

The background of the slide is a composite image. On the left side, there is a close-up of a white robot head with a yellow visor and black markings. On the right side, there is a blurred landscape featuring a body of water and distant mountains under a hazy sky.

PatrolKnight

Intelligent Patrol Security Robotics System

Team E: Sam Dong, Po-Ting Ko, Leo Xu, Pin-Wen Wang, Joshua Tsai



Our Team



Sam Dong



Po-Ting Ko



Leo Xu



Pin-Wen Wang



Joshua Tsai



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Project Description



User needs

- \$50/hr → \$3/hr
- \$758K → \$7000
- Efficient and reliable patrol coverage in large environments
- Reduced manual workload for security personnel
- Real-time awareness of abnormal activities





Proposed Method

- **AI-assisted waypoint recommendation for efficient patrol coverage**
- **Autonomous robot patrol with minimal human intervention**
- **Real-time monitoring and anomaly alerts to operators**
- **Dynamic response to incidents with human-in-the-loop control**





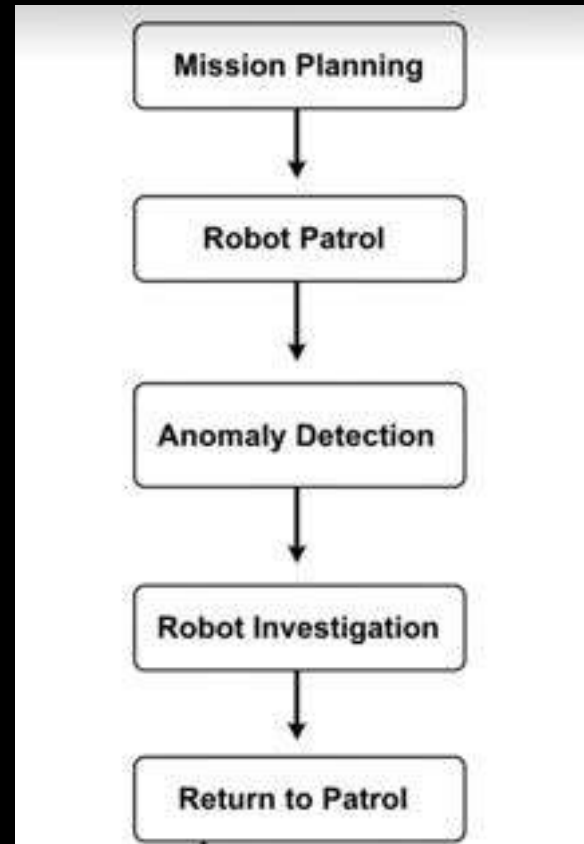
Use Case



Use cases

Workflow

1. Operator opens dashboard and reviews suggested waypoints
2. Operator confirms or edits patrol route
3. Robot autonomously patrols environment
4. System monitors and detects anomalies
5. Robot is redirected to investigate if needed
6. Operator verifies alerts and system resumes patrol





System-level Requirements



System-level Requirements

IDs	Functional Requirement
F.R.1	Provide waypoint suggestion to the user
F.R.2	Receive waypoints from the user
F.R.3	Enable K7 to navigate
F.R.4	Visualize patrol status
F.R.5	Detect anomaly
F.R.6	Redirect K7
F.R.7	Support alarm verification

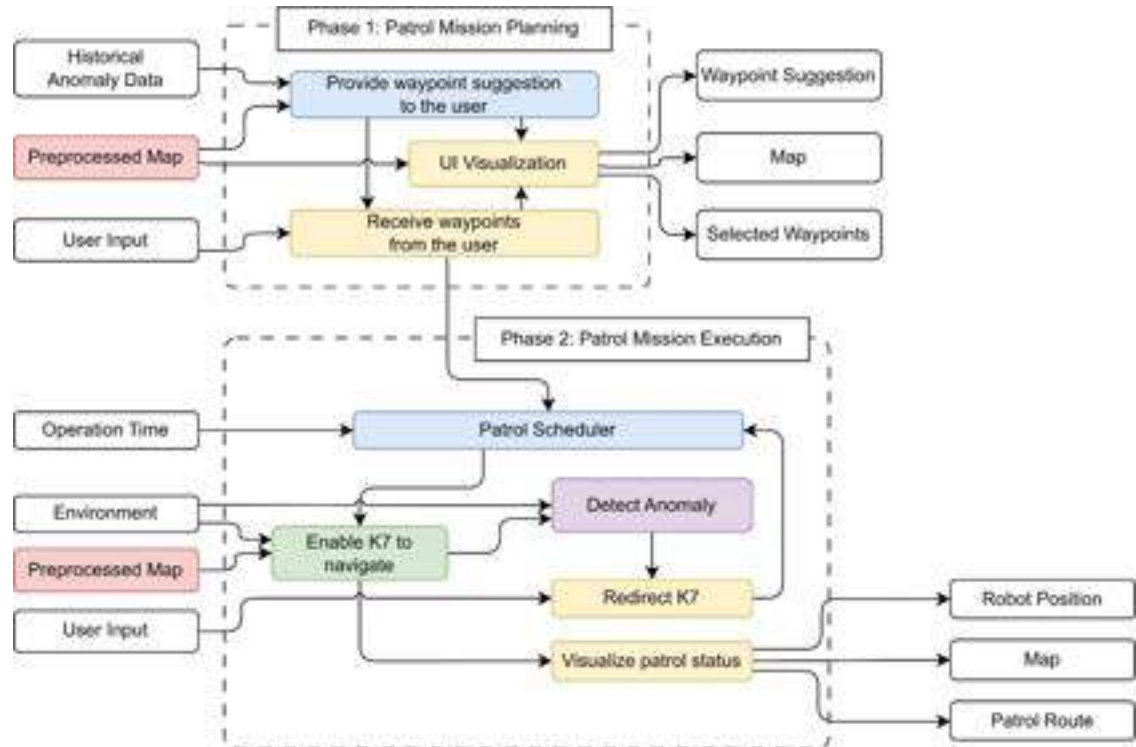


System Architecture



Functional Architecture

- Two Phases
 - Mission Planning
 - Mission Execution
- Anomaly Handling
- Human-in-the-loop





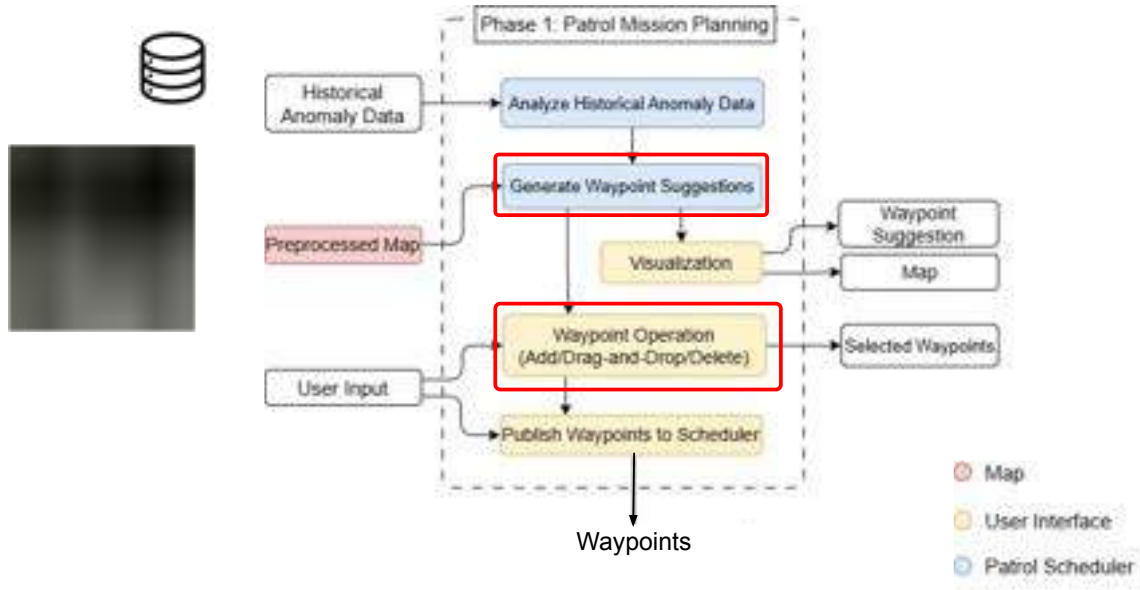
Functional Architecture

- Two Phases
 - Mission Planning
 - Mission Execution
- Anomaly Handling
- Human-in-the-loop



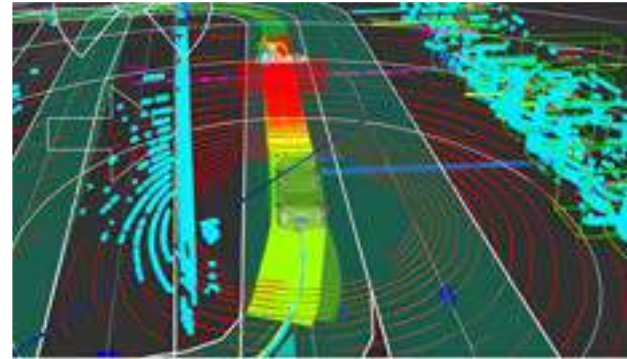


Patrol Mission Planning



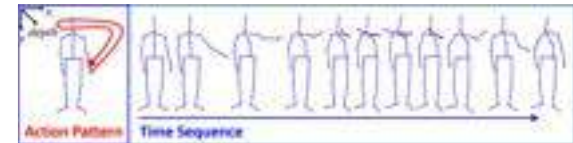
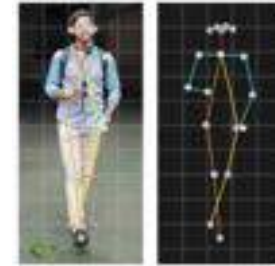
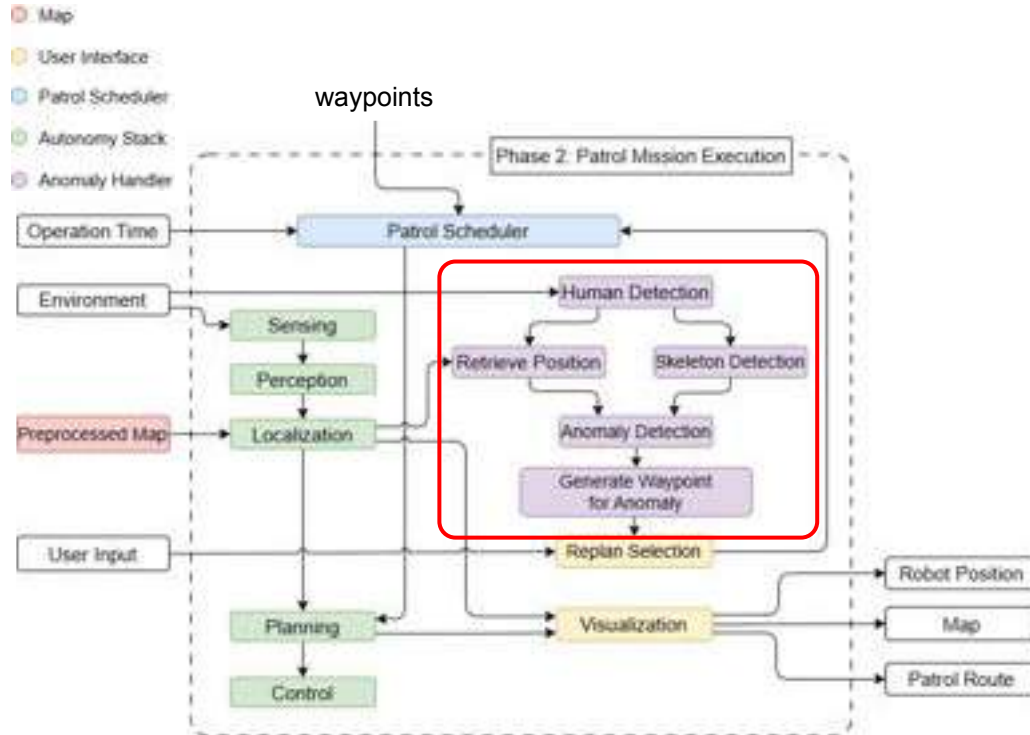


