

SMS Future Perspectives: How Can STAMP Support Safety Management Frameworks and Efforts

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What's next to evolve Safety Management in our industry?

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Safety Management maturity through addressing Complexity and context



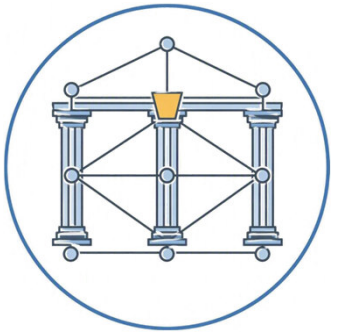
Mindset, understanding of the world

Mechanistic view of the world

Linear causality/component failure

Systemic view of the world

Loop structures/component interactions



Supportive framework to apply new methods and ways of thinking

From focus on Operational safety.

To Focus on system lifecycle (Design), emphasis on control and emergent properties.

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How do we design systems within Aviation Organization?

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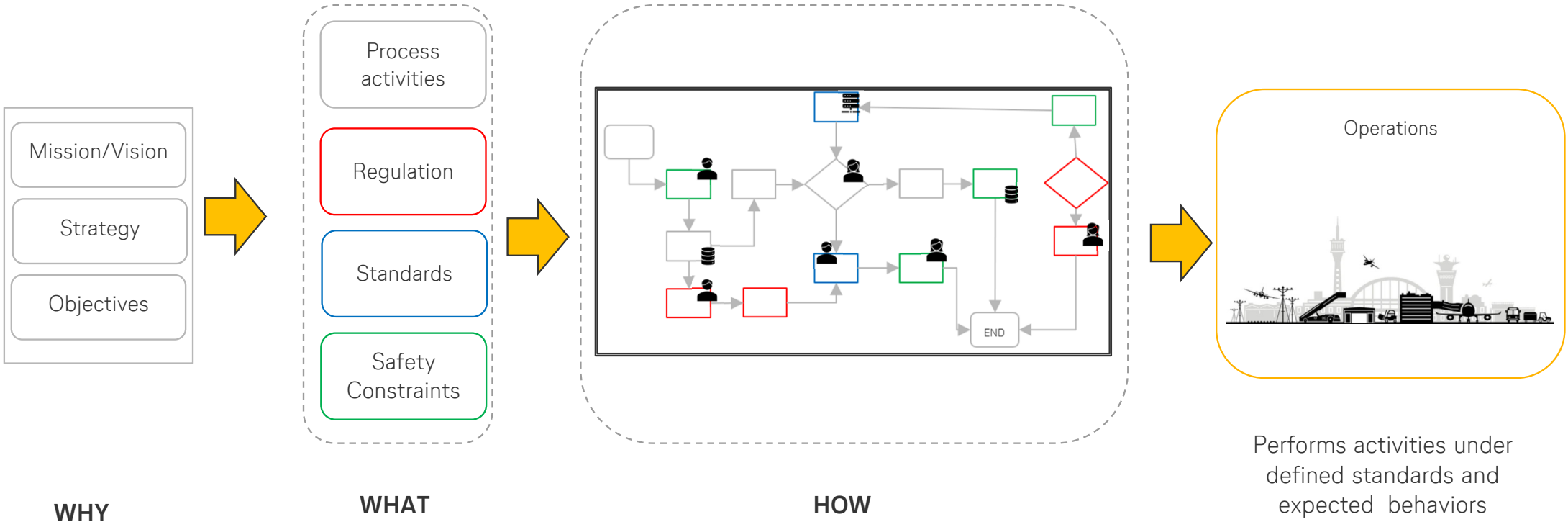
Operational system design is driven by organizational objectives and constraints to ensure performance, compliance, and safe outcomes.



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Definition of Safety Constraints through System Analysis of Safety-Critical Functions

System Description

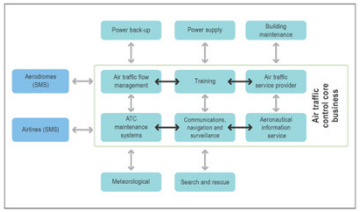
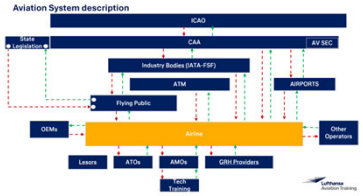
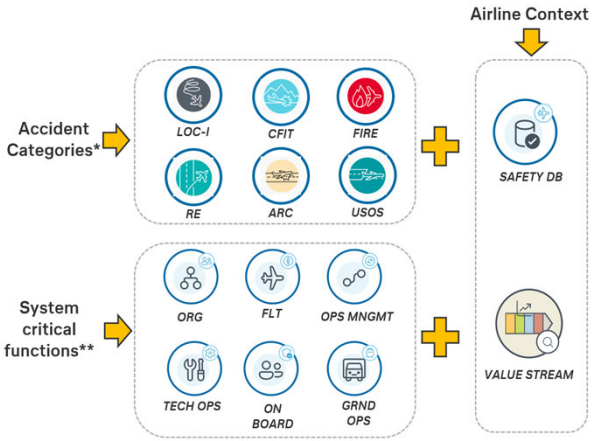


Figure 9-3. Example of air traffic service provider SMS interfaces



Safety critical functions



*Source: IATA-ICAO-FSF

**Source: FAA - IEP 8900.1 Vol 10 Ch 1 Sec 2 SAS overview

Hazard Analysis (STPA)



