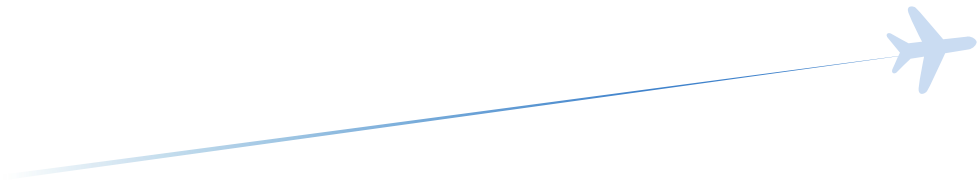

Representative Use Cases

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Copyright Statement

AEON

ADVANCED ENGINE OFF NAVIGATION

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Abstract

This document, entitled "Representative Use Cases", is the deliverable D3.1 of the SESAR Exploratory Research Project AEON (Advanced Engine-off Navigation).

AEON project. The document presents the defined use cases of AEON to explore the initial concept of operation described in D1.1 for reducing the environmental impact during taxiing operations.

These use cases along with the initial concept of operations and the state of the art (D2.1) will guide the elaboration of adequate algorithms (WP2), the design of new Human-Machine Interface (WP3) as well as the assessment (WP5) and the final solution demonstration (WP4).

The document briefly describes the possible impacts of the AEON solution on existing procedures used during ground operations. The document then defines use cases on strategical and tactical phases that illustrate the possible impacts of the AEON solution.

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Introduction

The SESAR Exploratory Research Project AEON (Advanced Engine-off Navigation) aims at reducing the environmental impact of ground operations by supporting the use of engine off taxiing techniques that will help reducing fuel consumption and emissions. As described in the initial version of the Concept of Operation in D1.1 we consider several engine-off techniques to be used in parallel such as Dispatch Towing Vehicle Electrical Taxiing System (DTVETS) or Single Engine Taxiing (SET). The use of such techniques will have an impact on current operations that AEON will try to mitigate with dedicated algorithms and Human-Machine Interactions (HMI) for specific use cases described in this document.

1.1 Purpose and scope of the document

This document describes several sets of use cases that highlight the changes and the new constraints that AEON brings to airport taxi operations. These use cases will support the design of solutions that mitigate the impact of these changes on airport safety and capacity while supporting the effort of limiting the environmental impact of taxi operations.

The use cases describe the stakeholders involved and focus on the changes in taxiing procedures and operations that may occur when several engine off taxiing techniques are operated on airport taxiways. The use cases are covering strategical and tactical phases to illustrates how operations can be planned in advance and used during actual operations. These use cases will be used to lead the design of algorithms in WP2, HMIs in WP3, the final technology integration in WP4 and its assessment in WP5.

1.2 Background

In order to define relevant use cases for the AEON solution, we carried out several activities:

- the analysis of the state of the art reported in D1.3, on collaborative work, multi-agent and path finding algorithms, and operations research for the management of a fleet towing. We also considered previous work on trajectory-based taxiing [1,2].
- the results of an online survey about green taxiing techniques organised by the consortium
- An analysis of current airport taxi operational procedures and data collection from taxi technology manufacturers (SAS, Safran) and stakeholders such as ground handlers, pilots and airport managers.
- the feedback collected from the Advisory Board during the first Advisory Board meeting held in September 2021.
- initial HMI design and algorithms proposals by the consortium members

These activities, along with the initial CONOPS definition described in D1.1 have paved the way to explore the potential impacts on, not only existing systems and taxi procedures, but also new procedures to be introduced by the AEON concept.

1.3 Structure of the document

Chapter 2 introduces the possible impacts of the AEON current concept of operation on ground operations. Chapter 3 describes the strategical and tactical use cases that will be considered for the design and evaluation of the final solution.

1.4 Relationship with other documents

This deliverable builds upon the initial version of the concept of operations (D1.1) and the state of art (D1.3) to provide an analysis of current challenges and relevant use cases to consider. The use cases will be referenced in the solution assessment plan (D5.1).

