

HARMONISATION OF HUMAN MACHINE INTERFACE

THE INTUITIVE APPROACH

Bob Graham

EUROCONTROL Experimental Centre

BP 15 – 91222

Brétigny Sur Orge

France Tel : (33 1) 69 88 76 66

Fax : (33 1) 69 88 73 33

email robert.graham@eurocontrol.fr

Who am I ?

Bob Graham; Air Traffic Controller, real time simulation Project Leader and currently Head of the EUROCONTROL Experimental Centre's (EEC) Controller Working Position (CWP) Centre of Expertise. Project Leader for the EEC PD/3 Demonstration.

This Paper ??

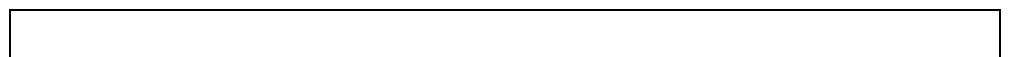
**Advanced HMI
(Human Machine
Interface)**

For several years, EUROCONTROL, in co-operation with European Aviation Administrations (and recently the FAA) has conducted experiments involving the use of advanced HMI for Controller Working Positions (CWP). The most visible of these include ODID (Operational Display and Input Development), PHARE (Programme for Harmonisation of Research and Development in EUROCONTROL) with PD/1 and PD/2, and fast approaching their sell by dates, PD/3 and EATCHIP III (European Air Traffic Control Harmonisation and Implementation Programme).

From ODID III and IV through to PD/1 and EATCHIP III, a baseline of HMI "look and feel" and use of colour has evolved. This involves an increasing use of dynamic graphical interaction and display, together with a logical use of system functions which are approaching realisable "in service" maturity (trajectory for conflict probe, conflict monitoring and resolution, and system assisted coordination).

This paper presents a glimpse at some of the projects and their findings, and of lessons learned including development methodology, look and feel, data interaction, use of colour, graphical tools and system assisted coordination.

Intuitive HMI



Participants in the experiments have commented that the HMI is Intuitive. Most data input relate to clearance instructions passed to the pilot, coordination effected with an adjacent sector/Centre or planning tasks such as strip integration and conflict calculation (checking the Sector Inbound List or a vertical view window for sector entry and exit conditions). This intuitive perception has been a major selling point since today's operational experts want to understand WHY, and the see the VALUE of any new data input workload.

**Evolving
Method**

In the ODID experiments, design commenced in a traditional manner with definition of objectives and clarification of the limits of the evaluation. From this starting point the “design” group (I use the phrase lightly since we saw ourselves as a “motley crew”) would prepare working papers on concept and tasks. This frequently included design proposals as means of expression, using simple PC based graphics packages – or even the white board!

Despite having designed the system before we understood the requirement or the task to be fulfilled, we had actually started a process of task definition .. “at time x the Planner checks vertical sector conditions ... if no problem ? ... flight plan is accepted etc.” Pretty heavy stuff!

**TLD –
Task Logic Diagram**

With the introduction of Human Factors expertise we have since learned that we were at the beginning of Task Logic definition. Today, the design team has evolved this process to a full investigation of the tasks to be played by the controller and the system BEFORE any design commences. This process is known in EUROCONTROL as TLD, or Task Logic Diagram.

The TLD serves as a functional skeleton in the design process onto which various HMI functions are hung as the “body” of the interface is defined. It provides a series of checks and balances where proposals for resolving design problems can be accepted or rejected by confirming their suitability against the task to be completed by the controller.

This task definition can help identify certain tasks best served by the system e.g. checking sector entry conditions for system detected conflicts (an example is provided in figure 1).

