Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

Executive summary

A selection of Human Factors tools: Measuring HCI aspects of flight deck technologies

Problem area
It is not simple to decide what tool, or set of tools, one should use when assessing Human Factors aspects of new cockpit technologies.
The relevance of being able to assess Human Factors aspects is that the Human Factors is often a contributing factor to incidents and accidents in aviation. Assessing whether new technologies include the potential risk of contributing to these incidents and accidents is the first step toward prevention.
Further it is desired to be able to provide new cockpit technologies or procedures with a so called Human Factors certification. That would help, prior to production and installation of new cockpit technologies and procedures to indentify flaws in the designs, and possibly come up with solutions.

Description of work
In the HILAS project a number of flight simulator experiments were executed in order to validate Human Factors tools. New cockpit technologies were applied, however merely as vehicles for testing whether the Human Factors tools, were relevant for assessing Human Factors aspects.

Results and conclusions
Detailed results are published in a number of deliverables, papers and articles. This document provides the 'over all' lessons learned from the series of experiments. Those come down to the following.
A set of tools provides better, more detailed, results than applying a number tools individually. The over all interpretation of the data is better when looked at in the context of other data sources.
The set of Human Factors tools and methods that were used in the HILAS experiments can form the base for a methodology for Human Factors certification.

Applicability
The HILAS methodology and set off Human Factors tools can be used under quite a lot of circumstances where Human Factors aspects of new (cockpit) technologies and procedures are subject of study. They might be used to contribute to a standardised way of performing Human Factors certifications.

Report no.
NLR-TP-2009-206

Author(s)
G.D.R. Zon
H. van Dijk

Report classification
UNCLASSIFIED

Date
June 2009

Knowledge area(s)
Training, Simulatie en Operator Performance

Descriptor(s)
HILAS
Human Factors
Civil Flight Deck
Simulation
Experiment

This report is based on a presentation held at the HCI International 2009 Conference, San Diego (CA), U.S.A., 19-24 July 2009.

A selection of Human Factors tools: Measuring HCI aspects of flight deck technologies

Nationaal Lucht- en Ruimtevaartlaboratorium, National Aerospace Laboratory NLR

Anthony Fokkerweg 2, 1059 CM Amsterdam,
P.O. Box 90502, 1006 BM Amsterdam, The Netherlands
Telephone +31 20 511 31 13, Fax +31 20 511 32 10, Web site: www.nlr.nl

Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

NLR-TP-2009-206

A selection of Human Factors tools: Measuring HCI aspects of flight deck technologies

G.D.R. Zon and H. van Dijk

This report is based on a presentation held at the HCI International 2009 Conference, San Diego (CA), U.S.A., 19-24 July 2009.
The contents of this report may be cited on condition that full credit is given to NLR and the authors.
This publication has been refereed by the Advisory Committee AIR TRANSPORT.

Customer	European Commission
Contract number	----
Owner	NLR
Division NLR	Air Transport
Distribution	Unlimited
Classification of title	Unclassified
	December 2009

Approved by:

Author	Reviewer	Managing department
22-1-'10	22-1-2010	31-1-2010

Contents

Introduction **3**

The HILAS project 3

The Flight Deck technologies strand 4

Related projects 4

Focus of this paper 4

The experiment **4**

Experimental design 5

HF tools 5

Technologies 6

Lessons identified **7**

Maturity of technologies 7

Spend time on scenarios in order to get most out of the HF tools 7

Predicting how scenarios will work out is not easy 8

Subject matter experts are needed 8

Added value of a set of tools **9**

Identify a set of HF tools 9

Converging evidence principle 9

Situational Awareness is hard to measure 10

Certification 10

References **11**

A selection of Human Factors tools: Measuring HCI aspects of flight deck technologies

Rolf Zon and Henk van Dijk

National Aerospace Laboratory NLR, P.O. Box 90502, 1006 BM Amsterdam, The Netherlands
zon@nlr.nl, dijkhvan@nlr.nl

Abstract. Within the HILAS project two experiments in high fidelity flight simulators were performed. In the current paper high level results from one of those experiments are discussed. Focus of that discussion is on the added value of using a set of Human Factors tools rather than individual tools and on a number of lessons that were identified from this experiment. The set of Human Factors tools that was applied in this experiment might be helpful for manufacturers of flight deck technologies or aviation authorities to establish whether new technologies should receive the predicate "Human Factors certified".