1.5 Acronyms and terminology

The following table reports the acronyms used in this deliverable:

Term	Definition
A-CDM	Advanced Collaborative Decision Making
APTO	Airport Operator
ATCO	Air Traffic Controller
CPDLC	Controller-pilot data link communication
DTVETS	Dispatch Towing Vehicle Electrical Taxiing System
HMI	Human Machine Interaction/Interface
MLGETS	Main Landing Gear Electric Taxiing System
NLGETS	Nose Landing Gear Electric Taxiing System
RWY	Runway
TWR	Control Tower
TFM	Tug Fleet Manager

Table 1: List of acronyms used in this document.

AEON considers three classes of engine-off taxiing techniques to be used concurrently: single-engine taxiing solutions, hybrid towing taxing solutions and autonomous taxiing solutions based on electric motors. For the sake of clarity, in this document, we will use the following terms:

- **tug** to designate hybrid towing taxing solutions named Dispatch Towing Vehicle Electric Taxiing System (DTVETS) in D.1.1.
- **electric taxi** to designate an autonomous taxiing solution embedded in landing gear/nose wheel gear named Nose Landing Gear Electric Taxiing System (NLGETS) and Main Landing Gear Electric Taxiing System (MLGETS) in D1.1.
- **tug drivers** to designate the drivers of the DTVETS that can operate them

- **tug fleet manager (TFM)** to designate a new stakeholder who is responsible of dispatching tugs when they are needed for pushbacks and for towing aircraft from and to the gates as suggested by the initial concept of operations in D1.1.

2 AEON possible impacts on operations

The variety of engine off taxiing techniques envisioned by the AEON project will impact current taxi operations from the strategical planning of the operations to the way traffic is managed on taxiways and how aircraft navigate through airport locations. For instance, the maximum speed limit of electric taxi technologies may impact the airport ground traffic flow. Also, the integration of more tugs for towing aircraft on taxiways will intensify the already dense traffic impacting controllers' and pilots' activities.

To cope with these changes, AEON will offer support for sizing the fleet of tugs and allocate them to specific aircraft. It will then support planning optimal ground traffic through novel algorithms that suggest the best taxi trajectories for each vehicle (aircraft and tug) on the airport taxiways. AEON will also provide a set of interactive tools that supports airline companies, airport service companies, airport ground controllers, tug fleet managers and pilots to perform airport taxi related tasks as well as the collaboration between stakeholders to optimize airport ground operations workflow.

The use cases presented in this document will highlight the changes from current operations and how they impact current operations so that we can design efficient mitigation solutions. In this section, we describe the possible impacts of the AEON solution on existing ground operations at two different phases: strategical and tactical. The strategical phase covers activities performed months before the day under consideration up to the day before. Tactical phase includes activities performed the day of operations. In the tactical phase we consider tactical planning as short term planning of future operations such as assigning tug to aircraft two hours in advance and tactical operations that are performed immediately such as communicating a route to a vehicle.

2.1 Possible impacts during the strategical phase

In AEON, the introduction of tugs for taxiing operations will create a new service on the airport in addition to existing ones. Before the actual operations, various actors will have to take this specificity into account.

Airport Operator (APTO) or the companies that will offer tugs as a service will have to size their fleet of vehicles according to their goals in terms of ecological, economic or operation performances.

Airlines will need to book the tugs service for their aircraft, and this will impact their ground handling strategies and the airport resource management. Since tugs might be limited in number, even more during peak traffic, airlines will be required to indicate the taxi capabilities of their aircraft and their taxi preferences as alternatives.

A benefit of using engine-off taxiing techniques will be the potential saving of the fuel devoted for taxi and associated emissions or noise. Thus, AEON will impact the estimated fuel needed by **pilots** for a flight.

