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ODID IV

Recording and Analysis Requirements

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Abstract:

A description of the analysis techniques available for assessing the compliance to the objectives of the ODID IV (AS08) simulation at the EEC and a reference for the analysis techniques available to the Project Leader for potential use in future real-time simulations at the EEC.

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ODID IV
Recording and Analysis Requirements

by

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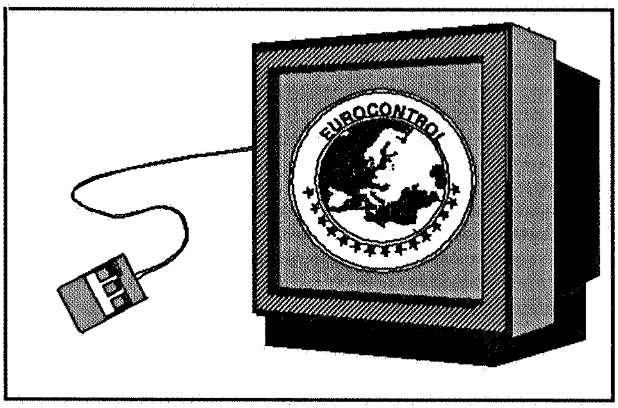
Summary and objectives

This document has been produced specifically in order to describe the analysis requirements and procedure in support of the ODID IV (AS08) real-time simulation to be conducted at the EEC in September and October 1993.

In more general terms it is proposed as a reference for the analysis techniques available to the Project Leader for future real-time simulations to be conducted at the EEC.



Contents

1. Introduction

This document contains the specification of the analysis of the data which will be collected during the ODID IV (AS08) real-time simulation. Its purpose is to expand on the analysis specification given in the ODID IV Facility Specification and to provide a record of how the data from this simulation will be collected and treated. The analysis report will contain precise details of all aspects of the analysis procedures which will allow easy re-use or reference of the simulation results should this be required in the future. (For example, comparison with results from a similar real-time simulation or fast-time simulation). Other specific detailed analysis relating to future real-time simulations will be performed according to the requirements of the Project Leader and will be described in a format similar to this document.

The ODID IV requirements for data collection and analysis are :

- Full debriefing of participants following each exercise.
- Non-intrusive observation of participants during exercises using video and audio recording equipment to determine controller behaviour as well as content, duration and method of verbal communication.
- Comprehensive structured questionnaire.
- 'One-to-one' interview at the completion of the simulation for each controller working a measured position.
- Comprehensive real-time recording of all controller and pilot inputs, telecom usage, as well as periodic recording of all aircraft state vectors.

ODID IV is a continuation of the development of a controller working environment, started in simulations ODID I, II and III. The broad aim of these ODID (Operational Display and Input Development) simulations has been the replacement of paper strips and the use of colour in ATC procedures. The specific objectives of ODID IV are given in the Facility Specification. However, the decision as to whether the proposed environment is acceptable or not will largely depend on the verbally expressed opinions of the participating controllers and the observations of Danish and EEC project staff. The role of analysis in this simulation is to provide information to support and/or explain the opinions of the participating controllers and to provide information in support of a full ergonomic study.

The Statistical Analysis Software (SAS) which has been developed for analysis of this simulation has (necessarily) been produced according to the specific objectives and data recording format of ODID IV. However, where possible individual modules are designed to be generic in order to necessitate minimal modification for the needs of future real-time simulations.

The participating controllers have now received tuition in the use of the ODID environment via various Computer Based Training sessions as well as, more importantly, during the ODID IV System Validation exercise conducted at the EEC during May and June 1993. This simulation gave the controllers the opportunity to acquaint themselves with the ODID facility and to become used to working in a 'highly monitored' environment. The System Validation phase also provided the opportunity for development and proving of a number of the analysis tools described herein.

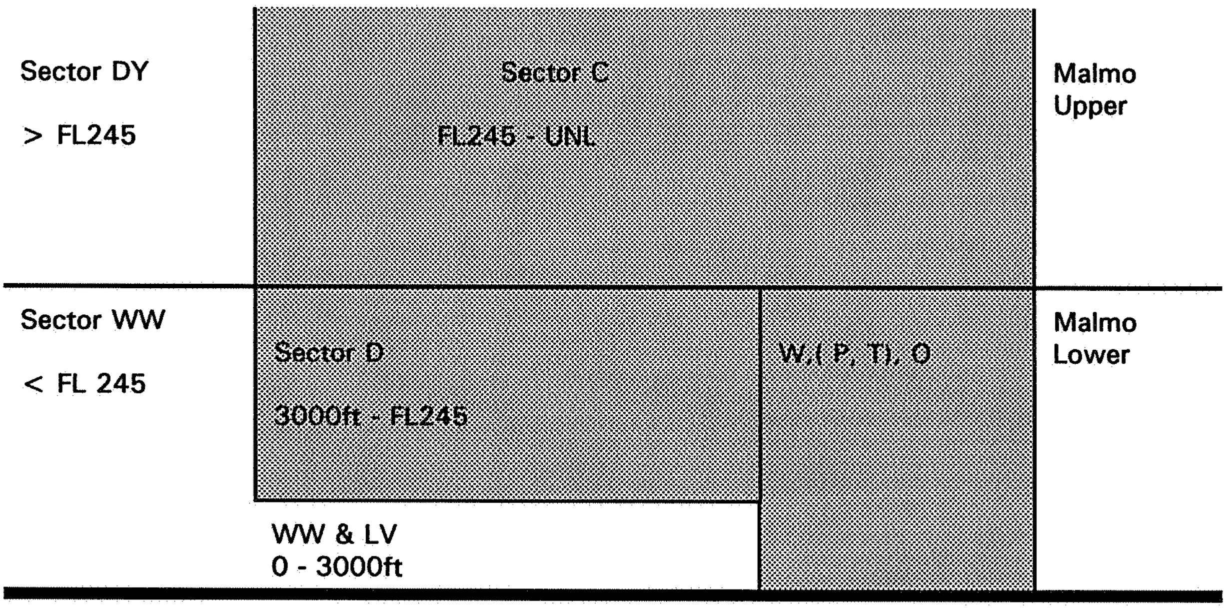
The initial stages of the AS08 Operational Simulation in September and October 1993 will again be devoted to controller training prior to full measured exercises when subjective parameters such as NASA TLX and ISA are expected to become more indicitive of controller workload.

2. Simulation outline

The experimental design of this simulation is relatively simple. There will be thirteen simulated sector positions of which six will be measured and seven will be feed sectors. These are (measured positions in **bold**):-

Sector C	**Executive**
Sector C	**Planner**
Sector D	**Executive**
Sector D	**Planner**
Sector O	**single controller**
Sector W	**single controller**
Sector MU (MALMO UPPER)	feed
Sector ML (MALMO LOWER)	feed
Sector DY (Maastricht)	feed
Sector WW (Bremen)	feed
Sector L/V	feed
Copenhagen TOWER	
Sector P	Arrival

The analysis of the recorded data from the ODID IV simulation is simplified in as much as one is not attempting to statistically assert that one airspace structure or working practice is 'better' than another. The purpose of the statistical analysis is to complement the verbally expressed opinions of the controllers and in many cases to provide a more detailed description of the way in which the ODID environment is used under a range of operational conditions. The vertical profile of the simulated airspace is illustrated in the following diagram with the measured sectors (excluding P, T) shaded :



3. Simulation objectives

The primary objectives of the ODID IV simulation can broadly be defined as continuing a natural progression of the previous ODID simulations in assessing the use of a single input device (Mouse) in conjunction with a large high-resolution Sony colour display. In order to assess the usefulness and useability of both the ODID interface and the specific tools provided to the controller for each measured sector position, the system will be assessed under a number of operational conditions, comprising a set of 'Primary Independant Variables'.

Charge

- Exercises will be run using both a 1992 traffic intensity level and projected intensity levels for years 1995, 1998 and year 2000 so that comparison can be made.

Complexity

- The use of three combinations of traffic complexity is anticipated allowing variations in the Route structure, incorporation of military traffic and runway direction as follows :

  TA - Normal Routes / No military / Runway 22L / Derived from morning sample
  TB - Direct Routes / No military / Runway 22L / Derived from morning sample
  TD - Normal Routes / military / Runway 04L / Derived from afternoon sample

A number of 'Secondary Independant Variables' will also be of interest :

Colours

- The impact upon the useability of the system according to the use of 'standard' colouring.

Controller effect

- Most analysis will be performed with reference to the measured position rather than the specific controller. In assessing the Human / Machine Interface some results may be presented for each controller in order to compare different approaches for execution of specific tasks. Attributes of each controller which may be taken into account include Experience, Age and number of exercises completed (learning curve). This analysis will also assist in complementing the one-to-one interview.

The traffic samples will be used to draw conclusions relating to the usefulness and useability of the tools provided to the controller in the ODID system as follows :

i) the evaluation of the incorporation of a metering tool between Approach and En-Route Sectors.

- Here the aim is to assess the interface rather than the metering tool itself. How the tool was accessed and how the controller responded to the 'advice' of the tool will be studied.

ii) to assess the use of the contents of the radar label provided to both Approach and En-Route controllers.

- The aim is to establish the use made of the information available by the controller. Did the controller access the information in the most efficient way? Did the use of colour enable the controller to readily understand the state of an aircraft ? etc.

iii) to evaluate the tools provided for identification of conflicts and conflict-risks.

- this concerns the MTCA windows, whether they were used, whether they were easy to use and the extent to which the 'advice' of the tool was heeded.

iv) to assess the effectiveness of a coordination mechanism on coordinations between Upper and Lower sectors.

- this concerns the use of procedures such as Entry and Exit level negotiations, TRANSFER, R.HANDOVER, SKIP etc.

Besides the stated primary objectives of the simulation there are other treatments of the available data which may be of interest. In particular certain variables may be of later use in studies conducted under the auspices of the EEC, for example investigations into quantifying sector capacity.

