

## Project Deliverable C: **Design Criteria**

GNG 1103 – Engineering Design

Faculty of Engineering – University of Ottawa

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## Design Criteria

Criteria	Importance
Weigh < 20 lbs. or be broken down into pieces that weigh < 20 lbs.	5
Simple to pilot	4
Safety shut down	2
Flashlight on camera end effector	4
Water resistance (IPX4)	2
Autonomous operation	5
Tool swap ease	3
Work efficiently enough to complete a 2m x 2m square in 4 hours	4
Dexterous	5
Simple Control mechanism	4
Tool weight < 1000 lbs.	5

## Technical benchmarking and User benchmarking

Product	Technical Attributes	User Review	Rating (1-5)
Hull treatment Carrier (HTC) ship painting robots: <a href="https://www.hapag-loyd.com/en/company/about-us/newsletter/2019/07/hapag-loyd-tests-ship-painting-robots.html">https://www.hapag-loyd.com/en/company/about-us/newsletter/2019/07/hapag-loyd-tests-ship-painting-robots.html</a>	<ul style="list-style-type: none"> <li>-Layers of paint applied at 90degree angle to minimize overspray</li> <li>-Removes old layers of paint with high pressure water</li> <li>-Can apply 600-800m<sup>2</sup> paint/hour</li> </ul>	<p>“The performance indicators show that the smoother surface results in both lower fuel consumption at the start and a greater resilience to fouling over the entire 60 months.”</p> <p>“We can ensure a certain level of quality with automated application systems, and the system is less harmful to the environment,”</p>	Efficiency: 5 Storability: 1 Multipurpose: 5 Ease of operation: 2 Maneuverability: 2 Durability: 5 Effectiveness:5  Overall: 3.125
	<ul style="list-style-type: none"> <li>-Cleaning rate: 60m<sup>2</sup>/hr, this is proven to be 8 times faster and manual work</li> <li>-1500mm cleaning width</li> <li>-wireless control</li> <li>-Powered by 70Vdc Motors</li> <li>-Multi directional swing arm</li> <li>-interchangeable applications</li> <li>-it designed to be compact and agile for cramped operation conditions</li> <li>- Multi-purpose: washing, cleaning, hydro blasting.</li> <li>-operates on vertical, horizontal and overhead surfaces</li> <li>-Magnetic, semi mobile base</li> </ul>	<p>“The VertiDrive M7 is a comprehensive solution for fast and efficient removal of industrial coatings, corrosion, and other types of contamination on large steel surfaces, such as storage tanks, ship hulls, and other large steel structures.”</p>	Efficiency: 2 Multipurpose: 4 Storability: 5 Maneuverability: 5 Durability: 2 Ease of Operation: 5 Effectiveness:4  Overall: 3.857
Okibo autonomous plastering robot: <a href="https://www.okibo.com/">https://www.okibo.com/</a>	<ul style="list-style-type: none"> <li>-Battery operated</li> <li>-Integrated Pump</li> <li>-Real-time 3d scanning</li> <li>-Prediction &amp; Analytics based off scans</li> <li>-Compact and On Wheels</li> <li>-Robust robotic platform</li> <li>-Autonomous path planning</li> <li>Predictions and analytics (BIM 5D)</li> <li>-built in safety features</li> </ul>	<p>“Okibo requires minimum personal intervention to operate.”</p>	Efficiency: 4 Storability: 3 Multipurpose: 2 Ease of operation: 4 Maneuverability: 5 Durability: 5 Effectiveness:5  Overall:4

<p>Robot Tank Inspection End Effector  <a href="https://www.dndkm.org/DOEKMDocuments/ITSR/Tank/Robot%20Tank%20Inspection%20End%20Effector.pdf">https://www.dndkm.org/DOEKMDocuments/ITSR/Tank/Robot Tank Inspection End Effector.pdf</a></p>	<ul style="list-style-type: none"> <li>- In the RTIEE, ACFM sensor coils are mounted in a 96-coil sensor array protected by a 0.010-inch stainless steel plate. This sensor array is driven across the RTIEE scanning frame for a detailed, quantified inspection of a 3- by 3-inch area.</li> <li>-Operated remotely from control trailer outside the tank</li> <li>-ACFM is an electromagnetic NDE technique specifically developed to overcome the shortcomings of eddy current techniques.</li> <li>-ACFM is far less sensitive than eddy current to deviations in standoff distance and orientation. electromagnetic technique that does not use a hazardous source and does not require interpretation of hard-to-read films.</li> <li>-ACFM does not produce secondary waste</li> <li>-The NDE system does not require electrical contact with the surface, eliminating the need for surface cleaning.</li> <li>- The RTIEE system can work through most coatings, including paint, epoxy, rubber, grease, and sludge.</li> </ul>	<p>“user-friendly software written at OSS to collect and analyze the inspection data”</p>	<p>Ease of Operation: 5  Effectiveness: 5  Storability: 5  Multipurpose: 1  Efficiency: 5</p>
<p>ABB’s FlexPainter  <a href="https://library.e.abb.com/public/396b885928754b56867a589c03bd43ab/IRB5500-Flex-RP50010EN-Rev.G.pdf?x-sign=CzLmYRh1quyvzA8aOUyMoEgHOJO6u6ADPBERhsvBscBdEsXkzesMVdjChrHntk2u">https://library.e.abb.com/public/396b885928754b56867a589c03bd43ab/IRB5500-Flex-RP50010EN-Rev.G.pdf?x-sign=CzLmYRh1quyvzA8aOUyMoEgHOJO6u6ADPBERhsvBscBdEsXkzesMVdjChrHntk2u</a></p>	<ul style="list-style-type: none"> <li>-light-weight paint application to reduce paint waste</li> <li>-Integrated Process System (IPS) that combines process control and motion</li> <li>-light-weight and compact components</li> <li>- high flow RB1000 atomizer for high speed painting</li> <li>- Mounting: Wall, floor, tilted, inverted, clean-wall rail</li> <li>-6 DOF</li> <li>-weight: 600kg</li> <li>- Payload on wrist 13 kg</li> <li>- Designed to reduces paint and solvent waste</li> </ul>	<p>“has a large work envelope, allowing it to reach across even large workpieces to paint the other side”</p>	<p>Efficiency: 5  Storability: 3  Multipurpose: 1  Ease of operation: 5  Maneuverability: 5  Durability: 5  Effectiveness: 3    Overall: 3.857</p>

