9th INTERNATIONAL SCIENTIFIC CONFERENCE
ON DEFENSIVE TECHNOLOGIES
OTEH 2020
Belgrade, Serbia, 15 – 16 October 2020

U75A41M "SOVA" CERTIFICATION UNDER CS-23

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Abstract: *In order to position their aircraft in the European and World market, companies try to design their products with high performances and, what is more important, with safe characteristics. For that reason, aircraft are being certified under different regulations but with the same goal, to prove its quality and safety.*

U75A41M "SOVA" prototype is in the final stage of certification under CS 23. Through the certification process, ground and flight tests were performed; controllability, stability, manoeuvrability, limitations were established; compliance with specified requirements for design and construction, powerplant, electrical and electronic system and operating limitations was shown.

Keywords: *Certification, compliance, testing, analysis, design.*

1. INTRODUCTION

UTVA Aviation Industry is constantly improving in order to keep up with global tendencies. It is a unique company because it summarizes everything in the cycle of creating an aircraft - design, production, flying tests and certification.

Already approved as design and production organization by CAD RS, UTVA AI is in the final stage of certification of U75A41M "SOVA" prototype by CS 23 in normal and utility category. In order to conduct certification, we had to implement and perform ground and flight tests and show compliance with specified requirements of CS 23.

In this paperwork, we will demonstrate compliance and tests for several paragraphs of CS 23 Subpart B (Flight), D (Design and Construction) and E (Powerplant) .

2. CERTIFICATION

2.1 SUBPART B - Takeoff/Landing and Climb speed

Flight testing, as an important segment of certification process, is performed in accordance with CS 23 Book 1/ Book 2 and Flight Testing Matrix which is approved by CAD. For each phase of flight testing Permit to Fly has been issued by CAD RS in accordance with Part 21. Before each flight pilot was informed about specific testing and expected results. After the flight, during debriefing, flight testing results and aircraft performance were analized.

One of the main parts in certifications for test flight is to define maximum climb speed, takeoff/landing speed and runway distance by modifying aircraft mass.

All tests are done for standard temperature and height. In the next steps diagrams will be presented for two tests phases (Takeoff/Landing and Climb speed) with further explanation.

Climb (CS 23.63, 23.65)

For different climbing speeds, it is required to define maximum and optimum vertical climb speed. Diagram for maximum and optimum climb speed is prepared for 3 different heights, and speed range was 60 to 90 [kts].

In **Figure 1** climb speed and approximate 2nd order polynomial line is presented, for which climbing to specific height is defined.

