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TESI DI LAUREA

Flight Test Program for a General Aviation aircraft in asymmetric configuration: planning, execution and data processing

Flight Test Program per un velivolo di Aviazione Generale in configurazione asimmetrica: pianificazione, esecuzione ed elaborazione dei dati raccolti

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Table of contents

1 Introduction **7**

2 Project description **9**

2.1 Description of change and classification 9

2.2 Certification basis (CS) 13

3 Flight Test Program **26**

3.1 Effects of Change on the Aircraft 26

3.1.1 Effects at $\boldsymbol{VNE = 141\ knots}$ 28

3.1.2 Effects at $\boldsymbol{VC = 81\ knots}$ 28

3.1.3 Effects at $\boldsymbol{1.1VS1 = 48\ knots}$ 28

3.2 Test Operations 30

3.2.1 Category of Flight Test 30

3.2.2 Flight Test Matrix 30

3.2.3 Test instrumentation 33

3.2.4 Test limitations 36

3.2.5 Aircraft loading conditions 37

3.3 Test Schedule 43

3.3.1 Flight Test Routine 46

4 Flight Test Execution **48**

4.1 Flight #1 51

4.1.1 Mission profile 51

4.1.2 Weight and Balance 53

4.1.3 Procedures and data recording 55

4.1.4 Results 56

4.2 Flight #2 62

4.2.1 Mission profile 62

4.2.2 Weight and Balance 64

4.2.3 Procedures description 66

4.2.4 Results 67

4.3 Flight #3 ... 71
4.3.1 Mission profile ... 71
4.3.2 Weight and Balance ... 73
4.3.3 Procedures description ... 74
4.3.4 Results ... 74
4.4 Flight #4 ... 79
4.4.1 Mission profile ... 79
4.4.2 Weight and Balance ... 82
4.4.3 Procedures description ... 83
4.4.4 Results ... 83
4.5 Flight #5 ... 87
4.5.1 Mission profile ... 87
4.5.2 Weight and Balance ... 90
4.5.3 Procedures description ... 91
4.5.4 Results ... 92
4.6 Flight #6 ... 101
4.6.1 Mission profile ... 101
4.6.2 Weight and Balance ... 103
4.6.3 Procedures description ... 105
4.6.4 Results ... 107
4.7 Flight #7 ... 111
4.7.1 Mission profile ... 111
4.7.2 Weight and Balance ... 114
4.7.3 Procedures description ... 116
4.7.4 Results ... 118
5 Conclusions and future work ... 125
Ringraziamenti ... 127
Acronyms ... 128
References ... 130

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1 Introduction

The market of aerial Earth observation services is mainly based on three different kind of platforms: satellites, aircrafts and UAVs offering a great variety of performance in terms of sensor class, ground resolution, hourly productivity and cost. DigiSky mainly focused on the General Aviation segment by developing a platform, SmartBay, able to cover wide areas, characterized by different terrain morphology, with high-resolution sensors while ensuring low operative costs, overcoming the limits imposed by low productivity and restrictions of UAVs and the costs of bigger aircraft classes.

SmartBay solution enables a GA aircraft with the capability of boarding up to three different sensors simultaneously under the wing, thanks to a carbon fiber pylon, in order to quickly and efficiently reconfigure the payload and to perform complex, aerial mapping missions. In addition, SmartBay is equipped with its own Payload Control System (PCS), which automatically manages all sensors activity during the mission while providing the pilot with navigation information and sensors data through the Crew Operator Deck (COD) screens.

The first aircraft to feature this system for certification purposes is a Tecnam P92JS. Several reasons led to this choice, such as: the availability of an ultralight version of the same aircraft, which allowed a preliminary testing of the solution in an easier normative context and the proximity to the manufacturer, which collaboration was essential. Finally, the certification of this system on an aircraft with such low MTOW and dimensions would pave the way to a possible up-scale on bigger airplanes.

The purpose of this dissertation is to present the work done during the final part of the certification program, involving the flight test activity, which led to the EASA Supplemental Type Certification approval of the Tecnam P92JS equipped with SmartBay system. The Flight Test Program was agreed upon with the DOA and ENAC; the whole process can be described as follows:

- Requirement analysis: Election of the affected requirements of CS-VLA;
- Flight Test Matrix generation: According to the affected requirements, all Test Points (TPs) necessary to the showing of compliance are listed identifying maneuvers, aircraft loading, altitude, speed and power settings;
- Flight Test Schedule generation: All Test Point are split into several flights according to specific criteria and a Test Plan is issued;
- Flight Conditions Approval: EASA approves the Flight Conditions based on the Test Program and structural and aerodynamic substantiations and issues a Permit to Fly;
- Flight Test Cards preparation: For each test flight a Test card is prepared. It shall contain a brief summary of the conditions of each test point and designed so that all necessary data can be easily recorded by the Flight Test Engineer;
- Flight Test Program execution: All TPs are carried out and data are recorded;

- Test Report Issuance: Based on the analysis of the results and the Pilot Flight Reports, a test report is produced;
- Results submission to ENAC: Results and conclusions are submitted to ENAC for approval;
- EASA issues the STC

The preparation of the Test Program and the execution of the tests was particularly interesting due to the asymmetry of the aircraft induced by such system and particular focus was on the procedures which involved lateral and directional maneuvers. All tests were carried out according to the test plan and no hazardous behaviors of the aircraft were encountered in any of the configurations tested. Some minor changes to the Aircraft Flight Manual performance section were however necessary, refer to chapter 5 for detailed information.

Figure 1-1: Tecnam P92JS equipped with SmartBay pylon

2 Project description

2.1 Description of change and classification

This change consists in the installation of the SmartBay kit designed by DigiSky on Tecnam P92 JS series aircrafts.

SmartBay system's (SBE) purpose is to equip an airborne platform with a set of interchangeable payloads mounting different types of sensors to cover a wide range of missions such as surveillance, aerial mapping, territory monitoring, multispectral mapping and many others.

SBE system is composed by a pylon which is adapted to the aircraft right wing where all the payloads as well as the processors and interfaces needed for payloads management and collection of data are located. In addition, a Crew Operator Display (COD) unit is installed in the cockpit for mission management.

In detail, SBE System is composed by the following, main elements:

- Pylon: The pylon is the physical component of SBE System whose purpose is to support the PCS/BIU and the trolleys under the wing of the aircraft.
- PCS/BIU: The Bus Interface Unit (BIU) is a board equipped with interfaces and processors, where the main processing unit is the Payload Control System (PCS). It represents the central element of SmartBay system handling the core system functionalities. This unit provides also an interface between the payloads and the COD.
- Up to 3 Trolley Slots: A trolley is a "plug-and-play" component with standardized dimensions equipped with dedicated payload used for data acquisition in a SmartBay Mission. The trolleys are connected one another as well as to the PCS/BIU and are installed inside the pylon. Each trolley is composed by a CFRP frame, with common characteristics between different trolleys, which is slid on the aluminum rails of the pylon and fastened to them. Common elements for the trolleys are the presence of the TCS (Trolley Control System), a wiring bundle and, except for the naked trolley, a PCU (Payload Control Unit) board.
- A Crew Operator Deck: The Crew Operator Deck (COD) is located in the aircraft cockpit and provides an interface between the crew (pilot and eventual operator) and the SBE System. The COD is divided into COD Pilot and COD Operator. COD Pilot consists of a screen displaying the necessary data for Mission accomplishment in terms of navigation aids, payload status and Mission progress (if applicable). COD Operator includes a screen for live video preview and a control unit for payloads requiring management from an onboard operator.

Figure 2-1 represents a three-view drawing of the Tecnam P92 JS equipped with the SmartBay pylon under its right wing. Besides the pylon, the biggest payload trolley available, a SmartGimbal, is shown.

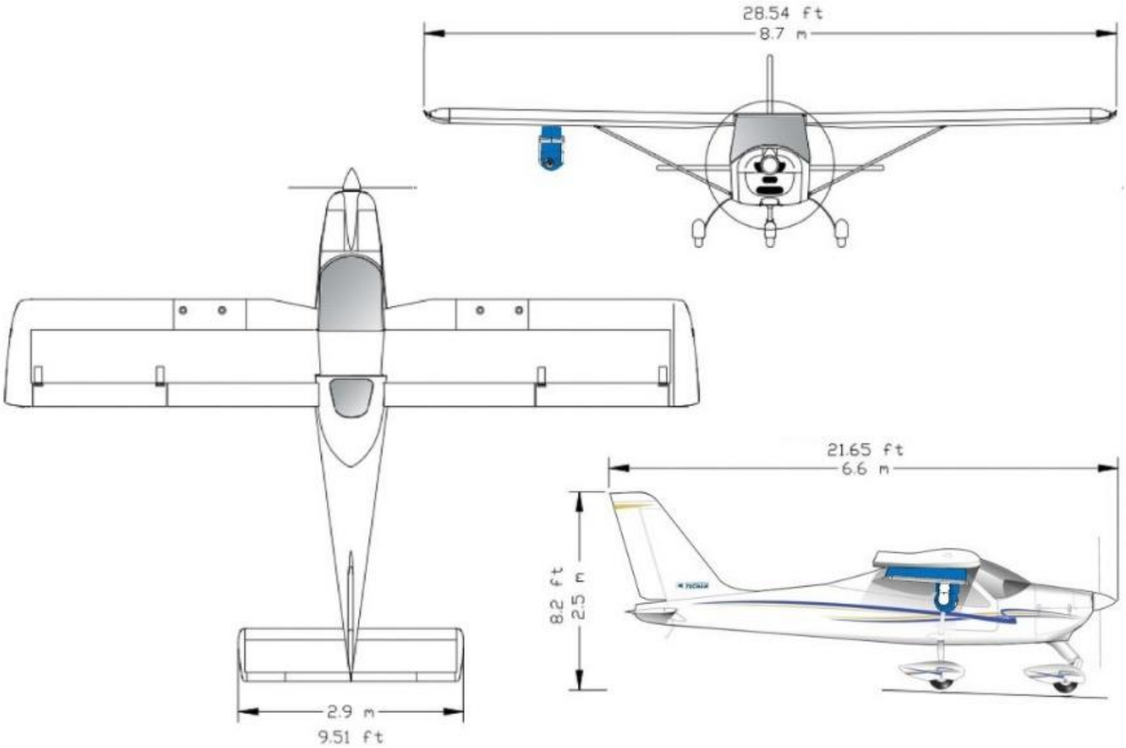


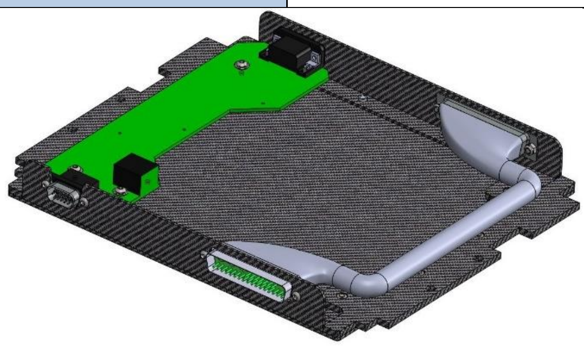
Figure 2-1: SmartBay pylon installed on Tecnam P92 JS aircraft

Within this change three payload trolleys are considered:

- **Naked Trolley:** The Naked Single Trolley is a trolley with no payload installed on it. It can be used as a bridge trolley between two trolleys equipped with some sensors or as a lid during a transfer flight.

Table 1: Naked Trolley specs

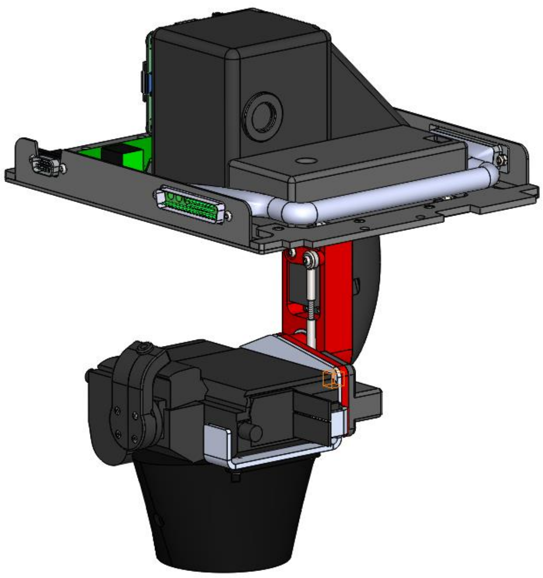
WIDTH	248 mm
LENGTH	209 mm
HEIGHT INSIDE PYLON	27 mm
HEIGHT OUTSIDE PYLON	2 mm
WEIGHT	0.4 kg



- **SmartCamera:** Is a single type trolley which can be installed in each of the three possible positions (front, center or rear). This trolley can accommodate only one sensor, selected according to the specific mission purpose. It is composed by a fixed part inside SmartBay pylon, where electronics resides, and a moving external part, where sensor is installed, stabilized along the roll axis, providing a correction for left or right turns up to 30° of bank and a correction for positive and negative aircraft pitch of 15°.

Table 2: SmartCamera specs

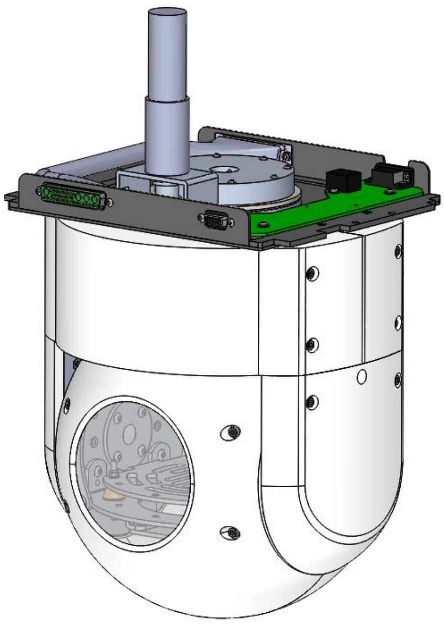
WIDTH	248 mm
LENGTH	209 mm
HEIGHT INSIDE PYLON	86 mm
HEIGHT OUTSIDE PYLON	132 mm (no sensor)
WEIGHT	1.3 kg (no sensor) 2.1 (with max approved sensor)
MAX PITCH CORRECTION	± 15°
MAX ROLL CORRECTION	± 30°



- **SmartGimbal:** Is a single trolley which can be installed in front position only both for weight and balance and operative reasons. This trolley can hold one sensor, usually a high-resolution video camera, selected according mission requirements. It is composed by a fixed part fastened to the pylon and two moving parts which independently swivel about pitch and yaw axes and accommodate the sensor. The trolley is controlled by an operator with a joystick inside the cabin.

Table 3: SmartGimbal specs

WIDTH	248 mm
LENGTH	230 mm
HEIGHT INSIDE PYLON	136 mm
HEIGHT OUTSIDE PYLON	285 mm
WEIGHT	6 kg (no sensor) 10 kg (with max approved sensor)
MAX PITCH CORRECTION	± 90°



According to EASA 21.A.91, cited here below, this change is classified as a Major Change as the modification may have significant impact on aerodynamic, mass, balance and operational characteristics of the aircraft. Such scenario requires the issuance of a Supplemental Type Certificate (STC) by EASA.

21.A.91 Classification of changes in type design

> *Changes in type design are classified as minor and major. A 'minor change' is one that has no appreciable effect on the mass, balance, structural strength, reliability, operational characteristics, noise, fuel venting, exhaust emission, or other characteristics affecting the airworthiness of the product. Without prejudice to point 21.A.19, all other changes are 'major changes' under this Subpart. Major and minor changes shall be approved in accordance with points 21.A.95 or 21.A.97 as appropriate, and shall be adequately identified.*

The applicable models for this change are listed in Table 4.

Table 4: Applicable models

TYPE	Costruzioni Aeronautiche TECNAM P92
MODEL(S)	P92-JS
S/N	All (Certified Staff shall evaluate applicability case by case)
TCDS	EASA.A.412

2.2 Certification basis (CS)

When applying for a change, all the requirements set by the aircraft Certification Basis shall be met; the CB which the aircraft complies to is identified in the Type Certificate Data Sheet (TCDS).Tecnam P92 complies with the CS-VLA which is the Certification Specification for Very Light Aircrafts.

Within this Major Change all the requirements of the CS-VLA (Amendment 1) have been analyzed but for the purpose of this dissertation only the affected requirements regarding flight performances (Subpart B of the CS-VLA) are reported.

Tables below list the object of the considered requirement, the Means of Compliance used (ref. to Table 5) and remarks about the fulfilment of the requirements.

GENERAL

CS-VLA 21 – Proof of Compliance		
Object	**MoC**	**Remarks**
(a) Each requirement of this subpart must be met at each appropriate combination of weight and centre of gravity within the range of loading conditions for which certification is requested. This must be shown: *(1) By tests upon an aeroplane of the type for which certification is requested, or by calculations based on, and equal in accuracy to, the results of testing; and* *(2) By systematic investigation of each probable combination of weight and centre of gravity, if compliance cannot be reasonably inferred upon combinations investigated.*	2/6	Requirements of this subpart are tested in-flight following an extensive weight and balance analysis.
(b) The following general tolerances are allowed during flight testing. However, greater tolerances may be allowed in particular tests. *Item — Tolerance* *Weight — +5% ,-10%* *Critical items affected by weight — +5%, -1%* *C.G — ±7% total travel.*	0	Tolerances stated have been considered during weight and balance analysis.
(c) Substantiation of the data and characteristics to be determined according to this subpart may not require exceptional piloting skill, alertness or exceptionally favourable conditions. (See AMC VLA 21(c).)	6	Test point identified don't require exceptional

		piloting skills, alertness or exceptionally favorable conditions.
(d) Consideration must be given to significant variations of performance and inflight characteristics caused by rain and the accumulation of insects. (See AMC VLA 21(d).)	6	Flight tests shall be carried out with no rain conditions.

CS-VLA 23 – Load distribution limits		
Object	**MoC**	**Remarks**
Ranges of weight and centres of gravity within which the aeroplane may be safely operated must be established and must include the range of lateral centres of gravity if possible loading conditions can result in significant variation of their positions. (See AMC VLA 23.)	2	An extensive weight and balance analysis has been carried out before the flight tests. Loading distribution limits of the original aircraft have not been modified

CS-VLA 25 – Weight limits		
Object	**MoC**	**Remarks**
(a) Maximum weight. The maximum weight is the highest weight at which compliance with each applicable requirement of this CSVLA is shown. The maximum weight must be established so that it is - *(1) Not more than -* *(i) The highest weight selected by the applicant;* *(ii) The design maximum weight, which is the highest weight at which compliance with each applicable structural loading condition of this CSVLA is shown; or* *(iii) The highest weight at which compliance with each applicable flight requirement of this CS-VLA is shown.* *(2) Assuming a weight of 86 kg for each occupant of each seat, not less than the weight with –* *(i) Each seat occupied, full quantity of oil, and at least enough fuel for one hour of operation at rated maximum continuous power; or* *(ii) One pilot, full quantity of oil, and fuel to full tank capacity.* *(b) Minimum weight. The minimum weigh (the lowest weight at which compliance with each applicable requirement of this CS-VLA is shown) must be established so that it is not more than the sum of –* *(1) The empty weight determined under CS-VLA 29;* *(2) The weight of the pilot (assumed as 55 kg); and* *(3) The fuel necessary for one half hour of operation at maximum continuous power.*	0	Weight limits of the basic Aircraft Flight Manual have not been modified. All flight tests are performed at the aircraft MTOW.

CS-VLA 29 – Empty weight and corresponding centre of gravity		
Object	**MoC**	**Remarks**
(a) The empty weight and corresponding centre of gravity must be determined by weighing the aeroplane with - (1) Fixed ballast; (2) Unusable fuel determined under CS VLA.959; and (3) Full operating fluids, including – (i) Oil; (ii) Hydraulic fluid; and (iii) Other fluids required for normal operation of aeroplane systems, except potable water, lavatory precharge water, and water intended for injection in the engines. (b) The condition of the aeroplane at the time of determining empty weight must be one that is well defined and can be easily repeated.	0	Empty weight is determined by weighting the aircraft after the installation of the SmartBay system. No payloads are installed for the empty weight.

PERFORMANCE

CS-VLA 45 – General		
Object	**MoC**	**Remarks**
Unless otherwise prescribed, the performance requirements of this CS-VLA must be met for still air and a standard atmosphere, at sea level. (See AMC VLA 45.)	0	Data obtained in non-standard conditions shall be reduced to standard conditions.

CS-VLA 49 – Stalling speed		
Object	**MoC**	**Remarks**
(a) VS0 is the stalling speed, if obtainable, or the minimum steady speed, in km/h (knots (CAS), at which the aeroplane is controllable, with the: (1) Power condition set forth in subparagraph (c); (2) Propeller in the take-off position; (3) Landing gear extended; (4) Wing flaps in the landing position; (5) Cowl flaps closed; (6) Centre of gravity in the most unfavourable position within the allowable range; and (7) Maximum weight.	0	-
(b) VS0 may not exceed 83 km/h (45 knots) (CAS).	6	Stalling speed is assessed through flight tests
(c) VS1 is the stalling speed, if obtainable, or the minimum steady speed, in km/h (knots) (CAS) at which the aeroplane is controllable with: (1) Engine idling, throttle closed; (2) Propeller in the take-off position; (3) Aeroplane in the condition existing in the test in which VS1 is being used; and (4) Maximum weight.	0	-

(d) VS0 and VS1 must be determined by flight tests, using the procedure specified in CSVLA 201.	0	-

CS-VLA 51 – Takeoff		
Object	**MoC**	**Remarks**
(a) The distance required to take-off from a dry, level, hard surface and climb over a 15 metre obstacle must be determined and must not exceed 500 metres. *(b) This must be determined, in a rational and conservative manner, with:* *(1) The engine operating within approved operating limitations; and* *(2) The cowl flaps in the normal take-off position.* *(c) Upon reaching a height of 15 metres above the take-off surface level, the aeroplane must have reached a speed of not less than 1.3 VS1.* *(d) The starting point for measuring take-off distance must be at rest except for seaplanes and amphibians where it may be a point at which a speed of not more than 5,6 km/h (three knots) is reached.*	6	As the original aircraft MTOW is not exceeded, there is no modification involving the engine and SmartBay aerodynamic influence is almost negligible at takeoff speed, the takeoff distance is not expected to change. A specific flight test is therefore not requested unless unusual behavior is experienced during the other tests.

CS-VLA 65 – Climbs		
Object	**MoC**	**Remarks**
The steady rate of climb must be at least 2m/sec with – *(a) Not more than take-off power;* *(b) Landing gear retracted;* *(c) Wing flaps in take-off position; and* *(d) Cowl flaps in the position used in the cooling tests.*	6	Rate of climb is verified with flight tests.

CS-VLA 75 – Landing		
Object	**MoC**	**Remarks**
The horizontal distance necessary to land and come to a complete stop (or to a speed of approximately 5,6 km/h (3 knots) for water landings of seaplanes and amphibians) from a point 15 m above the landing surface must be determined as follows: *(a) A steady gliding approach with a calibrated airspeed of at least 1.3 VS1 must be maintained down to the 15 m height.* *(b) The landing must be made without excessive vertical acceleration or tendency to bounce, nose over, ground loop, porpoise, or water loop.* *(c) It must be shown that a safe transition to the balked landing conditions of CS-VLA 77 can be made from the conditions that exist at the 15 m height.*	6	As the original aircraft MTOW is not exceeded, the landing distance is not expected to change. A specific flight test is therefore not requested unless unusual behavior

		is experienced during the other tests.

CS-VLA 77 – Balked Landing		
Object	**MoC**	**Remarks**
For balked landings, it must be possible to maintain - *(a) A steady angle of climb at sea level of at least 1:30; or* *(b) Level flight at an altitude of 915 m (3 000 ft) and at a speed at which the balked landing transition has been shown to be safe, with –* *(1) Take-off power;* *(2) The landing gear extended; and* *(3) The wing flaps in the landing position, except that if the flaps may be safely retracted in two seconds or less, without loss of altitude and without sudden changes of angle of attack or exceptional piloting skill, they may be retracted.*	6	Balked landing performances will be assessed through flight tests.

FLIGHT CHARACTERISTICS

CS-VLA 141 – General		
Object	**MoC**	**Remarks**
The aeroplane must meet the requirements of CS-VLA 143 to 251 at the normally expected operating altitudes.	0	-

CONTROLLABILITY AND MANOEUVRABILITY

CS-VLA 143 – General		
Object	**MoC**	**Remarks**
(a) The aeroplane must be safely controllable and manoeuvrable during: *(1) Take-off;* *(2) Climb;* *(3) Level flight;* *(4) Descent; and* *(5) Landing (power on and power off) with the wing flaps extended and retracted.* *(b) It must be possible to make a smooth transition from one flight condition to another (including turns and slips) without danger of exceeding the limit load factor, under any probable operating condition.* *(c) If marginal conditions exist with regard to required pilot strength, the 'strength of pilots limits must be shown by quantitative tests. In no case may the limits exceed those prescribed in the following table:*	6	Controllability and maneuverability will be assessed through flight tests. No criticalities are foreseen in any configuration. Force exerted on controls will be assessed by the test pilot with no specific test instrumentation.

Values in daN of force as applied to the controls		Pitch	Roll	Yaw	Flaps, Trim tabs, landing gear etc
(a)	For temporary application:				
	Stick----------------	20	10	------	
	Wheel (applied to rim)----------------	25	20	------	
	Rudder pedal-------	------	------	40	
	Other controls------	------	------	------	20
(b)	For prolonged application ---------	2	1·5	10	

CS-VLA 145 – Longitudinal Control		
Object	**MoC**	**Remarks**
(a) It must be possible at any speed below 1·3 VS1, to pitch the nose downwards so that a speed equal to 1-3 VS1 can be reached promptly. *(1) This must be shown with the aeroplane in all possible configurations, with power on at maximum continuous power and power idle, and with the aeroplane trimmed at 1·3 VS1.* *(b) It must be possible throughout the appropriate flight envelope to change the configuration (landing gear, wing flaps etc ...) without exceeding the pilot forces defined in CSVLA 143(c).* *(c) It must be possible to raise the nose at VDF at all permitted c.g. positions and engine powers.* *(d) It must be possible to maintain steady straight flight and transition into climbs, descents, or turning flight, without exceeding the forces defined in CS-VLA 143(c).* *(e) It must be possible to maintain approximately level flight when flap retraction from any position is made during steady horizontal flight at 1·1 VS1 with simultaneous application of not more than maximum continuous power.* *(f) For any trim setting required under CSVLA 161(b)(l) it must be possible to take-off, climb, descend and land the aeroplane in required configurations with no adverse effect and with acceptable control forces.*	6	No criticalities are expected on longitudinal control. Proper tests will be scheduled should unusual behavior occur during flight tests.

CS-VLA 153 – Control during landings		
Object	**MoC**	**Remarks**
It must be possible, while in the landing configuration, to safely complete a landing following an approach to land: *(a) At a speed 9.3 km/h (5 knots) less than the speed used in complying with CS-VLA 75 and with the aeroplane in trim or as nearly as possible in trim;* *(b) With neither the trimming control being moved throughout the manoeuvre nor the power being increased during the landing flare; and* *(c) With power off.*	6	Considering previous experiences with the same configuration on non-certified aircrafts, no criticalities are expected.

CS-VLA 155 – Elevator control forces in manoeuvres		
Object	**MoC**	**Remarks**
The elevator control forces during turns or when recovering from manoeuvres must be such that an increase in control forces is needed to cause an increase in load factor. It must be shown by flight measurements that the stick force per 'g' is such that the stick force to achieve the positive limit manoeuvring load factor is not less than 7 daN in the clean configuration.	6	No major differences from original aircraft are expected.

CS-VLA 157 – Rate of roll		
Object	**MoC**	**Remarks**
(a) Take-off. It must be possible, using a favourable combination of controls, to roll the aeroplane from a steady 30-degree banked turn through an angle of 60 degrees, so as to reverse the direction of the turn within 5 seconds from initiation of roll with – *(1) Flaps in the take-off position;* *(2) Landing gear retracted;* *(3) Maximum take-off power; and* *(4) The aeroplane trimmed at 1·2 VS1, or as nearly as possible in trim for straight flight.* *(b) Approach. It must be possible, using favourable combination of controls, to roll the aeroplane from a steady 30-degree banked turn through an angle of 60 degrees, so as to reverse the direction of the turn within 4 seconds from initiation of roll with -* *(1) Flaps extended;* *(2) Landing gear extended;* *(3) Engine operating at idle power and engine operating at the power for level flight; and* *(4) The aeroplane trimmed at 1·3 VS1.*	6	Rate of roll will be assessed through flight tests. According to previous experience, rate of roll is expected not to vary.

TRIM

CS-VLA 161 – Trim		
Object	**MoC**	**Remarks**
(a) Lateral and directional trim. In level flight at 0·9 VH or VC (whichever is lower) the aeroplane must remain in trimmed condition around roll and yaw axis with respective controls free. (VH is maximum speed in level flight with maximum continuous power.) *(b) Longitudinal trim* *(1) The aeroplane must maintain longitudinal trim in level flight at any speed from 1·4 VS1 to 0·9 VH or VC (whichever is lower).* *(2) The aeroplane must maintain longitudinal trim during -* *(i) A climb with maximum continuous power at a speed VY with landing gear and wing flaps retracted,* *(ii) A descent with idle power at a speed of 1·3 VS1 with landing gear extended, and Wing flaps in the landing position.*	6	Lateral and directional trim tab are fixed and not adjustable in-flight, they will be deflected accordingly to flight tests. No impacts are expected on longitudinal trim.

STABILITY

CS-VLA 171 – General		
Object	**MoC**	**Remarks**
The aeroplane must be longitudinally, directionally, and laterally stable under CS-VLA 173 to 181. In addition, the aeroplane must show suitable stability and control 'feel' (static stability) in any condition normally encountered in service, if flight tests show it is necessary for safe operation.	0	Refer to following requirements.

CS-VLA 173 – Static longitudinal stability		
Object	**MoC**	**Remarks**
Under the conditions specified in CS-VLA 175 and with the aeroplane trimmed as indicated, the characteristics of the elevator control forces and the friction within the control system must be as follows: *(a) A pull must be required to obtain and maintain speeds below the specified trim speed and a push required to obtain and maintain speeds above the specified trim speed. This must be shown at any speed that can be obtained, except that speeds requiring a control force in excess of 18 daN, or speeds above the maximum allowable speed or below the minimum speed for steady unstalled flight, need not be considered.* *(b) The airspeed must return to within ±10% of the original trim speed when the control force is slowly released at any speed within the speed range specified in sub-paragraph (a) of this paragraph.* *(c) The stick force must vary with speed so that any substantial speed change results in a stick force clearly perceptible to the pilot. (See AMC VLA 173 and AMC VLA 175.)*	6	Static longitudinal stability will be assessed through flight tests considering conditions described in CS-VLA 175.

CS-VLA 175 – Demonstration of static longitudinal stability		
Object	**MoC**	**Remarks**
Static longitudinal stability must be shown as follows: *(a) Climb. The stick force curve must have a stable slope, at speeds between 15% above and below the trim speed, with –* *(1) Flaps in the climb position;* *(2) Landing gear retracted;* *(3) At least 75% of maximum continuous power; and* *(4) The aeroplane trimmed for VY, except that the speed need not be less' than 1·4 VS1 or the speed used for showing compliance to the powerplant cooling requirement of CS-VLA 1041.*	6	Refer to CS-VLA 173.
(b) Cruise. The stick force curve must have a stable slope with a range of 15% of the trim speed, but not exceeding the range from 1·3 VS1to VNE, with – *(1) Flaps retracted;* *(2) Landing gear retracted;* *(3) 75% of maximum continuous power; and* *(4) The aeroplane trimmed for level flight.*		
(c) Approach and landing. The stick force curve must have a stable slope at speeds throughout the range of speeds between 1·1 VS1 and VFE or 1·8 VS1 if there is no VFE, with – *(1) Wing flaps in the landing position;* *(2) Landing gear extended;* *(3) Power idle; and* *(4) The aeroplane trimmed at 1·3 VS1.* *(See AMC VLA 173 and AMC VLA 175.)*		

CS-VLA 177 – Static directional and lateral		
Object	**MoC**	**Remarks**
(a) Three-control aeroplanes. The stability requirements for three-control aeroplanes are as follows: *(1) The static directional stability, as shown by the tendency to recover from a skid with the rudder free, must be positive for any landing gear and flap position appropriate to the take-off, climb, cruise, and approach configurations. This must be shown with power up to maximum continuous power, and at speeds from 1·2 VS1 up to maximum allowable speed for the condition being investigated. The angle of skid for these tests must be appropriate to the type of aeroplane. At larger angles of skid up to that at which full rudder is used or a control force limit in CS-VLA 143 is reached, whichever occurs first, and at speeds from 1·2 VS1 to VA, the rudder pedal force must not reverse.* *(2) The static lateral stability, as shown by the tendency to raise the low wing in a slip, must be positive for any landing gear and flap positions. This must be shown with power up to 75% of maximum continuous power at speeds above 1·2 VS1, up to the maximum allowable speed for the configuration being investigated. The static lateral stability may not be negative at 1·2 VS1. The angle of slip for these tests must be appropriate to the type of aeroplane, but in no case may the slip angle be less than that obtainable with 10° of bank.* *(3) In straight, steady slips at 1·2 VS1for any landing gear and flap positions, and for power conditions up to 50% of maximum continuous power, the aileron and rudder control movements and forces must increase steadily (but not necessarily in constant proportion) as the angle of slip is increased up to the maximum appropriate to the type of aeroplane. At larger slip angles up to the angle at which full rudder or aileron control is used or a control force limit contained in CSVLA 143 is obtained, the rudder pedal force may not reverse. Enough bank must accompany slipping to hold a constant heading. Rapid entry into, or recovery from, a maximum slip may not result in uncontrollable flight characteristics.*	6	Skid recovery, slip recovery and steady heading sideslips tests will assess static directional and lateral stability.
(b) Two-control (or simplified control) aeroplanes. The stability requirements for two-control aeroplanes are as follows: *(1) The directional stability of the aeroplane must be shown by showing that, in each configuration, it can be rapidly rolled from a 45° bank in one direction to a 45° bank in the opposite direction without showing dangerous skid characteristics.* *(2) The lateral stability of the aeroplane must be shown by showing that it will not assume a dangerous attitude or speed when the controls are abandoned for two minutes. This must be done in moderately smooth air with the aeroplane trimmed for straight level flight at 0-9 VH or VC, whichever is lower, with flaps and landing gear retracted, and with a rearward centre of gravity.*	N/A	N/A

CS-VLA 181 – Dynamic stability		
Object	**MoC**	**Remarks**
(a) Any short period oscillation not including combined lateral-directional oscillations occurring between the stalling speed and the maximum allowable speed appropriate to the configuration of the aeroplane must be 'heavily damped with the primary controls – *(1) Free; and* *(2) In a fixed position*	6	Longitudinal short period, phugoid and Dutch roll tests will assess dynamic stability.
(b) Any combined lateral-directional oscillations ('Dutch roll') occurring		

between the stalling speed and the maximum allowable speed appropriate to the configuration of the aeroplane must be damped to 1/10 amplitude in 7 cycles with the primary controls – *(1) Free; and* *(2) In a fixed position.*		

STALLS

CS-VLA 201 – Wings level stall		
Object	**MoC**	**Remarks**
(a) For an aeroplane with independently controlled roll and directional controls, it must be possible to produce and to correct roll by unreversed use of the rolling control and to produce and to correct yaw by unreversed use of the directional control, up to the time the aeroplane stalls. *(b) For an aeroplane with interconnected lateral and directional controls (2 controls) and for an aeroplane with only one of these controls, it must be possible to produce and correct roll by unreversed use of the rolling control without producing excessive yaw, up to the time the aeroplane stalls.* *(c) The wing level stall characteristics of the aeroplane must be demonstrated in flight as follows: The aeroplane speed must be reduced with the elevator control until the speed is slightly above the stalling speed, then the elevator control must be pulled back so that the rate of speed reduction will not exceed 1,9 km/h (one knot) per second until a stall is produced, as shown by an uncontrollable downward pitching motion of the aeroplane, or until the control reaches the stop. Normal use of the elevator control for recovery is allowed after the aeroplane has stalled.* *(d) Except where made inapplicable by the special features of a particular type of aeroplane, the following apply to the measurement of loss of altitude during a stall* *(1) The loss of altitude encountered in the stall (power on or power off) is the change in altitude (as observed on the sensitive altimeter testing installation) between the altitude at which the aeroplane pitches and the altitude at which horizontal fight is regained.* *(2) If power or thrust is required during stall recovery the power or thrust used must be that which would be used under the normal operating procedures selected by the applicant for this manoeuvre. However, the power used to regain level flight may not be applied until flying control is regained.* *(e) During the recovery part of the manoeuvre, it must be possible to prevent more than 15 degrees of roll Or yaw by the normal use of controls.* *(f) Compliance with the requirements of this paragraph must be shown under the following conditions:* *(1) Wing Flaps: Full up, full down and intermediate, if appropriate.* *(2) Landing Gear: Retracted and extended.* *(3) Cowl Flaps: Appropriate to configuration.* *(4) Power: Power or thrust off, and 75% maximum continuous power or thrust.* *(5) Trim: 1·5 VS1 or at the minimum trim speed, whichever is higher.* *(6) Propeller: Full increase rpm position for the power off condition.* *(See AMC VLA 201.)*	6	Wings level stall tests will assess stall recovery performances in all configurations described in this requirement.

CS-VLA 203 – Turning flight and accelerated stalls		
Object	**MoC**	**Remarks**
Turning flight and accelerated stalls must be demonstrated in tests as follows: *(a) Establish and maintain a coordinated turn in a 30 degree bank. Reduce speed by steadily and progressively tightening the turn with the elevator until*	6	Turning flight and

the aeroplane is stalled or until the elevator has reached its stop. The rate of speed reduction must be constant, and - *(1) For a turning flight stall, may not exceed 1,9 km/h (one knot) per second; and* *(2) For an accelerated stall, be 5,6 to 9,3 km/h (3 to 5 knots) per second with steadily increasing normal acceleration.*		accelerated stall tests will assess stall recovery performances in all configurations described in this requirement.
(b) When the stall has fully developed or the elevator has reached its stop, it must be *possible to regain level flight by normal use of controls and without –* *(1) Excessive loss of altitude;* *(2) Undue pitchup;* *(3) Uncontrollable tendency to spin;* *(4) Exceeding 60 degree of roll in either direction from the established 30 degree bank; and* *(5) For accelerated entry stalls, without exceeding the maximum permissible speed or the allowable limit load factor.*		
(c) Compliance with the requirements of this paragraph must be shown with – *(1) Wing Flaps: Retracted and fully extended for turning flight and accelerated entry stalls, and intermediate, if appropriate, for accelerated entry stalls;* *(2) Landing Gear: Retracted and extended;* *(3) Cowl Flaps: Appropriate to configuration;* *(4) Power: 75% maximum continuous power; and* *(5) Trim: 1·5 VS1 or minimum trim speed, whichever is higher.*		

CS-VLA 207 – Stall Warning		
Object	**MoC**	**Remarks**
(a) There must be a clear and distinctive stall warning, with the flaps and landing gear in any normal position, in straight and turning flight.	6	During stall tests, stall warning will be verified.
(b) The stall warning may be furnished either through the inherent aerodynamic qualities of the aeroplane or by a device that will give clearly distinguishable indications under expected conditions of flight. However, a visual stall warning device that requires the attention of the crew within the cockpit is not acceptable by itself.		
(c) The stall warning must begin at a speed exceeding the stalling speed by a margin of not less than 9,3 km/h (5 knots), but not more than 18,5 km/h (10 knots) and must continue until the stall occurs.		

