Aircraft Operational Availability

2nd Edition - 2022

Contents

Executive Summary

Aircraft Availability is a key indicator to monitor aircraft performance, as a complement to Operational Reliability, and can be employed to optimize the profitability of an airline.

This paper aims at defining the different types of availabilities based on a common approach developed by operators and aircraft manufacturers, the measure being done on the unavailability times. The different metrics of unavailabilities are based on a data collection for aircraft grounding times using the ATA Spec 2000 records. It enables the identification of the Aircraft Unavailability drivers in two main categories: the planned and the unplanned maintenance activities to identify all possible causes that will result in an aircraft becoming unavailable. This approach has the advantage to monitor the aircraft change before flight departure that are not counted in the reliability metrics. This will allow operators, OEMs, service providers and other interested stakeholders to use a common language and better understand aircraft unavailabilities.

According to the needs and the point of views, the following levels of Aircraft Availabilities are defined as a hierarchy:

- **Level 1: Total Unavailability (TU)** counts all the aircraft grounding due the maintenance (planned and unplanned technical events) and the non-maintenance events (non-technical events)

- **Level 2: Technical Grounding (TG)** counts all the aircraft grounding for technical reasons. The time of the Technical Grounding is measured as the period of time an aircraft is on ground in a non-airworthy condition (no valid certificate release to service): it covers both planned and unplanned maintenance activities for *technical* reasons. It includes factors that operators and aircraft manufacturers can measure and influence

- **Level 3: Operational Technical Grounding (OTG)** counts all the aircraft grounding for technical reasons *taking the Operations point of view*, only the maintenance grounding which impacts airline Operations is kept for the computation. As a result, the Operational Technical Grounding performance is specifically linked to the airline context (utilization, fleet, network, flight schedule, M&E organization, make or buy policy, maintenance program, planning) making the comparison of various contexts complex.

The unit is a number of days of unavailability per year per aircraft, but it can also be converted in % according to the needs.

Note: The Edition2 rationale is to enrich the paper content with best practices and to complete some definitions. It doesn't interfere with the paper objective as defined in the previous Edition. However, some terms have been modified to avoid any confusion with the ATA Spec 2000 terminology.

1. Introduction

For decades, the Technical Dispatch Reliability (TDR) was the leading key performance indicator (KPI) in the industry with all its existing flaws. The easiest example of one of those flaws is a situation with 3 reserve aircrafts and 3 AOGs, which can in some cases even lead to a TDR of 100 %. If you tell your management that you had 3 AOGs in one week but fulfilled your goals to 100 %, they will certainly be confused. Furthermore, the TDR does not reflect the volume of maintenance required to recover aircraft due to technical defects. Additionally it does not allow the determination of critical operational availability trends for fleets or sub-fleets. That's why the focus recently switched to Operational Availability as a new measurement to assess the technical and financial performance of an aircraft and its corresponding maintenance system.

It is commonly accepted that an aircraft generates revenues when flying and that, consequently, increased availability of the aircraft is crucial to optimized profitability. Aircraft Availability is a key measure.

Some airlines are implementing individual initiatives to measure availability, meeting different needs and covering various scopes. Such diverse measures, although valid, may create confusion in the industry as they are not comparable. It may result in a biased view of aircraft performance between different aircraft types and lead to misleading conclusions since definitions may differ, but figures are still all presented as "Aircraft Availability" data.

The aim of this paper is therefore to clarify what is Aircraft Availability and provide definitions of unavailabilities for the industry depending on their point of views, based on a common approach developed by operators and aircraft manufacturers.

The purpose of these new indicators is to measure the Aircraft Unavailability and allow airlines to monitor their fleet performance. This measurement can help airlines in many ways, e.g. fleet planning, aircraft retirement, assessing the number of reserve aircraft etc. Aircraft manufacturers on the other hand receive a tool to assess the behavior of their products, based on in-service aircraft data.

This paper has been co-authored by members of IATA's Maintenance Cost Technical Group (MCTG), airlines and aircraft manufacturers, in coordination with the ATA Spec 2000 Reliability group. We strongly encourage you to contact the MCTG (MCTG@iata.org) and share your feedback for the next revision.

This paper is intended for airline personnel in technical and operations divisions, especially fleet managers, continued airworthiness managers, and operations control center personnel. It may be useful to aircraft acquisition or leasing groups.

2. Definitions & Concept

2.1. Definitions

In this document, the following capitalized terms and expressions shall, except where the context otherwise requires, have the following respective meanings:

Aircraft Non-Operating Time	period of time when the aircraft is not under the responsibility of the airline's operations, for technical reasons (Planned and Unplanned Maintenance), or non-technical reasons "*Other (non-maintenance)*".
Aircraft Operating Time	period of time when the aircraft is flying and all other activities when the aircraft is under the responsibility of the airline's operations. This includes boarding and onboarding times, servicing, taxiing and aircraft turnaround time. Indeed during these times, the aircraft is fit for service, even if it is not flying. Natural downtimes such as night stops e.g. due to curfews (whenever they exist) are considered as aircraft operating time since the aircraft is fit for flying. Once available in the hands of the Operations, an aircraft is not necessarily used for flights, this is the case of a spare aircraft.
Cancellation	means when a scheduled revenue flight cannot take place due to an aircraft technical issue.
Delay	means when the aircraft final departure for a scheduled revenue flight is delayed after the scheduled departure time due to an aircraft technical issue.
Diversion	means when the aircraft lands at an airport other than the airport of origin or destination originally scheduled due to an aircraft technical issue.
In-flight Turn-back	means when the aircraft, after having become airborne, returns directly to the airport of origin due to an aircraft technical issue.
Operational Interruption (OI)	means any or all of the following: Delay, Cancellation, In-flight Turn-back, Diversion and taking into account all chargeability codes defined by the IATA, covering the aircraft chargeable events, not aircraft chargeable due to maintenance, logistics, operations, or other external reasons

Operational Technical Grounding (OTG)	counts the time an aircraft is on ground in a non-airworthy condition (no valid certificate release to service) for technical reasons but taking the airlines' operations point of view. Only maintenance groundings which impact the operations is kept for the computation. It is therefore the measure of the technical constraints to maintain the aircraft (checks, cabin, engine, operational interruptions, aircraft change) that impact the aircraft operations. Any maintenance done during the natural downtime (stand by, transit or night stop) is transparent for the Operations as they do not need the aircraft, and therefore is not taken into account (refer to coding rules in Section 3).
Other (non-maintenance)	this category covers the grounding when the aircraft is not available due to non-related aircraft technical issues, such as: diversion due to medical issue, weather, ATC, strikes, etc.
Planned Maintenance	covers any maintenance activity that can be anticipated in advance by the M&E organization, from few hours to several days, depending on the organization for the required maintenance activity. It includes all maintenance work related to Operator's Maintenance Planning (routine tasks of the aircraft MPD and rectifications of their associated findings, operator's cabin maintenance program and airlines' specifics tasks), deferred items, service bulletins and modifications, cabin refurbishment. But also maintenance activities on engine or APU shop visits and overhauls, engines wash, aircraft painting, predictable removals such as wheels-brakes-tires, etc.
Technical Grounding (TG)	counts the time an aircraft is on ground in a non-airworthy condition (no valid certificate release to service) for technical reasons. It covers both planned and unplanned maintenance activities.
Total Unavailability (TU)	counts all the aircraft grounding due to the maintenance (planned and unplanned technical events) and the non-maintenance events (non-technical events such as passenger-related issues, crew delays, weather or air traffic control problems). There is no exclusion rules, all the grounding times are kept for computation.
Unplanned Maintenance	covers any maintenance activity that cannot be planned/anticipated by the M&E organization, less than x days pre-notification, and needs to be managed at time of occurrence. It includes maintenance activities due to an aircraft technical issue leading to Operational Interruptions, aircraft changes without OI, or fixed during the transit time (not leading to an OI). The late releases from maintenance (i.e. check overrun) is also included. Note: by experience, the pre-notification time varies from 1 to 3 days.

2.2. Concept

The key to the definition is to consider the Aircraft Availability from an Operations point of view in the airline organization, hence the term Operational Availability. It means that an aircraft is:

- available when it is in the hands of Operations for flights (whether in service or on standby), it is ready to fly;
- unavailable when it is not in the hands of Operations or when an event creates a disturbance to the Operation.

The technical Operational Availability of a fleet or an aircraft is measured by the Unavailability through a suite of factors that operators and manufacturers (aircraft and engine) can measure and influence.

The following diagram is used to define the different types of Aircraft Availabilities & Unavailabilities:

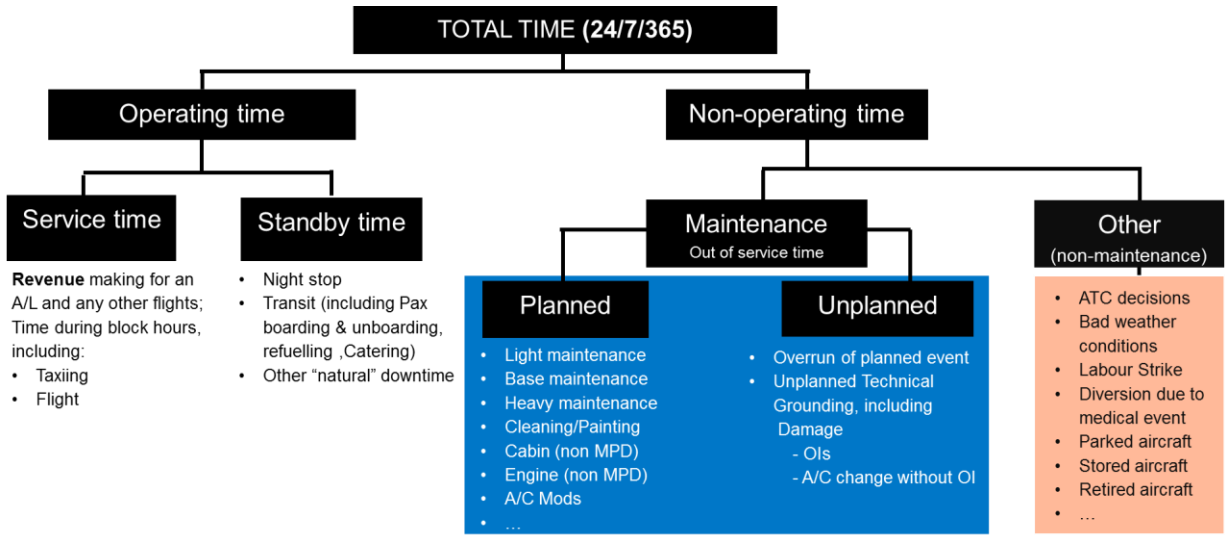

Figure 1 - Aircraft Availability Scope

The definitions of Operating and Non-Operating Time, Planned and Unplanned Maintenance, and Other (non-maintenance) are provided in the Section 2.1.

For practical reasons, the measure is done for the Aircraft Unavailability, which will, by deduction, give the Aircraft Availability figure over a predetermined period.

Availability time = Total time – Unavailability time

Aircraft Unavailability is calculated as the number of days in a year that the aircraft is not available, using the different levels of Availability defined below. The Aircraft Availability is therefore, by deduction, the remaining number of days in the same given year.

Unit: days per year per aircraft

When analyzing over a year, it is better to consider this metric in days per year per aircraft. For individual events, hours or minutes per year per aircraft may be a more suitable unit.

Alternatively and according to the needs, the unit can also be in % of unavailability or availability over a period.

The unavailability is cyclical depending on the maintenance events defined by the check interval, the maintenance policy (cabin, engine) and the unplanned events (aging effect over time).

According to the needs and the point of views, the following levels of aircraft unavailabilities are defined as a hierarchy:

- Level 1: Total Unavailability (TU)
- Level 2: Technical Grounding (TG)
- Level 3: Operational Technical Grounding (OTG)

The related definitions are provided in Section 2.1.

While the Technical Grounding (TG) aims at covering all the time the aircraft is on ground for maintenance, the Operational Technical Grounding (OTG) is specifically linked to the airline context (utilization, fleet, network, M&E organization, make or buy policy, maintenance program, planning) making the comparison of various contexts difficult.

3. Coding & Clocking Rules

3.1. Coding

3.1.1 Main Categories

The aircraft grounding events are collected using the Spec 2000 records (best practices are available in the Section 6.1) and then categorized to compute the Unavailability metrics (TG or OTG).

The categories of coding have been defined to process all the data in the same way.

The maintenance events (technical by definition) are categorized as "Planned" or "Unplanned", and the non-technical events (events related to ATC, weather, passengers, etc.) are categorized as "Other (non-maintenance)".

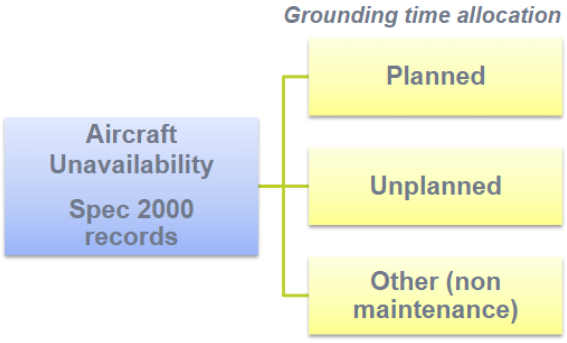

Figure 2 - Grounding Time Allocation as First Level of Coding

The coding of the maintenance event is done using the event description. The first level of coding "**Planned**" or "**Unplanned**" corresponds to the allocation of the grounding time

Then, each category can be broken-down into sub-categories according to the quality and granularity of the event description and the needs (analysis, KPI). More details in the data give more possibility to have detailed sub-categories.

3.1.2 Planned Maintenance Sub-Categories

The "Planned" activities can be split into various standard maintenance activities (i.e. Light, Base, Heavy) and specific maintenance activities (Cabin, Engine, Mods, etc.) according to the source of requirement: A/C manufacturer, OEM or Operator policy.

