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# A concept of voice guided general aviation aircraft

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ABSTRACT

The paper presents a concept of an airborne control system assisting the pilot, which differs from classical approaches. This is the concept of voice commanded control system. The paper analyzes the feasibility of realization of aircraft control system with the speech recognition module for general aviation aircraft. Authors try to define the main rules, which must be observed to design and operate such systems. The main functionality levels of the presented control system are defined and discussed. The use of voice commands for the direct controlling of the flight of the plane is also presented and analyzed in details. The paper discusses several types of voice commands a pilot could use to control the plane. The main requirements voice commands must meet are defined and discussed. The last section contains the short description of the experimental control system which can be the base for developing an experimental voice controlled general aviation aircraft.



## 1. Introduction

Constantly increasing air traffic of small general aviation aircraft (SGAA) creates the problem of a numerous group of pilots using SGAA as air cars. They use SGAA as a means of local transport for medium distances [1]. On the other hand they are usually not professional pilots and often have not much aviation experience. They represent a different approach to aircraft control process [5] than professional pilots do. They also expect plane's features to be a little different than professionals do. Therefore it seems to be purposeful to design an airplane equipped with avionics systems dedicated for that group of users. The systems mentioned above have been the subject of intense research at many scientific and technical centers all over the world. All of them focus on simplifying the process of aircraft controlling. They contain a very wide range of technical solutions in order to simplify not only the aircraft control process but also the navigation, on-board system service, system data interpretation, flight parameters identification and interpretation [9,10]. There are navigation devices, flight management systems, security systems, systems of automatic on-board installations supervising, displays and visualization systems among them.

The majority of the proposed solutions simplify piloting of plane but focus on a specific kind of stick or control wheel as a control device. These solutions can be called a "stick oriented" systems and all of them engage pilot's hands to control the plane. There is a proposition of modification of our approach to aircraft's systems operation problem included in this paper. Authors suggest giving up the concept of aircraft's systems controlled by hands. Nowadays it becomes technically possible to prepare the avionic system which can be voice controlled by the pilot. The pilot could give voice commands to control aircraft's systems and flights parameters. Probably, the most desired situation would be if we could speak to airplane just like to people. Presently we can see it only watching science-fiction movies.

The paper tries to discuss the generic profile of the avionics system using a voice interface. Generic rules defining forms of commands are also presented. Some solutions which allows to incorporate the speech recognition module into existing systems of autopilots are included in this paper too. Problems with practical realization of the speech recognition module are highlighted.

Authors would like to pay attention to feasibility of realization the control system recognizing pilot's speech commands.

## 2. System functionality

A few basic questions appear at the very beginning of the discussion of voice controlled aircraft (VCA). There are following sample questions among them:

- What functions of the on-board systems can be controlled by voice commands?
- Can the pilot "speak to the airplane" to control its flight?
- What level can the pilot control the plane by voice at?

This paper tries to answer both these and also many other questions.

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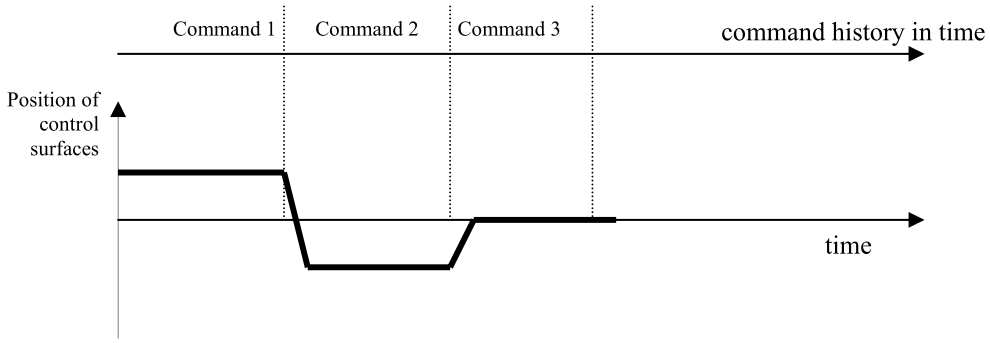


**Fig. 1.** Control surfaces can go to new positions only at discrete time moments.

The pilot controls a lot of functions of the on-board systems during the typical flight. These functions have different priority levels and different influence on aircraft safety. Taking into consideration foregoing facts three levels the VCA works at can be defined. They differ from each other in serviced functions and speech recognition procedures.

