NON-TSO FLIGHT INSTRUMENTS FOR AMATEUR-BUILT EXPERIMENTAL AIRCRAFT (ABE)

Introduction

1. This submission is written under the authority of this term of reference:
2. "*examine and make recommendations on options for improving future aviation safety regulatory reform having regard to international experience and stakeholder views, and the Government's objective of reducing the cost of regulation to business*";
3. CASA relies heavily on the comfort of mandating recognised standards as a primary means of assuring aircraft safety. The problem of course is that any written standard starts becoming obsolete the moment it is written as technological progress leaves it behind. This is particularly so where electronics replace mechanical devices. I write to improve the safety of light aircraft that seek to fly in instrument flight rules (IFR) conditions by taking advantage of modern technology that is now outlawed in favour of compliance with CAO 20.18 written over 40 years ago.
4. For some years now a number of ABE have been approved for IFR flight with non-TSO (Technical Standard Order) compliant electronic flight information system (Efis) flight instruments, provided they meet the performance standards laid down in (the former) AD/INST/9 and AD/RAD/43 and 47. This is consistent with USA practice where there is evidence that the FAA do not mandate TSO flight instruments for ABE. There are no recorded Australian accidents or incidents of an ABE aircraft endangering any other airspace user or persons on the ground due to failure of these non-TSO instruments.
5. CASA has recently moved to mandate TSO-compliant flight instruments for ABE under Reg 207. This paper assesses the risks of this approach and proposes an alternate means of compliance (AMOC) that increases the safety level provided by CAO 20.18.

Aim

6. The aim of this paper is to propose to CASA a method of ensuring an increased safety standard for IFR operations for ABE aircraft that does not rely on whether instruments are TSO'd or not, provided that all flight instruments pass the biennial performance tests.

Scope

7. This paper applies only to flight instruments in ABE aircraft. Communication and navigation radios and GPS navigation systems must meet approved standards and are not in discussion.

Safety Discussion.

8. I believe CASA's new policy for AE is contrary to the interests of safety because the cheapest way to comply is to revert to "steam gauge" instruments as provided in CAO 20.18. These regulations have some obsolescence that is less safe than solutions available in even cheaper modern non-TSO Efis.
9. CASA recognises the likelihood of failure of the artificial horizon (AH) and Directional Gyro (DG) by requiring that aircraft also carry a Turn and Balance (T&B) indicator with a separate power source. However flight on the limited panel is very demanding and not sustainable for any length of time, particularly whilst conducting an instrument approach. Therefore the existing minimum standard for continued flight with AH and/or DG inoperative is actually quite dangerous and accidents have occurred to certified aircraft under these conditions.

10. Existing instrument TSO's do not have any requirements related to instrument reliability and thus there is no safety assurance achieved by their use. We therefore suggest that increased safety can be achieved by consideration of the potential failure modes of each instrument , whether TSO'd or not. Safety can be increased by designing the instrument installation to take advantage of the inherent reliability of electronic rather than mechanical instruments. Analysis must recognise the scope for failures of integrated instruments to affect more than a single instrument function such as occurs in existing equipment.
11. Use of modern non-TSO'd instruments with suitable redundancy provisions offers a safer solution to the problems arising from instrument failures. The thesis is that cheap non-TSO Efis systems offer the opportunity to cost-effectively provide the charter standard of instrumentation at a cost about the same or even lower than a mechanical CAO 20.18 solution. More safety at the same or less cost is attainable.

TSO Limited Panel Risk Assessment

12. CAO 20.18 provides for instruments including:
    a. Magnetic compass, to overcome the precession in a mechanical directional gyro.
    b. Artificial horizon and directional gyro, conventionally vacuum powered.
    c. Turn and bank, on a separate power source, usually electric.
    d. ASI, altimeter and VSI.
13. Note that the only redundancy required is the turn and bank as standby for a failed artificial horizon. Separate power supplies are mandated to support this redundancy.
14. The skills required to fly on limited panel with only a turn and bank for roll control and using the ASI and Altimeter for pitch control is very high. We note that for charter operations CAO 20.18 mandates a second AH (and altimeter). This skill problem will be discussed later in this document.