SPINNING

CS-VLA 221 – Spinning		
Object	**MoC**	**Remarks**
(a) The aeroplane must be able to recover from a one-turn spin or a 3-second spin, whichever takes longer, in not more than one additional turn, with the controls used in the manner normally used for recovery. In addition – *(1) For both the flaps-retracted an flaps-extended conditions, the applicable airspeed limit and positive limit manoeuvring load factor may not be exceeded;* *(2) There may be no excessive back pressure during the spin or recovery; and* *(3) It must be impossible to obtain uncontrollable spins with any use of the controls.* *For the flaps-extended condition, the flaps may be retracted during recovery.*	2	According to an empirical method developed by NASA (ref. to [8]), and valid for general aviation aircrafts, the aircraft spin recovery capabilities show very small difference if compared
(b) Aeroplanes 'characteristically incapable of spinning'. If it is desired to designate an aeroplane as 'characteristically incapable of spinning', this		

characteristic must be shown with - *(1) A weight five percent more than the highest weight for which approval is requested;* *(2) A centre of gravity at least three percent of the mean aerodynamic chord aft of the rearmost position for which approval is requested;* *(3) An available elevator up-travel 4° in excess of that to which the elevator travel is to be limited for approval; and* *(4) An available rudder travel, 7° in both directions, in excess of that to which the rudder travel is to be limited for approval.*		with the original configuration. According to this technical note, the aerodynamic effects of external installations such as additional fuel tanks, has little or no effect on spin recovery, while the effects of a change in inertial moments can be important. Through this method, ambient conditions, tail damping effectiveness and aircraft mass distribution are considered and SmartBay installation is proved not to have an important effect in spin recovery capabilities.

MISCELLANEOUS FLIGHT REQUIREMENTS

CS-VLA 251 – Vibration and buffeting		
Object	**MoC**	**Remarks**
Each part of the aeroplane must be free from excessive vibration under any appropriate speed and power conditions up to at least the minimum value of VD allowed in CS-VLA 335. In addition, there may be no buffeting, in any normal flight condition, severe enough to interfere with the satisfactory control of the aeroplane, cause excessive fatigue to the pilot, or result in structural damage. Stall warning buffeting within these limits is allowable.	6	Vibrations will be evaluated by test pilot during flight tests

Means of Compliance codes in the tables above refer to Table 5 according to EASA guidelines.

Table 5: MoC codes

<table>
<tr><th>TYPE OF COMPLIANCE</th><th>MEANS OF COMPLIANCE</th><th>ASSOCIATED COMPLIANCE DOCUMENTS</th></tr>
<tr><td rowspan="4">Engineering Evaluation</td><td>MC 0:
Compliance statement
reference to TD documents
election of methods, factors
definitions</td><td>Type Design Documents Recorded Statements</td></tr>
<tr><td>MC 1: Design Review</td><td>Description, Drawings</td></tr>
<tr><td>MC 2: Calculation/Analysis</td><td>Substantiation Reports</td></tr>
<tr><td>MC 3: Safety Assessment</td><td>Safety Analysis</td></tr>
<tr><td rowspan="4">Tests</td><td>MC 4: Laboratory Tests</td><td rowspan="4">Test Programs
Test Reports
Test Interpretations</td></tr>
<tr><td>MC 5: Ground Tests on related product</td></tr>
<tr><td>MC 6: Flight Tests</td></tr>
<tr><td>MC 8: Simulation</td></tr>
<tr><td>Inspection</td><td>MC 7: Design Inspection</td><td>Inspection Reports</td></tr>
<tr><td>Equipment Qualification</td><td>MC 9: Equipment Qualification (e.g. ETSO)</td><td>Reference to existing approvals and their applicability</td></tr>
</table>

3 Flight Test Program

3.1 Effects of Change on the Aircraft

Before proceeding with the planning of the flight test program it is important to briefly understand the effects of the change on the aircraft. The impact of the introduction of the simple pylon and of the payload with the highest aerodynamic impact will be estimated in terms of lift and drag variations from the original aircraft configuration.

First, the drag coefficients of the original Tecnam P92JS in straight horizontal flight is estimated. The glide ratio reported on the AFM is a good approximation of the clean aircraft efficiency E:

$$E = \frac{L}{D} = 12.2$$

Considering:

- Weight: $W = MTOW$
- Angle of attack: $\alpha \approx 0°$
- Linear stabilized flight condition: $L = W$

$$D = \frac{L}{E} = \frac{MTOW}{E} = \frac{600kg \cdot 9.81m/s^2}{12.2} = 482.46\ N$$

The AFM indicates a glide IAS of 69 knots which corresponds to 67 knots CAS according to Figure 3-1.

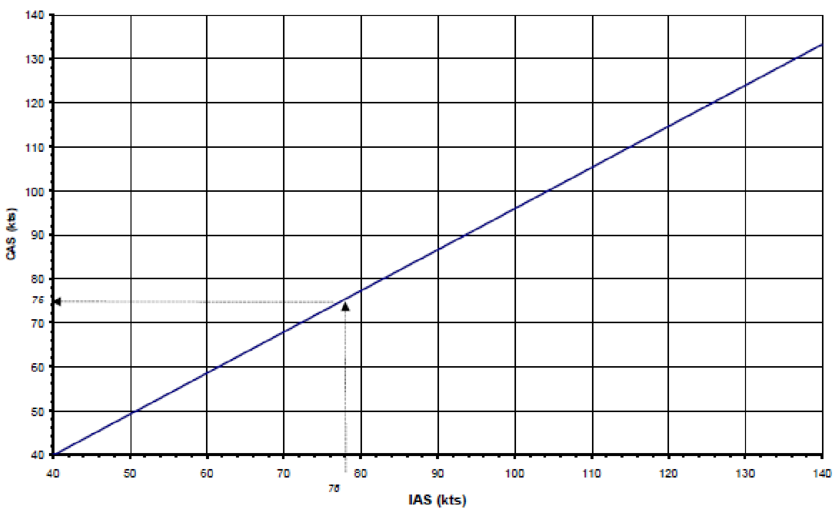


Figure 3-1: IAS to CAS converter for Tecnam P92 JS

Assuming sea level conditions and non-compressible fluid, the calibrated airspeed is equal to the true airspeed; in said conditions is possible to estimate the drag coefficient C_D.

$$D = \frac{1}{2}\rho V^2 C_D S \qquad\qquad C_D = \frac{2D}{\rho S V^2} = 0.0544$$

Where:

- Air density: $\rho = 1.225\ kg/m^3$
- Wing surface area: $S = 12.18\ m^2$
- True Airspeed: $V = 67\ knots = 34.47\ m/s$

The aircraft drag coefficient can be expressed through a drag polar function of parasite and induced drag as:

$$C_D = C_{D0} + kC_L^2$$

Where C_{D0} and k are the zero-lift drag coefficient and the lift-induced drag coefficient factor constants. According to flight mechanics, at maximum efficiency, the following relations are valid:

$$C_{D0} = \frac{C_D}{2}$$

$$E = \frac{1}{2\sqrt{kC_{D0}}}$$

Therefore, using the previously estimated C_D,

$$C_{D0} = 0.0272$$

$$k = \frac{1}{4C_{D0}E^2} = 0.061752$$

$$C_D = 0.0272 + 0.061752C_L^2$$

According to the CFD analysis, the SmartBay and its payload affect lift and drag as listed below.

Table 6: SmartBay effects on aerodynamic forces

CONDITION	**SMARTBAY CLEAN**		**SMARTBAY + SMARTGIMBAL**	
	LIFT [N]	**DRAG [N]**	**LIFT [N]**	**DRAG [N]**
$\boldsymbol{V_{NE} = 141\ knots}$ $\boldsymbol{\alpha = 0°}$	-9.91	+37.67	-56.93	+147.58
$\boldsymbol{V_C = 81\ knots}$ $\boldsymbol{\alpha = 0°}$	-3.64	+12.41	-18.04	+47.92
$\boldsymbol{1.1V_S = 48\ knots}$ $\boldsymbol{\alpha = 13°}$	-0.85	+3.27	-10.07	+11.16

3.1.1 Effects at $V_{NE} = 141\ knots$

Assuming a levelled flight condition at V_{NE} where $\alpha \approx 0°$, it is possible to estimate the lift coefficient according to:

$$C_L = \frac{2W}{\rho V_{NE}^2 S} = 0.14995$$

With this value and the drag polar function estimated before, the drag coefficient is calculated:

$$C_D = 0.0272 + 0.061752 C_L^2 = 0.02858$$

Finally, the total drag of the clean aircraft is:

$$D = \frac{1}{2} \rho V_{NE}^2 C_D S = 1122\ N$$

According to Table 6, the presence of SmartBay pylon clean and SmartBay equipped with SmartGimbal leads to an increase of +3.36% and +13.15% respectively. The reduction in lift is negligible for both configurations.

3.1.2 Effects at $V_C = 81\ knots$

Assuming a levelled flight condition at V_C where $\alpha \approx 0°$, it is possible to estimate the lift coefficient according to:

$$C_L = \frac{2W}{\rho V_C^2 S} = 0.454381$$

With this value and the drag polar function estimated before, the drag coefficient is calculated:

$$C_D = 0.0272 + 0.061752 C_L^2 = 0.03995$$

Finally, the total drag of the clean aircraft is:

$$D = \frac{1}{2} \rho V_C^2 C_D S = 518\ N$$

According to Table 6, the presence of SmartBay pylon clean and SmartBay equipped with SmartGimbal leads to an increase of +2.40% and +9.26% respectively. The reduction in lift is negligible for both configurations.

3.1.3 Effects at $1.1V_{S1} = 48\ knots$

The aircraft is assumed in levelled flight at $1.1V_{S1}$ with an angle of attack proximate to stall angle (about 13°). The lift coefficient is estimated according to:

$$C_L = \frac{2W/\cos\alpha}{\rho (1.1V_{S1})^2 S} = 1.3279$$

With this value and the drag polar function estimated before, the drag coefficient is calculated:

$$C_D = 0.0272 + 0.061752C_L^2 = 0.13609$$

Finally, the total drag of the clean aircraft is:

$$D = \frac{1}{2}\rho(1.1V_{S1})^2 C_D S = 619\ N$$

According to Table 6, the presence of SmartBay pylon clean and SmartBay equipped with SmartGimbal leads to an increase of +0.53% and +1.80% respectively. The reduction in lift is negligible for both configurations.

Results are summarized in the following table.

Table 7: SmartBay effect on original aircraft

CONDITION	SMARTBAY CLEAN		SMARTBAY + SMARTGIMBAL	
	LIFT [N]	DRAG [N]	LIFT [N]	DRAG [N]
$V_{NE} = 141\ knots$ $\alpha = 0°$	-0.17%	+ 3.36%	-0.97%	+ 13.15%
$V_C = 81\ knots$ $\alpha = 0°$	-0.06%	+ 2.40%	-0.31%	+ 9.26%
$1.1V_S = 48\ knots$ $\alpha = 13°$	-0.01%	+ 0.53%	-0.17%	+ 1.80%

3.2 Test Operations

3.2.1 Category of Flight Test

According to the analysis illustrated in paragraph 3.1 and the experience already acquired with the Advanced Ultralight version of the Tecnam P92, no significant differences in performance, handling characteristics and stability are expected between the original aircraft and the heaviest modified configuration featuring SmartGimbal trolley. For the same reason no excessive vibration or abnormal behaviors are envisaged.

According to the guidelines described in the Notice Of Proposed Amendment (NPA) NO 2008-20 [3], the Flight Test Activity is classified as Category 2, which is defined as:

- *Flights done in the part of the flight envelope already opened and comprising manoeuvres, during which it is not envisaged to encounter flight and/or handling characteristics (performance and flying qualities) significantly different from those already known.*
- *Display flights and demonstration flights of a non-type-certificated aircraft.*
- *Flights conducted for the purpose of determining whether there is reasonable assurance that the aircraft, its parts and appliances are reliable and function properly.*

3.2.2 Flight Test Matrix

The flight test matrix represents all the conditions that will be tested during the flight tests univocally identified with a Test Point number (TP). For each TP, Table 8 reports:

- Associated requirement of CS-VLA (See [1] and §2.2)
- Procedure used
- Payload Configuration of SmartBay (ref. to Table 10)
- Center of Gravity position Forward (FWD) or Aft (AFT)
- Flaps setting clean, takeoff or landing (CLEAN – TO – LND)
- Trim speed at which the maneuver is initiated
- Power setting for the maneuver
- Altitude (fixed or range)
- Number of runs of the same maneuver

All maneuvers indicated as well as the aircraft settings necessary for each TP are deduced directly from CS-VLA, AC 23-15A, AC 23-8C and Book 2 of CS-23 (ref. to [1], [4], [7] and [5]) which report all the acceptable Means of Compliance to the Certification Specifications.

Table 8: Flight Test Matrix

REQUIREMENT	PROCEDURE	SBE CONF.	CG	FLAPS	TRIM SPEED [KIAS]	PWR	ALTITUDE [ft]	RUNS	TP
65 – Climb	TO climbs	1	FWD	TO	V_{FE}	MAX TO	2500-3500	2	1
		6a	FWD	TO	V_{FE}	MAX TO	2500-3500	2	2
		1	FWD	TO	V_{FE}	MAX TO	8500-9500	2	3
		6a	FWD	TO	V_{FE}	MAX TO	8500-9500	2	4
	Sawtooth climbs	1	FWD	CLEAN	V_Y	MAX TO	2500-3500	6	5
		6a	FWD	CLEAN	V_Y	MAX TO	2500-3500	6	6
		1	FWD	CLEAN	V_Y	MAX TO	8500-9500	6	7
		6a	FWD	CLEAN	V_Y	MAX TO	8500-9500	6	8
77 – Balked Landing	Balked Landing Climbs	1	FWD	LND	1.3 V_{S_1}	MAX TO	2500-3500	2	9
		6a	FWD	LND	1.3 V_{S_1}	MAX TO	2500-3500	2	10
157 – Rate of Roll	Bank to Bank Controllability	1	AFT	TO	1.2 V_{S_1}	MAX TO	3500	4	11
		1	AFT	LND	1.3 V_{S_1}	LF	3500	4	12
		1	AFT	LND	1.3 V_{S_1}	IDLE	3500	4	13
		3	AFT	TO	1.2 V_{S_1}	MAX TO	3500	4	14
		3	AFT	LND	1.3 V_{S_1}	LF	3500	4	15
		3	AFT	LND	1.3 V_{S_1}	IDLE	3500	4	16
		6b	AFT	TO	1.2 V_{S_1}	MAX TO	3500	4	17
		6b	AFT	LND	1.3 V_{S_1}	LF	3500	4	18
		6b	AFT	LND	1.3 V_{S_1}	IDLE	3500	4	19
173 – Static Longitudinal Stability	Stick Force per V	6b	AFT	CLEAN	1.3 V_{S_1} to V_{NE}	75% MCP LF	3500	2	20

		6b	AFT	CLEAN	V_Y	MCP	3500	2	21
		6b	AFT	LND	1.3 V_{S_1}	LF	3500	2	22
177 - Static Directional and Lateral	Directional recovery	1	AFT	CLEAN	1.2 V_{S_1} to V_{NE}	LF	3500	4	23
		1	AFT	TO	1.2 V_{S_1} to V_{FE}	LF	3500	4	24
		1	AFT	LND	1.2 V_{S_1} to V_{FE}	LF	3500	2	25
		3	AFT	CLEAN	1.2 V_{S_1} to V_{NE}	LF	3500	4	26
		3	AFT	TO	1.2 V_{S_1} to V_{FE}	LF	3500	4	27
		3	AFT	LND	1.2 V_{S_1} to V_{FE}	LF	3500	2	28
		6b	AFT	CLEAN	1.2 V_{S_1} to V_{NE}	LF	3500	4	29
		6b	AFT	TO	1.2 V_{S_1} to V_{FE}	LF	3500	4	30
		6b	AFT	LND	1.2 V_{S_1} to V_{FE}	LF	3500	2	31
	Lateral recovery	6b	AFT	CLEAN	1.2 V_{S_1} to V_{NE}	LF	3500	3	32
		6b	AFT	TO	1.2 V_{S_1} to V_{FE}	LF	3500	4	33
		6b	AFT	LND	1.2 V_{S_1} to V_{FE}	LF	3500	2	34
181 – Dynamic Stability	Longitudinal Short Period	6b	AFT	CLEAN	V_{S_1} to V_{NE}	LF	3500	3	35
		6b	AFT	TO	V_{S_1} to V_{FE}	LF	3500	2	36
		6b	AFT	LND	V_{S_1} to V_{FE}	LF	3500	1	37
	Lateral Directional Dutch Roll	6b	AFT	CLEAN	V_{S_1} to V_{NE}	LF	3500	3	38
		6b	AFT	TO	V_{S_1} to V_{FE}	LF	3500	2	39
		6b	AFT	LND	V_{S_1} to V_{FE}	LF	3500	1	40
	Longitudinal	6b	AFT	CLEAN	V_{S_1} to	LF	3500	3	41

	Phugoid				V_{NE}				
		6b	AFT	TO	V_{S_1} to V_{FE}	LF	3500	1	42
		6b	AFT	LND	V_{S_1} to V_{FE}	LF	3500	2	43
201 – Wing Level Stalls	Wing Level Stalls	6b	AFT	CLEAN	1.5 V_{S_1}	IDLE	5000	1	44
		6b	AFT	CLEAN	1.5 V_{S_1}	MCP	5000	1	45
		6b	AFT	TO	1.5 V_{S_1}	IDLE	5000	1	46
		6b	AFT	TO	1.5 V_{S_1}	MCP	5000	1	47
		6b	AFT	LND	1.5 V_{S_1}	IDLE	5000	1	48
		6b	AFT	LND	1.5 V_{S_1}	MCP	5000	1	49
203 - Turning Flight and Accelerated Stalls	Accelerated Stalls	6b	AFT	CLEAN	1.5 V_{S_1}	75% MCP	5000	1	50
		6b	AFT	LND	1.5 V_{S_1}	75% MCP	5000	1	51
	Turning stall	6b	AFT	CLEAN	1.5 V_{S_1}	IDLE	5000	1	52
		6b	AFT	CLEAN	1.5 V_{S_1}	MCP	5000	1	53
		6b	AFT	TO	1.5 V_{S_1}	IDLE	5000	1	54
		6b	AFT	TO	1.5 V_{S_1}	MCP	5000	1	55
		6b	AFT	LND	1.5 V_{S_1}	IDLE	5000	1	56
		6b	AFT	LND	1.5 V_{S_1}	MCP	5000	1	57

3.2.3 Test instrumentation

As no hazardous situation and behavior are expected within the flight tests, no certified Flight Test Instrument (FTI) is installed on the aircraft. Necessary flight parameters, indicated in the Flight Test Cards (FTC), will be manually recorded by the Flight Test Engineer (FTE); a high-resolution video camera is installed in the cockpit, Figure 3-2, to record aircraft and crew behavior as well as instrument readings in case the FTE is unable to properly read and record them.

This last provision follows the FAA Advisory Circular AC23 15-A [4] § 5.a.2.c.2. which states:

> *Video cameras may also be used to record instrument readings and pilot actions to show compliance with flight and performance provisions. Also, the use of traditional equipment such as knee pad, stopwatch, force gauge, etc., is appropriate for many tasks and their use is encouraged.*

The aircraft is certified under EASA CS-VLA therefore the minimum flight instrumentation is available aboard and is considered reliable. Aircraft instrumentation used is:

- Anemometer
- Altimeter
- Attitude indicator
- Vertical Speed indicator
- Turn and slip indicator

Besides aircraft basic instrumentation and the wide-range high-quality video camera, a Flight Data Logger (FDL) designed by DigiSky is installed aboard. Even though it is not a certified flight test instrument, outputs from this device will be used as a backup source and compared with data manually recorded by the FTE. This data logger is equipped with:

- GPS + compass module
- IMU board (6 axis, gyro + accelerometer)
- Differential pressure sensor which provides information about IAS and altitude

FTE personal equipment will feature:

- 1 Stopwatch
- 1 Kneepad
- 1 Flight Test Card
- 2 Pens

Figure 3-2: View from the cockpit video camera

Some tests may be more difficult than others to record without proper test instrumentation due to the rapidity of the event to record or the difficulty to gather appropriate data from the aircraft instruments. However, no specific FTI will be used according to the assumptions here reported:

- **Stalls**: According to [4] § 5.h.2, compliance may be shown by qualitative test pilot assessments. Stall speed, altitude loss and potential banking will be manually recorded by the FTE through instrument reading.
- **Static longitudinal stability**: To comply with static longitudinal stability requirements, the stick force per V test will be conducted as later described. To perform this test no specific recording instrument is used as, by experience with the ULM version of this aircraft, changes in speed are reflected in stick force variations, according to [4] § 5.g.2.a.
- **Dynamic longitudinal stability**: Compliancy is shown by evaluating short period and phugoid modes. According to the Flight Test Guide (FTG) of the CS23 Amdt.4 (ref. to [5] §23.181), as quantitative data on short period characteristics from cockpit instruments is difficult or almost impossible if the motion is heavily damped, if the pilot cannot see enough of the motion to measure and time a half cycle amplitude ratio, the short period motion should be qualitatively described as essentially deadbeat. In case of a different behavior a specific test with appropriate FTI will be conducted. The phugoid motion instead, proceeds slowly enough that it is reasonable to record minimum and maximum airspeed excursions as a function of time and thus enable construction of an envelope from which time to half double amplitude may be determined.
- **Static lateral and directional stability:** compliancy is shown by evaluating slips and skid behavior of the aircraft. According to [5] §23.177 no specific FTI is necessary as long as the data recorded either directly, through video recording analysis or by test pilot qualitative assessment are sufficient for showing compliance.
- **Dynamic lateral and directional stability:** compliancy is shown by evaluating Dutch roll behavior of the aircraft. According to [5] §23.181, as quantitative information on Dutch roll characteristics from cockpit instruments and visual observations is difficult, particularly if the motion is heavily damped, compliance can be demonstrated by test pilot qualitative assessment on Dutch roll mode dumping.

3.2.4 Test limitations

When preparing a Flight Test Program it is important to identify possible limitations to aircraft maneuvers due to the introduction of the change as well as safety limitations for the conduct of certain test.

As far as the aircraft is concerned, no further limitations are introduced; the original flight envelop still applies. The aircraft is certified for non-aerobatic operation only. Non-aerobatic operation includes:

- Any maneuver pertaining to “normal” flight
- Stalls (except whip stalls)
- Lazy eights
- Chandelles
- Turns in which the angle of bank is not more than 60°

Maneuvering load factors are as follows:

Table 9: Maneuvering load factors

FLAPS	Positive	Negative
0°	+3.8	-1.9
38°	+1.9	0

Following specific limitations are valid throughout this flight test campaign:

- Minimum altitude for stall speed determination is 5000 ft AGL,
- Maximum operating pressure altitude is 12000 ft MSL,
- Flight test activity shall be conducted in Visual Meteorological Conditions (VMC), with 3000 ft clouds ceiling and turbulence level low.

Other limitations may be stated in each test card according to the mission profile.

The following tolerances are acceptable during flight testing (ref. [1] § 21 (b)):

- Weight: +5 %, -10 %
- Weight, when critical: +5%, -1%
- C.G. +/- 7 % of total travel

3.2.5 Aircraft loading conditions

In the Subpart B of the Certification Specification is stated that all flight tests shall be conducted at MTOW in the most unfavorable Center of Gravity position, which for some test points is at the forward CG limit whether for the others is the aft CG limit.

To assess which loading conditions ensure these conditions, a full weight and balance analysis is carried out. Items of mass which contribute to aircraft weight and balance are separated into fixed and variables, the latter are then let vary from their minimum to their maximum allowable values; results are then plotted on the weight and balance chart extracted by the Aircraft Flight Manual [6].

SmartBay configuration taken into account for flight testing purposes are reported in the following table. SmartGimbal is considered in 2 different weight configurations to comply easier with CG limits requirements.

Table 10: Payload configurations

CONF.	FRONT	CENTER	REAR	BIU
1	NT	NT	NT	BIU
3	SC	SC	NT	BIU
6a	SG L	NT	SC	BIU
6b	SG H	NT	SC	BIU

Where:

- NT: Naked Trolley
- SC: SmartCamera
- SG L: SmartGimbal Light
- SG H: SmartGimbal Heavy

The following table lists the fixed weight elements considered in the analysis with the following assumptions:

- Aircraft Empty Weight with SmartBay and COD installed;
- PIC and FTE weights include clothes, fireproof suit and personal equipment;
- Naked Trolley and SmartCamera can be installed in front, center or rear positions (F-C-R);
- SmartGimbal has two weight configurations, for each test flight featuring this trolley the configuration is specified.

Table 11: Fixed weight and CG position

ITEM	WEIGHT [kg]	ARM [m]
AIRCRAFT EMPTY WEIGHT	401	1.734
PILOT IN COMMAND	83	1.760
FLIGHT TEST ENGINEER	73	1.760
BIU TROLLEY	0.5	2.310
NAKED TROLLEY	0.4	1.710 (F) 1.910 (C) 2.110 (R)
SMARTCAMERA	2.1	1.710 (F) 1.910 (C) 2.110 (R)
SMARTGIMBAL LIGHT	7.5	1.710
SMARTGIMBAL HEAVY	10	1.710

Variable weights are listed in

Table 12. Note that:

- Fuel can vary from 15 to 90 liters, conversion factor between fuel liters and kg is 0.72;
- Fuel arm is assumed fixed in time;
- Baggage compartment is located right behind seats

Table 12: Variable weights and CG position

ITEM	WEIGHT [kg]		ARM [m]
	MIN	MAX	
FUEL	10.8	64.8	1.660
BAGGAGE COMP.	0	20	2.210

Through a MATLAB script, the effect of all possible combinations of variable elements, summed with fixed ones and for all payload configuration considered in the flight test, is evaluated. Results of such analysis are shown below in Figure 3-3.

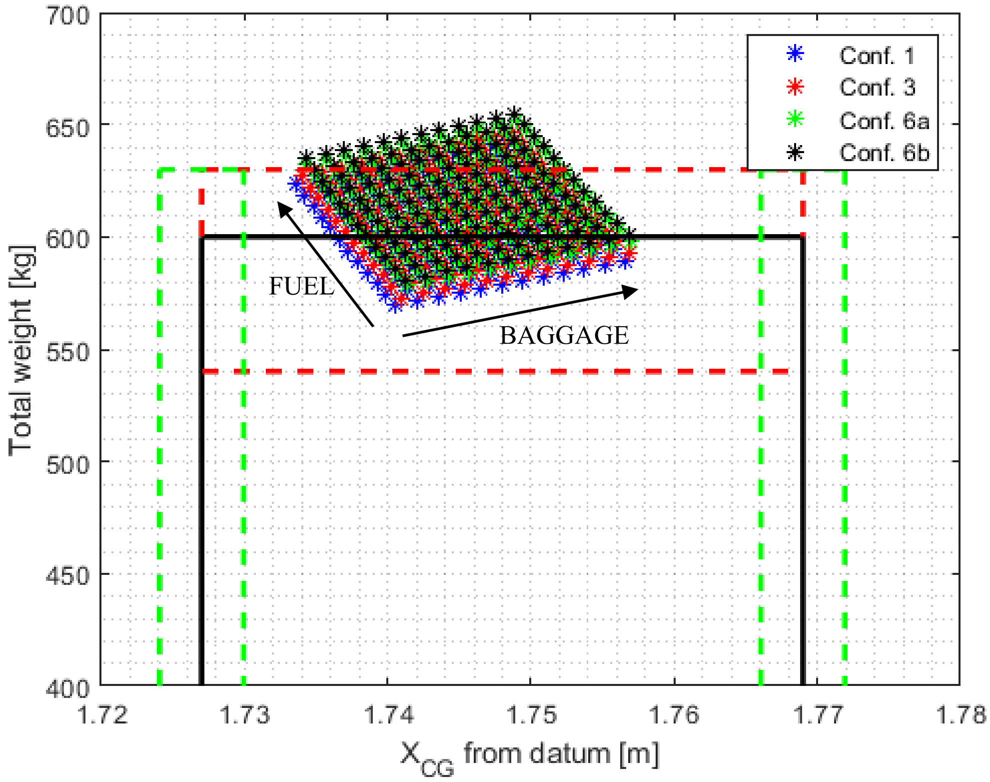


Figure 3-3: Weight and balance analysis results

Figure 3-3 is structured as follows:

- Solid black line represents normal limitation stated in the AFM:
    - Forward CG limit: 1.727 m
    - Aft CG limit: 1.769 m
    - MTOW: 600 kg
- Dotted green lines represent acceptable tolerance on CG position for flight tests (±7% of total CG travel as per [1] § 21(b));
- Dotted red line represents acceptable tolerance on weight for flight tests (+5% and -10% of MTOW as per [1] § 21(b));

The effect of the variation between the limits listed in Table 12 is clear in the picture: adding baggage tends to shift rapidly backwards the CG whether adding fuel moves it slightly forward. Note that some combinations exceed weight limits and are, for this reason, unusable. As expected, configuration 1 is the lightest and the 6b is the heaviest; in any SmartBay configuration the CG is slightly shifted backwards with respect to the clean configuration and with the same loading conditions.

Regulations state that the flight tests shall be conducted in specific aircraft loading conditions, which are the MTOW and the limit approved CG position forward or aft, whichever is the worst condition for the specific maneuver. It is evident from Figure 3-3 that by varying only fuel and baggage it is impossible to reach such conditions aboard the aircraft; following subparagraphs will study the two limit conditions.

Forward limit position

The only items which positively contribute to shift forward the CG are fuel and the frontmost SmartBay slot, moreover, the less the pilot and copilot weight the forward the CG translates. As shown in Figure 3-4, considering:

- Pilot weight: 50 kg
- No copilot
- Configuration 5 with only SmartGimbal Heavy in the frontmost position

The forward limit can be achieved but the resulting weight at takeoff is way lower than the minimum weight limit. The conclusion is that there is no reasonable possibility of loading the airplane so that the forward CG limit is reached or exceeded, let alone at MTOW. The use of ballasts to reach the limit CG position is considered for this reason unnecessary, moreover, no safe location was either indicated in the AFM or was identified by Certifying Staff for their installation.

Flight tests requiring the most forward CG position will thus be conducted referring to Figure 3-3 with:

- Configuration 6a. The most weight possible on SmartBay is necessary to test aircraft response to the most asymmetrical condition
- No baggage
- The most possible fuel (without exceeding MTOW)

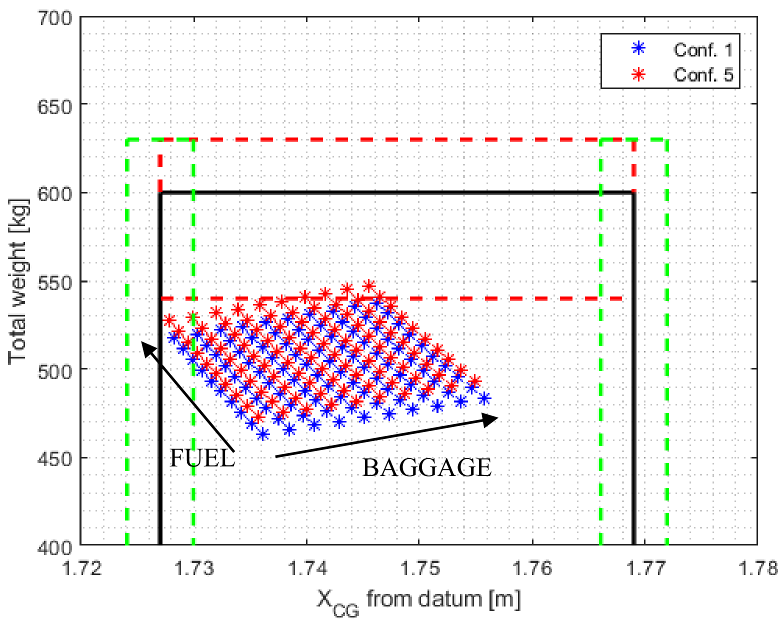


Figure 3-4: Most forward possible CG

Aft limit position

As shown in Figure 3-5, it is not possible, by varying only crew, fuel and baggage, to reach the aft CG limit either. In this case, however, we would like in some way to put the aircraft to its loading limits to investigate its behavior during the flight tests mainly for one reason. Crew CG position of 1.76m is stated in the AFM as the mean seat longitudinal position, and, in case of tall and heavy crew, CG can shift considerably backward. Moreover, even if it is forbidden to do so, the aircraft could be erroneously loaded improperly by exceeding baggage limit. Such events may lead to a limit condition which worsen the more the fuel is burned.

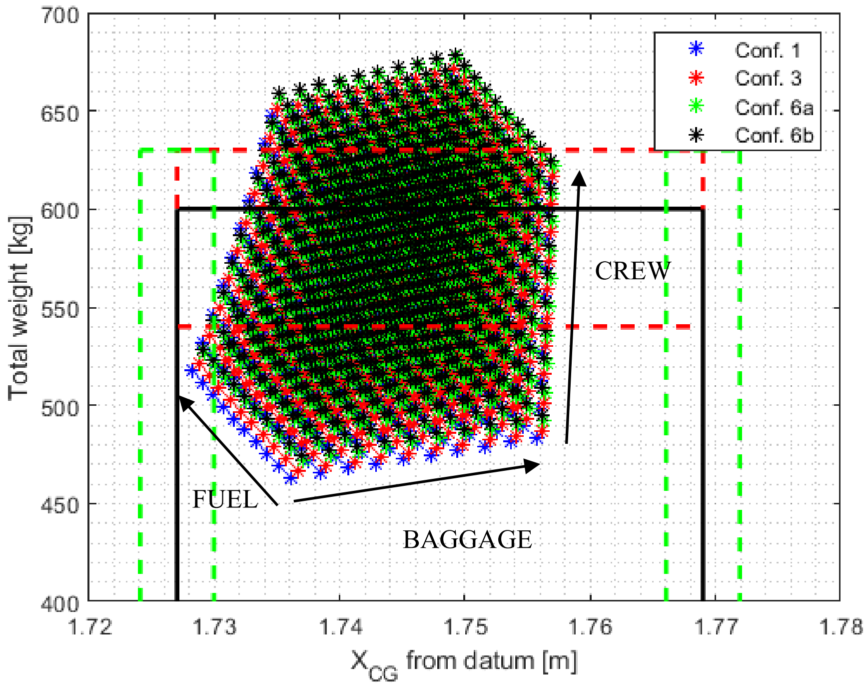


Figure 3-5: Most rear possible CG

To shift in the desired position the CG, we decided to use a ballast weight; this ballast shall be the lightest possible and secured as far as possible from the empty weight CG in a safe manner. The farthest accessible location is the battery compartment in the tail cone shown in Figure 3-6.

Figure 3-6: Battery compartment location

Inside of this compartment a tiny gap allows the safe installation of up to 3.5 kg lead weights, the graph in Figure 3-7 shows the introduction of such ballast (0 to 3.5 kg) where for a small increase in weight a great CG variation is achieved.

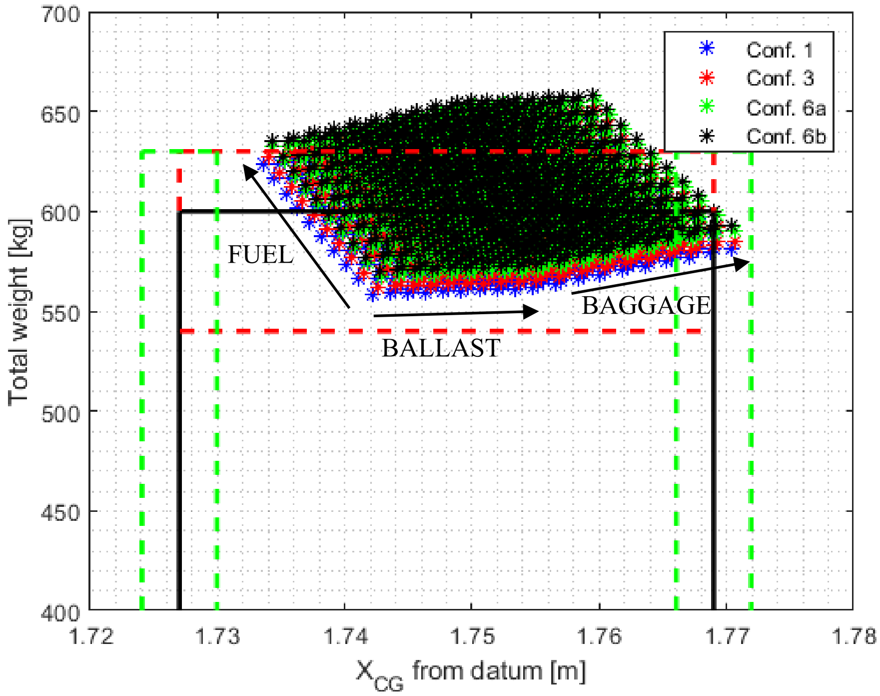


Figure 3-7: Most rear possible CG for flight test with ballast

Flight tests requiring the most rear CG position will then be conducted with:

- Configuration 6b. It is chosen the light SmartGimbal because contributes negatively for this CG requirement and the total weight is close to the MTOW
- The most allowable baggage (without exceeding MTOW)
- The least possible fuel for a safe flight

3.3 Test Schedule

Once all the combinations to be tested have been identified, see Table 8, it is necessary to distribute all the TPs into Test Flights taking into account the following requirements:

- Flights number shall be the least possible
- Loading configuration shall have the least possible variation between one flight and the following one
- Flight Test activity shall take place in a safe airspace within gliding distance from a airport or a flat field
- Flight Test activity shall not last more than 2 hours per flight (takeoff, ferry, approach and landing excluded)
- Flight Level changes shall be reduced to a minimum
- TPs involving the same maneuver shall be executed in the same flight and in sequence from the least to the most critical condition (when applicable)

The only information missing from Table 8 for an effective flight scheduling is the duration of each test point; such unknowns have been estimated by timing the execution of the same maneuvers with the same aircraft on the flight simulation software X-Plane 11. Results of this investigation are listed in Table 13.

Table 13: Test points duration

PROCEDURE	TIME PER RUN
TO climbs (low altitude)	2.5 min climb + 1 min descent
TO climbs (high altitude)	4 min climb + 1 min descent
Sawtooth climbs (low altitude)	2.5 min climb + 1 min descent
Sawtooth climbs (high altitude)	4 min climb + 1 min descent
Balked landing climb	2.5 min climb +1 min descent
Bank to bank	5 sec + 30 sec positioning
Stick force per V	3 min + 1 min positioning
Skid recovery	50 sec + 1 min positioning
Slip recovery	50 sec + 1 min positioning
Steady Heading Sideslips	50 sec + 1 min positioning
Longitudinal Short Period	15 sec + 15 sec positioning
Lateral Directional Dutch Roll	10 sec + 40 sec positioning
Longitudinal Phugoid	1 min + 1.5 min positioning
Wing Level Stalls	35 sec + 45 sec positioning

Accelerated Stalls	35 sec + 50 sec positioning
Turning stall	35 sec + 50 sec positioning

Following the abovementioned requirements and considering the execution time for each procedure, a total of 7 flights have been scheduled. Following table summarizes those flights listing the procedure and their associated Test Points and flight duration; further reference and the detailed calculation basis will be reported for each flight in the next chapter.