Patrol Mission Execution



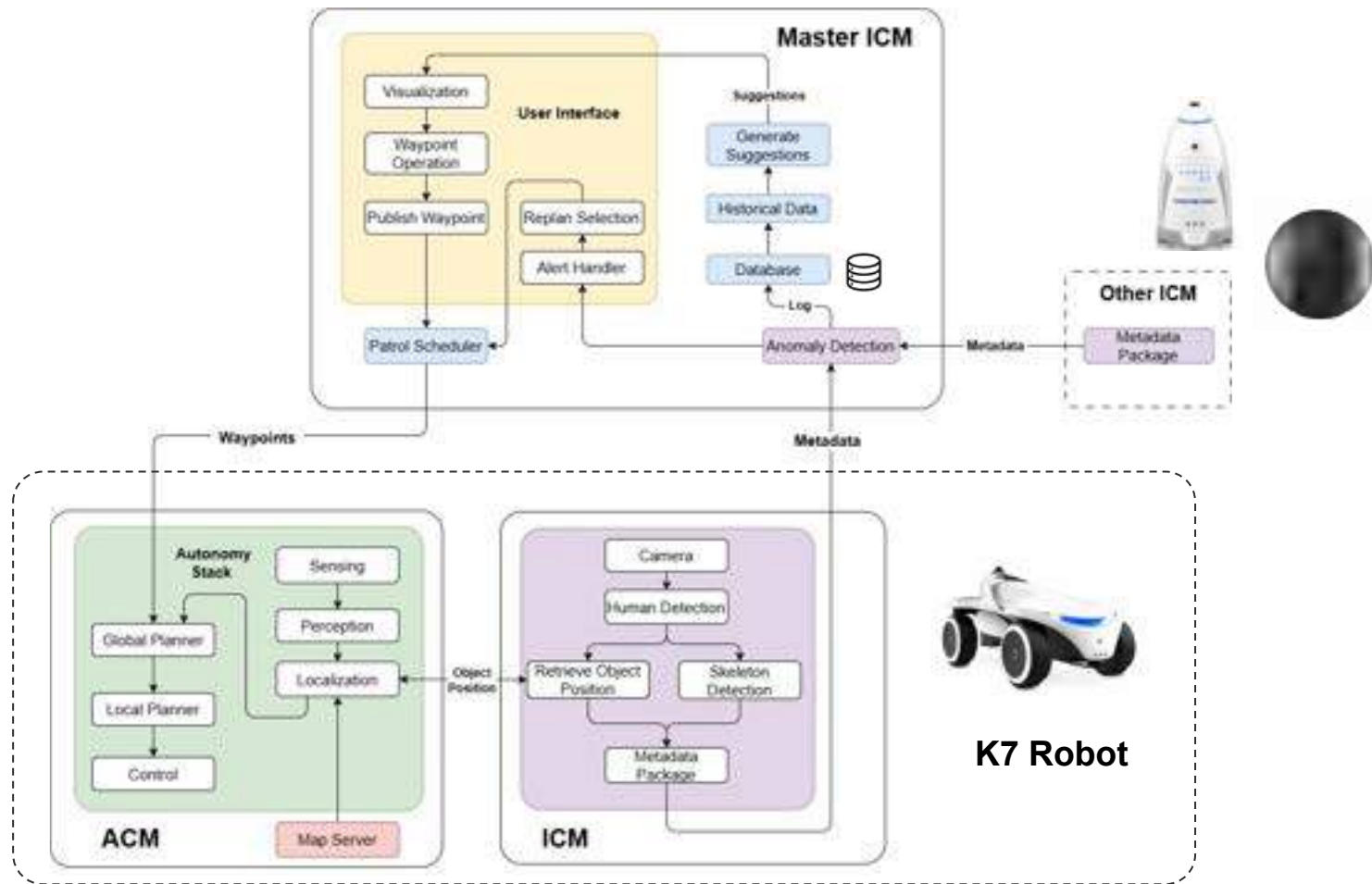


Patrol Mission Execution



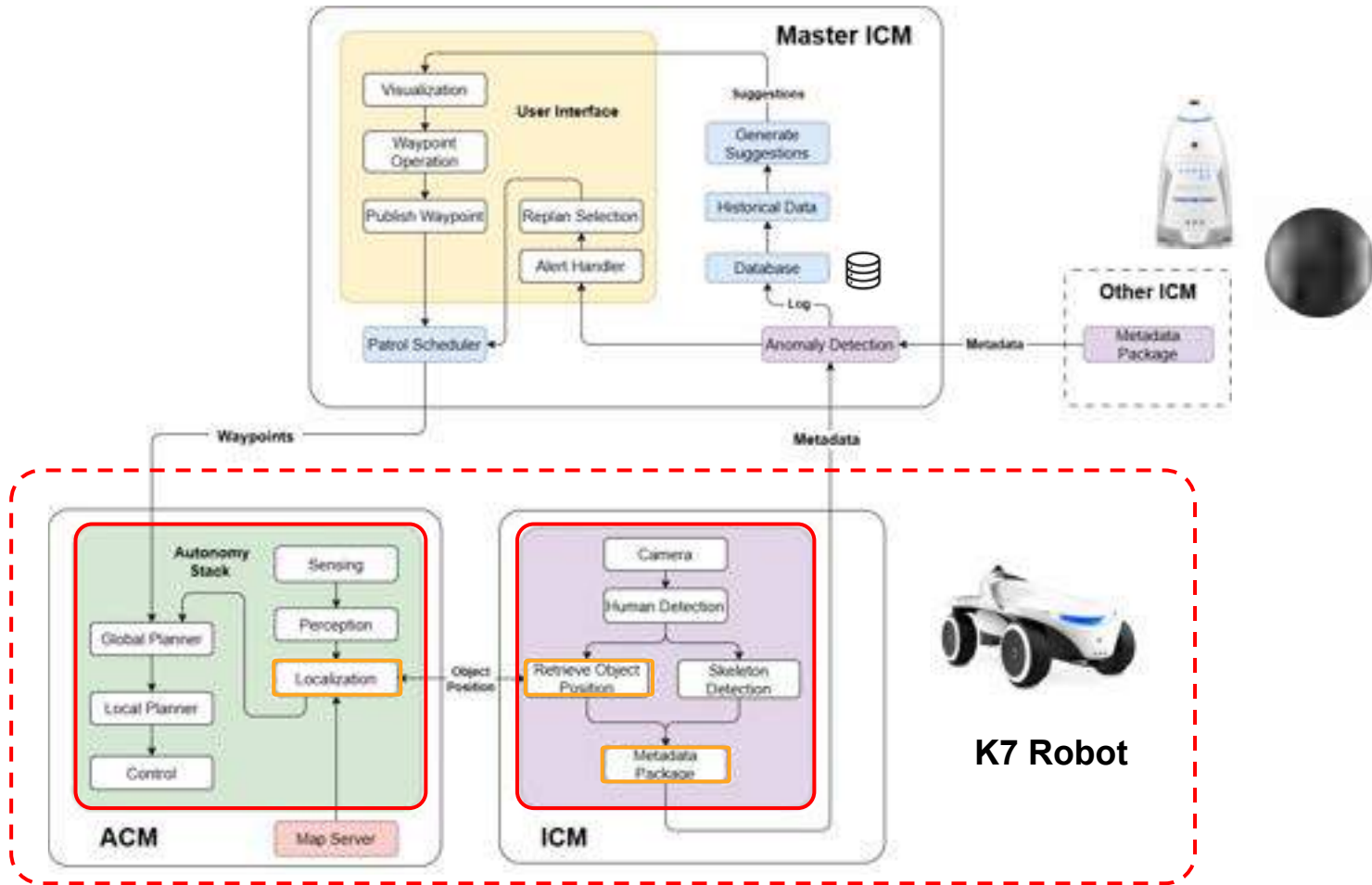


Cyberphysical Architecture



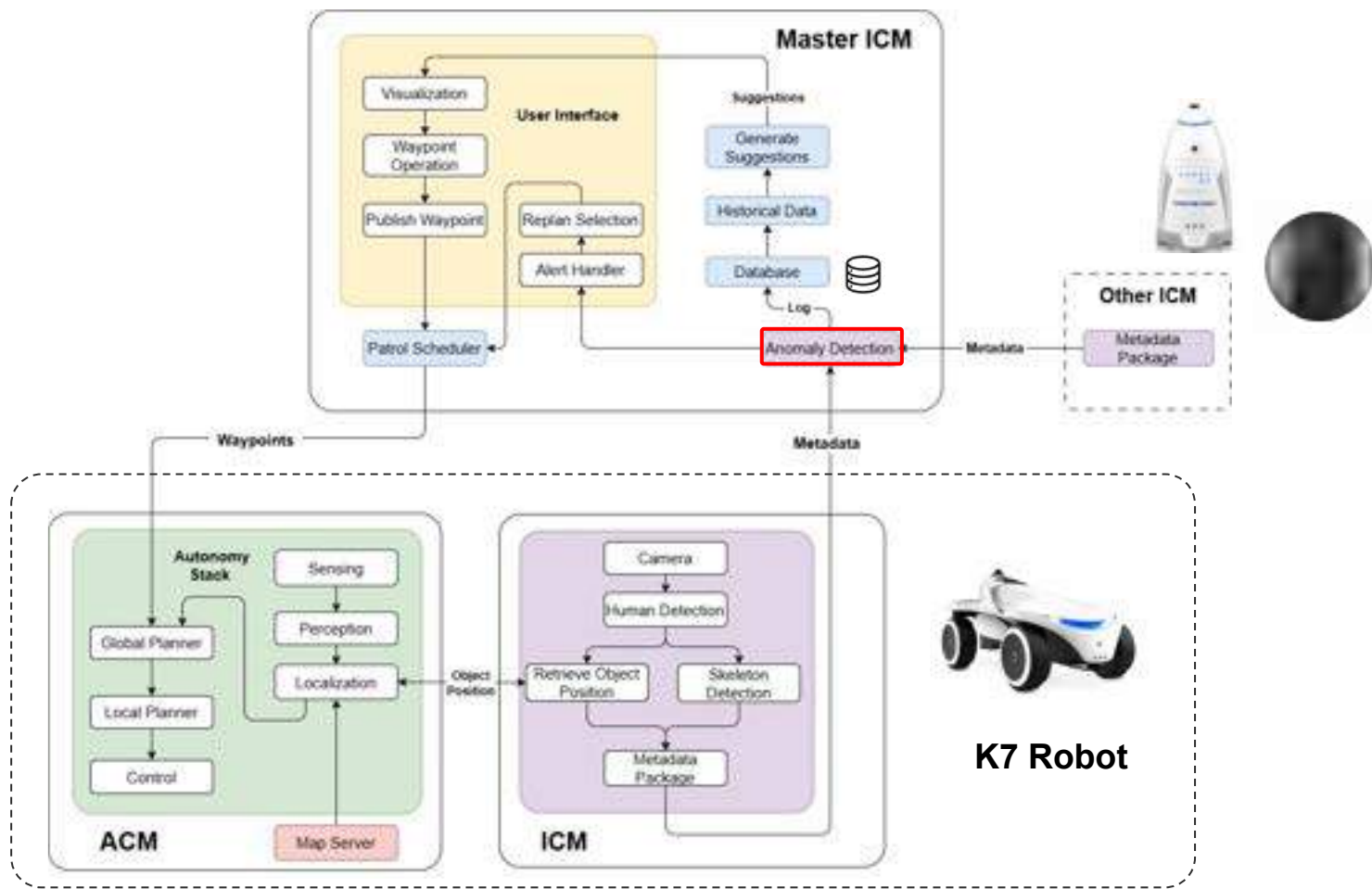


Cyberphysical Architecture



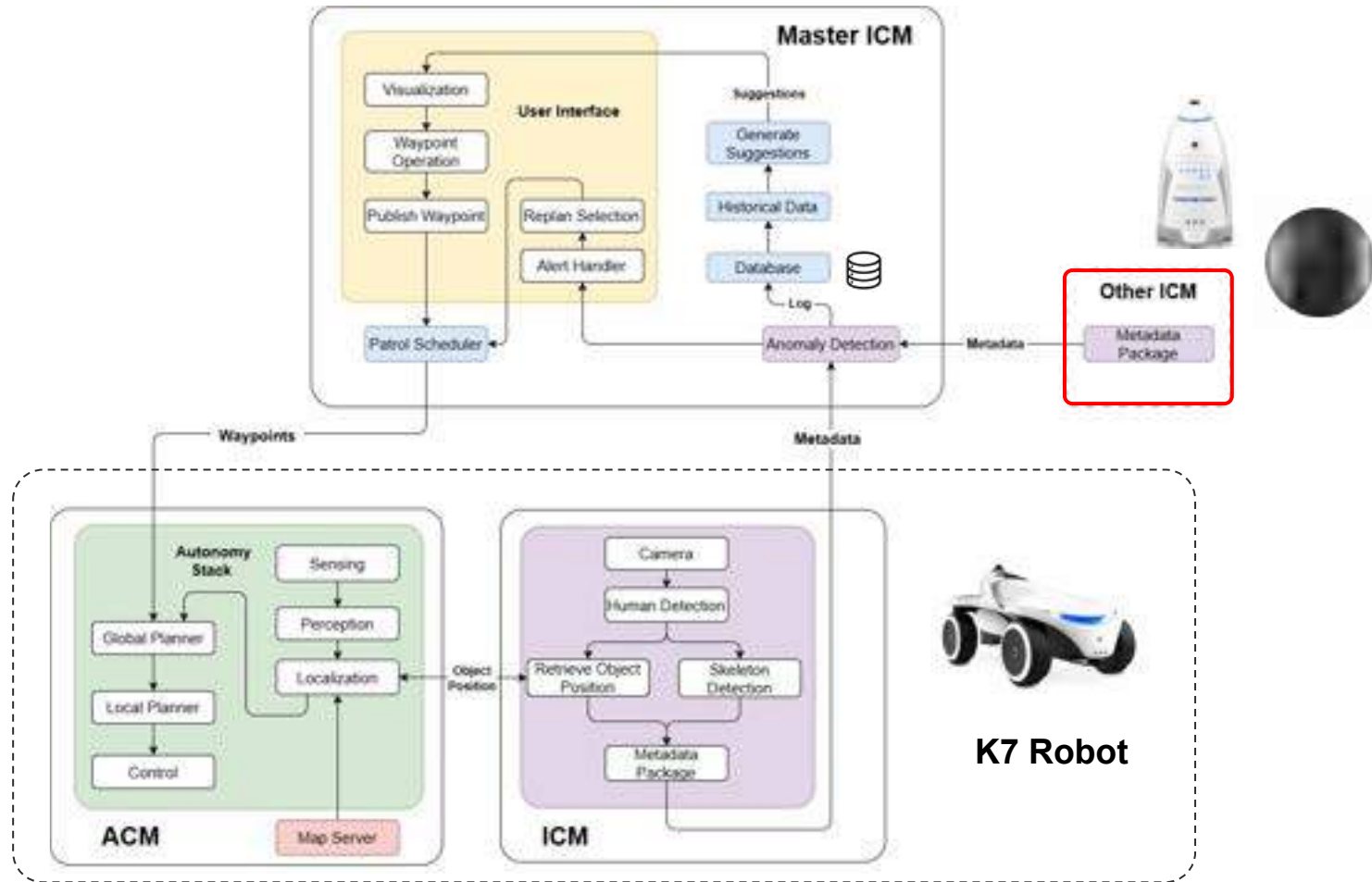


Cyberphysical Architecture



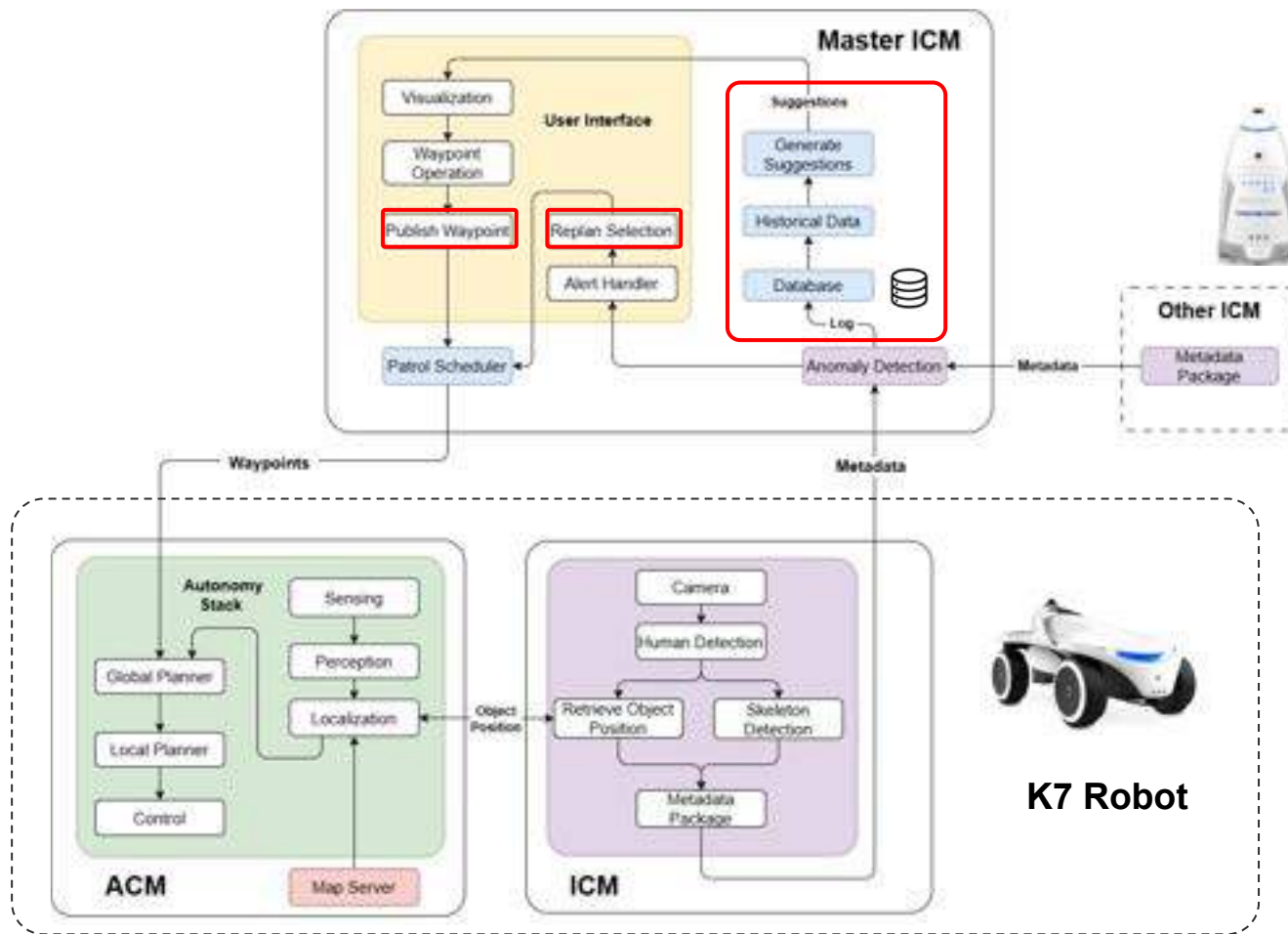


Cyberphysical Architecture





Cyberphysical Architecture





Current System Status

