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CONFLICT MODELLING IN HIGHLY INTERACTIVE PROBLEM SOLVER

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Abstract. *Describes a new concept in planning and problem solving for air traffic controllers with the help of Highly Interactive Problem Solver. The modeling results of interactive method for conflict resolution with help of the program developed by the authors are introduced.*

Keywords: conflict situation; Highly Interactive Problem Solver; interactive method; No-go zone; risk.

1. Introduction

In Air Traffic Management systems which are based on principles of air space controlling in area control center the Air Traffic Controllers (ATCo) are responsible for ensuring the separation minima between aircraft. Since the intensity of air traffic flow grows constantly, the abilities of ATCo to solve potential-conflict situations is limited. And one of the possible solutions of this problem is the implementation of Problem Solver (PS) which gives the controller a rapid and reliable means of planning aircraft trajectories and solving problems, particularly conflicts between aircraft.

The PS has two main components: a set of displays which give a comprehensive picture of air situations, and an aircraft trajectory editor. These are coupled together to allow route, altitude and speed maneuvers to be evaluated and implemented in any combination on any aircraft. The PS itself is not an autonomous unit (i.e. it does not solve problems by itself), but rather is an interactive tool for use by the air-traffic controller. For this reason the concept has been named Highly Interactive Problem Solver (HIPS).

2. Problem solver deconfliction concept

Construction of No-go zone. HIPS proposes abstracted diagrams as a novel approach to aid problem solving in ATC.

Abstracted diagrams are 2D graphical representations of aircraft conflicts and performance limits which present the controller with information in the form of time-independent “No-go” zones for a chosen subject aircraft. Such 2D displays are an abstracted form of a 4D geometric model of intersections, projections and transformations. They are interactive to allow the controller to manipulate trajectories in order to avoid the No-go zones.

There are three forms of abstracted display: route, speed and altitude, corresponding to the three types of basic maneuvers available to the controller. The most important of these displays, the route display, could be superimposed upon conventional synthetic radar or conflict assistance displays. A simple explanation of the approach which does not require an understanding of 4D geometry follows: It is possible to mark on the track of an aircraft’s predicted trajectory the sections for which that aircraft will be in conflict with another. If an alternative trajectory (representing, for example, a heading change) is drawn alongside the original, the conflict could be marked in a similar way for that trajectory. If a closely packed series of alternative trajectories are drawn and the conflict lines are marked on each one, then these lines could be combined to form a “No-go” (or conflict) zone which represents a conflict for all the possible alternative trajectories, which is represented at Fig. 1 [Whiteley 1999].

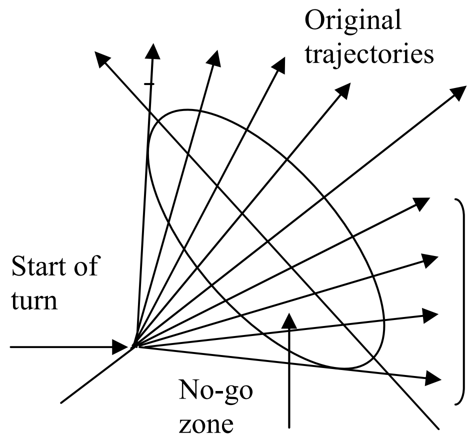

Fig. 1. Constructing No-go Zone

These zones are shown on an abstracted display, and give a clear indication of the position and nature of potential conflicts, and a good idea of maneuvers which may be applied to solve them. The selection of the set of alternative trajectories used to develop the zones is important. Once the No-go zones are displayed in an appropriate way, it is a relatively simple matter for the controller to edit the 'subject' trajectory using simple mouse click and/or drag operations.

Editing functions normally allow for adding, deleting and moving constraint points, insertion of doglegs etc. The original versions of HIPS allowed changes in horizontal, vertical and/or speed/time dimensions, but this paper only considers horizontal changes.

