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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 Out of Service record. 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 Operational Reliability metric. 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: Maintenance Unavailability (MU)** counts all the aircraft grounding due the maintenance. The Maintenance Unavailability time 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 Unavailability (OU)** counts all the aircraft grounding due the maintenance taking the Operations point of view, only the maintenance grounding which impact the airline 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 aircraft natural downtime (long transit or night stop) is transparent for the Operations, and therefore is not taken into account in the metric.

As a result, the Operational Unavailability 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.
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Section 1—Introduction

Working in aircraft maintenance is a difficult task. We deal with complex machines, spend a lot of money and people are satisfied with our work when we are “invisible”. But how do we measure “invisibility”. For decades 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. 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 the 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 behaviour of their products, based on in-service aircraft data.

And for the sake of completeness, we even get a measurement for “invisibility”.

This paper has been co-authored by members of IATA’s Maintenance Cost Task Force (MCTF), airlines and aircraft manufacturers, as a first version, in coordination with the ATA Spec 2000 Reliability group. We strongly encourage you to contact the MCTF (MCTF@iata.org) and share your feedback for the next revision.

This paper is intended for airline personnel 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.
Section 2—Hierarchy of Unavailabilities

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

**Figure 1.** Aircraft Availability scope

### Aircraft Operating Time

Starting from the total aircraft time, the “aircraft operating time” is the 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 unboarding 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 (whenever they exist) are considered as aircraft operating time since the aircraft is again fit for flying but cannot fly due to airport constraints.

Once available in the hands of the Operations, an aircraft is not necessarily used for flights, this is the case of a spare aircraft.

Therefore an aircraft can be “available and used for flight” or “available and not used for flight”, it is up to the Operations to use it or not according to its network and constraints.

### Aircraft Non-Operating Time

The “aircraft non-operating time” includes all planned and unplanned maintenance for technical or non-technical reasons. As the measure focuses on the reasons which can be influenced by the operators and the aircraft manufacturers, all non-technical causes are part of the group called “Other (non-maintenance)”.

Planned maintenance includes the tasks from the airline maintenance program (routine and non-routine), cabin reconfiguration/refurbishment, painting, modification packages, engine and phase-in/phase-out activities.

Unplanned maintenance includes maintenance resulting from Operational Interruptions (OI), aircraft changes without OI, and late releases from maintenance (i.e. check overrun). The unplanned unavailability periods are included in the aircraft non-operating time as the sum of delay, aircraft change, diversion, in-flight turn back times and late release.

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

\[
\text{Availability time} = \text{Total time} - \text{Unavailability time}
\]

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 units.

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 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 such as passenger-related issues, crew delays, weather or air traffic control problems). There is no exclusion rule, all the grounding times are kept for computation.

- **Level 2: Maintenance Unavailability (MU)** counts all the aircraft grounding due the maintenance. The Maintenance Unavailability time 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. There is no exclusion rule, all the grounding times are kept for computation.

- **Level 3: Operational Unavailability (OU)** counts all the aircraft grounding due the maintenance taking the Operations point of view, only the maintenance grounding which impact the airline 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.
maintenance done during the stand-by time natural downtime (long transit or night stop) is transparent for the Operations as they do not need the aircraft, and therefore is not taken into account in the Unavailability metric (i.e. using exclusion rules)

As a result, the Operational Unavailability performance 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.

This leads to the definition of an Operational Unavailability indicator, which aims at measuring the unavailability of the aircraft for flights, i.e. from the point of view of the airline's operations.

The indicator is called the “Operational Availability” and it measures the capability to declare an aircraft fit for service within Airline Operations. The following statement sums up what Operational Unavailability includes:

**Operational Unavailability 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 of 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 be used
- unavailable when it is not in the hands of Operations for flights or when an event creates a disturbance to the Operations
Section 3—Coding & Clocking Rules

3.1 Coding

3.1.1 Main Categories

The aircraft grounding events are collected using the Spec 2000 Out of Service records, in which the records are then categorized to compute the Unavailability metrics.

The categories of coding have be 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)”.

For the maintenance events, 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.