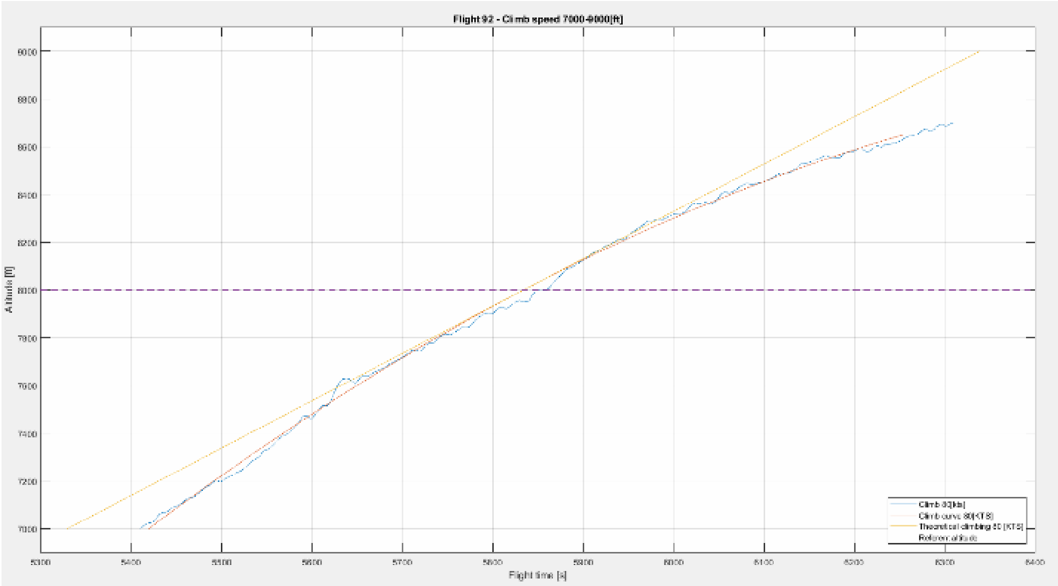

Figure 1. Climb speed and calculated climb speed

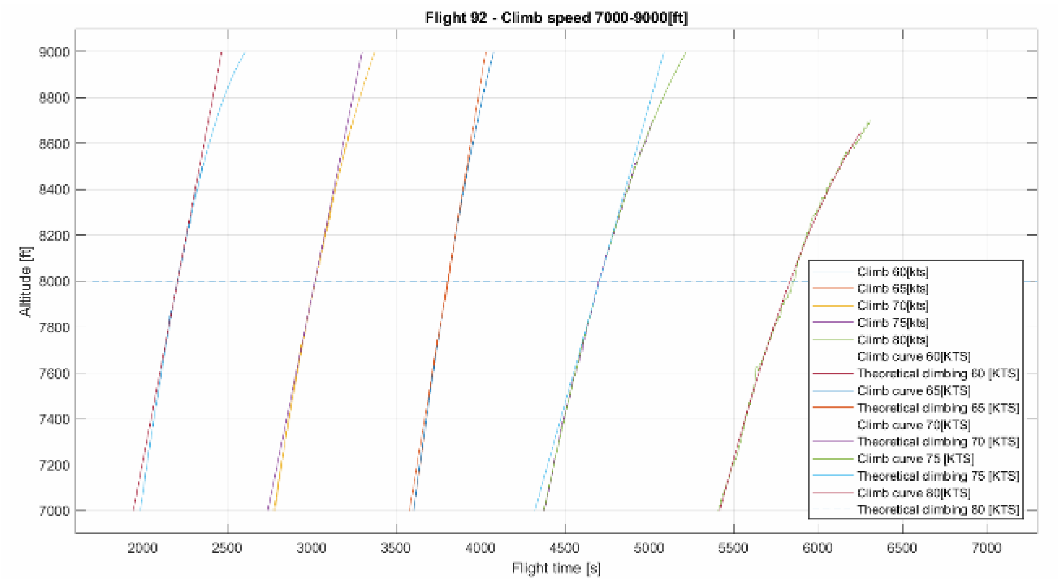

Figure 2. Curve for climbing and approximate lines for specific climb speed

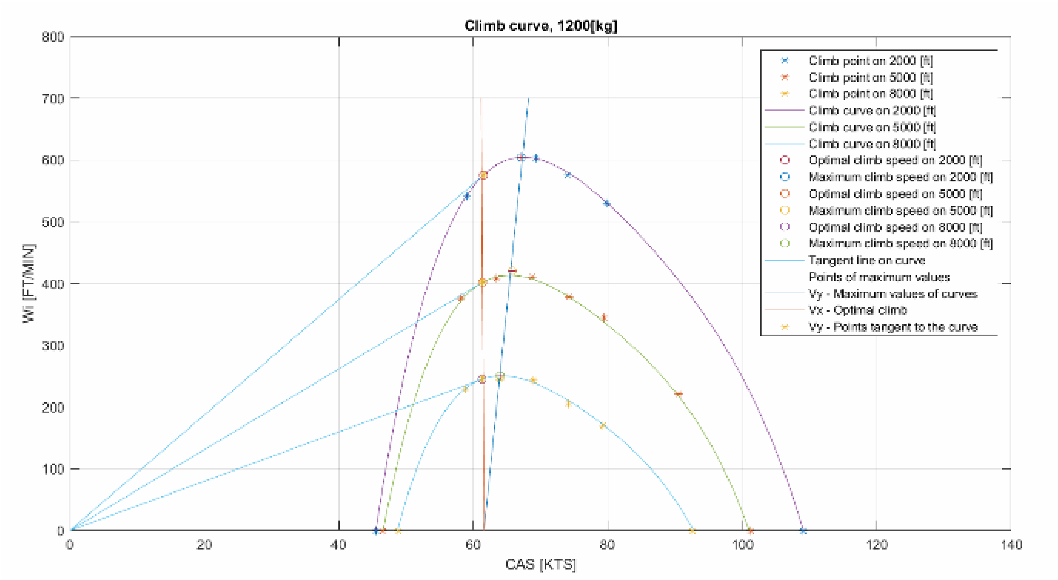

Figure 3. Climb speed for specific height and speed

On each curve for climbing speed, tangent lines are passing through specific points that represent referent height. Presented speeds are important for aircraft performance.

Table 1. Rate of climb

Climb speed [IAS]	60	65	70	75	80	90
Rate of climb [%]	11.6	13.09	13.20	13.54	13.16	8.4

Table 1 represents rate of climb at sea level for range of speed, and all rates are greater than 8.3%. This shows complience with CS 23.65 (a).

Takeoff and Landing (CS 23.51, 23.53, 23.73, 23.75)

For the requirements required by CS 23, it is necessary to determine:

– minimum takeoff and landing runway distance (for a certain mass and temperature during the test), and

– minimum speed that the aircraft must have at rotation speed V_R and in the approach to the takeoff and landing runway.