Keywords. HILAS, Human Factors, HF, flight deck, experiment, flight simulation, HF tools registry, certification.

Introduction

The HILAS project

HILAS[1] stands for "Human Integration into the Lifecycle of Aviation Systems". It is an international research initiative with 40 partners from across the aviation industry and academia in Europe and beyond.

The HILAS project (HILASa) develops a model of good practice for the integration of Human Factors (HF) across the full life-cycle of aviation systems. The project contains four parallel strands of work: the integration and management of HF knowledge; the flight operations environment and performance; the evaluation of new flight deck technologies, and the monitoring and assessment of maintenance operations.

[1] The HILAS project runs from June 2005 until June 2009 and was funded by the European Communities as part of the 6th framework.

The Flight Deck technologies strand

All of those four strands focus on different aspects of HF in aviation. Within the HILAS Flight Deck Technologies strand two high fidelity flight simulator experiments (Roerdink and Zon, 2006, Kooi et al, 2007, Van Dijk and Zon, 2008a and 2008b) were performed. The general aim of these experiments was to select a set of HF tools for measurement of numerous possible HCI aspects of new technologies (Zon and Roerdink, 2006). The plans for the first experiment were presented at HCI International 2007 in Beijing (Zon and Roerdink, 2007). In that first experiment the HILAS Flight Deck Technologies strand partners installed and evaluated HF tools[2] and new flight deck technologies in a high fidelity flight simulator. In the second experiment the lessons that were identified from the first were taken into account. This resulted in an adjusted set of improved HF tools and a more integrated approach in selection of tools, experimental design and in data analysis.

Related projects

The experiment that is described in this paper was based upon the first HILAS simulator experiment. It was also based upon a longer lasting series of projects and experiments in which the use of individual tools to measure mental workload and Situational Awareness (SA) was studied. Examples are Zon and Van Avermaete (1997), Zon et al, (2004), Hoogeboom and Mulder (2004).

Focus of this paper

In this paper the focus is on the added value of having a set of HF tools, instead of using these HF tools individually. The HF tools are described briefly in the current paper; a more detailed description is provided in Zon and Roerdink (2007) and most up-to-date description of the individual HF tools may be found at HILASb.

Besides describing the added value of applying the HF tools as a set of tools, the current paper identified a number of lessons from the HILAS experiments. These form a second point of focus of this paper. For more details about these lessons the reader is again referred to HILASb.

The experiment

Two newly developed flight deck technologies were the vehicles for validation of the HF tools. These technologies were the "dual layer display" and the "interseat haptic touch screen". The HF tools were used to verify the hypotheses regarding the

[2] In the current paper the words "HF tools" and "flight deck technologies" are frequently used. Both have a clearly different meaning. In the current paper HF tools are those tools that researchers use to study the interaction between pilot and flight deck, while flight deck technologies refer to technologies that are installed on the flightdeck and that are meant to assist pilots while performing their tasks.

technologies. Furthermore, the toolset was also evaluated by studying pilot behaviour in simulated flights where none of the above mentioned specific technologies were applied. Examples of human behaviour in this context are pilot “mental workload” and “SA”.

Experimental design

Seven crews each comprising two airline pilots (a captain and a first officer) participated in the experiment for two consecutive days. The experiment consisted of a total of 11 experimental runs per crew, which were flown in pseudo-randomised order. Runs focussed on either the use of “dual layer display” and the “interseat haptic touch screen”, or they focussed on a particular construct that the HF tools could measure. Examples of such constructs are mental workload or SA. The approach followed (i.e. a number of short flight runs in one experiment) allowed to compare a great number of HF tools in a systematic way.