The Planned maintenance covers any activity that can be anticipated (some time) in advance by the M&E organization, from few hours to several days, depending on the organization for checks, deferred items, etc. It includes any maintenance activities that is planned by the Airline maintenance organisation to be performed during available maintenance slots (transit, night stops, checks, SB, mods, Cabin refurbishment, etc.).

It includes, for example, all work related to Operator Maintenance Planning (MPD + Cabin tasks + Specifics), SB, Mods, Cabin refurbishment and its associated defects & rectifications, engine & APU shop visits, overhauls, predictable removals such as wheels-brakes-tires and deferred items.

The Unplanned maintenance covers any activity that cannot be planned/anticipated by the organization, and needs to be managed at time of occurrence, such as overrun of a planned event, delay, A/C change, etc.
The *Other (non-maintenance)* category covers the grounding when the aircraft is not available for activities not related to maintenance.

Examples: Diversion due to medical issue, weather issues, ATC, Family day, etc.

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 Sub-Categories](image)
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 into 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 out of checks, the following sub-categories can be used to classify the specific grounding:

**A/C external cleaning, painting**

A/C external cleaning, 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 programme or cabin mods).
Ex: Cabin refurbishment, upgrade cabin (Premium economy, Business, etc), specific grounding for cabin maintenance program

A/C Mods
A/C Mods is used for specific A/C grounding to inspect, modify or fix an issue (Inspection SB, Modification SB) 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.

E.g.: 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, etc

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

As a general rule, in case of several activities performed in parallel during the same event, the category retained is the main reason for grounding. This is due to the fact that the unavailability measures with one value that consequences of several activities done in parallel.

For instance, in case of C-check + Engine removal, the A/C was in maintenance due to the C-check interval limit, and the operator took the opportunity to remove the engine. The categories are: “Planned” and “Base maintenance” due to the C-check. The engine activity is therefore hidden in the Base maintenance.

Also, additional rules can be defined to avoid any interpretation in the categorization.

3.1.3 Unplanned Maintenance Sub-Categories

The Unplanned reason covers the events which create a disruption to the Operations. They are categorized into two groups: the Unplanned Technical Grounding and the Overrun of planned event.
Unplanned Technical Grounding (UTG):
The UTG are composed of events can be either Operational Interruptional (OI) related or non-OI related.

The OIs are therefore fully included in the OU indicator, using the standard rules of OI coding (IATA codes, A/C chargeable, A/C not chargeable, delays >15'), consequential delays of a first delay into the network not taken into account.

In addition to the OIs, the OU indicator 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.

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.

Unknown (information unavailable)
The “Unknown” category is used to compute any maintenance activities not covered by the previous Unplanned categories.
3.1.4 Damage Indicator

The damage indicator is defined in the Spec 2000 Out of service record 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.

![Damage Indicator Diagram]

3.1.5 Unavailability Coding Grid

The Unavailability coding grid gives the overview of the Out of Service record categorization, according to the details and granularity provided.
## Coding & Clocking Rules