A number of variables are recorded as standard for all simulations even though they may not in this instance be of use in assessing the simulation. For this simulation a modification of the MBB Workload will be used to give an indication of the traffic charge at any given instant. This will require the calculation of the complexity of traffic in the sector every two minutes rather than the one hour period (NB the standard one hour period will also be used).

Due to the detailed non-intrusive observation planned for this simulation a lot more data will be available than is normally the case. This additional data may be particulary useful in determining the allocation of time by a controller to the various ATC tasks. Normally only the time dedicated to r/t usage is accurately recorded but with observation it should be possible to analyse the r/t communications themselves and thus establish the r/t time required to handle flights of differing complexity. Although it is unlikely that any coefficients thus obtained could be extrapolated to a non-ODID environment, the comparison with existing coefficients (as computed by MBB) will be of interest.

4. Analyses to be Undertaken

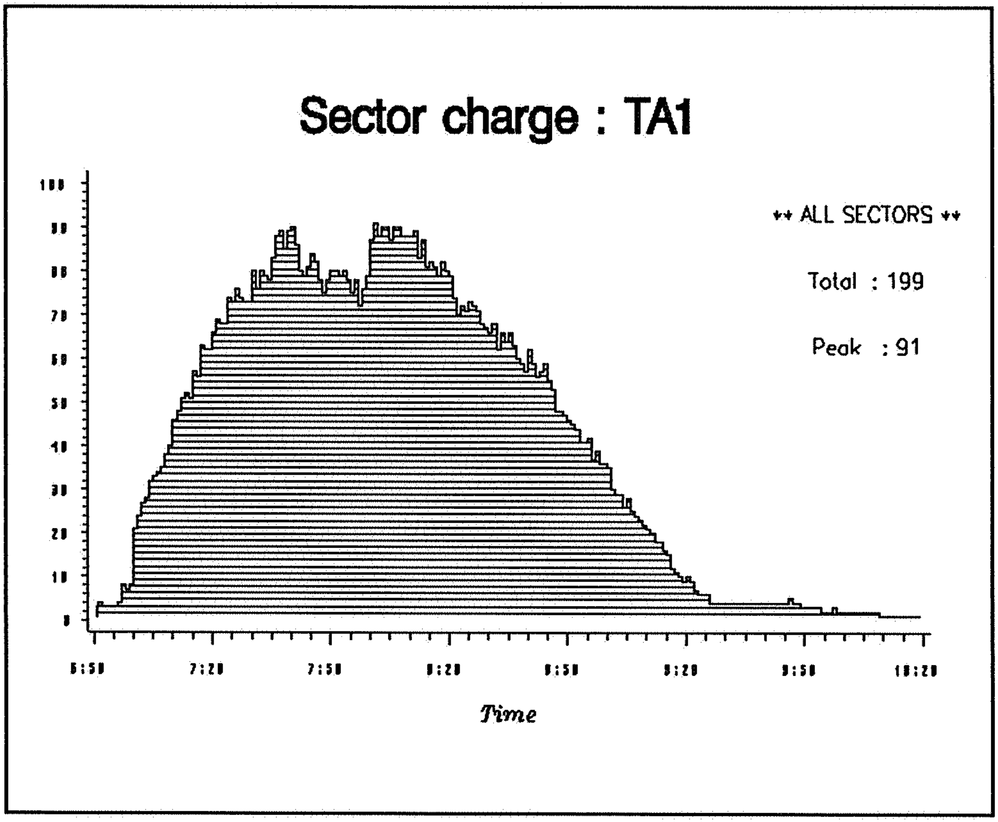
The following sections indicate in general terms the sources of information available in support of the statistical and ergonomic study of the ODID interface. A more detailed description of the system recorded data gathered during the exercise and the treatment of this data is given in Section 7.

4.1 Traffic sample analysis

The primary analysis to be performed before the simulation is a statistical study of the traffic samples. As described in Section 3, three different traffic sample complexity levels incorporating four different charge levels are anticipated to be employed. A SAS Software package has been developed which provides summary statistics relating to the state vectors of each aircraft. The minimum information provided includes the time distribution of aircraft occupancy for each sector (mean and standard deviation), a description of the use of the available routes and the use made of each standard arrival route to Copenhagen (EKCH).

The information pertaining to each traffic sample is provided to the Project Leader in both a textual and graphic form and will be used to ensure the 'realism' of the traffic sample as well as allowing specification of the 'measured hour' according to the distribution of traffic.

An example of the variation of traffic in the entire simulated airspace for sample TA1 (TA complexity, year 1992) is indicated below :



The information to be gathered during the exercise is described in Sections 4.2 - 4.6

4.2 Non-Intrusive observation

During each exercise non-intrusive observation of the controllers will be undertaken by means of video and audio recording of each position. Four observers will be used to observe the six measured positions. The observers will watch video screens showing the controller at work in real-time and will note significant events according to a pre-defined code list. These events will be recorded on a paper grid using the codes to fill in several fields. At the end of the exercise any points of uncertainty can be resolved by replaying the video and talking to the controller if necessary. Post-exercise discussions with the controller will be particularly useful in gaining an insight into the purely mental activities which occurred which were not betrayed by a corresponding physical action and will also give an insight into the controllers reasoning at a particular instant which lead to a certain control strategy.

The information will be then input to the mainframe via a similar grill presented on the terminal screen (GRILL EXEC). Although a certain amount of the analysis of these observer grills will have to be carried out by hand, the use of the mainframe will enable some processing using SAS, to count the number of occurrences of certain events.

Information to be recorded on the observer grills will generally be as follows:-

TIME	the hour and minute of the observation (start and end)	
TYPE	the type of event : Radio, Telephone, Informal or Motion Only	
SENDER	a two letter code indicating the controller position {OE,WE,CE,CP,DE,DP,MU,ML,DY,WW,LV,T,P,}	
RECEIVER	as for sender	
AIM	can be typically :	an order, a transfer, a demand, a proposal, a response or a counter-proposal.
TASK	can be typically :	Entry Coordination, Exit Coordination or Conflict Resolution
CONTENT	Any key words that the observer can detect to explain the cause of the exchange , e.g. a callsign , a flight level, an entity such as XFL or SPEED etc.	
MOTION	Any motion of the controller either in isolation or as part of the task. Typical actions of interest to the Human Factors analysis are: Looking or pointing at an adjacent screen Pointing at own screen Writing Use of the telephone deck Abnormal mouse movement Relaxation Indications of agitation or annoyance	

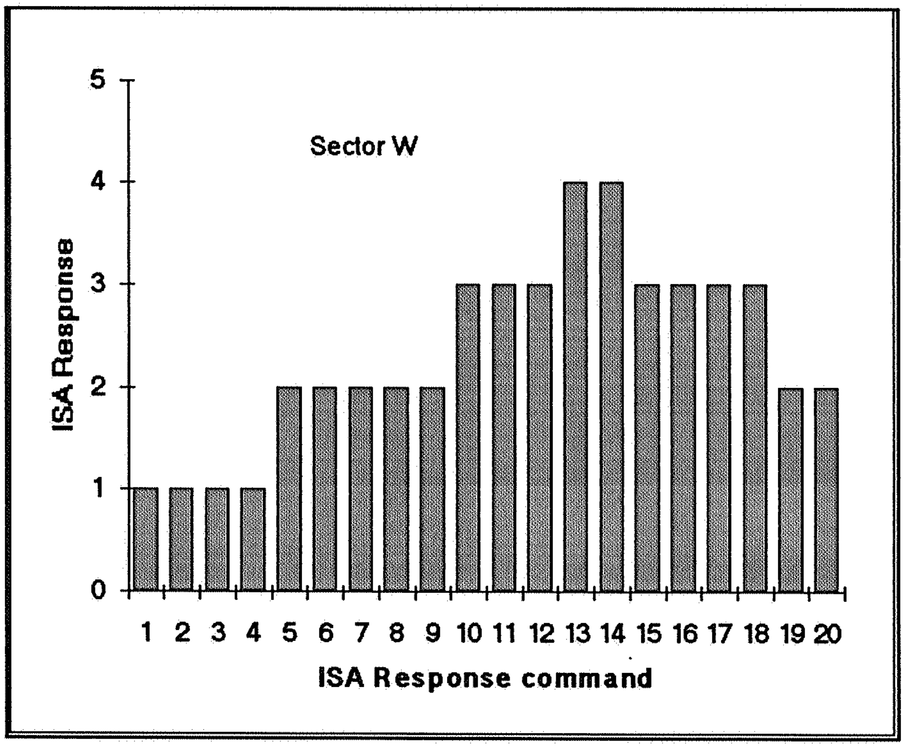
Further information regarding the completion of the grids as well as the philosophy behind the Non-Intrusive observation method is contained in the 'ODID IV Observer booklet', incorporated in this document as Appendix C.

4.3 ISA

A modified version of the Instantaneous Subjective Analysis (ISA) (based on techniques developed at ATCEU, Hurn) will be employed for the first time in an EEC real-time simulation. The method is essentially very simple: the controller is provided with a small box containing five colour-coded buttons. The buttons are labelled as follows:

5 (RED)	=	Very High
4 (YELLOW)	=	High
3 (WHITE)	=	Fair
2 (GREEN)	=	Low
1 (BLUE)	=	Very Low

Every two minutes the controller is prompted to press one of these buttons according to his/her perceived workload at that point. The prompt remains visible for thirty seconds during which time the controller must press a button. After thirty seconds no value will be accepted and the score for that two minute period is considered as "missing". The data will be collated using EXCEL on a PC in the control room and presented in real-time for each of the six measured positions. Data from each exercise will then be transferred to the mainframe, where it will be stored and presented using SAS. An example of the graphical representation of ISA data is indicated below with the response categories corresponding to the button labels. Such a graph is produced for each measured sector along with textual summary statistics (Mean response; mean and standard deviation of response times etc). The ISA process is also described in detail in Appendix B, which also formed part of the teaching material for the Danish controllers.