Table 14: Flight schedule

FLIGTH N.	CONF.	PROCEDURE	TP	TEST PROCEDURE DURATION
1	1	TO climbs (low altitude)	1	1h 42 min
		Sawtooth climbs (low altitude)	5	
		Balked landing climb	9	
		TO climbs (high altitude)	3	
		Sawtooth climbs (high altitude)	7	
2	1	Bank to bank	11	26 min
			12	
			13	
		Directional recovery	23	
			24	
			25	
3	3	Bank to bank	14	26 min
			15	
			16	
		Directional recovery	26	
			27	
			28	
4	6a	TO climbs (low altitude)	2	1h 42 min
		Sawtooth climbs (low altitude)	6	

		Balked landing climb	10	
		TO climbs (high altitude)	4	
		Sawtooth climbs (high altitude)	8	
5	6b	Bank to bank	17	57 min
			18	
			19	
		Stick force per V	20	
			21	
			22	
		Directional recovery	29	
			30	
			31	
6	6b	Lateral recovery	32	29 min
			33	
			34	
		Longitudinal Short Period	35	
			36	
			37	
		Accelerated stalls	50	
			51	
7	6b	Lateral Directional Dutch Roll	38	44 min
			39	
			40	
		Longitudinal Phugoid	41	
			42	
			43	
		Wing Level Stalls	44	
			45	
			46	
			47	

			48	
			49	
		Turning Stalls	52	
			53	
			54	
			55	
			56	
			57	

3.3.1 Flight Test Routine

For each flight the procedure listed below is followed to ensure the highest level of safety and results accuracy.

1. Aircraft inspection: the aircraft is inspected at the beginning of the day according to the daily inspection checklist;
2. Refueling: the aircraft is refueled according to the specific mission profile;
3. Payload loading: SmartBay payload is loaded according to mission profile;
4. Ballast loading: ballast weights and baggage are loaded if required by mission profile;
5. Weight and Balance report generation: center of gravity and its datum are calculated and certified by ground staff;
6. Crew briefing: PIC and FTE are briefed about the test to perform.
    a. Weight and Balance report acknowledgement
    b. Flight Test Card examination
    c. Emergency procedures review
    d. Risk assessment, taking into account:
        i. PIC experience, stress level, fatigue and crew day length
        ii. Mission and aircraft complexity
        iii. Environmental conditions (location, weather and airspace type)
7. Preflight aircraft inspection by crew: PIC and FTE verify loading conditions, overall airframe and engine status;
8. Flight Data Logger and GoPro camera installation: FDL and GoPro camera will provide aircraft behavior data which integrate data recorded by FTE on the test cards;
9. Flight execution;
10. Flight Data Logger and GoPro data download;

11. Fuel tanks unloading fuel tanks are drained to establish the exact fuel consumption (the fuel indicator is analog and not precise);
12. Post flight aircraft inspection: the aircraft and especially SmartBay pylon and payloads under test are inspected;
13. Crew debriefing: PIC and FTE share data gathered with ground crew;
14. Preparation for following flight or aircraft storage.

4 Flight Test Execution

The execution of the flight tests took place in June 2019 in Turin area having Aeritalia Airport (LIMA), where DigiSky is located, as operative base. The area identified for the flight test activity is close to LIMA airport just outside Torino 2 CTR as shown in Figure 4-1. The area selected is classified as uncontrolled class G airspace until FL85 while above this limit there is Milano 10 – Piemonte CTA class D controlled airspace, therefore, all flight-testing activity is conducted in uncontrolled airspace except for high altitude takeoffs and sawtooth climbs of flights #1 and #4.

Such area was therefore chosen because:

- is very close from base airport and transfer time is minimized to 5 minutes from takeoff to test area;
- crew is very familiar with the area;
- the airspace is class G uncontrolled which ensures a certain freedom for test activity;
- air traffic is minimum;
- its surroundings feature two airfields (Aviosuperficie Musinè and Campo Volo Valsusa), two airports (Torino Caselle LIMF and Torino Aeritalia LIMA) and plenty of flat fields ensuring the highest level of safety in case an emergency landing is necessary.

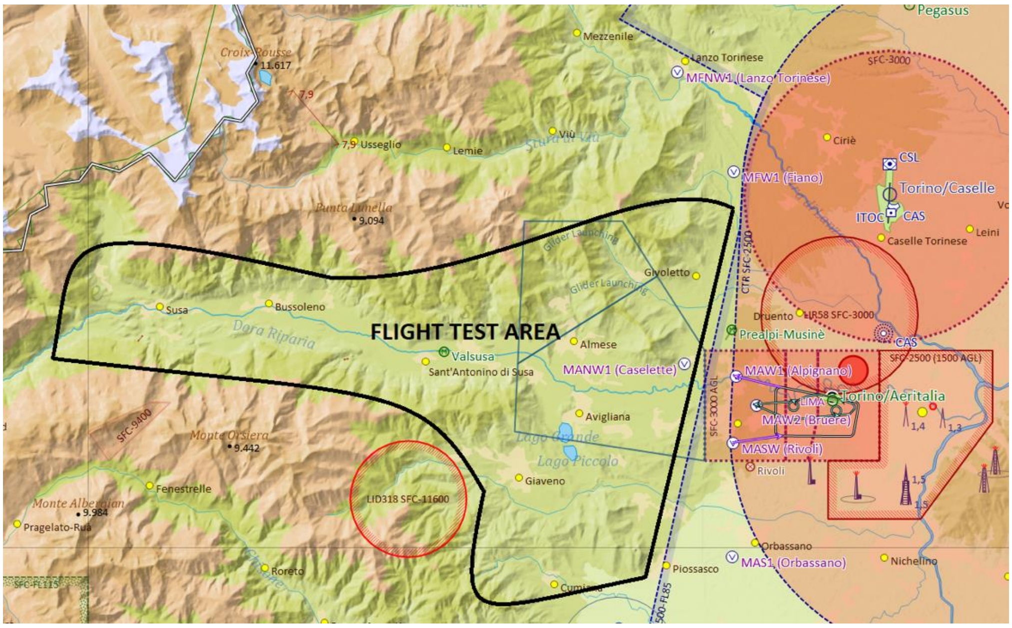


Figure 4-1: Flight Test Area

In the following paragraphs, mission profiles and test results will be thoroughly analyzed for each test flight.

Mission profiles take into account the flight test schedule described in the previous paragraph and further analyze each maneuver in terms of time required for its execution as well as fuel consumption according to the engine power settings required by FTP and tested in the simulator.

Aircraft fuel consumption is deduced by interpolating AFM data. Table 15 shows fuel consumption estimation in liters per hour with respect to the engine power settings and pressure altitude of the aircraft. Note that green cells values are reported from the AFM (ISA conditions), white cells values are interpolated and the fuel consumption at idle is 1000 RPM is set to 6 l/h for all altitudes.

Table 15: Fuel consumption estimation

PRESSURE ALTITUDE [ft]					
0	**1000**	**1900**	**2050**	**2150**	**RPM**
	6	15	18	20	**l/h**
1000	**1000**	**1925**	**2060**	**2150**	**RPM**
	6	15	18	19.5	**l/h**
1500	**1000**	**1937.5**	**2065**	**2150**	**RPM**
	6	15	18	19.25	**l/h**
2000	**1000**	**1950**	**2070**	**2150**	**RPM**
	6	15	18	19	**l/h**
2500	**1000**	**1967.5**	**2072.5**	**2150**	**RPM**
	6	15	17.75	18.875	**l/h**
3000	**1000**	**1985**	**2075**	**2150**	**RPM**
	6	15	17.5	18.75	**l/h**
3500	**1000**	**2002.5**	**2077.5**	**2150**	**RPM**
	6	15	17.25	18.625	**l/h**
4000	**1000**	**2020**	**2080**	**2150**	**RPM**
	6	15	17	18.5	**l/h**
4500	**1000**	**2030**	**2150**		**RPM**
	6	15	18.125		**l/h**
5000	**1000**	**2040**	**2150**		**RPM**
	6	15	17.75		**l/h**
5500	**1000**	**2050**	**2150**		**RPM**
	6	15	17.375		**l/h**
6000	**1000**	**2060**	**2150**		**RPM**
	6	15	17		**l/h**
6500	**1000**	**2075**	**2150**		**RPM**
	6	15	16.75		**l/h**
7000	**1000**	**2090**	**2150**		**RPM**
	6	15	16.5		**l/h**
7500	**1000**	**2105**	**2150**		**RPM**
	6	15	16.25		**l/h**
8000	**1000**	**2120**	**2150**		**RPM**
	6	15	16		**l/h**
8500	**1000**	**2120**	**2150**		**RPM**
	6	14.7	15.68		**l/h**
9000	**1000**	**2120**	**2150**		**RPM**
	6	14.406	15.3664		**l/h**
9500	**1000**	**2120**	**2150**		**RPM**
	6	14.11788	15.059072		**l/h**

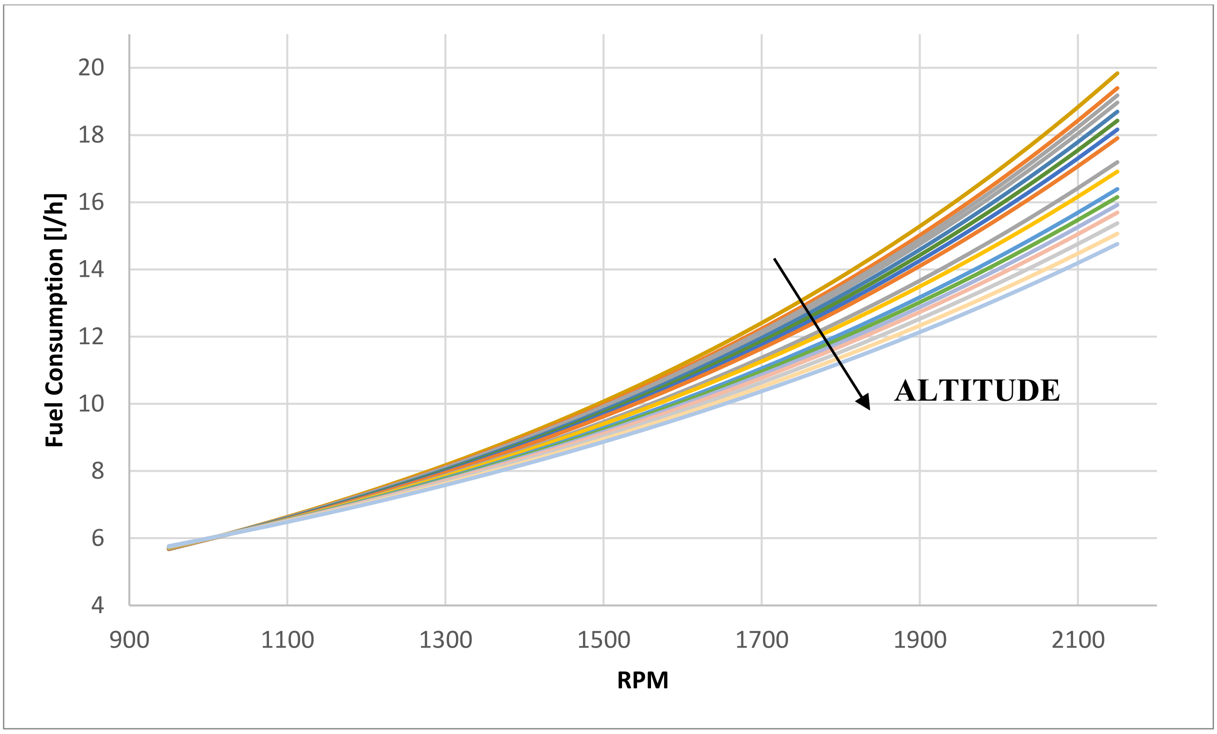


Figure 4-2: Fuel consumption per altitude and power settings

4.1 Flight #1

Following table summarizes the procedures that are carried out during flight #1. This flight is performed with configuration 1 (clean) and its duration is estimated to be 1 hour and 42 minutes.

Table 16: Flight #1 recap

FLIGTH N.	CONF.	PROCEDURE	TP	TEST PROCEDURE DURATION
1	1	TO climbs (low altitude)	1	1h 42 min
		Sawtooth climbs (low altitude)	5	
		Balked landing climb	9	
		TO climbs (high altitude)	3	
		Sawtooth climbs (high altitude)	7	

4.1.1 Mission profile

An extract of the spreadsheet used for the mission profile calculation is provided here below. For each flight segment and maneuver procedure it is estimated a duration and a mean engine RPM through the flight simulator software and, according to those data, a detailed account of the fuel consumption is achieved through interpolation from Figure 4-2.

The estimated duration of the flight is about 2 hours and 10 minutes with a test procedure duration of 1 hour and 42 minutes therefore complying with requirements of par. 3.3; fuel consumption estimation is of 33 liters plus 3 liters for taxiing and ground operations.

Table 17: Flight #1 mission profile data

			MAN. TIME	TOTAL TIME	MEAN RPM	ALT. [ft]	FUEL CONS. [l/h]	CONS. FUEL [l]	TOTAL FUEL [l]
Start			00:00:00	00:00:00	0	1000	0.000	0	0
Takeoff			00:01:00	00:01:00	2150	2000	18.966	0.316	0.316
Ferry			00:05:00	00:06:00	2150	2500	18.695	1.558	1.874
1	TO Climbs Low Altitude (2 runs)	Climb	00:02:30	00:08:30	2150	3500	18.164	0.757	2.631
		Descent	00:01:00	00:09:30	1800	2500	13.210	0.220	2.851
		Positioning	00:00:15	00:09:45	2150	2500	18.695	0.078	2.929
		Climb	00:02:30	00:12:15	2150	3500	18.164	0.757	3.686
		Descent	00:01:00	00:13:15	1800	2500	13.210	0.220	3.906
5	Sawtooth Climbs Low Altitude (6 runs)	Positioning	00:00:15	00:13:30	2150	2500	18.695	0.078	3.984
		Climb	00:02:30	00:16:00	2150	3500	18.164	0.757	4.741
		Descent	00:01:00	00:17:00	1800	2500	13.210	0.220	4.961
		Positioning	00:00:15	00:17:15	2150	2500	18.695	0.078	5.039
		Climb	00:02:30	00:19:45	2150	3500	18.164	0.757	5.796
		Descent	00:01:00	00:20:45	1800	2500	13.210	0.220	6.016
		Positioning	00:00:15	00:21:00	2150	2500	18.695	0.078	6.094
		Climb	00:02:30	00:23:30	2150	3500	18.164	0.757	6.850

		Descent	00:01:00	00:24:30	1800	2500	13.210	0.220	7.071
		Positioning	00:00:15	00:24:45	2150	2500	18.695	0.078	7.149
		Climb	00:02:30	00:27:15	2150	3500	18.164	0.757	7.905
		Descent	00:01:00	00:28:15	1800	2500	13.210	0.220	8.126
		Positioning	00:00:15	00:28:30	2150	2500	18.695	0.078	8.203
		Climb	00:02:30	00:31:00	2150	3500	18.164	0.757	8.960
		Descent	00:01:00	00:32:00	1800	2500	13.210	0.220	9.180
		Positioning	00:00:15	00:32:15	2150	2500	18.695	0.078	9.258
		Climb	00:02:30	00:34:45	2150	3500	18.164	0.757	10.015
		Descent	00:01:00	00:35:45	1800	2500	13.210	0.220	10.235
		Positioning	00:00:15	00:36:00	2150	2500	18.695	0.078	10.313
		Climb	00:02:30	00:38:30	2150	3500	18.164	0.757	11.070
		Descent	00:01:00	00:39:30	1800	2500	13.210	0.220	11.290
		Positioning	00:00:15	00:39:45	2150	2500	18.695	0.078	11.368
		Climb	00:02:30	00:42:15	2150	3500	18.164	0.757	12.125
		Descent	00:01:00	00:43:15	1800	2500	13.210	0.220	12.345
9	Balked Landings (2 runs)	Positioning	00:00:15	00:43:30	2150	2500	18.695	0.078	12.423
		Climb	00:02:30	00:46:00	2150	3500	18.164	0.757	13.180
		Descent	00:01:00	00:47:00	1800	2500	13.210	0.220	13.400
		Positioning	00:00:15	00:47:15	2150	2500	18.695	0.078	13.478
		Climb	00:02:30	00:49:45	2150	3500	18.164	0.757	14.235
		Hold	00:00:10	00:49:55	2150	3500	18.164	0.050	14.285
Transfer Climb		Climb	00:02:00	00:51:55	2150	4500	17.475	0.583	14.868
		Climb	00:02:15	00:54:10	2150	5500	16.912	0.634	15.502
		Climb	00:02:30	00:56:40	2150	6500	16.392	0.683	16.185
		Climb	00:02:45	00:59:25	2150	7500	15.920	0.730	16.915
		Climb	00:03:00	01:02:25	2150	8500	15.374	0.769	17.683
3	TO Climbs High Altitude (2 runs)	Climb	00:04:00	01:06:25	2150	9500	14.757	0.984	18.667
		Descent	00:01:00	01:07:25	2000	8500	13.597	0.227	18.894
		Positioning	00:00:25	01:07:50	2150	8500	15.374	0.107	19.000
		Climb	00:04:00	01:11:50	2150	9500	14.757	0.984	19.984
		Descent	00:01:00	01:12:50	2000	8500	13.597	0.227	20.211
7	Sawtooth Climbs High Altitude (6 runs)	Positioning	00:00:25	01:13:15	2150	8500	15.374	0.107	20.318
		Climb	00:04:00	01:17:15	2150	9500	14.757	0.984	21.301
		Descent	00:01:00	01:18:15	2000	8500	13.597	0.227	21.528
		Positioning	00:00:25	01:18:40	2150	8500	15.374	0.107	21.635
		Climb	00:04:00	01:22:40	2150	9500	14.757	0.984	22.619
		Descent	00:01:00	01:23:40	2000	8500	13.597	0.227	22.845
		Positioning	00:00:25	01:24:05	2150	8500	15.374	0.107	22.952
		Climb	00:04:00	01:28:05	2150	9500	14.757	0.984	23.936
		Descent	00:01:00	01:29:05	2000	8500	13.597	0.227	24.162
		Positioning	00:00:25	01:29:30	2150	8500	15.374	0.107	24.269
		Climb	00:04:00	01:33:30	2150	9500	14.757	0.984	25.253
		Descent	00:01:00	01:34:30	2000	8500	13.597	0.227	25.480
		Positioning	00:00:25	01:34:55	2150	8500	15.374	0.107	25.586
		Climb	00:04:00	01:38:55	2150	9500	14.757	0.984	26.570
		Descent	00:01:00	01:39:55	2000	8500	13.597	0.227	26.797
		Positioning	00:00:25	01:40:20	2150	8500	15.374	0.107	26.904
		Climb	00:04:00	01:44:20	2150	9500	14.757	0.984	27.887
		Descent	00:01:00	01:45:20	2000	8500	13.597	0.227	28.114
		Positioning	00:00:25	01:45:45	2150	8500	15.374	0.107	28.221
		Climb	00:04:00	01:49:45	2150	9500	14.757	0.984	29.205
		Descent	00:01:00	01:50:45	2000	8500	13.597	0.227	29.431
		Positioning	00:00:25	01:51:10	2150	8500	15.374	0.107	29.538
		Climb	00:04:00	01:55:10	2150	9500	14.757	0.984	30.522
Initial Descent		Descent	00:01:00	01:56:10	2000	8500	13.597	0.227	30.748
		Descent	00:01:00	01:57:10	1800	7500	11.827	0.197	30.946
		Descent	00:01:00	01:58:10	1800	6500	12.067	0.201	31.147
		Descent	00:01:00	01:59:10	1800	5500	12.328	0.205	31.352
		Descent	00:01:00	02:00:10	1800	4500	12.606	0.210	31.562
		Descent	00:01:00	02:01:10	1800	3500	12.946	0.216	31.778

	Descent	00:01:00	02:02:10	1800	2500	13.210	0.220	31.998
Approach		00:06:00	02:08:10	1600	1500	10.981	1.098	33.096
Landing		00:01:00	02:09:10	1200	1000	7.335	0.122	33.218

Figure 4-3 shows the flight altitude profile: sawtooth climbs and takeoff climbs procedures are clearly distinguishable and the transfer climb from 3000 ft to 9000 ft is separated into 1000 ft increments to consider the reduction of the rate of climb with altitude.

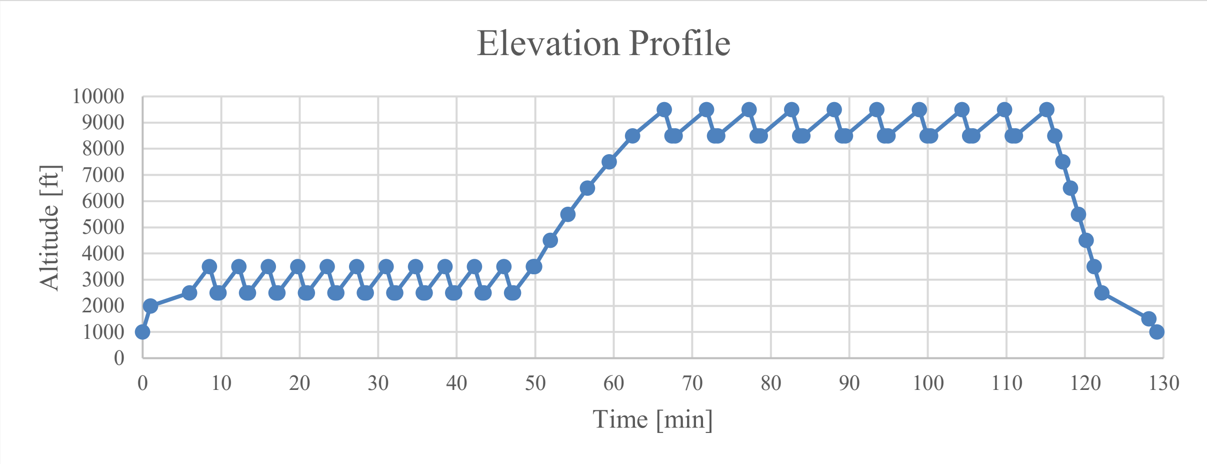


Figure 4-3: Estimated altitude profile of Flight #1

An estimation for fuel consumption is provided in Figure 4-4. It is evident the difference between the climbing and descending sections of the sawtooth climbs as well as the reduction of the fuel consumption with the altitude increase.

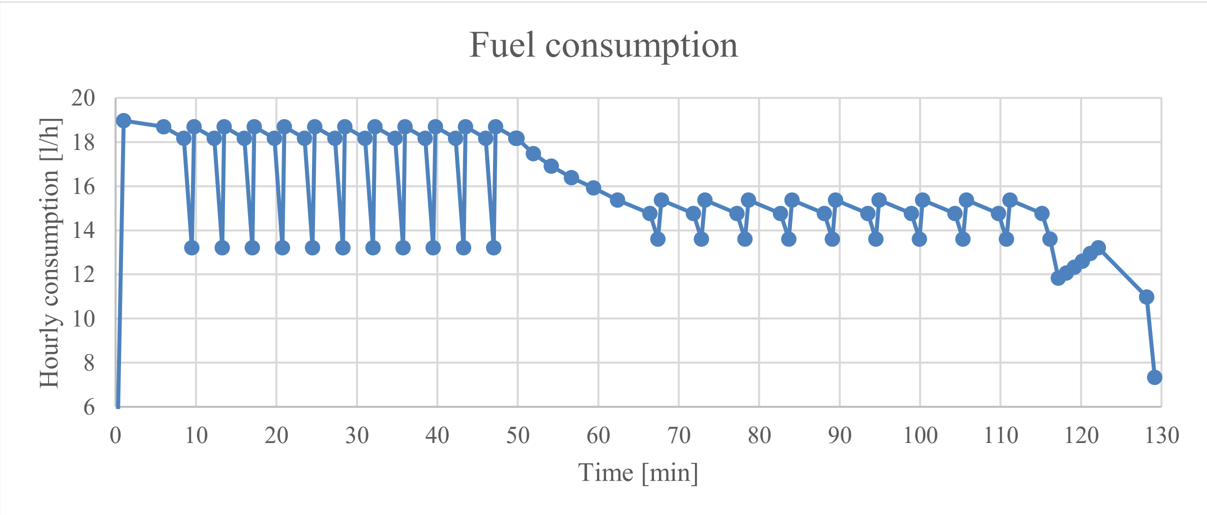


Figure 4-4: Estimated fuel consumption of Flight #1

4.1.2 Weight and Balance

The first flight requires the SmartBay in clean configuration and a forward CG. To achieve such configuration, without exceeding MTOW, 80 liters of fuel are loaded and no ballast or baggage are installed. Note that at takeoff the aircraft weight is approximately 616 kg, so within the MTOW+5% limitation while at landing is estimated to be 590 kg, again within

MTOW-10% limitation. The CG, however, cannot fall within the ±7% of the forward limit as explained in §3.2.5.

Table 18: Flight #1, Weight and Balance calculation

		WEIGHT [kg]		ARM [m]	MOMENTUM [kg*m]	
		TO	LND		TO	LND
	EMPTY WEIGHT	401	401	1.734	695.45	695.45
	FUEL (80 l)	57.6	31.68	1.660	95.616	52.5888
	PILOT	83	83	1.760	146.08	146.08
	COPILOT	73	73	1.760	128.48	128.48
SMARTBAY	NAKED TROLLEY	0.4	0.4	1.710	0.684	0.684
SMARTBAY	NAKED TROLLEY	0.4	0.4	1.910	0.764	0.764
SMARTBAY	NAKED TROLLEY	0.4	0.4	2.110	0.844	0.844
SMARTBAY	BIU	0.5	0.5	2.310	1.155	1.155
	BAGGAGE	0	0	2.210	0	0
	REAR BALLAST	0	0	4.100	0	0
	TOTAL	616.3	590.38	-	1069.07	1026.05
	CG [m]	1.735	1.738			

Figure 4-5 plots the results of the table above and the excursion of the CG due to fuel consumption. The orange line sets MTOW+5% limit (630 kg) while the green lines represent the ±7% limitation around forward and aft limits.

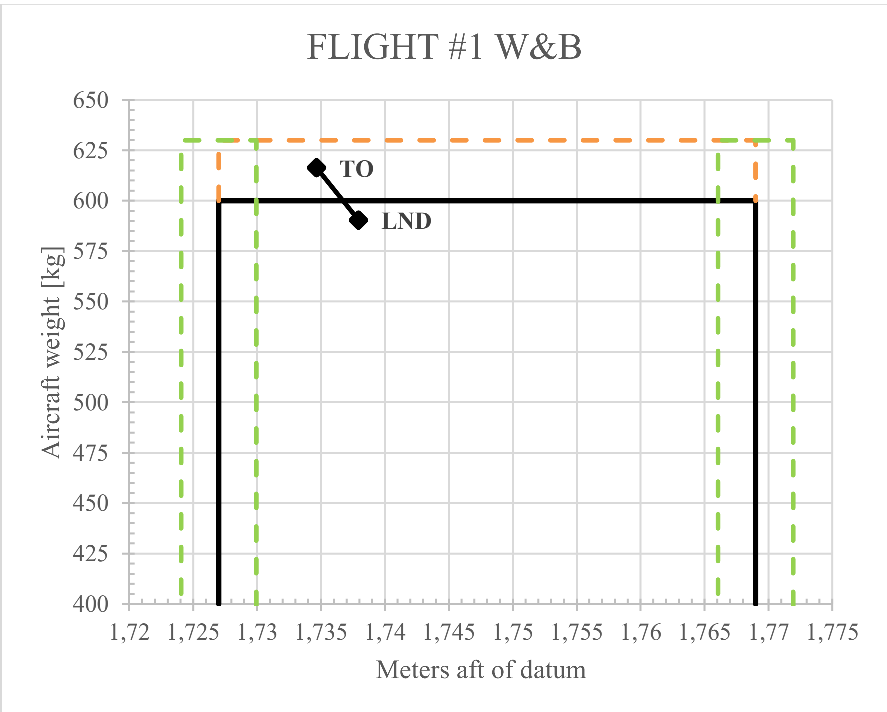


Figure 4-5: Flight #1, Weight and CG excursion during flight

4.1.3 Procedures and data recording

Maneuvers included in this flight are simulated takeoff climbs at low and high altitude, sawtooth climbs at low and high altitude and simulated balked landing climbs. Procedures related to those maneuvers are listed hereafter.

Takeoff Climbs:

- Set flaps to TO
- Stabilize airspeed and power prior to recording data at the indicated trim speed and power setting 200 ft below the specified starting altitude.
- Climb 1000 ft to the specified altitude with constant airspeed
- Descent rapidly to 200ft below the specified starting altitude
- Repeat this procedure as many times as indicated

Sawtooth Climbs:

- Set flaps to 0°
- Stabilize airspeed and power prior to recording data at the indicated trim speed and power setting 200 ft below the specified starting altitude.
- Climb 1000 ft to the specified altitude with constant airspeed
- Descent rapidly to 200ft below the specified starting altitude
- Repeat this procedure as many times as indicated

Balked Landing Climb:

- Set flaps to LND
- Stabilize airspeed and power prior to recording data at the indicated trim speed and power setting 200 ft below the specified starting altitude.
- Climb 1000 ft to the specified altitude with constant airspeed
- Descent rapidly to 200ft below the specified starting altitude
- Repeat this procedure as many times as indicated

Climbs shall be conducted 90° to the wind, and alternately, on reciprocal headings to minimize the effects of wind-shear.

Data to be recorded manually by the FTE on the Flight Test Card for all TPs are:

- IAS: Indicated Airspeed at initial and final pressure altitude
- RPM: Engine RPM at initial and final pressure altitude
- OAT: OAT at initial and final pressure altitude
- TIME: Stopwatch time for each climb segments

Data recorded automatically during Test Flight #1 are:

- GPS data
- IMU data
- Video

4.1.4 Results

The first flight was carried out in the afternoon of June 6, 2019. Table 19 reports main flight information regarding flight times and fuel consumed while Figure 4-6 shows the complex path on a map. Note that flight time and fuel consumption estimation are consistent with the actual data.

Table 19: Flight #1 summary

FLIGHT SUMMARY			
TAKEOFF		**LANDING**	
AIRPORT:	LIMA	**AIRPORT:**	LIMA
TIME:	14:38	**TIME:**	16:49
WIND SPEED:	5 KTS	**WIND SPEED:**	VAR 3 KTS
WIND HDG:	330°	**WIND HDG:**	-
FUEL:	80 L	**FUEL:**	42 L
ESTIMATED FLIGHT TIME		2h 09 min	
ACTUAL FLIGHT TIME:		**2h 11min** (+1.5% from estimation)	
ESTIMATED FUEL CONSUMPTION		36 liters	
ACTUAL FUEL CONSUMPTION:		**38 liters** (+5.5% from estimation)	

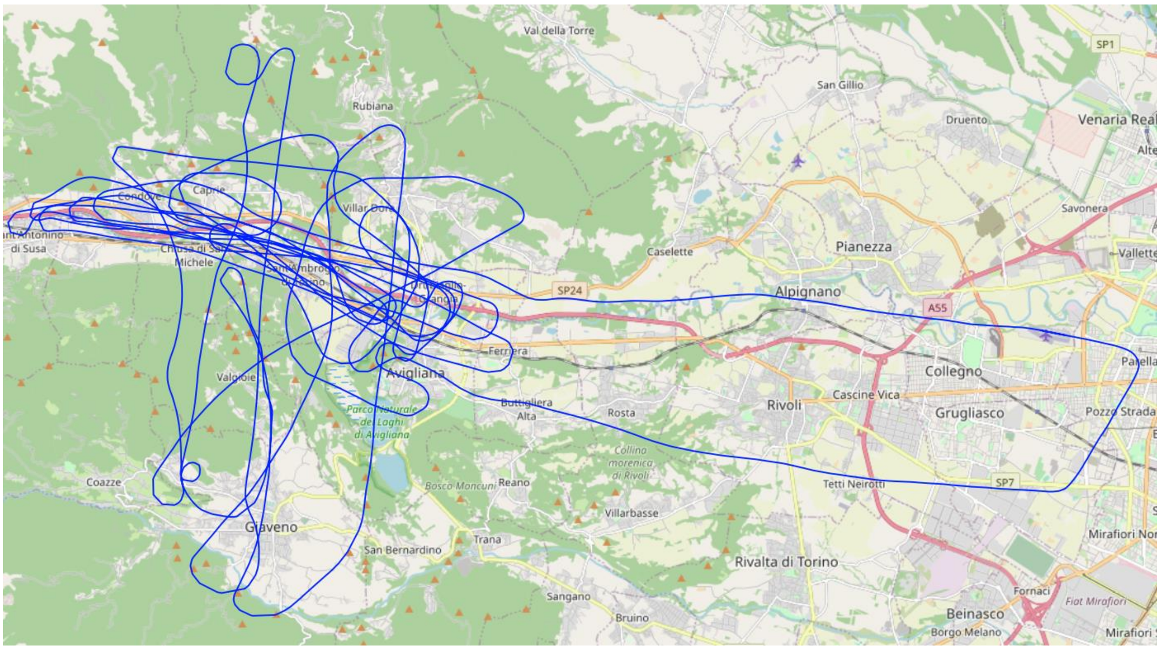


Figure 4-6: Flight #1 path

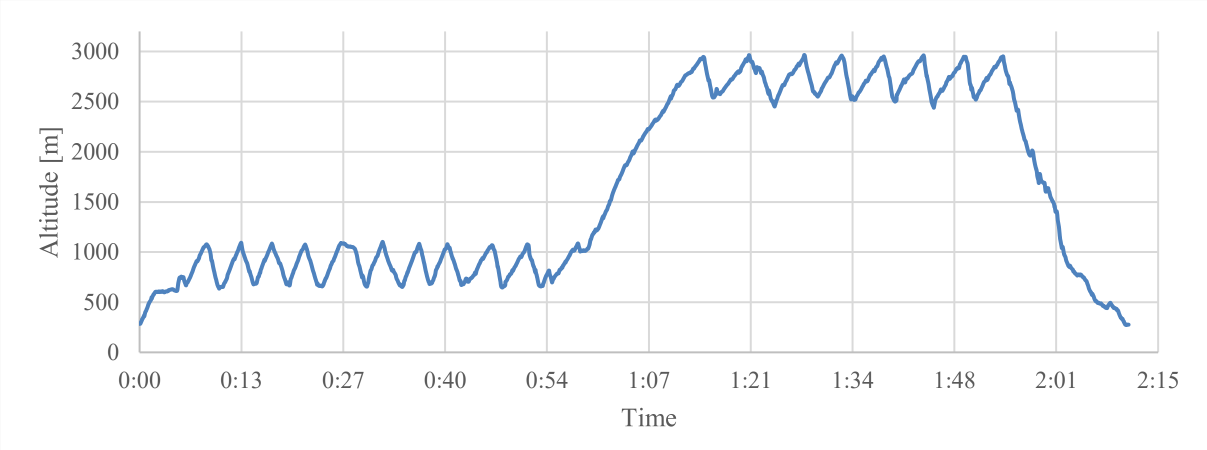


Figure 4-7: Flight #1 actual altitude profile

All TPs of this flight test are related to climb performances of the aircraft, for this reason, to compare results with the AFM declared performances is necessary to reduce data to the same standard conditions. Factors which influence climb performances during testing are:

- Outside Air Temperature
- Power setting
- Gross Weight
- Wind conditions

Steps hereby reported to ensure a precise performance evaluation refer to the Altitude Density Method detailed in AC 23-8C [7].

1. The Rate of Climb (RC) observed during the flight test is computed by measuring the time taken to reach pressure altitude H_{p2} from H_{p1}according to:

$$RC_{TEST} = \frac{H_{p2} - H_{p1}}{\Delta t}$$

2. RC_{TEST} is then corrected for the effect of OAT. in non-standard temperature conditions, pressure altitude variation is different from real altitude variation. The measured Rate of Climb has to be corrected:

$$RC_{TRUE} = RC_{TEST} \frac{T_{TEST}}{T_{STD}}$$

Where T_{STD} is the standard ISA temperature for $\frac{H_{p2}-H_{p1}}{2}$ pressure altitude. Note that both temperatures are expressed in K.

3. RC_{TRUE} has now to be corrected with the variation of the test weight from the standard MTOW as during this flight weight varies of 27 kg approximately. The variation of the RC is:

$$\Delta RC_W = RC_{TRUE} \left(\frac{W_{TEST} - MTOW}{W_{TEST}} \right)$$

4. A non-standard weight condition implies that the wing has to provide different lift compared to standard conditions, with the associated induced drag. The variation of Induced drag equals to:

$$\Delta D_i = \frac{(W_{TEST}^2 - MTOW^2)}{\frac{1}{2}\rho V^2 \pi e b^2}$$

Where V is the True Airspeed (TAS), *e* is the Oswald factor (estimated 0.8), ρ is the air density and *b* is the wingspan. Rate of Climb variation is thus:

$$\Delta RC_{D_i} = \frac{\Delta D_i V}{MTOW}$$

5. If the power available in test condition is different than that in standard conditions, a correction has to be applied (note that temperature also affects power available). The thrust horsepower (THP) is equal to the brake horsepower (BHP) multiplied by propeller efficiency. The variation of thrust horsepower is equal to:

$$\Delta THP = \left(P_{a_{STD}} - P_{a_{TEST}}\right)\eta_P$$

Where $P_{a_{TEST}}$ is the available BHP on test day, $P_{a_{STD}}$ is the reference BHP to which we want to reduce data; and η_P is the propeller efficiency (estimated at 0.8). Since the climb performance data in the AFM have been obtained with a "full throttle" setting, with no other specific indication of RPM achieved, it is not possible to determine a precise $P_{a_{STD}}$. Considering that the tests have also been carried out with a full throttle setting, the only correction on power that will be applied here is the one involving non-standard temperature:

$$P_{a_{TEST}} = P_{a_{STD}} \frac{T_{STD}}{T_{TEST}}$$

Where temperatures are expressed in *K*.

Power performances has been estimated by using the chart in Figure 4-8.

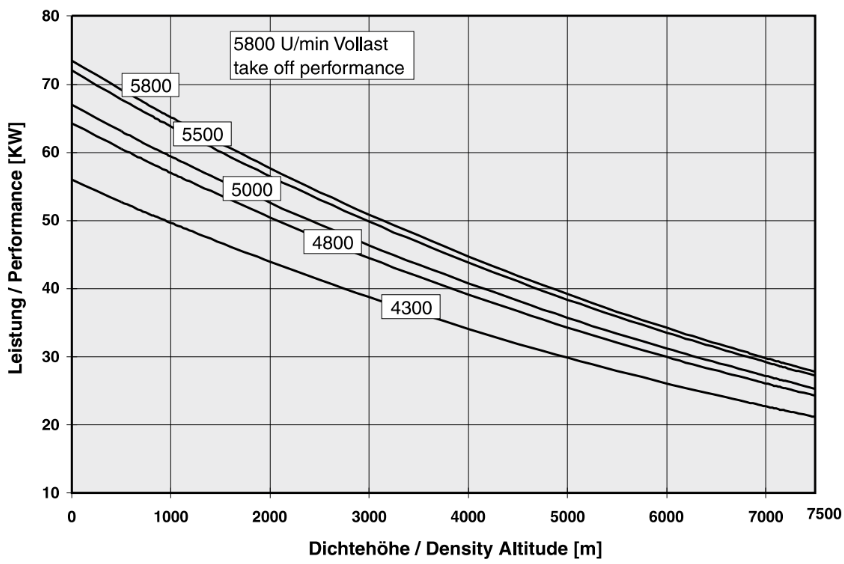


Figure 4-8: Rotax 912 S2 performances chart

The variation in rate of climb caused by variation in power is then:

$$\Delta RC_P = \frac{\Delta THP}{MTOW}$$

6. Finally, the standard RC is calculated:

$$RC_{STD} = RC_{TRUE} + \Delta RC_W + \Delta RC_{D_i} + \Delta RC_P$$

Take-off Climbs (TPs 1-3)

Results of climb performances during take-off climbs reduced according to the method stated above are reported in Table 20.

