Chapter 7 – FRA-2: PEA "HUMAN FACTORS AND AUTHORITY SHARING" (FHPA)

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7.1 DATES

PEA FHPA: 2007 – 2011.

7.2 LOCATION

Paris, France.

Demonstration done at LTO – Laboratoire Technico-Opérationnel DGA (Arcueil / France).

7.3 SCENARIO/TASKS

The second French Tech Demo is related to an upstream program named "Human Factors and Human/ Automate Authority Sharing in Unmanned Aerial Systems". The main objective of this program is to define new means of cooperation and interaction between Humans and Automates, based on the concept of "Authority Sharing". In practical terms, it is intended to optimize the workload of existing UAV systems by allocating dynamically the operators' functions, allowing thus the integration of multiple UAVs and payloads without necessarily augmenting the number of operators.

The program is organized in 4 phases during 36 months:

- Phase 1: "RETEX" (RETour d'EXpérience) – experience feedback from the French Army;
- Phase 2: Search for innovative solutions on HF and Authority Sharing;
- Phase 3: Implementation of the innovative solutions; and
- Phase 4: Experiments / HF evaluation.

The scenario envisioned for this project sets two Ground Control Stations (GCS) collaborating together toward the identification of a common enemy:

- The first GCS controls two tactical UAVs (fixed-wing UAVs), with one payload each, flying at two different locations on the map (in the same geographical area).

- The other GCS controls one MALE UAV (fixed-wing), with one payload, flying in the same geographical area as the others.

