One-Page Technical Summary

Failure Boundaries in Autonomous Planning Systems

Subtitle

Empirical analysis of geometric feasibility and planning–control mismatch in autonomous navigation

1. Problem Framing (Top left, 3–4 lines)

Modern autonomous systems often fail not due to poor planning, but because geometry and control feasibility dominate execution.

This work studies when planning stops being the limiting factor, and identifies sharp failure boundaries driven by environment constraints and tracking error.

2. Experimental Setup (Small diagram or bullets)

Continuous 2D navigation environment

Velocity-based dynamics with collision checking

Planners:

Rule-based reactive planner

Grid-based A* planner

Scenarios:

Adversarial narrow corridors

Tracking noise injected at execution time

Metrics:

Collision rate

Success rate

Failure timing and distance

3. Phase Transition I — Geometric Feasibility (Center, main result)

Experiment: Corridor width is varied while holding planner and dynamics fixed.

Observation: A sharp phase transition exists at a critical gap width (~0.35):

Above threshold → all planners succeed

Below threshold → all planners fail with probability 1

Key Insight:

Planning optimality becomes irrelevant once geometry is untrackable.

(Insert: corridor_phase_transition.png)

4. Phase Transition II — Collision Distance vs Geometry

Experiment: Measure distance to obstacle at first collision across corridor widths.

Observation:

Collision distance collapses to a narrow band near feasibility boundary

Failures occur early and deterministically

Interpretation: This indicates execution infeasibility, not long-horizon planning error.

(Insert: collision_distance_vs_gap.png)

5. Phase Transition III — Planning–Control Mismatch (Bottom section)

Experiment: Inject tracking noise into the execution of planner-generated trajectories.

Results:

Planning remains "correct"

Controller fails to track safely

Collision rate rises monotonically with tracking error

Key Insight:

Safety violations emerge even with optimal planning due to control limitations.

(Insert: tracking_error_phase_transition.png)

6. Why This Matters for Autonomous Vehicles (Right column)

Explains real-world AV disengagements

Highlights why safety cannot be solved by planning alone

Motivates:

Feasibility-aware planning

Control-aware evaluation

Risk-based metrics beyond success rate

7. One-Line Takeaway (Bottom)

Autonomous system failures are governed by feasibility boundaries, not planner optimality.