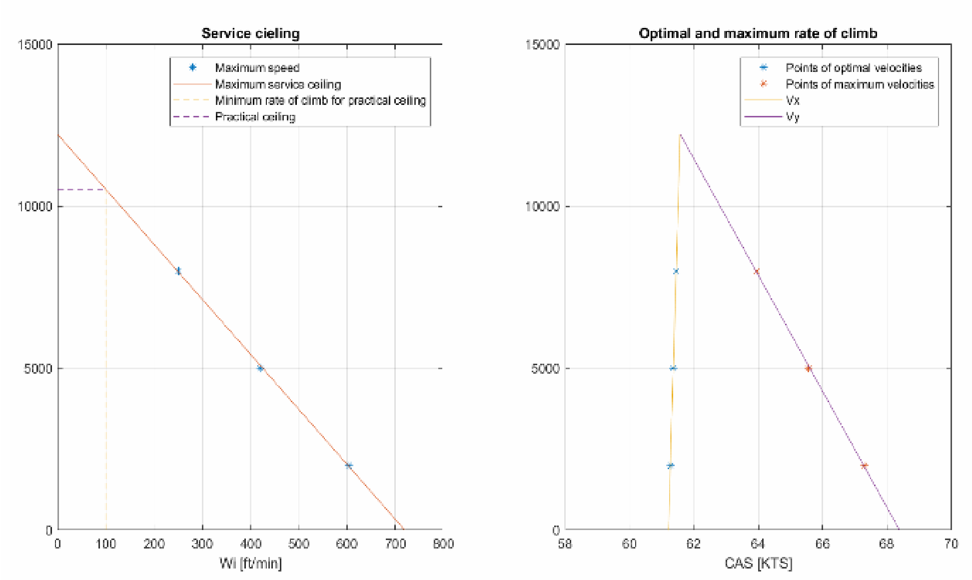

Figure 4. Maximum height and climb at sea level

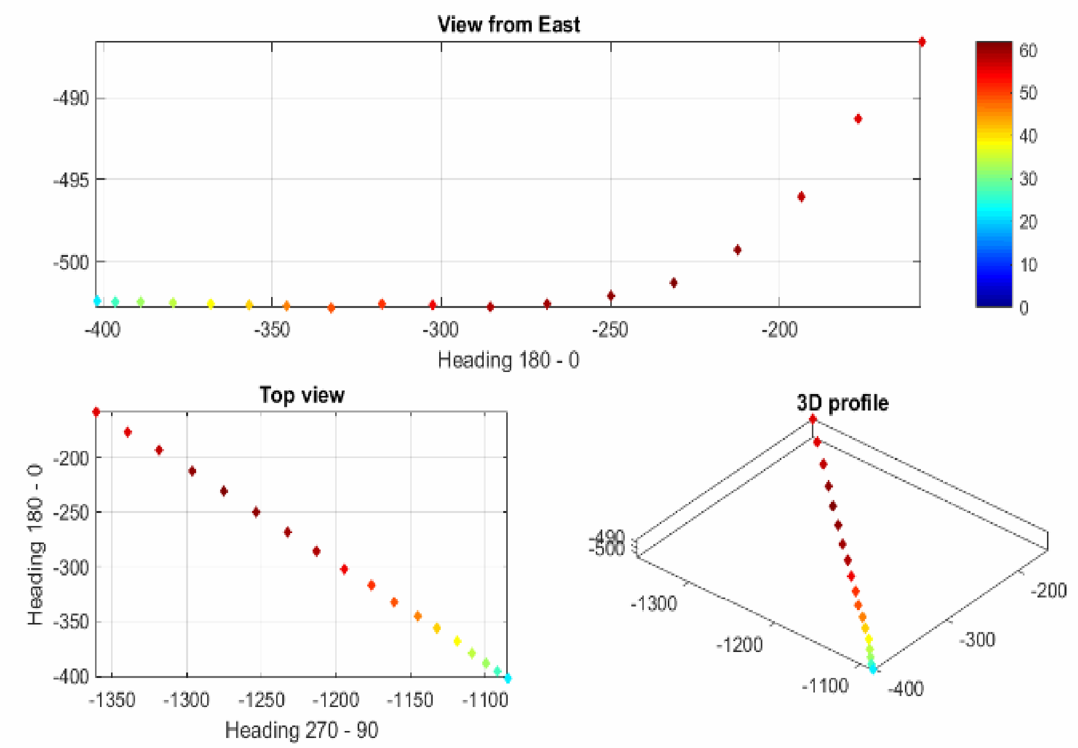

Figure 5. Graphical display of take-off via GPS coordinates shown by the iAero acquisition device

Table 2. Take-off lengths obtained on the day of the test as well as the climbing angles and the time required for the take-off to take place.

