INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA-PACIFIC AIR TRAFFIC MANAGEMENT PERFORMANCE MEASUREMENT FRAMEWORK

Version 1.0, November 2019

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BACKGROUND

Overview

1.1 With huge economic increase in Asia-Pacific region, air transportation has been developing rapidly, which leads to a large raise of flights. Considering massive and high density of air traffic is exposed to countries in Asia-Pacific region, some of the international flights may cross the national border during the flight operation phase. Lack of unified management approach and evaluation standard, many unexpected accidents have taken place.

1.2 ICAO data indicates that the Asia/Pacific Region in 2011 was the busiest in the world in terms of Passenger Kilometres Performed (PKP): 1,496 billion compared to 1,434 for North America and 1,385 for Europe, with growth rates of 8.0 - 8.8%, 2.3 - 3.5% and 4.2 - 4.8% over the 2012-2014 period respectively. In 2012, the Asia/Pacific region had the largest regional market share of total domestic and international Revenue Passenger Kilometres (RPK) at 30%, compared to 27% for both Europe and North America. Under the circumstances of those, in 2013, ICAO has published Asia-Pacific Seamless ATM Plan, which provides a framework for a transition to a seamless ATM environment, in order to meet future performance requirements. The objective of this plan is to facilitate Asia-Pacific Seamless ATM operations, by developing and deploying ATM solutions capable of ensuring safety and efficiency of air transport throughout the Asia-Pacific region. In the context of globalization, this plan provides the opportunity for the Asia/Pacific region to adopt the benefits from research and development conducted by various States including the NextGen (United States of America), the European Single European Sky ATM Research (SESAR), and Japanese Collaborative Actions for Renovation of Air Traffic Systems (CARATS).

1.3 This report is aimed at providing a systematic and scientific performance framework to evaluate the operation performance which is subject to Key Performance Area of air transport system in Asia-Pacific region. The performance oriented and data based approach is according to Doc 9883 Manual on Global Performance of the Air Navigation System to select the Key Performance Indicators, which has been considered about the operation features and the availability of data of Asia-Pacific region. To achieve the goals of Seamless ATM operations, the most widely accepted KPAs such as safety, capacity, efficiency, predictability, environment and cost-efficiency to evaluate the operation performance of ANSPs (Air Navigation Service Providers) and AOs (Aerodrome Operators) should be used. Furthermore, this would improve the performance of air transportation system and aid decision making for ANSPs and AOs.

1.4 Most of current practice for KPA and KPI can be found in the International Civil Aviation Organization (ICAO). A review of current practice which is carried out by ANSPs and national regulating authorities shows that most organizations attempt to comply with the ICAO framework when monitoring performance. However, not all KPAs have useful KPIs to provide stakeholders with unique information. The following sources provide some of the additional information of KPAs and KPIs, which are regionally and globally used:

- Global Air Traffic Management Operational Concept (ICAO Doc 9854) International Civil Aviation Organization, 2005.
- Global Air navigation plan (ICAO Doc 9750), International Civil Aviation Organization, 2013.
- Manual on Global Performance of the Air Navigation System (ICAO Doc 9883), International Civil Aviation Organization, 2009.
- EUR Region Performance Framework Document (EUR Doc 030), International Civil Aviation Organization, 2014.
- Airport CDM Implementation, European Organization for the Safety of Air Navigation, 2012.

- The PRC'S European ATM Performance Measurement System, European Organization for the Safety of Air Navigation, 2011.
- Comparison of Air Traffic Management-Related 2013 Operational Performance: U.S./Europe, EUROCONTROL/FAA Air Traffic Organization System Operations Services, 2014.
- Performance Review Report: An Assessment of ATM in EUROPE during the Calendar Year 2014, European Organization for the Safety of Air Navigation, 2015.
- Recommended Key Performance Indicators for Measuring ANSP Operational Performance, civil air navigation services organization, 2015.
- Services Charter 2014/15-2015/16, Airservices Australia, 2015.
- A brief to china's ATM KPIs, 2014.
- The report of china civil flights operation efficiency in 2014, Airspace Operation Center of China,2015.
- European Union Regulation (EU) No 390/2013,
- UK NATS Fuel Efficiency Metric (3Di)

1.5 In consideration of serviceability of those practices, ICAO and EUROCONTROL's work was used as reference. ICAO has identified 11 KPAs for monitoring performance of ATM system, which have been described in ICAO's Global Air Traffic Management Operational Concept Report (Doc 9854) and Manual on Global Performance of the Air Navigation System (Doc 9883). Those documents contain a high level description of goals of the Performance-Based Approach (PBA) to management, especially the Doc 9883 which describes the foundational requirements for measuring performance and a list of key performance indicators (KPIs) that may be considered for tracking operational performance.

1.6 Following the 12th Air Navigation Conference (ANC/12), ICAO produced the Global Air Navigation Plan 2013-2018, Fourth Edition (Doc 9750) (GANP). This document specifies air navigation technology improvements as a series of 'Aviation System Block Upgrades' (ASBUs), which is a programmatic and flexible global system engineering approach to allowing all Member States to advance their air navigation capabilities based on their specific operational requirements. The ultimate objective of ICAO is to urge all Member States to align their future aviation system developments against the GANP to achieve a seamless sky and global harmonization. The Sixth Edition of the GANP (2019) is taken as reference.

1.7 More detailed information on the ASBUs is provided on the ICAO GANP Portal at https://www4.icao.int/ganpportal/.

1.8 As is shown in **Figure 1**, ICAO has identified a number of concepts to describe different elements which have different characters and function. This introduces the concept of the performance evaluation framework to refine the indicators.

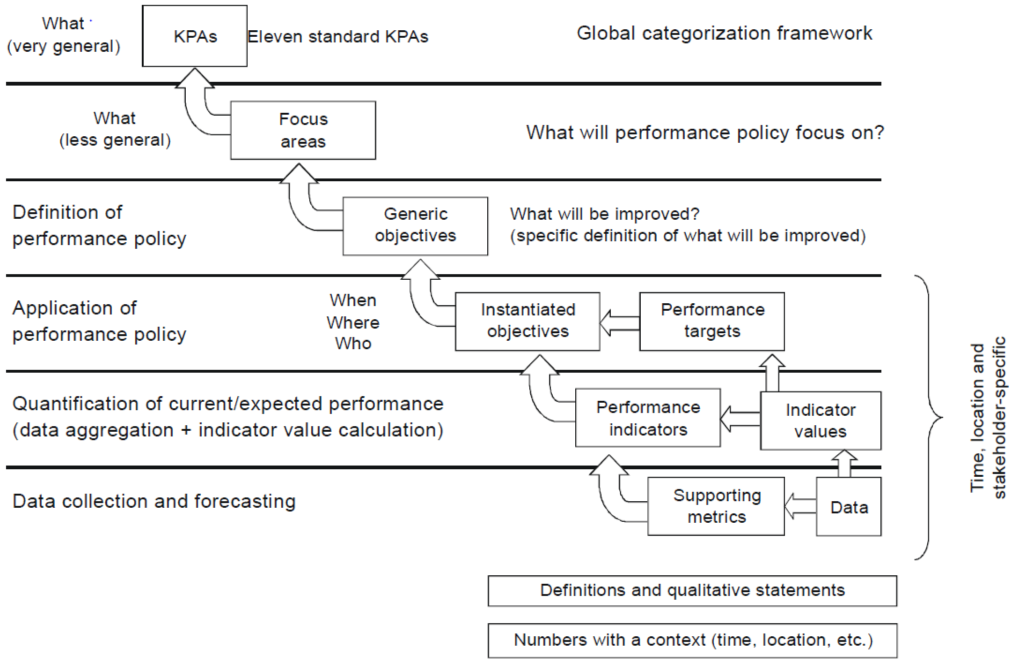


Figure 1: ICAO Performance Evaluation Framework

1.9 Moreover, CANSO's safety programme helps ANSPs improve safety through elements such as safety management systems, best practices and benchmarking. Seeking predictive measures of risk and positive safety performance metrics, the Safety Performance Measurement Workgroup (SPMWG) in Canso creates new leading indicators so that members of CANSO can better understand their safety performance and risk control effectiveness.

1.10 In China, CAAC (Air Traffic Management Bureau) formulates the Civil Aviation ATM Modernization Strategy(CAAMS). CAAMS evolves from navigation alone to providing comprehensive ATM services, in combine with the Required Communication Performance (RCP), Required Navigation Performance (RNP) and Required Surveillance Performance (RSP) of airborne system and ground system, so as to provide differentiated ATM service capability based on different performance levels and requirements of airspace users. Besides, CAAMS has developed a complete performance system about its main tasks, including safety, capacity, efficiency, service, management.

FRAMEWORK COMPOSITION

Key Performance Areas

2.1 There are a number of features of the air transport system which have constraints imposed by external bodies. These constraints reduce the ability of stakeholders to make a full trade-off between KPAs. The requirements imposed by external agencies must be strictly observed and performance must be optimized subject to those requirements.

2.2 Over and above these constraints, there are trade-offs that can be made. For example, an ATSP may choose to implement a higher level of safety than imposed by the regulator if it believes this reflects the users' preferences. This choice would be made in the full knowledge that there would be trade-offs with other KPAs e.g. delays may increase or costs would be higher.

2.3 It is possible that the regulatory process may facilitate this type of information exchange between users and ATS Providers by establishing a formal means of consultation. Since trade-offs between the key performances areas are inevitable, it is necessary to ensure that the trade-offs that will be made are done in such a way as to increase the overall benefits of the system to users.

2.4 To assist the process of assessing the costs and benefits of the trade-offs it is necessary to have an over-arching objective for the air transport system. An appropriate objective is to give users over the long term safe services and the levels of capacity and quality they require, and for which they are prepared to pay, with price being based on the costs of efficient operations."

2.5 With a focus on this objective, stakeholders can decide how changes to the current system will increase the benefits over and above the status quo and how this will be monitored by the indicators. For example, if demand for ATS is expected to grow beyond the present capacity of the system there are two possible outcomes. If capacity does not expand to meet the demand then indirect costs will increase due to, for example, additional delays.

2.6 If capacity is increased to cope with the additional demand, the direct cost of providing ATS will increase. There is a direct conflict between indicators measuring delays and indicators measuring cost. The decision to go ahead with the capacity increase will depend on the relative value users place on increased delays that will occur when current capacity is fully utilized and the increased cost of ATS necessary to fund the extra capacity. The desired response is for additional capacity to be provided up to the point where the additional benefits cover the extra costs.

2.7 As the Asia-Pacific Seamless ATM Plan said, the applicability of Preferred Aerodrome/Airspace, Route Specifications (PARS) and Preferred ATM Service Levels (PASL) should be verified by analysing safety, current and forecast traffic demand, efficiency, predictability, cost effectiveness and environment to meet expectations of stakeholders. In those KPAs, cost effectiveness and environment are highly related to efficiency, and traffic demand has also been embodied in capacity.

Capacity

2.8 Capacity of airport terminal, runway and en-route ATC sector mentioned in the performance improvement plan of the Asia-Pacific Seamless ATM Plan should be monitored and assessed. In research and development part, the problem about balancing demand and capacity is emphasized to be integrated within the ATM system. There are some specific requirements in ASBU. Before 2018 Asia-Pacific ATM performance of capacity was expected to reach the standard level of Block 0. For example, B0-APAT, B0-RESQ, B0-ACDM in performance improvement areas of greener airport are mentioned in order to improve the capacity of runway, namely, the capacity bottleneck.

2.9 Never before has air transport been so rapidly developing as it is today. Accordingly, compared with the early stage of development, the complexity of air traffic environment is increasing as well.

2.10 The method of how to accurately , reasonably and effectively assess airspace and airport capacity will become the most important basis of the implementation of air traffic flow management, maintain the balance of airspace system between supply and demand and improve the flight punctuality. Capacity is the description of airspace and airport capability. To meet the demand of air traffic, it is needed to select and implement comprehensive capacity assessment indicators to improve the ability to assess the accuracy and timeliness of the results.

2.1 It will bring benefits to improvement and perfection of airspace and airport management and can help to improve level of air traffic flow management, go further to promote air space proper planning. It has an extremely important significance to alleviate the contradiction between the increasing air traffic flow and the scarce air space resource. Next, assess air space capacity from the perspective of the spatial dimension and the match of capacity and demands.

2.11 All of capacity KPIs should be implemented in Stage 1.

Efficiency

2.12 Efficiency, the same as safety, is another main goal of Asia-Pacific Seamless ATM operations plan. Asia-Pacific Seamless ATM Plan divides the operation phase into aerodrome operation, terminal operation and en-route operation to execute performance evaluation and performance improvement plan. So, our report establishes a phased evaluation approach according to the plan to making a fine analysis and finding the targeted pressure point. The seamless skies initiative is designed to improve the efficiency of air navigation services through increased harmonization, interoperability and flight path optimization which are detailed in B0-SURF, B0-FICE, B0-AMET, B0-RESQ, B0-ACDM, B0-FRTO, B0-OPFL, B0-TBO, B0-CDO and B0-CCO.

2.13 The efficiency of air traffic control department reflects the utilization of airspace resources. As *Doc.9883* stated, efficiency should comprise both “Temporal Efficiency” (i.e. delay) and “Flight Efficiency” (trajectory oriented), so the indicators are enumerated to assess the efficiency of air traffic control system from the dimension of time and space.

Time Dimension

2.14 Based on a time dimension for evaluating efficiency, indicators which are called delay or additional flight time, mainly reflect the difference between estimated or unimpeded time and actual time by each airspace unit. Due to large difference in operating characteristics of each flight phase and management of ANSPs, it is necessary to evaluate the efficiency of aircraft in terms of different flight phases.

Space dimension

2.15 The space discussed here not only refers to habitable three-dimensional space but also the conditional space of capacity and complexity etc. Efficiency based on the dimension of space is the utilization ratio of space resource of ANSPs.

2.16 Flight Efficiency under space dimension can be measured in terms of the deviation from four- dimension trajectory or flight dynamic data.(i.e. number of changing heading) Deviation can take several forms and include additional route length, non-optimum vertical profile, speed differences from the optimum, additional taxi time and time in stack. For example, a measure of efficiency should be based on fuel consumption, though it varies markedly by phase of flight.

2.17 Comparing total fuel consumption for a given journey with the optimum for aircraft types in service, might be a better measure. However, this was abandoned considering the accessibility of fuel consumption data.