More information about the exact content of the scenarios and the procedure in general may be found in Van Dijk and Zon (2008a and b) and Zon and Van Dijk (2009) and Van Dijk and Zon (2009). More information about the Generic Research And Cockpit Environment (GRACE), the high fidelity flight simulator in which the experiment was performed, may be found in Egter van Wissekerke (2004) and in Heesbeen et al (2006). Photographs of GRACE are displayed in Figures 1 and 2.

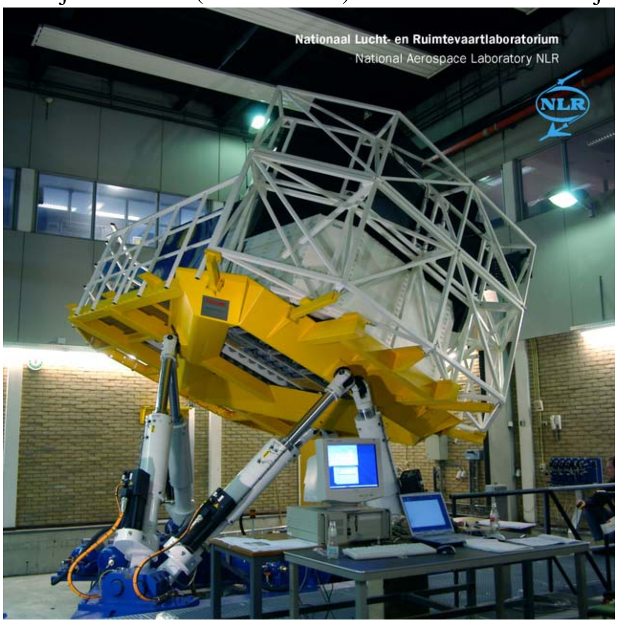


Fig. 1. Generic Research And Cockpit Environment (GRACE).

HF tools

The HF tools that were used in the second high fidelity simulator experiment were:

- Questionnaires and rating scales were offered to the crews via an Electronic Flight Bag (EFB) in the cockpit, and via a desktop PC outside the cockpit for the longer questionnaires. The open and closed questions were formulated by project partners and standardised by the University of Groningen. Two of the rating scales that were used were: Crew Awareness Rating Scale

(CARS) for crew SA, the Rating Scale Mental Effort (RSME) (Zijlstra and Van Doorn, 1985, Zijlstra, 1993) for pilot mental workload.

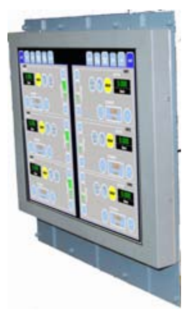
- (Debriefing) interviews, based on knowledge of the scenarios, pilot performance during the experiments and answers to the questionnaires and rating scales, were performed by specialists from NLR; i.e. Human Factors Expert Administered Debriefing Survey (HEADS) and from Deep Blue; i.e. CRitical Interaction Analysis (CRIA).
- ASL head mounted eye trackers with optical head trackers, brought into the experiment by NLR, were used to record, on video as well as in databases, the crews' eye scanning behaviour.
- Heart rate variability and respiration rate were recorded as psychophysiological indices of mental workload by the University of Groningen. While TNO added for reasons of comparison the facial temperature as another psychophysiological measure for mental workload.

- All crew behaviour in the cockpit was recorded on video and audio by NLR.
- A great number of simulator parameters were recorded by NLR. There were basically two kinds of parameters: the pilot inputs to the aircraft and the aircraft performance itself.
- Two software applications were used for quicker and easier data analysis. From BAE SYSTEMS: Gwylio and from Noldus Information Technology: The Observer.

