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SAFETY METRICS:
FIVE PRACTICAL TOOLS TO MANAGE DIFFERENT ASPECTS OF SAFETY

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Aviation Academy

Aviation Safety Day, 7th December 2017
Athens International Airport, Greece
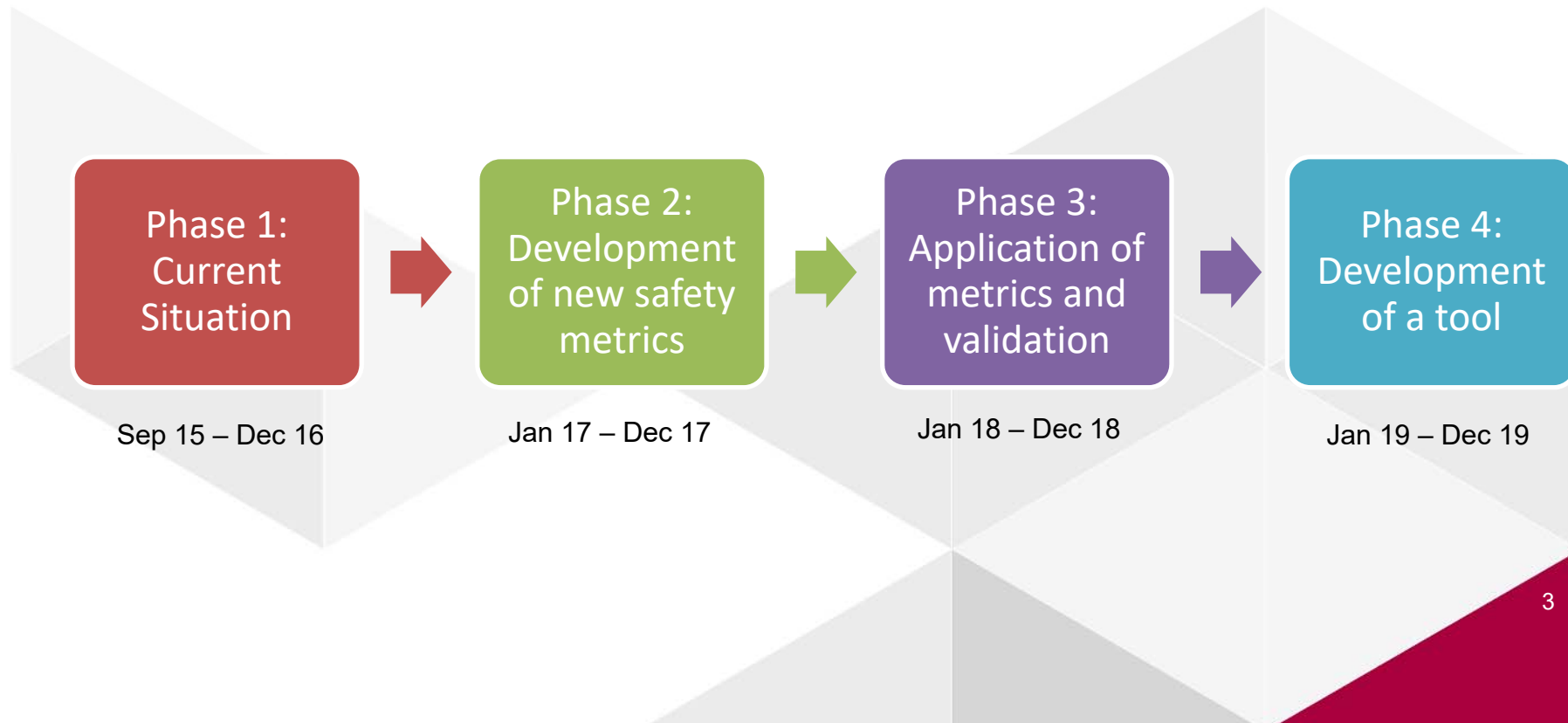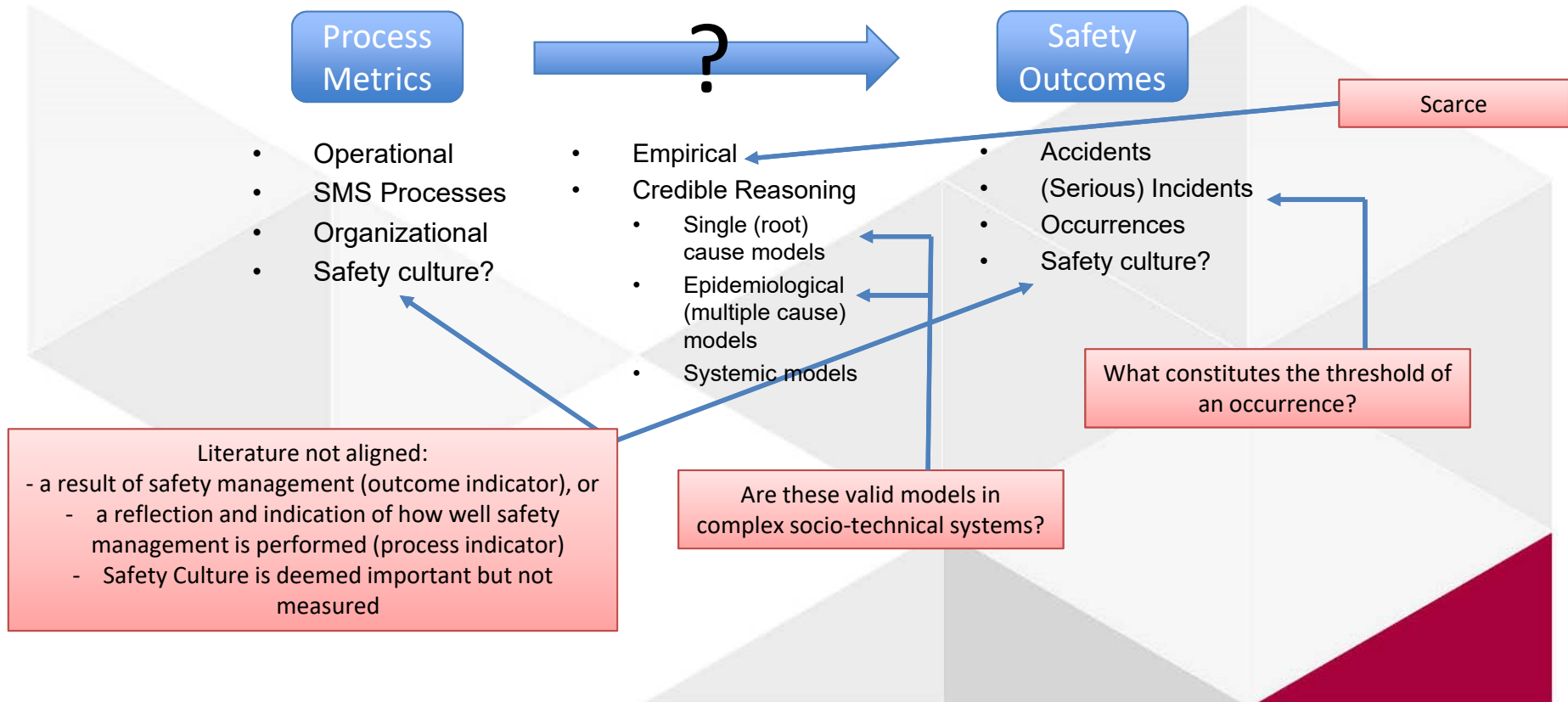
CREATING TOMORROW