4.4 MBB Workload

The MBB workload calculation will be used in this simulation using the standard set of coefficients. The determination of the MBB value will be made immediately after the simulation using the recorded aircraft state vectors. This immediate calculation of the traffic workload introduces the possibility of applying the method to periods other than the usual one hour - (see EMBB Workload below). The summation to be performed is as follows :-

$$MBB = Tot + 0.2 \times mil + 0.24 \times Evol + 0.26 \times FIR + 0.38 \times TMA + 0.3 \times RV + 1.3 \times AFIL + 1.4 \times Nconf + 0.6 \times Nhold$$

where

Tot = the total number of flights entering
mil = the number of military flights entering
Evol = the number of flights changing flight-level
FIR = the number of flights transitting between FIR and UIR
TMA = the number of flights transferring to or from APPROACH
RV = the number of radar vector inputs made by the controller
AFIL = the number flights transferring from VFR to IFR
N_{conf} = the number of inputs to resolve conflicts made by the controller
N_{Hold} = the number of flights placed in a holding pattern.

The coefficients listed above were originally defined by MBB according to the R/T time spent by controllers in managing flights of differing complexity in the early 1960s. The value of derived MBB workload must therefore be treated with some caution as their applicability to modern air traffic control practices and procedures is open to question, particularly so within an environment such as ODID. Within ODID IV a detailed analysis of R/T usage (via the TELECOM recorded file and Non-intrusive observation) will take place and it is anticipated that this will lead to a better understanding of the applicability of the MBB weights to an ODID environment.

An additional problem with MBB is in determining the difference between an input made to resolve a potential conflict and a 'radar vectoring'. By definition if the input is to avoid a conflict then that conflict will not arise and so will not be detected by the system. Previously it has been considered that the use of DIRECT ROUTE, FL and SPEED TAS inputs are most likely to be conflict resolvers and others such as HEADING are not. These uncertainties need not detract from the value of the result as a useful indicator of traffic charge.

4.5 EMBB Workload

As mentioned above the possibility exists for this simulation to compute an MBB-like summation using a shorter measuring period than usual. Initially the period chosen will be 2 minutes to enable direct comparison with the ISA results. However the period will be a variable parameter at the discretion of the experimenter so that longer periods can be selected if required.

4.6 Controller and Pilot Inputs

The analysis of pilot inputs will be performed as usual i.e. the number of times that each pilot inputs a certain order will be derived. Initially this will be done for every possible pilot input. In addition the inputs made on any flight during its passage through the system will be available.

Every time a controller instructs a pilot to input an order he should update his/her own system as well. Using the recordings from the ODID windows the number of occurrences of each controller action corresponding to a pilot input will be counted and compared. Ideally there should be a high correlation between controller and pilot inputs. The counting of relevant controller inputs from the mass of data available from the ODID screens will require careful filtering. There will be several sequences which correspond to a given pilot input and there are likely to be erroneous inputs contained within the sequences (see Error Analysis below).

4.6.1 Determination of tasks

An important consideration in the analysis of data recorded from the ODID windows is the determination of the tasks to be achieved by the controller. These can be loosely divided as window management tasks and operational tasks, although clearly the ease with which operational tasks can be achieved is dependent on the window set-up. Of particular interest will be the sequences used by controllers to achieve particular tasks. Where a task entails a series of controller inputs there is often more than one permutation of inputs possible. For certain tasks the series of inputs used will be studied to see if

- i) the controller uses the most efficient sequence
- ii) there are different sequences used by different controllers
- iii) there are different sequences used by the same controller (learning perhaps).

4.6.2 Error Analysis

A problem in the analysis of controller inputs is the presence of erroneous inputs in the sequences. Errors may be caused by the incorrect choice of mouse button, misunderstanding of the role of a selected object, repeated input on the same object or simply from an unintended click. Whatever the cause, the result is that the sequence of inputs to achieve a certain goal is interrupted. This makes it very difficult to program the analysis of sequences. Data from the ODID screens will be sorted by time for each controller and then processed to check for repetition of an input. The data will then be checked for occurrences of any recognisable sequences. The presence of erroneous inputs may lead to a better understanding of the possible presence of shortcomings in the Human / Machine interface at both the physical and task levels.

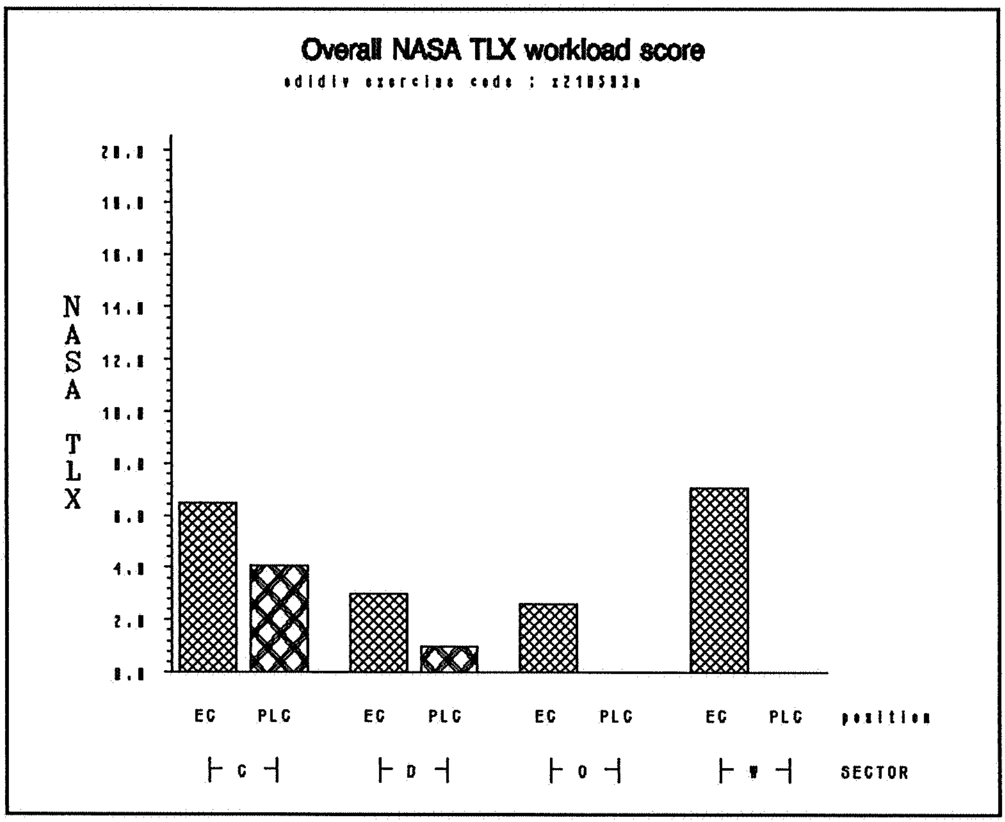
The following information will be gathered at the end of each exercise

4.7 NASA TLX

The collection of NASA TLX data will be carried out via a SAS/AF Program using IBM mainframe terminals. This is the first time during an operational simulation that the weighting and ratings forms have been presented on a screen and not on paper. Other than this the utilisation is as per normal. The method of data entry and processing has been validated during the ODID IV System Evaluation phase.

A detailed description of the NASA TLX method is given in Appendix A. This appendix also provided a major form of teaching material for the Danish controllers prior to the System Evaluation simulation where the material was again reinforced via a tutorial presentation prior to commencement of measured exercises.

The output of the NASA TLX method is a (subjective) assessment of the workload associated with each of the six measured positions. The information can be presented in both textual and graphical format and software has also been developed to allow analysis of the six constituent workload factors which form the NASA TLX process. This analysis can be performed for a specific exercise or for a range of exercises. An example of the SAS generated graphical representation of the overall NASA TLX score is given below.



The interactive NASA TLX package on the IBM mainframe has also been adapted to allow a number of operational questions to be presented at the end of each exercise. These questions relate to the usefulness of facilities offered to the radar and planning controllers. Each controller is presented with a series of questions depending on the position that they have just worked and each selects a response which most closely reflects their opinion from a set of options. These questions are described in more detail in Appendix A. By recording the data on computer a permanant record of the opinion of the ODID tools is maintained throughout the simulation. The information gathered in this way is complementary to that gathered via the use of the comprehensive questionnaire (Section 4.9)

The interactive NASA TLX package is also designed to be adapted to the needs of other simulations beyond ODID IV where information regarding operational tools may be required from each measured controller.

4.8 Exercise debriefing

The post exercise debriefing will be used to obtain the participants (both measured and feed controllers) subjective opinions of the ODID environment. This will provide each controller with the opportunity to highlight any difficulty in the use of the ODID facilities or interface.

The following information will be gathered toward the end of the simulation

4.9 Structured Questionnaire

The questionnaire to be completed by each controller at the end of the simulation will seek information relating to the ODID interface and the specific assistance tools provided to the approach and en-route sectors.

The responses will be gathered both in a multiple choice format and in a more detailed 'written response' format.

4.10 One-to-one interview

A One-to-one interview with each participating controller will take place at the end of the simulation. This is designed to provide a more detailed understanding of each controller's opinion of the ODID environment and may provide information not highlighted in the exercise debriefs.

5. Presentation of Results

Presentation of the recorded information from this simulation will be undertaken in tabular and graphical forms according to the requirements of the project leader. A number of routines for this purpose have already been written using SAS and the available output is summarised in more detail in the following sections.

6. Provision for Data Storage

For this simulation all data relating to the simulation exercises will be stored on the IBM mainframe, either as mixed binary and text files as generated by the HP750 (MASS data files) or as SAS data files.