Technologies

The two new cockpit technologies used in the experiment were:

- The dual layer display was brought into the experiment by TNO. Two of those displays were installed to replace the navigation displays. The information that is normally presented on the navigation displays was now split over two layers where all fixed information (i.e. terrain and beacons) were presented on the further display and the moving information (i.e. other traffic) on the nearest display. For more detail about the dual layer display in general see (Kooi and Toet, 2003). The role of the dual layer display in the current experiment is described in more detail in Zon et al (2009).
- The interseat haptic touch screen was brought into the experiment by GE Aviation Systems. This touch screen gives the sensation as if one presses a button when touching it. It replaced the radio panel and was as such mounted at the pedestal behind the throttles. For more information about the interseat haptic touch screen the reader is referred to (Lewis et al, 2009). The role of the interseat haptic touch screen in the current experiment is described in more detail in Zon et al (2009).



Lessons identified

The most generic lesson that was identified, and where a number of the lessons that are described below are related to, is that the thread, or critical path, of the experiment should not be interfered with by other aspects of the experiment. This is especially true because creating good scenarios for HF experiments takes time, and this time should really be available to fine tune the experiment. Only then high quality HF experiments can be performed.

Maturity of technologies

In the first high fidelity simulator experiment the emphasis was supposed to be on HF tools. However, new cockpit technologies (i.e. new displays or panels that the pilots can use in the cockpit to fly aircraft easier, safer or more efficient) were used as vehicles to validate the HF tools. It was assumed that less mature technologies might be helpful for validation of HF tools because there need to be flaws in the technologies in order to enable the HF tools to demonstrate that they can identify such flaws. Basically that is true but in order to evaluate technologies in a high fidelity simulator still requires that the technologies themselves have reached a certain level of maturity as well. Otherwise other environments, and therefore other HF tools, are more appropriate, for validation.

The consortium evaluated for each cockpit technology that was installed in the simulator whether it had the right level of maturity for validation in a high fidelity flight simulator. Two of the technologies that were already applied in the first experiment and that were developed further in the one and a half year between the two experiments have reached that level and were installed.

The dual layer display was available for both sides of the cockpit and the content (navigation display in the second experiment instead of primary flight display in the first experiment) was more appropriate to validate the potential of a dual layer display (i.e. being able to display more information at once before the pilots perceive the display as too cluttered).

The interseat haptic touch screen was different from the previous experiment because it was indeed haptic now, while in the first experiment it was just a touch screen. As such pilots could actually feel the display vibrate when they touched a button on it. Further the application that was running on the display had a number of complementary features that have added value compared to the ordinary radio panel.

It turned out to be true that these two, not fully developed, technologies were precisely right for evaluation of the HF tools.

Spend time on scenarios in order to get most out of the HF tools

In order to avoid getting carried away in installing and fine tuning flight deck technologies and not enough focus on HF tools, the consortium decided to perform some smaller scale technology related experiments in other simulators. The (high fidelity simulator) time that was saved by that change of plans was used to create scenarios that were aimed at manipulating the constructs that the HF tools were designed to measure.

There were scenarios where mental workload slowly increased and where some moments where build-in that would generate peaks of workload. These scenarios were approaches to Sion airport in Switserland. Those flights started at cruise level with relatively low workload. But due to a low cloudbase, a visual approach, mountainous terrain and a relatively small runway the workload progressively increased while approaching the runway. During the flight specific requests from ATC increased workload at particular moments. The subjective workload ratings, the heart rate, respiration rate and facial temperature were all recorded during these flights so that afterwards it could be studied to what extend these measures are redundant and whether they are also complementary to each other.

There where also scenarios in which SA was manipulated. The definition of SA that was used in these studies was the often cited definition from Endsley (1988). By manipulating SA in the like it was done here, one can say that pilots have a decreased SA and researchers can study the information that the HF tools provide about those situations. In one scenario an indicated air speed (IAS) discrepancy was simulated. On the left and right side of the cockpit the speedtapes gave different information. It was the pilots' task to first find out that this was happening, and secondly to find out which of the speedtapes gave the accurate IAS. With external observers, questionnaires and eye trackers the researchers formed and impression of pilot SA and about the added value of each of the HF tools that were applied.