CHALLENGES FOR AVIATION COMPANIES

- **Small – Medium Enterprises:** lack of adequate safety/operational data to monitor safety

- **Large companies:** operational/safety data available, but they need leading metrics of better quality

- **How to move** from compliance-based to performance-based monitoring?

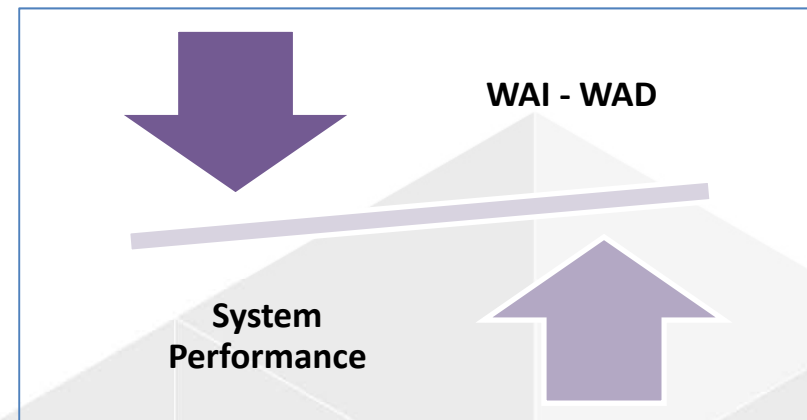# RESEARCH PROJECT – HIGH LEVEL PLANNING

Phase 1: Current Situation

Phase 2: Development of new safety metrics

Phase 3: Application of metrics and validation

Phase 4: Development of a tool

Sep 15 – Dec 16

Jan 17 – Dec 17

Jan 18 – Dec 18

Jan 19 – Dec 19

THE OVERALL PICTURE

Process Metrics

?

