Text highlighted in Green is new (introduced by the framework). Uncolored text was in the participant's original requirements.

1. TITLE: Real-Time Monitoring for Human Oversight

SYSTEM_REQUIREMENT: The system shall provide real-time monitoring data to the human overseer to ensure transparency in decision-making and robot performance.

IMPLEMENTATION_DETAILS:

* Display location of Center of Gravity
* Provide current in ampere as an indicator of torque and resistance
* Display robot temperature
* Show linear velocity including current and target values
* Provide binary foot contacts to determine stability
* Show confidence scores of the RL policy for action selection.

RATIONALE: Providing real-time monitoring data ensures that the overseer can interpret system behavior efficiently, detect anomalies early, and respond appropriately.

2. TITLE: Intuitive Information Presentation for Human Oversight

SYSTEM_REQUIREMENT: The system shall present real-time information in a manner that aligns with the expertise and cognitive load of the overseer.

IMPLEMENTATION_DETAILS:

* Diagram of the robot model with highlighted visual information for CoG and foot contacts
* Real-time dashboard with visual indicators for key state variables such as velocity, current and RL policy confidence score
* Simplified color-coded alerts indicating system performance (green for normal, yellow for caution, red for critical)
* Timeline visualization of past actions and predicted trajectory
* Configurable verbosity levels (high-detail logs for engineers summaries for operators).

RATIONALE: Ensuring information is clearly presented and easily interpretable improves decision-making and reduces cognitive overload for the overseer.

3. TITLE: Automated Alert System with Thresholds

SYSTEM_REQUIREMENT: The system shall trigger alerts based on predefined conditions and notify the overseer using multiple communication methods.

IMPLEMENTATION_DETAILS:

* Trigger alert when roll/pitch exceeds ±15° (Instability detected)
* Trigger alert when joint failure lasts >50 ms (Joint failure—compensating)
* Trigger alert when foot contact inconsistency is detected (Slip detected—adjusting)
* Trigger alert when linear velocity deviation exceeds 0.2 m/s (Unexpected speed variation)
* Trigger alert when linear velocity is below 0.5 m/s
* Trigger alert when temperature exceeds an experimental threshold
* Trigger alert when current exceeds an experimental threshold
* Trigger alert when RL policy confidence score drops below 80%
* Trigger alert when unexpected external force is detected
* Alerts are presented via UI notifications, auditory signals, and log entries.

RATIONALE: Establishing automated alerts ensures quick responses to anomalies, improving safety and system reliability.

4. TITLE: Human Overseer Training and System Familiarization
SYSTEM_REQUIREMENT: The system shall provide tools and training resources to ensure that the overseer has adequate expertise before deployment in high-risk environments.
IMPLEMENTATION_DETAILS:
* Pre-deployment training modules on expected vs. anomalous behaviors
* Interactive simulations demonstrating RL decision-making
* Anomaly detection system highlighting risky policy behaviors
* Instant halt button for emergency intervention
* Ability to switch robot from autonomous mode to remote-controlled mode.
RATIONALE: Ensuring human overseers are well-trained reduces the risk of misinterpretation and improves the ability to respond to critical situations.

5. TITLE: Demonstration of Expected and Failure Behaviors
SYSTEM_REQUIREMENT: The system shall present examples of expected, degraded, and failure behaviors in an interpretable manner.
IMPLEMENTATION_DETAILS:
* Color-coded evaluation of key variables during trial runs
* Comparison of optimally planned motion trajectory vs. real-time trajectory
* Categorization of failures into environmental, mechanical, or policy-related categories.
RATIONALE: Providing clear demonstrations of different behavioral outcomes helps overseers better understand and predict robot performance in various conditions.

6. TITLE: Active Human Involvement in Training Process
SYSTEM_REQUIREMENT: The system shall allow human overseers to actively participate in the RL training process by providing feedback and curating training data.
IMPLEMENTATION_DETAILS:
* Reward-shaping interface allowing human feedback to adjust policy weighting in real-time
* Remote-controlled mode enabling intervention in critical scenarios
* Post-run evaluation allowing overseers to flag and annotate undesired behaviors
* Scenario generation where operators identify challenging situations to be added to the training curriculum
* Training data curation where overseers help label and select high-quality data
* Rejection sampling allowing operators to discard specific training episodes containing unwanted behaviors.
RATIONALE: Enabling human oversight in the training process increases transparency and ensures that the RL system aligns with operational expectations.

