Hazard Taxonomy Examples

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This paper was prepared by the Standardization Workgroup of the Safety Management International Collaboration Group (SM ICG). The purpose of the SM ICG is to promote a common understanding of Safety Management System (SMS)/State Safety Program (SSP) principles and requirements, facilitating their application across the international aviation community.

The current core membership of the SM ICG includes the Aviation Safety and Security Agency (AESA) of Spain, the National Civil Aviation Agency (ANAC) of Brazil, the Civil Aviation Authority of the Netherlands (CAA NL), the Civil Aviation Authority of New Zealand, the Civil Aviation Safety Authority (CASA) of Australia, the Direction Générale de l'Aviation Civile (DGAC) in France, the European Aviation Safety Agency (EASA), the Federal Office of Civil Aviation (FOCA) of Switzerland, Japan Civil Aviation Bureau (JCAB), the United States Federal Aviation Administration (FAA) Aviation Safety Organization, Transport Canada Civil Aviation (TCCA) and the Civil Aviation Authority of United Kingdom (UK CAA). Additionally, the International Civil Aviation Organization (ICAO) is an observer to this group.

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- Share lessons learned
- Encourage the progression of a harmonized SMS
- Share products with the aviation community
- Collaborate with international organizations such as ICAO and civil aviation authorities that have implemented or are implementing SMS

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PURPOSE

The purpose of this document is to introduce a hazard taxonomy and provide examples of specific aviation sector hazards in each of the taxonomy categories. This document is intended to be used by civil aviation authorities (CAAs) and service providers that are in the initial stages of safety management development/ implementation. This document only introduces basic taxonomy examples; therefore, use of additional sources in conjunction is recommended. Additionally, this document will be provided to the Commercial Aviation Safety Team (CAST)/ICAO Common Taxonomy Team (CICTT) for further consideration.

BACKGROUND

The SM ICG previously published *Development of a Common Taxonomy for Hazards*, which proposed a process for the development of a common taxonomy for hazards related to civil aviation. That document provided the rationale for developing a hazard taxonomy, proposed general definitions of a hazard, and also proposed a near term and far term approach to developing a taxonomy and categorizing hazards.

This document supports the near term taxonomy development approach, which recommended that the CICTT utilize subject matter expert knowledge and judgment to further refine the high level hazard categories proposed in the previous SM ICG published document *Development of a Common Taxonomy for Hazards*.

In coordination with the CICTT, the following high level hazard taxonomy categories have been established:

a. Organizational – Management or documentation, processes and procedures
b. Environmental – Weather or Wildlife
c. Human – Limitation of the human which in the system has the potential for causing harm
d. Technical – Aerodrome, Air Navigation, Operations, Maintenance, and Design and Manufacturing

Note: Since the publication of the last Safety Management International Collaboration Group (SM ICG) paper on this topic, the SM ICG has further developed its definition of a hazard. According to the recently published SM ICG Safety Management Terminology document, a hazard, is defined as a condition that could cause or contribute to an aircraft incident or accident.

