Abstract

In the controlled airspace, safe aircraft separations have to be guaranteed by the responsible controller of the sector. For safe separation the controller has to apply horizontal or vertical separation. Conventional Radar displays represent the information in 2 Dimensions (2D). With such displays, the horizontal separation between various aircraft are easily perceptible by the human operator. In case the horizontal separation is not guaranteed any more, vertical separation has to be applied. Vertical separation is based on data collected from the Secondary Surveillance Radar (SSR). These SSR data contain the flight altitude information from the aircraft beside other information.

The altitude information is expressed in Flight Levels (FL) as three digit number in the second line of the label associated with the aircraft symbol. Therewith the FL information is not exploitable from the controller with the first glance on his Operational Display System (ODS). For the vertical separation the ATCO (Air Traffic Control Operator) has to permanently scan, read, memorize and compare the shown flight level numbers of all tracks under his responsibility. Therewith the controller creates in his mind a mental picture of the traffic situation. This task requires a strong mental effort from the controller.

Based on the idea that for a controller applying vertical separation to two aircraft, a priori it is more important to know that these aircraft are flying on different FL, then extracting the real FL numbers from the labels and comparing them. The proposed tool introduces a mobile horizontal filter function to answer quickly with: ’the same’ or ’a different’ FL. The mobile horizontal filter is moved in the steps of the used flight levels (…, 220, 230, 240, …) with the wheel of a mouse. The mouse wheel represents a simple and quick way to move the basis of the filter which acts as reference flight level. All aircraft flying the selected reference flight level are displayed graphically to stand out of all other (flying higher or lower) displayed aircraft and can so be identified easily in a first glance.

The mobile horizontal filter function moved by the mouse wheel, will support controllers’ permanent scanning, reading and comparing tasks for the vertical separation. It stimulate controllers to see their actual traffic situation under another aspect.

Introduction

In general, ATC (Air Traffic Control) center receive information for their surveillance task from one or more sensors (PSR – Primary Surveillance Radar, SSR – Secondary Surveillance Radar). These sensors can furnish 2D position (x-, y-coordinates), altitude (z-coordinate) and aircraft identification (PSR: x, y only). The data of the different sensors are correlated for the ODS. The major part of the ODS is the 2D (x, y) representation of the traffic situation, called Radar or Radar picture. With this radar picture, a experienced controller is able to observe horizontal separation in a first glance.

ATCO have to guarantee safe horizontal or vertical separation for the aircraft under their responsibility. As stated above, safe horizontal separation is observed by the aircraft positions on the Radar picture. On the Radar there are labels associated to the aircraft position.

The CoRe HMI Specification [1] for these label allows 2 (minimum) and up to 6 label lines. The large number of lines permits advanced ATC systems going towards a stripless environment and place flight plan information in the label lines. Currently most conventional ATCs have the CoRe minimum 2 line label as standard. Figure 1 shows two different CoRe label representations as example. The aircraft track on the left hand has a minimum 2-line label including aircraft identification and the actual FL with a 3 digit number. The FL number is the aircraft altitude in feet divided by 100 (i.e. 32 000 feet → FL 320).
The right aircraft track shows a 3-lines label. Aircraft identification and the name of the Next Sector (NS) are in the first line. Line 2 contain the actual FL, the cleared FL and the speed (i.e. actually FL 230 climbing to FL 250, speed 420 NM/h). The last line defines exit FL and the first waypoint in the next sector. The labels are attached to the current aircraft positions. Past positions are showed as afterglows. The speed vector points to the estimated aircraft position in 1 minute of flight. Its direction and length is calculated from the past aircraft positions.

To observe safe vertical separation the ATCO has to scan all tracks under his responsibility permanently. He has to read the current FL number from the label, memorize it and compare it with the current FL numbers of the other aircraft tracks. This task requires a strong mental effort from the controller and becomes more difficult for the extended labels with more than 2 lines. For simplification, this document shows in its examples the 2 lines minimum labels only.

In 1999, Hering [2] proposed the idea of a horizontal filter for an ATC utility called Mosaic. This paper takes up this idea for the Radar picture on the ODS, by exploiting the idea of Mosaic: ‘aircraft flying on different FL can not cause horizontal neither vertical separation problems’. For an ATCO the relative information that, two aircraft are flying on different FL may be enough to ensure separation in a first glance.

A horizontal filter function hives off all aircraft of a selected FL and displays them on the ODS differently than all others. All aircraft climbing or descending are selected in both adjoining FL. The selected FL represents the reference for the horizontal filter function. The reference FL is selected, changed quick and easily with the wheel of the ODS mouse, therefore the tools is called Wheelie.

Wheelie supports and tries to reduce ATCOs’ mental effort by displaying aircraft at the reference FL in a outstanding way. Hypothetically ATCOs’ mental effort for permanent scanning of the controlled airspace to create a mental representation of the traffic situation may be simplified with the Wheelie functionality.

**Technology of Wheelie**

ATCOs job is to guarantee safe separation of all aircraft in space and time. At any given time the controller has to separate aircraft either in horizontal or vertical direction by a specified safe distance. The applied horizontal separation minima may vary with the traffic situation and the ATC centers. Vertically the airspace is divided in fixed layers called FL (i.e. …220, 230, 240, …). These FL layers can be seen as the different floors of a shelf, where aircraft are cruising. All aircraft flying on different FL (floors) are safely separated in the vertical direction.

