

Table : Key Risks and Mitigation Plans

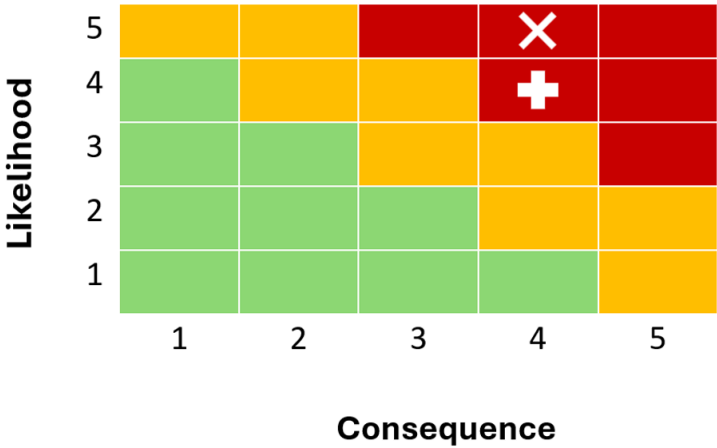
RISK ID	RISK	REQ. TYPE	RISK TYPE	DESCRIPTION	LIKE.	CONS.	MITIGATION PLAN
1	End-Effector Damage/Failure During Operation	FR.04 + FR.05 + FR.08	Technical + Schedule	Structural or functional breakdown of the gripper or cutter assembly due to excessive mechanical stress	4	4	<ol style="list-style-type: none"> 1. Ensure the availability of spare end-effectors to mitigate downtime and maintain adherence to the timeline. 2. Allocate extended buffer periods for end-effector testing to evaluate functionality and durability.
2	Possibility of Collision between two xArm-7	FR.03 + FR.04 + NRF.08	Technical	Potential for physical collision between the two xArm-7 units during testing resulting in damaged components.	3	5	<ol style="list-style-type: none"> 1. xArm-7 can be programmed with software constraints to define the allowable range of motion and hence "bound" their task space. 2. Implement algorithms to detect collisions during path planning by analyzing the 3D environment map.
RISK ID	RISK	REQ. TYPE	RISK TYPE	DESCRIPTION	LIKE.	CONS.	MITIGATION PLAN
3	Unavailability/delay in access to the second XARM-7	PR.05 + PR.06	Schedule	Delay in accessing the second XARM-7 unit due to its extended use by other teams.	4	3	<ol style="list-style-type: none"> 1. Enforce strict version control practices using systems like Git. 2. Implement continuous integration (CI) practices to test the integration of subsystems frequently.
4	Integration issues with subsystem	PR.01 + PR.02	Technical + Schedule	Challenges arising when integrating subsystem code due to mismatched or	3	4	

	code due to different interfaces	+ PR.03		incompatible interfaces between different software modules.			<ol style="list-style-type: none"> 1. Enforce strict version control practices using systems like Git. 2. Implement continuous integration (CI) practices to test the integration of subsystems frequently.
5	Compatibility Issues in Hardware and Software Interfaces	FR.01 + FR.02 + FR.03 + FR.04	Technical + Schedule	Hardware-Software Integration Issues failure to exchange data correctly, misinterpretation of commands, or inability to synchronize operations effectively	1	3	<ol style="list-style-type: none"> 1. Develop a software layer or interface to simplify how the program communicates with hardware making it easier to swap or upgrade hardware. 2. Ensure constant collaboration between hardware and software teams to align
6	Failure of electrical or mechanical components in provided arms.		Technical ; Schedule		1	5	<ol style="list-style-type: none"> 1. Conduct regular inspections to detect early signs of wear or failure in the joints. 2. Include safety checks to monitor for slippage or irregular motion.
RISK ID	NAME		TYPE				MITIGATION PLAN
7			Schedule		4	3	

