Supplementary of Additional Simulation Examples

➢ Control Conflicts in High-Density UAV Operations

We have conducted additional simulation verification scenarios with denser formations. Specifically, we performed simulations with **20, 30, 40, and 50 UAVs**, respectively, where both initial and target positions were randomly generated. The simulation results, as illustrated in Figures S1 through S8, demonstrate the effectiveness of our proposed collision avoidance strategy even in relatively dense formations.

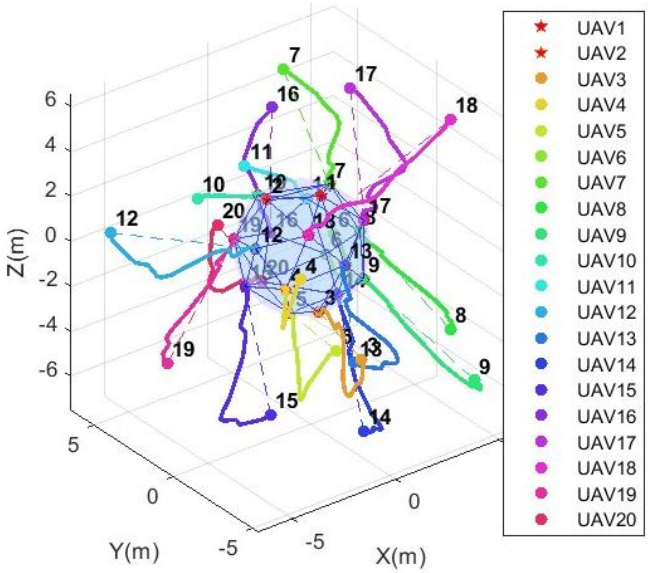


Fig. S1. Trajectories of the followers (20 UAVs).

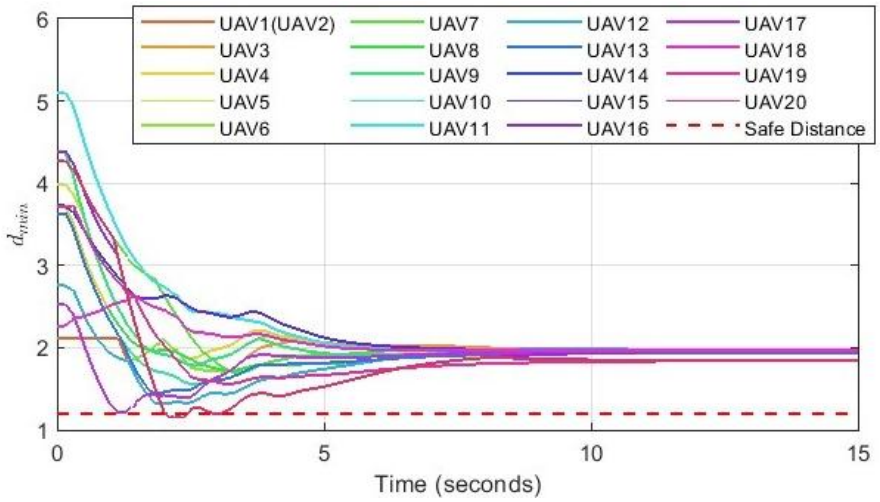


Fig. S2. The minimum distance between each UAV and others (20 UAVs, d_{safe}=1.2m).

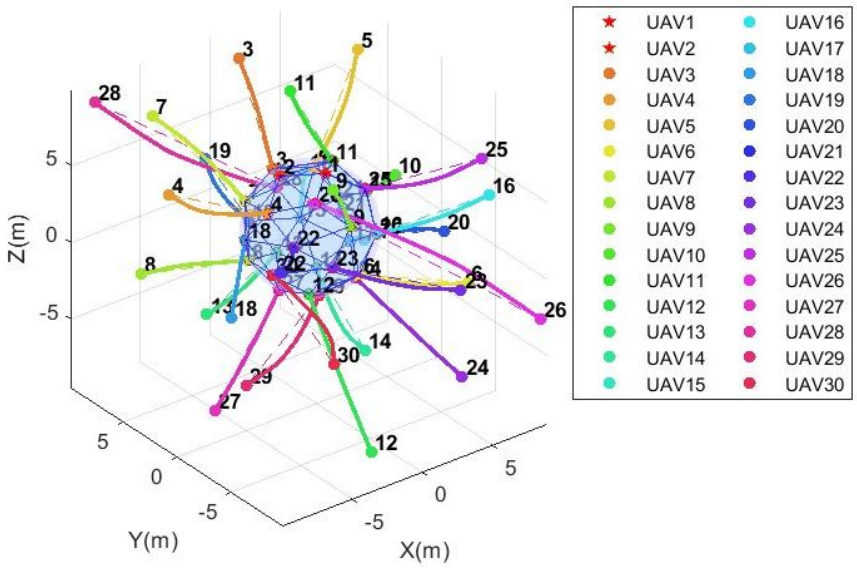


Fig. S3. Trajectories of the followers (30 UAVs).