SCOPE

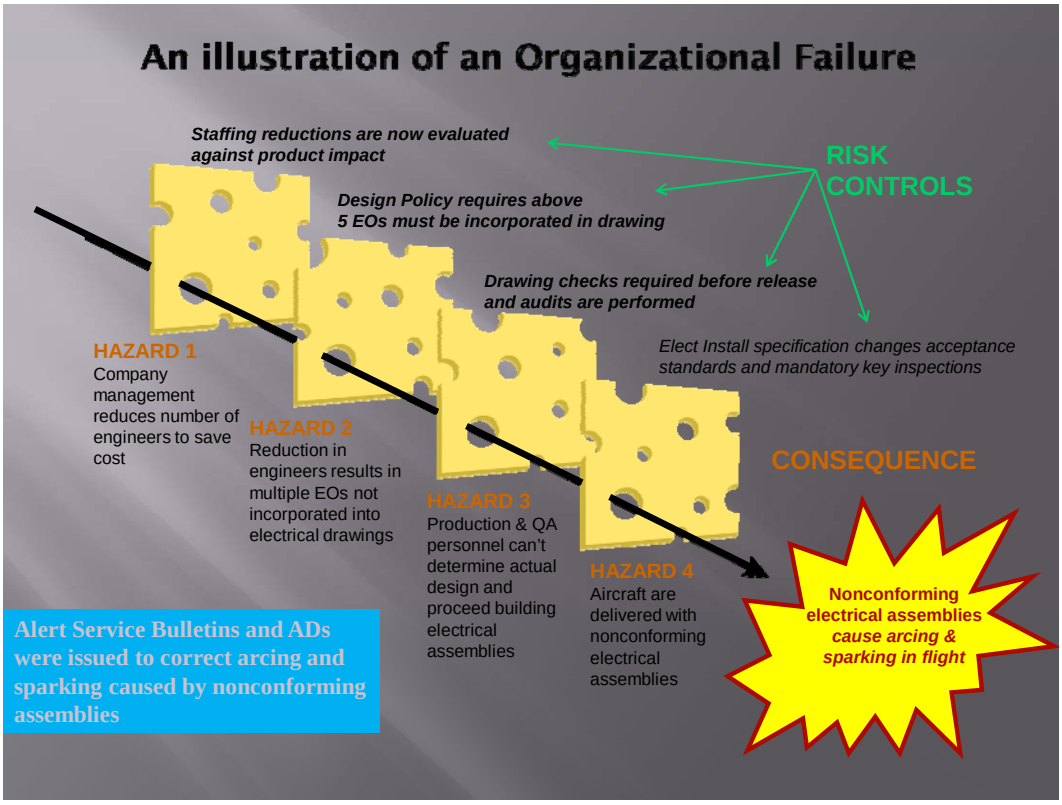
The CICTT hazard taxonomy development effort is being supported by the SM ICG Standardization Working Group. The initial focus was to develop a classification methodology to group the types of hazards into broad categories that would apply to all aviation sectors. As stated above, the SM ICG recommended that the CICTT categorize the hazard taxonomy into the following general categories: Environmental, Technical, Organizational, and Human. The CICTT agreed to this categorization schema. This document contains specific taxonomy examples that the SM ICG is proposing for each of the categories applicable to Aerodrome, Air Navigation, Air Operation, Maintenance, and Design and Manufacturing aviation sectors. The examples align with the specific hazard definition stated above.

In this document, specific hazards have been described at a high level for each aviation sector. Additionally, it was determined that organizational, environmental, and human hazards are mostly generic, and apply to all aviation sectors at the high level. Human hazards are described as both hazards that have a direct safety effect in each aviation sector and hazards with latent effects of human factors considerations in the design aspects of the man-machine interface that could later surface during aircraft design/manufacturing, operations and maintenance.

During the development of this document, aviation sector experts determined that specific aviation sector hazards may have descriptions of absence and/or judgmental adjectives since experience through accident/incident investigation and subsequent root cause analysis validates those types of specific hazards.

Due to the nature of the incident/accident causal chain, hazards are often described at various points in the causal chain.[1] Thus, risk mitigation strategies can also be applied at various points in the hazard causal chain. Therefore it is important to understand this causal chain to identify the opportunities for potential risk mitigation options. For this reason, many of the technical category hazards are not necessarily independent and could stem from certain common organizational hazards. For example, a runway incursion could be described as a hazard itself. However, one could also argue that the runway incursion is not the hazard, but rather the effect (consequence) of lower level hazards, such as lack of proper runway design and/or lack of runway signage. It can further be argued that lack of proper runway design and signage is due to mismanagement stemming from an organizational hazard. Therefore, an organization should strive to develop risk controls to mitigate the runway incursion hazard risk in all hazard categories. However, it is generally impractical to have risk mitigation strategies at every possible point in the incident/accident causal chain, so an organization should strive to identify all hazards in its organization or activities and develop effective risk mitigation strategies for those hazards determined to have unacceptable risk.

The following illustration shows an example of this causal chain concept in the Design and Manufacturing sector:



[1] Note that there are many more complex accident/incident models than the one cited here. Over the years, accident models have moved from linear cause-effect sequences to systemic descriptions of emergent phenomena (e.g., Functional Resonance Accident Model by Erik Hollnagel, which uses the principle of stochastic resonance in a system context).