Transport of Lithium Batteries in passenger cabin



Transport of Lithium Batteries in cargo bellies of Pax Aircraft

Safety constraints for process requirements



List of Constraints for Process Owner

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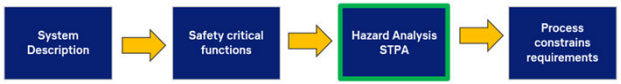
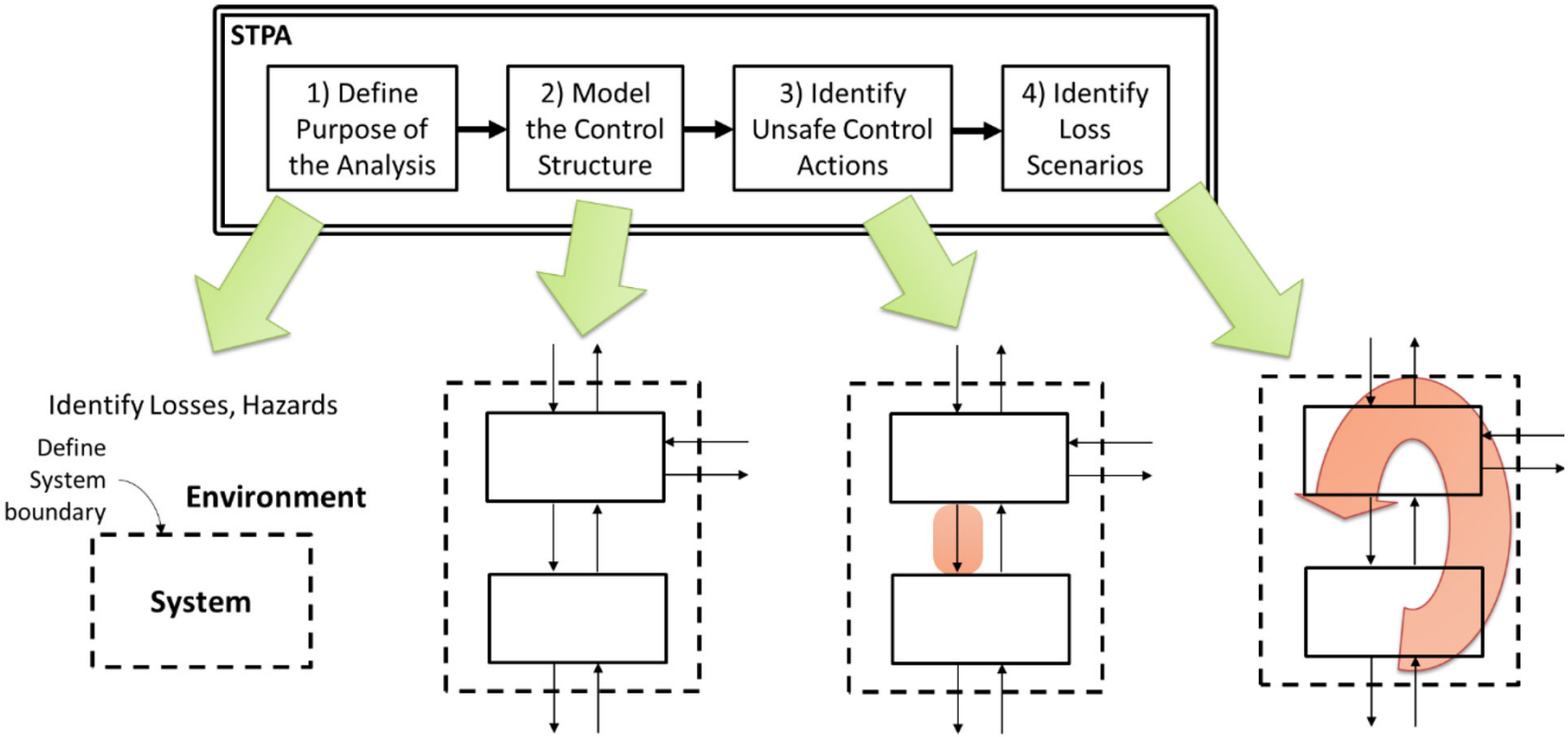
STPA methodology is based on 4 steps





Source: STPA Handbook

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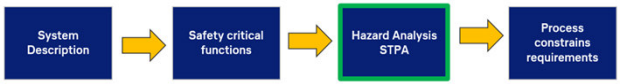
Transport of Lithium Batteries in Passenger Aircraft Cabin



1) Define Purpose of the Analysis

Losses

- L1 Loss of aircraft
- L2 Loss of life of passengers, crew, or ground personnel
- L3 Fire, smoke, explosion, or thermal runaway involving passenger-carried lithium batteries
- L4 Transport of undeclared, prohibited, or non-compliant lithium batteries

Hazards

- H1 Passengers carry prohibited, undeclared, or non-compliant lithium batteries. (L1, L2, L3, L4)
- H3 Check-in, boarding, or security controls fail to identify non-compliant lithium batteries. (L1, L2, L3, L4)
- H4 Passengers lack awareness of lithium battery restrictions and requirements. (L1, L2, L3, L4)
- H6 Cabin crew is unaware of, or unable to manage, a lithium battery event. (L1, L2, L3)
- H9 A lithium battery event cannot be effectively detected, contained, or controlled onboard. (L1, L2, L3)

General Constraints

- SC1 Only compliant lithium batteries shall be transported by passengers. (H1)
- SC3 Passenger handling controls shall identify and prevent transport of non-compliant lithium batteries. (H3)
- SC4 Passengers shall receive clear, accurate, and timely lithium battery guidance. (H4)
- SC6 Cabin crew shall be able to identify, assess, and respond to lithium battery events. (H6)
- SC9 Aircraft operations shall maintain the capability to detect, contain, and manage lithium battery events. (H9)

