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大会第 38 届会议

技术委员会

议程项目 29：航空安全 —— 监控和分析

安全绩效衡量系统

（由美国提交）

执行摘要

本文件将讨论安全绩效指标系统的必要性，该系统虑及结果和程序措施之间的联系，以便评估管理航空运输体系风险的能力。该文件基于这样一个前提，即安全绩效应该通过整个航空运输体系内的风险管理水平予以评估。衡量安全绩效必须考虑到监管者影响产品/服务提供者安全管理进程绩效的作用及其对于航空运输系统层面上结果的效应。安全绩效必须考虑到产生预期结果绩效的过程绩效，并且应该拟定相应指数。本文件将提议一种安全衡量方法，基于三级系统行为的基础：高级别安全结果、服务提供者的行为，以及监管机构的活动。

行动：建议国际民航组织考虑采用本文件附录所载的拟议框架，以便进一步制订关于界定安全绩效指标的方法。

战略目标:	本信息文件涉及安全战略目标。
财务影响:	预期这将由预算草案予以涵盖。
参考文件:	Doc 9859 号文件：《安全管理手册》 2010 年高级别安全会议，建议 2/3a Doc 9958 号文件：《大会有效决议》（截至 2010 年 10 月）

1. 引言

1.1 国际民航组织（附件 19 第 1 章）规定了安全的运行定义：“将航空活动的相关风险减少并控制在一个可接受水平的状态”。该定义源于这样一种定义，即安全衡量应该包括服务提供者有效管理安全风险的能力，应该通过实施安全管理进程来做到这一点。

2. 讨论

2.1 安全绩效的衡量应该侧重于系统管理安全风险的能力水平。将重点放在能够减轻负面结果风险的系统行为方面，就可以形成有意义的安全绩效衡量标准。有效的安全衡量必须反映出与安全风险控制相关的系统行为，并且有助于做出减轻风险的决策。

2.2 拟定有效的衡量模式还必须考虑到监督活动的有效性，其对于服务提供者减轻负面安全结果（即事故和事故症候）风险的行为影响。

2.3 衡量还必须既考虑到过程（组织及其成员的活动和行为），也考虑到结果（那些过程的结果）。

2.4 为了拟定如何全面系统订立衡量标准的指导，安全管理国际协调组（SM ICG）[1]拟定了一个绩效管理框架，载于本文件附录。本文件虽然是由美国提交的，但是和安全管理国际协调组成员协作编写的。

2.5 本文件附录提议的绩效管理框架提供了以下级别的衡量标准：

a) 总体系统结果，包括事故率和重大安全问题（例如有控飞行撞地（CFIT）、失控、跑道入侵）；

b) 航空服务提供者的系统行为（例如包括培训、维护、运行控制和机舱安全在内的关键系统的过程绩效）；和

c) 航空监管机构的活动（例如合格审定、保障持续运行安全等）。

2.6 拟议的三级做法通过在不同层面上将结果与过程挂钩，提供了衡量安全的基石：高级别安全结果、服务提供者的行为，以及监管机构的活动。这些衡量标准提供了评估航空运输系统的能力及其管理风险的方法[2]。关于这一框架的进一步详细内容载于本文件附录。

3. 建议

3.1 请大会同意以下建议：

a. 建议国际民航组织考虑采用本文件附录所载的拟议框架，以便进一步制订关于界定安全绩效指标的方法。

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[1] 本文件是与安全管理国际协调组成员组织协作编写的，这些组织包括西班牙安全和保安机构（AESA）、巴西国家民航局（ANAC）、荷兰民航局（CAA NL）、新西兰民航局、澳大利亚民航安全局（CASA）、法国民航总局（DGAC）、欧洲航空安全机构（EASA）、瑞士联邦民航局（FOCA）、日本民航局（JCAB）、美国联邦航空局（FAA）航空安全组织、加拿大运输部民航局（TCCA）和联合王国民航局（UK CAA）。

[2] 国有航空器不在国家安全方案的范畴之内。

APPENDIX

A SYSTEM FOR SAFETY PERFORMANCE MEASUREMENT

1. Introduction

1.1 A system for safety performance measurement, created by the SM ICG, considers the role of the regulator to influence performance of product/service provider safety management processes and their impact on outcomes in the air transportation system. The proposed three-tier approach provides a foundation for measurement of safety through correlation of outcomes and processes at various levels: high level safety outcomes, service provider behaviors, and regulatory agency activities. These measures provide the means to assess the capability and to manage risk in the air transportation system.