The following tables indicate the different sources of information which will be gathered during the simulation and the applicability of each to verifying the usefulness and useability of the system

	ISA	NASA	MBB EMBB	Conflict	MASS state vects	Controller inputs	Pilot orders	Telecom	Non Intrusive	Inter view	Questaire
Assessment of utility											
Frequency of tool use						X					
Mouse useability						X			X	X	X
Telecom usage						X		X	X		
'Elbow' coordination									X		
Context of use											
ATC action						X					
Display adjustment						X					
Sequences to perform actions						X					

	ISA	NASA	MBB EMBB	Conflict	MASS state vects	Controller inputs	Pilot orders	Telecom	N.I.O	Inter view	Questaire
Workload											
Subjective	X	X								X	X
Deterministic			X								
Traffic											
Conflict occurrence				X							
radar vectoring / RFL assignment					X		X				
Aircraft throughput					X						
Direct route authorisation					X	X	X				
System weaknesses											
Acceptability										X	X
Potential changes									X	X	X

7. Variables Recorded

7.1 Independant variables

During the simulation a SAS file named EXSPEC.AS08 will be maintained up to date. This file will contain one observation per exercise and the following variables:

The Exercise Code in the form DDMMYYL e.g.091193A	(EX)
The name of the traffic sample used	(TRAF)
The start of the measured hour in minutes after the start of the exercise	(STMH)
The end of the measured hour (60 minutes after STMH providing the exercise is not interrupted)	(ENMH)

Along with the dependant variables specified below the following independant variables will generally appear in all files output :

The Exercise Code
The name of the sector (C, D, W, O)
The name of the working position i.e. EC or PLC

7.2 Dependant Variables

For the ODID IV simulation it is convenient to classify the dependant variables according to the system used to record them. Data will be recorded from the following sources :-

MASS - all information regarding traffic behaviour in the system as well as pilot input orders. After each exercise a file is output from mass ("navigator file") which is transferred to IBM VM/ESA where all data storage will take place. Most quantitative data will be derived directly from this file.

TELECOMS - all recordings concerning the use of telephone and radio communications between controllers and pilots are recorded in a separate file for each exercise. These recordings are transferred to the VM/ESA at the end of each exercise.

ODID - recordings from the ODID screens are collected on HP 750 workstations and will be transferred to VM/ESA at the end of each exercise.

SUBJECTIVE - Results from the NASA TLX and operational questionnaires will be collected directly on VM/ESA using the SAS/AF application "NASA". Recordings from ISA will be recorded on to a PC before being transferred to VM/ESA.

A number of Statistical Analysis Software (SAS) packages have been developed to provide information pertaining to each exercise. The aim of this analysis suite of software is to interface directly with the system recorded data files (Navigator, Pilot Orders etc) without the intermediate need for creating large SAS data sets, thereby reducing both potential sources of error and disk storage requirements. This procedure has also been adopted to allow a more varied analysis to take place for future real time simulations according to the requirements of the Project Leader.

7.2.1 MASS file analysis

The following programs for treating the MASS simulation output data will be available:-

1. CHARGE.SAS

This module provides analysis of the behaviour of the traffic sample in each sector and will be used in conjunction with known parameters of the traffic sample (see traffic analysis section 4.1) to determine the effect of controller 'navigation'. For each sector the following variables will be computed:

The **total number of a/c** in the sector during the measured period.
The **instantaneous peak** number of a/c in the sector during the measured period.
The **mean and deviation of the number of a/c** present in the sector during the measured period. The time resolution for gathering samples to evaluate the mean is 1 minute.
The **total flight time** in the sector ie for all aircraft.
The **mean flight time** within the sector.
The **standard deviation of flight time** within the sector.
The **minimum flight time** within the sector.
The **maximum flight time** within the sector.
The total **time of a/c in level flight** as a percentage of the total time of flight within the sector.
Similarly the percentage of **time climbing** and **descending**.
The **total time of flight at the RFL** as a percentage of the total time of flight
The **total time of flight at flight levels greater than RFL** as a percentage of the total time of flight .
The **total time of flight at flight levels less than RFL** as a percentage of the total time of flight.

The sector occupancy sequence for each aircraft callsign is also provided along with summary statistics relating to the use of Copenhagen Standard Arrival Routes.

Graphical representation of flight time (and deviation about the mean) within a sector as well as the instantaneous charge throughout the measured period is also available.

2. PILORDS.SAS

The function of this module is to analyse the type and number or orders input from the pilot positions. For each pilot position the following parameters are provided as standard :

The **total number** of orders issued
The number of **CHANGE FREQUENCY** orders issued
The number of **FL** orders issued.
The number of **HEADING** orders issued
The number of **DIRECT ROUTE** orders issued .
The number of **NEW ROUTE** orders issued.
The number of **HOLD** orders issued .
The number of **SPEED TAS** orders issued .
The **total number of other** orders issued.

3. CONFLICT

To analyse the number of times the separation criteria specified for this airspace were lost. Loss of separation (conflicts) are classified as "outside norm" , "serious" or "grave" depending on the minimum vertical and horizontal separation maintained between the flights. The number of occurrences of each conflict category along with the callsigns of all concerned aircraft will be produced.

7.2.2 Telecom file analysis

A single SAS software package is available to analyse all aspects of the Telecom recordings.

The function of this module is to analyse all of the recorded communication events for each controller. The forms of communication can be R/T with pilot positions, Direct Access to another controller position via the use of an on-screen window and selection menu or indirect access to another controller via the use of a telephone. The SAS module interfaces directly with the recorded Telecom event list and the following parameters are generated as standard :

The **number of direct access calls made from** each controller position.
The **number of direct access calls received** by each controller position.
The **mean time spent waiting for a response** to a direct access call.
The **mean time taken to give a response** to a direct access call.
The **mean duration** of direct access calls.
The **number of R/T channel usage** periods.
The **total time spent on the R/T frequency**
The **percentage of time spent on the R/T frequency** as a function of the measurement period.
The **mean and standard deviation of R/T call duration.**
The **number of indirect access calls made** by each controller position.
The **number of indirect access calls received** by each controller position.
The **mean time spent waiting for a response** to an indirect access call.
The **mean time taken to give a response** to an indirect access call.

The above information can also be made available in the form of an EXCEL spreadsheet via the use of SQL.

7.2.3 ODID screen file analysis

Recordings from the ODID screens are stored as files containing several record types. For each record, the system time (LSB = 1ms) and the internal (simulation) time (LSB = 1s) will be recorded. Computed variables will be constructed from these recordings. The different record types contain information relating to the following areas :

- Internal system 'entity' updates (eg aircraft parameters or window contents), either of a periodic nature or following controller interaction with the system.
- Details of all controller inputs / information requests from the system.
- Details of all system detected conflict information.

Of particular interest to the analysis task are those records which describe the controller interaction with the system. The information contained in these records will typically be as follows :

Record type IN (=Input record)

This relates to controller window management tasks (iconise, scrolling, moving sizing etc). For each record, along with the time information described above, the type of action and related window name are recorded.

Record type PK (=Pick record)

This relates to controller dialogue with the system, be it a request for further information (eg opening the extended radar label or use of the MTCA tools) or updating the system with current flight information (eg a change to a CFL). The recorded information relates to the relevant window, button action and identifier, relevant callsign and the type of event.

Record type BT (=Button record)

This relates to the use of the Mouse. For each mouse action, the type of button trigger , the button name and the related window name will be output.

Record Type STCA (=Short Term Conflict Alert record)

The callsigns of system detected (short term) conflicting aircraft will be output.

Record Type CONF (=Conflict record MTCA)

The callsigns of system detected (medium term) conflicting aircraft will be output along with the predicted time of minimum separation and corresponding predicted minimal distance of separation.

The output from the ODID screen files will be used most simply to gain an insight into the use frequency of the various tools. More detailed analysis of the occurrences of possible errors and the input sequences performed by controllers will also be studied.

7.2.4 Workload analysis (subjective and MBB/EMBB)

The SAS/AF program 'NASA' will be used for gathering NASA TLX inputs and the responses to the operational questions from each controller at the conclusion of each exercise.

The ISA responses are stored on a PC using EXCEL during the progress of an exercise and a 'hard-copy' of the ISA responses (in histogram style) for each measured position can readily be obtained for discussion during the exercise de-brief.

An integrated SAS module (WORKLOAD.SAS) has been developed to analyse all of the workload estimates arising from an exercise, namely, NASA TLX, ISA and MBB/EMBB. This module provides the following parameters for each measured position :

The **number of ISA responses** for each workload category.
The **number of missed ISA responses**, ie no response from the controller.
The **mean ISA response** value.
The **mean time to enter** an ISA response.
The **percentage of ISA responses** corresponding to workload categories of 'HIGH' or 'VERY HIGH'.

The **MBB** (1 hour measurement interval) value.
The **mean EMBB** value.
The **standard deviation of EMBB** value.
The **minimum EMBB** value.
The **maximum EMBB** value.

The **subjective workload** for each of the six NASA TLX categories.
The **overall calculated NASA TLX** value.

The **coefficient of linear correlation** and associated statistical confidence between the **mean ISA responses and each NASA TLX** category and between the mean ISA responses and the overall NASA TLX score.

In addition, graphical output of all aspects of the NASA TLX process is provided for each controller working position.

For the responses to operational questions the number of responses to each question against each response category is provided.

The program NASALL.SAS provides a similar analysis (both graphical and textual) of the NASA TLX data but provides overall results for a series of exercises, primarily mean and standard deviation. This may be of particular interest when assessing the impact on the NASA TLX responses of a change in traffic sample for example.

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APPENDIX A

NASA TLX

A1 Overview of Workload Measurement

The concept of workload is one which is familiar to all, although trying to quantify or measure just how much work is required to complete a given task is somewhat less familiar.

