U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: **ACTION:** Documentation of Equivalent Level of Safety (ELOS) Finding No. ACE-01-02, Sino Swearingen Aircraft Company Model SJ30-2, 14CFR 23.1305, Digital Display of N2 and Fuel Flow.

Date: April 18, 2001

From: Manager, Airplane Certification Office, ASW-150

Reply to Attn. of: Eric Haight (817) 222-5204

To: Manager, Small Airplane Directorate, ACE-100

This memorandum documents concurrence of Equivalent Level of Safety (ELOS) Finding No. ACE-01-02, per ACE-112 memorandum, dated February 20, 2001. This ELOS applies to selected regulations of 14 CFR 23 for use of a digital display for engine high-pressure turbine speed (N2) and Fuel Flow for the Sino Swearingen Aircraft Model SJ30-2. The basic content of the issue paper is presented below with the exclusion of the proprietary information.

Background

Sino Swearingen Aircraft Company (SSAC) has requested an Equivalent Level of Safety (ELOS) to 14CFR 23.1305(c)(2), (c)(5), 23.1549, as required by 14 CFR 21.21(b), on SSAC Model SJ30-2. This ELOS is requested for the use of direct-reading digital only displays for high pressure turbine speed (N_2) and fuel flow. SSAC has installed a Honeywell Primus EPIC CDS electronic multi-function display system that displays engine instruments N_2 and fuel flow information in a digital only format.

Discussion

Turbine engine powered Part 23 aircraft are required to have powerplant instruments to display the rotor speed and fuel flow for each engine per 23.1305(c)(5) and (c)(2), respectively. 14CFR Part 23.1305 states:

§ 23.1305 Powerplant Instruments, (c)(2)& (c)(5).

"(c) For turbine engine-powered airplanes. In addition to the powerplant instruments required by paragraph (a) of this section, the following powerplant instruments are required:

(2) A fuel flowmeter indicator for each engine.

(5) A tachometer indicator (to indicate the speed of the rotors with established limiting speeds) for each engine."

Furthermore, these instruments are required to have specific markings defining minimum and maximum operating limits and specific operating ranges per 14CFR Part 23.1549, which states:

*§ **23.1549 Powerplant and Auxiliary Power Unit Instruments, (a),(b), & (c).***

For each required powerplant and auxiliary power unit instrument, as appropriate to the type of instruments-

(a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line;

(b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;

(c) Each takeoff and precautionary range must be marked with a yellow arc or a yellow line; and

Advisory Circular (AC) 23.1311-1A, paragraph 8.5.6 defines the specific information that must be addressed to obtain an ELOS for use of digital only displays. These items are presented in the applicant position of this issue paper.

In addition, paragraph 8.5.7 defines that the marking of electronic displays on powerplant parameters is not always the most efficient when performed in accordance with 23.1549. AC 20-88A provides alternate methods of marking electronic powerplant displays for which an ELOS may be granted.

It is worth mentioning that several other airplanes have been granted an ELOS for direct reading, digital only displays for N_2 and fuel flow. One recent example that is very similar to the SSAC SJ30-2 is the Raytheon Model 390, which is also a Part 23 airplane and uses the same Williams FJ44-2A engine. Other examples include Part 25 airplanes for Cessna Models 550, S550, 552, and 560 (Type Certificate Data Sheet (TCDS) A22CE) and the Cessna Model 750 on TCDS T00007WI. It should be noted that the Part 23 and Part 25 xx.1549 regulations are identical.

Applicable Regulations

Regulations Reference: §§ 21.21(b)(1), 21.261, 23.1305, 23.1311, 23.1321, & 23.1549, National Policy Ref. AC 20-88A, AC23.1311-1A

Applicant's Position

Review of AC 23.1311-1A, Section 8.5.6 states that powerplant instruments under 23.1305 referred to as "indicators" should have the ability to provide trend or rate-of-change information, unless a finding of equivalence is made for direct-reading

alphanumeric displays. AC 23.1311-1A list several compensating factors that should be considered. These factors are listed below along with the applicant's position of compensating factors.

In addition review of AC 23.1311-1A, Section 8.5.7 states that the marking of electronic displays on powerplant parameters is not always the most efficient or effective when performed in accordance with 23.1549. AC 20-88A provides alternate methods of marking electronic powerplant parameters. A finding of equivalence for other methods of marking the displays may be performed. AC 20-88A outlines some of the factors to be considered for an ELOS which are contained within the applicant's position of compensating factors as appropriate.