2. Oversight Responsibilities of States

2.1 ICAO State Safety Oversight System (Annex 19, Appendix 1) Critical Element 2 (CE-2) states that regulations should be designed to control the system design, management practices, and organizational behavior of service providers. One measurement of the overall effectiveness of a State's regulations would be the degree to which they cover key areas of risk.

2.2 Assurance that the service provider has incorporated appropriate risk controls into the design of its systems and processes becomes a basis for the issue of certificates, authorizations, or approvals on the part of the authority (CE-6). This assurance process provides a critical interface between the State Safety Risk Management (SRM), service provider SRM, and State safety assurance. Measures of the State's safety performance must represent how well the State assures that regulations are translated into the operational processes of product and service providers.

2.3 States must conduct surveillance (CE-7) activities to assure continued safety performance as part of their safety assurance process. Measures must be available to evaluate service providers' continuing performance and the effectiveness of the State's performance assurance process.

3. Types of Risks: Common and Unique Causes

3.1 Figure 1 depicts accident rates over time, dividing the trends shown (steep decline, slow decline, level) into categories that are dependent on the organizational processes used to manage safety. Common cause occurrences are those to which all or a large segment of the population of interest are exposed and for which there are equivalent or highly similar (and thus "common") causes. In phase 1, prescriptive rules or regulations manage common cause failures.

3.2 In phase 2, many of the risks that can be effectively controlled through prescriptive regulations have been addressed. Remaining risks occur more randomly, associated with problems unique to individual service providers. Service providers' SMS processes are essential to identify and treat these risks. Safety measurements must, therefore, address the design and performance of service providers' SMS processes and their ability to address unique risks.

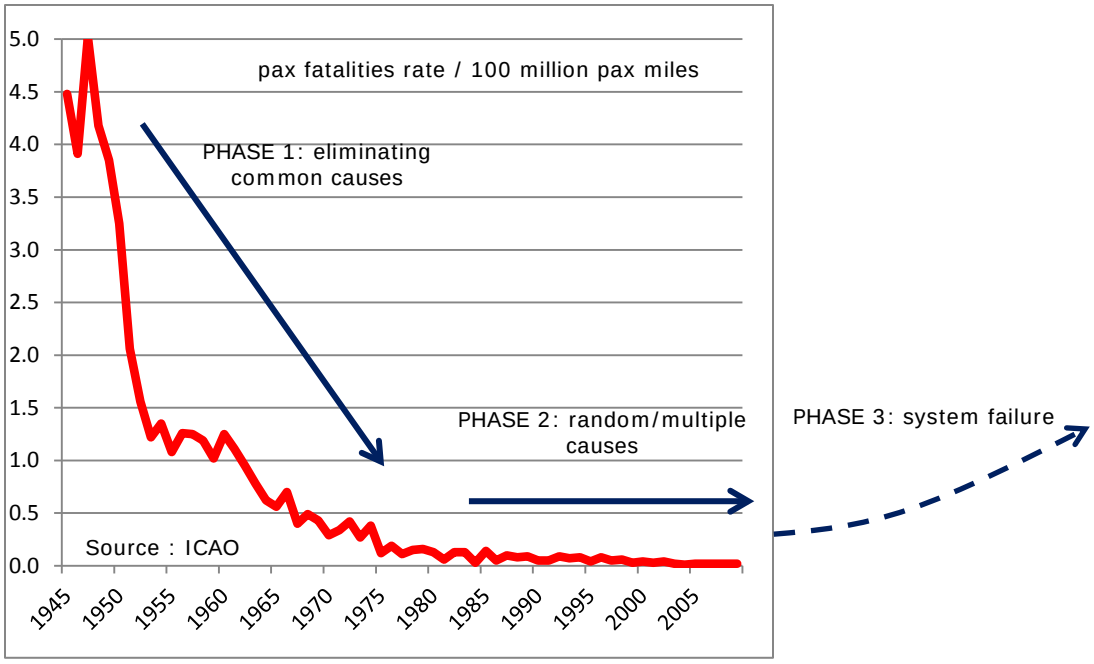

Figure 1. Accident Trends and Causes

3.3 At the same time, management of risks addressed through compliance with existing rules must be maintained. Phase 3 represents a situation in which the relaxation of prescriptive regulations would mean that the gains made in phase 1 are reversed. Thus implementation and compliance with basic safety standards must be part of the safety management strategy and must, therefore, be part of the measurement strategy.