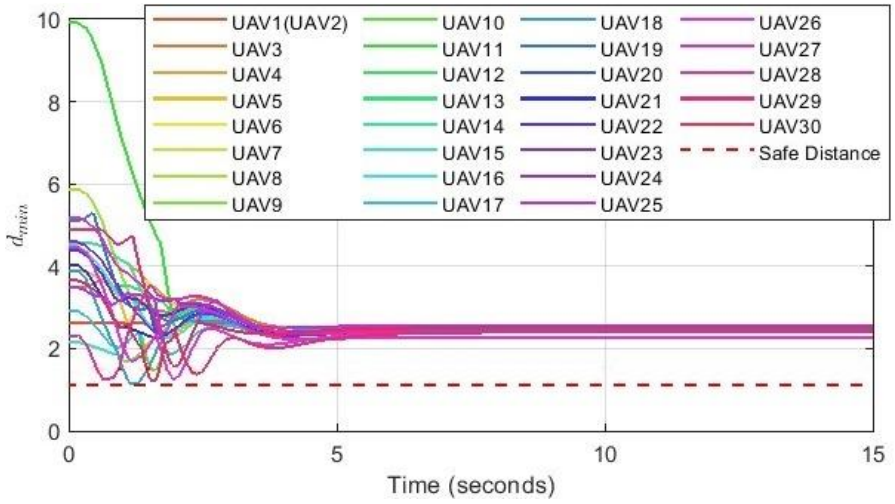


Fig. S4. The minimum distance between each UAV and others (30 UAVs, d_{safe}=1.2m).

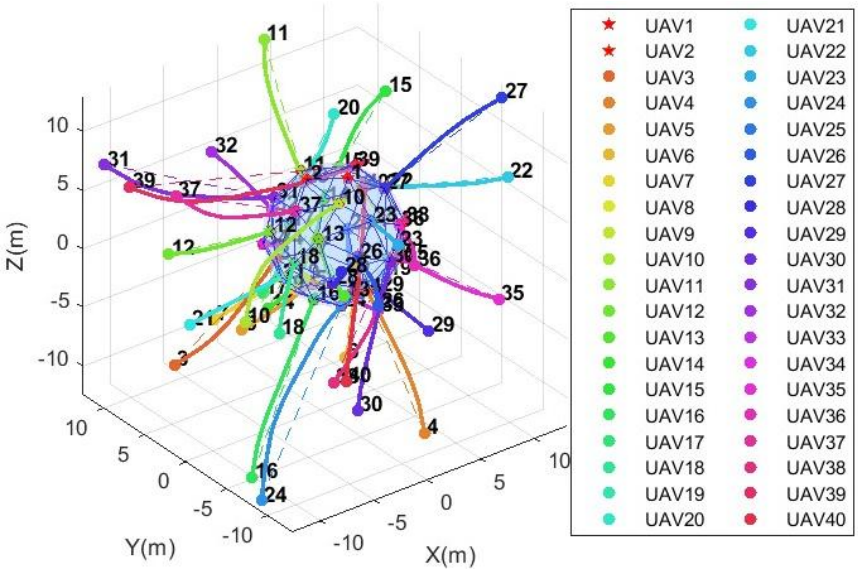


Fig. S5. Trajectories of the followers (40 UAVs).

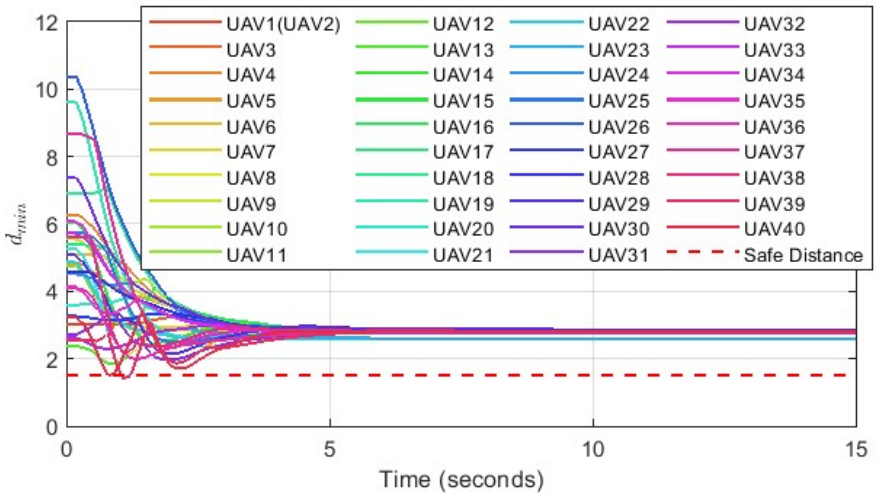


Fig. S6. The minimum distance between each UAV and others (40 UAVs, d_{safe}=1.5m).

