FLIGHT TEST CATEGORIES IN CERTIFICATION AND TEST CREW COMPETENCY REQUIREMENTS

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Introduction

Due to Civil Aviation Rules and EASA Part-21 Appendix XII [1]; flight crew involved in the conduct of flight tests for aircraft certified or to be certified, should satisfy some specified qualifications. These certification activities should be upon EASA CS-23 for aircraft with a maximum take-off mass (MTOM) of or above 2 000 kg, CS-25, CS-27, CS-29 or equivalent airworthiness codes and also FAA's CFR Codes.

Here in this paper, the categories of flight tests and the rotary and fixed wing piloted air vehicle flight crew requirements compatible with these categories are explained. Explanations of a flight test, the purpose of a flight test, it is relation with certification and type certified air vehicles are also explained. The most asked questions and answers related to this topic are explained.

What is a Flight Test?

A brief explanation from Royal Aeronautical Society (RAeS):

Flight activities from research and development (R&D) flying through to verification and validation that an air vehicle and its subsystems are safe to operate and fit for purpose. It covers a spectrum of airborne data gathering and evaluation activities for this purpose [2].

Three fundamental reasons for flight testing given in the AGARD Flight Test Manual are briefed as follows [3]:

- To determine the actual characteristics of the air vehicle (as contrasted to the computed and predicted characteristics)
- To provide developmental information.
- To obtain research information.

Besides to these, flight tests are also held for [4]:

- Certification
- Developmental Test and Evaluation
- Operational Test and Evaluation

According to EASA Part-21, flight tests are;

- Flights for the development phase of a new design (aircraft, propulsion systems, parts and appliances);
- Flights to demonstrate compliance to certification basis or conformity to type design;
- Flights intended to experiment new design concepts, requiring unconventional maneuvers or profiles for which it could be possible to exit the already approved envelope of the aircraft;
- Flight test training flights

Why some specifications are needed for the crew of flight tests like pilots, flight test engineers?

The testing of aircraft performance, handling qualities and systems, including checking compliance with vertification Specifications (CSs), requires specialist techniques, skills and theoretical knowledge. Therefore, flight test training and specific experiences are required to enable a test crew to:

— safely perform systematic and comprehensive flight envelope exploration;
— acquire specific skills and abilities for some particularly difficult tests;

— mitigate risks by anticipating potentially hazardous situations, and by applying methods that permit the safest flight possible in these situations;
— understand the relevant CSs; and
— learn methods to assess whether the aircraft or its systems comply with these regulations.

Why do we use categories of flight tests in certification?

To understand the requirements of pilot- crew- flight test engineers competence levels with tests. This is indicated specifically in EASA PART – FCL [5] or FAA 14 CFR Part 61 [6].

An important note here is; these categories are not related to the significant changes that may lead to TC or STC issuance or not related to the "Permit to Fly".

Besides to these, even if the flight tests are not related to the certification activities, the needed qualifications indicated in Part-FCL or 14 CFR Part 61 can be taken into account by companies dealing with flight tests. These are good guides to minimize unsafe flight occurrences.

What are the categories of flight tests?

There are four main flight test categories listed in EASA PART.21 [4] can be described briefly as :

Flight Test Categories	**Description**
Category- 1	Initial flights
Category- 2	Modifications of envelope expansions to initial flights
Category- 3	Tests after TC/STC issue (like production flights)
Category- 4	Test of modifications not effecting overall flight characteristics

CATEGORY – 1 :

(a) Initial flight(s) of a new type of aircraft or of an aircraft of which flight or handling characteristics may have been significantly modified;
(b) Flights during which it can be envisaged to potentially encounter flight characteristics significantly different from those already known;
(c) Flights to investigate novel or unusual aircraft design features or techniques; (d) Flights to determine or expand the flight envelope;
(e) Flights to determine the regulatory performances, flight characteristics and handling qualities when flight envelope limits are approached;
(f) Flight test training for Category 1 flight tests.

