Airport Departure Flow Management System
(ADFMS)

Architecture

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Table of Contents

1. Operational Architecture 1
- **1.1 Purpose:** 1
- **1.2 Viewpoint:** 1
- **1.3 Scope:** 1
- **1.4 Organizational Relationship:** 1
- **1.5 Class Diagram:** 2
- **1.6 Operational Concept:** 3
- **1.7 Use Cases:** 4
- **1.8 Operational Activity Diagrams:** 8
- **1.9 Operational Rules Model** 14
- **1.10 Operational State Charts** 14

2. Systems Architecture 17
- **2.1 Long Term Scheduling and Initial Slot Assignment** 17
- **2.2 Near Term Scheduling and Flight Management** 18
- **2.3 Flight Rescheduling** 19
- **2.4 Sequence Diagrams** 20
- **2.5 Fallback Due to a Lack of Trade for a Later Slot** 21
- **2.6 Create Long Term Schedule** 22
- **2.7 Trade for Earlier Departure Slot** 23
- **2.8 Trade for Later Departure** 24
- **2.9 State Charts** 25
- **2.10 Class Diagram** 27

3. Structured Analysis 28
- **3.1 External Diagram** 28
- **3.2 A-0 Diagram** 28
- **3.3 A0 Diagram** 29
- **3.4 A1 Diagram** 30
- **3.5 A2 Diagram** 31
- **3.6 A3 Diagram** 32
- **3.7 A4 Diagram** 33

1. Operational Architecture

1.1 Purpose:

The purpose for this architecture is to assist in developing a design to implement a departure slot reservation and queuing system for airplane departures from Philadelphia International Airport (PHL).

1.2 Viewpoint:

The viewpoint is that of the airport operations manager who understands the management of airplanes around the airport and the detailed operations of the airport.

1.3 Scope:

Operational and Systems Architecture

1.4 Organizational Relationship:

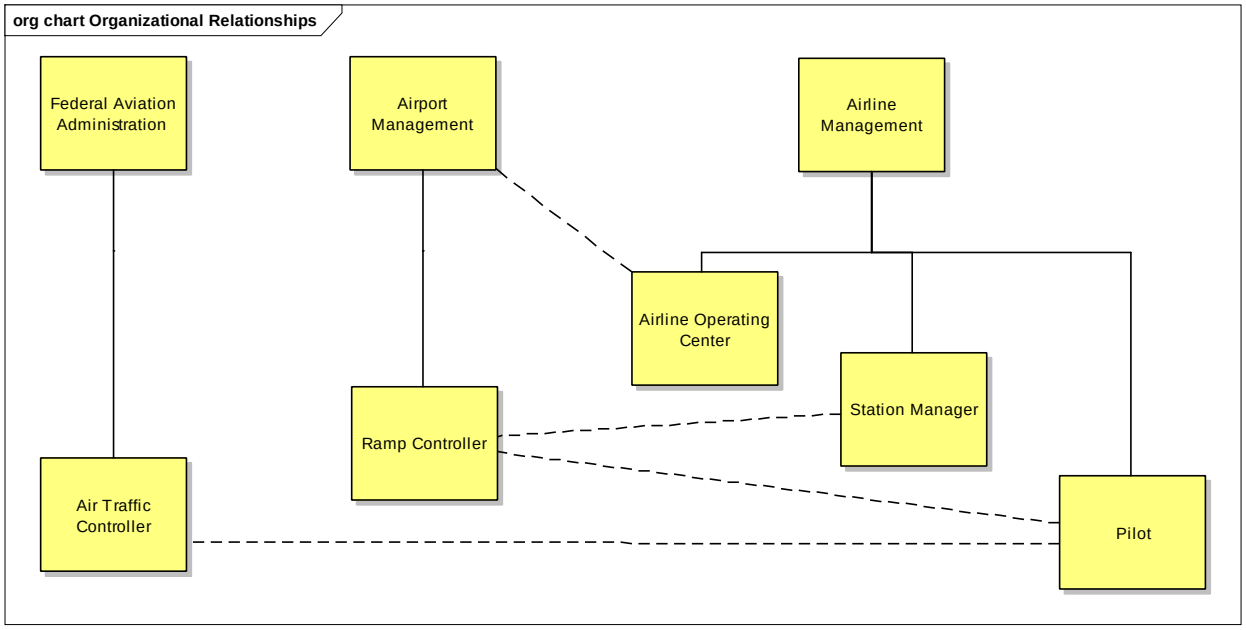


Figure 1 Organizational Relationship

1.5 Class Diagram:

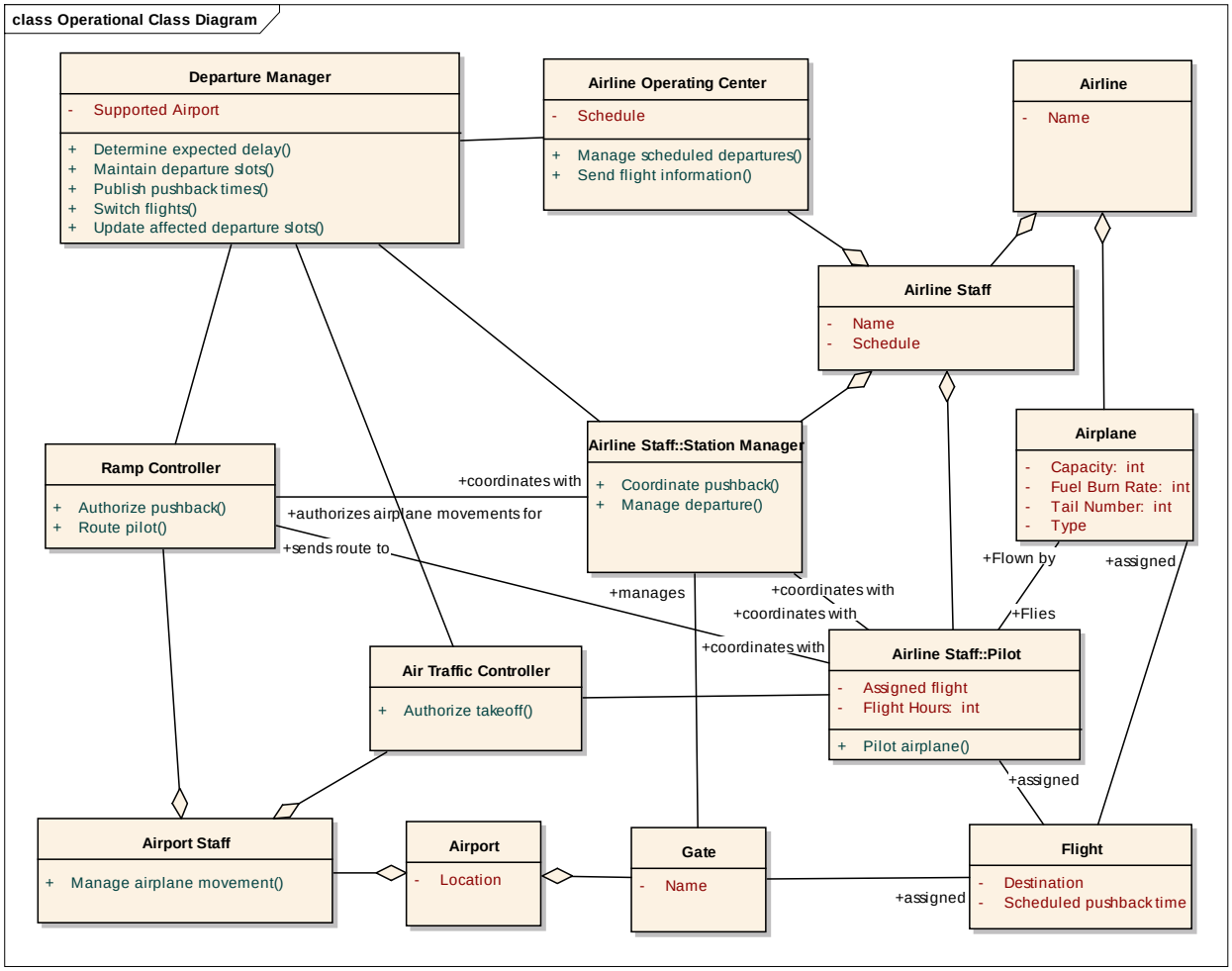


Figure 2 Operational Class Diagram

1.6 Operational Concept:

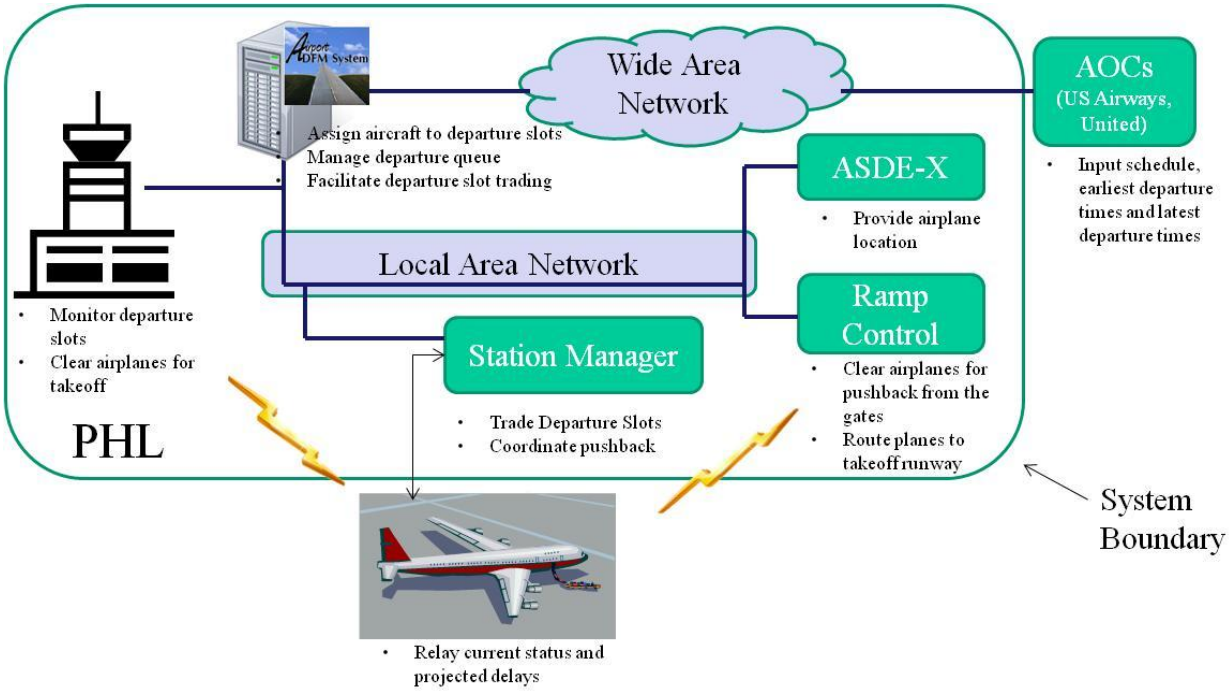


Figure 3 Operational Concept

- Airlines reserve departure slots at the airport based on their flight schedules. ADFMS uses information about ramp use and gate to runway taxi times to compute when the plane should push back for departure to meet its departure slot time.
- Departure slot information and expected pushback times are used by Station Managers and Ramp Control to manage aircraft departures.
- If a flight is running late for mechanical or other problems then the airline can trade the departure slot for a later departure slot.
- ADFMS tracks the airplanes that it is projected to release from each ramp in order to account for ramp congestion.
- ADFMS accounts for taxiway congestion when calculating the proper pushback time.