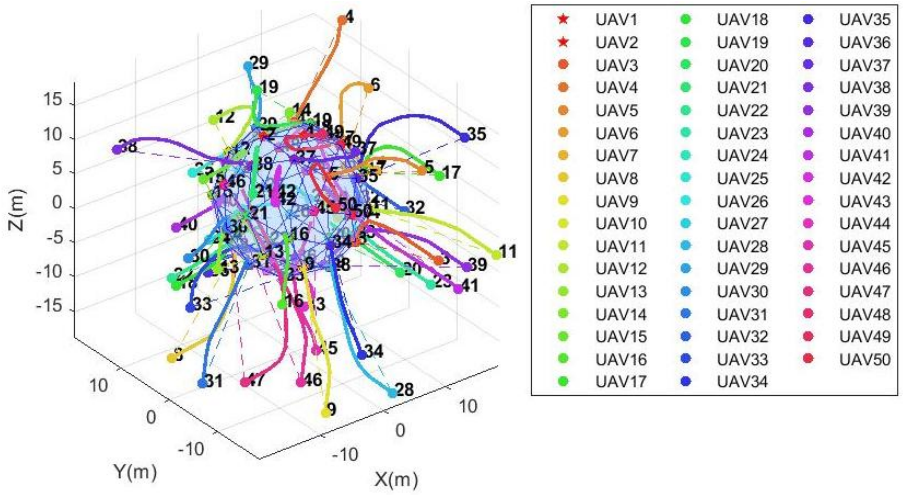


Fig. S7. Trajectories of the followers (50 UAVs).

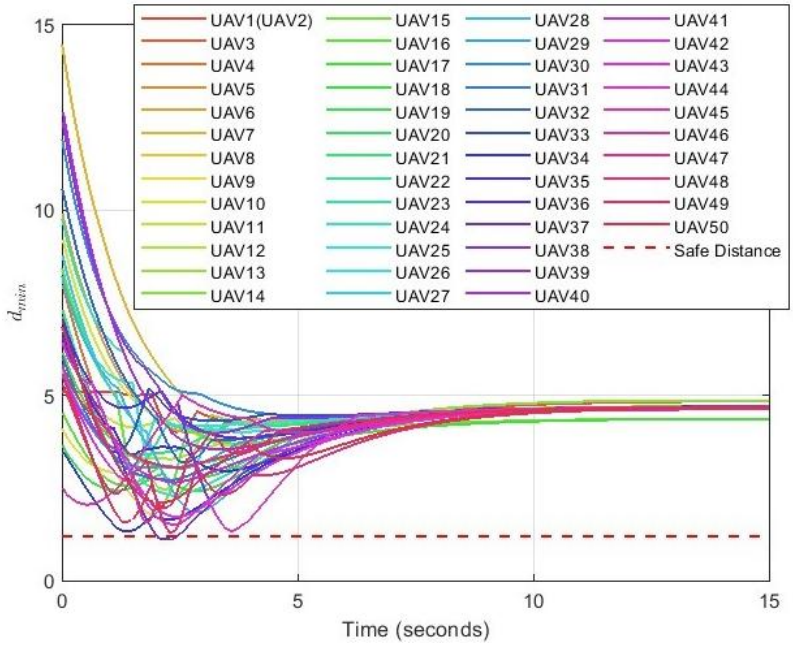


Fig. S8. The minimum distance between each UAV and others (50 UAVs, d_{safe}=1.5m).

➢ **Expanded Simulation Scenarios**

We have also enhanced the experimental validation by incorporating more diverse and complex test scenarios. Specifically, as shown in Figures S9 through S16, provide concrete evidence of our method's adaptability across diverse scenarios. By testing with randomized initial and target positions and larger swarm sizes, we demonstrate that the proposed approach remains effective and stable under a variety of conditions, thereby reinforcing its robustness and potential for practical applications.

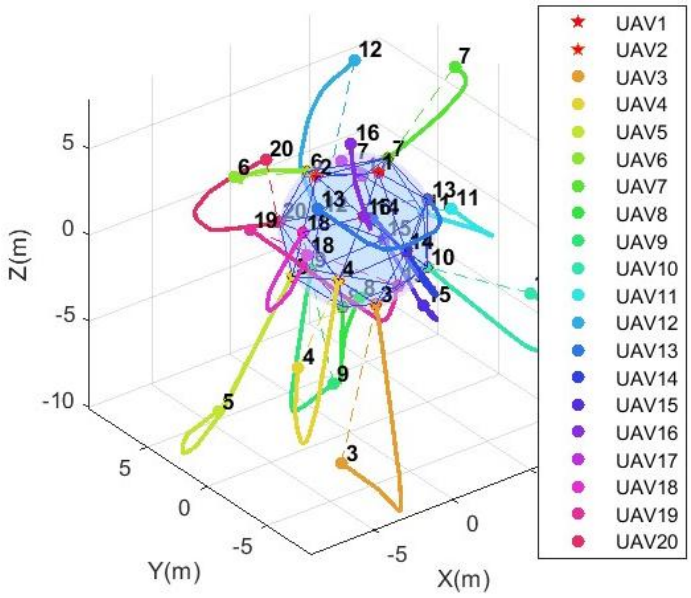


Fig. S9. Trajectories of the followers (20 UAVs).