Workload is not a directly measurable quantity, but is a hypothetical idea which broadly represents the cost (mental and physical) incurred by a human operator in achieving a particular level of performance. An operator's subjective assessment of workload brings together all of the many factors which he individually associates with the notion of work. The level of workload emerges from the interaction between the requirements of a task, the circumstances under which it is performed and the skills, behaviour and perception of the Operator.

When people evaluate workload associated with a task there is no objective standard, ie its 'actual' workload against which their assessment can be compared. In addition, there are no physical units of measurement that are appropriate for quantifying workload or its many component factors and the perceived workload by different individuals faced with identical task requirements may be quite different.

In order to attempt to quantify workload, a set of categories must be defined, against which the notion of workload will be derived. This ensures that different operators are assessing their workload against the same clearly defined parameters.

A measure of workload, such as that given by the NASA TLX method, is designed to give an overall indication of the work required to complete a task. Taken in isolation it does not indicate the degree to which the component aspects contributed toward the overall workload. For example, the workload of one task might be created by time pressure whilst that of another might be created by the stressful conditions under which it is performed.

The workload associated with each task can be evaluated but two apparently comparable ratings would actually represent two different underlying factors.

In order to determine a workload estimate, two types of information are required for each factor to be included in the workload scale :

i) Its perceived degree of importance as a source of loading for that type of task (referred to as the weight value).

ii) Its magnitude in a particular example of the task.

The NASA TLX method consists of six component scales. A measure of the workload associated with a given task is evaluated using the weight values and the magnitude of each of the six component scales during each execution of the task. A more detailed description of the NASA TLX method in relation to ATC is provided in the following section.

A2. The NASA TLX method of workload calculation

The objective of the NASA TLX method in an ATC environment is to evaluate the workload associated with each measured position during each exercise.

A2.1 Definition of the constituent factors

The NASA TLX method is centred around the analysis of six component factors which are considered to be the main contributory sources of workload. These component factors are defined below along with a description of each and the key-words associated with them.

Mental Demand	:	How much mental or perceptual activity was required ? How much concentration was necessary ? Consider the following actions : Thinking, Decision making, calculating, memorising, observing or searching. Was the task simple or complex, exacting or forgiving ?
Physical Demand	:	How much physical activity was required ? How much body movement was involved ? Consider the following actions : Pushing, pulling, reaching, standing, turning. Was the task restful or laborious, slack or strenuous ?
Temporal Demand	:	How much time pressure did you experience as a result of the rate or pace at which the tasks presented themselves ? Was the pace leisurely or frantic ? Were the tasks presented smoothly or sporadically?
Own Performance	:	How successfully do you feel you accomplished the objectives of the task ? How satisfied do you feel with your own performance during that exercise ?
Effort	:	How much effort did you have to put into the task to achieve the level of performance attained.
Frustration	:	What was the task like to do ? How did you feel during or after the exercise ? Was the task enjoyable or irritating ? Did you feel content or annoyed ?

A2.2 The procedure for completion of the NASA TLX

The NASA TLX is a two part evaluation consisting of both weightings and ratings. The first part is for the controller to decide on the comparative contribution of each of the factors of the workload of the ATC task. There are fifteen pair comparisons of the six factors. The controller is shown each pair and asked to pick the member of the pair which contributes the greater of the two to their perceived workload in an ATC environment. The number of times that a particular factor is selected is totalled and this becomes the attributed weighting. Weightings therefore range from zero to five. The weighting value associated with each of the six scales for each participating controller will then be stored.

Note that this part of the NASA TLX evaluation is completed once only prior to the start of the simulation. An example of each of the pairs of the NASA TLX weightings section is given below and the controller is required to select one member from each pair as being the greater contributory factor to their perceived workload in an ATC environment.

<u>NASA TLX Weights setup</u>

Temporal Demand :			: Physical Demand
Performance :			: Physical Demand
Effort :			: Physical Demand
Frustration :			: Physical Demand
Physical Demand :			: Mental Demand
Performance :			: Temporal Demand
Effort :			: Temporal Demand
Temporal Demand :			: Frustration
Mental Demand :			: Temporal Demand
Effort :			: Performance
Performance :			: Frustration
Performance :			: Mental Demand
Effort :			: Frustration
Effort :			: Mental Demand
Frustration :			: Mental Demand

The reason for formulating weights for each controller in evaluating the workload associated with a sector is to attempt to reduce what is known as the 'between subject variation'. This can most easily be thought of as the perceived variation in workload between individuals performing the same task. For example, the degree to which physical demand contributes to the workload is purely a function of the individual and their own attitude to physical exertion.

The second part of the procedure is to obtain the numerical ratings for each of the six scales that reflect the degree of workload associated with each factor following every exercise of the simulation. The controller responds by marking the scale in their desired location.

Mental Demand	low	______________	high
Physical Demand	low	______________	high
Temporal Demand	low	______________	high
Own Performance	good	______________	poor
Effort	low	______________	high
Frustration	low	______________	high

Using these selections for the given sector, in conjunction with the weightings for the controller operating that sector, a NASA TLX value for the sector can then be determined as described below.

A2.3 An example of a NASA TLX calculation

Suppose that prior to the start of the simulation, a controller makes the following selections as to the relative importance of each factor associated with ATC (Weights Form)

Temporal Demand :		X	: Physical Demand
Performance :	X		: Physical Demand
Effort :	X		: Physical Demand
Frustration :	X		: Physical Demand
Physical Demand :		X	: Mental Demand
Performance :	X		: Temporal Demand
Effort :	X		: Temporal Demand
Temporal Demand :		X	: Frustration
Mental Demand :	X		: Temporal Demand
Effort :		X	: Performance
Performance :	X		: Frustration
Performance :	X		: Mental Demand
Effort :		X	: Frustration
Effort :		X	: Mental Demand
Frustration :	X		: Mental Demand

corresponding to weightings of :

Mental Demand	= 3
Physical Demand	= 1
Temporal Demand	= 0
Own Performance	= 5
Effort	= 2
Frustration	= 4

At the end of an exercise, this same controller working as an Executive Controller at position C selects the following scores for each of the six scales relating to that exercise :

Mental Demand	low	___x__________	high
Physical Demand	low	_____x________	high
Temporal Demand	low	___x__________	high
Own Performance	good	_____x________	poor
Effort	low	______x_______	high
Frustration	low	_____x________	high

corresponding to values of :

Mental Demand	= 5
Physical Demand	= 7
Temporal Demand	= 4
Own Performance	= 7
Effort	= 10
Frustration	= 9

the **NASA TLX value for position C** for that exercise is then calculated by multiplying each weight value by its corresponding numerically rated value for that exercise :

NASA TLX = (3*5 + 1*7 + 0*4 + 5*7 + 2*10 + 4*9) / 15

= 113 / 15

= <u>7.5</u>

When considering workload and its measurements via the NASA TLX method, the following key points should be borne in mind :

i) Workload is not a directly measurable quantity.

ii) There are no units associated with workload and there is no baseline of 'actual workload' against which the estimate can be compared.

iii) An overall assessment of workload does not indicate the degree of contribution of the constituent aspects associated with work.

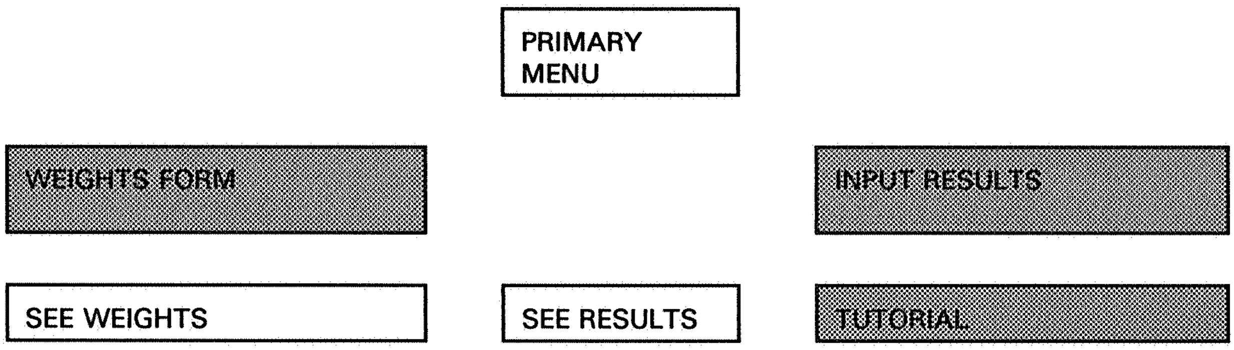
iv) The level of workload associated with a task will largely be defined by the requirements of the task, the environment in which it is performed and the skills and perception of the participants. Any variation in these parameters between exercises can introduce large variations into the calculated workload value.

A3. Use of NASA TLX during the ODIDIV Simulation

The administration of the NASA TLX method during previous exercises has been carried out using paper sheets distributed to each controller at the completion of each exercise which were then combined with the previously gathered weight values. This method has been found to be time consuming for both controller and analyst as well as more prone to error. For this reason, a package has been developed for use on an IBM mainframe which allows input of both the weight values and the workload scales at the end of each exercise. In addition, graphical output of the NASA TLX value for each measured sector for the exercises completed to data can readily be displayed for discussion during the exercise debriefs.

The ODIDIV real-time simulation will be the first time that this package will be used. Each controller will be presented with a menu allowing either the weight values to be input prior to the start of the simulation or the numerical value against each of the six sub-scales at the completion of each exercise.

The menu presented to the controller will appear as follows :



The options of specific interest to the controller are the **'Weights Form'**, **'Input Results'** and **'Tutorial'**. The remaining options are for use during the analysis after the simulation.

Weights Form

Selection of this option causes a list of the surnames of participating controllers to be displayed from which each controller should click the mouse on the appropriate selection. The program then presents the fifteen pairings of the NASA TLX subscales in randomised order and the controller should click the mouse on the icon corresponding to the member of the pair which contributes the greater to their perceived daily workload in an ATC environment (as described in section 2.2). On completion, the controller will be thanked and the terminal will indicate that it is ready to receive the weight values of the next controller. This will be performed once only during the simulation.