Table 20: Take-off climbs data reduced

TP	H_p $[ft]$	IAS $[kts]$	RC_{TEST} $[ft/min]$	RC_{TRUE} $[ft/min]$	ΔRC_W $[ft/min]$	ΔRC_{Di} $[ft/min]$	ΔRC_P $[ft/min]$	RC_{STD} $[ft/min]$	RC_{STD} mean $[ft/min]$
1	3000	71	526.3	542.9	8.6	10.5	52.0	614	634
	3000	71	566.0	583.9	8.7	9.8	52.0	654	
3	9000	71	284.4	293.6	-2.7	-7.7	46.4	330	339
	9000	71	304.6	314.5	-3.5	-9.4	46.4	348	

CS-VLA 65 requires a minimum climb rate of 2 m/s (397.7 ft/min) at sea level; results show that this requirement is largely met at 3000 ft, and almost up to 9000 ft, therefore the installation is considered compliant with CS-VLA 65.

Sawtooth climbs (TPs 5-7)

Results of climb performances during take-off climbs reduced according to the method stated above are reported in Table 20.

Table 21: Sawtooth climbs data reduced

TP	H_p $[ft]$	IAS $[kts]$	RC_{TEST} $[ft/min]$	RC_{TRUE} $[ft/min]$	ΔRC_W $[ft/min]$	ΔRC_{Di} $[ft/min]$	ΔRC_P $[ft/min]$	RC_{STD} $[ft/min]$	RC_{STD} mean $[ft/min]$
5	3000	68	560.7	578.4	7.4	8.8	52.0	647	657
	3000	68	582.5	600.9	6.5	7.4	52.0	667	
	3000	73	560.7	578.4	5.0	5.6	52.0	641	669
	3000	73	618.6	638.0	3.9	3.9	52.0	698	
	3000	78	588.2	606.8	1.8	1.8	52.0	662	664
	3000	78	594.1	612.8	0.2	0.2	52.0	665	
7	9000	68	339.0	349.4	-4.9	-12.1	43.9	376	396
	9000	68	379.7	391.4	-5.9	-13.0	43.9	416	
	9000	73	340.9	351.4	-6.4	-14.7	43.9	374	367
	9000	73	331.5	341.7	-7.4	-17.3	43.9	361	
	9000	78	340.9	351.4	-8.5	-18.2	43.9	368	370
	9000	78	346.8	357.5	-9.7	-20.2	43.9	371	

Data is then compared with the climb section of the AFM shown in Figure 4-9. At ISA conditions, stated RC for 3000 ft and 9000 ft at MTOW are 480 ft/min and 810 ft/min respectively. Climb performances where tested for $V_Y \pm 5\ kts$ to evaluate possible deviations from the statedV_Y of 73 kts; results however show that no clear trend is visible in RC for the different indicated airspeed tested. It is concluded that the installation does not change V_Y.

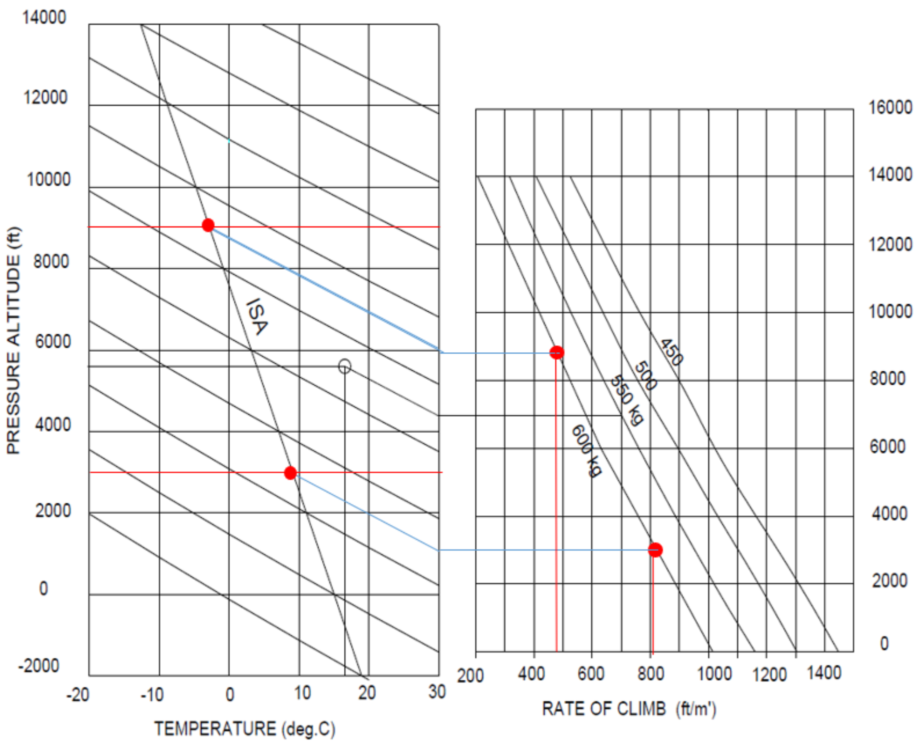


Figure 4-9: AFM performance section extract

Figure 4-10 shows that the deviations from the original AFM climb performances are of -141 and -113 ft/min at 9000 ft and 3000 ft respectively with an average deficit of 127 ft/min.

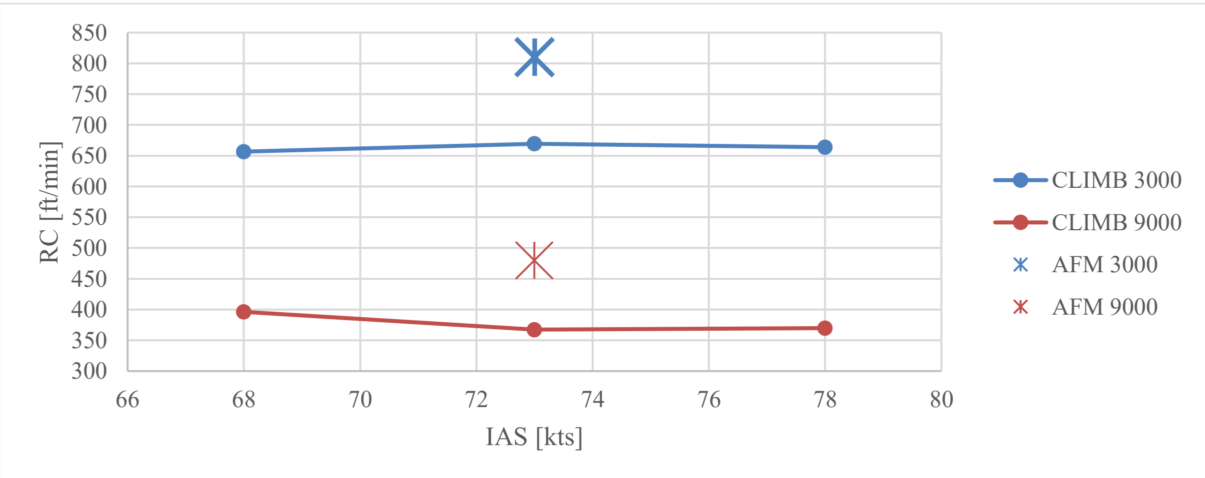


Figure 4-10: Climb performances deviation from AFM

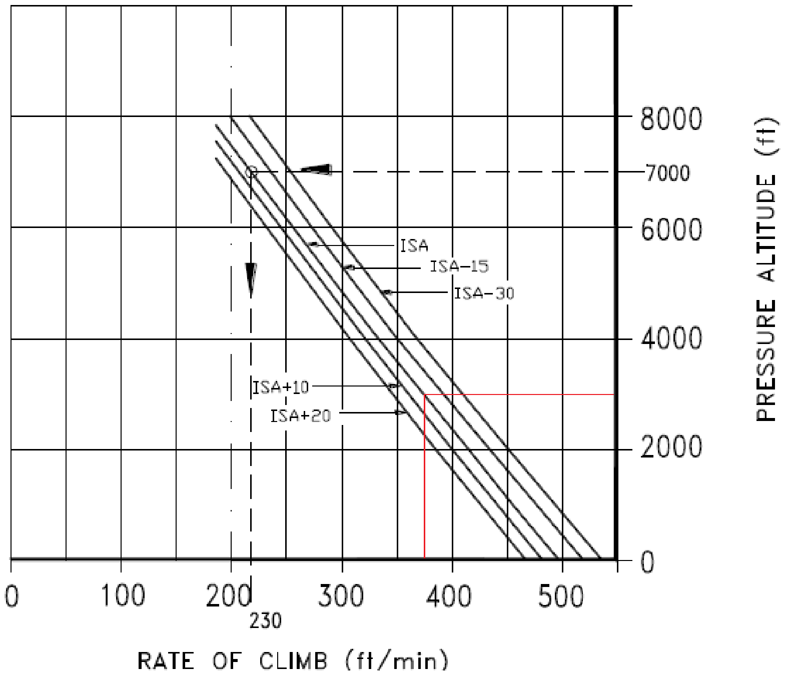
Balked landing climbs (TP 9)

Table 22: Balked landing climbs data reduced

TP	H_p $[ft]$	IAS $[kts]$	RC_{TEST} $[ft/min]$	RC_{TRUE} $[ft/min]$	ΔRC_W $[ft/min]$	ΔRC_{Di} $[ft/min]$	ΔRC_P $[ft/min]$	RC_{STD} $[ft/min]$	RC_{STD} $mean$ $[ft/min]$
9	3000	60	405.4	418.2	-1.2	-2.1	52.0	467	430
	3000	60	335.2	345.8	-1.7	-3.7	52.0	392	

CS-VLA 77 requires a minimum climb angle of 1:30 (corresponding to 203 ft/min for an airspeed of 60 kts) at sea level. As a higher climb rate is obtained at a higher altitude, the requirement has been met and the installation is considered compliant with CS-VLA 77.

According to the AFM (see Figure 4-11) the rate of climb, is ISA conditions, is 375 ft/min for a balked landing and decreases to 338 ft/min as the MTOW of the aircraft is 600 kg. As the recorded data show a higher RC than the one reported in the AFM, no correction will be made to the latter.



NOTE

If the maximum takeoff weight is 600 kg, the rate of climb decreases about 10%

Figure 4-11: AFM Balked landing performances

4.2 Flight #2

Following table summarizes the procedures that are carried out during flight #2. This flight is performed with configuration 1 (clean) and its duration, as far as testing procedures are concerned, is estimated to be 26 minutes.

Table 23: Flight #2 recap

FLIGTH N.	CONF.	PROCEDURE	TP	TEST PROCEDURE DURATION
2	1	Bank to bank	11	26 min
			12	
			13	
		Skid recovery	23	
			24	
			25	

4.2.1 Mission profile

An extract of the spreadsheet used for the mission profile calculation is provided here below. Same considerations of the other flights for RPM and fuel consumption calculation apply.

The estimated duration of the flight is about 40 minutes with a test procedure duration of 26 minutes, complying with requirements of par. 3.3; fuel consumption estimation is of 8.5 liters plus 3 liters for taxiing and ground operations.

Table 24: Flight #2 mission profile data

			MAN. TIME	TOTAL TIME	MEAN RPM	ALT. [ft]	FUEL CONS. [l/h]	CONS. FUEL [l]	TOTAL FUEL [l]
Start			00:00:00	00:00:00	0	1000	0.000	0	0
Takeoff			00:01:00	00:01:00	2150	2000	18.966	0.316	0.316
Ferry			00:05:00	00:06:00	2150	3500	18.164	1.514	1.830
11	Bank to Bank Controllability MAX TO (4 runs)	Roll	00:00:05	00:06:05	2150	3500	18.164	0.025	1.855
		Positioning	00:00:30	00:06:35	2150	3500	18.164	0.151	2.006
		Roll	00:00:05	00:06:40	2150	3500	18.164	0.025	2.032
		Positioning	00:00:30	00:07:10	2150	3500	18.164	0.151	2.183
		Roll	00:00:05	00:07:15	2150	3500	18.164	0.025	2.208
		Positioning	00:00:30	00:07:45	2150	3500	18.164	0.151	2.360
		Roll	00:00:05	00:07:50	2150	3500	18.164	0.025	2.385
		Positioning	00:01:00	00:08:50	1700	3500	11.752	0.196	2.581
12	Bank to Bank Controllability LND LF (4 runs)	Roll	00:00:05	00:08:55	1700	3500	11.752	0.016	2.597
		Positioning	00:00:30	00:09:25	1700	3500	11.752	0.098	2.695
		Roll	00:00:05	00:09:30	1700	3500	11.752	0.016	2.711
		Positioning	00:00:30	00:10:00	1700	3500	11.752	0.098	2.809
		Roll	00:00:05	00:10:05	1700	3500	11.752	0.016	2.825
		Positioning	00:00:30	00:10:35	1700	3500	11.752	0.098	2.923

		Roll	00:00:05	00:10:40	1700	3500	11.752	0.016	2.940
		Positioning	00:01:00	00:11:40	1700	3500	11.752	0.196	3.136
13	Bank to Bank Controllability LND IDLE (4 runs)	Roll	00:00:05	00:11:45	1000	3500	5.970	0.008	3.144
		Positioning	00:00:30	00:12:15	1000	3500	5.970	0.050	3.194
		Roll	00:00:05	00:12:20	1000	3500	5.970	0.008	3.202
		Positioning	00:00:30	00:12:50	1000	3500	5.970	0.050	3.252
		Roll	00:00:05	00:12:55	1000	3500	5.970	0.008	3.260
		Positioning	00:00:30	00:13:25	1000	3500	5.970	0.050	3.310
		Roll	00:00:05	00:13:30	1000	3500	5.970	0.008	3.318
		Positioning	00:01:00	00:14:30	1000	3500	5.970	0.099	3.417
23	Directional recovery CLEAN (4 runs)	Right	00:00:25	00:14:55	1600	3500	10.668	0.074	3.492
		Left	00:00:25	00:15:20	1600	3500	10.668	0.074	3.566
		Positioning	00:01:00	00:16:20	1600	3500	10.668	0.178	3.743
		Right	00:00:25	00:16:45	1800	3500	12.946	0.090	3.833
		Left	00:00:25	00:17:10	1800	3500	12.946	0.090	3.923
		Positioning	00:01:00	00:18:10	1800	3500	12.946	0.216	4.139
		Right	00:00:25	00:18:35	2000	3500	15.710	0.109	4.248
		Left	00:00:25	00:19:00	2000	3500	15.710	0.109	4.357
		Positioning	00:01:00	00:20:00	2000	3500	15.710	0.262	4.619
		Right	00:00:25	00:20:25	2150	3500	18.164	0.126	4.745
		Left	00:00:25	00:20:50	2150	3500	18.164	0.126	4.871
		Positioning	00:01:00	00:21:50	2150	3500	18.164	0.303	5.174
24	Directional recovery TO (4 runs)	Right	00:00:25	00:22:15	1600	3500	10.668	0.074	5.248
		Left	00:00:25	00:22:40	1600	3500	10.668	0.074	5.322
		Positioning	00:01:00	00:23:40	1600	3500	10.668	0.178	5.500
		Right	00:00:25	00:24:05	1700	3500	11.752	0.082	5.582
		Left	00:00:25	00:24:30	1700	3500	11.752	0.082	5.663
		Positioning	00:01:00	00:25:30	1700	3500	11.752	0.196	5.859
		Right	00:00:25	00:25:55	1700	3500	11.752	0.082	5.941
		Left	00:00:25	00:26:20	1700	3500	11.752	0.082	6.022
		Positioning	00:01:00	00:27:20	1700	3500	11.752	0.196	6.218
		Right	00:00:25	00:27:45	1800	3500	12.946	0.090	6.308
		Left	00:00:25	00:28:10	1800	3500	12.946	0.090	6.398
		Positioning	00:01:00	00:29:10	1800	3500	12.946	0.216	6.614
25	Directional recovery LND (2 runs)	Right	00:00:25	00:29:35	1700	3500	11.752	0.082	6.695
		Left	00:00:25	00:30:00	1700	3500	11.752	0.082	6.777
		Positioning	00:01:00	00:31:00	1700	3500	11.752	0.196	6.973
		Right	00:00:25	00:31:25	1700	3500	11.752	0.082	7.054
		Left	00:00:25	00:31:50	1700	3500	11.752	0.082	7.136
Descent			00:01:00	00:32:50	1800	2500	13.210	0.220	7.356
Approach			00:06:00	00:38:50	1600	1500	10.981	1.098	8.454
Landing			00:01:00	00:39:50	1200	1000	7.335	0.122	8.577

Figure 4-12 shows the flight altitude profile: all maneuvers take place at the same altitude of 3500 ft, takeoff, ferry, approach and landing are clearly distinguishable.

An estimation for fuel consumption is provided in Figure 4-13. Different maneuvers are here identifiable:

- Bank to bank controllability test is conducted with 3 different power settings with decreasing progression;
- Skid recovery is then conducted with flaps clean from 1.2 V_{S_1} to V_{NE} requiring gradually increasing power setting;
- Finally skid recovery with flaps TO and LND from 1.2 V_{S_1} to V_{FE} requiring a gradually increasing power setting but within a narrower range.

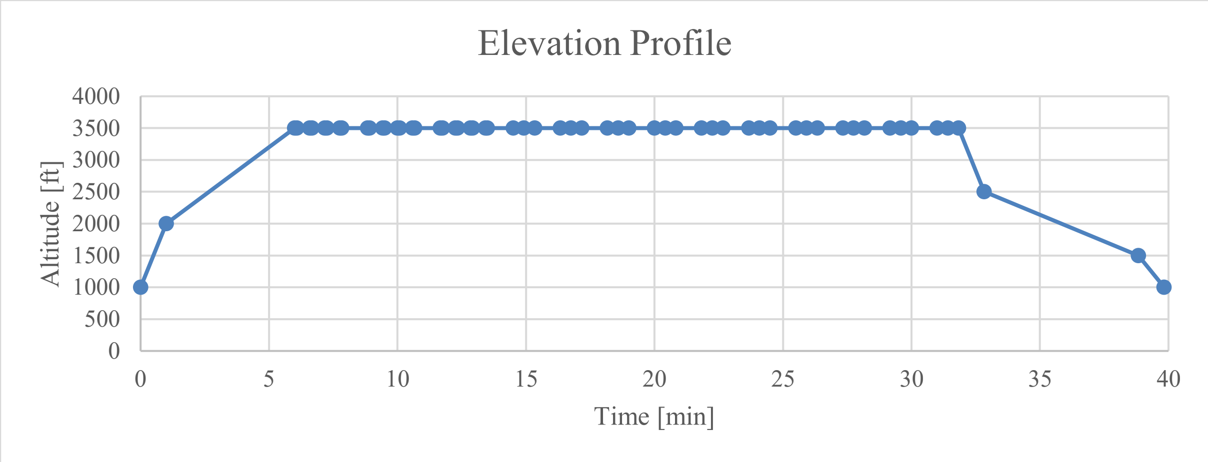


Figure 4-12: Estimated altitude profile of Flight #2

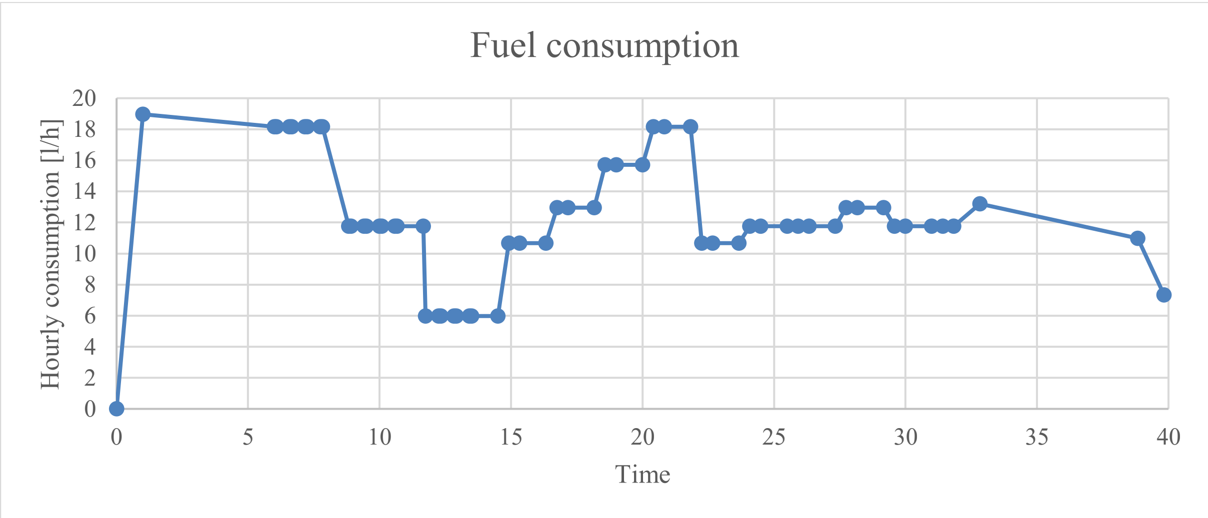


Figure 4-13: Estimated fuel consumption of Flight #2

4.2.2 Weight and Balance

This flight is conducted again in clean configuration according to the requirement explained in §3.3 stating that test shall be carried out from the least to the most critical condition. CG, however, shall be in the rearmost position: baggage compartment is then loaded with a sandbag secured to the airframe with ropes and a small ballast is inserted in the battery compartment.

Note that at takeoff the aircraft weight is approximately 604 kg, so within the MTOW+5% limitation while at landing is estimated to be 595 kg, again within MTOW-10% limitation. The CG, however, cannot fall within the ±7% of the forward limit as explained in §3.2.5.

Table 25: Flight #2, Weight and Balance calculation

		WEIGHT [kg]		ARM [m]	MOMENTUM [kg*m]	
		TO	**LND**		**TO**	**LND**
	EMPTY WEIGHT	401	401	1.734	695.45	695.45
	FUEL (40 l)	28.8	20.52	1.660	47.808	34.0632
	PILOT	83	83	1.760	146.08	146.08
	COPILOT	73	73	1.760	128.48	128.48
SMARTBAY	**NAKED TROLLEY**	0.4	0.4	1.710	0.684	0.684
SMARTBAY	**NAKED TROLLEY**	0.4	0.4	1.910	0.764	0.764
SMARTBAY	**NAKED TROLLEY**	0.4	0.4	2.110	0.844	0.844
SMARTBAY	**BIU**	0.5	0.5	2.310	1.155	1.155
	BAGGAGE	13	13	2.210	28.73	28.73
	REAR BALLAST	3	3	4.100	12.3	12.3
	TOTAL	**603.5**	**595.22**	**-**	**1062.30**	**1048.55**
	CG [m]	**1.760**	**1.762**			

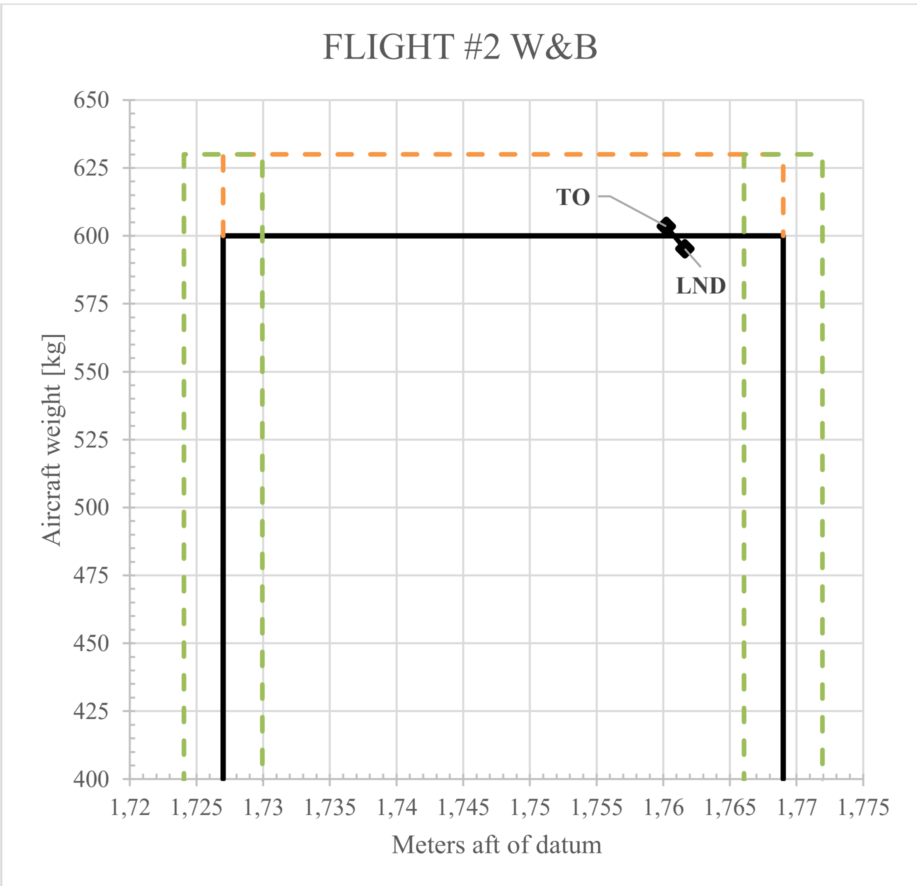


Figure 4-14: Flight #2, Weight and CG excursion during flight

4.2.3 Procedures description

Maneuvers included in this flight are bank to bank rolls and skid recovery. Procedures related to those maneuvers are listed hereafter.

Bank to bank rolls:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings
- Stabilize the aircraft in a 30° bank and roll through an angle of 60° in the opposite direction. For example, with the aircraft in a steady 30° left bank, roll to a 30° right bank.
- Repeat this procedure for the opposite roll direction
- Repeat this procedure as many times as indicated

Directional recovery:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings
- Slowly yaw the aircraft in one direction keeping the wings leveled with ailerons
- Release the rudder
- Repeat for opposite yaw direction
- Repeat this procedure as many times as indicated

Data to be recorded manually by the FTE are:

- Bank to bank:
    - ROLL DIRECTION: Indicate if roll is left to right or right to left
    - IAS: Indicated Airspeed maintained during the maneuver
    - RPM: Engine RPM maintained during the maneuver
    - TIME: Stopwatch time from roll start through 60° roll

- Directional recovery:
    - YAW DIRECTION: Indicate if the aircraft is the rudder is originally excited to the left or right
    - CONTROL MAX DISPLACEMENTS: Indicate how much ailerons and rudder are excited to carry out the maneuver in terms of controls travel
    - RETURN TO STRAIGHT FLIGHT: Specify whether the aircraft tends to return to straight flight or not
    - FORCES INCREASE: Specify whether the forces the pilot exerts on the controls increases or not during maneuver execution

Data recorded automatically during Test Flight #2 are:

- GPS data
- IMU data
- Video

4.2.4 Results

Table 26 reports main flight information regarding flight times and fuel consumed while Figure 4-15 shows the flight path on a map where bank to bank rolls are distinguishable. Note that flight time and fuel consumption estimation are consistent with the actual data even though small differences result in larger relative error due to the brevity of the flight.

Table 26: Flight #2 summary

FLIGHT SUMMARY			
TAKEOFF		**LANDING**	
AIRPORT:	LIMA	**AIRPORT:**	LIMA
TIME:	07:23	**TIME:**	08:08
WIND SPEED:	-	**WIND SPEED:**	-
WIND HDG:	-	**WIND HDG:**	-
FUEL:	40 L	**FUEL:**	25 L
ESTIMATED FLIGHT TIME		40 min	
ACTUAL FLIGHT TIME:		**45 min** (+12% from estimation)	
ESTIMATED FUEL CONSUMPTION		11.5 liters	
ACTUAL FUEL CONSUMPTION:		**15 liters** (+30% from estimation)	

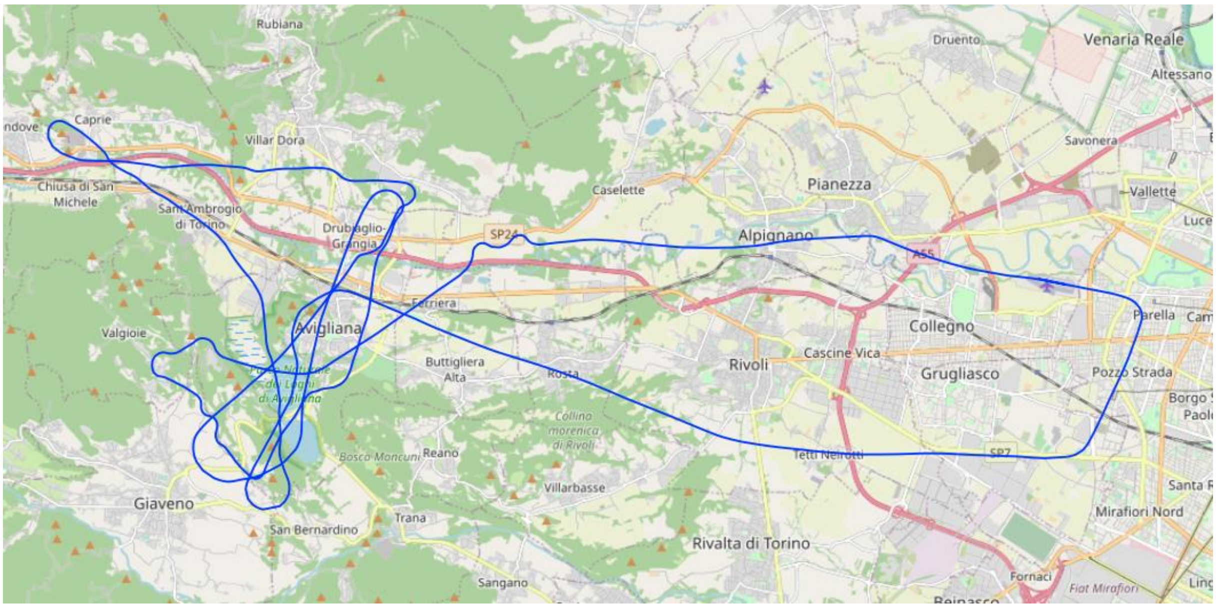


Figure 4-15: Flight #2 path

The actual altitude profile is shown here below where the dotted line represents the scheduled 3500 ft cruise altitude for this flight. The actual path shows that part of the bank to bank maneuvers are conducted at a higher altitude (up to 4500 ft); such difference however does not influence test results. Skid recovery runs at V_{NE} are carried out during a descent as was not possible to reach such airspeed in straight flight.

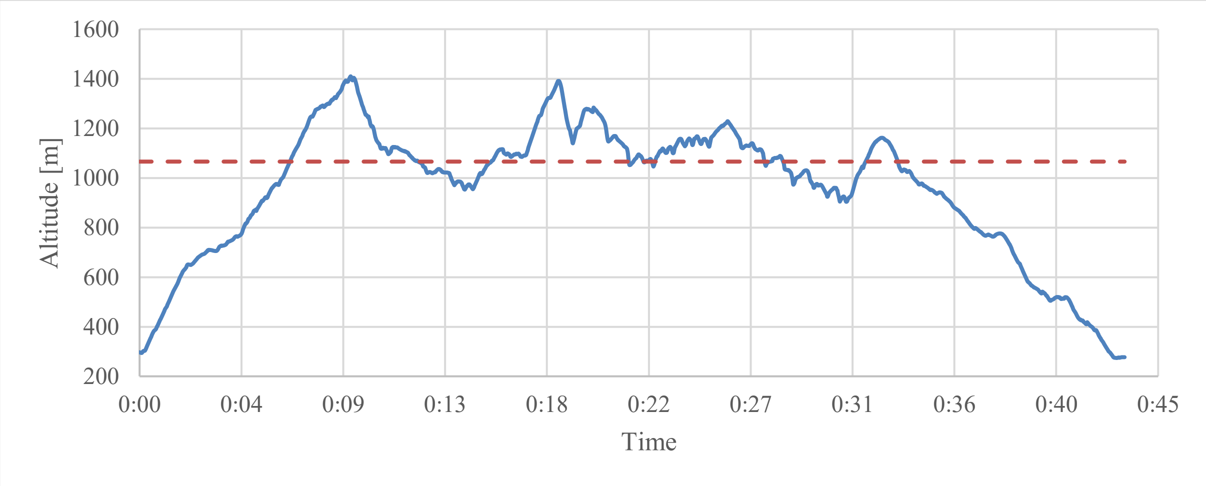


Figure 4-16: Flight #2 actual altitude profile

Bank to bank (TPs 11-12-13)

Following table summarizes the data gathered during bank to bank maneuver. Note that SmartBay is installed under the right wing generating a rolling moment to the right which counteracts the left rolling moment due to the propeller torque. As clean configuration has a very low effect on aerodynamic forces, as assessed in §3.1, the engine torque prevails in TPs 11 and 12 resulting in faster right to left rolls on average. With power at IDLE level, the aerodynamic effect of the SmartBay leads to faster left to right rolls.

Table 27: Bank to bank results

TP 11 – TO FLAPS, MAX TO PWR				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	55	2150	2.97
2	L → R	55	2150	3.87
3	R → L	55	2150	2.49
4	L → R	55	2150	3.66
TP 12 – LND FLAPS, PWR for LF				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	60	2000	2.82
2	L → R	60	2000	3.01
3	R → L	60	2000	2.33
4	L → R	60	2000	3.01

TP 13 – LND FLAPS, PWR IDLE				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	60	900	3.35
2	L → R	60	900	2.50
3	R → L	60	900	3.15
4	L → R	60	900	2.49

CS-VLA 157 requires a bank to bank time of less than 5 seconds, therefore, this configuration is compliant with the regulation. This bank to bank test will be later compared with the same test in different configurations.

Directional recovery (TPs 23-24-25)

The following table shows the data gathered during the test flight regarding directional behavior. All test points were successfully performed, and the aircraft always showed a positive directional stability with positive force gradients.

Maneuvers performed by applying right pedal, at relatively low speeds (up to about 70 KIAS) required a full left aileron command. This behavior was apparent in every flap configuration. Nevertheless with TO flaps, left aileron saturation occurred with about 4/5 of rudder command, while with LND flaps it occurred with full rudder deflection (i.e. both aileron and rudder commands were saturated). This indicates that with LND flaps it is possible to achieve and maintain a higher sideslip angle than with TO flap.

At relatively high speeds (above about 100 KIAS), recovery was more prompt when the aircraft was yawed to the right, with respect to the left yaw case.

Table 28: Directional recovery results

TP 23 – CLEAN FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	9/10	FULL	YES	YES
		L	FULL	3/4	YES	YES
2	79	R	3/4	FULL	YES	YES
		L	FULL	3/4	YES	YES
3	103	R	3/4	3/4	YES	YES
		L	3/4	1/2	YES	YES
4	130	R	1/2	1/4	YES (FAST)	YES
		L	1/2	1/4	YES (SLOW)	YES

TP 24 – TO FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
2	60	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
3	65	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
4	71	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
TP 25 – LND FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	FULL	FULL	YES	YES
		L	FULL	1/2	YES	YES
2	71	R	FULL	FULL	YES	YES
		L	FULL	1/2	YES	YES

During the tests, aileron and rudder forces always steadily increased and never reversed; for this reason compliance with CS-VLA177 was demonstrated.

These tests highlighted the two most relevant characteristics observed during flight testing of the SmartBay installation: the asymmetrical saturation of aileron control during low-speed steady heading sideslips, and the asymmetrical reduction in directional stability at high speed. These aspects are going to be analyzed in the next paragraphs after the other flights involving the same maneuvers are presented.

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4.3 Flight #3

Following table summarizes the procedures that are carried out during flight #3. This flight is performed with configuration 3 (2 SmartCamera and a Naked Trolley) and includes the same maneuvers of flight #2.

Table 29: Flight #3 recap

FLIGTH N.	CONF.	PROCEDURE	TP	TEST PROCEDURE DURATION
3	3	Bank to bank	14	26 min
			15	
			16	
		Skid recovery	26	
			27	
			28	

4.3.1 Mission profile

As this flight is planned with the same maneuvers of flight #2, the mission profile does not change apart from the TP numbers.

The estimated duration of the flight is again of 40 minutes with a test procedure duration of 26 minutes, complying with requirements of par. 3.3; fuel consumption estimation is of 8.5 liters plus 3 liters for taxiing and ground operations.