### Figure 6. Unavailability coding grid

<table>
<thead>
<tr>
<th>Group 1 (Grounding time allocation)</th>
<th>Group 2 Planned</th>
<th>Group 3 Planned</th>
<th>Group 4 Planned</th>
<th>Group 5 Planned</th>
<th>Damage indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out of service record</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Planned</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Light maintenance</td>
<td>Transit Check</td>
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<td></td>
<td>Daily Check</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Weekly Check type</td>
<td>Weekly pure</td>
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<td></td>
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<tr>
<td>A-check type</td>
<td>A pure</td>
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<tr>
<td>Specific light check type</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Dedicated work package / deferred items</td>
<td>refer to the Blue list</td>
<td>refer to the Orange list</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out of phase package</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pre-light check</td>
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<tr>
<td>Post-light check</td>
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<td></td>
<td></td>
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<tr>
<td>Base maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-check type</td>
<td>C pure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific base check type</td>
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<tr>
<td>Pre-base check</td>
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<tr>
<td>A/C weighting</td>
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</tr>
<tr>
<td>Dedicated work package / deferred items</td>
<td>refer to the Blue list</td>
<td>refer to the Orange list</td>
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<tr>
<td>Out of phase package</td>
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<tr>
<td>Heavy maintenance</td>
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<tr>
<td>Heavy check type</td>
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<tr>
<td>Pre-heavy check</td>
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<tr>
<td>Post-heavy check</td>
<td></td>
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</tr>
<tr>
<td>A/C external cleaning, painting</td>
<td>Full external painting</td>
<td>Paint touch-up</td>
<td></td>
<td></td>
<td>Yes or No</td>
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<td></td>
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</tr>
<tr>
<td>Cabin maintenance (non MPD)</td>
<td>Cabin operator programme</td>
<td>FE</td>
<td>Connectivity (Wifi, mobile telephony)</td>
<td>Inspection / modification (SB, AD)</td>
<td>Refurbishment</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Partial Major</td>
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<td>A/C Mods</td>
<td>Mandatory inspection/modification</td>
<td>Recommended inspection/modification</td>
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<td>A/C Optional changes</td>
<td>System</td>
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<td>refer to the Blue list</td>
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<td>Structure</td>
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<td>refer to the Blue list</td>
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<td>System and Structure</td>
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<td>Engine maintenance (non MPD)</td>
<td>Cleaning</td>
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<td>Repair</td>
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<td></td>
<td>Inspection / modification (SB, AD)</td>
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<td>Servicing</td>
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<td>Part / LRU change</td>
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<td></td>
<td>Engine removal / installation</td>
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<td></td>
<td>Engine run</td>
<td></td>
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</tr>
<tr>
<td>A/C phase in / phase out maintenance</td>
<td>Phase in inspection/check</td>
<td>Phase out inspection/check</td>
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</tr>
<tr>
<td>Unknown (info unavailable)</td>
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</tr>
</tbody>
</table>

### Groups

- **Group 1 (Grounding time allocation)**: Indicates whether the unavailability is due to a planned or unplanned event.
- **Group 2 (Planned)**: Details the planned maintenance tasks.
- **Group 3 (Planned)**: Details the planned technical grounding tasks.
- **Group 4 (Unplanned)**: Details the unplanned technical grounding tasks.
- **Group 5 (Damage indicator)**: Indicates whether the damage is due to a planned or unplanned event.

### Codes

- **Daily Check**: Routine daily maintenance.
- **Weekly pure**: Weekly maintenance without additional work.
- **A pure**: Annual maintenance without additional work.
- **Pre-light check**: Pre-light check before an aircraft leaves the ground.
- **Post-light check**: Post-light check after an aircraft returns to the ground.
- **C pure**: Annual maintenance with additional work.
- **C + other**: Annual maintenance with additional work.
- **Partial**: Partial refurbishment.
- **Major**: Major refurbishment.
- **Enabling**: Enabling changes to the aircraft.
- **Disabling**: Disabling changes to the aircraft.
- **Delay without A/C change (OI)**: Delay due to unexpected events without aircraft change.
- **Diversion (OI)**: Diversion due to unexpected events.
- **In flight turn back (OI)**: In-flight turn back due to unexpected events.
- **Cancellation (OI)**: Cancellation due to unexpected events.
- **Delay with A/C change (OI)**: Delay due to unexpected events with aircraft change.
- **A/C change without OI**: Aircraft change without unexpected events.
- **Findings**: Findings from aircraft inspection.
- **Additional work package**: Additional work due to unexpected events.
- **Spare issue**: Issue of spare parts.
- **Resource issue**: Resource issue due to unexpected events.
- **Tooling issue**: Tooling issue due to unexpected events.
- **Hangar issue**: Hangar issue due to unexpected events.
- **Delay without A/C change (OI)**: Delay due to unexpected events without aircraft change.
- **Unavailability coding**: Indicates whether the unavailability is due to a planned or unplanned event.

