

## CHAPTER 5 – CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions based on the results of this thesis and recommendations for further development and implementation.

### 5.1 Conclusions

This thesis presents a solution to handle the material handling challenges at PT Sat Nusapersada Tbk Batam through focusing on mechanical structural validation, scissor lifting mechanism, and investigating the effects of each navigational component. While the procurement constraints and lead time prevented physical fabrication of the proposed design within the thesis period, the simulation-based validation and experiments conducted on the existing hardware resulted in the following conclusions.

The proposed AMR chassis fully calculated in CAD with hollow steel square frame achieved a FoS of 4.60 and structural stiffness of 5350.9 N/mm under a 120kg static load, approximately 9.7 times stiffer than the base plate alone. The top lifter achieved a FoS of 7.55 and scissor lift achieved a FoS of 1.55 for minimum angle. Therefore, the mechanical design is accepted within the 1.5-2.0 FoS range, accepting H1.

Physical measurement of the scaled-down scissor lift implementation demonstrated an average positioning error of 1.74% or 0.73mm under 75kg load, but the moving shaft did start to bend due to overloading 75kg at the minimum angle as seen in Figure 4.25, which means that the maximum load of this scissor lift is 70kg, this experiment resulted in rejecting H2.

The investigation of each of the navigational component were done with the existing hardware, but with the configuration of the proposed design, in this case the use of dual LiDAR. The full fusion navigation configuration achieved an average physical positional error of 3.16cm. Paired sample t-tests confirmed that without encoder produced the worst degradation with an average positional error of 20.46cm, followed

by without LiDAR with an average positional error of 9.15cm. However, without IMU, the configuration did not produce a significant change, partially accepting H3.

## 5.2 Recommendations

In order to further develop this system, the following recommendations are proposed:

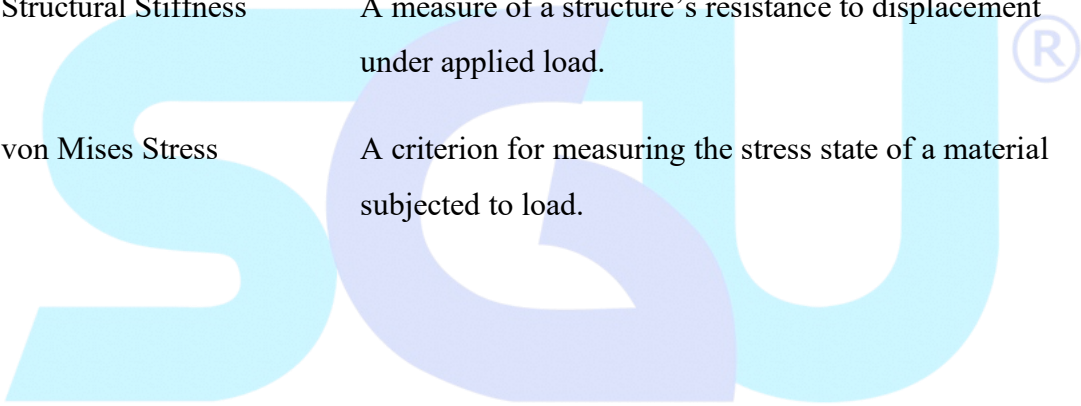
- Physical fabrication of the AMR design should be done once procured components arrived to do physical validation of the FEA results.
- The scissor lift moving shaft should be reinforced with additional support to eliminate the bending and the design at should be modified to achieve FoS 2.0 at minimum angle.
- Even though the IMU's contribution is not significant under the tested conditions, it should still be kept in the system as it may be helpful in unpredictable and/or uneven surface conditions. Further tests with those conditions could also be done to validate and investigate the significance of IMU.
- Further testing in the actual production area using the mapping capabilities and GMCL localization developed in this thesis could be done.

## GLOSSARY

| Terms                           | Description                                                                                                                                            |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Automated Guided Vehicle (AGV)  | A transport vehicle that navigates along pre-determined paths using magnetic tape or inductive wiring without independent navigational decisions.      |
| Autonomous Mobile Robot (AMR)   | A mobile robot capable of navigating itself in dynamic environments using sensors and computational intelligence.                                      |
| Chassis                         | The structural frame that supports mechanical and electrical components and holds the payload during operation.                                        |
| Differential Drive              | A configuration using two independent driven wheels on either side of the vehicle, where steering is done by varying the speed of each wheel.          |
| Extended Kalman Filter (EKF)    | A state estimation algorithm used to fuse sensor data to produce a continuous pose estimation.                                                         |
| Factor of Safety (FoS)          | A dimensionless ratio of material's yield strength to the maximum stress experienced, quantifying the safety margin.                                   |
| GMapping                        | A particle filter SLAM algorithm used in ROS Noetic to generate grid map from LiDAR scan data.                                                         |
| Inertial Measurement Unit (IMU) | An electronic sensor component that measures force, angular rate, and orientation through accelerometers, gyroscopes, and conditionally magnetometers. |

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|                                     |                                                                                                                                    |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| LiDAR (Light Detection and Ranging) | An electronic sensor that uses laser light to measure distances to surrounding object.                                             |
| Odometry                            | Use of data from motion sensors to estimate a change in position and orientation over time.                                        |
| Paired Sample t-Test                | A statistical test used to determine whether the average difference between two sets of measurements is statistically significant. |
| Robot Operating System (ROS)        | An open-source middleware framework used to write, manage, and execute complex robotic software.                                   |
| Structural Stiffness                | A measure of a structure's resistance to displacement under applied load.                                                          |
| von Mises Stress                    | A criterion for measuring the stress state of a material subjected to load.                                                        |



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## APPENDIX A - Tables

**Table A.1 Electrical BOM Table**

| No | Part Name                                                                       | Qty | Unit  |
|----|---------------------------------------------------------------------------------|-----|-------|
| 1  | RPLiDAR S3                                                                      | 2   | pcs   |
| 2  | Teensy 4.1                                                                      | 2   | pcs   |
| 3  | MINI PC INTEL NUC i7 GEN 13 FULLSET+RAM+SSD+ W11<br> NUC13ANH7 - 16GB +512 NVME | 1   | pcs   |
| 4  | ZLLG80ASM250-L V3.0                                                             | 2   | pcs   |
| 5  | ZLTECH ZLAC8015D<br>Motor Driver                                                | 2   | pcs   |
| 6  | Meanwell DDR-15G-5 (PSU 24-12V DC<br>Converter to 5V DC 15W)                    | 2   | pcs   |
| 7  | Meanwell DDR-120B-12 (PSU 24-12V DC<br>Converter 120W)                          | 2   | pcs   |
| 8  | C-CTEJ125-N Caster<br>Wheel Misumi                                              | 4   | pcs   |
| 9  | LiFePO4 Battery 24V 60AH (Include charger)                                      | 1   | pcs   |
| 10 | Arducam OV9782                                                                  | 1   | pcs   |
| 11 | ZED 2 Camera                                                                    | 1   | pcs   |
| 12 | Noctua NF-A12X15 PWM Fan                                                        | 1   | pcs   |
| 13 | Emergency Stop Schneider XB5AS8442                                              | 5   | pcs   |
| 14 | Contactactor SDC15-100A 24V DC                                                  | 1   | pcs   |
| 15 | 6 Way Fuse Holder                                                               | 2   | pcs   |
| 16 | Fuse (2A, 5A, 10A)                                                              | 15  | pcs   |
| 17 | Aluminum DIN Rail                                                               | 2   | meter |
| 18 | NEMA 34 External Ball Screw Linear Stepper Motor Actuator<br>34E30S5504B1N5-    | 1   | pcs   |
| 19 | Stepper Motor Driver DM860T                                                     | 1   | pcs   |

|    |                                                |   |     |
|----|------------------------------------------------|---|-----|
| 20 | 12mm Stainless Push-Button Self-Locking Switch | 2 | pcs |
| 21 | 12mm Stainless Push Button Momentary           | 2 | pcs |
| 22 | USB TO RS232 / RS485<br>/ TTL Converter        | 1 | pcs |
| 23 | Voltmeter Display                              | 1 | pcs |
| 24 | Speaker ROBOT RS260                            | 2 | pcs |