Predictability

2.18 Predictability is defined in ICAO document 9854, Global Air Traffic Management Operational Concept as the "ability of airspace users and ANSPs to provide consistent and dependable levels of performance". If delay is entirely predictable at different time of a day not varying from its predicted value, an aircraft operator will calculate anticipated delays in consideration of schedule and flights will always arrive on time. As delay variability grows, more and more disruption will influence an aircraft operator's schedule and flight connectivity will be damaged. Lateness causes increased operating costs for an aircraft operator due to the inefficient use of resources and support facilities. Earliness could be considered as a lost opportunity for fleet and crew usage.

2.19 Similar to efficiency focusing on the utilization of resource, predictability, however, pays particular emphasis on consistent and efficient use of airspace or other resource based on flight plan and history data.

Safety

2.20 In the Asia/Pacific region, safety is certainly the number one priority of air navigation service providers. For this reason, a large share of KPIs and activities supporting this over-arching goal are related to safety. To ensure that safety remains an integral part in evolution of aviation system which becomes more and more complex, States and service providers are encouraged to proactively engage in safety risk modelling. The improved understanding of how various elements of ATM system contribute to overall safety levels can not only help to better identify risk areas today but also ameliorate the system to improve performance in the future.

2.21 For safety performance metrics, there is specific working group to study and promote the performance indicators. In the construction of this framework, safety is taken as an individual section which will not be focused on. However, relevant indicators are provided as reference.

2.22 According to ICAO, within the safety KPA common metrics focus on the number of accidents normalized through the number of operations or the total flight hours. Differences arise in definition of terms and filtering criteria are used for data counting. The part introduces some KPIs for evaluating the management level and going further to improve the safety performance. Indicators are divided into lagging indicators and leading indicators. Lagging indicators are some statistics about aviation safety accident and potential accident, which reflect the aviation safety condition directly; leading indicators is safety predication indicator which could analysis flight operation situation through civil aviation big data to predict pressure point and ensure the aviation safety in strategy and pre-tactical phase.

2.23 Accident occurrences only provide a limited insight into flight operations safety, in part because they represent a very narrow range from which to draw conclusions. Traditional accident or serious incident reports may only reveal the tip of the pyramid. Therefore, as illustrated in **Figure 2**, the SRC intends to adopt progressively a more thorough approach to safety performance measurement.

2.24 The role of ATM safety is to ensure adequate separation of aircraft from one another, from other objects and from the ground. The principal basis of the SRC assessment of safety performance therefore reflects this role, and mainly consists of measurement of the ATM contribution to aircraft accidents and incidents, for all types of operations occurring in all classes of airspace, categorized according to the level of risk and expressed in terms of air to air, air to ground or ground to ground safety occurrences.

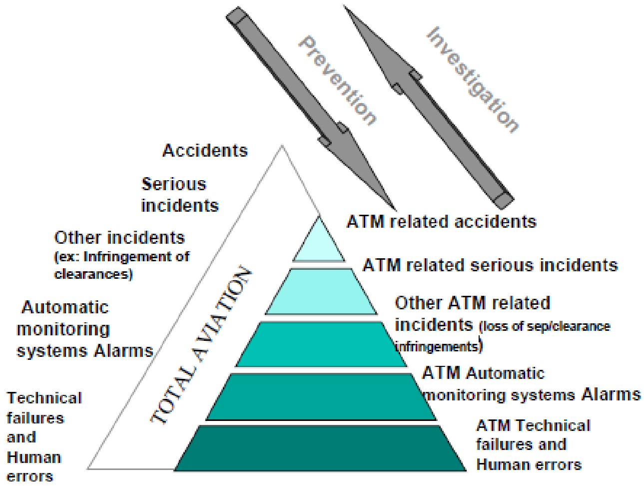


Figure 2: Safety triangle

Environment

2.25 According to the development plan of *Asia/Pacific Seamless ATM Plan*, environment is one of the requisite performance objective areas for meeting the expectation of stakeholders. Considering the technical aspect of Asia-Pacific region, many countries can't meet the requirement of data statistics. In the view of PRU, the performance of environment could be expressed by inefficiency in terms of time, fuel and emission. But in Asia-Pacific region, inappropriate city planning makes noise of flight during the operation phase of approaching and climbing a serious problem. Those KPIs are expected to help Asia-Pacific region to abate the adverse impact on environment in the future. So in the first implement stage which has been defined in this report, some efficiency KPIs are used as alternatives.

Cost-Efficiency

2.26 There is a high level of heterogeneity in the Air Navigation Services (ANS) industry. The relationship between inputs and outputs of provision of ATM/CNS services is obviously displayed in **Figure 3**. [ANSPs econometric cost-efficiency benchmarking].

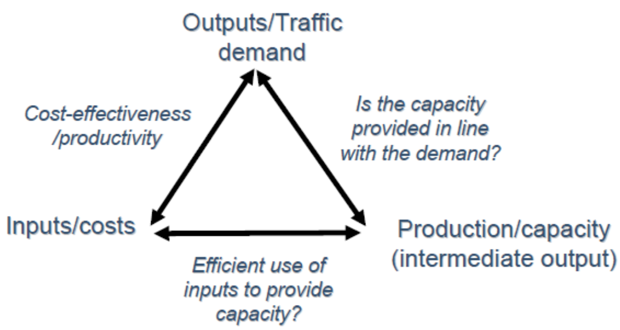


Figure 3: Relationship between costs and outputs

2.27 An ANSP provides a specific level of ATC capacity which is determined by the number of airspace sectors that can be opened in its airspace for a given duration. This ATC capacity is used to cope with a specific and exogenous traffic demand (number of aircraft/flights that are planned to cross the ANSP's airspace).One could consider that the capacity provided by the ANSP corresponds to an "intermediate" output while the "final" output would be measured in terms of traffic volumes controlled in the ANSP's airspace.

2.28 The relationship between inputs/costs and final output/traffic demand depends on the ANSP's ability to efficiently use its resources to provide a certain level of ATC capacity and on the extent to which the capacity provided is in line with the traffic demand. The overall "outcome" of this process is the extent to which the flight (final output) has been safely controlled in a swift and timely manner.

2.29 According to the development plan of Asia-Pacific Seamless ATM plan, the cost efficiency is one of the four requisite performance objectives. And the implementation of ABSU Block upgrades will require investment decision to be made by ANSPs. However, Asia-Pacific ANSPs operate in operational and economic conditions that vary significantly from country to country. Significant time is required to implement some KPIs and most of the cost KPIs are placed in the second stage.

Key Performance Indicators

2.30 An indicator is a unit or a method of performance measurement. Driven by data, it is based on the expectation of performance improvement to select key performance indicators. Divided by the way of function of KPI in each key performance area and differences in Dimensions of Statistics, it systematically displays the hierarchical construction of indicator framework. Some indicators that get more attention are separately defined to highlight its importance. Description of each key performance indicator includes Measurement Units, Variants, Parameters, Data Requirement and References.

2.31 Relevantly, indicators need to correctly express the intention of the associated performance objective. Since indicators support objectives, they should be defined to have a specific performance objective in mind. Indicators are not often directly measured. They are calculated from supporting metrics according to clearly calculation procedure.

Display forms of indicator value

2.32 As one of attributes of indicators, indicator value should have different display forms in response to different analysis objects and assessment objectives. For example, totality highlights the overall workload of air traffic system in statistics of flight time, which is applied to publication of national statistics; average reflects the general operating state of aircraft in designated airspace; standard deviation examines the deviation of operating state of the aircraft groups. Therefore, in this framework, there appear no specific descriptions for display forms of such indicators, but gives available categories to select from when facing different situations.

Induced factors of indicator value

2.33 Air traffic system is a complex system. The index value whose performance is a result of both external and internal factors is used to determine main direction of optimization by division of main responsibilities. Therefore, descriptions of induced factors of indicator value are added in this framework when describing the display forms of indicators. For instance, different causes are given according to different types of delays: en-route flight delays are subdivided into capacity constraints, traffic control, weather, military training, pre-departure delay distribution and some other common factors; causes of off-block delays include air traffic control, airport capacity constraints, weather, turnover, pre-departure delay.

Supporting metrics

2.34 Supporting metrics are used to calculate the values of performance indicators and determine which data need to be collected to calculate values for the performance indicators. The supporting metrics define which data need to be collected and/or forecasted to calculate values for the performance indicators.

2.35 Alternatively, the need for supporting metrics (such as the number of flights) lasts much longer because metrics are seldom indicator-specific, i.e. they are typically used to calculate a variety of indicators. When deciding which data to collect, a sufficiently broad spectrum of supporting metrics will have to be considered.

Implementation Stage

2.36 In fact, different countries in Asia-Pacific region have different methods and standards of data collection and definition, but the calculation and application of KPIs need uniform standard. Then set up three implement stages of KPIs (described in **Table 1** in detail) to insure that each country could make it standardized and have time to join the revision of standard. The first stage lasts until the year 2019, Stage 2 will continue until the year of 2021, and the last stage is expected to continue until 2023 (**Figure 4**).

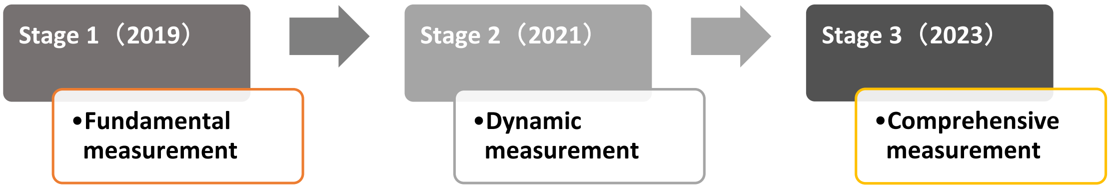


Figure 4: Implementation Stages

2.37 KPIs in the first stage are easy to calculate because their rough definitions at time point within large statistical range. And the second stage needs us to set detailed distinction in each phase of flight operation as to different characteristics. More concern about flight dynamic information and the impact of non-operation elements in the third stage is needed to improve the development of the *Asia/Pacific Seamless ANS Plan* but also for the advancement of civil aviation in Asia-Pacific region. The foundation of parting the implement stage is the flight phase. For example, indicators in the first stage mean that the implement of indicators should both start and finish in this stage.

2.38 In the first stage, there are 10 indicators containing some fundamental and coarse-grain statistic and simple calculation on basis of those statistics. Corresponding flight phases have been divided into two main phases i.e. ground operation phase and runway-to-runway flight phase by the differentiation between airport and airspace. In order to make those indicators unified and comparable under now situation, the flight phase of runway-to-runway is defined from take-off to land of flights (as is shown in **Figure 5**).

2.39 The second stage is up to 13 indicators. In this stage, the flight phase partition is more detailed and runway-to-runway flight phase is split into terminal departure, en-route, terminal arrival, and phase. Corresponding discontinuous points is the time of take-off, passing terminal departure fix, passing terminal arrival fix, landing. The ground operation phase is divided into turnaround, taxi-in and taxi out phases, and adding off-block and in-block time as discontinuous points. The data collection and performance evaluation need flight plan and actual time information such as FPL, ADS-B and radar data.

2.40 Finally, the third stage cares more about flight dynamic information and some nonoperation factors (i.e. climbing, cruising and descending).

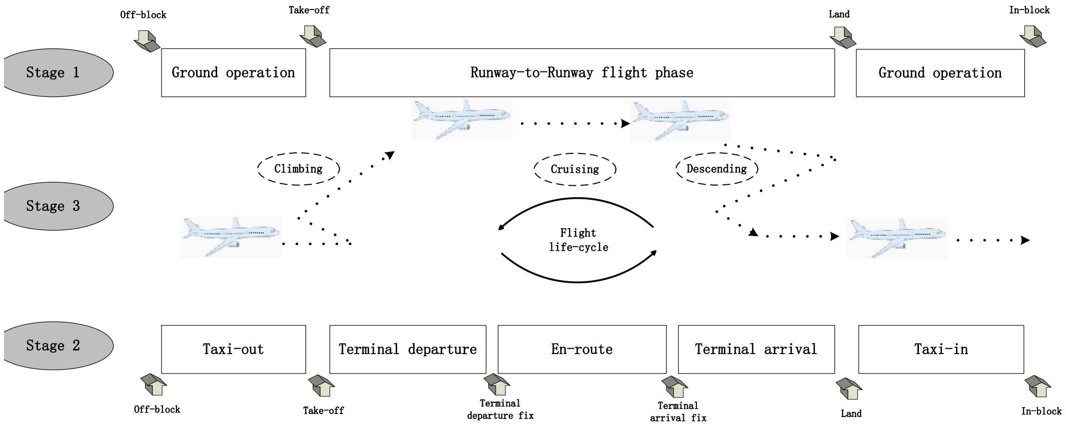


Figure 5: Flight life cycle in different implement stages

2.41 The specific indicator framework is shown below. Between KPAs and KPIs, some categories are set to make KPIs more regular. Furthermore, the level of KPIs is introduced in order to increase the engagement and participation of this plan. So, in this column 'SR' means those indicators are strongly recommended to complete to meet the need of performance measurement and 'R' shows they are recommended to finish in this stage. More detailed introduction is discussed in the following section.

<u>Indicator Measurement Roadmap</u>

2.42 As the Asia/Pacific is a region with so many diversified countries, a strategic plan in carrying out the relative indicator measurement is necessary. In the first phase, the Framework is already set, thus some more advanced States could provide technical support to other States, such as the way of collecting data, the computation algorithm, and some guidelines as to how to implement the measurement work. This should encourage more and more participants to voluntarily take part in the work and adopt the KPIs.

2.43 In the second phase, more advanced States could build a platform as a sharing tool for the measurement as well as a demonstration of these tools to show the outcomes of the measurement work by some of the participants in the field. Sharing is also optional.