PSR and SSR sensors provided the controller with much more information as he needs for the specific task. In our days, the sensor data are reduced by vertical filters selected by the ATCO. Therewith the ODS shows aircraft only, flying on a FLs under ATCO’s responsibility. Further vertical filtering was proposed by Huge David [3][4] combined with color coding to reduce complexity of the en-rout traffic of a sector. Figure 2 shows a snapshot of an en-route traffic situation (conventional ODS).
These filters work in a static way and may not be easily adaptable for the dynamic support. Wheelie is designed for the permanent dynamic use with the wheel of the ODS mouse. Data selected by the Wheelie filter (reference FL) presented on the ODS in a graphical outstanding way. Wheelie never suppress information shown on the ODS screen. Now the ATCO can see in a first glance: potential conflicting aircraft flying the same, the reference FL. All other aircraft are on different FLs and regardless of their horizontal position out of conflict with the other aircraft selected by Wheelie.

Wheelie presents the selected reference FL in a discreet manner in the background of the ODS. For all aircraft flying on this FL many possibilities like blinking, highlighting, changing color or changing the tack symbol have been studied with the aim to catch controller’s attention. None of them has been selected as all have been assessed - too intrusive. In 2003, Monica Tavanti [5] presented and evaluated in a human factor study for EUROCONTROL means to let stand out tracks. The idea to place an invisible light behind the aircraft symbol which creates an aureole for the symbol has been evaluated best. Wheelie picks up this idea (see Figure 3).

The wheel of a mouse represents the ideal tool for changing the reference FL. The movements up and down with the wheel are natural to humans. In general they need no supplementary training neither mental effort to handle the wheel of the mouse.Scrolling the reference FL will be very quick, as mainly less than a dozen of FL are used in an en-route sector. The selected reference FL will be shown discreet as part of the background.

Climbing or descending aircraft are selected by the Wheelie function for the reference FL in case their FL difference is smaller than ±10 to the reference FL. This means, an aircraft which label indicates a FL of i.e. ‘281’ will be shown with an aureole in the reference FL 280 and 290.

Figure 4 shows the same traffic situation as in Figure 2, with Wheelie set to the reference FL 330 and stressing the pending lose of separation, between AFR1304 and BAW2330, in about 2 minutes.
Basic HF Aspects of Wheelie

The major aim of Wheelie is not to be another tool to help controller to create their mental 4D picture of the actual traffic situation. Neither to be another safety-net tool. Wheelie should stimulate the controller to see his traffic situation under a restricted ‘vision’. The restricted ‘vision’ is created by selecting all aircraft on the same FL through filtering. All the selected aircraft are displayed in a common way, with an aureole around the symbol to be distinguished from all other aircraft flying on different levels. Human factor ‘Gestalt’ principles let perceive the selection as a unit with a common property, the same FL. To this selection, the simpler horizontal separation rules can to be applied. The 2D horizontal separations are directly visible on the ODS. The horizontal separation demands from an experienced controller little mental effort.

Wheelie’s user interface is based on the conceptual model of the user task (separation). The conceptual model is based on the internal representation and understanding of the human. IBM [6] states: “A mental model does not necessarily reflect a situation and its components accurately. Still a mental model helps people predict what will happen next in a given situation, and it serves as a framework for analysis, understanding and decision-making.” Wheelie stimulate humans perception with a part of the complete situation only and cue for an answer (separated ?) of the presented stimulus.

For Theo Mandel [7] using real-world metaphors is one of the basis of the user interface design. ATC organize the airspace in a FL system similar to floors in a shelf, which are used by aircraft. On the ODS display all these ‘floors’ information are superposed to build the known, complex single pane Radar picture. Wheelie filters the sector traffic, to show in a outstanding way the traffic of the selected level (‘one shelf floor’) only. With the wheel of the mouse this reference level is scrolled up and down in the FLs of the sector. Wheelie uses a ‘shelf’ metaphor (Figure 5) with different floors. The information on the floor is ‘accessed’ by a lift handled by the mouse wheel.

Wheelie focuses the human attention and initiates a visual cue to produce an answer to a restricted 2D situation in controllers mind. The answers on these 2D cues will demand much less mental effort than the 3D situation. Manipulating Wheelie with the finger can be seen as routine task in the cognitive sense. Routine tasks, like body movements are controlled from humans lower level memory and not affecting humans working memory. So, supplementary mental effort by using Wheelie may not be expected.

For limiting the influence of Wheelie on the ODS image, a time limited activation is proposed. This means, that most of the time Wheelie is sleeping and wakes up by the turn of the mouse wheel, only. Wheelie starts displaying with the last reference FL used. After operators final wheel turn (delay i.e. 10…20s), the Wheelie functionality will
return to sleep again and disappear from the display.

**Conclusion**

Filter techniques for horizontal FL layers are largely used for the ODSs. The aim of these techniques is to reduce the displayed information to a required level of information that a controller needs to fulfill his task safely. The controller selects the filter function which he wants to use. The filter functions are selected in the general settings for the controller working position. These functions cannot be used dynamically in the control task as they require too much mental effort for the menu navigation selection process.

Wheelie proposes a real world metaphor for a quick level filter concept. The level filter is easily selected by the mouse wheel. Manipulating a mouse wheel is a basic task for humans like walking, finger pointing, and so on. The use of Wheelie is natural and does not require training or supplementary mental capacity from the human working memory.

Based on the human factors ‘Gestalt’ principles, the selected aircraft of a common layer will stimulate the ATCO to see this specific traffic situation under a different aspect to which simpler 2D separation rules (horizontal separations) for safe separation can be applied.

The eye catching aircraft symbol presentation with an aureole have been successfully evaluated in an EEC human factor study.

The EEC develops, for an early ‘look and feel’ evaluation a graphical user interface with a rapid prototyping tool.

**References**


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