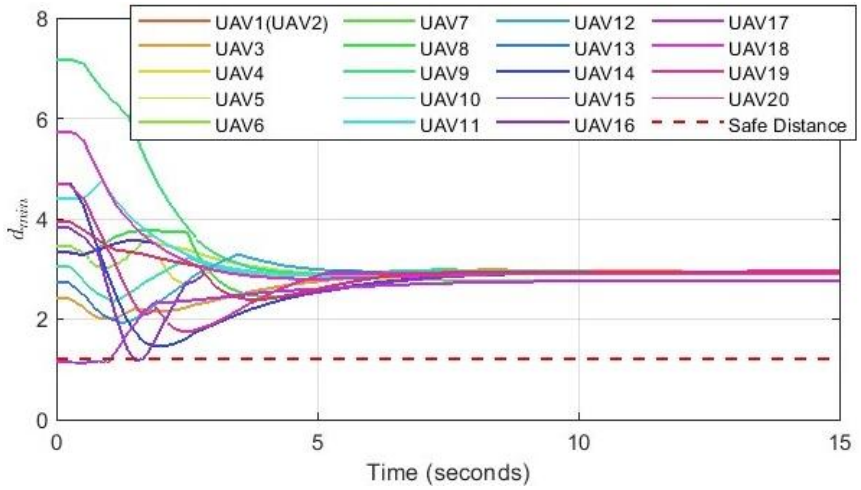
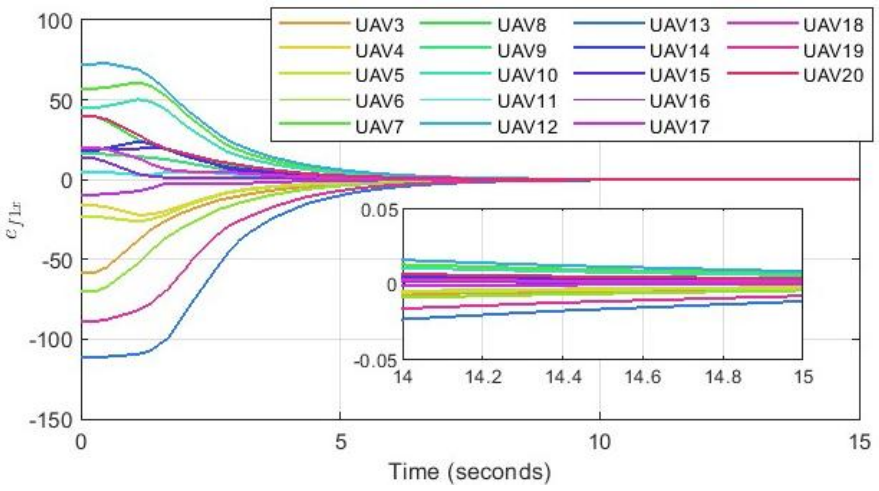
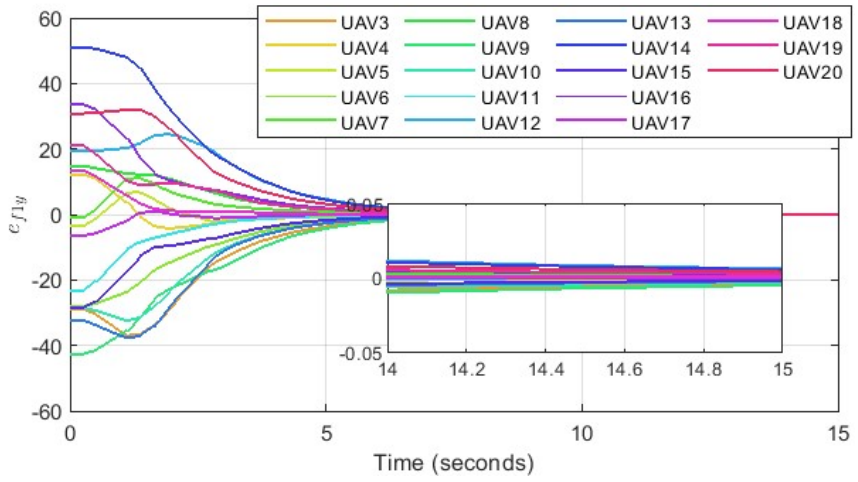


