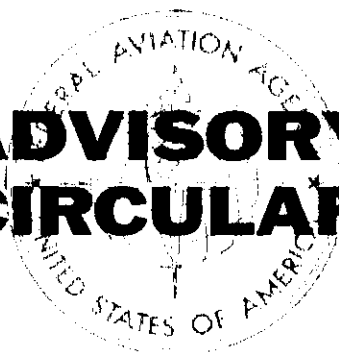


Federal Aviation Agency

ADVISORY CIRCULAR



AC NO: AC 120-13

AIR CARRIER AND
COMMERCIAL OPERATIONS

EFFECTIVE :

6/26/64

SUBJECT : JET TRANSPORT AIRCRAFT ATTITUDE INSTRUMENT SYSTEMS

- 1. PURPOSE.** This advisory circular is to advise interested persons of the characteristics of some attitude instrument systems presently installed in some jet transport aircraft, particularly when controlling aircraft under IFR conditions in turbulence so that they may evaluate their equipment and make improvements therein in the interest of safety. This Advisory Circular is also to inform all interested persons of the discussions relating to this subject held by those parties in attendance at a symposium of airline operators, manufacturers, and personnel of Government agencies held by the Flight Standards Service at Oklahoma City, Oklahoma, on April 14, 1964.
- 2. BACKGROUND.** In the past, it has been generally accepted that transport airplanes would rarely, if ever, exceed ± 25 degrees in pitch and 60 degrees in bank. The aircraft, its attitude instruments, (airplane attitude display) and pilot training requirements have been based on operations within this range of values. Recent jet transport operational experience and flight testing has shown a need to take into account flight conditions beyond this range and to consider whether improvements can be made in existing instrumentation, instrument flying techniques, procedures and some existing instrument maintenance practices. Studies have been conducted by the Flight Standards Service of various attitude instruments currently used in jet transports. These included flight demonstrations with photographic recordation to ascertain the need of the pilot for improved orientation information under extreme conditions. The results of these studies, as well as a general review of some current industry programs for improvement of displays, were publically discussed at the symposium.
- 3. INFORMATION.** The following areas are suggested as warranting special attention with reference to maintaining or increasing the effectiveness of existing attitude instrument displays by which the pilot maintains proper control of his airplane, particularly under conditions of extreme atmospheric turbulence.

- a. Reliable 360 Degree Range of Operation. It is desirable that attitude instruments be operable throughout the 360 degree range so that the pilot will have reliable information at all aircraft attitudes so that he may execute proper control procedures. The state of the art, however, has not been such that attitude instruments operable throughout the 360 degree range with the necessary reliability have been available. Technical Standard Order C4c for bank and pitch indicators now requires that these instruments be functional after maneuvers of 360 degrees in pitch and bank.
- b. Pitch Attitude Range and Sphere Markings. The pilot should be able to obtain a quick and accurate appraisal of total airplane attitude at a glance. Some attitude displays provide information only 30 degrees above and below the zero pitch reference line (and in some cases less than that). The attitude index lines should be effective in conveying automatically to the pilot an exact sense of total attitude, the rate of angular motion, and a ready sensing of motion following corrective action being applied. An improvement and extension of the pitch attitude indications up to and beyond 30 degrees (approaching 90 degrees as closely as practicable) as well as indication of the sphere reference lines to insure a ready depiction of total airplane attitude may be desirable. In the interest of continuing simplicity of the instrument presentation, the number of added markings should be held to the minimum necessary to achieve the intended purpose. They should be of sufficient boldness and contrast to be easily read under day and night IFR lighting conditions, including stormy weather.
- c. Color Presentation. The effectiveness of some attitude instruments can be improved by changing the background color presentation of the sphere or card. It is desirable that the coloring used provide the greatest possible contrast for the sky and ground, such as light blue for the sky and black for the ground.
- d. Improved Failure Warning. Most of the presently used airplane attitude display instrumentation systems sense and provide positive warning (usually a flag) of very limited system failure conditions (generally power failure to the vertical gyro system). Experience has shown that other kinds of failures can occur which, if not detected, can result in the instrument giving a false indication of aircraft attitude without giving a warning of system malfunction. Instrument manufacturers are aware of these problems and are developing monitoring systems designed to provide positive warning of most of all the likely types of failures. Some airline

operators are studying this problem and instituting failure warning system design improvements. Provisions for a "push-to-test" system permitting preflight operational checkout is considered desirable.

e. Training.

- (1) Pilots of jet transport aircraft flying in IFR conditions should be thoroughly familiar with the operational characteristics and limitations of the particular attitude display instruments used on the airplane types which they are flying. Familiarity in their use through all attitudes with emphasis on extreme attitude interpretations is very important. Pilot confidence in the instrument is an essential factor in maintaining proper control during extreme attitude situations.
- (2) Careful cross-checking of the duplicate instruments by all members of the flight crew, particularly during IFR and night conditions of flight, is emphasized.

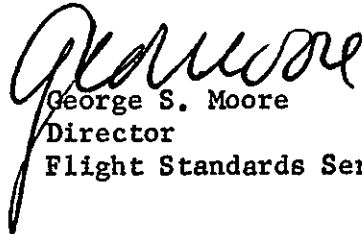
f. Maintenance.

- (1) Operators are encouraged to review carefully all factors surrounding each attitude instrument failure to determine if additional maintenance procedures, or more frequent inspection or overhaul, will improve instrument system reliability. Operators are also encouraged to insure that shop test equipment and standards are upgraded where practicable and that instrument calibration values reflect the highest possible standard, rather than the minimum acceptable tolerance.
- (2) Most manufacturers have developed engineering changes which improve their products. Information regarding such engineering changes are frequently made available to operators by bulletins of the manufacturer. Careful evaluation of and compliance with these bulletins can be expected to increase the reliability of the system. In addition, several manufacturers are producing improved test features or test equipment which are valuable for instilling pilot confidence and in rapid troubleshooting of defective systems.
- (3) Mishandling of flight instruments during shipping and storage has been reported to be a major cause of instrument damage. It is important, therefore, that all manufacturers and users critically examine the procedures utilized in this phase of their operation to prevent damaged instrument system components from being installed in aircraft.

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4. RECOMMENDED ACTION.

- a. Jet aircraft operators are encouraged to evaluate their currently used attitude instrument systems, their maintenance and operating procedures, and their training programs in light of the various factors discussed in this advisory circular and any other pertinent features and instrument characteristics not covered herein. Where operators find instrument changes and system modifications are necessary, they should coordinate the changes and modifications with the instrument and airplane manufacturers involved.
- b. The Flight Standards Service is collecting factual information on adverse experiences encountered in service with present systems. It would be helpful if significant reports of all incidents and difficulties encountered in flight operations involving attitude instruments and systems are furnished directly to the representative of the FAA having responsibility for this type liaison. The Flight Standards Service intends to continue studies of this subject.


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