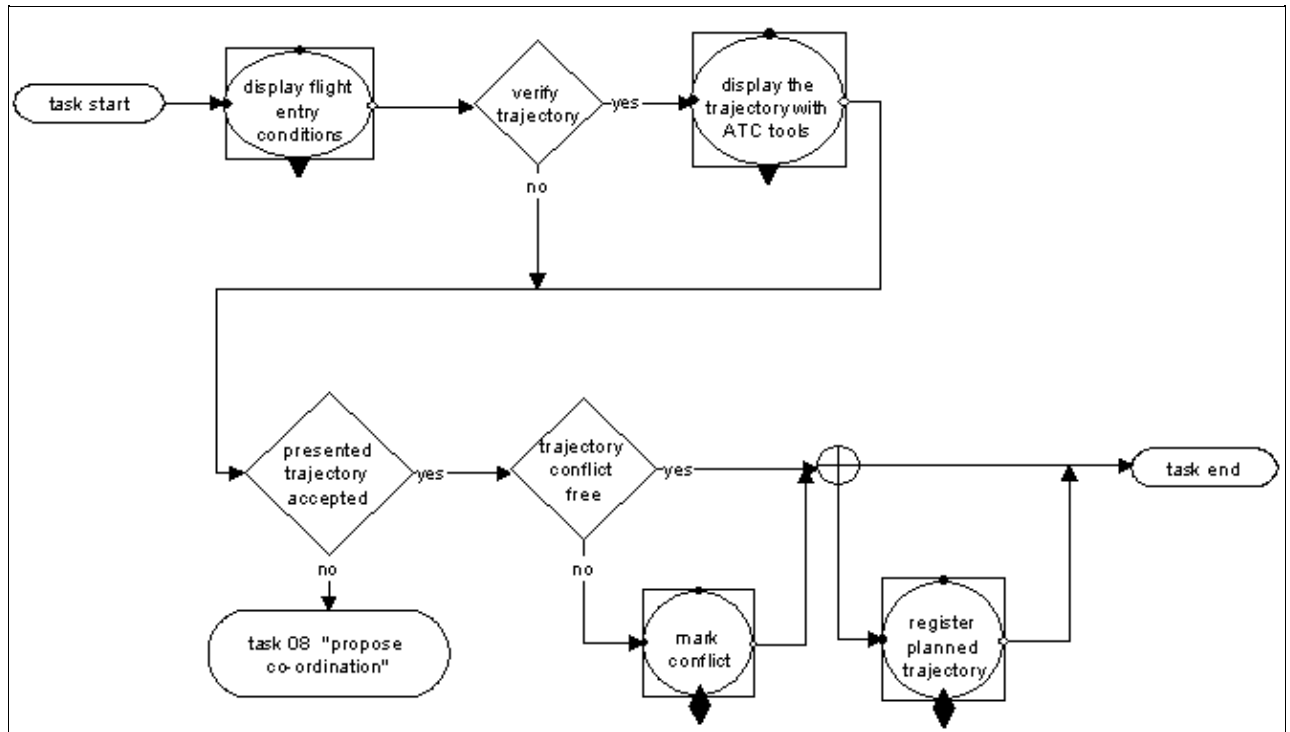


Figure 1 Example of Task Logic Diagram

Multi-Discipline Teams

Results have been achieved through small multi-discipline teams including HMI and Human Factors Experts, Controllers and System Designers, working together on the concepts, interface designs, and experiment conduct and reporting.

Facilitate User Requirements

It is often the case that “users” (controllers in our case) have difficulty in expressing their requirements clearly and in sufficient detail. Interaction between Human Factors and Software Experts in a multi-discipline team can bring out the necessary detail and understanding, facilitating the development of user requirements. These Experts also provide original ideas which can push the Operational Expert to explore opportunities outside their current experience.

Of course, Controllers are very quick to correct the other team members when they go “too far” in their thinking, this is their prerogative, provided, of course, that it does not prevent evolution.

Filter Individual Working Method Changes from “Whole System” needs

A lesson learned is that when problems are identified and fixes agreed they should be implemented as soon as possible to show the operational team that their input has been captured and is of value. This does not mean changing functionality from team to team; this has already caused great difficulty for a number of major system upgrade projects. However, it does mean that a good facilitator is required. Someone who has a good working relationship with the operational experts and a clear understanding of the overall system requirement and who is able to filter individual “working method” changes from genuine “whole system” improvements or evolution ... and explain it to the operational team.

Where possible, the design team should also be part of the implementation team. This “utopia” avoids mis-interpretation of specifications or changes of direction due to disagreement with the chosen approach. It usually ensures commitment to the project and its successful conclusion.