Table 30: Flight #3 mission profile data

			MAN. TIME	TOTAL TIME	MEAN RPM	ALT. [ft]	FUEL CONS. [l/h]	CONS. FUEL [l]	TOTAL FUEL [l]
Start			00:00:00	00:00:00	0	1000	0.000	0	0
Takeoff			00:01:00	00:01:00	2150	2000	18.966	0.316	0.316
Ferry			00:05:00	00:06:00	2150	3500	18.164	1.514	1.830
14	Bank to Bank Controllability MAX TO (4 runs)	Roll	00:00:05	00:06:05	2150	3500	18.164	0.025	1.855
		Positioning	00:00:30	00:06:35	2150	3500	18.164	0.151	2.006
		Roll	00:00:05	00:06:40	2150	3500	18.164	0.025	2.032
		Positioning	00:00:30	00:07:10	2150	3500	18.164	0.151	2.183
		Roll	00:00:05	00:07:15	2150	3500	18.164	0.025	2.208
		Positioning	00:00:30	00:07:45	2150	3500	18.164	0.151	2.360
		Roll	00:00:05	00:07:50	2150	3500	18.164	0.025	2.385
		Positioning	00:01:00	00:08:50	1700	3500	11.752	0.196	2.581
15	Bank to Bank Controllability LND LF (4 runs)	Roll	00:00:05	00:08:55	1700	3500	11.752	0.016	2.597
		Positioning	00:00:30	00:09:25	1700	3500	11.752	0.098	2.695
		Roll	00:00:05	00:09:30	1700	3500	11.752	0.016	2.711
		Positioning	00:00:30	00:10:00	1700	3500	11.752	0.098	2.809
		Roll	00:00:05	00:10:05	1700	3500	11.752	0.016	2.825
		Positioning	00:00:30	00:10:35	1700	3500	11.752	0.098	2.923

		Roll	00:00:05	00:10:40	1700	3500	11.752	0.016	2.940
		Positioning	00:01:00	00:11:40	1700	3500	11.752	0.196	3.136
16	Bank to Bank Controllability LND IDLE (4 runs)	Roll	00:00:05	00:11:45	1000	3500	5.970	0.008	3.144
		Positioning	00:00:30	00:12:15	1000	3500	5.970	0.050	3.194
		Roll	00:00:05	00:12:20	1000	3500	5.970	0.008	3.202
		Positioning	00:00:30	00:12:50	1000	3500	5.970	0.050	3.252
		Roll	00:00:05	00:12:55	1000	3500	5.970	0.008	3.260
		Positioning	00:00:30	00:13:25	1000	3500	5.970	0.050	3.310
		Roll	00:00:05	00:13:30	1000	3500	5.970	0.008	3.318
		Positioning	00:01:00	00:14:30	1000	3500	5.970	0.099	3.417
26	Skid recovery CLEAN (4 runs)	Right	00:00:25	00:14:55	1600	3500	10.668	0.074	3.492
		Left	00:00:25	00:15:20	1600	3500	10.668	0.074	3.566
		Positioning	00:01:00	00:16:20	1600	3500	10.668	0.178	3.743
		Right	00:00:25	00:16:45	1800	3500	12.946	0.090	3.833
		Left	00:00:25	00:17:10	1800	3500	12.946	0.090	3.923
		Positioning	00:01:00	00:18:10	1800	3500	12.946	0.216	4.139
		Right	00:00:25	00:18:35	2000	3500	15.710	0.109	4.248
		Left	00:00:25	00:19:00	2000	3500	15.710	0.109	4.357
		Positioning	00:01:00	00:20:00	2000	3500	15.710	0.262	4.619
		Right	00:00:25	00:20:25	2150	3500	18.164	0.126	4.745
		Left	00:00:25	00:20:50	2150	3500	18.164	0.126	4.871
		Positioning	00:01:00	00:21:50	2150	3500	18.164	0.303	5.174
27	Skid recovery TO (4 runs)	Right	00:00:25	00:22:15	1600	3500	10.668	0.074	5.248
		Left	00:00:25	00:22:40	1600	3500	10.668	0.074	5.322
		Positioning	00:01:00	00:23:40	1600	3500	10.668	0.178	5.500
		Right	00:00:25	00:24:05	1700	3500	11.752	0.082	5.582
		Left	00:00:25	00:24:30	1700	3500	11.752	0.082	5.663
		Positioning	00:01:00	00:25:30	1700	3500	11.752	0.196	5.859
		Right	00:00:25	00:25:55	1700	3500	11.752	0.082	5.941
		Left	00:00:25	00:26:20	1700	3500	11.752	0.082	6.022
		Positioning	00:01:00	00:27:20	1700	3500	11.752	0.196	6.218
		Right	00:00:25	00:27:45	1800	3500	12.946	0.090	6.308
		Left	00:00:25	00:28:10	1800	3500	12.946	0.090	6.398
		Positioning	00:01:00	00:29:10	1800	3500	12.946	0.216	6.614
28	Skid recovery LND (2 runs)	Right	00:00:25	00:29:35	1700	3500	11.752	0.082	6.695
		Left	00:00:25	00:30:00	1700	3500	11.752	0.082	6.777
		Positioning	00:01:00	00:31:00	1700	3500	11.752	0.196	6.973
		Right	00:00:25	00:31:25	1700	3500	11.752	0.082	7.054
		Left	00:00:25	00:31:50	1700	3500	11.752	0.082	7.136
Descent			00:01:00	00:32:50	1800	2500	13.210	0.220	7.356
Approach			00:06:00	00:38:50	1600	1500	10.981	1.098	8.454
Landing			00:01:00	00:39:50	1200	1000	7.335	0.122	8.577

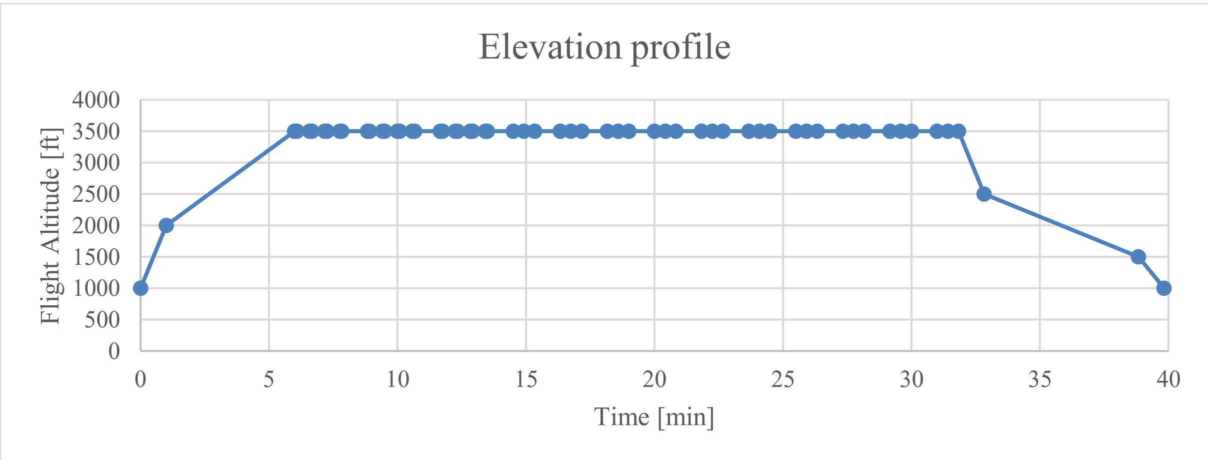

Figure 4-17: Estimated altitude profile of Flight #3

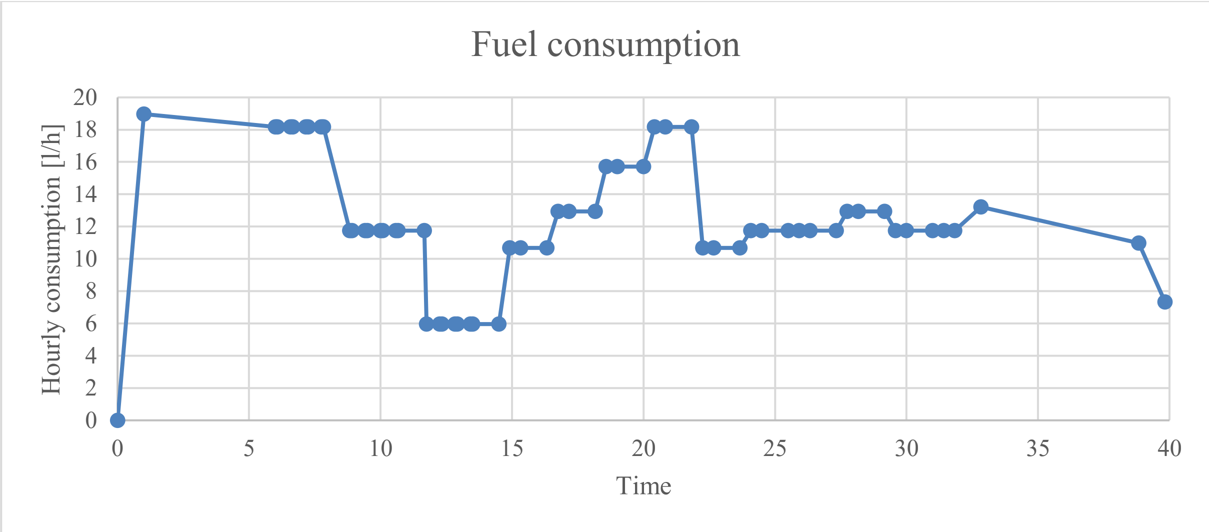

Figure 4-18: Estimated fuel consumption of Flight #3

4.3.2 Weight and Balance

This flight is conducted with configuration n.3 according to the requirement explained in §3.3 stating that test shall be carried out from the least to the most critical condition. CG shall be in the rearmost position: baggage compartment is then loaded with a sandbag secured to the airframe with ropes and a small ballast is inserted in the battery compartment.

Note that at takeoff the aircraft weight is approximately 610 kg, so within the MTOW+5% limitation while at landing is estimated to be 598 kg, again within MTOW-10% limitation. The CG, however, cannot fall within the ±7% of the forward limit as explained in §3.2.5.

Table 31: Flight #3, Weight and Balance calculation

		WEIGHT [kg]		ARM [m]	MOMENTUM [kg*m]	
		TO	LND		TO	LND
	EMPTY WEIGHT	401	401	1.734	695.45	695.45
	FUEL (40 l)	28.8	20.52	1.660	47.808	34.0632
	PILOT	83	83	1.760	146.08	146.08
	COPILOT	73	73	1.760	128.48	128.48
SMARTBAY	SMARTCAMERA	2.1	2.1	1.710	3.591	3.591
SMARTBAY	SMARTCAMERA	2.1	2.1	1.910	4.011	4.011
SMARTBAY	NAKED TROLLEY	0.4	0.4	2.110	0.844	0.844
SMARTBAY	BIU	0.5	0.5	2.310	1.155	1.155
	BAGGAGE	13	13	2.210	28.73	28.73
	REAR BALLAST	3	3	4.100	12.3	12.3
	TOTAL	606.9	598.62	-	1068.45	1054.70
	CG [m]	1.761	1.762			

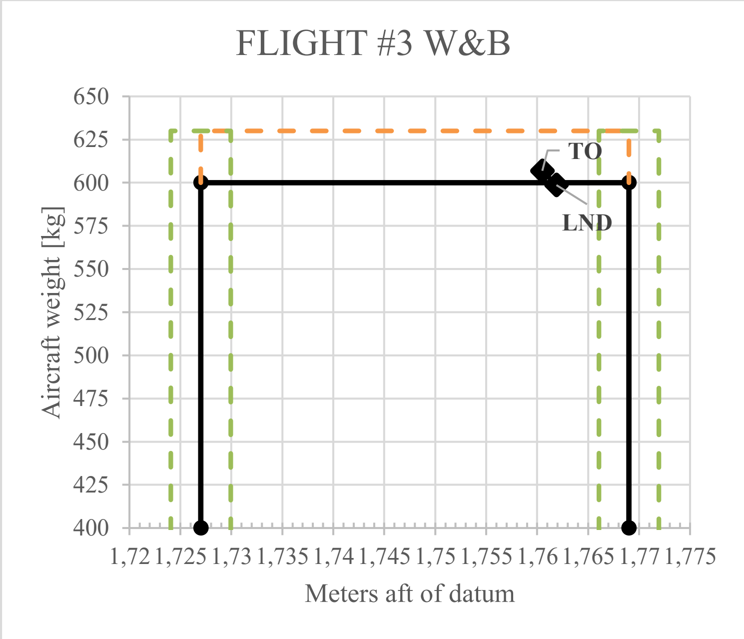

Figure 4-19: Flight #3, Weight and CG excursion during flight

4.3.3 Procedures description

Maneuvers are the same of flight #2, refer to §4.2.3.

4.3.4 Results

Table 32 reports main flight information regarding flight times and fuel consumed while Figure 4-20 shows the flight path on a map where bank to bank rolls are distinguishable. Note that flight time and fuel consumption estimation are consistent with the actual data even though small differences result in larger relative error due to the brevity of the flight. The reduction in flight time as compared to the previous flight was probably due to the acquired familiarity with the maneuvers.

Table 32: Flight #3 summary

FLIGHT SUMMARY			
TAKEOFF		**LANDING**	
AIRPORT:	LIMA	**AIRPORT:**	LIMA
TIME:	12:20	**TIME:**	12:55
WIND SPEED:	4 KTS	**WIND SPEED:**	-
WIND HDG:	160°	**WIND HDG:**	-
FUEL:	40 l	**FUEL:**	27 l
ESTIMATED FLIGHT TIME		40 min	
ACTUAL FLIGHT TIME:		**36 min** (-11% from estimation)	
ESTIMATED FUEL CONSUMPTION		11.5 liters	
ACTUAL FUEL CONSUMPTION:		**13 liters** (+13% from estimation)	

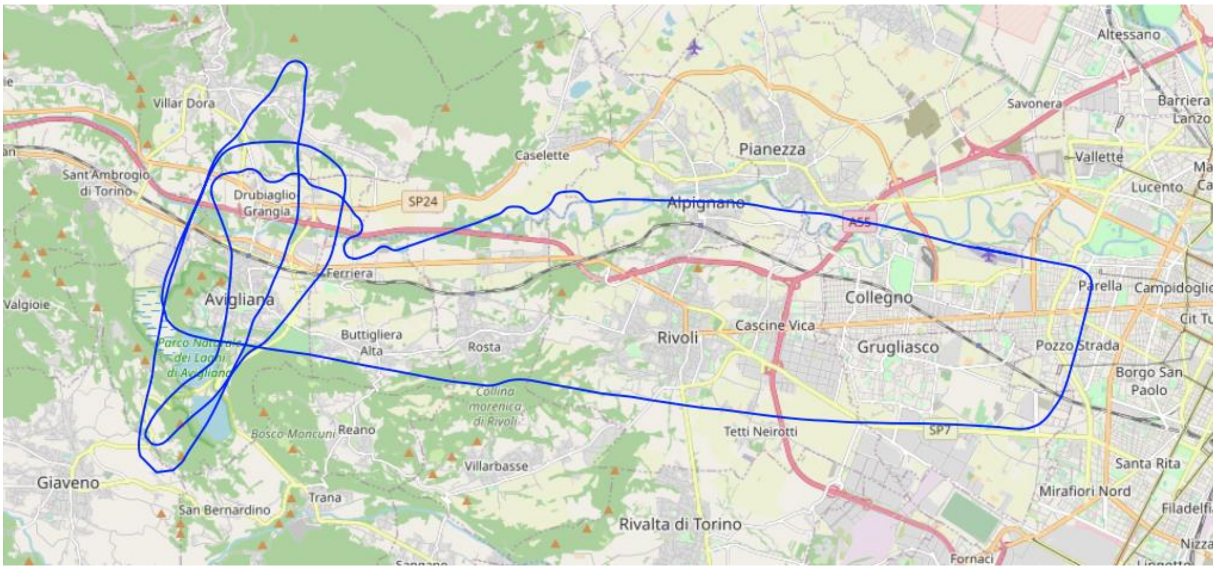

Figure 4-20: Flight #3 path

The actual altitude profile is shown here below where the dotted line represents the scheduled 3500 ft cruise altitude for this flight. The actual path shows that part of maneuvers is conducted at a higher or lower altitude; such difference however does not influence test results. Skid recovery runs at V_{NE} are carried out during a descent as was not possible to reach such airspeed in levelled flight.

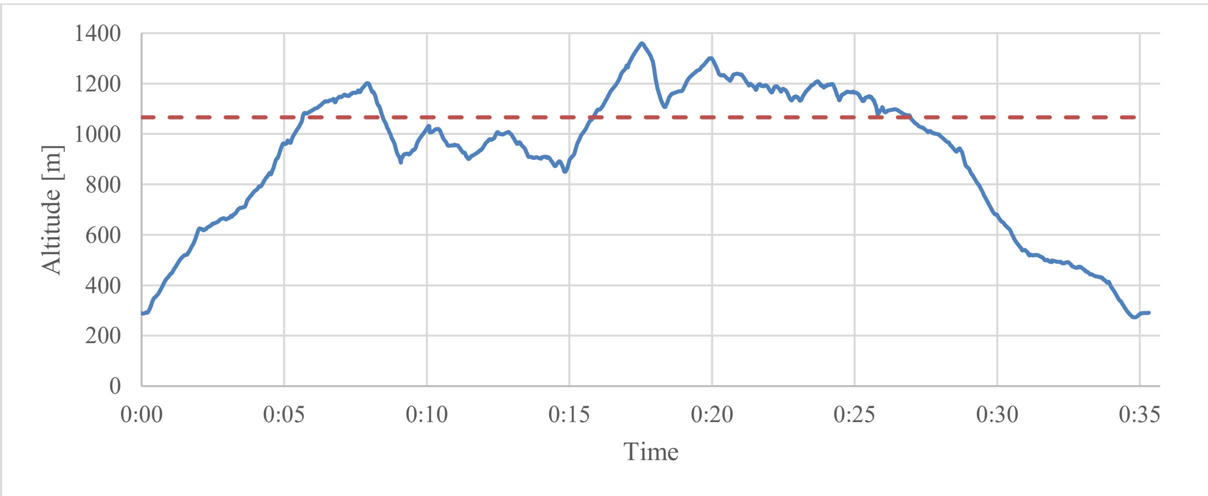

Figure 4-21: Flight #3 actual altitude profile

Bank to bank (TPs 14-15-16)

The following table summarizes data gathered during bank to bank maneuver. If compared to the clean configuration, the higher aerodynamic impact and the asymmetric weight of the payload induces a right rolling moment which can't be compensated by the engine torque. The results is a tendency to roll faster from left to right; this behavior is even more evident with power at IDLE level, where rolls to the right are even faster.

Table 33: Bank to bank results

TP 14 – TO FLAPS, MAX TO PWR				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	55	2140	4.06
2	L → R	55	2140	3.03
3	R → L	55	2140	3.16
4	L → R	55	2140	3.01
TP 15 – LND FLAPS, PWR for LF				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	60	2180	3.16
2	L → R	60	2180	3.03
3	R → L	60	2180	2.96
4	L → R	60	2180	2.37
TP 16 – LND FLAPS, PWR IDLE				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	60	950	3.62
2	L → R	60	950	2.56
3	R → L	60	950	3.66
4	L → R	60	950	2.44

CS-VLA 157 requires a bank to bank time of less than 5 seconds, therefore, this configuration is compliant with the regulation too. This bank to bank test will be later compared with the same test in different configurations.

Directional recovery (TPs 26-27-28)

The following table shows the data gathered during the test flight regarding directional behavior. All test points have been successfully performed, and the aircraft has always shown a positive directional and lateral stability with positive force gradients. A positive centering tendency to eliminate sideslip was noticed in all flight conditions with rudder pedals left free.

Concerning skids performed by applying right pedal, at relatively low speeds (up to about 70 KIAS) a full left aileron command was required in order to maintain a constant heading, before the full rudder excursion was reached. This behavior has been evident in every flap configuration.

For example, in clean configuration at 55 KIAS with about 4/5 of right pedal command the aileron control was saturated. In this condition it was not possible to flight straight, although the aircraft behavior was stable and no signs of departure have been noticed.

Table 34: Directional recovery results

TP 26 – CLEAN FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	4/5	FULL	YES	YES
		L	FULL	9/10	YES	YES
2	79	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
3	103	R	3/4	4/5	YES	YES
		L	3/4	1/2	YES	YES
4	130	R	1/2	1/4	YES	YES
		L	1/2	1/4	YES	YES
TP 27 – TO FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
2	60	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
3	65	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
4	71	R	4/5	FULL	YES	YES
		L	FULL	3/4	YES	YES
TP 28 – LND FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	FULL	FULL	YES	YES
		L	FULL	1/2	YES	YES
2	71	R	FULL	FULL	YES	YES
		L	FULL	1/2	YES	YES

It is worth noting that also with TO flaps, (left) aileron saturation occurred with about 4/5 of rudder command, while with LND flaps it occurred with full rudder deflection (i.e. both aileron and rudder commands were saturated). This indicates that with LND flaps it is possible to achieve and maintain a higher sideslip angle than with TO flap as in the clean configuration case.

In all the left pedal sideslips and skids at low speed, full rudder application was possible before reaching full right aileron travel. At the highest tested speed (about 130 KIAS), skid recovery appeared to be slower than at slower speeds. In this condition the recovery resulted to be a bit faster when the aircraft was yawed to the left. In any case, a positive self-recovery was present.

During the tests, aileron and rudder forces always steadily increased and never reversed; for this reason compliance with CS-VLA177 was demonstrated. Asymmetrical directional stability and aileron saturation will be further examined once all flight involving these maneuvers are presented.

4.4 Flight #4

Following table summarizes the procedures that are carried out during flight #4. This flight is performed with configuration 6a (Heavy: SC and SG H) and its duration is estimated to be 1 hour and 42 minutes.

Table 35: Flight #4 recap

FLIGTH N.	CONF.	PROCEDURE	TP	TEST PROCEDURE DURATION
4	6a	TO climbs (low altitude)	2	1h 42 min
		Sawtooth climbs (low altitude)	6	
		Balked landing climb	10	
		TO climbs (high altitude)	4	
		Sawtooth climbs (high altitude)	8	

4.4.1 Mission profile

An extract of the spreadsheet used for the mission profile calculation is provided here below. Same considerations of the other flights for RPM and fuel consumption calculation apply.

The estimated duration of the flight is about 2 hours and 10 minutes with a test procedure duration of 1 hour and 42 minutes therefore complying with requirements of par. 3.3; fuel consumption estimation is of 33 liters plus 3 liters for taxiing and ground operations.

Table 36: Flight #4 mission profile data

			MAN. TIME	TOTAL TIME	MEAN RPM	ALT. [ft]	FUEL CONS. [l/h]	CONS. FUEL [l]	TOTAL FUEL [l]
Start			00:00:00	00:00:00	0	1000	0.000	0	0
Takeoff			00:01:00	00:01:00	2150	2000	18.966	0.316	0.316
Ferry			00:05:00	00:06:00	2150	2500	18.695	1.558	1.874
2	TO Climbs Low Altitude (2 runs)	Climb	00:02:30	00:08:30	2150	3500	18.164	0.757	2.631
		Descent	00:01:00	00:09:30	1800	2500	13.210	0.220	2.851
		Positioning	00:00:15	00:09:45	2150	2500	18.695	0.078	2.929
		Climb	00:02:30	00:12:15	2150	3500	18.164	0.757	3.686
		Descent	00:01:00	00:13:15	1800	2500	13.210	0.220	3.906
6	Sawtooth Climbs Low Altitude (6 runs)	Positioning	00:00:15	00:13:30	2150	2500	18.695	0.078	3.984
		Climb	00:02:30	00:16:00	2150	3500	18.164	0.757	4.741
		Descent	00:01:00	00:17:00	1800	2500	13.210	0.220	4.961
		Positioning	00:00:15	00:17:15	2150	2500	18.695	0.078	5.039
		Climb	00:02:30	00:19:45	2150	3500	18.164	0.757	5.796
		Descent	00:01:00	00:20:45	1800	2500	13.210	0.220	6.016
		Positioning	00:00:15	00:21:00	2150	2500	18.695	0.078	6.094
		Climb	00:02:30	00:23:30	2150	3500	18.164	0.757	6.850
		Descent	00:01:00	00:24:30	1800	2500	13.210	0.220	7.071
		Positioning	00:00:15	00:24:45	2150	2500	18.695	0.078	7.149
		Climb	00:02:30	00:27:15	2150	3500	18.164	0.757	7.905

		Descent	00:01:00	00:28:15	1800	2500	13.210	0.220	8.126
		Positioning	00:00:15	00:28:30	2150	2500	18.695	0.078	8.203
		Climb	00:02:30	00:31:00	2150	3500	18.164	0.757	8.960
		Descent	00:01:00	00:32:00	1800	2500	13.210	0.220	9.180
		Positioning	00:00:15	00:32:15	2150	2500	18.695	0.078	9.258
		Climb	00:02:30	00:34:45	2150	3500	18.164	0.757	10.015
		Descent	00:01:00	00:35:45	1800	2500	13.210	0.220	10.235
		Positioning	00:00:15	00:36:00	2150	2500	18.695	0.078	10.313
		Climb	00:02:30	00:38:30	2150	3500	18.164	0.757	11.070
		Descent	00:01:00	00:39:30	1800	2500	13.210	0.220	11.290
		Positioning	00:00:15	00:39:45	2150	2500	18.695	0.078	11.368
		Climb	00:02:30	00:42:15	2150	3500	18.164	0.757	12.125
		Descent	00:01:00	00:43:15	1800	2500	13.210	0.220	12.345
10	Balked Landings (2 runs)	Positioning	00:00:15	00:43:30	2150	2500	18.695	0.078	12.423
		Climb	00:02:30	00:46:00	2150	3500	18.164	0.757	13.180
		Descent	00:01:00	00:47:00	1800	2500	13.210	0.220	13.400
		Positioning	00:00:15	00:47:15	2150	2500	18.695	0.078	13.478
		Climb	00:02:30	00:49:45	2150	3500	18.164	0.757	14.235
		Hold	00:00:10	00:49:55	2150	3500	18.164	0.050	14.285
Transfer Climb		Climb	00:02:00	00:51:55	2150	4500	17.475	0.583	14.868
		Climb	00:02:15	00:54:10	2150	5500	16.912	0.634	15.502
		Climb	00:02:30	00:56:40	2150	6500	16.392	0.683	16.185
		Climb	00:02:45	00:59:25	2150	7500	15.920	0.730	16.915
		Climb	00:03:00	01:02:25	2150	8500	15.374	0.769	17.683
4	TO Climbs High Altitude (2 runs)	Climb	00:04:00	01:06:25	2150	9500	14.757	0.984	18.667
		Descent	00:01:00	01:07:25	2000	8500	13.597	0.227	18.894
		Positioning	00:00:25	01:07:50	2150	8500	15.374	0.107	19.000
		Climb	00:04:00	01:11:50	2150	9500	14.757	0.984	19.984
		Descent	00:01:00	01:12:50	2000	8500	13.597	0.227	20.211
8	Sawtooth Climbs High Altitude (6 runs)	Positioning	00:00:25	01:13:15	2150	8500	15.374	0.107	20.318
		Climb	00:04:00	01:17:15	2150	9500	14.757	0.984	21.301
		Descent	00:01:00	01:18:15	2000	8500	13.597	0.227	21.528
		Positioning	00:00:25	01:18:40	2150	8500	15.374	0.107	21.635
		Climb	00:04:00	01:22:40	2150	9500	14.757	0.984	22.619
		Descent	00:01:00	01:23:40	2000	8500	13.597	0.227	22.845
		Positioning	00:00:25	01:24:05	2150	8500	15.374	0.107	22.952
		Climb	00:04:00	01:28:05	2150	9500	14.757	0.984	23.936
		Descent	00:01:00	01:29:05	2000	8500	13.597	0.227	24.162
		Positioning	00:00:25	01:29:30	2150	8500	15.374	0.107	24.269
		Climb	00:04:00	01:33:30	2150	9500	14.757	0.984	25.253
		Descent	00:01:00	01:34:30	2000	8500	13.597	0.227	25.480
		Positioning	00:00:25	01:34:55	2150	8500	15.374	0.107	25.586
		Climb	00:04:00	01:38:55	2150	9500	14.757	0.984	26.570
		Descent	00:01:00	01:39:55	2000	8500	13.597	0.227	26.797
		Positioning	00:00:25	01:40:20	2150	8500	15.374	0.107	26.904
		Climb	00:04:00	01:44:20	2150	9500	14.757	0.984	27.887
		Descent	00:01:00	01:45:20	2000	8500	13.597	0.227	28.114
		Positioning	00:00:25	01:45:45	2150	8500	15.374	0.107	28.221
		Climb	00:04:00	01:49:45	2150	9500	14.757	0.984	29.205
		Descent	00:01:00	01:50:45	2000	8500	13.597	0.227	29.431
		Positioning	00:00:25	01:51:10	2150	8500	15.374	0.107	29.538
		Climb	00:04:00	01:55:10	2150	9500	14.757	0.984	30.522
Initial Descent		Descent	00:01:00	01:56:10	2000	8500	13.597	0.227	30.748
		Descent	00:01:00	01:57:10	1800	7500	11.827	0.197	30.946
		Descent	00:01:00	01:58:10	1800	6500	12.067	0.201	31.147
		Descent	00:01:00	01:59:10	1800	5500	12.328	0.205	31.352
		Descent	00:01:00	02:00:10	1800	4500	12.606	0.210	31.562
		Descent	00:01:00	02:01:10	1800	3500	12.946	0.216	31.778
		Descent	00:01:00	02:02:10	1800	2500	13.210	0.220	31.998
Approach			00:06:00	02:08:10	1600	1500	10.981	1.098	33.096
Landing			00:01:00	02:09:10	1200	1000	7.335	0.122	33.218

Figure 4-22 shows the flight altitude profile which is the same of flight #1, same considerations apply.

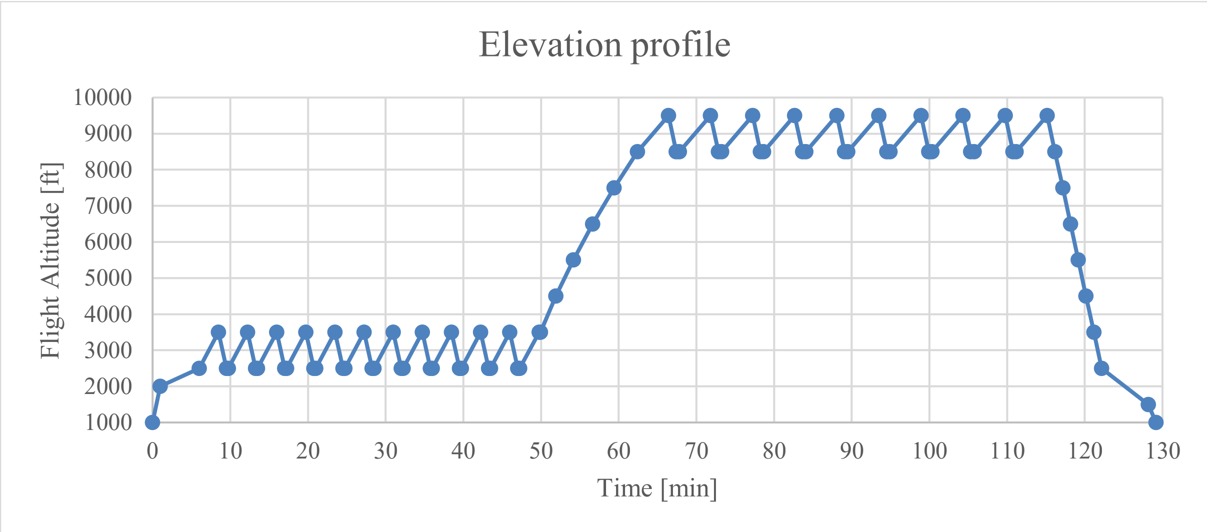

Figure 4-22: Estimated altitude profile of Flight #4

An estimation for fuel consumption is provided in Figure 4-23. Note that it is the same of flight #1 as the mission profile is unchanged.

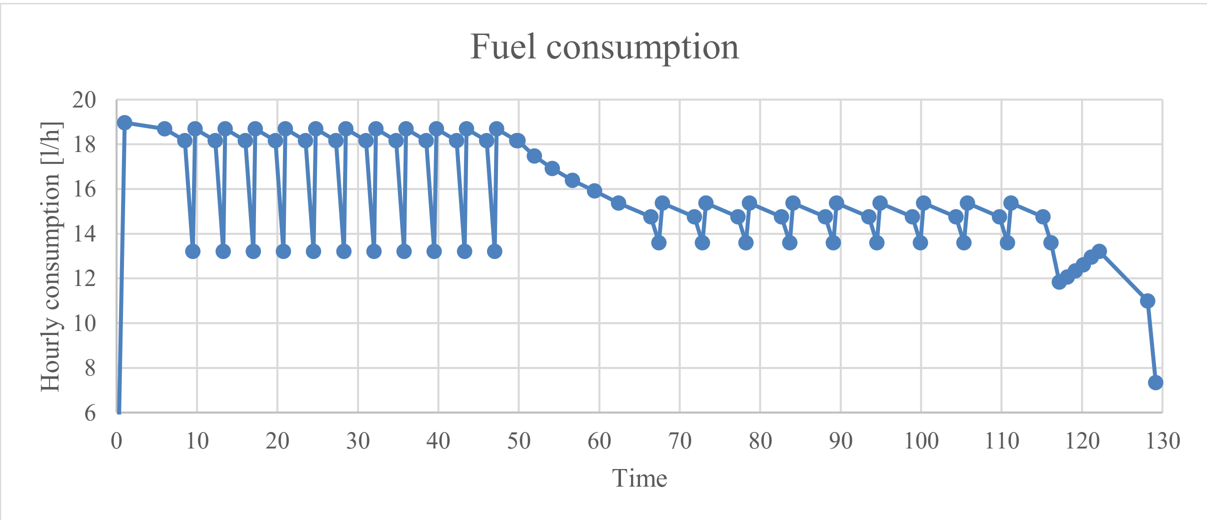

Figure 4-23: Estimated fuel consumption of Flight #4

4.4.2 Weight and Balance

This flight requires the SmartBay in its heaviest configuration and a forward CG. To achieve such configuration, without exceeding MTOW, 50 liters of fuel are loaded along with the SmartGimbal ballasted to 10kg and a SmartCamera; no further ballast or baggage are installed. Note that at takeoff the aircraft weight is approximately 620 kg, so within the MTOW+5% limitation while at landing is estimated to be 594 kg, again within MTOW-10% limitation. The CG, however, cannot fall within the ±7% of the forward limit as explained in §3.2.5

Table 37: Flight #4, Weight and Balance calculation

		WEIGHT [kg]		ARM [m]	MOMENTUM [kg*m]	
		TO	LND		TO	LND
	EMPTY WEIGHT	401	401	1.734	695.45	695.45
	FUEL (50 l)	50.4	24.48	1.660	83.664	40.6368
	PILOT	83	83	1.760	146.08	146.08
	COPILOT	73	73	1.760	128.48	128.48
SMARTBAY	SMARTGIMBAL H	10	10	1.710	17.1	17.1
SMARTBAY	NAKED TROLLEY	0.4	0.4	1.910	0.764	0.764
SMARTBAY	SMARTCAMERA	2.1	2.1	2.110	4.431	4.431
SMARTBAY	BIU	0.5	0.5	2.310	1.155	1.155
	BAGGAGE	0	0	2.210	0	0
	REAR BALLAST	0	0	4.100	0	0
	TOTAL	620.4	594.48	-	1077.12	1034.10
	CG [m]	1.736	1.739			

Figure 4-24 plots the results of the table above and the excursion of the CG due to fuel consumption. The orange line sets MTOW+5% limit (630 kg) while the green lines represent the ±7% limitation around forward and aft limits.

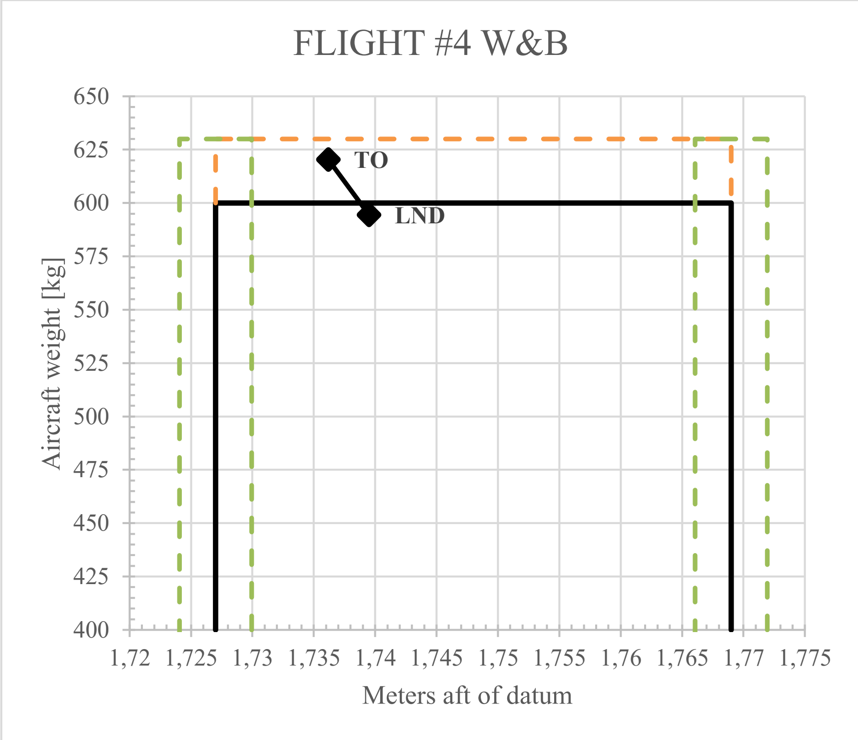

Figure 4-24: Flight #4, Weight and CG excursion during flight

4.4.3 Procedures description

Maneuvers included in this flight are simulated takeoff climbs at low and high altitude, sawtooth climbs at low and high altitude and simulated balked landing climbs. Procedures related to those maneuvers are the same of flight #1, refer to §4.1.3.

4.4.4 Results

Table 38 reports main flight information regarding flight times and fuel consumed while Figure 4-25 shows the complex flight path on a map. Note that flight time and fuel consumption estimation are consistent with the actual data

Table 38: Flight #4 summary

FLIGHT SUMMARY			
TAKEOFF		LANDING	
AIRPORT:	LIMA	**AIRPORT:**	LIMA
TIME:	09:06	**TIME:**	11:04
WIND SPEED:	5 KTS	**WIND SPEED:**	VAR 3 KTS
WIND HDG:	050°	**WIND HDG:**	-
FUEL:	70 l	**FUEL:**	30 l
ESTIMATED FLIGHT TIME		2 h 09 min	
ACTUAL FLIGHT TIME:		**1h 58 min** (-8.5% from estimation)	
ESTIMATED FUEL CONSUMPTION		36 liters	
ACTUAL FUEL CONSUMPTION:		**40 liters** (+11% from estimation)	

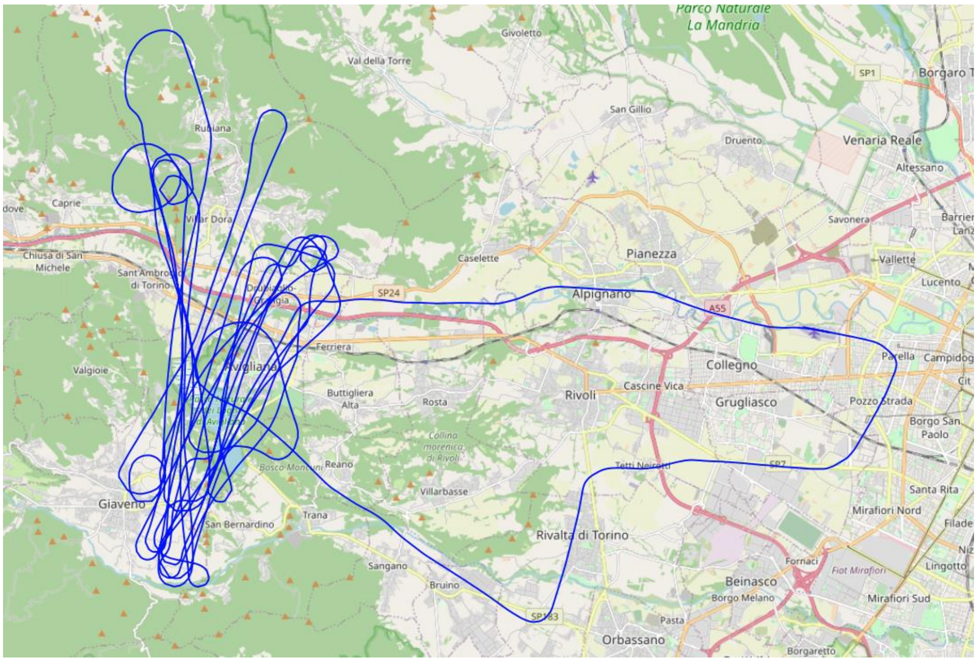

Figure 4-25: Flight #4 path

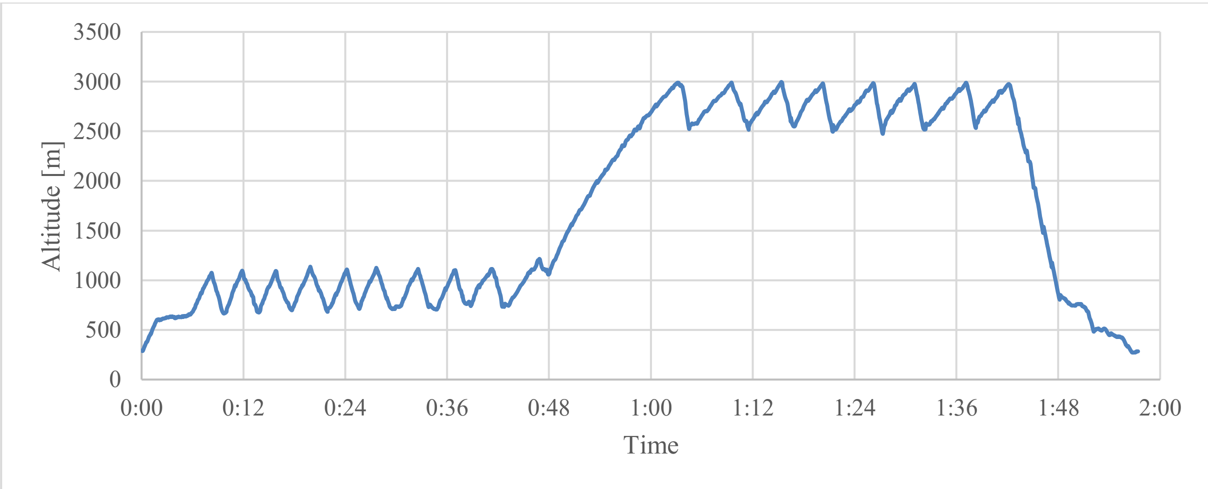

Figure 4-26: Flight #4 actual altitude profile

Take-off Climbs (TPs 2-4)

Results of climb performances during take-off climbs reduced according to the method stated in §4.1.4 are reported in Table 39.