**Table A.2 Mechanical BOM Table**

| No. | Part Name                         | Qty | Unit |
|-----|-----------------------------------|-----|------|
| 1   | 38x38 HOLLOW METAL<br>840MM       | 4   | pcs  |
| 2   | 38x38 HOLLOW METAL<br>500MM       | 4   | pcs  |
| 3   | 38x38 HOLLOW METAL<br>120MM FLAT  | 4   | pcs  |
| 4   | BASE PLATE 2                      | 1   | pcs  |
| 5   | BATTERY HOLDER<br>BOTTOM 2        | 1   | pcs  |
| 6   | BRACKET ZED 2<br>CAMERA           | 1   | pcs  |
| 7   | ASSEM 2 SCISSOR<br>LIFTER         | 1   | pcs  |
| 8   | FEET BASE SCISSOR<br>LIFTER       | 4   | pcs  |
| 9   | WHEEL SUSPENSION<br>ROD           | 4   | pcs  |
| 10  | WHEEL SUSPENSION<br>TOP           | 2   | pcs  |
| 11  | WHEEL SUSPENSION<br>WHEEL BRACKET | 2   | pcs  |
| 12  | FBJ LMH16UU LINEAR<br>BUSHING     | 4   | pcs  |
| 13  | WHEEL SUSPENSION<br>STOPPER       | 4   | pcs  |
| 14  | CASTER CTEJ125-N                  | 4   | pcs  |
| 15  | 8020-30-3030 X 80                 | 2   | pcs  |

|    |                           |   |     |
|----|---------------------------|---|-----|
| 16 | ELECTRONICS BASE 3        | 1 | pcs |
| 17 | FAN BRACKET               | 1 | pcs |
| 18 | NEMA 34 HOLDER<br>BASE    | 1 | pcs |
| 19 | NEMA 34 HOLDER<br>BRACKET | 1 | pcs |
| 20 | AMR COVER FRONT           | 1 | pcs |
| 21 | AMR COVER RIGHT           | 1 | pcs |
| 22 | AMR COVER LEFT            | 1 | pcs |
| 23 | AMR COVER BACK            | 1 | pcs |
| 24 | ARDUCAM OV9782<br>BRACKET | 1 | pcs |
| 25 | SPACER M2 M F 15MM        | 4 | pcs |
| 26 | CHARGER BASE              | 1 | pcs |
| 27 | CHARGER COPPER            | 2 | pcs |
| 28 | AMR COVER TOP             | 1 | pcs |
| 29 | TOP LIFTER                | 1 | pcs |
| 30 | SWH25-60                  | 8 | pcs |
| 31 | SPEAKER BRACKET           | 2 | pcs |

## APPENDIX B – Equations

$$P_{out} = 45 W + 2.5 W + 1.5 W = 49 W \quad (B.1)$$

$$\begin{aligned} P_{out} &= P_{loss} = P_{out} \left( \frac{1}{n} - 1 \right) \\ &= 49 W \times \left( \frac{1}{0.9} - 1 \right) = 5.39 W \end{aligned} \quad (B.2)$$

$$\begin{aligned} P_{static} &= P_{PC} + P_{LiDAR} + P_{Teensy} + P_{loss} = (45 + 2.5 + 1.5 + 5.39)W \\ &= 54.39 W \end{aligned} \quad (B.3)$$

$$I_{static} = \frac{P_{static}}{V} = \frac{54.39 W}{24 V} \approx 2.26 A \quad (B.4)$$

$$F_r = m \times g \times \mu_r = 140 kg \times 9.81 \times 0.08 = 109.8 N \quad (B.5)$$

$$\tau_{cruise} = \frac{F_{rr} \times r}{2} = \frac{109.8 N \times 0.0865 m}{2} \approx 4.75 Nm \quad (B.6)$$

$$I_{cruise} = \frac{\tau_{cruise}}{K_t} = \frac{4.75 Nm}{1} = 4.75 A \quad (B.7)$$

$$P_{cruise} = V \times I_{cruise} = 24 V \times 4.75 A = 114 W \quad (B.8)$$

$$F_{acc} = m \times a = 140 kg \times 0.1 m/s^2 = 14 N \quad (B.9)$$

$$F_{total} = F_{rr} + F_{acc} = 109.8 N + 14 N = 123.8 N \quad (B.10)$$

$$\tau_{peak} = \frac{F_{total} \times r}{2} = \frac{123.8 N \times 0.0865 m}{2} = 5.35 Nm \quad (B.11)$$

$$I_{acc} = \frac{\tau_{peak}}{K_t} = \frac{5.35 Nm}{1} = 5.35 A \quad (B.12)$$

$$P_{cruise} = V \times I_{cruise} = 24 V \times 5.35 A \approx 128.5 W \quad (B.13)$$

$$I_{cruise\ total} = I_{static} + I_{cruise} = 2.26\ A + (4.75\ A \times 2) = 11.76\ A \quad (B.14)$$

$$P_{cruise\ total} = P_{static} + P_{cruise} = 54.39\ W + 114\ W = 168.39\ W \quad (B.15)$$

$$I_{peak} = I_{static} + I_{acc} = 2.26\ A + (5.35\ A \times 2) = 12.96\ A \quad (B.16)$$

$$P_{peak} = P_{static} + P_{peak} = 54.39\ W + 128.5\ W = 182.89\ W \quad (B.17)$$

$$T_{cruise} = \frac{60\ A \times 1\ h}{11.76\ A} = 5.10\ h \quad (B.18)$$

$$T_{acc} = \frac{60\ A \times 1\ h}{12.96\ A} = 4.63\ h \quad (B.19)$$

$$I_{avg} = (I_{cruise} \times 0.7) + (I_{peak} \times 0.3) = (8.23 + 3.88)A = 12.12\ A \quad (B.20)$$

$$T_{acc} = \frac{60\ A \times 1\ h}{13.57\ A} = 4.95\ h \quad (B.21)$$

$$\Sigma M_B = \left(\frac{w}{2} \cdot 2L \cdot \cos(\theta)\right) - (F_y \cdot L \cdot \cos(\theta)) - (F_x \cdot L \cdot \sin(\theta)) \quad (B.22)$$

