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AEON

ADVANCED ENGINE OFF NAVIGATION

This This “Description of final validation platform” deliverable is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 892869 under European Union’s Horizon 2020 research and innovation programme.

Abstract

This document describes the updated architecture of the simulation platform that will be used for AEON concepts evaluation both on a physical and software point of view. More specifically this document will list the data exchanged between the different software agents and the data logged for evaluation purpose.

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1 Introduction

AEON aims at fostering the usage of environmentally friendly ground operations techniques:

- Non autonomous taxiing such as TaxiBots
- Autonomous taxiing like Electric Green Taxi System
- Single Engine Taxiing as last option.

The project aims at defining a concept of operations focusing on engine-off taxiing techniques based on a set of dedicated tools such as fleet management for TaxiBots and supervision interfaces to support the operators and their collaborations.

The global architecture of the simulation platform that will be used for AEON concepts evaluation described in D4.1 is still applicable. This document will focus on the actual information used by the different agents. Finally, it will also lists the data that can be automatically logged during a simulation for the solution performance assessment.

1.1 Structure of the document

Chapter 2 lists all the data exchanged between the software agents involved in the simulation.

Chapter 3 lists the information that will be logged for the concept evaluation.

1.2 Acronyms and terminology

The following table reports the acronyms used in this deliverable.

Term	Definition
A-CDM	Advanced Collaborative Decision Making
ACHIL	Aeronautical Computer Human Interaction Lab (achil.recherche.enac.fr)
AMAN	Arrival manager
A-SMGCS	Advanced surface management guidance and control system
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air traffic management
CATC	Conflicting ATC clearances
CMAC	Conformance monitoring alerts for controllers
CPDLC	Controller-pilot data link communication
CTOT	Computed Take Off Time
DMAN	Departure manager
D-Taxi	Datalink communication during the taxi phase
DTVETS	Dispatch Towing Vehicle Electrical Taxiing System

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ETA	Estimated Time of Arrival
EOBT	Estimated off block time
FTOT	Forecasted take off times
HMI	Human Machine Interface
IVY	Communication middleware (see D4.1)
JSON	Java Script Object Notation
PMP	Project Management Plan
RMAC	Runway monitoring and conflict alerting
RMAN	Runway manger
RWY	Runway
SVG	Scalable Vector Graphics
TCAS	Traffic Collision Avoidance System
TLDTs	Target Landing times
TOBT	Target off block time
TTOTs	Target take off time
TWR	Control Tower

1.3 Applicable reference material

- AEON Grant Agreement Description of Action - GA-892869-AEON
- AEON D4.1 Description of the initial validation platform

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2 Data exchanges

This chapter describes the information exchanged via IVY messages (see deliverable D4.1) during a simulation exercise.

In addition to the platform description in D4.1, 2 new agents have been added:

- Pseudo pilots: HMI based on the A-SMGCS prototype that allows pilots to send orders to the simulation engine
- Orchestrator: Supervision agent that updates flight information when needed for coherence, for instance it delays an aircraft TOBT if the current value has been exceeded and the aircraft has not pushed back yet.

The information exchanged via IVY messages are either:

- Information pushed periodically or as event messages upon data modification (e.g., flight plan modifications)
- Request from an agent for a specific information (e.g., a route for a given a/c)
- Answer to a request

The diagram below shows an overview of the updated data flows and message types:

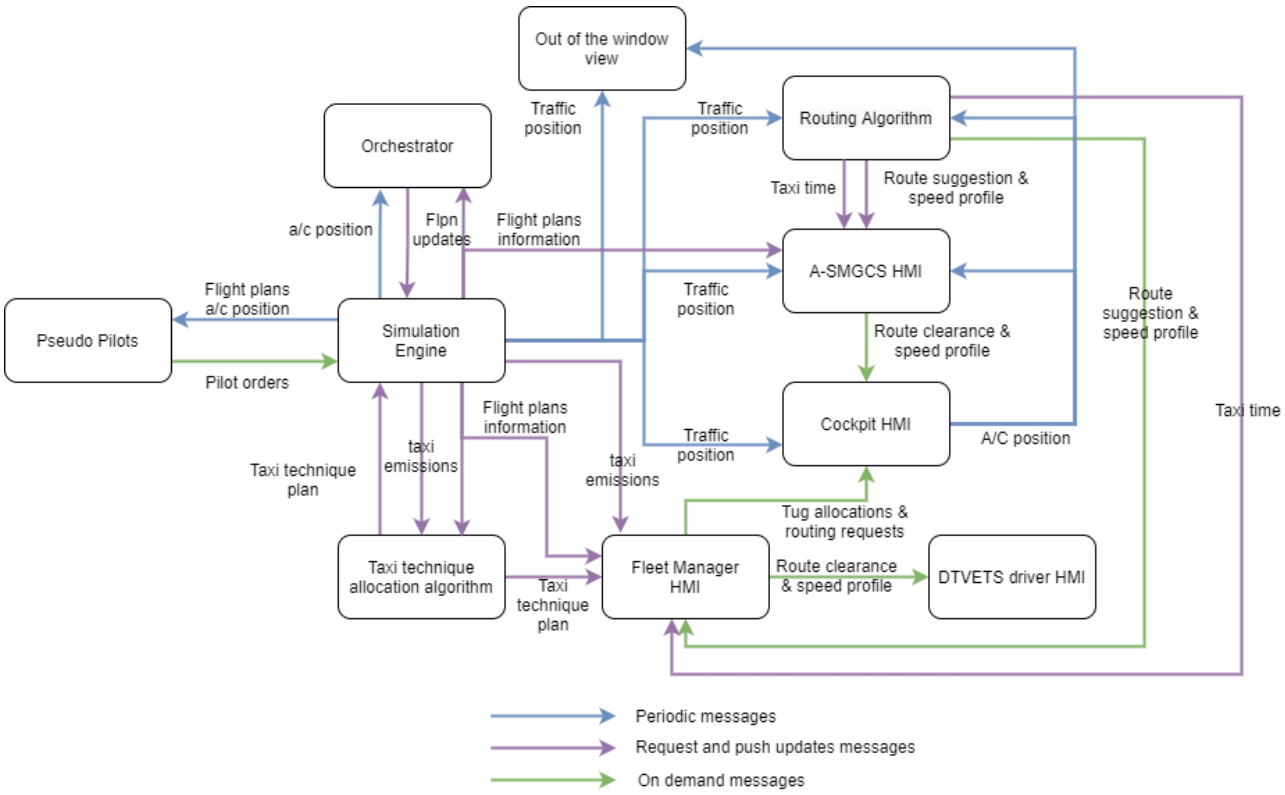

Figure 1: Updated architecture overview

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In case of a request, the initial message will contain a “MsgName” value that is repeated in the answer message to identify the discussion.

Each vehicle in the simulation engine is identified by a unique number that is usually called “Flight” in the IVY messages.

2.1 General information

In the following chapter, only non-obvious data field are explained.

2.2 Simulation initialization

At execution start-up, an IVY agent will usually follow the sequence below:

1. Send a message to get the list of the simulated vehicles, either GetDatabaseInfos or GetCurrentFlights
2. It will receive a list of identifiers and for each one will send a request for its position (GetGroundPosition), its flight plan (GetPln) and its taxi technique (GetTaxiMethod)
3. Then during the simulation, these data will be updated via event messages.

2.2.1 GetDatabaseInfos

Message sent to Simulation Engine to get all the flights id present in the database.

Message: “GetDatabaseInfos MsgName Cond=CallSign=*”

The response is “DatabaseInfos MsgName Nb= List=” with nb the number of flights present in the database and List a list with all their id.

The Simulation Engine will give all the flight identifiers used in the simulated traffic, past, present and future.

2.2.2 GetCurrentFlights

Message sent to Simulation Engine to get all flights id who are used at the time asked in the message.

Message: “GetCurrentFlights MsgName Time=”

The response is: “CurrentFlights MsgName Time= List=” with the same time and the list with all flights id present at that time.

Only the flights that are currently active are listed in the response.

2.2.3 GetGroundPosition

The GetGroundPosition message is sent to Simulation Engine for a given aircraft to get its position at the current simulation time.

Message: “GetGroundPosition MsgName Flight=”

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The response is: “GroundPosition MsgName Flight= Position=” where the position can be an id of a gate or a holding point, or the name of a taxiway if the aircraft is moving (matching the identifiers for these elements in the SVG file).