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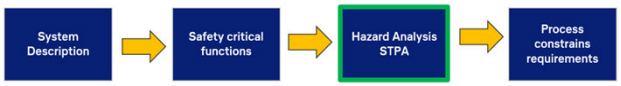
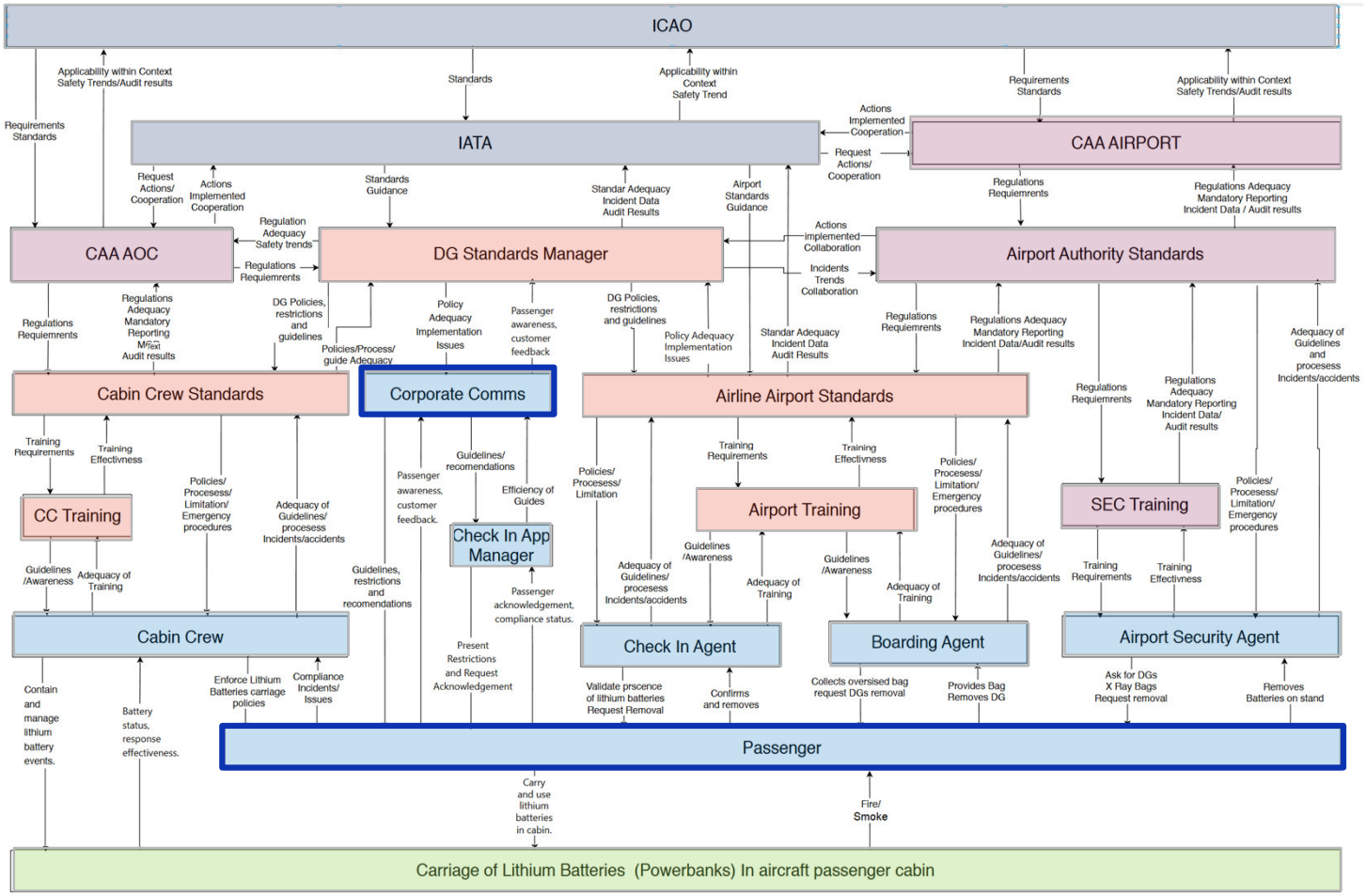
Transport of Lithium Batteries in Pax Cabin



2) Model the Control Structure



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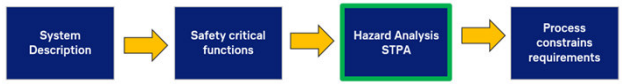
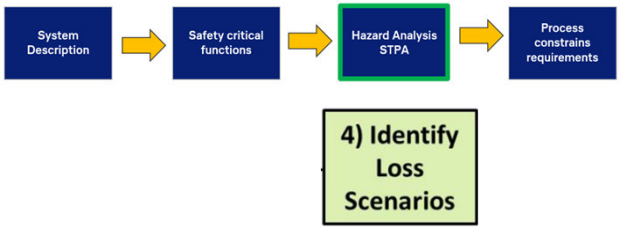