2.44 In the third phase, a data sharing platform could be built by consensus.

KPAs	**Categories**	**ID**	**KPIs**	**Stage1**		**Stage2**		**Stage3**	
Capacity	Capacity value	KPI01	Airport peak arrival capacity (GANP)	SR	1				
		KPI02	Airport peak departure capacity	SR	1				
		KPI03	En-route sector capacity (GANP)			R	2		
	Capacity utilization	KPI04	Airport arrival capacity utilization (GANP)			R	2	SR	3
		KPI05	Airport departure capacity utilization			R	2	SR	3
		KPI06	En-route sector capacity utilization					R	3
Efficiency	Additional flight time	KPI07	Additional runway-to-runway time	R	1	R	2		
		KPI08	Additional en-route flight time					R	3
		KPI09	Additional taxi-in time (GANP)	R	1	SR	2		

		KPI10	Additional taxi-out time (GANP)	R	1	SR	2		
		KPI11	Additional runway occupation time					R	3
		KPI12	Additional terminal area arrival flight time (GANP)			R	2		
	Delay	KPI13	Arrival delay	R	1				
		KPI14	Departure delay	R	1				
		KPI15	En-route airspace ATFM delay(GANP)					R	3
		KPI16	Airport/Terminal ATFM delay(GANP)					R	3
		KPI17	Delay on board (newly added)					R	3
	Level flight efficiency	KPI18	Filed flight plan en-route extension rate(GANP)					R	3
		KPI19	Actual en-route extension rate(GANP)					R	3
	Flow	KPI20	Airport arrival throughput (GANP)	R	1	SR	2		
		KPI21	Airport departure throughput	R	1	SR	2		
Predictability	Flight time	KPI22	Flight arrival punctuality (GANP)	R	1	SR	2		
		KPI23	Flight departure punctuality (GANP)	R	1	SR	2		
		KPI24	Flight time variability (GANP)			R	2		
		KPI25	Flight plan variation (newly added)					R	3
		KPI26	ATFM slot adherence (GANP) (newly added)			R	2		
	Flight distance	KPI18	Filed flight plan en-route extension rate (GANP)					R	3
	Flow demand	KPI04	Airport arrival capacity utilization (GANP)	R	1	SR	2		
		KPI05	Airport departure capacity utilization	R	1	SR	2		
		KPI06	En-route sector capacity utilization			R	2		
Environment	Indirect environment influence	KPI27	Additional fuel burn (GANP)					R	3
		KPI19	Actual en-route extension rate (GANP)					R	3
Cost-efficiency	Outputs	KPI28	ANSP's Cost of Per IFR hours (newly added)						

Table 1: KPIs in different stages

KPI FRAMEWORK – FIRST STAGE

Key Performance Indicators Framework in the First Implementation Stage

3.1 According to the partition of implementing stage in the executive summary, the most fundamental indicators framework are built in this stage which data is easily to collect and don't need special definition of flight phase. Those indicators mostly reflect performance of the entire flight phase.

ID	KPIs	Level	KPAs
KPI01	**Airport peak arrival capacity**	SR	Capacity, Cost-efficiency
KPI02	Airport peak departure capacity	SR	Capacity, Cost-efficiency
KPI09	**Additional taxi-in time**	R	Efficiency
KPI10	**Additional taxi-out time**	R	Efficiency
KPI13	Arrival delay	R	Efficiency
KPI14	Departure delay	R	Efficiency
KPI20	Airport arrival throughput	R	Efficiency, Cost-efficiency
KPI21	Airport departure throughput	R	Efficiency, Cost-efficiency
KPI22	**Flight arrival punctuality**	R	Predictability
KPI23	**Flight departure punctuality**	R	Predictability

Table 2: KPIs in Stage1

Capacity

3.2 Capacity could reflect an upper bound on the allowable throughput of an en-route facility or sector or indicates the highest landing or take-off rate that an airport will accept, using the most favorable runway configuration under optimum operational conditions.

KPI Name	Airport peak arrival capacity
ID	KPI01
Definition	The highest number of landings an airport can accept in a one-hour time frame.
Measurement Units	Number of landings / hour
Variants	None
Parameters	None
Data requirement	Scheduling parameters for slot controlled airports Airport Acceptance Rates (AAR)
Calculation procedure	At the level of an individual airport: 1. Select highest value from the set of declared arrival capacities 2. Compute the KPI: convert the value to an hourly landing rate, if the declaration is at smaller time intervals
References	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition - 2016)

KPI Name	Airport peak departure capacity
ID	KPI02
Definition	The highest number of take-offs an airport can release to departure in a

	one-hour time frame.
Measurement Units	Number of take-offs / hour
Variants	None
Parameters	None
Data requirement	Scheduling parameters for slot controlled airports
Calculation procedure	At the level of an individual airport: 1. Select highest value from the set of declared departure capacities 2. Compute the KPI: convert the value to an hourly take-off rate, if the declaration is at smaller time intervals
Reference	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016–2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition – 2016)

Efficiency: Additional Flight Time

3.3 Those KPIs are intended to give an indication of the efficiency of each flight phase operations on the surface or en-route.

KPI Name	Additional taxi-in time
ID	KPI09
Definition	Actual taxi-in time compared to an unimpeded/reference taxi-in time
Measurement Units	Minutes/flight
Variants	Variant 1 – basic (computed without landing runway and arrival gate data) Variant 2 – advanced (computed with landing runway and arrival gate data)
Parameters	Unimpeded/reference taxi-in time: -Recommended approach for the basic variant of the KPI: a single value at airport level, e.g. the 20th percentile of actual taxi times recorded at an airport, sorted from the shortest to the longest -Recommended approach for the advanced variant of the KPI: a separate value for each runway/gate combination, e.g. 20th percentile of actual taxi-in time recorded.
Data requirement	For each arriving flight: - Actual landing time (ALDT) - Actual in-block time (AIBT) In addition for the advanced KPI variant: - Landing runway ID - Arrival gate ID
Calculation procedure	At the level of individual flights: 1. Select arrival flights, exclude helicopters 2. Compute actual taxi-in duration: AIBT minus ADLT 3. Compute additional taxi-out time: actual taxi-out duration minus unimpeded taxi-in time At aggregated level: 4. Compute the KPI: sum of additional taxi-in times divided by number of IFR arrivals

References	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) PRC Performance Review Report (EUROCONTROL 2015) CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Notes: In order to stress the seasonal influences, data should be uploaded monthly refer to the statistical period of the additional runway-to-runway time.

KPI Name	Additional taxi-out time
ID	KPI10
Definition	Actual taxi-out time compared to an unimpeded/reference taxi-out time
Measurement Units	Minutes/flight
Variants	Variant 1 – basic (computed without departure gate and runway data) Variant 2 – advanced (computed with departure gate and runway data)
Parameters	Unimpeded/reference taxi-out time: - Recommended approach for the basic variant of the KPI: a single value at airport level, e.g. the 20th percentile of actual taxi times recorded at an airport, sorted from the shortest to the longest - Recommended approach for the advanced variant of the KPI: a separate value for each gate/runway combination, 20th percentile of actual taxi-out time recorded.
Data requirement	For each departing flight: - Actual off-block time (AOBT) - Actual take-off time (ATOT) In addition for the advanced KPI variant: - Departure gate ID - Take-off runway ID
Calculation procedure	At the level of individual flights: 1. Select departing flights, exclude helicopters 2. Compute actual taxi-out duration: ATOT minus AOBT 3. Compute additional taxi-out time: actual taxi-out duration minus unimpeded taxi-out time At aggregated level: 4. Compute the KPI: sum of additional taxi-out times divided by number of IFR departures
References	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) PRC Performance Review Report (EUROCONTROL 2015) CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Notes: In order to stress the seasonal influences, data should be uploaded monthly refer to the statistical period of the additional runway-to-runway time.

Delay

3.4 This part gives lots of forms of delay, which could be used as average value and standard deviation to meet different demand of statistics in macroscopic scale and parallel comparison.(i.e. average delay contains the average delay of all flights or all delayed flights.) Many KPIs of delay that may be implemented for the different phases of flight cycle compare an actual time against a scheduled time for the purpose of determining a delay. However, there are often two additional conditions that are met before an event is determined to be inefficient. These include meeting a minimum threshold for delay as well as information on causal factors. Typical minimum thresholds include 5, 10 or 15 minutes.

KPI Name	Arrival delay
ID	KPI13
Definition	Actual in-block time compared to a schedule time of arrival [avg. per airport or per cluster of airports]
Measurement Units	Minutes/flight
Variants	Variant 1 – basic (computed for all flights) Variant 2 – advanced (computed for delayed flights)
Parameters	Threshold of delayed flights: -Recommended value: 15 minutes
Data requirement	For each arriving flight: - Schedule Time of Arrival (STA) - Actual In-block Time (AIBT)
Calculation Procedure	For Variant 1: At the level of individual flights: 1.Select arriving flights 2.Compute arrival delay: AIBT minus STA At aggregated level: 3.Compute the KPI: sum of arrival delays divided by number of arrivals For Variant 2: At the level of individual flights: 1.Select arriving flights 2.Compute arrival delay: AIBT minus STA 3.Use parameters to determine which flight is delayed At aggregated level: 1.Compute the KPI: sum of arrival delays divided by number of delayed arrivals
References	Manual on Global Performance of the Air Navigation System(Doc.9883 First Edition — 2009)

Notes: Referring to the indication of delay, KPIs of delay will show different statistical characteristics in distinct uploading or statistical periods. If just handing in the results of calculation, it would be better to upload the data by month to show the seasonal influence.

KPI Name	Departure delay
ID	KPI14
Definition	Actual off-block time compared to schedule time of departure [avg. per airport or per cluster of airports]
Measurement Units	Minutes/flight
Variants	Variant 1 – basic (computed for all flights) Variant 2 – advanced (computed for delayed flights)
Parameters	Threshold of delayed flights:

	-Recommended value: 15 minutes
Data requirement	For each departing flight: - Scheduled time of departure (STD) - Actual off-block time (AOBT)
Calculation Procedure	For Variant 1: At the level of individual flights: 1.Select departure flights 2.Compute departure delay: AOBT minus STD At aggregated level: 3.Compute the KPI: sum of departure delays divided by number of departures For Variant 2: At the level of individual flights: 1.Select departure flights 2.Compute arrival delay: AOBT minus STD 3.Use parameters to determine which flight is delayed At aggregated level: 1.Compute the KPI: sum of departure delays divided by number of delayed departures
References	Manual on Global Performance of the Air Navigation System(Doc.9883 First Edition — 2009)

Notes: Similarly, KPIs of delay will show different statistical characteristics in distinct uploading or statistical periods. If just handing in the results of calculation, it should be uploaded by month to show the seasonal influence.

<u>Flow</u>

3.5 Traffic flow means the number of flights served by airport or airspace. Average value reflects the common demand and peak value tells the effectively realized capacity.

KPI Name	Airport arrival throughput
ID	KPI20
Definition	The number of landings recorded at an airport under normal conditions in a given time period
Measurement Units	Flights/hr
Variants	Variant 1: average Variant 2: peak throughput
Parameters	For variant2: The 95th percentile of the hourly number of landings recorded at an airport, in the “rolling” hours sorted from the least busy to the busiest hour. Time interval for “rolling” hours. Recommended value: 15 minutes. The percentile chosen to exclude outliers. Recommended value: 95th percentile.
Data requirement	For each arriving flight: - Actual landing time (ALDT)

Calculation Procedure	For Variant 1: 1.Select arrival flights 2.Compute the throughput: count the number of actual landings in a given period based on ALDT 3.Compute the KPI: throughput divided by number of the selected hours For Variant 2: 1. Select arrival flights 2. Convert the set of landings to hourly landing rates by “rolling” hour 3. Sort the “rolling” hours from the least busy to the busiest hour 4. Compute the KPI: it equals the landing rate value of the 95th percentile of the “rolling” hours
Reference	Manual on Global Performance of the Air Navigation System(Doc.9883 First Edition — 2009) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

KPI Name	Airport departure throughput
ID	KPI21
Definition	The number of take-offs recorded at an airport under normal conditions in a given time period
Measurement Units	Flights/hr
Variants	Variant 1: average Variant 2: peak throughput
Parameters	For variant1: … For variant2: The 95th percentile of the hourly number of landings recorded at an airport, in the “rolling” hours sorted from the least busy to the busiest hour. Time interval for “rolling” hours. Recommended value: 15 minutes. The percentile chosen to exclude outliers. Recommended value: 95th percentile.
Data requirement	For each departing flight: - Actual take-off time (ATOT)
Calculation Procedure	For Variant 1: 1.Select departing flights 2.Compute the throughput: count the number of actual take-offs in a given period based on ALDT 3.Compute the KPI: throughput divided by number of the selected hours For Variant 2: 1. Select departing flights 2. Convert the set of take-offs to hourly departing rates by “rolling” hour 3. Sort the “rolling” hours from the least busy to the busiest hour 4. Compute the KPI: it equals the departing rate value of the 95th percentile of the “rolling” hours
Reference	Manual on Global Performance of the Air Navigation System x (Doc.9883 First Edition — 2009) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Predictability: Flight Time

KPI Name	**Flight arrival punctuality**
ID	KPI22
Definition	Percentage of flights arriving at the gate on-time (compared to schedule)
Measurement Units	Percentage(%)
Variants	Variant1 – arrival punctuality after 15 minutes of Scheduled time(SOBT) of arrival
Parameters	On-time threshold (maximum delay from Scheduled time of arrival) which defines whether a flight is counted as on-time or not. Recommended values: 15 minutes.
Data requirement	For each arriving scheduled flight: - Scheduled time of arrival (STA) - Actual in-block time (AIBT)
Calculation Procedure	At the level of individual flights: 1.Exclude non-scheduled arrivals 2.Categorize each scheduled arrival as on-time or not (flights arriving ahead of schedule defaulted to be on time) At aggregated level: 1.Compute the KPI: number of on-time arrivals divided by total number of scheduled arrivals
References	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

KPI Name	**Flight departure punctuality**
ID	KPI23
Definition	Percentage of flights departing from the gate on-time (compared to schedule)
Measurement Units	Percentage (%)
Variants	Variant 1 – departure punctuality after 15 minutes of Scheduled time(SOBT) of departure
Parameters	On-time threshold (maximum delay from Scheduled time of departure) which defines whether a flight is counted as on-time or not. Recommended values: 15 minutes.
Data requirement	For each departing scheduled flight: - Scheduled time of departure (STD) - Actual off-block time (AOBT)
Calculation Procedure	At the level of individual flights: 1.Exclude non-scheduled departures 2.Categorize each scheduled departure as on-time or not At aggregated level: 3.Compute the KPI: number of on-time departures divided by total number of scheduled departures
References	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Environment

Cost-efficiency – Immediate Outputs

3.6 KPI01 Airport peak arrival capacity (refer to Capacity)

3.7 KPI02 Airport peak departure capacity (refer to Capacity)

Cost-efficiency – Immediate Outputs

3.8 KPI20 Airport arrival throughput (refer to Efficiency – Additional Flight Time)

3.9 KPI21 Airport departure throughput (refer to Efficiency – Additional Flight Time)

KPI FRAMEWORK – SECOND STAGE

Key Performance Indicators Framework in the First Implementation Stage

4.1 In the second stage, more detailed information of flight life cycle to design indicators are introduced.

ID	KPIs	Level	KPAs
KPI03	**En-route sector capacity**	R	Capacity, Cost-efficiency
KPI04	**Airport arrival capacity utilization**	R	Capacity, Predictability
KPI05	Airport departure capacity utilization	R	Capacity, Predictability
KPI07	Additional runway-to-runway time	R	Efficiency
KPI09	**Additional taxi-in time**	SR	Efficiency
KPI10	**Additional taxi-out time**	SR	Efficiency
KPI12	**Additional terminal area arrival flight time**	R	Efficiency
KPI20	**Airport arrival throughput**	SR	Efficiency, Cost-efficiency
KPI21	Airport departure throughput	SR	Efficiency, Cost-efficiency
KPI22	**Flight arrival punctuality**	SR	Predictability
KPI23	**Flight departure punctuality**	SR	Predictability
KPI24	**Flight time variability**	R	Predictability
KPI26	**ATFM slot adherence**	R	Predictability

Table 3: KPIs in Stage2

KPI Name	En-route sector capacity
ID	KPI03
Definition	The maximum number of movements an airspace volume will accept under normal conditions in a given time period (also called declared capacity)
Measurement Units	Movements/quarter
Variants	None
Parameters	Time interval at which to perform the most granular calculations. Recommended value: 15 minutes.
Data requirement	Declared capacities are determined by the ANSP, and are dependent on traffic pattern and sector configuration.
Calculation procedure	At the level of an individual en-route airspace unit: 1. Select highest value from the set of declared capacities (the maximum configuration capacity) 2. Compute the KPI: convert the value to movement rate in a quarter, if the declaration is at smaller or larger time intervals
References	CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016–2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition – 2016)

Capacity Utilization

4.2 Capacity utilization can directly reflect the Capacity utilization which helps push for the further improvement of capacity management.