Takeoff number Grass, 1050 [kg]	Length up to V_{ROT}	Length up to 50 [ft] height	Current mass	Takeoff angle	Duration of take off to altitude 50 [ft]
/	[ft (m)]	[ft (m)]	[kg]	[°]	[s]
Takeoff No. 1	594.71 (181.27)	984.25 (300)	1059.0	5.93	15.76
Takeoff No. 2	603.6 (183.98)	923.22 (281.4)	1057.11	7.31	15.26
Takeoff No. 3	570.63 (173.93)	880.84 (268.48)	1055.23	6.32	15.02

Table 3. Length at take-off depending on the weight of the aircraft and temperature

Weight [kg]	Takeoff speed–IAS [kts]		Altitude [ft]	0°		10°		20°		30°		40°	
				Length [ft]									
	up to V_R	up to 50 [ft]		up to V_R	up to 50	up to V_R	up to 50	up to V_R	up to 50	up to V_R	up to 50	up to V_R	up to 50
1050	50	60	SL	745	1620	770	1680	800	1740	825	1800	855	1855
			1000	765	1670	795	1730	825	1790	850	1855	880	1915
			2000	790	1720	820	1780	850	1845	875	1910	905	1970
			3000	815	1770	845	1835	875	1900	905	1965	935	2030
			4000	840	1825	870	1890	900	1960	930	2025	960	2095
			5000	865	1880	895	1950	930	2020	960	2090	990	2155
			6000	890	1940	925	2010	955	2080	990	2155	1020	2225
1200	55	65	SL	1190	2070	1235	2145	1280	2220	1325	2295	1365	2370
			1000	1230	2130	1275	2210	1320	2285	1365	2365	1410	2442
			2000	1265	2195	1310	2275	1355	2355	1405	2435	1450	2515
			3000	1305	2260	1350	2345	1400	2425	1445	2510	1495	2590
			4000	1345	2330	1390	2415	1440	2500	1490	2585	1540	2670
			5000	1385	2400	1435	2490	1485	2575	1535	2665	1585	2750
			6000	1425	2475	1480	2565	1530	2655	1585	2745	1635	2835

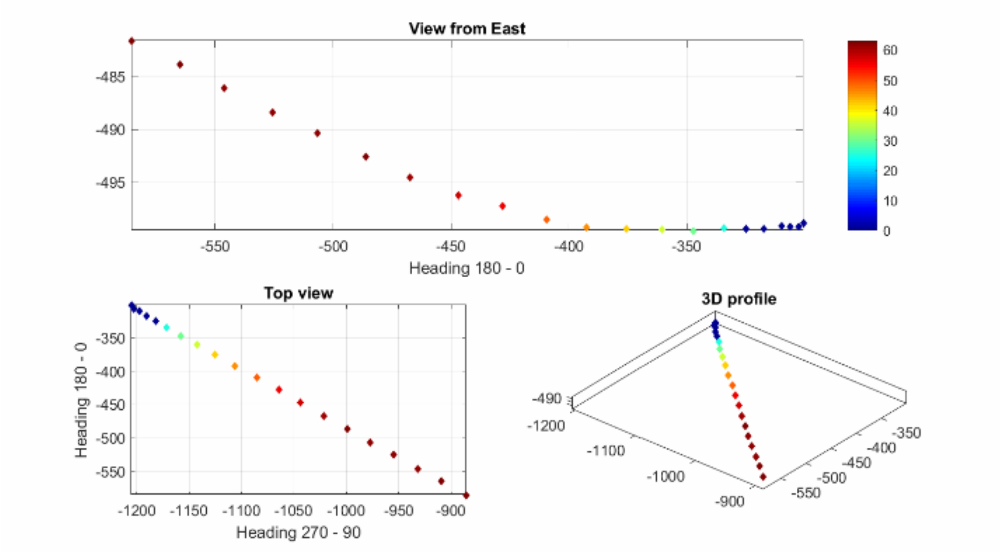

Figure 6. Graphical representation of the landing via GPS coordinates shown by the iAero acquisition device

Table 4. Landing speeds, takeoff and landing runway approach angle as well as time required for landing

Landing number Grass, 1200 [kg]	Speed V_{REF} – IAS	Speed V_{REF} – CAS	Landing time	Approach angle	1.3 V_{S0} [CAS]
	[kts]	[kts]	[s]	[°]	[kts]
Landing No. 1	69	69.91	20.01	4.327	69.57
Landing No. 2	69.1	70.02	18.88	5.233	69.50
Landing No. 3	69	69.91	18.52	4.376	69.44

Table 5. Landing distance depending on the weight of the aircraft and temperature