4. Risk Control: Measurements of Compliance and Risk Management

4.1 Figure 2 shows the relationship between "things that are unsafe" (risk – circle on the right) and "things that are illegal" (contrary to prescriptive regulations – circle on the left). Managing risk of all sources of risk would entail identification and management of all possible "unsafe" situations. Measurement of the effectiveness of risk management involves assessing how completely this is done. Though there is typically an intersection between the two, the overlap is not total and not zero. The intersection between the two circles represents the set of situations in which hazards and threats are covered by regulations, typically focusing on technology, training, or procedures. These are the "common cause" hazards that were discussed above. Note that this is a subset of compliance and, if all rules appropriately addressed legitimate hazards, would represent the totality of compliance.

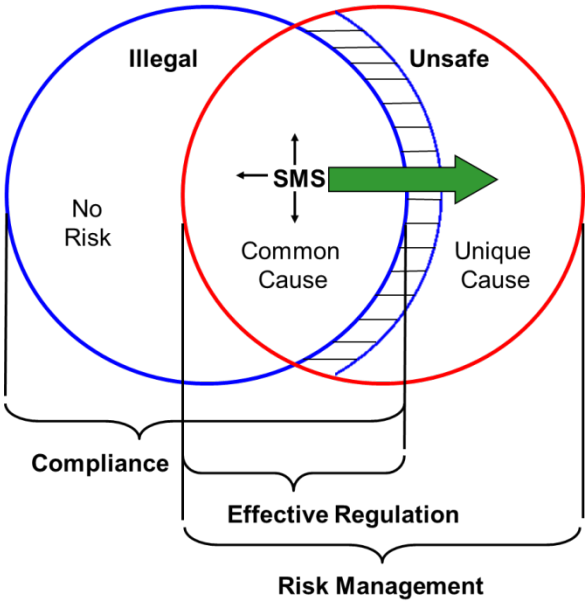

Figure 2. Relationship Between Regulatory Requirements and Risk

4.2 The requirement for an SMS is placed in this overlap area between the circles. This takes the position that the need for an SMS is common to all service providers. It further recognizes that effective compliance entails use of an operator's SRM processes to tailor the method of compliance to its situation. However, service providers must also control hazards that are outside of the scope of practical regulations but that exist in their operational environment. Control of unique problems is best controlled by the processes incorporated in an SMS. The SMS also requires a product/service provider to identify hazards in their systems and operational environment, assess these hazards for their degree of risk, take action to control those that pose an unacceptable degree of potential harm, whether those risks are the subject of regulations or not.

4.3 Note then that the overlap area is labeled with the bracket "effective regulation". This is not to say that all rules and compliance efforts are assumed a priori to be effective but that assessment of regulatory effectiveness should be based on how well this is done.

4.4 The area of "things that are unsafe" but not illegal, represents unique cause risks that generally cannot be controlled by regulation. The area bounded by the hatched area outside of the area of overlap represents a situation where effective risk controls are either outside of current technology or where the costs of implementing controls outweigh their benefits to society.

4.5 The area of "things that are illegal" but not harmful (the part of the left hand circle outside of the "unsafe" circle) represents ineffective regulations where compliance is not correlated with safety. This could be because the rules were inadequately developed to begin with, are obsolete, or were applied too broadly to service provider groups that are not exposed to the hazard that the regulation addresses.

5. The Safety Performance Measurement System

5.1 The measurement system structure depicted in Figure 3 is based on three tiers[3] (2000) of analysis that represent the activities and performance of both the State and service providers in the civil aviation system. The levels of the system include: measures of the integrated civil aviation system, measures of service provider system behaviors, and measures of activities of regulatory authorities, as well as four pillars which describe the way safety is measured and managed.