Example: two aircraft A1 and A2 are in conflict, if at a given time they don't respect the separation minima, e.g. vertical separation S_v, of 1000 ft (2000 ft above FL 290) and horizontal separation S_h of 5 nautical miles (approximately 9 km). A more mathematical formulation: A1 conflicts with

$$A2 :\Leftrightarrow \exists t : d_h(A1, A2, t) < S_h \wedge d_v(A1, A2, t) < S_v$$

with $T_0 \le t \le T_{0v}$, where $[T_0, T_1]$ is the interval were both involved aircraft are simultaneously within the sector [Van Doorn et al…]. This safety buffer around the aircraft is called separation tube. The controller has several options to resolve a conflict once he had detected it [Stamatakis 1999].

Route changes. Let's consider one of the options to resolve the conflict, mainly a horizontal maneuver.

Fig. 2 shows the sort of plan-view that can be displayed. This figure shows that ABC123 is the subject aircraft.

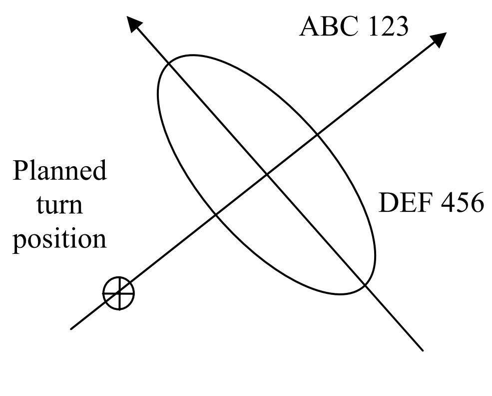

Fig. 2. Plan view of a predicted conflict situation

Aircraft DEF456 is an environmental aircraft (from the point of view of ABC123) whose planned trajectory is predicted to be in conflict with that of ABC123. The relevant No-go zone is displayed for a planned turn position as indicated.

For the controller, a possible solution is to re-route ABC123 so that it passes either to the north or to the south of its current planned position. The turn starts at the planned turn position. In practice, a controller would probably select to pass ABC123 behind DEF456 as shown in Fig. 3.

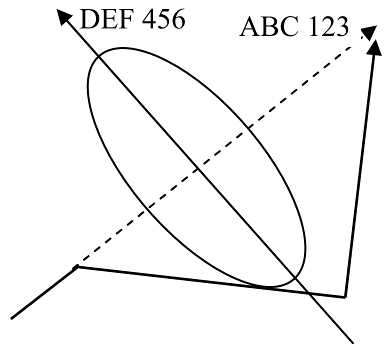

Fig. 3. Plan view of a possible conflict-free trajectory for ABC123

The No-go zone shown in Fig. 3 indicates that the new trajectory of ABC123 is no longer in conflict with that of DEF456.

Altitude profile changes. Here we'll consider another option to resolve the conflict, as vertical maneuver or in other words-climb or descent of one of the aircraft on Fig. 4.

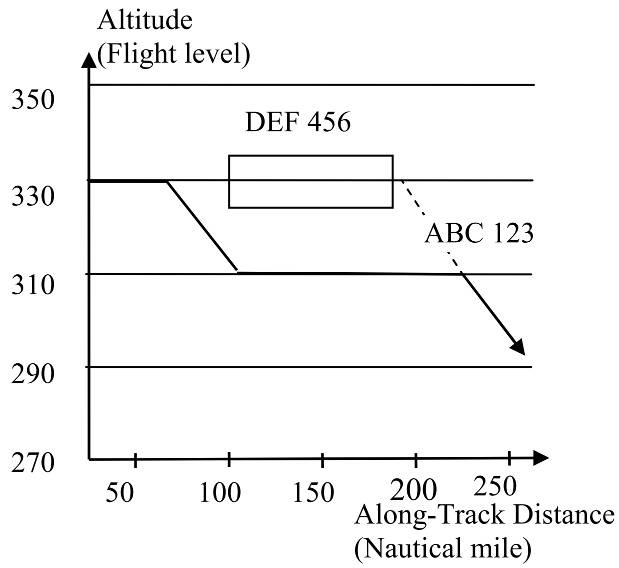

Fig. 4. Altitude profile view of a predicted conflict situation

With this situation, a possible solution is to descend ABC123 before the predicted conflict situation arises and so pass ABC123 under DEF456 as indicated in Fig. 5.

