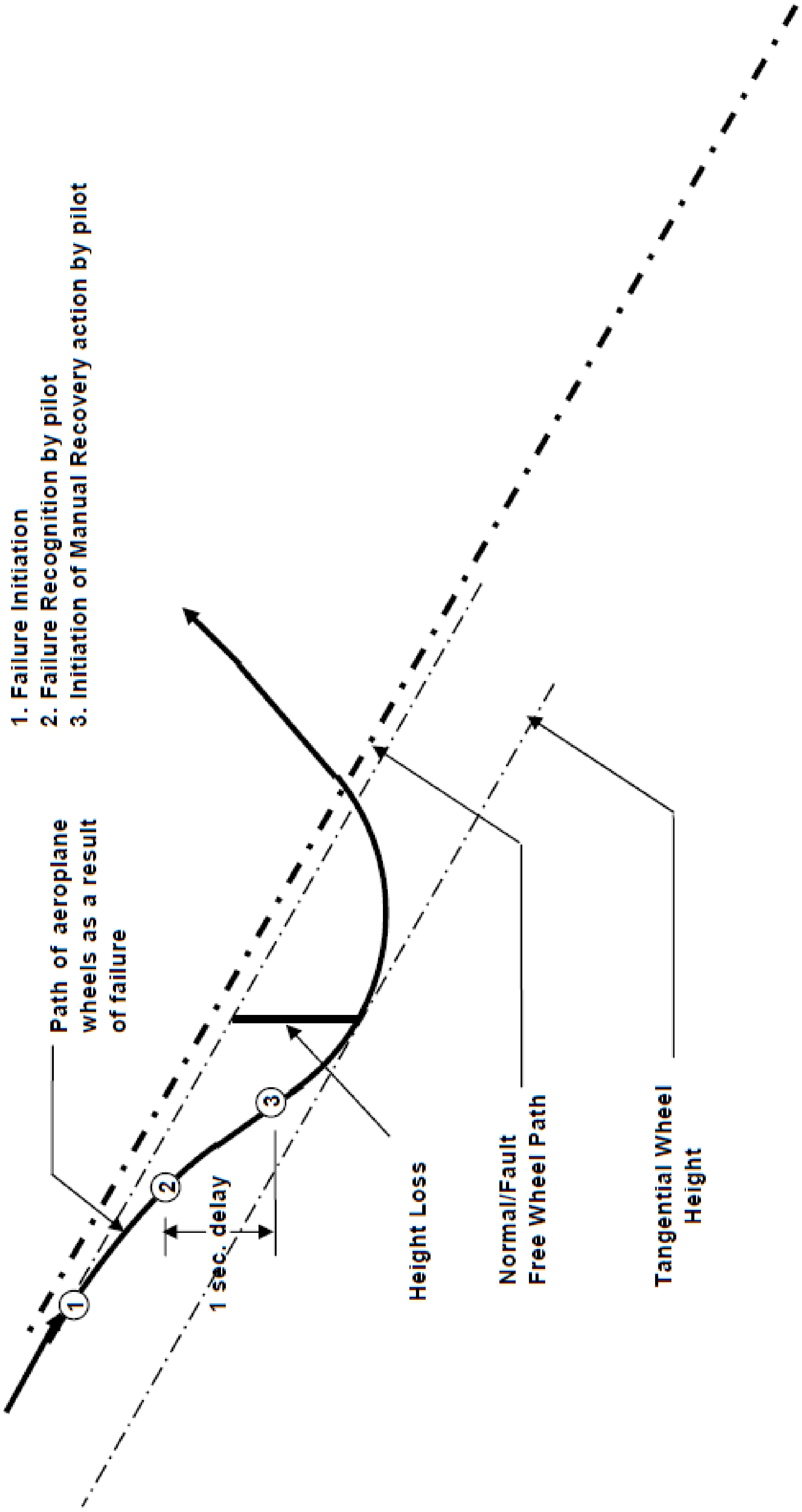

Figure FT-2: Height Loss Method

4.3 Autopilot Override

The initial tests to demonstrate compliance should be accomplished at an intermediate altitude and airspeed e.g. 4500 m (15000 ft) MSL and 460 km/h (250 kt). With the autopilot engaged in altitude hold, the pilot should apply a low force (sustained and incremental) to the control wheel (or equivalent) and verify that the automatic trim system does not produce motion resulting in a hazardous condition. The pilot should then gradually increase the applied force to the control wheel (or equivalent) until the autopilot disengages. When the autopilot disengagement occurs, observe the transient response of the aeroplane. Verify that the transient response is in compliance with Section 8.4 of AMC No. 1 to CS 25.1329.

Disengagement caused by flight crew override should be verified by applying an input on the control wheel (or equivalent) to each axis for which the FGS is designed to disengage, i.e. the pitch and roll yoke, or the rudder pedals (if applicable). The inputs by the pilot should build up to a point where they are sharp and forceful, so that the FGS can immediately be disengaged for the flight crew to assume manual control of the aeroplane.

If the autopilot is designed such that it does not automatically disengage during an autopilot override and instead provides a flight deck Alert to mitigate any potentially hazardous conditions, the timeliness and effectiveness of this Alert. The pilot should follow the evaluation procedure identified above until such time as an Alert is provided. At that time, the pilot should respond to the Alert in a responsive manner consistent with the level of the alert (i.e., a Caution, a Warning) and with the appropriate flight crew procedure defined for that Alert. When the autopilot is manually disengaged, observe the transient response of the aeroplane and verify that the transient response is in compliance with AMC No. 1 to CS 25.1329 Section 8.4.

After the initial tests have been successfully completed, the above tests should be repeated at higher altitudes and airspeeds until reaching MMO at high cruise altitudes.

[Amdt 25/4]

CS 25.1331 Instruments using a power supply

ED Decision 2003/2/RM

(a) For each instrument required by CS 25.1303(b) that uses a power supply, the following apply:

(1) Each instrument must have a visual means integral with the instrument, to indicate when power adequate to sustain proper instrument performance is not being supplied. The power must be measured at or near the point where it enters the instruments. For electric instruments, the power is considered to be adequate when the voltage is within approved limits.

(2) Each instrument must, in the event of the failure of one power source, be supplied by another power source. This may be accomplished automatically or by manual means. The failure of one power source must not affect the same instrument of both pilot stations.

(3) If an instrument presenting flight and/or navigation data receives information from sources external to that instrument and loss of that information would render the presented data unreliable, a clear and unambiguous visual warning must be given to the

crew when such loss of information occurs that the presented data should not be relied upon. The indication must be incorporated in the instrument.

(b) As used in this paragraph, 'instrument' includes devices that are physically contained in one unit, and devices that are composed of two or more physically separate units or components connected together (such as a remote indicating gyroscopic direction indicator that includes a magnetic sensing element, a gyroscopic unit, an amplifier, and an indicator connected together).

CS 25.1333 Instrument systems

ED Decision 2016/010/R

(See AMC 25.1333)

(a) For systems that operate the instruments required by CS 25.1303(b), which are located at each pilot's station, means must be provided to connect the required instruments at the first pilot's station to operating systems, which are independent of the operating systems at other flight crew stations, or other equipment.

(b) Equipment, systems, and installations must be designed so that sufficient information is available to assure control of the aeroplane in airspeed, altitude, direction and attitude by one of the pilots without additional flight crew action after any single failure or combination of failures that is not assessed to be extremely improbable (see AMC 25.1333(b)); and

(c) Additional instruments, systems, or equipment may not be connected to the operating systems for the instruments required by CS 25.1303(b), unless provisions are made to ensure the continued normal functioning of the required instruments in the event of any malfunction of the additional instruments, systems, or equipment which is not shown to be extremely improbable.

