ACRONYM: TACTIC

Title: in flight Trajectory optimizAtion through advanCed simulation TechnICs

State of the art – Background

The Commercial and Airline Pilots are skilled to deal with their aircraft emergencies, because trained to handle such situations with standardized behaviour. On the contrary, when the occurrence of unusual situations, depending upon different and various mentioned factors, requires trajectory change during IFR navigation, pilot in command, involved in a short time analysis and synthesis, could be not able to consider all those aspects affecting the new flight trajectory negotiation.
In such situations the pilot may have great advantages in using additional capability providing supports and increased awareness in answering to trajectory change requests. A Decision Support System (DSS) can be introduced to allow the pilot to have in every instant the awareness of alternative paths, suggested by the tool, that can decrease trip time, fuel consumption and consequently chemical emissions and noise.

Theoretical context

In order to study the behaviour of pilots in facing unforeseen events and to make easier the decision making process to tackle the new situation, in recent years many behavioural models have been developed.
All the most complete decisional schemes, like DECIDE (Detect-Estimate-Choose-Identify-Do-Evaluate) and 3P (Perceive-Process-Perform), follow an iterative path, starting from the detection that something has changed in the perceived scenario up to the undertaking of the needed actions to handle the new situation and the evaluation of their effects.
In such a context, a valid help can be provided by equipment able to evaluate in almost real time a new trajectory optimised in terms of emission and noise minimisation and suggested by means of a friendly MMI for a ready and easy interaction with the Decision Maker.
In addition, having in mind the present and future ATM environment, the procedures for having clearance by ATM to undertake the new proposed trajectory should be accurately evaluated too, for calculating the advantages (mainly in terms of time saving) of adopting such new equipment by comparison to the lack of it.

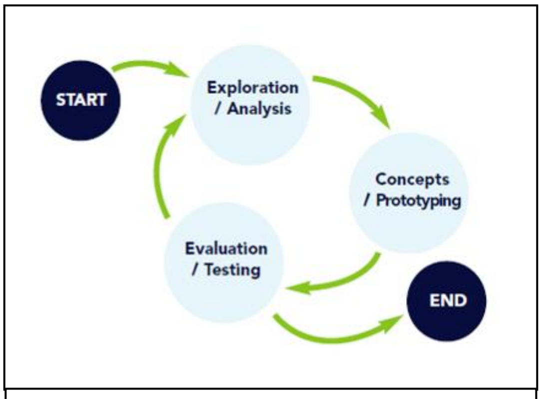
Objectives

TACTIC project analysed and addressed the pilot's behaviour in decision making process when unforeseen events force to a change in the reference trajectory with or without the help of an on-board Decision Support System.
The main objective of TACTIC has been to evaluate such a Decision Support System. The quantification of the advantages of such an interactive tool was the main output of the project. Eventual suggestions for enhancements of the tool as well as new interaction modalities or uses were also provided.
To reach this objective, a simulation environment that replicates present and future ATC and airborne system configurations was set up.

Description of work

Validation Framework

The overall evaluation strategy for the assessment of the concept followed Human-Centred design approach and E-OCVM methodology. In line with these approaches, two main topics were investigated:



Human Centred Design process for DSS evaluation

- Human Factors, usability and safety: how the tool impacts pilot's workload? How does it fit in the current tasks, procedures and strategies? Does it affect flight safety?
- System performance: how the DSS impact parameters such as fuel consumption, chemical emissions, flight duration? Which are the differences between the configuration with the tool and the configuration without the tool?

Operational Scenario

The simulation campaign consisted of two distinct simulation sessions; a set of exercises with a specific environment configuration (weather conditions, unforeseen events, trajectory negotiation operative procedures) was executed

for each session. All sessions used the Real Time Simulation (RTS) technique.
Each exercise was executed with and without DSS.
DSS validation was executed in two different flight phases:

- En-route
- TMA Approach descending phase, starting from the end of En-route segment to the PMS entry points for the Transition Approach Procedure to LIRF Airport.

Simulation Environment

To implement the scenario described above a simulation system is necessary to allow the cooperation of pilots (with a Decision Support System) and Air Traffic Controllers in position that replicates the interface they normally use during real flights.

Cockpit Simulator and Decision Support System Display

A simulation system owned by IDS was used. The simulation system architecture main tools are the Cockpit Simulator the ATC simulator. Decision Support System was integrated in the Cockpit Simulator receiving information about the simulation status in order to calculate the optimized aircraft trajectory.
The operators involved in the TACTIC simulations are:

- Cockpit Simulator pilot – he is the operator that will be evaluated to analyse the impact of a Decision Support System in trajectory change management operations. This pilot will control an aircraft with a replica of its instrumentation
- Air Traffic controllers – they have the responsibility to handle the aircraft traffic in a specific airspace maintaining safety conditions
- Pseudo pilots – they handle, through a dedicated high level command, more than one flight in a specific airspace, they create the surrounding traffic for the Cockpit Simulator and interface with ATC operator that is controlling their current position.