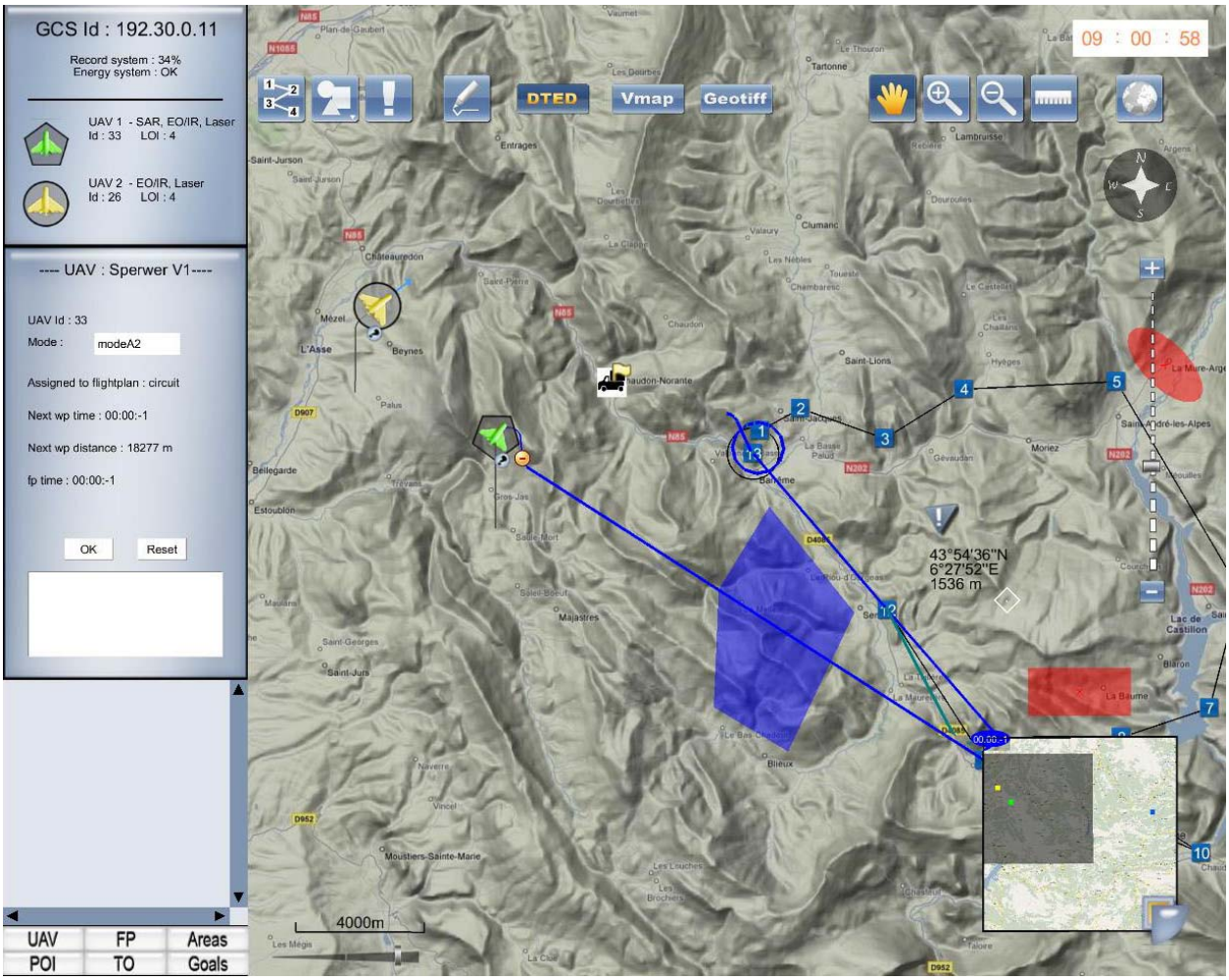

Figure 7-1: Tactical AVO’s Cartography Screen.