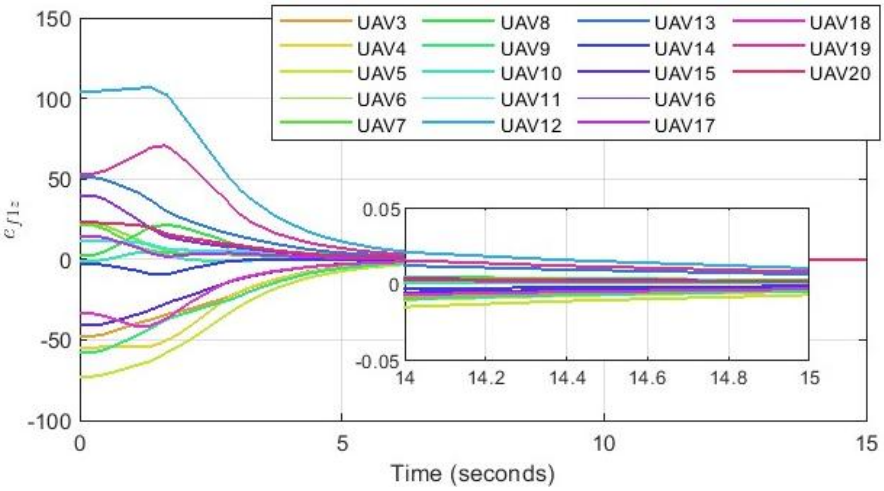
Fig. S10. The minimum distance between each UAV and others (20 UAVs, d_{safe}=1.2m).