**The Projects –
What About
Them ?**

To date there have been four ODID simulations, excluding quite a few ODID “like” simulation which have been conducted on behalf of National Administrations to evaluate the use of ODID principles in their new systems. These include projects for Hungary, Romania, Portugal, Sweden, Denmark, and in 1996, an FAA simulation using ODID to compare potential benefits of an “advanced ATC system” against baseline measurements of the current FAA En-Route ATC system [14, 15].

These simulations have studied the use of colour in ATC, and more recently the feasibility of the replacement of paper strips by graphic tools, direct dialogue with the system, and system assisted coordination.

I do not want to go through the simulations in detail since the reports are available and in any case they are now history. It is, however, worthwhile mentioning some of the significant results.

The most important finding is that we know for sure that controllers are human beings! ODID I included a number of “physiological” measures that confirmed this. Thank goodness! Jestng aside, ODID I provided some important input towards the use of colour. Some of these findings are pretty evident today but it is worthwhile repeating them :

**ODID I and
Colour**

- the use of too many or too powerful highlights tend to negate their utility;
- inversion of whole lines of data is too strong an indicator;
- half brilliance is not an acceptable distinction;
- the use of colour to indicate the direction of flight is unnecessary;
- warning of impending events should only be used if an action has been overlooked, not as a routine warning that an action is due.

ODID I also showed that the shape of a radar label could be used to prioritise actions. This important finding was later used to great effect in ODID III & IV.

ODID II provided two important lessons :

- label overlapping requires special attention (who is giving this requirement the special attention it deserves – CENA);
- all information required by the radar controller should be provided on a single display, through the radar label or via Sector Inbound List windows.

**ODID II and
Coordination**

We are still suffering from label overlapping, but we have been applying the second finding since ODID III.

Another finding proposed that coordination should be “by exception” and system managed. This has also been applied continuously since ODID III.

Major changes were introduced in ODID III and IV. The use of large 2K by 2K screens were used for the first time permitting the introduction of graphical images and the use of a mouse input device.

ODID III [1, 2] evaluated two organisations, one with electronic strips and some graphical planning aids, the second one without strips but with greater dependence on graphical aids.

**ODID III, Large
Colour Displays,
Electronic
Strips
and Graphical
Planning Aids**

ODID III showed that controllers were able to control traffic without electronic strips and were happy to do so. The use of graphical planning tools for planning entry and exit conditions facilitated the removal of strips, and a conflict risk display used together with the entry and exit aids was considered beneficial to planning. ODID III also demonstrated that a radar display is important for the planning controller in today's radar environment for the evaluation of inbound traffic flows.

In ODID III the notion of minimum information was introduced for the first time. This was highly commended by the participants. It operated on the basis that the controller should only be provided with frequently used information. All other data is hidden but readily available on request.

Following ODID III, an EATCHIP Guideline document [3] was published. This has served as a major influence on ODID IV and other European projects (e.g SWIFT [4]).

*ODID IV,
Colour Planning
States and System
Assisted
Coordination*

ODID IV [5] (Figure 2) experimented with a full ATC environment except for those services provided on the ground. This simulation confirmed the use of colour for planning states and outstanding tasks, in particular coordination.

System assisted coordination was considered to be one of the best functions in ODID IV. Post exercise analysis showed that messages were generally cleared between 10 and 30 seconds of posting, dramatically cutting telephone coordination.

The use of a dynamic colour coded radar label was found to be an exploitable interface for system dialogue. Controllers did most of their data input through the radar label, and they found the label shape to be a clear indicator of outstanding tasks and potential workload.

Cursor defaulting was also used. This was applied to letters of agreement and logical "next action" defaults based on control input e.g. assume of control, transfer of control.

The evaluation also showed that controller input (and actions) must not be influenced by slow response times; immediate feedback and "unlocking" the controller from the input process are essential.

Simple tabular lists used in ODID IV en-route and approach displays were found to provide sufficient information to start planning tasks. The preferred graphical tools

were Vertical Aid Window (VAW) and Flight Leg.

It was interesting to note that providing graphical tools may reduce the controllers ability to build a traffic picture. This appeared related to the use of colour as a conflict indicator. Today the controller reads strip information and then checks against other traffic for conflicts. Using graphics which display a system conflict prediction permits the controller to quickly check many aircraft for conflicts without reading the “strip information,” but just validating the colour representation. ODID controllers were observed on numerous occasions going back to flight plan data when aircraft first called on frequency, to confirm level requests, destination, type and routing information.

