DANGEROUS GOODS PANEL (DGP)

THIRTIETH MEETING

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Agenda Item 4: Managing safety risks posed by the carriage of energy storage devices by air *(Ref: Job Card DGP.003.05)*

SYSTEMS THEORETIC PROCESS ANALYSIS (STPA) ON THE CARRAIGE OF LITHIUM BATTERY POWERED MOBILITY AIDS ON AIRCRAFT

(Presented by the Rapporteur of DGP TF/MA)

SUMMARY

This information paper presents a report of a systems theoretic process analysis (STPA) conducted by the Dangerous Goods Panel Task Force on Mobility Aids (DGP-TF/MA).

1. INTRODUCTION

1.1 The Dangerous Goods Panel (DGP) established a DGP Task Force on Mobility Aids (DGP-TF/MA) to conduct a safety risk assessment, identify possible mitigations, and develop policy options related to the carriage of lithium ion battery powered mobility aids. The group undertook an analysis utilizing the Systems Theoretic Process Analysis (STPA) method. The STPA method is a structured approach that assumes accidents are caused by unsafe interactions among system components. Unsafe actions can arise from a lack of control and missing or inadequate feedback among system components. These unsafe actions can lead to hazards that, if left uncontrolled, lead to losses such as injuries and damage to aircraft.

1.2 The STPA method involves four basic steps. The process starts from a stakeholder prioritized list of system losses and identifying high level hazards (system states) that can lead to those losses. The second step involves modelling the system as a set of control and feedback loops to identify functional relationships and interactions. The third step analyses the control structure to identify control actions and examine how they could lead to one or more of the losses. The fourth step involves constructing scenarios that describe why unsafe control actions could occur.

1.3 The working group assembled subject matter experts from air operations, aircraft design and manufacturing, and dangerous goods. The facilitator was a systems safety specialist from the ICAO Secretariat. Subject matter experts participated in a series of focused workshop sessions where they were asked to identify relevant interactions and scenarios that lead to unsafe actions. These scenarios ultimately informed the development of requirements. These requirements represent controls that manage unsafe behaviours. These controls were then plotted onto a 5x5 matrix that identified the relative strength of the control and the severity of the impact if the requirement was not met.

2. FINDINGS

2.1 The assessment identified several factors that impact the safe transport of passenger owned mobility aids, including weak communication controls between the passenger and the air operator, a lack of strong device design controls, inadequate diagnostic feedback from the mobility aid that limits the ability of a mobility aid user or air operator to determine whether the battery has been damaged, or whether the mobility aid is otherwise unsafe for transport. Inspections completed by air operators are generally cursory in nature and rely on information provided by passengers and sensory feedback. Further, many of the requirements identified in the Technical Instructions rely on physical inspections that are largely ineffective at identifying damage to the mobility aid battery. Additional controls regarding the stowage and handling of mobility aids are aimed at preventing external damage to the mobility aid and its battery(ies) once loaded on board the aircraft but do little to prevent stowing a damaged mobility aid.

2.2 Notably operator acceptance personnel lack the ability to identify the safety condition of a mobility aid or the battery(ies). While operators request information from passengers regarding the type of battery and the particulars of the mobility aid, workshop participants reported instances of missing information or passengers arriving at the airport without prior notification or approval by the operator.

2.3 Lithium ion battery powered mobility aids contain high energy batteries with relatively few controls governing product quality or compatibility in the air transport environment. The Technical Instructions require the lithium ion battery to meet certain requirements, however the airline passenger is often not able to obtain this information and the level of knowledge a passenger possesses about their mobility aid and its battery varies greatly. Workshop participants identified realistic scenarios in which a battery, while originally meeting the required tests and criteria, could have become damaged for example, from off nominal charging or operating the mobility aid outside of its designed parameters or replacing the battery with a different battery or one not originally intended for that device.

2.4 Operator acceptance procedures, while providing a potential opportunity to verify the safety of the battery or device, are largely inadequate to identify underlying damage since mobility aid designs often preclude a thorough physical examination of the battery. Passenger check-in staff and ground handling service personnel are often the last persons who see and handle a mobility aid, but they are not required or trained to inspect mobility aids for potential damage. Time pressures to load aircraft and facilitate passenger journeys were identified as factors that could lead to inadvertently accepting a damaged mobility aid / battery or a mobility aid with an unknown safety condition. Some workshop participants identified escalation procedures for visibly damaged mobility aids or mobility aids of an unknown condition, but specific training to identify and report damage is not typical.