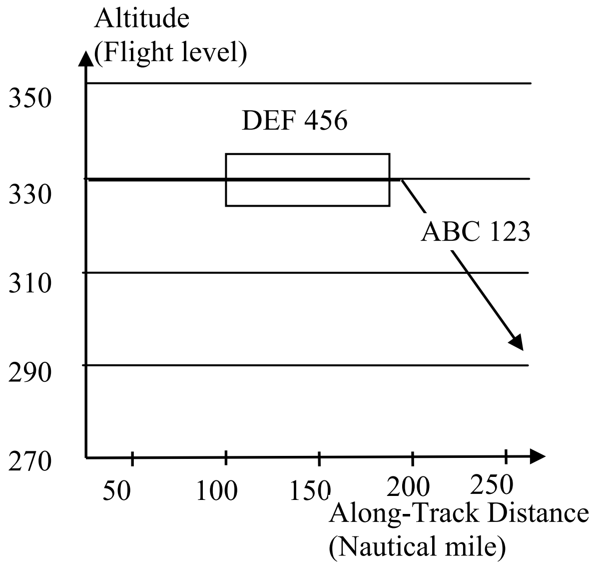

Fig. 5. Altitude profile view of a possible conflict-free trajectory for ABC123

The reports on the PD/1 and PD/3 results give for more detail of working in an integrated system with the Trajectory Predictor.

Speed profile changes. It is also possible to delay or expedite an aircraft to clear a conflict. This can be shown graphically in a similar way to the other dimensions in Fig. 6.

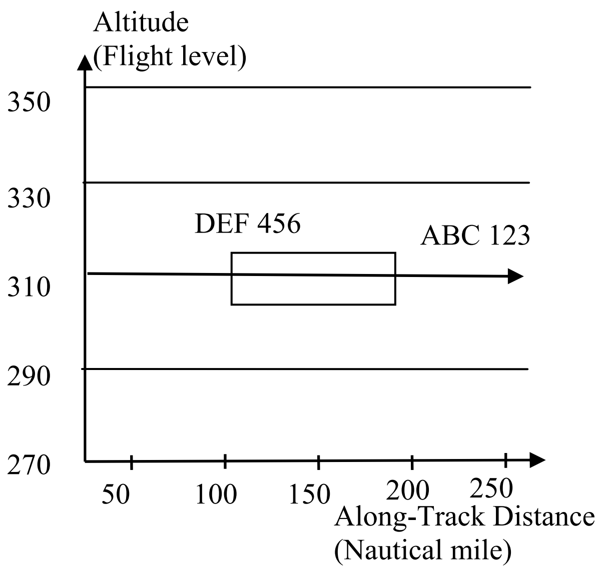

Fig. 6. Speed/time profile view of a predicted conflict situation

With a conflict such as that in Fig.6, a controller could apply a speed modification to the planned trajectory of ABC123 so that it arrives at the particular along-track distances earlier or later than planned at the moment.

The planned speed of ABC123 has been reduced, resulting in the fact that the aircraft would now arrive one minute later at points further along the trajectory, which is shown in Fig. 7.

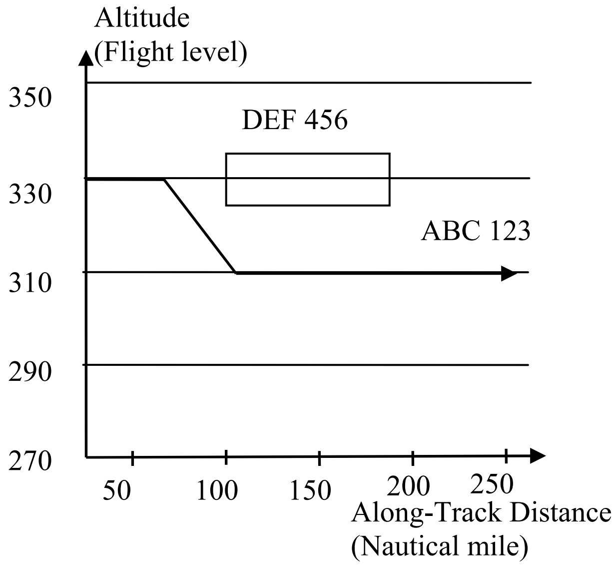

Fig. 7. Speed/time profile view of a possible conflict-free trajectory for ABC123