Table 39: Take-off climbs data reduced

TP	H_p $[ft]$	IAS $[kts]$	RC_{TEST} $[ft/min]$	RC_{TRUE} $[ft/min]$	ΔRC_W $[ft/min]$	ΔRC_{Di} $[ft/min]$	ΔRC_P $[ft/min]$	RC_{STD} $[ft/min]$	RC_{STD} $mean$ $[ft/min]$
2	3000	71	582.5	594.7	11.3	12.6	34.8	653	712
	3000	71	697.7	712.2	12.0	11.2	34.8	770	
4	9000	71	312.5	322.7	-0.4	-1.0	46.4	368	354
	9000	71	287.1	296.4	-0.7	-1.9	46.4	340	

CS-VLA 65 requires a minimum climb rate of 2 m/s (397.7 ft/min) at sea level; results show that this requirement is largely met at 3000 ft, and almost up to 9000 ft, therefore the installation is considered compliant with CS-VLA 65.

Sawtooth climbs (TPs 6-8)

Results of climb performances during take-off climbs reduced according to the method stated in §4.1.4 are reported in Table 40.

Table 40: Sawtooth climbs data reduced

TP	H_p $[ft]$	IAS $[kts]$	RC_{TEST} $[ft/min]$	RC_{TRUE} $[ft/min]$	ΔRC_W $[ft/min]$	ΔRC_{Di} $[ft/min]$	ΔRC_P $[ft/min]$	RC_{STD} $[ft/min]$	RC_{STD} mean $[ft/min]$
6	3000	68	625.0	607.2	7.8	8.8	34.8	659	657
	3000	68	625.0	605.9	6.5	7.4	34.8	655	
	3000	73	659.3	604.7	5.3	5.6	34.8	650	648
	3000	73	588.2	603.7	3.7	3.9	34.8	646	
	3000	78	566.0	603.1	1.8	1.8	34.8	641	639
	3000	78	594.1	602.1	0.2	0.2	34.8	637	
8	9000	68	335.2	345.5	-1.5	-3.8	43.9	384	391
	9000	68	352.9	363.7	-2.5	-6.1	43.9	399	
	9000	73	306.1	315.5	-2.9	-7.4	43.9	349	367
	9000	73	342.9	353.4	-4.0	-9.2	43.9	384	
	9000	78	288.5	297.3	-4.0	-10.2	43.9	327	327
	9000	78	291.3	300.2	-4.7	-11.8	43.9	328	

Data is then compared with the climb section of the AFM shown in Figure 4-9. At ISA conditions, stated RC for 3000 ft and 9000 ft at MTOW are 480 ft/min and 810 ft/min respectively. Climb performances where tested for $V_Y \pm 5\ kts$ to evaluate possible deviations from the statedV_Y of 73 kts; results however show that no clear trend is visible in RC for the different indicated airspeed tested. It is concluded that the installation does not change V_Y.

Figure 4-27 shows that the deviations from the original AFM climb performances are of -162 and -113 ft/min at 9000 ft and 3000 ft respectively with an average deficit of 138 ft/min.

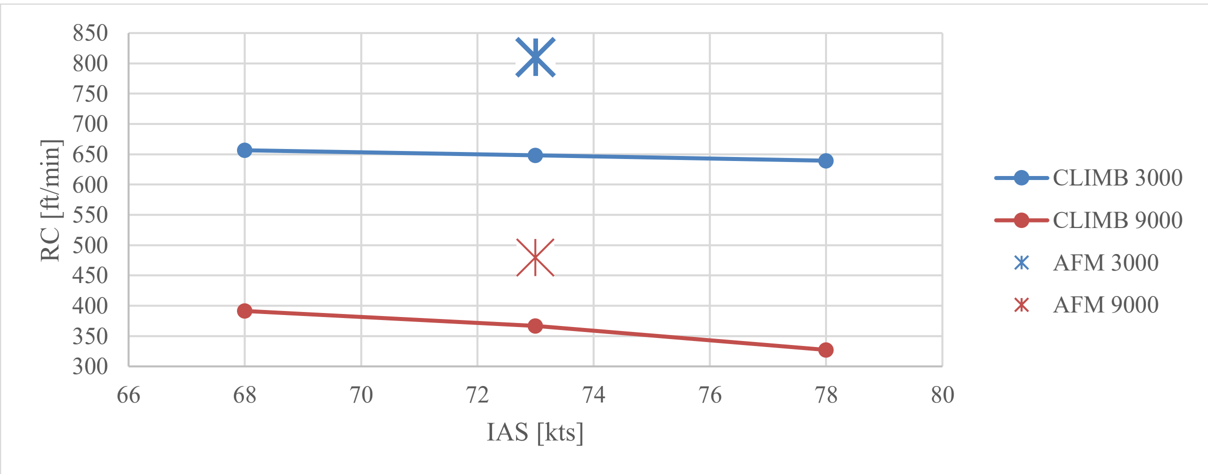

Figure 4-27 : Climb performances deviation from AFM

Balked landing climbs (TP 10)

Table 41: Balked landing climbs data reduced

TP	H_p $[ft]$	IAS $[kts]$	RC_{TEST} $[ft/min]$	RC_{TRUE} $[ft/min]$	ΔRC_W $[ft/min]$	ΔRC_{Di} $[ft/min]$	ΔRC_P $[ft/min]$	RC_{STD} $[ft/min]$	RC_{STD} $mean$ $[ft/min]$
010	3000	60	483.9	494.0	1.0	1.5	34.8	531	496
	3000	60	416.7	425.4	0.4	0.7	34.8	461	

CS-VLA 77 requires a minimum climb angle of 1:30 (corresponding to 203 ft/min for an airspeed of 60 kts) at sea level. As a higher climb rate is obtained at a higher altitude, the requirement has been met and the installation is considered compliant with CS-VLA 77.

According to the AFM (see Figure 4-11) the rate of climb, is ISA conditions, is 375 ft/min for a balked landing and decreases to 338 ft/min as the MTOW of the aircraft is 600 kg. As the recorded data show a higher RC than the one reported in the AFM, no correction will be made to the latter.

4.5 Flight #5

Following table summarizes the procedures that are carried out during flight #5. This flight is performed with configuration 6b (1 SmartGimbal L, 1 Naked Trolley and 1 SmartCamera) and includes the same maneuvers of flight #2 and #3 plus the static longitudinal stability test.

Table 42: Flight #5 recap

FLIGTH N.	CONF.	PROCEDURE	TP	TEST PROCEDURE DURATION
5	6b	Bank to bank	17	57 min
			18	
			19	
		Stick force per V	20	
			21	
			22	
		Directional recovery	29	
			30	
			31	

4.5.1 Mission profile

An extract of the spreadsheet used for the mission profile calculation is provided here below. Same considerations of the other flights for RPM and fuel consumption calculation apply.

The estimated duration of the flight is about 1 hour and 10 minutes with a test procedure duration of 57 minutes, complying with requirements of par. 3.3; fuel consumption estimation is of 16 liters plus 3 liters for taxiing and ground operations.

Table 43: Flight #5 mission profile data

			MAN. TIME	TOTAL TIME	MEAN RPM	ALT. [ft]	FUEL CONS. [l/h]	CONS. FUEL [l]	TOTAL FUEL [l]
Start			00:00:00	00:00:00	0	1000	0.000	0	0
Takeoff			00:01:00	00:01:00	2150	2000	18.966	0.316	0.316
Ferry			00:05:00	00:06:00	2150	3500	18.164	1.514	1.830
17	Bank to Bank Controllability MAX TO (4 runs)	Roll	00:00:05	00:06:05	2150	3500	18.164	0.025	1.855
		Positioning	00:00:30	00:06:35	2150	3500	18.164	0.151	2.006
		Roll	00:00:05	00:06:40	2150	3500	18.164	0.025	2.032
		Positioning	00:00:30	00:07:10	2150	3500	18.164	0.151	2.183
		Roll	00:00:05	00:07:15	2150	3500	18.164	0.025	2.208
		Positioning	00:00:30	00:07:45	2150	3500	18.164	0.151	2.360
		Roll	00:00:05	00:07:50	2150	3500	18.164	0.025	2.385
		Positioning	00:01:00	00:08:50	1700	3500	11.752	0.196	2.581

18	Bank to Bank Controllability LND LF (4 runs)	Roll	00:00:05	00:08:55	1700	3500	11.752	0.016	2.597
		Positioning	00:00:30	00:09:25	1700	3500	11.752	0.098	2.695
		Roll	00:00:05	00:09:30	1700	3500	11.752	0.016	2.711
		Positioning	00:00:30	00:10:00	1700	3500	11.752	0.098	2.809
		Roll	00:00:05	00:10:05	1700	3500	11.752	0.016	2.825
		Positioning	00:00:30	00:10:35	1700	3500	11.752	0.098	2.923
		Roll	00:00:05	00:10:40	1700	3500	11.752	0.016	2.940
		Positioning	00:01:00	00:11:40	1700	3500	11.752	0.196	3.136
19	Bank to Bank Controllability LND IDLE (4 runs)	Roll	00:00:05	00:11:45	1000	3500	5.970	0.008	3.144
		Positioning	00:00:30	00:12:15	1000	3500	5.970	0.050	3.194
		Roll	00:00:05	00:12:20	1000	3500	5.970	0.008	3.202
		Positioning	00:00:30	00:12:50	1000	3500	5.970	0.050	3.252
		Roll	00:00:05	00:12:55	1000	3500	5.970	0.008	3.260
		Positioning	00:00:30	00:13:25	1000	3500	5.970	0.050	3.310
		Roll	00:00:05	00:13:30	1000	3500	5.970	0.008	3.318
		Positioning	00:01:00	00:14:30	1000	3500	5.970	0.099	3.417
20	Stick force per V CLEAN 75% MCP high speed (2 runs)	Push	00:02:00	00:16:30	2150	3500	18.164	0.605	4.023
		Positioning	00:01:00	00:17:30	2150	3500	18.164	0.303	4.326
		Pull	00:01:25	00:18:55	2150	3500	18.164	0.429	4.755
		Positioning	00:01:00	00:19:55	2150	3500	18.164	0.303	5.057
		Push	00:02:00	00:21:55	2150	3500	18.164	0.605	5.663
		Positioning	00:01:00	00:22:55	2150	3500	18.164	0.303	5.965
		Pull	00:01:25	00:24:20	2150	3500	18.164	0.429	6.394
		Positioning	00:01:00	00:25:20	2150	3500	18.164	0.303	6.697
21	Stick force per V CLEAN MCP low speed (2 runs)	Push	00:01:30	00:26:50	1800	3500	12.946	0.324	7.021
		Positioning	00:01:00	00:27:50	1800	3500	12.946	0.216	7.236
		Pull	00:01:30	00:29:20	1800	3500	12.946	0.324	7.560
		Positioning	00:01:00	00:30:20	1800	3500	12.946	0.216	7.776
		Push	00:01:30	00:31:50	1800	3500	12.946	0.324	8.100
		Positioning	00:01:00	00:32:50	1800	3500	12.946	0.216	8.315
		Pull	00:01:30	00:34:20	1800	3500	12.946	0.324	8.639
		Positioning	00:01:00	00:35:20	1800	3500	12.946	0.216	8.855
22	Stick force per V LND LF (2 runs)	Push	00:01:30	00:36:50	1500	3500	9.684	0.242	9.097
		Positioning	00:01:00	00:37:50	1500	3500	9.684	0.161	9.258
		Pull	00:01:30	00:39:20	1500	3500	9.684	0.242	9.500
		Positioning	00:01:00	00:40:20	1500	3500	9.684	0.161	9.662
		Push	00:01:30	00:41:50	1500	3500	9.684	0.242	9.904
		Positioning	00:01:00	00:42:50	1500	3500	9.684	0.161	10.065
		Pull	00:01:30	00:44:20	1500	3500	9.684	0.242	10.307
		Positioning	00:01:00	00:45:20	1500	3500	9.684	0.161	10.469
29	Directional recovery CLEAN (4 runs)	Right	00:00:25	00:45:45	1600	3500	10.668	0.074	10.543
		Left	00:00:25	00:46:10	1600	3500	10.668	0.074	10.617
		Positioning	00:01:00	00:47:10	1600	3500	10.668	0.178	10.795
		Right	00:00:25	00:47:35	1800	3500	12.946	0.090	10.885
		Left	00:00:25	00:48:00	1800	3500	12.946	0.090	10.975
		Positioning	00:01:00	00:49:00	1800	3500	12.946	0.216	11.190
		Right	00:00:25	00:49:25	2000	3500	15.710	0.109	11.299
		Left	00:00:25	00:49:50	2000	3500	15.710	0.109	11.408
		Positioning	00:01:00	00:50:50	2000	3500	15.710	0.262	11.670
		Right	00:00:25	00:51:15	2150	3500	18.164	0.126	11.796
		Left	00:00:25	00:51:40	2150	3500	18.164	0.126	11.923
		Positioning	00:01:00	00:52:40	2150	3500	18.164	0.303	12.225
30	Directional recovery TO (4 runs)	Right	00:00:25	00:53:05	1600	3500	10.668	0.074	12.299
		Left	00:00:25	00:53:30	1600	3500	10.668	0.074	12.373
		Positioning	00:01:00	00:54:30	1600	3500	10.668	0.178	12.551
		Right	00:00:25	00:54:55	1700	3500	11.752	0.082	12.633
		Left	00:00:25	00:55:20	1700	3500	11.752	0.082	12.715
		Positioning	00:01:00	00:56:20	1700	3500	11.752	0.196	12.910
		Right	00:00:25	00:56:45	1700	3500	11.752	0.082	12.992
		Left	00:00:25	00:57:10	1700	3500	11.752	0.082	13.074
		Positioning	00:01:00	00:58:10	1700	3500	11.752	0.196	13.269
		Right	00:00:25	00:58:35	1800	3500	12.946	0.090	13.359
		Left	00:00:25	00:59:00	1800	3500	12.946	0.090	13.449
		Positioning	00:01:00	01:00:00	1800	3500	12.946	0.216	13.665

31	Directional recovery LND (2 runs)	Right	00:00:25	01:00:25	1700	3500	11.752	0.082	13.747
		Left	00:00:25	01:00:50	1700	3500	11.752	0.082	13.828
		Positioning	00:01:00	01:01:50	1700	3500	11.752	0.196	14.024
		Right	00:00:25	01:02:15	1700	3500	11.752	0.082	14.106
		Left	00:00:25	01:02:40	1700	3500	11.752	0.082	14.187
Descent			00:01:00	01:03:40	1800	3500	12.946	0.216	14.403
			00:01:00	01:04:40	1800	2500	13.210	0.220	14.623
Approach			00:06:00	01:10:40	1600	1500	10.981	1.098	15.721
Landing			00:01:00	01:11:40	1200	1000	7.335	0.122	15.844

Figure 4-28 shows the flight altitude profile: all maneuvers take place at the same altitude of 3500 ft, takeoff, ferry, approach and landing are clearly distinguishable.

An estimation for fuel consumption is provided in Figure 4-29. Different maneuvers are here identifiable:

- Bank to bank controllability test is conducted with 3 different power settings with decreasing progression;
- Stick force per V test at high speed and low speed with clean flaps and at low speed with flaps fully extended;
- Skid recovery is then conducted with flaps clean from 1.2 V_{S_1} to V_{NE} requiring gradually increasing power setting;
- Finally skid recovery with flaps TO and LND from 1.2 V_{S_1} to V_{FE} requiring a gradually increasing power setting but within a narrower range.

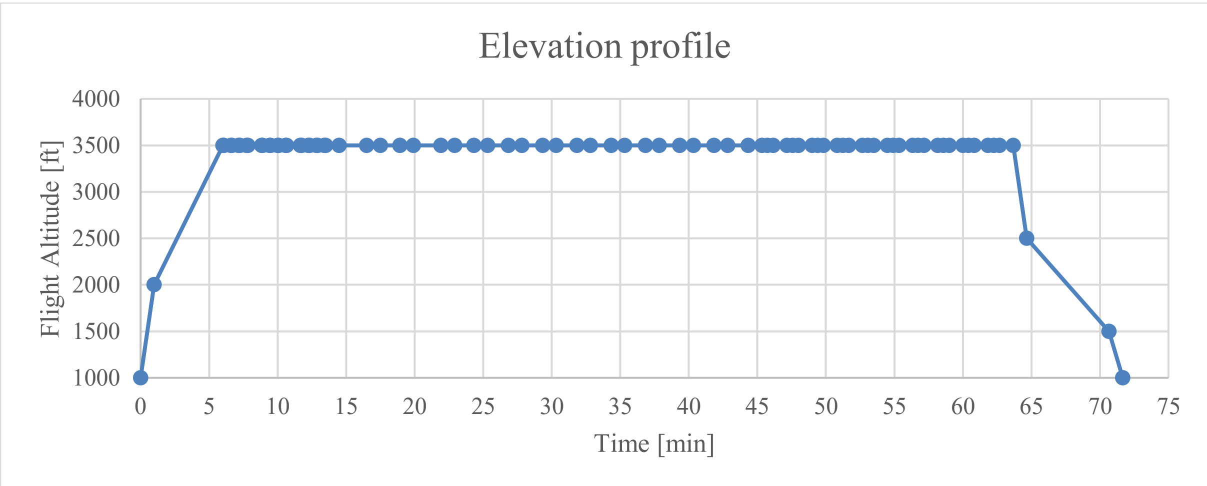

Figure 4-28: Estimated altitude profile of Flight #5

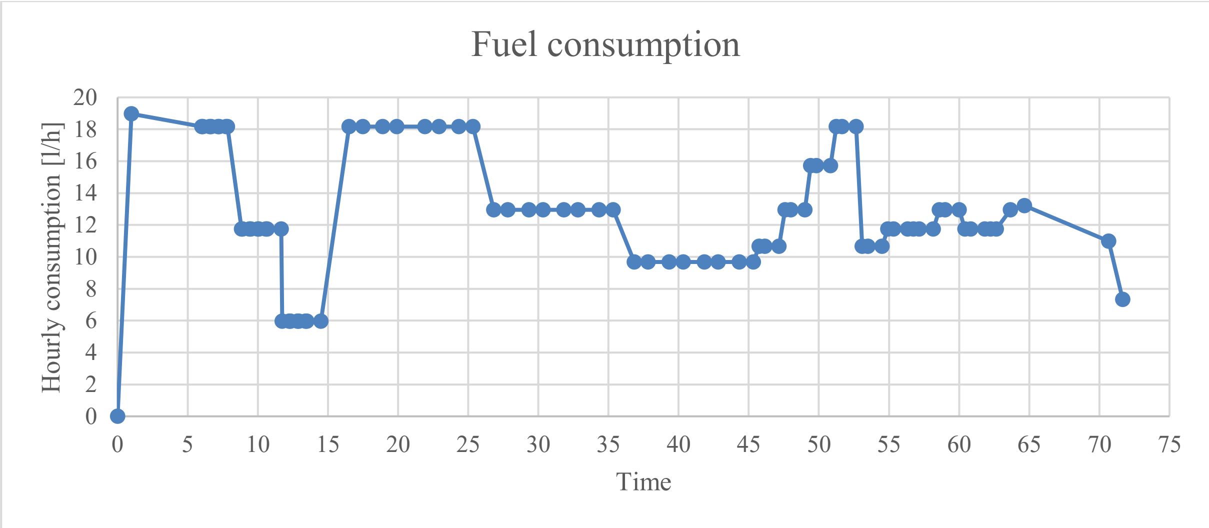

Figure 4-29: Estimated fuel consumption of Flight #5

4.5.2 Weight and Balance

This flight is conducted with configuration n.6b according to the requirement explained in §3.3 stating that test shall be carried out from the least to the most critical condition. CG shall be in the rearmost position: baggage compartment is then loaded with a sandbag secured to the airframe with ropes and a small ballast is inserted in the battery compartment.

Note that at takeoff the aircraft weight is approximately 620 kg, so within the MTOW+5% limitation while at landing is estimated to be slightly overweight. To avoid an overweight landing would be necessary to decrease baggage load or initial fuel but it would result is a CG too much forward or less safety margin respectively.

Table 44: Flight #5, Weight and Balance calculation

		WEIGHT [kg]		ARM [m]	MOMENTUM [kg*m]	
		TO	LND		TO	LND
	EMPTY WEIGHT	401	401	1.734	695.45	695.45
	FUEL (50 l)	36	22.32	1.660	59.76	37.0512
	PILOT	83	83	1.760	146.08	146.08
	COPILOT	73	73	1.760	128.48	128.48
SMARTBAY	SMARTGIMBAL	7.5	7.5	1.710	12.825	12.825
SMARTBAY	NAKED TROLLEY	0.4	0.4	1.910	0.764	0.764
SMARTBAY	SMARTCAMERA	2.1	2.1	2.110	4.431	4.431
SMARTBAY	BIU	0.5	0.5	2.310	1.155	1.155
	BAGGAGE	13	13	2.210	28.73	28.73
	REAR BALLAST	3	3	4.100	12.3	12.3
	TOTAL	619.5	605.85	-	1089.98	1067.27
	CG [m]	1.759	1.762			

Nonetheless it was decided to load 50 liters of fuel and the crew was informed to let the flight last at least 1 hour and 20 minutes to burn enough fuel. The CG, however, cannot fall within the ±7% of the forward limit as explained in §3.2.5.

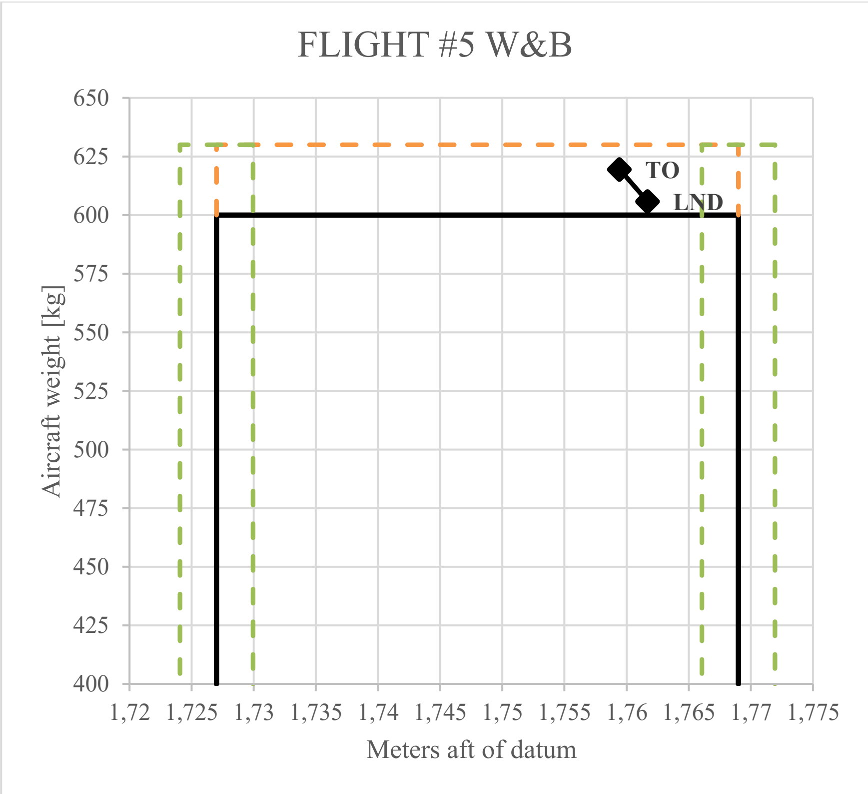

Figure 4-30: Flight #5, Weight and CG excursion during flight

4.5.3 Procedures description

Maneuvers included in this flight are bank to bank rolls, directional recovery and stick force per V. First two maneuvers are already described for flights #2 and #3, stick force per V procedure is hereby described.

Stick force per V:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings
- Push the stick gently to increase IAS with 5 kts steps until the airspeed specified
- Release stick and let airspeed stabilize
- Trim the aircraft to initial settings
- Pull the stick gently to decrease IAS with 5 kts steps until the airspeed specified
- Release stick and let airspeed stabilize
- Repeat the procedure at the specified configurations

Data to be recorded manually by the FTE are:

- Bank to bank and directional recovery:
  - Same as flight #2 and #3
- Stick force per V:
  - RETURN IAS: Indicate the IAS at which the aircraft stabilizes after the release of the stick
  - TIME TO RETURN: Indicate the time elapsed from stick release to IAS stabilization
  - FORCE PROPORTIONAL TO IAS INCREASE/DECREASE: Indicate whether the force exerted on the stick increases proportionally with IAS.
  - IAS FOR SLOPE INVERSION: Indicate the IAS at which the force exerted on the stick stops to increase proportionally with IAS (if such event occurs)

Data recorded automatically during Test Flight #5 are:

- GPS data
- IMU data
- Video

4.5.4 Results

Table 45 reports main flight information regarding flight times and fuel consumed while Figure 4-31 shows the flight path on a map. Note that flight time and fuel consumption estimation are consistent with the actual data even though longer actual flight time, and consequently higher fuel consumption, were achieved to ensure a safe landing as explained in §4.5.2.

Table 45: Flight #5 summary

FLIGHT SUMMARY			
TAKEOFF		**LANDING**	
AIRPORT:	LIMA	**AIRPORT:**	LIMA
TIME:	12.25	**TIME:**	13:49
WIND SPEED:	VAR 3 KTS	**WIND SPEED:**	VAR 3 KTS
WIND HDG:	-	**WIND HDG:**	-
FUEL:	50 l	**FUEL:**	25 l
ESTIMATED FLIGHT TIME		1h 12 min	
ACTUAL FLIGHT TIME:		**1h 24min** (+16% from estimation)	
ESTIMATED FUEL CONSUMPTION		19 liters	
ACTUAL FUEL CONSUMPTION:		**25 liters** (+31% from estimation)	

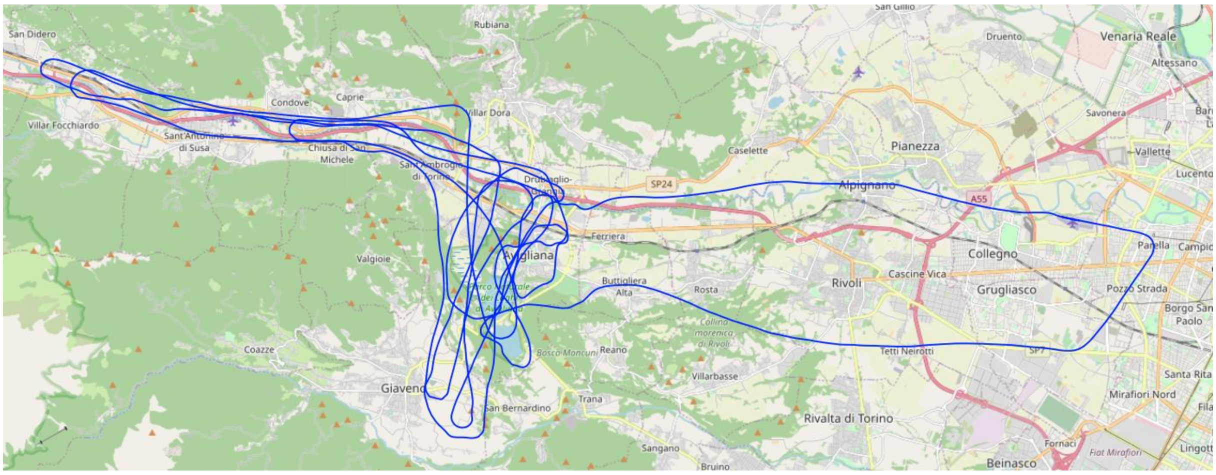

Figure 4-31: Flight #5 path

The actual altitude profile is shown here below where the dotted line represents the scheduled 3500 ft cruise altitude for this flight. The actual path shows that part of maneuvers is conducted at a higher or lower altitude; such difference however does not influence test results. Skid recovery runs at V_{NE} are carried out during a descent as was not possible to reach such airspeed in levelled flight.

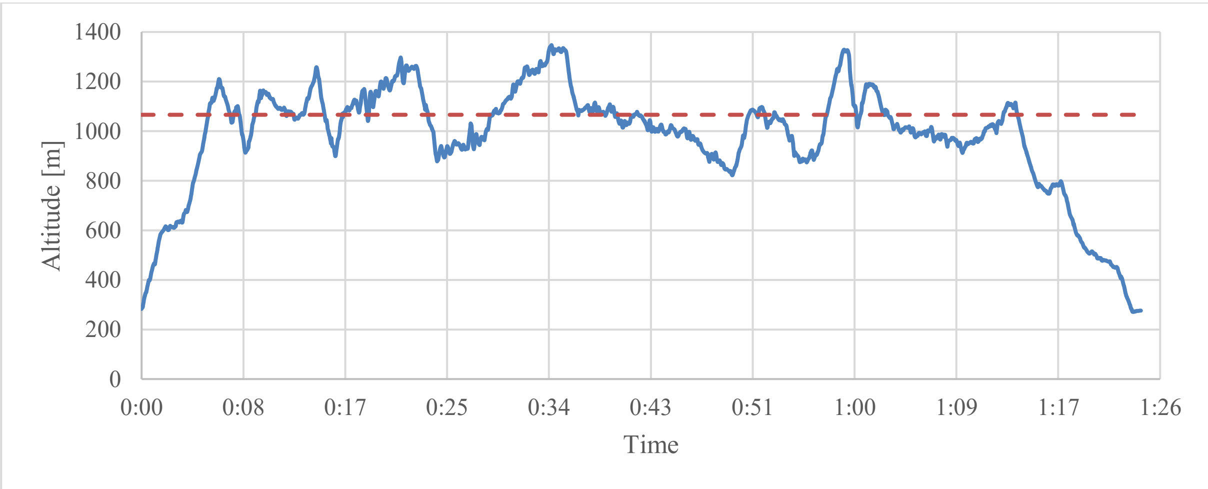

Figure 4-32: Flight #5 actual altitude profile

Bank to bank (TPs 17-18-19)

Following table summarizes the data gathered during bank to bank maneuver. As observed in flight #3, the aerodynamic impact and the asymmetric weight of the payload induce a right rolling moment which can't be compensated by the engine torque. The result is a tendency to roll faster from left to right; this behavior is even more evident with power at IDLE level, where rolls to the right are even faster.

Table 46: Bank to bank results

TP 14 – TO FLAPS, MAX TO PWR				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	55	2100	2.68
2	L → R	55	2100	2.50
3	R → L	55	2100	3.42
4	L → R	55	2100	2.63
TP 15 – LND FLAPS, PWR for LF				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	60	1690	3.22
2	L → R	60	1690	2.43
3	R → L	60	1690	3.22
4	L → R	60	1690	2.16
TP 16 – LND FLAPS, PWR IDLE				
RUN	**ROLL DIR.**	**IAS [kts]**	**RPM**	**TIME [s]**
1	R → L	60	990	3.61
2	L → R	60	990	2.00
3	R → L	60	990	3.21
4	L → R	60	990	1.71

CS-VLA 157 requires a bank to bank time of less than 5 seconds, therefore, this configuration is compliant with the regulation too. Results of all configurations are then compared in the following table considering mean values. Figure 4-33 clearly shows that right rolls are generally faster when a payload is installed on SmartBay due to the right rolling moment induced by the asymmetric weight and lift of the wing (weight has a much higher influence rather than lift loss).

Table 47: Bank to bank results comparison

CONDITION	**ROLL DIR.**	**PAYLOAD CONFIGURATION**		
		CLEAN (1)	**MEDIUM (3)**	**HEAVY (6b)**
TO, MAX PWR	R → L	2.73 s	3.61 s	3.05 s
	L → R	3.76 s	3.02 s	2.56 s
LND, LF	R → L	2.57 s	3.06 s	3.22 s
	L → R	3.01 s	3.00 s	2.29 s
LND, IDLE	R → L	3.25 s	3.64 s	3.41 s
	L → R	2.49 s	2.50 s	1.85 s

From this graph is also evident the influence of the engine setting over the rolling time as the higher RPM the engine is set, the higher is the left gyroscopic moment induced by the propeller

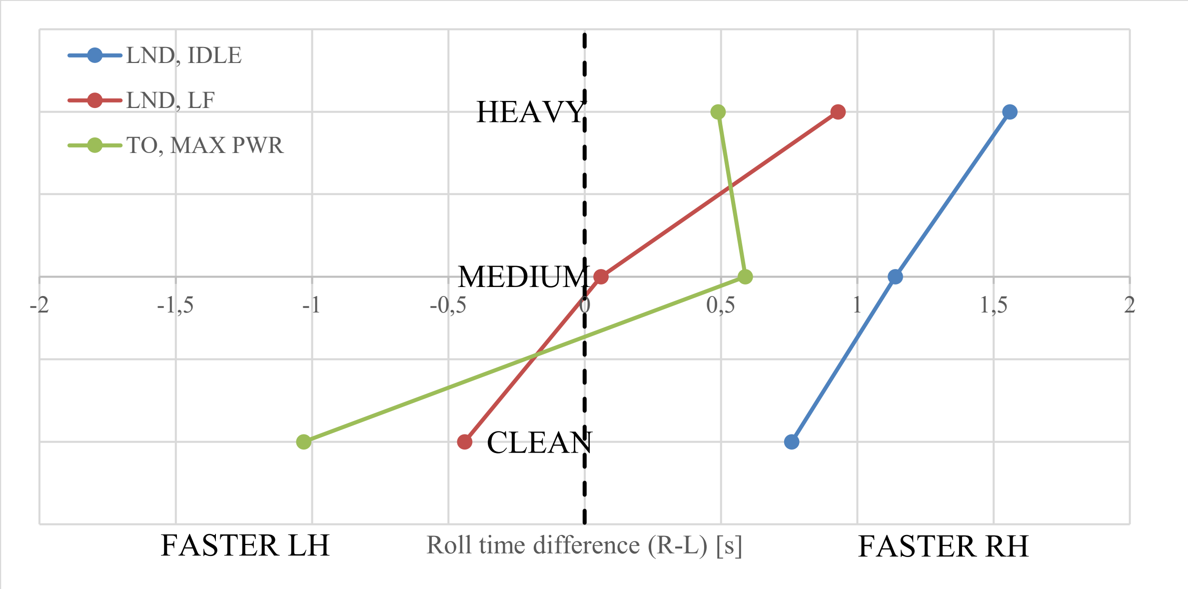

Figure 4-33: Bank to bank results comparison

Stick Force per V (TPs 20-21-22)

As required by CS-VLA 173, the test pilot qualitatively assessed stick force by pushing and pulling the stick to accelerate and decelerate from a trim airspeed until a specified value. The aircraft always showed a clear static longitudinal stability (i.e. a pushing force was always needed to accelerate from trim position, while a pulling force was needed to decelerate). When control force was released, the return velocity always fell within the range prescribed (+/- 10% of trim speed).

Table 48: Stick force per V test results

RUN	PWR	FLAPS	TRIM IAS	IAS RANGE	RETURN IAS	TIME	FORCE PROP. TO IAS CHANGE
1	75% MCP	CLEAN	103	PUSH 103 → 123	103	1'56"	YES
				PULL 103 → 83	100	57"	YES
2				PUSH 103 → 123	105	2'01"	YES
				PULL 103 → 83	102	1'23"	YES

1	MCP	CLEAN	73	PUSH 73→ 84	73	50”	YES
				PULL 73 → 62	73	56”	YES
2				PUSH 73→ 84	73	1’26”	YES
				PULL 73 → 62	75	1’38”	YES
1	LF	LND	60	PUSH 60 → 71	61	1’15”	YES
				PULL 60 → 51	59	57”	YES
2				PUSH 60 → 71	58	1’51”	YES
				PULL 60 → 51	59	1’06”	YES

A visual representation of the results listed above is shown in Figure 4-34; trim speed are shown as squares; dashed lines represent the +/- 10% interval prescribed by CS-VLA 173(b), X markers represent the extremes of the tested airspeed range and diamonds markers represent the measured return speed. Note that the return airspeed is quite precise.

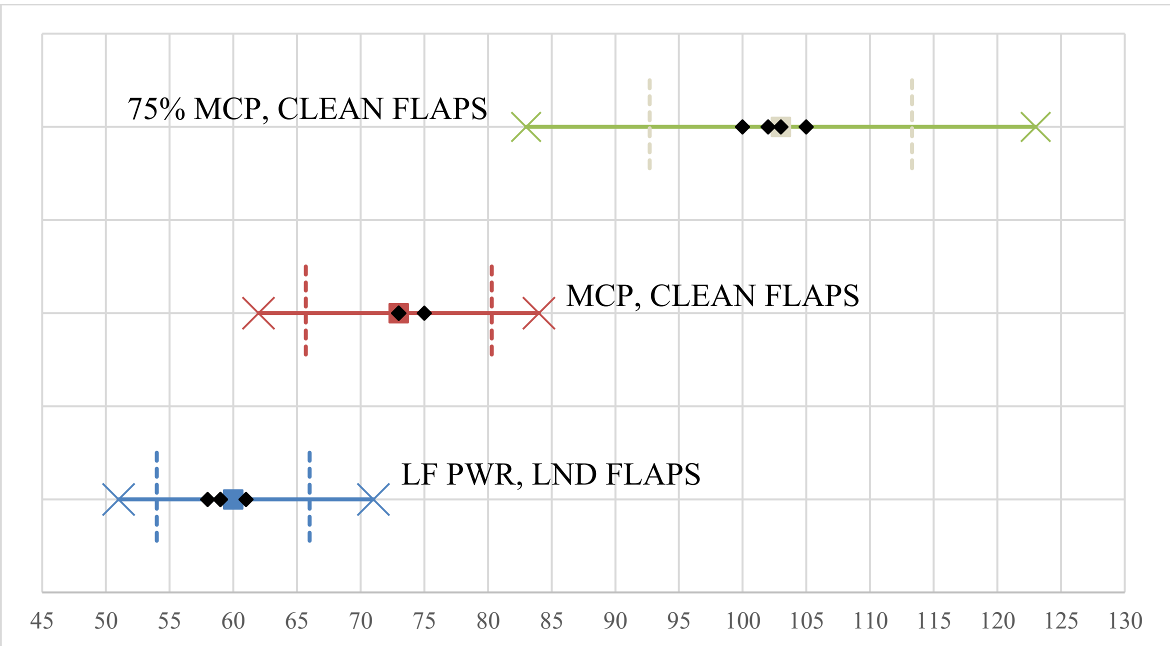

Figure 4-34: Stick force per V test results

Directional recovery (TPs 29-30-31)

The following table shows the data gathered during the test flight regarding directional behavior. Skid recovery test points have been successfully performed, and the aircraft behaved in a satisfactory, and safe manner. Aircraft has always shown a positive directional stability. In general skid recovery has resulted to be slower when the aircraft has been yawed to the right, with respect to maneuvers with left yaw. Nevertheless, with LND flap this difference appeared to be less noticeable, and also skids with right pedal have shown a fairly prompt recovery.

At speeds lower than 100 KIAS approximately, the application of right pedal and left roll input caused the roll command to reach the end of its travel (leftward), when the rudder command was still far from its full deflection (generally between 1/2 and 2/3 of it full deflection). This characteristic is due to the mass and aerodynamic unbalance caused by the heavy SmartBay payload, and it limits the maximum angle of sideslip that can be achieved and maintained in comparison to the original aircraft.

Table 49: Directional recovery results

TP 26 – CLEAN FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	2/3	FULL	YES (SLOW)	YES
		L	FULL	3/4	YES (FAST)	YES
2	79	R	2/3	FULL	YES (SLOW)	YES
		L	FULL	2/3	YES	YES
3	103	R	1/2	1/4	YES (SLOW)	YES
		L	1/2	2/3	YES (SLOW)	YES
4	130	R	1/2	1/2	YES (V. SLOW)	YES
		L	1/2	1/2	YES	YES
TP 27 – TO FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	1/2	FULL	YES	YES
		L	FULL	FULL	YES	YES
2	60	R	2/3	FULL	YES	YES
		L	FULL	4/5	YES	YES
3	65	R	2/3	FULL	YES	YES
		L	FULL	3/4	YES	YES
4	71	R	2/3	FULL	YES	YES
		L	FULL	3/4	YES	YES

TP 28 – LND FLAPS, LF PWR						
RUN	**KIAS**	**YAW DIR.**	**RUDDER**	**AILERON**	**RET. TO STRAIGHT FLIGHT**	**FORCES INCREASE**
1	55	R	2/3	FULL	YES (FAST)	YES
		L	FULL	1/2	YES (FAST)	YES
2	71	R	2/3	FULL	YES	YES
		L	FULL	2/3	YES	YES

At relatively high speed (about 103 KIAS), a reduction in apparent directional stability has been observed while reaching about half pedal displacement. This behavior has been observed both during left and right yaw maneuvers. The pedal effort gradient always remained positive, but at about the half of its travel the rudder tended to maintain its deflection also when the pedal effort has been released. Because of this behavior the maximum rudder deflection, during these test points, has been indeed limited to about the half of its travel.

