ICAUS 2021

International Conference on Autonomous Unmanned Systems

Sept.24-26, 2021 Changsha China

TCLF-based Obstacle avoidance path planning for HSV using Pigeon-inspired Optimization

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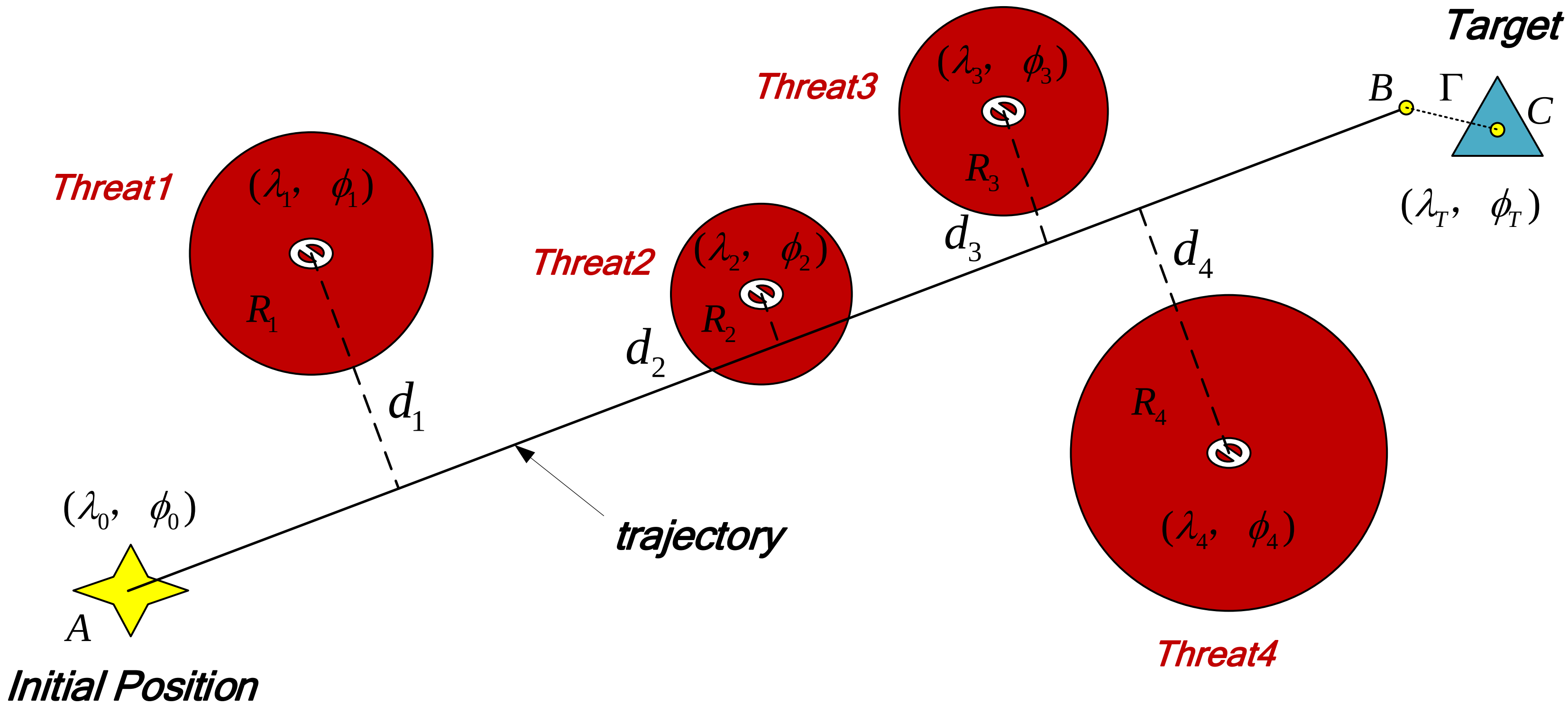
Background



Motivation. To find a trajectory where the landing error Γ satisfies the accuracy requirement and obstacles are effectively avoided as $d_i > R_i (i = 1, 2, \cdots, N)$.

Assumptions.

✓ The target is in the range of the HSV.

✓ The threat zone radius is between 100-500 km.