Safety Outcomes

- Operational
- SMS Processes
- Organizational
- Safety culture?

- Empirical
- Credible Reasoning
  - Single (root) cause models
  - Epidemiological (multiple cause) models
  - Systemic models

- Accidents
- (Serious) Incidents
- Occurrences
- Safety culture?

Scarce

What constitutes the threshold of an occurrence?

Literature not aligned:
- a result of safety management (outcome indicator), or
- a reflection and indication of how well safety management is performed (process indicator)
- Safety Culture is deemed important but not measured

Are these valid models in complex socio-technical systems?

OUR PRINCIPAL CONCEPT

Work as Imagined (WAI)

Work as Done (WAD)

WAI - WAD

System Performance

- In practice, the industry considers the gaps, **but we haven't uniformly depicted/measured those and searched** for their effects
- We focus on the gaps; we do **not claim authenticity of either WAD or WAI**
- **Aim: operationalisation of concepts** discussed but not yet used
- **Focus: Safety is not the only system objective**

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5+1 NEW SAFETY METRICS HAVE BEEN IDENTIFIED

- SMS assessment
- Safety culture prerequisites
- Risk control effectiveness
- Resource gaps
- System complexity / coupling
- (Work-as-imagined vs work-as-done at the task level)

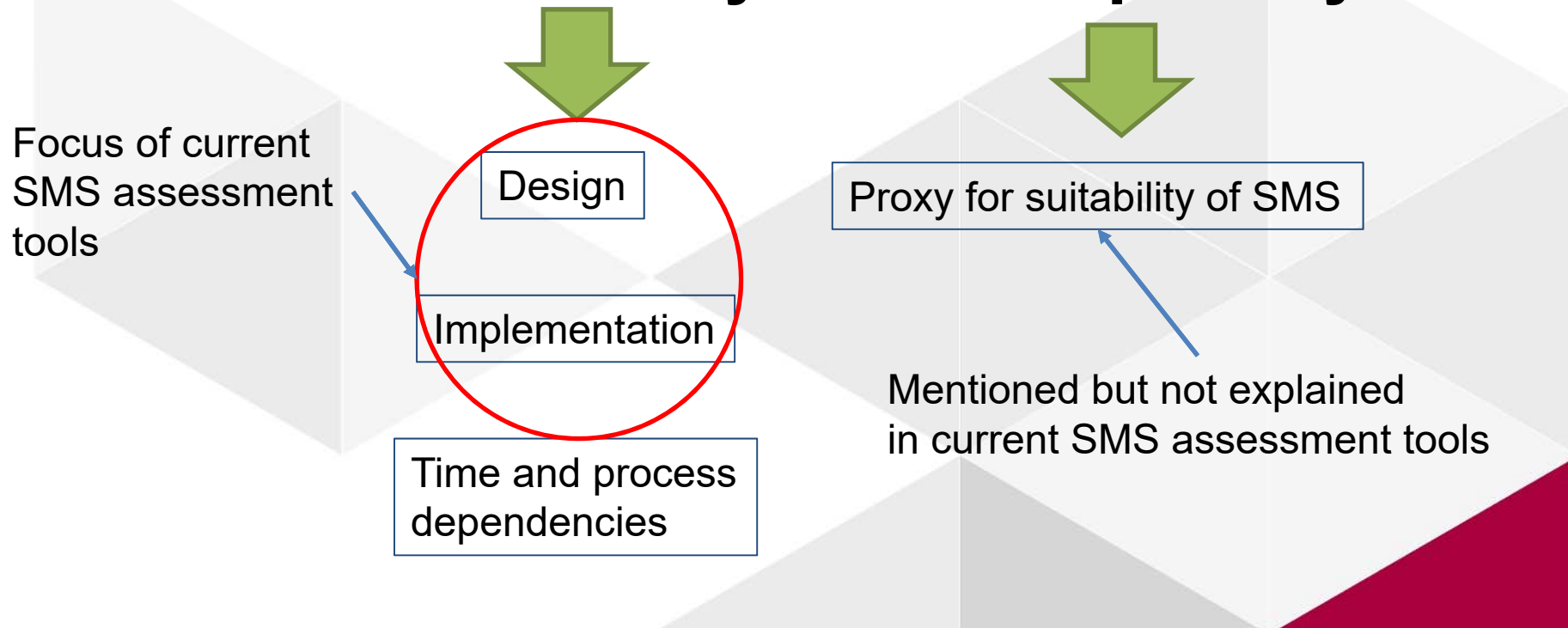# METRIC 1: SELF-ASSESSMENT OF SAFETY MANAGEMENT SYSTEMS

SMS Functioning =

SMS Maturity * SMS Capability

Focus of current SMS assessment tools

Design

Implementation

Time and process dependencies

Proxy for suitability of SMS

Mentioned but not explained in current SMS assessment tools

SMS ASSESSMENT: PART 2

SMS Effectiveness=
f(Quantity, Quality, Timeliness)

SMS MATURITY: DETAILED

SMS
(149 assessment topics)

4 Components

12 Elements

Design/Documentation
(51 topics)

Implementation
(50 topics)

Time and Process Dependencies
(48 topics)

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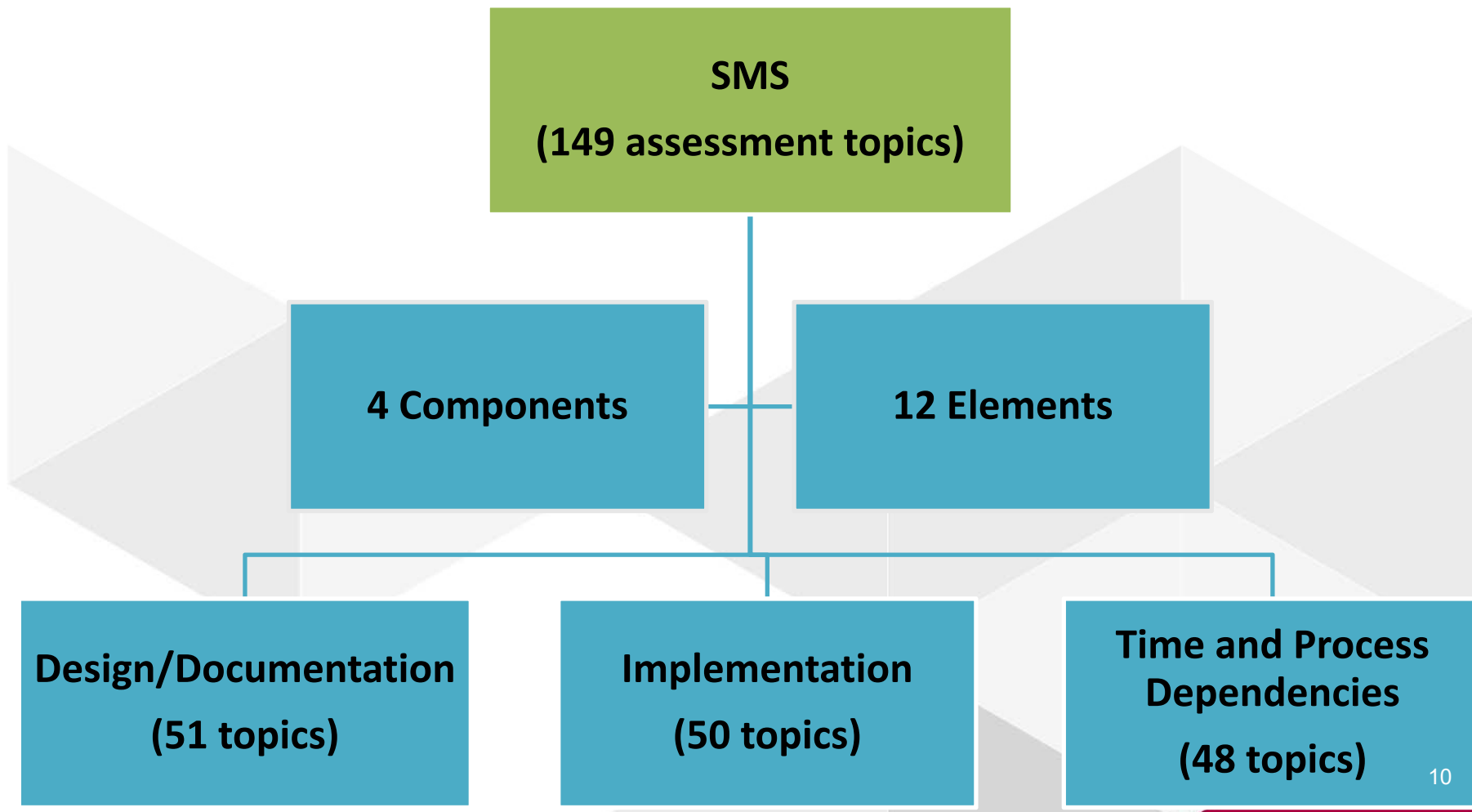
EXAMPLE: SMS MATURITY TOPICS AND SCORING WITH THE HIGHEST DETAIL