[Amdt 25/18]

AMC 25.1333(b) Instruments systems

ED Decision 2003/2/RM

1. *Attitude displays systems.* If three displays are used to show compliance with CS 25.1333(b), the reliability and independence of those displays should be confirmed by a suitable assessment in accordance with CS 25.1309. Each display should have independent sensors and power supplies. If a total failure of the generated electrical power causes the loss of both main instruments, the power supply to the third (standby) attitude indicator and its appropriate lighting should be such that the display is usable from each pilot's station for a time duration in accordance with AMC 25.1351(d).

   Note: the time for which the display remains usable will be stated in the Aeroplane Flight Manual (AFM).

2. *Airspeed, altitude, and direction display systems.* The reliability and independence of the displays used to show compliance with CS 25.1333(b) should be sufficient to ensure continued safe flight and landing appropriate to the intended operation of the aeroplane.

   Historically, "sufficient information" to control attitude, airspeed, altitude, and direction has been provided by specific indicators of the state of each parameter. However, since control is considered to be the ability to change or maintain a given parameter to a desired value, it is assumed that these parameters will be available without flight crew action.

There may be alternate parameters in the cockpit that provide equivalent means to control attitude, airspeed, altitude and direction, without displaying those parameters directly (for example, without display of standby airspeed, by using a suitable angle-of-attack display). For these alternate cases, compliance to CS 25.1333(b) must be shown by analysis and flight test.

CS 25.1337 Powerplant instruments

ED Decision 2003/2/RM

(a) Instruments and instrument lines

(1) Each powerplant instrument line must meet the requirements of CS 25.993 and CS 25.1183.

(2) Each line carrying flammable fluids under pressure must –

(i) Have restricting orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line fails; and

(ii) Be installed and located so that the escape of fluids would not create a hazard.

(3) Each powerplant instrument that utilises flammable fluids must be installed and located so that the escape of fluid would not create a hazard.

(b) *Fuel quantity indicator*. There must be means to indicate to the flight-crew members, the quantity, in litres, (gallons), or equivalent units, of usable fuel in each tank during flight. In addition –

(1) Each fuel quantity indicator must be calibrated to read 'zero' during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under CS 25.959;

(2) Tanks with interconnected outlets and airspaces may be treated as one tank and need not have separate indicators; and

(3) Each exposed sight gauge, used as a fuel quantity indicator, must be protected against damage.

(c) *Fuel flow meter system*. If a fuel flow meter system is installed, each metering component must have a means for bypassing the fuel supply if malfunction of that component severely restricts fuel flow.

(d) *Oil quantity indicator*. There must be a stick gauge or equivalent means to indicate the quantity of oil in each tank. If an oil transfer or reserve oil supply system is installed, there must be a means to indicate to the flight crew, in flight, the quantity of oil in each tank.

(e) *Turbo-propeller blade position indicator.* Required turbo-propeller blade position indicators must begin indicating before the blade moves more than 8° below the flight low pitch stop. The source of indication must directly sense the blade position.

ELECTRICAL SYSTEMS AND EQUIPMENT

CS 25.1351 General

ED Decision 2016/010/R

(See AMC 25.1351)

(a) *Electrical system capacity*. The required generating capacity, and number and kinds of power sources must –

(1) Be determined by an electrical load analysis; and

(2) Meet the requirements of CS 25.1309.

(b) *Generating system*. The generating system includes electrical power sources, main power busses, transmission cables, and associated control, regulation, and protective devices. It must be designed so that –

(1) Power sources function properly when independent and when connected in combination;

(2) No failure or malfunction of any power source can create a hazard or impair the ability of remaining sources to supply essential loads;

(3) The system voltage and frequency (as applicable) at the terminals of all essential load equipment can be maintained within the limits for which the equipment is designed, during any probable operating condition;

(4) System transients due to switching, fault clearing, or other causes do not make essential loads inoperative, and do not cause a smoke or fire hazard;

(5) There are means accessible where necessary, in flight, to appropriate crew members for the individual and rapid disconnection of each electrical power source (see AMC 25.1351(b)(5)); and

(6) There are means to indicate to appropriate crew members the generating system quantities essential for the safe operation of the system, such as the voltage and current supplied by each generator (see AMC 25.1351(b)(6)).