1.7 Use Cases:

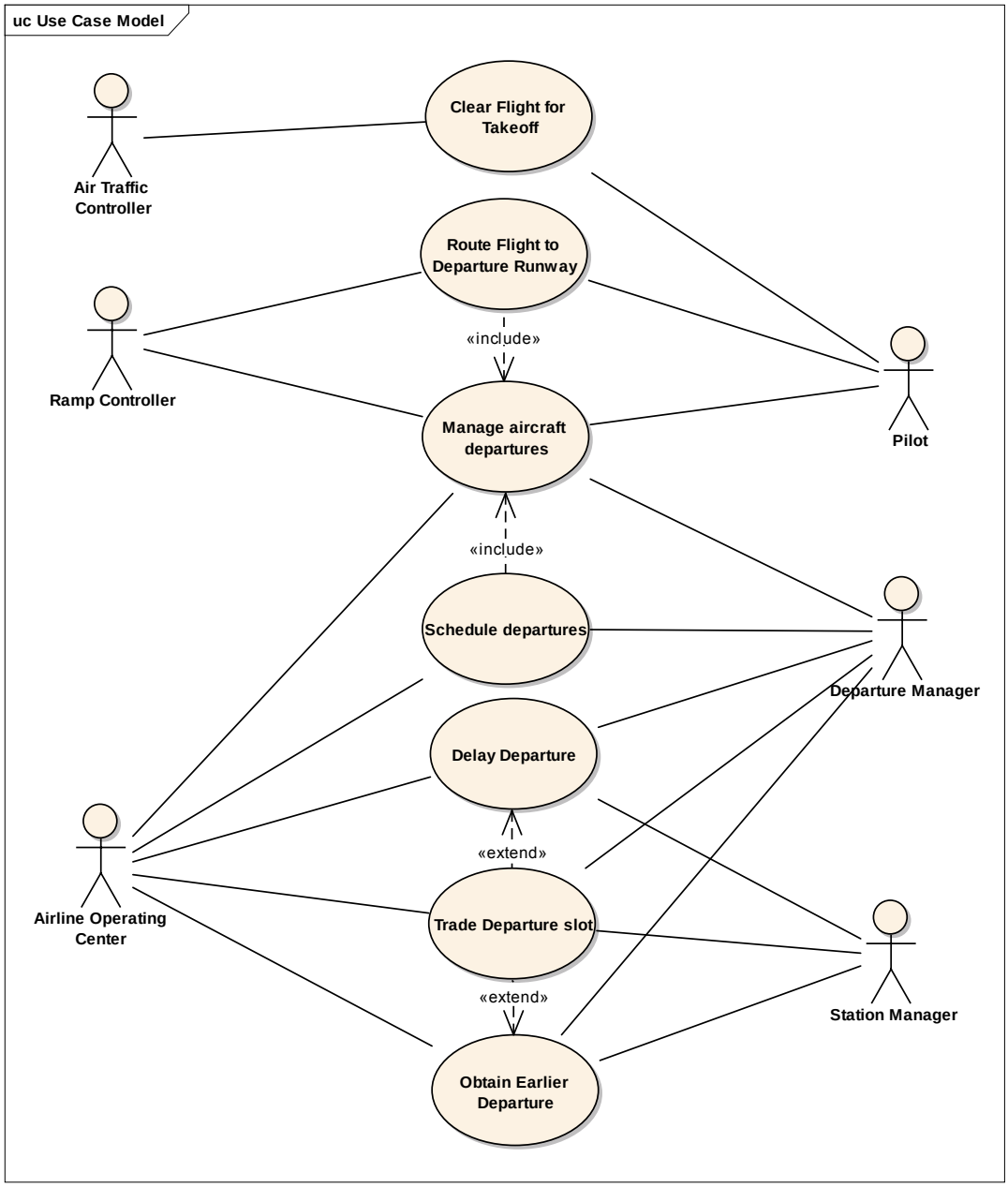


Figure 4 Use Case Diagram

Use Case: Manage airplane departures.

Precondition: Airline schedule available for input

Actors: Airline Operating Center, Ramp Controller, Pilot, Station Manager

Goal Level: Above Sea Level

1. Airline Operating Center calculates preliminary schedule and requests departure slots.
2. Departure manager assigns departure slots.
3. The Station Manager assigns gates to the flights.
4. Departure manager calculates expected pushback times.
5. Ramp Controller contacts pilot for pushback based on expected pushback times.
6. Pilot proceeds to departure runway based on Ramp Controller instructions.
7. Pilot contacts air traffic control for departure.

Post-condition: Airplane ready for departure.

Use Case: Attempt to secure a later departure slot

Pre-condition: Flight needs to be delayed

Actors: Station Manager #1, Station Manager #2 (or Airline Operating Center depending on timeframe)

Goal Level: Sea Level

Main Success Scenario

1. Station Manager #1 selects the affected flight and inputs a scheduled pushback time and earliest and latest wheels up time.
2. Departure manager reviews empty departure slots and selects the closest available, minimizing the difference between the expected push back time and the scheduled push back time.
3. Departure manager places a reservation in the departure slot and keeps the other slot information to see if another airline wishes to trade.
4. Departure manager places a sell order for the original departure slot.
5. Departure manager sends the departure slot and expected push back time.
6. Station Manager #1 accepts the new departure slot.
7. Upon reaching the scheduled pushback time associated with the original reservation, Departure manager removes the reservation if it still exists.

Main Success Scenario Extensions:

2a. An empty departure slot is established by shifting the schedule. (All departure slots move forward one slot creating an open slot for the aircraft)

1. Departure manager sends new schedule to Station Managers.

2b. Later departure slot is not available within the requested time window.

1. Departure manager assigns the next closest slot.
2. Departure manager notifies Station Manager #1 of the new slot. (Station Manager can now try to buy an earlier slot).

4a. Station Manager #2 in interested in the available departure slot

1. Station Manager #2 logs selects departure slot sale.
2. Station Manager #2 the flight to move to an earlier departure slot.
3. Departure manager switches the flights and calculates updated pushback times.

Post-condition: departure slot is updated based on delay.

Use Case: Attempt to secure an earlier departure slot

Pre-condition: Flight is able to leave earlier than scheduled

Actors: Station Manager #1, Station Manager #2 (or Airline Operating Center depending on timeframe)

Goal Level: Sea Level

Main Success Scenario

1. Station Manager #1 selects the affected flight and inputs a scheduled pushback time and earliest and latest wheels up time.
2. Departure manager reviews empty departure slots and selects the closest available, minimizing the difference between the expected push back time and the scheduled push back time.
3. Departure manager sends the departure slot and expected push back time.
4. Station Manager #1 accepts the information.

Main Success Scenario Extensions:

2a. Primary departure slots filled but next best is acceptable

1. Departure manager determines that all departure slots are filled for the desired time.
2. Departure manager sends the two best available options based on latest departure time and scheduled departure time. Departure manager also sends the option to enter a buy option along with the airline point total and price for the move.
3. Station Manager #1 selects a best available option

2b. Airline Operating Center selects the buy option

1. Departure manager determines that all departure slots are filled for the desired time.
2. Departure manager sends the two best available options based on latest departure time and scheduled departure time. ADFMS also displays the option to enter a buy option along with the airline point total and price for the move.
3. Station Manager #1 selects the buy option
4. Departure manager notifies all PHL users of the buy option
5. Station Manager #2 accepts the buy option
6. Departure manager switches the flights assigned to the departure slots and conducts the point transaction.

Use Case: Taxi Airplane

Pre-condition: Airplane is ready for pushback.

Actors: Station Manager, Ramp Controller, Pilot

Goal Level: Sea Level

Main Success Scenario

1. Station Manager tells Ramp Control that flight is prepared for pushback.
2. ADFMS notifies Ramp Controller than a flight needs to pushback.
3. Ramp Controller examines ramp and clears airplane for push back from gate.
4. Plane is pushed from gate by ground crew.
5. Ramp Controller clears airplane to the end of the ramp.
6. Ground controller sends the pilot directions to reach the takeoff runway.
7. Pilot takes plane to the takeoff runway following ground controller instructions.
8. Ground control notifies pilot to contact air control.

Post-condition: Airplane is ready for takeoff.

Below are diagrams showing some additional uses cases that were identified, but were not expanded upon as part of this analysis.