MCR1	There is a safety policy	100%
MCR2	The overall organisational policy views safety as core business function	0%
MCR3	Safety staff and officers participate in all planning and review management meetings (across all organizational levels and sections, as applicable)	30%
MCR4	Safety is a parameter in decision-making during all planning and review management meetings (across all organizational levels and sections, as applicable)	60%
MCR5	The possible need to change the safety policy has been always discussed by management during significant changes within the organization	20%
MCR6	Current safety policy is included in all safety education/training programs	100%

EXAMPLE: SMS MATURITY WITH LESS DETAIL (QUESTIONS TO SAFETY DEPARTMENT)

Element	Factors affecting SMS element maturity			
	To what degree are the activities included in this element designed/documented according to standards?	To what degree are the activities of this element, as described in standards, implemented?	To what degree are the activities of this element accomplished within the defined timelines / when needed?	When necessary, to what degree are the activities of this element performed by using available inputs from other SMS and organisational processes?
Management Commitment & Responsibility [Management's primary responsibility for ensuring a safe and efficient operation is discharged through ensuring adherence to SOPs (safety compliance) and establishment and maintenance of a dedicated SMS that establishes the necessary safety risk controls (safety performance).]	60%	60%	70%	30%

EXAMPLE: SMS CAPABILITY (QUESTIONS TO MANAGERS)

Factors affecting SMS element capability					
How capable do you feel of executing your activities related to this element according to the SMS manual?	How adequate are the means provided to you to execute the activities related to this element as described in the SMS manual?	To what degree do you conflict with other persons that work on the same activities of the SMS element?	How adequate are any inputs from other organisational activities you need to execute your activities of this element according to the SMS manual?	How timely are any inputs from other organisational activities delivered so you can execute your activities of this element according to the SMS manual?	To what degree external factors disturb you in the execution of your activities of this element as described in the SMS manual?

EXAMPLE: SMS EFFECTIVENESS (QUESTIONS TO EMPLOYEES)

Factors indicating SMS element effectiveness		
Is the amount of activities of this element adequate to support your daily and safety-related tasks?	Is the quality of the activities of this element sufficient to support your daily and safety-related tasks?	How timely are the activities of this element executed by responsible persons to support your daily and safety-related tasks?

EXAMPLE: SMS PERFORMANCE

SMS CAPABILITY: ELEMENT	Distance	Maximum	Capability Score
Euclidean Distance of Current SMS from Ideal SMS with equal weights	3.46	3.46	0.00%
Euclidean Distance of Current SMS from Ideal SMS weighted according to the number of individual elements included	20.78	20.78	0.00%

Total SMS Functioning Score	
Task Maturity	Element Maturity
0.00%	0.00%
0.00%	0.00%

SMS EFFECTIVENESS: ELEMENT	Distance	Maximum	Capability Score
Euclidean Distance of Current SMS from Ideal SMS with equal weights	3.46	3.46	0.00%
Euclidean Distance of Current SMS from Ideal SMS weighted according to the number of individual elements included	10.39	10.39	0.00%

# SMS ASSESSMENT: CUSTOMIZATION TO SIZE AND COMPLEXITY OF COMPANY

	Checking points (Deskwork): SMS maturity		
Survey questions to staff: SMS capability (managers) and effectiveness (employees)	149 (51 design points, 50 implementation points, 48 "dependency" points)	48 12 SMS elements * (1 design + 1 implementation +4 dependency questions/points)	16 4 SMS components * (1 design + 1 implementation +2 dependency questions/points)
SMS elements **72 Capability questions** **36 Effectiveness questions**	Part CAT (Option 1)	N/A	N/A
SMS components **24 Capability questions** **12 Effectiveness questions**	Part CAT (Option 2)	Complex – Part NCC (Option 1)	N/A
Whole SMS **6 Capability questions** **3 Effectiveness questions**	N/A	Complex – Part NCC (Option 2)	Non Complex – Part NCC

METRIC 2: SAFETY CULTURE PREREQUISITES

OVERALL APPROACH

Safety culture assessment → What to do next?