Since ODID IV the EUROCONTROL Experimental Centre has run several ODID type experiments for National Administrations seeking to understand their own requirements for new system developments. However, the FAA simulation was the first time that a measured “baseline” [14, 15] was used to compare ODID with a current system.

**FAA ODID IV
Baseline
Comparison**

This joint FAA/EUROCONTROL [10, 15] simulation was requested to compare modern ATC technologies demonstrated in ODID with the FAA current en route Plan View Display (PVD) system [13]. The comparison sought to identify controller productivity and user benefits to help FAA investment ATC requirement decisions.

FAA Findings

The simulation showed that compared with the PVD Baseline ODID provided :

- less average sector flight time, specifically in low altitude sectors;
- fewer altitude changes per aircraft. This reduction resulted from controllers planning aircraft using the VAW and System Assisted Coordination to check for conflicts and co-ordinate changes such as sector entry or exit altitudes;
- from 66 to 85% fewer speed and heading changes per aircraft;
- reduced telephone communications by 50%. However, there was up to 44% increase in total coordination using ODID (calls plus System Assisted Coordination messages);
- lower subjective workload for 3 of 4 sectors.

Controllers unanimously agreed the System Assisted Coordination capability to be the single most useful benefit provided in ODID.

The study provided the FAA with increased understanding into how new ATC technologies might change controller productivity and benefit the user. The baseline comparisons [13] yielded several trends, including :

FAA Trends

- fewer calls yet more coordination using System Assisted Coordination;
- fewer control instructions issued to aircraft;
- access to ATC information without paper strips;
- simple system dialogue through mouse and popup menus;
- more information on the radar display through the Flight Leg and colour

- coding, and
- greater integration of the Planning Controller.

Cost Benefit

For the user these trends included reduced average sector flight times and fewer altitude, speed and heading changes per aircraft. This was later calculated to equate to savings of \$835,300 US dollars per year for the 2 low level sectors based on 3 rushes per day.

These figures were calculated based on sector throughput, aircraft types and fuel burn, and operating costs (salaries ..) in 1996.

The study commented that ODID principle of displaying minimum information and accessing supplementary information on the radar display showed an efficient approach to eventually replace paper strips.

**TE3C
(Tools
Evaluation
Control Centre
Copenhagen)**

Another trial worthwhile mentioning was TE3C.

The TE3C “shadow mode trials” [6] took place in December 1995. This was a joint project between the EUROCONTROL Experimental Centre (EEC) and the Danish Civil Aviation Authority. The project provided input to the specification process for the new Copenhagen Control Centre.

The impact of graphical tools displaying predicted traffic situations as observed during this evaluation would be the ability of the planning controller to reduce radar controller workload by pre-planning the traffic situation and provision of advanced resolution to predicted conflicts.

The feasibility of replacing paper strips through graphic tools was demonstrated, however, the evaluation highlighted the importance of accurate trajectory calculation, trajectory re-calculation and conformance monitoring.

As a result of this evaluation, the EUROCONTROL Experimental Centre has developed the capability to connect its simulation facility to Flight Data and Radar Data Processing Systems for use in future field trials of new ATC system developments.

**PD/1 – PHARE
Demonstration**

EUROCONTROL’s involvement in the PHARE programme has included HMI design and tool development (e.g. HIPS – Highly Interactive Problem Solver; figure 3). Three PHARE demonstration are planned, of which the first two are complete. Results from PD/2 are not yet available but it is worth commenting on PD/1.

PD/1 saw the integration of the ODID colour philosophy for aircraft planning states [5] with the NATS [8] use of label infill and carefully layered map backgrounds and use of transparency.

But, PD/1 involved much more than HMI. It evaluated a scenario involving air ground integration through data linking, including trajectory negotiation, and provided the controller with a graphical interface which included a “Problem Solving Tool.”

PD/1 shows that an integrated air ground air traffic management scenario is feasible but it has left many questions unanswered on the benefits of advanced tools and HMI concerning significant workload reduction and capacity gains.