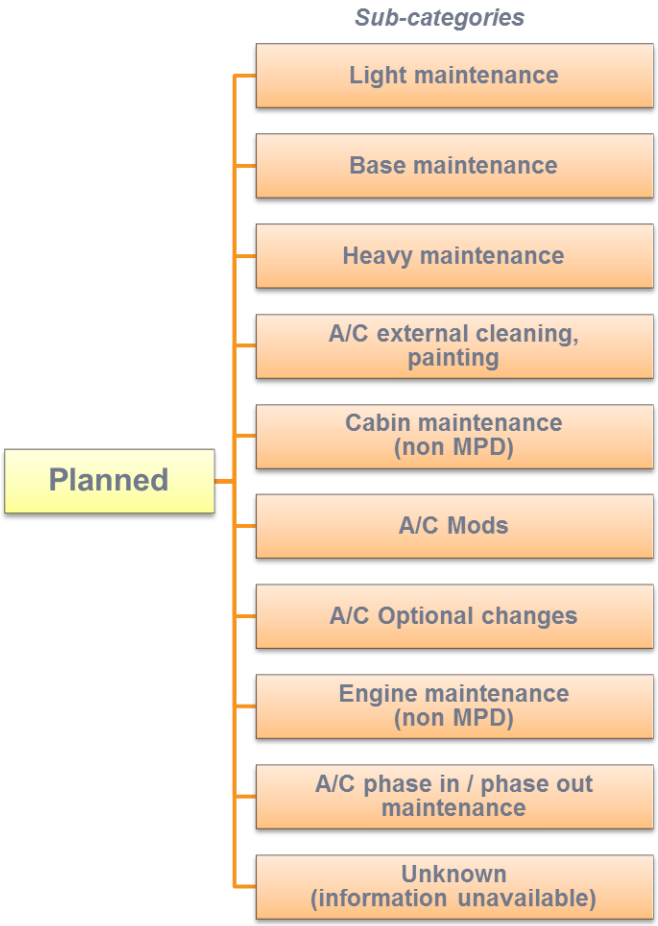

Figure 3 - Planned Maintenance Sub-Categories

The standard maintenance coming from the A/C manufacturer MPD is part of the Light, Base and Heavy maintenance. The wording "non-MPD" means that the requirement is not coming from the A/C manufacturer, it can be from other OEMs (e.g. engine) or from the operator policy (e.g. cabin).

Light maintenance

The light maintenance consists of maintenance activities done at the ramp or in a hangar (if available), such as:

- Weekly checks (when not completed during the stand-by time)
- Light check (e.g. A-check, equalized maintenance)
- Dedicated work package & deferred items (work performed as one-off or any deferred work)
- Out-of-phase package

Base maintenance

The base maintenance is the maintenance driven by the MPD which requires a hangar (docks, specific tooling, etc.); typically C-check event, out-of-phase package for base tasks. It usually includes maintenance activities on the cabin, engine, mods, etc. that are done in parallel of the check.

Heavy maintenance

The heavy maintenance is related to structure checks driven by the MPD. Pre-heavy checks and post-heavy checks are events to prepare or finalize this activity. It usually includes maintenance activities on the cabin, engine, mods, etc. that are done in parallel of the check.

Maintenance activities on major components (APU, nacelle, landing gear, wheel brakes tires) and generic LRU are covered in Light, Base or Heavy maintenance events.

For the sake of clarity, the following sub-categories are categorized as Light, Base or Heavy maintenance when they are performed in conjunction with checks.

When they are performed outside of checks, the following sub-categories can be used to classify the specific grounding:

A/C external cleaning, painting

A/C external cleaning and painting are related to specific slots for cleaning or painting activities. For the painting, it can be full external painting, or some paint touch-up only. Painting is generally done after a base or heavy check. The external cleaning is generally referenced as cosmetic wash.

Cabin maintenance (non MPD)

Cabin maintenance (non MPD) is for any specific grounding for cabin maintenance due to the operator policy (operator's cabin program or cabin mods).

Ex: Cabin refurbishment, upgrade cabin (Premium economy, Business, etc.), specific grounding for cabin maintenance program, IFE, connectivity, power-to-the-seat, lighting installations or modifications

A/C Mods

A/C Mods is used for specific A/C grounding to inspect, modify or fix an issue (Inspection SB, Modification SB, life extension modification, implementation of AD requirements) that are recommended or mandatory.

A/C Optional changes

A/C Optional changes are used for specific groundings such as optional SBs / upgrades as per the operator's policy.

Engine maintenance (non MPD)

The Engine (non MPD) is used for any specific A/C grounding due to the engine manufacturer's requirement and not required by the MPD. It covers on-wing and near-wing engine maintenance.

E.g.: borescope inspections, engine wash, engine change, etc.

A/C phase in / phase out maintenance

A/C phase in / phase out maintenance covers any specific activity linked to A/C leasing or entry into service of an A/C in a fleet: phase-in inspection, end of lease check, return to service after storage, etc.

Unknown (information unavailable)

Unknown is used as a category for any maintenance not covered by one of the other categories.

Coding general rules are provided in Section 3.1.6 for the case of several activities performed in parallel during the same event.

3.1.3 Unplanned Maintenance Sub-Categories

The "Unplanned" activities can be split into the unplanned maintenance impacting the operations (Unplanned Technical Grounding) and the unplanned maintenance without impact on the operations (Unplanned other –not UTG).

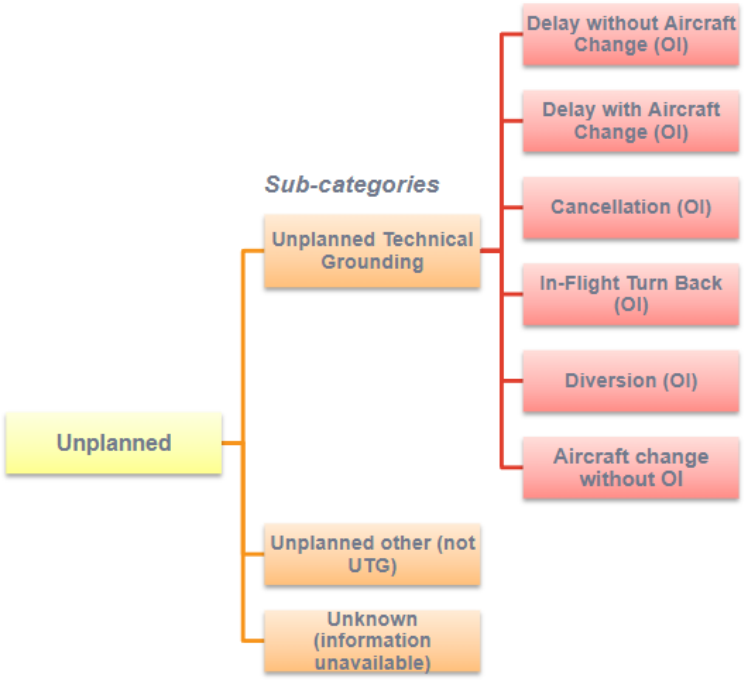

Figure 4 - Unplanned Maintenance Sub-Categories

Unplanned Technical Grounding (UTG)

The UTG includes the unplanned maintenance with impact on the airline operations:

- the unplanned maintenance linked to an Operational Interruption
- the unplanned maintenance leading to an aircraft change

In addition to the OIs, the UTG takes into account the specific case of the A/C change without OI (A/C swap during the transit), not monitored through the traditional OI data collection.

Unplanned other (not UTG)

The unplanned maintenance "other" includes the unplanned maintenance without impact on the operations, occurring and managed during the transit time (not leading to operational interruption nor aircraft change).

Unknown (information unavailable)

The "Unknown" category is used to compute any maintenance activities not covered by the previous unplanned categories.

Note: Coding of the overrun of planned event

The overrun of a planned event occurs when an event lasts longer than what was initially planned (actual > forecast). For instance, the C-check forecast duration is 5 days and it takes 7 days to perform. The planned grounding time is 5 days, the overrun corresponds to the unplanned grounding time of 2 days. The total grounding time is 7 days.

For the sake of clarity, the overrun grounding time is coded as

- UTG when there is an impact on the operations (overrun leading to an OI and/or an aircraft change)
- "Unplanned other (not UTG)" when there is no impact on the operations (without OI nor aircraft change)

3.1.4 Damage Indicator

The damage indicator is defined in the Spec 2000 records and is applicable to Planned and Unplanned categories as an additional attribute to identify the grounding related to damage such as: FOD, bird strike, lightning strike, collision on ground, etc.

Generally, an event due to damage will start by an unplanned event and then, it will generate a planned event for the repair.

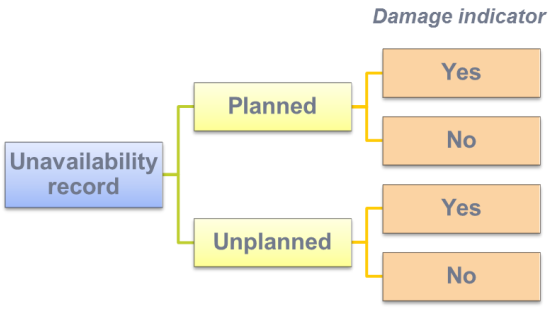

Figure 5 - Damage Indicator

3.1.5 Unavailability Coding Grid

The Unavailability coding grid gives the overview of the maintenance events categorization, according to the details and granularity provided.

Unavailability coding					
Group 1 Grounding time allocation	**Group 2 Planned**	**Group 3 Planned**	**Group 4 Planned**	**Group 5 Planned**	**Damage indicator**
Planned	**Light maintenance**	Weekly check type			
		A-check type	A pure		
			A + other		
		Specific light check type			
		Dedicated work package / deferred items	refer to the Blue list	refer to the Orange list	
		Out of phase package			
		Pre-light check			
		Post-light check			
	Base maintenance	C-check type	C pure		
			C + other		
		Specific base check type			
		Pre-base check			
		Post-base check			
		A/C weighting			
		Dedicated work package / deferred items	refer to the Blue list	refer to the Orange list	
		Out of phase package			
	Heavy maintenance	Heavy check type			
		Pre-heavy check			
		Post-heavy check			
	A/C external cleaning, painting	Full external painting			
		Paint touch-up			
		Cleaning			
	Cabin maintenance (non MPD)	Cabin operator programme			
		IFE			
		Connectivity (Wifi, mobile telephony)			
		Inspection / modification (SB, AD)			
		Refurbishment	Partial		
			Major		
	A/C Mods	Mandatory inspection/modification	refer to the Blue list		
		Recommended inspection/modification			
		Life extension			
	A/C Optional changes	System	refer to the Blue list		
		Structure			
		System and Structure			
	Engine maintenance (non MPD)	Cleaning			
		Repair			
		Inspection / modification (SB, AD)			
		Servicing			
		Part / LRU change			
		Engine removal / installation			
		Engine run			
		Engine wash			
	A/C phase in / phase out maintenance	Phase in inspection/check			
		Phase out inspection/check			
	Unknown (info unavailable)				
Group 1 Grounding time allocation	**Group 2 Unplanned**	**Group 3 Unplanned**	**Group 4 Unplanned**	**Group 5 Unplanned**	**Damage indicator**
Unplanned	**Unplanned Technical Grounding**	Delay without A/C change	Delay without A/C change (OI)	Overrun	Yes or No
		Major events	Diversion (OI)		
			In flight turn back (OI)		
			Cancellation (OI)		
			Delay with A/C change (OI)		
			A/C change without OI		
	Unplanned other (not UTG)			Overrun	
	Unknown (info unavailable)				
Other (non maintenance)	**N/A**				

Figure 6 - Unavailability Coding Grid

The Blue and Orange lists give more details for the coding into the sub-categories:

Blue list
Structure
Cabin (MPD)
Engine (MPD)
APU
Nacelle
Landing gear
Brakes
Wheels
Tyres
Slide raft
THS actuator
RAT
Pax door
Cargo door
Flying Control Surfaces
Fuel
Generic LRU
Systems

Orange list
Servicing
Test
Repair
Inspection
Modification
Sub-component replacement
Replacement
Robbery
Software loading / update

Figure 7 - Unavailability Coding Sub-Categories

3.1.6 Coding General Rules

The unavailability categorization is done according to the unavailability coding grid.

When several activities (check, cabin, engine …) are done in parallel during a planned event, the main reason for grounding is retained if no additional information is provided.

Example: for an event "C-check + Engine change + Cabin mod"

The aircraft goes in C-check due to the interval limit on the maintenance tasks packaging, so the coding is done as Planned/Base Maintenance/C-check type/ C + other. It is considered that during the C-check grounding, it was an opportunity to perform additional work-package such as the Engine change and the Cabin mod.

Additional information may change the coding: if the event was created for a major cabin mod (and the grounding for the mod takes much more time that a usual C-check), it can be considered that it was an opportunity to perform a C-check during the cabin mod. In this case, the coding is: Planned / Cabin maintenance (non-MPD).

3.2. Clocking Rules

The six following cases illustrate how to record the Technical Grounding (TG) and the Operational Technical Grounding (OTG).

- Case 1: Planned Technical Grounding event and unplanned overrun
- Case 2: Unplanned Technical Grounding – Delay without A/C change
- Case 3: Unplanned Technical Grounding – Delay with A/C change
- Case 4: Unplanned Technical Grounding – A/C change without OI
- Case 5: Unplanned Technical Grounding – Cancellation
- Case 6: Unplanned Technical Grounding – In-flight turn back or Diversion

In some cases, the Operations and Maintenance Departments have to define where the aircraft should be positioned for the A/C transfer from the Maintenance to the Operations (e.g. at a specified gate or parked after maintenance is completed). Then, the unavailability ends when the aircraft is released to Operations at the agreed location with CRS valid.

Refer to 3.2.7 for the complementary information on the OTG clocking rules.

