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CONTROLLABILITY OF EVENTS AND ASSOCIATED FACTORS: LESSONS LEARNED FROM AVIATION

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CREATING TOMORROW

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RESEARCH BACKGROUND

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BACKGROUND

- Safety performance:
  - Safety performance in the industry is measured based on the severity of events (incidents, serious incidents and accidents) through respective indicators (e.g., number of accidents / unit of exposure).
  - Aviation safety performance has been continuously increased over the last half-century.
- Authorities and organizations try to improve safety levels through:
  - Proactive methods (i.e. before an unwanted event occurs), such as audits, analysis of hazard reports etc.
  - Reactive methods (i.e. after an unwanted event happens) activities, mainly safety investigations.

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BACKGROUND

- Results from safety investigations target to:
  - Reveal causes of safety events
  - Make recommendations about prevention of future safety events
- According to ICAO (2010) and EC (2010), safety investigations are mandatory for accidents and serious incidents.
- Although safety incidents can comprise valuable sources for improving safety levels further, limited resources have led:
  - Authorities to not investigate all incidents.
  - Some authorities monitor trends over time and decide to investigate causes for a set of incidents.
  - Organizations to investigate a limited number of incidents without any criteria for the priority of events that should be investigated. Trends over time can be also consulted.

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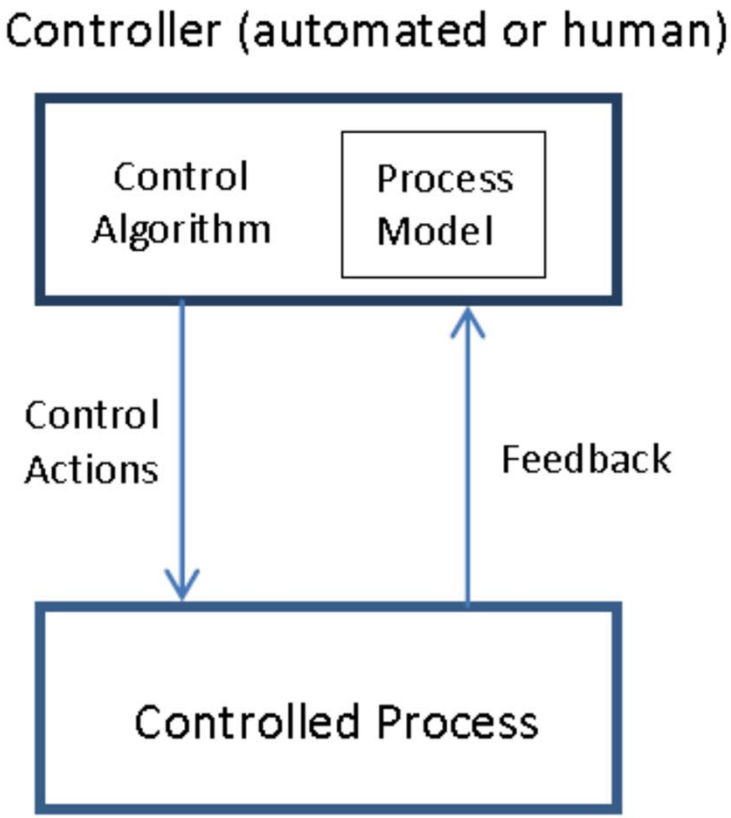
BACKGROUND

- The emphasis on actual event severity does not provide information about the extent to which outcomes were a matter of control.
- Therefore we do not:
  - Consider the potential of an event to escalate to a category of higher severity
  - Obtain a picture of the degree to which our systems are under control
- The focus on actual outcomes might lead to stronger biases: the higher the severity, the higher the importance of the causal factors revealed from the investigation.

BACKGROUND

- Contemporary safety theory and research suggest that:
  - Safety events do not occur merely due to unreliable system components (i.e. individual causes revealed from investigations).
  - Complexity of modern socio-technical systems necessitates also the consideration of interlinks and dependencies.
  - Efforts must be first directed to the control of systems even when behaviour of components is as expected.



Leveson, N. (2011), Engineering a Safer World. MIT Press, Cambridge, USA

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BACKGROUND

EVENT CONTROL CLASSIFICATION	USER REACTION CLASSIFICATION
CONTROLLED: The user attempted to control the event march.	POSITIVE: User's actions did not worsen the outcome; the event outcome was managed successfully; no errors or violations were noticed during the control attempt.
	NEGATIVE: User's actions following the safety event initiation resulted in adverse outcomes due to human errors or violations.
UNCONTROLLED: Safety event's consequences were developed without control; there had been no intervention until the time the outcomes were noticed.	NONE
NEUTRAL: Inevitable application of normal procedures; standard reactions to identified problem.	AS EXPECTED BY PRESCRIBED PROCEDURES.