Due to complexity in the aviation system, it would be very difficult to develop comprehensive hazard taxonomies for each aviation sector, unless all of the possible causal chains can be described and documented, and continually updated based on potential future incidents/accidents, which is beyond the scope of this document. In addition, hazards may be different in service provider organizations based on their specific business processes. Therefore, the specific hazard taxonomy elements in this document are only examples of some of the more basic understood hazards in each aviation sector based on expert opinion. It is anticipated that with more mature safety management processes in place, these example hazards will be developed further based on aggregate data from multiple service providers.

Finally, the aviation community has recently initiated activities to further develop a more systematic and comprehensive hazard taxonomy effort. This future development will enable the global aviation community to share and aggregate information related to hazards.

HAZARD TAXONOMY EXAMPLES[2]

Organizational

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aerodrome, Air Navigation Service Provider, Air Operation, Maintenance Organization, Design & Manufacturing Organization	Regulator	Lack of, poor or ineffective legislation and/or regulations
		Lack of or ineffective accident investigation capability
		Inadequate oversight capability
	Management	Limited or lack of management commitment – Management do not demonstrate support for the activity
		Lack of or incomplete description of roles, accountabilities and responsibilities
		Limited or lack of resource availability or planning, including staffing
		Lack of or ineffective policies
		Incorrect or incomplete procedures including instructions
		Lack of or poor management and labor relationships
		Lack of or ineffective organizational structure
		Poor organizational safety culture
		Lack of or ineffective safety management processes (including risk management, safety assurance, auditing, training and resource allocation)
		Lack or ineffective audit procedures
		Lack of or limited resource allocation

[2] Security issues can certainly effect safety; however, the SM ICG has intentionally left out potential security hazards since this group does not possess the expertise to address this topic.

Organizational

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aerodrome, Air Navigation Service Provider, Air Operation, Maintenance Organization, Design & Manufacturing Organization (continued)	Management (continued)	Incorrect or incomplete or lack of training and knowledge transfer. *Note: Training should reflect the needs of the organization. Accidents have shown that inadequate training is a hazard and may even lead to accidents.*
		Unofficial organizational structures *Note: These structures may be of a benefit but also may lead to a hazard.*
		Growth, strikes, recession or organizational financial distress
		Mergers or acquisition
		Changes, upgrades or new tools, equipment, processes or facilities
		Incorrect or ineffective shift/crew member change over procedures
		Changes or turnover in management or employees
		Informal processes (Standard Operating Procedures)
		Lack of or poor or inappropriate materials/equipment acquisition decisions
		Lack of, poor staffing recruitment/assignment *Note: Staff should be hired or assigned according to organizational needs but also according to their skills, qualifications and abilities. An employee with the wrong skill set can be a hazard. This includes management.*
	Documentation, Processes and Procedures	Incorrect, poor or lack of internal and external communication including language barriers
		Lack of, incorrect or incomplete manuals, or operating procedures (including maintenance)
		Lack of, incorrect or incomplete employee duty descriptions
		Lack of, incorrect, incomplete or complicated document update processes
		Lack of, incorrect or incomplete reports and records
		Lack of, incorrect or incomplete control of necessary documents for personnel (licenses, ratings, and certificates)

Environmental

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aerodrome, Air Navigation Service Provider, Air Operation, Maintenance Organization (Effects may not be all encompassing)	Weather/Natural Disasters	Thunderstorms and lightning
		Hail
		Heavy rain
		Fog (reduced visibility)
		Wind shear
		Sand storm
		Snow or ice storms
		Excessive or cross winds
		Hurricane, Tsunami, or tornado
		Floods
		Ash (including volcanic or forest fire)
		Earthquake
		Extreme temperatures
		Icing conditions (Impact on aircraft surfaces)
	Geography	Mountains or bodies of water
		Altitude at the aerodrome
	Wildlife	Wildlife on airfield
		Flying wildlife

Human

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aerodrome, Air Navigation Service Provider, Air Operation, Maintenance Organization, Design & Manufacturing Organization	Sudden Incapacitation	Heart attack, Stroke, Kidney stone, Seizure
	Subtle Incapacitation/ Impairment	Nausea, Diarrhea, Carbon monoxide, Medication, Fatigue
	Illness	Influenza, Upper Respiratory Tract Infection (TI), Urinary TI
	Static Limitations	Color vision, Visual field limitations, Mobility limitations, Colostomy bag, Hearing loss
	Self-Imposed Stresses	Fatigue (lack of sleep), Alcohol and substance abuse, Medications, Complacency