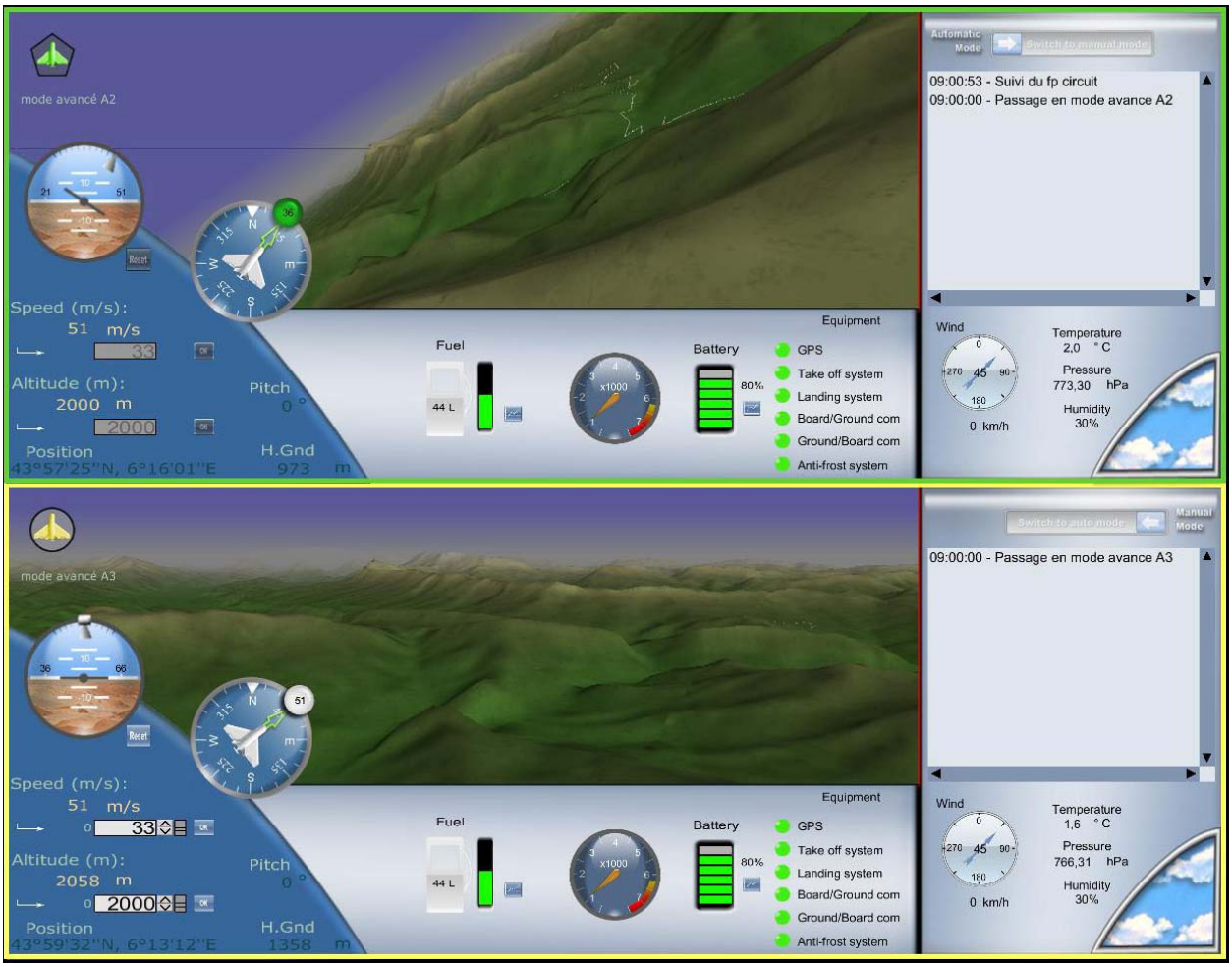

Figure 7-2: Tactical AVO’s Manual Control Screen.

Figure 7-3: Tactical PO’s Camera Views Screen.

Each station welcomes a 2-member team: an Aerial Vehicle Operator (AVO) and a Payload Operator (PO). At the beginning of the scenario, each team is unaware of the other team’s presence in the area.

The tactical GCS’s mission is two-fold: UAV1’s goal is to open a road for a convoy by detecting and identifying all the potential targets along that road while UAV2 is watching the convoy and its surroundings. The MALE GCS’s mission is to watch the activity along a border.

At a certain point of the scenario, the MALE UAV is rerouted to a meeting area but an air traffic lane appears and prevents it from reaching the meeting point on time. One of the tactical UAVs is then rerouted to the meeting area and shares its payload (EO camera) with the MALE GCS. The video feedback provided allows the MALE station to perform its mission and, as the air traffic lane closes, the MALE UAV can be directly directed to the meeting point.

7.4 TECHNOLOGIES EXPLORED

Within the scenario presented before, two different concepts are assessed: an “authority sharing” concept, between the AVO and the automate controlling each UAV (throughout the mission), and a human-human collaboration concept between the two payload operators (while sharing the video feed).

7.4.1 Authority Sharing

After the definition of the three different operative modes (automatic, intermediary and manual), each corresponding to different levels of function allocation, a set of HMI was designed to support each operative mode with a focus on the *trajectory management* macro-task.