Karanikas, N. (2015), An Introduction of Accidents' Classification Based on their Outcome Control, Safety Science, 72, pp. 182-189. DOI: 10.1016/j.ssci.2014.09.006

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RESEARCH OBJECTIVES AND QUESTIONS

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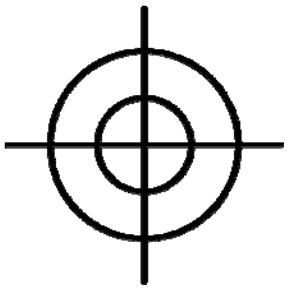
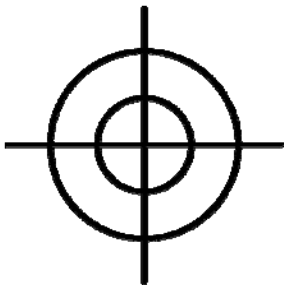


RESEARCH OBJECTIVES

- Examine whether the current classification of events based on their controllability needs improvement.
- Explore how much aviation safety events have been controlled.
- Assess the association between severity & controllability and the introduction of the latter as a metric of safety performance prior to the consideration of actual severities.
- Identify factors/variables that might be linked to controllability of events.



RESEARCH OBJECTIVES

- Provide information to the aviation industry for current levels of controllability of safety events and associated factors.
- Recommend how controllability, regardless industry sector, might be used:
  - As criterion for prioritizing investigation of safety events
  - Reactively and/or proactively in safety management
  - As metric for safety performance

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RESEARCH QUESTIONS

- Is the current classification of safety events based on the degree of their controllability sufficiently reliable?
- To what extent have aviation safety events been controlled?
- What factors are associated with the controllability of safety events in aviation?

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RESEARCH METHODOLOGY

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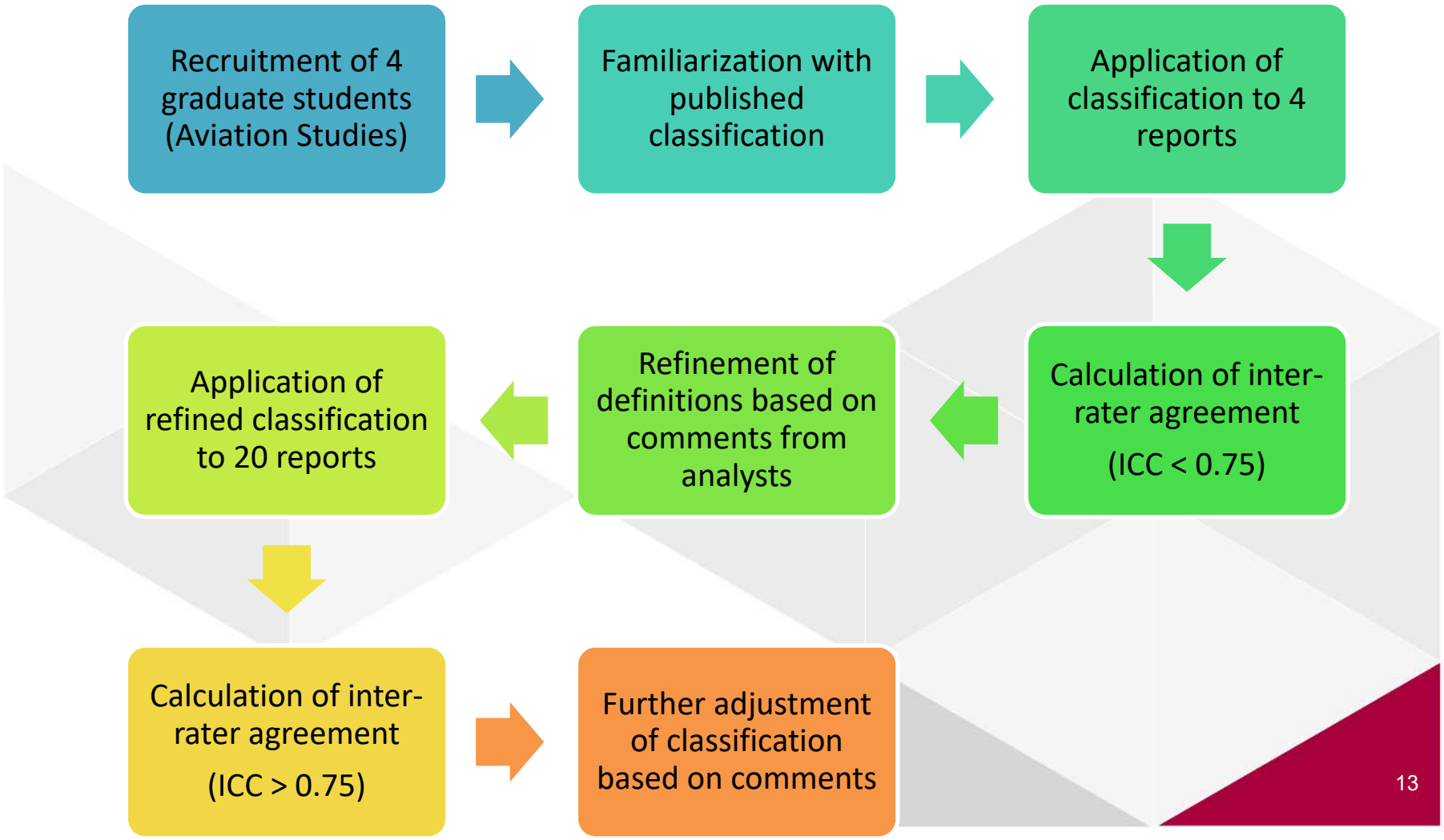
IMPROVEMENT OF CLASSIFICATION