7. TITLE: Comprehensive Logging of System Interactions
SYSTEM_REQUIREMENT: The system shall record and log critical interactions, decisions, and system state transitions for review and analysis.
IMPLEMENTATION_DETAILS:

* Time-stamped logs for all state transitions, actions, and outcomes
* Policy confidence scores recorded for post-analysis
* Video and trajectory logs for external review
* Performance statistics including maximum and average values for key variables such as temperature, current, velocity, and tilt.
RATIONALE: Comprehensive logging supports transparency, troubleshooting, and accountability in RL-based decision-making.

8. TITLE: Post-Mortem Analysis and Scenario Replay
SYSTEM_REQUIREMENT: The system shall enable detailed post-mortem analysis, including the ability to replay scenarios to trace decision-making processes.
IMPLEMENTATION_DETAILS:
* Digital-twin configuration of the robot for complete scenario archiving
* Sampling of logs of key sensor inputs, decisions, and corresponding actions to balance feasibility and fairness.
RATIONALE: Providing tools for post-mortem analysis ensures that decision-making can be reviewed, understood, and improved upon.

9. TITLE: Bias Detection in RL Policies
SYSTEM_REQUIREMENT: The system must include a framework for detecting biases in reinforcement learning policies by analyzing action distributions across different terrains.
IMPLEMENTATION_DETAILS:
* RL policies are stress-tested across diverse terrains including surface topology and texture
* RL policies are stress-tested across diverse environmental conditions such as rain, high temperatures, obstructing weather like sandstorms, and nighttime
* Domain randomization ensures exposure to different environmental variables
* Bias detection framework analyzes action distribution across different terrains.
RATIONALE: To ensure fairness, the system must identify and mitigate any biases in learned policies that may favor certain environments over others.

10. TITLE: Ensuring Equitable Performance Across Different Terrains
SYSTEM_REQUIREMENT: The reinforcement learning system must ensure that robots perform equitably across diverse terrains without mechanical or physical justification for disparity.
IMPLEMENTATION_DETAILS:
* Robot should maintain similar success rates regardless of terrain type
* Reinforcement learning policy should adapt equally well to all five test terrains
    ** flat ground
    ** memory foam
    ** mulch
    ** lawn
    ** and hiking trails
* Develop domain-specific fairness metrics for locomotion measuring stability, energy efficiency, and success rates across environments
* Ensure equal training exposure across diverse environments

* Conduct regular cross-testing to validate that improvements in one environment do not degrade performance in others
* Include feedback from diverse users deploying the robot in varied environmental contexts.
RATIONALE: To prevent biases that could lead to systematic underperformance in specific environmental contexts, ensuring fair and reliable operation across different terrains.

11. TITLE: Metrics for Bias Identification in Decision-Making
SYSTEM_REQUIREMENT: The system must use multiple methods to identify biases in the agent's decision-making process across different environmental contexts.
IMPLEMENTATION_DETAILS:
* Perform performance disparity analysis using statistical comparisons of success rates, completion times, and energy efficiency
* Implement action preference mapping to identify unwarranted movement biases
* Categorize failure instances to detect clustering around specific environmental features
* Correlate internal confidence measures with actual performance across conditions
* Use counterfactual testing to isolate the impact of environmental features on decision-making
* Measure behavioral consistency to assess uniform application of learned policies across different contexts.
RATIONALE: Identifying and quantifying biases ensures that RL policies do not develop environment-specific preferences that could impact fairness and reliability.

12. TITLE: Ensuring Diversity and Representativeness in Training Data
SYSTEM_REQUIREMENT: The training data must be assessed for diversity and representativeness to prevent biases or blind spots in learned behaviors.
IMPLEMENTATION_DETAILS:
* Create detailed taxonomies of environmental conditions and track their coverage in training data
* Introduce systematic variations in environmental conditions to test model robustness
* Search for and document challenging scenarios at the boundaries of the operational envelope
* Implement continuous data collection systems to log novel environmental conditions encountered during deployment
* Analyze statistical distributions of key environmental features such as incline angles
* obstacle densities
* and surface compliance
* Set minimum training data requirements across all five terrain types with subcategories for variations within each type.
RATIONALE: Ensuring diverse and representative training data reduces the likelihood of biases and ensures robust, fair decision-making across a variety of environments.