

## CUMCM-2025 Problem A

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### Dropping Strategy of Smoke Screen Interference Bombs

Smoke screen interference bombs mainly disperse through chemical combustion or explosion to form smoke screens or aerosol clouds, forming a shield in a specific airspace in front of the target. They interfere with enemy missiles, which have the advantages of low cost and high cost-effectiveness. With the continuous development of the smoke screen interference technology, there are now multiple dropping methods to achieve precise and targeted scattering of smoke screen interference bombs that can be accurately controlled to reach the predetermined position before scattering, and the detonation time can be controlled by the timing of the time fuse.

Consider the dropping strategy of the smoke screen interference bombs using UAVs. A UAV with long endurance capability is equipped with a certain type of smoke screen interference bomb to patrol in a specific airspace. After receiving the mission, the UAV drops the smoke screen interference bombs to form a smoke screen between incoming weapons and protected targets. Each UAV is required to drop two smoke screen interference bombs with an interval of at least 1 second. After the smoke screen interference bomb separates from the drone, it moves under the action of gravity. After detonation of the smoke screen interference bomb, a spherical smoke cloud is instantly formed. By using the specific technology, the smoke cloud sinks uniformly at a speed of 3 m/s. According to experimental data, the smoke concentration within 10 m of the cloud center can provide effective shielding for the target within 20 seconds of detonation.

The incoming weapon is an air-to-ground missile with a flight speed of 300 m/s. The flight direction of the missile is aimed directly at a false target specially set up to cover a cylindrical real fixed target with a radius of 7 m and a height of 10 m. Taking the false target as the origin, the horizontal plane as the  $xy$  plane, and the center of the bottom surface of the real target as  $(0, 200, 0)$ . When the alert radar detects incoming missiles, 3 missiles M1, M2, and M3 are located at  $(20000, 0, 2000)$ ,  $(19000, 600, 2100)$ , and  $(18000, -600, 1900)$ , respectively, and the location of 5 UAVs are FY1(17800, 0, 1800), FY2(12000, 1400, 1400), FY3(6000, -3000, 700), FY4(11000, 2000, 1800), FY5(13000, -2000, 1300).

During the missile attack, it is necessary to try to avoid the incoming missile from detecting the real target by dropping the smoke screen interference bombs. When the control center detects incoming missiles by the surveillance radar, it immediately assigns a task to UAVs. After receiving the mission, the UAVs can instantly adjust its flight direction as needed, and then fly in a straight line at a speed of 70~140 m/s in a constant altitude. The flying direction and speed of each UAV may vary, but will not be adjusted once determined.

To achieve a more effective smoke screen interference effect, it is necessary to design a dropping strategy for the smoke screen interference bombs, mainly including the flying directions and speeds of UAVs, the dropping points and the detonation points of the smoke screen interference bombs. For the different situations of the problems, please establish mathematical models for designing dropping strategies for the smoke screen interference bombs, to achieve the longest effective shielding time of multiple smoke screen interference bombs on the real target. The shielding of different smoke screen interference bombs may not be continuous.

**Problem 1** Use the UAV FY1 to drop 1 smoke screen interference bomb to interfere with M1. Assume that FY1 flies towards the false target at a speed of 120 m/s, drop 1 smoke screen interference bomb 1.5 seconds after receiving the mission, and detonate it 3.6 seconds after. Please give the duration of effective shielding of the smoke screen interference bomb on M1.

**Problem 2** Use the UAV FY01 to drop 1 smoke screen interference bomb to interfere with D01. Please determine the flight direction, flight speed, the dropping point of the smoke screen interference bomb, and the explosion point of the smoke screen interference bomb of FY01, to maximize the duration of shielding.

**Problem 3** Use the UAV FY1 to drop 3 smoke screen interference bomb to interfere with M1. Please give the dropping strategy of the smoke screen interference bomb, and save the results to the file result1.xlsx (the template file is provided in annex).

**Problem 4** Using 3 UAVs FY1, FY2, FY3 to drop 1 smoke screen interference bomb each to interfere with M1. Please give the dropping strategy of the smoke screen interference bomb, and save the results to the file result2.xlsx (the template file is provided in annex).

**Problem 5** Using 5 UAVs to drop at most 3 smoke screen interference bombs each to interfere with 3 incoming missiles, including M1, M2, and M3. Please give the dropping strategy of the smoke screen interference bomb, and save the results to the file result3.xlsx ((the template file is provided in annex).