The graphical display allows controllers to modify a planned trajectory and see the results immediately. This allows rapid assessment of potential deconfliction actions and identification and implementation of the most efficient action.

3. Computer modeling of interactive method for conflict resolution

Conflict resolution by route change. To represent the problem solver work we decided to model a conflict and to show its resolve by two different methods, mainly, the route changing and level changing. The input data was the speed of two airplanes– V1,V2, headings of two airplanes – $\psi 1$, $\psi 2$, altitude of the first airplane and second one – H1, H2.

So let's consider the first case. In our program we modeled the flight of two aircraft, one moving along it's trajectory and another one – along trajectory in opposite direction to it, in other words, closing traffic and this is represented in Fig. 8.

The program will analyze their trajectories, calculate the time to maximum approach and distance between them by the formula and in case when the distance between these two airplanes is less than separation minima, the program will detect the conflict and solve the problem by giving the trajectory change to one of the airplanes with the aim to avoid conflict, this is represented in Fig. 9.

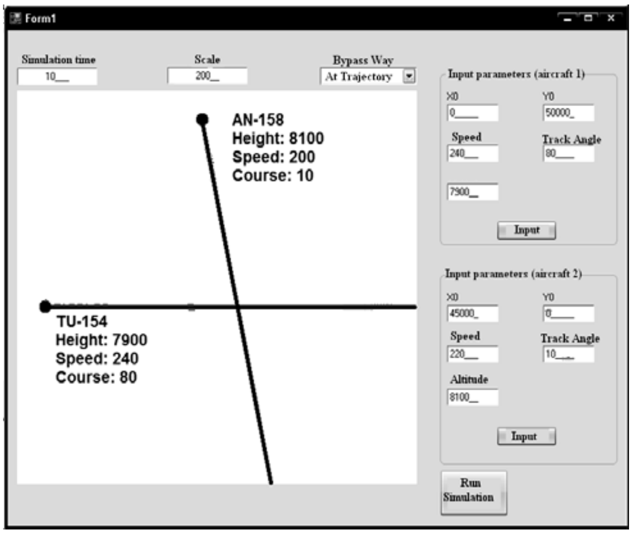

Fig. 8. Initial flight of the airplanes along their trajectories

When the conflict is resolved and there is no any risk of loss of separation between aircraft the airplane with changed trajectory will return to its initial flight pass, in other words, resume his own navigation to the planned route (Fig. 10).

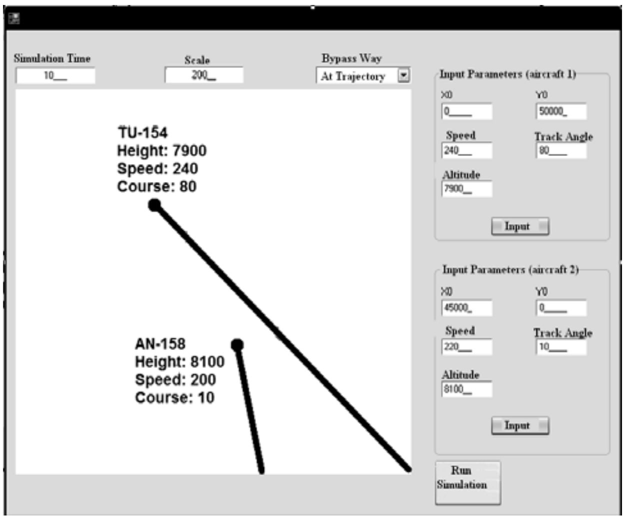

Fig. 10. Return to initial trajectory

4. Conclusions

The PS is a computer-based tool that provides certain views of the predicted air traffic situation that, combined with a means to modify planned aircraft trajectories, allows a sector planning controller to design trajectories that are conflict-free. The PS provides a view of the predicted air traffic situation from the point of view of a particular aircraft, known as the subject aircraft.