In addition, test points foreseen at 141 KIAS have instead been carried out at 130 KIAS. Also at this speed a similar reduction in apparent directional stability has been noticed. In these conditions the aircraft has anyway shown a positive centering tendency that eliminated the sideslip with rudder pedals left free.

Directional recovery data can now be compared between different payload configuration to assess their impact on aircraft behavior. Steady heading sideslip tests showed a tendency at low speed to saturate aileron controls before reaching full rudder inputs, with a characteristic asymmetrical behavior; in the following table are collected the control displacement for 55 knots steady heading sideslips, with different SBE and flaps configurations. Only data at low speed in shown since this is the case for which the phenomenon was stronger. Color codes are used to highlight the cases were aileron saturated before rudder.

Table 50: Asymmetrical aileron saturation at low speed

FLAPS	**YAW DIR.**	**SBE CLEAN (1)**		**SBE MEDIUM (3)**		**SBE HEAVY (6b)**	
		RUDDER	**AILERON**	**RUDDER**	**AILERON**	**RUDDER**	**AILERON**
CLEAN	**L**	FULL	3/4	FULL	9/10	FULL	3/4
	R	9/10	FULL	4/5	FULL	2/3	FULL
TO	**L**	FULL	3/4	FULL	3/4	FULL	FULL
	R	4/5	FULL	4/5	FULL	1/2	FULL
LND	**L**	FULL	1/2	FULL	1/2	FULL	1/2
	R	FULL	FULL	FULL	FULL	2/3	FULL

Based on this data, the aileron tends to saturate before full rudder input only in a right-hand steady heading sideslip (rudder to the right aileron to the left). This is particularly noticeable with Heavy SmartBay configuration and TO and LND flaps where left aileron input saturates while a right pedal input is still at 1/2 - 2/3 of its total travel.

These results seem to point out that the aircraft with SmartBay installation (particularly in Heavy configuration) can be harder to control in a left crosswind approach and landing scenario. It is then important to estimate the crosswind component developed during these maneuvers and compare it to the original AFM which states that the maximum allowed crosswind component is 15 kts.

As there was no ad hoc instrumentation to measure the sideslip angle (β), an alternative method is used here to estimate the sideslip angle from the on-board camera and visual fixed references. Using the video captured during the maneuvers, the maximum sideslip angle reached is estimated with the position of fixed elements of the landscape (i.e. mountain peaks in the horizon) with respect to known elements of the cockpit. The difference in angular position of these references between straight flight and max sideslip achieved is the estimated sideslip angle β, see Figure 4-35.

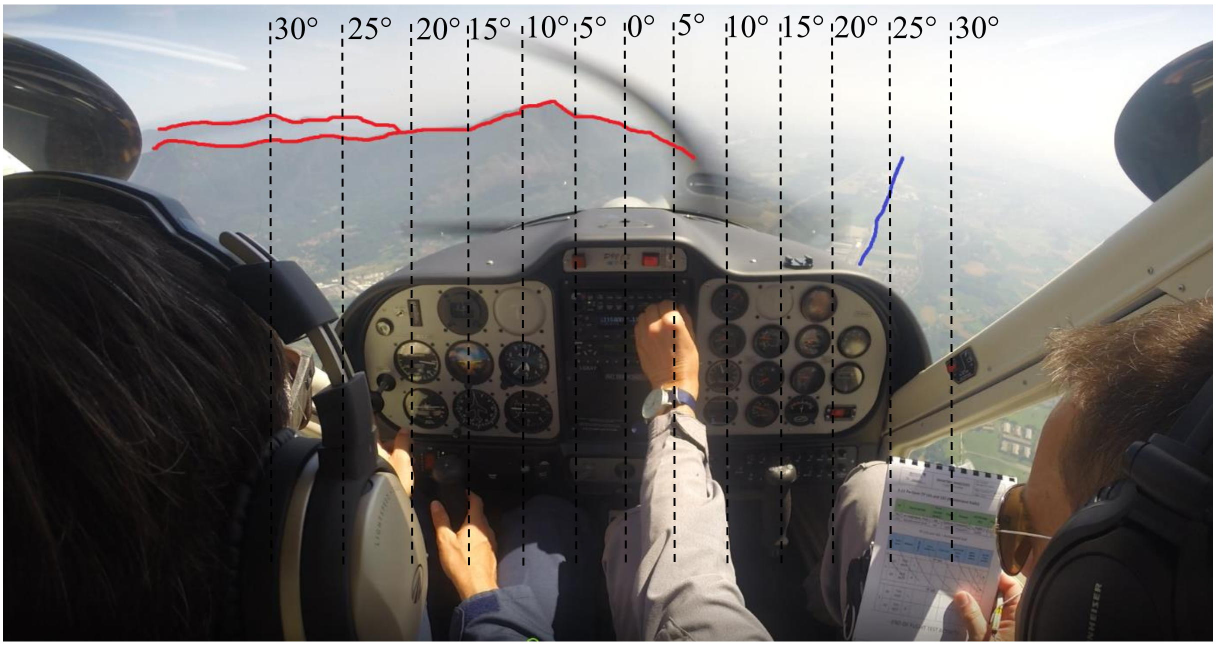

Figure 4-35: Visual estimation method for β angle

Crosswind component can be estimated with the following formula:

$$V_{XWIND} = V_{TAS} \cdot \sin \beta$$

The results of the calculated sideslip angles and crosswinds are reported in the next table, for the heavy SBE configuration (6b) at low speed (55 kts) where the phenomenon was most apparent. Despite the inherent inaccuracies in this estimation method, the crosswind component sustained was more than 15 knots in both left-hand and right-hand sideslips.

According to these considerations, no further limitations on crosswind are introduced for SmartBay installation.

Table 51: Estimated crosswind component

SBE CONFIG.	FLAPS	KTAS	YAW DIR.	ESTIM. SIDESLIP [deg]	ESTIM. XWIND [knots]
HEAVY (6b)	CLEAN	58	L	20	19.8
			R	25	24.5
	TO	58	L	20	19.8
			R	25	24.5
	LND	58	L	18	17.9
			R	20	19.8

4.6 Flight #6

Following table summarizes the procedures that are carried out during flight #6. This flight is performed again with configuration 6b (1 SmartGimbal L, 1 Naked Trolley and 1 SmartCamera) and includes lateral recovery from a slip, short period mode and accelerated stalls.

Table 52: Flight #6 recap

FLIGTH N.	CONF.	PROCEDURE	TP	TEST PROCEDURE DURATION
6	6b	Lateral recovery	32	29 min
			33	
			34	
		Longitudinal Short Period	35	
			36	
			37	
		Accelerated stalls	50	
			51	

4.6.1 Mission profile

An extract of the spreadsheet used for the mission profile calculation is provided here below. Same considerations of the other flights for RPM and fuel consumption calculation apply.

The estimated duration of the flight is about 45 minutes with a test procedure duration of 29 minutes, complying with requirements of par. 3.3; fuel consumption estimation is of 10.5 liters plus 3 liters for taxiing and ground operations.

Table 53: Flight #6 mission profile data

			MAN. TIME	TOTAL TIME	MEAN RPM	ALT. [ft]	FUEL CONS. [l/h]	CONS. FUEL [l]	TOTAL FUEL [l]
Start			00:00:00	00:00:00	0	1000	0.000	0	0
Takeoff			00:01:00	00:01:00	2150	2000	18.966	0.316	0.316
Ferry			00:05:00	00:06:00	2150	3500	18.164	1.514	1.830
32	Slip recovery CLEAN (3 runs)	Right	00:00:25	00:06:25	1600	3500	10.668	0.074	1.904
		Left	00:00:25	00:06:50	1600	3500	10.668	0.074	1.978
		Positioning	00:01:00	00:07:50	1600	3500	10.668	0.178	2.156
		Right	00:00:25	00:08:15	1900	3500	14.261	0.099	2.255
		Left	00:00:25	00:08:40	1900	3500	14.261	0.099	2.354
		Positioning	00:01:00	00:09:40	1900	3500	14.261	0.238	2.591
		Right	00:00:25	00:10:05	2150	3500	18.164	0.126	2.718
		Left	00:00:25	00:10:30	2150	3500	18.164	0.126	2.844
		Positioning	00:01:00	00:11:30	2150	3500	18.164	0.303	3.146

33	Slip recovery TO (4 runs)	Right	00:00:25	00:11:55	1600	3500	10.668	0.074	3.221
		Left	00:00:25	00:12:20	1600	3500	10.668	0.074	3.295
		Positioning	00:01:00	00:13:20	1600	3500	10.668	0.178	3.472
		Right	00:00:25	00:13:45	1700	3500	11.752	0.082	3.554
		Left	00:00:25	00:14:10	1700	3500	11.752	0.082	3.636
		Positioning	00:01:00	00:15:10	1700	3500	11.752	0.196	3.832
		Right	00:00:25	00:15:35	1800	3500	12.946	0.090	3.921
		Left	00:00:25	00:16:00	1800	3500	12.946	0.090	4.011
		Positioning	00:01:00	00:17:00	1800	3500	12.946	0.216	4.227
		Right	00:00:25	00:17:25	1900	3500	14.261	0.099	4.326
		Left	00:00:25	00:17:50	1900	3500	14.261	0.099	4.425
		Positioning	00:01:00	00:18:50	1900	3500	14.261	0.238	4.663
34	Slip recovery LND (2 runs)	Right	00:00:25	00:19:15	1600	3500	10.668	0.074	4.737
		Left	00:00:25	00:19:40	1600	3500	10.668	0.074	4.811
		Positioning	00:01:00	00:20:40	1600	3500	10.668	0.178	4.989
		Right	00:00:25	00:21:05	1800	3500	12.946	0.090	5.079
		Left	00:00:25	00:21:30	1800	3500	12.946	0.090	5.169
		Positioning	00:01:00	00:22:30	1800	3500	12.946	0.216	5.384
35	Short Period CLEAN (3 runs)	Maneuver	00:00:15	00:22:45	1600	3500	10.668	0.044	5.429
		Positioning	00:00:15	00:23:00	1600	3500	10.668	0.044	5.473
		Maneuver	00:00:15	00:23:15	1900	3500	14.261	0.059	5.533
		Positioning	00:00:15	00:23:30	1900	3500	14.261	0.059	5.592
		Maneuver	00:00:15	00:23:45	2150	3500	18.164	0.076	5.668
		Positioning	00:00:15	00:24:00	2150	3500	18.164	0.076	5.744
36	Short Period TO (2 runs)	Maneuver	00:00:15	00:24:15	1800	3500	12.946	0.054	5.797
		Positioning	00:00:15	00:24:30	1800	3500	12.946	0.054	5.851
		Maneuver	00:00:15	00:24:45	1800	3500	12.946	0.054	5.905
		Positioning	00:00:15	00:25:00	1800	3500	12.946	0.054	5.959
37	Short Period LND (1 runs)	Maneuver	00:00:15	00:25:15	1800	3500	12.946	0.054	6.013
		Positioning	00:00:15	00:25:30	1800	3500	12.946	0.054	6.067
Climb			00:02:00	00:27:30	2150	4500	17.475	0.583	6.650
			00:02:00	00:29:30	2150	5000	17.191	0.573	7.223
50	Accelerated stall CLEAN L (1 runs)	Maneuver	00:00:35	00:30:05	2150	5000	17.191	0.167	7.390
		Positioning	00:00:50	00:30:55	2000	5000	14.979	0.208	7.598
	Accelerated stall CLEAN R (1 runs)	Maneuver	00:00:35	00:31:30	2150	5000	17.191	0.167	7.765
		Positioning	00:00:50	00:32:20	2000	5000	14.979	0.208	7.973
51	Accelerated stall LND L (1 runs)	Maneuver	00:00:35	00:32:55	2150	5000	17.191	0.167	8.140
		Positioning	00:00:50	00:33:45	2000	5000	14.979	0.208	8.348
	Accelerated stall LND R (1 runs)	Maneuver	00:00:35	00:34:20	2150	5000	17.191	0.167	8.515
		Positioning	00:00:10	00:34:30	2000	5000	14.979	0.042	8.557
Descent			00:01:00	00:35:30	1800	4500	12.606	0.210	8.767
			00:01:00	00:36:30	1800	3500	12.946	0.216	8.983
			00:01:00	00:37:30	1800	2500	13.210	0.220	9.203
Approach			00:06:00	00:43:30	1600	1200	10.981	1.098	10.301
Landing			00:01:00	00:44:30	1200	1000	7.335	0.122	10.423

Figure 4-36 shows the flight altitude profile: all maneuvers take place at the same altitude of 3500 ft except for accelerated stalls which shall be performed at a higher altitude for safety reasons; takeoff, ferry, approach and landing are clearly distinguishable.

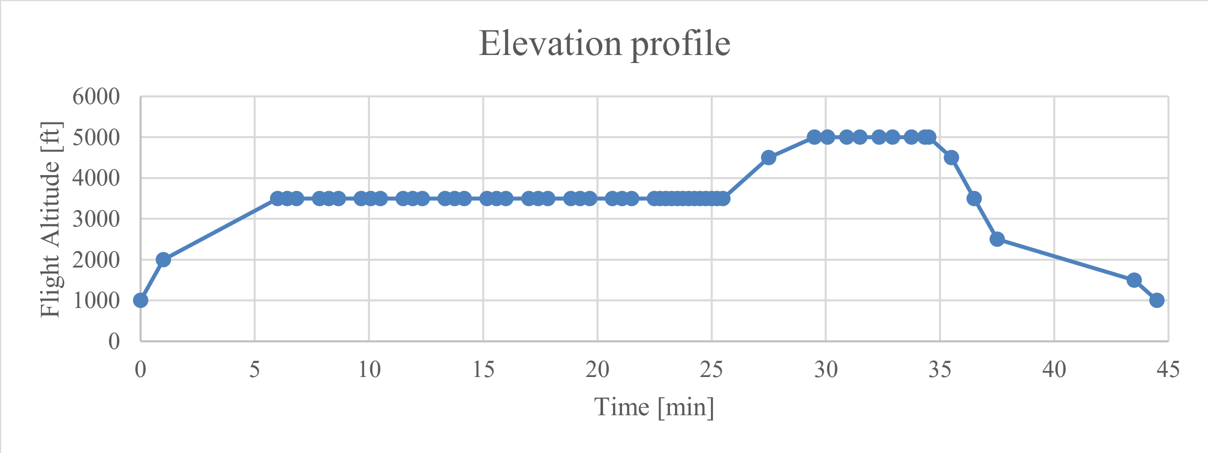

Figure 4-36: Estimated altitude profile of Flight #6

An estimation for fuel consumption is provided in Figure 4-37. Different maneuvers are here identifiable:

- Slip recovery test is conducted with 3 different power settings with increasing progression with clean flaps, then with TO and LND flaps again in increasing progression;
- Short period mode is then excited at increasing power settings with no flaps than at constant power for TO and LND flaps
- After climbing phase accelerated stalls take place at MCP followed by repositioning at lower RPM

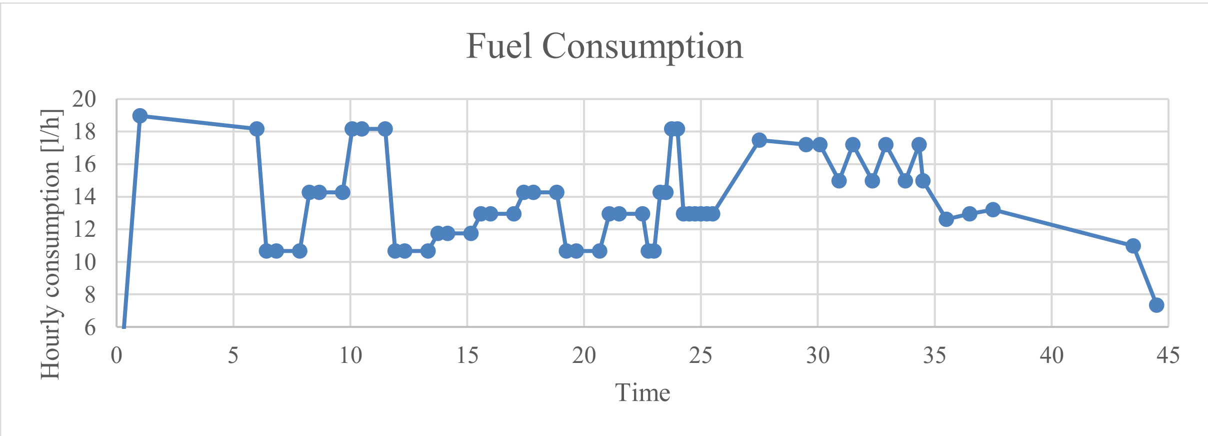

Figure 4-37: Estimated fuel consumption of Flight #6

4.6.2 Weight and Balance

This flight is conducted with configuration n.6b. CG shall be in the rearmost position: baggage compartment is then loaded with a sandbag secured to the airframe with ropes and a small ballast is inserted in the battery compartment.

Note that at takeoff the aircraft weight is approximately 612 kg, so within the MTOW+5% limitation while at landing is estimated to be slightly overweight. As for flight #5, to avoid an overweight landing would be necessary to decrease baggage load or initial fuel but it would result is a CG too much forward or less safety margin respectively. The CG, however, cannot fall within the ±7% of the forward limit as explained in §3.2.5.

Table 54: Flight #6, Weight and Balance calculation

<table>
<tr><th></th><th></th><th colspan="2">WEIGHT [kg]</th><th rowspan="2">ARM [m]</th><th colspan="2">MOMENTUM [kg*m]</th></tr>
<tr><th></th><th></th><th>TO</th><th>LND</th><th>TO</th><th>LND</th></tr>
<tr><td></td><td>EMPTY WEIGHT</td><td>401</td><td>401</td><td>1.734</td><td>695.45</td><td>695.45</td></tr>
<tr><td></td><td>FUEL (40 l)</td><td>28.8</td><td>19.22</td><td>1.660</td><td>47.808</td><td>31.9118</td></tr>
<tr><td></td><td>PILOT</td><td>83</td><td>83</td><td>1.760</td><td>146.08</td><td>146.08</td></tr>
<tr><td></td><td>COPILOT</td><td>73</td><td>73</td><td>1.760</td><td>128.48</td><td>128.48</td></tr>
<tr><td rowspan="4">SMARTBAY</td><td>SMARTGIMBAL</td><td>7.5</td><td>7.5</td><td>1.710</td><td>12.825</td><td>12.825</td></tr>
<tr><td>NAKED TROLLEY</td><td>0.4</td><td>0.4</td><td>1.910</td><td>0.764</td><td>0.764</td></tr>
<tr><td>SMARTCAMERA</td><td>2.1</td><td>2.1</td><td>2.110</td><td>4.431</td><td>4.431</td></tr>
<tr><td>BIU</td><td>0.5</td><td>0.5</td><td>2.310</td><td>1.155</td><td>1.155</td></tr>
<tr><td></td><td>BAGGAGE</td><td>13</td><td>13</td><td>2.210</td><td>28.73</td><td>28.73</td></tr>
<tr><td></td><td>REAR BALLAST</td><td>3</td><td>3</td><td>4.100</td><td>12.3</td><td>12.3</td></tr>
<tr><td></td><td colspan="6"></td></tr>
<tr><td></td><td>TOTAL</td><td>612.3</td><td>602.9</td><td>-</td><td>1078.02</td><td>1062.13</td></tr>
<tr><td></td><td></td><td colspan="5"></td></tr>
<tr><td></td><td>CG [m]</td><td>1.761</td><td>1.762</td><td></td><td></td><td></td></tr>
</table>

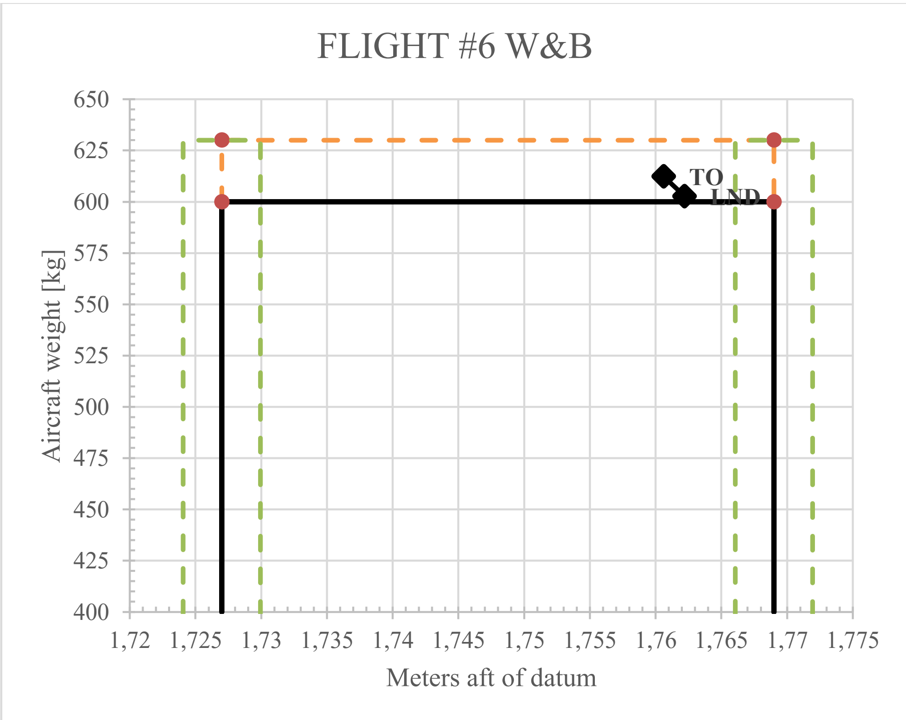

Figure 4-38: Flight #6, Weight and CG excursion during flight

4.6.3 Procedures description

Maneuvers performed during test flight are described here below.

Lateral recovery:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings
- Slowly turn the aircraft in one direction and apply opposite rudder to excite forward slip. Bank angle should be no less than 10°.
- Release the stick
- Repeat for opposite roll direction
- Repeat this procedure for the number of runs specified

Short Period:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings
- Excite Short Period with a 'doublet input': With a smooth, but rapid motion, apply nose-down longitudinal control to decrease pitch attitude a few degrees, then reverse the input to nose-up longitudinal control to bring the pitch attitude back to trim. As pitch attitude reaches trim, return the stick to trim position and release it.
- Repeat this procedure for the number of runs specified

Accelerated Stalls:

- Trim the aircraft with specified airspeed and power settings
- Establish and maintain a coordinated turn in a 30-degree bank
- Reduce speed by steadily and progressively tightening the turn with the elevator until the aircraft is stalled or until the elevator has reached its stop. The rate of speed reduction must be constant and be 5,6 to 9,3 km/h (3 to 5 knots) per second with steadily increasing normal acceleration.
- Recover the aircraft
- Repeat for opposite direction of bank
- Repeat this procedure for the number of runs specified

Data to be recorded manually by the FTE are:

- Slip recovery:
    - LOW WING BEHAVIOR: Specify whether the low wing tends to rise after the stick is released

    - TIME FOR LEVELLED WINGS: Indicate the time from stick release to wing levelling
- Short Period:
    - SHORT PERIOD DAMPING: If short period oscillations amplitude is very low and the mode extinguish itself rapidly then short period motion should be qualitatively described as essentially deadbeat and satisfactory. In this event mark YES, otherwise, NO. If NO has been marked, short period mode shall be described in the specific section of the Test Card. This is a qualitative evaluation; more precise investigation can be achieved through the inspection of the video
- Accelerated Stalls:
    - STALL WARNING IAS: Indicated airspeed at which stall warning activates
    - STALL IAS: Indicated airspeed at which stall occurs. Stall occurs when the first of the below conditions occurs:
        - Uncontrollable downward pitching motion;
        - The control reaches the stop
    - ALTITUDE LOSS: Indicate the loss of altitude in feet caused by the stall occurrence
    - MAX BANK ANGLE: Indicate the maximum bank angle occurred during stall
    - SATISFACTORY STALL BEHAVIOR: The turning stall behavior is considered satisfactory when:
        - The altitude lost is not, in the test pilot's opinion, excessive
        - There is no undue pitch-up
        - There are no uncontrollable spinning tendencies; i.e. while the aircraft may have a tendency to spin, a spin entry is readily preventable
        - The test pilot can complete the recovery with normal use of the controls and average piloting skill
        - The aircraft does not exceed 60° of bank in either direction from the established 30° bank.

        If NO has been marked, a detailed explanation shall be provided

Data recorded automatically during Test Flight #6 are:

- GPS data
- IMU data
- Video

4.6.4 Results

Table 55 reports main flight information regarding flight times and fuel consumed while Figure 4-39 shows the flight path on a map. Note that flight time and fuel consumption estimation are consistent with the actual data.

Table 55: Flight #6 summary

FLIGHT SUMMARY			
TAKEOFF		**LANDING**	
AIRPORT:	LIMA	**AIRPORT:**	LIMA
TIME:	10:16	**TIME:**	11:04
WIND SPEED:	VAR 4 KTS	**WIND SPEED:**	VAR 3 KTS
WIND HDG:	-	**WIND HDG:**	-
FUEL:	40 l	**FUEL:**	27 l
ESTIMATED FLIGHT TIME		45 min	
ACTUAL FLIGHT TIME:		**48 min** (+6.3% from estimation)	
ESTIMATED FUEL CONSUMPTION		13.5 liters	
ACTUAL FUEL CONSUMPTION:		**13 liters** (-3.5% from estimation)	

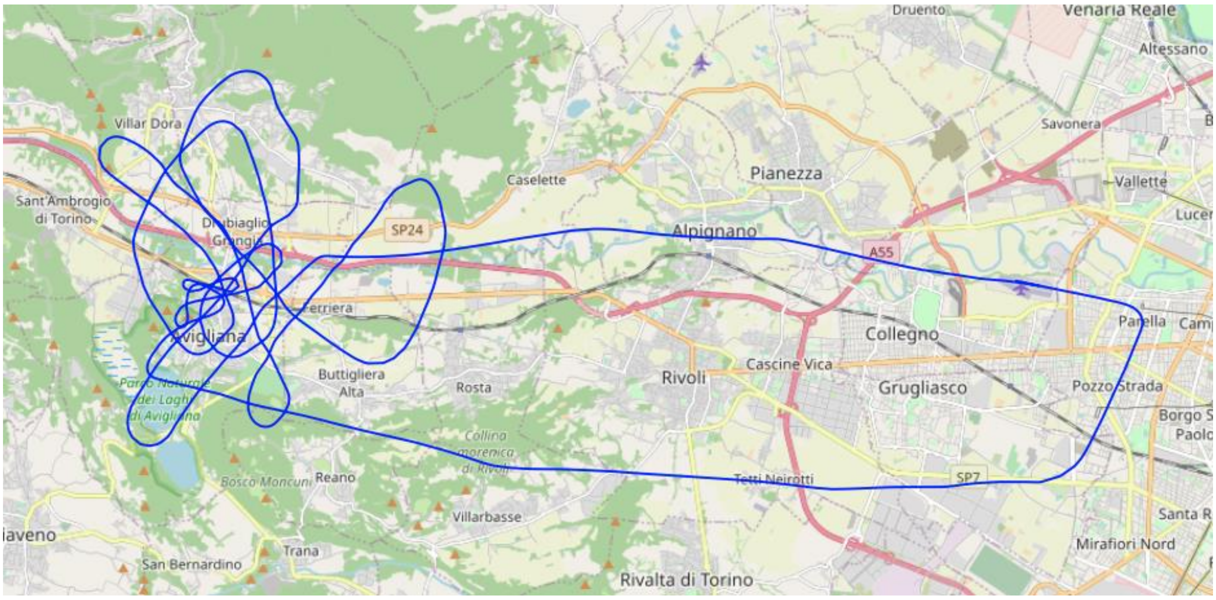

Figure 4-39: Flight #6 path

The actual altitude profile is shown here below where the dotted red and green lines represents the scheduled 3500 ft and 5000 ft cruise altitude for this flight. The actual path shows that part of maneuvers is conducted at a higher or lower altitude; such difference however does not influence test results. Accelerated stalls, which have been carried out at a lower altitude due to clouds at 5000 ft, are clearly identifiable in this graph due to the sudden drops occurring during stalls.

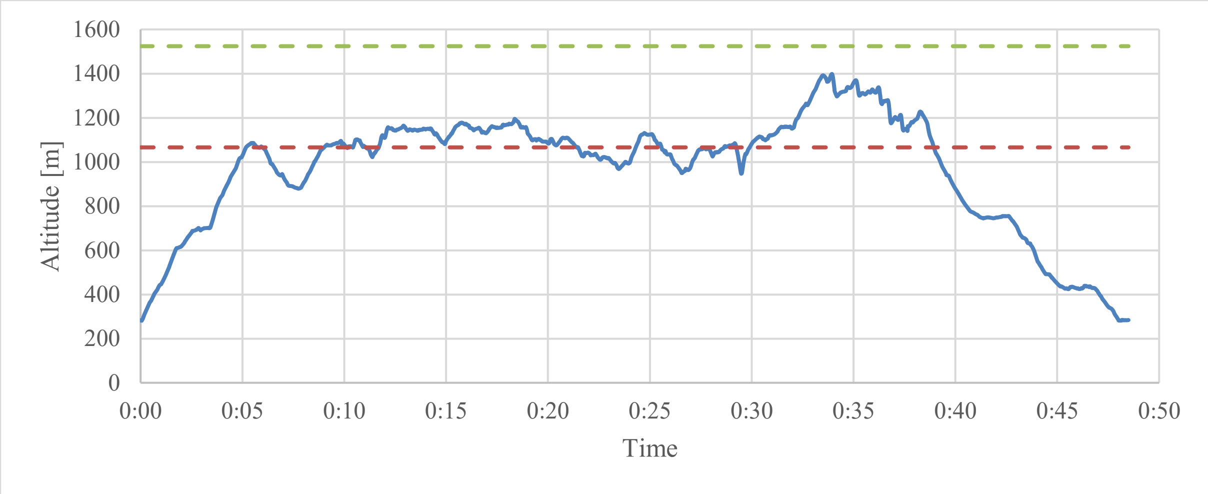

Figure 4-40: Flight #6 actual altitude profile

Lateral recovery (TPs 32-33-34)

Lateral static stability has been tested with slip recovery maneuvers. The plane is trimmed in level flight in the specified conditions and then a slip is initiated on either side with a 10° bank angle. When the condition is stabilized, ailerons are released and the tendency of the A/C to raise the low wing is observed. The time to reach 0° bank angle was measured during testing. Results of the tests are reported in Table 56

Table 56: Lateral recovery data

TP 32 – CLEAN FLAPS, LF PWR				
RUN	**ROLL DIR.**	**IAS [kts]**	**LOW WING RISES**	**TIME [s]**
1	L	55	YES	1”.90
	R		YES	2”.00
2	L	97	YES	1”.98
	R		YES	0”.98
3	L	130	YES	1”.33
	R		YES	1”.13
TP 33 – TO FLAPS, LF PWR				
RUN	**ROLL DIR.**	**IAS [kts]**	**LOW WING RISES**	**TIME [s]**
1	L	55	YES	1”.78
	R		YES	1”.39
2	L	71	YES	1”.84
	R		YES	1”.06
3	L	60	YES	1”.84
	R		YES	1”.06

4	L	65	YES	2”.06
	R		YES	1”.06
TP 34 – LND FLAPS, LF PWR				
RUN	**ROLL DIR.**	**IAS [kts]**	**LOW WING RISES**	**TIME [s]**
1	L	55	YES	2”.75
	R		YES	2”.49
2	L	71	YES	1”.92
	R		YES	3”.14

As shown in the table above, the aircraft has a positive tendency to raise the lower wing during a 10° bank slip in a very short time when the stick is released in every condition tested with a minimum difference between left or right rolls. This test was carried out in the most intrusive configuration from the aerodynamic and weight point of view only, therefore the aircraft is considered compliant with the regulation for the other configurations too.

Short period mode (TPs 35-36-37)

Short period oscillations were excited by a doublet input as described in §4.6.3. The test was carried out in several flap and velocity configurations to cover all requirements of CS-VLA 181.

As shown in Table 57, oscillations were always heavily damped and was not possible for the pilot to distinguish clear peaks and overshoots. For this reason, short period mode is considered compliant with CS-VLA 181 for this heavy payload configuration and therefore compliant for all other lighter configurations.

Table 57: Short period mode data

RUN	TRIM KIAS	OSCILLATIONS HEAVILY DAMPED
FLAPS CLEAN, LF PWR		
1	51	YES
2	94	YES
3	141	YES
FLAPS TO, LF PWR		
1	46	YES
2	71	YES
FLAPS LND, LF PWR		
1	59	YES

Accelerated stalls (TPs 50-51)

Accelerated stall results are reported in the following table. During accelerated stalls, it was always possible to easily regain control of the aircraft, there was never an excessive loss of altitude, no pitch-up or tendency to spin, and within 60° of roll in either direction from the established 30° turn were never exceeded. Based on these considerations, it is judged that compliance has been shown with CS-VLA 203(b). Stall warning was always activated within limits prescribed by CS-VLA 207 (10 to 5 knots above stalling speed).

Table 58: Accelerated stall results

RUN	TRIM KIAS	PWR	TURN DIR.	STALL WARN KIAS	STALL KIAS	ALT. LOSS [ft]	BANK DROP	SATISF. STALL BEHAV.
FLAPS CLEAN								
1	69	75% MCP	L	56	48	200	50° RIGHT	YES
	69	75% MCP	R	55	45	200	50° LEFT	YES
FLAPS LND								
1	69	75% MCP	L	61	51	150	30° RIGHT	YES
	69	75% MCP	R	61	51	150	60° LEFT	YES

4.7 Flight #7

Following table summarizes the procedures that are carried out during last test flight. This flight is performed again with configuration 6b (1 SmartGimbal L, 1 Naked Trolley and 1 SmartCamera) and includes Dutch roll mode, phugoid mode, wing level stalls and turning stalls.

Table 59: Flight #7 recap

<table>
<tr><th>FLIGTH N.</th><th>CONF.</th><th>PROCEDURE</th><th>TP</th><th>TEST PROCEDURE DURATION</th></tr>
<tr><td rowspan="18">7</td><td rowspan="18">6b</td><td rowspan="3">Lateral Directional Dutch Roll</td><td>38</td><td rowspan="18">44 min</td></tr>
<tr><td>39</td></tr>
<tr><td>40</td></tr>
<tr><td rowspan="3">Longitudinal Phugoid</td><td>41</td></tr>
<tr><td>42</td></tr>
<tr><td>43</td></tr>
<tr><td rowspan="6">Wing Level Stalls</td><td>44</td></tr>
<tr><td>45</td></tr>
<tr><td>46</td></tr>
<tr><td>47</td></tr>
<tr><td>48</td></tr>
<tr><td>49</td></tr>
<tr><td rowspan="6">Turning Stalls</td><td>52</td></tr>
<tr><td>53</td></tr>
<tr><td>54</td></tr>
<tr><td>55</td></tr>
<tr><td>56</td></tr>
<tr><td>57</td></tr>
</table>

4.7.1 Mission profile

An extract of the spreadsheet used for the mission profile calculation is provided here below. Same considerations of the other flights for RPM and fuel consumption calculation apply.

The estimated duration of the flight is about 1 hour with a test procedure duration of 44 minutes, complying with requirements of par. 3.3; fuel consumption estimation is of 14 liters plus 3 liters for taxiing and ground operations.

