

Additive Manufacturing

Criticality in Systems Applications

(amended for 8-12th Nov. 2021 AM Event – S. Waite)

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Your safety is our mission.

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“Classical” safety approach for systems

- Identification of failure conditions using a Functional Hazard Assessment (FHA)**
- Assessing failure condition effects to determine the severity**
- Severity drives the probability objective**
- Analysis of probabilities based on (parts/equipment) failure rates**

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Severity of the Effects	Effect on Aeroplane	No effect on operational capabilities or safety	Slight reduction in functional capabilities or safety margins	Significant reduction in functional capabilities or safety margins	Large reduction in functional capabilities or safety margins	Normally with hull loss
	Effect on Occupants excluding Flight Crew	Inconvenience	Physical discomfort	Physical distress, possibly including injuries	Serious or fatal injury to a small number of passengers or cabin crew	Multiple fatalities
	Effect on Flight Crew	No effect on flight crew	Slight increase in workload	Physical discomfort or a significant increase in workload	Physical distress or excessive workload impairs ability to perform tasks	Fatalities or incapacitation
Classification of Failure Conditions		No Safety Effect	Minor	Major	Hazardous	Catastrophic

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Classification of Failure Conditions	No Safety Effect	Minor	Major	Hazardous	Catastrophic
Allowable Qualitative Probability	No Probability Requirement	<-Probable->	<--Remote-->	Extremely <-----> Remote	Extremely Improbable
Allowable Quantitative Probability: Average Probability per Flight Hour on the Order of:	No Probability Requirement	<-----> <10 ⁻³ Note 1	<-----> <10 ⁻⁵	<-----> <10 ⁻⁷	<10 ⁻⁹

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- Evaluation of AM parts/equipment criticality could be based on FHA
- No definition of No/Low Criticality in CS 25.1309
- FHA severities “No Safety Effect” or “Minor” might be used as “No/Low Criticality”

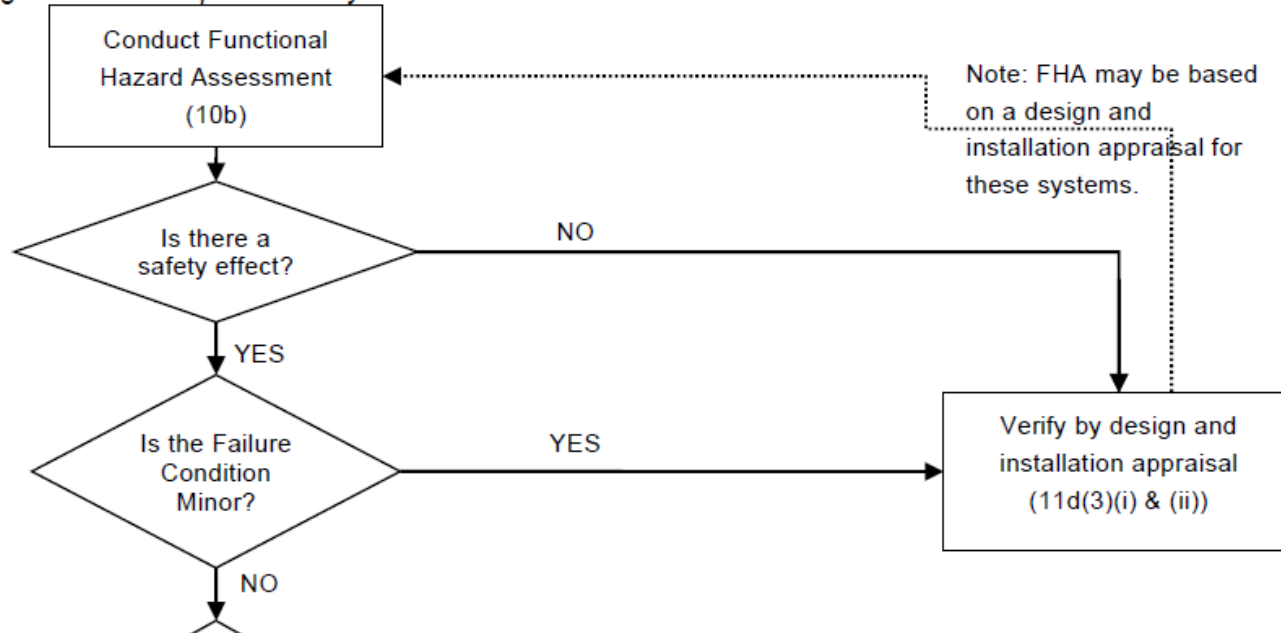
(1) *No Safety Effect*: Failure conditions that would have no effect on safety; for example, Failure Conditions that would not affect the operational capability of the aeroplane or increase crew workload.