2.2.4 GetTaxiMethod

The GetTaxiMethod message is sent to Simulation Engine for a given aircraft to get its taxi method at the current simulation time.

Message: “GetTaxiMethod MsgName Flight=”

The response is: “TaxiMethod MsgName Flight= Taxi= Tug=”

where Taxi can be classic, set, etaxi, wheeltug or taxibot and Tug is the id of the coupled tug if the current taxi method is taxibot.

2.3 Clock messages

These messages are used to handle the simulation time flow.

2.3.1 ClockStart

Message sent to Simulation Engine by another application to restart the simulation clock.

2.3.2 ClockStop

Message sent to Simulation Engine by another application to stop the simulation clock.

2.4 Flights information

Any agent can ask the Simulation Engine to get the flight plan or update its content if necessary.

2.4.1 GetPln

Message: “GetPln MsgName Flight= From=now”

The response gives all information for the given flight with the message:

“Pln MsgName Flight= Time= CallSign= AircraftType= Ssr= Speed= Rfl= Dep= Arr= Rvsm= Tcas= Adsb= Dlink= Proc= Rwy= Pkg= PossibleTmos= PlannedTmo= Tibt= Tobt= Ctot= Ttot= Eta= List=”

2.4.2 SetPln

Any agent can update one or many flight plan data by sending this message:

Message form: “SetPln Flight= Time= PlannedTmo= Eta= Tibt= Tobt= Ttot= Ctot= Pkg= List=”

In this message, it just needs to fill the field to be updated.

2.4.3 SetSectorIn

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The SetSectorIn message is sent to Simulation Engine to set the sector or the frequencies of a given aircraft at a given time.

Message: “SetSectorIn Flight= Sector= Time=”

Simulation Engine will automatically send a SectorEvent if necessary (if the time is equal to the current simulation time).

2.5 Periodic messages

2.5.1 ClockEvent

The ClockEvent message is sent by Simulation Engine every second to notify all agents the current simulated time.

Message: “ClockEvent Time= Rate= Bs=0” where the time is the simulated time, rate is the rhythm of the simulation (=1 in normal simulation) and Bs=0 is corresponding to a normal simulation

2.5.2 TrackMovedEvent

The TrackMovedEvent is sent by Simulation Engine to notify the position and others information for a given flight at a given time. In our simulator, this message is automatically sent every second for all used flights.

Message: “TrackMovedEvent Flight= CallSign= Ssr= Sector= Layers= X= Y= Vx= Vy= Afl= Alti= Rate= Yaw= Pitch= Roll= GroundSpeed= Tendency= EdgeId= NextNode= DistNextNode= TlastNode= Time=”

with specific information needed for the routing dependant to the layout and the routing network (edge id, next node, distance to the next node, and the time where the aircraft passed the last node).

2.5.3 TrackDiedEvent

The TrackDiedEvent is sent by Simulation Engine automatically after a few seconds where the simulator has no more information about its position. For example, when a taxibot is attached to an aircraft, a track died event is send for this given taxibot.

Message: “TrackDiedEvent Flight=”

2.5.4 SectorEvent

The SectorEvent is automatically sent by Simulation Engine when the aircraft will change its sector or its frequency.

Message: “SectorEvent Flight= SectorOut= SectorIn=”

2.5.5 BeaconEvent

The BeaconEvent is automatically sent by Simulation Engine when an aircraft pass over a beacon (for an aircraft, it corresponds to a holding stop or a gate).

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Message: “BeaconEvent Flight= Beacon= Fl= Mode= Time=” where Fl is the flight level (0 on the airport), and mode is vertical or abeam (only useful for airborne a/c)

2.5.6 TaxiwayEvent

The TaxiwayEvent is automatically sent by Simulation Engine when an aircraft changes taxiways. This message is useful for A-SMGCS HMI to display this information.

Message: “TaxiwayEvent Flight= Taxiway=”

2.5.7 PlnEvent

The PlnEvent is automatically sent by Simulation Engine when the flight plan is changed, exactly after each SetPln received.