(c) *External power*. If provisions are made for connecting external power to the aeroplane, and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no external power supply having a reverse polarity, a reverse phase sequence (including crossed phase and neutral), open circuit line, incorrect frequency or voltage, can supply power to the aeroplane's electrical system.

(d) *Operation without normal electrical power.* (See AMC 25.1351(d).) The following apply:

(1) Unless it can be shown that the loss of the normal electrical power generating system(s) is Extremely Improbable, alternate high integrity electrical power system(s), independent of the normal electrical power generating system(s), must be provided to power those services necessary to complete a flight and make a safe landing.

(2) The services to be powered must include –

(i) Those required for immediate safety and which must continue to operate following the loss of the normal electrical power generating system(s), without the need for flight crew action;

(ii) Those required for continued controlled flight; and

(iii) Those required for descent, approach and landing.

(3) Failures, including junction box, control panel or wire bundle fires, which would result in the loss of the normal and alternate systems must be shown to be Extremely Improbable.

[Amdt 25/18]

AMC 25.1351(b)(5) Generating System

ED Decision 2003/2/RM

1 The disconnect means required by CS 25.1351(b)(5) should be accessible to the appropriate flight-crew members in their normal seated positions.

2 The power source controls should be considered as cockpit controls and therefore also comply with CS 25.777.

3 It may not be necessary to provide disconnection controls for all power sources, for example RAT generators or engine control dedicated generators. Where it is necessary to isolate the alternate power source when normal generator power is restored, such isolation should be possible.

AMC 25.1351(b)(6) Generating System

ED Decision 2003/2/RM

Each source of electrical supply (e.g. generators and batteries) should be provided with means to give the flight crew immediate warning of the failure of its output. These warning means are additional to the system indication requirements of CS 25.1351(b)(6). For multiphase systems the warning should also indicate the loss of any phase.

AMC 25.1351(d) Operation without Normal Electrical Power

ED Decision 2020/024/R

1 Provision should be made to ensure adequate electrical supplies to those services, which are necessary to complete the flight and make a safe landing in the event of a failure of all normal generated electrical power. All components and wiring of the alternate supplies should be physically and electrically segregated from the normal system and be such that no single failure, including the effects of fire, the cutting of a cable bundle, the loss of a junction box or control panel, will affect both normal and alternate supplies.

2 When ensuring the adequacy of electrical supplies relative to alternate power source duration and integrity, special consideration should be given to aeroplanes such as those with fly-by-wire, for which the total loss of electrical supplies could result in an immediate loss of control.

3 In considering the services which should remain available following the loss of the normal generated electrical power systems, consideration should be given to the role and flight conditions of the aeroplane and the possible duration of flight time to reach an airfield and make a safe landing.

4 The services required by CS 25.1351(d)(1) may differ between aeroplane types and roles and should be agreed with the Agency. These should normally include –

a. Attitude information;

b. Radio communication and intercommunication;

c. Navigation;

d. Cockpit and instrument lighting;

e. Heading, airspeed and altitude, including appropriate pitot head heating;

f. Adequate flight controls;

g. Adequate engine control; and

Restart capability with critical type fuel (from the standpoint of flame-out and restart capability) and with the aeroplane initially at the maximum certificated altitude;

h. Adequate engine instrumentation;

i. Such warning, cautions and indications as are required for continued safe flight and landing;

j. Any other services required for continued safe flight and landing.

5 Consideration should also be given to the equipment and the duration of services required to make a controlled descent and forced landing in the event of failure and inability to restart all engines.