Human

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aerodrome, Air Navigation Service Provider, Air Operation, Maintenance Organization, Design & Manufacturing Organization (continued)	Psycho-Social Stresses	Financial, Birth of child, Divorce, Bereavement, Challenging timelines, Inadequate resources
	Trauma	Inflight turbulence cabin crew injury, injury caused to personnel during ground aircraft operations or luggage handling
	Environmental/ Occupational	Jet lag, Paint shop, Solvents, Chemical/Biological exposures, Noise, Vibrations, Distractions
	Latent Failures Related to Man/ Machine/ Process Interface	Human factors related to design, manufacturing, maintenance and operations.
	Cognitive Capacity	Excessive number of aircraft in a controller's area; Varying multi-tasking actions; Over saturation of digital information

Technical - Aerodrome

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aerodrome	Runway Operations	Construction, vehicles and people on movement area
		Poor aerodrome design (Intersecting runways; Obstacle clearance; Taxiway crossing runways)
		Distracting lights
		Lack of coordination with Air Traffic Control (ATC)
		Improper, inadequate, or lack of Notices to Airmen (NOTAMs) issuance
		Laser beams
	Runway Condition	Poor condition or improper runway surface
		Inadequate runway length
		Lack of, or inadequate runway protected areas

Technical - Aerodrome

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aerodrome (continued)	Airfield Apron Operation Airfield Apron Operation (continued)	Jet blast
		Lack of, limited or incorrect type of aircraft parking
		Improper marshaling
		Lack of, or insufficient protective pylons around aircraft
		Lack of, or inadequate chalks when aircraft parks
		Lack of, or improper foreign object debris (FOD) control
		Lack of, or improper ramp control tie down procedures
		Improper fuel or hazardous material spill containment and cleanup
		Poor refueling procedures
	Airside Vehicle Operations	Vehicle failure during aerodrome services
		Poor mechanical condition
		Poor radio or communication equipment condition
		Oil spills on apron and/or in passenger areas
		Lack of vehicle maintenance
		Poor Emergency Reponses Planning
		Erratic driving or not complying with flight line driving regulations
		Driving too fast
		Improper parking
		Failure to chalk vehicles
		Leaving engine running while vehicle is unattended
		Lack of coordination between vehicles during aircraft servicing
	Action of Individuals	Pedestrians on apron areas
		Ignoring aircraft hazard beacons
		Improper checking around aircraft during departure marshaling
		Misinterpreting apron markings
		Smoking on the apron
		Passenger failure to follow guidance

Technical - Aerodrome

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aerodrome (continued)	Action of Individuals (continued)	Use of cell phone within 15 meters of a refueling operation
		Littering on ramp
		Running on apron
	Facilities	Faulty electrical power supply systems on airport or navigational aids (radars, satellites, very high frequency (VHF) omni-directional radio range (VOR), Automatic Dependent Surveillance - Broadcast (ADS-B), etc.)
		Faulty, incorrect or incomplete airfield markings (especially in movement areas)
		Faulty, incorrect, or incomplete airfield lighting (especially in movement areas)
		Faulty, incorrect, or incomplete approach lighting
		Poor condition or inappropriate runway surface
		Poor condition or inappropriate apron surface
		Taxiway and runway system complexity
		Inadequate airfield or terrain drainage
		Insufficient equipment, radios, infrastructure, or personnel
		Issues that attract wildlife (high grass, proximity of landfills, nearby water bodies)
		Inadequate or inappropriate firefighting equipment
		Lack of or limited parking areas
		Lack of safety protective equipment

Technical - Air Navigation Service Provider (ANSP)