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Guidance strategy

Gliding Section

$$\alpha = \begin{cases} 40^{\circ} & v > 4570m/s \\ 40^{\circ} - k(v-4570)^2 & v \le 4570m/s \end{cases}$$

Heat Flow

Structural Strength

Aerodynamics

Turning Section

1. The Desired Rate $\dot{\sigma}$ $\dot{\theta}$

Input/Trajectory parameter

↓

2. The Aerodynamic Force

Physical Model

↓

3. The Guidance Signal γ_v α

control parameter

Guidance strategy

Turning Section

1

$$\dot{\sigma} = -k_1\left(\sigma - \sigma_d\right)$$

$$\dot{\theta} = -k_2(\theta - \theta_d)$$

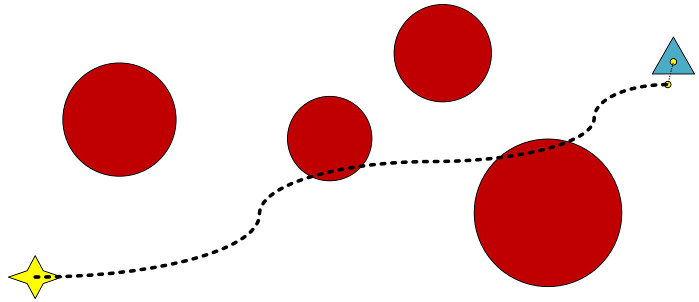
2

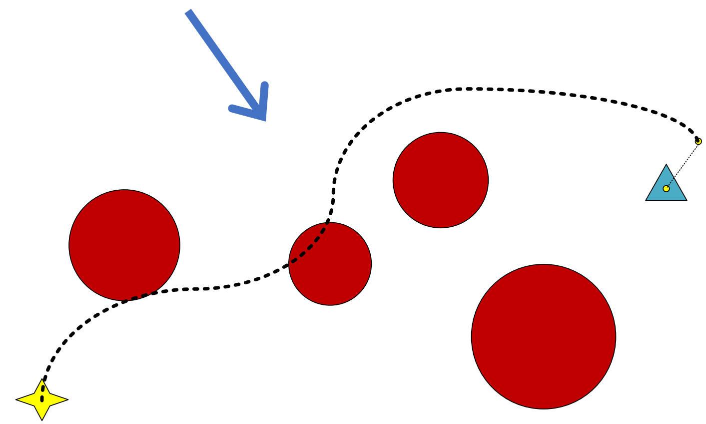
$$F_{aero,y3} = mV\dot{\theta} - mg_{y3}$$

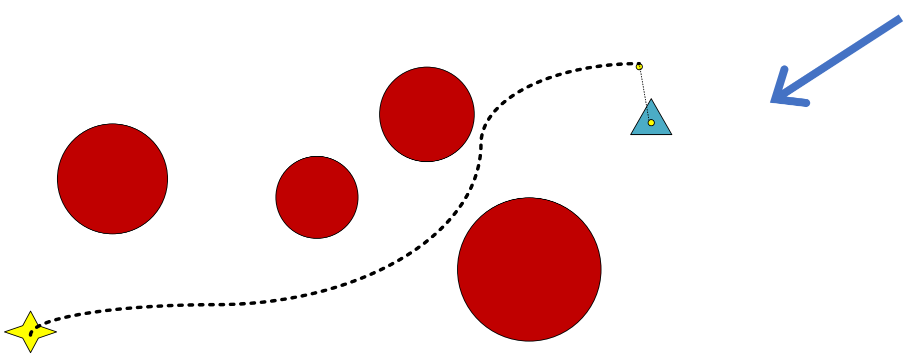
$$F_{aero,z3} = -mV\dot{\sigma}\cos\theta - mg_{z3}$$

3

$$\begin{bmatrix} \cos\gamma_v & \sin\gamma_v \\ -\sin\gamma_0 & \cos\gamma_0 \end{bmatrix} \begin{bmatrix} F_{y_3} \\ F_{z_3} \end{bmatrix} = \begin{bmatrix} C_y^{\alpha}\alpha qs \\ -C_y^{\alpha}\beta qs \end{bmatrix}$$