(a) e_{f1x}

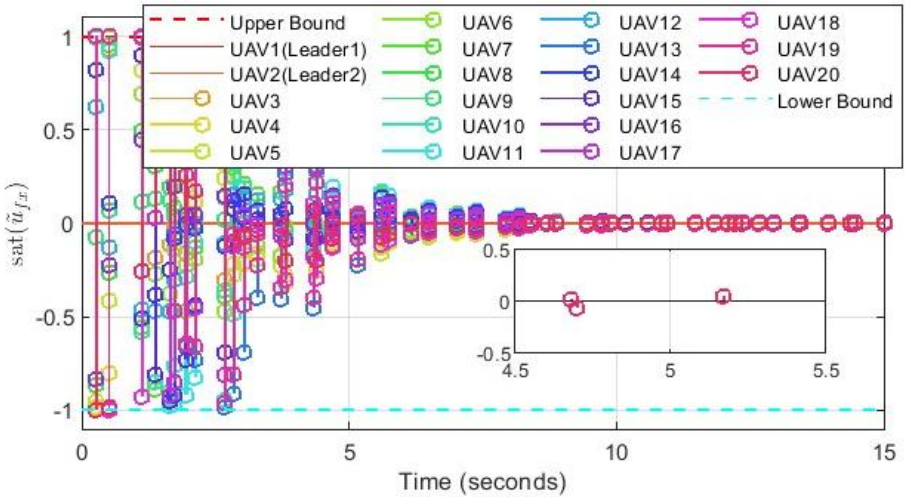


(b) e_{f1y}

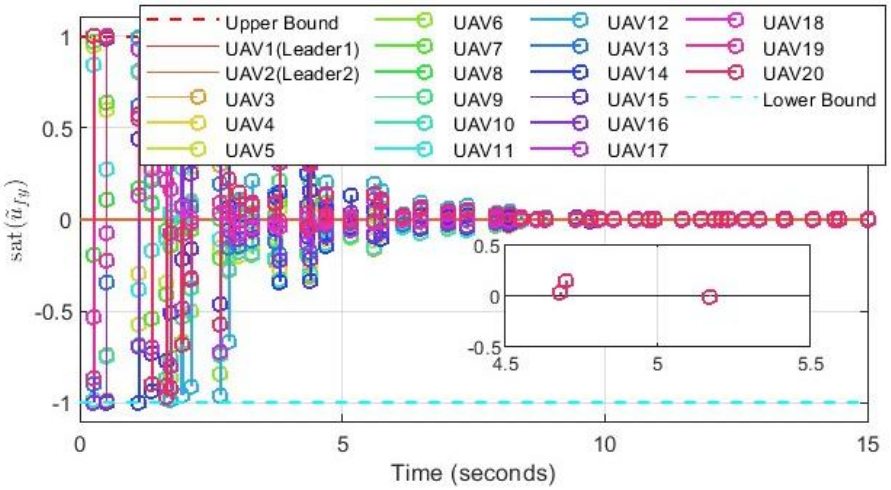


(c) e_{f1z}

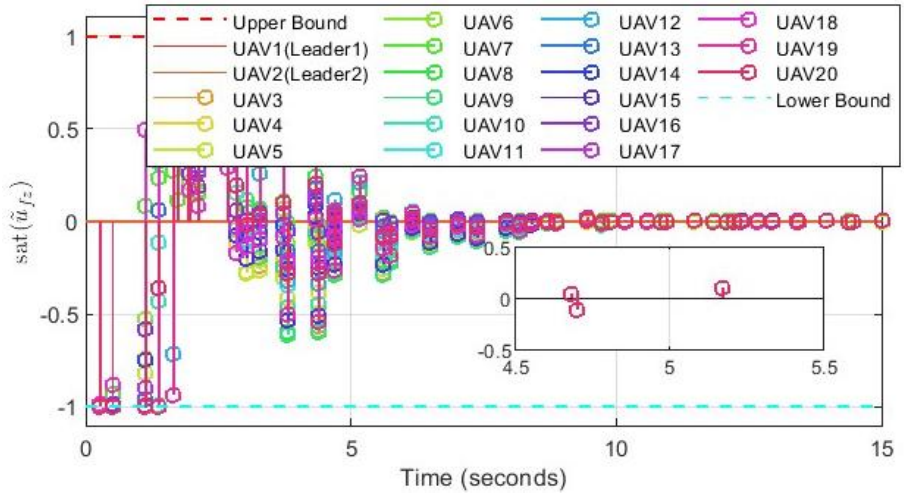
Fig. S11. The bearing error of each follower (20 UAVs).



(a) $\mathrm{sat}(\tilde{u}_{\varepsilon fx})$



(b) $\mathrm{sat}(\tilde{u}_{\varepsilon fy})$



(c) $\mathrm{sat}(\tilde{u}_{\varepsilon fz})$

Fig. S12. The control signals of each UAV (20 UAVs).

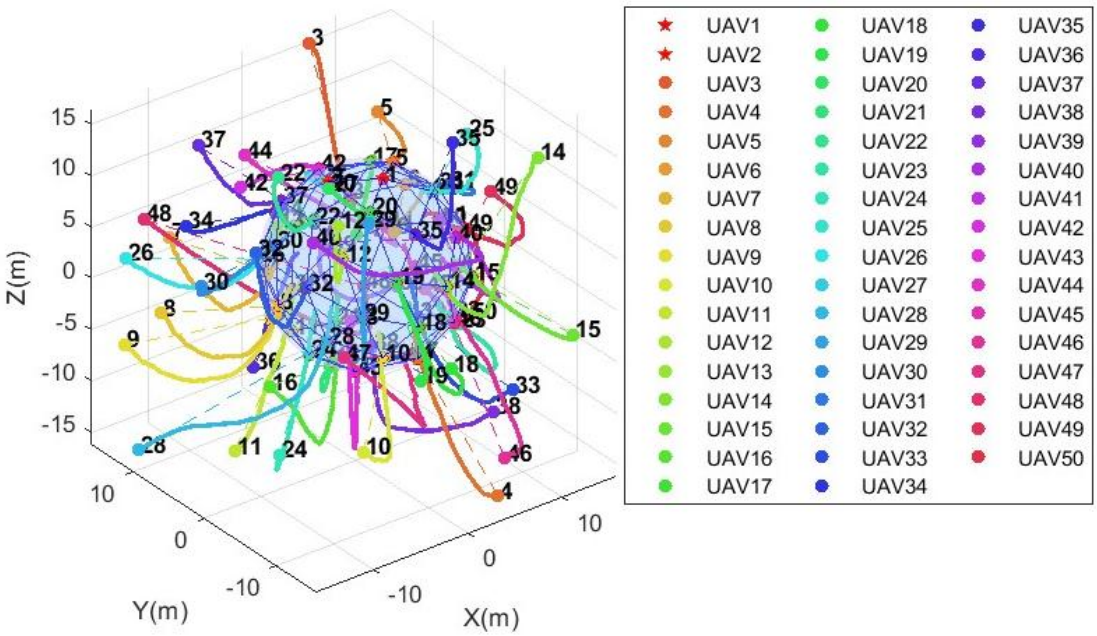


Fig. S13. Trajectories of the followers (50 UAVs).

