

GISELLE

Pedestrian-Aware Emergency Braking for Low-Friction Settlement Roads

FORUM8

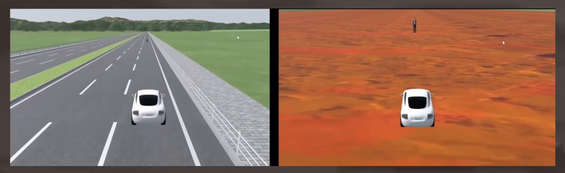
14th CPWC

GISELLE

Concept & Problem

Settlements are becoming towns. Lunar and Martian outposts are no longer single habitats — they are growing into settlements with residential zones, logistics routes, roads, traffic, and people who live there. Regolith-covered surfaces behave like μ ≈ 0.17, so braking behaves like ice, all the time. ADAS was tuned for asphalt: every braking assumption presumes μ ≈ 1.0. On settlement roads, that assumption breaks.

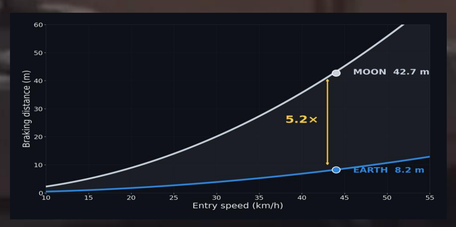
Permanent settlements → Low-friction roads → Earth-tuned ADAS fails



Earth (μ=1.0): stops safely
Moon (μ=0.17): fails to stop

	Earth	Moon
Entry speed	43.9 km/h	43.7 km/h
Braking distance	8.2 m	42.7 m
Braking time	1.4 s	7.0 s
Deceleration	9.06 m/s²	1.73 m/s²

Same Brake, Different Result: only the friction coefficient was changed. On loose soil, a wheel can only deliver a fraction of the braking force it has on Earth — validated on real rover test beds. This is physics, not a guess. A pedestrian a driver could always stop for on Earth is a collision on the Moon.



5.2×
longer braking distance on lunar-like roads (μ = 0.17)

System

Why simulator-based? Untestable in reality — low-gravity, low-μ pedestrian emergencies must never be rehearsed with real people. Full physics control — set surface friction per road and replay the identical emergency hundreds of times. Ground truth built in — perception is cross-verified against true positions every frame.

DETECT
YOLO11 transfer-trained on settlement footage

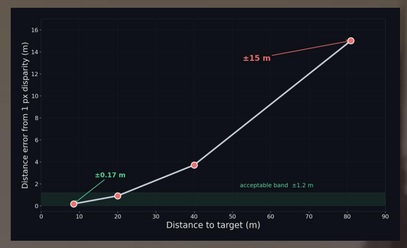
→ MEASURE
Twin virtual cameras, B = 0.5 m

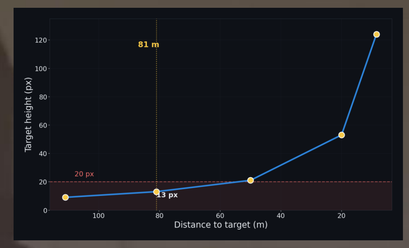
→ VERIFY
Telemetry cross-check by azimuth and range

→ BRAKE
PWM parking-brake, PI duty control

Two independent processes share one UC-win/Road access layer (common.py) — perception can crash, restart, or lag without ever taking the brake loop down.

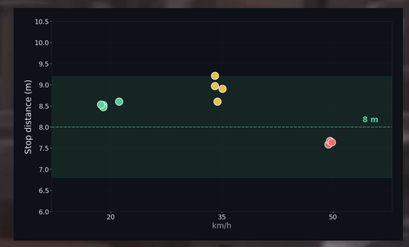
Perception & Control





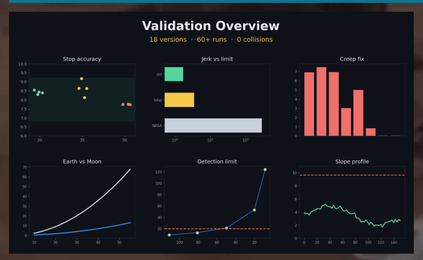
Near, trust the camera. Far, verify everything. Stereo error grows from ±0.17 m at 9 m to ±15 m at 81 m, where a pedestrian is 13 px tall, below the 20 px floor — so stereo vision owns the near field and telemetry cross-verification the far field. Trained to recognize astronauts on the lunar surface, GISELLE runs real-time pedestrian detection and distance estimation.





One brake profile, repeatable to the meter: distance-scheduled braking holds the deceleration plan, then PWM brake pulses with PI duty correction plant the stop. All 11 emergency runs at 20 / 35 / 50 km/h land inside ±1.2 m of the 8 m line on μ = 0.17. Children get 10 m. Adults get 8 m.

Result



18 versions · 60+ runs · 0 collisions, validated on UC-win/Road Ver.19

10.1 % · 1.2 % of NASA-STD deceleration & jerk limits used

6.92 m → 0.02 m post-stop creep, root-caused across 8 versions

1.99 m/s² controlled glide — firm enough to stop in time, gentle enough to be a ride, not an event.

Future

V2V hazard relay — a rover-to-rover link relays a detected pedestrian to vehicles that cannot see them yet: around curves, through dust, in convoy.

Perception hardening — second-stage YOLO training: close-range children, negative mining on look-alikes, and dust / lighting augmentation.

Digital-twin friction maps — live μ estimation fed back into a settlement-wide digital twin, shared by every vehicle.