2.5 Aircraft cargo compartments are equipped with smoke detectors or fire detection systems that give warning to the pilot or flight engineer who activate fire suppression systems in the cargo compartment. These mitigations rely on detection of a smoke or fire, and fire suppression systems currently utilized in aircraft cargo compartments have limited effectiveness against thermal events involving lithium batteries. Aircraft unit load devices provide protection and ease of handling, reducing the likelihood that the mobility aid is damaged during handling, stowage and transit; however some may not be capable of containing a thermal event should one occur and could impair early smoke and fire detection. Fire resistant containers and fire containment covers offer protection well above the capability of a typical aircraft unit load device. Some containers are available on the market now; however, there is no recognized performance standard for evaluation, and industry use of such containment devices is currently limited. Flight crews have access to fire extinguishers and are trained to respond to smoke and fire events in the aircraft cabin. Some workshop participants indicated they also use containment devices in the cabin such as specially designed boxes or bags to enhance fire-fighting/containment capabilities. The effectiveness of the equipment available to cabin crew to respond to a thermal event involving a battery powered mobility aid is however unknown.

2.6 Many of the existing controls rely on mitigations including inspection and verification at the point of acceptance, but these can fail to detect a damaged or poorly designed product. Inevitably these types of mitigations will have limited effect at controlling hazards. Robust design and testing standards that create safety through design throughout the product life are most effective at mitigating hazards. Enhancing the ability to identify a poorly designed or damaged product and thereby prevent its acceptance in air transport can partially mitigate known hazards. Finally, robust fire response and containment capabilities would lessen the severity of fire hazards.

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APPENDIX

THE STPA METHOD APPLIED TO BATTERY POWERED MOBILITY AIDS

1. STPA FRAMEWORK

Using the STPA framework the group analysed the air transport system of passenger owned battery powered mobility aids. The basic STPA method involves (4) four steps.

Define the purpose of the analysis

- Identify losses (injury or loss of life, aircraft or cargo, mission)
- Identify system-level hazards (fire, damaged batteries in transport)
- Identify system-level constraints

Model the control structure

- System model consisting of control-feedback loops
- Control structure enforces constraints across the system

Identify unsafe control actions

- Control action that in a particular context and worst-case environment, will lead to a hazard
- Identify the behaviors that should be prevented

Identify causal scenarios

- Why would Unsafe Control Actions occur?
- Why would control actions be improperly executed or not executed, leading to hazards?

2. DEFINE THE PURPOSE OF THE ANALYSIS

2.1 Identifying losses

2.1.1 For the purposes of this analysis, a loss involves something of value to stakeholders. The table below identifies the losses considered in this analysis and include injury and loss of human life property damage, damage to the environment, a loss of mission, and loss of reputation.

Loss ID	Loss description
L1	Loss or damage to the aircraft
L2	Loss of human life or injury

Loss ID	Loss description
L3	Loss of cargo/mobility aid
L4	Damage to environment or objects outside of the aircraft
L5	Loss of transportation i.e. inability to start or complete a scheduled flight or transport a passenger
L6	Loss of customer loyalty/loss of confidence in air travel

2.2 **System Hazards**

2.2.1 Hazards are developed by linking losses to a set of conditions that combined with a worst-case environmental condition could lead to a loss. This does not necessarily guarantee that a hazard will always result in a loss. System level hazards here are restricted to those which can be controlled or managed by controllers within the system. The goal of the analysis is to eliminate or mitigate hazards that can lead to losses.

System hazard ID	Hazard description	Loss link
H1	Aircraft integrity is lost	L1-L6
H2	Aircraft environment unsuitable for persons	L1, L2, L3, L5, L6
H3	Aircraft cargo/baggage exposed to hazardous conditions (excessive heat, fire, smoke)	L3, L5, L6
H4	Aircraft improperly loaded i.e. unauthorized cargo, improper weight, or balance	L3, L5, L6
H5	Aircraft unable to accommodate passenger	L5, L6

3. **MODELLING THE SYSTEM**

3.1 An analysis of the whole air transport system inclusive of international organizations, national aviation authorities, air operators, airports, aircraft manufacturers, airline passengers, mobility aids (and the associated batteries) is needed for a comprehensive analysis. For the purposes of this analysis the air transport system for battery powered mobility aids was limited to the air operators (inclusive of management, pilots, ground handling agents, passenger handling staff, flight crew), airline passengers, mobility aids, and the aircraft itself.