EXAMPLES:

Fixed-wing aircraft: VMCG, VMU, spinning, initial stalling, or for rotary-wing aircraft: H/V diagrams and Category A engine failures.
— Where encounter of surprising or even hazardous flight characteristics can be expected.
— Upon determination, aircraft handling and performance in conditions where at least one of the following parameters is approaching the actual limits of the aircraft envelope: altitude, attitudes, weights, CG, speed/Mach, stalls, temperature, engine and aerofoil performance.
— Where the embodiment of new systems is anticipated to significantly affect the aircraft's handling or performance characteristics.
— When the crew of the chase aircraft has the duty to assist the test aircraft crew in recovering from a critical flight situation (i.e. assist the spinning aircraft crew in assessing the spin or triggering recovery actions).

CATEGORY – 2 :

(a) Flights not classified as Category 1 on an aircraft whose type is not yet certified;
(b) Flights not classified Category 1 on an aircraft of an already certified type, after embodiment of a not yet approved modification and which:
(i) require an assessment of the general behaviour of the aircraft; or
(ii) require an assessment of basic crew procedures, when a new or modified system is operating or is needed; or
(iii) are required to intentionally fly outside of the limitations of the currently approved operational envelope, but within the investigated flight envelope.
(c) Flight test training for Category 2 flight tests.

EXAMPLES:

The flight test envelope has already been opened and it has been demonstrated that the general behaviour of the aircraft is adequately safe and there are no unsafe flight characteristics.
— All-engines-operating climb performance.
— Cruise performance.
— Static stability demonstration.
— Function and reliability flights.
— Systems tests of autopilot or guidance/warning systems such as Terrain Awareness and Warning System (TAWS) or Airborne Collision Avoidance System (ACAS), when the modes themselves are tested, requiring operating the aircraft by deviating from the standard operational procedures. Additionally, in the case of embodiment of such systems on an already certified aircraft, when the system integration in an existing cockpit requires a more global crew procedure assessment — for example, when the system has been integrated in cockpit screens and a centralised warning system which requires a new cockpit procedure assessment (note that some system tests may fall under Category 4; see below).

CATEGORY -3

Flights performed for the issuance of statement of conformity for a new-built aircraft which do not require flying outside of the limitations of the type certificate or the aircraft flight manual.

EXAMPLES:

These flights are commonly referred to as production flight tests. They are performed on each new aircraft of a type that is already certified. The aim is to check that the aircraft and its systems are working properly and conform to the certified type. As the type is already certified, the behaviour of the aircraft is known.
However, experience has shown that during production flight tests of a new aircraft, unexpected failures can occur which could not be described in the Aircraft Flight Manual (AFM). For this reason, it is considered that special experience should be required. It should be noted that a TC or a Supplemental Type Certificate (STC) should have been issued in order for a production flight test to be considered as Category 3. Until a TC or STC is issued, any flight, including production flight tests, will be Category 1, 2 or 4 according to classification criteria.

CATEGORY -4

Flights not classified as Category 1 or 2 on an aircraft of an already certified type, in case of an embodiment of a not yet approved design change.

Typical Category 4 flights are those required by a DOA to demonstrate compliance with the airworthiness requirements of “not yet approved data”:

— cabin conversion;

— zonal drying system installation;
— Emergency Locator Transmission (ELT) installation;
— new cabin installation;
— cabin aircraft location pictorial system installation;
— new entertainment system installation;
— SATCOM and telephone installation; and
— new radio equipment installation.

Category 4 includes also flights after embodiment of guidance/warning systems which are not Category 2 and for which:
— good functioning test only is required; and
— there is no need to fly the aircraft outside the AFM limitations.

The modification should not affect the behavior of the aircraft in any way.

What is "behavior of the aircraft"?

Mainly the "flight characteristics of an aircraft". If a TC is hold before, overall behavior of the A/C is indicated in the Aircraft Flight Manual (AFM) approved with the TC, the flight characteristics and behavior that is not compatible with CS requirements are defined in the TC specifically. Modification of the flight behavior requires a change need in AFM Flight Characteristics indications.