KPI Name	Airport arrival capacity utilization
ID	KPI04
Definition	Airport arrival throughput (accommodated demand) compared to arrival capacity. The arrival capacity refer to the declared capacity at present, in later stages, it could be replaced by dynamic capacity. KPI should be strongly recommended if the airport runs near capacity.
Measurement Units	Percentage (%)
Variants	None
Parameters	Time interval at which to perform the most granular calculations. Recommended value: 1 hour.
Data requirement	For each arriving flight: - Actual landing time (ALDT) For each time interval: - Declared landing capacity of the airport
Calculation procedure	For each time interval: 1. Compute the throughput: count the number of actual landings based on ALDT 2. Compute the utilization = throughput / capacity At the level of an individual airport: 3. Compute the KPI: sum(utilization* capacity) / sum(capacity)
References	CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016–2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition – 2016) Airspace management Handbook Version 2.2 December 2005

KPI Name	Airport departure capacity utilization
ID	KPI05
Definition	Airport departure throughput compared to departure capacity. The departure capacity refer to the declared capacity at present, in later stages, it could be replaced by dynamic capacity. KPI should be strongly recommended if the airport runs near capacity.
Measurement Units	Percentage (%)
Variants	None
Parameters	Time interval at which to perform the most granular calculations. Recommended value: 1 hour.
Data requirement	For each arriving flight: - Actual take-off time (ATOT) For each time interval: - Declared take-off capacity of the airport
Calculation procedure	For each time interval: 1. Compute the throughput: count the number of actual take-offs based on ATOT 2. Compute the utilization = throughput / capacity At the level of an individual airport: 3. Compute the KPI: sum(utilization* capacity) / sum(capacity)

References	CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016–2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition – 2016) Airspace management Handbook Version 2.2 December 2005

<u>Efficiency – Additional Flight Time</u>

4.3 Those KPIs are intended to give an indication of the efficiency of each flight phase operations on the surface or en-route.

KPI Name	Additional runway-to-runway time
ID	KPI08
Definition	Actual runway-to-runway time compared to an unimpeded/reference operation time.
Measurement Units	Minutes/flight
Variants	Variant 1 – basic (computed without take-off and landing airport) Variant 1 – advanced (computed with take-off and landing airport)
Parameters	Unimpeded/reference runway-to-runway time: - Recommended approach for the KPI: a value from a single-flight perspective, e.g. the 20th percentile of actual operation times recorded at airlines which have the same route, sorted from the shortest to the longest
Data requirement	For each departing scheduled flight: - Location indicator for take-off airport - Actual take-off time (ATOT) For each arriving scheduled flight: - Location indicator for landing airport - Actual landing time (ALDT)
Calculation procedure	At the level of individual flights: 1. Select the flights, exclude those with departure and arrival airport out of the region or specific states. 2. Compute actual duration: ALDT minus ATOT 3. Compute additional flight time: actual duration minus unimpeded flight time At aggregated level: 1. Compute the KPI: sum of additional flight times divided by number of IFR flights
References	None

Notes: The calculation of the additional operation time needs to consider the influence of performance evaluation from different statistical periods. For example, the performance evaluation by month should reflect the seasonal impact more efficiently, and may focus on running characteristics of the flow both in peak and normal period by hour. However, considering the transmission standard and methods haven't been united, if just handing in the results of calculation, it should be uploaded by month to show the seasonal influence.

4.4 KPI09 Additional taxi-in time (refer to Efficiency)

4.5 KPI10 Additional taxi-out time (refer to Efficiency)

KPI Name	Additional terminal area arrival flight time
ID	KPI12
Definition	Actual terminal arrival time compared to a unimpeded time [avg. per airport or per cluster of airports]
Measurement Units	Minutes/flight
Variants	Variants are possible depending on the chosen size of terminal airspace (40 NM or 100 NM cylinder) and the richness of the data feed: basic (without arrival runway ID) or advanced (with arrival runway ID) Variants with 100 NM cylinder are useful if airports have holding patterns outside the 40 NM cylinder The use of generic cylinders abstracts local specifics in terms of approach airspace design (e.g. TMA) and ensures comparability across different airports.
Parameters	Unimpeded terminal area arrival flight time: - Recommended approach for the basic variants of the KPI: a single value at airport level = the 20th percentile of actual terminal airspace arrival times recorded at an airport, sorted from the shortest to the longest - Recommended approach for the advanced variants of the KPI: a separate value for each entry segment/landing runway combination = the 20th percentile of actual terminal airspace arrival times recorded.~~ during periods of non-congestion (needs to be periodically reassessed)~~
Data requirement	For each arriving flight: - Terminal airspace entry time, computed from surveillance data (radar, ADS-B…) - Actual landing time (ALDT) In addition for the advanced KPI variants: - Terminal airspace entry segment, computed from surveillance data (radar, ADS-B…) - Landing runway ID
Calculation procedure	At the level of individual flights: 1. Select arrivals, exclude helicopters 2. Compute actual terminal airspace transit time: ALDT minus terminal airspace entry time 3. Compute additional terminal airspace transit time: actual terminal airspace transit time minus unimpeded terminal airspace transit time At aggregated level: 4. Compute the KPI: sum of additional terminal airspace transit times divided by number of IFR arrivals
References	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) PRC Performance Review Report (EUROCONTROL 2015) Single European Sky Performance Scheme CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Notes: In order to stress the seasonal influences, data should be uploaded monthly refer to the statistical period of the additional runway-to-runway time.

Flow

4.6 KPI20 Airport arrival throughput (refer to Cost Efficiency)

4.7 KPI21 Flight departure punctuality (refer to Cost Efficiency)

Predictability – Flight Time

4.8 KPI22 Flight arrival punctuality (refer to Predictability)

4.9 KPI23 Flight departure punctuality (refer to Predictability)

KPI Name	**Flight time variability**
ID	**KPI34**
Definition	Distribution of the flight (phase) duration around the average value
Measurement Units	Minutes/flight
Variants	None
Parameters	Minimum monthly flight frequency filter: flights with a frequency less than 20 times per month are not included in the indicator. 70% of the (remaining) flights are considered in the indicator, i.e. the 15th percentile (percentile 1) is used to determine the shortest duration, the 85th percentile (percentile 2) is used to determine the longest duration, and the remaining parts is used to calculate average duration.
Data requirement	For each flight: - Actual off-block time (AOBT) - Actual take-off time (ATOT) - Terminal airspace depart time - Terminal airspace entry time - Actual landing time (ALDT) - Actual in-block time (AIBT)
Calculation Procedure	1. Exclude flights with frequency less than 20 times per month At the level of individual flights: 2. Compute the flight time of certain flight phase At aggregated level: 3. Sort the flight time from the shortest to the longest to form a flights time sequence 4. Choose values from percentile 15th to 85th of the flight time sequence to compute the average flight duration For each flight: 5. Compute the KPI: Variance of total flight time based on the average flight duration
Reference	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) PRC Performance Review Report (EUROCONTROL 2015) CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015)

Capacity utilization

4.10 KPI04 Airport arrival capacity utilization (refer to Capacity)

4.11 KPI05 Airport departure capacity utilization (refer to Capacity)

Environment

4.12 All indicators will be introduced in following stages.

Cost-efficiency – Immediate Outputs

4.13 KPI03 En-route airspace capacity (refer to Capacity)

Cost-efficiency –Outputs

4.14 KPI20 Airport arrival throughput (refer to Efficiency)

4.15 KPI21 Airport departure throughput (refer to Efficiency)

KPI FRAMEWORK – THIRD STAGE

Key Performance Indicators Framework in the Third Implementation Stage

5.1 The third implement stage needs unified identification of flight phase and a certain number of data storage during the stages before. And this stage may require to use some technique& equipment.

ID	KPIs	Level	KPAs
KPI04	**Airport arrival capacity utilization**	SR	Capacity, Predictability
KPI05	Airport departure capacity utilization	SR	Capacity, Predictability
KPI06	En-route sector capacity utilization	R	Capacity, Predictability
KPI08	Additional en-route flight time	R	Efficiency
KPI11	Additional runway occupation time	R	Efficiency
KPI15	**En-route airspace ATFM delay**	R	Efficiency
KPI16	**Airport/Terminal ATFM delay**	R	Efficiency
KPI17	Delay on board	R	Efficiency
KPI18	**Filed flight plan en-route extension rate**	R	Efficiency, Predictability
KPI19	**Actual en-route extension rate**	R	Efficiency, Environment
KPI25	Flight plan variation	R	Predictability
KPI27	**Additional fuel burn**	R	Environment
KPI28	ANSP's Cost of Per IFR hours	R	Cost-efficiency

Table 4: KPIs in Stage 3

Capacity

5.2 KPI04 Airport arrival capacity utilization (Refer to 3.2.1)

5.3 KPI05 Airport departure capacity utilization (Refer to 3.2.1)

KPI Name	En-route sector capacity utilization
ID	KPI06
Definition	Actual airspace throughput compared to the declared airspace capacity.
Measurement Units	Percentage (%)
Variants	None
Parameters	Time interval at which to perform the most granular calculations. Recommended value: 15 minutes.
Data requirement	Declared capacities are determined by the ANSP, and are dependent on traffic pattern and sector configuration.
Calculation procedure	For each time interval: 1. Compute the throughput: count the number of actual flights based on ANSPs 2. Compute the utilization = throughput / capacity At aggregated level (longer time periods): 3. Compute the KPI: sum(utilization* capacity) / sum(capacity)
References	CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016–2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition – 2016)

Efficiency - Additional Flight Time

KPI Name	Additional en-route flight time
ID	KPI08
Definition	Actual en-route time flown compared to a unimpeded time
Measurement Units	Minutes/flight
Variants	None
Parameters	Unimpeded/reference en-route flight time: - Recommended approach for the the KPI: a value from a single-flight perspective, e.g. the 20th percentile of actual en-route flight times recorded at airlines have similar routes, sorted from the shortest to the longest
Data requirement	For each IFR flight with same terminal fix: - En-route airspace entry time - En-route airspace exit time - Airspace volume associated with the flow restriction
Calculation procedure	At the level of individual flights: 1. Select the flights crossing the volume of en-route airspace~~, exclude helicopters~~ 2. Compute actual crossing duration: airspace exit time –airspace entry time 3. Compute additional en-route flight time: actual en-route airspace flight time minus unimpeded en-route airspace flight time At aggregated level: 4. Compute the KPI: sum of additional en-route flight time divided by number of IFR flights
References	PRC Performance Review Report (EUROCONTROL 2015)

Notes: In order to stress the seasonal influences, data should be uploaded monthly refer to the statistical period of the additional runway-to-runway time.

KPI Name	Additional runway occupation time
ID	KPI11
Definition	Actual runway occupation time compared to a unimpeded time [avg. per airport or per cluster of airports]
Measurement Units	Minutes/flight
Variants	Variant 1 – basic (computed without landing or departure runway data) Variant 2 – advanced (computed with landing or departure runway data)
Parameters	Unimpeded/reference runway occupation time: - Recommended approach for the KPI: a single value at airport level, e.g. the 20th percentile of actual runway occupation recorded at an airport, sorted from the shortest to the longest
Data requirement	For each landing flight: - Actual landing time (ALDT) - The time leaving the runway For each departing flight: - Actual take-off time (ATOT) - The time entering the runway In addition for the advanced KPI variant: - Landing runway ID - Take-off runway ID
Calculation procedure	- At the level of individual flights 1. Select arrival flights, exclude helicopters

	2. Compute actual duration: the time leaving the runway minus ALDT 3. Compute additional runway occupation time: actual duration minus unimpeded runway occupation time 4. Select departing flights, exclude helicopters 5. Compute additional runway occupation time: ATOT minus the time entering the runway 6. Compute additional runway occupation time: actual duration minus unimpeded runway occupation time - At aggregated level: 7. Compute the KPI: sum of additional runway occupation times divided by number of IFR departures
References	None

Notes: In order to stress the seasonal impacts, data should be uploaded monthly refer to the statistical period of the additional runway-to-runway time.

Delay

KPI Name	En-route airspace ATFM delay
ID	KPI15
Definition	ATFM delay attributed to flow restrictions in a given airspace volume. Delay means the different between estimated and actual time.
Measurement Units	Minutes/flight
Variants	Variant 1: calculated with all flights. Variant 2 calculated with delayed flights.
Parameters	None
Data requirement	For each IFR flight: - Schedule Time of departure (STD) - Actual Off-block Time (AOBT) - ID of the flow restriction generating the ATFM delay - Airspace volume associated with the flow restriction - Delay code associated with the flow restriction
Calculation Procedure	At the level of individual flights: 1.Select delayed flights attributed to flow restrictions in a given airspace volume 2.Compute en-route ATFM delay: AOBT minus STD At aggregated level: 3.Compute the KPI: sum of en-route ATFM delays divided by number of flights(all flights for Variant 1 or delayed flights for Variant 2)
References	ICAO EUR Doc 030 EUR Region Performance Framework Document (July 2013) PRC Performance Review Report (EUROCONTROL 2015) Single European Sky Performance Scheme CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Notes: Similarly, KPIs of delay will show different statistical characteristics in distinct uploading or statistical periods. If just handing in the results of calculation, it would be better to upload the data by month to show the seasonal influence.