- Level I. Only supplementary functions not directly influencing the flight are available, e.g.: *deicing on/off*, *taxi light on/off*, *pilot heater on/off*, etc. Speech recognition procedure can be a word spotting application and some mistakes committed by the application are allowed.
- Level II. Supplementary functions influencing the flight state are available: *gear down/up*, *flaps down/approach/up*. An autopilot can be engaged and disengaged and basically no critical navigation functions can be activated. It means *heading, altitude and airspeed stabilization functions* can be available if special safety mechanisms are implemented. The system must be equipped with functions protecting against both abnormal values of stabilized flight parameters and too dynamic maneuvers. Speech recognition procedure can also be the word spotting application but the requirements as for speech recognition accuracy are higher than at the level I. However some mistakes of the system are still allowed.
- Level III. Aircraft's space altitude stabilization functions are available, e.g. *pitch and roll stabilization functions*. Any *emergency functions recovering* the aircraft from dangerous and abnormal flight states should be implemented also. This level requires nearly 100% speech recognition accuracy and very small delays of the procedure. The speech recognition procedure should be small vocabulary connected words recognition system.

In order to ensure flight safety, all functions initialized by the speech recognition module have to be doubled by standard control devices. All commands recognized by the speech recognition module can be acknowledged by voice. Pilots should be trained how to utilize speech recognition functionality and how to deal with possible mistakes of the speech recognition module especially at the levels II and III.

The classification of VCA proposed earlier in this paper assumes, that higher level include functions of lower one. Levels II and III include functions which are strictly related to airplane's flight control. It implies they have direct influence on flight safety. It is a reason why more attention is paid to them later in this paper.

## 3. Flight control

Before the discussion of the voice commanded flight control system starts it is necessary to make an attempt to define the way the aircraft can be controlled in. Following features of hand control decide that it is rather difficult to imagine the situation when the pilot will directly steer control surfaces using voice commands.

1) Pilots move control surfaces continuously, by hand. It would be rather difficult to realize such kind of command processing if pilots gave voice command. The control can be only discrete one, even if pilot gives commands in one stream of words (Fig. 1).
   Moreover, it is impossible to correct any pilot's mistake immediately. Some time period is lost. The plane will be driven incorrectly until the new command is said and activated.
2) How should the commands be formulated – incrementally, as absolute positions of control surfaces or any mixed solution?
3) It is rather difficult to imagine the situation when just after the wind turbulence the pilot can say "*aileron one degree right more*" for instance. Such situation would mean the pilot could calculate a new position of ailerons in his mind. It is impossible especially that the system is intended not for professionals.
4) Not only is the position of the control device important to the pilot but also the pattern of its displacement. It is important whether movement of stick is dynamical or sluggish. Moreover, the control has an impulse character or another one sometimes.
5) The pilots often deflect more than one set of control surfaces simultaneously – ailerons and ruder for instance. The pilot controlling the plane by voice will not be able to generate movements more than one set of control surfaces at the same moment unless the special commands are implemented (Fig. 2).

Facts put at foregoing points probably decide that it is possible to control the plane indirectly only. The indirect control means control with the use of any system autonomously stabilizing selected flight parameters. So, projecting such system it is necessary to integrate the speech recognition module (SRM) with any kind of autopilot (Fig. 3).

It will realize basic functions of the aircraft flight parameter control activated by SRM. There are such sample functions as space attitude controlling, altitude, heading and speed stabilization among them.

## 4. Possibility of realization

The voice commands can be used to control aircraft if speech-processing procedures enable fast and reliable command recognition only. The system must correctly recognize commands in the time period shorter than the pilot can indicate any delay. Taking into consideration human's perception possibilities it can be said