---

1st Edition 2018
The Blue and Orange lists give more details for the coding into the sub-categories:

<table>
<thead>
<tr>
<th>Blue list</th>
<th>Orange list</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Servicing</td>
</tr>
<tr>
<td>Cabin (MPD)</td>
<td>Test</td>
</tr>
<tr>
<td>Engine (MPD)</td>
<td>Repair</td>
</tr>
<tr>
<td>APU</td>
<td>Inspection</td>
</tr>
<tr>
<td>Nacelle</td>
<td>Modification</td>
</tr>
<tr>
<td>Landing gear</td>
<td>Sub-component replacement</td>
</tr>
<tr>
<td>Brakes</td>
<td>Replacement</td>
</tr>
<tr>
<td>Wheels</td>
<td>Robbery</td>
</tr>
<tr>
<td>Tyres</td>
<td>Software loading / update</td>
</tr>
<tr>
<td>Slide raft</td>
<td></td>
</tr>
<tr>
<td>THS actuator</td>
<td></td>
</tr>
<tr>
<td>RAT</td>
<td></td>
</tr>
<tr>
<td>Pax door</td>
<td></td>
</tr>
<tr>
<td>Cargo door</td>
<td></td>
</tr>
<tr>
<td>Flying Control Surfaces</td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td></td>
</tr>
<tr>
<td>Generic LRU</td>
<td></td>
</tr>
<tr>
<td>Systems</td>
<td></td>
</tr>
</tbody>
</table>

![Figure 7](image-url) Unavailability coding sub-categories

### 3.2 Clocking Rules

The **Maintenance Unavailability (MU)** time is measured as the period of time an aircraft is on ground in a non-airworthy condition (i.e. with no valid CRS): when the maintenance starts until the maintenance ends.

The **Operational Unavailability (OU)** is the portion of the maintenance unavailability which has an impact on the Operations: the aircraft is either removed from Operations (planned maintenance) or the aircraft has an unplanned event and impact the flight schedule.

The six following cases illustrate how to record the maintenance and operational unavailabilities.

- Case 1: Planned Maintenance 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.

### 3.2.1 Planned Maintenance Event and Overrun

**Figure 8.** Planned Event + Unplanned Overrun

The planned maintenance unavailability event starts when the aircraft goes in maintenance, until it is released from the Maintenance. 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 Operational Unavailability is the unavailability as seen by the Operations: in case the planned activity is done transparently into the flight schedule (typically the planned line maintenance transit check, daily check, weekly check), the planned operational unavailability 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.
3.2.2 Unplanned Technical Grounding – Delay without A/C Change

![Diagram of Unplanned Technical Grounding - Delay without A/C Change]

**Figure 9.** Unplanned Technical Grounding - Delay without A/C Change

Delay < 15' is indicated in the figure above for illustration purpose only; airlines should refer to their own on-time performance objective.

Unplanned Operational Unavailability for “Delay without A/C change” equals Delay duration as per the OI reporting.

3.2.3 Unplanned Technical Grounding – Delay with A/C Change

![Diagram of Unplanned Technical Grounding - Delay with A/C Change]

**Figure 10.** Unplanned technical grounding – Delay with A/C Change
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 – A/C Change without OI

![Figure 11. Unplanned Technical Grounding- A/C Change without OI](image)

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 (but the maintenance has started earlier at time of failure occurrence), until it is released to Operations.

### 3.2.5 Unplanned Technical Grounding - Cancellation

![Figure 12. Unplanned Technical Grounding- Cancellation](image)
The grounding duration of a cancellation is not collected through traditional OI data collection. For Cancellations, the unavailability time depends on when the decision is taken to cancel the flight.

- If it occurs after the flight's scheduled departure time, the clock starts at the scheduled departure time (as shown on the figure above).
- If it occurs before the flight's scheduled departure time, the clock starts at time of the decision to cancel the flight (i.e. when the A/C is removed from the operations).

In case the Cancellation occurs during the Block TAT, the clocks starts at time of decision to cancel the flight and stops at time of A/C released to service / operations (same as Case 4: “A/C change without OI”)

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

Unplanned technical grounding duration for in-flight turn back (IFTB) or diversion is not provided in the OI traditional data collection. The unavailability is recorded from the time the aircraft lands at the returned or diverted airport to the aircraft release to service.

In case of delay at the gate before the IFTB or diversion, the duration of the delay has to be added to the unavailability period of the IFTB or diversion.
Section 4—Focus on Operational Unavailability (OU)

The Operational Unavailability (OU) is the third level of unavailibility 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, Operational Availability (OA) measures the capability to declare an aircraft fit for service within Airline Operations.