For each interaction and control action, UCAs were defined

3) Identify Unsafe Control Actions

	Interaction			
	Corporate Comms → Passenger			
	Control Action	Communicate airline lithium battery transport restrictions and passenger obligations		
	Feedback	Passenger understanding, guidance effectiveness, recurring passenger issues		
		UCA Number	**UCA Description**	Safety Constraint
UCA	**Not providing causes hazards**	**UCA-COM-PAX-1.1**	Corporate Comms does not communicate airline lithium battery transport restrictions and passenger obligations when passenger awareness is required.	Corporate Comms shall communicate airline lithium battery transport restrictions, limitations, and passenger obligations before travel and check-in activities occur.
	Providing causes hazards	**UCA-COM-PAX-1.2**	Corporate Comms communicates inaccurate, incomplete, misleading, or outdated lithium battery transport restrictions or passenger obligations.	Corporate Comms shall communicate accurate, complete, current, and consistent lithium battery transport restrictions and passenger obligations.
	Too early, too late, out of order	**UCA-COM-PAX-1.3**	Corporate Comms communicates lithium battery transport restrictions after passengers have already booked, packed, checked in, or presented baggage for transport.	Corporate Comms shall communicate lithium battery transport restrictions before passengers make packing, baggage, and transport decisions.
	Stopped too soon, applied too long	**UCA-COM-PAX-1.4**	Corporate Comms continues communicating outdated lithium battery transport restrictions after regulations, operator policies, technologies, or operational practices have changed.	Corporate Comms shall review and update passenger-facing lithium battery communications whenever regulations, operator policies, technologies, or operational practices change.

Context-specific loss scenarios were developed for each relevant UCA.



		Interaction						
		Dispatcher → GRH Supervisor						
	Control Action	Issue Load Instruction Report (LIR), loading authorization, and DG loading requirements						
	Feedback	Final loading status, DG quantities and locations loaded						
		Loss Scenario						
		Inadequate Feedback	Inadequate Algorithim	Unsafe Control Input	Inadequate Process Model			
		Feedback or information not received o Feedback/info sent by sensor(s) but not received by controller o Feedback/info is not sent by	Flawed implementation of the specified control algorithm o The specified control algorithm is flawed. The specified control algorithm	UCA received from another controller (already addressed when considering UCAs from other controllers)	receives incorrect feedback/information	receives correct feedback/information but interprets it incorrectly or ignores it	does not receive feedback/information when needed (delayed or never received)	Necessary controller feedback/information does not exist
UCA	Not providing causes hazards	Dispatcher does not receive complete loading status, DG quantities loaded, cargo substitutions, loading deviations, excess cargo loaded, revised LIR information, or final aircraft loading configuration and therefore does not provide accurate loading instructions to GRH Supervisor.	LIR preparation and loading authorization procedures do not require verification of actual loaded cargo, DG quantities, cargo locations, loading deviations, excess cargo presented at ramp, or reconciliation between planned and actual aircraft loading configuration before issuing loading instructions.	N/A	N/A	N/A	Dispatcher does not receive updated loading information, DG changes, aircraft loading restrictions, cargo substitutions, loading deviations, or last-minute operational changes before issuing the LIR and loading authorization.	No mechanism exists to ensure loading status, DG quantities, cargo locations, aircraft configuration, and loading deviations are confirmed before issuing the LIR and loading authorization.
	Providing causes hazards	Dispatcher receives incomplete, inaccurate, or misleading cargo information, DG quantities, loading status, cargo locations, aircraft configuration information, or operational restrictions and therefore issues incorrect loading instructions and DG loading requirements.	The dispatch process does not adequately address DG quantity verification, loading deviation management, excess cargo presentation, LIR reconciliation, aircraft loading restrictions, last-minute changes, or differences between planned and actual aircraft loading configuration.	Dispatcher receives inaccurate cargo information, loading status, DG quantities, aircraft allocation information, or operational instructions from planning and operational areas and consequently issues incorrect LIR information and loading authorization.	Dispatcher receives incorrect information indicating that cargo quantities, DG locations, aircraft loading configuration, approved cargo, or loading priorities differ from the actual operational situation and therefore issues incorrect loading instructions.	Dispatcher receives correct loading information and DG data but incorrectly evaluates cargo priorities, DG loading requirements, aircraft loading restrictions, cargo locations, or loading deviations when issuing the LIR.	N/A	N/A
	Too early, too late, out of order	Dispatcher receives late loading information, revised cargo quantities, DG updates, cargo substitutions, loading deviations, aircraft allocation changes, or operational restrictions after cargo preparation or loading activities have already started.	The LIR issuance process does not require all loading information, DG data, aircraft restrictions, and cargo reconciliation activities to be completed before loading authorization and loading instructions are issued.	Dispatcher receives late cargo updates, revised DG quantities, loading deviations, cargo additions, cargo removals, or revised aircraft restrictions from operational functions after loading activities have already begun.	Dispatcher receives incorrect information indicating that loading instructions, DG requirements, cargo changes, or LIR updates can be communicated after loading activities have already started without affecting loading safety.	Dispatcher receives correct loading timelines and dispatch requirements but incorrectly assumes loading activities can begin before cargo reconciliation, DG verification, and aircraft loading information have been finalized.	Dispatcher does not receive timely notification of loading deviations, revised cargo quantities, DG updates, aircraft restrictions, cargo substitutions, or operational changes before loading activities begin.	No mechanism exists to prevent loading authorization and LIR issuance before loading verification, DG reconciliation, and aircraft loading information have been finalized.
	Stopped too soon, applied too long	Dispatcher does not receive notification that DG quantities, cargo quantities, aircraft configuration, cargo locations, loading deviations, aircraft restrictions, or operational priorities have changed after the LIR has been issued.	The dispatch process does not require reassessment and reissuance of the LIR when cargo quantities, DG information, loading configuration, aircraft allocation, cargo priorities, or operational restrictions change.	Dispatcher receives outdated loading information, DG quantities, cargo locations, loading priorities, aircraft restrictions, or operational constraints and continues applying obsolete loading instructions.	Dispatcher receives incorrect information indicating that previously issued LIR information, loading authorization, DG loading requirements, and cargo priorities remain valid despite subsequent operational changes.	Dispatcher receives updated loading information but incorrectly assumes existing loading instructions and loading authorization remain valid.	Dispatcher does not receive updated information regarding cargo additions, cargo removals, excess cargo presented for loading, revised DG quantities, loading deviations, aircraft restrictions, or revised loading priorities after the LIR has been issued.	No mechanism exists to automatically review and reissue the LIR when cargo quantities, DG information, aircraft loading configuration, loading deviations, cargo priorities, or operational restrictions change after dispatch authorization.