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APPLICATION OF CLASSIFICATION

- Sample of 297 safety investigation reports published by:
  - Air Accident Investigation Board of the United Kingdom (AAIB)
  - Australian Transport Safety Bureau (ATSB)
  - Dutch Safety Board (DSB)
  - National Transport Safety Board of the United States (NTSB)
  - Transport Safety Board of Canada (TSB)
- Reports randomly selected based on:
  - Availability online
  - Publication in English language
  - Sample used in concurrent studies performed in the Aviation Academy
  - Time constraints
- Time span of safety events: 1990 - 2014

INDEPENDENT VARIABLES & STATISTICS

Groups of Independent Variables	Dependent Variables		
	Controllability	Reaction level	Outcome
Origin of aircraft registration	X	X	X
Temporal and seasonal factors	X	X	X
Aircraft characteristics	X	X	X
Operational characteristics	X	X	X
Event characteristics	X	X	X
Crew/ground staff fatigue			X

Statistics:

- Chi-square or Fisher's Exact tests of independency (depending on sample distribution across variable cases).
- Significance level: 0,05

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RESULTS & DISCUSSION

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REFINED CLASSIFICATION

CONTROLLABILITY	LEVEL OF USER'S REACTION	OUTCOME FROM REACTIONS
CONTROLLED: The user attempted to control the accident march.	SKILL – RULE BASED (SRB): Reaction to a single event and standard application of procedures described in check-lists and manuals. RULE – KNOWLEDGE BASED (RKB): Reaction to complex situations by combining existing rules, partially/not described in check-lists and manuals, and generally acquired knowledge.	POSITIVE: User's actions did not worsen the outcome or the accident outcome was managed successfully. No errors or violations were noticed during the control attempt in reference to established procedures and/or training provided. NEGATIVE: User's actions following the safety event initiation resulted in adverse outcomes due to human errors or violations in reference to established procedures and/or training provided.
UNCONTROLLED: Safety event's consequences were developed without control; there had been no planned intervention with the scope to prevent the event until the time the outcomes were noticed.	Not applicable	Not applicable

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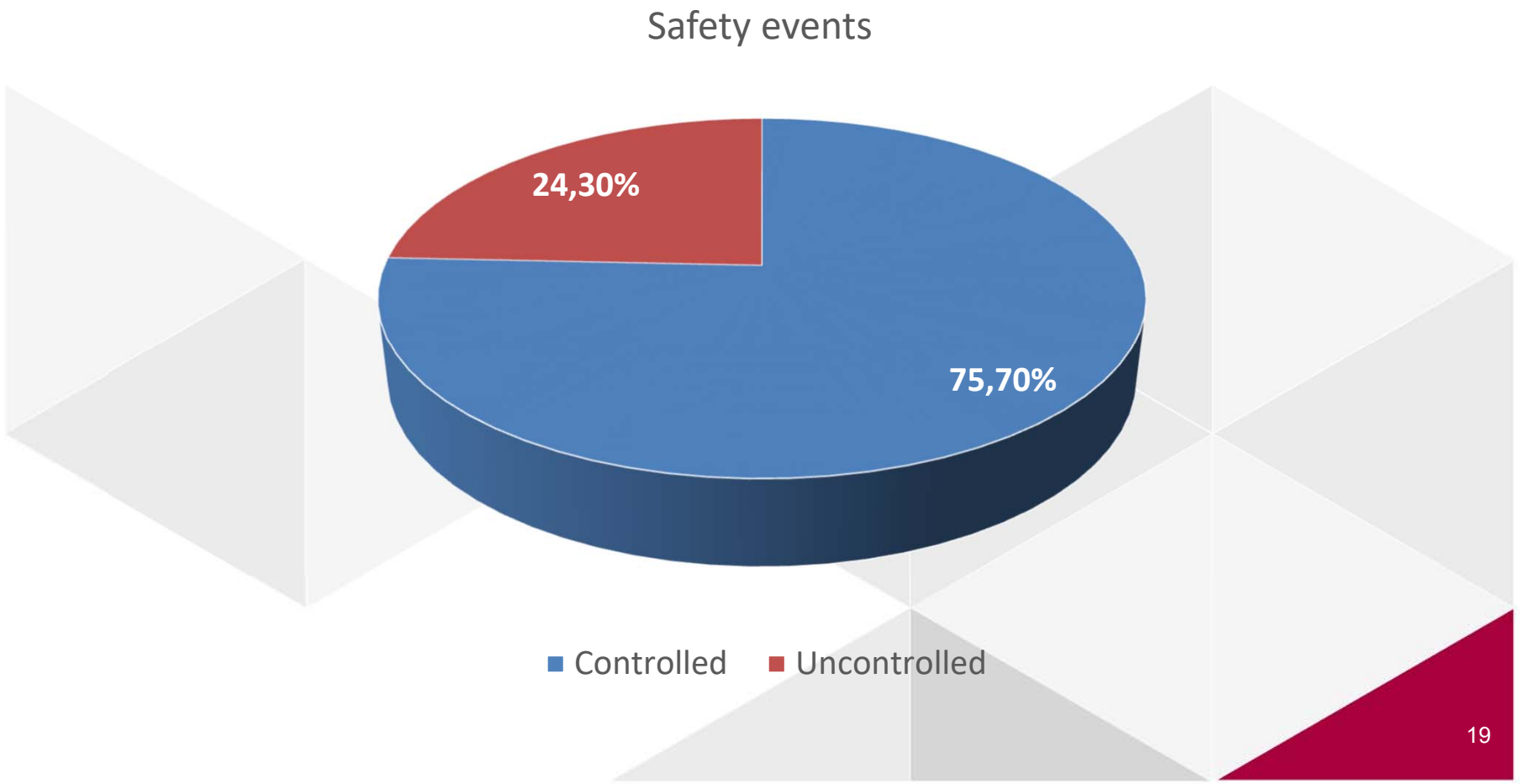
EXAMPLES OF APPLICATION