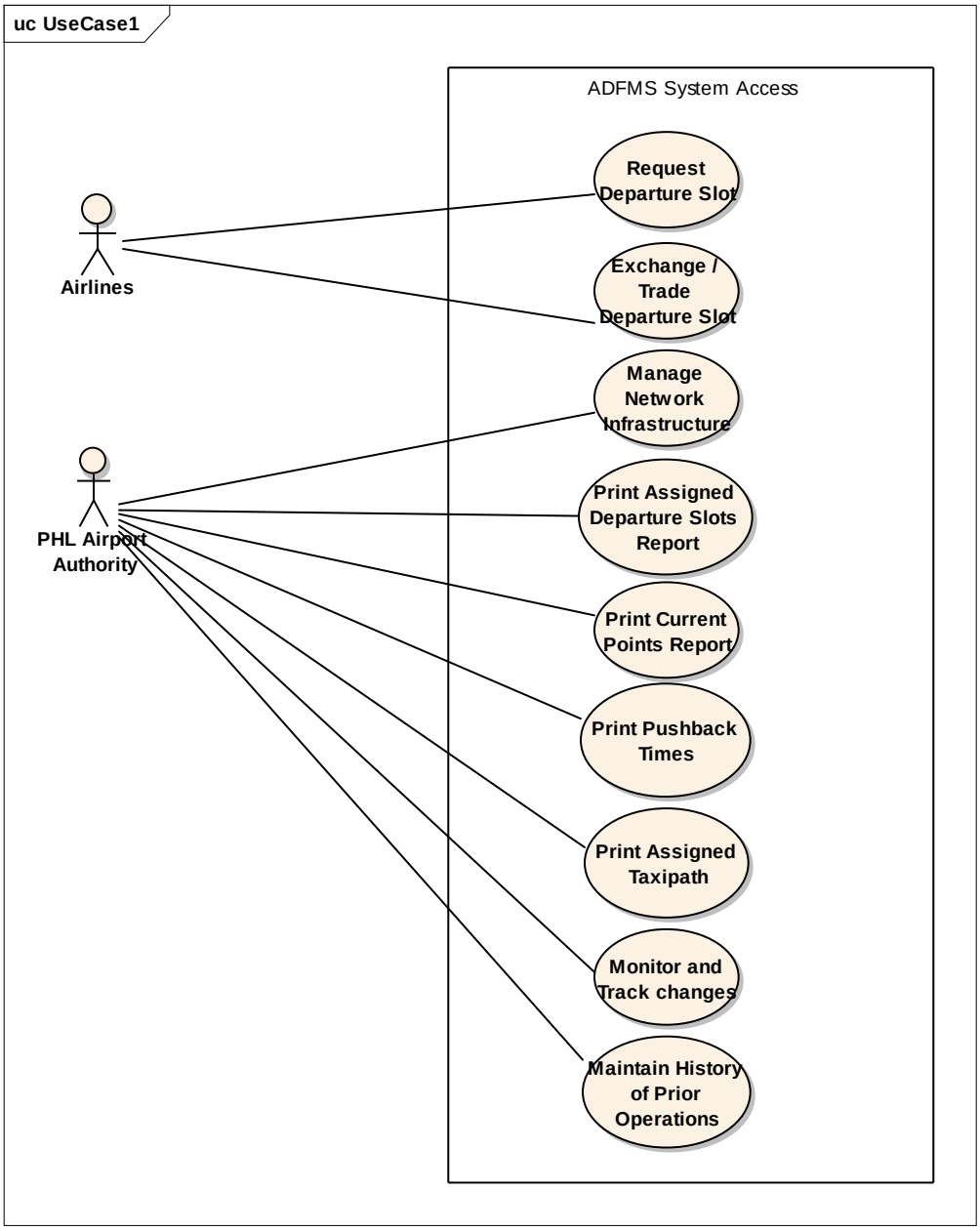


Figure 5 Additional Use Cases 1

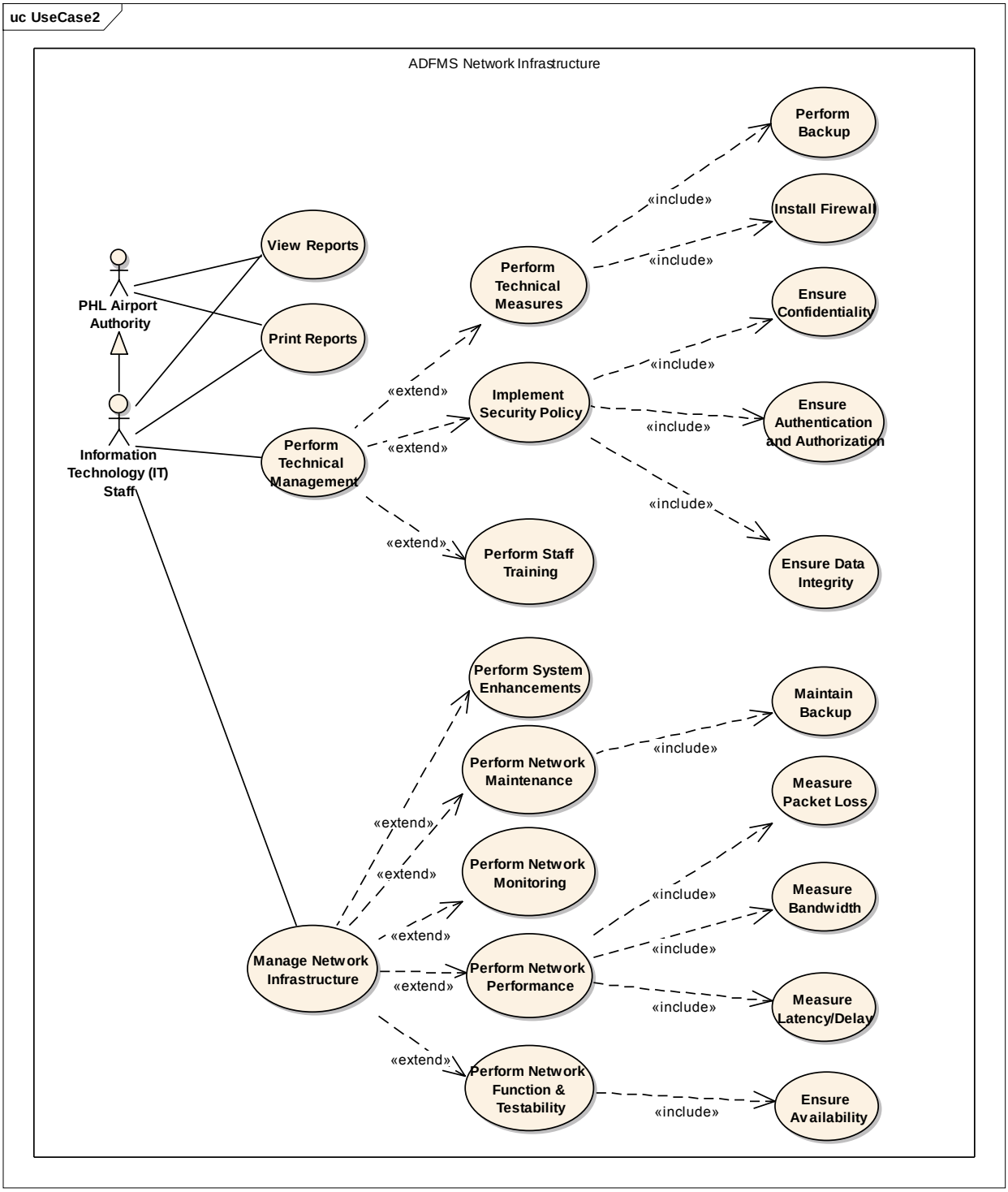


Figure 6 Additional Use Cases 2

1.8 Operational Activity Diagrams:

Use Case: Attempt to secure a later departure slot

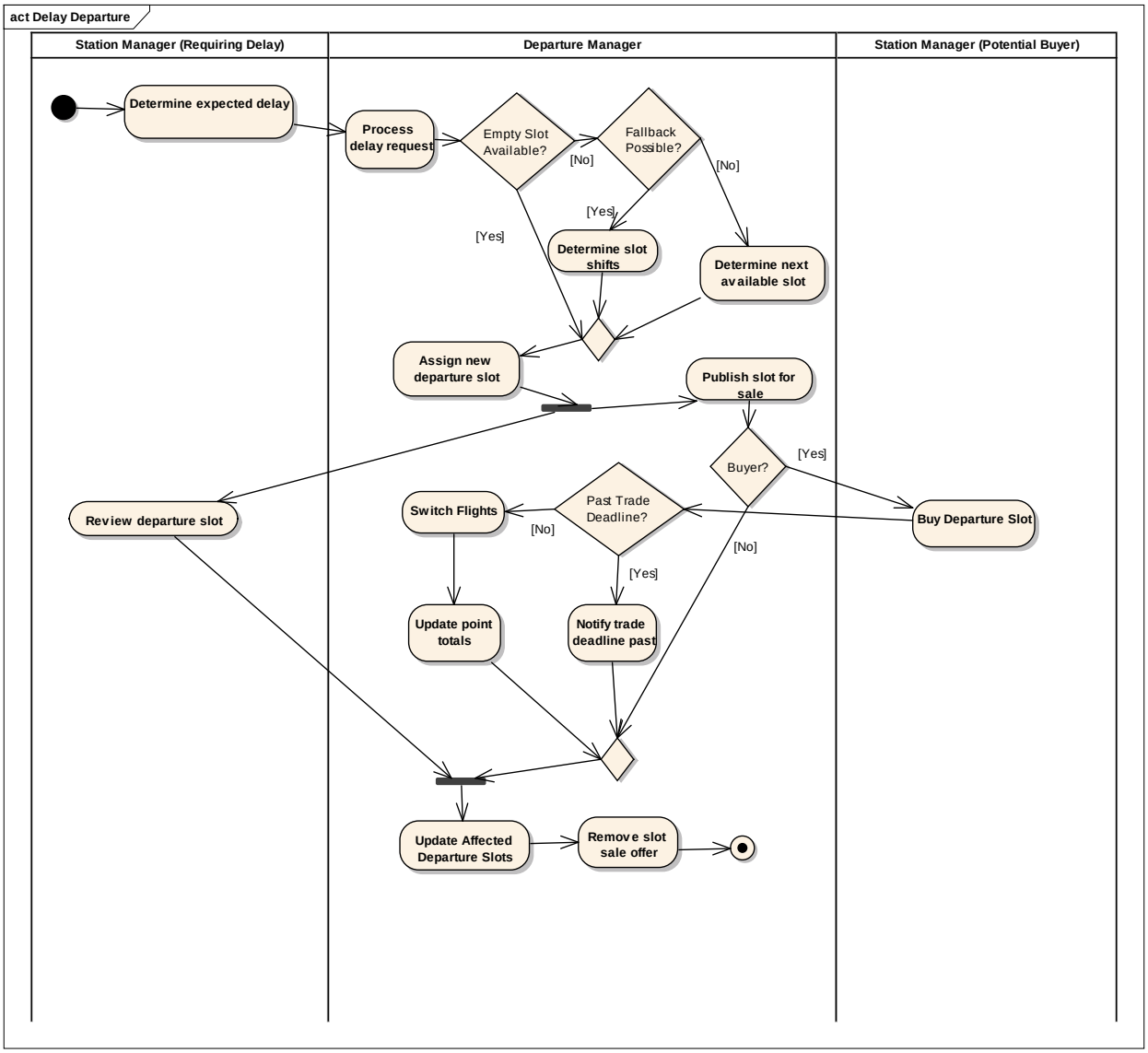


Figure 7 Attempt to secure a later departure slot Activity Diagram

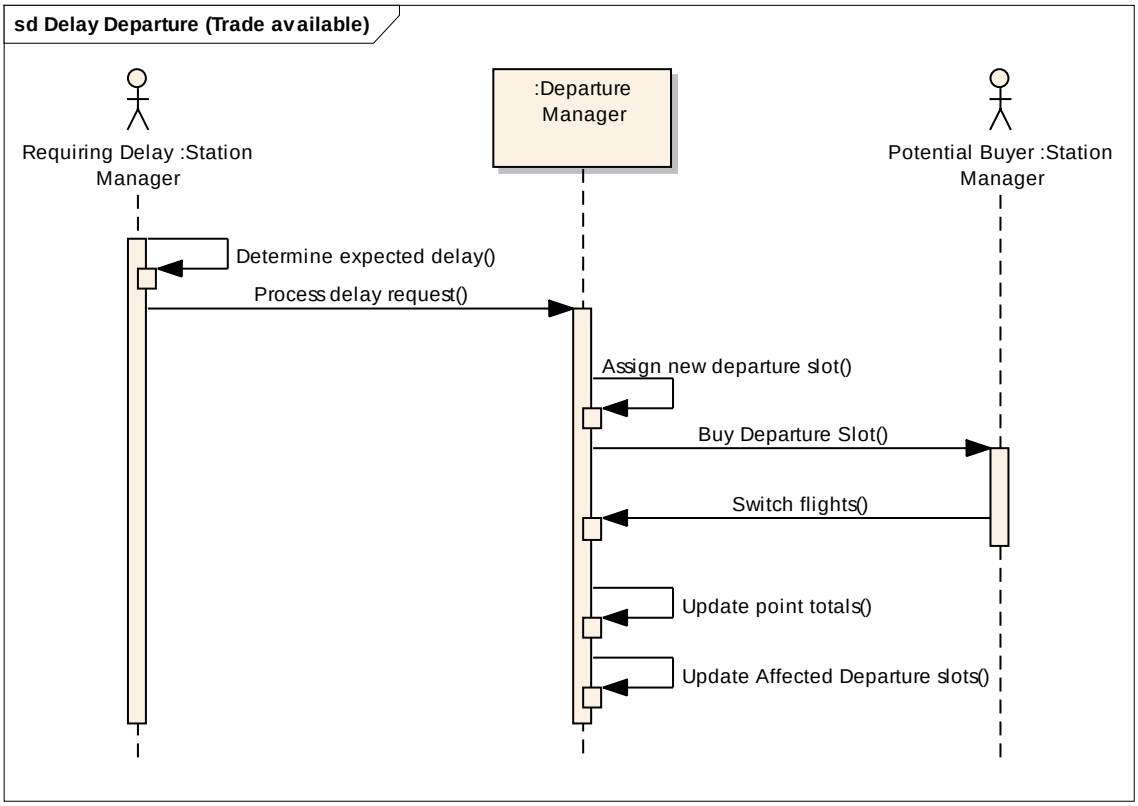


Figure 8 Delay Departure (Trade available) Sequence Diagram

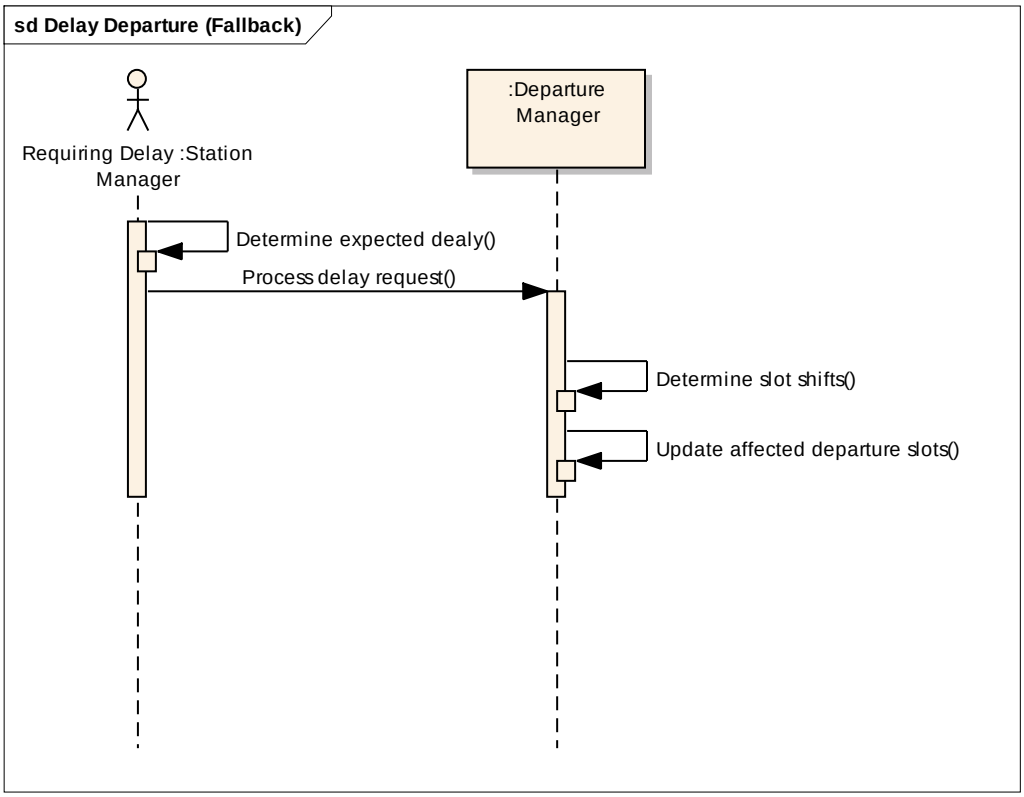