3.2 The group constructed several models to of the transport system composed of a control structure that identify control and feedback loops. Each control structure contains the following elements:

a) controllers;

b) control actions;

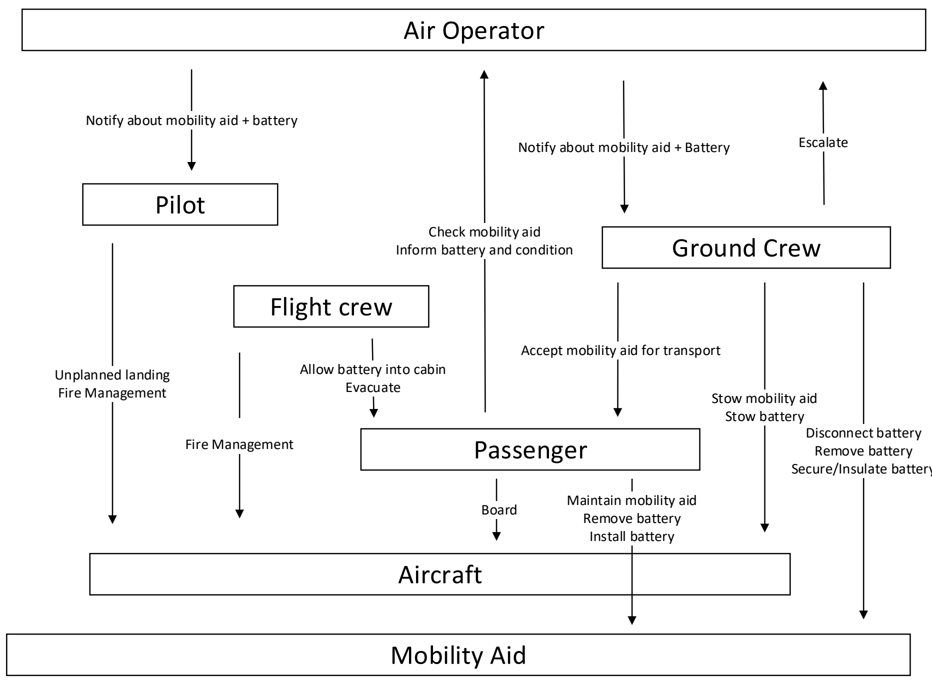
c) feedback;

d) other inputs to and outputs from components (neither control nor feedback); and

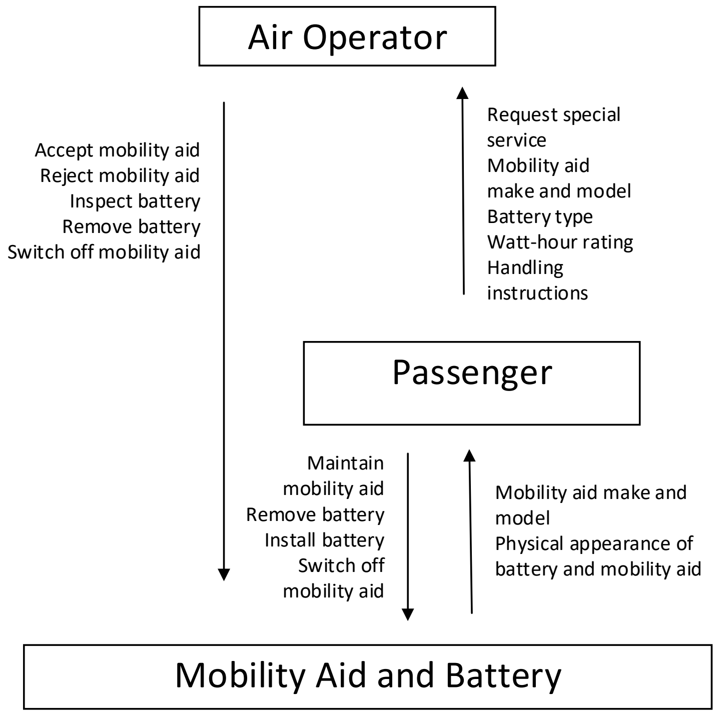
e) controlled processes.

