A TMA 4DT CD/CR causal model based in path shortening/path stretching techniques

Zúñiga C.A.,* Piera M.A.,** Ruiz S.***
Faculty of Telecommunication and Systems Engineering,
Autonomous University of Barcelona
Barcelona, Spain
*catyaatziry.zuniga@uab.cat, **miquelangel.piera@uab.es, ***sergio.ruiz@uab.cat

Abstract— **In the present paper a discrete event model for Conflict Detection and Conflict Resolution algorithm in a TMA 4D trajectory scenario in presented which focuses mainly on the arrival phase. This arises from the overcrowding of airspace near large airports and the need to more efficiently land and take off larger numbers of aircraft. Some attempts to alleviate airspace congestion such as the reduced vertical separation minima, negotiation of voluntary reductions in scheduled service, and the construction of additional runways at major airports, have been done, however, there is still a pending matter to be solved regarding how to improve available airspace capacity avoiding non efficient procedures such as the use of holding trajectories. A deep knowledge about all the events that take place in the management of 4DT and their interactions in a TMA is essential to remove non-effective operations, to avoid delay propagation between arrivals and optimize the occupancy of the runway. The causal model developed considers different alternative pre-defined turning points for each flight evaluating path shortening/path stretching of all trajectories upwards the merging point in a TMA.**

Keywords-component; ATM, trajectories, DSS, CPNs, Conflict Detection, Conflict Resolution.

I. INTRODUCTION

The significant growth in air travels is outstripping the capacity of the airport and air traffic control (ATC) system, resulting in increasing congestion and delays [3]. Capacity lags a few years behind traffic demand and available capacity cannot always be fully exploited, in particular due to the air traffic controller shortages (ie. conventional operating methods). In addition, the present ATM organization and infrastructure have their limitations and will be unable to cope with the total forecast traffic increase, which is expected to result in a doubling of aircraft movements by 2020 when compared to those in 1998 [1].

Concerns for airspace exert a growing influence on ATM, especially around airports where airspace congestion is becoming a serious problem at many major airports and will become a more severe constraint, especially at the international hub airports serving major European cities and tourist destinations where their ATM-related operations have not yet been fully integrated into the overall ATM organization [5,7].

In the approach phase at the conventional operating methods controllers' further vector the aircraft to fine tune the sequence and integrate traffic flows from different Initial Approach Fixes (IAFs) to the runway axis avoiding unnecessary gaps at the runway threshold. In this context, the strategy followed by controllers for managing arrivals in approach (with the objective of giving themselves more time and margins to make the implementation and fine tuning of the sequence easier) often results in aircraft flying low and slow. Most optimization procedures are generally fully applied only under low to medium traffic loads [2].

An integrated approach that could consider en-route trajectories in TMA and airport operations would contribute to move one step forward to true efficient flexibility, in order to coordinate dynamically flight trajectories according to departure and arrival times. It is easy to note that flexibility is not synonymous of benefits, in fact present technology has contributed to increase flexibility, which repercuted not only in an increment on the number of the decision variables and their domain, but also the system cause-effect time relationships, which complicates the decision making activities. Flexibility can lead to benefits but can also lead to earliness/tardiness in the ETA's and ETD's. The difference between obtaining benefits or handicaps on the quality service factors may depend on the decision-making activity.

The progressive merging of arrival flows into a runway sequence is often performed in current day operation through the use of open-loop vectoring. This method is highly flexible; however it results in high workload both for flight crews and controllers, and in an intensive use of the R/T. Indeed, it generally requires numerous actions to deviate aircraft from their most direct route for path stretching – and later put them back towards a waypoint (e.g. the Initial Approach Fix or IAF) or the runway axis for integration.

In this sense, a simulation model could help to analyze the operational efficiency of the current traffic control procedure together with airport operations and propose new procedures to optimize the use of available airspace in terms of capacity, environmental aspects, and where possible in terms of track by a proper integration of flows in busy traffic periods [4].