3.2.1 Planned Technical Grounding Event and Overrun

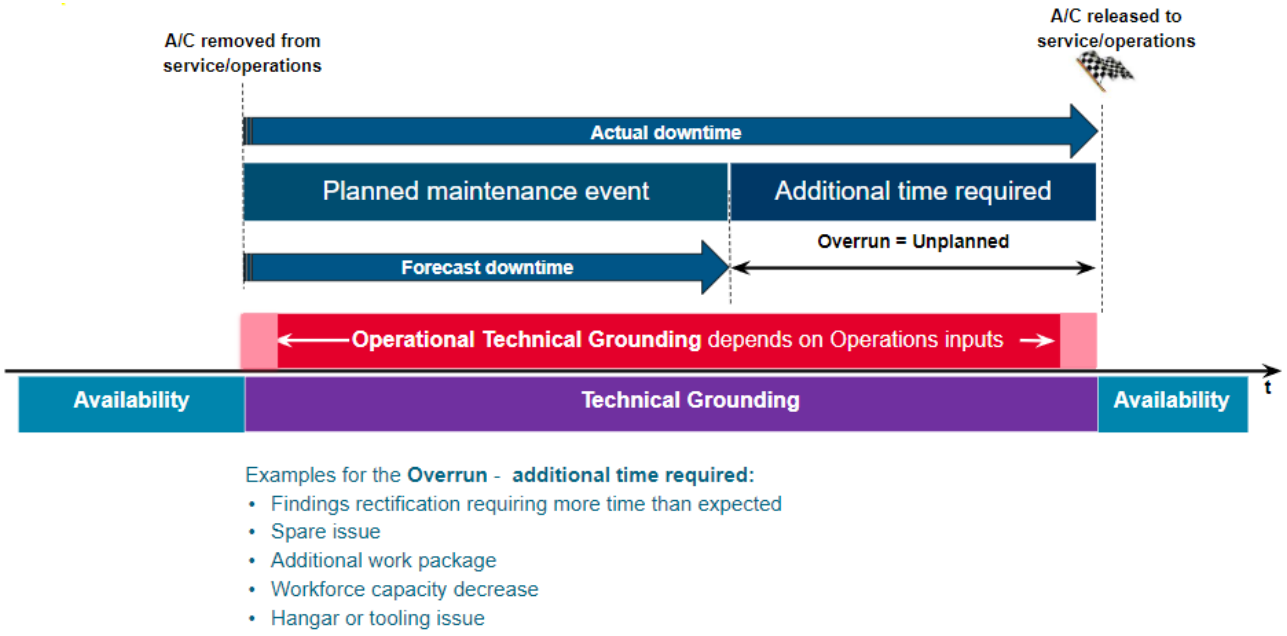

Figure 8 - Planned Event + Unplanned Overrun

The Planned Technical Grounding (PTG) event starts when the aircraft is removed from service and goes in maintenance, until it is released from the Maintenance and is declared serviceable. The event is planned as per the forecast downtime; however an overrun may occur due to findings (for instance). In this case, the forecast downtime is counted as the "planned" grounding time, whereas the overrun downtime is counted as the "unplanned" grounding time.

The planned OTG is the unavailability as seen by the Operations: in case the planned activity is done transparently into the flight schedule, the planned OTG is zero.

Note: The overrun may have an impact on the Operations: it can create an Operational Interruption or an aircraft change, depending on the time of the next flight. The overrun coding is detailed in chapter 3.1.3, and the unplanned maintenance clocking rules in the following sections.

3.2.2 Unplanned Technical Grounding – Delay without Aircraft Change

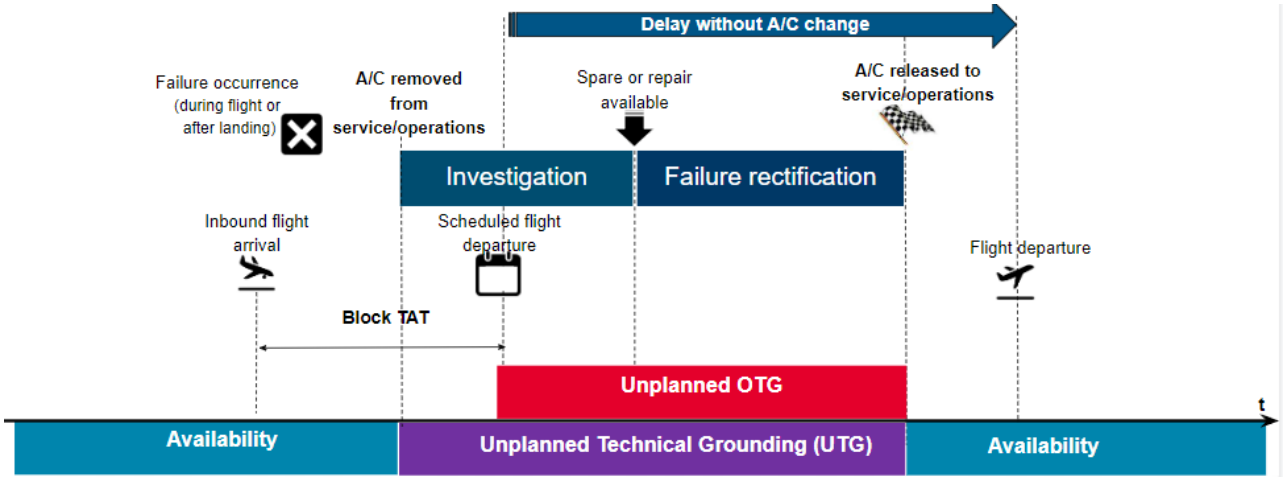

Figure 9 - Unplanned Technical Grounding - Delay with Aircraft Change

The Unplanned Technical Grounding starts when the aircraft is removed from service and goes in maintenance, until it is released from the Maintenance and is declared serviceable.

The Unplanned OTG is the unavailability as seen by the Operations: it starts at the scheduled flight departure time; it ends when the aircraft is released from the Maintenance and is declared serviceable.

3.2.3 Unplanned Technical Grounding – Delay with Aircraft Change

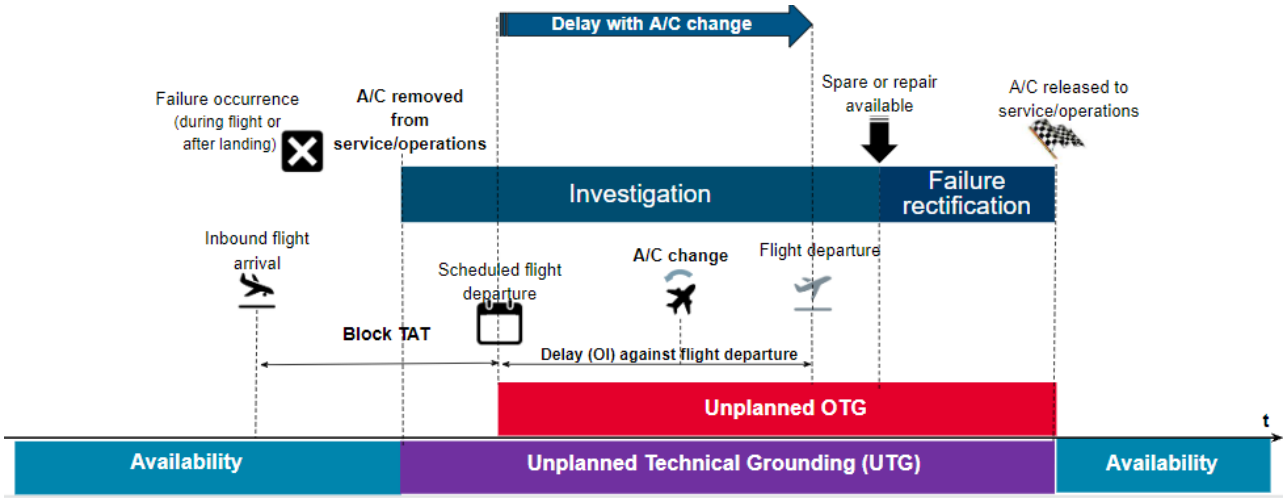

Figure 10 - Unplanned Technical Grounding - Delay with Aircraft Change

The Unplanned Technical Grounding starts when the aircraft is removed from service and goes in maintenance, until it is released from the Maintenance and is declared serviceable.

The Unplanned OTG is the unavailability as seen by the Operations: it starts either at the scheduled flight departure time (if the a/c change time is later, as shown on the figure above) or at the aircraft change time (if the a/c change time is prior to the scheduled flight departure), it ends when the aircraft is released from the Maintenance and is declared serviceable.

With traditional OI data collection, only the OI delay duration is known against the flight departure. In case of A/C change, the grounding time collected is the total time to recover the grounded A/C changed (whereas the delay is reported against the flight departure).

3.2.4 Unplanned Technical Grounding – Aircraft Change without OI

Aircraft change without OI during Operations

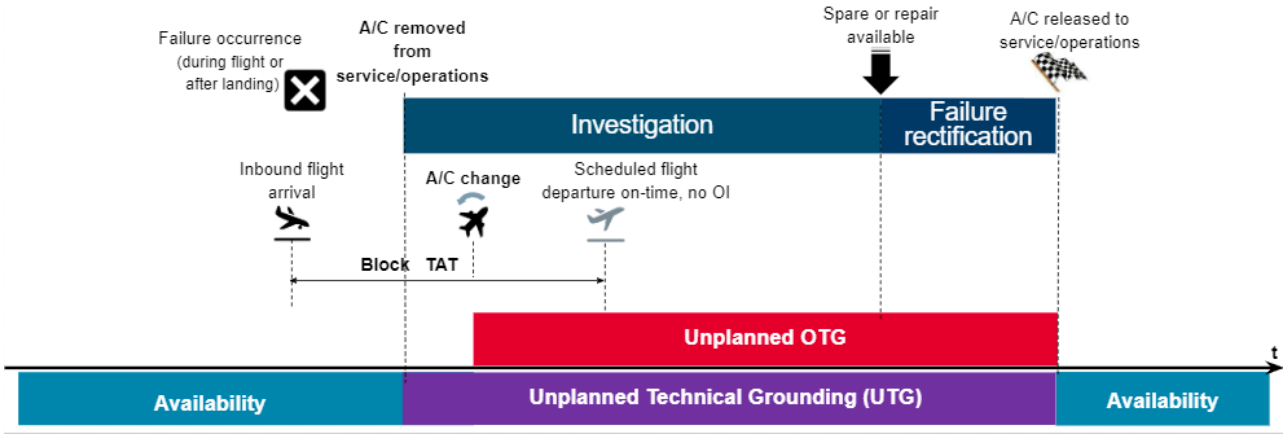

Figure 11 - Unplanned Technical Grounding - Aircraft Change Without OI during Operations

The Unplanned Technical Grounding starts when the aircraft is removed from service and goes in maintenance, until it is released from the Maintenance and is declared serviceable.

The Unplanned OTG is the unavailability as seen by the Operations: it starts at the time when the aircraft is changed, it ends when the aircraft is released from the Maintenance and is declared serviceable

This case is not collected through OI traditional data collection as no operational interruption. The A/C is unavailable for the Operations from the time of the decision to remove it from Operations, until it is declared serviceable.

Aircraft change without OI during Maintenance

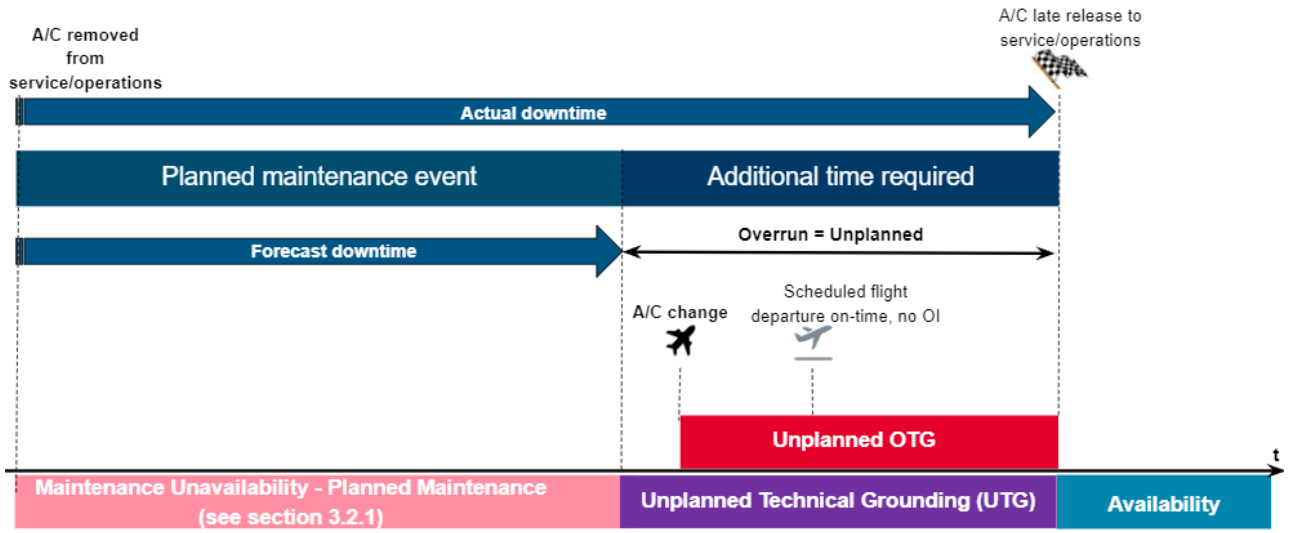

Figure 12 - Unplanned Technical Grounding - Aircraft Change without OI during Maintenance

The Unplanned Technical Grounding starts at the beginning of the planned maintenance overrun time, until the Aircraft is released from the Maintenance and is declared serviceable.

The Unplanned OTG is the unavailability as seen by the Operations: it starts either at the aircraft change time (if the a/c change time occurs during the overrun downtime, as shown on the figure above) or at the beginning of the overrun time (if the a/c change time occurs during the forecast downtime). It ends when the aircraft is released from the Maintenance and is declared serviceable.

3.2.5 Unplanned Technical Grounding – Cancellation

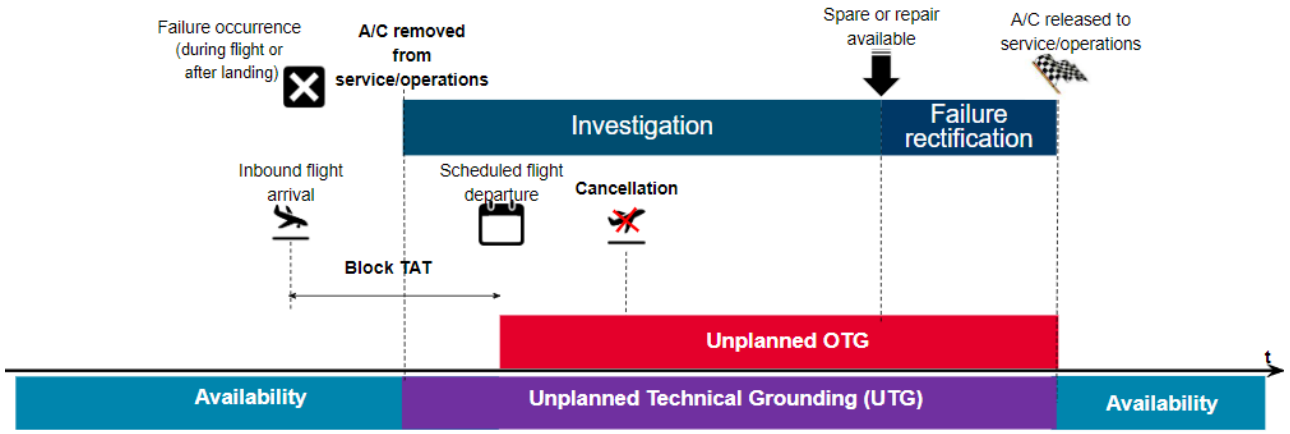

Figure 13 - Unplanned Technical Grounding - Cancellation

The Unplanned Technical Grounding starts when the aircraft is removed from service and goes in maintenance, until it is released from the Maintenance and is declared serviceable.

