



International Coordinating Council of Aerospace Industries Associations

International Federation of Airline Pilots Association

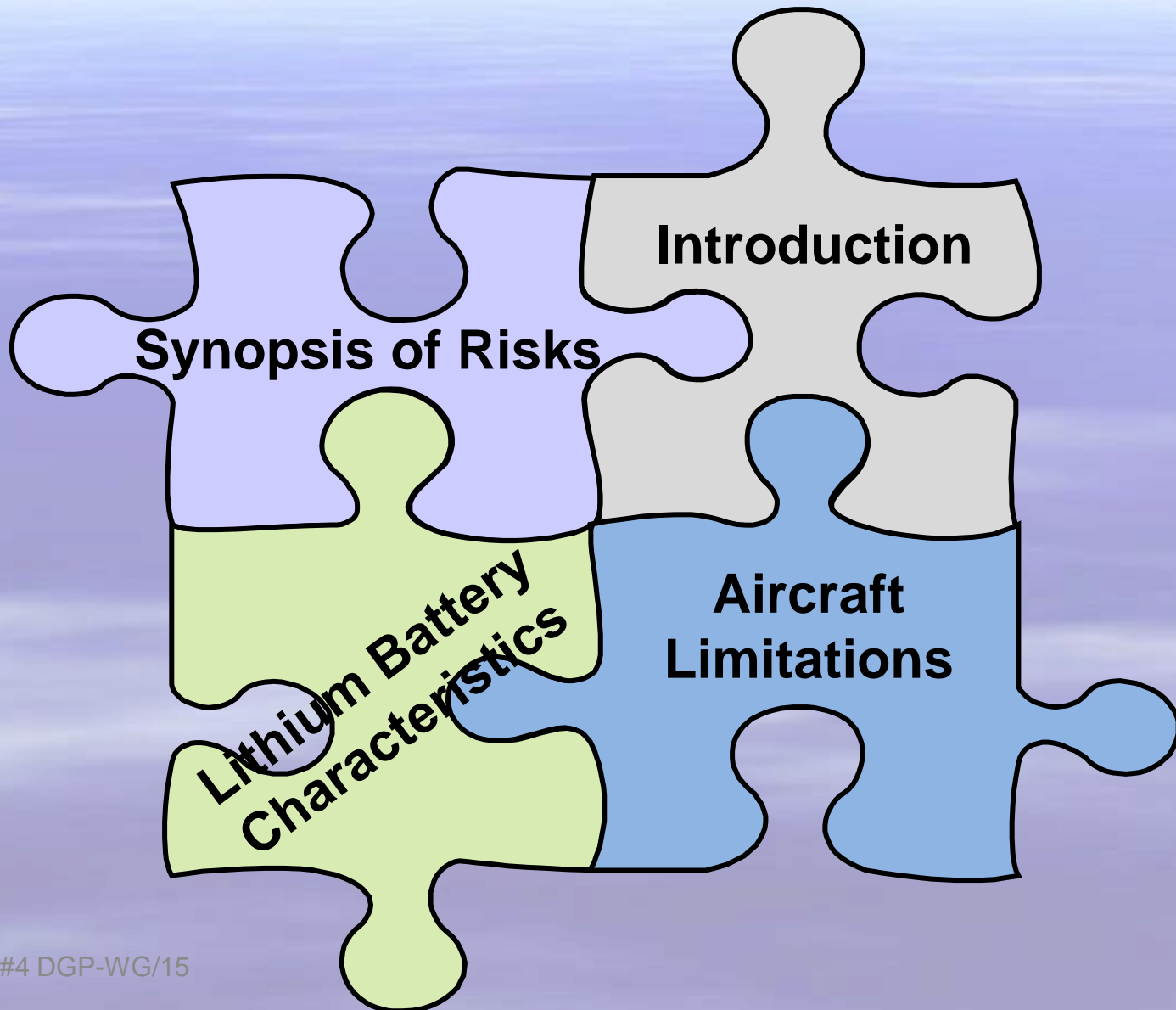


# Transport of Lithium Batteries as Cargo via Air

Presented by ICCAIA and IFALPA

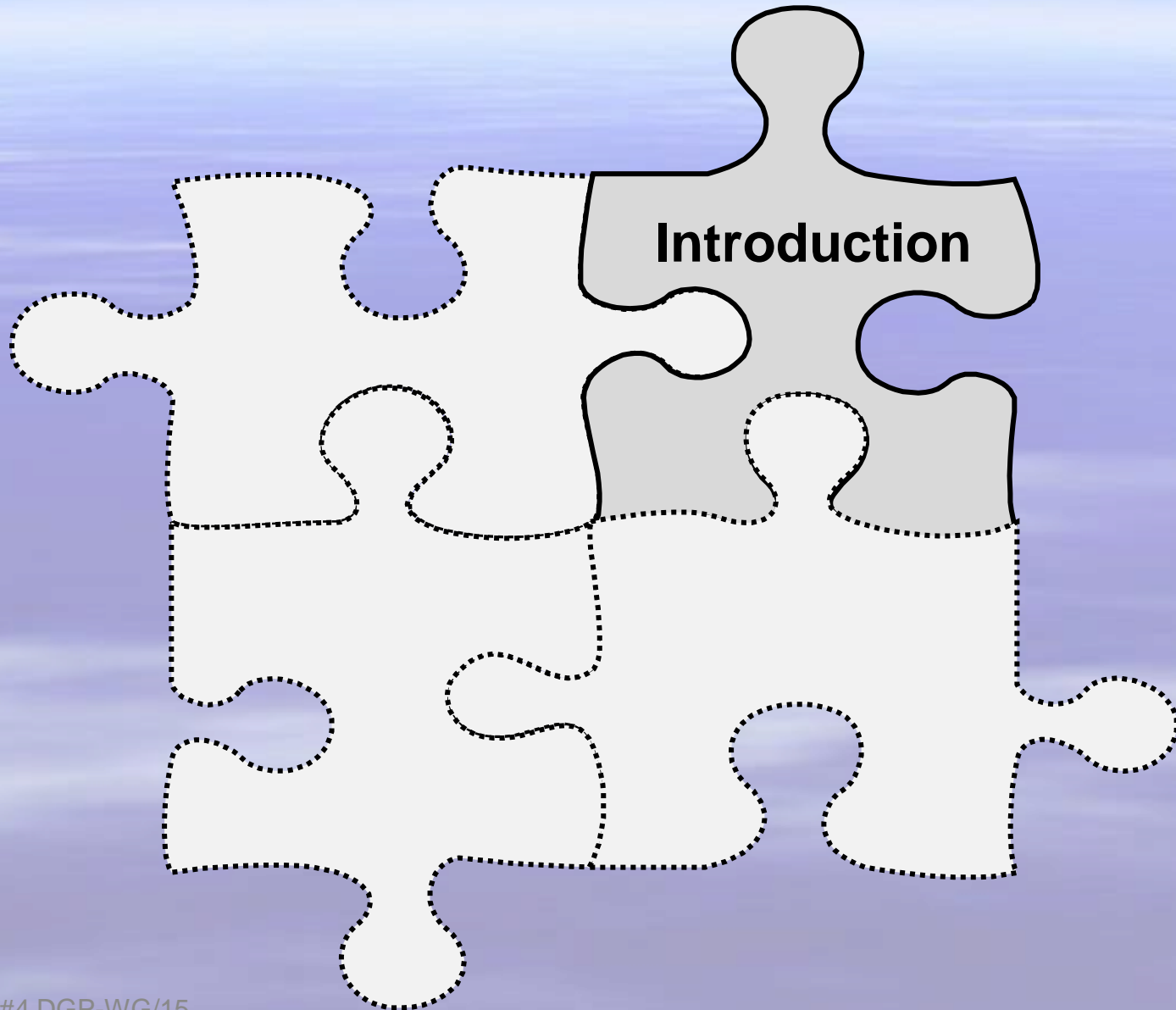


# Scope of Presentation





# Scope of Presentation





## Introduction / Summary

The ICAO Dangerous Goods Panel asked the International Coordination Council for Aerospace Industry Association (ICCAIA) for their expertise with respect to cargo compartment fire protection capability, especially related to carriage of lithium batteries as cargo.

This presentation will provide ICCAIA's perspective on those questions and explain ICCAIA's and IFALPA's conclusions and recommendations in WP/4.