Aspects that should be considered when developing a decision support model are:

-The integration of traffic flows into a runway sequence,

- To take account of wake turbulence constraints,

- To facilitate departures from the same runway

A simulation model that could cope with the TMA airspace capacity should integrate and manage different sources of information to analyze the perturbations that affect the different arrival flows and design mitigation mechanism to avoid the propagation of those perturbations on the runway throughput. Thus, the model should consider data such as:

- Number of aircrafts in the TMA arrival flows.
- Expected trajectories profile: waypoint pass time, speed, weight.
- Expected minimum separation standard (MSS);
- Current state of aircraft (level flight; altitude; speed; passing time);
- Geometry information: merging points, entry points, CDA profile for the different aircrafts.

An efficient landing sequence will contribute to maintaining the throughput as close as possible to the available runway capacity, while conforming to the separation requirements and will also enable the more widespread use of Continuous Descent Approaches (CDAs). [6]

An innovative technique to tackle the airspace congestion has been developed by the EUROCONTROL Experimental Centre called Point Merge [2]. The Point Merge (PM) technique aims at optimising the use of available airspace in terms of capacity, environmental aspects, and where possible in terms of track distance flown [6].

In response to the need for an alternative model to build up an efficient landing sequence, this paper propose a discrete event model in Coloured Petri Nets (CPNs) that deals with similar ideas as the Point Merge (Eurocontrol) but supports heavier peaks of arrival traffic. One of the most important similarities between both approaches is the use of a pre-defined route structure: TMA trajectories are characterized by one IAF and a sequence of waypoints some of which are used as merging points with other arrival trajectories. In order to preserve safety distances at merging points speed adjustments must be properly evaluated which are implemented by means of a path stretching/shortening technique. Thus, both algorithms must compute the exact turning points, (see Fig. 1) according to the type of aircraft (heavy/medium/light), the entry time at the IAF, the expected speed and the safety distance that should be preserved at the merging point.

At the right hand side of figure 1, a trombone area representing the PM approach with two entry points is represented, while at the left hand side of the same figure the fixed re-routes of the new approach are also represented for the same TMA configuration. Thus, with the proposed method, each entry point has associated a fixed re-route which is computed by a turn of 45º from the arrival route at the IAF.

One of the main differences between both methodologies is the geometrical configuration of the model proposed. Figure 1 shows a significant difference in terms of the use of path shortening or path stretching technique, it can be noticed that more distance can be flown in the DES model developed which supports a higher capacity for path stretching without affecting path shortening.

Furthermore, the proposed model has been tested using three different IAFs and two merging points, providing excellent results for a traffic peak. In fact the causal CPN model could be extended to different number of IAF and merging point configurations, while multiple point merge systems require the analysis of particular solutions to evaluate the appropriate spacing between successive aircrafts.

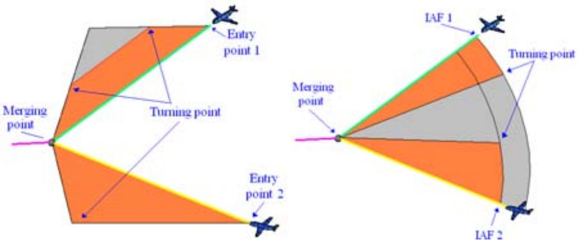

Figure 1. Example of new trajectory with turning point.

In section II the problem scenario is presented and an overview of the conflict detection and resolution algorithm proposed is explained. Section III summarizes the main aspects behind Coloured Petri Nets (CPNs) algorithm. Section IV provides the model description proposed and finally a summary and conclusions are presented in section V.

II. PROBLEM SCENARIO

In the proposed Air Traffic Management System architecture, each aircraft follows a nominal path from source airport to destination airport described by a sequence of waypoints which are fixed points in the airspace. Furthermore, each fixed point has attached a time stamp which represents the expected aircraft pass time through the waypoint.(4DT's). This pre-defined route structure will be call route. The proposed algorithms are based in a given a sequence of aircraft entering by three different IAFs and flying into three routes that must join into one route in two different merging points.

In the present model, the Gran Canaria TMA is used to test the CPN model (see Fig. 2). There are three different approaching routes from Europe (IAF *1-Rwy*, IAF *2-Rwy* and IAF *3-Rwy*); two different intersection waypoints called *Merging point 1(Fayta)* and *merging point 2(Cannis)*. If the approaching is done by IAF *2 (Rusik)* or *3* (Nwpt) then the *Merging point 1* is the first waypoint where these two routes fuse into one. If the approach is done by IAF *1(Terto)* then the merging point is *Merging point 2;* in here the three routes (two previously fused), fused again (see Fig. 2).

