AIR TRAFFIC CONTROL SYSTEM

Software Design CW

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D0.

Acronyms

Throughout the report I will refer to various systems and actors by acronym. I have listed below all acronyms that will be used and their full title.

AIC – Air Controller	PDB – Pilots Database
APC – Approach Controller	FPDB – Flight Plan Database
GMC – Ground Movements Controller	FPL – Flight Plan Logging System
CMS – Command Messaging System	ATCC – Air Traffic Control Centre
FP – Flight Plan	CZ – Control Zone
WS – Weather Station	WR – Weather Report
ETA – Expected Time of Arrival	ATA – Actual Time of Arrival
ETD – Expected Time of Departure	ATD – Actual Time of Departure

Figure 1. – Acronyms

D1.

Assumptions

A.1 – All staff will be trained in the use of the CMS.

A.2 – Communications between internal systems are functioning correctly.

A.3 – CMS is functioning correctly.

A.4 – WS will include sensors to measure the weather.

A.5 – All times will be local time.

A.6 – APC will have present glide paths depending on wind direction.

A.7 – GMC always know the status of each gate .

A.8 – WS has a timer to send WR every 15 minutes.

A.9 – PDB system has a secure connection and is functioning correctly.

A.10 – FPDB system is functioning correctly.

A.11 – The APC, GMC and AIC are stationed at the ATCC.

A.12 – WR's are automatically transmitted from WS.

A.13 – APC is automatically alerted when aircraft enter the CZ.

A.14 – A day is a 24-hour period from 00:00 until 00:00.

A.15 – All aircraft will maintain safe separation with aid of APC.

All assumptions have impacted upon my design in various ways, firstly I assume all staff will be trained in the use of the Command Messaging System as well as assuming that the CMS System, FPDB and PDB will be functioning correctly as well as communications between internal systems such as APC and aircrafts onboard computers. I assume the WS will include sensors in order to measure the wind speed, direction, visibility and it also has a timer to record when to send WR's. I assume that a day is defined as midnight to midnight and that all times used will be the local time to the airport, this avoids confusion with ATA and ATD. I assume the APC will have set glide paths based on the wind direction, this avoids delays in the aircraft landing. I assume that GMC will always know the status of all gates (i.e. If they are available) this also avoids delays in the aircraft getting to their designated gate. All controllers will be stationed at the ATCC based at the airport, this aids communication and mitigates external factors such as weather influencing the communication between controllers. Finally, I also assume that APC is automatically alerted when an aircraft enters the CZ (Via pending eFPS).

D2.

Functional Requirements

ID	Description	Priority
FR.1	Flight Plan will be submitted before an aircraft enters controller airspace.	M
FR.2	Flight Plan Logging System will allow pilots to electronically log their Flight Plan.	M
FR.3	Flight Plan Logging System will automatically generate an electronic Flight Progress Strip.	M
FR.4	Flight Plan Database will hold all archived Flight Plans .	S
FR.5	Pilots Database will validate details.	S
FR.6	Approach Controller and Air Controller will use touch screens.	S
FR.7	All pilots will have a valid licence.	M
FR.8	Air Controller will have control over all aircraft within 3 miles of the runway.	M
FR.9	Flight Plan Database must archive the flight plan when it is complete.	M
FR.10	Air Controller must update the Actual Time of Arrival and Actual Time of Departure for all flights.	M
FR.11	Weather Station produces Weather Reports	S
FR.12	All staff must be trained in the use of the secondary communication method.	S
FR.13	Approach Controller must have a secure connection to all aircraft computers.	M
FR.14	Command Messaging System must be the primary form of communication.	M
FR.15	Approach Controller and Air Controller manage the electronic Flight Progress Strip.	M
FR.16	Pilots communicate with systems via the Command Messaging System.	S

Figure 2. – Functional Requirements

Non-Functional Requirements

ID	Description
NFR.1	Command Messaging System will be available 24 hours per day.
NFR.2	Flight Plan Database will have expandable storage.
NFR.3	Weather Station will be available 24 hours per day
NFR.4	Pilots database will be online 24 hours per day.
NFR.5	Flight Plan Database will be online 24 hours per day.
NFR.6	Weather Station will have expandable storage for Weather Reports.

Figure 3. – Non-functional requirments

D3.

