APPENDIX 1. PARTIAL LIST OF FUNCTIONAL HAZARD ASSESSMENT (FHA) FOR CONSIDERATION TO MEET 14 CFR PART 23 REQUIREMENTS FOR IFR CLASS I AIRPLANES

Aircraft Function	Classification of Failure Conditions			Analysis Consideration
	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Display of attitude information to control roll and pitch	Catastrophic	Major	Catastrophic	For electronic displays, dual independent attitude systems generally meet requirements for 14 CFR part 23, §§ 23.1301, 23.1309. & 23.1311 for airplanes with less than 10 passengers and for conventional mechanical or analog electromechanical systems, a single attitude display meets requirements to operate under IFR for part 91. If the certification basis includes Amendment 23-43 or later, two independent power sources are required by § 23.1331. The requirement of two power sources of § 23.1331 are not applicable for pitot-static pneumatic systems. Partial panel techniques may be used in some cases where it has been historically shown to be acceptable. Credit (mitigation) may be given for automatic flight control systems if the system can maintain stable attitude independent of the primary attitude display.
Display of directional heading information	Major	Minor	Major	A hazardously misleading heading is usually when the accuracy error is greater than 10 degrees on the primary heading instrument and it is an undetected error. Assumes installation of a single stabilized heading system and only a non-stabilized magnetic compass to operate under IFR for part 91. If the certification basis includes Amendment 23-43 or later, two independent power sources are required by § 23.1331. The requirement of two power sources of § 23.1331 are not applicable for pitot-static pneumatic systems. Navigation assumed to be operating. See AC 23-17B for additional information.

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Aircraft Function	Classification of Failure Conditions			Analysis Consideration
	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Display of altitude information	Hazardous	Minor	Catastrophic	For electronic displays, dual independent altitude systems generally meet requirements for 14 CFR part 23, §§ 23.1301, 23.1309. & 23.1311 and for conventional mechanical or analog electromechanical systems, a single altitude display meets requirements to operate under IFR for part 91. If the certification basis includes Amendment 23-43 or later, two independent power sources are required by § 23.1331. The requirement of two power sources of § 23.1331 are not applicable for pitot-static pneumatic systems. Existing single static systems that are heated have been historically acceptable based on similarity and may be used for programs that have certification basis prior to Amendment 23-42. If a single or dual air data computer is used, it must meet the requirements of this AC with respect to safety and DAL..

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Aircraft Function	Classification of Failure Conditions			Analysis Consideration
	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Display of airspeed information	Major. May be Hazardous for higher performance airplanes.	Minor	Major. May be hazardous or catastrophic for higher performance airplanes.	For electronic displays, dual independent airspeed systems generally meet requirements for 14 CFR part 23, §§ 23.1301, 23.1309. & 23.1311 and for conventional mechanical or analog electromechanical systems, a single airspeed display meets requirements to operate under IFR for part 91. If the certification basis includes Amendment 23-43 or later, two independent power sources are required by § 23.1331. The two power sources of § 23.1331 are not applicable for pitot-static pneumatic systems. Classification as usually Major, if overspeed and underspeed airspeed alerting is acceptable (alerting may be provided by inherent aerodynamic qualities or independent alerting system); otherwise, loss of function, malfunction, or misleading of information is Hazardous. It may be catastrophic when combined with the loss of stall warning or overspeed warning functions. Assumes no vertical speed indicator. Existing single pitot static systems that are heated have been historically acceptable based on similarity and may be used for programs that have certification basis prior to Amendment 23-42. If a single or dual air data computer is used, it must meet the requirements of this AC with respect to safety and DAL.
Display of Flight Path Vector	Minor	R	Major	Providing the other normal cues remains for primary flight information. Loss of the sensor should remove the flight path vector. The pilot should recognize it and use other displays. Misleading indication could cause the pilot to temporarily maneuver the aircraft using erroneous guidance information.
Display of rate-of-turn information	Minor	Minor	Minor	Rate-of-turn display is generally required to operate under IFR for part 91 unless a third attitude is installed. If the certification basis includes Amendment 23-43 or later, two independent power sources are required. In IMC misleading rate-of-turn information is consider to be Minor if there is a functional attitude display.
Display of slip-skid information	Minor	Minor	Minor	R