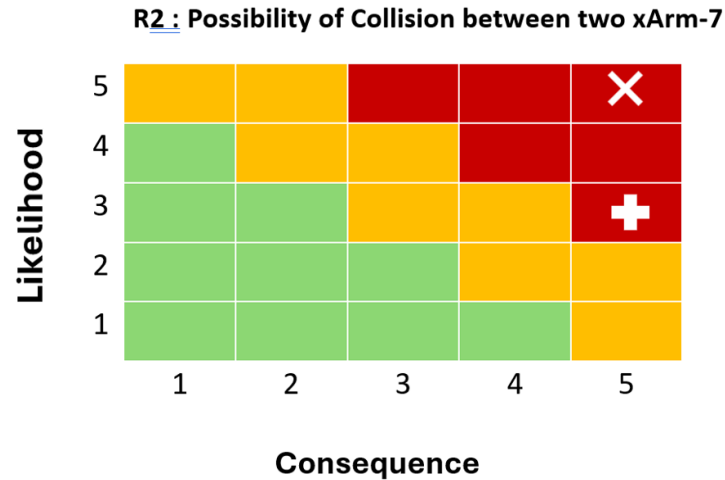
	Missed internal deadlines due to life conflicts						<ol style="list-style-type: none">1. Ensure critical deadlines are planned with some margin to allow flexibility.2. Break tasks into smaller milestones with rolling deadlines, allowing the team to recover from minor delays without significant disruption.3. Train multiple team members to handle critical tasks, ensuring continuity if someone is unavailable due to personal conflicts.4. Have regular scrums to avoid delays
8	One of the POCs for the project leaves or graduates, and information is lost		Technical; Schedule		5	2	<ol style="list-style-type: none">1. Schedule meetings for knowledge transfers between us and the PhD students.2. Get in touch with the new PhD student in advance of Dominik's graduation.3. Find other people in the lab for support with the project.

Risk ID	Risk Title	Risk Owner	Date Created
1	End-Effector Damage/Failure During Operation	Mechanical Design Engineer	10.09.2024
Description		Risk Type	Risk Level
Structural or functional breakdown of the gripper or cutter assembly due to excessive mechanical stress		Technical ; Schedule	80%
Consequence		Mitigation Plan	
<ol style="list-style-type: none"> System partially or fully inoperable, leading to unplanned downtime until repairs or replacements are made. A malfunctioning end-effector may compromise its precision, leading to incomplete or inaccurate cuts. 		<ol style="list-style-type: none"> Ensure the availability of spare end-effectors to mitigate downtime and maintain adherence to the timeline. Allocate extended buffer periods for end-effector testing to evaluate functionality and durability. 	

R1 : End-Effector Damage/Failure During Operation

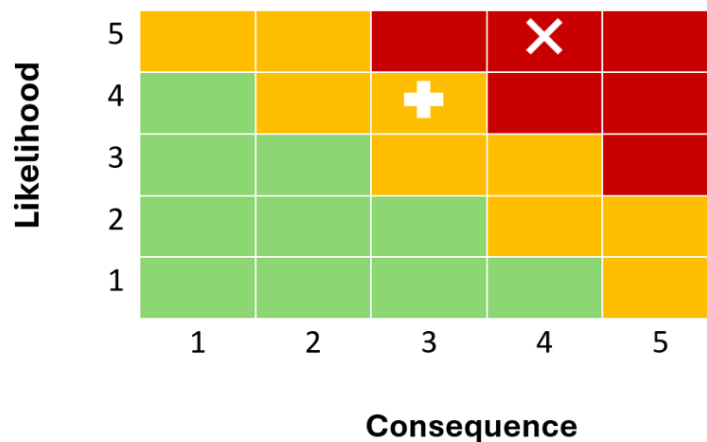


Risk ID	Risk Title	Risk Owner	Date Created
2	Possibility of Collision between two xArm-7	Robotics Systems Lead	12.03.2024
Description		Risk Type	Risk Level
Potential for physical collision between the two xArm-7 units during testing resulting in damaged components.		Technical	60%
Consequence		Mitigation Plan	
<ol style="list-style-type: none"> Could cause significant damage to critical components such as motors, or structural parts impacting operational efficiency. If severe damage then acquiring new xArm-7 units may be unaffordable, jeopardizing the continuation of the project and forcing a halt to further development. 		<ol style="list-style-type: none"> xArm-7 can be programmed with software constraints to define the allowable range of motion and hence "bound" their task space. Implement algorithms to detect collisions during path planning by analyzing the 3D environment map. Implement an emergency stop mechanism that instantly halts both arms' motion. Execute pre-deployment testing in simulation to identify potential failures. 	