$$\Sigma F_x = F_x - R_{x1} \quad (B.23)$$

$$\Sigma F_y = F_y + R_{y1} - \frac{w}{2} \quad (B.24)$$

$$\Sigma M_A = \left(\frac{-w}{2} \cdot 2L \cdot \cos(\theta)\right) - (F_y \cdot L \cdot \cos(\theta)) + (F_x \cdot L \cdot \sin(\theta)) \quad (B.25)$$

$$\Sigma F_x = -F_x + R_{x2} \quad (B.26)$$

$$\Sigma F_y = R_{y1} - F_y - \frac{w}{2} \quad (B.27)$$

$$\Sigma M_B = 0 \quad (B.28)$$

$$0 = \frac{w}{2} \cdot 2L \cdot \cos(\theta) - (F_y \cdot L \cdot \cos(\theta)) - (F_x \cdot L \cdot \sin(\theta)) \quad (B.29)$$

$$F_y = w - F_x \cdot \tan(\theta) \quad (B.30)$$

$$F_x - R_{x1} = 0 \quad (B.31)$$

$$F_x = R_{x1} \quad (B.32)$$

$$R_{x2} - F_x = 0 \quad (B.33)$$

$$F_x = R_{x1} = R_{x2} \quad (B.34)$$

$$\Sigma M_A = 0 \quad (B.35)$$

$$0 = \left(\frac{-w}{2} \cdot 2L \cdot \cos(\theta)\right) - (F_y \cdot L \cdot \cos(\theta)) + (F_x \cdot L \cdot \sin(\theta)) \quad (B.36)$$

$$F_x = \frac{w}{\tan(\theta)} + \frac{F_y}{\tan(\theta)} \quad (B.37)$$

$$F_x = \frac{w}{\tan(\theta)} + \frac{w - F_x \cdot \tan(\theta)}{\tan(\theta)} \quad (B.38)$$

$$\text{Payload} = 100 \text{ kg} \quad (B.39)$$

$$\text{AMR Mass} = 50 \text{ kg}$$

$$\text{Wheel Diameter} = 200 \text{ mm}$$

$$\text{Wheel Radius} = 100 \text{ mm} = 0.1 \text{ m}$$

$$V = 24 \text{ VDC}$$

$$\tau_{rated} = 8 \text{ Nm}$$

$$I_{rated} = 6 \text{ A}$$

$$I_{peak} = 18 \text{ A}$$

$$F_r = 150 \text{ kg} \cdot 9,81 \cdot 0,08 = 117,7 \text{ N} \quad (B.40)$$

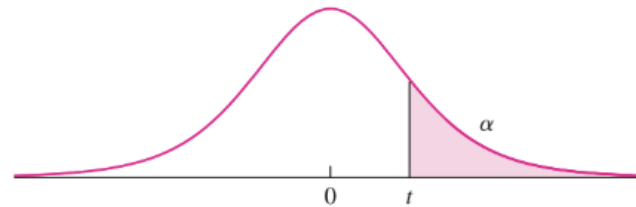
$$F_a = 150 \text{ kg} \cdot 0,05 \frac{\text{m}}{\text{s}^2} = 7,5 \text{ N} \quad (B.41)$$

$$\tau_{peak} = \frac{(117,7 + 7,5) \text{ N} \cdot 0,1 \text{ m}}{2} = 6,26 \text{ Nm} \quad (B.42)$$

$$P_{per \text{ motor needed}} = \frac{F_{total} \cdot 1 \text{ m/s}}{2} = 62,6 \text{ W} \quad (B.43)$$

## APPENDIX C – Figures

**TABLE A.3** Upper percentage points for the Student's *t* distribution



| $\nu$    | $\alpha$ |       |       |       |        |        |        |         |         |
|----------|----------|-------|-------|-------|--------|--------|--------|---------|---------|
|          | 0.40     | 0.25  | 0.10  | 0.05  | 0.025  | 0.01   | 0.005  | 0.001   | 0.0005  |
| 1        | 0.325    | 1.000 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 | 318.309 | 636.619 |
| 2        | 0.289    | 0.816 | 1.886 | 2.920 | 4.303  | 6.965  | 9.925  | 22.327  | 31.599  |
| 3        | 0.277    | 0.765 | 1.638 | 2.353 | 3.182  | 4.541  | 5.841  | 10.215  | 12.924  |
| 4        | 0.271    | 0.741 | 1.533 | 2.132 | 2.776  | 3.747  | 4.604  | 7.173   | 8.610   |
| 5        | 0.267    | 0.727 | 1.476 | 2.015 | 2.571  | 3.365  | 4.032  | 5.893   | 6.869   |
| 6        | 0.265    | 0.718 | 1.440 | 1.943 | 2.447  | 3.143  | 3.707  | 5.208   | 5.959   |
| 7        | 0.263    | 0.711 | 1.415 | 1.895 | 2.365  | 2.998  | 3.499  | 4.785   | 5.408   |
| 8        | 0.262    | 0.706 | 1.397 | 1.860 | 2.306  | 2.896  | 3.355  | 4.501   | 5.041   |
| 9        | 0.261    | 0.703 | 1.383 | 1.833 | 2.262  | 2.821  | 3.250  | 4.297   | 4.781   |
| 10       | 0.260    | 0.700 | 1.372 | 1.812 | 2.228  | 2.764  | 3.169  | 4.144   | 4.587   |
| 11       | 0.260    | 0.697 | 1.363 | 1.796 | 2.201  | 2.718  | 3.106  | 4.025   | 4.437   |
| 12       | 0.259    | 0.695 | 1.356 | 1.782 | 2.179  | 2.681  | 3.055  | 3.930   | 4.318   |
| 13       | 0.259    | 0.694 | 1.350 | 1.771 | 2.160  | 2.650  | 3.012  | 3.852   | 4.221   |
| 14       | 0.258    | 0.692 | 1.345 | 1.761 | 2.145  | 2.624  | 2.977  | 3.787   | 4.140   |
| 15       | 0.258    | 0.691 | 1.341 | 1.753 | 2.131  | 2.602  | 2.947  | 3.733   | 4.073   |
| 16       | 0.258    | 0.690 | 1.337 | 1.746 | 2.120  | 2.583  | 2.921  | 3.686   | 4.015   |
| 17       | 0.257    | 0.689 | 1.333 | 1.740 | 2.110  | 2.567  | 2.898  | 3.646   | 3.965   |
| 18       | 0.257    | 0.688 | 1.330 | 1.734 | 2.101  | 2.552  | 2.878  | 3.610   | 3.922   |
| 19       | 0.257    | 0.688 | 1.328 | 1.729 | 2.093  | 2.539  | 2.861  | 3.579   | 3.883   |
| 20       | 0.257    | 0.687 | 1.325 | 1.725 | 2.086  | 2.528  | 2.845  | 3.552   | 3.850   |
| 21       | 0.257    | 0.686 | 1.323 | 1.721 | 2.080  | 2.518  | 2.831  | 3.527   | 3.819   |
| 22       | 0.256    | 0.686 | 1.321 | 1.717 | 2.074  | 2.508  | 2.819  | 3.505   | 3.792   |
| 23       | 0.256    | 0.685 | 1.319 | 1.714 | 2.069  | 2.500  | 2.807  | 3.485   | 3.768   |
| 24       | 0.256    | 0.685 | 1.318 | 1.711 | 2.064  | 2.492  | 2.797  | 3.467   | 3.745   |
| 25       | 0.256    | 0.684 | 1.316 | 1.708 | 2.060  | 2.485  | 2.787  | 3.450   | 3.725   |
| 26       | 0.256    | 0.684 | 1.315 | 1.706 | 2.056  | 2.479  | 2.779  | 3.435   | 3.707   |
| 27       | 0.256    | 0.684 | 1.314 | 1.703 | 2.052  | 2.473  | 2.771  | 3.421   | 3.690   |
| 28       | 0.256    | 0.683 | 1.313 | 1.701 | 2.048  | 2.467  | 2.763  | 3.408   | 3.674   |
| 29       | 0.256    | 0.683 | 1.311 | 1.699 | 2.045  | 2.462  | 2.756  | 3.396   | 3.659   |
| 30       | 0.256    | 0.683 | 1.310 | 1.697 | 2.042  | 2.457  | 2.750  | 3.385   | 3.646   |
| 35       | 0.255    | 0.682 | 1.306 | 1.690 | 2.030  | 2.438  | 2.724  | 3.340   | 3.591   |
| 40       | 0.255    | 0.681 | 1.303 | 1.684 | 2.021  | 2.423  | 2.704  | 3.307   | 3.551   |
| 60       | 0.254    | 0.679 | 1.296 | 1.671 | 2.000  | 2.390  | 2.660  | 3.232   | 3.460   |
| 120      | 0.254    | 0.677 | 1.289 | 1.658 | 1.980  | 2.358  | 2.617  | 3.160   | 3.373   |
| $\infty$ | 0.253    | 0.674 | 1.282 | 1.645 | 1.960  | 2.326  | 2.576  | 3.090   | 3.291   |