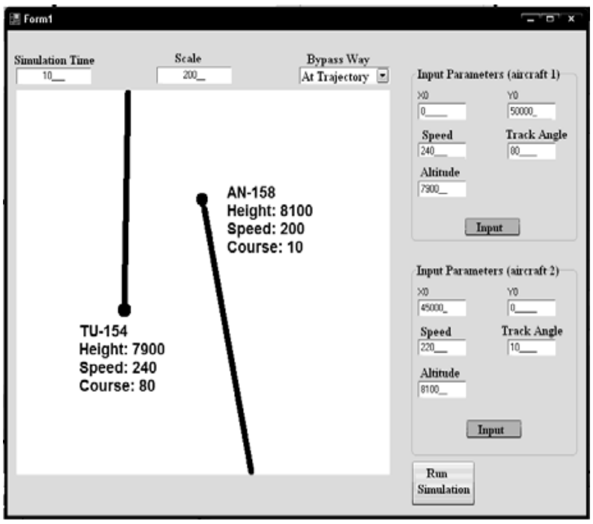

Fig. 9. Illustration of trajectory change by one of the aircraft

So, the PS may be successfully used by sector planning controllers to design conflict - free trajectories when accurate descriptions of the planned trajectories are available twenty minutes or so ahead. And as we can see that application of this system for conflicts resolution can give very good results, mainly, improving of situational awareness of air traffic controller, increase capacity, flexible usage of airspace, reduce air traffic controller workload and in this way increase the level of safety.

We should understand that the PS concepts can be used in other applications. Sector tactical controllers could use a version of the PS if a way could be found to display the relevant information on the same display as the plan-position display. Another version of the PS has been developed so that its applicability to oceanic control at the Oceanic Area Control Centre at Prestwick, Scotland can be assessed.

Airlines would like more control over how their aircraft go from A to B. A pilot cannot act alone, however. He must have an idea of the air traffic situation around him. A version of the PS could be used for this.

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М.М. Богуненко[1], К.О.Пивоварська[2]. Моделювання конфліктної ситуації в інтерактивній програмі для вирішення конфліктних ситуацій
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Розглянуто нову концепцію планування та вирішення конфліктних ситуацій, яка розроблена для авіадиспетчерів управління повітряним рухом за допомогою інтерактивної системи вирішення конфліктних ситуацій. Подано результати моделювання інтерактивного методу для вирішення конфлікту за допомогою розробленої програми. Показано, що розроблений фрагмент програми вирішення конфліктної ситуації може бути застосований у системі управління повітряним рухом для гнучкого використання повітряного простору, зменшення завантаження авіадиспетчера та покращення рівня безпеки.

Ключові слова: зона обходження конфлікту; інтерактивна система вирішення конфліктних ситуацій; інтерактивний метод; конфліктна ситуація; ризик.

Н.Н. Богуненко[1], К.А. Пивоварская[2]. Моделирование конфликтной ситуации в интерактивной программе для решения конфликтных ситуаций
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Рассмотрена новая концепция планирования и решения конфликтных ситуаций, разработанная для авиадиспетчеров управления воздушным движением с помощью интерактивной системы решения конфликтных ситуаций. Представлены результаты моделирования интерактивного метода для решения конфликта с помощью разработанной программы. Показано, что разработанный фрагмент программы решения конфликтной ситуации может применяться в системе управления воздушным движением для гибкого использования воздушного пространства, уменьшения загруженности авиадиспетчера и улучшения уровня безопасности.

Ключевые слова: зона обхождения конфликта; интерактивная система решения конфликтных ситуаций; интерактивный метод; конфликтная ситуация; риск.

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