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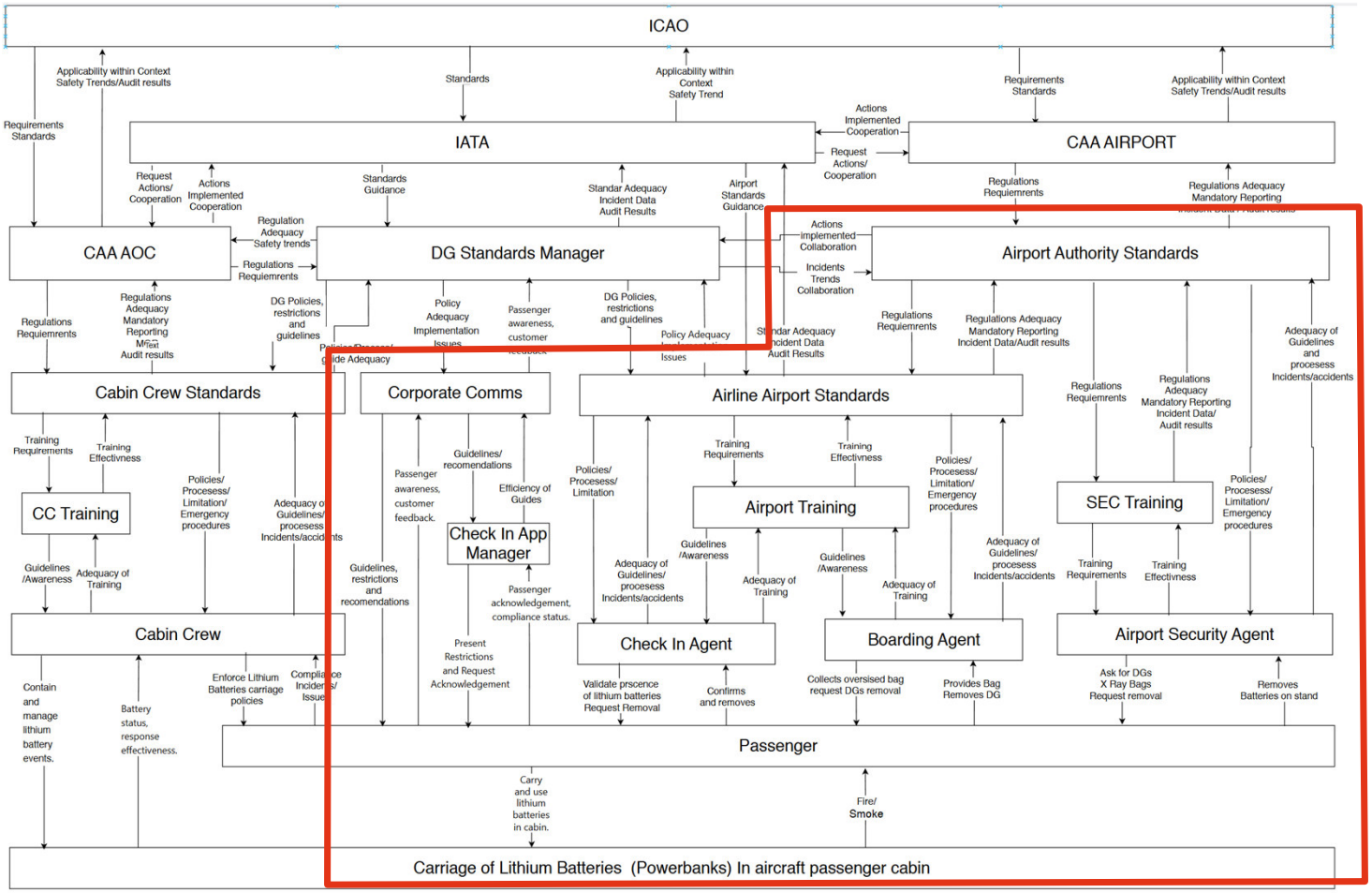
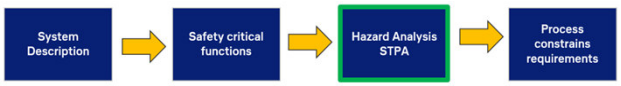
Transport of Lithium Batteries in Pax Cabin





2) Model the Control Structure

- 15+ Controllers and operational functions identified
- 30+ Control interactions analyzed
- 140+ Unsafe Control Actions and constraints identified
- 600+ Causal scenarios and control degradations analyzed
- 12 Critical Feedback Loops identified

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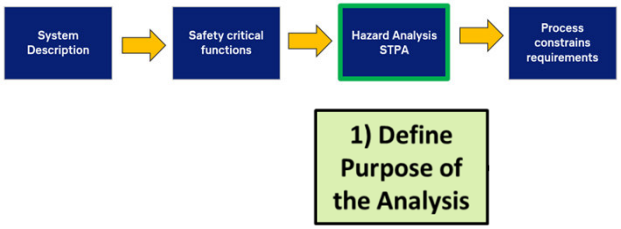
Transport of Lithium Batteries in Passenger Aircraft cargo hold



Losses

- L1 Loss of aircraft
- L2 Loss of life of passengers, crew, or ground personnel
- L3 Fire, explosion, or uncontrolled thermal runaway involving lithium batteries
- L4 Transport of undeclared, misdeclared, mishandled, or non-compliant dangerous goods

