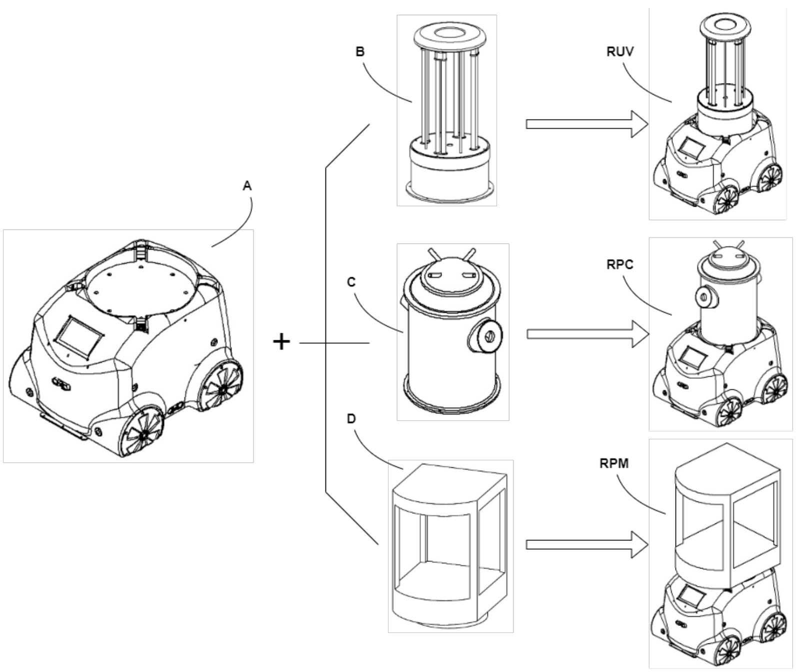

Figure 4. Modular concept of ROM20 [31]

(a) (b) (c)

Figure 5. ROM20 Prototype [32]: (a) UVC robot; (b) disinfectant spray robot; and (c) food warmer robot

correctly/precisely attach the modular subsystem. This robot is equipped with multi-directional wheels that can move freely, namely back and forth, or even move sideways. In addition, ultrasonic/infrared sensors are installed on this robot to detect existing obstacles to anticipate movements when working in autonomous mode when performing tasks indoors. Figure 5 shows the ROM20 prototype where each subsystem is installed on the mobile platform [32]. ROM20 moves automatically but can be controlled using a gadget with the line follower route stored in the system and can also facilitate communication using Bluetooth and wifi with a maximum distance of 20 meters.

A. UVC subsystem

In the UVC subsystem, a UV lamp with a wavelength between 200 to 280 nm is installed, functioning as inactivation of pathogens. Four pieces of UVC lamps are installed in a circle with a 360-degree range that can illuminate the entire room to the maximum. Each lamp can be turned on or off separately through the application on the gadget, and the lights will automatically turn off if there is a movement of living things in the room detected.

B. Disinfectant spray subsystem

The disinfectant spray subsystem is equipped with a tube to store the disinfectant liquid, a mist maker that creates mist from the disinfectant liquid, a blower to push the mist, and six nozzles to spray mist. These nozzles can rotate continuously so that the disinfectant liquid spreads evenly throughout the entire room. In addition, there is an indicator of the height of the disinfectant. So that the volume of disinfectant in the tube will always be monitored, the indicator will activate an alarm when the disinfectant level has reached the minimum level.

C. Food warmer subsystem

In the food warmer subsystem, a compartment is equipped with a heating panel and a temperature sensor to regulate the temperature and humidity. The maximum temperature that can be set through the application on the gadget is 60 °C.

D. DCL calculation for ROM20

According to Figure 3, various procedures are required to calculate ROM20 DCL, including breaking down all component subsystems as given in Table 1.

Table 1.
ROM20 components

Items	Items	Items	Items
Platform	- ADS1115	- Lamp socket terminal	Food warmer subsystem
- Mechanic	- Stepdown 24 VDC to 5 VDC	- UV socket	- Microcontroller
- Mecanum wheel	- Stepdown 48 VDC to 24 VDC	Disinfectant spray subsystem	- Stepdown 24 VDC to 5 VDC
- Motor	- Holder fuse blade	- Microcontroller	- Inverter 24 VDC to 220 VAC
- Stepper driver	- Fuse blade 5 A & 20 A	- Relay 5 VDC 1 channel	- Relay module 30 A
- Battery	- Emergency stop	- Stepdown 24 VDC to 5 VDC	- Fuse blade holder
- Body	- Heat shrink tube	- StepUp 24 VDC to 36 VDC	- Fuse blade
- Microcontroller	- Key switch	- Relay module 30 A	- Showcase food warmer
- Mosfet IRF520	- Accessories	- Mist maker 6 holes	- 7 Segment LED tube display
- IR sensor	UVC subsystem	- Cooling fan 12 cm	- Heating element 24 VDC
- Current & voltage sensor	- Microcontroller	- Cooling fan 8 cm	- Temperature & humidity sensor
- Ultrasonic sensor	- Relay 8 channel solid state	- Power socket	- Indicator lamp 24 VDC
- ESP32-CAM	- Stepdown 24 to 5 VDC	- Mist socket	
- Bluetooth HC-05	- Inverter 24 to 220 VAC	- Pot	
- LCD USART 5 inch	- UV sterilizer lamp		

Furthermore, Tables 2 to 5 determine the second layer on the components of the subsystem and the magnitude of the weight of domestic and overseas components. Therefore, the amount of DCL will be completely determined after this phase.