Targeted Requirements

IDs	Functional Requirement
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User Interface
Subsystem

- Frontend Server
- Bridge Node
- Communication

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Autonomy Subsystem

- F1TENTH
- Simulation

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User Interface
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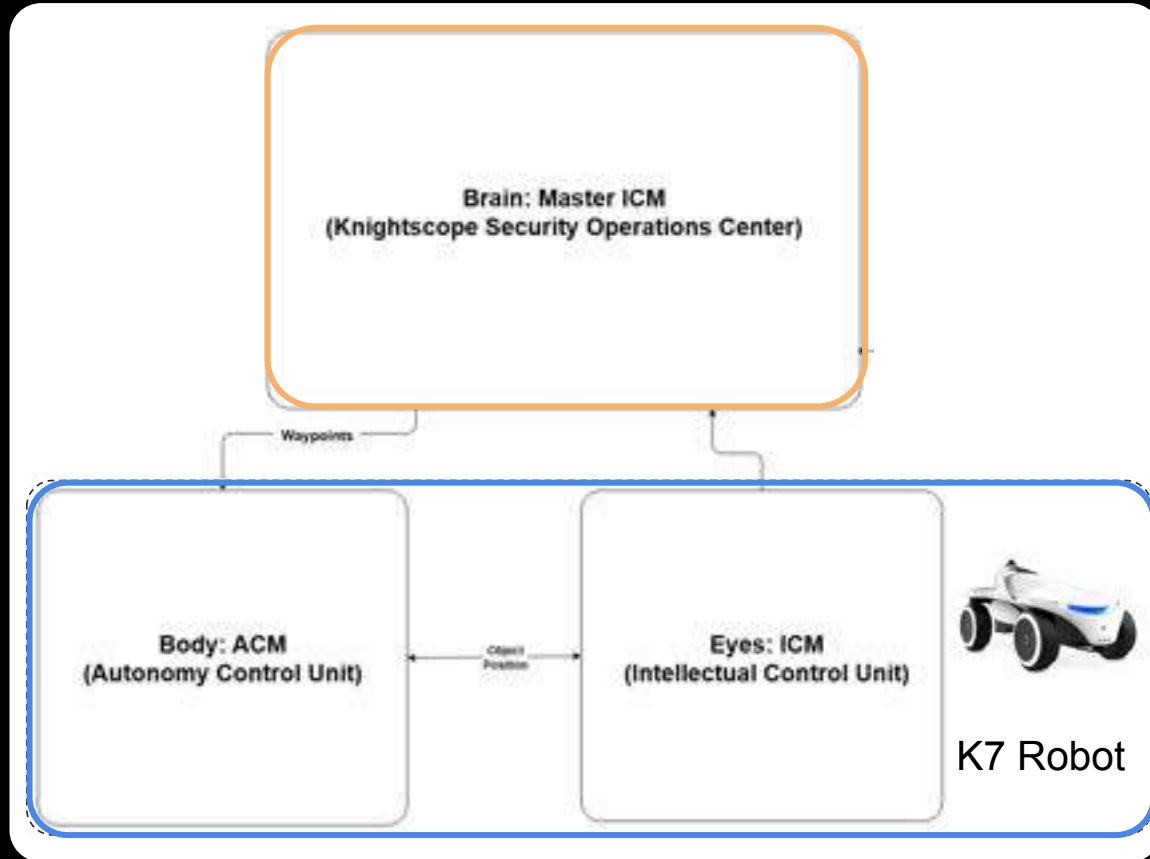
Autonomy Subsystem