KPI Name	Airport/Terminal ATFM delay
ID	KPI16
Definition	ATFM delay attributed to arrival flow restrictions at a given airport and/or associated terminal airspace volume. Delay means the different between estimated and actual time.
Measurement Units	Minutes/flight
Variants	Variant 1: calculated with all flights. Variant 2 calculated with delayed flights.
Parameters	None
Data requirement	For each IFR flight: - Schedule Time of Arrival (STA) - Actual In-block Time (AIBT) - ID of the flow restriction generating the ATFM delay - Airport/terminal volume associated with the flow restriction - Delay code associated with the flow restriction
Calculation Procedure	At the level of individual flights: 1.Select delayed flights attributed to arrival flow restrictions at a given airport and/or associated terminal airspace volume. 2.Compute airport/terminal ATFM delay: AIBT minus STA At aggregated level: 3.Compute the KPI: sum of airport/terminal ATFM delays divided by number of flights(all flights for Variant 1 or delayed flights for Variant 2)
References	ICAO EUR Doc 030 EUR Region Performance Framework Document (July 2013) PRC Performance Review Report (EUROCONTROL 2015) Single European Sky Performance Scheme CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Notes: Similarly, KPIs of delay will show different statistical characteristics in distinct uploading or statistical periods. If just handing in the results of calculation, it would be better to upload the data by month to show the seasonal influence.

KPI Name	Delay on board
ID	KPI17
Definition	Time range between take-off(landing) and boarding-completed (disembarking-completed) exceeds the specified taxing time. [avg. per airport or per cluster of airports]
Measurement Units	Minutes/flight
Variants	Variant 1 – basic (computed without take-off/landing runway ID) Variant 2 – advanced (computed with take-off/landing runway ID)
Parameters	None
Data requirement	For each departing flight: - Actual take-off time (ATOT) - Actual boarding completed time - Specified taxing time For each arriving flight: - Actual landing time (ALDT) - Actual disembarking completed time

	- Specified taxing time In addition for the advanced KPI variants: - Take-off runway ID
Calculation Procedure	For Variant 1: At the level of individual flights: 1.Select departure flights. 2.Compute departure onboard time: ATOT minus actual boarding completed time. 3. Compute departure onboard delay: departure onboard time minus specified taxing time. 4. Select arrival flights 5. Compute arrival onboard time: Actual disembarking completed time minus ALDT. 6. Compute arrival onboard delay: arrival onboard time minus specified taxing time At aggregated level: 7. Compute the KPI: sum of arrival delays divided by number of arrivals or sum of departure delays divided by number of departures For Variant 2: 1.Select departure flights using specified runway. 2.Compute departure onboard time: ATOT minus actual boarding completed time. 3. Compute departure onboard delay: departure onboard time minus specified taxing time. 4. Select arrival flights using specified runway. 5. Compute arrival onboard time: Actual disembarking completed time minus ALDT. 6. Compute arrival onboard delay: arrival onboard time minus specified taxing time At aggregated level: 7. Compute the KPI: sum of arrival delays divided by number of arrivals or sum of departure delays divided by number of departures
References	Normal flight management method (2016)

Level flight efficiency

5.4 Those KPIs measures the en-route horizontal flight (in) efficiency contained in a set of filed flight plans or actual flight trace crossing an airspace volume. Its value is influenced by route network design, route & airspace availability, airspace user choice (e.g. to ensure safety, to minimize cost and to take into account wind and weather) and airspace user constraints (e.g. overflight permits, aircraft limitations).

KPI Name	Filed flight plan en-route extension rate
ID	KPI18
Definition	Flied flight planned en-route distance compared to a reference ideal distance
Measurement Units	Percentage(%)
Variants	Variant 1: Filed flight plan en-route extension rate under the influence of en-route condition. Variant 2: Filed flight plan en-route extension rate under the influence

	of terminal area condition.
Parameters	Departure terminal area proxy: a cylinder with 40 NM radius around the departure airport. Destination terminal area proxy: a cylinder with 100 NM radius around the destination airport
Data requirement	For each flight plan: - Departure airport (Point A) - Destination airport (Point B) - Exit point of the Departure terminal area proxy (Point C) - Entry points of the Destination terminal area proxy (Points D) - Planned distance for each AB portion of the flight
Calculation Procedure	Detailed calculation procedure is shown in the third appendix. However, flights with starting and destination points out of the range should be excluded.
Reference	ICAO EUR Doc 030 EUR Region Performance Framework Document (July 2013) Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) PRC Performance Review Report (EUROCONTROL 2015) Single European Sky Performance Scheme CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Notes: The calculation of the level flight efficiency needs to consider the influence of performance evaluation from different statistical periods. For example, the performance evaluation by month should reflect the seasonal impact more efficiently, and may focus on running characteristics of the flow both in peak and normal period by hour. However, considering the transmission standard and methods haven't been united, if just handing in the results of calculation, it should be uploaded by month to show the seasonal influence.

KPI Name	Actual en-route extension rate
ID	KPI19
Definition	Actual en-route distance flown compared to a reference ideal distance
Measurement Units	Percentage(%)
Variants	Variant 1: Actual en-route extension rate under the influence of en-route condition. Variant 2: Actual en-route extension rate under the influence of terminal area condition.
Parameters	Departure terminal area proxy: a cylinder with 40 NM radius around the departure airport. Destination terminal area proxy: a cylinder with 100 NM radius around the destination airport.
Data requirement	For each actual flight trajectory: - Departure airport (Point A) - Destination airport (Point B) - Exit point of the Departure terminal area proxy (Point C) - Entry points of the Destination terminal area proxy (Points D) - Distance flown for each NX portion of the actual flight trajectory, derived from surveillance data (radar, ADS-B…).
Calculation Procedure	Identical to the formula/algorithm of the 'Filed Flight Plan en-Route Extension Rate' KPI.

Reference	ICAO EUR Doc 030 EUR Region Performance Framework Document (July 2013) Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014) PRC Performance Review Report (EUROCONTROL 2015) Single European Sky Performance Scheme CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015) 2016-2030 Global Air Navigation Plan(Doc 9750-AN/963 Fifth Edition-2016)

Notes: The calculation of the level flight efficiency needs to consider the influence of performance evaluation from different statistical periods. For example, the performance evaluation by month should reflect the seasonal impact more efficiently, and may focus on running characteristics of the flow both in peak and normal period by hour. However, considering the transmission standard and methods haven't been united, if just handing in the results of calculation, it should be uploaded by month to show the seasonal influence.

Predictability – Flight Time

KPI Name	Flight plan variation
ID	KPI25
Definition	Difference between the 85th and 15th percentile flight plan distance or time for a city pair.
Measurement Units	Kilometers or minutes
Variants	Variant 1 – flight time Variant 2 – flight distance
Parameters	None
Data requirement	For each departing flight: -Planed flight distance and time for certain city pairs.
Calculation Procedure	For variant 1: For each flight's flight plan in certain city pair: 1. Select all the flight plan belong to one flight. 2. Order those flight time from biggest to smallest. 3. Compute the variation= 85th flight time minus 15th flight time. At aggregated level: 1.Compute the KPI: sum of variations divided by number of flights. For variant 2: For each flight's flight plan in certain city pair: 1. Select all the flight plan belong to one flight. 2. Order those flight distance from biggest to smallest. 3. Compute the variation= 85th flight distance minus 15th flight distance. At aggregated level: 1.Compute the KPI: sum of variations divided by number of flights.
References	CANSO Recommended KPIs for Measuring ANSP Operational Performance (2015)

Flight distance

5.5 KPI18 Filed flight plan en-route extension rate (refer to Efficiency).

Environment – Indirect Environmental Influence

5.6 KPI19 Actual en-route extension rate (refer to Efficiency).

KPI Name	Additional fuel burn
ID	KPI27
Definition	The full extent of fuel combustion.
Measurement Units	kg fuel/flight
Variants	None
Parameters	Average fuel flow (kg/min) during taxi Average fuel flow (kg/min) during arrival in terminal airspace Average fuel flow (kg/km) in en-route airspace
Data requirement	Indicator values to be converted to estimated additional fuel burn: Additional Taxi-Out Time (min/flight) Additional Taxi-In Time (min/flight) Actual en-Route Extension (km/flight) Additional time in terminal airspace (min/flight)
Calculation procedure	Compute the KPI: sum of average fuel flow * addition operation time of different flight phases(i.e. taxi-out, taxi-in, en-route, and terminal airspace)
Reference	Comparison of ATM-Related Operational Performance: U.S./Europe (June 2014)

<u>Cost-efficiency - Outputs</u>

KPI Name	ANSP's Cost of Per IFR hour
ID	KPI28
Definition	Actual ANSP's cost of per IFR hour
Measurement Units	$/hour
Variants	None
Parameters	Costs IFR hours
Calculation procedure	Compute the KPI: $\frac{Costs}{IFR\ hours}$ The Costs consists of ATCOs in OPS costs and other costs. ATCOs in OPS costs is composed of 'ATCOs in OPS employment cost per ATCO hour' (Compute it: $\frac{ATCOs\ in\ OPS\ employment\ costs}{ATCOs\ in\ OPS\ hours}$) and 'ATCOs in OPS hour productivity' (Compute it: $\frac{IFR\ hours}{ATCOs\ in\ OPS\ hours}$).
Data requirement	For each ANSP: ATCOs in OPS costs Other costs, including frontline staff costs, ATCOs in non-OPS, remaining employment costs, remaining operational costs, depreciation costs, capital costs, etc IFR hours For each country: ATCOs in OPS costs of the country Other costs of the country IFR hours of the corresponding country
Reference	CANSO Global Air Navigation Services Performance Report 2016 (2011-2015 ANSP Performance Results Executive Summary)

KEY PERFORMANCE INDICATORS FOR SAFETY

6.1 For safety performance metrics, there is a specific working group to study and promote the performance indicators. In the construction of the framework, safety is taken as an individual section which will not be focused on, although relevant indicators are still provided suggestion for reference. The specific indicators for safety are shown below.

ID	KPIs	Stage1		Stage2		Stage3	
KPI36	Rate of flights under safety control	R	1				
KPI37	Growth rate of safety level			R	2		
KPI38	Rate of various types of aircraft accidents	R	1				
KPI39	Rate of aircraft incidents and errors	R	1				
KPI40	Rate of aircraft surface accidents			R	2		
KPI41	Rate of airspace infringements			R	2		

Table 5: KPIs for Safety

Statistics of Safety Operation

KPI Name	Rate of flights under safety control
ID	KPI36
Definition	This KPI measures the rate of flights encountering no occurrences associated with the operation of an aircraft which take place between the time any person boards the aircraft with the intention of flight until all such persons have disembarked, where a person is fatally or seriously injured, the aircraft sustains damage or structural failure or the aircraft is missing or is completely inaccessible under the protection and supervision of ATC, airline and so on.
Measurement Units	Percentage(%)
Variants	Variant 1 – number of flights (computed by number of flights) Variant 2 – flight time (computed by flight time of flights)
Parameters	Statistical Period Recommended value: 1 month or calendar quarter.
Data requirement	Number of safety controlled flights. Number of controlled flights.
Calculation procedure	1. Get total number of flights in such area. 2. Select and get number of the flights under safety control in the same statistical range of step1. 3. Compute the KPI: number of safety flight divide total number of flights.
References	None

KPI Name	Growth rate of safety level
ID	KPI37
Definition	This KPI measures the rate of change on increasing level of safety in given time
Measurement Units	Percentage(%)
Variants	Variant 1 – number of flights (computed by number of flights) Variant 2 – flight time (computed by flight time of flights)
Parameters	Statistical Period:

	Recommended value: 1 year.
Data requirement	Rate of flights under safety control
Calculation procedure	1. Get Rate of flights under safety control in such area both a year and a month. 2a. Compute the year-on-year KPI: growth rate= rate of flights under safety control of this year/ rate of flights under safety control last year 2b. Compute the month-on-month KPI: growth rate= rate of flights under safety control of this month/ rate of flights under safety control of this month last year
References	None

Aircraft Unsafe Incidents

KPI Name	Rate of various types of aircraft accidents
ID	KPI38
Definition	The rate of occurrences associated with the operation of an aircraft, which take place between the time any person boards the aircraft with the intention of flight until all such persons have disembarked, where a person is fatally or seriously injured, the aircraft sustains damage or structural failure or the aircraft is missing or is completely inaccessible.
Measurement Units	Percentage(%)
Variants	Variant 1 –extremely large accidents Variant 2 –serious accidents Variant 3–accidents
Parameters	Statistical Period Recommended value: 1 year.
Data requirement	Number of controlled flights. For variant 1： Number of extremely large accidents. For variant 2： Number of serious accidents. For variant 3： Number of accidents.
Calculation procedure	1. Get total number of flights in such area. 2. Select and get number of the flights suffer different kinds of accidents in the same statistical range of step1. For variant 1： 3a. Compute the KPI: number of flights suffer extremely large accidents divide total number of flights. For variant 2： 3b. Compute the KPI: number of flights suffer serious accidents divide total number of flights. For variant 3： 3c. Compute the KPI: number of flights accidents divide total number of flights.
References	PRC Performance Review Report (EUROCONTROL 2015)

KPI Name	Rate of aircraft incidents and errors
ID	KPI39
Definition	Rate of flight incidents and errors .Aircraft incident is an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation; Error averages that something has been done that was not intended by the actor; not desired by a set of rules or an external observer; or that led the task or system outside its acceptable limits. In short, it is a deviation from intention, expectation or desirability.
Measurement Units	Percentage(%)
Variants	Variant 1 –incidents Variant 2 –errors
Parameters	Statistical Period Recommended value: 1 year.
Data requirement	Number of controlled flights. For variant 1： Number of flight incidents. For variant 2： Number of flight errors.
Calculation procedure	1. Get total number of flights in such area. 2. Select and get number of the flights suffer incidents and errors in the same statistical range of step1. For variant 1： 3a. Compute the KPI: number of flights suffer incidents divide total number of flights. For variant 2： 3b. Compute the KPI: number of flights suffer flight errors divide total number of flights.
References	PRC Performance Review Report (EUROCONTROL 2015)

<u>Aircraft Accidents and Incidents</u>

KPI Name	Rate of aircraft surface accidents
ID	KPI40
Definition	This KPI is the rate of aircraft accidents and incidents occur on the ground(including runway, taxiway and apron)
Measurement Units	Percentage(%)
Variants	None
Parameters	Statistical Period Recommended value: 1 year.
Data requirement	Number of controlled flights. Number of flights suffer surface accidents.
Calculation procedure	1. Get total number of flights in such area. 2. Select and get number of the flights suffer surface accidents in the same statistical range of step1. 3. Compute the KPI: number of flights suffer surface accidents divide total number of flights.
References	EUROCONTROL. Cognitive Complexity in Air Traffic Control: A Literature Review, 2004.