**Figure C.1** t-Test Distribution Table

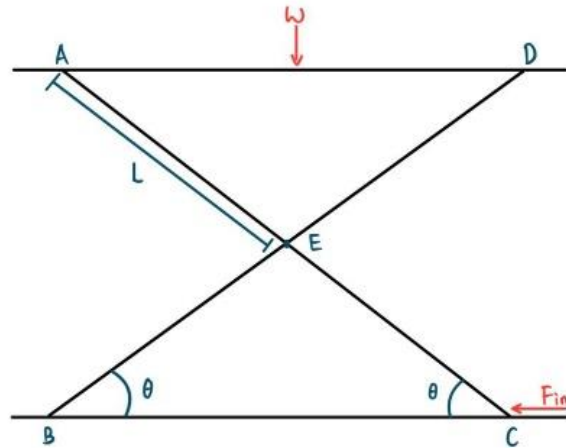


Figure C.2 Scissor Lift Simplified

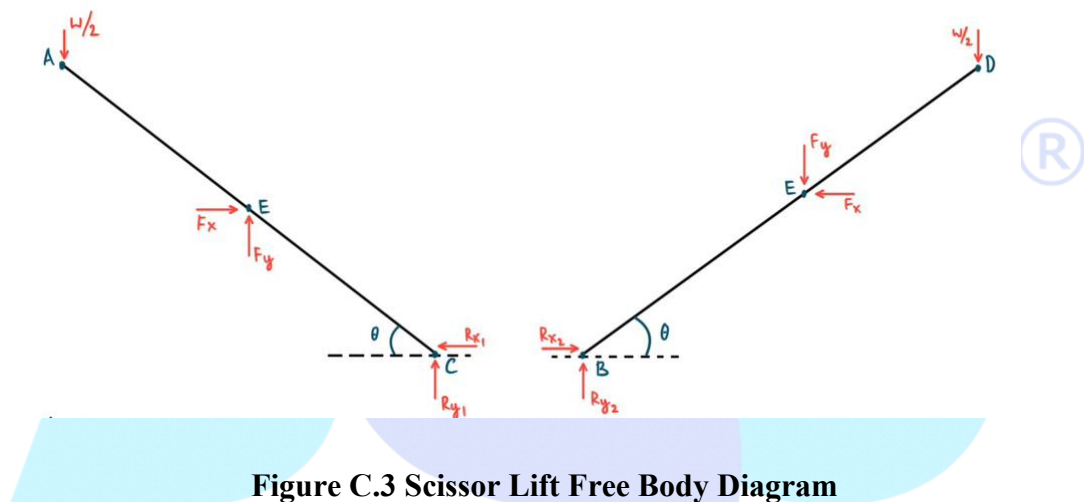


Figure C.3 Scissor Lift Free Body Diagram

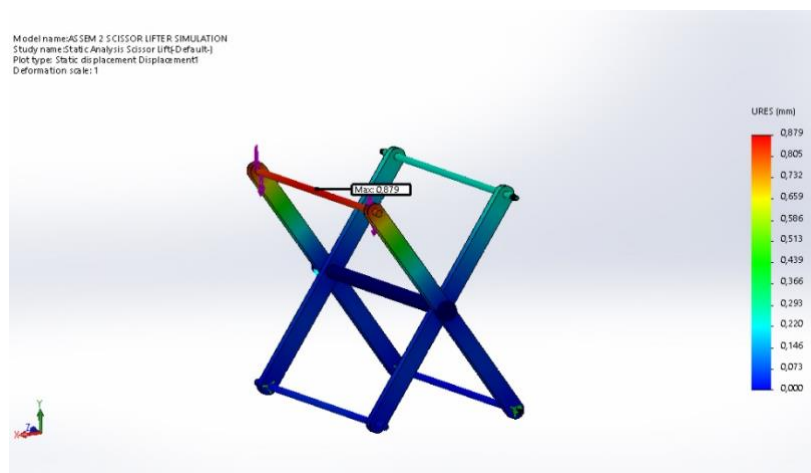


Figure C.4 Scissor Lift Non-Ideal Condition Front Focus Displacement

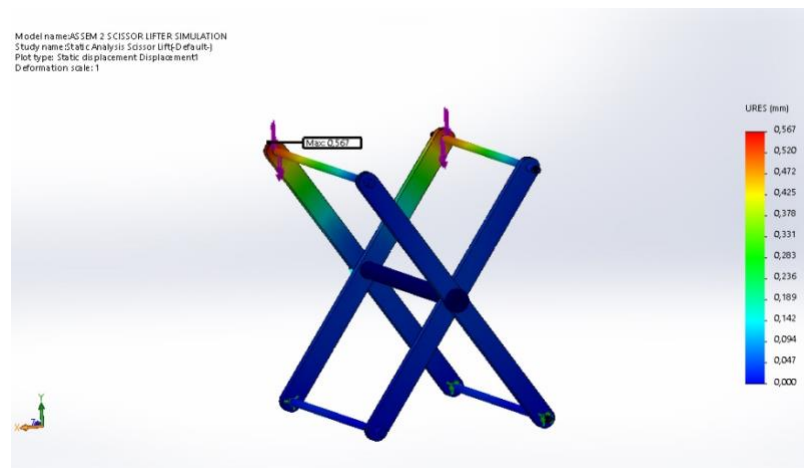


**Figure C.5 Scissor Lift Non-Ideal Condition Right Focus Displacement**

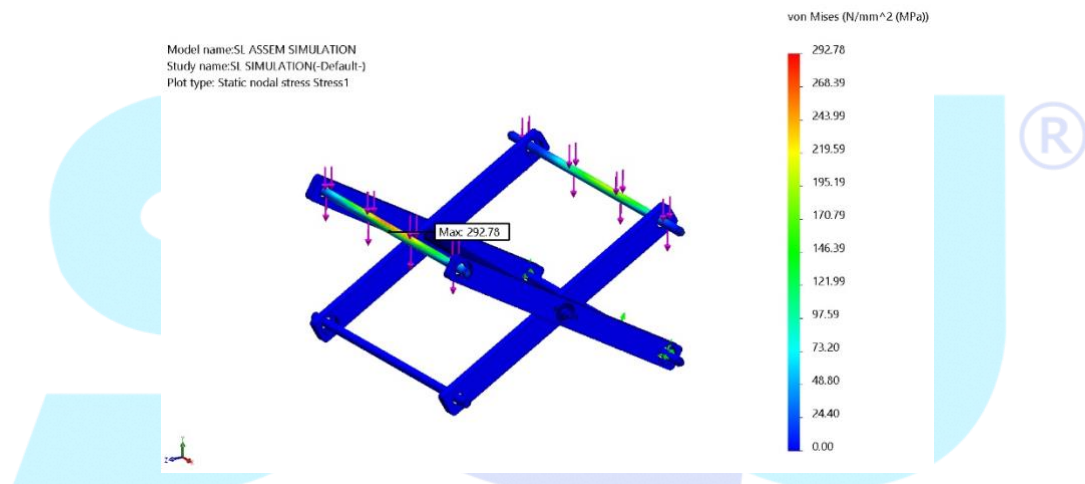


**Figure C.6 Scaled Down Scissor Lift Stress Analysis with 120kg Load**

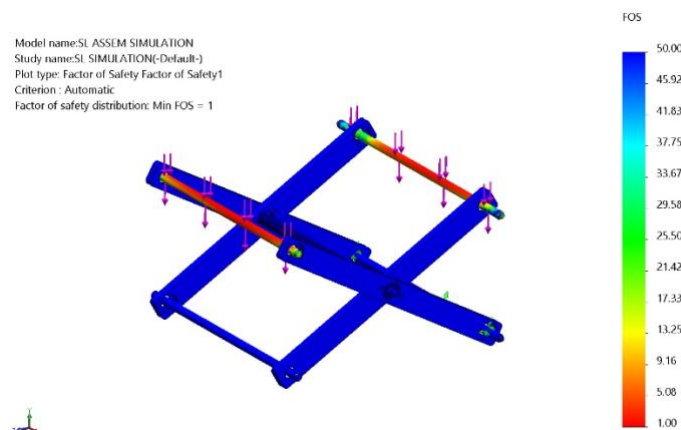


**Figure C.7 Scaled Down Scissor Lift FoS Analysis with 120kg Load**

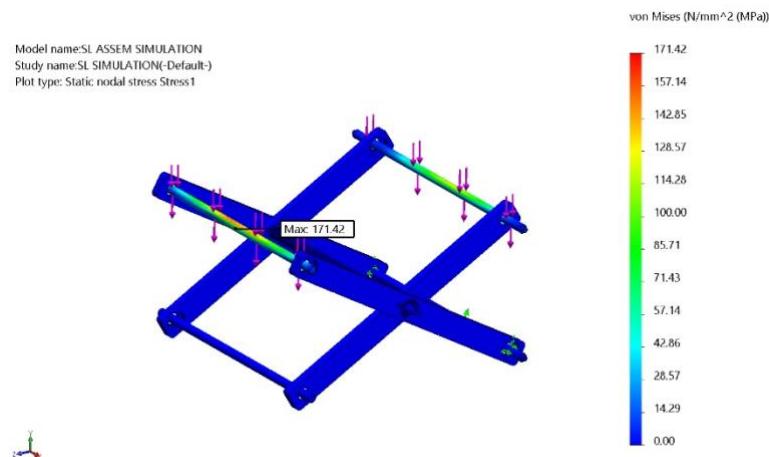