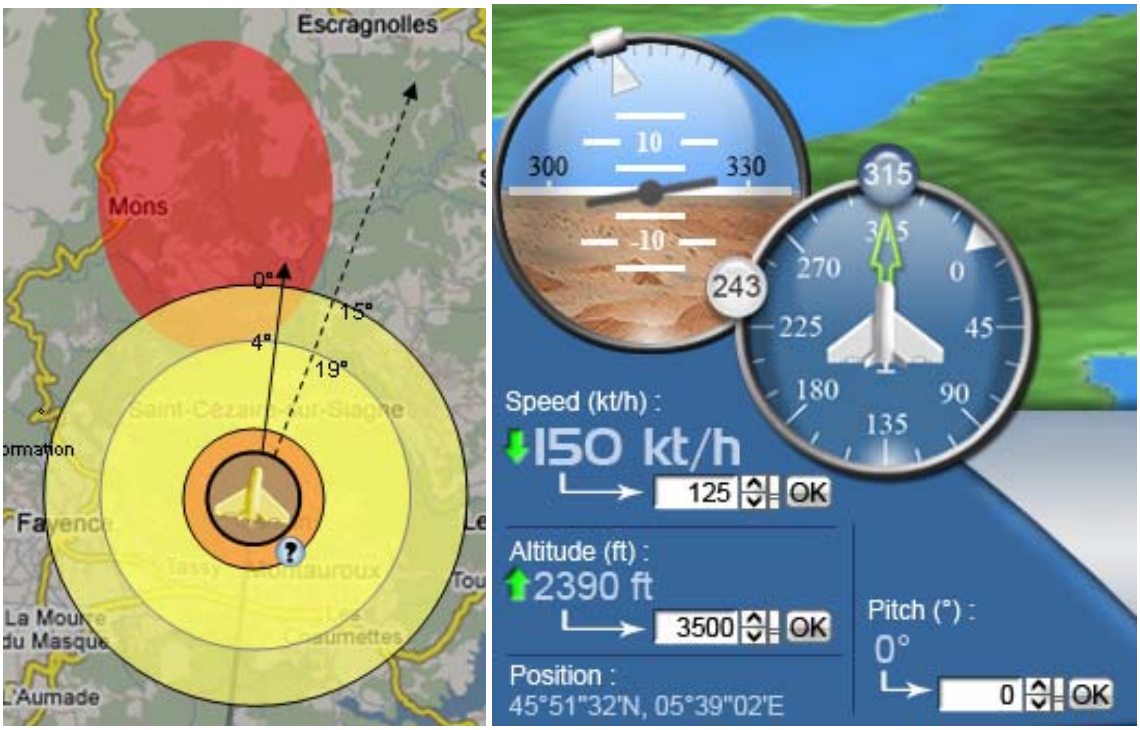

Figure 7-4: Examples of UI Designed to Support the Different Operative Modes: (a) Draggable Vector Tool and (b) Manual Controls.

7.4.2 Human-Human Collaboration

The human-human collaboration part of this project focuses on the payload sharing between the two ground control stations. During the mission, the tactical payload operator "lends" the payload of one UAV to the MALE payload operator. Two levels of sharing are defined: one where the full control of the tactical payload is transferred to the MALE operator, and the second where only the video feedback is sent to the MALE operator while the control remains under the tactical operator's responsibility.