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Aircraft Function	Classification of Failure Conditions			Analysis Consideration
	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Display of time information	Minor	Minor	Minor	R
Display of primary navigation information	Major	Major. Minor, if two navigation systems are installed.	Major for CAT I ILS. Hazardous or major depending on type of WAAS operations.	Two navigation systems are generally installed to support navigation, but two are not required for 14 CFR part 91 operations. Dual ILS receivers below Category I limits are required with single antenna for part 91 operations. See AC 20-138A for more guidance on WAAS operations.
Display of navigation information on MFD	Minor	R	Minor	Pilot should cross check with the course deviation indicator and other navigation sources.
Weather displays for situation awareness	Minor	Minor	Minor	Pilot is responsible to use standard procedures. It is used for only strategic planning and operation and is not intended for tactical maneuvering.
Terrain Awareness and Warning System (TAWS)	Minor	R	Major	The loss of that system should be no greater than 10-3 per average flight hour, and the possibility of misleading information on the display due to undetected or latent failures should be no greater than 10-4 per average flight hour. For a Class A TAWS, the software development assurance level should be at least to Level C as defined in RTCA DO-178B or an acceptable alternative approved by the FAA. For Class B TAWS, the software development assurance level should be at least to Level D providing the required alerts and visual annunciations are independent of the terrain display(s). If the required alerts and visual annunciations are integrated on the displays, the DAL should be at least Level C. NOTE: A terrain display is not mandatory for Class B equipment. See AC 23-18 for more information.

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Communication	Minor. Total loss of navigation and communication is Hazardous.	Minor	Major, if data link. Otherwise, Minor.	Future installations may use data link for primary functions and voice for secondary.
Traffic information for situation awareness	Minor	Minor	Minor to Major depending on the intended function of the alert warning or caution signal.	Pilot is responsible to use standards "see and avoid procedures". Traffic information is not an approved substitute for traffic avoidance. See the applicable AC and TSO for additional guidance.
Mode A or C Transponder	Minor	R	Minor to Major depending on the intended function of signals from the transponder.	Air Traffic Control may receive misleading or loss of airplane identification, or altitude, which increases their workload. An incorrect resolution advisory may increase pilot workload in another aircraft. See the applicable AC and TSO for additional guidance.
Display of radio altitude information	Minor	R	Minor	Not required for 14 CFR part 91 operations, Category I ILS. Loss of function may affect other equipment that depends upon radio altimeter.

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Display of vertical speed information	Minor	R	Minor or Major.	Not required for most 14 CFR part 91 operations. May be major classification when required by the operational requirements of parts 91 (Category II), 121, and 135 and it is considered required equipment essential to safe operation.
Display of flight guidance commands (Category I operation)	Minor	R	Major	Not required for 14 CFR part 91 operations, Category I ILS. For Category II ILS, an autopilot or flight director is required. Minor for loss of flight guidance commands for Category I operations providing the other normal cues remains for primary flight information. Loss of the sensor should remove the guidance command. The pilot should recognize it and use other displays. Misleading indication could cause the pilot to temporary maneuver the airplane if using erroneous guidance information.
Autopilot	Minor, with warning. Major, without warning.	R	Major, single axis and limited authority. Hazardous, multi-axis and limited authority. Catastrophic, if authority is unlimited.	Malfunction effects of autopilot hardovers are very dependent on the design and installation details. Maximum inputs (hardovers) or (slowovers) to aircraft primary control surfaces should not exceed aircraft structural limits. See AC 23.17B under section 23.1329 for additional information.
Autopilot guidance or flight director cue on display	Minor	Minor	Major for pitch. Minor for roll.	Pilot must monitor autopilot operation and disconnect autopilot to recover flight promptly. May cause go around and reductions in safety margins.