The Unplanned OTG is the unavailability as seen by the Operations: it starts either at the scheduled flight departure time (if the decision to cancel the flight comes later, as shown on the figure above) or at the cancellation time (if the decision to cancel the flight comes before the scheduled flight departure), it ends when the aircraft is released from the Maintenance and is declared serviceable.

The grounding duration of a cancellation is not collected through traditional OI data collection.

3.2.6 Unplanned Technical Grounding – In-flight Turn Back or Diversion

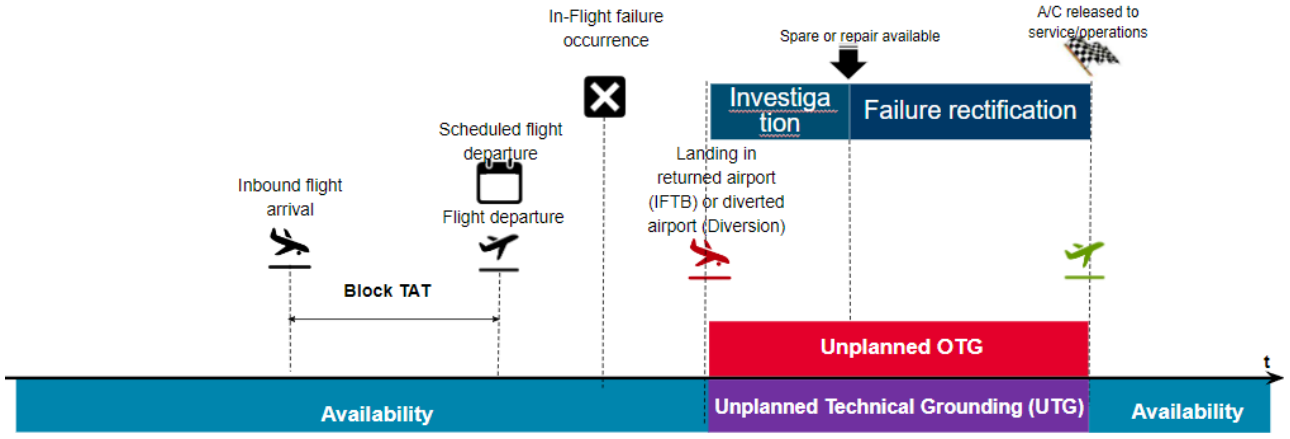

Figure 14 - Unplanned Technical Grounding - IFTB or Diversion

The Unplanned Technical Grounding and unplanned OTG start when the aircraft lands at the returned or diverted airport, until it is released from the Maintenance and is declared serviceable.

The grounding duration of an in-flight-turn-back or a diversion is not collected through traditional OI data collection In case of delay at the gate before the in-flight-turn-back or diversion, the duration of the delay has to be added to the unavailability period of the IFTB or diversion.

3.2.7 Clocking rules for OTG Time Computation

Grounding time computation has to be done in accordance with the Operational Technical Grounding definition: use rules to retain the maintenance events which impact the Operations.

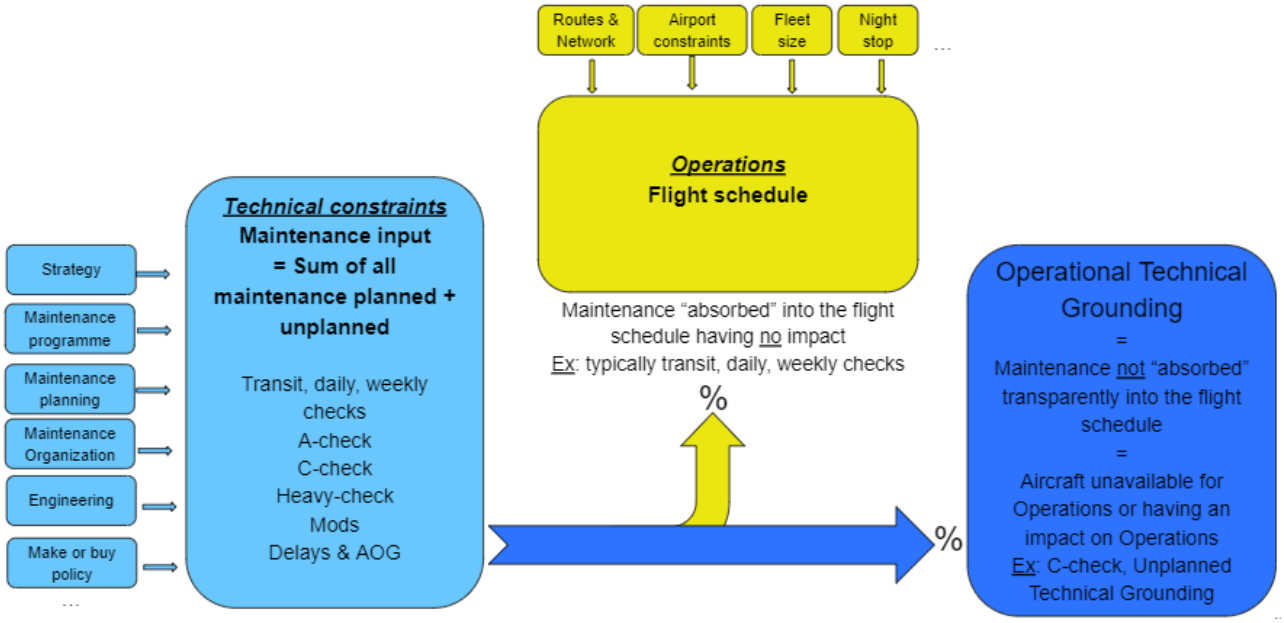

Figure 15 - How to Measure Unavailability

- **Clocking rules for the planned OTG**

  For the planned OTG, general rules can be used as a global approach for the operational context definition. For this, the following clocking rules are used:

  All types of operations: short- or long-range operations

  In general, the line activity is transparent for the Operations (short grounding time events are considered having no impact). For example, the transit, daily, weekly checks are usually removed.

- **Rule 1:** As a general rule defined by the IATA & ATA for the planned maintenance, any planned maintenance event <2 hours is excluded from the OTG computation. The aim is to remove any planned maintenance activity done transparently for the Operations.

  Note: in case a technical issue is found during the TAT during a planned event <2h, leading to an impact on the operations, an unplanned event is created as an Unplanned Technical Grounding event (Operational Interruption or aircraft change without OI), and is therefore taken into account in the OTG metric.

Short-range operations with airport curfew

Operators take advantage of the night stop to perform some maintenance when the Operations do not need the aircraft (e.g. at night in Europe due to airport restrictions). The Night Stop start time and end time are part of the Spec 2000 records.

- **Rule 2:** The portion of planned maintenance (A-check, mods, cabin, etc.) done overnight has no impact on the Operations and is removed from the OTG computation for event <24h. A night stop has to be defined by the Operator to apply its own "night stop" rule and can be reported through the Spec 2000 attributes.

  Note: that for planned events of more than 24 hours, the night stop is not removed as in this case, it is considered that the total grounding time is necessary to perform the maintenance.

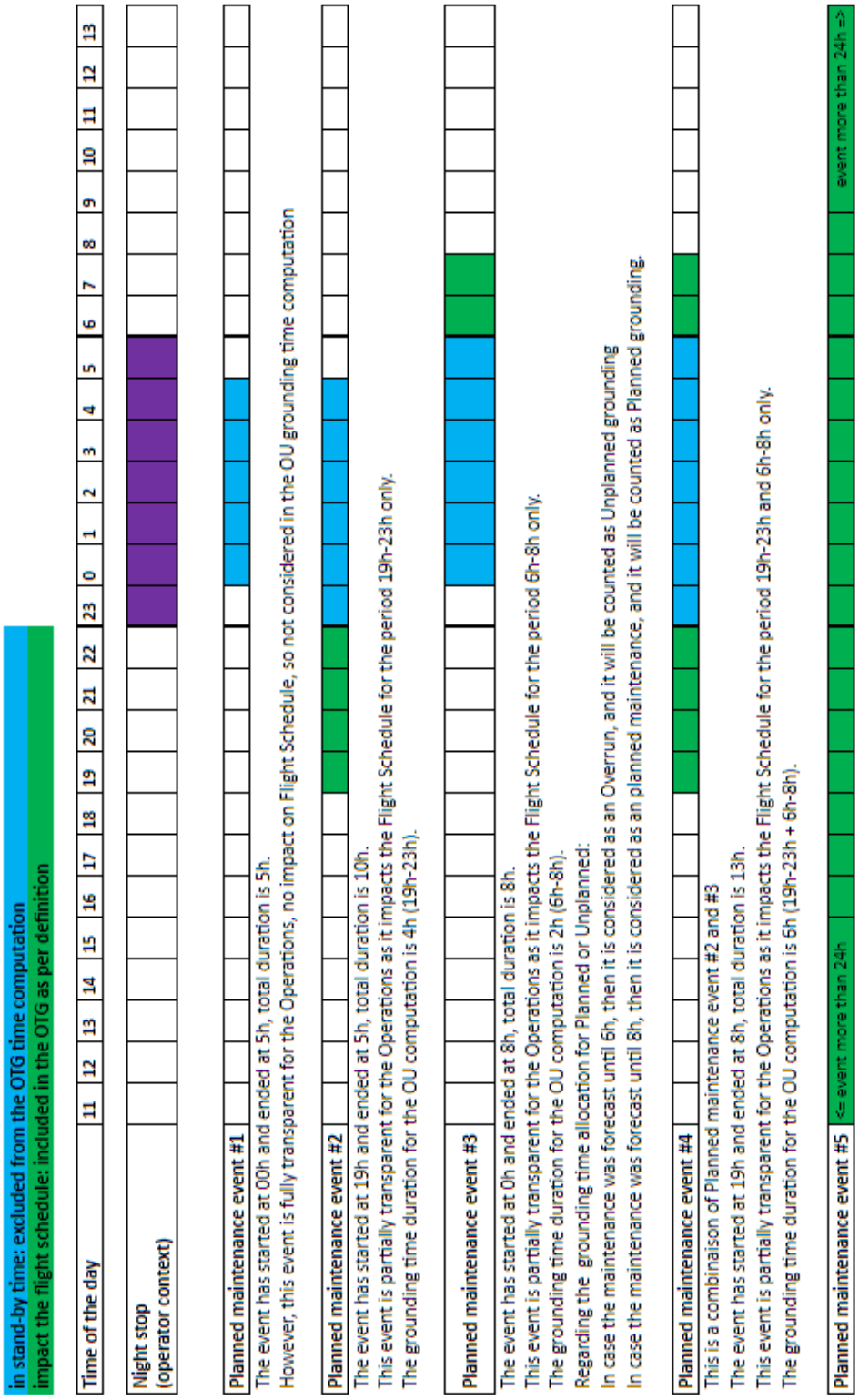

Figure 16 - Planned Maintenance and Night Stop Implications (when applicable)

Note: In Europe, a standard night stop for Single Aisle operations can be defined as 11pm to 6am. It may be used to apply the same context (night stop) to different operators for comparison.

- **Clocking rules for the unplanned OTG**

In order to compute the grounding time for the OTG, the following portion of the unplanned maintenance event has to be removed, to keep the portion which impacts the Operations.

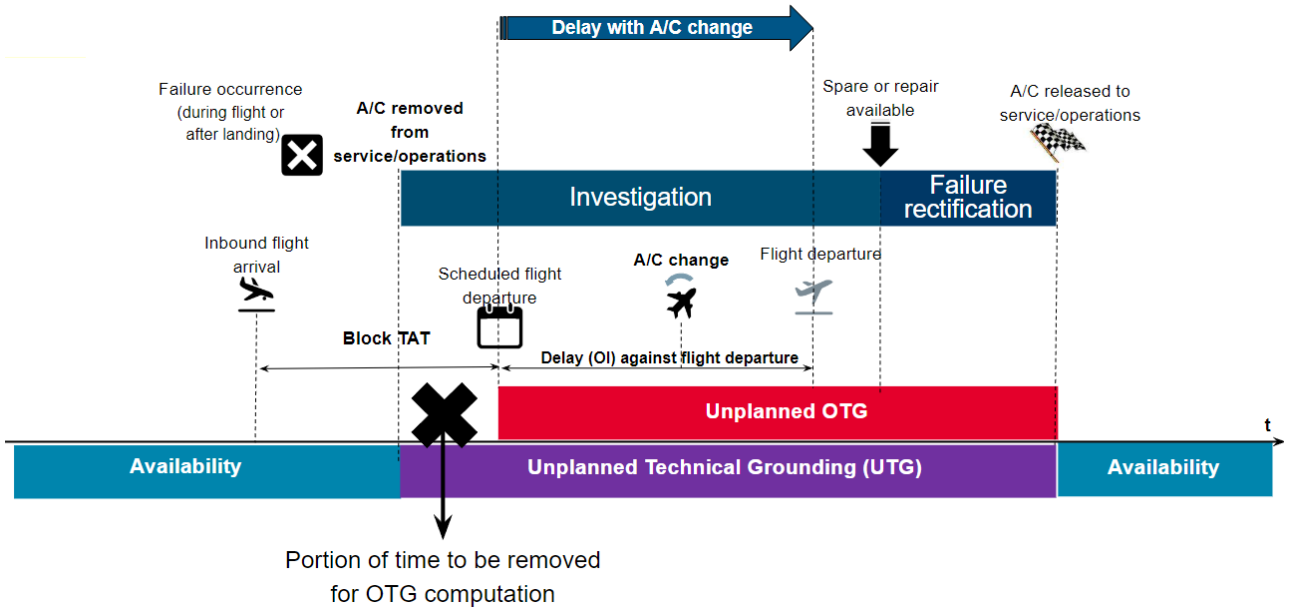

Figure 17 - Time to be removed for unplanned maintenance grounding time computation

The figure above is based on the delay with aircraft change example (applicable to all Unplanned cases).