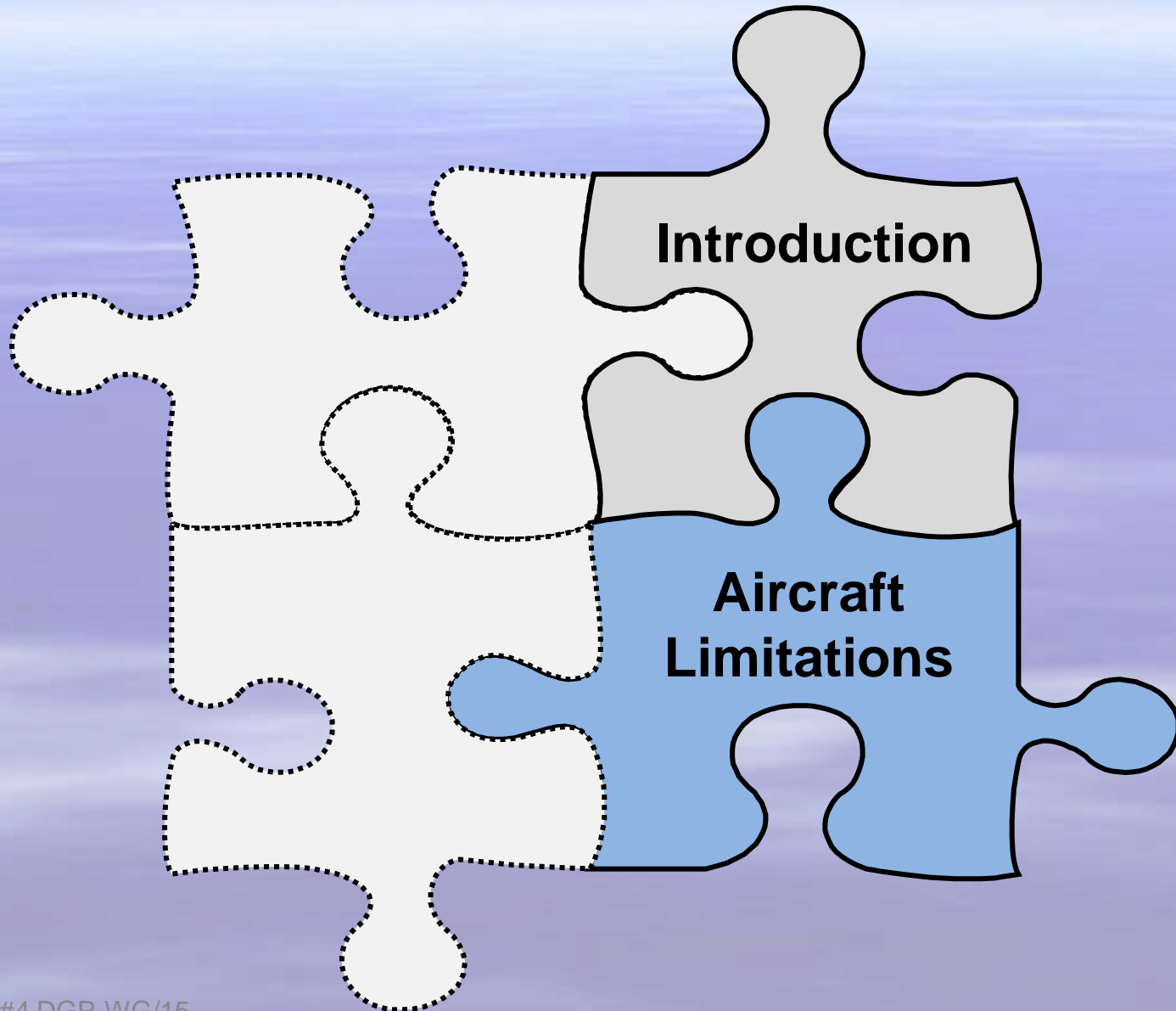


## Where are we Today

- The transport of lithium batteries via air has become a significant part of the logistic chain. There were 4.3 billion lithium ion batteries produced in 2013.
- After three aircraft accidents caused by cargo compartment fires, significant quantities of lithium batteries as cargo on those and other flights, and separate occurrences of lithium battery thermal runaways at different stages of the transport process not in flight, the failure case and the consequences of a lithium battery thermal runaway need to be considered.
- Investigations have shown that the cargo compartment fire protection standards described in CS/FAR25 are not sufficient to protect the aircraft from fires involving high density shipments of lithium metal batteries being shipped in compliance with the ICAO DGP Technical Instructions.
- The transport of lithium metal batteries as cargo has been prohibited on passenger aircraft since January 2015
- **Further investigations have shown similar hazards for the transport of high density shipments of lithium ion batteries.**



## Scope of Presentation





# Aircraft Cargo Compartment

## Fire Protection Definition

- Around 40 years ago the current design regulations CS/FAR 25.857 were developed to protect the aircraft for the duration of flight from fires which were likely to occur in cargo compartments.
  - Mainly class A fire loads: combustible materials such as wood, cloth, paper, rubber, and plastics.
- Some unique hazards from dangerous goods, especially fires involving lithium batteries, are not considered within the current aircraft design standards.
  - Mitigations for the hazards from Dangerous Goods are specified and regulated by the dangerous goods regulations ICAO Annex 18 and the operational regulations ICAO Annex 6



# Cargo Compartments Fire Protection Means

- Protecting an aircraft cargo against fire considers three areas:
  1. Prevention by regulating the load and condition of transport.
  2. Protecting the outside of the compartment from internal hazards created by fire → E.G. heat and fumes/smoke.
  3. Controlling the fire in the compartment through a combination of active and passive means.
- Class C & E cargo compartments have different protection mechanisms

Lower Deck "Class C" Cargo Compartment



Passive protection:

- Full protection ← →
- Essential system only ← →
- Smoke barrier ← →

Active protection:

- Smoke/fire detection ← →
- Ventilation Shutoff ← →
- Fire suppression system ← →

Main Deck "Class E" Cargo Compartment





# Passive and Active Protection

## Design Standards

### Passive Protection

- Class C cargo lining and Class E cargo shielding qualified against flame penetration test Part III Appendix F (CS/FAR 25):
  - $T_{\max}$  927°C (1700°F) - Temp above panel < 205°C @ 102mm, for 5 mins
  - 5 min requirement based on assumption that after this time fire will be under control.

### Active Protection

- Class C compartment Fire suppression system:
  - Designed to control fire from 60 → 360 minutes (aircraft specific)
  - Designed for compartment specific leakage rate.
  - Agent is Halon 1301: Design concentrations of 5% initial / 3% suppression designed for fire loads that are likely to occur.
- Class E suppression based on procedure for oxygen starvation.