In another SA related scenario the crew was informed after a break that 'something' will be changed after the break. By doing so the researchers forced the crew to be aware of a decreased SA. In fact a fuel leak was simulated and the researchers used the same HF tools as in the other SA scenario to study how the pilots regained their SA.

Because the researchers controlled and manipulated mental workload and SA in these scenarios this kind of scenarios was really aimed at validation of the HF tools rather than using the HF tools to validate new cockpit technologies.

Predicting how scenarios will work out is not easy

Even though the task of flying an aircraft has a lot of procedural aspects it still offers a great deal of freedom for pilots how to operate in particular situations. Because of that freedom it is difficult to create scenarios that will work out the same way for every crew that participates in the experiment with as major disadvantage that not all data from every crew can be compared with the data from all the other crews. Especially responses to off-nominal events like TCAS TAs or unruly passengers are not the same for all crews.

Subject matter experts are needed

It was efficient to record lots of data like eye tracker output and psychophysiological data automatically. However, not all of these automatically recorded data are easy to interpret without background knowledge. It turned out that at least three different kinds of experts were needed to interpret the results of the experiments.

1. Simulator experts who know the differences between high fidelity flight simulators and the real aircraft.
2. Pilots who can explain why subjects in the experiment make particular decisions.
3. Human Factors experts who are familiar with the kinds of data that are recorded and are able to state when a seemingly different result is truly different or just an artefact.

Besides for interpretation of results also in the design processes of technologies and scenarios, specialist knowledge is needed. A number of partners from the Flight Deck Technologies strand needed either more knowledge about HF or the aviation domain.

Even though pilots tend to report a lot about why they made certain decisions and how they felt at that moment, they are not fully aware of everything that is relevant and takes place around them. For researchers it is relevant as well to understand if there is information that pilots have missed. Subject matter experts who are pilots and are aware of all aspects of the simulated scenarios can evaluate the pilot behaviour.

However, not just in the evaluation but also in earlier stages, like experimental design, subject matter experts can play crucial roles. Pilots have experiences from situations that they had to deal with themselves in their daily work that might be interesting to simulate. They can help in designing the scenarios in such a way that they will really work out like the researchers intended.

All three kinds of specialists are needed during all phases of experimenting, from design to analysis, in order to obtain a complete picture of what has happened during the simulated flights.

Added value of a set of tools

Identify a set of HF tools

The focus of the experiment itself was on HF tools. In the period between the first and second experiment a number of the HF tools, and the ways how they were applied in the experiments, were further developed. This resulted in a better more refined set of HF tools.

The most important development is that by applying the tools together as a set quicker and easier access to data is the result. Tools that allow to store all data in one database and that allow to study all data streams in the context of the others are a major improvement compared to analysing individual tools and afterwards compare the outcomes of the different tools.

Converging evidence principle

Combining data streams (see Figure 2) greatly increases researchers' insight and makes the current HF performance measures more objective. It turned out that the quality of interpretations of what has happened during the experiments is better when, in a holistic way, all data sources are included. For example to compare the psychophysiologically measure mental workload with the mental workload as reported by the pilots on rating scales. This pleads for (software) tools that enable a quick and intuitive fusion of data streams so that researchers will be better able to get an overview of data streams, in the context of all other data sources that were recorded, at the same time.

Fig. 2. Combining data streams. Pilot in simulator while several tools (e.g. eye tracker IR camera) are registering data.

For a number of HF tools it is clear that they measure aspects of an underlying concept. For example a set of HF tools was applied that all indicate mental workload. A number of these tools are sensitive as well to other concepts than mental workload. Some of them are sensitive to psychological stress, coffee intake, etcetera. By comparing the data from different tools and deducing what most of them indicate it becomes more likely that the deduced trend is indeed true, not an artefact. Such artefacts may result from the fact that the tool is sensitive to other concepts than mental workload. This is what is called the converging evidence principle.
Two of the HF tools that were applied, are “Gwylio” and “The Observer”. Both of these tools offer the opportunity to store data from a number of data sources in one database. This enables integration and synchronized display of multiple full-resolution video streams, eye tracking data, psychophysiological signals and event data from the high fidelity flight simulator and eventually to make quick and easy comparisons between the different data streams. Therefore these tools contribute significantly to applying the converging evidence principle.