Indeed, the experiment suggested that some controller workload was transferred from the task of controlling traffic with the R/t to managing the tools in preparing conflict free trajectories. It also highlighted a significant shift from tactical to planning control responsibility causing an imbalance in workload.

PD/1, like many other evaluations, clearly highlighted the need for good training. This includes not only HMI training but also ensuring a good understanding of the concepts employed.

Many questions have been posed by PD/1 concerning advanced ATC systems, some of which will hopefully be answered in PD/3 and perhaps other trials. However, it is clear that decisions concerning the division of responsibilities between man and machine now have to be made; is it Human in the Loop with situation awareness (i.e. the traffic picture) or Human in the Loop with system awareness (i.e. the system has the picture!)

**EATCHIP III –
Civil military
and SYSCO**

Recently the Experimental Centre together with DED2 have completed a series of experiments on civil military coordination and SYSCO. Although too soon for detailed results the evaluations have reinforced the use of minimum information and the ODID/NATS colour planning states and selected label infill approach.

Controllers have reacted positively to the system assisted coordination. The need for trajectory editing via a dedicated dynamic flight leg trajectory editing tool to facilitate airspace crossing requests was identified.

**Some New
Studies**

The EUROCONTROL learning experience in HMI shall continue in with a number of studies including EATCHIP III, EOLIA and PD/3.

EATCHIP III has the primary aim of demonstrating Advanced System Operational Requirements produced by the EUROCONTROL Administrations. These demonstrations will include functions such as MTCD, AMAN, MONA, CORA and Data link applications. Work is already underway in Brétigny to implement the core functionality, whilst HMI prototyping continues on the Prototyping Platform in DED2, Brussels.

The EOLIA project will demonstrate ATN and datalink. The ground system CWP HMI shall be based on EATCHIP III and will provide an opportunity to explore the requirement of CPDLC message composition and interaction.

PD/3, which is planned to run in May 1998, shall demonstrate an integrated air-ground system for 2015. This demonstration will include advanced controller tools, data linking with 4 D trajectory negotiation, the concept of multi-sector planning, and advanced air and ground HMI. It is hoped to evaluate these various functions and concepts in a “Gate to Gate” operational environment.

PD/3 is a large simulation involving all of the PHARE partners and is the last of the PHARE demonstrations.

Back to the Title
– **Intuitive.**

Participants in the experiments comment that the HMI is Intuitive.

Why intuitive? Most data input relates to clearance instructions passed to the pilot, coordination effected with an adjacent sector/Centre, or planning tasks such as strip integration and conflict calculation (checking the Sector Inbound List or a vertical view for sector inbound conditions).

In relating today’s controller tasks to HMI oriented towards radar data block text fields for input and information, the experiments have managed to retain a degree of “comfort or familiarity” for the controller.

It is important that we recognise that there is a trade off when introducing functionality requiring controller update. The benefit must be clear otherwise the controller will avoid it; this may have drastic consequences when updating is linked to trajectory calculation and conflict prediction.

Findings
Basic Stuff

What have these evaluations furnished ?

Some basic yet obvious lessons have emerged. These include :

- robustness : protect against unintentional/accidental input;
- consistency : same actions on same fields, same way in different areas;
- transparency : input fields and actions should be clearly understood; avoid designing functions that require cognitive effort i.e. “thinking time!!”
- non-intrusive : interface should not interfere with the ATC task;
- interuptability : short input sequences and easy way out to facilitate other tasks, without losing the work done.

Today the controller is “in control” not only of the traffic situation, but also of the interface. ATC is not ready to be “system driven” (will it ever? should it ever??) therefore the system must not impede the controller from taking the initiative.

This is summed up by the statement [7]:

“as far as possible, the controller should not be forced to be reactive to the interface, but should be presented with information which permits the decision how to allocate resources and priorities to tasks generated by the traffic.”

**Multi-Discipline
Teams**

One simple requirement can be addressed at project start; small multi-discipline teams. This “team” approach can facilitate unambiguous requirements and good user interaction. If possible, the same team should be part of the development process.

**Lessons
Learned**

The following represents basic “lessons learned” from the evaluations. Obviously there is much more than can be presented here, but what is presented provides the basis for most of our current work.