Table 60: Flight #7 mission profile data

			MAN. TIME	TOTAL TIME	MEAN RPM	ALT. [ft]	FUEL CONS. [l/h]	CONS. FUEL [l]	TOTAL FUEL [l]
Start			00:00:00	00:00:00	0	1000	0.000	0	0
Takeoff			00:01:00	00:01:00	2150	2000	18.966	0.316	0.316
Ferry			00:05:00	00:06:00	2150	3500	18.164	1.514	1.830
38	Dutch Roll CLEAN (3 runs)	Maneuver	00:00:10	00:06:10	1600	3500	10.668	0.030	1.859
		Positioning	00:00:40	00:06:50	2000	3500	15.710	0.175	2.034
		Maneuver	00:00:10	00:07:00	2000	3500	15.710	0.044	2.078
		Positioning	00:00:40	00:07:40	2150	3500	18.164	0.202	2.279
		Maneuver	00:00:10	00:07:50	2150	3500	18.164	0.050	2.330
		Positioning	00:00:40	00:08:30	2000	3500	15.710	0.175	2.504
39	Dutch Roll TO (2 runs)	Maneuver	00:00:10	00:08:40	1600	3500	10.668	0.030	2.534
		Positioning	00:00:40	00:09:20	2000	3500	15.710	0.175	2.709
		Maneuver	00:00:10	00:09:30	2000	3500	15.710	0.044	2.752
		Positioning	00:00:40	00:10:10	2000	3500	15.710	0.175	2.927
40	Dutch Roll LND (1 runs)	Maneuver	00:00:10	00:10:20	1700	3500	11.752	0.033	2.959
		Positioning	00:01:00	00:11:20	1800	3500	12.946	0.216	3.175
41	Phugoid CLEAN (3 runs)	Maneuver	00:01:00	00:12:20	1500	3500	9.684	0.161	3.337
		Positioning	00:01:30	00:13:50	2000	3500	15.710	0.393	3.729
		Maneuver	00:01:00	00:14:50	2000	3500	15.710	0.262	3.991
		Positioning	00:01:30	00:16:20	2150	3500	18.164	0.454	4.445
		Maneuver	00:01:00	00:17:20	2150	3500	18.164	0.303	4.748
		Positioning	00:01:30	00:18:50	1900	3500	14.261	0.357	5.105
42	Phugoid TO (1 runs)	Maneuver	00:01:00	00:19:50	1600	3500	10.668	0.178	5.282
		Positioning	00:01:30	00:21:20	1800	3500	12.946	0.324	5.606
43	Phugoid LND (1 runs)	Maneuver	00:01:00	00:22:20	2000	3500	15.710	0.262	5.868
		Positioning	00:00:40	00:23:00	2000	3500	15.710	0.175	6.042
Climb			00:02:00	00:25:00	2150	4500	17.475	0.583	6.625
			00:01:00	00:26:00	2150	5000	17.191	0.287	6.911
44	Wing Level Stall CLEAN IDLE	Stall	00:00:30	00:26:30	1000	5000	5.980	0.050	6.961
		Recover	00:00:05	00:26:35	1800	5000	12.466	0.017	6.979
		Positioning	00:00:45	00:27:20	2000	5000	14.979	0.187	7.166
45	Wing Level Stall CLEAN MCP	Stall	00:00:30	00:27:50	2150	5000	17.191	0.143	7.309
		Recover	00:00:05	00:27:55	2150	5000	17.191	0.024	7.333
		Positioning	00:00:45	00:28:40	1800	5000	12.466	0.156	7.489
46	Wing Level Stall TO IDLE	Stall	00:00:30	00:29:10	1000	5000	5.980	0.050	7.539
		Recover	00:00:05	00:29:15	1800	5000	12.466	0.017	7.556
		Positioning	00:00:45	00:30:00	2000	5000	14.979	0.187	7.743
47	Wing Level Stall TO MCP	Stall	00:00:30	00:30:30	2150	5000	17.191	0.143	7.886
		Recover	00:00:05	00:30:35	2150	5000	17.191	0.024	7.910
		Positioning	00:00:45	00:31:20	1800	5000	12.466	0.156	8.066
48	Wing Level Stall LND IDLE	Stall	00:00:30	00:31:50	1000	5000	5.980	0.050	8.116
		Recover	00:00:05	00:31:55	1800	5000	12.466	0.017	8.133
		Positioning	00:00:45	00:32:40	2000	5000	14.979	0.187	8.321
49	Wing Level Stall	Stall	00:00:30	00:33:10	2150	5000	17.191	0.143	8.464
		Recover	00:00:05	00:33:15	2150	5000	17.191	0.024	8.488

	LND MCP	Positioning	00:00:45	00:34:00	1800	5000	12.466	0.156	8.643
52	Turning Stall CLEAN IDLE L	Stall	00:00:30	00:34:30	1000	5000	5.980	0.050	8.693
		Recover	00:00:05	00:34:35	1800	5000	12.466	0.017	8.711
		Positioning	00:00:45	00:35:20	2000	5000	14.979	0.187	8.898
	Turning Stall CLEAN IDLE R	Stall	00:00:30	00:35:50	1000	5000	5.980	0.050	8.948
		Recover	00:00:05	00:35:55	1800	5000	12.466	0.017	8.965
		Positioning	00:00:45	00:36:40	2000	5000	14.979	0.187	9.152
53	Turning Stall CLEAN MCP L	Stall	00:00:30	00:37:10	2150	5000	17.191	0.143	9.296
		Recover	00:00:05	00:37:15	2150	5000	17.191	0.024	9.319
		Positioning	00:00:45	00:38:00	1800	5000	12.466	0.156	9.475
	Turning Stall CLEAN MCP R	Stall	00:00:30	00:38:30	2150	5000	17.191	0.143	9.618
		Recover	00:00:05	00:38:35	2150	5000	17.191	0.024	9.642
		Positioning	00:00:45	00:39:20	1800	5000	12.466	0.156	9.798
54	Turning Stall TO IDLE L	Stall	00:00:30	00:39:50	1000	5000	5.980	0.050	9.848
		Recover	00:00:05	00:39:55	1800	5000	12.466	0.017	9.865
		Positioning	00:00:50	00:40:45	2000	5000	14.979	0.208	10.073
	Turning Stall TO IDLE R	Stall	00:00:30	00:41:15	1000	5000	5.980	0.050	10.123
		Recover	00:00:05	00:41:20	1800	5000	12.466	0.017	10.141
		Positioning	00:00:50	00:42:10	2000	5000	14.979	0.208	10.349
55	Turning Stall TO MCP L	Stall	00:00:30	00:42:40	2150	5000	17.191	0.143	10.492
		Recover	00:00:05	00:42:45	2150	5000	17.191	0.024	10.516
		Positioning	00:00:50	00:43:35	1800	5000	12.466	0.173	10.689
	Turning Stall TO MCP R	Stall	00:00:30	00:44:05	2150	5000	17.191	0.143	10.832
		Recover	00:00:05	00:44:10	2150	5000	17.191	0.024	10.856
		Positioning	00:00:50	00:45:00	1800	5000	12.466	0.173	11.029
56	Turning Stall LND IDLE L	Stall	00:00:30	00:45:30	1000	5000	5.980	0.050	11.079
		Recover	00:00:05	00:45:35	1800	5000	12.466	0.017	11.096
		Positioning	00:00:50	00:46:25	2000	5000	14.979	0.208	11.304
	Turning Stall LND IDLE R	Stall	00:00:30	00:46:55	1000	5000	5.980	0.050	11.354
		Recover	00:00:05	00:47:00	1800	5000	12.466	0.017	11.371
		Positioning	00:00:50	00:47:50	2000	5000	14.979	0.208	11.580
57	Turning Stall LND MCP L	Stall	00:00:30	00:48:20	2150	5000	17.191	0.143	11.723
		Recover	00:00:05	00:48:25	2150	5000	17.191	0.024	11.747
		Positioning	00:00:20	00:48:45	1800	5000	12.466	0.069	11.816
	Turning Stall LND MCP R	Stall	00:00:30	00:49:15	2150	5000	17.191	0.143	11.959
		Recover	00:00:05	00:49:20	2150	5000	17.191	0.024	11.983
		Positioning	00:00:20	00:49:40	1800	5000	12.466	0.069	12.052
Descent			00:01:00	00:50:40	1800	4500	12.606	0.210	12.262
			00:01:00	00:51:40	1800	3500	12.946	0.216	12.478
			00:01:00	00:52:40	1800	2500	13.210	0.220	12.698
Approach			00:06:00	00:58:40	1600	1500	10.981	1.098	13.796
Landing			00:01:00	00:59:40	1200	1000	7.335	0.122	13.919

Figure 4-41 shows the flight altitude profile: Dutch roll and phugoid take place at 3500 ft while all stalls which shall be performed at a higher altitude for safety reasons; takeoff, ferry, approach and landing are clearly distinguishable.

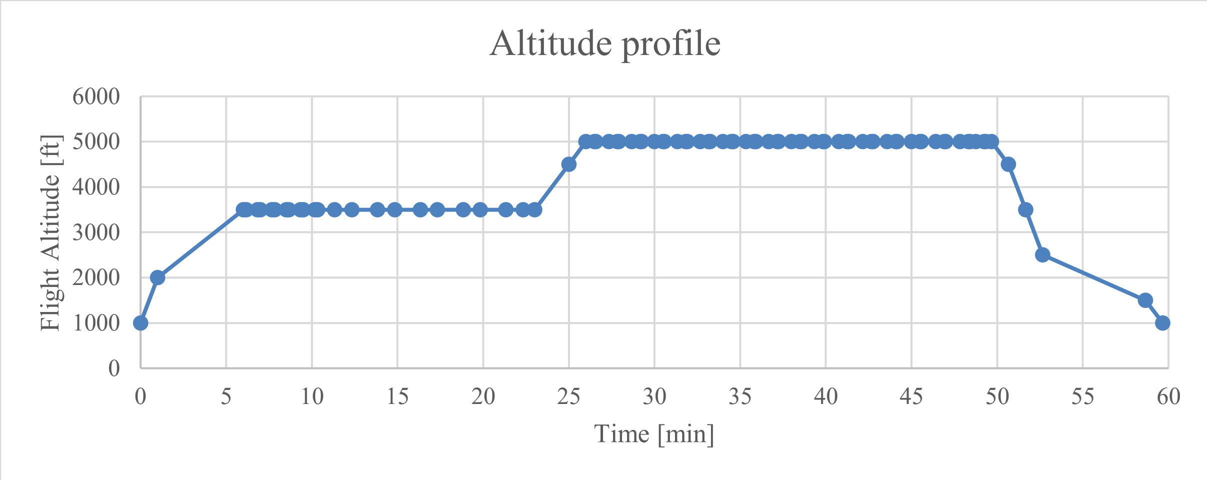

Figure 4-41: Estimated altitude profile of Flight #7

An estimation for fuel consumption is provided in Figure 4-42. Stalls are clearly identifiable as shall be performed alternately at idle and 75% MCP.

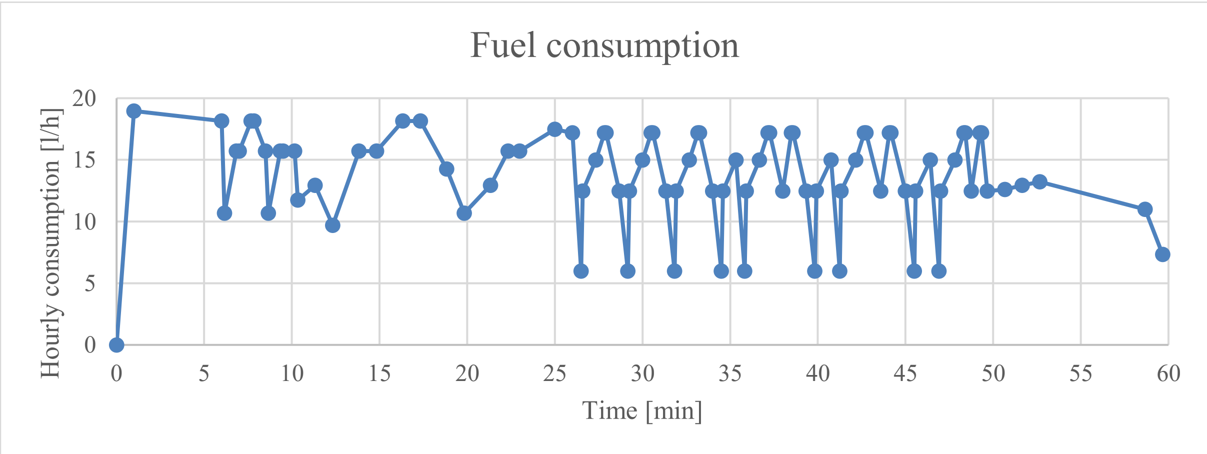

Figure 4-42: Estimated fuel consumption of Flight #7

4.7.2 Weight and Balance

This flight is conducted with configuration n.6b. CG shall be in the rearmost position: baggage compartment is then loaded with a sandbag secured to the airframe with ropes and a small ballast is inserted in the battery compartment.

Note that at takeoff the aircraft weight is approximately 620 kg, so within the MTOW+5% limitation while at landing is estimated to be slightly overweight. As for flight #5, to avoid an overweight landing would be necessary to decrease baggage load or initial fuel but it would result is a CG too much forward or less safety margin respectively. The pilot was then informed of this condition and advised to use extra caution during landing. The CG, however, cannot fall within the ±7% of the forward limit as explained in §3.2.5.

Table 61: Flight #7, Weight and Balance calculation

		WEIGHT [kg]		ARM [m]	MOMENTUM [kg*m]	
		TO	LND		TO	LND
	EMPTY WEIGHT	401	401	1.734	695.45	695.45
	FUEL (50 l)	36	24.48	1.660	59.76	40.6368
	PILOT	83	83	1.760	146.08	146.08
	COPILOT	73	73	1.760	128.48	128.48
SMARTBAY	SMARTGIMBAL	7.5	7.5	1.710	12.825	12.825
SMARTBAY	NAKED TROLLEY	0.4	0.4	1.910	0.764	0.764
SMARTBAY	SMARTCAMERA	2.1	2.1	2.110	4.431	4.431
SMARTBAY	BIU	0.5	0.5	2.310	1.155	1.155
	BAGGAGE	13	13	2.210	28.73	28.73
	REAR BALLAST	3	3	4.100	12.3	12.3
	TOTAL	619.5	607.98	-	1089.98	1070.85
	CG [m]	1.759	1.761			

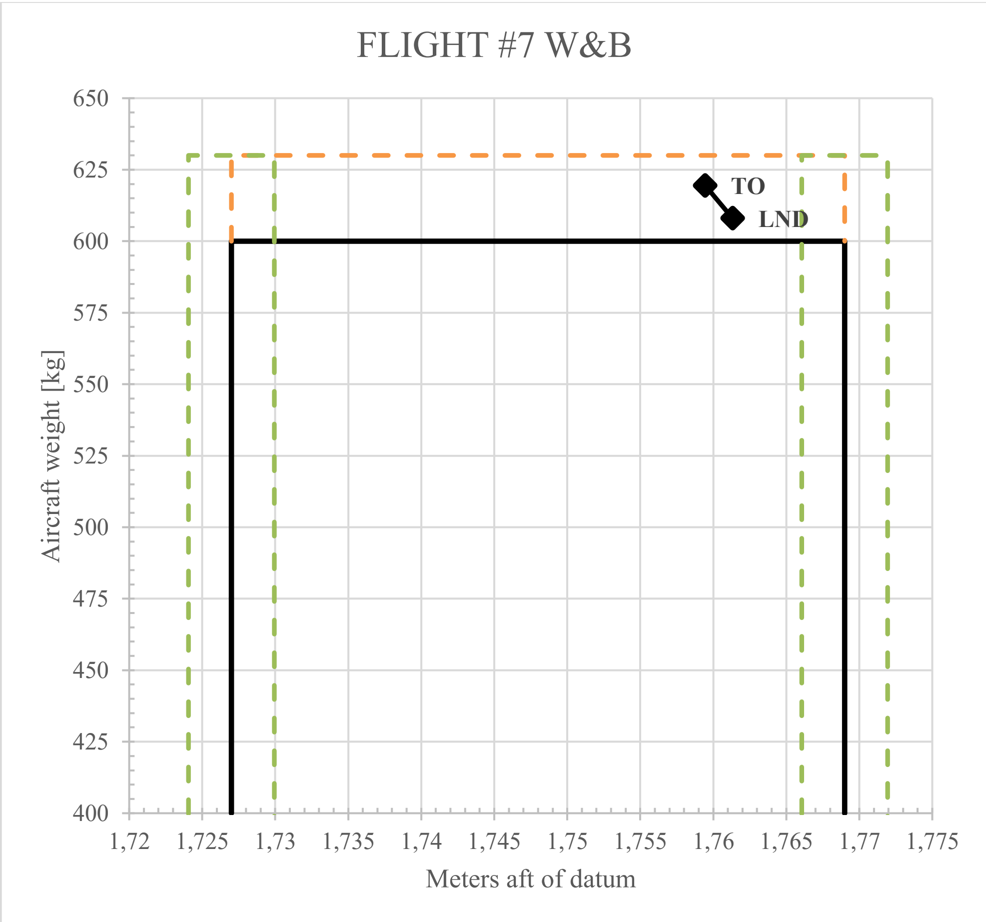

Figure 4-43: Flight #7, Weight and CG excursion during flight

4.7.3 Procedures description

Procedures used for this flight test are described here below.

Dutch roll:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings
- Smoothly apply alternating left and right rudder inputs in order to excite and reinforce the Dutch roll motion. Restrain the lateral cockpit control at the trim condition. Continue the cyclic rudder pulsing until the desired magnitude of oscillatory motion is attained, then smoothly return the rudder pedals to the trim position and restrain them in the trim position.
- Let the aircraft stabilize
- Repeat the procedure for the number of times indicated

Phugoid:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings
- Perform a slow elevator pull to cause the aircraft to decrease airspeed from the trim point and climb. Once the speed deviation is attained, the stick is moved back to the original position and released.
- Start the stopwatch when the aircraft returns to the trimmed altitude
- Observe phugoid mode for some oscillation periods
- Repeat the procedure for the number of times indicated.

Wing Levelled Stall:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings
- Slowly pull the stick to induce an airspeed reduction of approximately 1 knot per second until stall occurs.
- Recover from stall

Turning Stall:

- Set flaps as indicated
- Trim the aircraft with specified airspeed and power settings in a 30° turn
- Slowly pull the stick to induce an airspeed reduction of approximately 1 knot per second until stall occurs.

- Recover from stall
- Repeat for opposite roll direction

Data to be recorded manually by the FTE are:

- Dutch roll:
    - TOTAL PEAKS: Indicate the number of yaw peaks the aircraft develops after the excitement of the maneuver (3 peaks form a cycle)
    - DUTCH ROLL DAMPING: If Dutch Roll mode extinguish itself rapidly then this mode should be qualitatively described as essentially satisfactory. In this event mark YES, otherwise, NO. If NO has been marked, describe the mode in the appropriate section of the Test Card. This is a qualitative evaluation; more precise investigation can be achieved through the inspection of the video
- Phugoid:
    - For each mode peak:
        - TIME: Stopwatch time since the aircraft passes through the trim altitude after pulling the stick to excite phugoid mode
        - ALTITUDE
        - IAS
- Wing Levelled Stall:
    - STALL WARNING IAS: Indicated airspeed at which stall warning activates
    - STALL IAS: Indicated airspeed at which stall occurs. Stall occurs when the first of the below conditions occurs:
        - Uncontrollable downward pitching motion;
        - The control reaches the stop
    - ALTITUDE LOSS: Indicate the loss of altitude in feet caused by the stall occurrence
    - MAX BANK ANGLE: Indicate the maximum bank angle occurred during stall
    - SATISFACTORY STALL BEHAVIOR: The turning stall behavior is considered satisfactory when:
        - The altitude lost is not, in the test pilot’s opinion, excessive
        - There is no undue pitch-up
        - There are no uncontrollable spinning tendencies; i.e. while the aircraft may have a tendency to spin, a spin entry is readily preventable
        - The test pilot can complete the recovery with normal use of the controls and average piloting skill
        - The aircraft does not exceed 60° of bank in either direction from the established 30° bank.

      If NO has been marked, a detailed explanation shall be provided

- Turning Stall:
    - STALL WARNING IAS: Indicated airspeed at which stall warning activates
    - STALL IAS: Indicated airspeed at which stall occurs. Stall occurs when the first of the below conditions occurs:
        - Uncontrollable downward pitching motion;
        - The control reaches the stop
    - ALTITUDE LOSS: Indicate the loss of altitude in feet caused by the stall occurrence
    - MAX BANK ANGLE: Indicate the maximum bank angle occurred during stall
    - SATISFACTORY STALL BEHAVIOR: The turning stall behavior is considered satisfactory when:
        - The altitude lost is not, in the test pilot's opinion, excessive
        - There is no undue pitch-up
        - There are no uncontrollable spinning tendencies; i.e. while the aircraft may have a tendency to spin, a spin entry is readily preventable
        - The test pilot can complete the recovery with normal use of the controls and average piloting skill
        - The aircraft does not exceed 60° of bank in either direction from the established 30° bank.

4.7.4 Results

This flight had to be interrupted because of adverse weather condition which developed during flight, the remaining part of the test was performed in a different day. Table 62 and Table 63 report main flight information regarding flight times and fuel consumed while Figure 4-44 and Figure 4-45 show the flights path on a map. Note that turning stalls pattern during second flight is recognizable.

Table 62: Flight #7 part-1 summary

FLIGHT SUMMARY			
TAKEOFF		**LANDING**	
AIRPORT:	LIMA	**AIRPORT:**	LIMA
TIME:	12:17	**TIME:**	13:05
WIND SPEED:	-	**WIND SPEED:**	4 KTS
WIND HDG:	-	**WIND HDG:**	290°
FUEL:	50 l	**FUEL:**	32L
ESTIMATED FLIGHT TIME	N/A		
ACTUAL FLIGHT TIME:	**48 min**		
ESTIMATED FUEL CONSUMPTION	N/A		
ACTUAL FUEL CONSUMPTION:	**18 liters**		

Table 63: Flight #7 part-2 summary

FLIGHT SUMMARY			
TAKEOFF		**LANDING**	
AIRPORT:	LIMA	**AIRPORT:**	LIMA
TIME:	08:55	**TIME:**	09:29
WIND SPEED:	4 KTS	**WIND SPEED:**	VAR 3 KTS
WIND HDG:	180°	**WIND HDG:**	-
FUEL:	40 l	**FUEL:**	28 l
ESTIMATED FLIGHT TIME		N/A	
ACTUAL FLIGHT TIME:		**34 min**	
ESTIMATED FUEL CONSUMPTION		N/A	
ACTUAL FUEL CONSUMPTION:		**12 liters**	

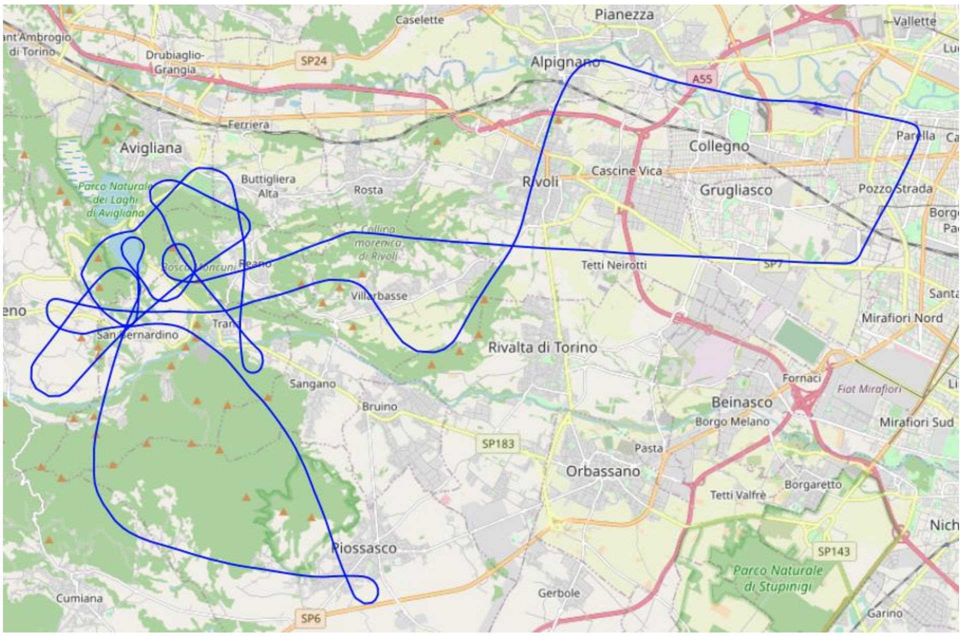

Figure 4-44: Flight #7 part-1 path

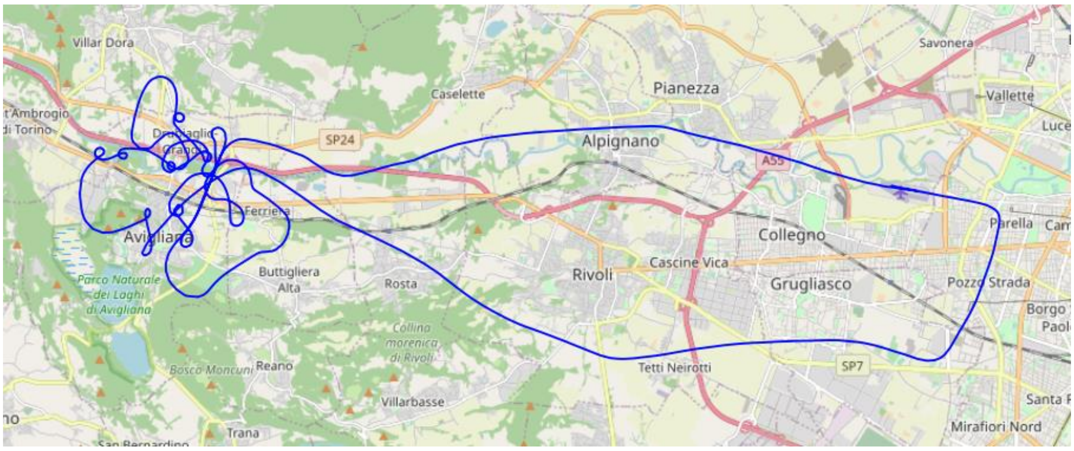

Figure 4-45: Flight #7 part-2 path

The actual altitude profiles are shown here below where the dotted red and green lines represent the scheduled 3500 ft and 5000 ft cruise altitude for this flight. During part-1 only maneuvers at 3500 ft were executed due to the cloudy weather which resulted in light rain by the end of the flight. Part-2 of this flight test regarded turning stalls and wing level stall only and was performed at 5000 ft.

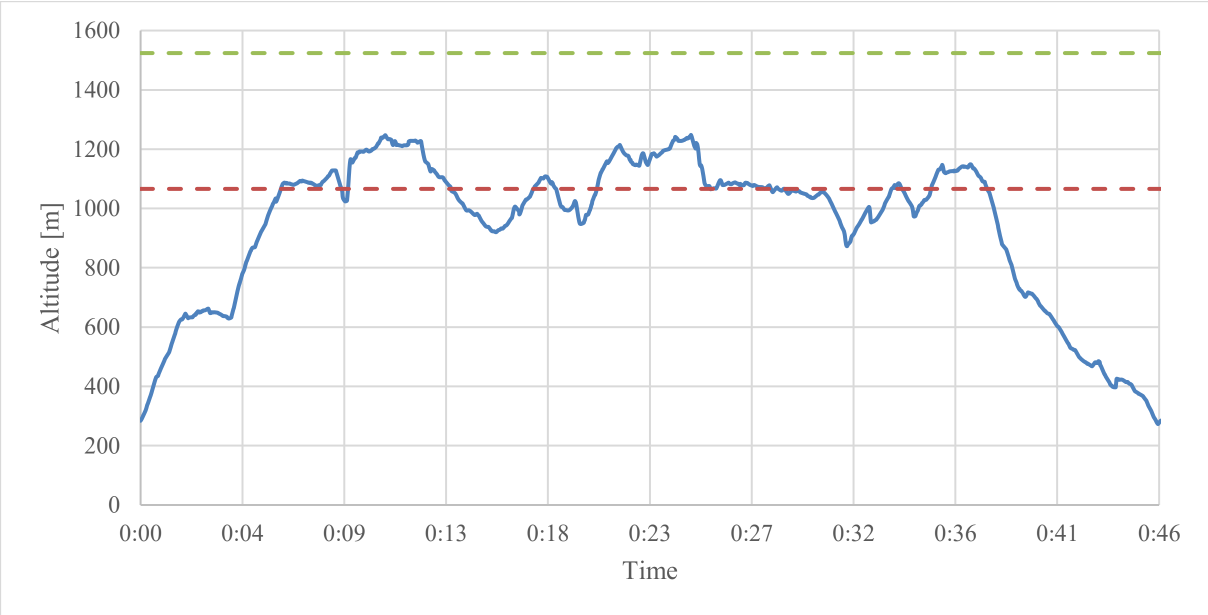

Figure 4-46: Flight #7 part-1 actual altitude profile

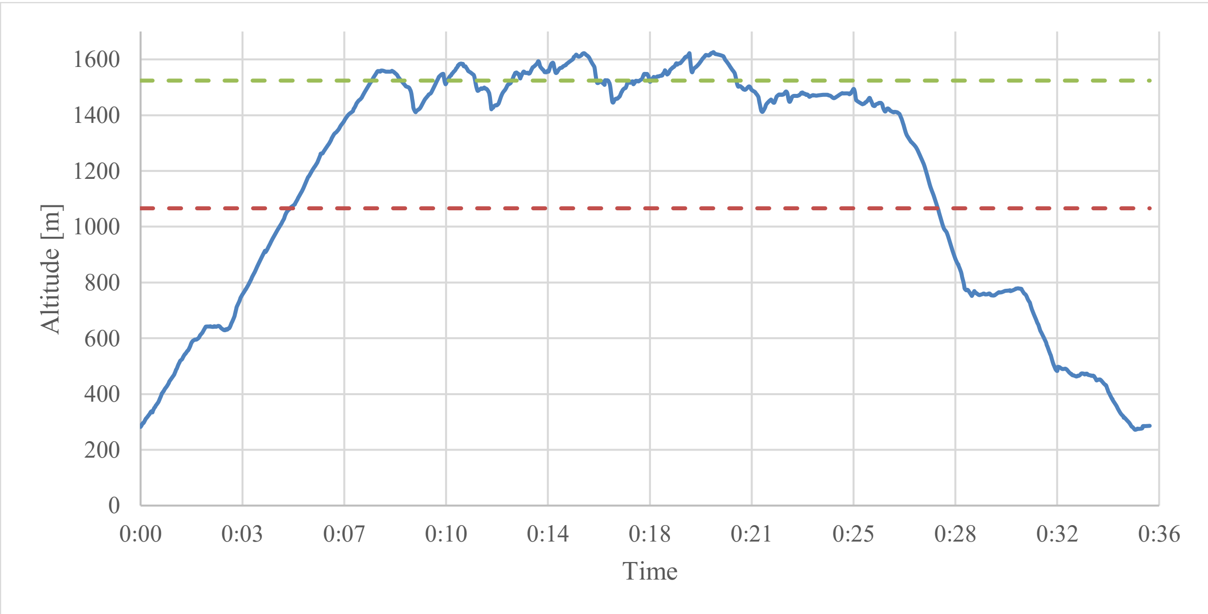

Figure 4-47: Flight #7 part-2 actual altitude profile

Dutch Roll (TPs 38-39-40)

Dutch Roll oscillations were excited following the "rudder pulsing" technique described in AC-23-8C reported in §4.7.3. The test was carried out for different flaps configurations and velocity ranges to cover the requirements of CS-VLA 181(b). Results are reported in Table 64. Dutch roll motions were satisfactorily damped and resulted to be totally damped in no more than 2 cycles (for Flaps in landing configurations) meeting with a great margin the requirements of 7 maximum cycles of damping time.

Based on these considerations, compliance has been shown with CS-VLA 81(b) using the most intrusive SmartBay configuration. By comparison, also less intrusive SmartBay configurations are considered compliant.

Table 64: Dutch Roll results

RUN	TRIM KIAS	TOTAL PEAKS	DUTCH ROLL DAMPING SATISFACTORY
FLAPS CLEAN, LF PWR			
1	54	2	YES
2	87	2	YES
3	119	2	YES
FLAPS TO, LF PWR			
1	50	2	YES
2	71	3 (1 cycle)	YES
FLAPS LND, LF PWR			
1	59	6 (2 cycles)	YES

Phugoid (TPs 41-42-43)

Phugoid was tested according to the procedure described in AC-23-8C (Ref. 8). Phugoid motions were excited after trimming the A/C in level flight in the desired condition and allowing a departure from the trim speed with a longitudinal stick movement. Then the longitudinal control is then left free and the altitude, and speed oscillations are measured when reaching a maximum or minimum of the phugoid trajectory. In the following tables are reported the data acquired during these tests.

The phugoid was always dynamically stable, with the velocity that tended to return towards the trim IAS within 3 or 4 cycles. Note that the aircraft did not develop a phugoid with a clear path and the recognition of the peaks was quite difficult also due to the slightly ascending or descending trend (within 100ft/min approximately) of the aircraft. In any case CS-VLA do not pose a specific requirement for longitudinal phugoid mode.

Table 65: Phugoid mode results

FLAPS CLEAN, LF PWR							
RUN	**TRIM KIAS**	**TRIM ALT**		**∨ 1**	**∧ 1**	**∨ 2**	**∧ 2**
1	55	3500	**TIME**	12”	24”	40”	1’04”
			ALT	3400	3410	3290	3220
			IAS	69	57	62	54
2	87	3200	**TIME**	8”	18”	33”	48”
			ALT	3250	3350	3300	3400
			IAS	77	90	82	86
3	115	4700	**TIME**	8”	20”	35”	47”
			ALT	3850	3750	3890	3820
			IAS	96	122	100	116
FLAPS TO, LF PWR							
RUN	**TRIM KIAS**	**TRIM ALT**		**∨ 1**	**∧ 1**	**∨ 2**	**∧ 2**
1	60	3500	**TIME**	8”	14”	20”	28”
			ALT	3520	3690	3520	3500
			IAS	55	64	58	53
FLAPS LND, LF PWR							
RUN	**TRIM KIAS**	**TRIM ALT**		**∨ 1**	**∧ 1**	**∨ 2**	**∧ 2**
1	60	3500	**TIME**	5”	12”	21”	32”
			ALT	3490	3430	3470	3420
			IAS	54	65	55	63

Wing level stalls (TPs 44-45-46-47-48-49)

Wing Level Stalls were tested to show compliance with CS-VLA 201 and CS-VLA 49. In the following table is reported the data collected during wing level stall testing. The wing level stalls always showed a safe and predictable behavior and happened at elevator control saturation. Idle power stalls showed a tendency to drop the right wing (probable effect of SBE installation weight on the right wing), while power on stalls generally showed a tendency to drop the left wing. The bank angle was moderate and could in any case be stopped by applying opposite aileron, which remained always effective and unreversed. Based on these data and considerations, it is judged that the installation in compliant with CS-VLA 201 and CS-VLA 49.

Table 66: Wing level stalls results

RUN	TRIM KIAS	PWR	TURN DIR.	STALL WARN KIAS	STALL KIAS	ALT. LOSS [ft]	BANK DROP	SATISF. STALL BEHAV.
FLAPS CLEAN								
1	69	IDLE	-	57	49	100	10° RIGHT	YES
	69	75% MCP	-	58	48	50	15° LEFT	YES
FLAPS TO								
1	69	IDLE	-	52	45	100	10° RIGHT	YES
	69	75% MCP	-	52	44	100	15° LEFT	YES
FLAPS LND								
1	69	IDLE	-	49	41	100	10° RIGHT	YES
	69	75% MCP		46	39	150	15° RIGHT	YES

Turning stalls (TPs 52-53-54-55-56-57)

Turning Flight Stalls were tested to show compliance with CS-VLA 203. A coordinated turn at 30° bank angle was established at the specified trim speed, then the speed was gradually reduced by pulling on the stick at a rate of 1 kt per second until a stall was reached or the elevator control reached its stop. The test was repeated in different flaps and power setting in order to cover the requirement of CS-VLA 203(c).

Table 67: Turning stalls

RUN	TRIM KIAS	PWR	TURN DIR.	STALL WARN KIAS	STALL KIAS	ALT. LOSS [ft]	BANK DROP	SATISF. STALL BEHAV.
FLAPS CLEAN								
1	69	IDLE	L	61	51	120	25° RIGHT	YES
	69	75% MCP	R	61	51	140	30° RIGHT	YES
2	69	IDLE	L	63	55	120	25° RIGHT	YES
	69	75% MCP	R	61	52	120	20° RIGHT	YES
FLAPS TO								
1	69	IDLE	L	55	48	180	60° RIGHT	YES
	69	75% MCP	R	55	48	180	20° RIGHT	YES
2	69	IDLE	L	61	51	50	25° RIGHT	YES
	69	75% MCP	R	60	52	50	30° LEFT	YES

FLAPS LND								
1	69	IDLE	L	51	44	100	20° RIGHT	YES
	69	75% MCP	R	51	43	100	20° LEFT	YES
2	69	IDLE	L	55	45	50	0°	YES
	69	75% MCP	R	53	45	50	40° LEFT	YES

During turning stalls, it was always possible to easily regain control of the aircraft, there was never an excessive loss of altitude, no pitch-up or tendency to spin, and within 60° of roll in either direction from the established 30° turn were never exceeded.

Based on these considerations, it is judged that compliance has been shown with CS-VLA 203. The stall warning both for wing level and turning stalls was always activated within the limits prescribed by CS-VLA 207, 10 to 5 knots above stalling speed.

The last step is to compare stall results with the AFM approved data to identify possible discrepancies. The AFM states stalling speed for wing with bank at 0° and 30° at MTOW with all flap configurations. All stall tests took place at a weight of approximately 612-615 kg, therefore, airspeeds recorded shall be corrected with the following formula reported in AC23-8C:

$$V_{S_{STD}} = V_{S_{TEST}} \sqrt{\frac{W_{STD}}{W_{TEST}}}$$

Compared results with the AFM are reported in the following table.

Table 68: Stall tests compared to AFM data

CONDITION	AFM STALL KIAS	TEST STALL KIAS CORRECTED
0° BANK, PWR IDLE		
CLEAN FLAPS	46	48.4
TO FLAPS	44	44.4
LND FLAPS	41	40.5
30° BANK, PWR IDLE		
CLEAN FLAPS	49	50.4
TO FLAPS	47	47.4
LND FLAPS	44	43.5

Considering the anemometer reading accuracy (of the order of +/- 2 kts) and the natural variability of experimental data, it is judged that the stalling speed of the modified A/C remains, within margin of error, the same of the basic A/C. For this reason, data reported in the AFM section regarding stalls does not require any change.

5 Conclusions and future work

All Test Points were carried out safely in a couple of weeks according to the test program and all data correctly recorded. The results of the seven flight tests and the analytical demonstrations carried out to assess the compliance of this modification to the applicable rules, have demonstrated that this installation is compatible with the P-92JS aircraft following CS-VLA regulation.

The asymmetric configuration did not cause any detrimental effect on controllability and handling qualities even though some small effects of this asymmetry have been detected during tests involving lateral and directional maneuvers. Specifically, the recover from a skid has always shown a positive centering tendency even though the aileron tended to saturate before full rudder input only in a right-hand steady heading sideslip (rudder to the right aileron to the left). This was particularly noticeable with Heavy SmartBay configuration and TO and LND flaps where left aileron input saturates while a right pedal input is still at 1/2 - 2/3 of its total travel. In spite of this situation, the aircraft was proven to withstand the maximum crosswind component stated in the AFM, not requiring any further limitation. The aircraft is equipped with an electric trim only for the longitudinal control, for lateral and directional controls two fixed tabs are located on the left aileron and rudder respectively. To reduce pilot workload, the rudder trim tab is deflected further to the right to induce a left yawing moment while left aileron trim tab is deflected further down to induce left rolling moment to compensate right yawing and rolling moment caused by SmartBay installation. The amount of this deflection was determined experimentally during test flights.

During cruise flight and during the execution of the test points, the vibrations or buffeting perceived by the crew inside the cockpit at any tested speed, resulted to be low. In any case, vibrations did not interfere with the satisfactory control of the aircraft or caused excessive fatigue to the crew. Moreover, SmartBay payload did not appear to be subjected to any relevant vibration level during the entire flight.

Based on performance testing and analysis, the following information will be presented in section 5 (Performances) of the supplement to the AFM.

- **Climb performance.** With SmartBay pylon installed, in any configuration, basic AFM climb performances are reduced by 150 ft/min at any altitude. V_Y speed remained unchanged.
- **Takeoff distance.** Even though no specific test was performed, the takeoff distance had no reasons to be reduced due to the very low aerodynamic impact of this installation at low speeds. Climb performance in takeoff configuration is reduced by 150 ft/min.
- **Cruise performance.** Based on the analysis on the impact of the installation on additional drag, the range performance is reduced conservatively by an average of 10%.

- **V_{NE} limitation.** Since vibration levels were tested up to V_{NE} instead of $1.1V_{NE}$, a limitation on this characteristic speed is imposed in the AFM supplement. A placard is positioned next to the airspeed indicator stating that the new V_{NE} is of 125 knots; the original limitation was 141 knots. In addition, a new V_{NE} red line indicator has been applied to the airspeed indicator.

Based on the results here reported, EASA, through ENAC, issued a Supplemental Type Certificate for this special operation aircraft configuration on March 2020. In the meantime, DigiSky, continues to develop new trolleys for SmartBay to accommodate new sensors and new innovative systems according to market demands. The key of this flight test campaign was to certify a heavy payload configuration with high aerodynamic impact (SmartGimbal, 10 kg in a single trolley) with the prospect of introducing new payloads with similar or lower mass and aerodynamic impact as Minor Changes without the need of a new flight test campaign and an easier and quicker certifying procedure.

Figure 5-1: Test aircraft I-SBAY at landing

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Acronyms

AC	Advisory Circular
AFM	Aircraft Flight Manual
AGL	Above Ground Level
BIU	Bus Interface Unit
CB	Certification Basis
COD	Crew Operator Deck
CS	Certification Specification
CTA	Control Area
CTR	Control Zone
DSK	DigiSky
EASA	European Union Aviation Safety Agency
FAA	Federal Aviation Authority
FDL	Flight Data Logger (DigiSky product)
FL	Flight Level
FTC	Flight Test Card
FTE	Flight Test Engineer
FTG	Flight Test Guide
FTI	Flight Test Instrumentation
FTP	Flight Test Program
FTR	Flight Test Report
GPS	Global Positioning System
HDG	Heading
IAS	Indicated Airspeed
IMU	Inertial Measurement Unit
ISA	International Standard Atmosphere
KIAS	Knots Indicated Airspeed
MSL	Mean Sea Level
NPA	Notice of Proposed Amendment

NT	Naked Trolley
PCS	Payload Control System
PCU	Payload Control Unit
PIC	Pilot In Command
PWR	Power
RC	Rate of Climb
SBE	SmartBay Embedded
SC	SmartCamera
SG	SmartGimbal
STC	Supplemental Type Certificate
TCDS	Type Certificate Data Sheet
TCS	Trolley Control System
TP	Test Point
VLA	Very Light Aircraft
VMC	Visual Meteorological Conditions
V_{FE}	Maximum flap extended speed
V_{NE}	Never Exceed Speed
V_{Y}	Speed that will allow for the best rate of climb
W&B	Weight and Balance

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