Weight [kg]	Landing speed – IAS [kts]		Altitude [ft]	0°		10°		20°		30°		40°	
				Length [ft]									
	from V_{REF}	from 50 [ft]		from V_R	from 50[ft]	from V_R	from 50 [ft]	from to	from 50 [ft]	from V_R	from 50 [ft]	from V_R	from 50 [ft]
1050	50	65	SL	470	1345	485	1395	505	1445	520	1495	540	1545
			1000	485	1385	500	1435	520	1490	535	1540	555	1590
			2000	500	1425	515	1480	535	1530	555	1585	570	1635
			3000	515	1470	535	1525	550	1580	570	1635	590	1685
			4000	530	1515	550	1570	570	1625	590	1680	605	1740
			5000	545	1560	565	1620	585	1675	605	1735	625	1790
			6000	565	1610	585	1670	605	1730	625	1790	645	1845
1200	55	70	SL	495	1365	510	1415	530	1465	550	1515	565	1565
			1000	510	1405	525	1455	545	1510	565	1560	585	1610
			2000	525	1450	545	1500	560	1555	580	1605	600	1660
			3000	540	1490	560	1545	580	1600	600	1655	620	1710
			4000	555	1535	575	1595	595	1650	615	1705	635	1760
			5000	575	1585	595	1640	615	1700	635	1760	655	1815
			6000	590	1635	610	1695	635	1750	655	1810	675	1870

Take-off and landing distances are determined according to paragraphs CS 23.51, 23.53, 23.73, 23.75.

2.2. SUBPART E - Firewall

According to paragraph **CS 23.1182**, instruments, components, piping and connections behind the firewall must be made of such materials and placed at such distances from the firewall that they will not suffer damage sufficient to endanger the aircraft if the side of the firewall in the engine compartment is exposed to flame temperature not less than 1093°C (2000°F) for a period of 15 minutes.

In order to prove this paragraph, it was necessary to make a plan for testing the plane's firewall of aircraft U75A41M "SOVA".

The aim of the test was to measure the temperature on the cold side of the firewall, to determine that there would be no damage to the equipment and instruments behind the firewall if a flame occurred in the engine compartment.

In order for the test to be regular, a firewall simulation of aircraft U75A41M "SOVA" was designed.

Before the start of the firewall test, the flame was calibrated. For this purpose, a flame-exposed temperature probe was used to calibrate the flame to a minimum of 1100°C.

When the flame was calibrated at 1100°C, the heating of the firewall was started for 15 minutes, on the side exposed to the engine compartment, the stainless steel side.

Measurements were performed every 5 minutes on the cold side of the firewall, with a laser thermometer.

Figure 7 shows the measurement zones, as well as diagram in **Figure 8** of the change in temperature as a function of time.

The firewall is designed from stainless steel sheet 1.4544.9, where the melting temperature of this sheet is 1400°C, which is much more than the temperature required by CS.

Figure 7. Temperature measurement zones

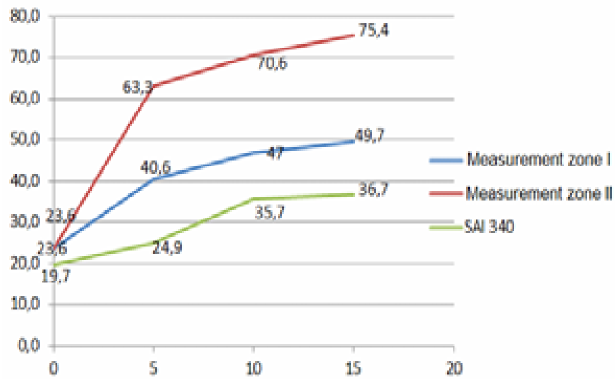

Figure 8. Temperatures as a function of time

This testing showed that the firewall has sufficient insulation to withstand heat convection and is designed so that the flame temperature in the engine compartment of at least 1100°C will not endanger the pipelines, connections, components and equipment behind the firewall.

2.3. SUBPART D - Trim systems

According to the paragraph **CS 23.677**, proper precautions must be taken to prevent inadvertent, improper, or abrupt trim tab operation.

Trimming devices must be designed so that, when any one connecting or transmitting element in the primary flight control system fails, adequate control for safe flight and landing is available with the longitudinal trimming devices.

It must be demonstrated that the aeroplane is safely controllable and that the pilot can perform all the manoeuvres and operations necessary to effect a safe landing following any probable powered trim system runaway that reasonably might be expected in service, allowing for appropriate time delay after pilot recognition of the trim system runaway. The demonstration must be conducted at the critical aeroplane weights and centre of gravity positions.

Elevator and aileron trim controls are activated by „trim hat" switch on the pilot stick (**Figure 9**), while the rudder trim control switch is positioned on the instrument panel. There is no possibility of their improper operation. All three trim tabs are driven by electric actuator, making their abrupt deflection improbable.

At the lower, central section of instrument panel, trim controls with their visual scheme are arranged within separate unit (**Figure 10**). Beside rudder trim control knob all three controls deflection is displayed (**Figure 11**). Neutral positions are marked, and deflection (left-right, UP-down) are represented by illumination of diodes.

