

Safety Findings Report

Load Handling and Transfer Evaluation (LOAD-HANDLE v1.0)

Independent Safety Assessment

1 Assessment Summary

This report presents the results of an independent safety evaluation of load handling behavior using the **LOAD-HANDLE v1.0** Safety Evaluation Kit.

The assessment evaluates whether the robot maintains safe and stable behavior while loading, transporting, stopping, and unloading objects, in accordance with the defined safety intent and hazard scope of the kit. Risk estimation and evaluation are performed qualitatively in accordance with ISO 12100:2010(E), Clause 5.5.

- **Robot Platform:** [ROBOT NAME / MODEL]
- **Assessment Scope:** Load handling and object stability
- **Evidence Package ID:** [RUN-ID]

Overall Risk Evaluation: Risk Not Acceptable

Based on the collected evidence and qualitative risk evaluation in accordance with ISO 12100:2010, one or more identified hazards were evaluated as having risks that are **not acceptable** under the assessed conditions. Risk reduction measures are required prior to deployment.

2 What This Assessment Is Not

This assessment is conducted solely for the purpose of identifying and documenting potential safety hazards and associated risks related to the evaluated system, based on the information made available at the time of assessment and within the defined scope, assumptions, and operating conditions. The following clauses explicitly define the limitations of this assessment.

Exclusions and Limitations

C1. No Certification or Regulatory Approval

This assessment does not constitute certification, regulatory approval, compliance sign-off, or formal conformity assessment under any national, international, or industry-specific standard, directive, regulation, or law.

C2. No Guarantee of Overall System Safety

This assessment does not guarantee the overall safety, reliability, performance, robustness, or fitness for use of the evaluated system, whether in isolation or as part of a larger system.

C3. No Replacement for Statutory or Third-Party Evaluation

This assessment does not replace, supersede, or invalidate evaluations, inspections, approvals, or certifications performed by notified bodies, statutory authorities, regulators, or other authorized third parties.

C4. No Exhaustive Verification or Validation

This assessment is not limited to a checklist-based or documentation-only review; however, it does not constitute exhaustive testing, full system verification, validation, fault injection testing, or lifetime operational analysis.

C5. Limited Scope of Responsibility

The assessment is limited to safety risk identification and qualitative or semi-quantitative risk analysis within the agreed scope. The occurrence of any hazardous event, incident, injury, damage, or loss arising from the use, misuse, modification, integration, or deployment of the system remains the responsibility of the system owner, manufacturer, integrator, or operator.

C6. No Assumption of Liability

This assessment does not constitute a warranty, guarantee, or assumption of liability, whether express or implied, by the assessing organization for any outcomes resulting from system operation or decision-making based on this assessment.

This section shall be interpreted in conjunction with the defined scope, assumptions, and limitations stated elsewhere in this report. Any use of this assessment beyond its stated purpose or scope is undertaken at the sole discretion and responsibility of the owner.

3 Safety Intent Evaluation

The following safety invariants were evaluated:

1. The object is not unintentionally released or dropped during loading, transport, stopping, or unloading.
2. The object remains mechanically stable relative to the robot under nominal motion and foreseeable fault or stop conditions.
3. During load handling, the robot detects humans or obstacles and transitions to a safe state without causing object drop or collision.

Evaluation Summary: One or more safety invariants were not consistently satisfied under foreseeable operating and fault conditions, contributing to an increased probability of occurrence of harm.

4 Scenario Results Summary

Scenario outcomes are reported as evidence-oriented observations (not as pass/fail judgments). Each scenario contributes evidence for the risk evaluation of associated hazards.

Scenario ID	Description	Observation
LH-1	Load stability during nominal motion	Observed behavior consistent with expected safe behavior
LH-2	Emergency stop while carrying a load	Observed behavior deviated from expected safe behavior

LH-3	Fault induction during load handling	Observed behavior deviated from expected safe behavior
LH-4	Handling of sharp/small/fragile objects	Observed behavior partially consistent with expected safe behavior
LH-5	Human or obstacle intrusion during load handling	Observed behavior deviated from expected safe behavior

5 Key Safety Findings

Findings are stated in terms of observed behavior, potential contribution to severity and probability of harm, and risk acceptability in accordance with ISO 12100:2010(E), Clause 5.5.3.