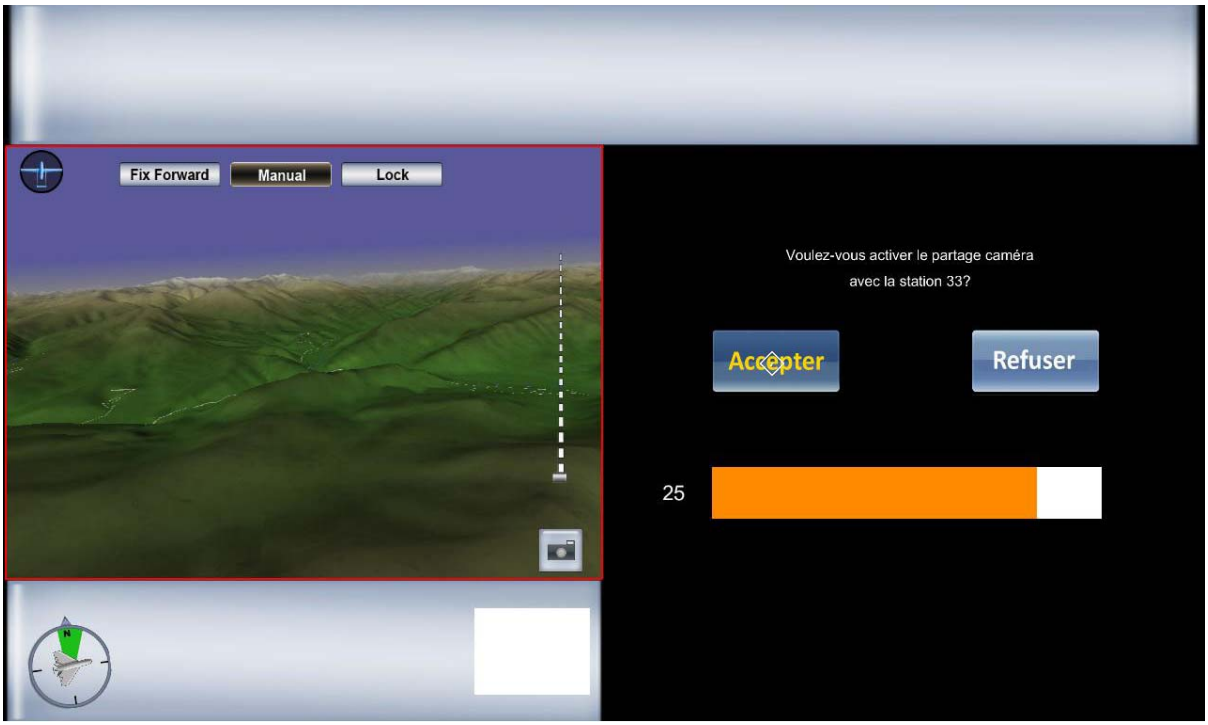

Figure 7-5: View of the MALE PO Screen When Receiving a Shared Camera.

The HMI designed to support these 2 concepts have been tested on a simulation environment during two experimentation campaigns with UAV military personnel from the French Army and the French Air Force.

7.5 HUMAN FACTORS ISSUES EXPLORED

7.5.1 Reference Frame

One of the project’s phases purpose was to design an “authority sharing” engine which function is to dynamically allocate the functions to either the automata or the operator, depending on the operational context. This “operational context” is mainly defined by different criteria:

- Number of UAVs;
- UAVs’ objectives and status;
- Types of missions / tactical environment; and
- Meteorology (specially gusts of wind).

Refining the classical approach of autonomy levels [4],[6], we defined a methodology based on Proud’s Level Of Autonomy (LOA) matrix [5] and Boyd’s OODA loop [1] in order to derive a general framework where different levels of function allocation can be coupled with the 4 phases of Boyd’s loop (Observe, Orient, Decide, Act). Three different operative modes (automatic, intermediary and manual) were implemented in the system, each corresponding to different levels of function allocation [2],[7], thus covering the spectrum of autonomy configurations [3].

7.5.2 Human Factors

During our experimentation campaigns, we assessed the impact of our new designs and the underlying concepts on operators' performance and workload.

Operators played the scenarios several times with the "authority sharing" engine activated or not. This allowed us to observe and evaluate the effects of letting the computer decide to whom (between the AVO and the automation) each task is allocated throughout the scenario.

The same factors (performance and workload) were assessed with the payload operators during the camera sharing phase: we studied how well the MALE operators performed their enemy-seeking task in two configurations: when fully controlling the tactical UAV's camera or only viewing the video feedback (and thus giving instructions to the tactical PO).

7.6 UNMANNED SYSTEMS USED

As described above, the Unmanned Systems used were not real but only existing in a simulation environment. It can be noted though that the GCS environment was reproduced: each team (1 aerial vehicle operator and 1 payload operator) was alone in a shelter-like room. The Mission Planner was remotely giving audio instructions to the teams.

7.7 SUMMARY OF ANY NATO COMMUNICATIONS/COLLABORATIONS/ INTERACTIONS

When the NATO HFM-170 Meeting took place in Paris (September 2009), only a small part of the program has been communicated to its members. Indeed, the Phase 4 (experiments / HF evaluation) of the program hadn't started yet.

	Planning/Design	***Execution***	***Analysis***
Communication			*X*
Coordination			
Collaboration			

7.8 SUMMARY OF TD RESULTS

1) A methodology based on Proud's Level Of Autonomy (LOA) matrix and Boyd's OODA loop has been used and tested, in order to derive a general framework where different levels of function allocation can be coupled with the 4 phases of Boyd's loop (Observe, Orient, Decide, Act). Three operative modes corresponding to different levels of function allocation were then defined, implemented, tested and validated.