Conflict detection (CD) is addressed in the proposed model in the following way: The time stamp of the leading and the following aircraft are compared when passing into a merging point to verify if safety distance (sd) is preserved.

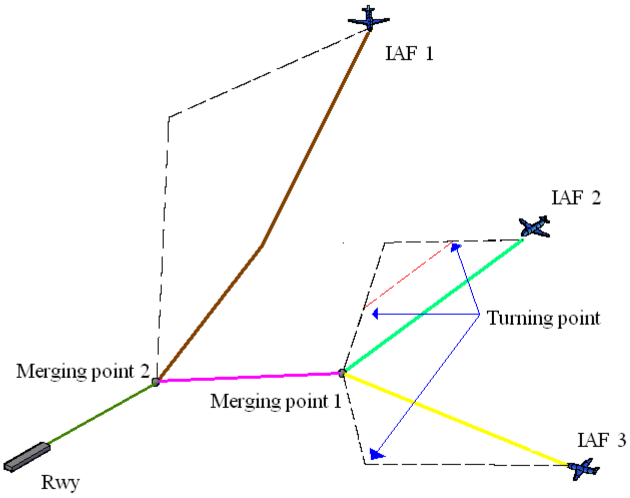

Figure 2. Three trajectories with two merging points.

As soon as the aircraft arrives at its corresponding IAF, a certain control action is evaluated to guarantee that the aircraft will arrive at the merging point, exactly at a safety distance of its heading aircraft. The safety distance in the merging point is evaluated independently of the route of each aircraft but taking into account the characteristics of each aircraft (weight). It is important to note that the new expected arrival time is computed at the arrival of the aircraft at the TMA, thus, control actions can be taken at the TMA entry point for each particular aircraft according to the delay to be generated or absorbed.

The predictive model computes and detect Medium Term Conflicts each time there is a new TMA arrival at any entry point, just by evaluating the passing time at the merging points and checking if the time between two consecutive aircrafts is smaller than the minimum separation standard (MSS) given in Table I.

TABLE I. MINIMUM SEPARATION STANDARDS (MSS). MINIMUM TIME BETWEEN SUCCESSIVE ARRIVALS AND DEPARTURES

Leading aircraft	**Following aircraft**					
	Heavy		Medium		Light	
Heavy	96	60	120	90	144	120
Medium	72	60	72	60	96	90
Light	72	60	72	60	72	60

Control actions that are implemented into the DES model to avoid a conflict (called conflict resolution: CR) are divided in three general aspects.

A. Evaluate an alternative trajectory (also called change of vector).

B. To speed up the aircraft.

C. To decrease the speed of the aircraft.

All control actions are performed by the following aircraft in a look ahead perspective and all are explained bellow. Fig. 3 summarizes the different control mitigation actions implemented as events that can be fired according to time stamp information in the merging points.

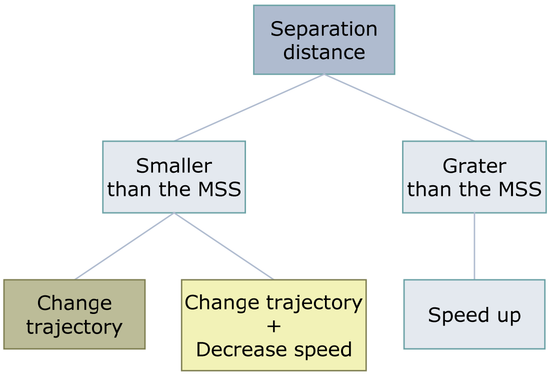

Figure 3. Control actions.

A. *Path shortening/Path stretching control action*

The objective of the change of vector is to stretch distance to be flown from the TMA to the merging point so an aircraft can arrive at the expected time maintaining its speed profile. Therefore, the delay required is absorbed by the alternative trajectory proposed.

In these algorithms the first approach to solve conflicts starts by modifying the trajectory to be flown. If the difference between the passing time of the leading and the following aircraft is less than the MSS (a conflict is detected) then the following aircraft change its original to modify the passing time to a later time so conflict is avoided.