The following statement sums up what Operational Unavailability includes:

Operational Unavailability 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 of 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 Unavailability 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
The combination of both maintenance and operations defines a specific context of the OU 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 OU metric, as this maintenance does not impact the flight schedule.
Network Density

Operational Unavailability 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 dependant 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 16. Aircraft Unavailability vs Utilization](image-url)
Section 5—Key Performance Indicators

Key Performance Indicators can be defined for the Total Unavailability (TU), Maintenance Unavailability (MU) and Operational Unavailability (OU), as detailed in the Spec 2000 Chapter 13-2-4.5 Availability Metrics.

In this paragraph, a focus is done on the OU metric:

The Operational Unavailability encompasses all the planned and unplanned maintenance which impact the Operations. Therefore it complements the traditional 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 OU calculations.

The OU calculation is 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.
  - The A/C change without OI and the planned maintenance are not taken into account.

- **OU:**
  - 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.
Based on the unavailability records collected over time, a profile of operational unavailability can be built over time per A/C:

For the purpose of this paper, the planned maintenance (i.e. checks) categories are defined in the table below. Definitions may differ between airlines, aircraft types and regions of operations, e.g. light maintenance can be part of line maintenance.

<table>
<thead>
<tr>
<th>Planned Maintenance</th>
<th>Hangar required</th>
<th>Impact on Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Light</td>
<td>Yes/No*</td>
<td>Yes/No*</td>
</tr>
<tr>
<td>Base</td>
<td>Yes</td>
<td>Yes/No*</td>
</tr>
<tr>
<td>Heavy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Yes/No: depends on airline organization and maintenance program

**Figure 17.** Fleet Performance Indicators Coverage

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* Table 1. Planned Maintenance Categories

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**Table 1.** Planned Maintenance Categories
Usually, the planned line maintenance has no impact on Operations (done transparently into the flight schedule), therefore is not taken into account in the OU metric.

**Figure 18.** Example of Unavailability Profile for an Aircraft over a 12-Year Period

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...

The unplanned grounding covers the OIs, the A/C changes without OI and the overruns, and evolves over time due the ageing effect.

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 operational unavailability drivers.
Key performance indicators (KPIs) can be defined based on the operational unavailability 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 utilisation
- 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, ...
- Number of days of unplanned technical unavailability with details per sub-category: delay, A/C change, cancellation, ...
- % of days due to damage (damage indicator = Yes)
- Comparison of new vs old A/C; first hand 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...
Section 6—Operational Unavailability Process: From the Data to the Metric

Once collected using the Out of service 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. The grounding times can then be computed according the OU rules based on exclusion rules to keep only the technical events impacting the operations. At the end, the operational unavailability can be used for the analysis and KPI monitoring.

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 detail each of these steps.

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.

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 21. IATA and Spec 2000 terminologies and correspondence

IATA

Group 1
- Light
- Base
- Heavy
- Cleaning, painting ...
- Cabin (non MPD)
- Mods...
- Engine (non MPD)
- ...
- Overrun
- Unplanned technical Grounding
- Non-aircraft related issues, Parked, Stored, ...

Group 2

100% of Scheduled, Planned, Optional is Planned maintenance

Spec 2000

Scheduled
- Checks MPD
- 100% of the Scheduled is Planned

Planned
- Recommended / mandatory service bulletins not falling under Scheduled
- Hanging interior, paint, optional modifications, operator discretion
- Non MPD related

Optional
- Wheels, Brakes, Tyres
- Engine overhaul instal./removal for performance restoration, policy

Unscheduled
- OI
- A/C change without OI
- Components failure/removal
- Engine removal due to failure
- Overrun of checks

Other (non-Maintenance)
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, etc. as shown on the template below.

The Spec 2000 Out of service XML record can be used to report the data.

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

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

Figure 22. Simplified Template for Unavailability Data Collection

6.2 Grounding Time Allocation and Data Categorization

The grounding time allocation and data 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 an 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).