6 *Alternate Power Source Duration and Integrity*

6.1 *Time Limited*. Where an alternate power source provided to comply with CS 25.1351(d) is time limited (e.g. battery), the required duration will depend on the type and role of the aeroplane. Unless it can be shown that a lesser time is adequate, such a power source should have an endurance of at least 60 minutes, at least 30 minutes of which is available under IMC. An endurance of less than 30 minutes under IMC would not normally be acceptable. The endurances, with any associated procedures, should be specified in the Flight Manual. The endurance time should be determined by calculation or test, due to allowance being made for –

a. Delays in flight crew recognition of failures and completion of the appropriate drill where flight crew action is necessary. This should be assumed to be 5 minutes provided that the failure warning system has clear and unambiguous attention-getting characteristics and where such a delay is acceptable and compatible with the crew's primary attention being given to other vital actions.

b. The minimum voltage acceptable for the required loads, the battery state of charge, the minimum capacity permitted during service life and the battery efficiency at the discharge rates and temperatures likely to be experienced. Unless otherwise agreed, for the purpose of this calculation, a battery capacity at normal ambient conditions of 80% of the nameplate rated capacity, at the one-hour rate, and a 90% state of charge, may be assumed (i.e. 72% of nominal demonstrated rated capacity at +20°C). The allowance for battery endurance presumes that adequate requirements for periodic battery maintenance have been agreed.

c. For those aeroplanes where the battery is also used for engine or APU starting on the ground, it should be shown that following engine starts, the charge rate of the battery is such that the battery is maintained in a state of charge that will ensure adequate alternate power source duration should a failure of generated power occur shortly after take-off.

NOTE: This may normally be achieved by ensuring that, following battery-powered starting, the battery charge current has fallen to a declared level prior to take-off.

d. For those aeroplanes where the battery is used for in-flight starting of the engines or APU, it may be necessary to include limitations on the number of attempted starts, or to provide a separate dedicated battery for such purposes.

6.2 *Non-Time Limited*. Where an alternate electrical supply is provided by a non time limited source, e.g. APU, ram air turbine, pneumatic or hydraulic motor, due account should be taken of any limitation imposed by aeroplane speed, attitude, altitude etc., which may affect the capabilities of that power source. In considering the power source, account should be taken of the following:

a. *Auxiliary Power Unit (APU).* An APU capable of continuous operation throughout an adequate flight envelope may be considered an acceptable means of supplying electrical power to the required services provided that its air start capability is adequate and may be guaranteed. Where, however the APU is dependent for its starting current on a battery source, which is supplying critical loads, such starting loads may prejudice the time duration of the flight if APU start is not achieved.

It may be necessary therefore to include limitations on the number of attempted starts or to provide a separate battery for APU starting, if this method of supplying electrical power is adopted. Consideration should also be given to the equipment, services and duration required prior to the APU generator coming online. Common failures, which could affect the operation of all engines and the APU, should be taken into consideration, e.g. fuel supply.

b. *Ram Air Turbine (RAT).* A ram air turbine may be utilised to provide an alternate electrical power source, but due consideration must be given to ensuring that the means of bringing the unit into use are not dependent on a source which may have been lost as a result of the original failure. This will normally necessitate independent, duplicate means of deployment. Particular attention should be given to ensuring that the RAT and its means of deployment satisfy the overall reliability requirements.

The continuity of electrical power to those services which must remain operative without crew action prior to the RAT being brought into operation, may necessitate the use of a battery, unless the operation of the emergency power source is automatic and is supplying power within a timespan so as not to jeopardise the continued safety of the aeroplane in the event of failure of normal generated electrical power.

c. *Pneumatic or Hydraulic Motor Drive Power Source.* A pneumatic or hydraulic motor driven electrical power source may be utilised subject to the same constraints on activation as the ram air turbine (see 6.2(b)). Care should be taken in ensuring that the operation of the pneumatic or hydraulic system is not prejudiced by faults leading to, or resulting from, the original failure, including the loss of, or inability to restart all engines.