Figure 9 Delay Departure (Fallback) Sequence Diagram

Use Case: Attempt to secure an earlier departure slot

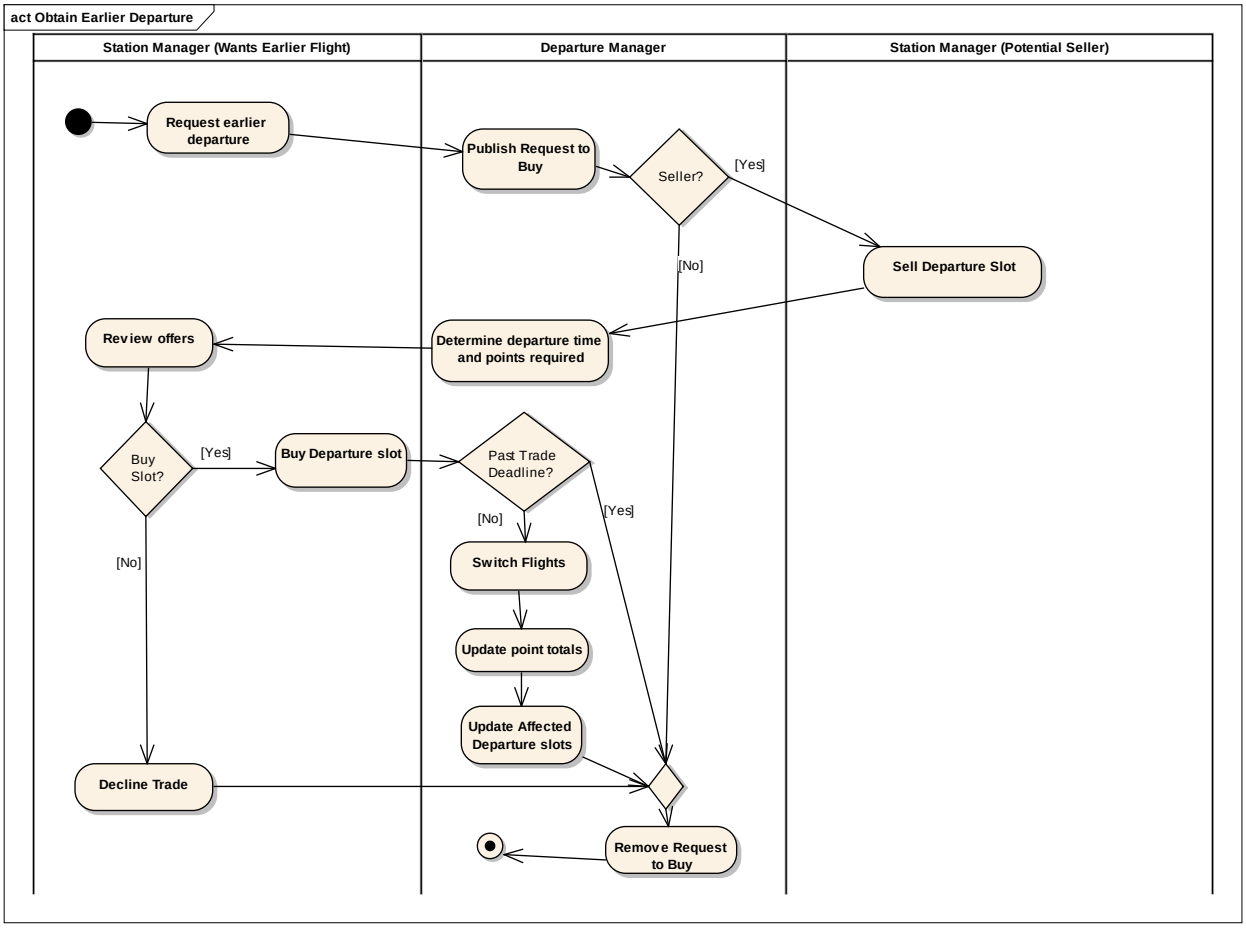


Figure 10 Attempt to secure an earlier departure slot Activity Diagram

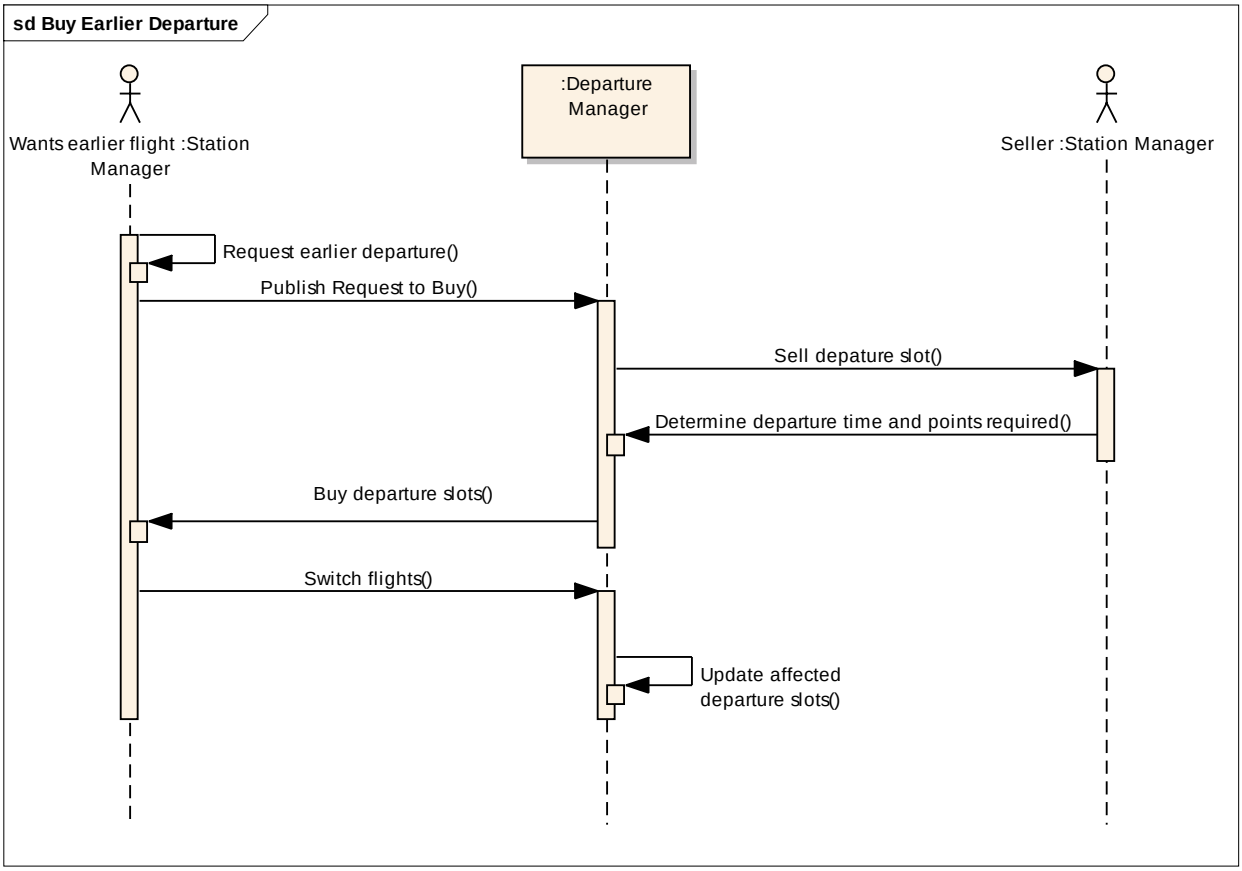


Figure 11 Buy Earlier Departure Sequence Diagram

Use case: Manage Aircraft Departures

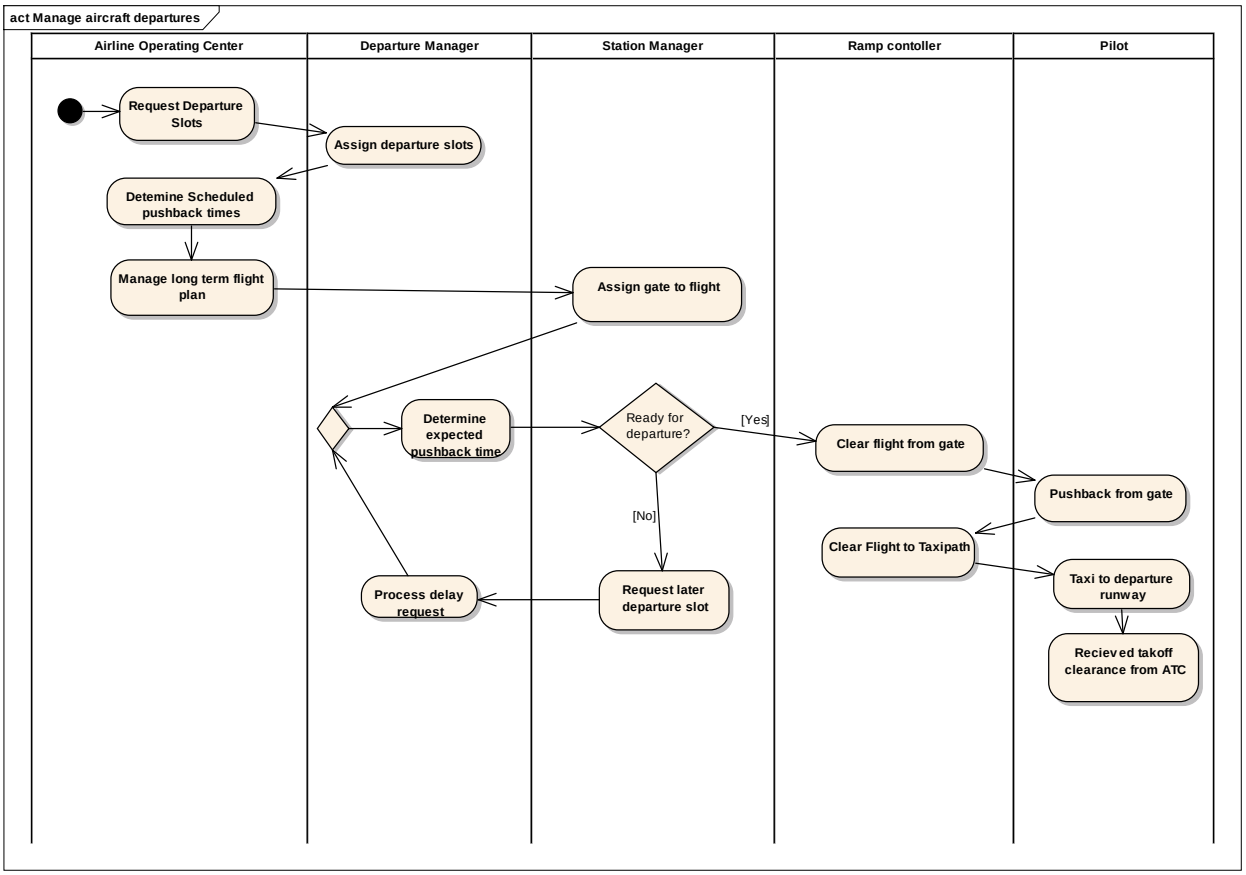


Figure 12 Manage Aircraft Departures Activity Diagram

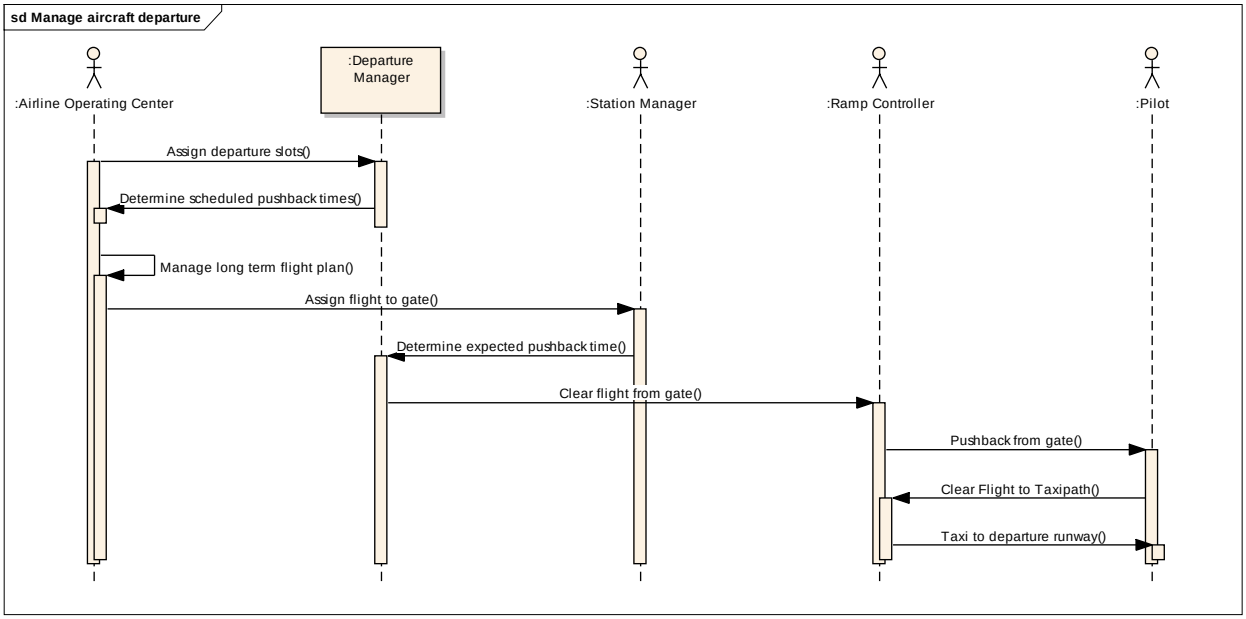


Figure 13 Manage Aircraft Departure Sequence Diagram

1.9 Operational Rules Model

If the request for delay is past the scheduled pushback time, then calculate new penalty total:

> Penalty = number of delays requested that are past scheduled pushback time with the last month divided by the total number of flights in the last month.

If penalty total is passed the threshold value of 5%, decrease the weekly rollover value by 50%. If an airline does not have enough points to complete a trade, do not allow the trade.

