

Testing Touch Screens in Realistic Aeronautic Turbulent Conditions (Light to Severe)

Sylvain Hourlier
Thales Avionics

Sandra Guérard and Jean Luc BAROU
Arts et Métiers ParisTech - I2M

Xavier Servantie
Thales Avionics

ABSTRACT

As touch screens are everywhere in the consumer market Thales has launched in depth evaluations on their introduction in the cockpit. One of the challenges is to verify its compatibility with in flight use under turbulence conditions, including light, moderate and severe. In flight accelerometer collections were performed to provide us with a baseline for choosing between possible simulation solutions. Thales recognized early on the need for such a tool as it would enable us to define recommendations for our HMI designs. The objectives were first to validate specific complex touch/gestures using all the potential of touch interactions for novel cockpit Human Machine Interfaces and second to look into the various physical anchoring solutions capable of facilitating touch screens interactions in aeronautical turbulent environments. Given the 6 axis accelerometer profiles that were collected, only an hexapod structure was capable of reproducing those profiles with acceptable validity. This paper presents the works that enabled us to validate such an hexapod as a viable simulator for our tests and the development of an avionics platform for touch interactions under light to severe turbulences. Pilots were asked to evaluate 6 simulated profiles designed to mimic the “inflight” references. Tests were performed to validate the best profiles for each level of turbulence. The selected profiles were then used to evaluate our touch screen propositions in light, moderate and severe turbulent conditions. Preliminary results are presented.

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INTRODUCTION: THE UBIQUITY OF TOUCH INTERACTIONS

The trend of touch technology for interaction is undisputed. DisplaySearch, a market analysis firm, forecasts it to grow to over \$16 billion by 2016 and \$31.9 billion by 2018. The market growth is being driven by increased demand from applications such as iPads and other tablet PCs, smart phones, and emerging notebook PC designs [1]. More recently another analyst confirms the trend and the touch screen market grew from \$1.5 billion in annual revenues in 2008 to over \$6 billion in 2011 [2]. Since the uprising of the inevitable Iphone, touch interactions overtook the cellphone industry. Nowadays, kids try to interact spontaneously on any screen they come by as if it “obviously” had to be a touch screen.

PREPARING FOR ITS UPCOMING TO THE COCKPIT

Facing such an inevitable trend, any HMI manufacturer would look into the future of touch technology in their field. The ODICIS concept demonstrator was presented at Le Bourget Air Show in 2011 as a long term (2035) prospective aim at the future of cockpit design and featured a large, single, seamless, freeform touch screen to accommodate all of the crew interactions. Since then the concept has matured into the AV2020 full touch screen cockpit, a sooner to be developed (2020) concept. It comprises multiple seamless touch screens in an integrated approach to pilots' HMI demands.

Yet implementing touch technology in a liner cockpit means complying with part 25 aircraft certification. The process is thorough and specifies that the design of systems should take into account aeronautical effects (such as turbulence) and the way they affect the efficiency of pilots' interactions. After consulting with EASA on the certification process of Touch screens, it was stated that the applicant must demonstrate that touch screens enable crew to perform the same

task, with at least the same level of performance than on non-touch systems, in all relevant aeronautical environment (including and up to severe turbulence).



Figure 1. Avionics 2020 full touch screens cockpit (courtesy of Thales Avionics)

Hence, a human factor evaluation and its Means of Compliance (MOC) technology was needed to prepare certification. Such simulation would also alleviate the risk on usability of touch displays in turbulence and refine design recommendations for interactions with touch technology (HMI design and physical installation).

Characterizing Aeronautical Turbulence

To characterize aeronautical turbulence one must specify its origin and its intensity.

Origin of Turbulence

Even with limited flight experience one can relate to the term “turbulence” in flight. Usually the captain orders passengers to their seat with their seat belt tightened due to upcoming turbulence. Atmospheric turbulence is defined as “small-scale, irregular air motions characterized by winds that vary in speed and direction” [3].

In a more aeronautical field, turbulence can be defined as small-scale, short-term, random and frequent changes to the velocity of air. In other words, when there are rapid changes to either the air's speed or its direction of movement or both, conditions are said to be turbulent [4]. Finally one must note that turbulence does not compare to a vibration, as it is chaotic by nature and not cyclic. There are four fundamental causes of aeronautical turbulence:

Thermal: When the earth surface is sufficiently warm, vertical currents of air form creating turbulent conditions for an aircraft flying through.

Mechanical: This is caused by interference of earth surface features (mountains, Tall buildings, Trees, etc.) on the horizontal flow of air. The amount of turbulence depends on wind speed and obstruction size and shape. It creates turbulence for an aircraft flying over or behind them.

Shear: When the direction or speed of wind changes dramatically within a short horizontal or vertical distance, an aircraft will experience turbulence when it flies through (typically a cumulonimbus).

Wake turbulence: An aircraft causes wake turbulence in its trail as it flies through the air. When an aircraft crosses such trail, it experiences turbulence.

Intensity of Turbulence

Turbulence is separated into four levels of intensity. Each different level of intensity can be described from both ‘reaction of the aircraft’, as well as the ‘reaction inside the aircraft’. These four levels are described below.

Table 1. FAA Turbulence Reporting Criteria Table [5].

Intensity	Aircraft reaction	Reaction inside aircraft
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as Light Turbulence or Turbulence that causes slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as Light Chop .	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking. - Occasional—Less than 1/3 of the time. - Intermittent—1/3 to 2/3. - Continuous—More than 2/3.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Report as Moderate Turbulence or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Report as Moderate Chop .	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report as Severe Turbulence	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food Service and walking are impossible.
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Report as Extreme Turbulence	

The objective of such a description is to recognize turbulence by its effects to enable reporting. As our objective is to analyze the effect of various controlled turbulence levels (in a simulator) on touch screen usability, we had to analyze beyond that description to come up with metrics on what such levels of turbulence mean in terms of displacement and acceleration.

Figure 2 represents the relationship between displacement and accelerations. The blue line characterizes the effects at 1Hz. In a sinusoid, displacement of 25 cm per second implies a maximum acceleration of 9.81m/s^2 (1G). One can undergo a maximum of 2 Gs when submitted to a displacement of 50 cm per second. Using such relationship, the various levels of turbulence were approximated with regards to maximum acceleration and maximum displacement withstood

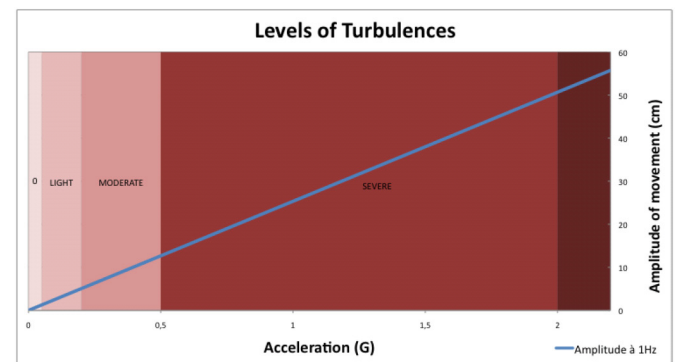


Figure 2. Level of turbulence as a function of acceleration and displacement