SIMPLIFIED VEHICLE OPERATIONS: PATHWAY TO AUTONOMY

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Simplified Vehicle Operations (SVO) is the concept of increasing safety and utility of aircraft or helicopters by eliminating the physical skill requirements of aircraft operations. Loss of Control of aircraft contributes to 70% of GA accidents. Can we reduce this number by making aircraft dramatically easier to fly? What sorts of things could be automated, and how would this affect aviation as we know it?

INTRODUCTION

There are a number of "revolutions" taking place almost simultaneously across the aviation marketplace. First of all is a revolution in small, high reliability, high performance computers. Second is a revolution in sensors and sensor processing, with both getting dramatically smaller and easier to use. Third is the interest in eVTOL, UAV, and other applications of multirotor and tiltrotor aircraft that do not use traditional control and surfaces to maneuver the aircraft, and instead rely on advanced FCC (flight control computers) to manage multiple control loops to engineer stability on an unstable system. Manual control (individual throttle control) of such an aircraft would be very difficult to impossible, making computer assistance a requirement. Finally, we have a revolution in artificial intelligence, allowing new ways of creating interfaces to vehicles and information

WHY SVO?

According to the FAA, 70% of General Aviation accidents (across aircraft, rotorcraft, experimental and ultralights) involve loss of control. The US Helicopter Safety Team (USHST) reports at 41% of helicopter accidents involve loss of control. Loss of control is a situation where the pilot of the aircraft is no longer controlling the flight path of the vehicle. This includes stall/spin accidents in fixed-wing aircraft, overspeed or overstress resulting in structural failure, loss of directional control on the runway or during taxi, or minimum controllable airspeed in a twin engine plane. In helicopters, which are far more difficult physically to control, the pilot may lose control in a hover, have a "settling with power" or vortex ring state uncontrollable descent, or face an LTE (Loss of Tail Rotor effectiveness) accident. Even a simple hard pull on the collective in a turbine helicopter may over torque the rotor system and do a million dollars of damage to a gearbox.

The premise put before you is to question if the addition of automation and/or autonomy in the aircraft could reduce the amount of risk in aircraft by adding an additional safety barrier to loss of control accidents by reducing the amount of physical skill involved in piloting, and creating an aircraft that "refuses to crash".

IMAGINE A WORLD – SVO EXAMPLE

Let's image one version of SVO. The objective in this thought experiment is to imagine if flying was as simple as driving from a physical standpoint. To start an airplane, we get in the plane and turn the key. The engine starts. No mixture, no prop, no priming. All the electrical systems come

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on and all the avionics start up. The radio tunes itself to the ground control frequency, and the ADIS information is displayed on the display in front of you. Once you get clearance, you drive the plane to the runway, using the yoke to point the plane down the taxiway and a brake pedal to adjust speed. During the taxi, the plane performs the runup by itself. By the time you arrive at the departure end, the plane is ready to go. The radio changes to tower frequency when the ground controller says “contact tower on 122.3”. You have already downloaded your flight plan from your tablet to the aircraft’s nav system. Then you get clearance and take the runway. You push the throttle to the stop and pull full back on the control yoke. The aircraft flies off the runway. You hold this configuration until reaching cruise altitude, then release the yoke and the aircraft levels off and turns on course for your destination. For landing, you put the throttle in “descend” detent, and point the aircraft at the runway with the yoke. The aircraft flies at the correct speed and you steer to the runway, pointing the nose of the aircraft at the numbers. The aircraft flares by itself, and touches down. You drive off the runway and to parking. A no point did you worry about speeds, angle of bank, coordination, or keeping a heading.

This would be a simplified control based paradigm for SVI. It still uses the controls but in a simplified manner. The next paradigm is very different.

BUTTON CONTROL – SVO PARADIGM

Another type of control technique for SVO we might call the “button” paradigm. For this mode, the pilot never touches the control yoke or stick, and instead uses a touch screen interface with buttons and sliding indicators. The startup and preflight are as above. For taxi, the operator selects the runway (and taxiway path) and hits “taxi” button. The aircraft moves by itself to the proper runway, avoiding other aircraft and other obstacles as necessary. The aircraft performs the runup by itself, and announced “ready for takeoff”. The pilot pushes a button for “take runway for takeoff” and once the aircraft is in position, and clearance received, pushes a “takeoff” button. The aircraft rolls and takes off, assuming a best rate of climb. Now the flight plan is engaged. At any point, the pilot can use “knobs” to modify the flight, turning the nose right or left, or climbing or descending by adjusting the altitude setpoint. The pilot selects the proper runway for landing, and the aircraft lines itself up for landing. Let’s say another aircraft cuts in front of you on downwind. You push a “circle” button to do a quick 360 to give spacing.

The entire flight is made without touching any controls. For helicopters, SVO reduces workload further by providing position hold hovering, vector controlled hover taxi, auto climbout, level flight, descent and hover at the other end. All coordination is controlled by the computer, which manages yaw and balances collective, cyclic, and anti-torque inputs.

WHAT ABOUT FAILURES

SVO does not mean that the aircraft reverts to manual control after a systems failure. Indeed, for eVTOL multicopter and other complex aircraft that may not be possible. The control system has to be designed to “fail safe” and to drop to a safe degraded mode. SVO systems may have a “pilot-on-the-loop” mode where the pilot can put in “knobs” commands – airspeed, altitude, heading, rate of climb/descent, airspeed, and have control of the flight path while still having the safety of the control system.

Another mode may include a joystick to “point” the aircraft – climb up, descend down, turn right, left.

SVO design must provide for fallback modes that still control the aircraft and provide safe operations.

WORRY FREE CONTROL

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A side benefit of SVO can be the concept of "worry free control", which can also be called "Carefree maneuvering". In this mode, the full operational envelope of the aircraft can be exploited, but with limitation to prevent loss of control. This may include g-limits, angle-of-attack limiters, bank angle limits. Other monitors may provide envelopes around power settings, torque limits, or propellor rpm. The concept is to allow the pilot to move the controls at any rate, to the stops, without exceeding the performance envelope of the aircraft. This may require auto leveling, coordination, or changing trim levels and force feedback detents.

NEXT STEPS

The industry has been working to define the rules around SVO. GAMA, the General Aviation Manufacturer's Association, has a SVO committee as does the NBAA. They are working with the FAA to determine the limitations around SVO, and to define if a new rating for SVO aircraft will be necessary.

Regardless, the safety benefits of SVO to reduce accidents must be investigated and developed.

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