# Smoke Barriers and Rapid Decompression Design Standards

## Smoke Barrier

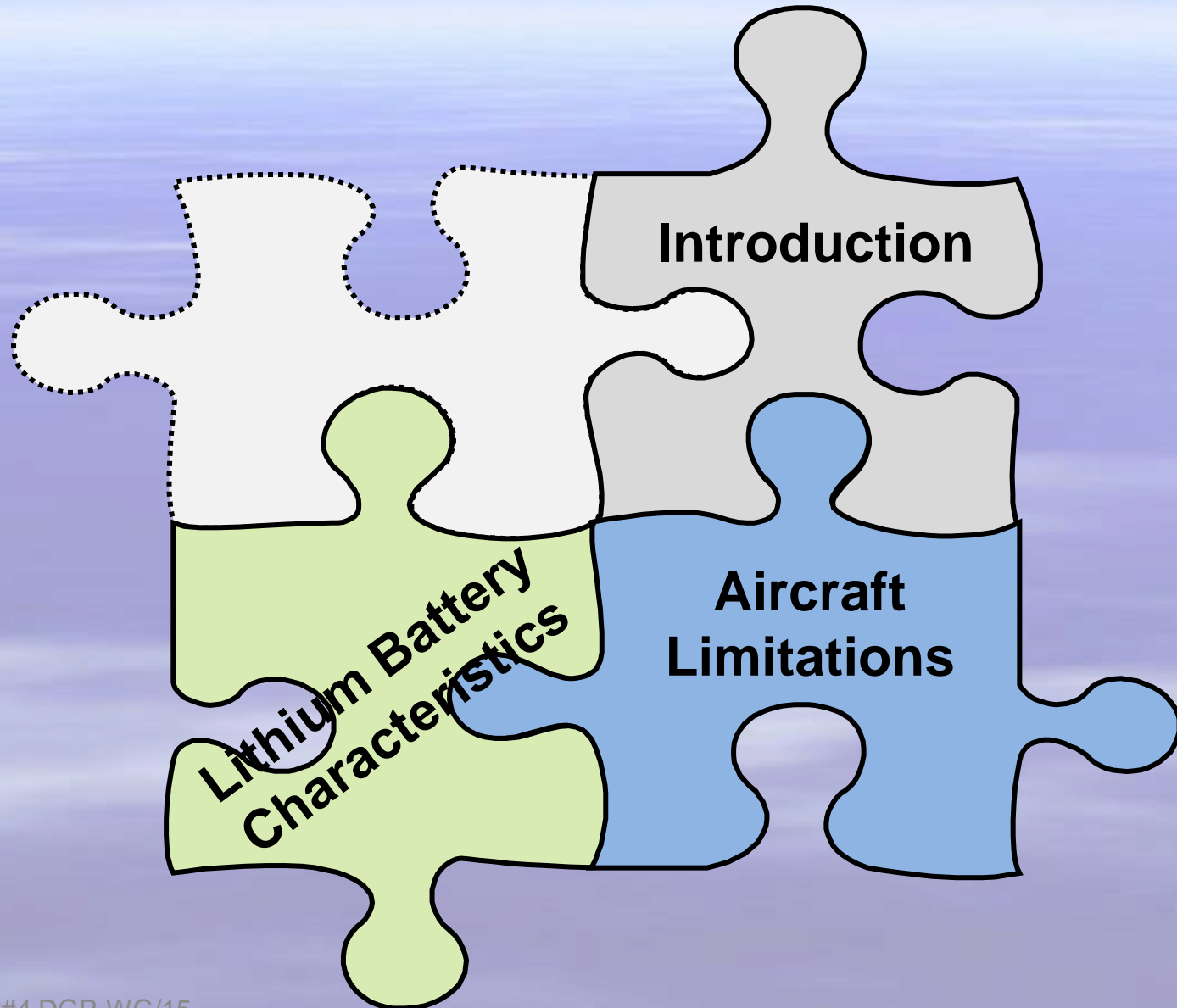
- Protects occupied areas against hazardous quantity of fumes and smoke from typical cargo compartments fires.
- Uses passive barriers and active air control functions.
  - Verified by test AC 25-9A