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
ANSP	Traffic Pattern	Traffic complexity (mixture of aircraft type)
		Excessive aircraft in pattern or given airspace
		Ineffective design and flow of traffic pattern
		Runway incursions by aircraft or vehicles
		Unauthorized flights entering into traffic pattern
		Unauthorized procedures by aircraft
		Similar sounding or confusing call signs
		Lack of or poor procedures for aircraft in distress.
	Airspace	Insufficient airspace for typical traffic
		Improperly distributed airspace
		Airspace combined during excessive traffic
		Confusing labeling of fixes or way points
		Improperly developed instrument procedures
		Aircraft incorrectly performing missed approach procedures
		Intermingling of ICAO and national instrument procedure criteria
	Controller Actions	Incomplete clearances
		Misidentification of aircraft or targets (radar)
		Improper reading of clearance instructions
		Loss of separation between aircraft
		Loss of separation between aircraft and terrain or obstacles
		Misinterpretation of pilot desires
		Incorrect judgment of aircraft characteristics
	Communications	Incorrect, confusing, or incomplete communications between ATC and aerodrome personnel
		Incorrect, confusing, or incomplete communications between ATC and aircraft
		Incorrect, confusing, or incomplete coordination between or within ATC facilities
		Radio/Frequency failures or anomalies
		Navigational aid (radars, satellites, VOR, ADS-B, etc) failures or anomalies

Technical - Air Navigation Service Provider (ANSP)

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
ANSP (continued)	Communications (continued)	Differences in ICAO and national Air Traffic Control phraseology
		Not using the standard international aviation language
		Language barriers (Multiple languages)
		Lack of, or wrong aeronautical information
	Facilities	Faulty electrical power supply systems on airport or navigational aids (radars, satellites, VOR, ADS-B, etc)
		Faulty, incorrect or incomplete airfield markings or lighting
		Faulty, incorrect, or incomplete approach lighting
		Taxiway and runway system complexity
		Inadequate airfield or terrain drainage
		Insufficient equipment, radios, infrastructure, or personnel

Technical - Air Operation and Maintenance

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Air Operation	Facilities	Faulty electrical power supply systems on airport or navigational aids (radars, satellites, VOR, ADS-B, etc)
		Faulty, incorrect or incomplete airfield markings and lighting
		Faulty, incorrect, or incomplete approach lighting
		Taxiway and runway system complexity
		Inadequate airfield drainage
		Insufficient equipment, radios, infrastructure, or personnel
		Lack of, limited or incorrect type of aircraft parking
		Poor HVAC (heating, ventilation, and air conditioning)
		Noisy environment
		Lack of or poor Lighting
		Poor facilities (inadequate space)
	Preflight Preparation	Lack of or poor airworthiness verification
		Lack of or poor verification of equipment and instruments necessary to a particular flight or operation

Technical - Air Operation and Maintenance

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Air Operation (continued)	Preflight Preparation (continued)	Lack of, incorrect or incomplete aircraft performance limitations verification
		Lack of, incorrect or incomplete flight planning
		Poor fueling processes
		Lack of or poor aircraft dispatch or release
		Lack of or poor maintenance release
	Aircraft Loading	Incorrect cargo loading and distribution
		Improper or unauthorized hazardous materials carriage
		Poor cargo and baggage stowage
		Incorrect information on cargo or baggage loaded
		Improper stowage of carry-on baggage
		Improper weight and balance calculations
	Flight Operation	Use of obsolete documents
		Absence of or incorrect flight and cabin crew manuals or charts on board
		Improper response to flight route changes
		Lack of, or poor crew resource management
		Lack of or poor flight following
		Improper execution of procedures in all flight phases (including taxiing and parking)
		Inadequate or complicated procedures
		Equipment and instruments necessary for a particular flight or operation not available or malfunctioning
		Lack of, or poor communication (ATC, ramp, maintenance, flight Ops, cabin, dispatch, etc)
		Language barriers (Multiple languages)
Maintenance	Facilities	Poor HVAC (heating, ventilation, and air conditioning)
		Noisy work environment
		Lack of, or poor Lighting
		Poor facilities (inadequate space, equipment or infrastructure)
	Maintenance Activity	Lack of, or poor maintenance release
		Lack of, or poor maintenance programs (Including imprecise maintenance data or transcription errors when creating job-cards)