3.3 Each controller in the system has certain responsibilities depicted as downward facing arrows. These responsibilities enforce safety constraints to prevent system level hazards. Feedback from the system is depicted as upward facing arrows. Air operators, airline passengers and mobility aids are the primary system components. Operators have control over personnel including the handling and placement of mobility aids, baggage, cargo, and mail on the aircraft within the constraints of regulation and procedures. Airline passengers exert control over the mobility aid through use, handling, maintenance, and modification. Both airline passengers and the mobility aids provide feedback to the air operator to enable them to complete control actions. The following figures illustrate a high-level control structure, and the various interactions examined by working group participants.

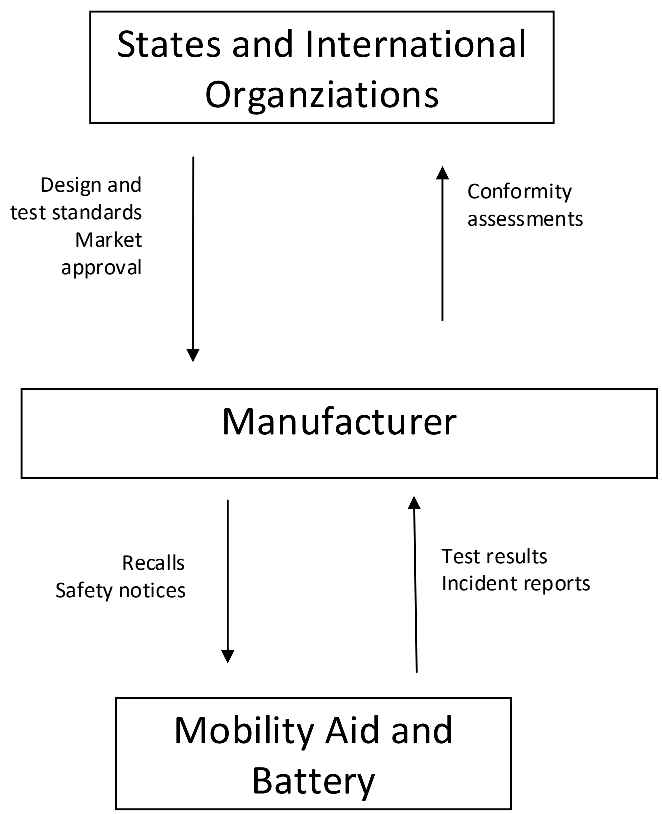
Air Operators



Passenger and Air Operator Interactions



Manufacturing



4. IDENTIFYING UNSAFE CONTROL ACTIONS (UCA)

4.1 Now that the actions and feedback through the control loops are defined, it is possible to identify potentially unsafe control actions. Unsafe control actions are linked to hazards. There are four ways a control action can be unsafe:

a) not providing the control action leads to a hazard;

b) providing the control action leads to a hazard;

c) providing a potentially safe control action but too early, too late, or in the wrong order; and

d) the control action lasts too long or is stopped too soon (for continuous control actions, not discrete ones).

It must be noted that an unsafe control action by itself does not always lead to a hazardous state. It may in fact require multiple unsafe control actions to occur to result in a hazardous state that in the worst case set of circumstances leads to a loss. The following table includes several examples of unsafe control actions reviewed by working group participants. The items in red were selected for addition review due to the safety critical nature of these unsafe control actions.

Control Action	**Not providing causes a hazard**	**Providing causes a hazard**	**Too early, too late, out of order**	**Stopped too soon, applied too long**
Accept Mobility Aid	GHSP/assenger handling staff does not accept mobility aid for transport (H6)	GHSP/passenger handling staff accepts a mobility aid with a high-risk energy source with an unknown safety condition (H1-H6) GHSP/passenger handling staff accepts a mobility aid containing an unstable energy source (H1-H6) GHSP/passenger handling staff accepts a mobility aid with an energy source different from the mobility aid identified during the booking (H4-H6) GHSP/passenger handling staff	GHSP/passenger handling staff accepts a mobility aid too late after aircraft has departed (H6)	