CASE	REACTION		CONTOLLABILITY	OUTCOME
	ACTION	CATEGORY		
One tyre of the main landing gear system blew out during taxiing.	The pilot stopped the aircraft	SRB	Controlled	Positive
Engine flame out during landing approach under adverse weather conditions.	The crew landed the aircraft safely	RKB	Controlled	Positive
Aircraft malfunction leads to an unstable state while in final approach.	Incorrect techniques resulted to a runway excursion	RKB	Controlled	Negative
Important impacts on the engine compressor blades due to Foreign Object Damages observed during After Flight Inspection.	Not applicable	Not applicable	Uncontrolled	Not applicable

DEGREE OF CONTROLLABILITY



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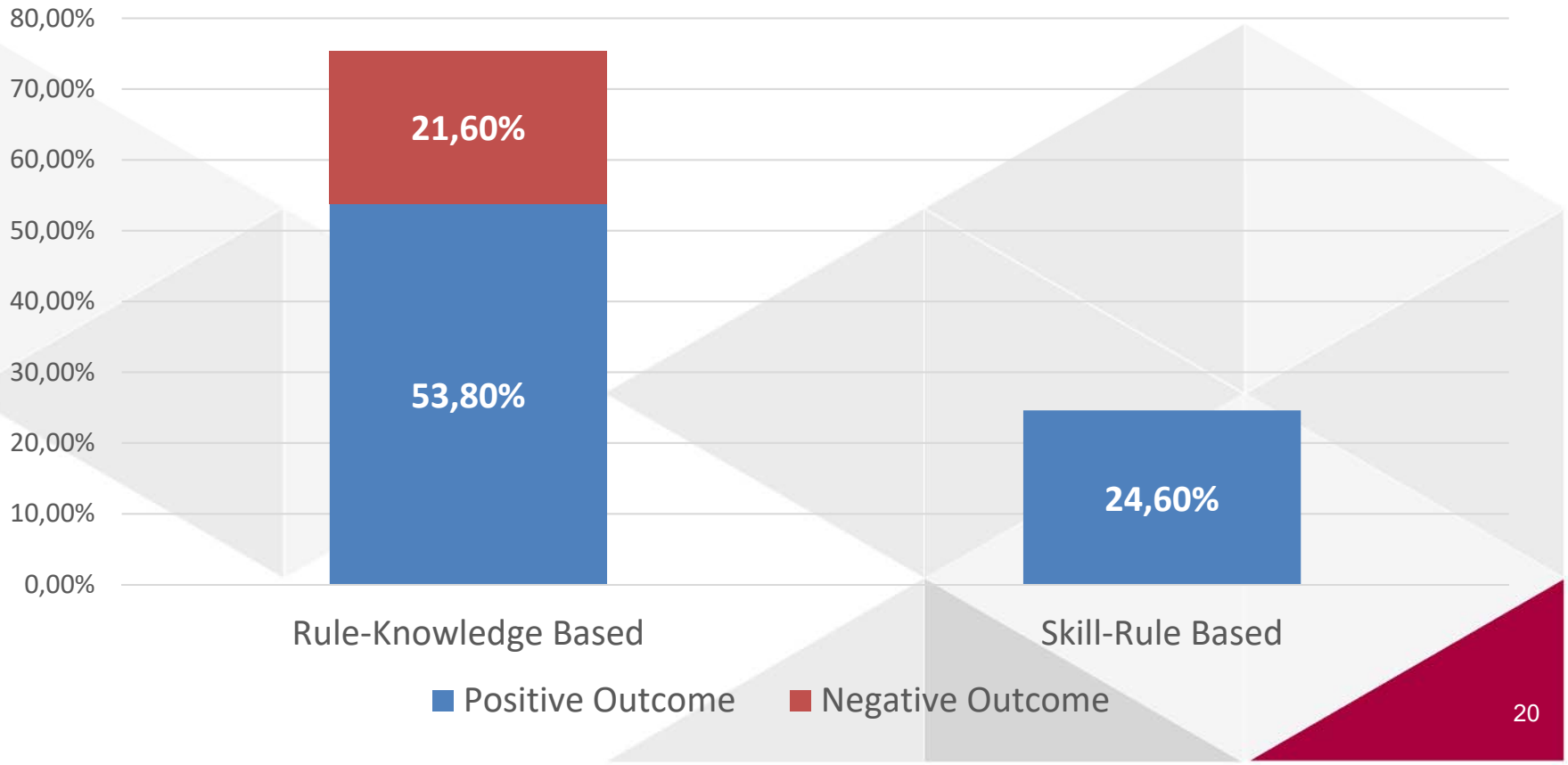
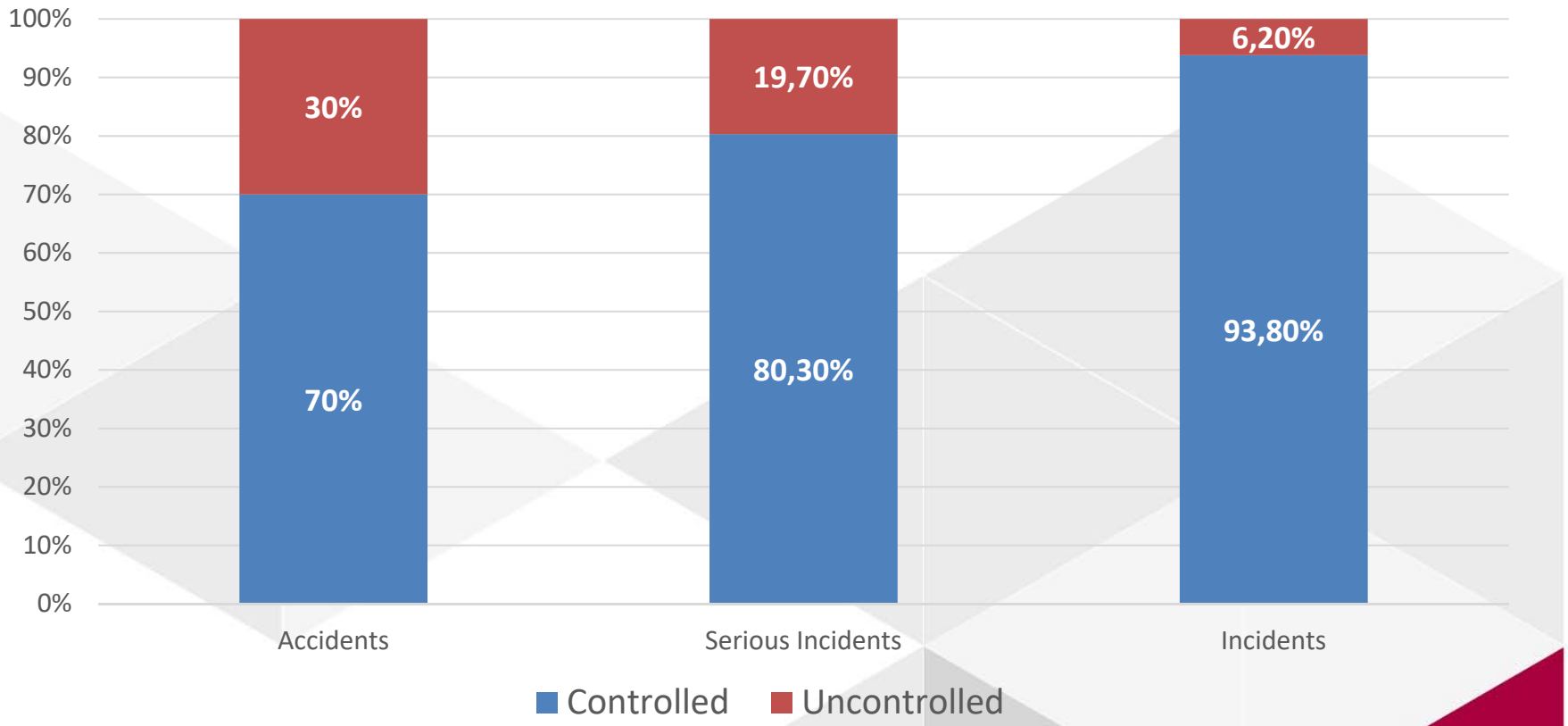
USER REACTIONS & OUTCOMES (CONTROLLED EVENTS)