## Rapid Decompression Features

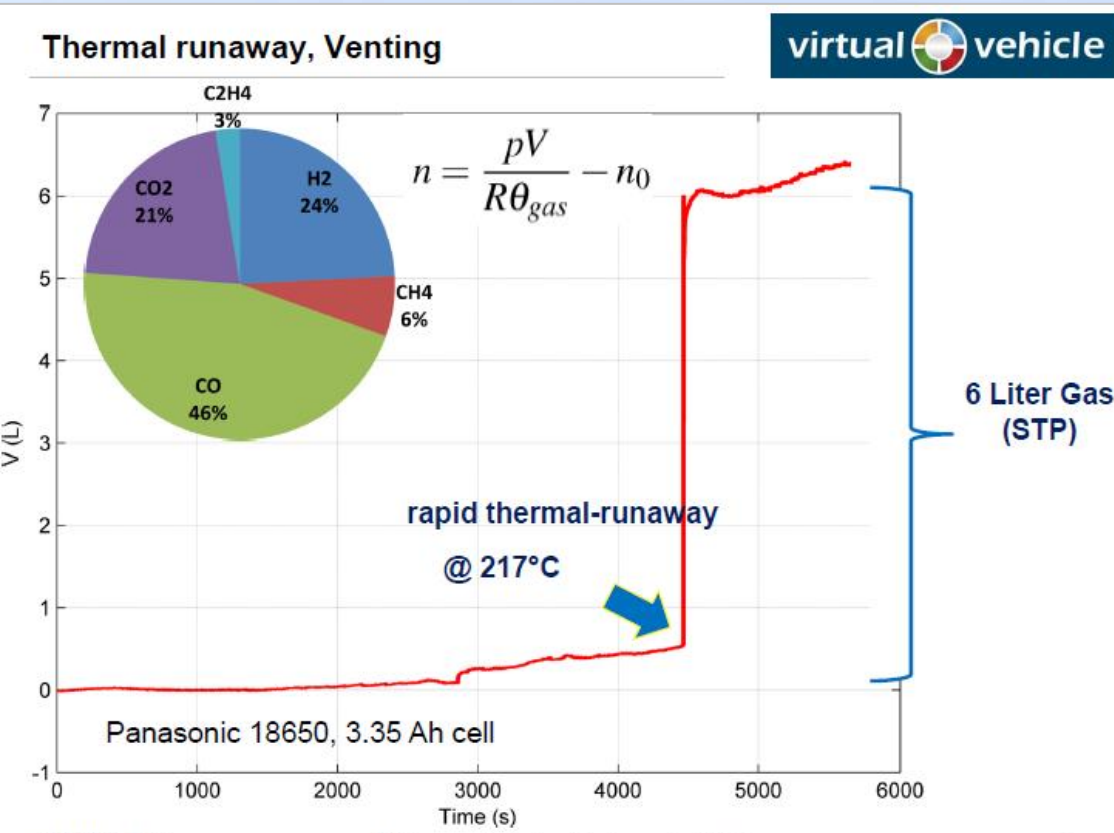
- Allow pressure equalization in event of rapid depressurization.
- Class C cargo compartments are equipped with panels or other features that open at a specific pressure differential.



## Scope of Presentation



# Lithium Battery Characteristics

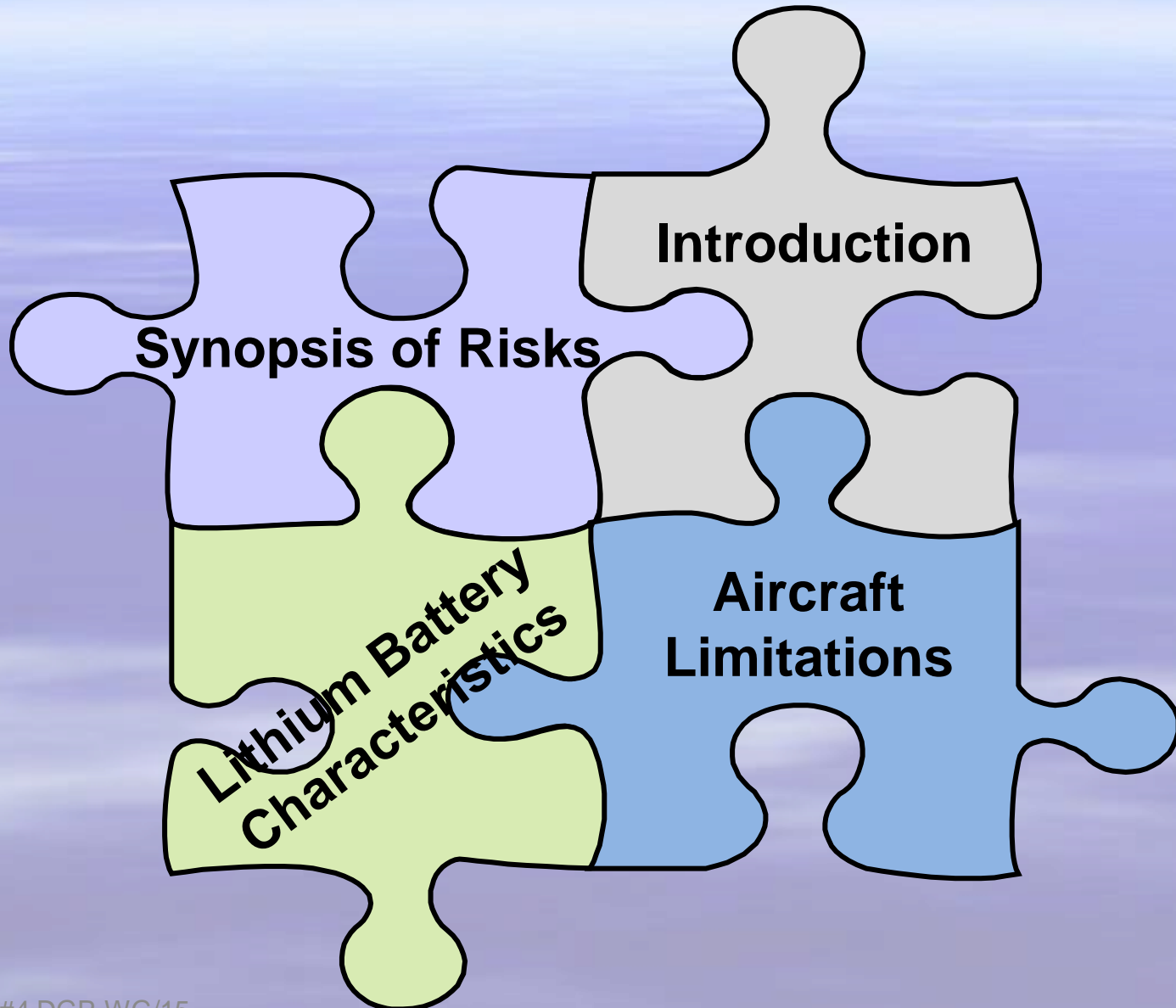


- It has been shown that the quantity of heat, smoke and fumes produced by a lithium battery fire is significantly greater than that produced by a fire involving general cargo.
- Furthermore as thermal runaway progresses throughout the packages of batteries in the compartment, the fume and smoke production rate continues to increase.