The delay (in time) needed to arrive on time at the merging point is calculated by comparing desired arrival time at the merging point minus the expected arrival time at the same merging point. This delay obtained is used to calculate the new distance to be flown (see Fig. 4).

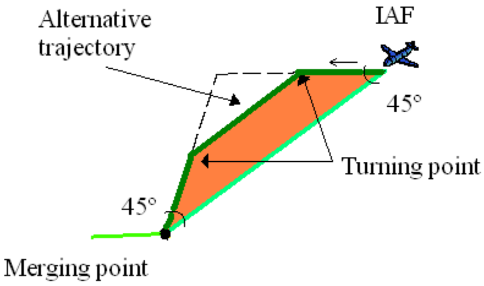

Figure 4. Alternatives trajectories.

To generate the alternative trajectory the new distance to be flown is applied straightforward to a predefined conflict resolution route as shown in Fig. 4. Thus, according to the delay that should be applied to satisfy the desired arrival time at the merging point, and preserving at the same time the speed profile, the aircraft turns 45º until a certain turning point in which the aircraft is redirected (could be parallel to the original route) towards the merging point. The geometry of the alternative trajectory can be triangle or trapezium shaped (see Fig.4).

B. Speed up control action

The objective of the speed up of the following aircraft is to reduce time to be flown from the TMA entry point to the merging point so and aircraft can avoid runway idleness or future conflicts but ensure a safety distance based on the MSS. By considering that distances between IAFs and the merging points are known variables, the nominal speed profile can be computed straightforward just using the desired time arrival at the merging point.

The following aircraft is speed up until the MSS in Table I is reached or as close to this one as possible (called best separations distance). Then, the best separation distance is the minimum possible distance between the leading and the following aircraft that depends on medium speed (not exceeding a maximum or minimum speed of each aircraft) and the initial time in the TMA that guarantees there is no conflict between them.

C. Decrease speed control action

The objective of decreasing speed of the following aircraft is to augment time to be flown from the TMA to the merging point. This alternative will be used only when the delay obtained through the stretching technique can not solve the conflict detected at the merging point, and an extra delay is required.

III. COLOURED PETRI NET OPTIMIZATION APPROACH

Coloured Petri Nets (CPN) have proved to be successful tools for modelling complex systems due to several advantages such as the conciseness of embodying both the static structure and the dynamics, the availability of the mathematical analysis techniques, and its graphical nature.

The main CPN components that fulfill the modelling requirements are:

- Places: They are very useful to specify both queues and logical conditions. Graphically represented by circles.
- Transitions: They represent the events of the system. Graphically represented by rectangles.
- Input Arc Expressions and Guards: Are used to indicate which type of tokens can be used to fire a transition.
- Output Arc Expressions: Are used to indicate the system state change that appears as a result of firing a transition.
- Colour Sets: Determines the types, operations and functions that can be used by the elements of the CPN model. Token colours can be seen as entity attributes of commercial simulation software packages
- State Vector: The smallest information needed to predict the events that can appear. The state vector represents the number of tokens in each place, and the colours of each token.

The Colour sets will allow the modeller to specify the entity attributes. The output arc expressions will allow specifying which actions should be coded in the event routines associated with each event (transition). The input arc expressions will allow specifying the event pre-conditions. The state vector will allow the modeller to understand why an event can appears, and consequently to introduce new pre-conditions (or remove them) in the model, or change some variable or attribute values in the event routines to disable active events.

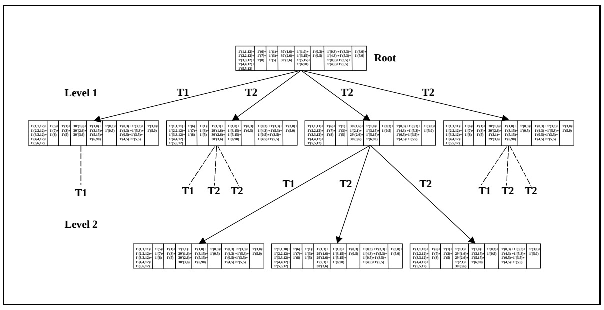

Figure 5. First 2 levels of a coverability tree.