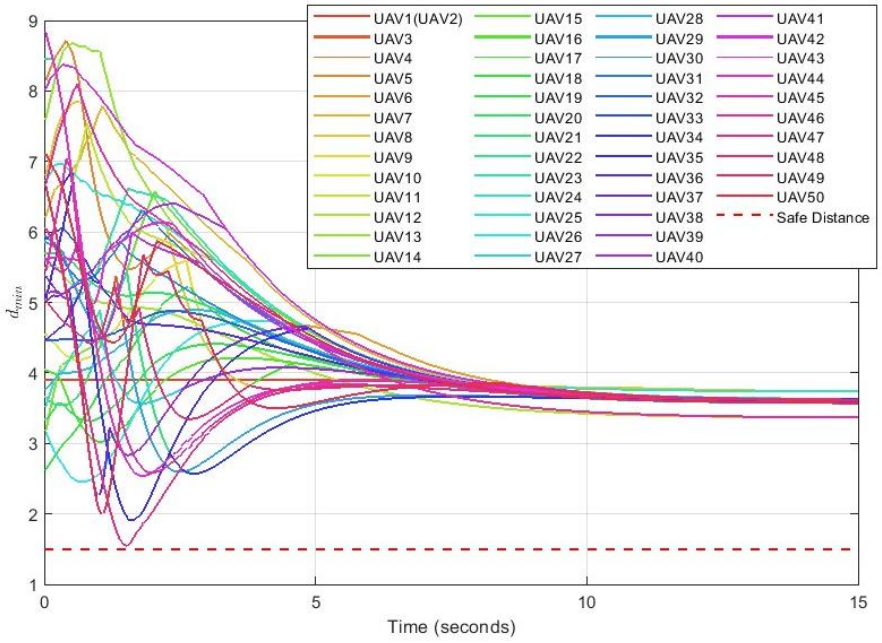
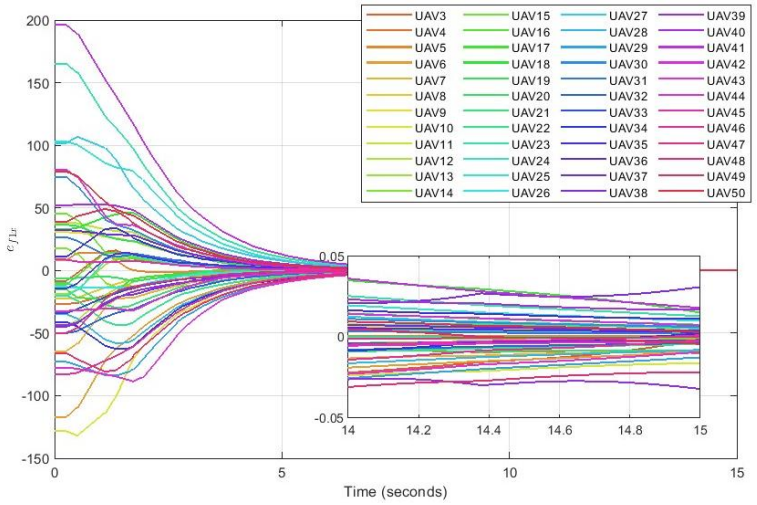
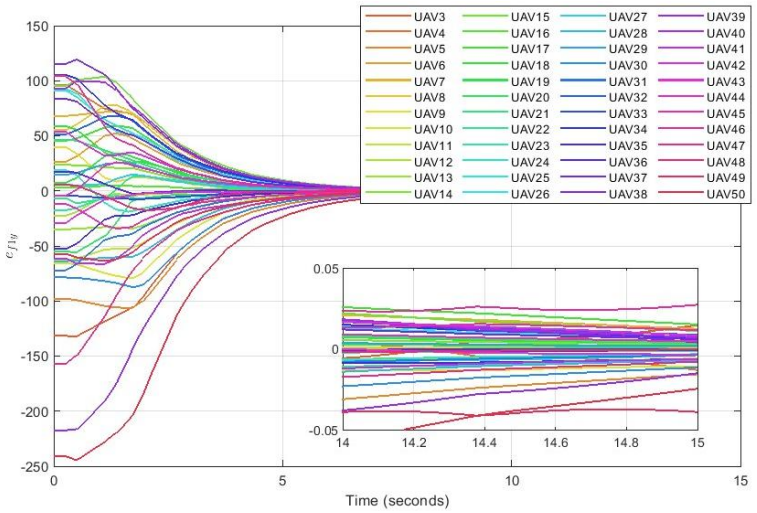


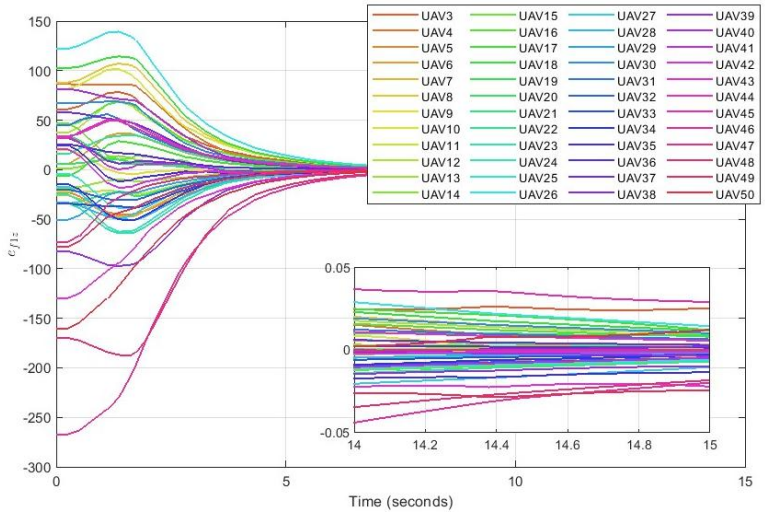
Fig. S14. The minimum distance between each UAV and others (50 UAVs, d_{safe}=1.5m).