(2) *Minor*: Failure conditions which would not significantly reduce aeroplane safety, and which involve crew actions that are well within their capabilities. Minor failure conditions may include, for example, a slight reduction in safety margins or functional capabilities, a slight increase in crew workload, such as routine flight plan changes, or some physical discomfort to passengers or cabin crew.

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→ For FHA severities with “No Safety Effect” or “Minor” no quantitative analysis (Fault Tree) required

Figure A2-2: Depth of Analysis Flowchart



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- What to do if no FHA exists? Perform simple “FHA”
- Identify possible failures of AM part/equipment (rupture, crack, etc.)
- Assess failure impact on function of AM part/equipment
- Engineering judgement of the severity of the failure condition

(1) Before a detailed safety assessment is proceeded with, a functional hazard assessment (FHA) of the aeroplane and system functions to determine the need for and scope of subsequent analysis should be prepared. This assessment may be conducted using service experience, engineering and operational judgement, and/or a top-down deductive qualitative examination of each function. An FHA is a systematic,

Note: Should be limited to No/Low Criticality

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- What is '**Criticality**'? (PART 21 AMC 21.B.100(a) 'Level of Involvement' (LoI))... as defined in context of LoI:
'... measure of **the potential impact of a non-compliance with part of the certification basis on product safety** or on the environment'

The supporting guidance continues:

'...The **potential impact** of a non-compliance within a Compliance Demonstration Item (CDI) should be **classified as critical if**, for example: ...a function, component or system is introduced or affected where the **failure of that function, component or system may contribute to a failure condition that is classified as hazardous or catastrophic at the aircraft level ...**'

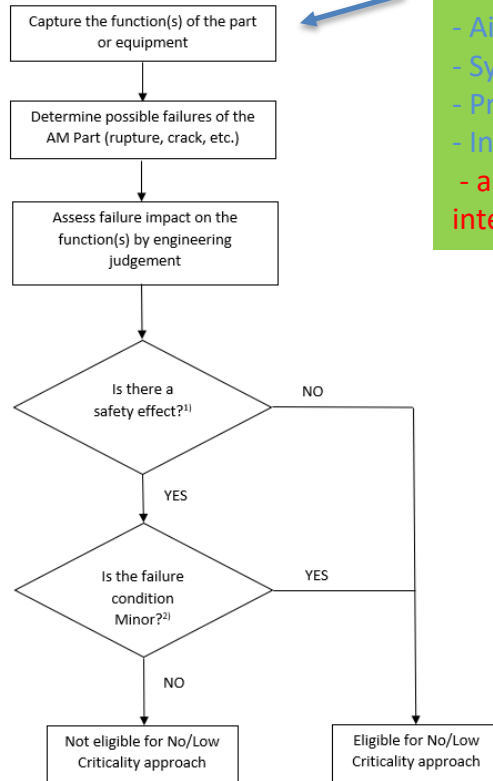
- Criticality according to LOI determination is used to identify higher EASA involvement in Hazardous or Catastrophic failure conditions
- Major conditions have a significant impact on safety and should not be treated as Low Criticality

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- Encourage similar more systematic and broad simplified FHA thought process for use with AM Parts of no/low criticality:
 - the part may impact other disciplines
 - consider broader cross disciplines:
 - Airframe
 - Propulsion
 - Systems
 - Cabin Safety (including seats)

SIMPLIFIED FHA FOR AM PARTS – NO/LOW CRITICALITY

Simplified Functional Hazard Assessment (FHA) for No/Low Criticality AM Parts



Consider:

- Airframe
- Systems
- Propulsion
- Interiors (including seats)
- and any potential for interaction between these

Reminder: available published TCH data is based upon extensive knowledge, experience, testing... mostly unpublished

Need to also review potential use of Risk Assessment Specification (RAS) for this purpose (see previous WG1 Dann Kerman (FAA) prep. presentation)

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Thank you!

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