From the OR point of view, the CPN model can provide with the following mathematical structures:

- Variables: A variable can be identified for each colour specified in every place node.
- Domains: The domains of the variables can be easily determined by enumerating all the tokens specified in the initial state.
- Constraints: Can be obtained by straightforward from the arc and guard expressions. Arc expressions can contain constant values, colour variables or mathematical expressions.

From the AI point of view, the coverability tree of a CPN model allows to determine:

- All the events that could appear according to a particular system state (Fig. 5).
- All the events that can set off the firing of a particular event.

- All the system states (markings) that can be reached starting from a certain initial system operating conditions *M0*.
- The transition sequence to be fired to drive the system from a certain initial state to a desired end-state.

IV. MODEL DESCRIPTION

The medium term CD&CR model proposed has been specified in the Coloured Petri Net (CPN) formalism. The discrete event approach has been specified using seven colours, five places and nine transitions. This model can be integrated with the AMAN/DMAN CPN model [6] to optimize a shared mode runway in which the best landing sequence can also be computed.

As shown in Fig. 3, three different control actions attached to each merging point could be fired. These events are represented by different transitions in the CPN model.

- The event "Change trajectory" takes place when a conflict between two aircraft is detected in a merging point. Taking into account the scenario presented in Fig. 2, three transitions derivates from this event: Change trajectory from IAF 1 to merging point 2, change trajectory from IAF 2 to merging point 2 and finally change trajectory from IAF 3 to merging point 2.
- The event "Change trajectory + decrease speed" takes place when a conflict between two aircraft is detected in a merging point and can not be solved only by a changing vector procedure. Therefore, taking into account the scenario presented in Fig.2, three transitions derivates from this event: reduce speed from IAF 1 to merging point 2, reduce speed from IAF 2 to merging point 2 and finally reduce speed from IAF 3 to merging point 2.
- The event "Speed up" takes place when the separation distance between the leading and the following aircraft is greater than the MSS. In order to acquire a reduction of time from the TMA entry point to the merging point the following aircraft is accelerated until an optimal or best separations distance (in time) is reached. Another transition is used to compute the speed profile along the new trajectory so no extra speed changes will be required.

A. Net specification & description

Table II summarizes the colours used to describe all the information required in the places to define the aircraft trajectory in 4D.

Place specifications are shown in Table III and detailed as follows: Place "*Segments*" supports the information regarding each aircraft trajectory. Colour *aid* corresponds to the aircraft identification in a trajectory; the first *idp* colour corresponds to the waypoint identification of the beginning of the trajectory (entry point in the TMA) while the second *idp* keeps the information regarding to the passing waypoint identification; colour *t* and *vel* carry on its corresponding current time and speed. The third *idp* colour corresponds to the next waypoint identification of the trajectory while second colour *t* has information about IAFs entry time. Finally the *t* and *de* colour corresponds to IAFs entry time and distance in the TMA, respectively.

TABLE II. COLOUR SPECIFICATION

Colour	**Meaning**
aid	Aircraft identification
idp	Waypoint identification
t	Time
vel	Average speed
de	Distance between two waypoints
c	Control variables
wp	Waypoint information

TABLE III. PLACE SPECIFICATION

Place	**Colour**	**Definition**
Segments	S	aid*wp*wp*t*v*wp*t*de
G	G	c,c,c
Solution	R	aid,wp,v,de
Pair	P	aid, aid,t,wp,wp

Place "*G*" considers only three colours as shown in Table 4. The first colour (ie. *d10) takes a value 0* only when the pair of consecutive aircrafts has not previously evaluated or they have been forced to change the speed in order to avoid conflicts. The same colour takes value *2* when the pair of aircrafts has to be evaluated in merging point 1 after a vector change (path stretching) has been proposed. Finally, colour *d10 takes value 3* when the pair of aircrafts has to be evaluated in merging point 2 after a speed-up control action has been applied. Colour *c3* and *c4* are control variables that indicate the number of the following aircraft to be evaluated in Fayta and Canis, respectively. Therefore if the transition concerns to Fayta, colour *c3* will be incremented in one unit to update the next pair to be evaluated in this waypoint.

Place "*Solutions*" store the information regarding to the aircraft successfully solved. This node contains the aircraft identification, its corresponding passing time, medium speed and distance to be flown.