KPI Name	Rate of aircraft airspace infringements
ID	KPI41
Definition	Rate of a flight into a notified airspace that has not been subject to approval by the designated controlling authority of that airspace in accordance with international and national regulations.
Measurement Units	Percentage(%)
Variants	None
Parameters	Statistical Period Recommended value: 1 year.
Data requirement	Number of controlled flights. Number of flights cause airspace infringements.
Calculation procedure	1. Get total number of flights in such area. 2. Select and get number of the flights cause airspace infringement in the same statistical range of step1. 3. Compute the KPI: number of flights cause airspace infringement divide total number of flights.
References	PRC Performance Review Report (EUROCONTROL 2015)

Step-By-Step Performance-Based Approach

Introduction

7.1 The performance-based approach is a way of organizing the performance management process. This approach can be broken down into manageable, easy-to-understand steps. By systematically following these steps, ATM community members will gain confidence in their ability to apply the approach in a successful manner, and benefit from participating in a globally harmonized approach.

7.2 **Figure 6**: outlines the general sequence of steps in the performance management process. It serves as general guidance.

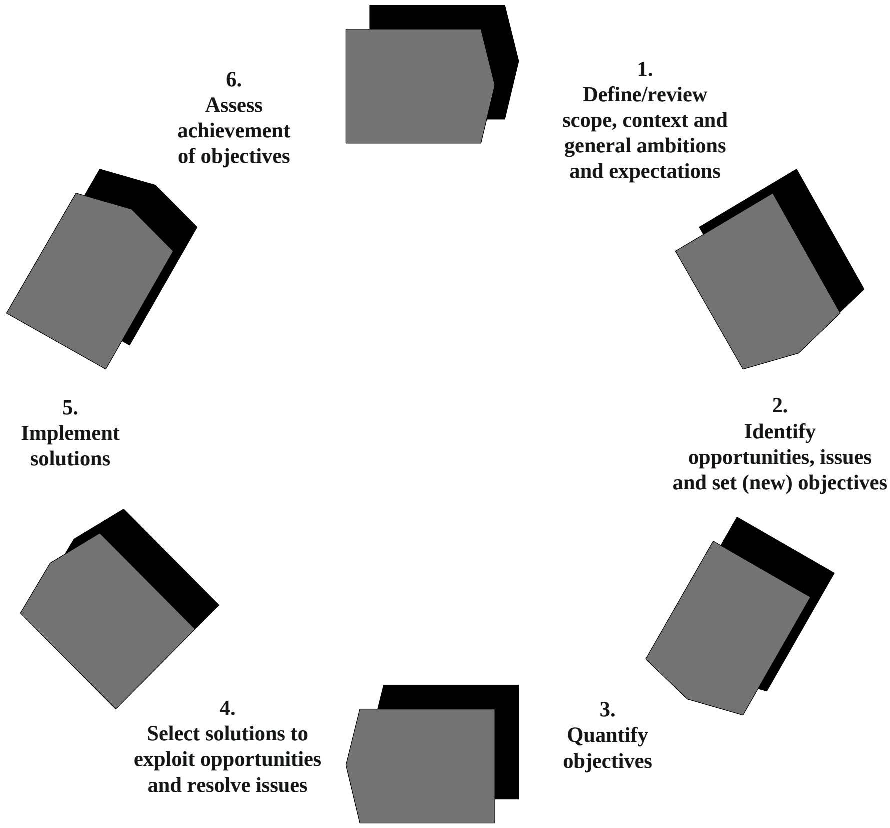


Figure 6: General Performance Management Process

7.3 The steps cover the following activities:

- Step 1: Define/review scope, context and general ambitions/expectations.
  - Step 1.1: Define scope;
  - Step 1.2: Define context;
  - Step 1.3: Identify ambitions and expectations.
- Step 2: Identify opportunities, issues and set (new) objectives.
  - Step 2.1: Develop a list of present and future opportunities and issues that require performance management attention;
  - Step 2.2: Focus efforts by defining and prioritizing performance objectives as needed.

- Step 3: Quantify objectives.
  - Step 3.1: Define how progress in achieving performance objectives will be measured and which data are required to do so;
  - Step 3.2: Define the desired speed of progress in terms of baseline and target performance.
- Step 4: Select solutions to exploit opportunities and resolve issues.
  - Step 4.1: Select the decisive factors to reach the target performance;
  - Step 4.2: Identify solutions to exploit opportunities and mitigate the effects of the selected drivers and blocking factors;
  - Step 4.3: Select a sufficient set of solutions.
- Step 5: Implement solutions.
- Step 6: Assess achievement of objectives.

<u>Step 1: Define/Review Scope, Context and General Ambitions/Expectations</u>

7.4 The purpose of Step 1 is to reach a common agreement on the scope and (assumed) context of the "system" on which the performance management process will be applied, as well as a common view on the general nature of the expected performance improvements.

<u>Step 1.1: Define Scope</u>

7.5 There is not just one global application of the performance management process, but many simultaneous — and often interrelated — applications at more specialized and localized levels. Scope definition is important to avoid misunderstandings, in particular about the performance (improvement) which can be expected within the given scope. For example, the possibilities for managing safety or environmental impact vary depending on whether one considers only the role of ATM or approaches the subject at the level of the entire air transport system. By defining the scope of the performance management activity, the limits of responsibility and accountability are also defined.

<u>Step 1.2: Define Context</u>

7.6 Once the scope is defined, it is necessary to make clear assumptions on what is "surrounding" the performance management activity. This includes clarifying what the strategic fit is within a larger (parent scope) performance management activity, with whom there is a need to coordinate and collaborate, and what the external drivers and constraints are for the scope.

<u>Step 1.3: Identify Ambitions and Expectations</u>

7.7 Within a given scope, the purpose of identifying general ambitions and expectations is to develop a strategic view on the (performance) results that are expected. The term "expectation" refers to desired results from an external perspective. The term "ambition" indicates that the desired results refer to an internal initiative. For example, in ATM, the performance-based approach can be used to better meet society's aviation expectations, as well as improve the business performance of airlines, service providers, etc. To achieve this, identify ambitions and expectations with regard to the performance of flight operations, airspace/airport usage and air navigation services in areas such as:

a) safety;

b) security;

c) environmental impact;

d) cost effectiveness;

e) capacity;

f) flight efficiency;

g) flexibility;

h) predictability;

i) access and equity;

j) participation and collaboration; and

k) interoperability.

7.8 These are the eleven key performance areas (KPAs) as identified in the Global Air Traffic Management Operational Concept (Doc 9854). Achievable performance is made possible by the following enabler levels:

a) services and procedures;

b) human resources;

c) physical infrastructure;

d) systems and technology; and

e) regulation and standardization.

7.9 The performance-based approach (PBA) can be applied at each of these enabler levels for the purposes of understanding the impact on the eleven KPAs. For example, for the systems and technology level, the focus includes technical performance characteristics such as service/system availability, continuity, reliability, integrity, resilience, maintainability, scalability etc. An important part of the PBA is the development of cause-effect relationships between these technical performance characteristics and the higher level 11 KPAs.

Step 2: Identify Opportunities, Issues and Set (New) Objectives

7.10 The purpose of Step 2 is to develop a detailed understanding of the performance behavior of the system (this includes producing a list of opportunities and issues), and to decide which specific performance aspects are essential for meeting the general expectations. The essential performance aspects are those which need to be actively managed (and perhaps improved) by setting performance objectives.

7.11 Step 2.1: Develop a list of present and future opportunities and issues that require performance management attention. Based on the scope, context and general ambitions/expectations which were agreed to during the previous step, the system should be analyzed in order to develop an inventory of present and future opportunities and issues (weaknesses, threats) that may require performance management attention. This part of the process is generally known as the SWOT (strengths, weaknesses, opportunities and threats) analysis. Strengths are (internal) attributes of a system or an organization that help in the realization of ambitions or in meeting expectations. Weaknesses are (internal) attributes of a system or an organization that are a detriment to realizing ambitions or meeting expectations. Opportunities are external conditions that help in the realization of ambitions or in meeting expectations. Threats are external conditions that are a detriment or harmful to realizing ambitions or meeting expectations.

7.12 Note that what may represent strengths with respect to one ambition or expectation may be weaknesses for another one. The term "issues" is used in this document to refer to weaknesses as well as threats. A good understanding of the opportunities and issues should be developed early in the process, to provide background information for deciding which performance objectives to set, what to measure and how/where to change the system. When possible (second or later iteration in the process), advantage should be taken of the results of Step 6: Assess achievement of objectives. In general, this activity should take place as part of the forecasting and performance review.

7.13 Once the strengths, weaknesses, opportunities and threats are identified, action can be taken to target and exploit or remove these factors, thereby leading to performance improvements directly related to meeting the expectations.

Step 2.2: Focus efforts by defining and prioritizing performance objectives as needed

7.14 The purpose of this activity is to focus and prioritize the application of the performance-based approach:

a) Focus is necessary to aim general expectations into specific performance objectives, which in turn will be the basis for deciding on improvement actions.

b) Prioritization is required because, even though the scope of the process has already been limited, in practice, not everything can and/or needs to be performance managed.

c) Prioritization is supported by risk management which helps identify the risks that are most urgent or must be avoided, those that should be transferred or reduced, and those that are reasonable to retain.

7.15 Focusing the performance-based approach is a two-stage process:

a) Within each KPA, identify a number of specific areas — focus areas — in which there are potential intentions to establish performance management. Focus areas are typically needed where issues have been identified (see Step 2.1). For example, within the capacity KPA one can identify airport capacity, runway capacity and apron capacity as focus areas. Within the safety KPA, the list of focus areas might include: accidents, incidents, runway incursions, safety management system maturity, etc. There may be a need to define hierarchical groupings of focus areas; and

b) Within focus areas, the potential intention to establish performance management is "activated" by defining one or more performance objectives. These define a desired trend in a qualitative and focused way in today's performance; they specifically focus on what has to be achieved, but do not make statements about the when, where, who or how much. These objectives may be developed iteratively with the development of indicators. Significant analysis of historical data, performance modeling or simulation may be required to understand the necessary objectives. For example, "improve safety" is not specific enough to be an objective, but represents a starting point. Further analysis would reveal that "reduce the total number of accidents" and even more specifically "reduce the number of CFIT accidents" would qualify as performance objectives. Because at this level of detail no mention is made about the when, where and who, it does not make sense to try to associate numbers (indicator values or targets) at this level. That is done during the next step of the process.

7.16 Prioritizing the performance-based approach averages that performance objectives will only be defined in those focus areas where a real (present or anticipated) need for action and improvement has been identified (preferably through analysis of historical or projected performance data).

Step 3: Quantify Objectives

7.17 The principle of "reliance on facts and data for decision-making" implies that objectives should be specific, measurable, achievable, relevant and time-bound (SMART). The purpose of Step 3 in the process is to ensure that these aspects are properly addressed.

7.18 Step 3.1: Define how progress in achieving performance objectives will be measured and which data are required. This section explains briefly that as part of the performance-based approach there is a need for defining: indicators; the metrics underpinning those indicators; and common definitions for data aggregation and event classification. It also addresses the measurement granularity and the need for harmonization. Current/past performance, expected future performance (estimated as part of forecasting and performance modeling), as well as actual progress in achieving performance objectives is quantitatively expressed by averages of indicators (sometimes called Key Performance Indicators, or KPIs).

7.19 Indicators are not often directly measured. They are calculated from supporting metrics according to clearly defined formulas, e.g. cost-per-flight-indicator = Sum(cost)/Sum(flights). Performance measurement is therefore done through the collection of data for the supporting metrics (e.g. leads to a requirement for cost data collection and flight data collection).

7.20 Indicators need to be defined carefully:

a) To be relevant, they need to correctly express the intention of the performance objective. Since indicators support objectives, they should not be defined without having a specific performance objective in mind.

b) They need to be expressed in terms of supporting metrics for which there is adequate data availability.

7.21 When there is a problem with data availability, there are two possibilities:

a) Set up the appropriate data reporting flows and/or modeling activities, to ensure all supporting metrics are populated with data as required to calculate the indicator(s) associated with the objective;

b) If this is not possible, aim for a different kind of performance improvement, by choosing a different performance objective, as constrained by data availability.

7.22 Note that the need for an indicator lasts only as long as the corresponding performance objective exists. Alternatively, the need for supporting metrics (such as the number of flights) lasts much longer because metrics are seldom indicator-specific, i.e. they are typically used to calculate a variety of indicators. When deciding which data to collect, a sufficiently broad spectrum of supporting metrics will have to be considered.

7.23 Data collection should take place at the most detailed level of granularity that can be afforded because the availability of detailed data greatly increases the effectiveness of the performance-based approach.

7.24 Common aggregation hierarchies and classification schemes (taxonomies) are then used to condense the detailed supporting metrics into clearly scoped summary indicators.

7.25 To conclude: in a collaborative environment in which many stakeholders contribute to the achievement of objectives and/or have performance reporting obligations, it is important to harmonize not only the definition of indicators and supporting metrics, but also the scope definitions, e.g. aggregation hierarchies and classification schemes (taxonomies).

<u>Step 3.2: Define Desired Speed of Progress in Terms of Baseline and Target Performance</u>

7.26 The above-mentioned performance indicators are the quantifiers for how well performance objectives have been achieved. Performance targets are closely associated with performance indicators: they represent the values of performance indicators that need to be reached or exceeded to consider a performance objective as being fully achieved. Note that performance targets can be set as a function of time (e.g. to plan yearly improvement); they can also vary by geographic area, stakeholder, etc. In addition, targets can be set at different levels: local, regional or global.

7.27 Once the scope of a target has been agreed, it becomes clear where and at which level performance management will need to be applied, between which stakeholders the achievement of the objective needs to be coordinated, and who will need to be involved in trade-off decisions. The term target is used with different averages:

a) current versus future: when the aim of the objective is to improve current performance over time, the term "target" refers to a future desired or required performance level;

b) real versus design specifications: when the aim of the objective is to manage real performance so as to stay within pre-defined limits, the term "target" refers to design specifications.

7.28 Performance targets may be set with different intentions, for example:

a) as a strategic design target, to support transition planning;

b) as a recommendation or incentive to promote the need for action and accelerate improvements;

c) as a legal requirement;

d) as a performance level which needs to be achieved to enable other performance improvements;

e) as a mandatory performance requirement which is necessary for safety reasons;

f) to gain access to certain airspace or receive certain levels of service.