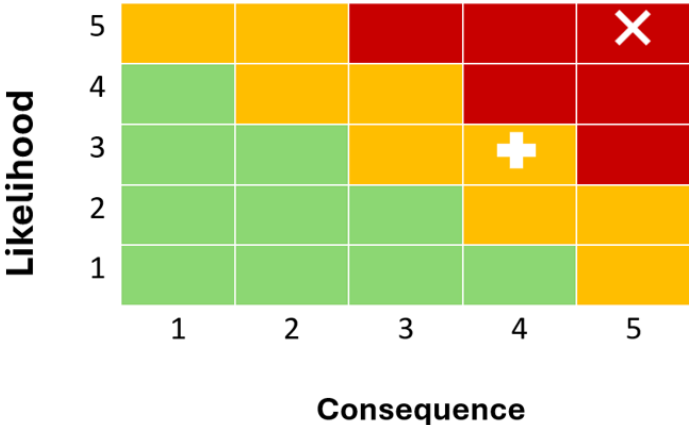
Risk ID	Risk Title	Risk Owner	Date Created
3	Unavailability/delay in access to the second XARM-7	Project Manager	18.10.2024
Description		Risk Type	Risk Level
Delay in accessing the second XARM-7 unit due to its extended use by other teams.		Schedule	70%
Consequence		Mitigation Plan	
<ol style="list-style-type: none"> Lack of timely access the second XARM-7 for testing can result in project schedule setbacks and challenges in meeting milestones. Need for reallocating resources and prioritizing tasks differently as a work around causing hinderance in productivity. Insufficient test runs for bimanual setup on the physical arms. 		<ol style="list-style-type: none"> Identify and prioritize tasks requiring the second XARM-7 to ensure critical testing is conducted during the allocated time. Prioritize testing in sim for two arm operation in case of delays in hardware testing. 	

R3 : Unavailability/delay in access to the second XARM-7



Risk ID	Risk Title	Risk Owner	Date Created
4	Integration issues with subsystem code due to different interfaces	System Integration Engineer	11.26.2024
Description		Risk Type	Risk Level
Challenges arising when integrating subsystem code due to mismatched or incompatible interfaces between different software modules.		Technical ; Schedule	90%
Consequence		Mitigation Plan	
1. Version control is not properly implemented leading to integration issues for different subsystems. 2. Each subsystem may have its own specific input and output parameters, which may not align or be compatible when integrated.		3. Enforce strict version control practices using systems like Git. 4. Implement continuous integration (CI) practices to test the integration of subsystems frequently. 5. Clearly define API interfaces between subsystems, ensuring compatibility in terms of data types, formats, and protocols.	

R4 : Integration issues with subsystem code due to different interfaces



Risk ID	Risk Title	Risk Owner	Date Created
5	Compatibility Issues in Hardware and Software Interfaces	Project Lead	09.30.2024
Description		Risk Type	Risk Level
Hardware-Software Integration Issues failure to exchange data correctly, misinterpretation of commands, or inability to synchronize operations effectively		Technical ; Schedule	75%
Consequence		Mitigation Plan	
<ol style="list-style-type: none"> The system may experience functional breakdowns due to incompatible data formats or communication protocols. Resolving compatibility issues often requires extensive code modification and potential redesigning. Persistent integration issues can jeopardize meeting project deadlines and milestones. 		<ol style="list-style-type: none"> Develop a software layer or interface to simplify how the program communicates with hardware making it easier to swap or upgrade hardware. Ensure constant collaboration between hardware and software teams to align expectations, particularly for sensor calibration and data interpretation. 	

R5 : Compatibility Issues in Hardware and Software Interfaces