Control Action	Not providing causes a hazard	Providing causes a hazard	Too early, too late, out of order	Stopped too soon, applied too long
		accepts a mobility aid energy source for carriage in the cabin that exceeds fire capabilities		
Stow Mobility Aid	GHSP does not stow mobility aid when the mobility aid was accepted for transport (H5, H7)	GHSP stows the mobility aid in a manner that violates aircraft weight and balance requirements (H1, H5, H6) GHSP stows the mobility aid with a high-risk energy source with an unknown safety condition (H1, H4, H6) GHSP stows the mobility aid with a high-risk energy source that exceeds (or is not compatible with) the capabilities of fire suppression systems (H1, H4, H6) GHSP stows the mobility aid in a manner that risks damage (H1, H2, H4)		

Control Action	Not providing causes a hazard	Providing causes a hazard	Too early, too late, out of order	Stopped too soon, applied too long
Maintain mobility aid	Airline passenger does not properly maintain mobility aid creating an unknown safety condition (H1-H6)	Airline passenger maintains the mobility aid with an energy source from a source other than the original equipment manufacturer i.e. OEM spec. (H1-H6) Airline passenger maintains the mobility aid in a manner that creates an unknown safety condition (H1-H6) Airline passenger maintains a mobility aid in a condition in which the battery is not suitable for transport (H1-H6)		

5. IDENTIFYING CAUSAL SCENARIOS ASSOCIATED WITH UNSAFE CONTROL ACTIONS

5.1 The following table includes various contextualized scenarios that help explain why a particular controller provided or did not provide a control action. Generally, causal scenarios explain how incorrect or inadequate feedback, information exchange, and other factors create conditions that lead to hazardous states. The scenarios also explain how control actions when provided might not be received or improperly executed. Following development of causal scenarios, mitigation measures can be identified and discussed in view of whether measure(s) prevent, reduce, or mitigate unsafe control actions (UCAs) or the occurrence of unsafe causal scenarios that lead to system hazards. In this case the strength of mitigation measures could be ranked based on a hierarchy where controls that prevent the occurrence of an unsafe action through system design are especially powerful while those that rely on detection and warnings are less impactful.

Unsafe Control Action (UCA)	Causal Scenario Description	Potential Mitigation
GHSP/Passenger handling staff accepts a mobility aid with a high-risk energy source with an unknown safety condition (H1-H6)	GHSP loads a mobility aid onto an aircraft that has visible damage but incorrectly interprets the visible evidence of damage.	Establish visual inspection procedures to identify and report damage.
	GHSP loads a mobility aid onto an aircraft that has visible damage due to previous benign experience loading a mobility aid with similar damage.	Train GHSP to identify and report suspected damage to a mobility aid.
	GHSP loads a mobility aid onto an aircraft that has visible damage due to the threat of financial consequences (fines, delays etc.)	Incentivize the identification and reporting of safety related damage or modifications to mobility aids by acceptance staff and ground handling service providers
	GHSP loads a mobility aid onto an aircraft that has visible damage because it was assumed the mobility aid was determined acceptable for transport by another entity	Incentivize the identification and reporting of safety related damage or modifications to mobility aids by acceptance staff and ground handling service providers
	GHSP loads a mobility aid onto an aircraft that has visible damage due to task overload or inattention.	Train GHSP to identify and report suspected damage to a mobility aid.
	GHSP loads a mobility aid onto an aircraft that has visible damage because the GHSP did not believe it was necessary to inspect the mobility aid for damage.	Train GHSP to identify and report suspected damage to a mobility aid.
	GHSP loads a mobility aid that has visible tampering because the GHSP assumed this was an acceptable modification	Incentivize the identification and reporting of safety related damage or modifications to mobility aids by acceptance staff and ground handling service providers
GHSP/Passenger handling staff accepts a mobility aid containing an unstable energy source	GHSP/Passenger handling staff accepts a mobility aid containing an unstable energy source because the damage to the energy source was only visible when the mobility aid is collapsed, and the battery is visible.	Establish visual inspection procedures to identify and report damage.
	GHSP/Passenger handling staff accepts a mobility aid containing an unstable energy source because the GHSP misinterprets the special service request information	
	GHSP/Passenger handling staff accepts a mobility aid containing an unstable energy source because the GHSP misinterprets the STOP code because there are multiple reasons for the STOP code	
	GHSP/passenger handling staff accepts a mobility aid containing an unstable energy source because inputs indicating the mobility aid is unsafe are conflicting or not obvious to the acceptance staff.	