Equation (1) was used as a guide to emphasize DCL calculations, which is more focused on manufacturing, the country of origin of the components used, and the workers' origins. Furthermore, because ROM20 is a digital product, the DCL calculation is split into two halves, with the manufacturing aspect weight being 70 % and the development aspect being 30 %.

Table 2 shows the weight of the DC and OC for each component in the platform section. The inventory book of goods and services of domestic production issued by the Indonesian Ministry of Industry can be referred to determine the weights of DC and OC. The mechanical component consists of several components, one of which is metal. This metal raw material is produced by Krakatau Steel, a state-owned company that is domestically produced. Because metal is one of the components that make up the mechanic component, the weight for DC is 60 %, and the weight for OC is 40 %. Resin is one of the body-forming materials for body components. Again, this material is produced domestically, so the body components are given a DC weight of 60 % and 40 % OC. For components manufactured abroad, the weight for DC is 0 %, and OC is 100 %.

Table 3 shows the weight of DC and OC for the components of the UVC subsystem. The weight for DC is shown 0 %, and OC is 100 % because all components in the subsystem were foreign production. In addition to Table 4, most of the components that make up the disinfectant spray subsystem are foreign products, so the DC weight is 0 %, and the OC is 100 %. On the other hand, domestic production is only on pot components, so that the weight of DC is 60 % and OC is 40 %. Table 5 shows all components of the food warmer subsystem which use the foreign product so that the DC weight is 0 % and the OC is 100 %.

Table 6 shows the result of the DCL calculation for each subsystem, where the cost of the domestic component is divided by the total cost of the domestic and overseas components. The DCL value for these subsystems is 0 % because all UVC and food warmer subsystems components are imported from abroad. However, even though the DCL is 0 %, to calculate the total DCL value, there is still the overseas component (Y_2 and Y_4) cost from the UVC and food warmer subsystems as the divisor value. Therefore, the total DCL is increasing. Overall, the DCL value of ROM20 is 31.76 %.

Table 2.
DCL 2 weight of ROM20 platform

Items	Domestic component	Overseas component
Mechanic	60 %	40 %
Mecanum wheel	0 %	100 %
Motor	0 %	100 %
Stepper driver	0 %	100 %
Battery	0 %	100 %
Body	60 %	40 %
Microcontroller	0 %	100 %
Mosfet IRF520	0 %	100 %
IR sensor	0 %	100 %
Current & voltage sensor	0 %	100 %
Ultrasonic sensor	0 %	100 %
ESP32-CAM	0 %	100 %
Bluetooth HC-05	0 %	100 %
LCD USART 5 inch	0 %	100 %
ADS1115	0 %	100 %
Stepdown 24 V to 5 V	0 %	100 %
Stepdown 48 V to 24 V	0 %	100 %
Holder fuse blade	0 %	100 %
Fuse blade 5 A & 20 A	0 %	100 %
Emergency stop	0 %	100 %
Heat shrink tube	0 %	100 %
Key switch	0 %	100 %
Accessories	70 %	30%

Table 3.
DCL 2 weight of UVC subsystem

Items	Domestic component	Overseas component
Microcontroller	0 %	100 %
Relay 8 channel solid state	0 %	100 %
Stepdown 24 to 5 V	0 %	100 %
Inverter 24 to 220 VAC	0 %	100 %
UV sterilizer lamp	0 %	100 %
Lamp socket terminal	0 %	100 %
UV socket	0 %	100 %

Table 4.
DCL 2 weight of disinfectant spray subsystem

Items	Domestic component	Overseas component
Microcontroller	0 %	100 %
Relay 5 V 1 channel	0 %	100 %
Stepdown 24 V to 5 V	0 %	100 %
StepUp 24 V to 36 V	0 %	100 %
Relay module 30 A	0 %	100 %
Mist maker 6 holes	0 %	100 %
Cooling fan 12 cm	0 %	100 %
Cooling fan 8 cm	0 %	100 %
Power socket	0 %	100 %
Mist socket	0 %	100 %
Pot	60 %	40 %