7.29 To understand how challenging it is to reach a target, one should know the baseline performance. The difference between the baseline and the target is called the performance gap. In a "current versus future" application, the size of the gap is often expressed as a percentage of the baseline performance (e.g. 10 per cent improvement needed to reach the target). For "real versus design specifications" applications, targets are usually expressed as absolute values, without reference to a baseline.

7.30 The determination of the baseline performance (calculation of baseline indicator values) is done during the previous iteration of the process. It is one of the results of Step 6: Assess achievement of objectives. This is part of the performance review.

7.31 The time available to achieve performance objectives is always limited. Therefore, targets should always be time-bound.

7.32 The target and the time available to reach the target determine the required speed of progress for the performance objective. Care should be taken to set targets so that the required speed of progress is realistic. Target setting is used as a tool by managers, policymakers, regulatory bodies and standardization organizations. Targets can have far reaching consequences depending on how challenging they are and how serious they are taken.

7.33 In the air navigation system, appropriate decision-making/policymaking processes need to be in place to collaboratively agree on performance objectives, performance indicators and the values of performance targets at the local, regional and, where required, global levels.

Step 4: Select Solutions to Exploit Opportunities and Resolve Issues

7.34 The purpose of this step is to apply the principle of "informed decision-making, driven by the desired/required results".

7.35 It combines the knowledge of baseline performance, opportunities and issues with the performance objectives and targets, in order to make decisions in terms of priorities, trade-offs, selection of solutions and resource allocation. The aim is to optimize the decisions to maximize the achievement of the desired/required (performance) results.

Step 4.1: Select Decisive Factors to Reach the Target Performance

7.36 This part of the process is sometimes called performance gap analysis. As a result of Step 2, a qualitative inventory of present and future opportunities and issues that may require performance management attention is already available. When analyzing blocking factors for runway capacity improvement for example, it may turn out that for a given airport (example: single runway without parallel taxiway), the dominant blocking factor is runway occupancy time, rather than wake vortex separation minima. Knowing this, it is clear that solutions that reduce runway occupancy time will contribute to runway capacity enhancement, whereas solutions which reduce wake vortex separation minima will not contribute to the achievement of the objective in this particular example. Likewise, at some airports the dominant constraining factor may be runway capacity, but elsewhere it may be gate and apron capacity.

7.37 In order to make progress in reaching an objective, the dominant factors first need to be undertaken. So the outcome of this activity is a selection and prioritization of opportunities and issues. This can be seen as the development of a "performance strategy" for the achievement of a given objective: working "backwards" from expectation related objectives, it cascades performance requirements down to a selection of subordinate, enabling objectives and targets (e.g. to improve airport capacity, to improve runway capacity, to reduce runway occupancy time) so the process:

a) eliminates/defers issues that do not immediately or significantly affect the achievement of objective(s);

b) helps to maximize effectiveness if performance improvements have to be realized with limited resources (e.g. budget, manpower);

c) creates a "traceability chain", and/or a "performance case" which explains what will be improved and how much, prior to the selection of solutions;

d) progresses the decision-making to the point where it is appropriate to start thinking in terms of available solutions (options).

Step 4.2: Identify Solutions to Exploit Opportunities and Mitigate the Effects of the Selected Drivers and Blocking Factors

7.38 At this stage, decision-makers need to know their options for mitigating pre-identified issues and therefore to exploit available opportunities. This part of the process is about establishing the list of options, i.e. defining the "solution space" which is at the disposal of decision-makers for optimizing the achievement of performance objectives.

7.39 In the above example, for the objective "reducing runway occupancy time", the list of possible solutions/options may include: building extra taxiways to avoid the need for backtracking or to eliminate the need for runway crossings; building high speed runway exits to give more options for vacating the runway, thereby reducing runway occupancy time; and equipping aircraft with "brake-to-vacate" technology, which enables pilots to select a runway exit while the aircraft is making its landing approach. This increases the predictability of runway occupancy time, which in turn allows reducing the separation minima on final approach. The latter will lead to increased capacity if runway occupancy time is the dominating blocking factor. The list of solutions relates to the list of issues. In this example, each solution addresses a different issue (which may or may not be present at a given airport), but they all contribute to the same performance objective.

7.40 When the task is to improve the effectiveness of the day-to-day economic and operational management, the list of options will most likely be populated with off-the-shelf solutions and best practices, i.e. solutions which are readily available.

7.41 When working with longer time horizons (during transition planning), a number of the options or operational improvements may still be in their research, development and trials phases, averaging that decision-makers will have to work with a "living" list of options, which are still surrounded by a certain degree of uncertainty.

7.42 In any case, decision-makers need to gain a good understanding of the strategic fit, the benefits, cost and feasibility of each option for operational improvement. Therefore, the description of the operational improvements in the list needs to show that they have been developed from different complementary perspectives. To produce this list of options, the performance-based approach should be applied at each level.

7.43 In those cases where a list of options/operational improvements was already developed during a previous planning cycle, the task consists of updating the list to take the latest developments into account. In the case of transition planning-where the process may be executed only once every five years-"updating the list" averages significantly "refining the list".

<u>Step 4.3: Select a Sufficient Set of Solutions</u>

7.44 This is the part of the process where decisions are made based on which solution(s) to implement. The following information is available to support decision-making:

a) definition of system/expectation scope and context;

b) the required results in terms of performance objectives and targets (in some cases, for a certain date, in other cases, as an evolution through time, specifying a "required speed of progress", e.g. four percent improvement per year);

c) prioritized issues and opportunities, and their impact on performance; and

d) an overview of candidate solutions and their capability to resolve issues and exploit opportunities, in terms of:

- list of operational improvements;
- associated enablers (services and procedures, human resources, systems and technology, and regulation and standardization).

7.45 It is within this framework that decisions have to be taken. The nature of the decision and the method best applied depend on the situation, as explained below. Assume an example in which one has identified a number of candidate solutions to increase runway capacity. The requirement is to exceed a certain capacity target while staying below a certain cost target. This is illustrated in Figure 4-2. For each candidate solution, the expected runway capacity and associated cost have been assessed during the previous step. With this information, the various candidate solutions can be positioned in the capacity/cost diagram of **Figure 7**.

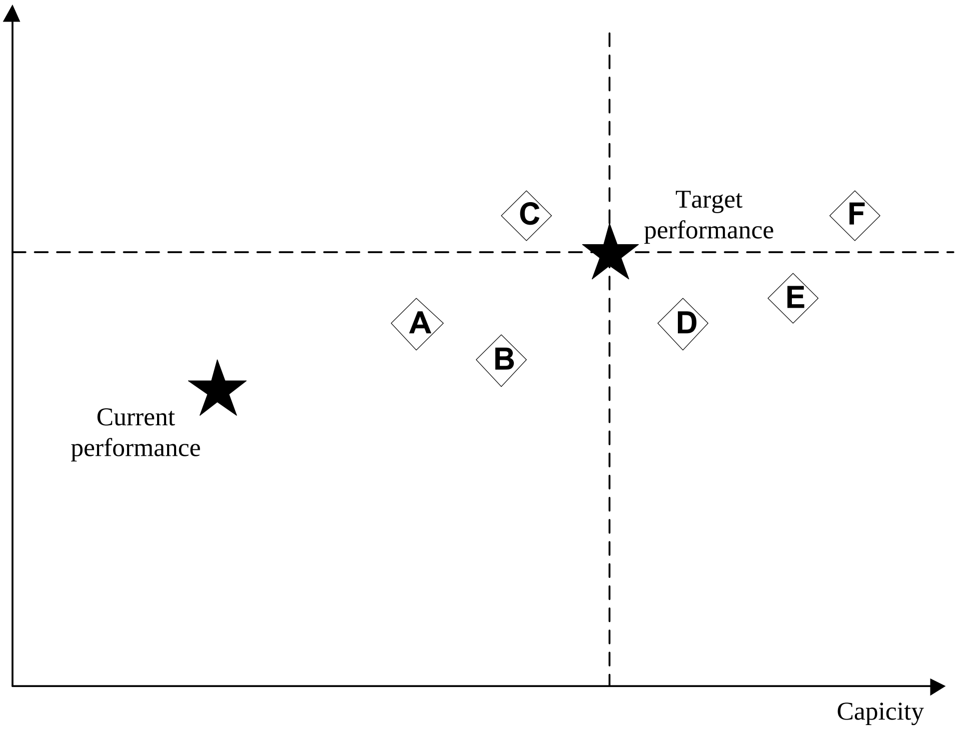


Figure 7: Expected performance of candidate solutions (example)

7.46 What is the decision to be taken and which method is to be used? Depending on which subset of the solutions is available, the answer will vary. Your project may be faced with any combination of the situations described in **Table 6**.

Case	Solutions	Decision
1	Only A, B, C, and F are available. None of these solutions meets both targets.	None of the proposed solutions is satisfactory. Decide whether to: — continue searching for solutions which address the selected issues and opportunities and meet all targets; — focus on different issues and opportunities (this assumes that the objectives can be achieved using a different method or by setting different priorities); — relax the target(s) (which makes it easier to achieve the objective(s), but the impact of this would need to be assessed); — abandon the performance objective(s) altogether (this also requires an impact assessment).
2	D and E are under development and not yet available when needed.	Decide what can be done to advance the availability date of D and E. In many cases, availability constraints are imposed by enabler deployment and this would imply a need to accelerate the deployment of certain enablers.
3	Only D is available and/or meets all targets.	There are no alternatives to choose from. Accept solution D.
4	Only D and E are available. They are mutually exclusive.	Both candidate solutions exceed the targets. Select the "best buy". Is it worth choosing E instead of D? A commonly used method for making the decision is multi-criteria decision analysis (MCDA).
5	Only D and E are available. They can be applied simultaneously.	D and E may be complementary in delivering performance benefits (improving performance in different places, at different times of the day, under

		different conditions). Decide whether to combine them into one “implementation package”.
6	Only D and E are available.	It may make sense to first use solution D, and after a while (some years) to replace D by E to achieve better performance. Decide how to include D and E in the “road map” or “deployment sequence”.
7	D is available, but its capacity will suffer if solution G is also applied.	This is the case where D and G interfere with each other from a performance perspective. Trade-off considerations will need to be part of the decision process. The aim is to take a balanced decision. See Appendix A for more information about trade-offs.

Table 6: Selection of solutions (example)

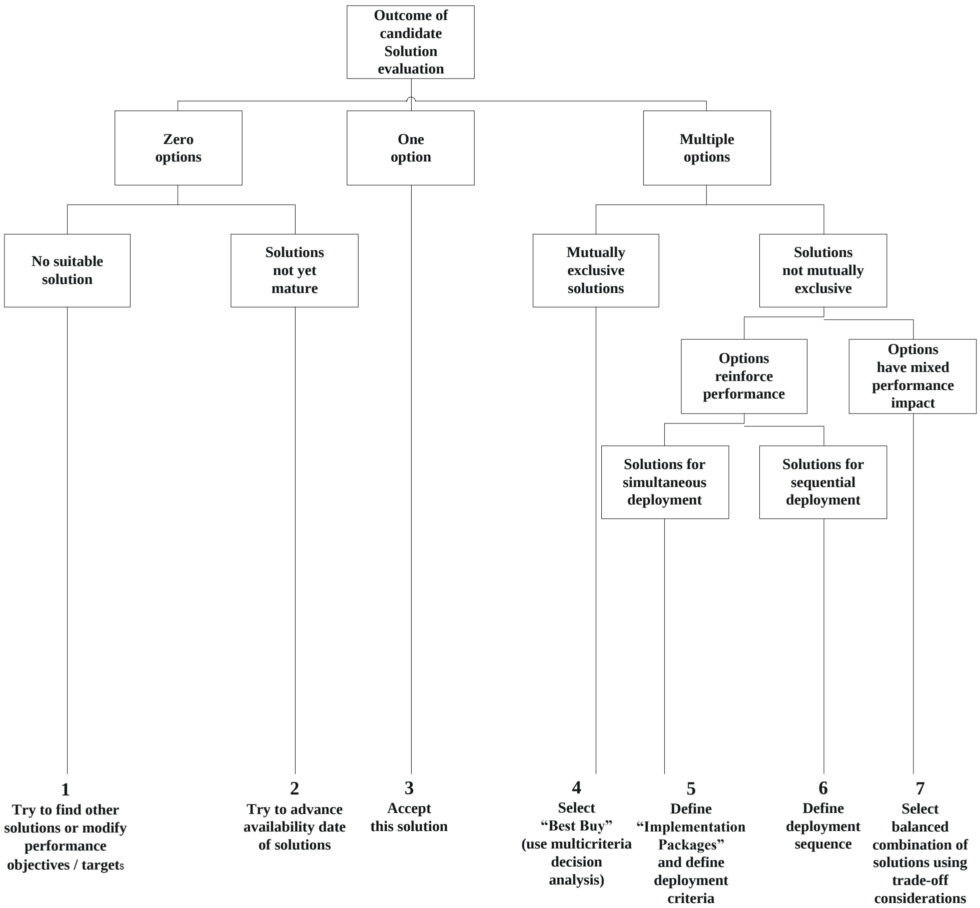


Figure 8: Selection of solutions

7.47 Depending on the nature of the project, the output of this process step is either a single preferred solution, or a road map of selected solutions (combined into implementation packages and sequenced into a deployment sequence), accompanied by an initial performance case that describes those issues which are resolved and opportunities exploited, together with the expected costs and benefits in terms of performance improvement towards the specified targets.

Step 5: Implement Solutions

7.48 This step is the execution phase of the performance management process. This is where the changes and improvements that were decided upon during the previous step are organized into detailed plans, implemented, and begin delivering benefits. Depending on the nature and magnitude of the change, this could average:

a) in the case of small-scale changes or day-to-day management:

- Assigning management responsibility for the implementation to an individual;
- Assigning responsibility and accountability for reaching a performance target to an individual or organization; and

b) in the case of major or multi-year changes:

- Refining the road map of selected solutions into a detailed implementation plan, followed by the launching of implementation projects.
- Ensure that each individual implementation project is operated in accordance with the performance-based approach. This averages launching and executing the performance management process at the level of individual projects. Each project derives its scope, context and expectations (see Step 1 of the process) from the overall implementation plan.

<u>Step 6: Assess Achievement of Objectives</u>

7.49 The purpose of Step 6 is to continuously keep track of performance and monitor whether performance gaps are being closed as planned and expected. This implies data collection to populate the supporting metrics with the data needed to calculate the performance indicators. The indicators are then compared with the targets defined during Step 3 to draw conclusions on the speed of progress in achieving the objectives. This step includes monitoring progress of the implementation projects, particularly in those cases where the implementation of solutions takes several years (as in the example), as well as checking periodically whether all assumptions are still valid and the planned performance of the solutions is still meeting the (perhaps changed) requirements.