For this situation, there is a need to correlate the unplanned maintenance record with additional information: Flight Schedule, which is now covered by the Spec 2000 Flight record.

Note: in the event the night stop starts before the release of the aircraft, the period between the night starting time and the aircraft release time is not counted in the OTG computation.

4. Focus on Operational Technical Grounding (OTG)

The Operational Technical Grounding (OTG) is the third level in the hierarchy of unavailabilities. It aims at measuring the unavailability of the aircraft for flights, i.e. from the point of view of the airline's operations. As a result, the operational technical availability measures the capability to declare an aircraft fit for service within airline operations.

The following statement sums up what Operational Technical Grounding includes:

Operational Technical Grounding covers both planned and unplanned maintenance activities for technical reasons that have a direct impact on aircraft operations. It includes factors that operators and aircraft manufacturers can measure and influence.

The key to the definition is to consider the Aircraft Availability from *Operations* point of view in the airline organization, hence the term Aircraft *Operational* Availability. It means that an aircraft is:

- Available when it is in hands of Operations for flights (whether in service or in standby)
- Unavailable when it is not in the hands of Operations for flights or when an event creates a disturbance to the Operations

Operational Technical Grounding is influenced by the following parameters:

- Maintenance:
  - A/C manufacturer and OEM maintenance (MPD, engine, modifications) and Operator specific maintenance (Specifics and Cabin) as part of the maintenance program, planning and packaging
  - M&E organization and strategy: make or buy policy, number of mechanics, management of planned and unplanned events, etc.

- Operations:
  - Network
  - Flight schedule, A/C stand-by time, night stop
  - Fleet size
  - A/C utilization

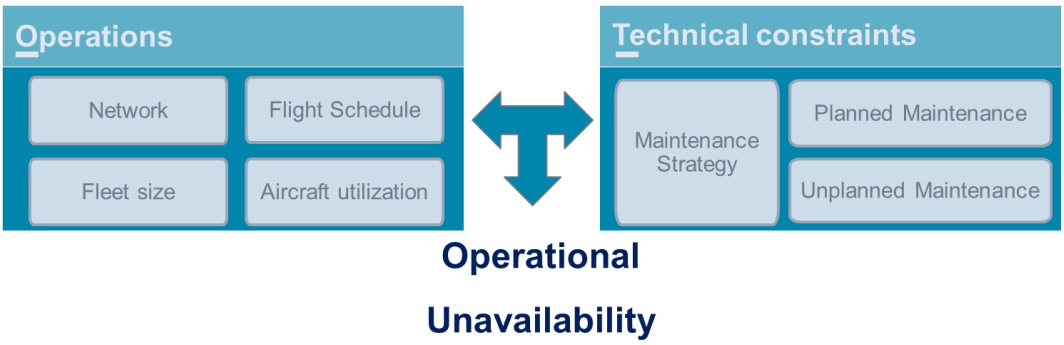

Figure 18 - Operations and Maintenance Implications

The combination of both maintenance and operations defines a specific context of the OTG measure.

Specific attention has to be given to the maintenance done during the aircraft stand-by time. (e.g. long transit or night stop). When the aircraft is removed from Operations and goes into the hands of Maintenance, the aircraft is unavailable. However, any maintenance done when the aircraft is in the hands of Operations, without impacting the Operations, is not counted in the OTG metric, as this maintenance does not impact the flight schedule.

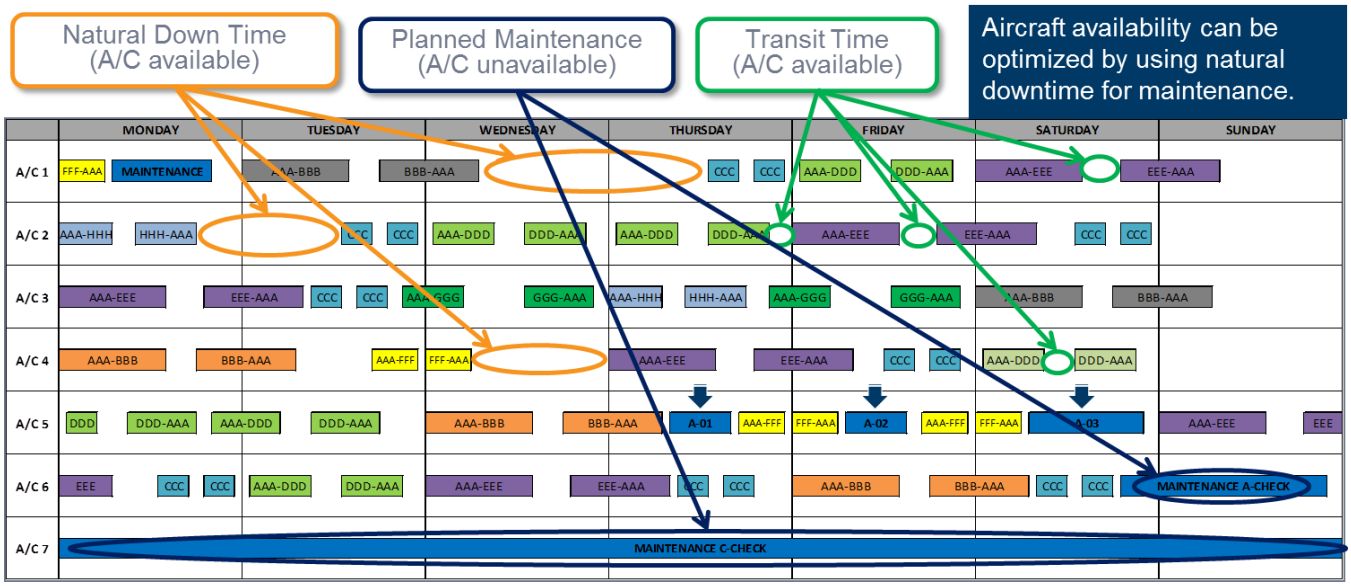

Figure 19 - Flight Schedule and Maintenance Implications

The measure of the OTG is linked to the operator context, making the comparison between operators complex in the case of different contexts (e.g. low-cost carrier with high utilization vs. legacy carrier with medium utilization).

Network Density

The Operational Technical Grounding is strongly influenced by the network density (when it relates to fleet mix, cabin configuration, aircraft utilization, crew duty time limitation, ground time between flights and network model – point to point, hub, etc.) and the operational strategy of the airline's network planning.

For aircraft operating in high density network, a delay to a scheduled service resulting from Technical or non-Technical contributor leads to a spate of delays across the network which are challenging to recover over the day of operation.

The availability of an operational spare aircraft or using the schedule to slide in a serviceable aircraft to operate the delayed service reduces the impact of the delays. However this is dependent on the airline's ability to switch aircraft, crews, passengers, catering within the short turn around or transit times typically associated with high density network operations.

Regarding the planned activities, a highly dense network will be more impacted by the planned maintenance as there are fewer opportunities to perform the maintenance transparently to the Operations (i.e. during the A/C stand-by time).

Accurately calculating and allocating the delay is complex given the multiple fast paced decisions to prevent operational delays from spreading across the network in a high-density environment.

Conversely, medium or low-density networks deliver the ability to reduce the unavailability by design of the network operations to include multiple switch points to replace unserviceable aircraft, or longer transit times for maintenance to attend to technical faults on unserviceable aircraft.

Optimization of maintenance programs resulting in task escalations and subsequent reduction in hangar slot requirements provides greater flexibility to network planning.

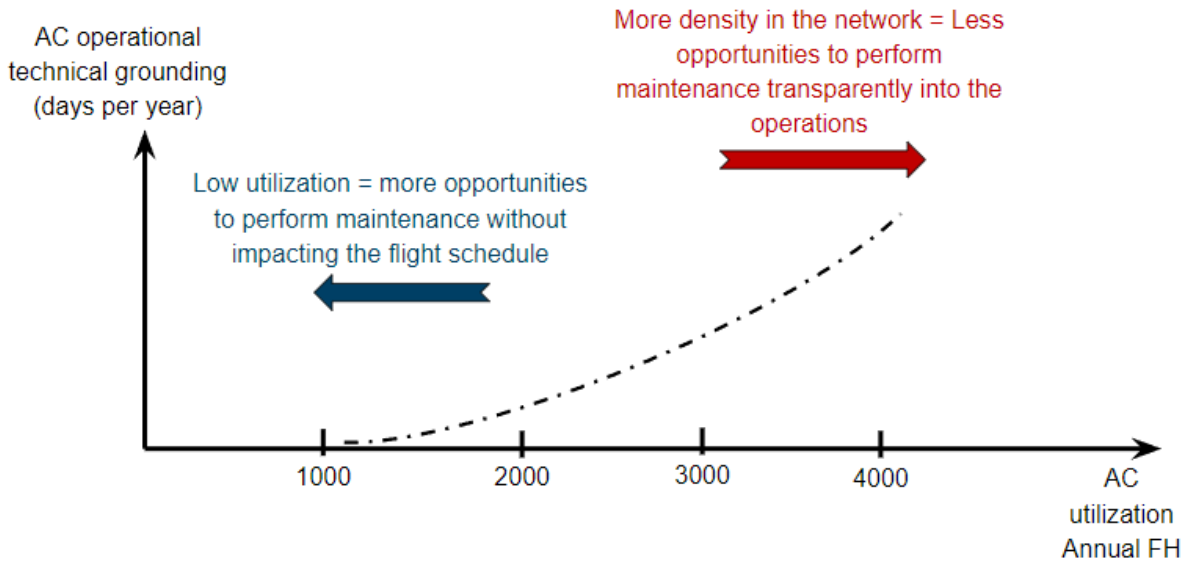

Figure 20 - Aircraft Unavailability vs Utilization

5. Key Performance Indicators

Key Performance Indicators can be defined for the Total Unavailability (TU), Technical Grounding (TG) and Operational Technical Grounding (OTG), or by the Spec 2000 Chapter 13-2-4.5 Availability Metrics.

These indicators complement the traditional Technical Dispatch Reliability or the Operational Reliability (OR) indicators. The OR A/C chargeable and the OR all chargeabilities (usually called On-Time Performance), as the Operational Interruptions (OI) are taken into account in the TG and OTG calculations.

The TG and OTG calculations are not based on the same approach as the OR calculation:

- OR
  - All OI events have the same weight whatever the severity (a delay of 15' or more has the same weight as a cancellation).
  - The scope is limited to the operational interruptions for technical reasons.
  - The A/C change without OI and the planned maintenance are not taken into account.

- TG or OTG
  - Each unavailability event has its own weight, which is the grounding time duration, allowing the identification of the contributors to the aircraft unavailability.
  - The scope is extended to the planned maintenance as well.
  - The A/C change without OI are taken into account.

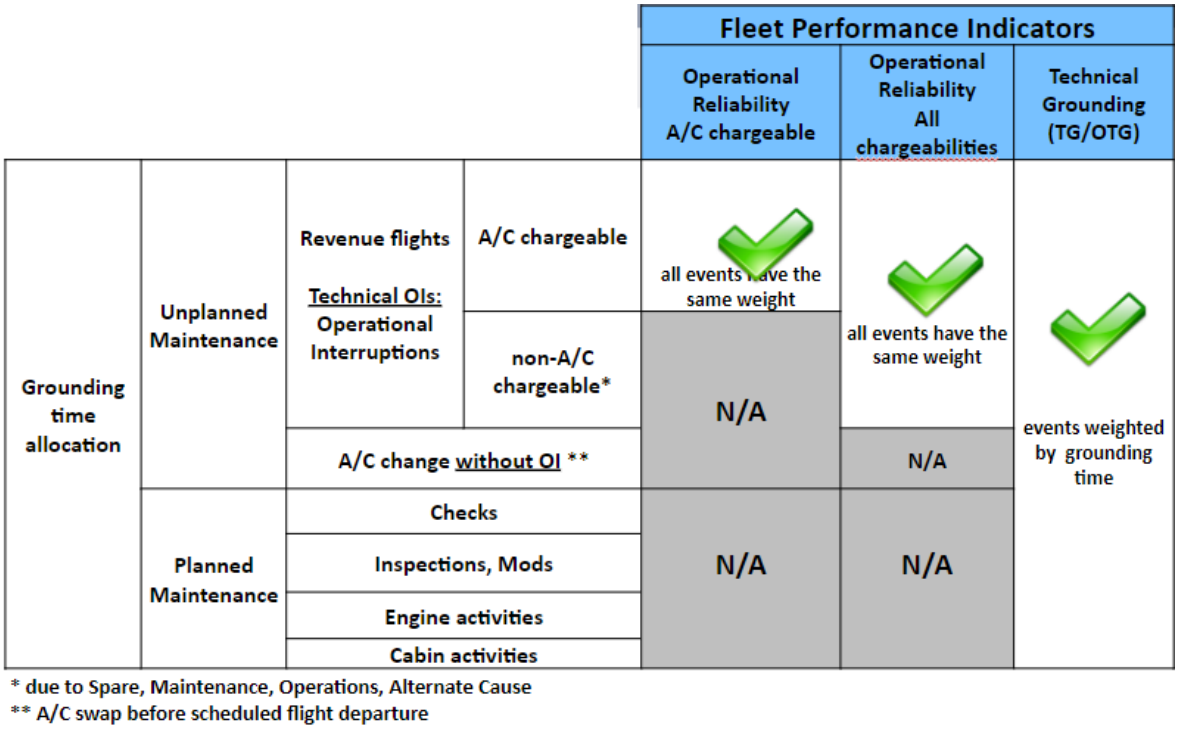

Figure 21 - Fleet Performance Indicator Coverage

The planned maintenance is cyclic according to the operator maintenance program choice (A-check, C-check, heavy check interval), cabin operator policy (refurbishment), A/C mods, A/C painting, etc.

The unplanned grounding evolves over time due the ageing effect.

An example of unavailability profile for an aircraft over a 12-year period is presented in Section 6.2.3.

Over a period of 12 years, the total grounding can be broken down into Planned/Unplanned and per sub-category (e.g. Light, Heavy, Engine, A/C mods, etc.). It allows the identification of the TG or OTG drivers. An example of grounding time breakdown is presented in Section 6.2.3.

Key performance indicators (KPIs) can be defined based on the TG or OTG metric: it is a number of days per unavailability category for the fleet, per tail number or per event and per year. The A/C age has to be taken into account in the KPI target due to the cyclic effect of the maintenance program (i.e. the base and heavy checks increase the A/C unavailability when they occur).