The AEON CONOPs assumes that tugs are maintained and operated by the **APTO or dedicated companies**. Having a fleet of tugs will require supervision. **The tug fleet manager (TFM)** will ensure the best availability of the vehicles fleet by monitoring their status, allocating them to aircraft and planning maintenance operations.

2.2 Possible impacts during the tactical phase

Engine-off technologies introduced in AEON will change aircraft's speed profiles on taxiways and will introduce additional vehicles on taxiways. This will have significant impacts on taxi procedures and the way stakeholders operate.

Aircraft will have disparate speed profiles and manoeuvrability levels. This variability will impact airport schedule as it may require more time to reach a given location on the airport using such taxi technologies. **Airlines and APTO** may have to replan ground handling strategies to cope with longer taxiing time.

Since aircraft will be able to taxi engine-off, **pilots** will have to plan for engine start time and location to optimise fuel consumption while following engine start-up airline companies' and airports' procedures and avoiding any timeout. In addition, when towed to or from runways, **pilots** will have to incorporate attaching/detaching time and location with the tug before departure or after landing. Finally, every aircraft will be required to follow speed recommendations to optimise the traffic flow and fuel consumption. Therefore, pilots will have to monitor and control the aircraft speed accordingly.

The hypothesis of AEON is that tugs will use the taxiways. This will increase work demand for routing and communication between **ATCOs** and taxiways users. Like aircraft, taxi clearances and routes will be needed for **tugs drivers** to navigate throughout the airport. This could increase **ATCOs'** workload and intensify verbal communication on ground control frequencies. The heterogeneity of vehicles characteristics on taxiways may create conflicts which will need stakeholders' collaborative efforts to resolve.

On a tactical planning level, the **tug fleet manager** will be responsible of proposing an allocation plan to provide tugs on time for towing operations to be performed as requested. In particular, the manager will have to assign the towing vehicles to aircraft according to technical requirements and companies' preferences. The fleet manager will also ensure the **tugs** usage optimisation by dispatching any available **tug** at any time if required. When incidents arise, available **tug** may be dispatched to resolve taxiways traffic congestion at the fleet manager's discretion.

2.3 Other possible impacts not covered by the use cases

While we tried to cover as much of the possible impact of the solutions on the current operations, there are a few possible impacts that we identified that will not be considered in our use cases.

The implantation of charging stations and the definition of charging strategies will have an impact on the sizing of the tugs fleet. Also, maintenance on one or many tugs will be necessary and maintenance operations will need to be planned in advance to minimize the impact on the performance of the AEON solution. We might cover these aspects in the final solution, but this is considered as a low priority and not described in our use cases.

The level of traffic will necessarily have an impact on the performance on ground operations. Adding additional vehicles in an already almost saturated context might prove challenging. We do anticipate that peak traffic might pose specific challenges for the workload of all involved stakeholders, human or algorithms, due to the quantity of information to be exchanged and processed. In our use cases, we will consider medium traffic situations but will not cover the peak traffic situations.

Also, we identified that some aircraft have specific wind constraints for starting their engines. For instance, some cannot start the engines when the wind is stronger than twenty knots and coming from the back. This could have implications for the moment and place to start the engines when using engine-off taxiing techniques. We might cover this aspect in the final solution, but we do not propose it as a use case that will be necessarily considered during the design.

Current tugs can only tow specific aircrafts. This might require the need of heterogeneous fleet of tugs to accommodate as many aircraft as possible. This might cause allocations errors and mismatch between the tug and the aircraft to be towed. We will not consider this specific problem in our use cases.

Another identified impact is created by the use of transponders by tugs. When coupled with an aircraft also using a transponder this might cause technical challenges and operational problems to discriminate the two vehicles If both are active at the same place. We will not cover this technical impact within AEON.