**Figure C.8 Scaled Down Scissor Lift Stress Analysis with 70kg Load**

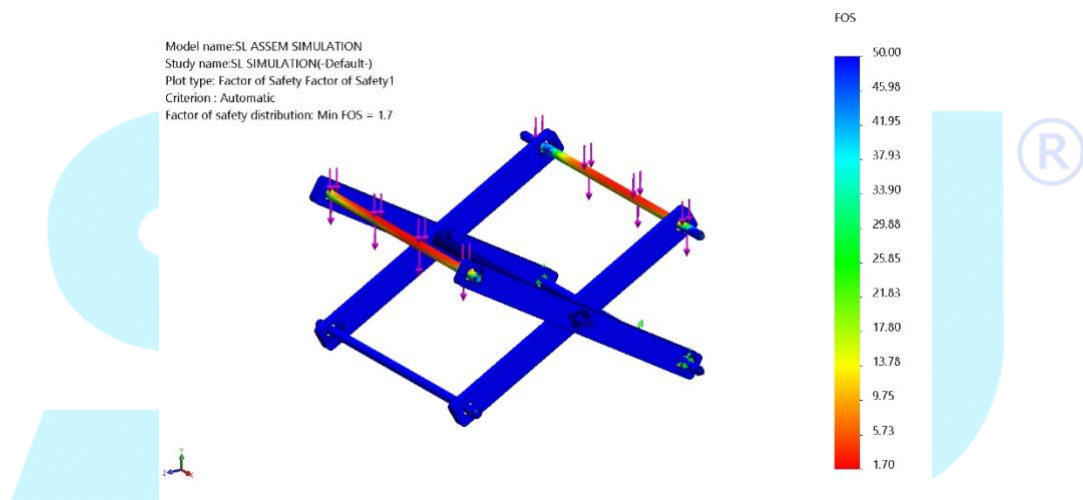


**Figure C.9 Scaled Down Scissor Lift FoS Analysis with 70kg Load**

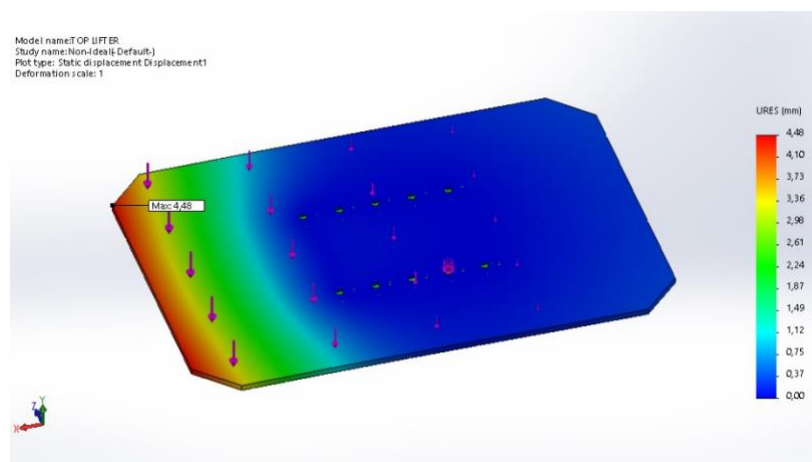


**Figure C.10 Top Lifter Non-Ideal Condition Front Focus**

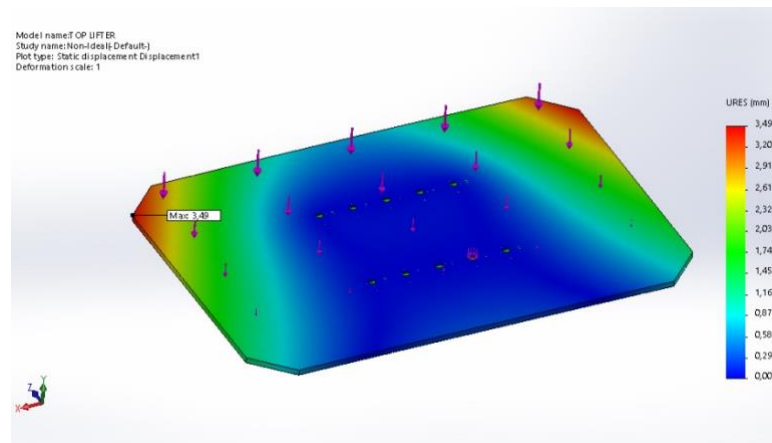


**Figure C.11 Top Lifter Non-Ideal Condition Right Focus Displacement**

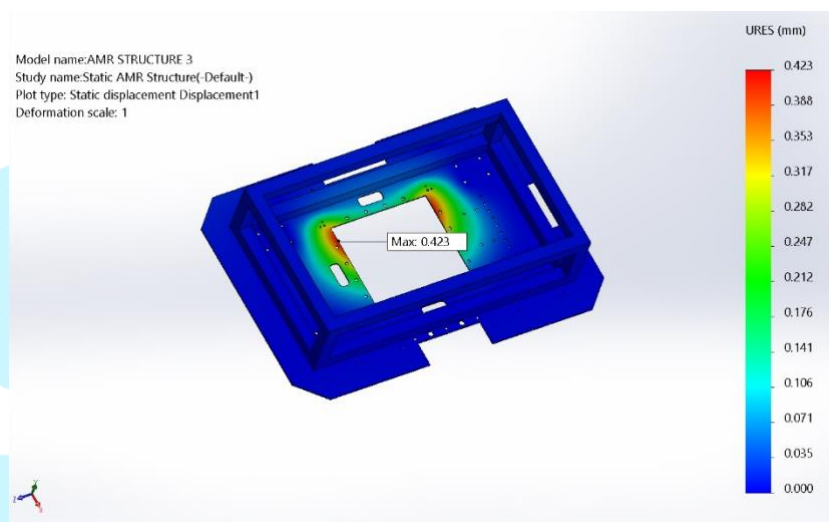


**Figure C.12 Base Plate with Hollow Steel Frame Non-Ideal Right Focus Displacement**

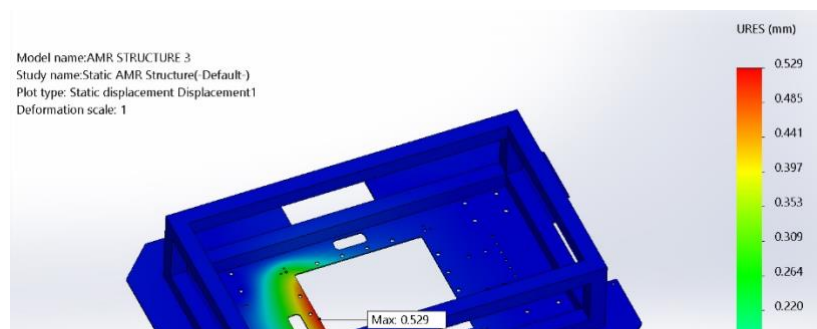


**Figure C.13 Base Plate with Hollow Steel Frame Non-Ideal Front Focus Displacement**

**Figure C.14 RQT Graph Full Fusion**  
**Figure C.13 Base Plate with Hollow Steel Frame Non-Ideal Front Focus Displacement**