Suggestion

Safety culture prerequisites ⇄ **Safety culture assessment**
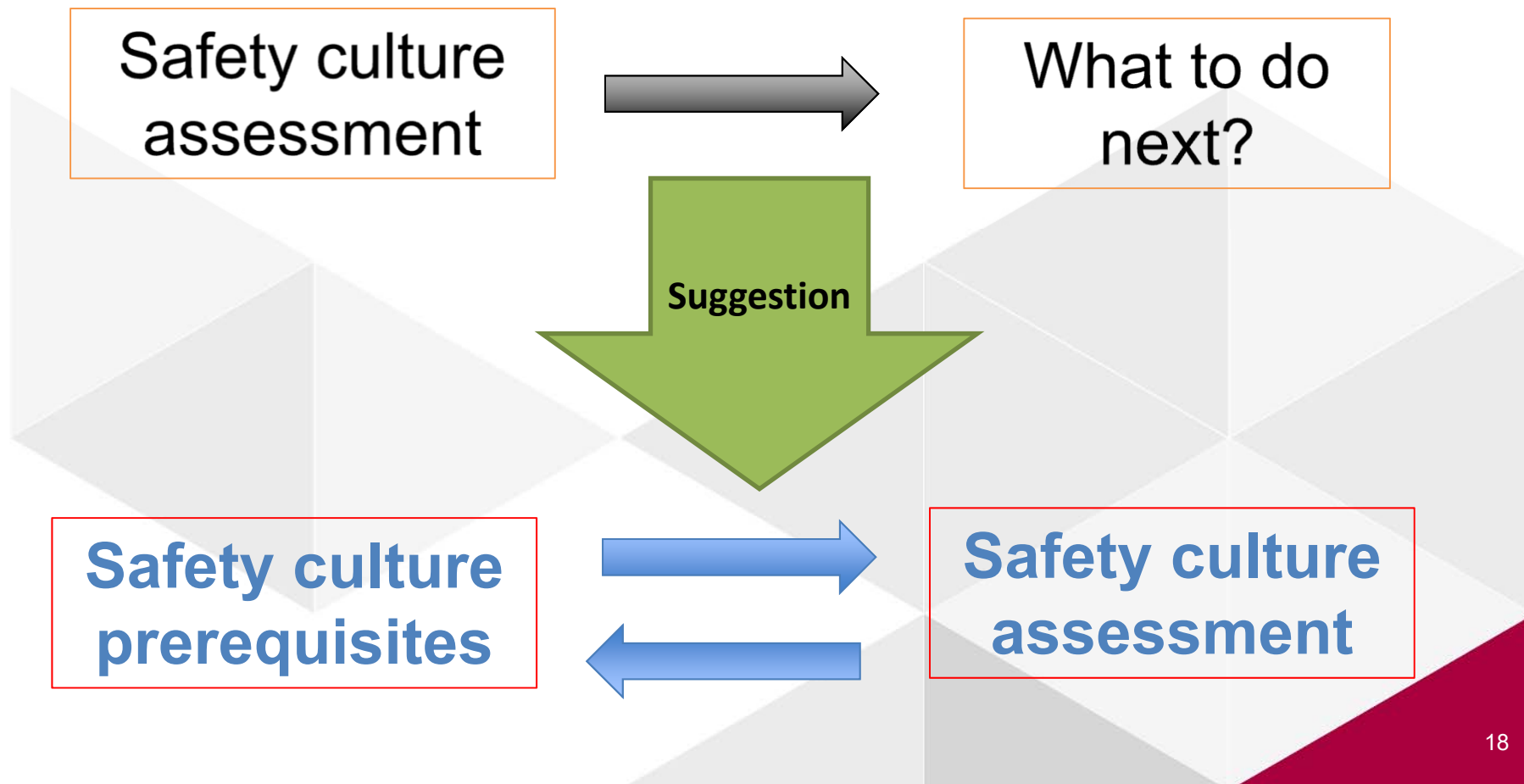
A THREE PART SURVEY HAS BEEN DEVELOPED TO IDENTIFY GAPS

- Three parts:
  - Document analysis
  - Implementation check
  - Perception assessment
- Scoring: Euclidean distance
  - Versus ideal
  - Gap between each of the three parts

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EXAMPLE: DESIGN/DOCUMENTATION