Examples of KPIs are provided hereafter. Other metrics can be defined to monitor the fleet performance according to the operator needs and categories.

KPIs at fleet level (monthly, yearly)

- Total number of days of technical unavailability
- Breakdown Planned Vs. Unplanned
- Number of days of Planned technical unavailability with details per sub-category: Light, Base, Heavy, …
- Number of days of Unplanned technical unavailability with details per sub-category: Delay, A/C change, Cancellation …
- Unavailability per Station, per type of Maintenance (Planned/Unplanned)
- Unavailability per sub-fleet according to utilization
- Unavailability per group of A/C (same age)
- % of Days due to Damage (Damage Indicator = Yes)
- Missing parts

KPIs at tail number level (monthly, yearly)

- Total number of days of technical unavailability
- Breakdown planned vs. unplanned
- Number of days of planned technical unavailability with details per sub-category: Light, Base, Heavy, etc.
- Number of days of unplanned technical unavailability with details per sub-category: delay, A/C change, cancellation, etc.
- % of days due to damage (damage indicator = Yes)
- Comparison of new vs old A/C; firsthand operator vs used (e.g. effect of similar configurations)

KPI at event level

- Grounding time per type of event (A-check, C-check, heavy check, etc.) and per station
- % of overrun per type of event, per station
- Unplanned technical grounding duration per type of event: Cancellation, A/C change, engine or component (APU) change, etc.

6. Best Practices: From Data to Metric

Once collected using the Spec 2000 records, the grounding times have to be allocated to "Planned" or "Unplanned" and then they have to be categorized according to the coding grid into the sub-categories (See Section 3.1). The grounding times can then be computed according to the TG or OTG rules (See Section 3.2). Finally, the OTG or TG can be used for the analysis and KPI monitoring.

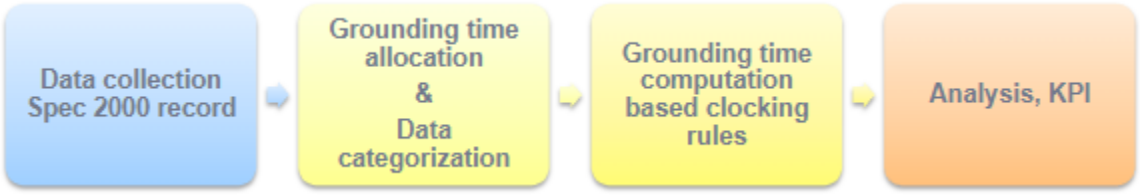

Figure 22 - Process for Unavailability Metric Computation

The steps "grounding time allocation", "categorization" and "computation" of this process may be done in parallel to ensure the consistency in the data treatment. The next sections provide airlines best practices applied for Data collection, KPI and analysis.

6.1. Data Collection & Exchange

The data collection has to enable the measure of unavailability times per aircraft covering any maintenance event, planned or unplanned, over time. The ATA Spec 2000 has defined the unavailability reporting in the Chapter 11–15 "Out of service" record. It gives the detailed definition of the type of information that needs to be produced by airlines in order to collect Unavailability data using a Spec 2000 format.

The Unplanned Technical Grounding reporting is also available in the Step 2000 Chapter 11-07 "Aircraft Event" record.

In the Spec 2000 version 2014, the following terms are defined:

- **Scheduled Out of Service:** number of days an aircraft is scheduled to be out of service for scheduled maintenance. This information is required for documenting work as specified in the Maintenance Planning Document.
- **Unscheduled Out of Service:** number of days that an aircraft is out of service due to unscheduled maintenance.
- **Planned Out of Service:** number of days that an aircraft is out of service due to planned maintenance such as recommended / mandatory service bulletins that do not fall into the category of scheduled maintenance.
- **Optional Out of Service:** number of days that an aircraft is out of service due to optional maintenance such as changing interior, paint, optional modifications, operator discretion. This field is for non MPD Items.

The figure below indicates the correspondence between the coding grid and the Spec 2000 version 2014 for the terminology.

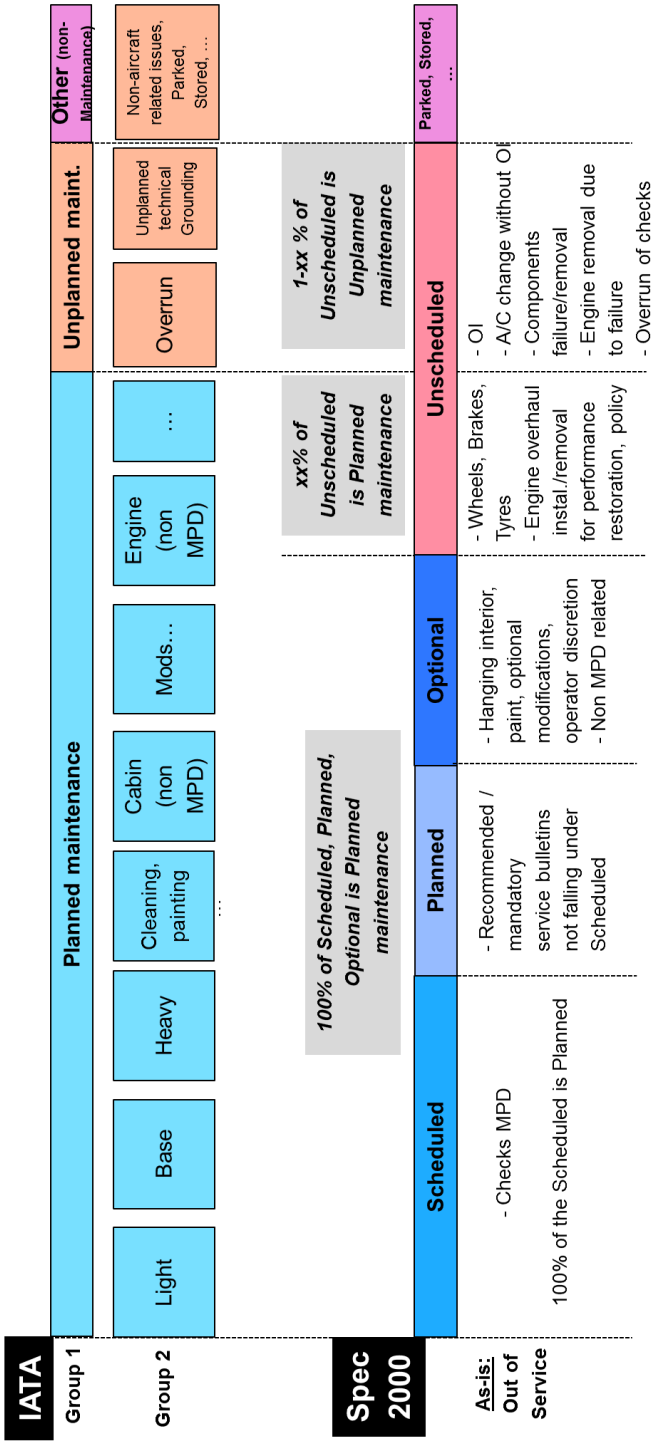

Figure 23 - IATA and Spec 2000 Terminologies and Correspondence

Evolutions of the Spec 2000 are under discussion to have the same terminology as the coding grid.

The data collection may require the use of specific exports from different systems in Maintenance and Operations organization to gather all the necessary information such as A/C registration, Event description, actual start date & time, actual end date & time, total maintenance downtime, etc.

The Spec 2000 XML records can be used to report the data.

Examples of planned and unplanned unavailability data collection used today by airlines are provided below.

Planned maintenance	Registration REG	Unavailability Station REP	Event start date ODD	Event start time OTM	Event end date MCC	Event end time TMT	Total Maintenance Downtime TMD (day)	Event description ART
Light maintenance	ABCDE	AAA	2021-01-24	08:00:00	2021-01-25	08:00:00	1	Check A04 + W0-A
Base maintenance	BCDEF	BBB	2021-03-04	21:30:00	2021-03-11	20:03:00	5,2	SCHED MX C2
Base maintenance (Base + other)	CDEFG	AAA	2021-02-12	05:00:00	2021-02-18	22:32:00	6,7	CHECK C1 + A09 + WO
Heavy check type	DEFGH	AAA	2021-05-01	03:00:00	2021-05-13	04:00:00	12	12Y check / Major
A/C external cleaning, painting	EDCBA	BBB	2021-10-22	07:00:00	2021-10-27	19:00:00	5,5	STRIP & PAINT //Other Maintenance Input
Cabin maintenance (non MPD)	FEDCB	BBB	2021-02-13	22:00:00	2021-02-14	07:30:00	1,4	Pax seat change
A/C Mods	GFEDC	BBB	2021-01-03	07:30:00	2021-01-05	01:00:00	1,7	MOD input / NLG SB works
A/C optional changes	ABCDE	AAA	2021-10-02	20:00:00	2021-10-02	10:25:00	0,6	optional SB
Engine maintenance (non MPD)	BCDEF	AAA	2021-03-22	03:00:00	2021-03-25	05:25:00	3,1	Engine change
A/C phase in/ phase out maintenance	DEFGH	BBB	2021-03-21	16:00:00	2021-03-22	04:30:00	1,5	Exit check / inspection

Figure 24 - Unavailability Data Collection – Planned Technical Grounding (Spec2000 Out of Service Record)

Unplanned technical events	Event Occurence Date IOD	Registration REG	Station from REP	Delay Indicator DLY	Delay Duration DTM	Total Maintenance Down Time TMD	Cancellation CNX	Aircraft changed SUB	In flight turn back ATB	Diversion DIV	Description DCT	Work performed MNT	ATA
Delay without A/C change	2021-03-11T15:30:00Z	ABCDE	AAA	TRUE	72	94	FALSE	FALSE	FALSE	FALSE	APU BLEED FAULT DURING START	APU BLEED VLV FAULT DISPATCH MEL xx-yy-zz	36
Cancellation	2021-03-05T08:32:00Z	ABCDE	BBB	FALSE		459	TRUE	FALSE	FALSE	FALSE	P1 SIDE ND MAP NOT AVAIL	REFERENCE DOSSIER 80xxxxx/003, TSM TASK xxx FOLLOWED ,FCU (2CA) REPLACED.POST INSTALLATION AFS OPS TEST CARRIED OUT IAW AMM xxx ,FOUND OK ,LAND CAT 3 CAPABILITY TEST CARRIED OUT IAW AMM xxx FOUND OK ,BOTH PFD & ND PARAMETER FOUND SATISFACTORY ,ECAM STATUS NORMAL .	22
A/C change without OI	2021-03-18T16:05:00Z	ABCDE	CCC	FALSE		948	FALSE	TRUE	FALSE	FALSE	ENG#1 N2 HIGH VIB,ECAM ALERT DURING INITIAL CLIMB (1000FT+ABOVE) VIB UNIT 6.0	TSM xxx AND TC19 OF 2020 REV01 FOLLOWED. PFR,PLR,REPORT 75 REVIEWED,FAULT CONFIRMED ON ENG#1 N2 VIB OF 6.0 CU FOR 48SEC. ENG#1 FADEC CH A&B SYSTEM TEST,GROUND SCAN AND SMR REPORT CHECKED,FOUND OK. IAW TSM GVI OF ENG#1 INLET & EXHAUST AREA CARRIED OUT IAW AMM TASK REFxxxA.FOUND SATISFACTORY.ENGINE EXTERNAL HARDWARE INSPECTION CARRIED OUT IAW AMM	72
Delay with A/C change	2021-03-03T11:50:00Z	ABCDE	AAA	TRUE	105	195	FALSE	TRUE	FALSE	FALSE	BIRD STRIKE ON SLAT N3 LEFT WING	DENT DIMENSION 8 IN WIDE 2.5 IN HIGH AND 0.040 IN DEEP DENT DEMAGE INSIDE THE LIMIT AS PER SRM xxxREV NOV 01 1018 MCC INFORMED Techlog Page 807832 Workorder Number NA MEL Ref NA	57
Diversion	25/03/2021 2021-03-25T14:12:00Z	ABCDE	BBB	TRUE	110	205	FALSE	FALSE	FALSE	TRUE	FLIGHT DIVERTED TO AAA DUE TO BOTH CENTER WING TANK PUMPS FAILS.	FUEL TANK PUMPS REPLACED	28
Delay due to Overrun of planned event	2021-03-21T07:28:00Z	ABCDE	CCC	TRUE	57	175	FALSE	FALSE	FALSE	FALSE	Late release. ENG1/ENG2 INNER/OUTER NOZZLE SEALS		78

Figure 25 - Unavailability data collection – Unplanned Technical Grounding (Spec2000 Aircraft Event Record)

Alternatively, other means such as an excel file can be used providing the mandatory attributes are given.

Aircraft registration	Unavailability event type	Event start date	Event start time	Event end date	Event end time	Event duration	Planned, event detail	Unplanned, event detail	Unplanned events associated ATA chapter	Technical unavailability origin	Event description	Unplanned events corrective action description
	Planned Unplanned						Light check Intermediate check Higher check Cabin Painting Modification package Defect correction	A/C change Cancellation Delay		Aircraft defect Operations Other		

Figure 26 - Simplified Template for Unavailability Data Collection

6.2. KPI Best Practices

Today some operators and manufacturers have implemented KPIs to monitor the unavailability time due to maintenance, to understand the impact of the various maintenance categories on the total grounding time along the aircraft life, and to identify the technical drivers of the aircraft unavailability.

The purpose of this paragraph is to present real examples of unavailability KPIs, already in use or in construction, and the analysis done with. These KPIs were developed in order to define, to implement and to automatize a standardized and unambiguous suite of metrics allowing to:

- Quantify the time an aircraft is not available for the operation due to the maintenance (planned or unplanned) on the airframe or the engines and the associated effort / cost on the aircraft
- Identify the root causes
- Prioritize and develop solutions
- Quantify the benefits of those solutions and project the impact on the availability of the aircraft and on the maintenance workload
- Predict future trends of service reliability
- Compare with objectives

6.2.1 Unplanned Technical Grounding (UTG)

A certain number of airlines, with various profiles, already use the UTG to track the grounding of an aircraft type as follows:

Definition

- According to the definition of UTG in Section 2.1, the UTG covers the time an aircraft is on ground due to unplanned maintenance either linked to an Operational Interruption or due to a technical event leading to an aircraft change.
- The UTG is used per airframe type and / or engine constellation.
- UTG unit: in days (as the sum of minutes, hours and days) over a period and per aircraft
- Period of computation: annually

Purpose

The UTG is meant to represent the unplanned time on ground for technical reasons. In addition or in substitution to the Technical Dispatch Reliability (TDR) or the Operational Reliability (OR), which are both gathered by the UTG. The UTG allows to identify the technical issues having a significant impact on the operation and on costs.