Situational Awareness is hard to measure

The concept SA is complex and comprises many aspects. Numerous researchers have tried to define it. As such it is not straightforward to measure SA. The best thing to do is to use a number of measures and see if they all convert to the same direction. For example ask pilots to rate their own SA and compare that with the ratings from a subject matter expert (e.g. another pilot) who monitored the flight on video.

In definitions of SA (e.g. Endsley, 1988) it is often stated that the pilots first have to notice a particular phenomenon in order to become aware, understand and project into the future. That first step, noticing, and also giving attention to something, can be measured by eye tracking. The eye tracker shows where the pilots focus, which under certain circumstances may be interpreted as giving attention to. As such an eye tracker is a helpful tool to measure the ‘base’ for SA.

Individual pilots normally have an impression of their own SA. This however, is not necessarily the right impression. For example when the pilot things that his SA is optimal, while in fact that is not the case, then the pilots SA is even worse then when he had reported that his SA is not optimal. In order to measure this discrepancy between the pilot's own impression and reality, several instruments for SA assessment are needed. Therefore: eye trackers, rating scales and expert observations together provide a more coherent impression of pilots' SA than all of those tools individually do.

Certification

The selected set of HF tools may eventually be used by authorities and industry as a structured way of measuring HF and HCI aspects of new technologies and applications. Besides evaluation of new technologies and applications this approach may also be used as a HF certification instrument.

Acknowledgements: This paper was prepared with information from the HILAS Flight Deck Technologies strand project partners[3].

References

1. Catton, L., Starr, A., Noyes, J., and Williams D., The use of Low Cost Simulators as a predictor of human performance. International Ergonomics Association conference in Beijing China 9 – 14 August 2009.
2. Dijk, H. van and Zon, G.D.R.: HILAS D3.3.3.1. - Description of conditions to be varied and the applicable scenarios, GRACE experiment August - September 2008, NLR-CR-2008-539, NLR, Amsterdam, (2008a).
3. Dijk, H. van and Zon, G.D.R.: HILAS D3.3.3.2. - Briefing guide GRACE experiment August - September 2008, NLR-CR-2008-478, NLR, Amsterdam, (2008b).
4. Dijk, H. van and Zon, G.D.R.: Situational Awareness assessment in flight simulator experiment. To be published in the proceedings of the International Symposium on Aviation psychology (ISAP) ,Dayton, OHIO, April 27-30, 2009.
5. Egter van Wissekerke, R.F.: GRACE - Generic Research Aircraft Cockpit Environment. NLR-Memorandum ATTH-2004-014, NLR, Amsterdam, (2004). (NLR internal report.)
6. Endsley, M.R. Situation Awareness Global Assessment Technique (SAGAT). IEEE CH2596-5/88/0000-0789, 789 – 795 (1988).
7. Heesbeen, W.W.M., Hoekstra, J.M. and R.C.J. Ruigrok, "GRACE – a Versatile Simulator Architecture Making Simulation of Multiple Complex Aircraft Simple",

[3] The project partners in the HILAS Flight Deck Technology strand are: GE Aviation and BAE SYSTEMS from the UK, NLR, TNO, Noldus Information Technology and the University of Groningen from the Netherlands, Elbit Systems from Israel, Selex Galileo and Deep Blue from Italy, Dyoptyka from Ireland, Lufthansa Systems from Germany and Avitronics Research from Greece.