- F1TENTH
- Simulation

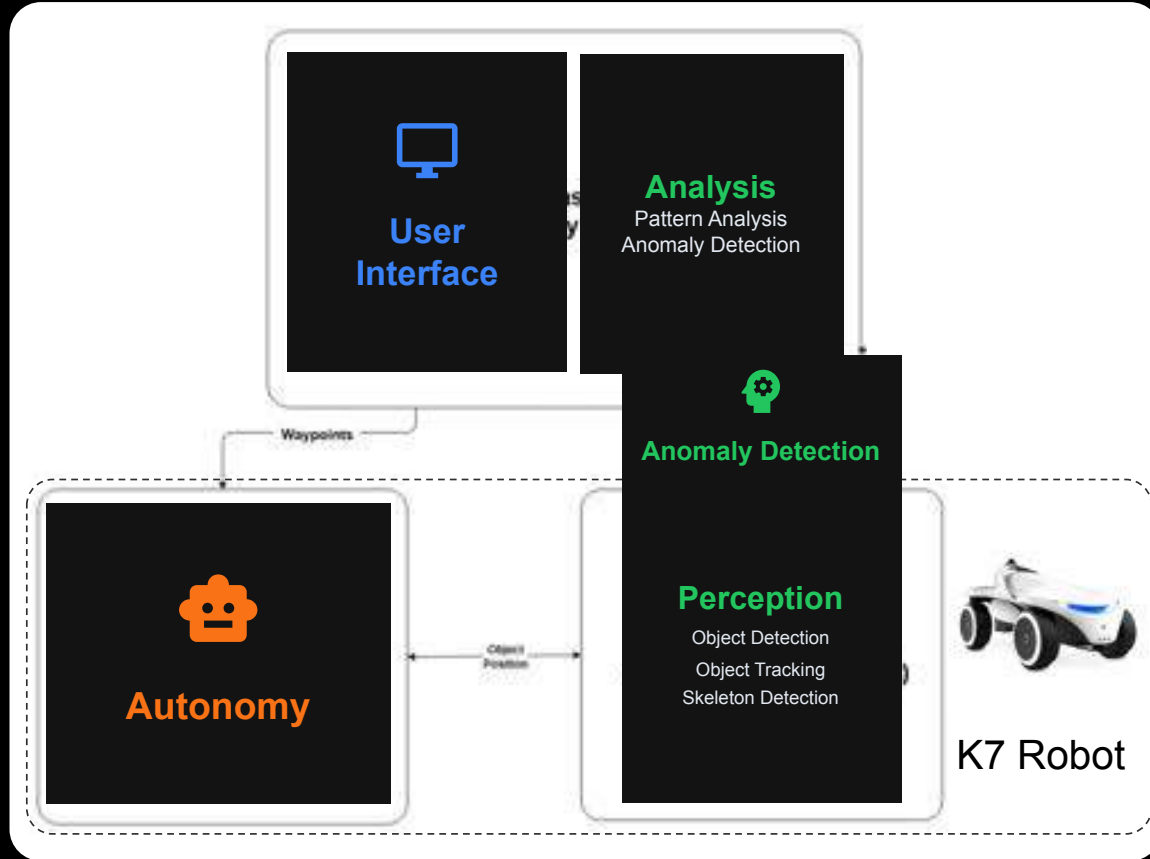
Anomaly Detection
Subsystem

- RealSense D435i
- Skeleton Detection
- Anomaly Detection

Overall System Depiction



Overall System Depiction





Prototype Recap



Prototype 1: F1TENTH

Scale Autonomous Racing Platform



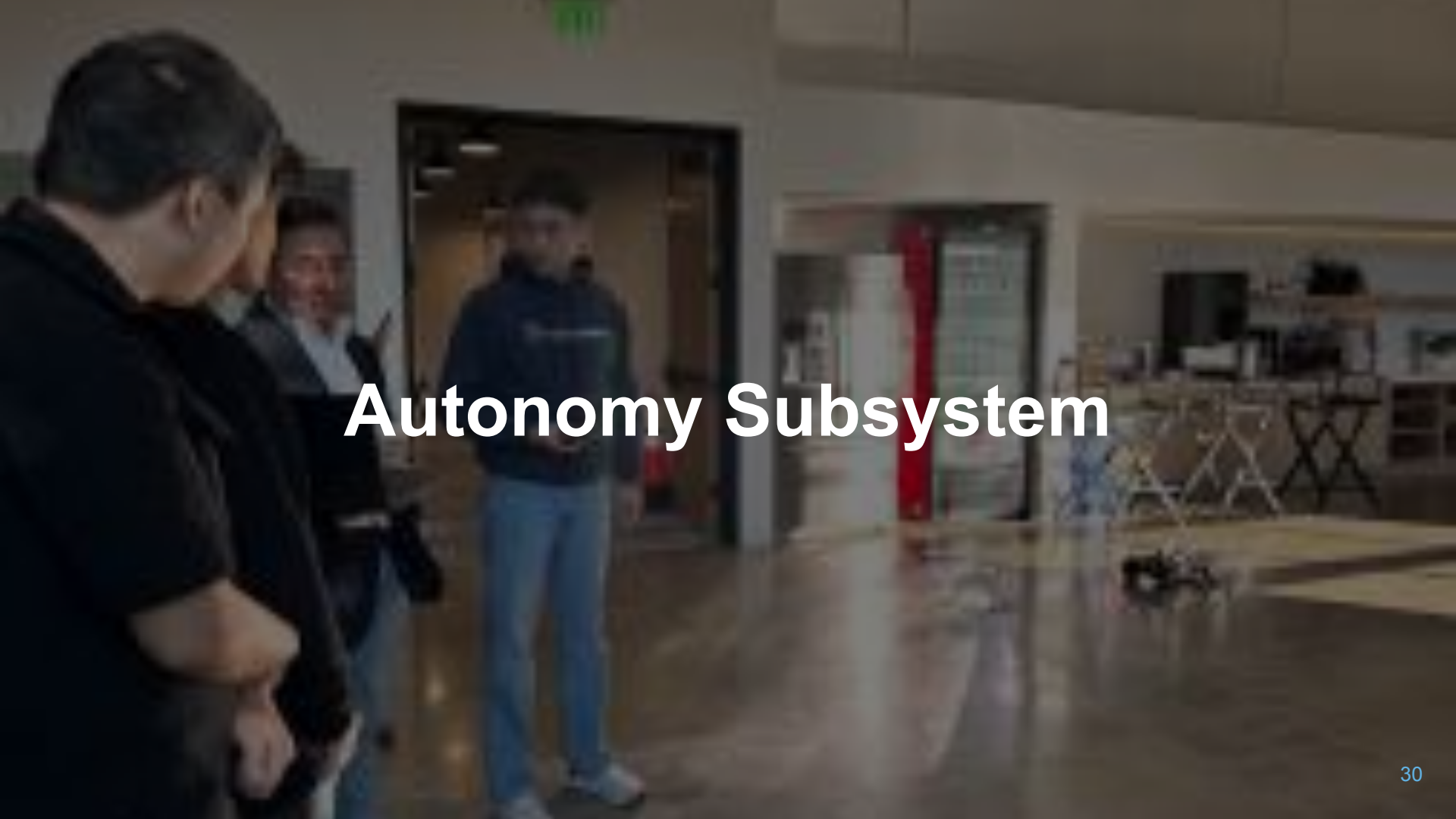
Prototype 2: LSV

Low-Speed Vehicle Platform



Prototype 3: K7

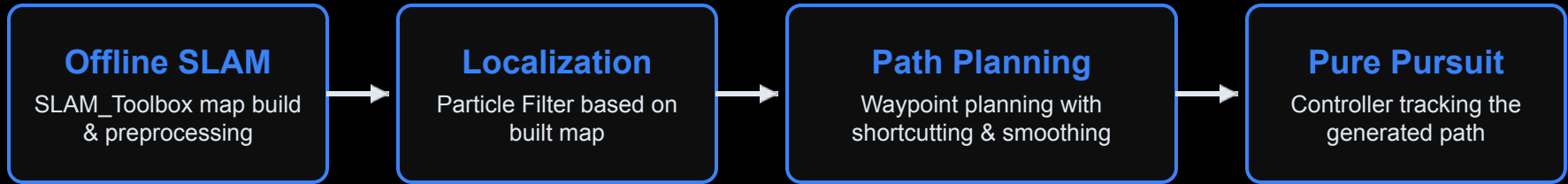
Knightscope Autonomous Security Robot



Autonomy Subsystem

Subsystem Description

F1TENTH Autonomy Pipeline (PDR Progress)



Implementation Details:

- SLAM Toolbox provides **offline map** generation followed by map preprocessing
- **Particle Filter** utilizes robot odometry (/scan, /odom) and the point map for **robot localization**.
- Planning unit consumes user waypoints to output a **smoothed path** for the controller.
- **Pure Pursuit Controller** manages vehicle-specific steering and velocity to track the trajectory.



Mapping

Acceptance Criteria:

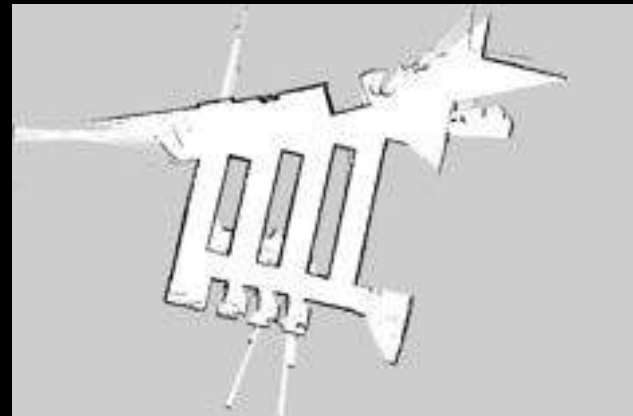
- **Offline** map preprocessing
- Ensure **map consistency** with no structural misalignment, dynamic obstacles, and outliers.



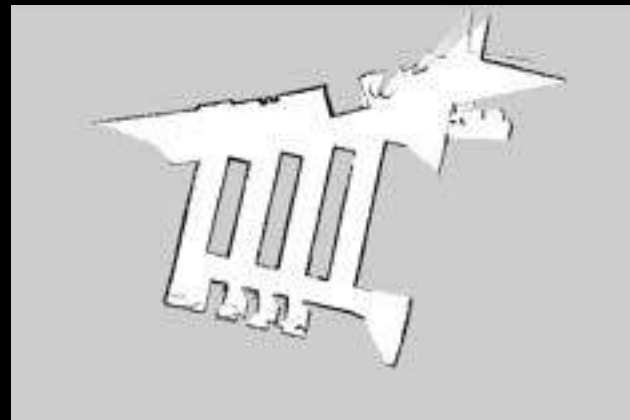
Dynamic Object, Outlier



Point Behind Wall



Raw Map



Static Map

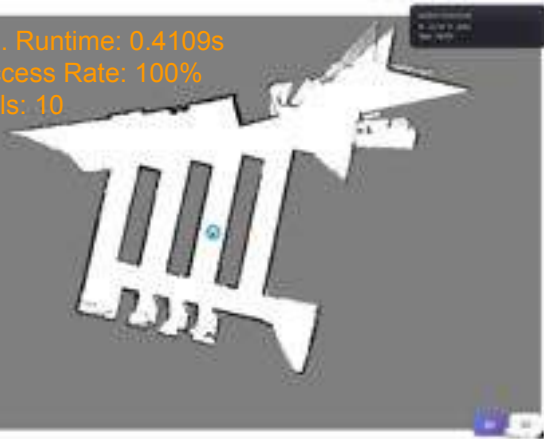


Initialization / Localization

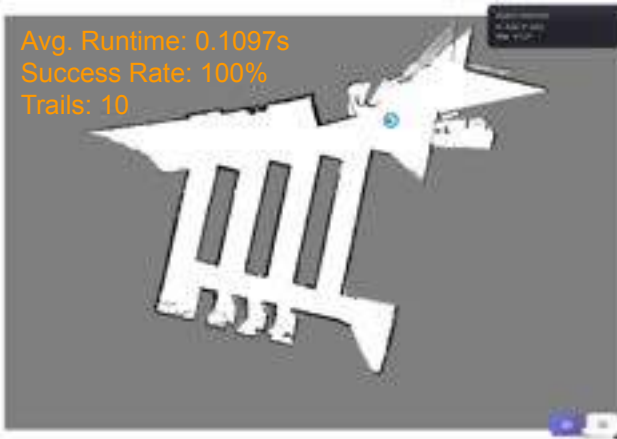
Acceptance Criteria:

Initialize F1TENTH with a **success rate > 90% at multiple locations.**

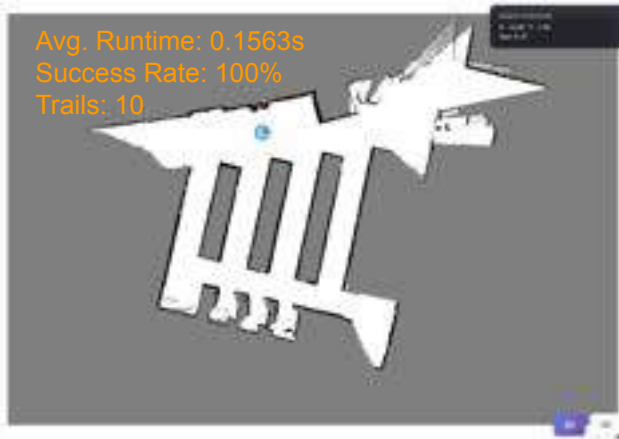
Avg. Runtime: 0.4109s
Success Rate: 100%
Trails: 10



Avg. Runtime: 0.1097s
Success Rate: 100%
Trails: 10



Avg. Runtime: 0.1563s
Success Rate: 100%
Trails: 10





Initialization / Localization

Acceptance Criteria:

- Localize F1TENTH with **x and y covariance** < 0.01
- Localize F1TENTH with **yaw covariance** < 0.005





Planning

Acceptance Criteria:

- Plan a collision-free and geometrically trackable path whose **95th-percentile** curvature is below the vehicle **limit 1.55**.

$$L = 0.30 \text{ m}$$

$$\delta_{\max} = 25^\circ$$

$$\kappa_{\max} = \frac{\tan(25^\circ)}{0.30} \approx 1.55 \text{ m}^{-1}.$$

F1TENTH **Curvature Limitation**

$$\theta_i = \arccos \left(\frac{\mathbf{v}_1 \cdot \mathbf{v}_2}{\|\mathbf{v}_1\| \|\mathbf{v}_2\|} \right)$$

$$\Delta s_i = \frac{\|p_i - p_{i-1}\| + \|p_{i+1} - p_i\|}{2}$$

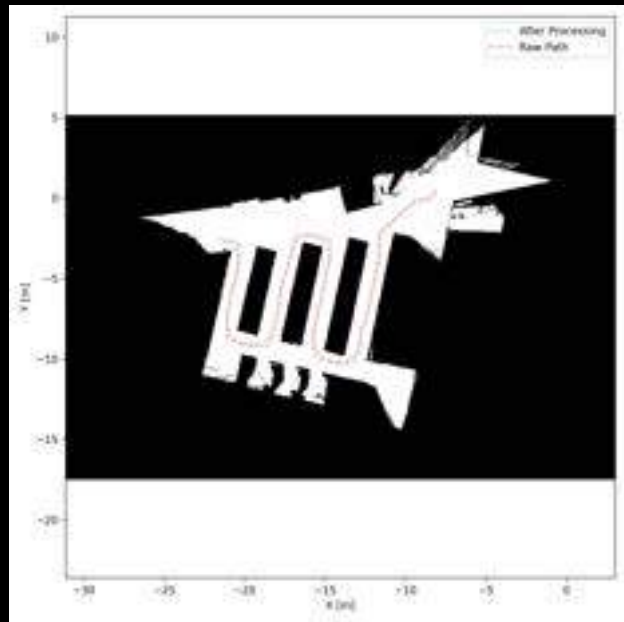
$$\kappa_i \approx \frac{\theta_i}{\Delta s_i}$$

Discrete Curvature for Path
With Requirement:

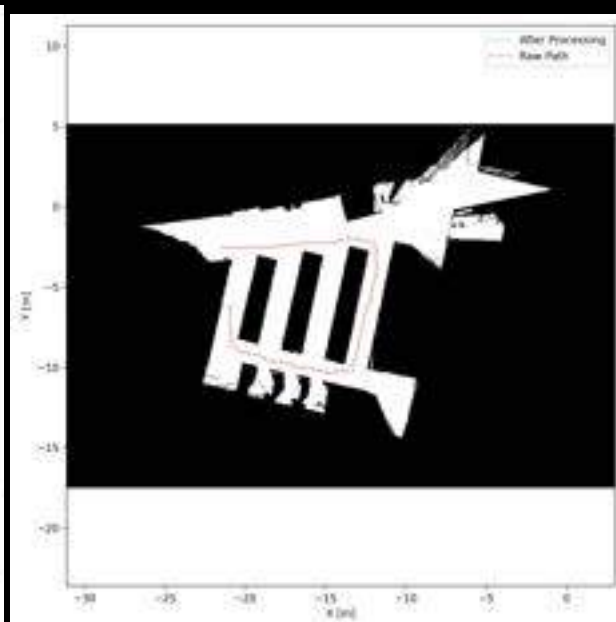
$$P_{95}(|\kappa|) = 95\text{th percentile of curvature, } P_{95}(|\kappa|) \leq 1.55 \text{ m}^{-1}$$