3 Use Cases Descriptions

This chapter describes the use cases that will be considered to design and assess the AEON solution. We focus on the use cases covering the impacts of the AEON solution identified in the previous section. We describe them in three main categories, strategical planning (SP), tactical planning (TP) and tactical operations (TO). The TO use cases are divided by nominal and contingency use cases. Both will be considered for the design of AEON tools, but only nominal ones will be considered for the final assessment of the solution. The same format is used to describe all use cases, with separate tables to describe each use case's characteristics. When necessary, we also detail the envisioned flow of activity for the use cases. Some use cases refer to previous ones and only details are changed.

Table 2 lists the use cases described in this section. The table indicates which work-packages and specific tasks of the projects that will consider the use cases for design and development activities. We also indicate an implementation priority for the use cases.

Use case	Concerned WP and Tasks	Implementation Priority
SP1: Decision support for sizing the tugs fleet	WP2 – T2.1.1	High
TP1: Tug allocation to aircraft during the day of operation	WP2 – T2.1.2 & T2.2.1	High
TP2: Updating an already assigned taxiing technique	WP2 – T2.2.1 WP3 – T3.2	Medium
TP3: Updating the allocation for a runway reconfiguration	WP2 – T2.2.1 WP3 – T3.2	Medium
TO1: Three departures with Engine-off taxiing techniques	WP2 – T2.2.1 WP3 – T3.2	High
TO2: Tug dispatching	WP2 – T2.2.1 WP3 – T3.2	High
TO3: Medium traffic with multiple engine-off taxiing techniques	WP2 – T2.2.1 & T2.2.2 WP3 – T3.2	High
TO4 A.B: Aircraft too slow or too fast not respecting speed targets	WP2 –T2.2.2 WP3 – T3.2	Medium
TO5: Tug failure on a taxiway	WP2 – T2.2.1 & T2.2.2 WP3 – T3.2 WP5 – T5.4	Medium
TO6: Dispatching tug to a departure delayed aircraft	WP2 – T2.2.1 WP3 – T3.2	Medium

Table 2: Overview of use cases and their characteristics.

All use cases will not necessarily be simulated in the final demonstration. However, they will all be used for design purpose and considered in the assessment activities. For instance, use cases illustrating safety cases such as TO5 will be used to assess the safety of the final solution but will not be demonstrated. The solution assessment plan (D5.1) will give more details on this aspect.

3.1 Strategical Use Case

This first use case focuses on the strategical planning aspects of the project. It covers the sizing of the tugs fleet for a specific airport before investing on the vehicles.

SP1: Decision support for sizing the tugs fleet

Description	This use case considers all aircraft that need to be towed. An optimal sizing of the tugs fleet is done at the strategic level such that all considered aircraft are towed. The algorithm will be run on several representative days of traffic.
Actors	APTO or tug service provider.
Preconditions	A list of arrival and departure times for the aircraft that need to be towed is available. The routing of these aircraft is available.
Postconditions	An optimal size of the tugs fleet is determined, and a timetable is available that specifies which tug tows which aircraft and at what time.
Assumptions	We assume as known which aircraft need towing, which aircraft are arriving/departing; their respective arrival/departure time and the sequence. We also assume that every aircraft eligible for towing will be towed.
Expected effects on operations	APTO or tug service provider will have to consider the identified number of tugs to size their fleet and use allocation plans to estimate possible impacts on operations.

Flow of activities:

#	Phase	APTO	AEON system
1	Specifying parameters	Specify parameters and data sets	Defines an optimal size of the tugs fleet.
2	Analysing results	Consider the results for sizing the tug fleet	

3.2 Tactical Planning Use Cases

This second set of use cases focuses on the tactical planning aspects of the project. It covers the work of airlines, ground ATCOs, tug fleet manager, pilots and tug drivers a few hours before the actual operations to allocate the tug fleet and plan the taxiing operations beforehand.