Results

From the analysis of the communication logs between pilots and ATC operator during the negotiation subsequent to the appearance of the risk zone it can be deduced that using the DSS requiring a trajectory negotiation based on published waypoints requires less phases. Using the DSS reduces also the radio frequency usage in terms of number of calls and total duration of the transmissions.
The simulations highlight neither relevant difference in the average duration of the radio communication nor in the total duration of the negotiation. The ATCO always requests a confirmation when the aircraft is clear of the bad weather zone and about to converge to the original flight plan. So the total duration of the process is almost only related to the bad weather zone extension. This happens even when the pilot asks for a flight plan revision which should completely substitute the old one.
The DSS based negotiation identifies the trajectory earlier and more clearly. In the first radio communication session the trajectory is already defined; if the ATCO accepted the first trajectory proposal, the whole negotiation process would terminate in a single ATCO-pilot exchange.
Without the DSS, the trajectory negotiation is composed of three phases, all of them required to determine the geographical form of the deviating path. First the pilot requests a new heading is to stay clear of the bad weather zone. Usually after a while, the ATCO initiates a radio communication asking how long the pilots need to deviate. After covering this distance, the pilots or the ATCO initiate a communication to negotiate the point where the original flight plan will be resumed.
Without the DSS, the whole negotiation process has the following characteristics:

- The trajectory is not defined until the last phase of the negotiation, when the resume point is identified.
- Communication follows no predetermined timings. A variable amount of time can pass between the trajectories negotiation steps, according for example to the situation of the surrounding traffic.
- Communication can be initiated by ATCOs or pilots, without any defined rule.

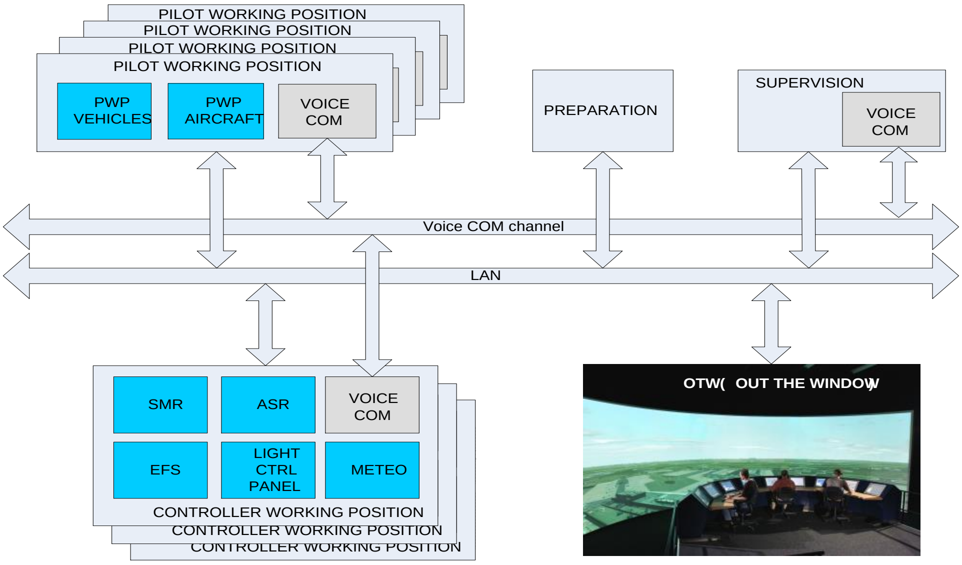
On the contrary, the DSS suggests a more standardized negotiation which defines the trajectory immediately with more defined roles between pilots and controllers.
From the point of view of the fuel consumption and of the emission of pollutants (CO_2, NOx), during the simulation a dedicated module of the CS

system computed and collected data. It came out a fuel consumption and emission savings of NOx and CO2 when using the DSS with respect to the simulations without DSS aid. The following considerations apply to the results of fuel consumption and pollutant emissions.

DSS suggests more direct trajectories generally leading to save fuel and consequently to reduce pollutant emissions.

Pilots flying without the aid of a DSS tend to join the scheduled flight plan earlier.

The DSS leads to the best results when it is used in a less constrained airspace system.



ATC simulator architecture diagram

Project Summary

Acronym:	TACTIC
Name of proposal:	in flight Trajectory optimizAtion through advanCed simulation TechnICs
Technical domain:	Simulation and Human Behaviour Evaluation
Involved ITD:	CleanSky SGO
Grant Agreement:	620121
Instrument:	Clean Sky JU
Total Cost:	549,847.20 €
Clean Sky contribution:	300,221.00 €
Call:	SP1-JTI-CS-2013-01
Starting date:	01/11/2013
Ending date:	31/07/2015
Duration:	21 months
Coordinator contact details:	Aldo Bonsignore Ingegneria Dei Sistemi S.p.A. Via Enrica Calabresi, 24 56121 Pisa - Italy a.bonsignore@idscorporation.com +39 0633217414
Project Officer:	Antonio Vecchio Antonio.Vecchio@cleansky.eu
Participating members	Ingegneria Dei Sistemi S.p.A. - IDS Deep Blue S.r.L.