(a) e_{f1x}

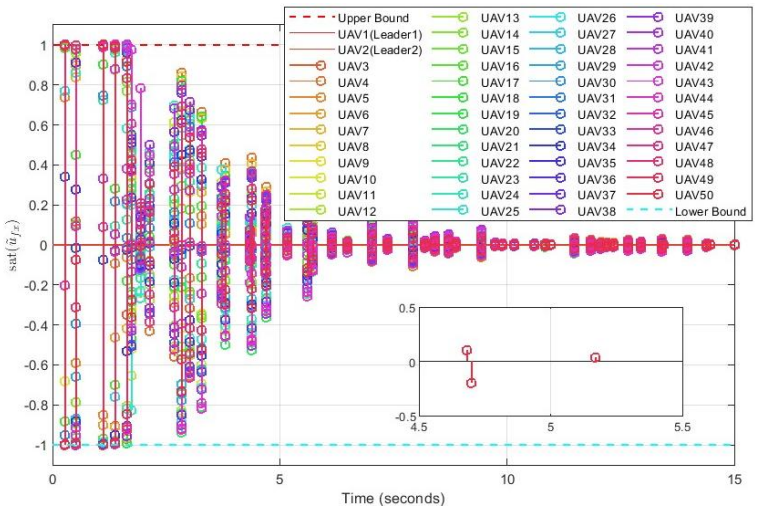


(b) e_{f1y}

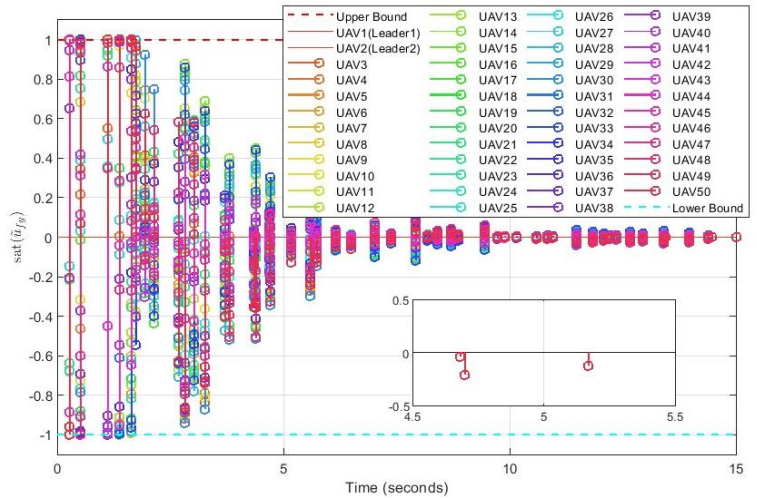


(c) e_{f1z}

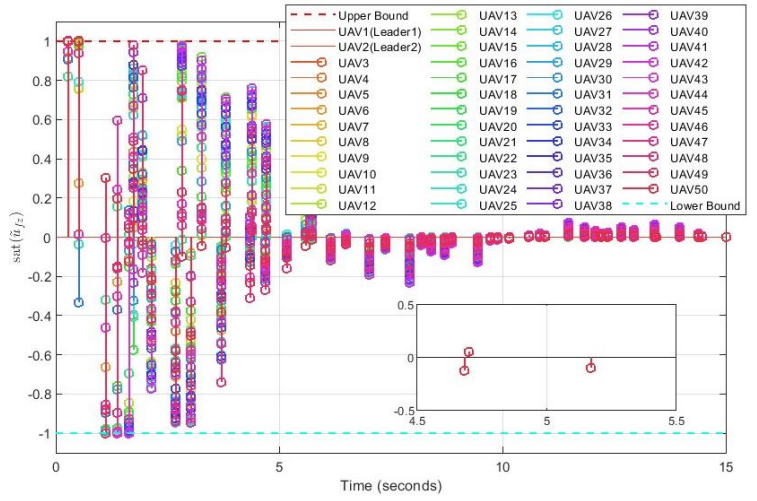
Fig. S15. The bearing error of each follower (50 UAVs).



(a) $\mathrm{sat}(\tilde{u}_{\varepsilon fx})$



(b) $\mathrm{sat}(\tilde{u}_{\varepsilon fy})$



(c) $\mathrm{sat}(\tilde{u}_{\varepsilon fz})$

Fig. S16. The control signals of each UAV (50 UAVs).