2) The Authority Sharing Tool does not vary significantly the overall performance whether it is activated or not, but the test panel size didn't allow us to statistically confirm this data. However, to illustrate this result, the table below shows the performance measured during a communication breakdown (workload increased).

	Overall Performance		Workload Level	
	Average	Standard Deviation	Average	Standard Deviation
AS tool active	65,50	8,52	3,00	1,15
AS tool inactive	77,28	13,94	2,50	1,29

3) AVOs may control two UAVs at the same time when (a) the workload level is acceptable and (b) they are assisted by an "authority sharing" tool, but only if (i) the operators trust the tool's choices and (ii) the choices help ensuring UAV's safety.

4) POs are not able to perform two missions with two different payloads, although operators may increase their situation awareness level if these two payloads are used for one mission and target the same area. Regarding the transfer modes, POs always preferred to keep control over the payload while performing the target-seeking task.

7.9 LESSONS LEARNED

The most important lesson learned is related to the relationship that humans have with automata (the "authority sharing" engine) capable of allocating in real time their tasks, sometimes distributing them the machine. Indeed, its acceptance degree is directly related to the situation awareness held by the operators and their trust in the automation.

7.10 STUDY CONSTRAINTS/LIMITATIONS

The study was carried out on a simulation environment and not with real UAVs. However, the experimentation campaigns involved several UAV-related military personnel. Results have to be confirmed statistically from an extended test panel.

7.11 CONCLUSIONS

The operators appreciated the HMIs designed during the program, in particular the "draggable vector tool" (it allows the operator to easily reroute the UAV in a drag-and-drop motion). Regarding the "authority sharing" engine, the overall performance does not change with or without the activation of the engine, but the test panel was too small to statistically confirm this data.

7.12 FUTURE RESEARCH NEEDS AND PLANS IN THIS AREA

Future research in the area should emphasize the following points:

- Managing the transitions between operating modes and related man-machine configurations so that the operators would not be handling too important gaps in subsequent configurations of the system; and
- Extend the human factors analysis, both in quantitative and qualitative way, through respectively an extended panel that will guarantee a better statistical reliability, and a focus on the instrumentation of

operators' states (stress, fatigue, focus of attention) so that the understanding and tuning of the different operating modes could be more adequate.

7.13 ACKNOWLEDGEMENTS

PEA FH/PA was supported by French MOD (DGA/UM-NBC 2006.94.0907).

7.14 REFERENCES

[1] J. Boyd. Military Theory of War, John Boyd's OODA loop. (Official US Air Force website) Available at http://www.au.af.mil/au/awc/awcgate/awc-thry.htm#boyd, last checked on 13/02/2011.

[2] A. Leal, J. Bouchet, G. Langlois and F. Jourde. Conception de l'Interaction Homme-Machine et Partage d'Autorité : Application aux Systèmes de Drones In proc. IHM'09, 2ème Conférence Francophone sur l'Interaction Homme-Machine. pp 283-290. 2009.

[3] F. Legras and G. Coppin. Autonomy spectrum for distributed systems. In: Proceedings of COGIS'07, Stanford, USA (2007).

[4] R. Parasuraman, T.B. Sheridan and C.D. Wickens. A model for types and levels of human interaction with automation. In: IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans. Volume 30. IEEE (2000) 286-297.

[5] R.W. Proud, J.J. Hart and R.B. Mrozinski. Methods for determining the level of autonomy to design into a human spaceflight vehicle: A function specific approach. In: Performance Metrics for Intelligent Systems Workshop, Gaithersburg, MD (2003).

[6] T.B. Sheridan. Telerobotics, automation, and human supervisory control. MIT Press, Cambridge, MA, USA (1992).

[7] T. Villaren, C. Madier, F. Legras, A. Leal, B. Kovacs and G. Coppin. Towards a method for context-dependant allocation of functions. HUMOUS 2010: Humans Operating Unmanned Systems, 26-27 April 2010, Toulouse, France, 2010.