Technical - Air Operation and Maintenance

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Maintenance (continued)	Maintenance activity (continued)	SUPS (Suspected Unapproved Parts)
		Maintenance movement of aircraft/run-ups
		Lack of, or poor communication (ATC, ramp, flight Ops, cabin, dispatch, etc)
		Language barriers in maintenance teams (Multiple languages)
		Poor control of outsourced maintenance (any maintenance completed outside the maintenance facility or organization including third party maintenance)
		Lack of or, inappropriate specialized processes (including NDT, plating, welding, composite repairs etc…)
		Lack of or, improper Airworthiness Directive Control
		Ineffective or lack of procedures to ensure materials, parts, or assemblies are worked or fabricated through a series of precisely controlled steps, and that undergo physical, chemical, or metallurgical transformation (some examples are heat-treating, brazing, welding, and processing of composite materials).
		Lack of or, inadequate reliability program
	Tooling	Lack of, or poor tool accountability (Including traceability or registration)
		Lack of or unsafe or unreliable equipment, tools, and safety equipment;
		Inappropriate layout of controls or displays
		Mis-calibrated tools
		Inappropriate or incorrect use of tools for the task
		Lack of, or inadequate instructions for equipment, tools, and safety equipment
	Maintainability	Complex design (Difficult fault isolation, multiple similar connections, etc)
		Inaccessible component/area
		Aircraft configuration variability (Similar parts on different models)

Technical - Design and Manufacturing

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aircraft Design	Safety Requirements Capture	Non compliance with applicable regulations (For example FAA 14 CFR part 23, 25, 27, 29, 33).
		Inadequate Functional Hazard Assessment.
		Inadequate structural static and dynamic loads analysis.
		Inadequate Preliminary System Safety Assessment.
		Inadequate common cause analysis.
	Safety Requirements Validation	Incomplete or ineffective design reviews, analysis, simulator, wind tunnel, and flight testing.
		Ineffective or incomplete structural external, internal, and elemental loads analysis.
	Safety Requirement Verification	Incomplete structures loads verification, such as static load tests, ground vibration tests, and flight tests.
		Inadequate System Safety Assessments (SSA) process including lack of, or improper verifying of, failure effects using failure performance testing.
		Inadequate verification of software and complex hardware
	Aircraft Integration	Inadequate requirements traceability.
		Inadequate design requirements control.
		Inadequate verification of system/system and system/structure unintended functions and physical interference, such as lack of Bench/Sim/Airplane Testing and inadequate zonal inspections
	Continued Operational Safety	Ineffective in-service monitoring methods such as lack of failure reporting and tracking.
		Inadequate or no root cause analysis, risk analysis, corrective action development, corrective action validation, and incorporation of corrective action and lessons learned into Design Process
	Design Control	Lack of methods for approving, controlling, and documenting initial designs and design changes.
		Inadequate planning and integration of the facility's procedures for continuously maintaining the integrity of design data, drawings, part lists, and specifications necessary to define the configuration and the design features of the product.
Aircraft Manufacturing	Manufacturing Processes	Lack of processes for the control of materials, parts, or assemblies, how they are accepted, worked or fabricated, tested, inspected, stored, and prepared for shipment.

Technical - Design and Manufacturing

Type of operation	Type of activity/ infrastructure/ system	Examples of Hazards
Aircraft Manufacturing (continued)	Manufacturing Processes (continued)	Problems with special manufacturing processes and specific functions and operations necessary for the fabrication and inspection of parts and assemblies (some examples are machining, riveting, and assembling).
		Ineffective or lack of procedures to ensure materials, parts, or assemblies are worked or fabricated through a series of precisely controlled steps, and that undergo physical, chemical, or metallurgical transformation (some examples are heat-treating, brazing, welding, and processing of composite materials).
		Inadequate methods used to accept and protect raw materials, parts, subassemblies, assemblies, and completed products during receipt, manufacture, inspection, test, storage, and preparation for shipment.
		Inadequate Airworthiness Determination, which is the function that provides for evaluation of completed products/parts thereof, and related documentation, to determine conformity to approved design data and their condition for safe operation.
	Manufacturing Controls	Ineffective methods that are used by the Production Approval Holder to control product quality by statistical methods, and that may be used for continuous improvement and/or product acceptance. Statistical Quality Control includes techniques such as statistical sampling, PRE-control, and statistical process control.
		Ineffective control of precision measuring devices (for example, tools, scales, gauges, fixtures, instruments, and automated measuring machines) used in fabrication, special processing, inspection, test of detail parts, assemblies, and completed products to determine conformity to approved design.
		Lack of functions that provide for static, destructive, and functional tests of production products/parts thereof to ensure conformity to approved design.
		Ineffective methods of controlling, evaluating, and dispositioning of any product/part thereof that does not conform to approved design.
	Supplier Control	Ineffective methods by which the production facility ensures supplier materials, parts, and services conform to approved design. The term “supplier” includes distributors.