Contents

1　Problem Restatement

Searching for a lost plane:

Recall the lost Malaysian flight MH370. Build a generic mathematical model that could assist "searchers" in planning a useful search for a lost plane feared to have crashed in open water such as the Atlantic, Pacific, Indian, Southern, or Arctic Ocean while flying from Point A to Point B. Assume that there are no signals from the downed plane. Your model should recognize that there are many different types of planes for which we might be searching and that there are many different types of search planes, often using different electronics or sensors. Additionally, prepare a 1-2 page non-technical paper for the airlines to use in their press conferences concerning their plan for future searches.

2　Terminologies and Conventions

- **SAR**. Search-And-Rescue.

- **MTOW**. Maximum Take Off Weight.

- $\tilde{r}$. Distance between point of last contact and point of incident.

3　Assumptions and their Justifications

About the Search Domain and the Missing Aircraft

- **The initial search domain is a 500km by 300km rectangle of unobstructed ocean.** This rectangle would cover the whole uncertainty range based on the last known state of the lost aircraft for an interval of 15 minutes to 1 hour based on INMARSAT's "Log-on Interrogation" old and newly recommended standards in light of the MH370 accident[**citation**].

- **The missing aircraft is assumed to be still in this domain at $t = 0$.** Although escaping the domain at a later time is allowed.

- **The crashed/force landed aircraft debris is assumed to be remain close to each other and floating at all time.** The assumption is that not enough time have passed for important targets (e.g. lifeboats)

- **The local trajectory of concern is straight**. In addition to the obvious smoothness arguments, it is always possible to apply a conformal transform on the entire search domain to obtain a solution based on a curved trajectory.

- **No banking maneuver was made from incident to crash.** This is reasonable for that even in the worse case of gliding due to single engine failure, the average time from initial to of roughly 11 minutes[**Citation or see derivation later**]. And this time is not long enough to cause trajectory deviations across different search cells.

- **Hijacking or on-board navigation system only problems are not the cause of the incident**. Although hijacking incidents account for nearly 20% of all accidents in past 50 years **Citation!**, SAR plane (or vessel) detectors are largely useless in finding a cruising rouge plane. Also see problem restatement.

- **The missing aircraft can be accurately modeled as either G280, Boeing 737-900ER, or Airbus 380.** These three types of aircraft are well-known representatives of small private/business jets, medium range commercial flights, and large international flights. Cruise speed and other aircraft form factors (e.g. Lift to Drag ratio) are derived based on this assumption.

- **Aircraft is operating at MTOW**. Assuming they have cargo and passengers

- **Cruise altitude of all types of aircraft is assumed to be the same**. Describe/Justify.

About Debris Drifting

- **The local drift direction can be accurately modeled as uniformly distributed across all angles.** In addition, the drift direction is assumed to be constant within each cell.

- **The local drift speed can be accurately modeled as a Gaussian distribution.**

About the Search Agents

- **All agents are commanded and controlled by the central planner at each update interval.** No command and control overhead is assumed for the sake of simplicity.

- **Agents arrive at the boundary of the search domain at $t = 0$.** Search agents are assumed to have arrived on the edge of the search domain at $t = 0$.

- **Unlimited bandwidth between search agent communications.** This is necessary from a planning perspective as to ignore the less than pertinent issues with sensor fusion and coordination. Moreover, this factor is more than likely fixed by the hardware.

- **Types of search agents considered are helicopter, fixed wing UAVs, and surface vessels.** Although the problem only mentions "search planes," it is very common to have sur

- **Search agents use either magnetometer or camera as their main detector.**

- **Search agents all have a lateral range function of a bivariate Gaussian as a function of their type, altitude, and speed.** Detection follows Koopman's Random search formula.

- **The probability of false alarm is assumed to be 5%.** Lack of exact literature references, pretty good generic guess.??

- **The search agents have perfect knowledge of local drift direction.** Although this is unlikely on the operations level, modern planning softwares used by professional SAR entities (e.g. SARPOS by U.S. Coastal Guards) all have existing database to accommodate real-time ocean drifting, data that are not useful on a fictitious geography.

4　Literature Review

5　Criteria for Optimal Solution

6　Describe Your Method

The coarse search cell is assumed to be 17km by 15km. This is based on computational issues. Further refinements are simply an exercise for the computers.

6.1 Description

6.2 Mathematical Interpretation

6.3 Comparison to Most Interesting Literature Paper

7 Comparison to a "Steepest Decent" Search Plan

8 Experimental Setup

9 Results

10 Sensitivity to Parameters

11 Strengths and Weaknesses

Strengths:

- **simple effective**. Description.

- **Short bullet point**. Description.

- **Short bullet point**. Description.

- **Short bullet point**. Description.

- **Short bullet point**. Description.

Weaknesses:

- **resolution/grid size**. Description.

- **renomalization/discretization error**. Description.

- **very simplified drifting**. Description.

- **Short bullet point**. Description.

- **Short bullet point**. Description.

12 Conclusion

- **Recommendation 1**. Why the data says so.

- **Recommendation 2**. Why the data says so.

- **Recommendation 3**. Why the data says so.

- **Recommendation 4**. Why the data says so.

References