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Autopilot, inability to disengage with A/P disconnect switch	Major	Major	Major	The pilot is assume to overcome the servo slip clutches in both pitch and roll and able to maintain control of aircraft. Minor if the circuit breaker to disconnect the autopilot is readily available in flight.
Electrical-Electronic primary powered flight controls	Catastrophic	Minor	Hazardous to catastrophic	Assumes redundant electrical/electronic primary flight control systems with no manual reversion that provide independent control for each axis. Hazardous for loss of one channel on the lateral or longitudinal axis. Some fly-by-wire system designs may incorporate many solutions which mitigate the severity of the loss of a single channel. They may have three or four independent channels for pitch and roll, so the loss of one has little functional effect and control can be maintained with a single channel, albeit normally with the loss of some envelope protections. Additionally there may be mitigating factors such as inherent stability which can reduce hazards.
Stability augmentation	Variable	Minor	Variable	It needs to be evaluated on a case-by-case basis since it depends on aircraft stability and handling characteristics when installed and required to meet minimum performance and flight handling requirements.
Stick pusher	Hazardous, if loss is not annunciated. Major if the stall warning is functioning. Minor, if failure is annunciated and the stall warning is functioning.	Minor	Catastrophic to hazardous if the pilot is able to override or able for quick disconnect.	The system is installed to protect against a hazardous stall characteristic and/or unrecoverable catastrophic condition such as a deep stall. Assumes dual systems to prevent single-failure modes. Stick pusher malfunction with or without warning can be catastrophic depending on phase of flight and system attributes. Airplane response to stick pusher may be considered and pilot procedures may mitigate to a lower failure condition.

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Stick shakers with Stall warning	Major without other means of stall warning and unannunciated loss of stall warning. Minor for annunciated loss of stall warning	Major without other means of stall warning and unannunciated loss of stall warning. Minor for annunciated loss of stall warning	Major without other means of stall warning.	Assumes that inherent airplane characteristics do not exist so the pilot is aware of being close to stall (for example, stick force changes, buffeting, etc.).
Trim control	Minor	Minor	Major, if manual trim. Catastrophic or hazardous for electrical.	Studies have shown trim runaways are not a significant problem if pilot takes quick corrective action. Major, for trim runaways if there is a trim-in-motion aural alert. Hazardous or catastrophic, for trim runaways without a failure indication depending on trim authority and phase of flight.
Gear control	Major	Minor	Major	R
Brake control	Major, for airplanes ≥ 6,000 lbs. Minor, for airplanes < 6,000 lbs.	Major. Could be minor, if thrust reversers are installed.	Major	Electronic anti-skid and brake systems can cause significant ground handling problems if they malfunction under adverse conditions due to asymmetrical loading. Light airplanes braking loss is not as significant and can be reviewed on a case-by-case basis.
Display of trim indications	Minor	Minor	Variable	Each airplane has to be reviewed on a case-by-case basis. The most severe case is the phase of flight before takeoff. After takeoff, the trim position indication is not as critical because the pilot will adjust the trim position to relieve the control forces.
Display of gear indications	Minor	R	Minor	R

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Display of fuel level indication	Minor	Minor	Minor	Pilot is required to calculate fuel range and endurance during normal flight planning operations.
Display of powerplant indication tachometer	Minor	Minor	Minor	Assumes fixed pitch propeller and reciprocating engine; otherwise, a propeller governor will maintain the engine r.p.m. Turbofan and turbojet engines may need r.p.m. data for inflight restart capability. Refer to 14 CFR part 23, § 23.1311.
Display of powerplant Cylinder Head Temperature (CHT)	Minor	Minor	Minor	Assumes a CHT indicator is required. Refer to 14 CFR part 23, § 23.1305.
Display of powerplant indication coolant temperature	Minor	Minor	Minor	Refer to 14 CFR part 23, § 23.1305.
Display of powerplant indication oil pressure	Minor	Minor	Minor	Assumes oil temperature is used as a backup.
Display of powerplant indication oil temperature	Minor	Minor	Minor	Assumes oil pressure is used as a backup.