1.10 Operational State Charts

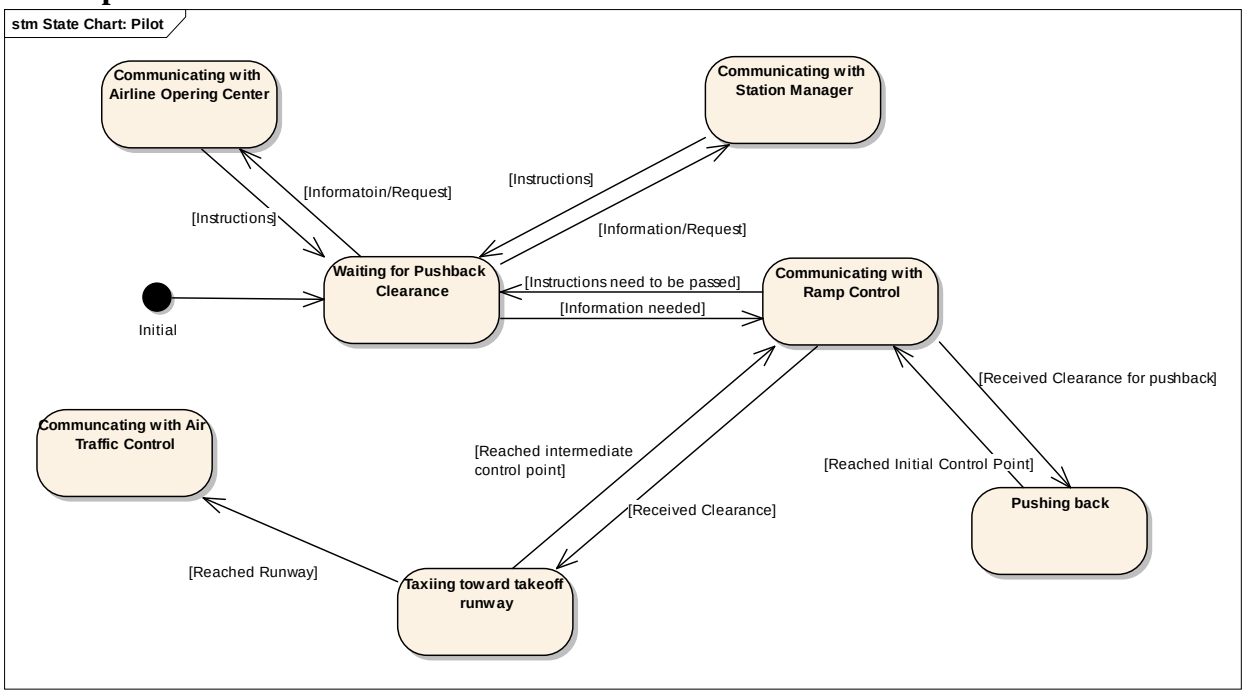


Figure 14 Pilot State Chart

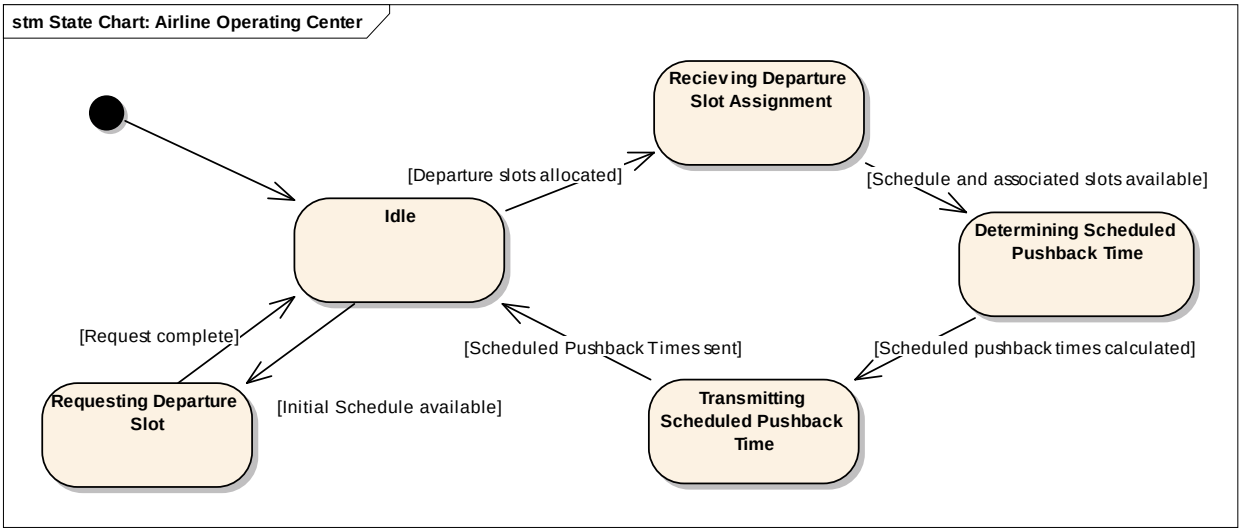


Figure 15 AOC State Chart

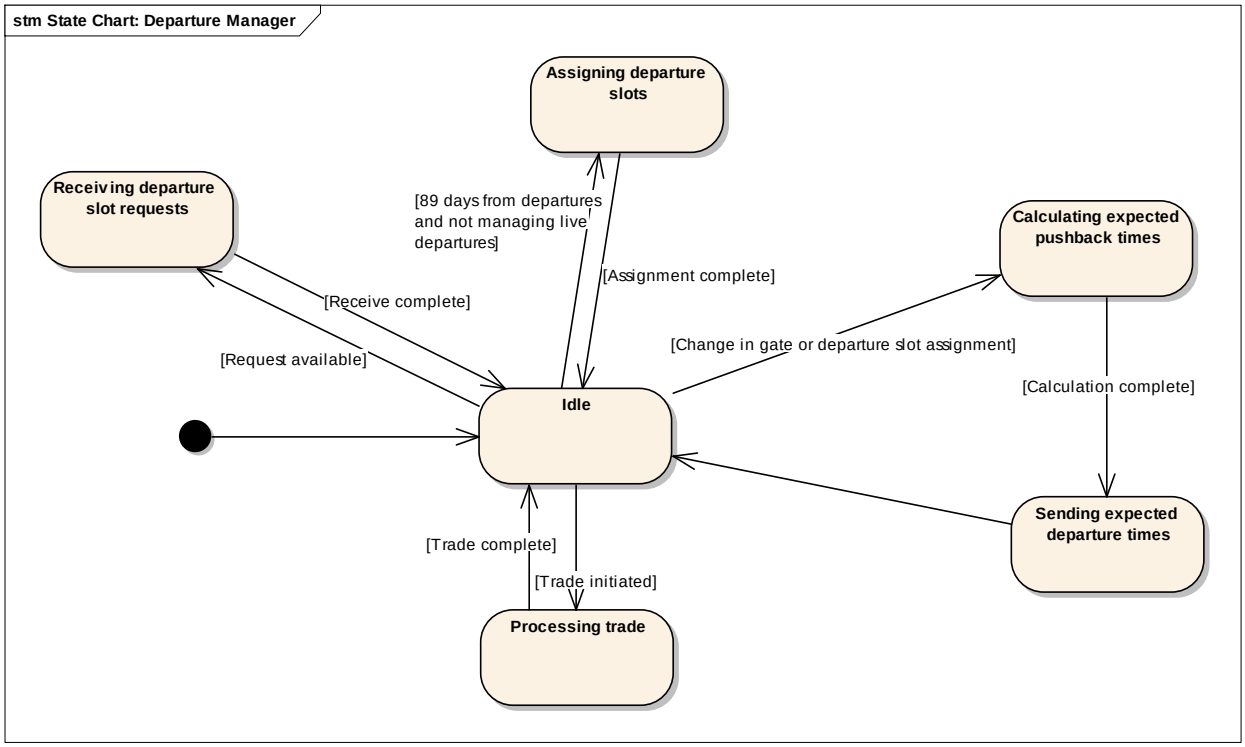


Figure 16 Departure Manager State Chart

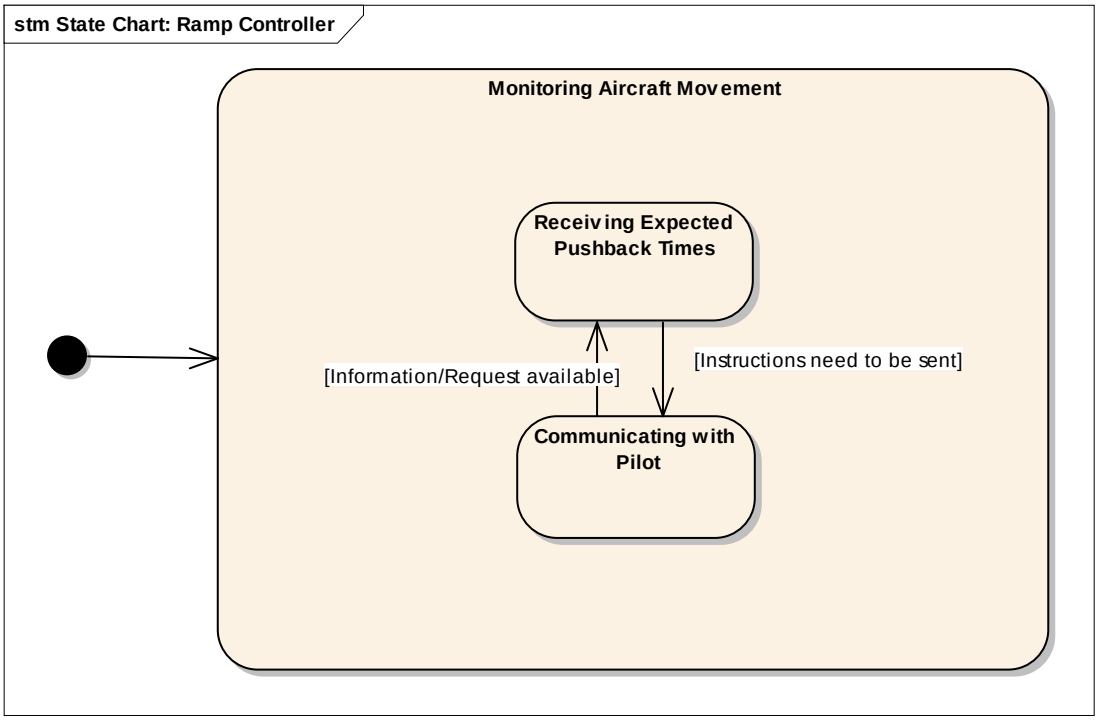


Figure 17 Ramp Controller State Chart

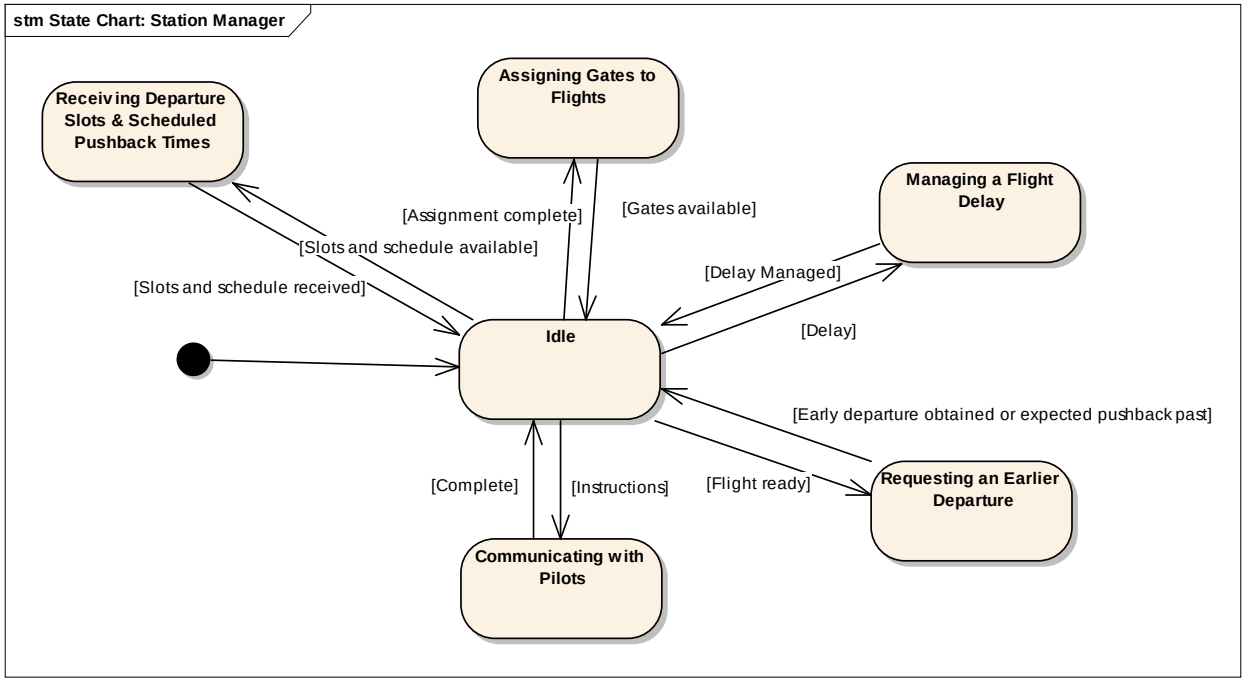


Figure 18 Station Manager State Chart

2. Systems Architecture

2.1 Long Term Scheduling and Initial Slot Assignment