CONTROLLABILITY & SEVERITY



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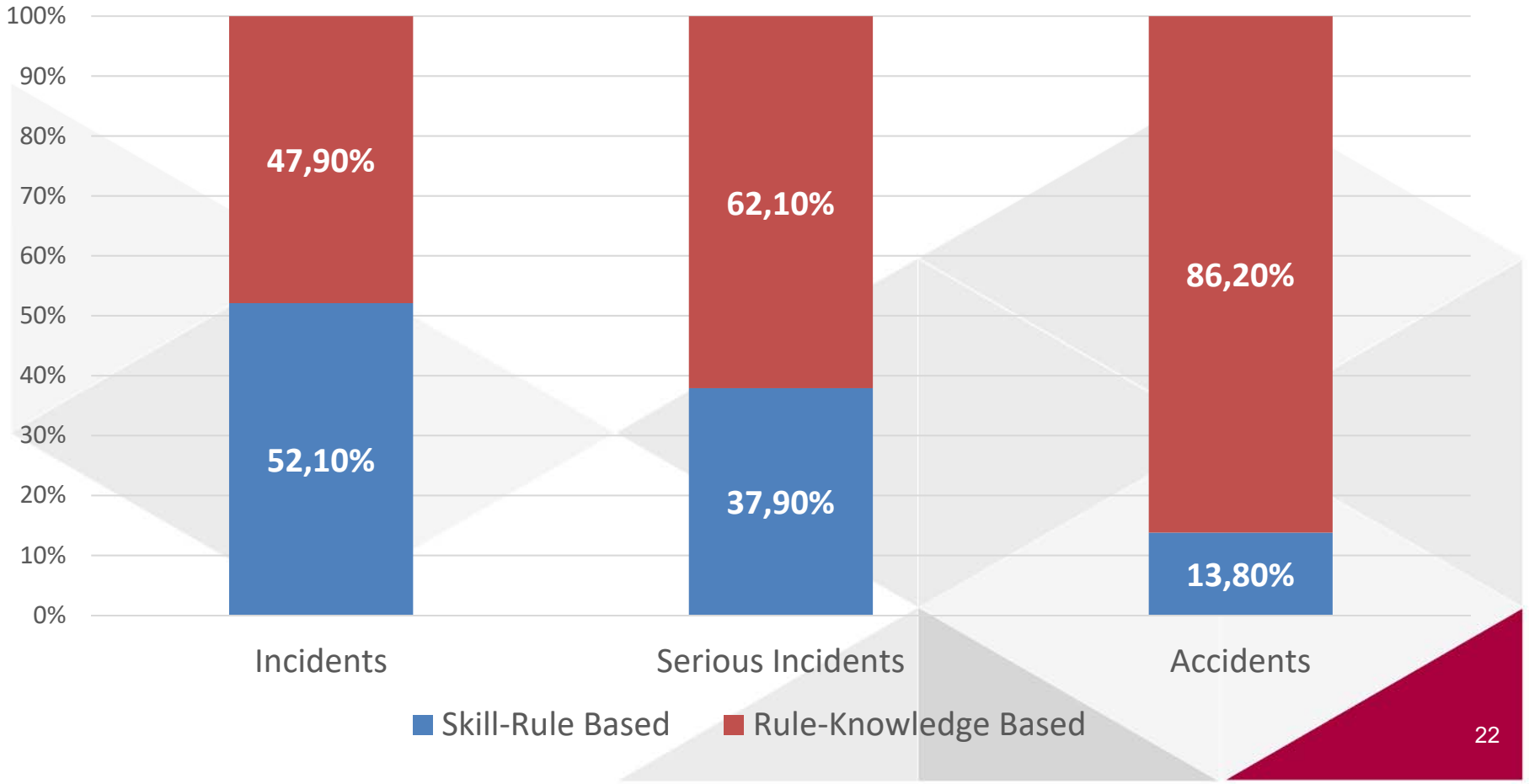
REACTION & SEVERITY (CONTROLLED EVENTS)