TP1: Tugs allocation to aircraft during the day of operation

Description	This use case considers the decision to allocate a limited fleet of towing vehicles to aircraft that are suitable for being towed. The allocation is made to complete all towing tasks with the minimal number of tugs.
Actors	APTO or tug service provider, Airlines
Preconditions	The set of aircraft that are suitable to being towed and the size of the fleet of available tugs. Flight schedule at the beginning of the day and intermediate updates of the flight schedule are known. The routing of the tugs and its update over time are known.
Postconditions	An initial or updated allocation plan of tugs to aircraft that are suitable for being towed with target coupling times for each departure and arrival.
Assumptions	Aircraft that are towed always have the right of way relative to the non-attached tugs, except if instructed otherwise by ATCOs.
Expected effects on operations	APTO, Airlines ATCOs and TFM will have to consider the allocation plan to implement it or its updates.

Flow of activities:

#	Phase	Ground Operations stakeholders (APTO, Airlines, ATCOs, TFM)	AEON system
1	Optimizing tugs allocation	Sending data (the planned traffic, the size of the tugs fleet and routing of the tugs) to the algorithm.	Computes an optimal allocation plan for each flight and share it with stakeholders via ACDM-portal.
2	Planning operations	Build upon the suggested allocation to plan ground operations	

TP2: Updating an already assigned taxiing technique

Description	This use case considers the update of a taxiing technique after its allocation by an airline, a tug service provider or the APTO via the A-CDM. For instance, the tug service provider might indicate that a tug is no longer functional or an airline prefers using tugs instead of SET technique.
Actors	APTO or tug service provider, Airlines
Preconditions	A predefined allocation of taxiing techniques
Postconditions	An updated allocation of taxiing techniques with target coupling time for each departing and arriving aircraft.
Assumptions	Airlines will be able to manually set their taxiing technique up to three hours before departure or arrival.
Expected effects on operations	Ground Handling, Pilots, ATCOs and TFM will have to update their plans if there are modifications.

Flow of activities:

#	Phase	Airlines	Ground Operations stakeholders (APTO, Airlines, ATCOs, TFM)	AEON System
1	Updating the taxiing techniques	Up to three hours before departure, the airline updates the taxiing technique for a flight. The changes are updated in the ACDM.		Update the tugs allocation plan and share it with stakeholders via ACDM-portal.
2	Notifying the update		Receive the updated allocation plan via A-CDM	

TP3: Updating the allocation due to a runway reconfiguration

Description	This use case considers a situation where the wind direction changes and impacts the runways flow. Tugs allocation will need to be updated from a specific point in time.
Actors	TFM, Tug Driver, Ground Controller, pilots
Preconditions	The runway and the routes to the runways are in configuration A. Time for the actual change is available and known by the system.

Postconditions	The runway and the routes to the runways are in configuration B.
Assumptions	In case of runways reconfiguration, stakeholders will have to be informed of the new optimal routes to reach their destination and the best locations for starting engines and coupling/decoupling tugs. The decision for a runway configuration change happens between 15 and 30 minutes before its execution.
Expected effect on operations	The change will impact the allocation plan for tugs that will possibly be reallocated to other aircraft according to specific optimization criteria (as in TP1).

Flow of activities:

#	Phase	TFM	Tug driver	ATCO	AEON system
1	Planning the runway reconfiguration			ATCO plan a runway reconfiguration	
2	Notification of the new plan	Receive the new allocation plan and identify actions to be performed			Computes the new allocation plan and share it via ACDM to concerned stakeholders
3	Taxi clearance and navigation	Re-allocate tugs and give updated routes to tugs	Drive to new attaching point		

3.3 Tactical Operation Use Cases

This third set of use cases focuses on the tactical operations aspects of the project. It covers the work of ground ATCOs, tug fleet manager, pilots and tug drivers during the operations to ask and give clearances for taxiing. The use cases reported here are representative of relevant categories of operational situations but not exhaustive. The impacts and flow that are described for departing aircraft would have similar implications and workflow for arriving aircraft.