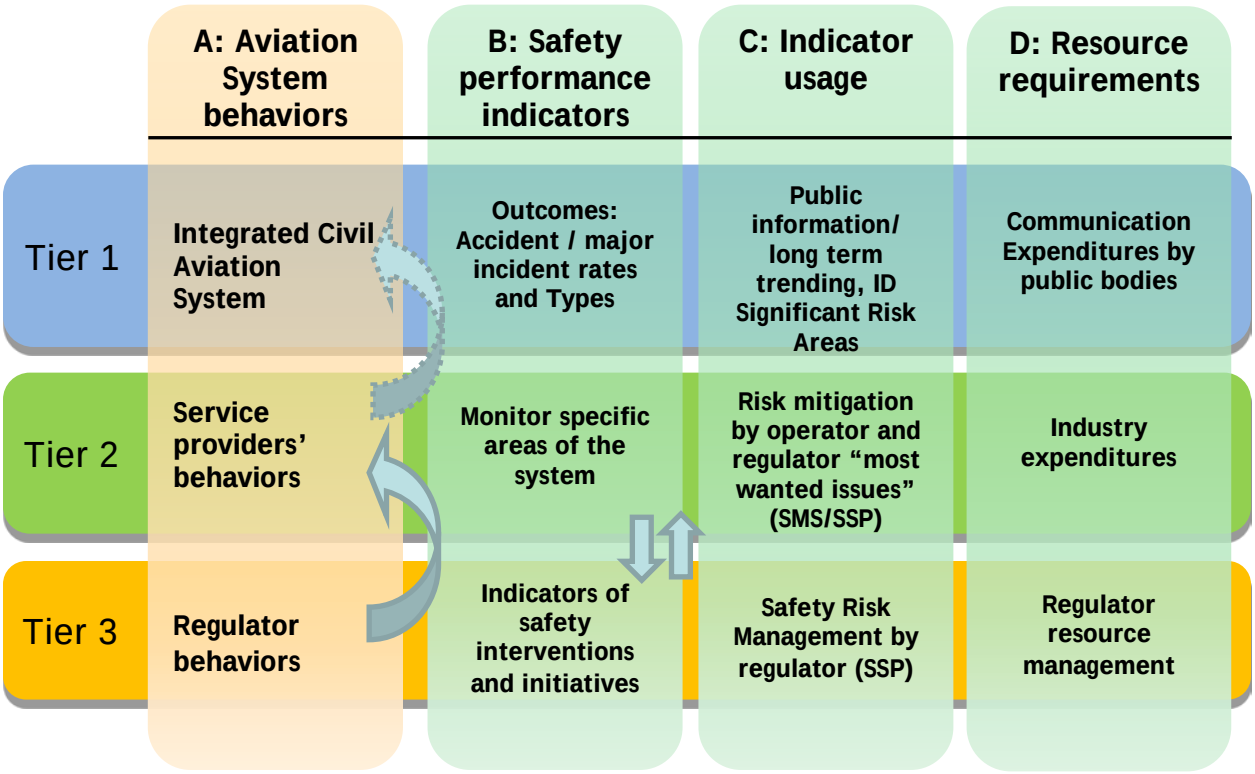

Figure 3. Safety Performance Measurement Matrix

5.2 Indicators of performance (column B) consist of both process and outcome measures. Process measures are measures of the functioning of key safety management processes such as safety risk management and safety assurance on the part of both States and service providers.

6. The Indicator Framework

6.1 The safety performance indicator model in Figure 4 provides a top-level concept for safety performance measurement that represents an expansion of the second column of the Safety Performance Measurement Matrix (Figure 3) to guide actual indicator development.

[3] The model for the matrix was adapted from *The Regulatory Craft: Controlling Risk, Solving Problems and Managing Compliance* by Dr. Malcolm Sparrow, Harvard University, 2000.