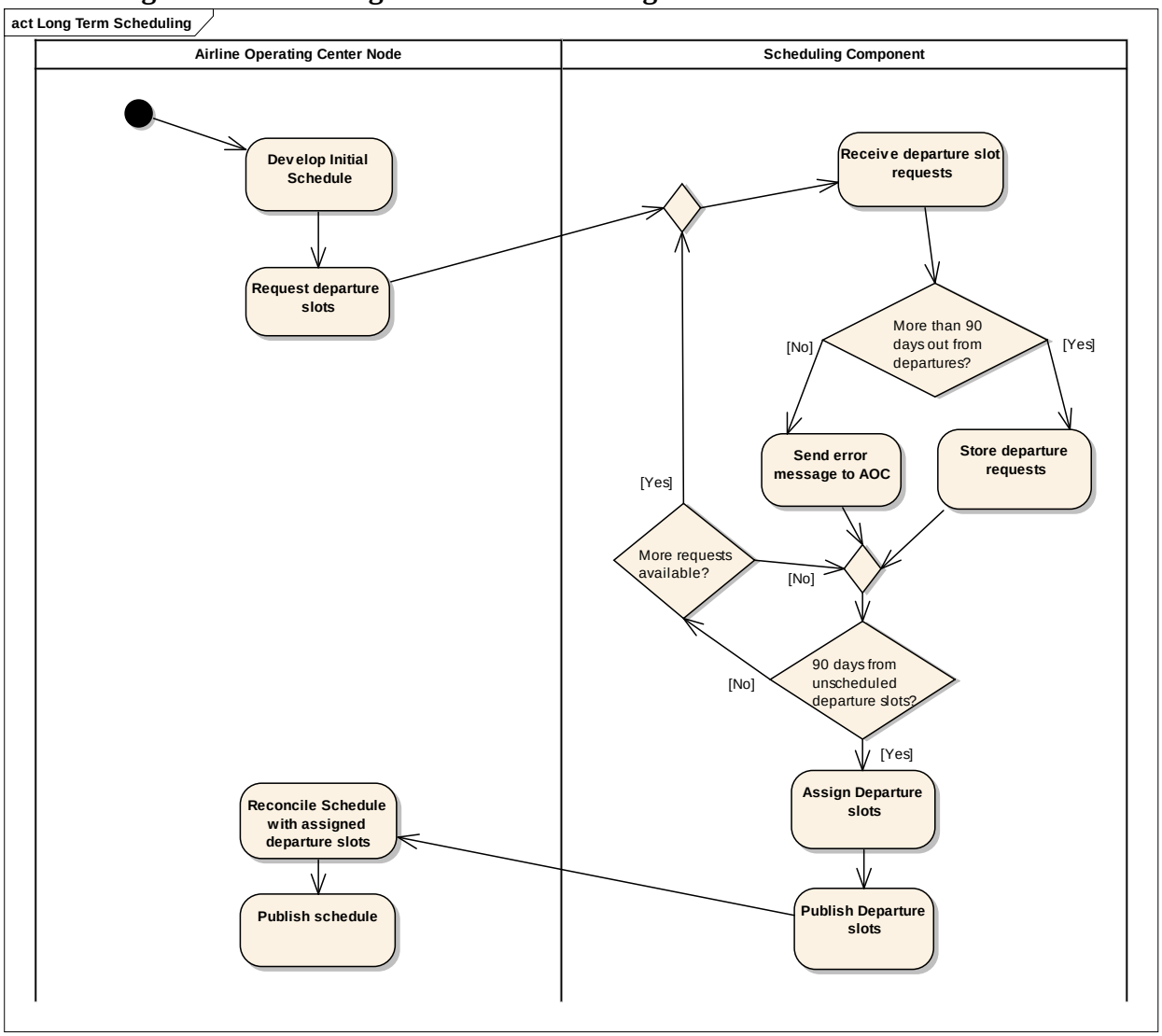


Figure 19 Long Term Scheduling and Initial Slot Assignment Activity Diagram

2.2 Near Term Scheduling and Flight Management

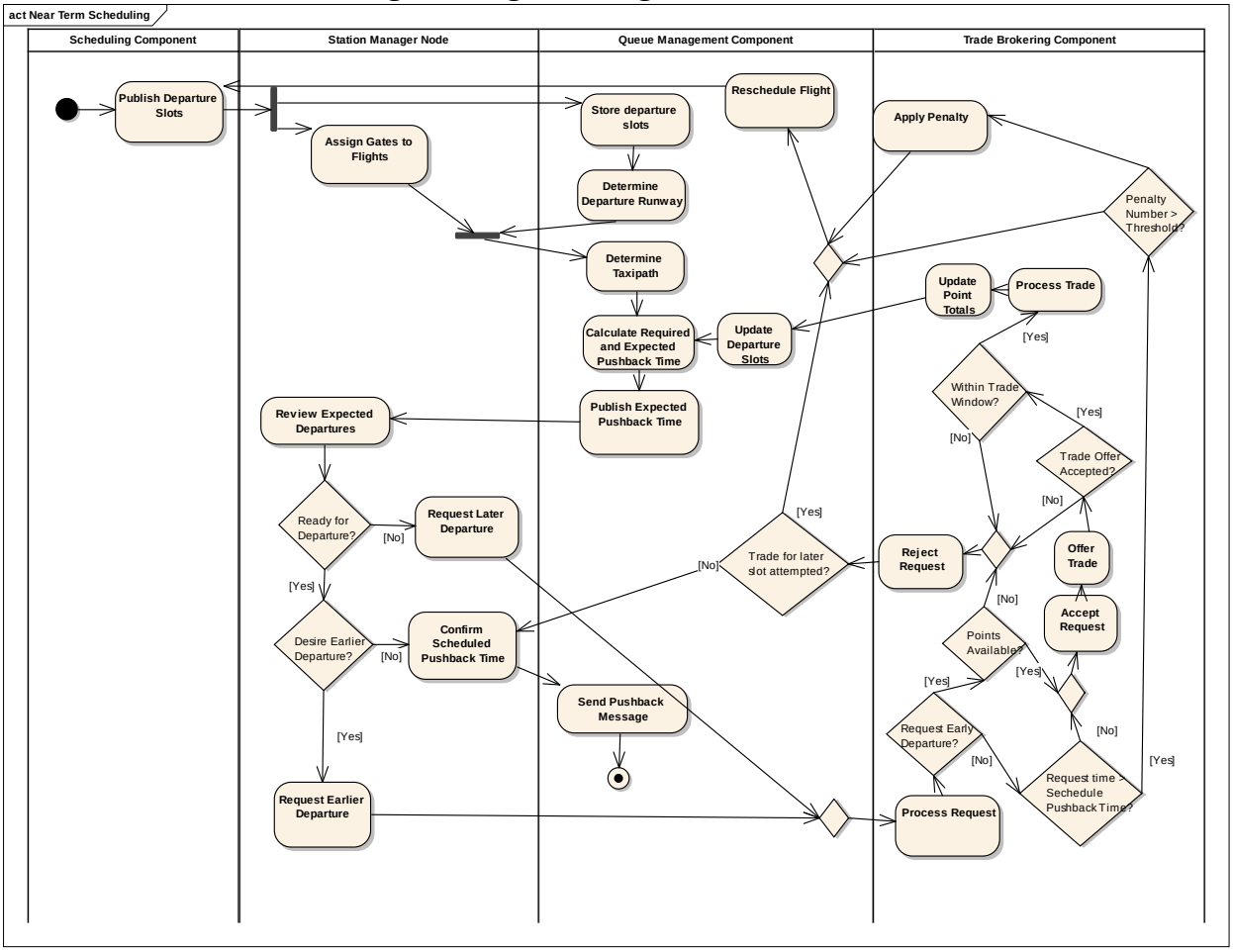


Figure 20 Near Term Scheduling and Flight Management Activity Diagram

2.3 Flight Rescheduling

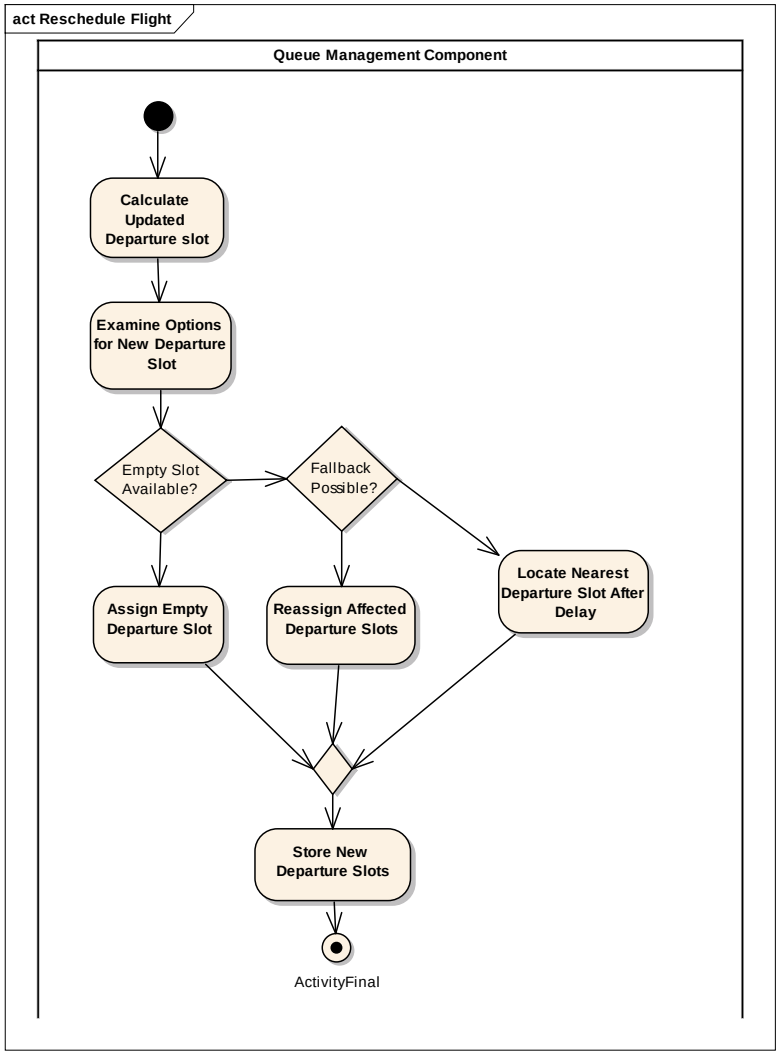


Figure 21 Flight Rescheduling Activity Diagram

2.4 Sequence Diagrams

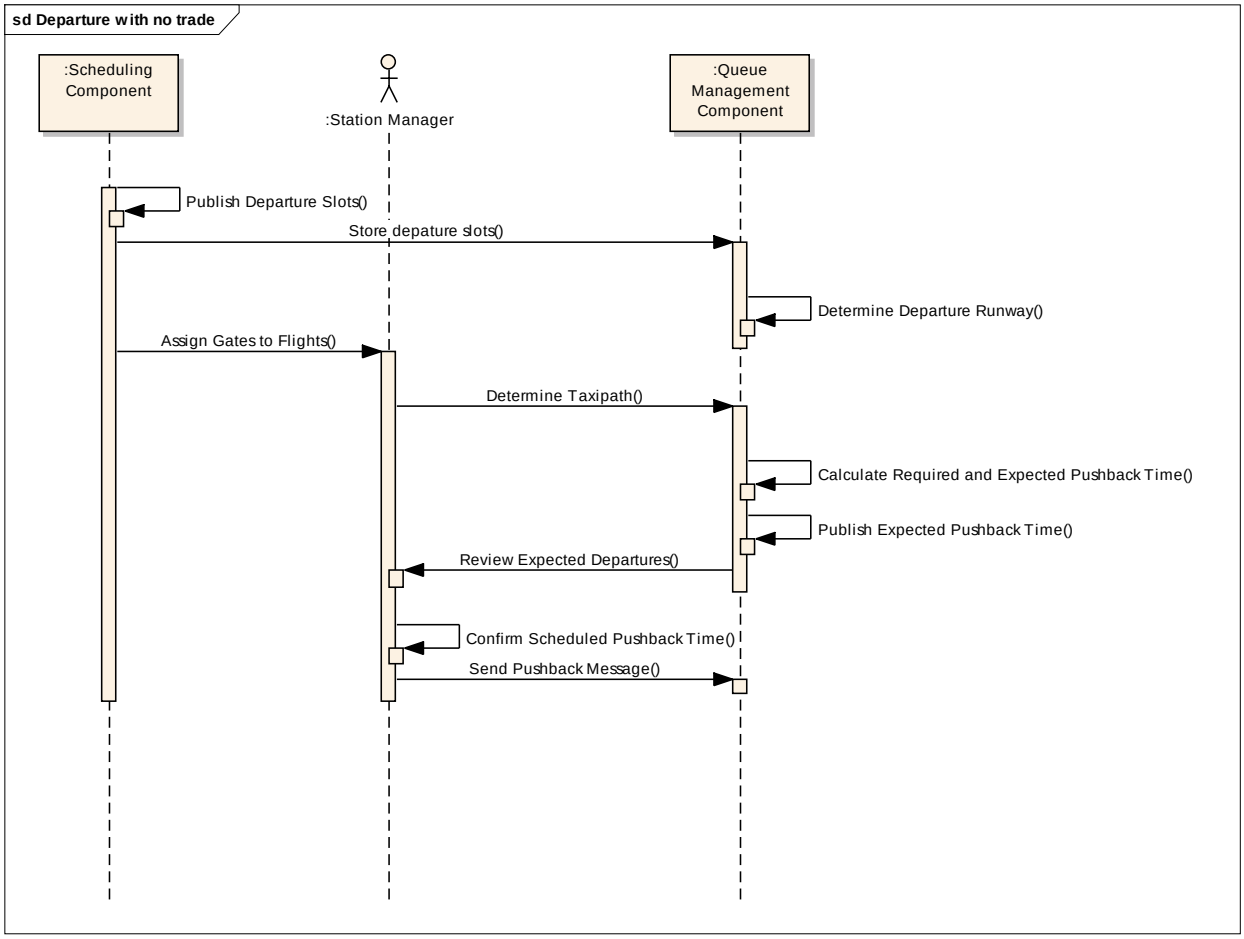


Figure 22 Departure with no Trade Sequence Diagram