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## Scope of Presentation





## Synopsis of Issue:

# Lithium Battery and Existing Designs

- In considering aircraft safety, Lithium battery fire characteristics need to be considered in conjunction with the capabilities of current cargo compartment design & fire protection features.
  - Existing cargo compartment fire protection systems certified to FAR/CS 25.857 are unable to control a fire involving high density shipments of lithium batteries.
  - Preventing propagation of thermal runaway from batteries in one package to batteries in adjacent packages is a basic necessity for adequately controlling the effects of a fire involving lithium batteries.



## Definition of High Density of Lithium Batteries

ICCAIA would like to assist the Panel members to find a way to allow operators to safely carry lithium-ion and lithium metal batteries:

“High density” describes a quantity of lithium battery accumulation which has the potential to overwhelm the cargo compartment fire protection features.

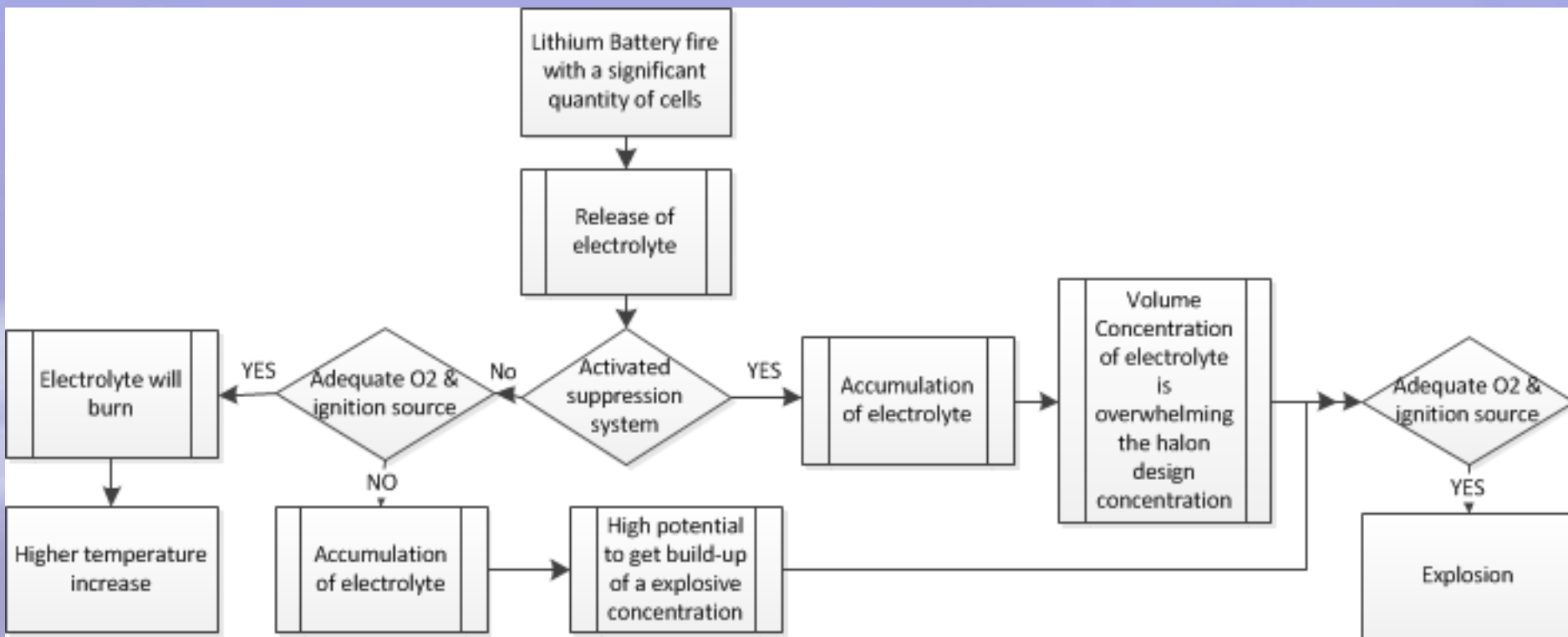
- The impact of different characteristics of the batteries, cargo compartments, and loading configurations make it very difficult to define a quantity limitation that is applicable at the aircraft level for all situations.
- Tests have demonstrated some configurations with accumulations of packages, each containing less than 5kg of 18650 lithium ion batteries, have the potential to lead to significant damage of an aircraft.



