Auxilium for Search and Rescue

[1]Rohini Ramakant Bhavsar, [2]Binu Jemima Nadar, [3]Calista Clifford Gonsalves, [4]Mukta Nivelkar

[1,2,3]Student, [4]Professor, Fr. C. Rodrigues Institute of Technology, Vashi, India,

[1]rbhavsar700@mail.com, [2]binujemima46@gmail.com, [3]gonsalvescalista21@gmail.com, [4]mukta.nivelkar@fcrit.ac.in

Abstract: Search and Rescue (SAR) is an integral mission carried out to save people who are in agony, whenever a danger occurs. They are classified into many different sub-fields like Ground Search and Rescue, Mountain Rescue, Maritime Search and Rescue, etc. Our project focuses on Maritime Search and Rescue which is carried out for airplanes in distress in the sea. Though there have been many technological advancements in the field of search and rescue, in the form of drones, robots, etc. Nevertheless, one part is always overlooked here, which is, the planning for SAR missions. When it comes to planning for search and rescue missions, the strategists, get data constantly and hence they need to reconsider and redo their plans simultaneously. Also, as the continuous incoming data can change drastically, they need to start the plan from scratch repeatedly. All this is usually done manually and at times can cause delays in the commencement of SAR missions. Hence, our aim is to help this planning sector, which will not only help them, but also decrease the time in planning as well. This paper summarizes the overall planning and execution of the Maritime Search and Rescue Operation which involves Search area, Search Pattern, and the current weather updates so that the SAR team can carry out the operation easily.

Keywords* — *SAR, LKP, IAMSAR, MCDA, GIS

I. Introduction

Airplanes can go missing because of several reasons due to accidents, harsh weather conditions, hijacking, etc. The Maritime Search and Rescue Operation's mission is to rescue people in distress due to some unforeseen situation, mainly in the sea. Also, airplanes crashing into the sea are difficult to locate, hence it furthermore adds difficulty in locating the missing airplane. Before any onset of SAR missions, a plan has to be made. The commencement of a SAR plan is done after the following basic necessities are calculated i.e., the search area and search pattern. After both the search area and search pattern are calculated, the other details are added, and accordingly, the search and rescue plan are designed. Another important thing considered is the climatic conditions of the region considered for the rescue mission, as the necessary precautions needs to be taken accordingly. SAR for airplanes is a bit tricky, keeping in mind the geographical factors, the climate which is not static and keeps changing every minute. Keeping all of this into consideration and drafting an efficient plan, can increase the probability of coherent rescue operation of airplanes that are either missing or in distress

Though there are many technological advancements in the rescue part, by building this we want to encourage the idea of using technology in the planning sector. As the basics in any rescue plan are search area and search pattern, our system will be able to do that with just the Last Known Position and the time at which the LKP was known. Hence, rather than doing the same procedure repeatedly, when latest information pours in, one can rely on the software for the initial part and go further on with the plan, without going back to square one.

II. Literature Survey

The main reference for this project was the manual published by IAMSAR which describes what all is needed and done when a search and rescue mission takes place. The International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual is a good source which gives us an outline about the behind-the-scenes of a Search and Rescue operation.

Emrah Soylemez's paper proposes [1] a system that makes use of MCDA [Multiple Criteria Decision Analysis] and Geographic Information System [GIS]. The basic idea of this system is to create probability maps with respective search patterns based on the data collected, such as the last known position, environmental data. However, one disadvantage of this system is that it needs manual intervention, to decide which search pattern needs to be considered. Lioa Guoxiang and Maofeng [2] have presented a model that uses predefined databases to assist in determining search areas and search patterns. However, here the chances of inaccuracy can increase if the database is not updated accordingly. Beni Krisbiantoro, Hilwadi Hindersah & Tunggal Mardiono [3] put forward a system that provides functions for users to access map data onto GIS servers throughout computer networking. The basic function of this system is to describe the architecture for aircraft simulation routes of Search and Rescue (SAR) operations. However,

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apart from this, it isn't of much help. Neither helps in providing the search area or the search pattern. Dieter Schuldt and Joel Kurucar [4] have discussed the methods where the Maritime SAR tasks are performed by a set of Unmanned Aerial Systems, it makes use of methods and functions to divide the space into smaller spaces, so as to find the object. Here the results are produced using simulation, but for smaller search areas efficiency is much lesser than larger areas. Seunghyeon Lee and James [5] have produced a system where a search task consists of a UAV traveling to an assigned cell and uses IR camera to seek survivors in that cell, if any survivor is found the UAVS visit each cell in the order prescribed by task allocation system, nonetheless, the paths used for UAV are not optimized.