Unsafe Control Action (UCA)	Causal Scenario Description	Potential Mitigation
	GHSP/passenger handling staff accepts a mobility aid containing an unstable energy source because the booking agent did not request information on the mobility aid due to a lack of awareness, training, or procedure to request information about the mobility aid or energy source.	
GHSP stows the mobility aid in a manner that risks damage (H1, H2, H4)	GHSP uses baggage to secure the mobility aid.	
	GHSP secures the mobility aid before loading other baggage, cargo, and mail.	
	Mobility aid securing points were inaccessible after baggage was loaded.	
	Securement straps were overtightened.	
	Securement damages mobility aid controls.	
GHSP does not remove an unprotected battery (H1, H2, H4)	GHSP does not remove a battery because the GHSP does not know the battery needed to be removed (e.g. the mobility aid tag fell off)	
	The battery declared at ticketing and identified on the booking record is different than the mobility aid physically brought to the airport	
	Customer provided incomplete or misleading information at the time of booking due to a misunderstanding of the operator requirements	
	Booking agent misinterpreted information provided by passengers or incorrectly transmitted information to the passenger name record	
	Acceptance personnel received conflicting information on the mobility aid	
Passenger or GHSP does not switch off the mobility aid before the mobility aid is stowed	Passenger or GHSP does not switch off the mobility aid before the mobility aid is stowed because the passenger thought the aid was switched off	
	Passenger or GHSP does not switch off the mobility aid before the mobility aid is stowed because the passenger or GHSP misinterpreted or incorrectly performed the deactivation procedure.	
GHSP/passenger handling staff accepts a mobility aid energy source	GHSP/passenger handling staff accepts a mobility aid energy source for carriage in the cabin that exceeds the response capabilities due to stowage adjacent to other lithium batteries	

Unsafe Control Action (UCA)	Causal Scenario Description	Potential Mitigation
for carriage in the cabin that exceeds fire suppression capabilities	GHSP/passenger handling staff accepts a mobility aid energy source for carriage in the cabin that exceeds the response capabilities due to an alteration of the fire suppression capabilities or response equipment	
	GHSP/passenger handling staff accepts a mobility aid energy source for carriage in the cabin that exceeds the response capabilities because the fire suppression capabilities in the cabin were believed to be superior.	
	Airline passenger installed a battery with a non-OEM replacement.	Manufacturers take steps to minimize the likelihood that users will replace batteries with unapproved batteries or use chargers not designed for use with the device
Airline passenger does not properly maintain mobility aid creating an unknown safety condition (H1-H6)	Airline passenger does not remove a battery that was supposed to be removed.	
	Airline passenger is not the original owner of the mobility aid and does not have the knowledge of the energy source or maintenance history.	Manufacturers take steps to minimize the likelihood of that users will use chargers not designed for use with the device.
	Airline passenger overcharges a battery from an incompatible energy source.	
	Airline Passenger does not receive, ignores, or misinterprets error, maintenance, or diagnostic messages.	Manufacturers design devices to provide diagnostic information to users.
	The battery powered mobility aid fire was not detected.	Fires involving battery powered mobility aids must be detected, and measures taken to extinguish until the aircraft can safely land
Flight crew does not suppress a fire involving battery powered mobility aid	The flight crew does not have the necessary resources to extinguish a fire involving a battery powered mobility aid.	Fires involving battery powered mobility aids must be detected, and measures taken to extinguish until the aircraft can safely land
	The fire occurs in a location not accessible to the flight crew.	

6. STRENGTH OF CONTROLS AND SEVERITY OF IMPACT IF UNSAFE BEHAVIOR IS NOT CONTROLLED

6.1 Select unsafe control actions identified in paragraph 5 were translated into requirements. These requirements were further plotted against the matrix shown below that identifies both the strength of the control i.e. how effective the control mitigates unsafe actions, and the severity of the impact if the unsafe behaviour is not controlled.