**Minimum
Information**

The controller has a requirement for immediate access to “frequent use” information. Other information should be “call down” or graphically displayed when required. This applies to most flight plan information currently provided on paper strips.

The application of Minimum Information also provides visual clues to the controller in that the radar data block can highlight outstanding tasks though data block shape. For example, the display of additional data block lines can clearly indicate that entry/exit flight level requirements have to be achieved, or that an aircraft has heading and speed constraints.

Significantly, most evaluations have provided minimum information through greater use of interaction with the data block and the data block contents have become extremely important as a consequence. An action on a given field can give rise to a trajectory recalculation or system assisted coordination. It can provide access to flight plan data and control options concerning transfer and hand-over of traffic to another sector. Such design ensures that the Controller’s attention is infrequently diverted from the screen.

Data Input

Data input should be “point and click” where possible, involving one (but maximum three) clicks. Separate input buttons should be allocated to “information” and cancel, and data selection. Some evidence suggests that a third button could be used for window management, or specific functions such as range and bearing or communications.

It is important to ensure that the same logical input option is available wherever a field is displayed to ensure consistency and comprehension by the user.

In order to assist the controller find data and to improve situation awareness, cross correlation of data via “highlighting” wherever data is displayed, is recommended.

A number of studies elsewhere (NLR, SWIFT [4]) have been effected concerning input devices, e.g. trackball versus mouse use. The conclusions do not significantly favour one or the other input devices. However, the mouse seems to be “de-facto” accepted; it does offer some advantages with the ability to click and drag objects.

**Managing
Windows
– Not
Windows 95©!!**

Move, re-size, pan and scroll, and priority swap actions are accepted.

Controllers always insist that they should have full authority over window management. It is a contentious point. However, Controllers agree that pre-defined

user preferences with reduced freedom of window management are acceptable (but ensure that the users ARE involved in the definition)..

Look and Feel !

An object oriented approach to data input and data updating is essential. For example, highlight a data block and associated data should be highlighted wherever displayed. Consistency of actions in all windows and on all data action fields must be achieved.

**Colour
– Or Is It Color
??**

Colour provokes critical discussion, but the application of colour as opposed to the actual colours themselves has found significant acceptance.

Four areas of colour use have emerged :

- Highlighting areas of interest (sector, military, danger).
- Aircraft planning status/Controller responsibility.
- Coordination/outstanding tasks.
- Warning, conflict and Urgency.

Use of colour has evolved significantly with colour studies done by NATS [8]. Most European interface work now contains aspects of both ODID and NATS standards (PD/1[9] and EATCHIP). ODID use is reflected by a task oriented approach [5, 7] such as the use of planning status and colouring of data block text, whereas NATS [8] use of in-fill and layering has provided easier access to data and a clearer definition of airspace composition.

ODID guidelines [3] for colour use include :

- use colour to distinguish specific information from general data;
- highlight important items to catch attention;
- avoid large blocks of colour unless it is to distinguish large areas such as sectors or military zones;
- currently selected fields should be highlighted;
- avoid using “slightly different colours in close proximity;
- keep the meaning of “convention” colours such as red amber and yellow;
- avoid using more than 8 colours for operational significance (or ensure that the controller is “not aware” of more than 8 colours).

Much of this may be obvious but it is surprising how often these guidelines are ignored and lesson re-learned.

Using colour to signal outstanding coordination facilitates the controllers search pattern and improves reaction to coordination since coordination can be identified wherever the co-ordinated item is displayed.

**Cursor
Defaulting**

What is it? Simply ensuring that the next logical input value is placed under the cursor when a pop up window is opened.

Much is known about local ATC operations through Standard Operating Procedures, and Letters Of Agreement. This permits defaulting the cursor to the next logical input value or function; for example, next cleared level, speed restrictions in terminal airspace and transfer of control at sector exit. This reduces input, is intuitive and removes frustration. It also provides an acceptable trade off for requiring the data input in the first place.

There can be drawbacks in cursor defaulting so it should be monitored to ensure proper application.

Coordination

As already indicated by the use of colour in coordination an object oriented approach should be used which permits warning of pending coordination when data scanning.