Message: “PlnEvent Flight= Time= CallSign= AircraftType= Ssr= Speed= Rfl= Dep= Arr= Rvsm= Tcas= Adsb= Dlink= Proc= Rwy= Pkg= PossibleTmos= PlannedTmo= Tibt= Tobt= Ctot= Ttot= Eta= List=”

2.5.8 TaxiMethodEvent

The TaxiMethodEvent is sent by Simulation Engine when the current taxi method changes during the simulation, e.g. when the pseudo pilot starts eTaxi.

Message: “TaxiMethodEvent Flight= TmoOld= TmoNew=”

2.6 Routing Messages

Some messages are used to communicate with the multi agent system to ask for path or others.

2.6.1 GetPath

The GetPath message is used to ask a path suggestion for a given flight from its position to a destination point via some points if the ATCO want to edit himself the path.

Message: “GetPath MsgName Flight= From= Via= To=”.

The ‘To’ field can be equal to ‘default’, meaning the routing has to find the best destination point depending to the traffic.

The response sent by the routing agent is defined as follow:

Response: “Path MsgName Flight= Path= TaxibotPoint= ToPoint=”

with TaxibotPoint is an id of a holding point where the taxibot will couple or decouple to the aircraft and ToPoint is an id of a destination holding point or id of a gate.

2.6.2 GetPushBackPath

The GetPushbackPath message is used to ask for the pushback path for a given flight from its gate.

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Message: “GetPushbackPath MsgName Flight= From=”.

The response sent by the routing agent is defined as follow:

Response: “Path MsgName Flight= Path=”

2.6.3 GetSpeedData

The GetSpeedData message is used to get the speed profile for a given aircraft.

Message: “GetSpeedData Flight=id data_mode=”

‘data_mode’ can either be ‘node’ or ‘profile’ depending on the desired format for the answer.

The response sent by the Routing agent is:

- For data_mode=nodes:

“SpeedData Flight= data_mode=nodes nodes=… t_nodes=… d_nodes=… v_nodes=…“

- For data_mode=profile:

“SpeedData Flight= data_mode=profile t_profile=… d_profile=… v_profile=… a_profile=…”

2.6.4 AircraftRouteValidated

The AircraftRouteValidated message is used to give the route cleared by ATCO for a given aircraft.

Message: “AircraftRouteValidated Flight= Airport= Stop= To= Edges=”

where ‘To’ is the id of the destination point.

2.6.5 GetTaxiTime

Any agent can ask the remaining taxiing time for a given aircraft for a given route.

Message: “GetTaxiTime MsgName= Flight= Route=”

The response sent by Simulation Engine or Routing Engine is defined as follow:

“TaxiTime MsgName Flight= Time=”

2.6.6 GetTaxiPerfo

Any agent can ask the ecological performances for a given aircraft for a given route.

Message: “GetTaxiPerfo MsgName Flight= Route= To=”

where the parameter ‘To’ must define the type of destination point (parking, parking_entry, runway_entry, deicing, transfer or undefined)

The response sent by Simulation Engine is defined as follow:

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"TaxiPerfo MsgName Flight= Time= Fuel= HC= CO= NOx="

2.7 A/C pilot orders

Some messages are used to modify aircraft behaviour in the simulation, all these messages are received and handled by Simulation Engine. When Simulation Engine processes a pilot orders, it recomputes the future positions of the given aircraft that will be sent in the TrackMovedEvent messages.

2.7.1 SetTaxiMethod

The SetTaxiMethod message is used to set the current taxiing method of a given flight.

Message: "SetTaxiMethod Flight= Tmo=".

After receiving this message, Simulation Engine sends a TaxiMethodEvent message described above.

2.7.2 AircraftTaxi

The AircraftTaxi message is sent to Simulation Engine to have an aircraft taxi on a given route.

Message: "AircraftTaxi Flight= Airport= Stop= To= Edges="

where 'Airport' is the airport of the given flight, 'Stop' is the final point on taxiing route, 'To' is the type of final point and 'Edges' the list of edges id defining the route to follow, read in the airport SVG map.

2.7.3 AircraftPushback

The AircraftPushback message is used to pilot an aircraft to taxi on its given pushback path.

Message: "AircraftPushback Flight= Airport= Stop= Edges="

where 'Airport' is the airport of the given flight, 'Stop' is the final point on taxiing route and 'Edges' the pushback route.

2.7.4 AircraftSpeedUp or AircraftSpeedDown

The AircraftSpeedUp and AircraftSpeedDown messages are used to speed up or speed down a given aircraft by step of one knot.