Strength of control			Severity of Impact if Uncontrolled				
			1 Very Low	2 Low	3 Moderate	4 High	5 Critical
Strength of control	Weak or non-existent	5	**Very Low**	**Low**	**Moderate**	**High**	**Critical**
	Marginally Adequate *Warning signs/detection*	4	**Very Low**	**Low**	**Moderate**	**High**	**Critical**
	Adequate *Engineered features or devices*	3	**Very Low**	**Very Low**	**Low**	**Moderate**	**High**
	Reasonably strong *Reduces risk through design alteration*	2	**Very Low**	**Very Low**	**Low**	**Moderate**	**Moderate**
	Strong *Eliminates Risk through design*	1	**Very Low**	**Very Low**	**Low**	**Low**	**Moderate**

UCA: Air Operator accepts for transport a battery powered mobility aid with a battery that is thermally or electrically unstable (H1-H5)

Requirement	**Strength of control**	**Severity of impact if uncontrolled**	**Category**	**Coverage (Full, Partial, None, Uncertain)**
The operator must validate the acceptability of a battery powered mobility aid.	4	5	**Critical**	Partial - Operators obtain information of the mobility aid make, model and battery type during ticketing process and may validate that information at passenger check-in. Working group participants indicated that this validation step is not always taken.

Requirement	Strength of control	Severity of impact if uncontrolled	Category	Coverage (Full, Partial, None, Uncertain)
The operator must validate the acceptability of spare batteries for a battery powered mobility aid.	4	5	Critical	Partial - Technical Instructions 7;2.13.3 require the operator to verify that spare batteries are carried in the cabin and protected from damage and short circuit. However, there is no requirement to inspect batteries for damage.
The operator must have a means to collect mobility aid information from the passenger.	4	5	Critical	Partial - Passengers are encouraged to make advanced arrangements with each operator and provide information on the type of battery installed and on the handling of the mobility aid. Technical Instructions 8-1, Regulation (EC) No 1107/2006/14 CFR 382.27.
The operator must have the capability to assess and validate information on the battery powered mobility aid provided by airline passengers.	4	4	High	Partial - Technical Instructions require the operator to verify that terminals are protected from short circuits and the battery is either protected from damage by the design of the mobility aid and securely attached to the mobility aid or the battery is removed from the mobility aid following the manufacturer's instructions.
If the operator accepts for transport a battery powered mobility aid containing an energy source with an unknown safety condition that mobility aid must not be stowed onto the aircraft.	4	5	Critical	Partial - After acceptance the mobility aid may become damaged, or an inspection may not have been completed prior to acceptance. However, if damage is identified there are rules in the Technical Instructions 7;2.5 requiring the operator to remove from the aircraft.

UCA: GHSP stowed a mobility aid containing a damaged or unstable energy source. (H1-H5)

Requirement	**Strength of control**	**Severity of impact if uncontrolled**	**Category**	**Coverage (Full, Partial, None, Uncertain)**
The service provided must have processes and procedures in place to recognize a mobility aid with a damaged or unstable energy source and prevent them from being stowed when they are discovered.	4	5	Critical	Partial - No requirements to inspect a mobility aid for damage. However, if damage is identified there are rules in the Technical Instructions 7;2.5 requiring the operator to remove from the aircraft.
All personnel involved in the handling of battery powered mobility aids must examine and identify potential damage to battery powered mobility aids during each change of custody.	4	5	Critical	Partial - While the Technical Instructions require the operator verify the battery terminals are protected against short circuit and the battery is protected against damage. The battery may become damaged after initial inspection but prior to loading. Damage must be identified.
All personnel involved in the handling of battery powered mobility aids must examine and report damage to the battery.	4	5	Critical	Partial - If damage is identified there rules in the Technical Instructions 7;2.5 requiring the operator to remove from the aircraft.

Requirement	Strength of control	Severity of impact if uncontrolled	Category	Coverage (Full, Partial, None, Uncertain)
If ground handling service provider stowed a battery powered mobility aid containing a damaged or unstable energy source there must be a means to detect and suppress a thermal event.	4	5	**Critical**	Partial - Halon fire suppression systems have limited effectiveness against lithium ion battery fires. Detection of a fire may be delayed due to stowage conditions e.g. placement inside of a unit load device. 1) Aircraft cargo compartments are equipped with an approved smoke detector or fire detector system to give warning at the pilot or flight engineer station. 2) There is an approved built-in fire-extinguishing system controllable from the pilot or flight engineer stations. 3) There are means to exclude hazardous quantities of smoke, flames, or extinguishing agent, from any compartment occupied by the crew or passengers. 4) There are means to control ventilation and drafts within the compartment so that the extinguishing agent used can control any fire that may start within the compartment.