7.50 With regard to the review of actually achieved performance, the output of Step 6 is simply an updated list of performance gaps and their causes. In practice, the scope of the activity is often interpreted as being much wider and includes recommendations to mitigate the gaps. This is then called performance monitoring and review, which in addition to Step 6 includes Steps 1, 2 and 3 of the performance management process.

7.51 For the purpose of organizing performance monitoring and review, the task can be broken down into five separate activities:

a) Data collection;

b) Data publication;

c) Data analysis;

d) Formulation of conclusions;

e) Formulation of recommendations.

Data collection

There are essentially two major categories of data feeds that performance monitoring and review will deal with:

a) data which are captured by automatic averages and forwarded in electronic form with little or no human intervention. This type of data feed is typical for high volume streaming measurement data and automated database-to-database exchanges;

b) manual reporting of information (electronically or on paper). This requires human effort to collect, interpret, analyze, structure and otherwise prepare the data for reporting. Typical for low-frequency, complex information data feeds in which the performance monitoring organization receives processed information (forms, reports) instead of raw data feeds.

7.52 To establish data feeds in each KPA, the following steps need to be undertaken:

a) identify information needs;

b) identify potential suppliers of data;

c) ensure information disclosure by candidate data suppliers;

d) manage the data feeds on an ongoing basis.

Data access and publication

7.53 The performance review can begin once the required data (performance targets and current/anticipated values for performance indicators) are available. The first activity in this process is data publication. With proper ATM community participation in place, ATM performance will be evaluated by two different groups: performance specialists (e.g. analysts from designated ATM performance review organizations); and people with a generally high level of interest in ATM performance. Each group has its own specific need for access to ATM performance data, which should be satisfied by appropriate data access and publication averages.

7.54 People with a general interest in ATM performance will wish to see executive level, quality-controlled data and draw their own conclusions, at which point, the need arises to make certain performance data publicly available in the interest of transparency. A capability is therefore required which enables them to monitor the current situation against the performance targets, and to provide them with the general trends, the “big picture” and their own performance in comparison with others. This need can be satisfied by publishing high-level performance indicator indices. These indices are periodically updated and generally allow limited or no interactivity by the user.

7.55 In addition, analysts from designated ATM performance review organizations are tasked with gaining an in-depth understanding of ATM performance and finding causes and effects. Their work is an integral part of the performance management process described earlier. Their data needs can be satisfied by publishing selected data in performance assessment databases which are designed to suit the analysts’ needs. These databases should allow high levels of interactivity (querying and analysis).

Data analysis

7.56 At the data analysis stage, the performance review organization should ensure that the data are already quality-checked. Rather than struggling with data quality issues, analysts should be able to focus on their main task: performance review. Analysts need to examine the reasons for (good/poor) performance, and explain these to decision-makers, while gaining a better insight into past, current and future ATM performances. To that effect, analysts will compare performance indicators against performance targets, identify performance evolution trends, analyze historical evolution of performance, and find relationships (correlations) between performance indicators, supporting metrics, etc.

7.57 They will look at the “big picture” (annual totals and averages, performance indicators summarized during the planning cycle) and break down the data into very detailed levels to find the causes of performance gaps and the reasons for trade-offs. Analysts will also make use of various modeling techniques to increase their understanding of system performance. As a side effect of data analysis, analysts will be able to propose performance objectives, define new performance indicators and identify data needs.

Formulation of conclusions

7.58 After completing the data analysis, analysts are expected to document the conclusions for each KPA. Normally, these conclusions contain an assessment of the current and expected future performance for each performance objective. Typically, the conclusions are published in a performance review report.

Formulation of recommendations

7.59 An integral part of the performance review process is the formulation of recommendations. These should be derived from the conclusions and also be included in the performance review report. Recommendations should focus on how to meet ATM community expectations through agreed upon performance objectives, performance indicators and performance targets. When an evaluation indicates inconsistency between ATM community expectations and performance objectives, performance indicators and performance targets, recommendations may include: the need to set or change performance objectives; the need to (re-)define performance indicators; the need to set or change performance targets.

7.60 Recommendations will typically fall into the following categories (non-exhaustive list):

a) the need to improve performance data collection;

b) suggested initiatives aimed at closing identified performance gaps;

c) suggestions to accelerate or delay performance improvements based on anticipated evolution of traffic demand and predicted performance indicator trends;

d) setting up task forces, defining action plans, etc., with a view to beginning the implementation process.

Positioning of performance review within the overall process

7.61 It is recommended that the performance monitoring and review activity is sufficiently integrated into the overall performance planning process to ensure that the conclusions and recommendations serve as direct input for Step 4 of the process, while simultaneously maintaining a degree of independence from the other parts of the process in order to ensure a sufficient level of objectivity and impartiality.

<u>Repeat the process</u>

7.62 Performance management is a closed loop process. The performance management process is intended to be a closed-loop process. Step 6 has identified deficiencies, i.e. cases where performance is not as expected, despite the implementation of changes designed to achieve performance improvements. These deficiencies are to be acted upon by starting the next iteration of the process.

7.63 One may be surprised to note that this implies revisiting Step 1: Define/review scope, context and general ambitions/expectations. It is strongly recommended not to skip this because the performance management scope, context and general expectations may be subject to continuous change.

7.64 The periodicity of the process greatly depends on where in the air navigation system and lifecycle it is applied. Depending on the nature of your project/activity you could be responsible for any of the following:

a) ensuring performance of concepts and systems:

- during concept validation;
- during and/or after implementation.

b) application of regulatory methods to organizations, people and systems:

- legal requirements, rules and regulations;
- certification and licensing;
- inspection and oversight.

c) annual performance review:

- performance is evaluated in annual cycles, in a reactive way;
- followed by actions in subsequent years to correct performance deficiencies.

d) proactive, collaborative performance planning:

- medium-term planning processes (annual cycles);
- strategic planning/seasonal scheduling (seasonal cycles); and
- pre-tactical planning (e.g. daily cycles).

Appendix A: ICAO and GANP Performance Indicators Frameworks

Key Performance Area	ICAO Key Performance Indicators
Access and Equity	Unsatisfied demand versus overall demand
Capacity	Number of flights or flight hours that may be accommodated. Separate measures for airspace and airport either through models or though actual values. Values may be specific for a weather condition.
Cost Effectiveness	Average cost per flight at a system-wide annual level. Total operating cost plus cost of capital divided by IFR flights. Total labour obligations to deliver one forecast IFR flight in the system, measured monthly and year-to-date.
Efficiency	Percentage of flights departing on-time. Percentage of flights with on-time arrival. Average departure delay per delayed flight Percentage of flights with normal flight duration. Average flight duration extension of flights with extended flight duration. Total number of minutes to actual gate arrival time exceeding planned arrival time. For all of the above consider 1) ATM caused delay, 2) target time for delay (filed or schedule) and 3) delay threshold value (i.e. 15 minutes)
Environment	Amount of emissions attributable to ATM inefficiency Number of people exposed to significant noise Fuel efficiency per revenue plane-mile
Flexibility	Number of rejected changes to the number of proposed changes to the number of flight plans initially filed each year Proportion of rejected changes for which an alternative was offered and taken.
Global Interoperability	Number of filed differences with ICAO Standards and Recommended Practices. Level of compliance of ATM operations with ICAO CNS/ATM plans and global Interoperability requirements.
Participation by ATM Community	Number of yearly meetings covering planning, implementation and operations.
Predictability	Closely related to delay measures under efficiency Possible refinement to delay measures by phase of flight.
Safety	Number of accidents normalized to either number of operations or number of flight hours
Security	Number of acts of unlawful interference to ATC Number of incidents involving direct unlawful interference to aircraft that require air traffic service provider response Number of incidents due to unintentional factors such as human error, natural disasters, etc., that have led to unacceptable reduction in air navigation system capacity

Table 1 Key Performance Area

Key Performance Area	GANP Key Performance Indicators
Capacity	Airport peak arrival capacity.
Efficiency	Additional taxi-in time. Additional taxi-out time. Airport arrival throughput.
Predictability	Flight arrival punctuality. Flight departure punctuality. Flight time deviation.
Cost Efficiency	Airport arrival throughput.

Table 2 Core Indicators in GANP

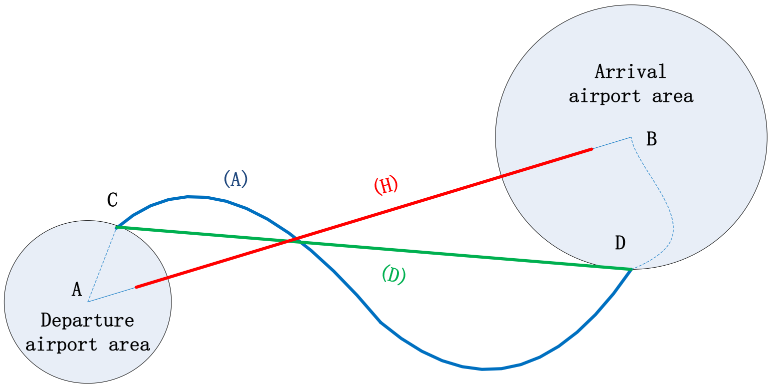
Appendix 2: Filed Flight Plan En-Route Extension Rate/Actual En-Route Extension Rate

Those indicators of filed flight plan en-route extension and actual en-route extension are defined by previous studies (E.g. Kettunen, et al. 2005; Boeing & CANSO, 2012; Eurocontrol & FAA, 2012). Trajectory based performance evaluation is mostly used to estimate the operational performance of efficiency and influence of environment due to the inefficiency operation.

Eurocontrol has further utilized the air route extension rate to estimate the level flight efficiency in PRR. In the main body of this report, two KPIs of air route extension rate are selected, which are respectively effected by terminal and en-route condition. As is shown in the picture below: (A) is the actual flight trajectory of s flight, (D) is the great circle between the departure airport area fix and the arrival airport area fix and (H) is the projection of (A) or (D) on the connection between two airports. Thus the calculation function:

Air route extension rate (affected by route condition) = ((A) – (D))/ (D)

Air route extension rate(affected by terminal condition)= ((D) – (H))/ (H)



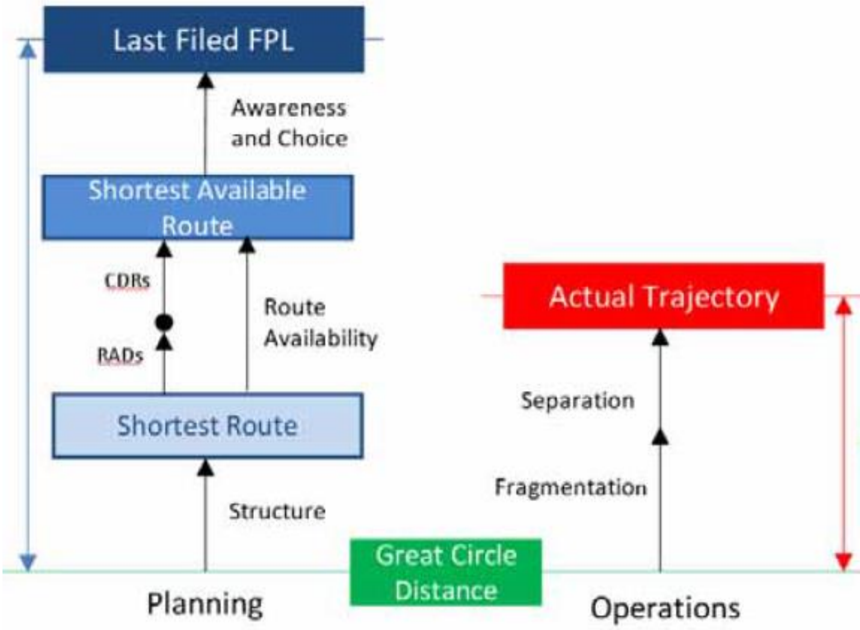
Filed flight plan en-route extension, compares the length of the en-route section of the last filed flight plan with the corresponding great circle distance. Similarly, actual en-route extension compares the length of the en-route section of the actual trajectory with the corresponding achieved distance. The indicator is calculated as the ratio of the two sums (length of trajectories and achieved distances), over all flights considered.

Filed flight plan en-route extension compares the filed flight plan to the great circle. While the filed, flight plan is the ultimate output of the planning process, this indicator would be possible to measure the inefficiency at intermediate stages by considering the shortest possible route on the route network and the shortest available route for the specific flight. The shortest possible route is constrained by the design of the route network. Historically, the route network was structured in reference to aircraft navigational limitations and to enable air traffic control to provide separation with the tools available. As performance of both aircraft and ATC has improved, the need for such a rigid en-route structure has diminished, to the extent that free route airspace would now be possible throughout the entire area. This would have positive effects both on the Filed flight plan en-route extension and the actual en-route extension.

The shortest available route is specific to a flight and takes into account the additional constraints introduced by the Route Availability Document (RAD) and Conditional Routes (CDRs). The RAD has the effect of modifying the route network available to specific flows of traffic, while CDRs have the effect of modifying the route network available at specific times. Both of these reduce the set of available routes. Differences between the shortest available route and the route in the filed flight plan can arise because the airspace user might not be aware that the route is available, or just choose an alternative route for operational or business reasons.

The actual en-route extension, on the other hand, reflects the actual environmental performance. In this case a distinction can be made between two separate components: “separation” and “fragmentation”. “Separation” relates to the need to safely manage the flow of traffic and has to be considered as a hard constraint. It is important to bear in mind that the level of inefficiencies cannot be reduced to zero. “Fragmentation” refers to operational inefficiencies created by non -homogenous processes and systems and airspace and sector design due to non-operational factors.

It is recognized that actual en-route extension can be a representation for fuel efficiency as the most fuel efficient route depends on wind. However, the wind optimal route might not necessarily



correspond to the choice of the airspace users because they might use different measures, such as total cost (which would be dependent on the airspace users).

Appendix 3: Abbreviations

AAR	Airport Acceptance Rates
ADS-B	Automatic Dependent Surveillance - Broadcast
AIBT	Actual in-block time
ALDT	Actual landing time
ANSP	Air navigation service provider
AOBT	Actual off-block time
ATC	Air traffic control
ATCOs	Air Traffic Control Officers
ATFM	Air traffic flow management
ATM	Air traffic management
ATOT	Actual take-off time
ELDT	Estimated landing time
ETOT	Estimated take-off time
KPI	Key Performance Indicator
ICAO	International Civil Aviation Organization
STA	Scheduled time of arrival
STD	Scheduled time of departure
TMA	Terminal area