Place "*Pair*" contains the information that links the leading and the following aircraft ('*x1*' and 'y1', respectively) with the next passing time (*x11*) of aircraft '*y*' and a control variable (*c3* or *c4*) that indicates the following aircraft to be evaluated in Fayta or Canis. After firing this transition the information is properly updated in all place nodes since the vector change has been completed.

V. EVENT SPECIFICATION EXAMPLE

Fig. 6 illustrates an event (represents an aircraft that will be speed up) that formalize the CD&CR model for merging point 1.

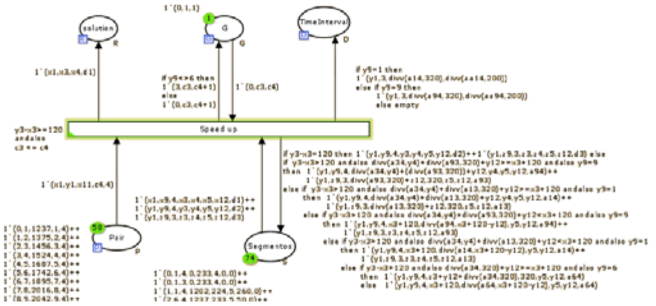

Figure 6. Example of the CPN for the CD&CR algorithm.

The CPN shows five nodes; the node "*Segments*" asks as initial conditions for a pair of aircraft (*x1* & *y1*) that comes from their corresponding passing waypoint identification (*x9, y9* & *z9*) and they are evaluated when passing in merging point 1 (*x2=y2=4*) and with passing time, speed profile, next waypoint identification, IAFs entry time and distance from IAFs (*x3,x4,x5,x12,d1* & *y3,y4,y5,y12,d2* & *z3,z4,z5,z12,d3* respectively).

As initial conditions, node "*Pair*" asks for the same pair of aircraft that node "Segments" (*x1* & *y1*), with a next passing time (*x11*), *c4* as a control variable to indicate the following aircraft, and finally *c3=4* indicating they are evaluated when passing in merging point 1).

Information supported in node "*G*" is used when colour *d10 takes value 0 since* the following aircraft has not been previously evaluated, and *c3,c4* are linked to node "*pair*".

When all initial conditions are properly specified in each place node, then node "*Solutions*" stores only information regarding the leading aircraft (note that this aircraft will not have conflict with any other aircraft). Node "*G*" will increase colour value *c4* in one unit to specify that the next aircraft has changed and should be evaluated; and if the following aircraft comes from IAF 2 or 3, *d10=3* in order to be re-evaluated in merging point to solve any possible conflict in this passing waypoint.

Finally place "Segments" will return information about the following aircraft with its corresponding new passing time in merging point 1, new speed profile , and/or new distance to be flown, if required.

VI. CASE STUDY

Arriving flow to the Gran Canaria TMA landing at Gran Canaria airport at a busy traffic period use to be between 20 to 30 aircraft in 1 hour. To test the performance of the proposed CD/CR CPN model, a synthetic workload of 35 aircrafts has been designed. Aircraft arrivals through the same entry point are conflict-free between them, however the merging of these arrivals generate conflicts at the merging point areas.

Table IV illustrates the 4DT specification of the first three aircraft arriving to Gran Canaria TMA. As it can be noted, 2 aircraft arrive through Rusik entry point and one aircraft arrives through Terto entry point. The aircrafts arriving through Rusik are conflict free between them, but there is a conflict in Cannis merging point.

TABLE IV. TWO TRAJECTORIES EXAMPLE

No	**TMA entry time (s)**	**TMA IAF**	**WPT merging point 1**	**WPT time (s)**	**WPT TAS (m/s)**	**WPT merging point 1**	**WPT time (s)**
1	260	2	3	972	224	4	1202
2	50	1	3	---	233	4	1237
3	470	2	3	1154	233	4	1375

According to this information in Table IV, the initial marking for places has the format shown in Table VI.