However, there may be modifications whose tests, despite the fact that they have no influence on the behavior of the aircraft, require flying in conditions which deviate significantly from the standard operational use of the aircraft. These unusual flight test conditions may require classifying the flight as Category 2, as mentioned above. The typical example to consider here is the approval of the modification of an already certified TAWS system. In this situation, it is required to fly at very low altitude and/or towards high terrain. Such a flight can be classified as Category 4 flight on a light aircraft (or helicopter) because that flight test is performed in a domain corresponding to the normal operation of the aircraft, whereas the same flight performed with a heavy CS-25 aircraft, especially if it needs to be flown in clean configuration significantly below gear and flaps warning heights, should be classified as Category 2 because such a flight does not correspond to the normal use of the aircraft and needs to adopt specific testing procedures as demonstrated in the Category 2 training.

Maintenance check flights are not included in the guidance material of EASA PART- 21.

Additional Notes:

If the A/C does not have any Type Certificate (TC), the tests should be considered either as Category 1 or Category 2. It should be noted also that if the flight of an aircraft with a TC or STC requires flying outside the AFM limitations, then this flight should be considered as Category 1 or Category 2 flight.

Flight tests for a modification of an already certified type may be Category 1, 2 or 4, depending on the purpose of the test.

If there is a chase A/C in the test, or if there are more than one aircraft in the test point(s) , every A/C participating in the test point(s) should be evaluated through this classification.

One can brief the information given in table as below:

FLIGHT TEST CATEGORIES	TEST PURPOSE (in general)	TC / STC ISSUE OF TYPE	MODIFICATION OF CERTIFIED TYPE	OUTSIDE ENVELOPE OF A CERTIFIED TYPE
CATEGORY 1	Initial flights of a new type	NO	YES (if there is a TC/STC issued before)	YES (if there is a TC/STC issued before)
CATEGORY 2	Test of a not yet approved modification	NO	YES (if there is a TC/STC issued before)	YES (if there is a TC/STC issued before)
CATEGORY 3	Production tests	YES	NO	NO
CATEGORY 4	Test of a not yet approved – non significant-modification (in the same envelope limit) like a repeated test	YES	YES	NO

What are the specifications regarding competence and experiences of crew?

The necessary competence levels of flight test pilots related with these tests can be tabulated as:

	Flight Test Categories			
Aircraft	1	2	3	4
CS-23 commuter or aircraft having a design diving speed (Md) above 0.6 or a maximum ceiling above 7 260 m (25 000 ft), CS-25, CS-27, CS-29 or equivalent airworthiness codes	Competence Level 1	Competence Level 2	Competence Level 3	Competence Level 4
Other CS-23 with an MTOM of or above 2 000 kg	Competence Level 2	Competence Level 2	Competence Level 3	Competence Level 3

The competence level requirements are indicated in PART-FCL.820 Flight test rating as below:

Holders of a pilot license for aeroplanes or helicopters shall only act as PIC in category 1 or 2 flight tests, as defined in Part-21, when they hold a flight test rating.

The obligation to hold a flight test rating established in (a) shall only apply to flight tests conducted on:

(1) helicopters certificated or to be certificated in accordance with the standards of CS-27 or CS-29 or equivalent airworthiness codes; or
(2) aeroplanes certificated or to be certificated in accordance with:
(i) the standards of CS-25 or equivalent airworthiness codes; or

(ii) the standards of CS-23 or equivalent airworthiness codes, except for aeroplanes with an maximum take-off mass of less than 2 000 kg.

Applicant pilots for the first issue of a flight test rating shall:

(1) hold at least a CPL and an IR in the appropriate aircraft category;
(2) have completed at least 1 000 hours of flight time in the appropriate aircraft category, of which at least 400 hours as PIC;
(3) have completed a training course at an ATO appropriate to the intended aircraft and category of flights. The training shall cover at least the following subjects:

— Performance,
— Stability and control/Handling qualities,
— Systems,
— Test management,
— Risk/Safety management.