Table 5.
DCL 2 weight of food warmer subsystem

Items	Domestic component	Overseas component
Microcontroller	0 %	100 %
Stepdown 24 V to 5 V	0 %	100 %
Inverter 24 VDC to 220 VAC	0 %	100 %
Relay module 30 A	0 %	100 %
Fuse blade holder	0 %	100 %
Fuse blade	0 %	100 %
Showcase food warmer	0 %	100 %
7 Segment LED tube display	0 %	100 %
Heating element 24 V	0 %	100 %
Temperature & humidity sensor	0 %	100 %
Indicator lamp 24 V	0 %	100 %

Table 6.
Domestic component level for each section

Section	Domestic component cost	Overseas component cost	Domestic component level (DCL)
(1)	(2)	(3)	(4) = (2)/((2)+(3))
Platform	X_1	Y_1	34.26 %
UVC subsystem	0	Y_2	0 %
Disinfectant spray subsystem	X_3	Y_3	1.50 %
Food warmer subsystem	0	Y_4	0 %
Total	X_1+X_3	Y_1+Y_2+Y_3+Y_4	31.76 %

Table 7.
DCL calculation refers to digital product

Aspect	ROM20 DCL	Digital product determination value	Domestic component level (DCL)
(1)	(2)	(3)	(4)= (2)x(3)
Manufacturing	31.76 %	70%	22.23%
Development	100%	30%	30.00%
Total ROM20 DCL			52.23%

Based on Regulation of Industrial Ministry No. 22, 2020 [33], ROM20 is categorized as a digital product because its primary function is to process binary numbers. The product's characteristics have new technology and a microcontroller to process input. This digital product's manufacturing aspect is 70 % and 30 % for the development aspect.

The manufacturing DCL of ROM20 is found to be 31.76 % based on the calculation using equation (1). Because ROM20 is included in the digital product category, the DCL weight for the manufacturing aspect is 70 %, so the ROM20 DCL for the manufacturing aspect is 22.23 %. On the other hand, the DCL weight for the development aspect is 30 %, so the total ROM20 DCL is 52.23 %. More details of the calculation result can be seen in Table 7.

The DCL with a development aspect of 30 % requires research and development documents in Bahasa. This documents aims to make the workforce in the research and development division able to create or to make a modification based on the research and development documents that have been made. The research documents include research blueprints, SOPs/activity manuals, designs (products, mechanics, mock-ups), user interface development, source code and compilers, and patents.

A product can become a national product, and the condition is that the DCL is at least 40 %. Based on the Strategic Plan of the Ministry of Industry for 2020 - 2024, to improve the ability of domestic industries with performance indicators, the target of DCL in 2020 should be 49 % and will continue to increase until 2024 by 53 % [34]. Therefore, ROM20 qualifies as a national product because its DCL exceeds the minimum required limit of 40 %.

The analysis of ROM20 DCL shows that the cost-based analysis was very dependent on the origin of the equipment components. It follows what was stated by Febijanto *et al.* [11]. In comparison, process-based analysis depends on the origin of the workforce, work tools, and material owners. For example, suppose the DCL value of an industry is to be high. The raw materials must be produced domestically as much as possible with the labor and work equipment belonging to the domestic industry.

Increasing the DCL value of ROM20 is very important because it will affect the costs associated with the production and competitiveness of the ROM20 product. Based on the results of previous studies, it is known that there is a relationship between the value of DCL with a reduction in overhead costs, investment, and operational costs [12][13]. Furthermore, increasing the value of DCL in the national industry will increase competitiveness against production from abroad [14]. Efforts to increase this value also help influence the domestic multipurpose autonomous robot industry and grow new businesses to reduce component costs and overhead.

IV. Conclusion

ROM20 is a researcher's contribution to combating the Covid-19 epidemic with three functions: UV robot, disinfectant spraying robot, and food warming robot. All of the components in ROM20 were derived to determine their percentage weight on the second layer, allowing the DCL value to be calculated from the breakdown results. Therefore, ROM20 is included in the digital product category. DCL calculation for a digital product consists of two aspects: the manufacturing aspect with a weight of 70 % and the development aspect with a weight of 30 %. Based on the calculation results, the total ROM20 DCL is 52.23 %. Therefore, ROM20 can be considered a national product because its DCL value surpasses the minimum DCL value at 40 %. Consequently, it impacts the competitiveness against overseas products and induces the expansion of the national medical device sector.

Acknowledgment

The authors would like to thank Mr. Hendri Maja Saputra, Mr. Catur Hilman Adritya H. B. Baskoro, and Mr. Midriem Mirdanies for providing ROM20 data. In addition, the authors would also like to gratitude Mr.

Sarjuni at Surveyor Indonesia for the consult and supervision on calculating ROM20 DCL.

Declarations

Author contribution

V. Susanti is the main contributor of this paper. All authors read and approved the final paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare no conflict of interest.

Additional information

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