Instrument Performance.

15. Safety is assured by the functional performance of aircraft instruments. All flight instruments must comply with the standards in AD/INST9, and AD/RAD/43 and 47, hence there is no difference in performance between TSO compliant and non-TSO instruments, and hence no difference in safety outcome..

Instrument Reliability

16. TSO do not specify reliability criteria. Hence there is no safety improvement attributable to the reliability of TSO instruments. We aim to treat the reliability risk that exists with TSO'd equipment as well as the proposed non-TSO'd equipment by increasing the redundancy carried by ABE using non-TSO equipment.
17. Before moving on it is worth considering the risks inherent with approved "steam gauges". CASA accepts TSO mechanical instruments that are vacuum powered. Vacuum pumps are, by modern standards, unreliable. Claims vary but mean time between failures of around 750hrs are common. Added to this consideration is the fact that mechanical gyro instruments suffer increased wear with subsequent reduced accuracy when subjected to aerobatics and turbulence. Mechanical precession, sticking and other mechanical failures also occur frequently. These risks can be reduced by adopting digital instruments that have very few moving parts.

A flight Instrument Standard for ABE in IFR.

18. Given that biennial instrument testing proves there is no instrument performance risk to be treated, the SAAA proposes to treat the risks of instrument failure that arise from the unknown reliability of both TSO and non TSO instruments by increasing the redundancy requirement beyond that mandated in CAO20.18 Appendix IV. In practice I propose to partially adopt the flight instrument standard for passenger charter operations for ABE aircraft, which are limited to private operations.

19. I propose as follows:

    a. A standby direct reading compass,

    b. A primary flight display Efis containing as a minimum AH, DG, ASI, Altimeter, VSI, rate of turn arrows and skid ball (mechanical or electronic).

    c. Standby instruments consisting of Efis or steam gauges, to include AH, ASI and Altimeter, or

    d. A complete second Efis as per b above.

    e. Main and standby instruments to be on separate electrical power supplies.

Fringe Benefits

20. A typical ABE outfit that complies with the paragraph above would be a complete Efis with a smaller, less sophisticated Efis that is simpler with just a AH and DG, with mechanical ASI and Altimeter, or just a smaller version of the main Efis, often marketed as a Sport version.

21. The majority of capable non-TSO Efis now offer as standard features multiple indicators not available with mechanical instruments that can include:

    a. Altitude alerting

    b. heading and altitude bugs,

    c. Flight Director capability

    d. aircraft vector: “the bird”,

    e. “highway in the sky” vector,

    f. Instantaneous wind vector at present altitude,

    g. Instantaneous TAS.

    h. Angle of Attack indicators

    i. Second differential capability of both ASI and Altimeter – where will the aircraft be in altitude and speed in a further ten seconds (example) – Trend indication.

22. Whilst none of these features are requirements of CAO 20.18, they are all well-known safety features available in part or in whole to ABE aircraft fitted with modern electronic displays.

23. An example of fringe benefits is in my own aircraft. I have a certified GNS480 navigator with a colour moving map that cost $14,000. It does not show civilian controlled airspace in Australia, nor does it show terrain. My standby uncertified Efis cost $3500 and shows civilian controlled airspace and terrain colour coded for its height below the aircraft. This is a major aid to reduce the risk of controlled flight into terrain.

Conclusions

24. I fully support the standard contained in CASR Part 21 which requires that the operation of ABE aircraft not endanger other airspace users or those on the ground. I find that:

a. Biennial performance testing ensures that both TSO and non-TSO flight instruments conform to the required performance standards.

b. Since there is no TSO-mandated reliability standard that there is no provable safety advantage in mandating TSO-compliant instrumentation.

c. A substantial safety improvement can be realised by removing the turn and bank as a standby instrument and substituting a second AH in a non-TSO Efis.

25. I make this proposal to CASA so that safety is enhanced by allowing use of arguably safer, more modern flight instrumentation. Safety is further improved by recognising the new failure modes such instruments may introduce and ensuring sufficient redundancy is carried to achieve a superior safety outcome regardless of any single point of failure.

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