Boundary conditions

- The UTG applies to the entire fleet, minus those aircraft parked / stored.
- Unplanned Maintenance is as per the definition in Section 2.1.
- Maintenance or inspection activities, other than those causing the UTG, may be performed during same grounding time but should not increase time on ground.

Calculations

$$UTG = \frac{aircraft\ time\ on\ ground\ due\ to\ unplanned\ maintenance\ (in\ days\ over\ a\ period)}{number\ of\ aircraft}$$

Example: 5 days / year / aircraft over a 12 year-period.

Examples of analysis

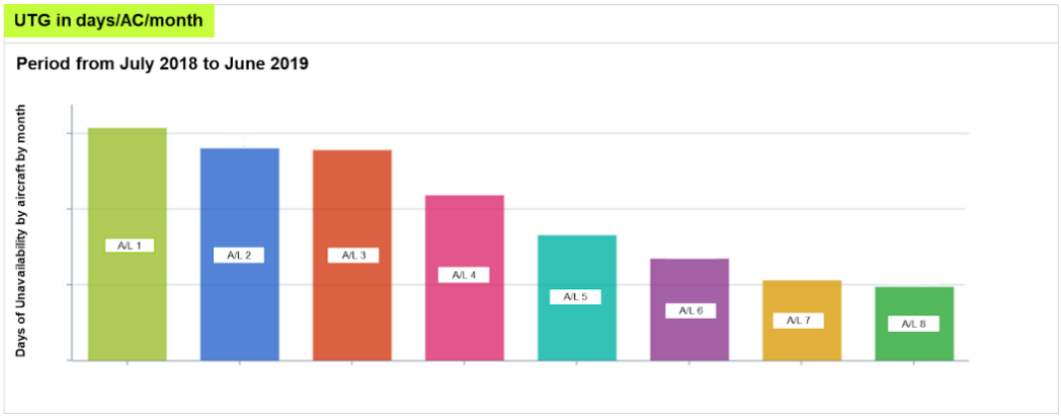

Figure 27 - Example of Unplanned Technical Grounding by Fleet

The above figure shows the UTG for several sub-fleets, for a selected period. The sub-fleet selection should be done through appropriate parameters (same age, same utilization, etc.).

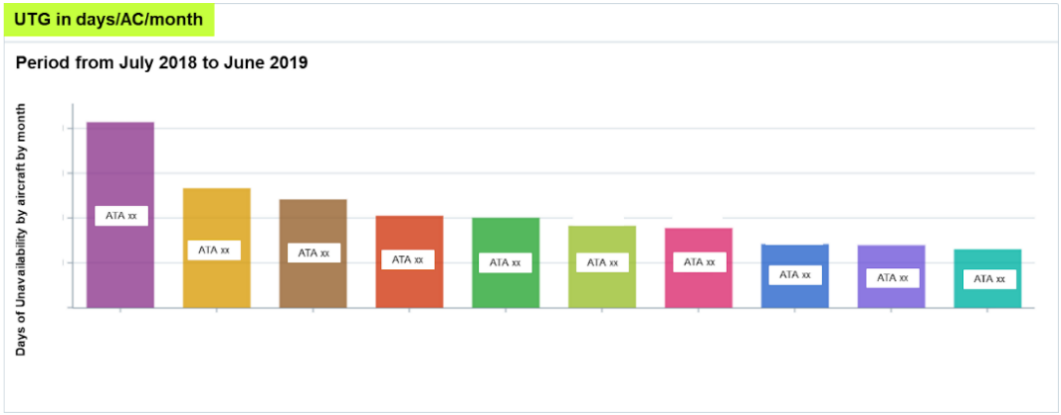

Figure 28 - Example of Unplanned Technical Grounding by ATA Chapter

The above figure provides the UTG distribution by ATA chapters on a given fleet. It allows the identification of the main technical contributors driving the unplanned unavailability.

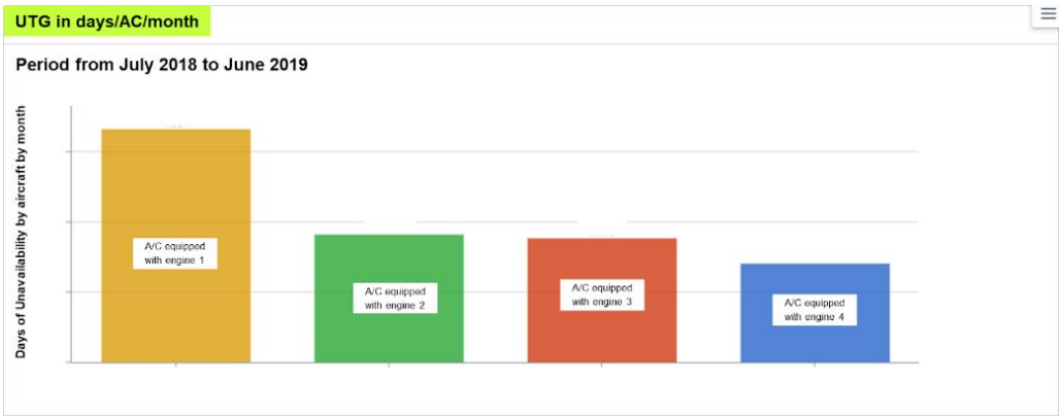

Figure 29 - Example of Unplanned Technical Grounding by Engine Type

The above figure provides the UTG by Engine type on a given fleet. This clearly identify the contribution of the engines or the power plant system to the UTG.

6.2.2 Severity of Unplanned Technical Grounding (UTG SI) - KPI under construction

The need of such KPI appeared when operated wanted to track technical events having a significant impact on unplanned grounding. This KPI is comparable to the Operational Reliability Severity Index and is developed for similar purposes.

Definition

- The UTG SI is the Severity Index (SI) evaluating the impact of an UTG on operational and economic performance by weighting the type and extent of their consequences from airlines operations perspective.
- The UTG SI is based on UTG data.
- The UTG SI is a per-event index to be generated for each aircraft type or airframe/engine constellation.
- Unit: index only (weighted Event/Event), no unit.
- This index requires the definition of the weighted factors such as:

Type of grounding	SI Factor
UTG with swap with an aircraft not from the fleet	xx
UTG in outstation	x
UTG with swap with an aircraft of the fleet	x
UTG with workload > 12 MH	x
UTG due to a severe event : IFTB, DIV	x
UTG due to a severe event : DY> 2h, CN	x
UTG due to a delay < 2h	x

Additional or different weighted factors could be taken into account, by example an UTG of an aircraft in ETOPS operation, or the Autoland capability. It is important at the end to define a common list of factors (not to long) and

weight. The difference in the weight of the most constraining event compared to the less one should reflect the economic gap between the two types of events.

Purpose

- The UTG SI should be used in conjunction with the UTG to identify the severe events.
- Target: reduction of UTG per severe event and the severity of all events, in particular as a main driver for cost.

Boundary Conditions

- As per the UTG

Calculation

$$\boldsymbol{UTG\ SI} = \sum \frac{UTG\ events\ on\ a\ period\ \times individual\ SI\ factor}{Qty.of\ UTG\ events\ on\ the\ same\ period}$$

6.2.3 Technical Grounding (TG)

The TG encompasses the aircraft grounding time due to Planned Maintenance (Planned Technical Grounding PTG) and due to the Unplanned Maintenance (Unplanned Technical Grounding UTG). This is the measurement of the unavailability of the aircraft to the operation for maintenance. It is particularly useful to identify room for improvement in the aircraft availability, to assess the efficiency of the maintenance strategy but also to optimize the number of aircraft needed to operate a network.

Definition

- According to the definition of the TG in Section 2.1, the TG covers the time an aircraft is on ground due to Planned and Unplanned Maintenance.
- The TG is used per airframe type and / or engine constellation.
- TG unit: in days (as the sum of minutes, hours and days) over a period and per aircraft.
- Period of computation: annually.
- Generally operators exclude from their TG metric the planned and unplanned line maintenance having no impact on the operations. They preferably monitor the cost of the workload instead, through a maintenance cost KPI: the LMW (see below).

Purpose

The TG is meant to represent the time an aircraft in on ground for maintenance and so not available for the operation.

Boundary conditions

- The TG applies to the entire fleet, minus those aircraft parked / stored.
- Planned and Unplanned Maintenance are as per the definition in Section 2.1.

Calculation

$$TG = \frac{aircraft\ time\ on\ ground\ due\ to\ maintenance\ (in\ days\ per\ year)\ over\ a\ period}{number\ of\ aircraft\ in\ the\ same\ period}$$

Example: 9 days / year / aircraft over a 12 year-period (average Aircraft unavailability due to maintenance for a time window of 12 years).

Examples of TG analysis

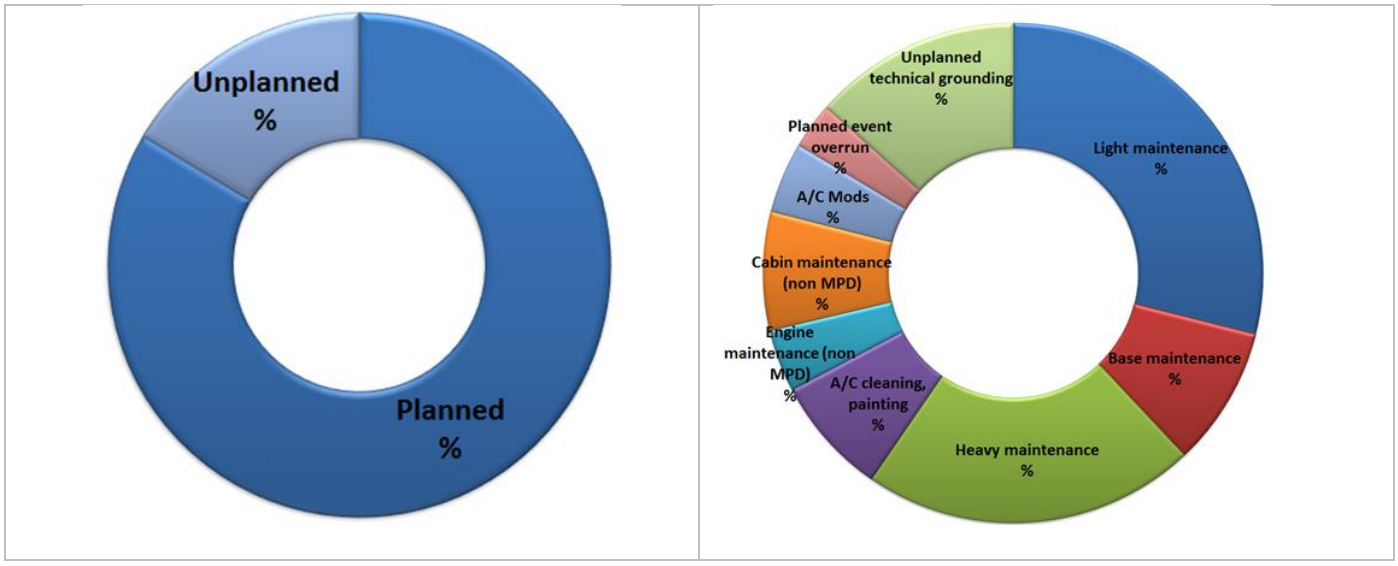

Figure 30 - Example of Technical Grounding (TG) - Time Breakdown: Planned/Unplanned and by Sub-Categories

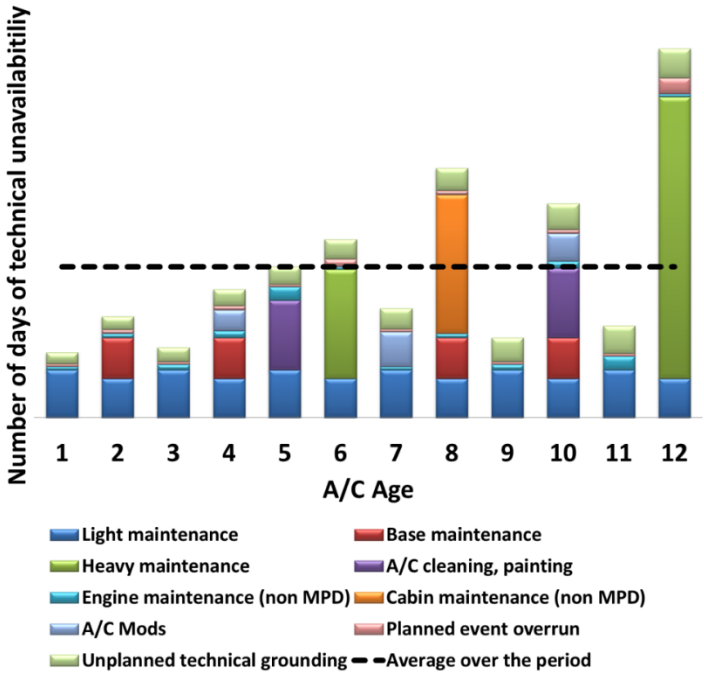

Figure 31 - Example of TG Profile for an Aircraft over a 12-Year Period

Over a period of 12 years, the total grounding is broken down into Planned/Unplanned categories (e.g. Light, Heavy, Engine, A/C mods, etc.). The figure provides the grounding time (in days) per type of maintenance, allowing the identification of the TG (or OTG) drivers and their evolution over the Aircraft life (cyclic maintenance, impact of aircraft age, etc.).

6.2.4 Line Maintenance Workload (LMW) - Connex KPIs contributing to the aircraft availability

Most of the operators having implemented the KPIs UTG or TG would like to follow the fleet performance in line maintenance. In this case the drive in more the workload needed to maintain the aircraft in line (and the associated costs). This is a Product Maturity oriented KPI.