Use Cases

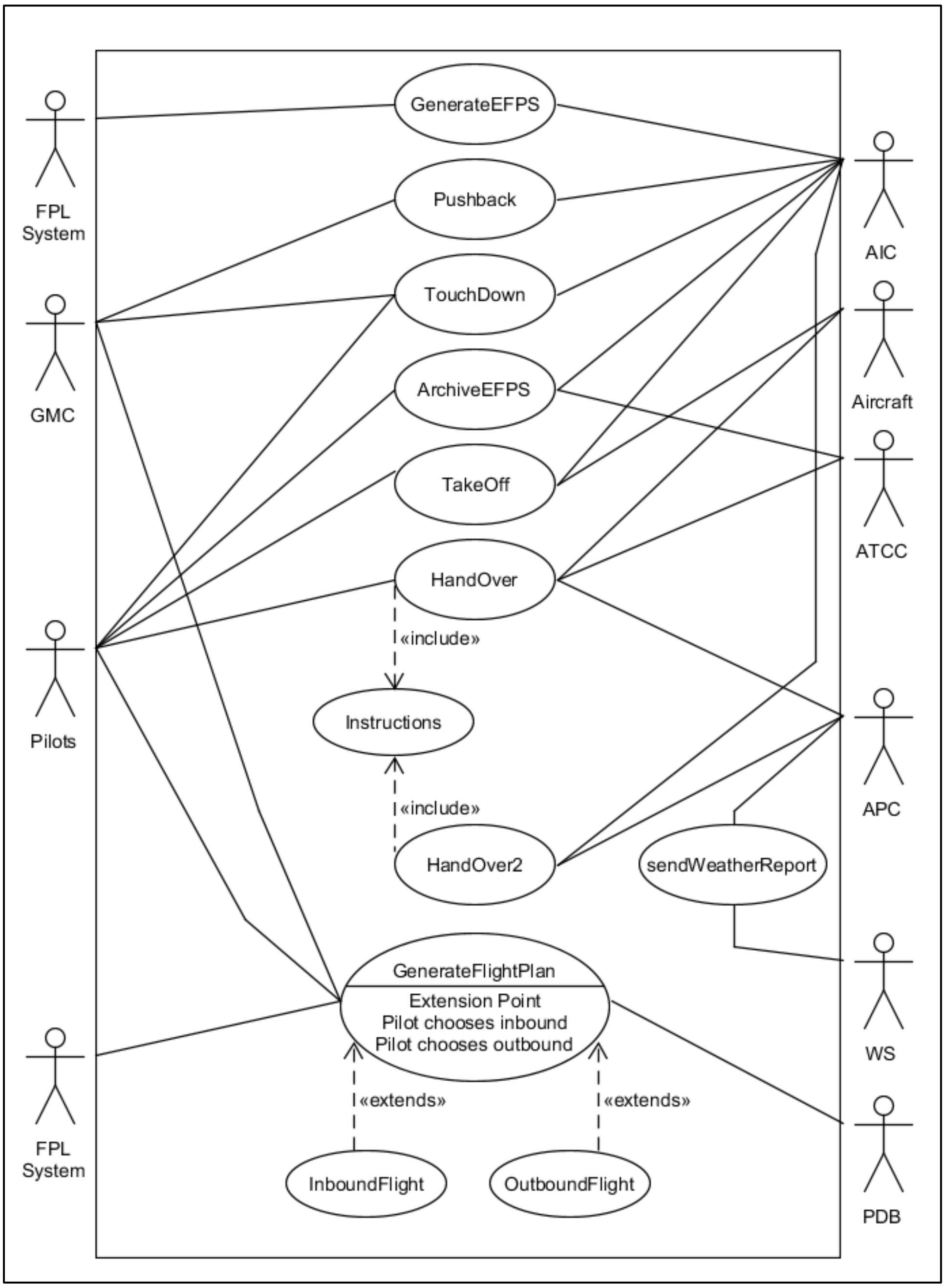

Figure 4. – Use Case Diagram

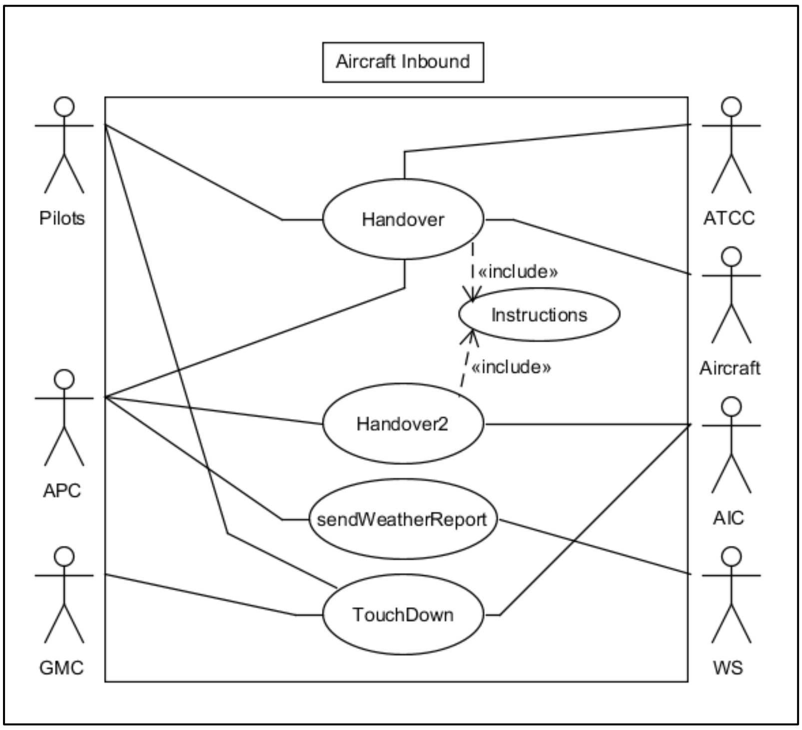

Figure 5. – Use Case Diagram (Inbound)

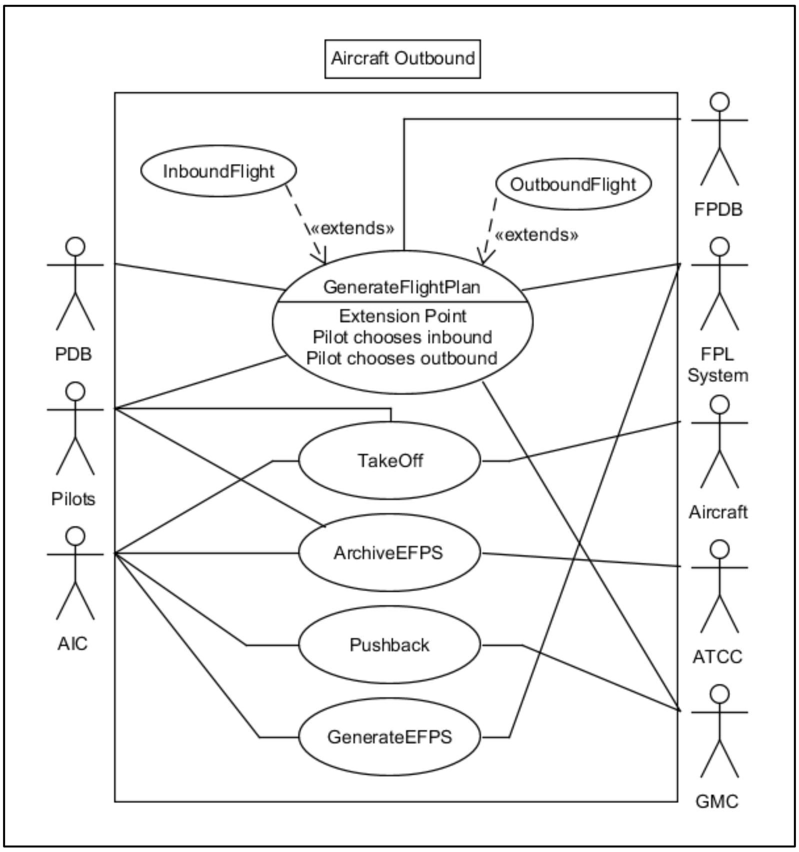

Figure 6. – Use Case Diagram (Outbound)