## Synopsis of issue:

# Lithium Battery Fire and Cargo Compartments

- It has been demonstrated that Halon 1301 is not able to interrupt a lithium battery thermal runaway nor the propagation from one cell to the next.
  - But it is able to suppress a fire fueled by burning electrolyte from a battery.
- The current design concentration of Halon is not able to prevent an explosion of a high quantity of accumulated electrolyte fumes.

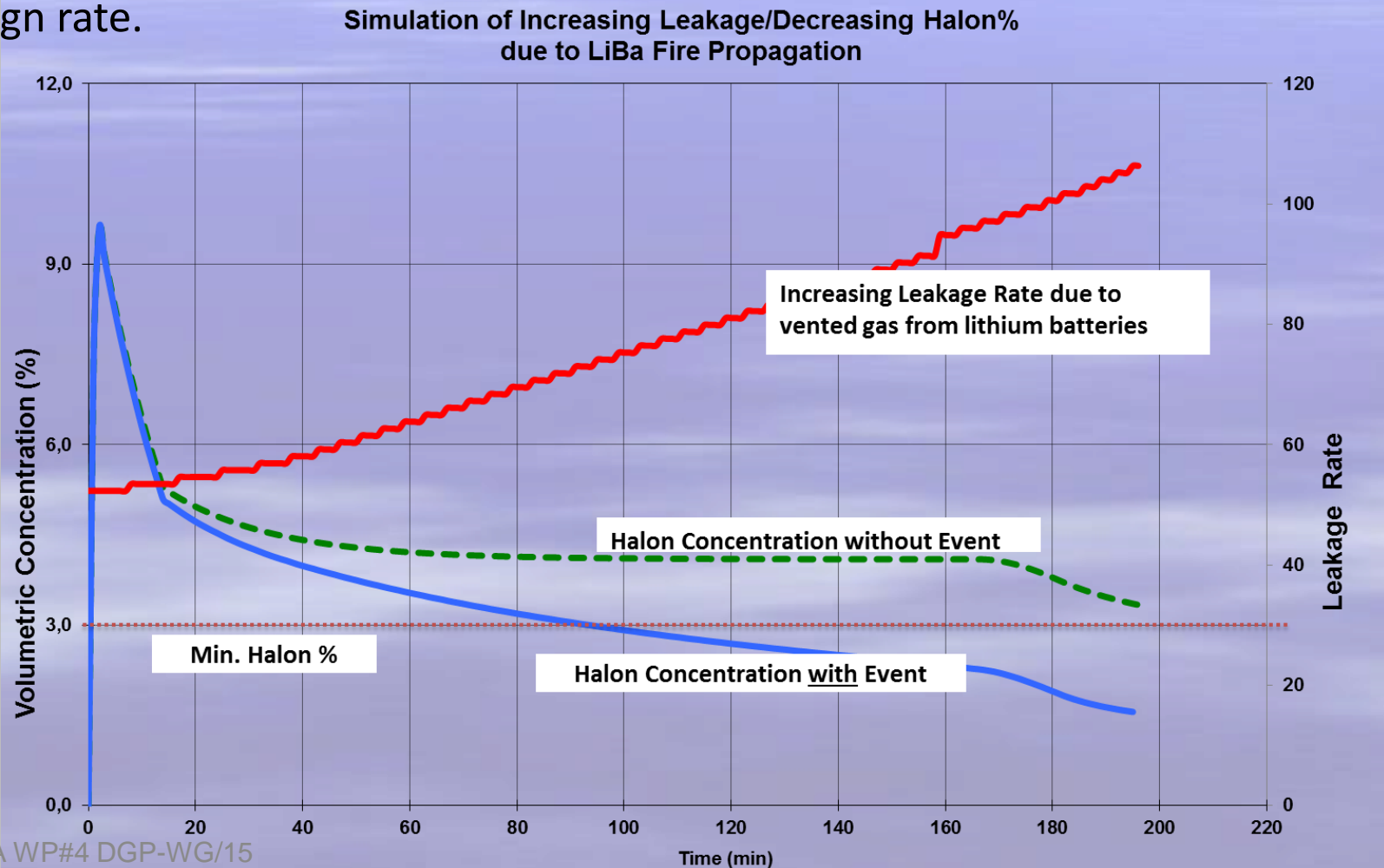




## Synopsis of issue:

# Lithium Battery Fire and Class C Compartments

- Considering only the quantity of electrolyte vapor released during a propagation process, the vapor contribution will overcome the specific leakage design rate.





## Synopsis of Issue:

### Lithium Battery and Existing Designs

- ICAO DGP regulations for transport of lithium batteries were not intended to control or to contain a fire within required packaging.
  - Flame and gases from a fire are not prevented from exiting the package .
  - Protection from an external ignition or heat source is not provided.
  - Propagation of fire from one package to adjacent package is not prevented, even with compartment fire suppression.
  - The quantity of lithium batteries in a compartment is unrestricted.
- Several characteristics of a lithium battery fire have the potential to defeat the aircraft cargo compartment fire protection system.



# Limitations of Protection Means to Lithium Battery Fire

## Passive Protection

- A fire involving a high density of lithium batteries will exceed a temperature of 927°C
- Heat release rate will exceed design targets over time

## Halon 1301

- Not able to stop a thermal runaway or propagation from one cell to next
- The required Halon concentration could be overwhelmed before the end of flight.