Definition

- Man-hours (MHs) spend on aircraft in line to maintain it in commercial and airworthy conditions.
- Based on Line-Maintenance MHs: maintenance tasks lower than first light check (e.g.: 1,200FH).
- It is an index of man-hours spent for planned and unplanned maintenance activity per aircraft/engine (fleet average) vs. specified maintenance workload (where applicable) or industry average (reference airframe/engine constellations).
  In measuring the LMW vs. expectations, this allows to identify the additional burden spent on line maintenance, the LMB.
- It is indirectly a per-aircraft/-engine index to be generated for each aircraft type or airframe/engine constellation.
- Unit: index only (spent man-hours / ref. man-hours), no unit.

Purpose

- Capacity-view only: degree of manpower necessary to keep fleet operable during daily business (planned and unplanned).
- Material cost would change picture plus bearing CLP and escalation dependency.
- **Note:** the LMB is expected to decrease after Entry Into Service/teething issues to reach LMW and may increase again for mid-life technical issues.

Boundary Conditions

- No differentiation between inspection and maintenance work since man-hour capacity doesn't differ.
- Actual hours as per signed-off job-cards apply (planned hours only in case actual hours are not specified).
- Only man hours covering the originating cause plus concurrent requirements (incl. testing, MCF, etc.) shall count.
- No material cost regarded.

Calculation

$$\boldsymbol{LMB} = \frac{\frac{\sum Line\ maintenance\ man\ hours}{Qty\ of\ airacraft\ in\ operation}}{Number\ of\ reference\ Line\ Maintenance\ hours}$$

6.2.5 Unplanned Engine Removals (UER) - Connex KPIs contributing to the aircraft availability

Developed by one major European airlines group, this KPI addresses engine technical issues directly influencing the aircraft availability.

Definition

- Unplanned removals non-related to maintenance schedule
- No fix on-wing possible but requiring shop induction
- Includes engines under watch for deteriorating conditions
- Unit: index only (Qty. events per Qty. engines), no unit

Purpose

- Engine removal corresponds with shop induction:
  - reveals quantity of shop visits per engine per life cycle,
  - indicates volume of lost life / stub life,
  - indicates on-wing robustness of engine.
- Quantity only - type and volume of shop visits not regarded.
- **Note:** UER is expected to decrease after Entry Into Service/teething issues and may increase again for mid-life technical issues.

Boundary Conditions

- Event counts as UER even if full performance restauration (originally due soon thereafter) results on top of removal reason.
- Necessary and recommended SBs with incorporation prior to next scheduled shop visit as well as inspection results, fatigue and damage drive unplanned removals.
- Independent from any authority advice (but may still apply).

Calculation

$$\boldsymbol{UER} = \frac{\sum Unplanned\ Engine\ removals}{2\ \times Quantity\ of\ aircraft\ in\ operation}$$

6.2.6 Build Status Shortfall Volume (SV) – Engine only - Connex KPIs contributing to the aircraft availability

Developed by a major European airline group, this KPI applies to engine, however the principle could be extended to the entire aircraft. This is a product maturity oriented KPI.

Definition

- Per engine: weighted sum of Service Bulletins not installed
- Per fleet/type: average weighted sum of Service Bulletins not installed
- Weighing factor determined through severity of potential thread to operational reliability
- Unit: index only, no unit

Purpose

- Degree of (engine) build status generally corresponds with operational reliability: the more SBs installed, the less likely operational disruptions.
- Shortfall value translates into (engine) product maturity status.
- Outlook: SV shall be used to translate into virtual UTG (VUTG) to predict operational trends.

Boundary Conditions

- SB consideration independent from any classification or authority advice (but may still apply).
- Actual SB does not need to be published yet, but technical problem needs to be known and ops impact may apply.
- Weighting-factor definition:
  - 0 = no ops impact;
  - 1 = slight ops impact (e.g. rare inspections);
  - 5 = significant ops impact (e.g. frequent inspections, increased maintenance burden, risk of delays, cancelations, etc.);
  - 10 = inherent risk for AOG, In Flight Shut Down, Aborted take-off, etc.
- Industry reference: SV ≈ 15 for mature engine types.

Calculation

$$\boldsymbol{SV} = \frac{\sum each\ missing\ SB\ \times specific\ weighting\ factor}{Quantity\ of\ engines\ (fleet\ or\ subfleet)}$$

6.2.7 LLP Life Expectation (LE) Engine - Connex KPIs contributing to the aircraft availability

Developed by one major European airlines group, this KPI applies to engine (but the principle could be extended to other aircraft equipment). This is a product maturity oriented KPI.

Definition: LE

- Per LLP part: life expectation of installed part vs. specified ultimate life expectation for same part
- Per engine type: average life expectation of all LLPs installed
- Unit: %

Purpose

- Degree of actual LLP life expectation vs. specified ultimate LLP life expectation
- Indicator to determine expected quantity of shop visits / runs during life cycle

Boundary Conditions

- Each LLP is considered of equal priority.
- LLP part number installed on (at least majority of) fleet to be taken for calculation.
- Specified ultimate LLP life limit to be taken as reference value against actual LLP life limit values.

- Specified ultimate life according to public documentation (e.g. all-customer meeting - or technical-review documentation).

Calculation

$$\boldsymbol{LEp} = \frac{actual\ life\ limit\ (cycles)}{specified\ ultimate\ life\ limit\ (cycles)}$$

$$\boldsymbol{LE} = \frac{\sum \frac{actual\ life\ limit\ (cycles)}{specified\ ultimate\ life\ limit\ (cycles)}}{Quantity\ of\ LLP\ part\ numbers}$$

7. Shortfalls

The Technical Grounding (TG) and Operational Technical Grounding (OTG) are indicators which complement the existing KPI such as the TDR or the OR. The OTG encompasses all the planned and unplanned maintenance and assesses the performance of the M&E vs. the Operator's choice (maintenance program, make or buy policy, organization, etc.). As for any other KPI, the TG and OTG KPI have some shortfalls:

- The OTG is a measure which takes the Operations point of view, meaning that any maintenance done during the A/C stand-by time is not taken into the unavailability KPI. In other words, the OTG is not a measure of the maintenance demand. The maintenance "absorbed" into the A/C natural downtime is not seen in the metric. To measure all the maintenance, the same data can be used without exclusion rules for the grounding time computation. In this case, the metric is the Technical Grounding (TG) (2nd level of unavailability in the hierarchy of unavailability).

- When performing some maintenance in the stand-by time, the A/C is in the operating time as per definition. However, in practice at that moment, the A/C is actually not fit for flight (with no impact on the flight schedule) and therefore cannot be used by the Operations as a spare A/C. As we work using past data, we are not in position to know this Operations needs afterwards.

- The comparison of the OTG performance between different operators is not straightforward as the OTG is linked to the operator context: M&E organization, maintenance choice and the Operations (flight schedule). However the data can be managed in a way to align the Operator contexts to have more comparable data (i.e. use the same night stop for short range operation in Europe).

- The TG metric is more suitable for comparison.

- When assessing a gain of availability, thanks to unavailability reduction, the notion of "usability" has to be introduced. Some of the gains can be used by the Operations, depending on the network, some of the gains cannot be used as they are too short. For instance, a gain of 2 hours may not be sufficient for the Operations to perform a revenue flight. Similarly, in case the A/C is released earlier from a check, if the information comes too late to the Operations, the A/C will be available for the Operations, but not used.

- The categorization of the records has some limits: several maintenance activities are most of the time done in parallel during a check. However the categorization assigns only one category for the main reason for grounding. For instance: C-check + partial Cabin refurbishment + Engine change are categorized as "Planned" and "Base maintenance". The partial cabin refurbishment and engine change are hidden in the main event. Additional categories can be used to fine-tune the classification.

- Airlines will need to integrate the new unavailability codes via software upgrades (when not already available) into the network operations systems to facilitate automated monitoring and reporting, based on industry standards (the ATA Spec2000 provides all necessary record definitions) and the rules defined in this document

8. Identified Topics to be Addressed in the Future

This document attempts at defining and measuring Aircraft Availability. It is not exhaustive yet, and we do not provide the answers to all the questions.

We have identified situations and issues that will be addressed in future versions of this paper.

- A critical element of unavailability is the distinction between planned and unplanned. Aircraft unavailability resulting from planned events has a different operational impact than when an unplanned event occurs. Usually the latter will result in significant impact to customers.
  A range of typical figures for the maintenance pre-notification time (1 to 3 days) is provided in this document (please refer to section 2.1 Definitions – Unplanned Maintenance), but can a standard time be defined?

- After a period of aircraft storage, some maintenance tasks are required before return to service.
  How should it be categorized? Is it part of the storage time, or part of the planned technical grounding?

- When computing the Operational Technical Grounding (OTG), meaning the technical grounding with impact on the Operations, the notion of operational day is taken into account. But the definition of the operational day differs depending on the region, on the type of operation (short/long range), on the airport constraint …

- The aircraft is about to be released to operations and an Airworthiness Directive (AD) comes in, effective immediately.
  How should it be categorized? Planned or unplanned?
  How to define the "operational impact"? How to address it?
  This is an exceptional situation. In principle, an AD is categorized as planned.

- An example of KPI measuring the severity of the Unplanned Technical Grounding (UTG SI) is described in the Section 6.2 of the document. This KPI evaluates the impact of an UTG by weighting the type of event and the consequence. A preliminary list of weighted factors is suggested. It is important at the end to define a common list of factors (not too long) and weight

- Improve the OTG computation for the Unplanned Maintenance by correlating the OOS and Aircraft Event records and the Flight record in order to keep only the portion of maintenance which impact the Operations.

We encourage readers to contact us and give their feedback and suggestions on how to address these issues at mctg@iata.org.

9. Glossary

A/C = Aircraft

AOG = Aircraft on Ground

CN = Cancellation

CRS = Certificate of Release to Service

DY = Delay

DV = Diversion

FOD = Foreign Object Damage

IFTB = In-Flight Turn Back

KPI = Key Performance Indicator

LLP = Life Limited Part

M&E = Maintenance & Engineering

MIS = Maintenance Information System

MPD = Maintenance Planning Document

OA = Operational Availability

OTG = Operational Technical Grounding

OI = Operational Interruption

OR = Operational Reliability

Operational Reliability is the percentage of revenue departures that do not incur a primary technical delay, primary technical cancellation, diversion or air turn back.

OR = 100 – ((Nb of chargeable interruptions during a computation period / Nb of Revenue Flights during the computation period) x 100)

OR = 100 – ((DY + CN + IFTB + DV) / TO rev) × 100

OR A/C chargeable considers the OIs that are A/C chargeable only.

OR all chargeabilities considers all the OIs that are A/C chargeable and non-A/C chargeable (commonly called On-Time Performance by operators).

PTG = Planned Technical Grounding

SB = Service Bulletin

TDR = Technical Dispatch Reliability

TG = Technical Grounding

TO rev = Revenue Take-off

TU = Total Unavailability

UTG = Unplanned Technical Grounding

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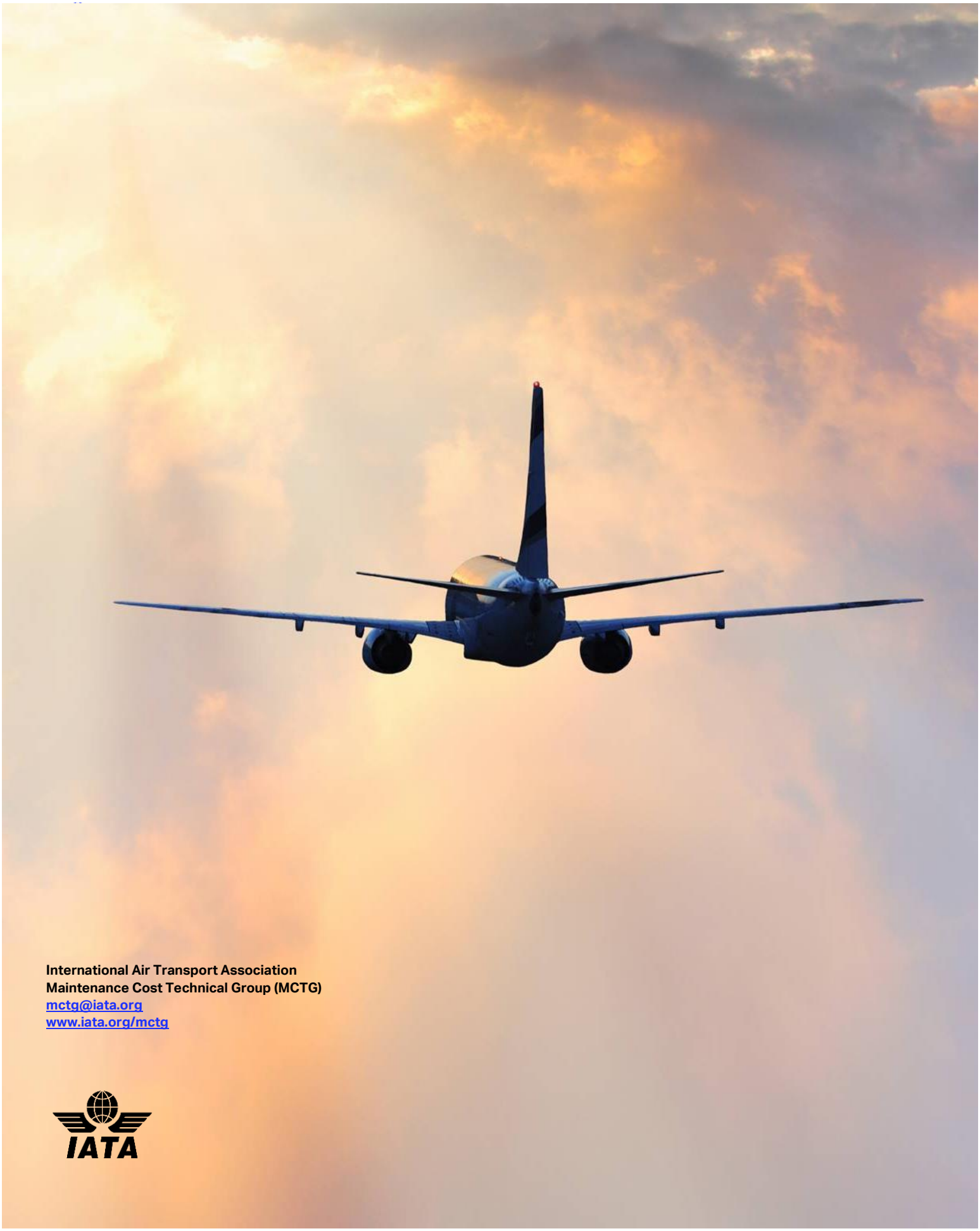

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