Use Case: GenerateFlightPlan
ID: 1
Goal: Log FP
Primary actor: Pilot
Secondary actor(s): FPL System, PDB, GMC, FPDB
Preconditions: *1. FPL System is functioning correctly* *2. PDB is functioning correctly* *3. FPDB Is functioning correctly*
Postconditions: *1. FP completed successfully*
Main flow: *1. Pilot awakens FPL system* *2. FPL system requests pilots name* *3. Pilot provides name* *4. FPL system requests pilots licence details* *5. Pilot provides licence details* *6. Pilot details are validated via PDB* *7. FPL system requests pilot to provide Aircraft Type* *8. Pilot provides Aircraft Type* *9. FPL system requests pilot to provide Call Sign* *10. Pilot provide Call Sign* *11. FPL system requests pilot to provide Altitude* *12. Pilot provides Altitude* *13. FPL system requests pilot to provide Gate Number* *14. GMC automatically provides Gate Number* *15. FPL system requests pilot to choose inbound or outbound* *Extension Point: Pilot chooses inbound* *Extension Point: Pilot chooses outbound* *16. Flight Plan is completed* *17. Flight Plan is archived to FPDB*
Alternative flows: *6a. Pilots details are not valid* *1. FPL system reports an invalid details error to pilot* *2. Return to step 4 of main flow*

Figure 7. – Use Case Templete (GenerateFlightPlan)

Extension Use Case: InboundFlight
ID: **2**
Goal: **Log Flight Plan for inbound flight**
Primary actor: **Pilot**
Secondary actor(s): **FPL system**
Segment Preconditions: ***1. FPL System is functioning correctly***
Segment Postconditions: ***1. Inbound Flight Plan completed successfully***
Segment flow: ***1. FPL system requests pilot to provide airspeed*** ***2. Pilot provides airspeed*** ***3. FPL system requests pilot to provide Expected Time of Arrival (ETA)*** ***4. Pilot provides ETA***

Figure 8. – Use Case Templete (InboundFlight)

Extension Use Case: OutboundFlight
ID: **3**
Goal: **Log Flight Plan for outbound flight**
Primary actor: **Pilot**
Secondary actor(s): **FPL system**
Segment Preconditions: ***1. FPL System is functioning correctly***
Segment Postconditions: ***1. Outbound Flight Plan completed successfully***
Segment flow: ***1. FPL system requests pilot to provide route information*** ***2. Pilot provides route information*** ***3. FPL system requests pilot to provide Expected Time of Departure (ETD)*** ***4. Pilot provides ETD***

Figure 9. – Use Case Templete (OutboundFlight)

Use Case: PushBack
ID: 4
Goal: Allow the aircraft to push back from gate
Primary actor: AIC
Secondary actor(s): GMC, Pilots
Preconditions: *1. CMS is functioning correctly* 2. Pilot have communicated their readiness
Postconditions: *1. Aircraft successfully pushes back from gate*
Main flow: *1. Pilots communicate their readiness via CMS* *2. GMC receives communication pilots* *3. GMC communicates to AIC via CMS* *4. AIC receives communication from GMC* *5. AIC assesses readiness for pushback* *6. AIC instruct GMC to allow aircraft to pushback from gate*
Alternative flows: *2a. GMC does not receive communication Pilots* *1. Pilots wait for conformation of received communication* *2. Return to step 1 of main flow* *4a. AIC does not receive communication from GMC* *1. GMC waits for conformation of received communication* *2. Return to step 3 of main flow* *5a. AIC is not ready to authorise pushback* *1. AIC waits and further assesses readiness for pushback* *2. Return to step 5 of main flow*

Figure 10. – Use Case Templete (PushBack)

Use Case: TakeOff
ID: 5
Goal: Aircraft takes off
Primary actor: AIC
Secondary actor(s): Aircraft, AIC
Preconditions: *1. Aircraft is at holding area* 2. CMS is functioning correctly
Postconditions: *1. Aircraft takes off*
Main flow: *1. AIC takes over direct control of the aircraft* *2. Aircraft departure slot arrives* *3. AIC instructs pilots to taxi to end of runway via CMS* *4. AIC gives final take-off clearance via CMS* *5. Aircraft takes off*
Alternative flows: *2a. Aircraft departure slot does not arrive* *1. AIC waits for departure slot to arrive* *2. Return to step 2 of the main flow*

Figure 11. – Use Case Templete (TakeOff)

Use Case: ArchiveEFPS
ID: 6
Goal: Archive eFPS
Primary actor: AIC
Secondary actor(s): ATCC, Pilots
Preconditions: *1. CMS is functioning correctly* 2. Aircraft is airborne 3. AIC system is functioning correctly
Postconditions: *1. eFPS is successfully archived*
Main flow: *1. AIC records the ATD on the eFPS using AIC system* *2. AIC requests Pilots to contact ATCC using CMS* *3. AIC sends copy to eFPS to ATCC* *4. AIC tags eFPS as archived*
Alternative flows: None

Figure 12. – Use Case Templete (ArchiveEFPS)

Use Case: GenerateEFPS
ID: 7
Goal: Generate eFPS
Primary actor: FPL system
Secondary actor(s): AIC
Preconditions: *1. Flight Plan has been completed* *2. FPL system is functioning correctly* *3. FPDB is functioning correctly*
Postconditions: *1. eFPS is successfully generated*
Main flow: *1. Flight Plan is achieved to FPDB* *2. eFPS is automatically generated by FPL System* *3. eFPS is sent to AIC system* *4. eFPS is set as pending*
Alternative flows: None

Figure 13. – Use Case Templete (GenerateEFPS)

Use Case: Handover
ID: 8
Goal: Handover between ATCC and APC for an inbound aircraft
Primary actor: ATCC
Secondary actor(s): APC, Pilots, Aircraft
Preconditions: *1. CMS is functioning correctly* 2. Aircraft is inbound to the CZ
Postconditions: *1. Handover between ATCC and APC is successful*
Main flow: *1. ATCC send inbound aircrafts eFPS to the APC system* *2. APC is alerted of inbound aircraft via pending eFPS* *3. ATCC instructs Pilots to contact APC* *4. Contact between Pilots and APC is established via CMS* *5. APC provides Pilots with directional information to locate glide path for runway* *6. Include(Instructions)*
Alternative flows: *4a. Contact is not established between Pilots and APC* *1. APC waits for contact from Pilots* *2. Return to step 3 of main flow*

Figure 14. – Use Case Templete (Handover)