## Overpressure Protection

- An overpressure event due to ignition of accumulated flammable vapors will result in opening designed pressure relief features that could feed and spread the fire.

## Smoke/Fumes Barrier

- Quantity of smoke/fumes produced is significantly higher than those resulting from general cargo.
- Continued increasing production of smoke/fumes overwhelming the design features could impact aircraft occupants.

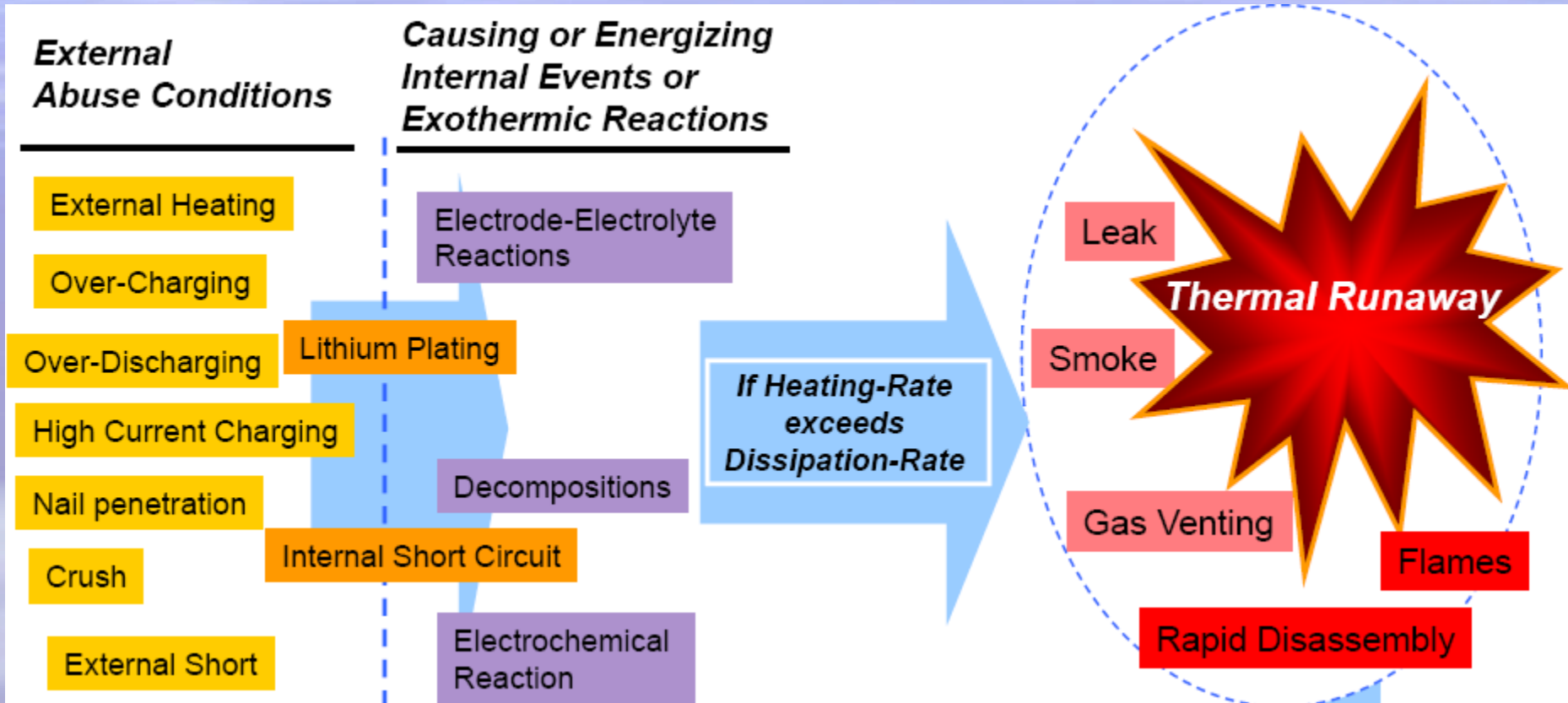


## Conclusion

- The known and unknown risks associated with transporting lithium batteries by air, coupled with the knowledge that the volume of such cargo is continually increasing, requires action to be taken.
- ICCAIA recommends that appropriate packaging and shipping requirements be established to safely ship lithium ion batteries as cargo on aircraft and that high density packages of lithium ion batteries and cells (such as defined by UN3480) not be transported as cargo on passenger aircraft until such time as safer methods of transport are established and followed.
- It is further recommended that appropriate packaging and shipping requirements are established to more safely ship lithium metal and lithium ion batteries as cargo on freighter aircraft



# Appendix





# Appendix

## NFPA 12A Standard

**Table 5.4.1.1.1 Halon 1301 Design Concentrations for Inerting**

<b>Fuel</b>	<b>Minimum Conc. % by Volume<sup>1</sup></b>
Acetone	7.6
Benzene	5.0
Ethanol	11.1
Ethylene	13.2
Hydrogen	31.4
Methane	7.7
n-Heptane	6.9
Propane	6.7