Figure 9. Elevator and aileron trim control

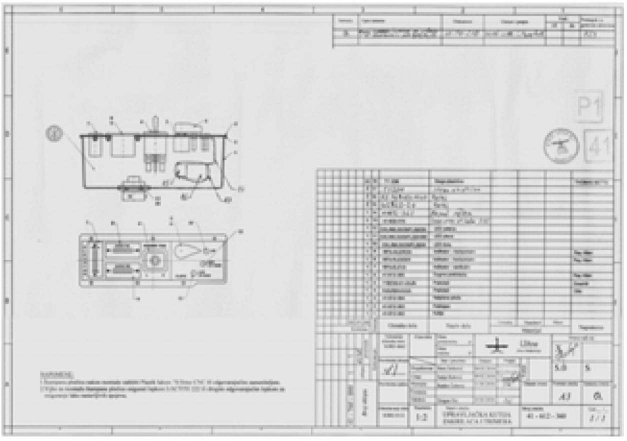

Figure 10. Flaps and trim tab control unit

Figure 11. Cockpit rudder trim control

Flight Testing has been performed in Pančevo airport zone (LYPA) under Batajnica Air Traffic Control.

Testing are performed in accordance with the program submitted to CAD RS performing the audit of testing procedure.

During testing, flight parameters were recorded by APIBOX SISTEM and Quantum X acquisition device. APIBOX SISTEM was calibrated per its instructions, and for Quantum X calibration was performed by device manufacturer during device installation.

In flight No.102, safety of flight and landing has been successfully demonstrated with aircraft controlled by trimmers only.

It has been demonstrated during flights 132 and 133 that the aircraft is controllable and capable of safe landing even after trim system fault occurrence.

Landing using elevator trimmer only

According to subparagraph **CS 23.677(b)** certification specification, it is required that, in case the primary controls fault occurs, aircraft is to be controllable and land safely using elevator trimmer only. That has been demonstrated during flight No. 102 when the pilot, using elevator trimmer control only, performed safe landing.

Based on constant value of elevator deflection during landing, displayed in the above diagram (**Figure 12**), it can be concluded that during landing, pilot was not using elevator control, but elevator trim tab control only.

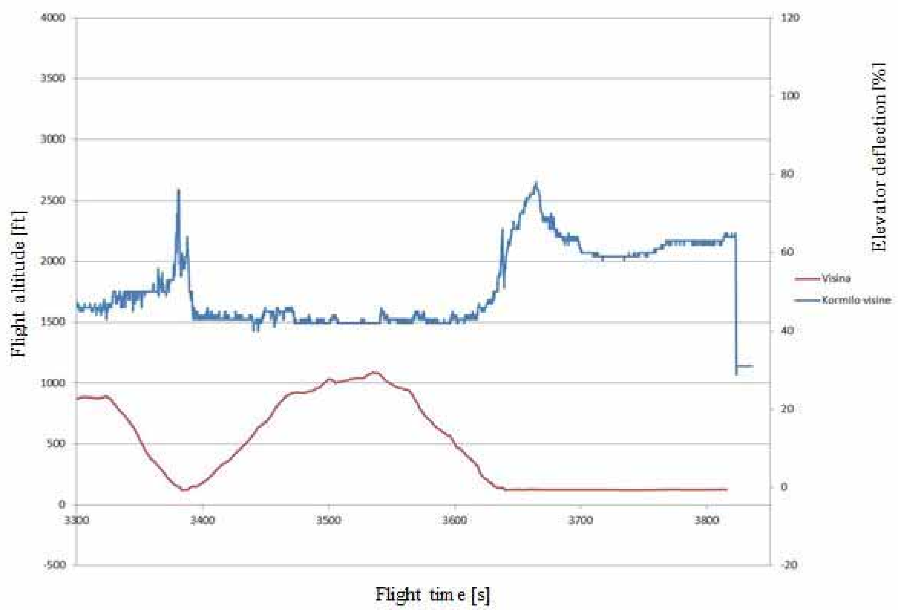

Figure 12. Elevator trim tab deflection and altitude change with time (Flight 102, landing with elevator trimmer only)