III. Existing System

Salvatore Aronica, Francesco has built [8] An Agent-based System for Maritime Search and Rescue Operations, this application is built to formulate a search plan by considering the positions of the distressed vehicle and the nearby search units. It finds the vessel that has requested for a rescue and plans the efficient path for the rescue operation. It not only localizes but also visualizes the location of the distressed vehicle. The basic idea is to formulate the location of the vehicle in distress and then consider all the multiple signals detected in different search units. All these factors are then used to formulate a search plan. The main drawback of this system is, it only relies on signals. Hence, if there are no signals sent or detected, it cannot formulate a plan. The accuracy is based on the number of search units who detected the signal, if the number of search units present in the region is less; so, will be the accuracy of the formulated plan.

A google play store application [9] Search and Rescue - SAR Tools Application, it is a mobile application that works as a handy calculator for simple SAR missions. It calculates speed, distance, and time according to the given parameters. The final output not only consists of the above calculations but also provides search patterns and their values.

However, this application is only applicable for SAR missions on a small scale. The calculation can be performed by other applications. The only added advantage it possesses is the search pattern recommendation with the values.

IV. Proposed Solution

Proposed solution is for finding missing or distress aircrafts in sea covered by the Indian territory. It is mentioned in the NMSARCA that Indian Maritime Search and Rescue System of India is divided into three areas which are Mumbai, Chennai, and Port Blair with Maritime Rescue Coordination Centers (MRCCs) [7].

The proposed solution, first calculates the search area and then suggests appropriate search patterns to cover the search area in minimum time. Also, weather condition for provided last known position is made known, so that it is taken into consideration before leaving for the mission. Solution is divided into three main modules namely - find search area, suggest search pattern, and information about the climate conditions.

A. Block Diagram

As block diagram, Fig. 1 shows there are four steps. In the first step - The last known position, the time at which the last known position was known, and the type of aircraft are inputs. Then the database helps us to determine the speed of the aircraft. After taking all inputs, the circular search area is computed using a formula. With the help of the search area, an appropriate search pattern is suggested. There are three search patterns [6] namely the square search pattern, sector search patterns, and parallel search pattern. To identify the correct search pattern, the radius of the calculated search area is taken into consideration. After finding appropriate search pattern, climate conditions like sea current, sea surface drift is taken via the Openweather API (application programming interfaces).

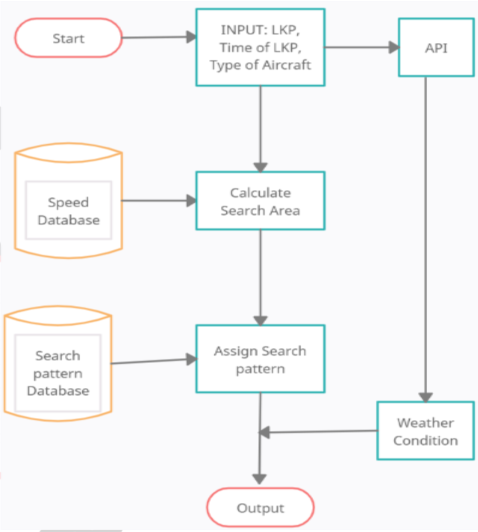

Fig. 1 Flow Diagram of system

Search and Rescue can happen either over land or water. But, the focus of this system is the water with the help of Indian Maritime Search and Rescue. The Indian Maritime Search and Rescue Region is divided into three areas which are located at Mumbai, Chennai, and Port Blair. The Indian Coast Guard supervise the SAR maritime missions. There are 10 Maritime Rescue Sub Centers (MRSCs) [7]. After giving the desired inputs, the area where the aircraft could be floating or missing can be determined for rescue missions.

B. Area covered

Search and Rescue can happen either over land or water. But, the focus of this system is the water with the help of Indian Maritime Search and Rescue. The Indian Maritime Search and Rescue Region is divided into three areas which are located at Mumbai, Chennai, and Port Blair. The Indian Coast Guard supervise the SAR maritime missions. There are 10 Maritime Rescue Sub Centers (MRSCs) [7]. After giving the desired inputs, the area where the aircraft could be floating or missing can be determined for rescue missions.

The search pattern will be applied in any of these search areas which will be calculated with some parameters and climatic

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conditions will also be stated so that the SAR team can take necessary precautions.

V. IMPLEMENTATION

Search area: This is the calculated area used by the SAR team while searching for the missing flight in minimum time. To find the appropriate area we will deduce distance by using the formula, distance= time*speed. For the time component we will consider the time difference between the time when the last known position was known and the time at which the SAR planning starts. When it comes to speed, different types of planes have a certain air cruising speed that they need to follow, and that will be taken into consideration for our speed component depending on the type of plane that needs to be searched for. Using both these components, we will be able to calculate the distance which is the radius for our search area.

Search pattern: Selecting appropriate search pattern helps to cover the search area in minimum time. For suggesting proper search pattern different parameters are considered, like radius of circular search area, information known about distress aircraft and search area. Datum is a geographical point used as reference for search planning [6]. Appropriate search pattern is assigned considering the area to be covered.

The search pattern's data, helps us to calculate how much time it will take to cover the search area. Each leg covers a particular length, this will help us to determine how much time it will take, for a vehicle of a particular speed to cover the search area.