Item 8.5.6.1:

Requires that the visibility and relative location of the indicated parameter should be reviewed including the appropriate conditions of lighting and instrument panel vibration.

Compensating Factors for 8.5.6.1:

Digital N_2 and Fuel Flow are presented in a vertical stack of primary engine instruments for both the left and right engine. This is shown in the figure below. This stack is displayed on the top of the multifunction flight display (MFD). The MFD is located slightly to the right of the pilot centerline view and is adjacent to the primary flight display. Due to the nature of electronic displays no pointer vibration will occur. Lighting and instrument panel vibration will have no appreciable effect on any of the engine displays.

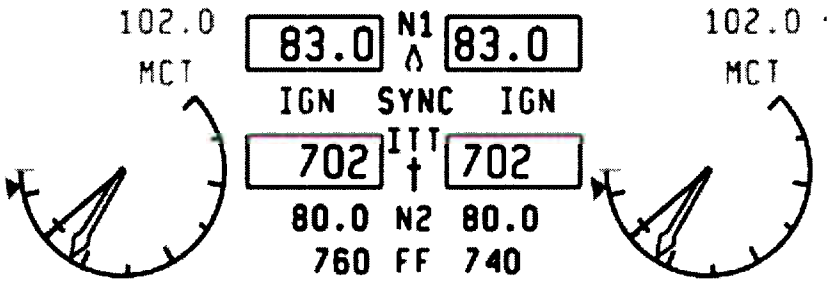

Figure 1 – Multifunction Flight Display Primary Engine Instrument Stack

Item 8.5.6.2:

States that the ability to quickly evaluate necessary trend or rate-of-change information, particularly during in-flight restarts be assessed.

Compensating Factors for 8.5.6.2:

Fuel Flow is not required to be monitored during engine starts or other engine operations as specified in Procedures outlined in the Williams FJ44-2A Operating Instructions. Fuel Flow rate-of-change information also does not provide any enhancement to safety during engine starts.

N_2 is used as a primary parameter only during starts of the Williams FJ44-2A engine. The start procedures outline a range of acceptable N_2 values, which are wide enough to allow for variation in assessing N_2 rate-of-change information. The only pilot action for the SJ30-2 during engine start that requires assessing N_2 is throttle movement from CUTOFF to IDLE. IGN activation/deactivation and starter disengagement is automatically controlled once the throttle is at the IDLE position and engine start begins. The start procedures from the FJ44-2A Operating Instructions are attached.

Item 8.5.6.3:

The ability to assess how close the indicated parameter is relative to a limit needs to be evaluated.

Compensating Factors for 8.5.6.3:

Fuel Flow compensating factors include that there are no minimum or maximum limits to fuel flow as stated in the Williams FJ44-2A Operating Instructions. Therefore 23.1549(a) is not applicable to Fuel Flow.

Compensating factors for N_2 include the fact that the design of the engine is such that the limiting N_2 can not be reached before exceeding the N_1 or ITT limits as stated in the correspondence from Williams International. In addition, the critical parameters (N1, ITT), relative to the N_2 limit issue have both analog and digital displays as shown in the figure 1.

Also, during engine starts where N_2 is a primary parameter, those values will be much less than the limit N_2 and thus will not require pilot action based on N_2.

An additional compensating feature is that the N_2 limit value is a fixed number (98.8%) as listed in the FJ44-2A Operating Instructions and does not change due to altitude, temperature, or speed.

Item 8.5.6.4:

For multi-engine aircraft, the value of the crew to quickly and accurately compare engine-to-engine data needs to be considered.

Compensating Factors for 8.5.6.4:

The design of the SJ30-2 primary engine instrument stack (Figure 1) shows that left and right engine digital parameters are adjacent to each other allowing for extreme ease in comparison including Fuel Flow and N_2.

Item 8.5.6.5:

Compensating engine design features or characteristics that would forewarn the crew to prior to the parameter reaching the operating limit (e.g., redline).

Compensating Factors for 8.5.6.5:

Fuel Flow compensating factors include that there are no operating limits to Fuel Flow as stated in the Williams FJ44-2A Operating Instructions.