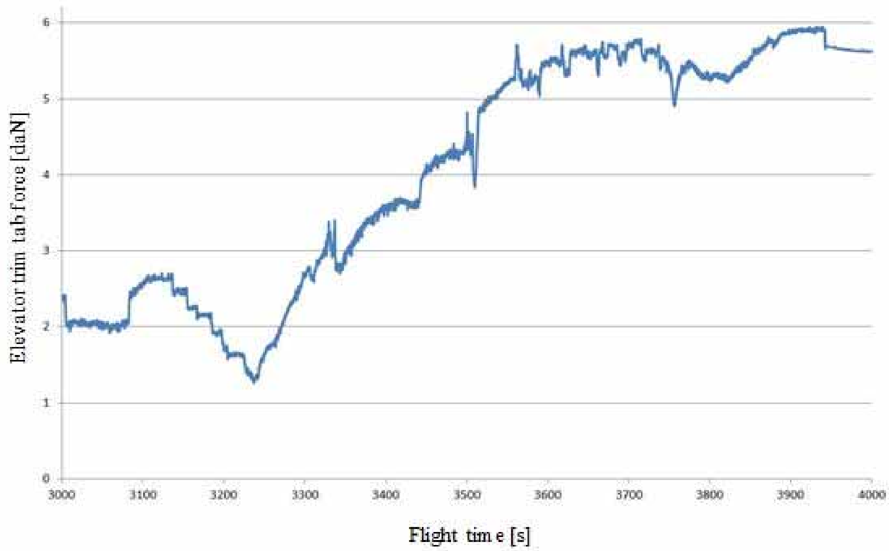

Figure 13. Force registered on elevator trim tab (Flight 102, Landing using elevator trim tab)

Increase in force on the elevator trim tab has been registered during landing, with maximum force of 5,8 daN (**Figure 13**).

Flight testing with elevator, rudder and aileron trim tab in maximum deflection position

Certification specification of subparagraph **23.677(d)** is considering possible trim systems faults. Therefore, appropriate analysis has been conducted and conclusion was made, there is a possibility of electric actuator jam or electric circuit break when trim tabs are used, causing them to stay in the position taken in the moment of fault. Example of most critical case of such fault is with trim tabs in maximum deflection position.

In flight 132, simulation of trim tabs jammed in maximum deflection positions were conducted. At 1000 ft altitude, the pilot performed airfield traffic patterns, with elevator, rudder and aileron trim tab deflected in maximum deflection position, respectively. It has been demonstrated in that flight that the aircraft is fully controllable at maximum deflection of each trim tab.

Maximum pilot stick force, with elevator trim tab deflected down (position UP), was registered during landing and it amounted 17,24 daN. With aileron trim tab deflected, maximum registered stick force was 13,77 daN and for rudder trim tab deflected, it was 71,42 daN force registered on pedals. The aircraft was fully controllable, as stated by pilot in his Report of 15 May 2020.

As per **Figure 14**, that trim tabs were deflected above 1000 ft altitude. The moment trim tab returned to its neutral position i shown in this diagram as well.

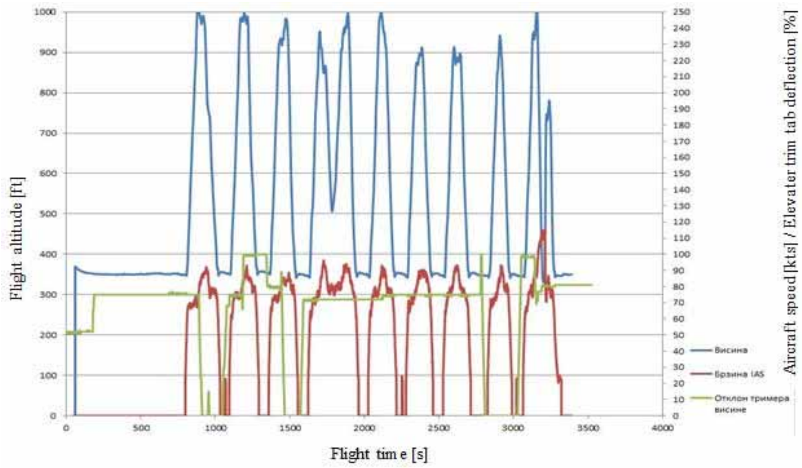

Figure 14. Elevator trim tab deflection, IAS and altitude change with time (Flight 132, Elevator trim tab maximum deflection)

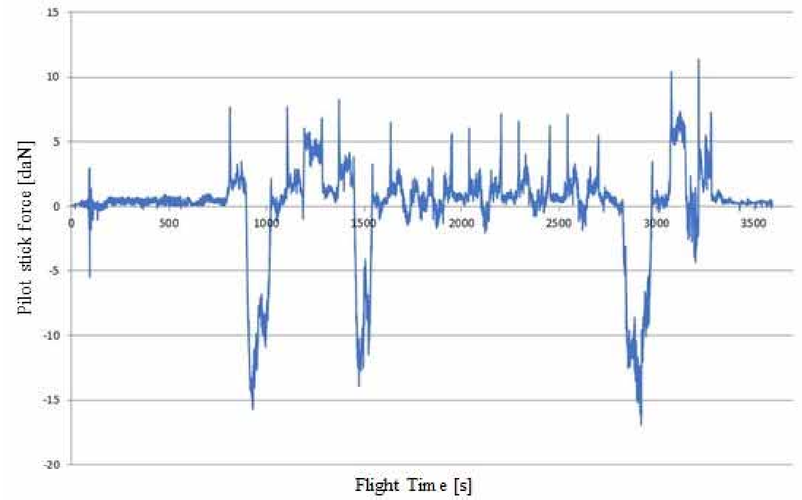

Figure 15. Pilot stick force change with time (Flight 132, Elevator trim tab maximum deflection)

During rudder and aileron trim tab testing, aircraft had slight tendency of sliding, and rolling, but in Pilot Report it has been stated that forces registered on pilot stick are very small and the aircraft is easily controllable all the time.