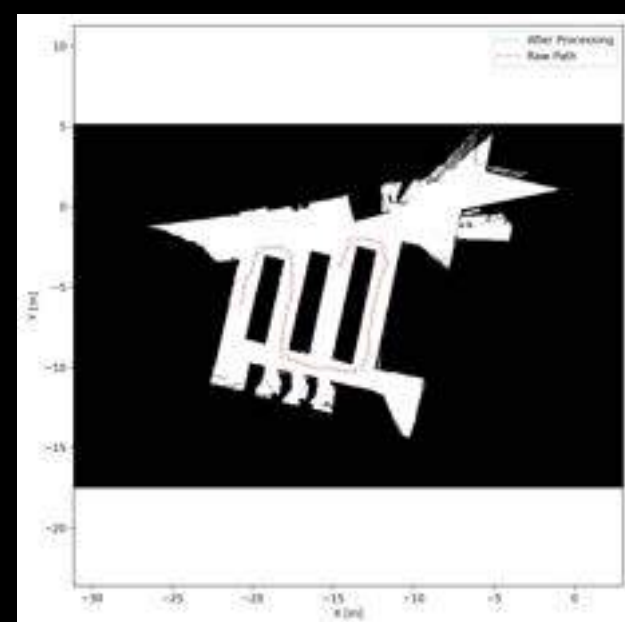
Planning



Path	Length	Curv95
Raw	42.50	5.81
Smooth	39.38	1.14



Path	Length	Curv95
Raw	29.12	5.81
Smooth	27.46	0.97



Path	Length	Curv95
Raw	30.55	5.81
Smooth	27.97	1.24



Pure Pursuit Controller

Acceptance Criteria:

- Patrol along the path with **Cross-Track Error (CTE) < 5cm. (Straight Line)**
- Patrol along the path with **Cross-Track Error (CTE) < 50cm. (Turning)**

Reason: CTE when turning is way larger than tracing straight line.





Autonomy Control Module (ACM)

Limitations of F1TENTH in real-world deployment

- Requires full autonomy stack (mission / behavior / local planning)
- Needs behavior tree / state machine for robust execution
- Requires scalable SLAM (e.g., LIO-SAM, NDT)

Migration to ACM (Knightscope)

- Provides production-level autonomy capabilities
- Enables scalable and real-world-ready system design

Current focus: simulation

- Physical robot not yet available
- Develop and validate system using simulation environment (RViz2)



A photograph of two people, a man and a woman, sitting at a desk in a dimly lit room. They are both looking at a laptop screen. The man is on the right, wearing a blue and white striped shirt, and the woman is on the left, wearing a light-colored top. In the background, there is a large screen displaying a greenish image. The overall atmosphere is focused and professional.

User Interface Subsystem

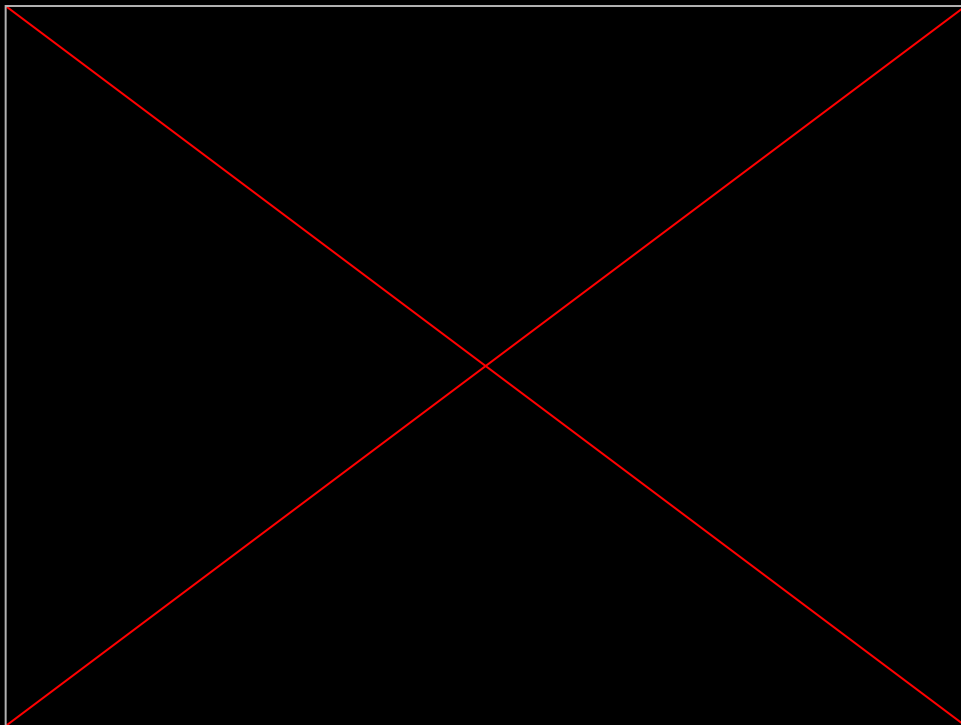
Subsystem Description

Capabilities

- **Operate** waypoint
(add / delete/ drag-and-drop)
- Visualize **path**
- Visualize **robot status**

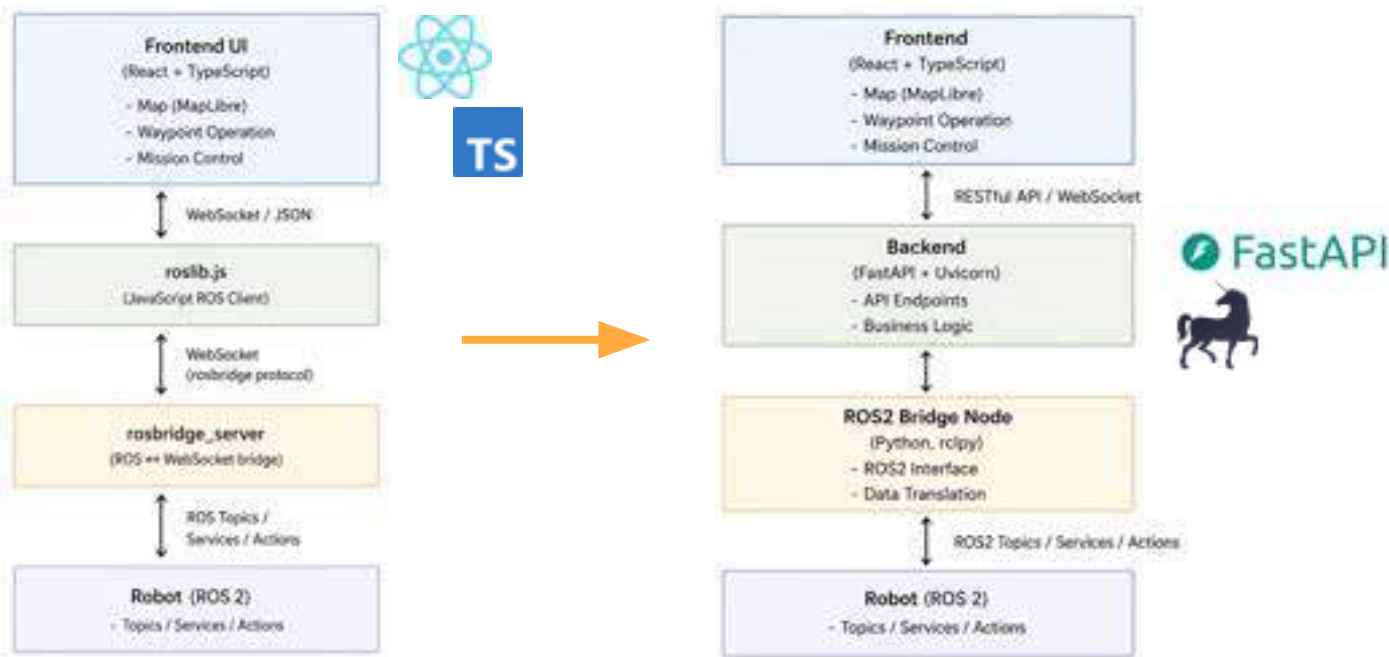
F1TENTH Interface

- Manually Initialization
- Occupancy Map



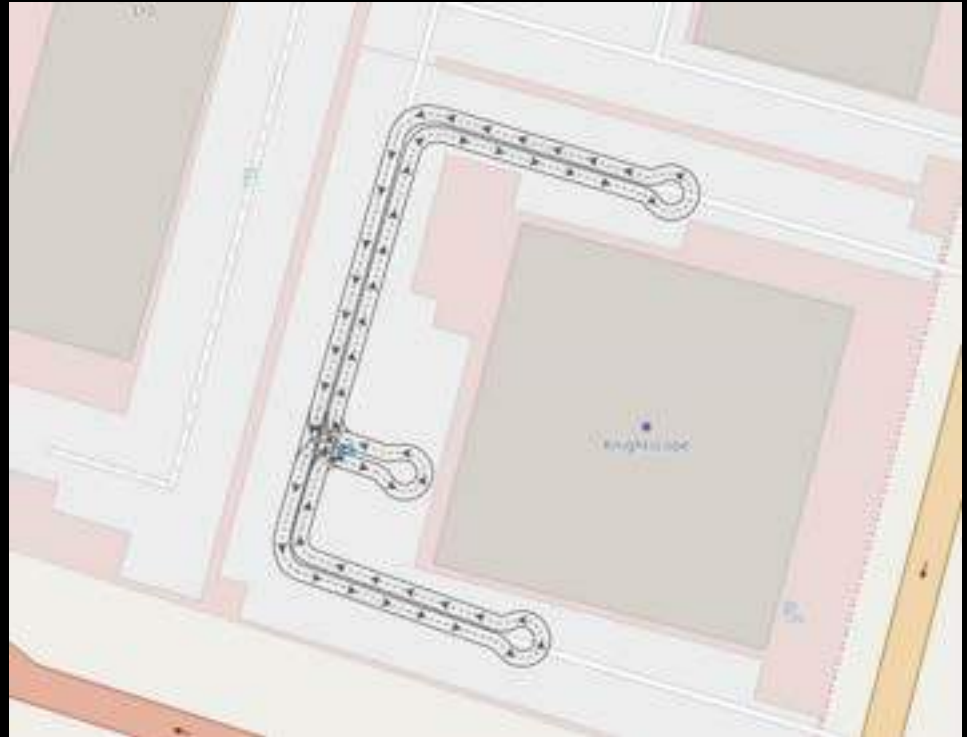
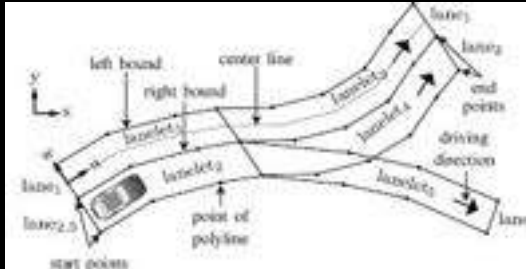
User Interface Migration

- Enable **scalable and stable** system architecture
- Support future extensions (**scheduler, AI modules**, database integration)



Lanelet Map

- Transition from occupancy maps to **lanelet-based maps**
- Enable lanelet-based route planning
- Provide route-level information (**distance, ETA**)



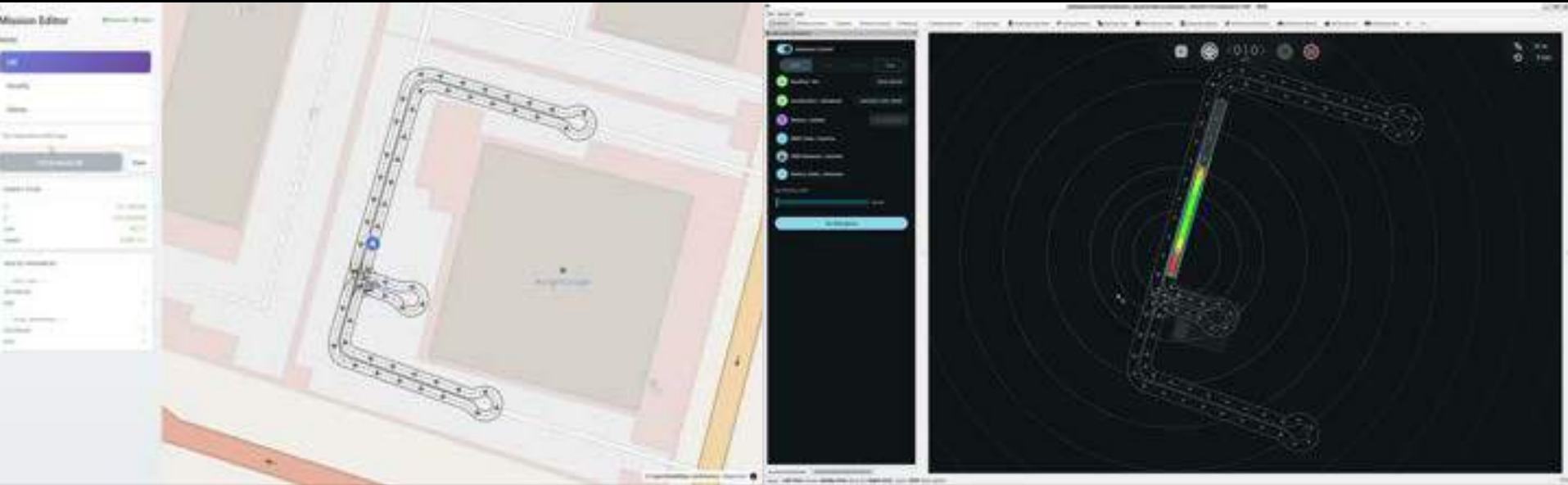
Heading Assignment & Waypoint Scheduler

- Infer **waypoint orientation** from lanelet geometry (given position-only input)
- Develop a **sequential mission scheduler** with integrated state management