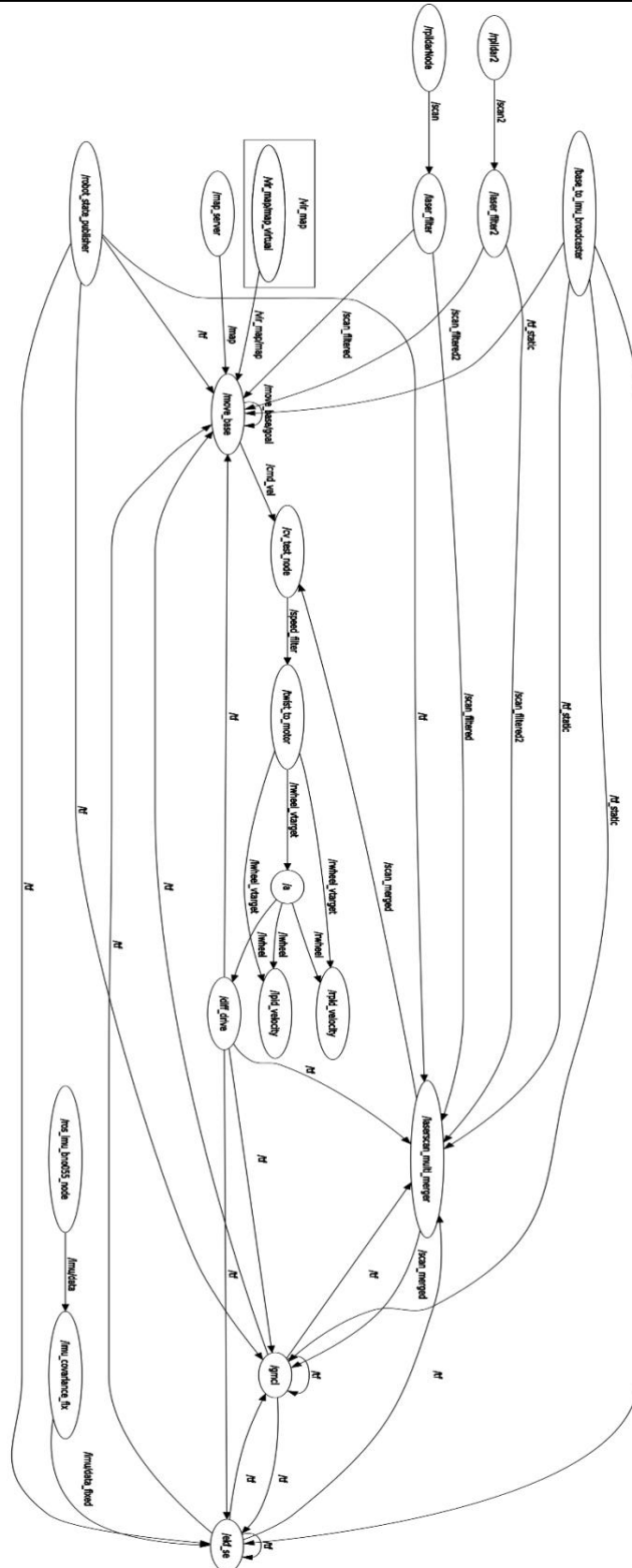


Figure C.14 RQT Graph Full Fusion

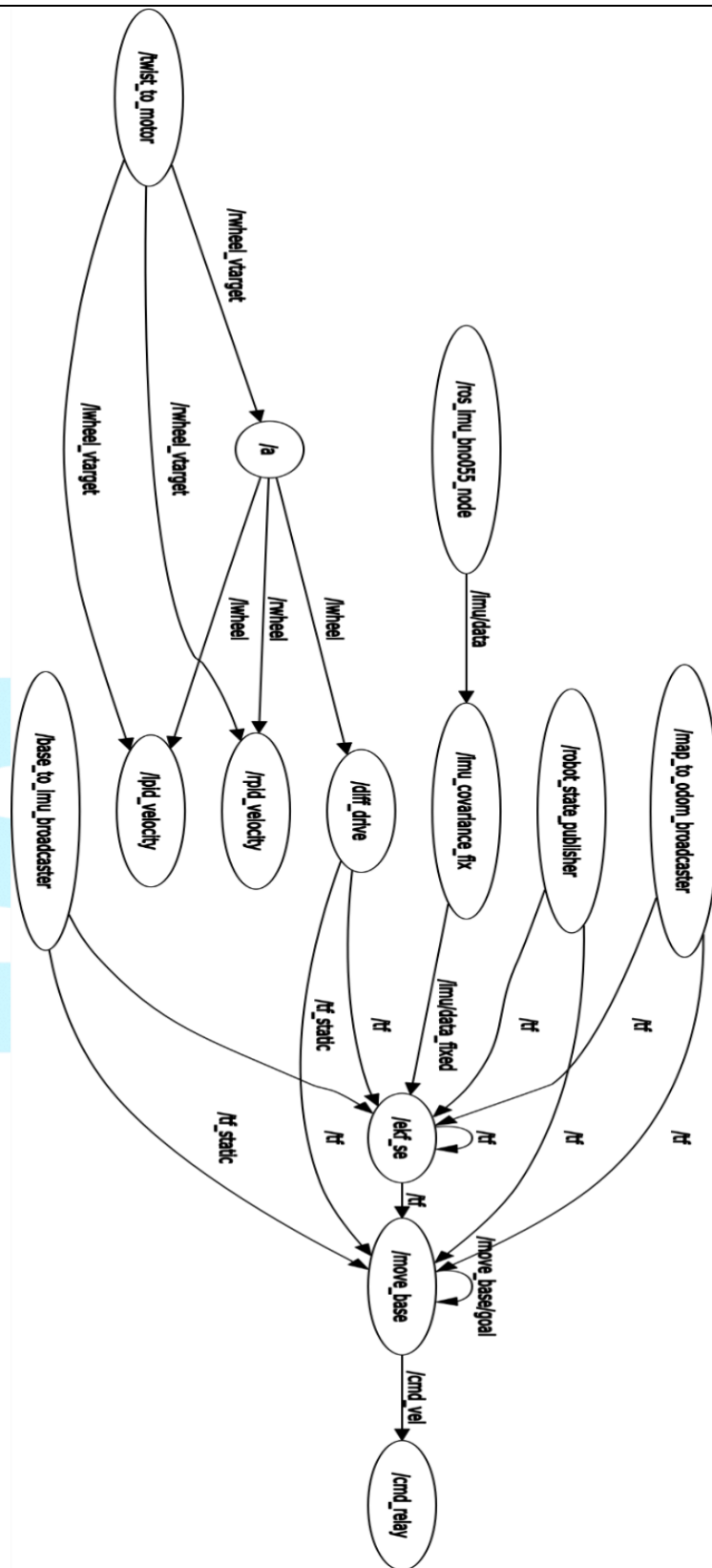