Use Case: SendWeatherReport
ID: 9
Goal: Generate and send Weather Report
Primary actor: Weather Station
Secondary actor(s): APC system
Preconditions: ***1. Weather Station is functioning correctly***   ***2. APC system is functioning correctly***
Postconditions: ***1. Weather Report is sent successfully***
Main flow: ***1. Wind speed is recorded by Weather Station (WS)***   ***2. Wind direction is recorded by WS***   ***3. Visibility is recorded by WS***   ***4. Weather Report (WR) is generated by WS***   ***5. WR is sent to APC system***
Alternative flows: None

Figure 15. – Use Case Templete (SendWeatherReport)

Use Case: Handover2
ID: 10
Goal: Handover from APC to AIC
Primary actor: APC
Secondary actor(s): AIC, Pilots, Aircraft
Preconditions: *1. CMS is functioning correctly* *2. Aircraft is coming onto final approach*
Postconditions: *1. Handover between APC and AIC is successful*
Main flow: *1. APC sends inbound aircrafts eFPS to AIC system* *2. AIC is alerted of inbound aircraft via pending eFPS* *3. APC instructs Pilots to contact AIC* *4. Contact between Pilots and AIC is established via CMS* *5. Include(Instructions)*
Alternative flows: *4a. Contact is not established between Pilots and AIC* *1. AIC waits for contact from Pilots* *2. Return to step 3 of main flow*

Figure 16. – Use Case Templete (Handover2)

Use Case: Instructions
ID: 11
Goal: Log instructions on eFPS
Primary actor: APC/ATCC
Secondary actor(s): APC, AIC
Preconditions: *1. Weather Station is functioning correctly* *2. APC system is functioning correctly* *3. AIC system is functioning correctly*
Postconditions: *1. Instructions are successfully logged on aircrafts eFPS*
Main flow: *1. Weather Report (WR) is sent to Aircraft* *2. Altitude instructions are logged on Aircrafts eFPS* *3. Airspeed instructions are logged on Aircrafts eFPS*
Alternative flows: None

Figure 17. – Use Case Templete (Instructions)

Use Case: TouchDown
ID: 12
Goal: Aircraft arrives at gate
Primary actor: AIC
Secondary actor(s): GMC, Pilots
Preconditions: *1. CMS is functioning correctly* *2. AIC System is functioning correctly* *3. Aircraft is ready to touch down*
Postconditions: *1. Aircraft arrives at gate successfully*
Main flow: *1. AIC contacts GMC via CMS* *2. Contact is established between AIC and GMC via CMS* *3. AIC requests gate number from GMC* *4. Gate number is logged on aircrafts eFPS by GMC* *5. Aircraft touches down* *6. AIC logs aircrafts ATA on eFPS* *7. AIC contacts Pilots via CMS* *8. Contact is established between AIC and Pilots* *9. AIC advices Pilots of their allocated gate* *10. eFPS is archived*
Alternative flows: *2a. Contact is not established between AIC and GMC via CMS* *1. GMC waits for contact from AIC on secondary communication* *2. Return to step 3 of main flow* *5a. Aircraft cannot land* *1. Aircraft is instructed to overshoot* *2. AIC hands aircraft back to APC* *3. Return to step 5 of main flow* *5a. Contact is not established between AIC and Pilots* *1. Pilots wait for contact from AIC* *2. Return to step 7 of main flow*

Figure 18. – Use Case Templete (TouchDown)

Traceability Matrix

	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9	UC10	UC11	UC12
FR.1	X	X	X				X					
FR.2	X	X	X				X					
FR.3					X	X	X	X		X	X	X
FR.4	X	X	X				X					
FR.5	X	X	X				X					
FR.6				X	X	X		X				
FR.7	X	X	X				X					
FR.8				X	X	X				X	X	
FR.9	X	X	X				X					
FR.10						X						X
FR.11									X		X	
FR.12				X	X	X		X				
FR.13										X		
FR.14				X		X		X		X		X
FR.15						X				X	X	
FR.16				X	X	X		X		X		X

Figure 19. – Traceability Matrix

D4.

Class Responsibility Collaborator

Class:	Flight Plan Logging System
Responsibilities	**Collaborators**
Obtaining pilot name	Pilot
Obtaining pilot licence details	Pilot
Validating pilots' details	Flight Plan Database
Obtaining aircraft type	Aircraft
Obtaining call sign	Aircraft
Obtaining altitude	eFPS
Obtaining gate number	eFPS
Obtaining airspeed	eFPS
Obtaining ETA	eFPS
Obtaining route information	eFPS
Obtaining ETD	eFPS
Generating eFPS	
Archiving flight plan	Flight Plan Database

Figure 20. – CRC (Flight Plan Logging System)

Class:	Pilot
Responsibilities	**Collaborators**
Knows pilot's name	
Knows pilot's licence details	

Figure 21. – CRC (Pilot)

Class:	Aircraft
Responsibilities	**Collaborators**
Knows aircraft call sign	
Knows aircraft type	

Figure 22. – CRC (Aircraft)

D5.