d. *Regaining of Main Generators*. In the event of a major loss of electrical power, provision may be made for regaining the output of one or more generators using separate control and switching arrangements on the generator side of the normal generator line contactor. Such a system would not normally be acceptable on aeroplanes with less than three engine-driven generators, as the probability of the loss of all engine-driven generators is unlikely to meet the requirements of CS 25.1351(d). To comply with CS 25.1351(d)(2) the system should be designed such that the loss of both the main and alternate means of control and distribution is Extremely Improbable. Consideration should be given to the services and duration required prior to the activation of the system and to enable a descent and forced landing to be made, in the event of the inability to restart all engines.

e. *Usage of a battery system to ensure continuity of electrical power.* This subparagraph applies if a battery system is used to ensure the continuity of electrical power when the non-time-limited alternate electrical power source(s) is(are) not providing electrical power. When establishing the minimum battery endurance requirements, the following conditions should be considered:

— It should be shown that following the loss of normal electrical power, and during the time periods when the non-time limited alternate electrical power source(s) does(do) not provide electrical power (per design), the battery system provides an adequate electrical power supply to those services which are necessary to make a controlled descent and landing, stop and complete a safe evacuation of the aeroplane (CS 25.1351(d) and 25.1362).

— The applicant should take into account the transient time period between the loss of normal electrical power and the non-time limited alternate electrical power source being operational, as well as other time period(s) when the non-time limited alternate electrical power source is not available. For example, the time period between when the RAT electrical generator goes off-line and when the aeroplane is stopped on ground and a safe evacuation of the aeroplane is performed.

— The most critical configuration, from a battery system point of view, should be considered. The loss of normal electrical power is usually associated with one of the following conditions: either the all-engine out case or the loss of power coming from the primary power centre. In the second case, the proximity of a battery to the power centre should be taken into account. Any battery located near this power centre should be considered as part of the normal electrical power generating system (ref. CS 25.1351(d)(1).

— The time periods corresponding to the intended usage of the battery system in the emergency scenario will need to be substantiated, with a due margin taken for any uncertainty. Any permanent load on the battery system (i.e. a hot bus) will also have to be accounted for.

— For determining the capacity of the battery system, Section 6.1(b) of this AMC, on time-limited power sources, applies.

— The capability of the backup battery system to provide adequate power for the required minimum duration should be demonstrated by actual testing or demonstrated equivalent means.

— Instructions for Continued Airworthiness for the battery system should be provided. These instructions should ensure that adequate battery power is available between maintenance cycles. There should be a means for the flight crew or maintenance personnel to determine the actual battery system charge state prior to take-off.

[Amdt 25/26]

CS 25.1353 Electrical equipment and installations

ED Decision 2016/010/R

(See AMC 25.1353)

(a) Electrical equipment and controls, must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other electrical unit or system essential to the safe operation. Any electrical interference likely to be present in the aeroplane must not result in hazardous effects upon the aeroplane or its systems except under extremely remote conditions. (See AMC 25.1353(a).)

(b) Electrical Wiring Interconnection System components must meet the requirements of 25.1703, 25.1707, 25.1711 and 25.1717.

(c) Storage batteries must be designed and installed as follows:

(1) Safe cell temperatures and pressures must be maintained during any probable charging or discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge) –

(i) At maximum regulated voltage or power;

(ii) During a flight of maximum duration; and

(iii) Under the most adverse cooling condition likely to occur in service.

(2) Compliance with sub-paragraph (1) of this paragraph must be shown by test unless experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures presents no problem.

(3) No explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the charging system or battery installation, may accumulate in hazardous quantities within the aeroplane.

(4) No corrosive fluids or gases that may escape from the battery may damage surrounding aeroplane structures or adjacent essential equipment.

(5) Each nickel cadmium battery installation must have provisions to prevent any hazardous effect on structure or essential systems that may be caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of individual cells.

(6) Nickel cadmium battery installations must have –

(i) A system to control the charging rate of the battery automatically so as to prevent battery overheating or;

(ii) A battery temperature sensing and over-temperature warning system with a means for disconnecting the battery from its charging source in the event of an overtemperature condition; or