TABLE V. INITIAL MARKING FOR TWO TRAJECTORIES EXAMPLE

Place	**Initial marking**
Segments	1`(1,1,3,972,224,260,0)+1`(1,1,4,1202,224,260,0)+ 1`(2,6,3,0,233,50,0)++1`(2,6,4,1237,233,50,0)++ 1`(3,1,4,1375,233,5,470,0)+ 1`(3,1,3,1154,233,4,470,0)
Pairs	1`(0,1,1237,1,4)++1`(1,2,1375,2,4)++1`(2,3,1456,3,4)
G	1`(0,1,1)
Solution	empty

For these three trajectories a feasible conflict free solution is reached (Table VI). It can be noticed that the aircraft number 1 has been accelerated (to 290m/s) and has new waypoint passing time in merging point 1 of 810s instead of 972s and in merging point 2 the passing time has changed from 1202s to 988s, as a result aircraft 3 has also a new waypoint passing time of 1043 instead of 1154 in merging point 1, and its corresponding speed has also been changed to 278m/s.

TABLE VI. SOLUTION FOR TWO TRAJECTORIES EXAMPLE

No	**TMA entry time (s)**	**TMA IAF**	**WPT merging point 1**	**WPT time (s)**	**WPT TAS (m/s)**	**WPT merging point 1**	**WPT time (s)**
1	260	2	3	810	290	4	988
2	50	1	3	---	290	4	1108
3	470	2	3	1043	278	4	1228

The entirely model has been tested with 35 aircraft and the results are shown in Table VII (see the Appendix A).

Information about aircraft are black colored while the results are in red color to be identified easily.

VII. CONCLUSIONS

The proposed approach has modelled the CD&CR problem for multi-aircraft using a discrete event approach in the CPN formalism. A case study with 35 aircrafts has been successfully solved.

The CD&CR model computes the future passing times, speed and positions of each aircraft according to certain characteristics (heavy, medium, light). The safety distance requirements due to vortex turbulences at merging points are specified to solve the problem properly. The solution is obtained using the reachability tree in CPN. A computer simulation has used to generate a feasible 4DT solution. The model scope can be extended with consume fuel aspects (BADA referenced) in order to design a cost function that would allow an efficient exploration of the reacheability tree.

One of the key-point of such a design is the use of the state space to understand the behavior of the model. Furthermore, the model has been designed in order to help the modeller to design new procedures to solve problems regarding the future free flight concept.

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VIII. APENDIX A

In this section the case study information can be found. Case study has been with 35 aircraft with initially 10 conflicts detected in the first point merge and 21 more cnflcicts in the second point merge. The results as well as all the regarding information to the name and nominal passing time of the IAF, nominal speed, distance to be flown, new speed and passing time, are shown in Table VII.