Competence Level 1 requirements for pilots and flight test engineers:

- Pilots shall comply with the requirements of Annex I (Part-FCL) to Commission Regulation (EU) No 1178/2011 of 3 November 201116 as given above.

- Lead flight test engineer shall have satisfactorily completed a Competence level 1 training course; and a minimum of 100 hours of flight experience, including flight testtraining.

Competence Level 2 requirements for pilots and flight test engineers:

- Pilots shall comply with the requirements of Annex I (Part-FCL) to Commission Regulation (EU) No 1178/2011 of 3 November 201116 as given above.

- The lead flight test engineer shall have satisfactorily completed a Competence level 1 or level 2 training course; and a minimum of 50 hours of flight experience, including flight test training.

Competence Level 3 for pilots and flight test engineers:

- Pilot(s) shall hold a valid licence appropriate to the category of aircraft under test, issued in accordance with Part-FCL and hold a Commercial Pilot Licence (CPL) as a minimum. In addition, the pilot-in-command shall hold a flight test rating, or have at least 1 000 hours of flight experience as pilot-incommand on aircraft having similar complexity and characteristics, and have participated, for each class or type of aircraft, in all flights that are part of the programme leading to the issuance of the individual certificate of airworthiness of at least five aircraft;

- Lead flight test engineer shall satisfy competence level 1 or level 2, or have gained a significant amount of flight experience relevant to the task; and have participated in all flights that are part of the programme leading to the issuance of the individual certificate of airworthiness of at least five aircraft.

Competence Level 4 for pilots and flight test engineers:

- Pilot(s) shall hold a valid licence appropriate to the category of aircraft under test, issued in accordance with Part-FCL and hold a CPL as a minimum. The pilot-in-command shall hold a flight test rating or have at least 1 000 hours as pilot-in-command on aircraft having similar complexity and characteristics.

All the competency and experience for lead flight test engineers (LFTES) should be defined in the flight test operations manual of the rating holder organization.

The minimum ground-flight training hours and course schedules of pilots and LFTEs are explained in EASA Part-ORA [7] and briefed in Part-21.

Which organizations give these ratings?

EASA Part-ORA indicates the specification of an approved training organization (ATO) that is eligible to give flight test training for pilot licenses and associated ratings and certificates. The requirements are upon the organization's application, personnel, record-keeping, training programme, manuals, training aircrafts and FSTDs (Flight Simulation Training Devices), training areas. There are many ATOs like NTPS (National test Pilot School), ITPS (International Test Pilot School) , ETPS (The Empire Test Pilot School) etc. approved by EASA or FAA and their own national certification authorities.

REFERENCES:

[1] Commission Regulation (EU) No 748/2012 of 3 August 2012 - Airworthiness and Environmental Certification Easy Access Rules: Part 21 Airworthiness and Environmental Certification (Regulation (EU) No 748/2012)

[2] Royal Aeronautical Society: *"https://www.aerosociety.com/get-involved/specialist-groups/engineering-design/flight-test/"*

[3] AGARDograph No.300, "*Agard Flight Test Techniques Series"* Volume 1, NATO

[4] *"Introduction to Flight Test Engineering"* Volume 1, Third Edition (2006), Don Ward, Thomas Strganac, Rob Niewoehner

[5] Commission Regulation (EU) No 1178/2011 of 3 November 2011 – Aircrew Easy Access Rules: Aircrew (Regulation (EU) No 1178/2011), Easy Access Rules for Flight Crew Licencing :Part- FCL

[6] FAA (CFR), Title 14: Aeronautics and Space, PART 61—Certification: Pilots, Flight Instructors, and Ground Instructors

[7] Commission Regulation (EU) No 1178/2011 of 3 November 2011 – Aircrew Easy Access Rules: Aircrew (Regulation (EU) No 1178/2011), Easy Access Rules for Organisation Requirements for Aircrew: Part-ORA