		Document Analysis	Please choose from dropdown	Reference	Score	
5	G.3-1	Responsibilities for safety have been defined across all management areas.	Partially		50	G
6	G.3-2	Accountabilities for safety have been defined across all management areas.	Partially		50	G
7	G.4-1	The safety department is responsible for safety planning.	Yes		100	G
		The safety department is accountable for safety				

EXAMPLE: IMPLEMENTATION

	Survey	Please choose from dropdown	Score	
G.6	To what extent do you continuously improve safety, regardless of past successes?	Sometimes	50	
G.7-1	How often do you base decisions, changes and plans on a risk management framework?	Never	0	

EXAMPLE: PERCEPTION & GAPS

			0
I think the culture in this organization is just			

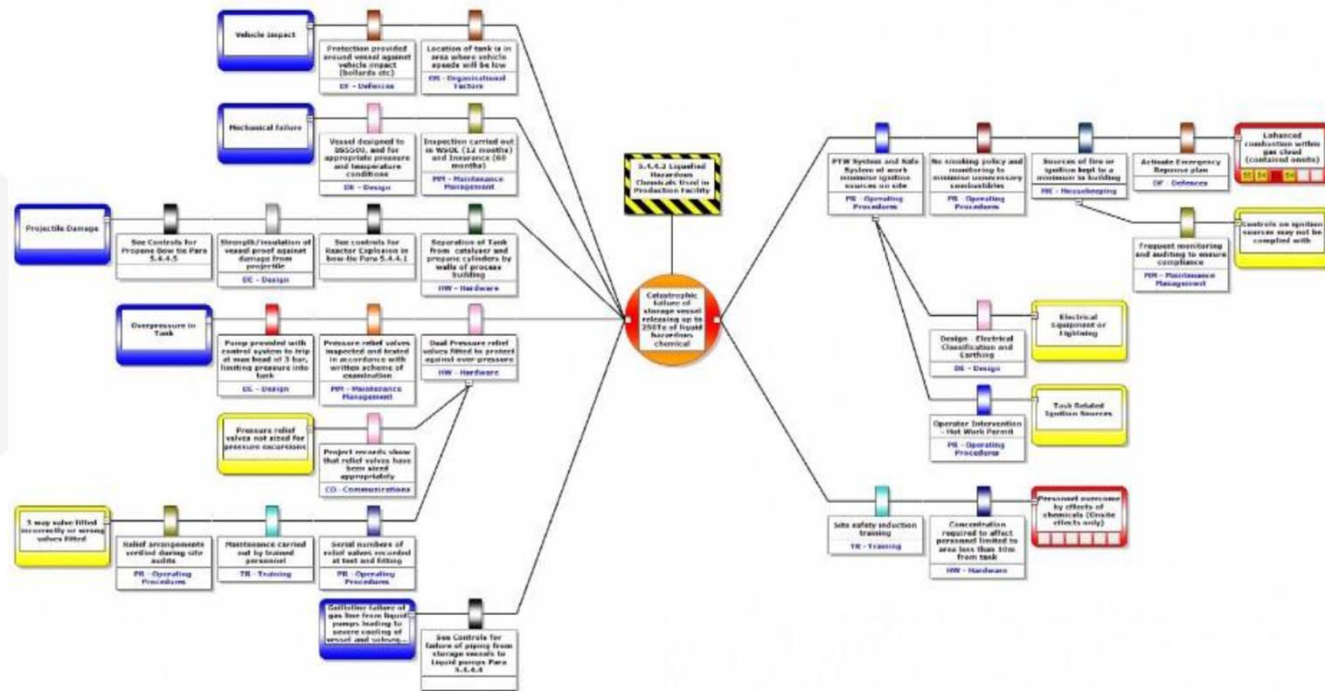| Culture		A. Document Analysis	B. Survey	C. Perception
General	General score	59,5	46,9	75,0
	Gap A - B	12,6		
	Gap B - C		28,1	
	Gap A - C	-15,5		

METRIC 3: RISK CONTROL EFFECTIVENESS

BACKGROUND

- Validation of the effectiveness of safety risk controls is essential element of safety assurance (ICAO 2013).
- → indicators based on the effectiveness of risk control measures.

METRICS FOR RISK CONTROL EFFECTIVENESS

- $100\% - \dfrac{\sum \text{failures of control when challenged}}{\sum \text{occasions control was challenged}}$

- $100\% - \dfrac{\sum \text{failures of control when tested}}{\sum \text{occasions the control was tested}}$

- $100\% - \dfrac{\sum(\text{unwanted events after a control was implemented}) \text{ per unit of time}}{\sum(\text{unwanted events before a control was implemented}) \text{ per unit of time}}$

- Failure: control does not result in the specific desired outcome
- These metrics are listed in preferential order (most preferred on top).