6.2.1 Grounding Time Computation

Grounding time computation has to be done in accordance with the Operational Unavailability definition: use rules to retain the maintenance events which impact the Operations.
6.2.2 Rules for Planned Maintenance

For the Planned maintenance, general rules can be used as a global approach for the operational context definition. For this, the following exclusion 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 event are considered having no impact). For example, the transit, daily, weekly checks are usually removed.

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

  **Note:** in case an issue is found during the TAT during a planned event <2h, an unplanned event is created and is therefore taken into account in the OU metric as an Unplanned Technical Grounding event (Operational Interruption or aircraft change without OI)

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 Out of Service record.

- **Exclusion 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 OU 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 OOS 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 24. Planned Maintenance and Night Stop Implications (when applicable)

| Time of the day | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|----------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Night stop (operator context) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Planned maintenance event #1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| The event has started at 00:00 and ended at 05:00, total duration is 5hrs. However, this event is fully transparent for the Operations, no impact on Flight Schedule, so not considered in the unavailability grounding time computation. |
| Planned maintenance event #2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| The event has started at 19:00 and ended at 05:00, total duration is 10hrs. This event is partially transparent for the Operations as it impacts the Flight Schedule for the period 19:00-23:00 only. The grounding time duration for the OA computation is 4hrs (19:00-23:00). |
| Planned maintenance event #3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| The event has started at 00:00 and ended at 08:00, total duration is 8hrs. This event is partially transparent for the Operations as it impacts the Flight Schedule for the period 06:00-08:00 only. The grounding time duration for the OA computation is 2hrs (06:00-08:00). |
| Planned maintenance event #4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| This is a combination of Planned maintenance event #2 and #3 The event has started at 19:00 and ended at 08:00, total duration is 13hrs. This event is partially transparent for the Operations as it impacts the Flight Schedule for the period 19:00-23:00 and 06:00-08:00 only. The grounding time duration for the OA computation is 6hrs (19:00-23:00 + 06:00-08:00). |
| Planned maintenance event #5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <= event more than 24hrs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

For event >24hrs, the night stop is not removed, and the total grounding time is used for the OA computation.
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.

6.2.3 Rules for Unplanned Maintenance

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

Figure 25. Time to be removed for unplanned maintenance grounding time computation, based on the Delay with A/C change example (applicable to all Unplanned cases)

For this, there is a need to correlate the OOS record with additional information: Flight Schedule, which now covered by the Flight record published in the last the Spec 2000 revision 2018.1.
Section 7—Shortfalls

The OU is an indicator which complements the existing KPI such as the OR. The OU 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 OU KPI has some shortfalls:

- The OU 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 OU is not a measure of the maintenance demand. The maintenance “absorbed” into the A/C natural down-time 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 Maintenance Unavailability (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 unavailability performance between different operators is not straightforward as the OU 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).

- 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.

- A separate and new coding system for unavailability metrics will need to be introduced and standardized across the industry. This new coding system must run in parallel to the current industry standard to be consistent with delay coding used by airlines to measure Operational Reliability and OTP.

- Airlines will need to integrate the new unavailability codes via software upgrades into the network operations systems to facilitate automated monitoring and reporting. Requirements for familiarization and training on utilization of the system to derive clearly defined outcomes on accurate unavailability measurements will need to be considered.
Section 8—Identified Topics to be addressed in the Future

This document is the first attempt at defining and measuring Aircraft Availability. It is not exhaustive yet, and we don't have 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.
  - In the future, we could use a factor to indicate the impact of the event.
- The aircraft is about to be released to operations and an 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.
- Improve the OU computation for the Unplanned maintenance by correlating the OOS record 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 mctf@iata.org.
Section 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
M&E = Maintenance & Engineering
MIS = Maintenance Information System
MPD = Maintenance Planning Document
MU = Maintenance Unavailability
OA = Operational Availability
OU = Operational Unavailability
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.

\[
OR = 100 - \left( \frac{\text{Nbr of chargeable interruptions during a computation period}}{\text{Nbr of Revenue Flights during the computation period}} \right) \times 100
\]

\[
OR = 100 - \left( \frac{DY + CN + IFTB + DV}{\text{TO rev}} \right) \times 100
\]

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).

TDR = Technical Dispatch Reliability
TO rev = Revenue Take-off
TU = Total Unavailability
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