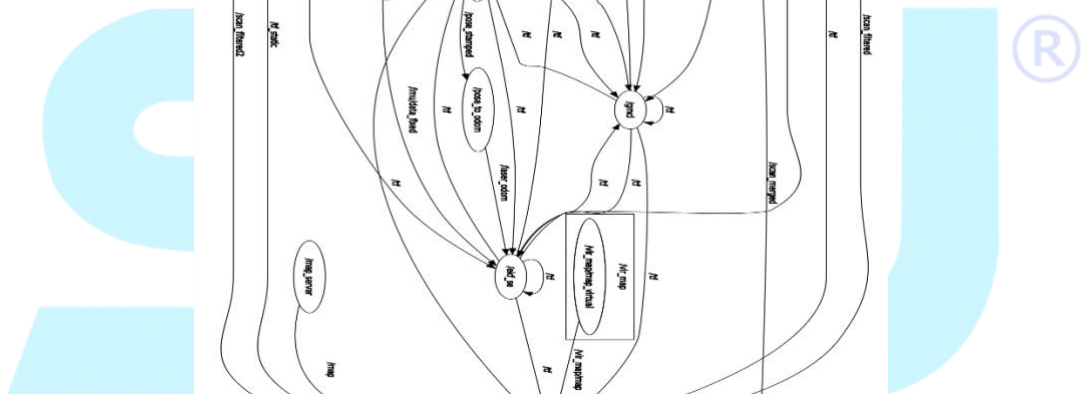
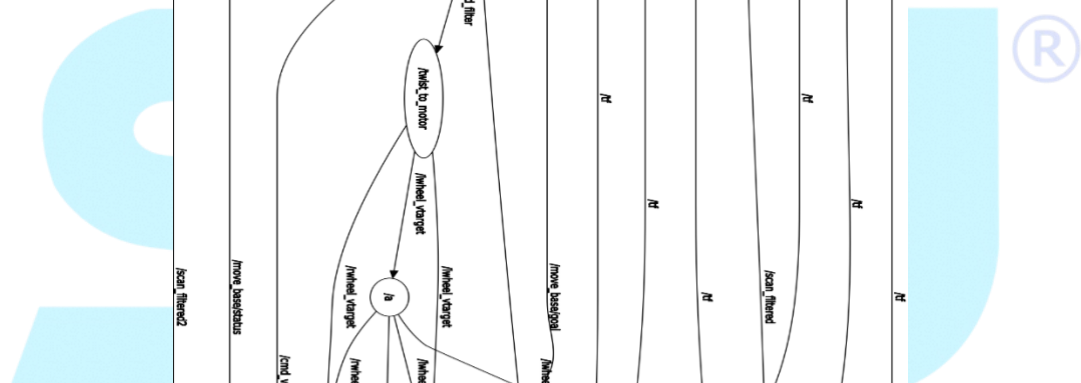