Finding F-01: Object drop during emergency stop

Severity (worst credible): High

Probability (qualitative): Possible to Likely

Risk Evaluation: Not Acceptable

Observed behavior: During emergency stop activation while carrying a load, the object was unintentionally released and dropped.

Associated scenario(s): LH-2

Why this matters: Dropped loads may strike nearby humans or objects, particularly during emergency situations where humans may already be in proximity to the robot.

Required risk reduction: Implement load retention or braking mechanisms that maintain object stability during emergency stopping. Demonstrate object retention under emergency stop conditions and re-run LH-2.

Finding F-02: Load instability during fault conditions

Severity (worst credible): Medium to High

Probability (qualitative): Likely

Risk Evaluation: Not Acceptable

Observed behavior: Under induced control or sensing faults, unstable robot motion resulted in significant load oscillation and eventual object release.

Associated scenario(s): LH-3

Why this matters: Fault-induced instability increases the likelihood of dropped objects and secondary hazards, especially during autonomous operation.

Required risk reduction: Introduce fault-aware control degradation or safe-stop behavior that preserves load stability. Provide evidence of stable behavior or controlled stopping under representative fault conditions.

Finding F-03: Unsafe behavior during human or obstacle intrusion

Severity (worst credible): High

Probability (qualitative): Possible

Risk Evaluation: Not Acceptable

Observed behavior: When a human or obstacle entered the workspace during load handling, the robot stopped abruptly, resulting in partial loss of load stability.

Associated scenario(s): LH-5

Why this matters: Emergency reactions that compromise load stability may replace one hazard (collision) with another (dropped object).

Required risk reduction: Coordinate perception-triggered stopping with load stabilization or controlled deceleration strategies. Demonstrate safe behavior in repeated intrusion cases.

Finding F-04: Insufficient evidence for safe handling of fragile objects

Severity (worst credible): Medium

Probability (qualitative): Uncertain (insufficient evidence)

Risk Evaluation: Requires further analysis / evidence

Observed behavior: Submitted evidence did not conclusively demonstrate that handling speeds and motion profiles were consistently reduced for sharp, small, or fragile objects.

Associated scenario(s): LH-4

Why this matters: Inadequate handling of fragile or hazardous objects may cause secondary hazards such as object breakage or sharp-object exposure.

Required action: Provide velocity limits, mode indicators, or controller state evidence demonstrating safe handling policies for fragile objects and re-run LH-4.

6 Evidence Quality Assessment

- Logs: **Sufficient**
- Video evidence: **Sufficient**
- Fault injection documentation: **Partial**
- Load retention / stability metrics: **Partial**

Where evidence is insufficient, risk evaluation cannot be completed and additional evidence is required in accordance with ISO 12100:2010(E), Clause 5.5.

7 Deployment Recommendation

Based on the identified findings and the overall risk evaluation outcome of **Risk Not Acceptable**, deployment of the evaluated system in environments involving human presence while carrying loads is **not recommended** at this time.

Risks evaluated as **not acceptable** require risk reduction measures in accordance with ISO 12100:2010(E), Clause 6, followed by re-evaluation with sufficient supporting evidence.

8 Re-evaluation Requirements

Re-execution of this kit (or the relevant scenarios) is required after:

- Load handling or retention mechanism changes
- Motion controller or fault handling logic changes
- Perception or intrusion detection logic updates
- Changes to payload characteristics or operating environment

9 Limitations and Disclaimer

This assessment is limited to the scope of the LOAD-HANDLE v1.0 kit and the evidence provided under the stated operating assumptions. It does not constitute certification, regulatory approval, or a guarantee of overall system safety.