Flight testing with elevator trim tab in neutral position.

With respect to trim system fault expected in service, there is a possibility of elevator trim control circuit break, that would disable its use during flight.

In flight 133, it has been shown that in case mechanical fault occurs, simulated by detached push/pull rod from electric actuator, the aircraft U75A41M "SOVA" is fully controllable and can perform safe landing.

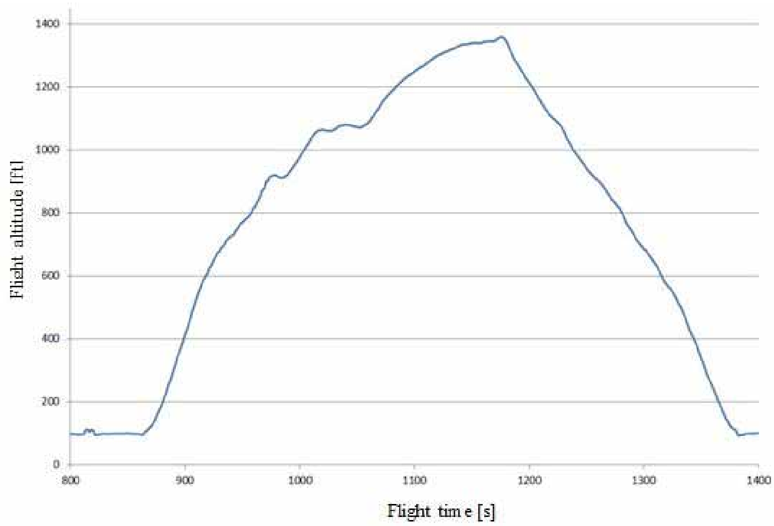

Figure 16. Flight altitude change with time (Flight 133, Elevator trim tab detached)

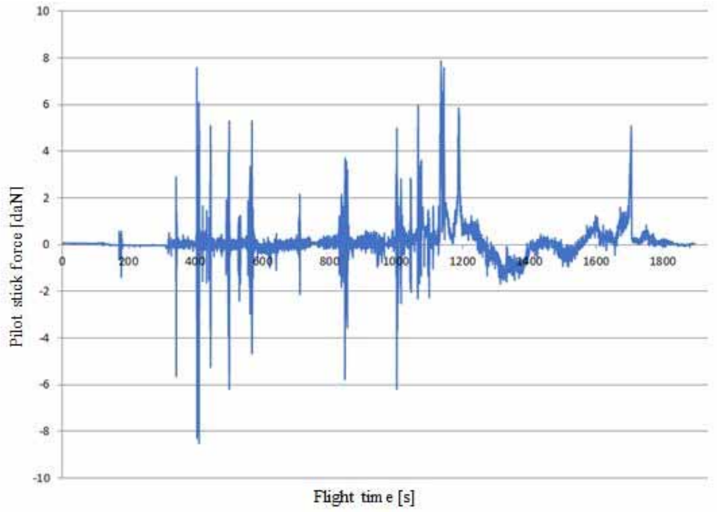

Figure 17. Pilot stick force change with time (Flight 133, Elevator trim tab detached)

Maximum pilot stick force of approximately 8 daN was registered during flight without use of the elevator trim tab (**Figure 17**).

These flights showed that, in case any element in the primary flight control system fails, safe flight with landing is possible using elevator trim tab only. It has also been shown that the aircraft is safely controllable and can be landed safely if powered trim system runaway occurs.

According to Pilot Reports, there were no occurrences on controls during take off or landing that could affect flight safety, pilot stick forces were moderate and the aircraft was fully controllable all the time.

3. CONCLUSION

Certifying an aircraft is a long and demanding process. It consists of defining the means of compliance for all CS 23 paragraphs, followed by test pilot selection and writing numerous flight test plans, as well as performing prototype modifications in order to comply with the requirements.

R&D team of engineers is proud to make all the necessary achievements in the certification process of U75A41M "SOVA" prototype. It was, above all, a very interesting experience. UTVA AI started from the idea of this prototype, designed it, manufactured it and finally successfully reached the end of certification process.

References

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