Definition of a Sailplane - Assessment of Advanced Technologies

Developed and disseminated by the Sailplane Development Panel of OSTIV

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Version control

Version	Date	Remark
1.0	October 2024	First version for dissemination by OSTIV

Content

1. INTRODUCTION

The recent World Gliding Championships 2024 in Uvalde saw the Nixus sailplane used by one competitor in the Open Class. The Nixus employs fly-by-wire that uses stored energy from batteries in order to influence the flow of air around the wing by automatically moving the flaps. This has raised questions

- whether Nixus is a glider according to the rules of FAI,
- whether the FAI Sporting Code in its general or section-wise rules needs to be adapted in order to allow for fair gliding competitions, taking into account recently developed technologies and developments that are conceivable in the future.

The present document aims at providing technically sound answers to the different dimensions of the raised questions.

2. TECHNICAL BACKGROUND

2.1 Clarification of the basic definitions

Definition of Glider: A glider is a fixed wing aerodyne capable of sustained soaring flight with no Means of Propulsion (MoP).

see https://www.fai.org/news/new-2023-sporting-code-and-disciplinary-code.

Explanatory notes:

1. The only means of gaining kinetic or potential energy during soaring flight is to gain energy from the surrounding atmosphere.

2. Energy stored on board, generated by the pilot or put into the aircraft systems by other means must not be used to drive a propulsion system.

Definition of propulsion: The action or an act of driving or pushing something (in later use esp. a vehicle) forward or onward [..].

see Oxford English Dictionary.

Explanatory notes:

1. In our context Means of Propulsion can be defined as a direct consequence of Newton's Second Law applied to fluid flow: "An active mechanical, chemical or electrical means suitable for adding momentum to the airflow around the aircraft, resulting in a propulsive force on the aircraft."
2. During steady, straight flight of an aircraft there are four forces in equilibrium: weight, lift, thrust, and drag. A Means of Propulsion introduces a thrust force or a lift force from energy that does not come from the potential or kinetic energy of the glider or the surrounding flow.
3. The reduction of drag is not a Means of Propulsion.

2.2 Technical features that deserve special attention

Flow control by flap setting on the wing is a means of varying the lift and /or reducing the viscous drag of the wing. The drag is usually reduced by maximizing the extent of laminar boundary layers. This mainly reduces the drag due to skin friction. Flap setting for controlling lift and drag is normally operated manually by the pilot. There are no suitable means known, by which flap variations can produce a propulsive force. Since flow control by manual flap setting is a generally accepted, effective technique to enhance the performance of gliders, there is no rationale to regard flow control by electric flap setting as a Means of Propulsion. However, electric flap setting comprises a fly-by-wire system and hence, uses stored energy on board.

Drag reduction by using stored or harvested energy on board: The use of energy stored on board for the purpose of drag reduction is standard practice on present high-performance gliders. Two well-known examples are the electric landing gear retraction employed by different sailplanes (e.g. EB29, Antares, some Arcus variants), and the electrically operated bug wipers on the wings of almost all competition sailplanes. At this point we mention possible future uses of alternative means of flow control that are detailed in the Appendix.

Autopilot: the classical definition of an autopilot describes a system used to control the path of a vehicle without requiring constant manual control by a human operator. Modern systems control the motion around the roll, pitch, yaw axes, and they employ the three classical primary control surfaces as well as additional controls such as direct lift flaps on the wing and speed brakes. The motivations to use an autopilot on gliders could be numerous. Suitable autopilot functions could increase safety against loss of control due to wing stall, they could reduce the workload of the pilot, or they could ensure an energy-optimized flight path through the moving atmosphere. Successful demonstrations of a 2-axis roll-pitch controller for circling flight of a glider have been recently published. Particularly interesting is the automatic electric setting of the wing flap, as the setting can be made a function of airspeed, wind speed vector, load factor for achieving optimum total energy path of the glider. The Nixus sailplane has the capability of automatic electrical setting of the wing flap. This can be characterized as an autopilot function that controls lift and drag, as the automatic flap setting of Nixus performs a flight control function without requiring constant manual control by the pilot. The control function could be quite complex, e.g. by involving dynamic derivatives of data, and it could be clearly beyond the pilot's manual capability. The autopilot function comes at significant cost, related to the required systems and airworthiness certification. And the obvious question is in how far should the air sport among humans take any advantage of installing autopilots on board.