Input Results

This is the option which is selected on completion of each exercise. The controller is again asked for their surname and in addition details of the sector which they have just worked. The six NASA subscales are then presented and the controller should click the mouse at the appropriate point for each subscale indicating their perceptions of the exercise just completed.

On completion of the workload scale selection, the controller will then be asked a series of questions relating to the facilities offered in the ODIDIV simulation eg the HAW, VAW and Mouse facility. A number of descriptive answers are given and the controller should click the mouse on the selection most closely resembling their own opinion.

An example of the format of these questions is as follows :

1. How useful was the Horizontal Assistance Window ?

Useless	A little	Quite	Very	Essential

2. Is the CARD useful for conflict managing ?

Useless	A little	Quite	Very	Essential

3. Did you confuse the functions of the mouse buttons ?

Usually	Often	Sometimes	Rarely	Never

Once the controller clicks on a selection, that option will be highlighted as illustrated, although there is opportunity for 'mind changing' as only the most recently selected option will be recorded.

Tutorial

This option can be selected at any time and contains details of the NASA TLX calculation and how the user should interface with the menu-driven package.

More detailed instruction on the use of this menu driven package will be provided at Brétigny prior to the start of the simulation.

The other options selectable from the menu are primarily for the benefit of the ODIDIV analysis and gathering information for exercise debriefs. No controller input is required in any of these selections.

Appendix B

Instantaneous Subjective Assessment (ISA)

The NASA TLX method described in the previous sections is designed to provide a single estimate of the overall workload on completion of each exercise. In order to determine how the workload varies throughout the duration of the task, the ISA method will be employed for the first time during the ODIDIV simulation.

The ISA method is essentially very simple. Each controller is presented with a small box with five colour-coded buttons. This box will be located adjacent to the ATC display and the mouse although its position can be moved a small amount to suit each controller. The box will additionally incorporate a red light to command the controllers attention as described below. The five ISA buttons are labelled as follows :

Very high	colour = red
High	colour = yellow
Fair	colour = white
Low	colour = green
Very low	colour = blue

Every two minutes the controller will be prompted to press one of these buttons according to their assessment of workload at that point. The requirement to do this will be indicated by the red light on the ISA box becoming illuminated. The prompt will remain illuminated for a fixed period of time (or until the controller makes his selection) after which no selection will be accepted. This time period can be varied but is currently set at 30 seconds.

The following definitions are recommended for use with ISA and the controllers should adhere to these as far as possible when making their selections :

Very High	You cannot cope with the current level of tasks which are presented and certain tasks are being shed or compromised.
High	You are managing with the current level of tasks which are presented but could not accept any additional tasks.
Adequate	The current level of tasks are completely under control and additional tasks could be accepted if required.
Low	You are underworked and would seek additional tasks to maintain interest.
Very low	The current level of tasks are completely inadequate, even resulting in boredom.

The very nature of the ISA system is that it imposes an additional task on the controller, which unlike the NASA TLX, is performed during the execution of the simulation. Statistical studies in other environments have indicated that the requirement to perform the ISA selection does not impose any significant additional workload on the user. The extent to which these studies will be applicable to ODID IV remains to be seen, particularly in situations of very high workload. The opinion of the controllers on the 'intrusiveness' of ISA will therefore be of considerable interest.

Appendix C

1. NON INTRUSIVE OBSERVATION REQUIREMENT

1.1 Objectives of the Non Intrusive Observation

In ODID III, the presence of the observers was found to be disturbing and bothered the controllers. For ODID IV a non intrusive observation method will be used. A methodology acceptance is necessary and will take the form of an iterative cycle of observation, debriefing and adjustment during the simulation.

The objectives are to obtain data concerning :

- Efficiency of the "Message Window" and the "Telecom Window":

  In order to reduce the use of the telephone, a tool is provided to assure silent coordination using pre-formatted messages which are displayed in a special window (the Message Window). Each message permits coordination of the following entities :
  - Heading,
  - Speed,
  - Rate of descent/climb
  - Entry Flight Level (PEL)
  - Exit Flight Level (XFL)
  - Departure Clearance

  Each message contains a single entity concerning one aircraft and every message must be acknowledged individually.

  Telecom is provided through an "on screen" window. A standby system is available on a trolley positioned under the desk.

  It is assumed that if the Message Window and the Telecom Window are insufficient, the controller will use the standby telecom panel and / or elbow coordination. It is important to note communication content in order to determine the limits of the coordination tools which are presented.

- Weaknesses in functions and in displayed information

  It is assumed that information not obtained from the Human Computer Interface (HCI) will be requested verbally from another controller or a pilot, and/or will obtained from an other information source such as another screen.

- Difficulties in using the mouse as an input device

- «Comfort» of the work position (desk, chair, large screen, lights...)

- Controller workload by studying their comportment, in terms of behaviour which expresses a need to reduce stress.
  The controllers have to express their workload via the ISA level. However it is interesting to note the behaviour such as breathing out which may betray a higher workload than that expressed by ISA.

These observations will <u>complement the analysis of controller inputs</u>. For example, if there is a surprisingly long response time for a message acknowledgment, a check can be made to see if the controller was involved in another task such as «elbow» coordination with another controller.

1.2 Data to be collected

The data collected by non intrusive observation will be the controller's observable activities and verbal communications.

To achieve the first two objectives (HCI weaknesses and silent coordination facilities) the verbal communications required to be recorded are :

i Telephone Communications in using
- either the «Telecom Window»
- or the telephone desk

ii «Elbow coordination» or informal communication between
- controllers from different sectors
- controllers (PLC and EC) of the same sector

iii Controller comportment/behaviour
- playing with the mouse, moving equipment
- gesticulating
- shouting coordination to other position
- displaying signs of stress and/or frustration

In addition and when time permits, Communications on the frequency (R/T) and more specifically the entity value request (query) to a pilot should be noted. These demands can illustrate a lack of reliability concerning the information displayed.

The data to be collected will describe what the controller does. His/her observable activities are for example :
- looks at the adjacent screen
- writes notes
- uses the telephone desk
- looks at the mouse buttons (before clicking)
- shakes the mouse...

(for further detail see the Grid Legend in the Annexe 4.1)

For each individual observation, the features to be recorded are as follows:

- Time : Start and End of observed feature
- Actor(s) : Sender and Receiver
- Mode : Telephone, Radio or Informal
- Content : sequence of entities and motions
- Aim : nature of observed feature i.e Transfer, Order, Demand, Response, Proposition and Counter-proposition
- Task: Entry coordination, Exit coordination and Conflict resolution

The data collection should be as precise as possible. Whatever the observation is, it should only be described by the features indicated above.
According to constraints and limits (technical eg sound quality and/ or human eg observer workload) the recorded data may be adjusted during the simulation.

1.3 Data Analyses

Due to the short time devoted to the analyses, no systematic tape transcription is planned. The observer will collect as much data as possible. If clarification of information is necessary, the tape can be re-run and analyzed after the exercise.

Minimum analyses will be computed from a data base composed of the collected data. In further analyses this data will be correlated with other automatically recorded information. The standard TELECOM Analyses will provide information concerning the correspondents, the time and the duration for each telephone communication.
Controller input recording will provide the time, the HCI Object(s) concerned (cursor locator) and the mouse button used for each input.

1.3.1 Minimum Analyses

For each objective the data recording specific analyses and correlation with other automatically recorded data (Controller Inputs and TELECOM data) are described below :

- To evaluate the utility and usability of the MESSAGE Window, a comparison will be made with telephone communication and "elbow coordination" between different sectors.
  For each Type of communication defined by the task, the aim, the correspondents and the content (entities sequence,...), in the three modes, ("elbow", telecom and "on screen"), the data compared will be :
  - Use Frequency
  - Number of exchanges per communication
  - Number of entities per exchange
  - Number of aircraft concerned
  - Average Duration

- To evaluate the utility and usability of the TELECOM Window, a comparison will be made with the telephone communications initiated on <u>the telephone desk</u>. For each Type of communication, the data compared will be :
  - Use Frequency
  - Average Duration

- To evaluate the weaknesses of the HCI, the three mode communication will be analyzed more in a qualitative way than in a quantitative way. However, the <u>frequency</u> of the following behaviour will be computed :
  - Looks at the screen of the other sector controller
  - Moves closer, Leans toward his screen
  - Writes on paper
  - Points at own screen or at the other sector controller's screen
  - Any comportment which betrays a lack of confidence in the information displayed or indicates a need from an "aide-memoir"

- To evaluate the difficulties in using the mouse as an input device, the <u>frequency</u> of the following behaviours will be computed :
  - Shakes the mouse
  - Looks at his mouse to choose a button
  - Uses his mouse away from mat

  Using the recorded time, the command confused may be examined in the ATCO input file.

- To evaluate the «Comfort» of the working position (desk, chair, large screen, lights...), the frequency of the following actions will be computed :
  - Relaxes his/ her neck
  - Relaxes his/her back
  - Gets up and walks around
  - Tries to adjust screen position
  - Tries to adjust chair

- To evaluate Controller workload, the frequency of the following behaviour will be computed :
  - Gets agitated
  - Breathes in/out noticeably
  - Movement becomes more/less animated

1.3.2 Additional analyses :

Position Effect
Analyses will be done according to the position (sector and job)

Controller Effect
Analyses will be done according to the individual controller effect.

Sector workload (MBB) Effect

Controller workload (ISA) Effect
The frequency of each type of comportment will be re-computed according to their ATC context. The operational context may be defined :
- either by the task (Entry,Exit coordination or Conflict solving), identified from the verbalisation made at the same time
- or by the sector workload (MBB) and/or from the controller workload (ISA).