Class Diagram

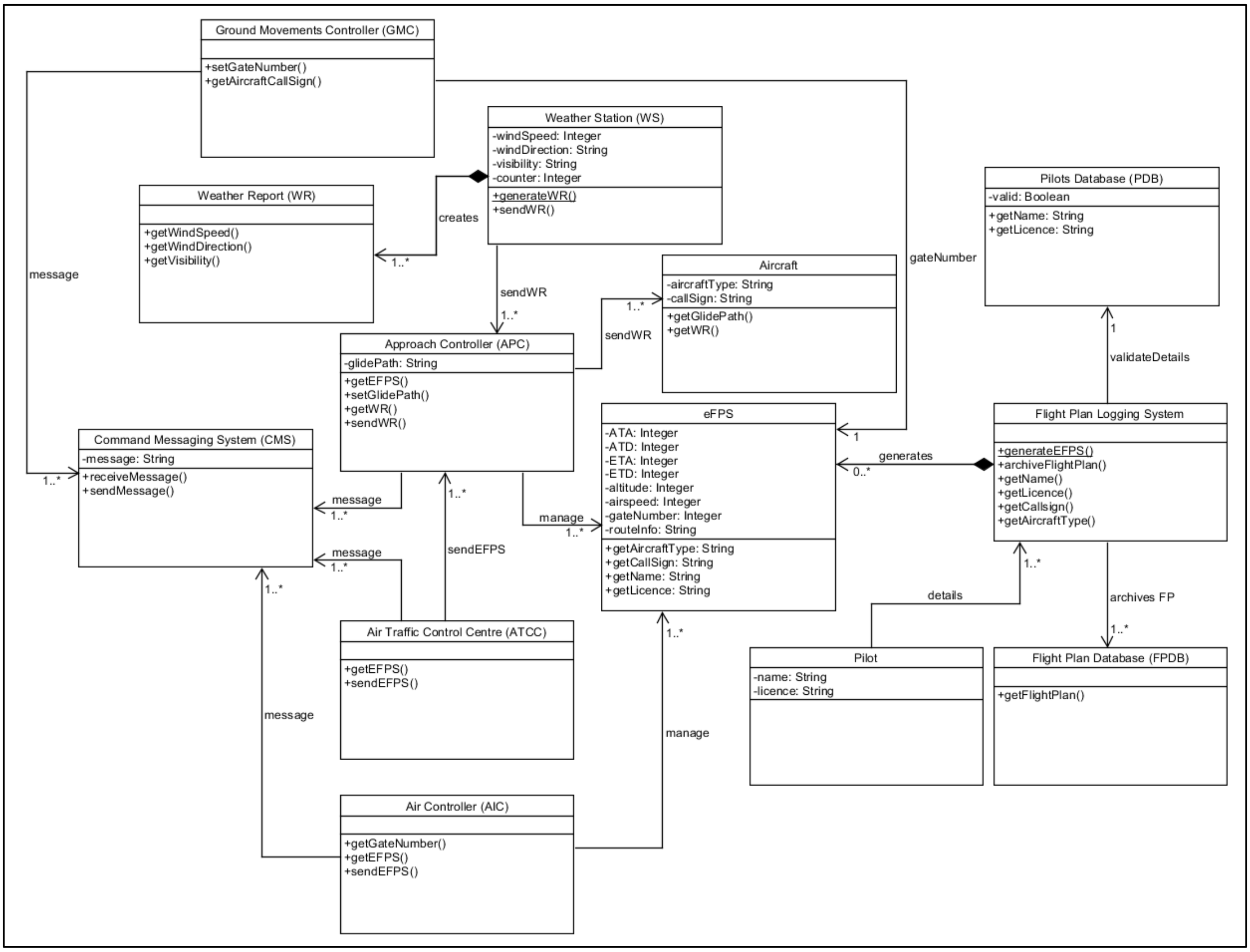

Figure 23. – Class Diagram

1. The composition relationship (denoted by a black diamond) is used to indicated the tight association between the FPL System class and the eFPS class. That is that the eFPS cannot exist without the FPL class.
2. The composition relationship is used to indicate the tight association between the WS class and the WR class. That is that the WR cannot exist without the WS class.
3. Pilot class has a unique identifier (String) licence.

D6.

Sequence Diagrams

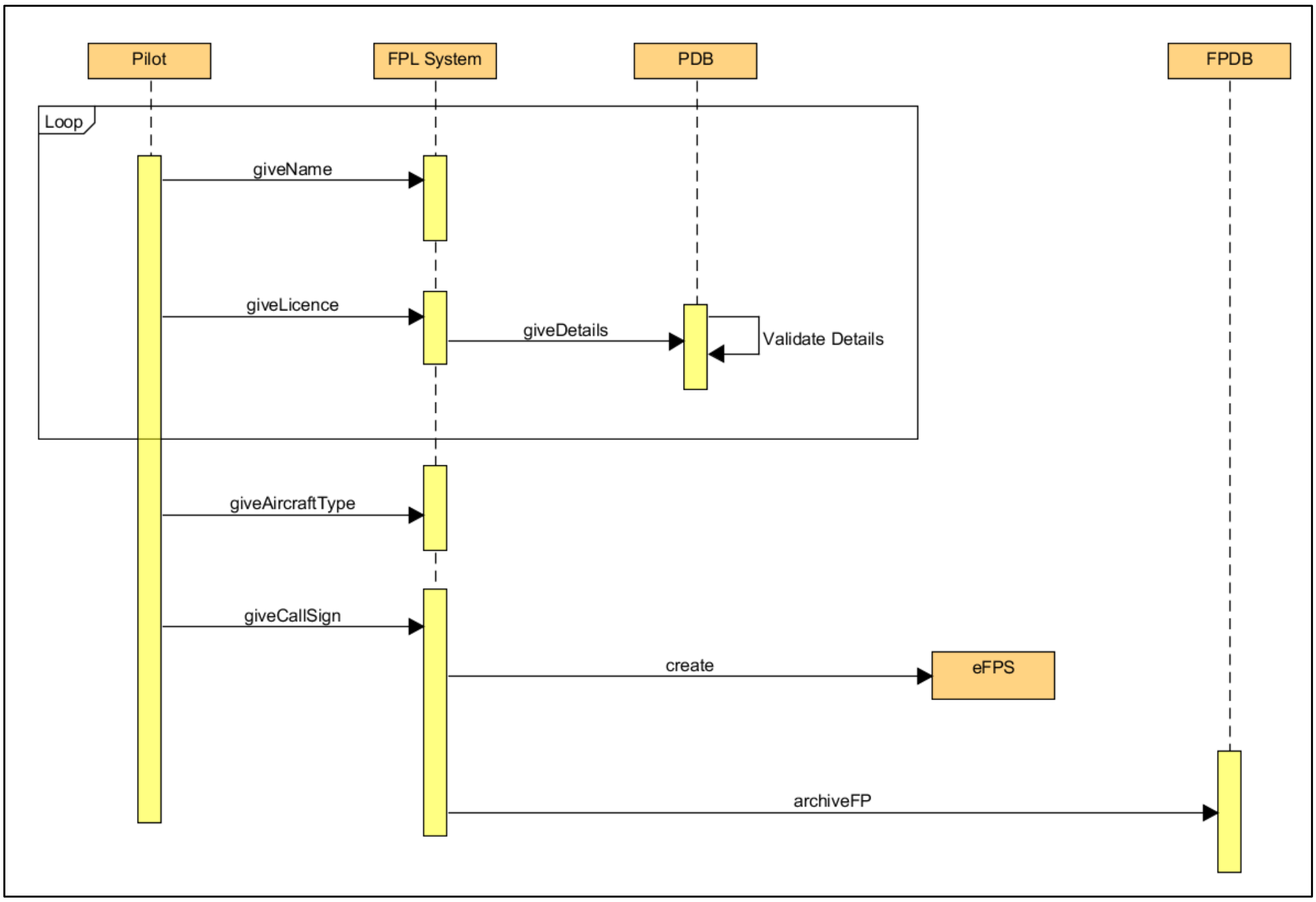

Figure 24. – Sequence Diagram (Generate eFPS)