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TCLF-based Optimization

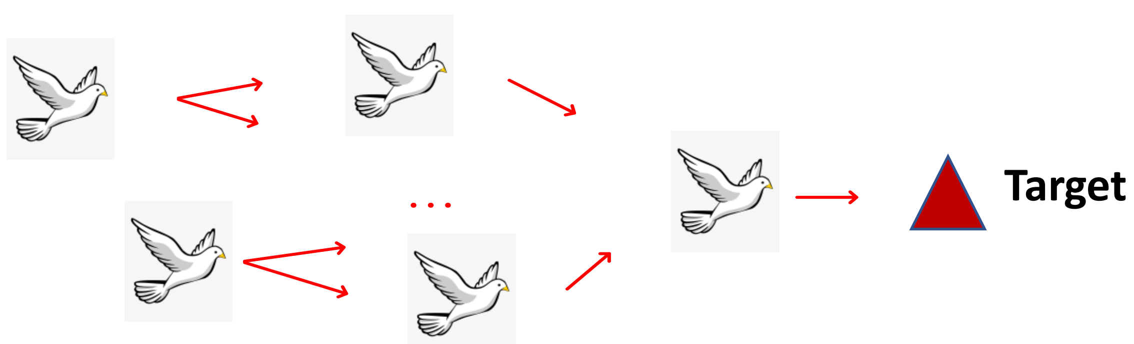
The Optimization Model

$$\begin{cases} \min\ f = \Gamma + \boxed{\sum_{i=1}^{N}\frac{1}{d_i^{2}}} \\ s.t.\quad 0 \le \alpha \le \bar{\alpha} \\ where\ \boxed{\frac{1}{d_i^{2}} = 0,\ \text{if}\ \ d_i > 1.5R_i} \end{cases}$$

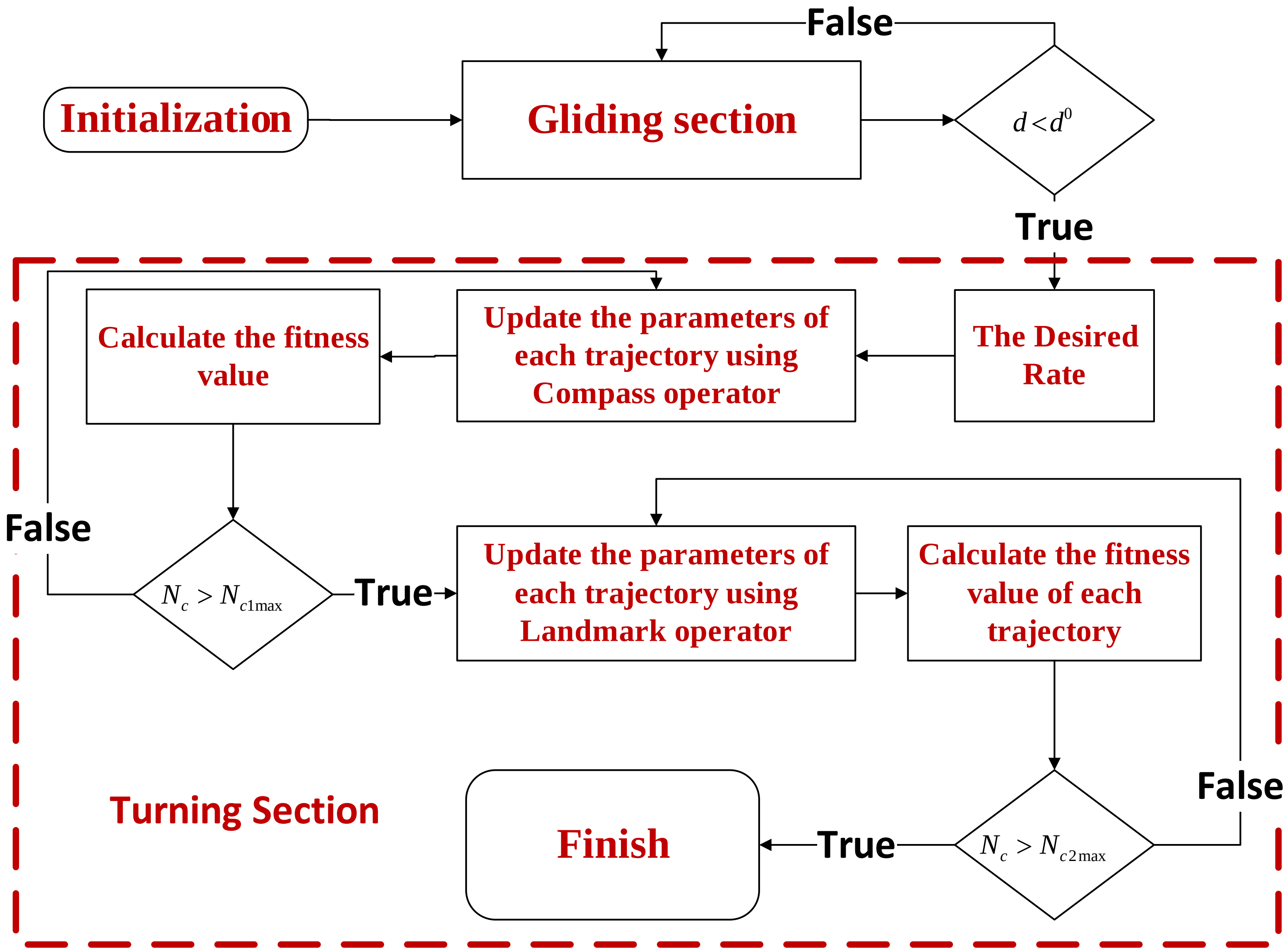
The Penalty Function

Truncation condition

Pigeon-inspired Optimization algorithm (PIO)