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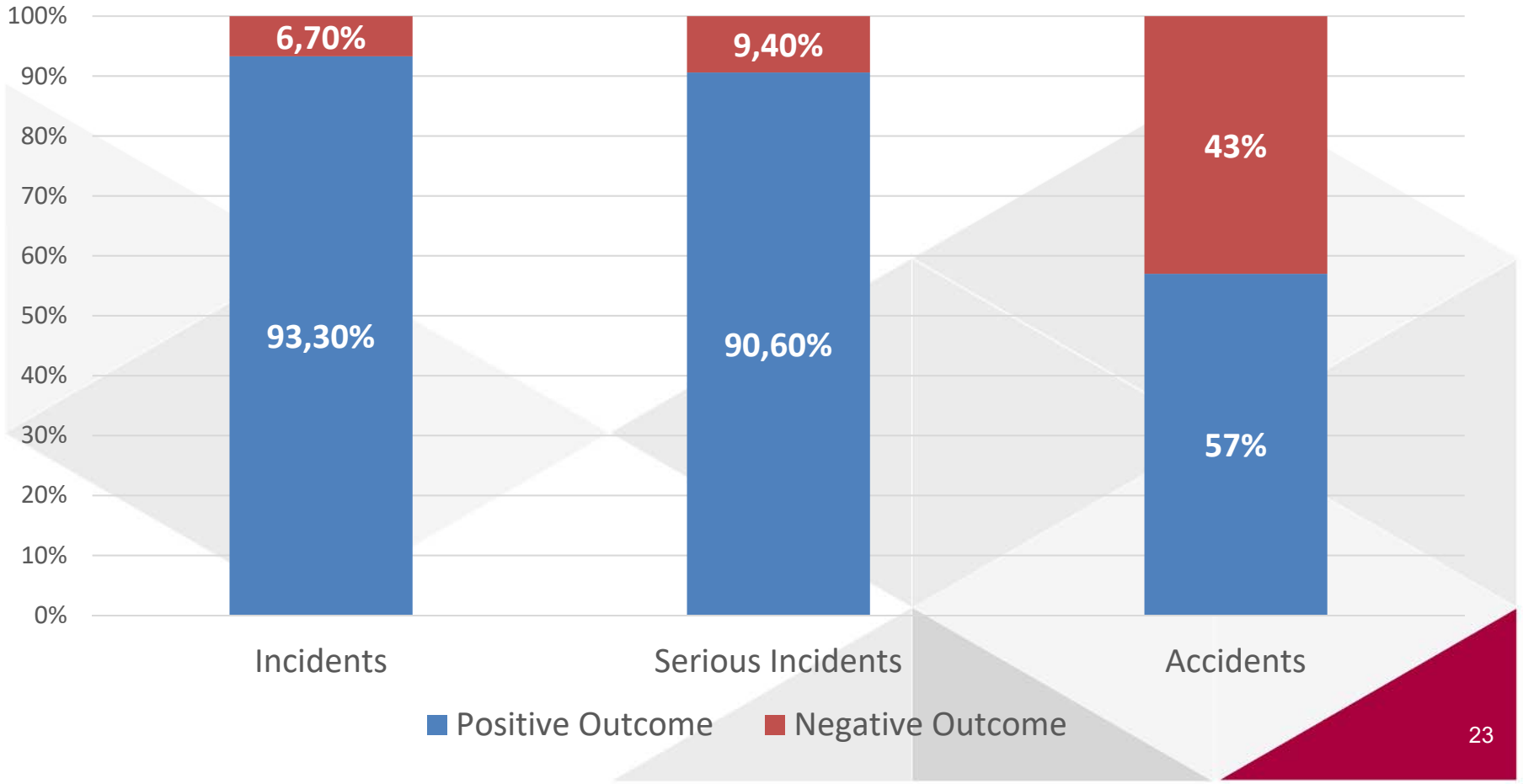
OUTCOMES & SEVERITY (CONTROLLED EVENTS)