	Input: $(x, y, yaw) = (-62.8, 37.5, 0.0)$ Output: $(x, y, yaw) = (-62.8, 37.5, 1.28)$ lanelet_id = 848
	Input: $(x, y, yaw) = (-49.2, 41.5, 0.0)$ Output: $(x, y, yaw) = (-49.2, 41.5, 3.10)$ lanelet_id = 3220
	Input: $(x, y, yaw) = (-24.7, 86.8, 0.0)$ Output: $(x, y, yaw) = (-24.7, 86.8, -0.29)$ lanelet_id = 3022

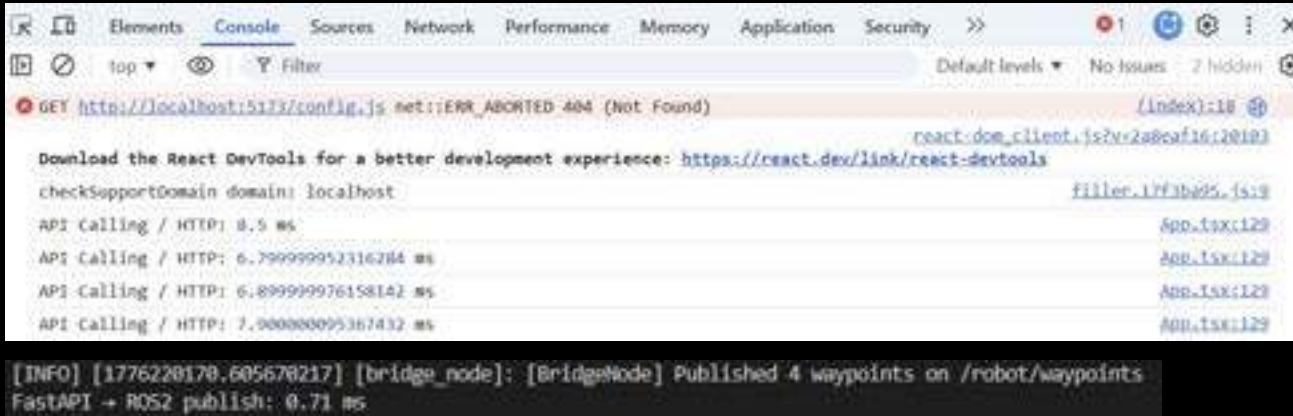
Demo



Performance Evaluation

Acceptance Criteria:

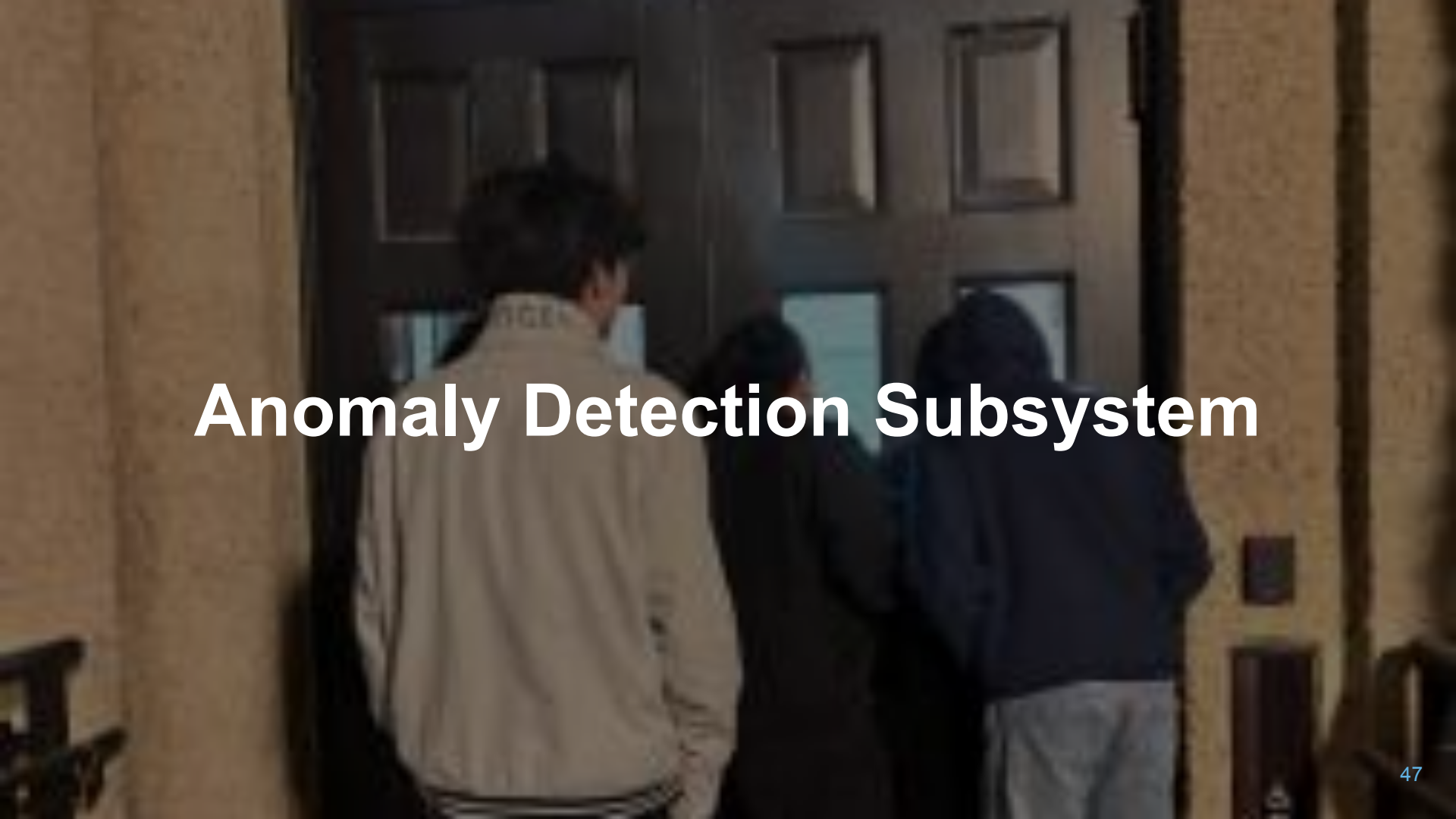
- ✓ User interface can **real-time display robot status**.
- ✓ The waypoint publishing should execute **within 50 ms**.



The screenshot shows the Chrome DevTools Console with the 'Console' tab selected. It displays a network error for 'GET http://localhost:5173/config.js' and a series of 'API Calling / HTTP' logs with timestamps. Below the console, a terminal window shows a message: '[INFO] [1776228178.605678217] [bridge_node]: [BridgeNode] Published 4 waypoints on /robot/waypoints' and 'FastAPI -> ROS2 publish: 0.71 ms'.

```
GET http://localhost:5173/config.js net::ERR_ABORTED 404 (Not Found)
Download the React DevTools for a better development experience: https://react.dev/link/react-devtools
checkSupportDomain domain: localhost
API Calling / HTTP: 8.5 ms
API Calling / HTTP: 6.7999999952316284 ms
API Calling / HTTP: 6.8999999976158142 ms
API Calling / HTTP: 7.000000005367432 ms
[INFO] [1776228178.605678217] [bridge_node]: [BridgeNode] Published 4 waypoints on /robot/waypoints
FastAPI -> ROS2 publish: 0.71 ms
```

Frontend to Backend	Bridge Node	ROS2 Execution	Total
7.6 ms (average)	0.78 ms (average)	2.1 ms (average)	10.48 ms (average)



Anomaly Detection Subsystem



Subsystem Description

Live Skeleton Detection

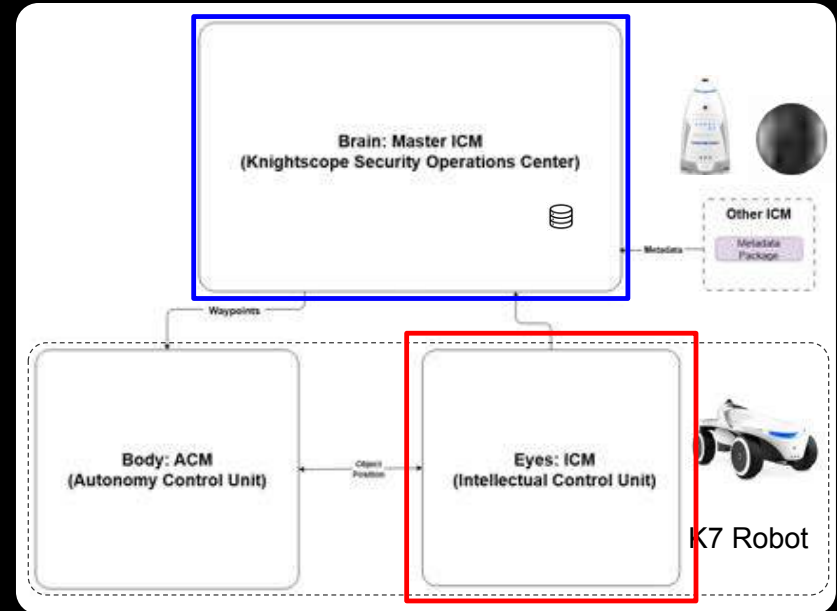
Real-time tracking of human joints and connections

Anomaly Analysis

- Fighting detection
- Trespassing alerts
- Falling incident detection
- ...

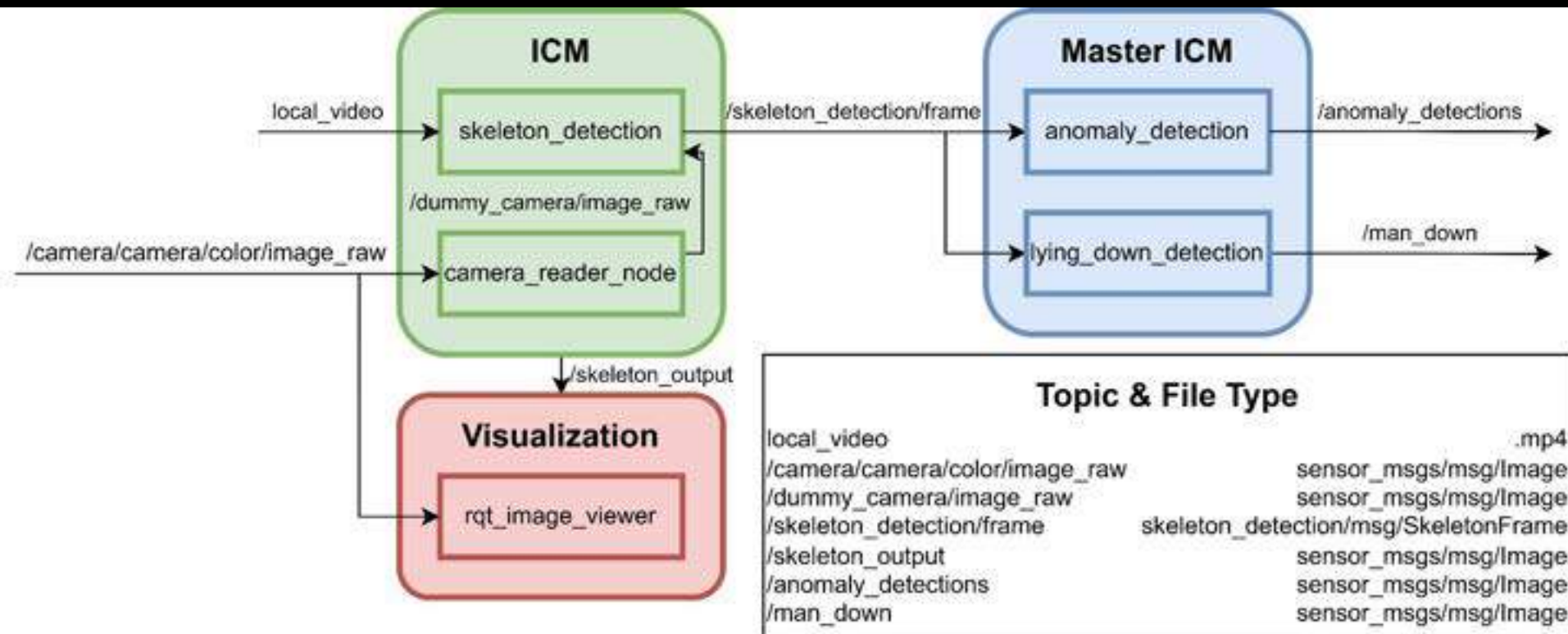
Lying Down Detection

Specific identification of person lying on the ground.