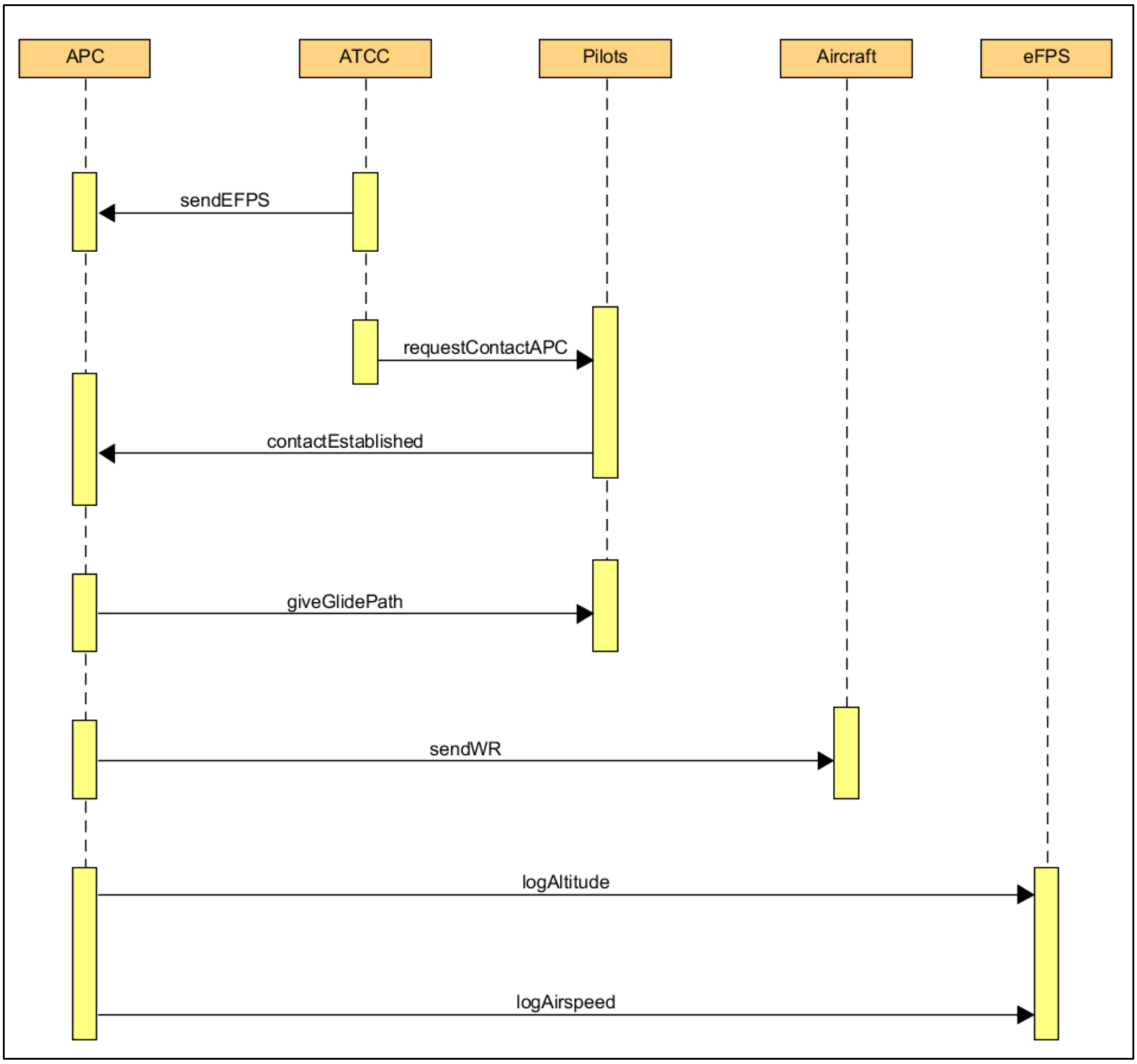

Figure 25. – Sequence Diagram (Handover)