Plain language messages should be used with minimum use of abbreviated indicators. Message windows are almost considered as secondary confirmation listings.

It is also clear that system assisted coordination – provoking coordination with the appropriate sectors – is of great value; reducing the controller’s need to identify these requirements and permitting a quick move onto the next task.

Use of Graphics

Is text better? I don’t think we know. The saying “a picture’s worth a thousand words maybe true!” but ?

Displaying situations in such a way that it is evident what the conflict represents, and even better, how it might be resolved is a challenge. Most of our experience has been with conflict pairs, using vertical and horizontal views with graphical flight plans to show route and conflict planning information.

The use of conflict planning data portrayed as “dynamic no go areas” which change through “click and drag” interaction can be very powerful. This has been experimented with a high level of acceptance with the HIPS tool.

Evaluations have highlighted the need for :

- validating sector entry and exit level conditions. A vertical display window presenting coloured blocks of “used airspace” is usually adopted;
- validating horizontal sector entry and exit conditions, and “in sector” conflicts. A flight leg displayed from the radar data block with minimum separation defined is adopted;
- monitoring the traffic situation as the controller updates flight plans and new flights are warned to the sector.

A graphical and textual conflict risk display has been adopted, but recent experience suggests that a textual list sorted by conflict priority (time to loss of separation?) may suffice.

One problem which has yet to be resolved in our evaluations, although it is being studied in great depth by CENA (ERATO), is that controllers do not think in terms of conflict pairs but in terms of conflict problems. This is an important aspect which we

must address now and which will most probably require a graphical approach.

The only lesson – keep it simple and related to the Controller’s understanding of traffic problems.

Cost Benefit

Until the FAA ODID [10] simulation very little data has been available for comparison with today’s system (our bad experiment design, I accept).

The FAA ODID simulation has shown that with minimum HMI improvements and simple conflict prediction controllers instructions and service to flights can be improved (more unrestricted climb and direct routes). The possible financial benefit to be realised by the airspace user in fuel saving could be significant.

Additionally, several evaluations have highlighted the potential benefit of system assisted coordination through improved advanced flight planning and significant reduction in voice coordination (get rid of all those costly land lines??).

Long Term Ambitions

Our HMI designs have long term ambitions. EUROCONTROL projects (EATCHIP III, EOLIA and PD/3) will help to consolidate and promote a greater consistency in European HMI design. Lessons learned are being applied.

Our challenge is to provide an example of an HMI together with HMI principles that can be used as a reference in future study, development and implementation projects throughout Europe..

Thanks

This paper has tried to highlight some of the European initiatives in HMI experimentation and design, and the lesson learned.

Much progress has been made towards defining acceptable HMI for today and tomorrow. These designs are being accepted into specifications for new systems already under development today.

Thank you.

References

1. EUROCONTROL Experimental Centre Report No. 242 – EEC Task AS02C, The Third ODID Real Time Simulation.
2. R V Graham, EUROCONTROL Experimental Centre ODID III Bis Supplementary Exercise presentations and “Hands-On” Experience.
3. EATCHIP – ODID Report and Guidelines.
4. SWIFT : 1 Set of commonly agreed HMI Functions (WPR/3.3/02). 2 Experimental Validation of Scenarios (WPR/5.2/2).
5. R V Graham, D Young, I Pichancourt, A Marsden, A Irkiz, EUROCONTROL Experimental Centre Report No. 269 – EEC Task AS08, ODID IV Simulation Report.
6. R V Graham, EUROCONTROL Experimental Centre Report No. 295 – EEC Task AM14, Tools Evaluation Control Centre Copenhagen TE3C.