Subsystem Description





Model Selection (Skeleton Detection)

Top-down Pose Estimation Method: **bounding box** → **joints**

The most accurate but become **slower** as the number of people in the frame increases.

Bottom-up Pose Estimation Method: **joints** → **person**

Speed is constant regardless of how many people are in the scene.





Model Selection (Skeleton Detection)

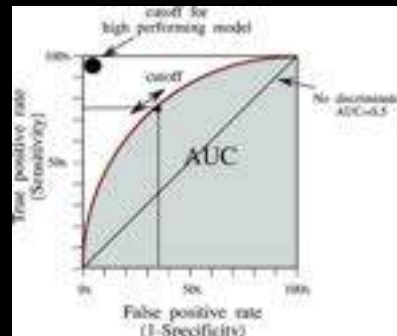
Evaluation Criteria	Weight	OpenPifPaf	OpenPose	HigherHRNet	MoveNet
Far-Field / Low-Res Accuracy	40%	5	3	4	2
Handle Occlusion	20%	5	4	3	2
Inference speed	20%	4	2	2	5
Deployment Difficulty (API compatability)	20%	4	3	3	4
Total Weighted Score	100%	4.6	3	3.2	3



Model Selection (Anomaly Detection)

- Dataset: **HR-Shanghai Tech**
 - Defined anomaly actions are likely happened around campus, meeting the needs of our use case
- Stage 1: **Graph Jigsawed Conditioned Diffusion model**
Anomaly score
- Stage 2: **Bart-large-mnli**
Zero-shot LLM
Anomaly classification

AUROC: Area under curve



Method	Params	AUROC
AED-SSMTL [◇] [12]	>80M	61.3
TimeSformer [◇] [3]	121M	68.6
TrajREC	4.9M	68.0
MoCoDAD	142K [†]	68.3 [†]
GiCiSAD	82.6K	68.6

1	Quick Overview Over Skeleton-based Anomaly Action Detection
2	Guides
3	Researcher's Guide (Overview)
4	Researcher's Guide (Advantages)
5	Evaluation and Transfer Evaluation
6	Deployment and Real-time Monitoring



Testing (Skeleton Detection)

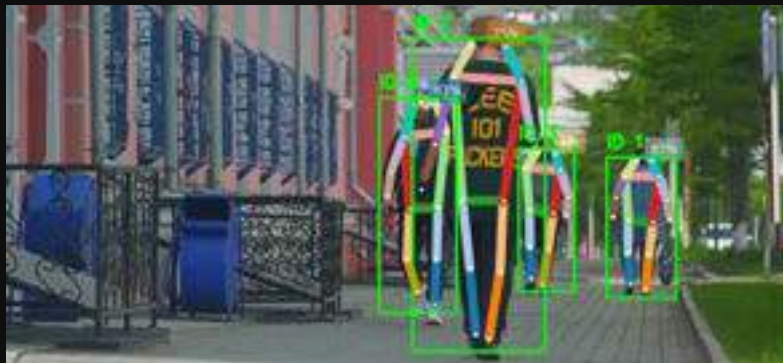
```
STEP | TIME (s)
-----|-----
Preprocessing | 0.0000
Inertial Network | 0.4000
Decoder | 0.3000
Post-processing | 0.7000
TOTAL TIME | 1.3000

Output saved to: ./data/test_image_1_fast_prediction.jpg
```

1. Command line output



2. Single frame image



3. Local video



4. Live video



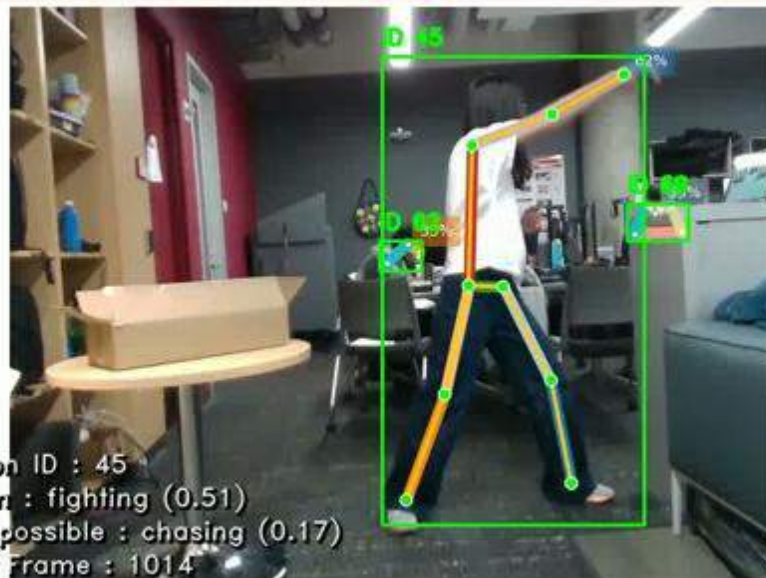
Testing (Anomaly Detection)

Scene Summary						
Scenario	Win	Loss	Q2%	Preproc	Stage1	Stage2
Falling	2	1	100%	1.8ms	1411.7ms	1481.1ms
Fighting	2	2	100%	0.9ms	1411.4ms	1391.1ms
Multi-person	8	9	87%	0.8ms	1421.3ms	1396.0ms
Normal walking	3	4	8%	0.8ms	1401.3ms	N/A
Partial occlusion	2	1	100%	1.8ms	1412.8ms	1423.8ms
Shuffle	20	10	70%	1.1ms	1426.8ms	1418.3ms

Scene 10: Real G3D / Stage 1: Real BMT

Scenario: fighting	
Window #001 person# ts1775484543.943s [ANOMALY]	
Stage 1 score= 0.872 1469.8 ms	
Stage 2 NORMAL 1588.4 ms	
Explain Classified as "normal" (0.25) with low margin over "falling" (0.21). Review recommended.	
Fused score= 0.624 preprocess: 0.9 ms	
Window #002 person# ts1775484944.443s [ANOMALY]	
Stage 1 score= 0.793 1413.8 ms	
Stage 2 NORMAL 1509.1 ms	
Explain Classified as "normal" (0.24) with low margin over "falling" (0.21). Review recommended.	
Fused score= 0.578 preprocess: 0.9 ms	
Results	
Windows processed:	2
Anomalies detected:	2 / 2
Stage 2 triggered:	2 (100%)
Label distribution:	normal=2
Latency (avg per window)	
Parse:	0.8 ms
Preprocessing:	0.9 ms
Stage 1 (G3D):	1411.4 ms
Stage 2 (BMT):	1588.2 ms

Frame 1014

ANOMALY DETECTED

Person ID : 45

Action : fighting (0.51)

Also possible : chasing (0.17)

Start Frame : 1014

End Frame : 1073

Duration : 59 frames



Performance Evaluation against SVD

Acceptance Criteria:

- ✓ Successfully detect $> 95\%$ of non-occluded human skeletons (joints & connections). (F.R.5)
- ✓ Generated bounding boxes accurately enclose a valid human subject. (F.R.5)
- ✓ Re-identify and maintain tracking of a human target even when occluded < 50 frames.(F.R.5)
- ✓ Detect people lying on the ground (width $>$ height). (F.R.5)
- ✗ Flag actions, throwing object, jumping, pushing, biker, fighting, chasing, loitering, hiding, playing with ball, are an anomaly action $> 50\%$ of the time. (F.R.5)



Conclusion (Autonomy)

Strong:

- **Modular** system architecture
- **Scalable design** for future real-world deployment
- ACM provides **robust navigation and execution** capabilities

Weak:

- **No physical robot** validation yet
- Simulation fidelity constraints (RViz2 vs real environment)

Area to refine:

- ❑ Integrate **real robot platform** for deployment validation



Conclusion (User Interface)

Strong:

- Clear separation between frontend, backend, and ROS2 interface
- Backend abstraction enables system scalability and extensibility

Weak:

- Still relies on simulation environment (no real-world latency)
- No persistent data layer (no database integration yet)

Area to refine:

- ❑ Add database layer for mission history and analytics
- ❑ Optimize real-time performance under larger system scale



Conclusion (Anomaly Detection)

Strong:

- Skeleton detection performs **accurately** on live **non-occluded** people
- Lying down detection is **quick and accurate**.

Weak:

- Skeleton detection still has **high inference latency**
- Person tracking is inaccurate when **passing behind** other people.
- Anomaly detection has **high latency and low accuracy**

Area to refine:

- ☐ Skeleton detection speed
- ☐ Person tracking accuracy
- ☐ Split anomaly detection



Project Management



Work Breakdown Structure



Work Breakdown Structure (WBS)





Work Breakdown Structure (WBS)

Complete
Simulation
Only
To Do





Schedule



Schedule Status

Major Milestones:

- **SVD (Done):** All major spring milestones completed ahead of SVD
- **Robot Platform (September):** Build robot(s) with full ACM/ICM capabilities
- **FVD (November):** Finalize system to meet FVD goals

Current Status:

- Achieved most promised goals for SVD
- Robot Platform delay due to contract agreement issues

Plan to Improve:

- Use alternative robots (F1TENTH, Husky, ...) and integrate required ACM/ICM functionalities



Test Plan





Fall Test Plan

	Month	Milestones	Tests
P.R.7	Early September	Internal network	Internal network test
P.R.8	Mid September	Anomaly action classification AI route optimizer	Anomaly classification test Waypoint suggestion test
P.R.9	Early October	UI alert LSV modification	UI test LSV in car test
P.R.10	Mid October	Integration	LSV in car test
P.R.11	Mid November	Full system test	Integration test
P.R.12	Late November	All system integrated and functioning	FVD



FVD

Location: NSH front porch, KSHQ

Equipment: LSV, K7

Demo:

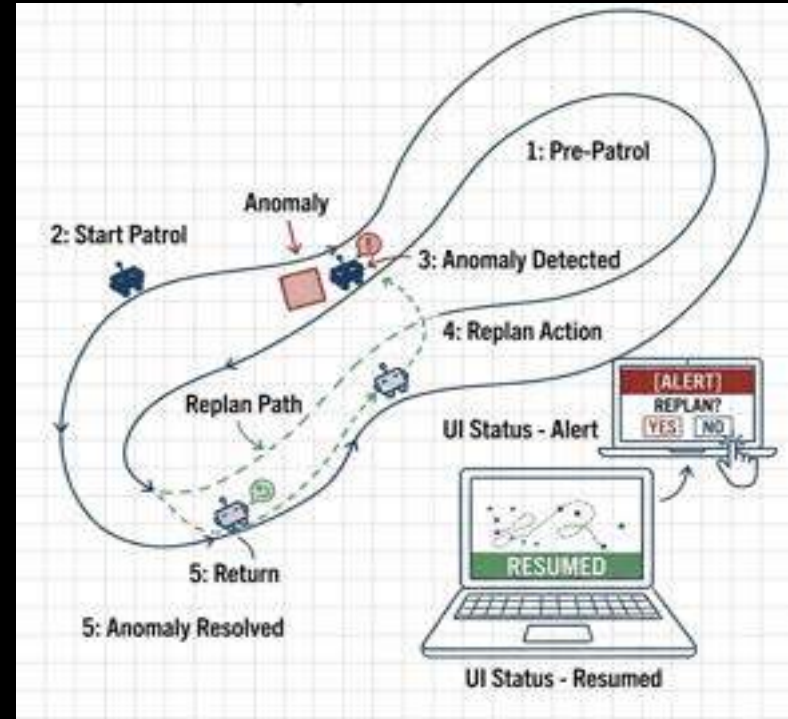
1. Generates suggested waypoints.
2. Accesses UI via laptop to manage and modify waypoints by the user.
3. Monitors for anomalies. If an anomaly occurs, the robot will ask the user for **replan**.
4. Calculates a new route and updates the UI based on the alert.
5. Returns to original route after solving the alert.

Objectives:

The system must identify anomalies with correction > 90%.

The system must suggest 3 efficient patrol waypoints to the user.

The system must demonstrate the robot's ability to change its path dynamically when an alert is triggered within 2 secs.