AIAA Modeling and Simulation Technologies Conference and Exhibit, Keystone, Colorado, Aug. 21-24, 2006, AIAA-2006-6477.
8. HILASa, http://www.hilas.info/mambo/
9. HILASb, http://www.hilas.info/toolsregistry/
10. Hoogeboom, P.J. and Mulder, L.J.M. (2004). Detection of Workload Elevation Using Different Types of Physiological Measures for use in Adaptive Automation: Some Practical Implications. Proceedings HCI Aero 2004 Toulouse, France, 29 Sep - 1 Oct 2004 (2004).
11. Human Factors Working Group for U.S. Department of Transportation Federal Aviation Administration: Advisory Circular, (2004).
12. Kooi, F.L., Santamaria Maurizio, C., et al.: HILAS D3.2.4.1 Report with the analysis results and the comparison with the results of the design analysis. HILAS D3.2.4.1 (2007).
13. Kooi, F. L., and Toet, A. (2003). Additive and subtractive transparent depth displays. In J. G. Verly (Ed.), Enhanced and synthetic vision 2003, SPIE-5081, 58-65. Bellingham, WA., USA: The International Society for Optical Engineering.
14. McGuinness, B. and Foy, L. (2000). A subjective measure of SA: the Crew Awareness Rating Scale (CARS). In D. B. Kaber and M. R. Endsley (Eds). Human performance, situation awareness and automation: User centered design for the new millennium. Atlanta, GA: SA Technologies. (Paper presented at the Human Performance, Situational Awareness and Automation Conference, Savannah, Georgia, 16-19 Oct 2000.)
15. Roerdink, M.I. and Zon, G.D.R.: Briefing guide GRACE experiment January – February 2007, NLR CR-2006-806, NLR, Amsterdam, (2006).
16. Zijlstra, F.R.H., (1993). Efficiency in Work behaviour. A Design Approach for Modern Tools. PhD thesis Delft University of Technology. Delft University Press
17. Zijlstra, F. R. H. & Van Doorn, L.. The construction of a scale to measure perceived effort. Delft, The Netherlands: Department of Philosophy and Social Sciences, Delft University of Technology (1985).
18. Zon G.D.R. and Avermaete, J.A.G. Van (1999). Measuring Eye point-of-Gaze for Assessment of Situational Awareness. Fourth Annual Symposium and Exhibition on Situational Awareness in the Tactical Air Environment, June 8-9, 1999, Patuxent River, Maryland.
19. Zon, G.D.R., Hanson, E.K.S., Joosse, M., Neary, C., Catchpole, K.R., Richards, D, Taylor, M.R., Alfredson, J., Berggren, P., Jacobsson, M., Andersen, H.H.K., Pedersen, R., Kahana Zurit, A., Grunwald, A.J., Gopher, D., Ober, J.K., Gryncewicz, W., Dylak, J. (2004). VINTHEC II - WP7 - TR 01 - Full-scale simulator experiment. NLR-CR-2004-029, NLR, Amsterdam, The Netherlands (2004).
20. Zon, G.D.R. and Roerdink, M.I.: HCI Testing in Flight Simulator: Set Up and Crew Briefing Procedures - Unique Design and Test Cycle. Proceedings HCI International 2007 (2007).
21. Zon, G.D.R. and Roerdink, M.I.: HILAS D3.1.2.1 Assessment methodology and tools, NLR-CR-2006-275, NLR, Amsterdam, (2006).
22. Zon, G.D.R., Dijk, H. van, Merwe, G.K. Van De, Bos, T.J.J., Joosse, M., Konstantinidis, C., Fassoulas, G., Amos, D., Hinton, J., Santamaria Maurizio, C., Terenzi, M., Orenstein, I., Waisman, T., Trousil, T., Ferrero, G., Ametta, A., Savarino, C., Noldus, L., Heffelaar, T., Mulder, B., Stuiver, A., Waard, D. De, Starr, A., Catton, L., Kooi, F., Brouwer, A.M..: HILAS D3.4.1.1 - Report with the results of the evaluation experiments. To be published in August 2009.
23. Zon, G.D.R., Waard, D. de and Heffelaar, T.: Human Factors measurement- and analysis tools for cockpit evaluation and pilot behaviour. Workshop at "Measuring Behavior" http://www.noldus.com/mb2008/. Conference 26 – 29 August 2008 in Maastricht, the Netherlands (2008).