METRIC 4: RESOURCE GAPS

BACKGROUND

- Availability of resources is limited and sometimes uncertain

- People adjust what they do to match the situation
  - Performance variability is inevitable, ubiquitous, and necessary.
  - Thus things normally go right, but also sometimes go wrong.

➔ Therefore it was worthwhile to explore the possibility of defining safety performance indicators based on the availability of resources.

RESOURCE TYPES & INDICATORS

Resource types

Human	Equipment
Budget	Time
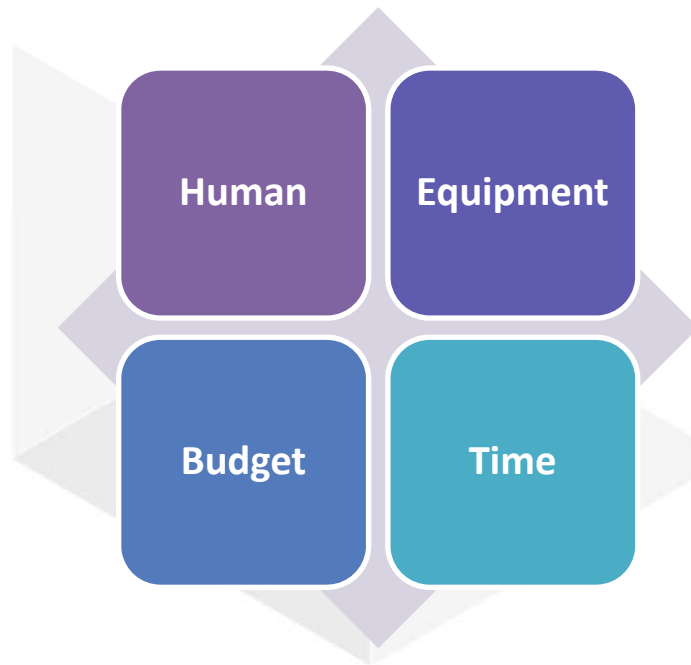
Indicators

- Available runtime / required runtime
- Available person-hours / required person-hours
- Staff turnover
- Budget invested / budget spent for a specific activity or a group of activities.
- Number of equipment available / number of equipment required

METRIC 5: SYSTEM COMPLEXITY / COUPLING

COMPLEXITY FACTORS

- Complexity cannot be fully understood
- Literature suggests various approaches to "measure" complexity for specific applications
- Our system complexity/coupling metric combines:
  - Number and timestamp of elements
  - Number and types of interactions
  - Resource slacks
  - User perception

COMPLEXITY/COUPLING FORMULAS

Total Complexity
$= SystemComplexity * HumanPerception$

$$SC_{perceived} = SC * HP \quad = \left[\sum_{i=1}^{NE}\sum_{j=1}^{NI_i}\left(\frac{\dot{d}_{ij}}{d_{ij}}\right)\right] * \frac{1}{SL} * HP$$

SL: "To what extent do you have adequate resources (human, technical, communication & information) to respond to unexpected disturbances/excessive demands when performing your tasks and still achieve your objectives?"

HP: "To what extent does your experience and skills match the demands to perform your tasks and meet their objectives?"

IN A NUTSHELL …

- The 5 new metrics meet adequately the accuracy, construct, content and face validity types: design process supported by about 40 partners.

- The particular metrics combine qualitative and quantitative assessments, without neglecting any organisational level.

- Companies can get a better understanding of their operations across the focus areas of the metrics.

- The quantified results allow benchmarking of systems and their evaluation over time: from compliance-based to performance-based evaluations.

- The specific metrics can complement current safety metrics, and support safety improvements in present and future air transport.

ARE YOU INTERESTED IN APPLYING THE METRICS?

- We will run surveys in early 2018.
- The SMS self-assessment and Safety Culture Prerequisites tools can be applied remotely and will be:
  - translated into online questionnaires
  - distributed across the company staff, as applicable
- The risk control effectiveness, resource gaps and complexity metrics can be self-applied, after some training, or applied by the researchers on-field.
- We will need data (not content) from your reporting systems
- Confidentiality of any data to be collected (NDA).
- Reception of individual reports including benchmarking against the rest of the partners

PARNTERS PARTICIPATED TO-DATE

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