Time Effect
The delta time from the exercise start will be studied as well. Independently of the workload, There may be a "vigilance" effect during the exercise.

1.4 Data collector or Observer

During the ODID III real time simulation controllers were frustrated by the intrusive effect of observers sitting closely in the course of a measured exercise.

ODID IV will employ a "non intrusive" method of observation to try to reduce the "intrusive effect". It has also been decided to employ ATC personnel in the task as the nature of the information to be recorded require an depth understanding of controller working procedures and phraseology.

1.5 Controller Working Position

The controller is placed in an «office type» control centre situated in the middle of the simulation room and separated from the other areas by partitioning.

This «office» contains standard office desks positioned in a three sector layout with large high definition colour raster scan Sony displays (20X20) mounted on moveable trolleys stationed behind each individual desks. In addition the position includes :

- A headset (plug under the desk top) as the only mean of R/T reception.
- A foot pedal for transmitting on frequency.
- An input device (a three buttons mouse and its mat).
- All other elements making up the ODID environment (radar picture, control tools, flight plan data, telecom etc) are accessed through the display.

In the event of a failure of the telecom «window», a standby system is maintained in a mobile trolley under the desk which provides frequency selection, telephone access and a push to transmit button.

1.6 Non Intrusive Observation Equipment Installation

1.6.1 Audio and video equipment layout in the simulation room

The equipment installed in the simulation room for observing the six measured positions is as follows (see figure 1) :

■ For sector C (EC and PLC positions) :
- one normal angle camera focused on EC (Kn Cec)
- one wide angle camera focused on PLC and EC (Kw Cplc)
- a «wide area» microphone in the desk top between both controllers
- the radio and telephone communication are recorded via the headset and its integrated microphone

■ For sector D (EC and PLC positions) :
- one normal angle camera focused on PLC (Kn Dplc)
- one wide angle camera focused on PLC and EC (Kw Dec)
- a "wide area" microphone in the desk top between both controllers
- the radio and telephone communication are recorded via the headset and its integrated microphone

■ For sector O :
- one wide angle camera focused on O and W (Kw OW)
- a "wide area" microphone in the desk top between both controllers (O and W)
- the radio and telephone communication are recorded via the headset and its integrated microphone

■ For the sector W :
- one wide angle camera focused on W and P (Kw WP)
- a "wide area" microphone in the desk top between both controllers O and W
- the radio and telephone communication are recorded via the headset and its integrated microphone

In addition, there is a camera which records a *global view* of the room (Kg).

1.6.2 Audio and video equipment layout in the «Non Intrusive Observation area»

The equipment used by the four observers in the «non intrusive area» is as follows (see figure 1) :

- For Observer C and the Observer D who observe respectively measured sector C and measured sector D, each position comprises:
  - 1 video QUAD which receives *data* from cameras Kn and Kw and from the «global» camera (Kg)
  - 1 large monitor divided into four parts displaying the three video sources and the time code (upon the «global» image). One part is not used.
  - a special box linked to the video to select which audio source to listen to either C + «ambience, D + «ambience» or C + D + «ambience.
  - 1 headset

- For Observer O and Observer W who observe respectively measured sector O and measured sector W, each position comprises :
  - 3 small monitors:
    - 1 displaying data from camera Kw OW
    - 1 displaying data from camera Kw WP
    - 1 displaying the time code on the data from the «global» camera
  - 1 video
  - 1 headset

All video equipment is managed by a PC. This means that the following actions can be done only once :

- the time code adjustment
- recording Start and End
- tape reviewing

However after the exercise, each observer can re-run his/her tape independently.

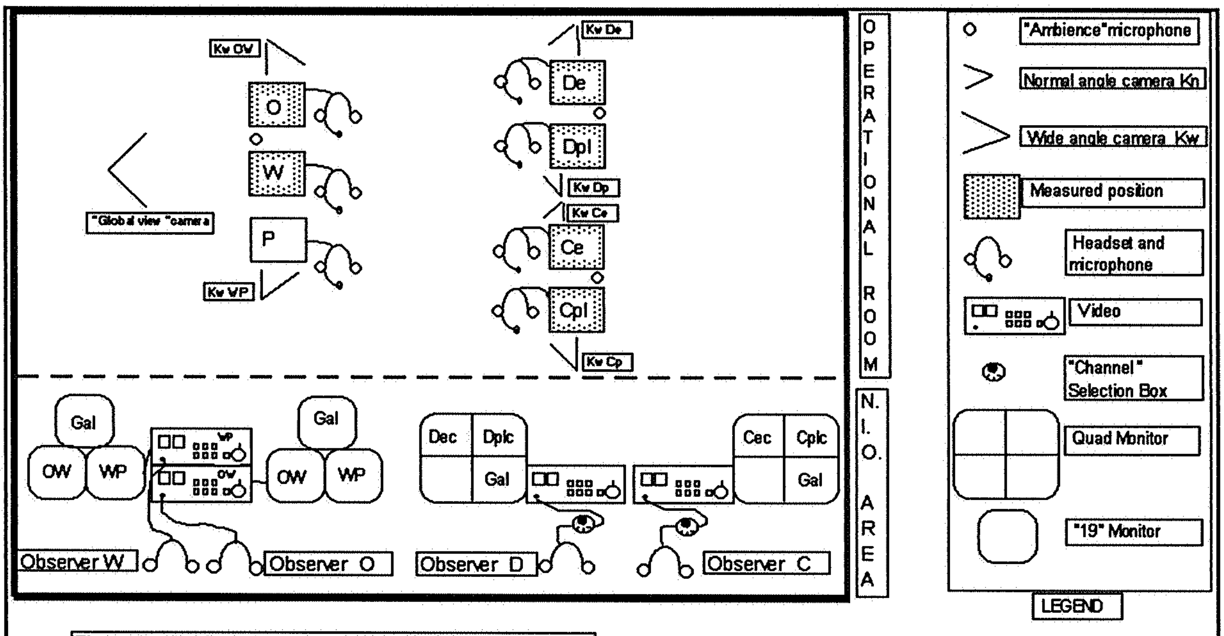


Figure 1 : Non Intrusive Observation Equipement Layout

Start TIME HHMM	End TIME HHMM	**Sen der** (XX / E/ P)/ **Re-ceiver** (XX / E/ P)	TYPE : **Tel, Elbow Motion** Radio	AIM : **Order, Transfer Demand Proposal** Counter-proposal	Communication CONTENT : PEL, CFL, XFL, ↗, ↘, →, RFL, XPT, HDG, SPD, ROC, AOC, SKip, TRF, REL, ...	AIM : O T D P C	TASK: **Entry eXit Conflict**	MOTION : or Observer comment LS , LA , PS, PA, UT, SM, OM, WP, RN; RB, SU, BO...

Figure n° 2 : Example of the GRID for the Non Intrusive Observation Recording

2 NON INTRUSIVE OBSERVATION TASK - OBSERVER INSTRUCTIONS

What do you have to do :

This task is considered to be quite difficult due to the quantity and the ambiguity of the data to note. A methodology is necessary. You can improve and optimize the proposed methodology described below.

2.1 Observation and manual recording

2.1.1 Before the exercise

Please

- Check that the tape is at the beginning
- Check that the time code value on the monitor is the exercise start time
- Check the video tape code value which must be 00:00:00
- Check the quality of the audio recording. The recording level designator should not be too much in red. If it is, ask for a level change.

2.1.2 During the exercise

Please note information according to the following priorities :

1) Telephone communication (T) between controllers on different sectors

2) "Elbow" communication (E) between controllers

3) Controller comportment (motion)

4) Entity value queries made to the pilot on the frequency- if you have enough time eg what is your level ?, what is your speed ? what is your heading...

A Grid is provided for notation (see figure 2)

Please give the priority to Content and Aim, then to the Sender and Receiver. In most cases, the Mode and the Task can be deduced.

Concerning Time

Caution, Use only the time code displayed on monitor. This is the exercise time. Do not use the video time code. Note both values at the exercise start to be able to compare later.

The TELECOM data recording will provide the duration for each communication so an accurate time for telephone communication is not required. However code the minutes in order to be able to retrieve communications for cross checking with the TELECOM list.

Duration of each "elbow coordination" is very important in order to be able to compare with other modes of coordination (via the Message Window or via the telephone). Code the time start and end accurately.

Concerning Sender / Receiver :

The Controller will not always introduce him/her-self. Please try to note the Sender/Receiver if possible.
For communications between measured positions you can compare notes with the other observers after the exercise.

Concerning Mode :

The most important aspect of mode is to insure coding for "elbow coordination"(E) or Telephone Communication(T).

Concerning Content

The entities composing the communication content should be recorded in the order they are given. If you can note the entity value, please do it.

Suggested codes to use are explained in Section 3 Annexe.
If you find different codes easier to use ensure that they are "known" and understand by the scientific team. Why not propose them for general use during debriefing.

Callsign :

Note callsigns when there is ambiguity between events which are closely spaced in time.
For example if the communication is about a conflict, the first proposal can be about one of the a/c and the second one can be about the other a/c. Or it could be two different communications very close.

complex communication

When a communication is composed of several exchanges, where only one entity is concerned, please note the number of exchanges. If several entities (or HCI objects) are discussed, note the content in as much detail as possible.

"elbow communication"

If it is a coordination then use the codes as in a telephone coordination.
If it concerns the HCI weaknesses do not code only the objects concerned but note if information is missing, is displayed with different values in different spaces, or is wrong. Note if anybody asks how to display, or update any information.

Concerning Aim :

The aim refers to the sender (whoever he is, either the observed controller or one of his correspondents)
It is an Order or a Demand when the communication sender is the "master" of the coordination i.e when he is the receiving sector for the a/c.
It is a Proposal when the sender is not the "master" of the coordination i.e when he is the offering sector.
The Transfer can be used in both cases.