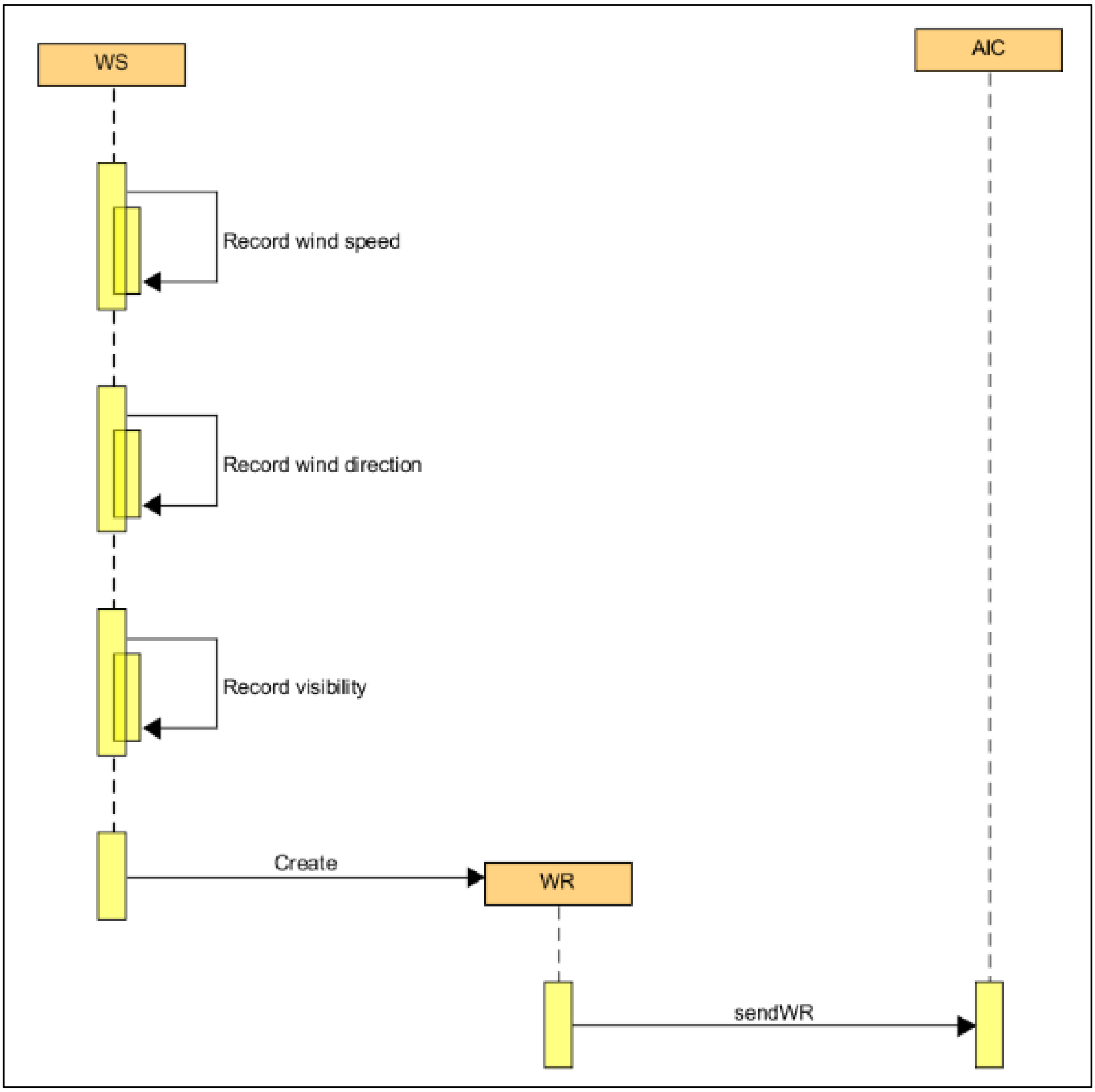

Figure 26. – Sequence Diagram (sendWeatherReport)

D7.

Activity Diagrams

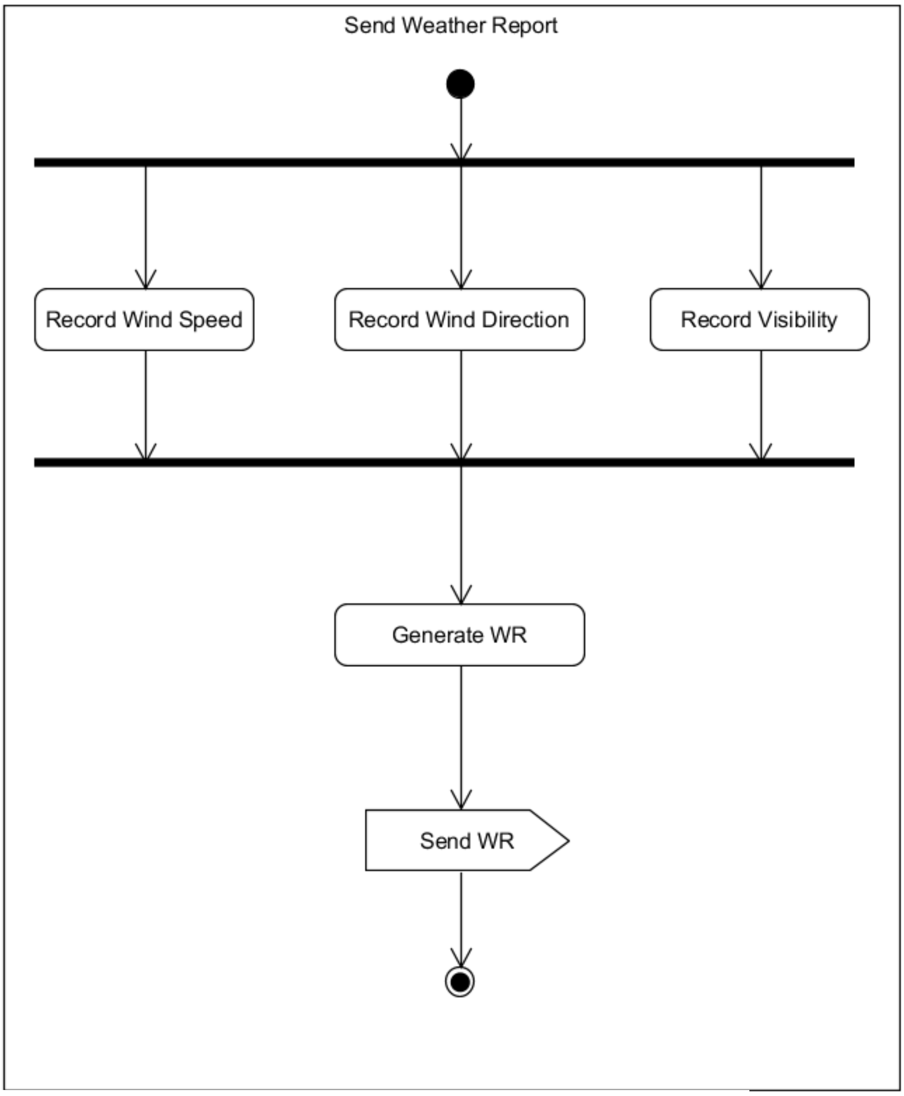

Figure 27. – Activity Diagram (Send Weather Report)