Pilot Assistance Systems: While cloud flying instruments are prohibited in international competitions, current avionics systems on board of competition gliders comprise a significant range of pilot assistance functions. These include wing stall indicators, airspace awareness assistants, navigation assistants, circling assistants, maximum total energy path indicators and others. Large potentials exist for employing fusion of data from onboard sensors with data from external sources, and combining them with suitable AI algorithms to create added value for the pilot.

At present, there appear no justifiable means to standardize or regulate the use of pilot assistance systems used by glider pilots. However, this assessment could rapidly change in the future.

Amount of energy on board: Current sailplanes carry a number of electrical instruments on board. Radio, transponder, collision warning systems, instruments for displaying the flight state, means of navigation as well as bug wipers need significant electric power. The requirement of energy on board depends linearly on flight duration. As the function of the electric systems is needed for reasons of flight safety and for reasons of gliding performance, one can hardly define an upper limit of energy stored on board a glider. It may also be worth mentioning that currently pursued fundamental research addresses the efficiency of solar energy harvesting, possibly leading to improvements by large factors.

3. CONCLUSIONS AND OPTIONS OF EXTENDING RULES OF FAIR AIR SPORTS

The example of an electric flap actuation, as recently demonstrated on the Nixus, is not a Means of Propulsion, according to well-established technical terms. Therefore, Nixus is a glider, according to the presently valid FAI Sporting Code.

But electric flap actuation offered by the introduction of a fly-by-wire system opens ways to extract energy out of the moving atmosphere in an automated way which would not be available to a pilot who manually operates a flap control system. Such means of improving glider performance fall in the category of autopilot functions. We recommend to initiate a decision among the stakeholders of gliding air sports whether the use of autopilot functions should be banned in gliding competitions and/or record flying.

The technical development of pilot assistance systems is rapidly progressing at present. It is rather uncertain how the available means of assisting the glider pilot will develop in the future. We recommend that FAI Air Sports Commission IGC installs a standing committee to monitor and review progress in the field. Particular attention should be paid to the development of increasingly immersive means of pilot assistance.

The use of stored or harvested energy on board for the purpose of drag reduction is already practiced on high-performance gliders. We advise that it is not justifiable to put a specific limit on the allowed amount of energy on board of gliders. With respect to emerging alternative means of controlling the flow for the purpose of drag reduction, only future demonstrations can provide an answer to the question whether such systems are more effective than e.g. increasing the span of a glider. Following OSTIV's constitutional objectives "to encourage and co-ordinate internationally the science and technology of soaring and the development and use of the sailplane in pure and applied research", we do not see a need or justification to regulate such emerging technologies at the present.

APPENDIX A

Alternate means of flow control: Here we consider, as a prominent example, active means of controlling the laminar boundary layers by suction. This approach employs suction surfaces distributed over the aerodyne's outer surface that allow for sucking a small portion of the near-wall laminar boundary layer into the aerodyne, thereby delaying laminar-to-turbulent transition and reducing viscous drag. The further treatment of the sucked-in airstream is critical. If that low-momentum airstream is put to higher pressure by a mechanically or electrically driven pump and eventually discharged into the direction opposite of flight, the treatment can be characterized as propulsion by boundary-layer ingestion. However, other solutions to the discharge problem may exist that avoid the creation of a propulsive force. The technology has been shown to reduce drag in wind tunnels, but has not yet been demonstrated to be effective on a glider.