Hazards

- H1 Lithium batteries are incorrectly identified, declared, or controlled. (L1, L2, L3, L4)
- H4 Aircraft is operated using incomplete, inaccurate, or outdated DG information. (L1, L2, L3, L4)
- H6 Lithium batteries are “not certified” and/or exposed to conditions that may initiate thermal runaway. (L1, L2, L3)
- H8 Safety-critical DG information is not effectively communicated. (L1, L2, L3, L4)
- H9 Actual cargo configuration differs from the approved transport configuration. (L1, L2, L3, L4)

General constraints

- SC1 Lithium batteries shall be correctly identified, declared, documented, and controlled. (H1)
- SC4 Dispatch and operational decisions shall use complete, accurate, and validated DG information. (H4)
- SC6 Lithium batteries shall be protected from conditions that could initiate thermal runaway/customer shall be required to transport “certified ”batteries. (H6)
- SC8 Safety-critical DG information shall be communicated accurately and on time. (H8)
- SC9 Actual aircraft configuration shall match the approved load plan and dispatch information. (H9)

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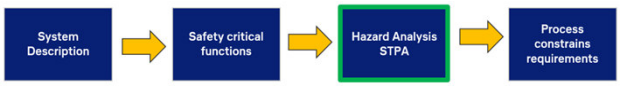
Transport of Lithium Batteries in Pax cargo hold



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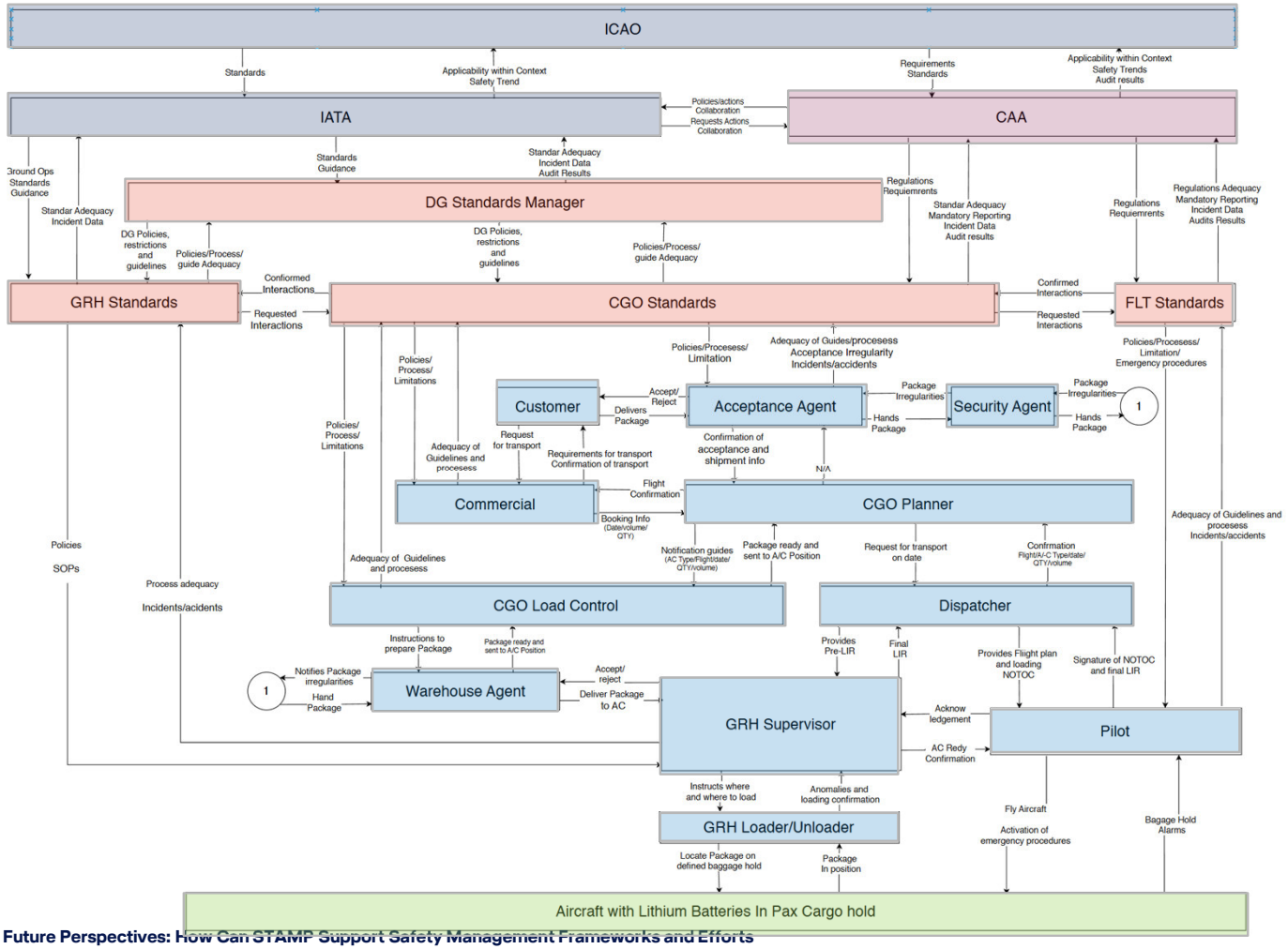