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Display of powerplant indication manifold pressure	Minor	Minor	Minor	Assumes backup use of CHT, Engine Gas Temperature (EGT), and possible fuel flow readings if installed.
Display of powerplant air inlet temperature	Minor	Minor	Minor	R
Display of powerplant indication fuel pressure	Minor	Minor	Minor	R
Display of powerplant indication fuel flow	Minor	Minor	Major	Manifold pressure and r.p.m. or torque indications can be used as an emergency backup to control power until a safe landing can be made.
Display of powerplant fire warning	Major	Major	Major	Required for commuter category and part 23 turbojet powered airplanes using special conditions. Part 23 airplanes usually have one fire warning system on board.
Display of powerplant indication thrust	Minor	Minor	Hazardous	System is not normally used in part 23 airplanes. Torque, Engine Pressure Ratio (EPR), EGT, or Turbine Inlet Temperature (TIT), fuel flow, and r.p.m. are normally displayed.

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Display of powerplant thrust reverser position	No effect	No effect	Major	No certification credit is given for enhanced performance when a thrust reverser is installed.
Thrust reversal	Minor	Minor	Variable (inadvertent deployment)	No certification credit is given for enhanced performance when a thrust reverser is installed. No credit can be given for a warning.
Display of powerplant torque	Minor	Minor	Major	Misleading torque could affect takeoff performance.
Display of powerplant propeller blade angle	No safety effect	No safety effect	No safety effect	System is not normally used in part 23 airplanes. Propeller governor would control r.p.m.
Electronic displays of significant powerplant parameters	Minor to Hazardous	R	Hazardous	Reversionary display is considered not available. If the risk of possible engine failure due to pilot mishandling can be mitigated by appropriate procedures or by EEC, the loss of function may be major or minor.
Visual warnings, cautions, and alerts	R	R	R	Failure conditions depend on the criticality of systems being monitored and pilot action required.
Display of air temperature	Minor	R	Minor	R

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Overspeed warning	Minor	Minor	Minor	Airspeed may be used as a backup to the overspeed warning for continued safe flight and landing. Crew recognizes conditions by other equipment and procedures.
Primary weather radar	Minor to Major depended on the intended operations	R	Major	The loss could be major when the equipment is required by operational regulations. Also, Air Traffic guidance in some locations might not be available to provide hazardous weather information. It could be minor if there are appropriate AFM limitations.
Flight Information Service Weather	Minor	Minor	Minor	Normal operating procedures should states that the weather information should be used only as a strategic planning tool for pilot decision.
Electronic Chart on the MFD	Minor Major, if paperless cockpit.	Minor, if backup available	Major with own-ship position.	While we are not requiring any backup, we strongly recommend that AFMS normal procedure section recommend that the pilot carry a paper backup with at least all other necessary information to make a successful approach at their destination or alternate airport. In addition, the AFMS should contain emergency procedures for loss of approach charts on the MFD. A backup to the electronic charts on the MFD could be an Electronic Flight Bag with charts, paper approach charts of the destination and alternate airports, or a pilot simply make notes of minimums and all other necessary information to make a successful approach at their destination or alternate airport. When the own-ship position is shown it is not considered the primary navigation display so a primary navigation display is required.

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	Total Loss of Function	**Loss of Primary Means of Providing Function**	**Misleading and/or Malfunction Without Warning**	
Aural warnings	Major	R	Major	Aural alerts tend to be reserved for required flight crew's immediate corrective action. Failure conditions depend on the criticality of the system. Crew recognizes conditions by other equipment and procedures.
Electrical system indication	Minor	Minor	Major	Depends on crew reference and analysis.
Vacuum pressure indication	Minor	Minor	Major	Provides an indication that flight instruments are operating within power source limits.
Electrical power	Catastrophic, if primary flight instruments require electrical power.	Hazardous for IFR. Depends upon capability of secondary power system.	Installation dependent	Depends on electrical system loads and the criticality of the functions.

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