		OUTCOMES	PROCESSES	INTER-TIER CORRELATIONS
I	INTEGRATED CIVIL AVIATION SYSTEM	(1) Accident rates, Incident rates, Fatalities (etc.) (2) Breakdown of Event rates for significant risk areas	∑ Safety Management capability (effectiveness of): - Identifying common cause hazards - Effectiveness of regulatory risk controls	N/A
P	SERVICE PROVIDER PERFORMANCE	per Service Provider: outcomes related to significant risk areas	SMS performance: - SRM/compliance with regulatory specifications - Ability to identify unique cause threats Effectiveness of risk control actions	Influence of Service Provider activities on safety outcomes
R	REGULATOR PERFORMANCE (ACTIVITIES)	Activities and initiatives to address specific risk areas - Effectiveness or risk controls (correlation with Service Provider behaviors and aggregate outcomes) - Effectiveness of risk control application (Oversight system performance – Design Assurance and Performance Assurance)	Safety risk management capability : - Ability to identify common cause threats - Ability to develop risk controls	Influence of regulator activities on Service Provider behaviors Influence of regulator activities on safety outcomes

Figure 4: Safety Performance Indicator Framework

6.2 The indicator framework is organized into the same three tiers used in the measurement matrix depicted in Figure 3. Each level of the proposed framework is divided into two related dimensions: outcomes and processes (the middle two columns). The fourth column represents correlations between tiers of the model. Validity of the measures in Tiers 2 and 3 is based upon the correlation with the next tier above them. For example, the validity of measures of oversight activities is based upon the relationship between the measured oversight activities and their influence on service provider behaviors and outcomes.

6.3 Tier 1 outcome measures come in two varieties: overall event rates (e.g. accident rates, hull loss rates), and event rates related to significant risk areas (for an example, see the UK CAA's "significant seven"). These event types are those associated with common cause hazards — those hazards to which all or large segments of the product/service provider community are exposed.

6.4 Tier 2 measures address the behavior of service provider systems whose performance relates to safety outcomes. At Tier 2, a set of safety outcomes should be identified for tracking. These should start with the significant risk areas identified for Tier 1, representing an association with common cause hazards. This set of outcomes should also include measures related to hazards that are unique to the product/service provider.

6.5 Compliance with regulations (the State's specifications for control of hazards common to the service provider's population) is part of the process of risk management. Therefore, measurement of compliance should also include measures of how well the service provider has used its SRM process to incorporate relevant regulations into its processes.

6.6 Tier 3 indicators are process and outcome measures to gauge the safety interventions and initiatives of the regulator. Effective regulator activities should motivate and facilitate service provider behaviors that, in the aggregate, result in overall improvements in safety outcomes. Tier 3 indicators will in many cases be linked directly to Tier 2 indicators as the latter are required to measure how effectively regulator activities and behaviors have addressed key safety issues identified. The ability to influence future performance is an important characteristic of both Tier 2 and Tier 3 indicators.

6.7 At Tier 3, regulator activities must be based upon influencing the behaviors of product and service providers. Regulator action at Tier 1 considers the entire civil aviation system or major system components. Accountability for identifying and designing risk controls for these common cause hazards rests primarily with the regulator. Measuring the effectiveness of the regulator's accomplishment of this responsibility is, therefore, a matter of evaluating these functions.[4]

6.8 Measures of regulator safety management performance should include measures of how well the regulator is able to accomplish its design assurance (certification) functions (part of the State's assurance process). Validity of these measures should reflect the degree to which the regulator is able to influence the system and process design of service providers. Regulators' design assessments include an assessment of how well the service provider has identified and controlled hazards that are unique to its own systems and environment.[5]

6.9 As part of their performance assurance function, regulators must also assure "continuing operational safety" on the part of service providers. To do this, they must measure and assess service provider performance.[6] Regulators must also take action on those areas of service provider performance that fail to control risk in their operations to an acceptable level.[7]

— END —

[4] This would also measure critical element of oversight number two (CE-2).

[5] This would also be a measure of critical element of oversight number six (CE-6). Such a measure should be based on the regulator's assessment of the service provider's effective use of their SRM process in order to assure that the designs of their systems effectively control hazards as intended in regulations as well as any hazards unique to the service provider.

[6] This would also measure critical element of oversight number seven (CE-7).

[7] This would also measure critical element of oversight number eight (CE-8).