N2 compensating factors include the fact that the design of the engine is such that the limiting N_2 can not be reached before exceeding the N_1 or ITT limits as stated in the correspondence from Williams International. The critical parameters (N1, ITT) have both analog and digital displays as shown in the Figure 1.

In addition, the digital display changes from a normal indication color "WHITE" to "RED" when exceeding N_2 redline limits. This feature is documented in Chapter 14, Page 15 of the Honeywell System Design Specification for the Sino Swearingen SJ30-2 Primus CDS.

8.5.7:

Details that the marking of electronic displays is not always the most efficient or effective when performed in accordance with 23.1549. AC 20-88A provides alternate methods of marking electronic powerplant displays. When AC 20-88A is not strictly adhered to, an ELOS on other methods may be performed. In regards to 23.1549, (a) through (c) apply as follows.

Item 23.1549(a):

Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line

Compensating Factors for 23.1549(a):

Compensating factors for digital N2 factors include those previously outlined in 8.5.6.3 and 8.5.6.4 such as;

The design of the engine is such that the limiting N_2 can not be reached before exceeding the N_1 or ITT limits as stated in the correspondence from Williams International.

In addition, the digital display changes from a normal indication color "WHITE" to "RED" when exceeding N_2 redline limits. This feature is documented in Chapter 14, Page 15 of the Honeywell System Design Specification for the Sino Swearingen SJ30-2 Primus CDS. This feature meets the criteria specified under AC 20-88A, section 6(c) and (d).

Fuel Flow compensating factors include that there are no operating limits to Fuel Flow as stated in the Williams FJ44-2A Operating Instructions.

Item 23.1549(b):

Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits.

Compensating factors for 23.1549(b):

Both digital N2 and Fuel Flow define normal operation using "WHITE" color digits.

Compensating factors for this color presentation is addressed in both AC 20-88A and AC 23.1311-1A as follows;

AC 20-88A, Section 6(d) states "A concept has been developed where normal engine operating conditions are not identified and only abnormal conditions are designated by colored markings. If all abnormal conditions are adequately indicated by specific design features, green markings are unnecessary based on finding of equivalency. Yellow and Red markings used by may be subdued until the parameter monitored reaches the caution or warning value. At that time the respective color is highlighted in some manner to alert the flight crew."

In addition, the use of "WHITE" digits for Normal Operations is in keeping with the Color Standardization outlined in AC 23.1311-1A, Section 9.14 for Color Set 1 as detailed in 9.14.1.2. This feature is documented in Chapter 14, Page 15 of the Honeywell System Design Specification for the Sino Swearingen SJ30-2 Primus CDS.

Item 23.1549(c):

Each takeoff and precautionary range must be marked with a yellow arc or a yellow line;

Compensating factors for 23.1549(c):

There is no defined takeoff or precautionary range defined for N2 or fuel flow as listed in the Williams International Operating Instructions.

Therefore, under the provisions of 21.21(b)(1), SSAC requests the FAA's concurrence with the stated ELOS for 14CFR 23.1305 (c)(2), (c)(5), and 23.1549, (a) through (c), for the use of direct reading, digital only displays for engine high-pressure turbine speed (N_2) and fuel flow for the SJ30-2 airplane.

FAA's Position

Applicable regulations and guidance material with regard to use of digital (direct-reading alphanumeric) displays were reviewed. Specific guidance is contained in AC 20-88A (Guidelines on the Marking of Aircraft Powerplant Instruments (Displays)) and AC 23.1311-1A (Installation of Electronic Display Instrument Systems in Part 23 Airplanes).
AC 23.1311-1A, section 8.5.6, items 8.5.6.1 through 8.5.6.5, and section 8.5.7 define the specific factors that should be considered when seeking an ELOS for use of digital only displays. These items have been addressed in the applicants position. The FAA agrees with the proposed ELOS.

Recommendation

The FAA concurs with the Sino Swearingen position and finds an Equivalent Level of Safety to 14 CFR part 23.1305 (c)(2), (c)(5), and 23.1549, (a) through (c) as required by 14 CFR Part 21.21(b) may be granted for the use of direct reading, digital only displays for engine high-pressure turbine speed (N_2) and fuel flow for the SJ30-2 airplane.

Richard L Vaughn

for Michele M. Owsley
Manager, Airplane Certification Office

Concurrence:

_____ Date: 4.25.01

Manager, Standards Office, ACE-110

_____ Date: 4-25-01

for Manager, Small Airplane Directorate, ACE-100