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No. 21

Comparative Risk Analysis of Accident Probability in Three-Wheel Motorcycles with Delta and Tadpole Structural Designs

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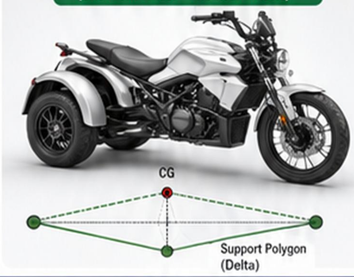
1 INTRODUCTION

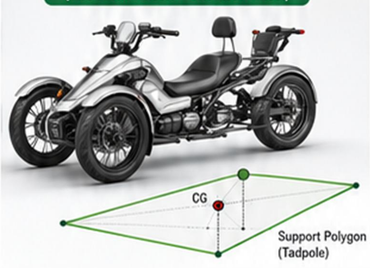
DELTA CONFIGURATION (One Front Wheel – Two Rear Wheels)



Tadpole = Higher Stability

- ✓ Wider Support Base
- ✓ Better Lateral Stability
- ✓ Higher Critical Speed
- ✓ Lower Rollover Risk

TADPOLE CONFIGURATION (Two Front Wheels – One Rear Wheel)



2 VEHICLE DYNAMICS MODEL

$$a_y = v^2/R \quad \text{Lateral acceleration } (m/s^2)$$

$$a_{y,crit} = g(d_{edge})/h$$

$$RI = \frac{(F_{ZRL} - F_{ZRR})}{(F_{ZRL} + F_{ZRR})} \quad \text{Rollover Index } (-)$$

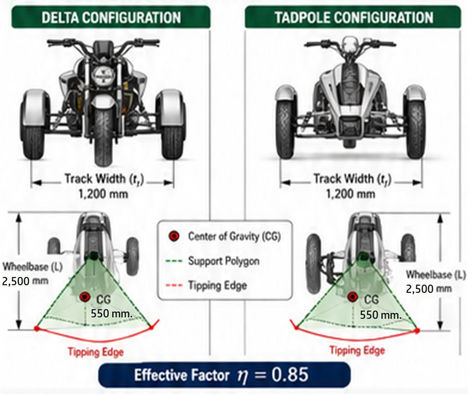
$$\Delta F = \frac{m a_y h}{t} \quad \text{Lateral load transfer } (N)$$

$$P(roll) = \frac{1}{[1+e^{-k(\zeta-1)}]}$$

Where $\zeta = \frac{\left(\frac{a_y}{g}\right)}{\left(\frac{a_{y,crit.}}{g}\right)}$

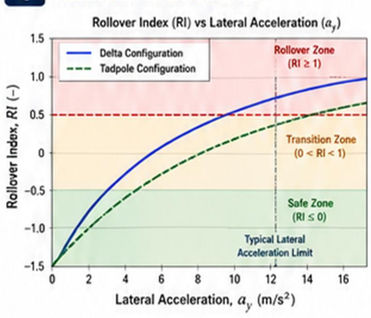
Vehicle Geometry → Lateral Acceleration → Load Transfer → Rollover Index → Probability of Rollover

3 GEOMETRIC COMPARISON

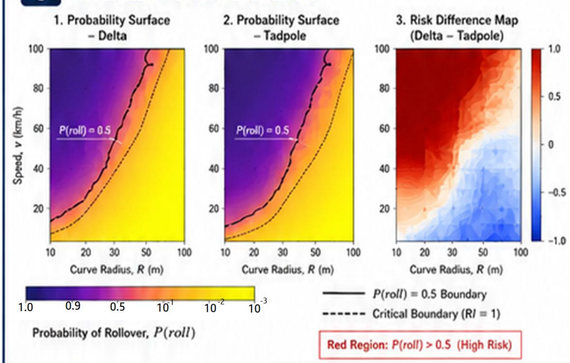


Effective Factor $\eta = 0.85$

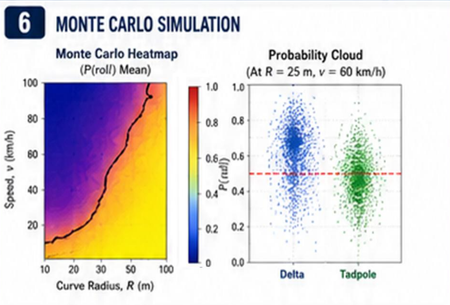
4 ROLLOVER INDEX ANALYSIS



5 PROBABILITY SURFACE ANALYSIS

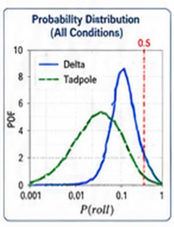


6 MONTE CARLO SIMULATION

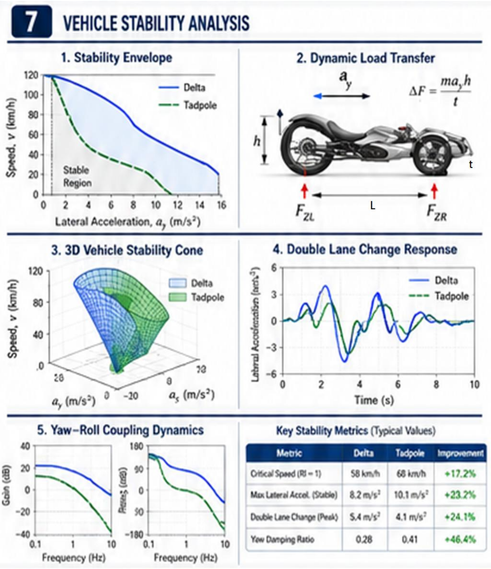


Simulation Settings
- 10,000 simulations
- Random sampling (Latin Hypercube)
- Vehicle parameters uncertainty
- Independent variables

Uncertainty Parameters (±3σ)
- CG height (h): ±15%
- Track width (t): ±10%
- Mass (m): ±10%
- Tire friction (μ): ±15%



7 VEHICLE STABILITY ANALYSIS



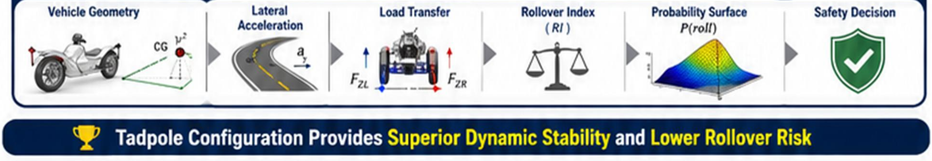
Key Stability Metrics (Typical Values)

Metric	Delta	Tadpole	Improvement
Critical Speed (RI = 1)	58 km/h	68 km/h	+17.2%
Max Lateral Accel. (Stable)	8.2 m/s²	10.1 m/s²	+23.2%
Double Lane Change (Peak)	5.4 m/s²	4.1 m/s²	+24.1%
Yaw Damping Ratio	0.28	0.41	+46.4%

8 KEY FINDINGS & CONCLUSIONS

- ✓ Delta exhibits ~15% higher rollover sensitivity.
- ✓ Tadpole maintains higher critical rollover speed.
- ✓ Monte Carlo simulations confirms superior robustness of Tadpole.
- ✓ Recommended for urban mobility and safety-critical applications.

GRAPHICAL ABSTRACT



🏆 Tadpole Configuration Provides **Superior Dynamic Stability** and **Lower Rollover Risk**