7. A Jackson, Dr I. Pichancourt, EUROCONTROL Experimental Centre Report No. 292 – EEC Task AT66, A Human Machine Interface Reference System for En-route Air Traffic Control.
8. Reynolds, L , Metcalfe, C. The Interim NATS Standard for the Use of Colour on Air Traffic Control Displays. CS Report 9213.
9. R Whitaker, D Marsh, EUROCONTROL/PHARE Report No. 96-70-24, PD/1 Final Report.
10. P Krois, A Marsden, EUROCONTROL Experimental Centre Report No. 311 – EEC Task SA5, FAA ODID IV Baseline Simulation Report.
11. SWEDEN Real Time Simulation 96.
12. EATCHIP III Civil Military & SYSCO.
13. Galushka, J., Frederick, J., Mogford, R., and Krois, P., Plan View Display Baseline Research Report, FAA Technical Center, DOT/FAA/CT-TN95/45, September 1995.
14. Keegan, C., Skiles, T., Krois, P., and Merkle, M., Baseline Measurement Approach to ATC Acquisitions, Journal of ATC, January-March, 1996.
15. Skiles, T , Graham, R , Marsden, M , and Krois, P , En Route ODID – PVD Baseline Comparisons : The Journal of Air Traffic Control – January-March 1997.

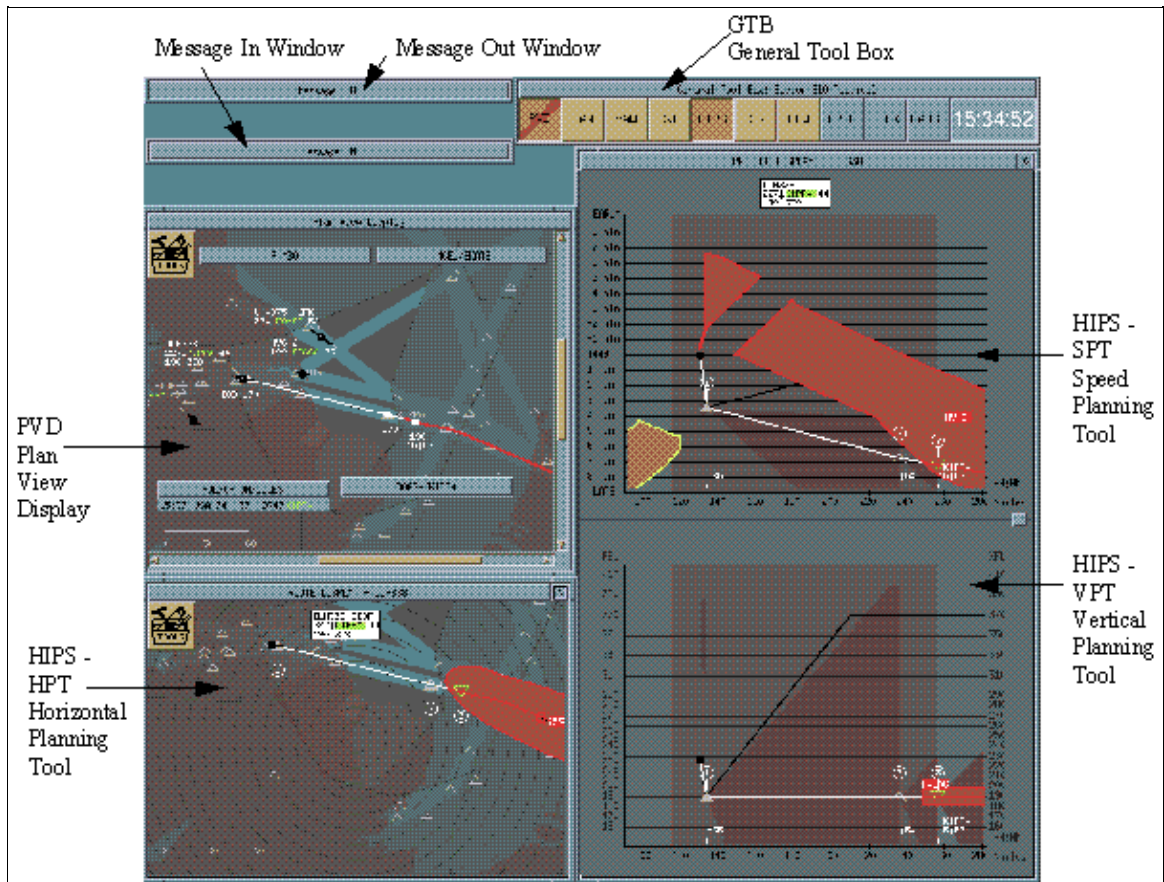


Figure2 PD/1 Display with HIPS Vertical, Speed and Horizontal Windows