	-Very user friendly, since combining process control and motion control as one, this simplified the system set up and enables for real savings and process perfection.		
FANUC's PaintMate <a href="https://www.fanucamerica.com/docs/default-source/fanuc-robot-datasheets-new/datasheet-paintmate-200ia-5l.pdf">https://www.fanucamerica.com/docs/default-source/fanuc-robot-datasheets-new/datasheet-paintmate-200ia-5l.pdf</a>	-compact -5kg payload capacity -reach of up to 892mm -floor, inverted, angle and wall mounting options -use for painting/coating, spot welding, material removal and dispensing -slim arm suitable for narrow space operation -weight is 35kg -collision guard and advanced path - designed for operation in a hazardous environment -6DOF - designed to work in hazardous conditions, keeping workers safe from conditions that could be unhealthy	-Poor display of values stored in numeric register; doesn't show measuring units thus if you want to modify parameters you must do so blindly -"excellent product" 4.5 stars	Efficiency: 3 Storability: 4 Multipurpose: 4 Ease of operation: 3 Maneuverability: 4 Durability: 5 Effectiveness:4  Overall: 3.857
Advanced Robotic Laser Coating Removal System (ARLCRS): <a href="https://www.cmu.edu/homepage/computing/2012/fall/paint-stripping-robot.shtml">https://www.cmu.edu/homepage/computing/2012/fall/paint-stripping-robot.shtml</a>	-uses high powered lasers to remove paint and other coatings -can selectively remove coatings -collects debris from removal, minimizing the environmental impact	"It is really many factors coming together, including advancements in robotics, lower cost and higher performing lasers, a greater emphasis on the sustainability and health benefits of the process, and private investment," said Clay Flannigan, the assistant director of robotics and automation engineering at Southwest Research Institute "The IPG fiber laser has proven to be extremely robust and operator-friendly. As laser prices continue to fall, we envision many coating removal jobs, across industries, being taken over by laser ablation systems,"	Efficiency: 5 Storability: 2 Multipurpose: 4 Ease of operation: 5 Maneuverability: 4 Durability: 5 Effectiveness:5  Overall: 4.286
KUKA and Dürr's ready2_spray <a href="https://directory.newequipment.com/cl">https://directory.newequipment.com/cl</a>	-painting of wood, plastics, glass and metal -Explosion proof robot with 6 axis and a reachability of 1.100mm	"Great product." 4/5 stars "perfect" 5/5 stars	Efficiency: 2 Storability: 5 Multipurpose: 2 Ease of operation: 3

<a href="https://www.product-reviews.com/assified/painting-robot-is-at-the-ready-237971.html#product-reviews-start">assified/painting-robot-is-at-the-ready-237971.html#product-reviews-start</a>	<ul style="list-style-type: none"> <li>-Flexible control system for motion and process</li> <li>-Various interfaces to connect with third party devices (e.g. Line-PLC)</li> <li>-Suitable for wall, ceiling or floor installation</li> <li>-Modern user interface</li> <li>-All common paint processes are supported (Bell / Gun, 1K / 2K, High- / Low-Pressure)</li> <li>- fully compatible</li> </ul>		Maneuverability: 4 Durability: 5 Effectiveness:4  Overall: 3.571
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## Target specifications

Functional:

Target Spec.	Relation	Value	Units	Verification Method
Removal/ Application Rate	=	1	M <sup>2</sup> /hour	Test
Individual Component Weight	<	20	lbs	Scale
Turning radius	=	360	degrees	Test
Frequency of Maintenance	<=	1	Maintenance/ year	
Mounted Flashlight	=	3200	Lumens	Measure

Non-Functional:

Target Spec.	Relation	Value	Units	Verification Method
Size	<	6	feet	Measure
Training	<=	4	hours	Teach people how to use it and time

Number of Operators	<=	2	Operators	Test
User appeal	=	10	Standard 1-10 beauty scale	Survey
Consistent Cleaning	=	Yes	N/A	Test
Quality of Paint Job	=	Clean-Finish	N/A	Test

Constraints:

Target Spec.	Relation	Value	Units	Verification Method
End-effector Cost	<	100	\$	N/A
Storage	<	0.5	m <sup>2</sup> / section	Practice storage
Safety	=	0	Injuries/ Yr	Test