TCLF-based Optimization



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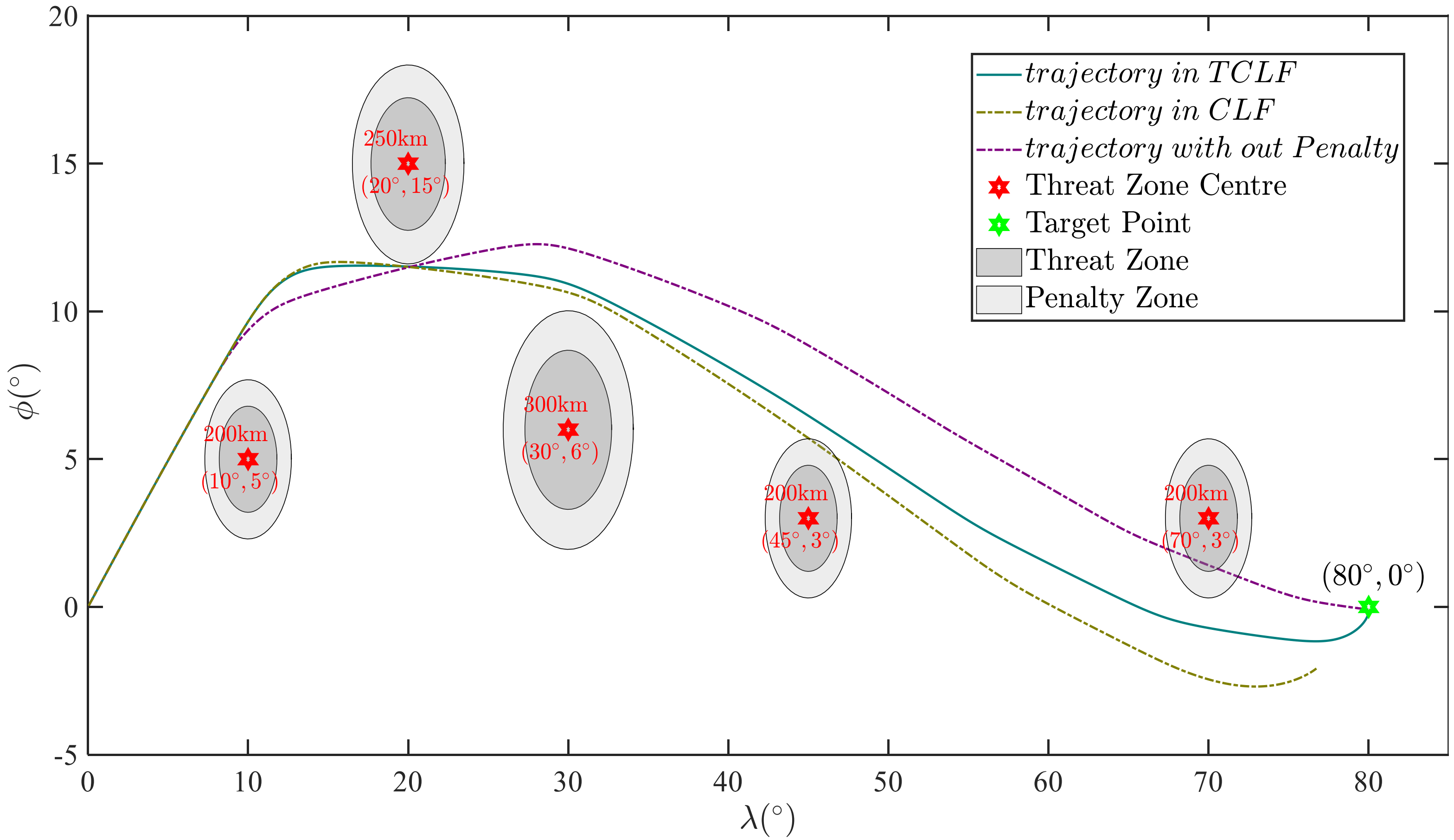
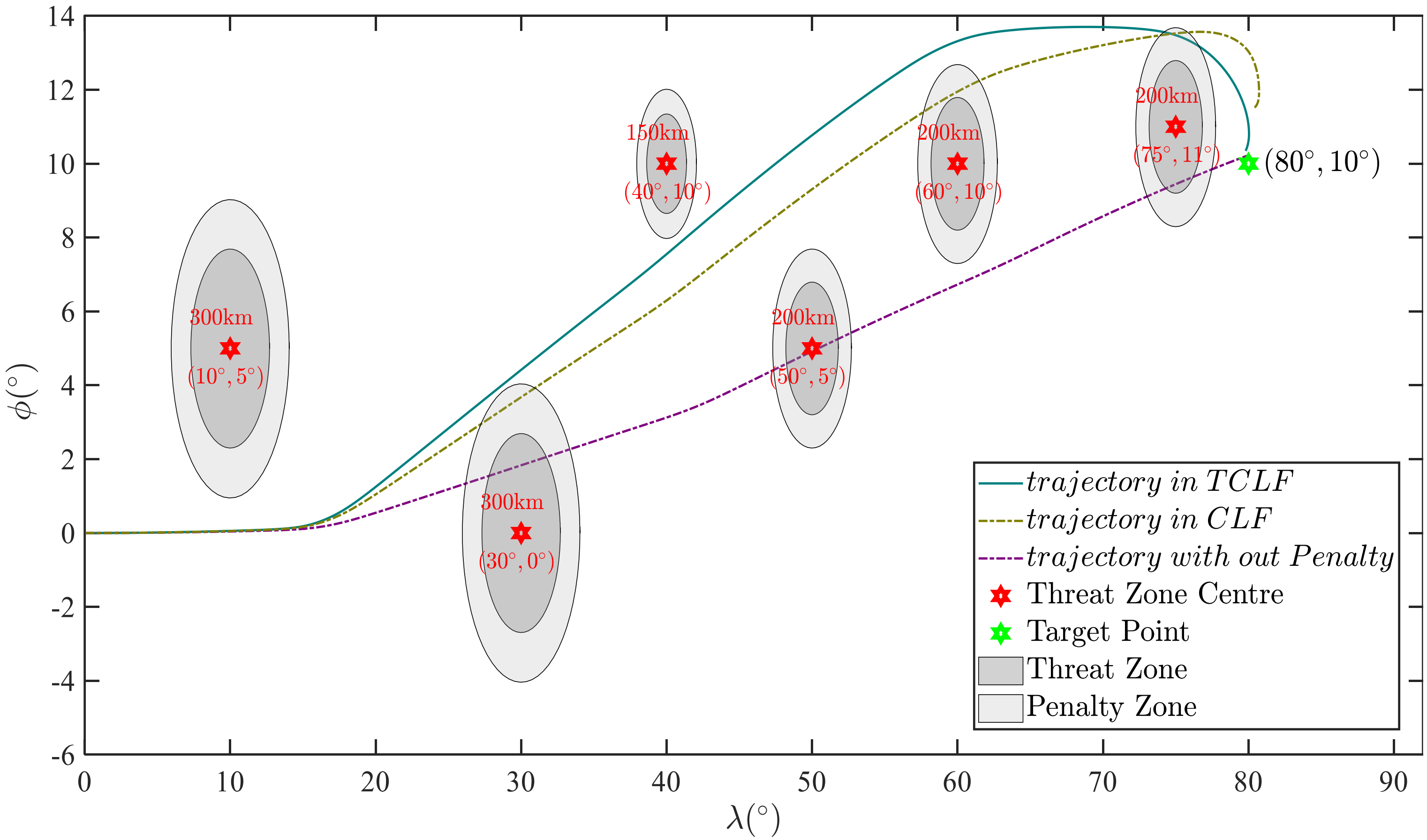
Numerical Examples



Mass	Velocity	Altitude	Location	Azimuth angle	Target
1800kg	24Ma	120000km	$(0°, 0°)$	$45°$	$(80°, 0°)$

Numerical Examples



Mass	Velocity	Altitude	Location	Azimuth angle	Target
1800kg	24Ma	120000km	$(0^\circ,0^\circ)$	90°	$(80^\circ,10^\circ)$

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Conclusion

TCLF-based

1. Good versatility and high efficiency
2. Real Guidance signals obtained
3. Adapt to different situations:
    - Launch conditions
    - threat zone settings
4. Insufficient back-range maneuverability

Thank you & Question ?

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