In SAR planning speed is considered in knots, and

1 knot= 1.85 kmph [10]

Square search pattern is used when small vessels or small boats are used for searching and when the search area is small [6]. Sector search pattern is used when the position of the distress object is precisely known and search area radius is between 2NM to 20 NM. In sector search pattern turn angle is 120° [6]. Parallel search pattern is used when an on-scene coordinator is present to give direction. In parallel search pattern, both aircraft and boats are used for searching. Hence, it gives a higher probability of search. [6]

$$Vs = (S \times Va) / (L+S) \quad [6]$$

Where,

Vs = Speed of surface facility in knots

Va = aircraft true air speed

S = track spacing in NM (nautical miles)

L = Length of aircraft search leg [6]

Fig.2 Square search pattern

Fig. 2 Shows the square search pattern having datum at center and the red circle is the search area which the SAR team will use to find the object in distress. The marker is the LKP of the object in distress.

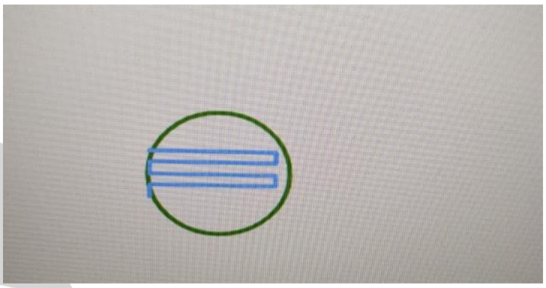

Fig.3 Parallel search pattern

Fig.3 Shows the parallel search pattern having datum at center and green circle shows the search area which the SAR team will use to navigate to find the object in distress. Figure 3 also shows 2 legs and each leg starts from the circumference of the search area.

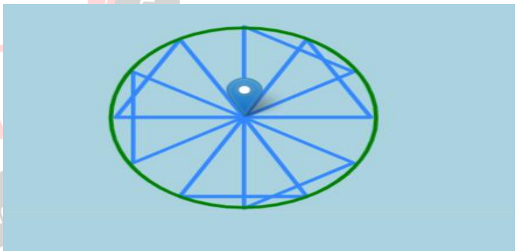

Fig.4 Sector search pattern

Figure 4 shows the sector search pattern having datum at center and the green circle shows the search area which the SAR team will use to navigate to find the object in distress. It also shows the legs and each leg starts from the center of the circular search area at an angle of 30°.

	leg	latitude	Longitude	Distance Covered	Time Required(Hr)
0	1.0	19.17375	72.290544	2.0	0.004615
1	2.0	19.18375	72.300544	4.0	0.009230
2	3.0	19.16375	72.280544	6.0	0.013845
3	4.0	19.19375	72.310544	8.0	0.018460
4	5.0	19.15375	72.270544	10.0	0.023075
5	6.0	19.20375	72.320544	12.0	0.027690
6	7.0	19.14375	72.260544	14.0	0.032305
7	8.0	19.21375	72.330544	16.0	0.036920
8	9.0	19.13375	72.250544	18.0	0.041535
9	10.0	19.22375	72.340544	20.0	0.046150

Fig. 5 Time required for each leg

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Fig. 5 The above data shows how much time it will take for a vehicle of a particular speed, to cover each leg of square pattern. After selecting appropriate search pattern SAR team starts searching from datum point and goes along the path of the search pattern with the possibility that distress aircraft is present near the calculated search area. Also, total search pattern area is calculated and using speed = distance/ time formula maximum time required for searching is calculated. Speed in knots and distance in kilometers and last known position in Decimal Degrees is given as an input to the system as shown in Fig.6. For plotting search pattern Folium python library is used.

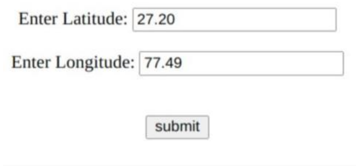

Fig. 6 Enter Longitude and Latitude as input

A. Weather condition: For SAR operation current weather condition for the given last known position is considered. The last known position is given as an input in the form of latitude and longitude as shown in Figure 6 and similarly Temperature, Humidity, wind speed, Wind Degree, Visibility, Pressure, Cloudiness, Maximum Temperature for given Last known position are noticed using openweather API. Fig. 7 shows the weather condition for provided last known position

Fig. 7 Weather condition for Last Known Position

VI. Conclusion And Future Scope

By making this system we will be able to locate aircrafts in distress and reach out to them much faster by providing the SAR team with an appropriate search area and a search pattern to help them navigate faster. As new data pours in continuously, it will be of great use for the planning sector, as they won't have to start the plan from scratch.

There are many technological advancements in the rescue part, however there is not much use of computers in the planning sector. By building this system we want to encourage the idea of using technology in the planning sector, as well. The system can be further updated, and can be used for much complex planning. We can add more factors to determine a more optimal search area which will further improvise the result. The system could be extended with more features like showing live location and direction on search pattern recommended by system. Probability maps could be implemented to find out and concentrate on areas that are highly probable that will reduce the time for the overall search area.

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