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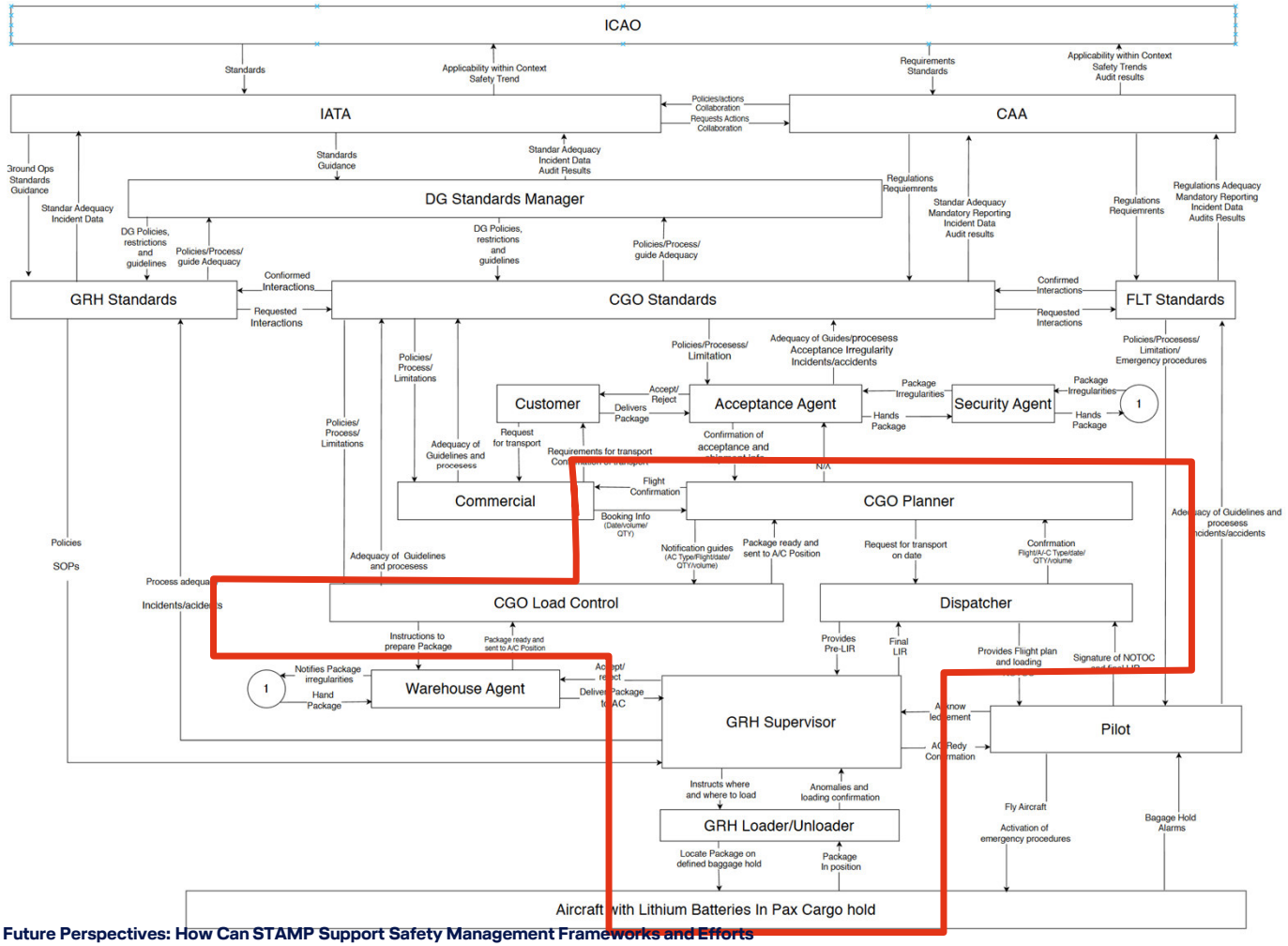
Transport of Lithium Batteries in Pax cargo hold



System Description → Safety critical functions → Hazard Analysis STPA → Process constrains requirements

2) Model the Control Structure

- 15+ Controllers and operational functions identified
- 34+ Control interactions analyzed
- 130+ Unsafe Control Actions and constrains identified
- 600+ causal scenarios analyzed
- 9 Critical Feedback Loops identified

Safety Constraints as Inputs for Process Design and Safety Assurance



Rev:Org	Safety Constraint Implementation Register							
Scope	Transport of Lithium Batteries in Passenger Aircraft Cabin							
Constraint ID	**Safety Constraint**	**Related UCA(s)**	**Interaction**	**Process Owner**	**Area**	**Supporting Roles**	**Due Date**	**Status**
SC-COM-01	Corporate Comms shall communicate airline lithium battery transport restrictions, limitations, and passenger obligations before travel and check-in activities occur.	UCA-COM-PAX-1.1	Corporate Comms → Passenger	Customer Communications Manager	Corporate Communications	DG Standards Manager, Digital Channels Manager	TBD	Open
SC-COM-02	Corporate Comms shall communicate accurate, complete, current, and consistent lithium battery transport restrictions and passenger obligations.	UCA-COM-PAX-1.2	Corporate Comms → Passenger	Customer Communications Manager	Corporate Communications	DG Standards Manager, Regulatory Affairs	TBD	Open
SC-COM-03	Corporate Comms shall communicate lithium battery transport restrictions before passengers make packing, baggage, and transport decisions.	UCA-COM-PAX-1.3	Corporate Comms → Passenger	Customer Communications Manager	Corporate Communications	Marketing, Digital Channels Manager	TBD	Open
SC-COM-04	Corporate Comms shall review and update passenger-facing lithium battery communications whenever regulations, operator policies, technologies, or operational practices change.	UCA-COM-PAX-1.4	Corporate Comms → Passenger	Customer Communications Manager	Corporate Communications	DG Standards Manager, Compliance Manager	TBD	Open