T01: Three departures with Engine-off taxiing techniques

Description	This use case considers the taxi operations within the AEON concept. Aircraft A, B, C are ready for start-up. Aircraft A is towed by a DTVETS, aircraft B uses an electric taxi system and aircraft C uses single engine taxi. The use case describes the impact of the concept on the stakeholders' activity.
Actors	TFM, Tug driver, Ground ATCOs, Pilots
Preconditions	The aircraft are ready to leave their gate for departure.
Postconditions	The aircraft are lined up for take-off at their runway holding point and the GND ATCO has transferred the aircraft responsibility to departure ATCO.
Assumptions	It is assumed that the stakeholders will require new tools to manage green taxi technologies and AEON concepts to keep the airport performance constant.
Expected effect on operations	AEON introduces changes in current taxi procedures. Stakeholders will receive sufficient feedback to dispatch electric tugs, manage the start-up of the engines at the most appropriate time and place, and decoupling aircraft and tugs when needed.

Flow of activity:

#	Phase	TFM	Tug driver	Pilot	GND ATCO	AEON system
1	Ground handling	TFM dispatches a tug to aircraft A				Provides information on tug availability and tug requests
2	Taxi route request			All Pilots request taxi clearance and route to runway from the Ground ATCO		
3	Taxi clearance				Ground ATCO issues clearance	Provides the optimal routes to minimize delays and

					for taxi procedure and routes to the runway holding position.	reduce environmental impact to Ground ATCO
4	Taxiways navigation	TFM monitors the fleet to be able to dispatch required tugs as soon as they become available		All pilots regulate aircraft speed according to AEON system recommendation	Ground ATCO monitors taxi progression of these 3 aircrafts	AEON system provides speed recommendation to aircraft for each route section
5	Engine start-up			All pilots start engine following AEON system recommendation		AEON system provides engine start-up recommendation to aircraft
6	Decoupling	TFM is informed of the dispatchable tug availability	Tug driver decouples the aircraft from the electric tug following AEON system recommendations			AEON system provides the location for decoupling to aircraft, Ground ATCO, TFM and tug drivers
7	Tug dispatching	TFM dispatches a tug to another aircraft if needed				AEON system provides information on tug availability and requests
8	Transfer of ground control to departure control				Ground ATCO transfers the aircraft	

					to TWR ATCO	

T02: Tug dispatching

Description	This use case considers tug dispatching and return to base when not needed anymore.
Actors	TFM, Tug Driver, Ground ATCO, Pilot
Preconditions	The tug is towing an aircraft to the runway
Postconditions	The tug has returned to the gate or charging location.
Assumptions	Tugs will navigate throughout the airport using taxiways. As such they will need clearance and route from GND ATCO to reach their locations in the airport.
Expected effect on operations	The tug will increase the traffic density on the taxiways and will impact ground control.

Flow of activity:

#	Phase	TFM	Pilot	Tug driver	GND ATCO	AEON system
1	Tug decoupling request	TFM monitors the fleet.	Pilot requests decoupling to the tug driver			
2	Tug decoupling	TFM is notified that a tug is available		Tug driver executes decoupling		AEON system updates tug availability status to available
3	Tug dispatching	TFM dispatches the tug to another runway to tow an aircraft about to land				AEON system updates tug availability status to not available

4	Tug route request			Tug driver requests taxi clearance and route from the ATCO		
5	Tug Taxi clearance				ATCO issues clearance and provide route for the tug according to AEON system suggestion	AEON system suggests the optimal route for taxi
6	Tug taxi			Tug driver executes planned route to runway exit holding point		AEON system provides route information to tug driver and possible priorities to aircrafts.
7	Tug coupling	TFM monitors the tug status.	Pilot requests coupling	Tug driver attaches the tug to the aircraft and gives control to the pilot		
8	Aircraft taxi clearance request		Pilot requests taxi clearance and route to gate from GND ATCO			
9	Aircraft taxi clearance				GND ATCO issues clearance and provide route for the aircraft according to AEON system suggestion	AEON system suggests the optimal route for taxi