Figure C.15 RQT Graph Without LiDAR



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Jonathan Garry Hartono



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Jonathan Garry Hartono

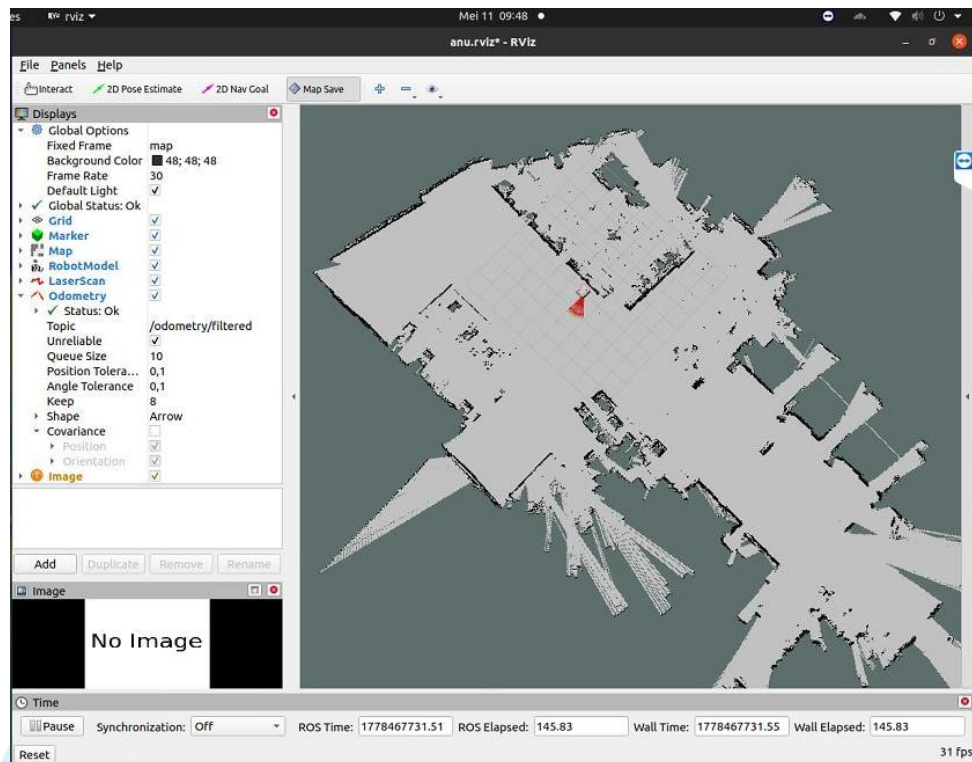


Figure C.18 Mapping with GMapping

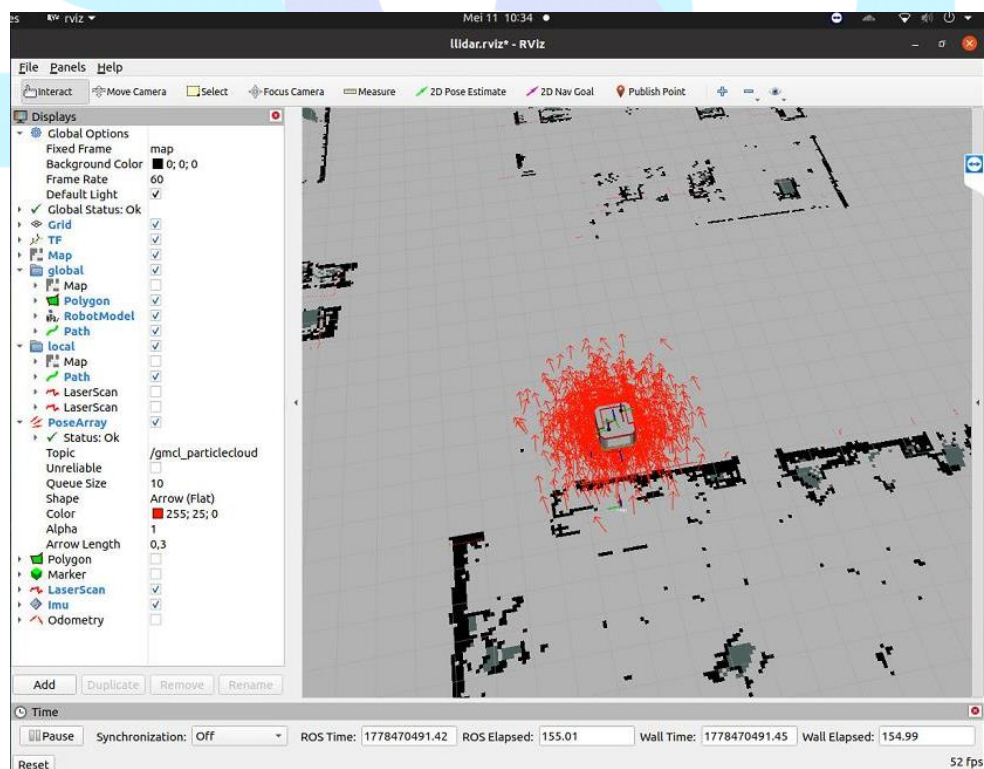


Figure C.19 GMCL Pose Array Arrows

## CURRICULUM VITAE



# JONATHAN GARRY HARTONO

## MECHATRONICS ENGINEER

### CONTACT

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### SKILLS

- CNC Programming
- Arduino C++ Programming
- Autodesk Inventor
- Solidworks (CSWA Certified)
- PLC TwinCAT Beckhoff
- PLC Omron
- Proteus PCB Designing

### LANGUAGES

- Indonesian (Fluent)
- English (Fluent)
- German (B1)

### CERTIFICATION

- CSWA Certification (2024)
- ATMI Trainee Certification (2023)
- B1 Goethe Zertifikat (2021)

### PROFILE

Final-year Mechatronics Engineering student at Swiss German University with a completed double degree from Fachhochschule Südwestfalen, Germany. Skilled in PLC programming, CAD modeling, and system integration, with a strong foundation in both theoretical and hands-on engineering. Motivated to apply technical expertise and international perspective to innovative solutions in robotics, automation, and product design.

### WORK EXPERIENCE

**Landpack GmbH Munich, Germany** 08.2025 - 01.2026  
Quality Management and Product Development Intern

- Develop filling system of wheat straws from source to press chamber
- Projecting continuous straw press automatic line for Landpack USA

**PT Sat Nusapersada Tbk Batam, Indonesia** 11.2023 - 02.2024  
Design Engineer Intern

- Automated press PCB machine.
  - Machineries assembly
  - CAD
  - Automation simulation
- Automated X-Ray counter machine
  - Layout projection
  - Reverse engineering
  - CAD

### EDUCATION

**Bachelor of Engineering (B.Eng)** 02.2025 - 08.2025  
Wirtschaftingineurwesen | Fachhochschule Südwestfalen Soest

**Sarjana Teknik (S.T)** 08.2022 - 08.2026  
Mechatronics Engineering | Swiss German University

**Organizations:**

- MT Day (Mechatronics Day)**
  - Vice Head Event Division (2022)
  - Vice Head of Organization (2023)
  - Head of Organization (2024)
- SGU Brand Champion**
- HMJMT (Mechatronics Student Association)**
  - Treasurer (2024)
- BEM (Student Board of Executives)**
  - Sports Division (2024)