UCA: GHSP stows the mobility aid in a manner that risks damage (H1-H4)

Requirement	Strength of control	Severity of impact if uncontrolled	Category	Coverage (Full, Partial, None, Uncertain)
Battery powered mobility aids must be stowed in a manner that prevents damage to the energy source.	3	5	**High**	Full - ICAO Technical Instructions 7; 2.13.3.1
Baggage, cargo, and mail must not damage the battery powered mobility aid energy source.	3	5	**High**	Full - ICAO Technical Instructions 7; 2.13.3.1
Battery powered mobility aids must be stowed in a manner to prevent inadvertent activation.	3	4	**Moderate**	None - The Technical Instructions do not require mobility aids to be stowed in a manner that prevents inadvertent activation.
Battery powered mobility aids must be stowed in a manner to prevent excessive movement.	3	4	**Moderate**	Partial - Technical Instructions 7;2.4.2 have a general requirement to secure dangerous goods in the aircraft in a manner that will prevent any movement. Technical Instructions 7; 2.13.3.1 requires the operator to secure the mobility aid.
Batteries removed from a mobility aid must be protected from damage and short circuit and stowed in the cabin.	4	4	**High**	Full - Technical Instructions 7;2.13.3.3.
Spare batteries must be protected from damage and short circuit and stowed in the cabin	4	4	**High**	Full - Technical Instructions 7;2.13.3.3.
Battery powered mobility aids must be switched off prior to stowage.	3	4	**Moderate**	None - The Technical Instructions do not require mobility aids to be switched off prior to stowage.

UCA: GHSP/passenger handling staff accepts a mobility aid energy source for carriage that exceeds aircraft fire suppression capabilities. (H1-H4)

Requirement	Strength of control	Severity of impact if uncontrolled	Category	Coverage (Full, Partial, None, Uncertain)
Aircraft cargo compartment fire suppression systems must suppress a fire event involving a battery powered mobility aid. Four configurations: a) Battery powered mobility aid stowed directly into the cargo compartment. b) Battery powered mobility aid loaded into a conventional aircraft unit load device. c) Battery powered mobility aid loaded into a fire-resistant container unit load device. d) Battery powered mobility aid enclosed by a fire containment cover.	4	5	**Critical**	Partial – a), b) Halon fire suppression systems have limited effectiveness against lithium ion battery fires. Detection of a fire may be delayed due to stowage conditions e.g. placement inside of a unit load device. c) Fire resistant containers offer superior ability to contain a thermal event relative to conventional unit load devices. Currently there is no recognized performance standard for evaluation. Effectiveness may be substantially reduced if the container is improperly closed. d) Fire containment covers utilized for palletized cargo may offer protection but their application to mobility aids is currently unknown.
Cabin crew must suppress fires involving battery powered mobility aid energy sources.	4	5	**Critical**	Partial - Fire suppression systems have limited effectiveness against a lithium ion battery fire. The larger batteries used in mobility aids may exceed fire suppression capabilities.

Requirement	Strength of control	Severity of impact if uncontrolled	Category	Coverage (Full, Partial, None, Uncertain)
If a mobility aid with an energy source that exceeds the aircraft fire suppression capabilities is accepted the flight crew must know the location of battery powered mobility aids.	4	3	**Moderate**	Full - The operator must inform the pilot in command of the location of any mobility aids with installed lithium ion batteries, removed batteries, and spare batteries.

UCA: Airline passenger does not properly maintain a battery powered mobility aid creating an unknown safety condition (H1-H5)

Requirement	Strength of control	Severity of impact if uncontrolled	Category	Coverage (Full, Partial, None, Uncertain)
Airline passengers must maintain battery powered mobility aids in accordance with manufacturer instructions.	4	3	**Moderate**	Partial - Outside of the scope of the Technical Instructions. If damage is identified there are rules in the Technical Instructions 7;2.5 requiring the operator to remove from the aircraft.
Battery powered mobility aids must only contain an energy source designed for the device.	3	4	**Moderate**	Partial - Technical Instructions 8-1 requires the battery to be of a type which meets UN Manual of Tests and Criteria Part III, Section 38.3.
Battery powered mobility aids must provide diagnostic information to ensure acceptability for transport.	4	4	**High**	None - Outside of the scope of the Technical Instructions.

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