Message: "AircraftSpeedUp Flight=" or "AircraftSpeedDown Flight="

2.7.5 AircraftSetSpeed

The AircraftSetSpeed message is used to set the speed for a given aircraft to a specific speed.

Message: "AircraftSetSpeed Flight= Target="

2.7.6 AircraftStopTaxi

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The AircraftStopTaxi message is used to stop a given aircraft.

Message: “AircraftStopTaxi Flight=”

2.7.7 AircraftResumeTaxi

The AircraftResumeTaxi message is used to resume the route of a given aircraft after an AircraftStop message.

Message: “AircraftResumeTaxi Flight=”

2.7.8 AircraftLineUp

The AircraftLineUp message is used to line up a given aircraft on a specific runway.

Message: “AircraftLineUp Flight= Rwy=”

2.7.9 AircraftTakeOff

The AircraftTakeOff message is used to take off a given aircraft on a specific runway.

Message: “AircraftTakeOff Flight= Rwy=”

2.7.10 AircraftRollingTakeOff

The AircraftRollingTakeOff message is used to line up and take off a given aircraft on a specific runway.

Message: “AircraftRollingTakeOff Flight= Rwy=”

2.8 Tug drivers orders

Similarly to the pilot orders, the following messages concern the handling of tugs.

2.8.1 AttachAircraft

The AttachAircraft message is used to attach a taxibot to an aircraft.

Message: “AttachAircraft Flight= Tug=” with the flight id and the tug id.

2.8.2 AircraftAttaching

The AircraftAttaching message is sent to the out of the window view HMI, A-SMGCS and Fleet Manager HMI to start the animation of coupling.

Message: “AircraftAttaching Flight= Tug=”

2.8.3 AircraftAttached

The AircraftAttached messge is used to tell the aircraft is attached to the taxibot at the end of the coupling phase animation from the out of the window view HMI.

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Message: “AircraftAttached Flight= Tug=”

2.8.4 DetachAircraft

The DetachAircraft message is used to detach a taxibot from an aircraft.

Message: “DetachAircraft Flight= Tug=” with the flight id and the tug id.

2.8.5 AircraftDetaching

The AircraftDetaching message is sent to the out of the window view HMI, A-SMGCS and Fleet Manager HMI to start the animation of decoupling.

Message: “AircraftDetaching Flight= Tug= TugPosition=” with TugPosition the future position of the taxibot after decoupling phase.

2.8.6 AircraftDetached

The AircraftDetached is used to tell the aircraft is detached from the taxibot at the end of the decoupling phase animation from the out of the window view HMI.

Message: “AircraftDetached Flight= Tug= TugPosition=” with TugPosition the position of the taxibot after decoupling phase.

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3 Data logging

In addition to observations and manual counting of events by the team, the information to be logged during the final evaluation exercises are the following:

- Number of TaxiBots allocation changed by the Fleet Manager
- Number of routes validated by ATCO
- Number of changes in path suggestion by ATCO
- Number of communications exchanged (datalink, phone calls, radio) between ATCO, pilots and Fleet Manager
- Time spent on ATC and Pilot frequencies
- Duration of information exchange over radio b/w ATC and Pilot/drivers
- Duration of information exchange over telephone b/w ATCO and FM
- Number of Telephone communication b/w ATCO and FM
- Number of D/L communication b/w ATCO and FM
- Number of Radio communication b/w ATCO and Pilots
- Number of D/L communication b/w ATCO and Pilots
- Number of D/L communication b/w FM and Pilots/Tug Drivers
- Number of radio communication for each aircraft
- Percentage of time spent in frequency ATCO over the run
- Time spent by ATCOs on telephone
- Time spent by FM on telephone
- Number of speed target has been modified per aircraft (i.e. number of recomputations triggered by MAS algorithm)
- Number of speed target alerts
- Fuel consumption by aircraft
- CO2 emissions by aircraft
- NOx emissions by aircraft
- Average taxiing time per e-Taxi
- Average taxiing time per TaxiBots

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- Average taxiing time per SET
- Average taxiing time per DET
- Ratio engines off time / engines on time per aircraft
- Taxiways occupancy (average number of aircraft taxiing at the same time)

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