- Safety constraints are assigned to process owners as inputs for process design and control implementation.
- The register maintains traceability between process requirements, controls, constraints, hazards and losses

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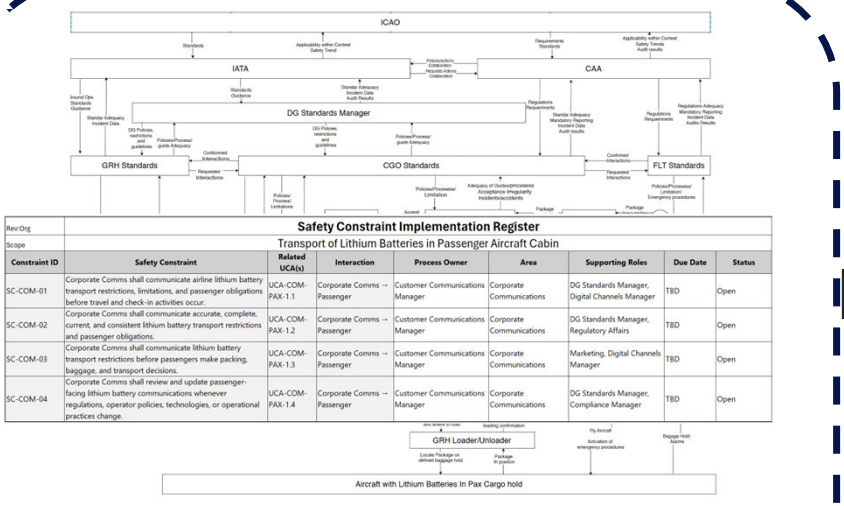
System Design as the Foundation of Safety Management at a glance



Safety Constraint Implementation Register

Transport of Lithium Batteries in Passenger Aircraft Cabin

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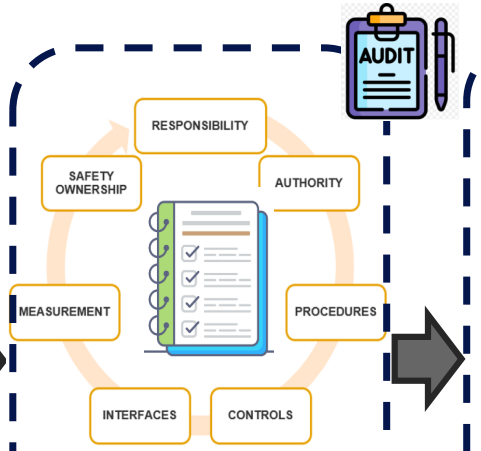
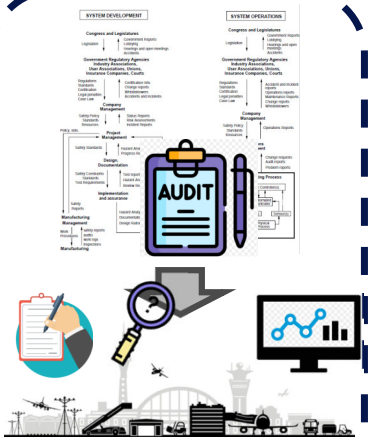
Safety Constraints derived from a control structure



Design under system safety attributes and safety constrains



Competence Based Training



Application of existing SMS tools

MoC

An explicit control structure provides a shared model for managing safety. It clarifies responsibilities, constraints, and feedback paths while aligning SRM and Safety Assurance activities around the same operational system.

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Existing tools and programs are still apply under a control structure philosophy, their scope expands or changes

Safety Reports	Primary source of hazard identification.	→	Identify edge cases , new hazards or operational scenarios.
Investigations	Find root cause.	→	Identify degraded controls, feedback loops and process models.
Audits	Procedure compliance.	→	Control effectiveness.
SPIs	Outcome measurement	→	Monitor control effectiveness and degradation.
MoC	Assess operational impact.	→	Assess impact on controllers, constraints and feedback loops.

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What did we learn so far?

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What were the conclusions of the application of STPA for process design?

Systems design benefits

- Provides a **holistic view of complex systems**.
- Reveals **new** controllers, interfaces, hazards, and risks.
- **Integrates** organizational, technical, and human factors under **one model**.
- Supports controls for human adaptation and variability.
- **Aligns** designers, operators, and decision-makers **mental models** of system status.
- Reduces **unnoticed degradation** of safety controls.

Safety management benefits

- **Adapts** to existing **safety frameworks**.
- Links **traceability** of processes, constraints, and hazards.
- Supports **empowerment of accountability within leadership** level
- **Enables** internal and external **cross-functional collaboration**.
- **Focused approach** for **Safety Managers** activities for controlling safety.
- Improves the effectiveness of existing SMS tools.

Implementation Effort

Step	Facilitator	SME
Preparation (Training)	40 hrs	2 hrs
Preparation (Scenario)	5hrs	-
Development	20 hrs	8 hrs

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Things to take into account while implementing this methodology

Preparation

- Adopt a **systems-thinking mindset**, not a component-failure mindset.
- Use **trained facilitators** to maintain focus on STAMP principles.
- **Align participants** on concepts, terminology, scope, and objectives.
- Define the **system description** and boundaries **before workshops**.
- Work in **focused sprints** to sustain SME engagement.
- Use a suitable **visual modeling tool** to structure, adjust and maintain the **control structure**

Execution

- Engage **SMEs** to explain how **control can degrade.**
- **Capture discussions systematically**; use **AI to structure and consolidate** inputs, with SME validation.
- Revisit the analysis purpose to **avoid** returning to **linear thinking.**
- Remember: a **control structure is not a process** map.
- **Use** the control structure **to clarify responsibilities** and interactions.

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