TABLE VII. 35 TRAJETORY STUDY CASE

	TMA entry time	**TMA IAF**	**WPT TAS (m/s)**	**WPT name**	**WPT TAS (m/s)**	**WPT name**	**WPT nominal time (s)**	**WPT TAS (m/s)**	**New WPT time (s)**	**New speed (m/s)**	**Distances to be flown (m)**	**WPT name**	**WPT nominal time (s)**	**WPT nominal TAS (m/s)**	**New WPT time (s)**	**New speed (m/s)**	**Distances to be flown (m)**	**WPT nominal time (s)**	**WPT nominal TAS (m/s)**
1	260	RUSIK	224	FTV	224	FAYTA	971,93	224	810	290	159867	CANIS	1202	218,67	988	290	211350	1373,23	191,19
2	50	TERTO	233	LZR	233	BETAN	978,90	233		290		CANIS	1237	221,20	1108	283	300208	1404,94	196,05
3	470	RUSIK	233	FTV	233	FAYTA	1154,47	233	1043	278	159867	CANIS	1375	224,06	1228	278	211350	1541,98	197,55
4	870	NWPT				FAYTA	1224,84	224	1050	274	79651	CANIS	1456	213,84	1348	274	131134	1630,42	188,52
5	180	TERTO	224	LZR	224	BETAN	1250,18	224				CANIS	1524	203,47	1468	233	300208	1706,55	181,41
6	400	TERTO	233	LZR	233	BETAN	1328,90	233				CANIS	1687	221,20	1588	252	300208	1754,94	196,05
7	800	RUSIK	224	FTV	224	FAYTA	1511,93	224	1486	232	159867	CANIS	1742	218,67	1708	232	211350	1913,23	218,67
8	990	RUSIK	233	FTV	233	FAYTA	1674,47	233	1623	252	159867	CANIS	1895	224,06	1828	252	211350	2061,98	197,55
9	1430	NWPT				FAYTA	1784,84	224	1625	253	79651	CANIS	2016	213,84	1948	253	131134	2190,42	188,52
10	1100	RUSIK	224	FTV	224	FAYTA	1811,93	224	1812	224	159867	CANIS	2042	218,67	2068	224	216832	2213,23	218,67
11	1290	RUSIK	233	FTV	233	FAYTA	1974,47	233	1969	235	159867	CANIS	2195	224,06	2188	235	211350	2361,98	197,55
12	1000	TERTO	233	LZR	233	BETAN	1928,90	233				CANIS	2287	221,20	2308	233	304764	2354,94	196,05
13	1800	NWPT				FAYTA	2154,84	224	2155	224	79651	CANIS	2386	213,84	2428	224	140672	2560,42	188,52
14	1180	TERTO	224	LZR	224	BETAN	2250,18	224				CANIS	2524	203,47	2548	224	306432	2706,55	181,41
15	1700	RUSIK	233	FTV	233	FAYTA	2384,47	233	2295	233	138635	CANIS	2605	224,06	2668	233	225544	2771,98	197,55
16	2060	NWPT				FAYTA	2414,84	224	2415	224	82979	CANIS	2646	213,84	2788	224	163072	2820,42	188,52
17	1500	TERTO	233	LZR	233	BETAN	2428,90	233				CANIS	2787	221,20	2908	233	328064	2854,94	196,05
18	1905	RUSIK	224	FTV	224	FAYTA	2616,93	224	2670	224	171459	CANIS	2847	218,67	3028	224	251552	3018,23	218,67
19	1690	TERTO	224	LZR	224	BETAN	2760,18	224				CANIS	3034	203,47	3148	224	326592	3216,55	181,41
20	2200	RUSIK	233	FTV	233	FAYTA	2884,47	233	2924	233	168751	CANIS	3105	224,06	3268	233	248844	3271,98	197,55
21	1900	TERTO	233	LZR	233	BETAN	2828,90	233				CANIS	3187	221,20	3388	233	346704	3254,94	196,05
22	2420	RUSIK	224	FTV	224	FAYTA	3131,93	224	3095	224	151200	CANIS	3362	218,67	3508	224	243712	3533,23	218,67
23	2860	NWPT				FAYTA	3214,84	224	3215	224	91939	CANIS	3446	213,84	3628	224	172032	3620,42	188,52
24	2150	TERTO	224	LZR	224	BETAN	3220,18	224				CANIS	3494	203,47	3748	224	357952	3676,55	181,41
25	2650	RUSIK	224	FTV	224	FAYTA	3361,93	224	3464	224	182336	CANIS	3592	218,67	3868	224	272832	3763,23	218,67
26	2400	TERTO	224	LZR	224	BETAN	3470,18	224				CANIS	3744	203,47	3988	224	355712	3926,55	181,41
27	2900	RUSIK	233	FTV	233	FAYTA	3584,47	233	3685	223	182905	CANIS	3805	224,06	4108	233	281464	3971,98	197,55
28	2600	TERTO	233	LZR	233	BETAN	3528,90	233				CANIS	3887	221,20	4228	233	379324	3954,94	196,05
29	3450	NWPT				FAYTA	3804,84	224	3805	224	121059	CANIS	4036	213,84	4348	224	201152	4210,42	188,52
30	2820	TERTO	224	LZR	224	BETAN	3890,18	224				CANIS	4164	203,47	4468	224	369152	4346,55	181,41
31	3300	RUSIK	224	FTV	224	FAYTA	4011,93	224	3892	224	132608	CANIS	4242	218,67	4588	224	288512	4413,23	218,67
32	3750	NWPT				FAYTA	4104,84	224	4334	212	123915	CANIS	4336	213,84	4708	212	204008	4510,42	188,52
33	3100	TERTO	233	LZR	233	BETAN	4028,90	233				CANIS	4387	221,20	4828	233	402624	4454,94	196,05
34	3600	RUSIK	233	FTV	233	FAYTA	4284,47	233	4604	233	233991	CANIS	4505	224,06	4948	233	314084	4671,98	197,55

35	3300	TERTO	224	LZR	224	BETAN	4370,18	224				CANIS	4644	203,47	5068	224	396032	4826,55	181,41