10	Aircraft taxi		Pilot executes planned route			AEON system suggests the optimal speed for each section of the route and decoupling location
11	Tug decoupling request	TFM monitors the tugs status and decoupling.	Pilot requests decoupling to the tug driver			
12	Tug decoupling	TFM is notified that a tug is available		Tug driver executes decoupling		AEON system updates tug availability status to available

TO3: Medium traffic with multiple engine-off taxiing techniques

This use case explores how to use multiple taxiing techniques at the same time with medium traffic. It will support the design of relevant tools to help the stakeholders identifying and assessing taxiing technology for each aircraft and explore the increasing taxiways traffic on stakeholders' workload.

Description	This use case considers the taxi operations for 10 departures and 10 arrivals distributed among runways and gates to create couplings between them. It will last approximately 20 minutes. This use case highlights the impact of AEON concepts on the taxi traffic management.
Actors	TFM, Ground ATCO, Pilots, Tug drivers
Preconditions	10 aircraft are ready to leave their gate for departure. 10 aircraft have or will land and are expected to the gates for handling operations.
Postconditions	Aircraft scheduled for departure have all lined up for take-off at their runway holding point and the GND ATCO has transferred the aircraft responsibility to TWR ATCO. Aircraft scheduled for ground service have all reached their gate.
Assumptions	Stakeholders will be required to monitor taxi resources and dispatch tugs at the relevant time and location, to follow routes, speeds, engine start-up times and taxi operations recommendations to keep the airport performance consistent.
Expected effect on operations	Stakeholders will have to perform additional tasks related to AEON to ensure smooth traffic and to lower the environmental impact

	of taxi. In addition, tugs will be a limited resource on the airport and will impact the traffic on the taxiways and the environmental impact of taxiing.

Flow of activity:

This use case extends use case 3.1.4 and 3.1.5 to investigate the scalability of AEON's tools. The flow of activity combines the flow of activity of use case 3.1.4 and 3.1.5.

3.4 Tactical Operation Contingency Use Cases

The following set of use cases focuses on contingency situation during the tactical operations. Although the expected effects on operation and flow of activity are described for departing aircrafts, they would be similar for arriving aircrafts. It is worth noting that other use cases can be derived from the ones described here. For example, towing an arriving aircraft to an occupied parking stand would be very similar to TO6. Finally, these use cases will be considered for design purpose but will not be evaluated in the final Human-Performance Assessment.

TO4 A.B: Aircraft too slow or too fast not respecting speed targets

This use case will be declined in two different variations. Variation A is for aircraft going faster than the speed target that might need to stop or force another aircraft or vehicle to stop. Variation B is for an aircraft going slower than the speed target that might cause slowing down other vehicles and thus making the optimal path plan not valid anymore.

Description	This use case considers an aircraft that taxis at a different speed than AEON system speed recommendation.
Actors	TFM, Tug Driver, Ground ATCO, Pilot
Preconditions	The aircraft is taxiing at a higher/lower speed than AEON system recommendation.
Postconditions	The aircraft is taxiing using recommended speeds by the AEON system. The other aircrafts routes and tugs allocation are possibly updated.
Assumptions	Pilots will require information to be able to follow speed recommendation.
Expected effect on operations	By not following AEON speed recommendation, the aircraft may consume more fuel, stop more frequently, delay other aircrafts, and increase its environmental impact.

Flow of activity:

#	Phase	TFM	Tug driver	Pilot	GND ATCO	AEON system
1	Taxi clearance				GND ATCO issues clearance for taxi and routes to the runway holding position.	AEON system provides the optimal route to reduce environmental impact of each aircraft.
2	Taxi speeding			Pilot is informed by ATCO or the AEON system that the aircraft speed does not follow the speed recommendation.		AEON system provides speed range recommendation for each aircraft on every section of the routes to the runway at all times.
3	Taxi speed correction			Pilot decelerates or accelerates to return to the recommended speed.		
4	Update on Other aircraft/vehicles	Considers the updates on tugs if any			Consider the new suggested optimal routes for other aircraft if any.	Update the allocation plan and path planning with the new status of the system if necessary.
5	New taxi clearance	Updates the allocation plan if required	Follow the updated instructions if any	Follow the updated instructions if any	ATCO issues clearances to tug drivers and aircraft if any	

TO5: Tug failure on a taxiway

This use case is provided as a means to assess safety in AEON but will not be demonstrated and validated in the final evaluation.