For "elbow communication" between the Executive and the Planner,

- if EC or PLC asks the other to do something, it is coded as an Order
- if EC or PLC asks the other his opinion about a conflict resolution, or a coordination, it is coded as a Proposal and if the answer is not an acknowledgment it is coded as a Counter-proposal.
- if EC or PLC asks the other the value of an entity or some additional information such as the aircraft position for example, it is coded as a Demand.
- all the other transfer of information are coded as a Transfer, (except when it is a warning, it should be coded W)

In the example below, for each mode of communication, the aim code is given for different types of content

CONTENT :	AIM CODE:
- "elbow communication" :	
- (Could you) transfer or coordinate ?	Order
- I have coordinated...	Transfer
- What is the PEL ?	Demand
- Should I skip ?	Proposal
- No, keep it	Counter-proposal
- Telephone communication:	
- What are (or can we use) the direct routes to day ?	Proposal
- Radio-communication	
- What is your speed ?	Demand
- Climb to...	Order

Detailed codes, coding rules and examples are in Section 3

Concerning Task

This is the most difficult field to fill. It may be deduced if the controllers speak explicitly about PEL or XFL. Try to identify the task where possible. If not, note as much information as possible, including the callsign.
It must always express the task for the observed sector.

Concerning Comportment

Please try to distinguish if the comportment occurs during a communication or independently. In the latter case code M in the Mode field.

Concerning Function Failure and Comment

Each system failure should be identified as soon as possible and recorded in the grid. Observers should attend the pre-exercise briefing when the project leader will list the system limits.
If during an exercise, one position fails, the reason why or at least the system failure should be noted. This will be stated in the LOG Book.

The following codes may be used in any field :

- ? : non understood content
-- (blank): no value
- xxxxx : literal comment if no codes exists yet

Fill the grid with codes or literally. Try to be as clear and concise as possible as your grid data will be encoded on a data base for analysis.

If you have a problem because you don't understand what you hear, write[?] or because the communication goes too quick, write[+] and let several empty lines in the grid.

If you are Observer C or D, don't hesitate to use the special box to select what you want to listen to. If you do select a specific channel then

- Mark E for Executive Controller + ambience
- Mark P for Planning Controller + ambience
- Mark EP for EC + PLC + ambience

Please don't forget to write [+], to indicate you need to complete this at the end of the exercise by referring back to the video recording.

- Headset Adjustment

  A volume button is available on the video.
  Another one is available on the Headset.
  If you find that one source is too loud against the others; ask the ergonomist (scientific officer) for assistance. For example the ambience microphone could be reduced because it provides tiring background noise).

- If the system fails....

  The equipment is driven by a PC. In the event of an observation equipment failure don't forget to note the system failure time.

2.1.3 After the exercise

- Please recover the controller' s notes.
  Ask the controller for an explanation of the data order and why (and when) he needed to note this information...
  Put the controller name, position name and the exercise name on the notes and attach it to the paper grid.

- Check the tape has an exercise name, the controller name, and position name.

2.1.4 Paper Grid Completion

In order to complete your Grid check for any omission or notes which need further clarification by references to the tape or through discussion with the observed controller.

- How to replay the tape :
  - without viewing : use the video buttons [■], [►►], [◄◄]....
  - with viewing : press the button [search] and then turn the large rotary selector to the left to go backward, to the right to go forward and turn it to the middle designator to stop.

Don't hesitate to compare with the other observers.

- Mini «One to One» Interview :

If some events are unclear, ask the controller for an explanation before he goes to the debriefing. For example if you have to distinguish weather the controller has eg looked at the adjacent screen to change visual target or to catch some additional information. If necessary show him/ her the tape

- The special «events»

Before finishing your observation inform the project leader if the controller you have just observed has displayed behaviour and comments which indicate a lack of understanding of the HCI.
The project leader will use this information during the debriefing.

2.2 Observers debriefing

The observers will be de-briefed at the end of each day :

- to decide whether the grid needs to be adjusted or if new codes are necessary,
- to decide on another camera position,
- to change the seating plan
- to indicate any significant observations concerning controller comportment and for understandings of the ODID IV HCI functions.

2.3 Schedule and Manning

- **Daily schedule**

As a general rule the day will commence at 0850. A short briefing prior to each exercise (two exercises a day) will keep participants informed of any amendments to the schedule.

0850-0900	0900-1100	1100-1200	1200-1330	1330-1530	1530-1630
General Briefing	Observation	Encoding + "Visitors"	Lunch	Observation	Encoding + Observers Debriefing

- **Seating Plan** (to be designed)

You are expected to check the seating plan displayed in the Non-intrusive area.

Each observer should see each position and each controller. But it may be better if the observer always watches the same position to become acquainted with the sector (route, beacon,...). Observer O and observer W could alternate each week and observer C and observer D as well. This is open to agreement between the participating observers and the scientific officer.

- **Simulation Schedule**

The first 3 days simulation will be Training for the controllers and the observers. Measured Exercises are expected to commence on the fourth day of week one.

3 ANNEXE

3.1 PAPER GRID CODE LEGEND and example

TIME

HHMM *(SS)* : the hour and minutes (and the seconds just for elbow com.)

MODE of communication

R : Radio
T : Telephone
E : "Elbow"coordination
M : Motion only

SENDER

a two letter code indicating the controller position for an in-coming call :

OE : sector O executive controller
WE : sector W executive controller
PE : sector P executive controller
CE : sector C executive controller
CP : sector C planning controller
DE : sector D executive controller
DP : sector D planning controller
MU : dummy sector MU controller
ML : dummy sector ML controller
DY : dummy sector DY controller
WW : dummy sector WW controller
LV : dummy sector LV controller
TW : dummy sector tower controller

The relevant correspondents list for each sector will be given to the sector observer.

RECEIVER

a two letter code indicating the controller position for an out-going call as for Sender.
The relevant correspondents list for each sector will be given to the sector observer.

AIM

O : order or instruction
T : transfer of information
D : demand
R : response
P : proposal
C : counter-proposal
W : warning

TASK

E : Entry coordination
X : Exit coordination
C : Conflict resolution

CONTENT

Any key words that the observer can detect to explain the cause of the exchange, e.g. a callsign, and each entity such as flight level, speed etc...

PEL : Entry Flight Level
CFL : Cleared Flight Level
XFL : Exit Flight Level
RFL : Request Flight Level
↗ : a/c climbing
↘ : a/c descending
→ : a/c maintaining (stable)
XPT : Exit point
EPT : Entry point
NPT: Next point
APT : Actual point
POS : Position

DCT : Direct route
HDG : Heading
RAD : Radial
ILS : ILS
RW : Runway
SPD : Speed
IAS : Indicated Air Speed
ROC : Rate of (change) climb or descent
LT : Loose or gain time
ETO : Estimated Time Over a beacon
TYP : Type
AOC : Assume of control
SKIP : Skip
TNR : Transfer
REL : Release of control
CON : conflict
RSK : conflict risk

HCI OBJECTS

for ACC only

HAW : Horizontal Aid Window
VAW: Vertical Aid Window
CARD: Conflict and Risk Display

for APP only

AMID: Approach Multi-input Device
LAN : Landing list

for both

MSG : Message in the Message Window
TEL : Telecom Window
DEP : Departure list
STA : Stack list
SIL : Sector Inbound list
FLEG : Flight Leg.

MOTION

a two letter code indicating the controller motion or behaviour (comportment):

LS : Leans toward his screen,Moves closer,
LA : Looks at adjacent screen
PS : Points at his screen
PA : Points at adjacent screen

SM : Shakes the mouse
LM : Looks at his mouse to choose a button
OM : Uses his mouse away from mat

UT : Uses the telephone desk

WP : Writes on paper
SU : Stands up
TB : Turns back to the other type sector (ACC vs APP) to coordinate (otherwise it is coded RLX)
GA : Gets agitated
RN/B : Relaxes his/ her neck or his/her back
RLX : Relaxes him/her self....
BO : Breathes out
FS : Problem with the foot switch

COMMENT

Literal comment or if some external event happens (system failure; project leader, supervisor or technician intervention...)

3.2 Coding Rules Examples

Literal Content	Content	CODE Type	Aim	Task
<u>Concerning RELEASE</u>				
A/B : "do you accept XXX ? OK, so I release"	REL	T	O	X
A/B: " could you release till..? (can I keep it until ?)	REL	T	P	X
B/A: " could you release from..?	REL	T	D	E
B/A: " I release until..? (I don't want it before...)	REL	T	O	E
O/W: do you want to release X in descent ?	REL	T	P	E
O/W: could you release Y in descent	REL	T	O	E
O/W: I release Z in climb	REL	T	P	X
W/O: I release X in descent	REL	T	P	X
<u>Concerning TRANSFER</u>				
A : I transfer"	TRN	T	T	X
A: " can I transfer (earlier)..?	TRN	T	P	X
B: " could you transfer (earlier)..?	TRN	T	O	E
B: " Have you transferred?	TRN	T	D	E
<u>Concerning Climbing / descending Aircraft</u>				
S/R : Is it climbing ?	↗	E/T	D	E/C/X
S/R : have I to climb it ?	↗	E/T	P	E/C/X
S/R : I climb it	↗	E/T	T	E/C/X
S/R : Climb it	↗	E/T	O	E/C/X

3.3 List of Correspondents for each Measured Sector

Sector C	Sector D	Sector W	Sector O	Sector P
D ec	C ec	T	T	T
D pl	C pl	O	W	W
LV	LV	P	P	O
O	O	D ec	D ec	RK / D ec
W	W	D pl	D pl	RK / D pl
DY	DY	C ec	C ec	VL / D ec
WW	WW	C pl	C pl	VL / D pl
ML	ML	LV	LV	
MU	MU	ML	ML	
	EKBI	MU	MU	
	EKOD		EKRK	
	EKSB		EKVL	
	EKSP			
	EKRK			
	EKVL			