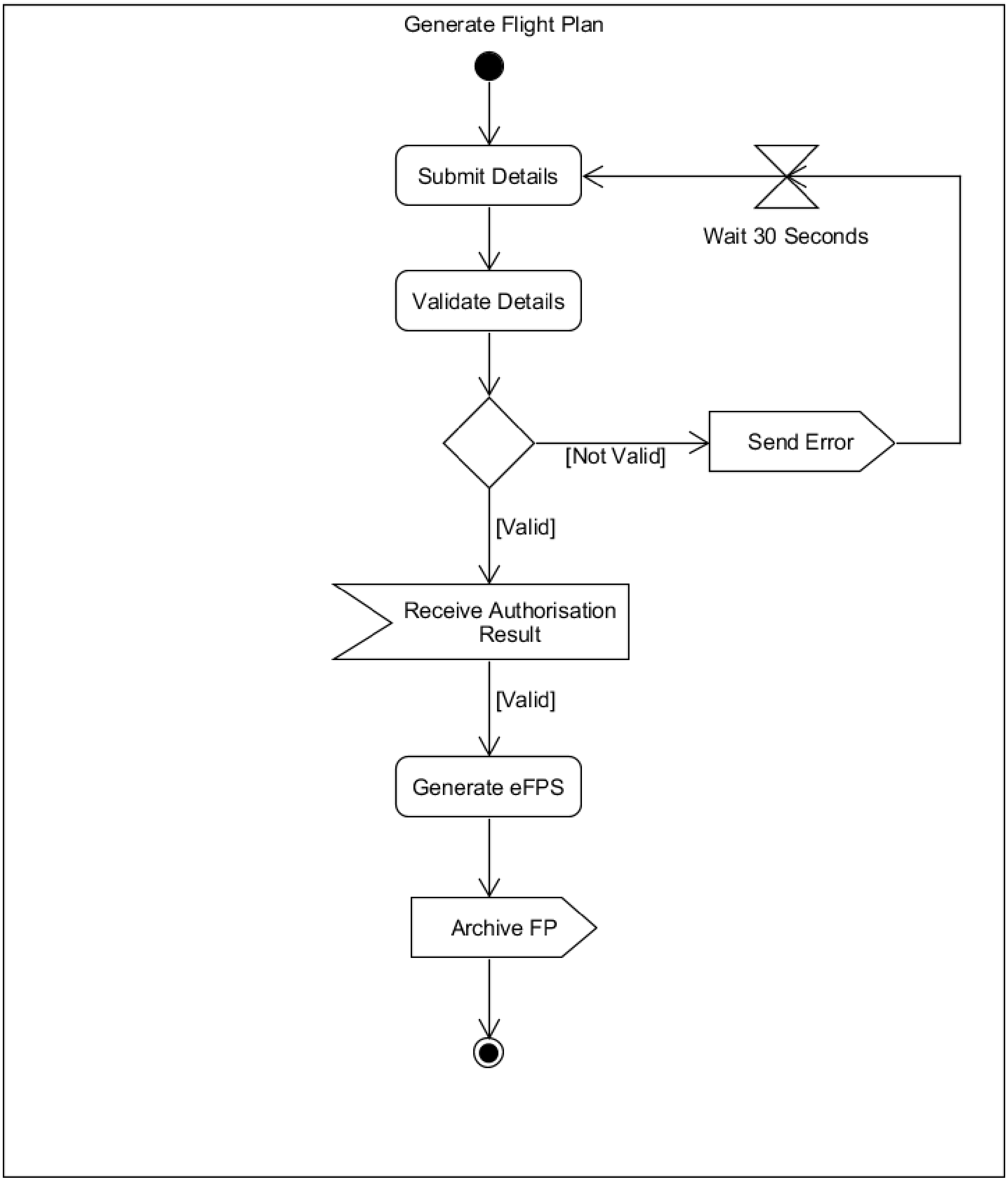

Figure 28. – Activity Diagram (Generate Flight Plan)

D8.

State Machine Diagram

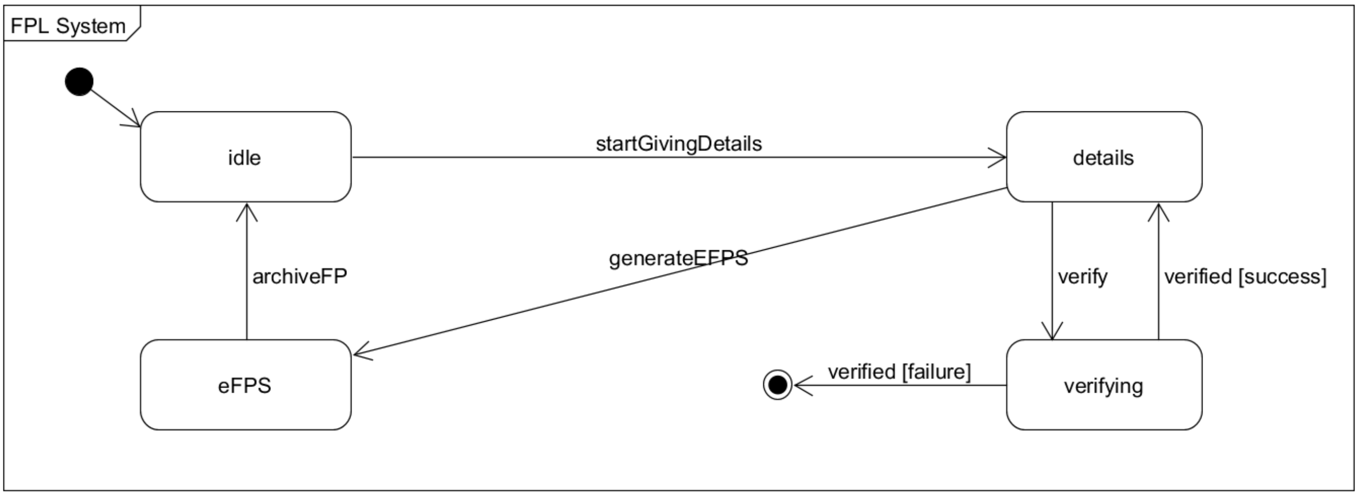

Figure 29. – State Machine (FPL System)

D9.

Strength & Limitations

My implementation of the ATC system has various strength and limitations. Firstly the strengths of the system are its efficiency and error handling, this can be shown through the assumptions that I have based the system on, having the APC using set glide paths allows for great error handling and efficiently, it will reduce the amount of aircraft having to overshoot or be put in the holding stack, in the case of a sudden weather change the APC can quickly change to a different pre-defined glide path based on the new weather rather than have to wait to calculate a glide path from scratch. Another strength of the system is the GMC knowing the status of all gates at all times, this reduces the need for extra communication between the GMC and airport staff when finding out if a gate is free to off/on load passengers or cargo. It also allows for quick maintenance reporting if there is a failure at one of the gates, it can be quickly set to ‘unavailable’ and avoids the scenario of an aircraft arriving at a gate that is not able to let passengers off. Finally, another strength of my ATC system is it has a scalable Pilots Database, allowing for both a secure connection in order to validate confidential pilot details as well as scalability allowing for the addition of unlimited pilots based on the storage capacity of the Pilots Database. One limitation of my ATC system is it is designed around having only staff member per controller (i.e. There is 1 APC, 1 AIC, 1 GMC), this keeps the system simple and efficient on a small scale however it can offer some problems when trying to scale the ATC system up to a large airport that has multiple controllers for each job.