Description	This use case considers the failure of a tug towing an aircraft on a taxiway. Two possibilities are considered, one in which another tug is available to tow the aircraft, the other in which the aircraft starts its engines.
Actors	TFM, Tug Driver, Ground ATCO, Pilot
Preconditions	The tug is towing an aircraft to the runway.
Postconditions	The traffic on the taxiway is back to normal. The aircraft is taxiing to the runway.
Assumptions	Stakeholders will require support to mitigate delays.
Expected effect on operations	The failure will create traffic jams and will slow down the traffic speed and create delays. In addition, the failure may trigger an over capacity situation where available tugs are not enough to cope with the demand.

Flow of activity:

#	Phase	TFM	Tug driver	Pilot	GND ATCO	AEON system
1	Taxi clearance				GND ATCO issues clearance for taxi and routes to the runway holding position.	Provides the optimal route to reduce environmental impact of each aircraft
2	Taxiway navigation	TFM monitors the fleet		Pilot regulates aircraft speed according to the AEON recommendation		AEON system provides speed recommendation to aircraft for each route section
3	Taxi failure		Tug driver notify the failure to the Pilot and the AEON System	Pilot notify failure to GND ATCO		AEON system informs stakeholders of the taxi failure.

4	Contingency procedure	TFM checks tugs availability and tug request schedule to dispatch another tug if possible.			GND ATCO uses suggestions for updated routes and coordinate with TFM to find if a new tug can be used or not.	AEON system computes new routes and speed profiles to avoid the jammed section and to limit the impact of the incident on taxiway traffic.
5	Alternative taxi option	TFM dispatches another tug to the aircraft.		Pilot waits for airport ground handling service crew to detach and clear the tug. If another tug is available, pilot is notified and waits for the tug. If no tug is available, pilot will request a clearance to start engines from GND ATCO	GDN ATCO gives routes clearance to the tug driver if possible.	
6	Taxi clearance		Tug driver attaches the tug to the aircraft and gives control to the pilot	Pilot requests coupling	GND ATCO issues clearance for taxi and new routes to the runway holding position.	

TO6: Dispatching tug to a departure delayed aircraft

Description	This use case considers the situation where a tug has been dispatched to an aircraft parked at the gate which is being delayed.

Actors	TFM, Tug Driver, Ground ATCO, Pilot
Preconditions	A tug has been dispatched by the fleet manager to an aircraft.
Postconditions	The tug has been dispatched to another aircraft.
Assumptions	There are other aircraft to towed at the same terminal
Expected effect on operations	Blocking a tug waiting until the aircraft is ready to taxi might prevent the tug to tow another aircraft planned afterward (arrival for instance) thus reducing the possible environmental benefits

Flow of activity:

#	Phase	TFM	Tug driver	Pilot	GND ATCO	AEON system
1	Tug dispatch	TFM dispatches a tug to an aircraft at the gate				AEON system updates tug availability status to not available
2	Aircraft delayed			Pilot informs APTO and TFM that the departure is delayed.		AEON system shares the information with all the stakeholders
3	Tug reallocation	TFM reallocates the tug to another aircraft.				AEON system updates taxi allocation
4	Tug rerouting		Tug driver requests taxi clearance and route from the GND ATCO			AEON system computes new routes and speed profiles following taxi reallocation.
5	Taxi clearance				ATCO gives new routes to the next coupling location.	

4 References

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