Budget



Budget

- Total Budget: 15,000
- Mostly for traveling
- PCB spent \$20.27
- About 40% were spent

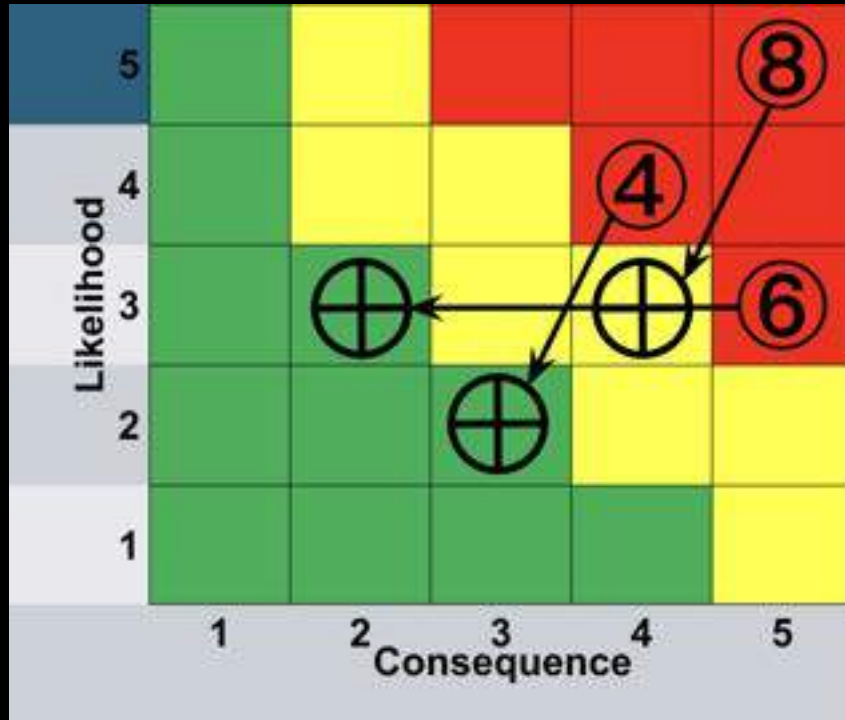
pay date	description	pay by		receipt status	amount
02/05/26	tickets (PIT - SJC)	Maddie	Travel...	full rec...	881.05
02/05/26	AirBnB	Maddie	Accom...	full rec...	900
02/15/26	AirBnB	Maddie	Accom...	full rec...	1143
02/28/26	checked bag	Joshua	Travel...	full rec...	35
03/01/26	uber	Joshua	Travel...	full rec...	69.98
03/01/26	car rental	Maddie	Travel...	full rec...	591.84
03/01/26	lunch	Joshua	Food	full rec...	75.45
03/01/26	dinner	Joshua	Food	full rec...	111.92
03/01/26	dinner	Maddie	Food	full rec...	19
03/01/26	grocery	Joshua	Food	full rec...	42.56
03/01/26	grocery	Joshua	Food	full rec...	61.03
02/06/26	tickets (SJC - PIT)	Maddie	Travel...	full rec...	841
03/02/26	lunch	Maddie	Food	full rec...	55.38
03/02/2026	dinner	Maddie	Food	full rec...	139.51
03/03/26	lunch	Maddie	Food	full rec...	15.06
03/03/26	dinner	Maddie	Food	full rec...	330.78
03/04/26	dinner	Maddie	Food	full rec...	410.75
03/05/26	gasoline	Maddie	Travel...	full rec...	28.55
03/05/26	checked bag	Maddie	Travel...	full rec...	35
03/05/26	breakfast	Maddie	Food	full rec...	53.18
03/05/26	lunch	Maddie	Food	full rec...	83.08
03/08/26	uber	Joshua	Travel...	full rec...	112.67
03/30/26	PCB	Koko	PCB	full rec...	20.27



Risk Management



Risk-Consequence Matrix



Key Risks:

- R4 - Insufficient Features for Prediction Model
- R6 - System Integration Blockage
- R8 - LSV Late Arrival

2:42 PM
Yes. There is controversy I am working through right now on ownership.



R1: K7 Availability Issue

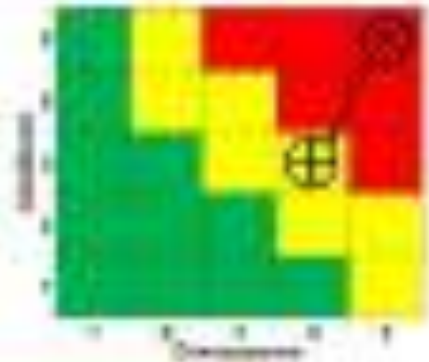
Risk ID	Risk Title	Risk Owner	
R1	K7 Availability Issue	Leo Xu	
Description		Date Added	
The LSV Patrol Robot in Fantom Robotics may not be available due to ownership conflicts and scheduling constraints.		11/26/2025	
Consequence		Date Updated	
No platform available for testing our system.		04/17/2026	
Risk Reduction Plan Summary		Risk Type:	Schedule, Cost
Action/Milestone	Success Criteria	Date Planned	Date Implemented
Use other prototypes (F1 Tenth, Golf Cart) for onboard testing.	Successfully run our system on the prototype.	11/28/2025	02/05/2026
Use simulators (CARLA, Gazebo, Rviz) for offline testing.	Successfully test developed features on the simulator.	11/28/2025	02/15/2026
Comments			

Likelihood

Consequence



R2: Incompatible between Environment & Platform

[illegible]

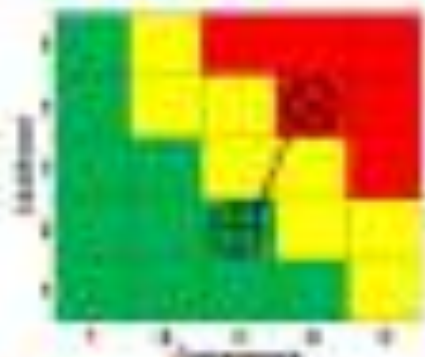


R3: Can not Access Company Training Data

[illegible]



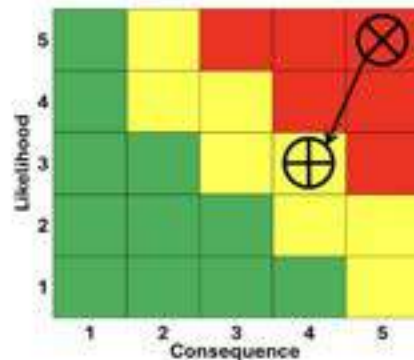
R4: Insufficient Log Data Features for Prediction Model

Step 22	Step 23	Step 24	
1	Insufficient Log Data Features for Prediction Model	No Feature	
Description		Step 24	
The model requires input data, which is not available for the model to train and validate.		TTT03000	
Recommendation		More data	
The system requires to generate a new data set which is not available for the model to train and validate.			
Risk & Mitigation Plan Summary		Risk Type	
Action Items		Current Status	
Complete data collection and data analysis for training dataset.	Eliminate all data collection	11/11/2022	Data Improvement
Process the data to select the features for the model.		11/12/2022	
Reporting on the data collection, processing, and analysis.	Find that the data is not sufficient and increase the accuracy and robustness.	11/13/2022	
Summary			



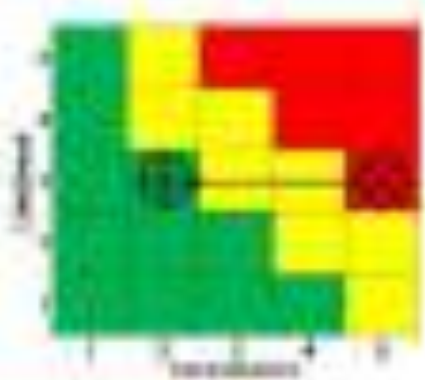
R5: Schedule Conflict Between Knightscope and CMU

Risk ID	Risk Title	Risk Owner
R5	Schedule Conflict between Knightscope and CMU	Sam Dong
Description		Date Added
Scheduling misalignment between Knightscope's availability (for meetings, reviews, and demo) and the CMU team's academic schedule (course deadlines, project milestones, and travel constraints).		11/29/2025
Consequence		Date Updated
Key deliverables may delay due to mismatched schedules. Also, lack of timely feedback from Knightscope cause the team to move in a suboptimal direction and later need revisions.		02/02/2026
Risk Reduction Plan Summary		
Action/Milestone	Success Criteria	
Set a weekly meeting with Knightscope with agenda and meeting notes to ensure efficient communication.	Most of action items are completed or updated before the next meeting.	
Align project milestones early and allocate time buffer to absorb possible communication delays.	Most of milestones are achieved on or before the buffered deadline.	
Comments		



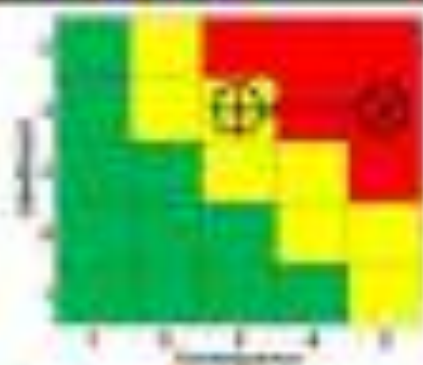


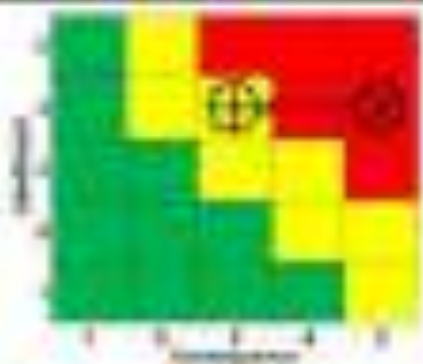
R6: System Integration Blockage by Incomplete Modules

Req ID	Req Title	Req Owner		
R#	System Integration Blockage by Incomplete Modules	System Test		
Description		Issue Label		
During the system integration process, the schedule may be delayed by incomplete modules that are not yet ready for integration and validation.		ISS ID:0000		
Development		Time Budget		
Because the modules that are not yet ready for integration are not yet ready for integration, the schedule for the system integration process is delayed. This is a critical issue that needs to be addressed immediately.			Impact Score	
Risk Reduction Measures			Risk Type	Risk Impact
Preventive Measures	Residual Risks	Risk Phase	Risk Assessment	
Could the system be delayed by the input and output of the modules that are not yet ready for integration?	Subsidiary issues caused by incomplete modules that are not yet ready for integration.	ISS ID:0000	ISS ID:0000	
Comments				



R7: F1TENTH Platform Malfunctioning

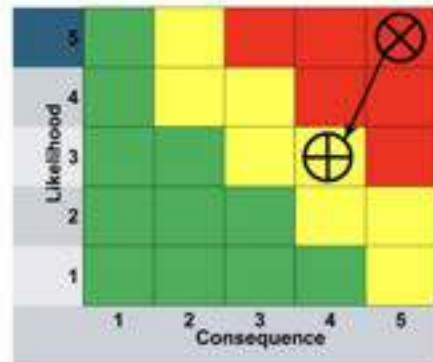
Page ID	Page Title	Web Owner		
01	F1TENTH Platform Malfunctioning	Ph. Fingert		
Description		Page Labels		
During development and testing, the F1TENTH platform may experience hardware or software malfunctions, such as power failure, system crash, or other issues.		00000000		
Comments		Code Status		
Such malfunctions may result in loss of data, delay the release of the program, and compromise the safety of the system.		00000000		
Risk Assessment Plan Summary			Risk Type	Severity
Actual/Expected	Frequency/Impact	Date Planned	Date Encountered	
Software: Software development, testing, and deployment phases, software error checks, performance checks, and validation checks.	At least one software component is expected to be developed, tested, and deployed successfully, and software error checks are verified.	00000000	00000000	
Hardware: Hardware hardware validation, including power checks and component checks.	The platform powers up and operates initially with no errors or warnings.	00000000	00000000	
Simulation: The system processing and execution of the code.	The code system functions and is not affected by hardware malfunctions.	00000000	00000000	
Comments				





R8: LSV Late Arrival

Risk ID	Risk Title	Risk Owner	
R8	LSV late arrival	Joshua Tsai	
Description		Date Added	
Due to ownership conflict and scheduling issue, the golf cart LSV might not arrive on time, blocking the development timeline		04/26/2026	
Consequence		Date Updated	
We might not have physical platform to implement and test our system; resulting in no delivery in FVD. And it will be hard to immigrate our final prototype		04/26/2026	
Risk Reduction Plan Summary		Risk Type:	Technical
Action/Milestone	Success Criteria	Date Planned	Date Implemented
Use different platform (Husky) and change the final delivery to demonstrating on that platform.	Platform can successfully work on the current ACM module.	04/26/2026	04/26/2026
Contact with Fantom Robotics and do the testing there.	Access the golf car LSV.	04/26/2026	04/26/2026
Comments			





Conclusion



Conclusion (Lessons Learned)

Technical:

1. Pretrained model → ✓ starting point × final model
2. Lack of **unit tests** in anomaly detection
3. ROS2 communication (**DDS & QoS**)

Systems engineering and project management:

1. Plan ahead
2. Task assignment based on each team member's working style



Conclusion (Future Plan)

1. Skeleton detection optimization
2. Tracking method replacement
3. Anomaly add action
4. Waypoint suggestion model development
5. Local Area Network (LAN)
6. LSV wiring
7. ACM deployment
8. Redirection development
9. Alert verification UI development
10. RealSense depth location transformation

IDs	Status	Functional Requirement
F.R.1	TODO	Provide waypoint suggestion to the user
F.R.2	Done	Receive waypoints from the user
F.R.3	Simulation Only	Enable K7 to navigate
F.R.4	Done	Visualize patrol status
F.R.5	Need to Speed Up & Split Model	Detect anomaly
F.R.6	TODO	Redirect K7
F.R.7	TODO	Support alarm verification



Thank You



Appendix