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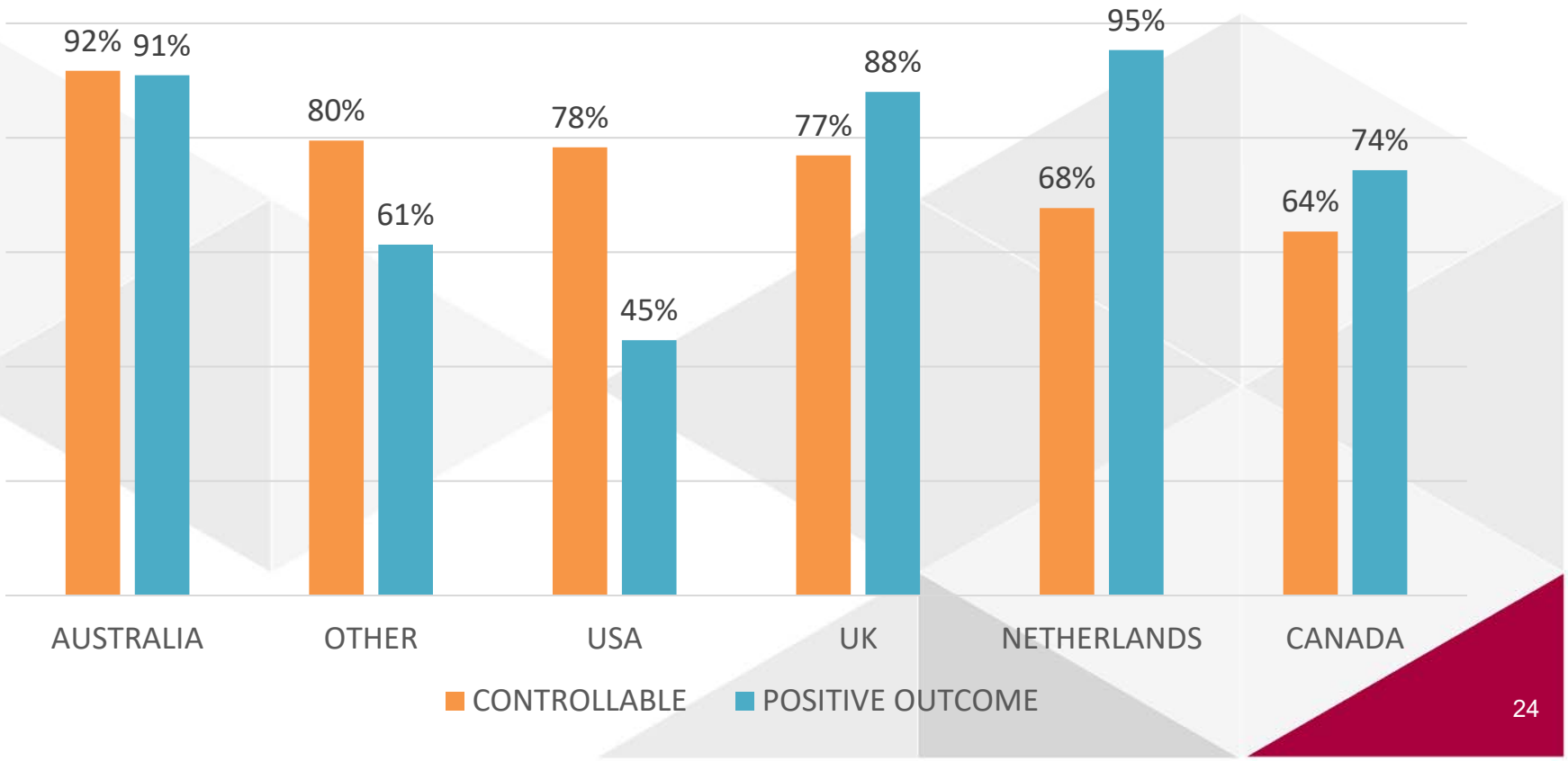
CONTROLLABILITY AND OUTCOMES PER COUNTRY OF REGISTRATION



OTHER INDICATIVE STATISTICALLY SIGNIFICANT ASSOCIATIONS

- Aircraft characteristics: newest (i.e. ≤ 6 years old), jet, and heavy (i.e. ≥ 27tons weight) aircraft were involved in more controlled events which required a higher frequency of Skill-Rule Based (SRB) actions.
- Flight characteristics:
  - Commercial Air Transport and passenger operations were associated with more controlled and SRB events.
  - En-route events were linked with more RKB reactions compared to events during “other” flight phases (i.e. take-off, climb, approach and landing) and on ground.
  - “Other” flight phases were associated with more negative outcomes.
- Fatigue was associated with increased negative outcomes.

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CONCLUSIONS & RECOMMENDATIONS

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CONCLUSIONS (1/2)

- The application of controllability classification:
  - Confirmed literature suggesting the relationship system control and unwanted outcomes.
  - Indicated that when end-users had the opportunity to control a system during an unfolding adverse situation, in about 80% of the cases they successfully applied procedures and used their experience to mitigate the outcomes.
  - Identified that safety incidents that were investigated as such could have escalated to serious incidents or accidents.

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CONCLUSIONS (2/2)

- The application of controllability classification:
  - Showed that events of higher severity were linked to cases with operational complexity (i.e. more Rule – Knowledge reactions).
  - Revealed that the distribution of the characteristics of the controllability classification varies across regions, event, flight and aircraft characteristics.
  - Indicated the effect of fatigue on human performance (i.e. more negatively controlled events).

RECOMMENDATIONS & REMARKS

- Suggested classification of event controllability can be:
  - Applied retrospectively with its current binary form in order to:
    - Analyse safety events, generate insights about the level and effectiveness of control over a system and examine associated factors.
    - Under limited resources, steer safety management efforts towards increasing controllability and positive outcomes of events.
  - Used proactively as part of hazard reporting systems:
    - End-users can state the perceived degree of controllability and level of reaction with the introduction of measurement scales.
    - Analysts can process respective data, monitor trends and assess the need for further research and interventions.

RECOMMENDATIONS & REMARKS

- Suggested classification of event controllability can be:
  - Adapted as criterion for performing incident investigations under limited resources: priority to uncontrolled events.
  - Added as metric of safety performance and effectiveness of safety management.
- In regard to the application of the proposed classification:
  - Users must become familiar with the definitions. Common understanding might be assessed through inter-rater agreement tests.
  - The reaction level is subject to interpretation of the operational complexity and its assignment depends on the context.
  - The assignment of negative outcomes in relation to procedures established and training provided does not intend to blame the end-users but to indicate mismatches.

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Questions time!

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