2.5 Fallback Due to a Lack of Trade for a Later Slot

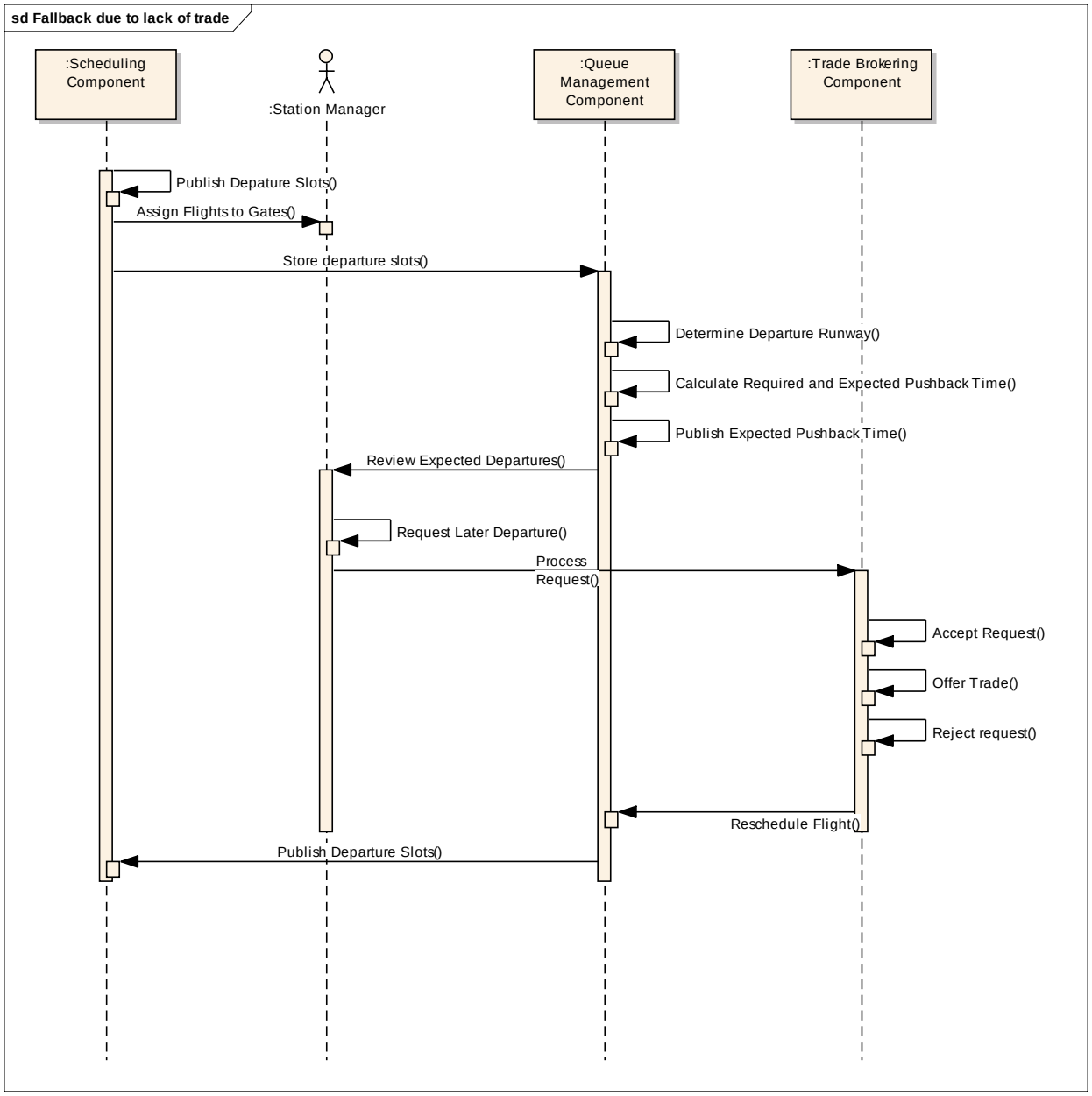


Figure 23 Fallback Due to a Lack of Trade for a Later Slot Sequence Diagram

2.6 Create Long Term Schedule

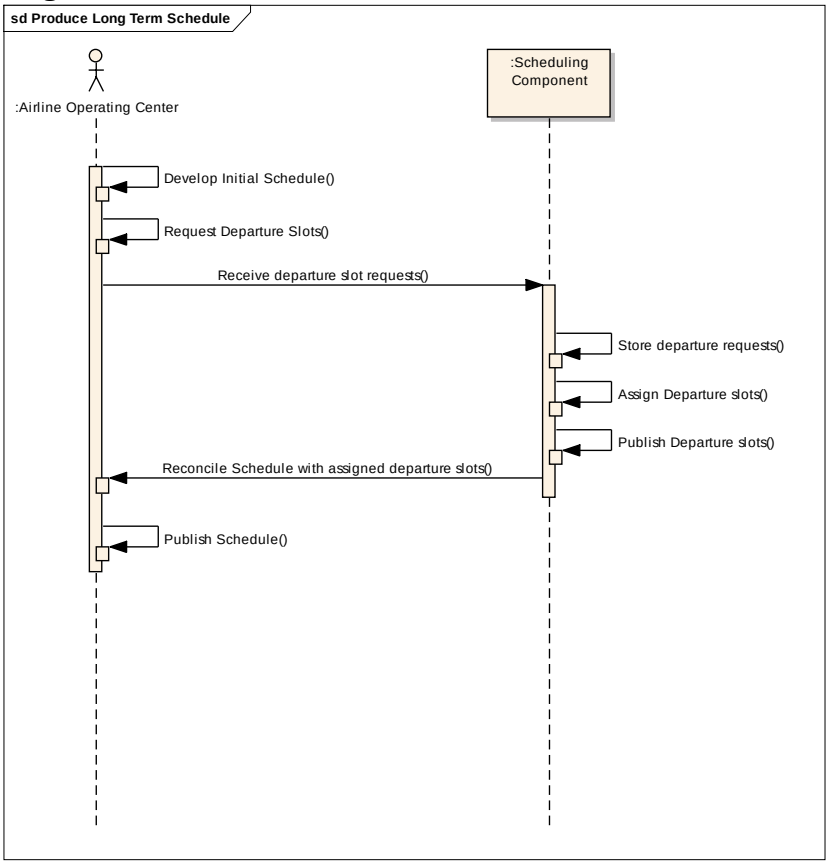


Figure 24 Create Long Term Schedule Sequence Diagram

2.7 Trade for Earlier Departure Slot

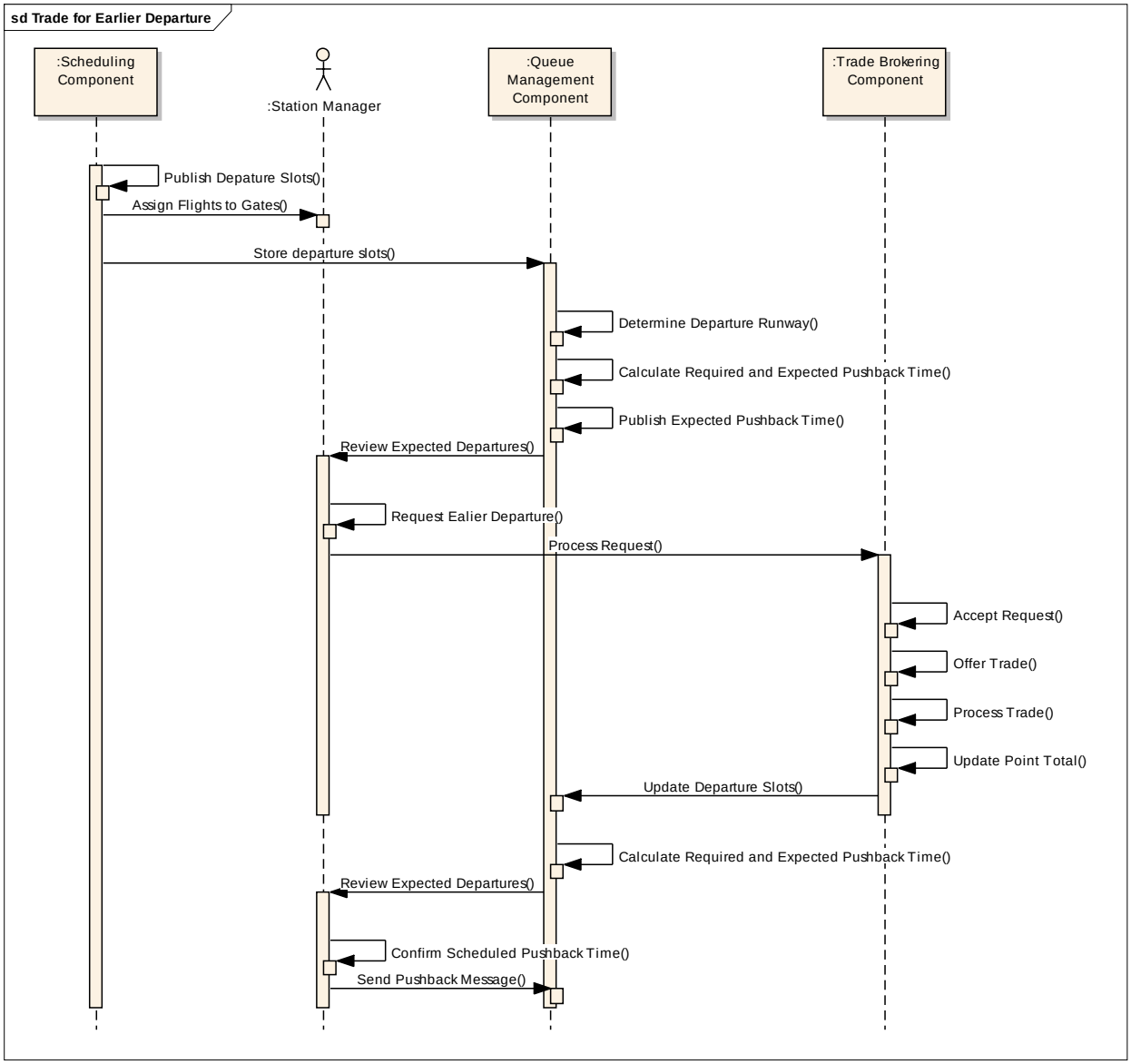


Figure 25 Trade for Earlier Departure Slot Sequence Diagram

2.8 Trade for Later Departure

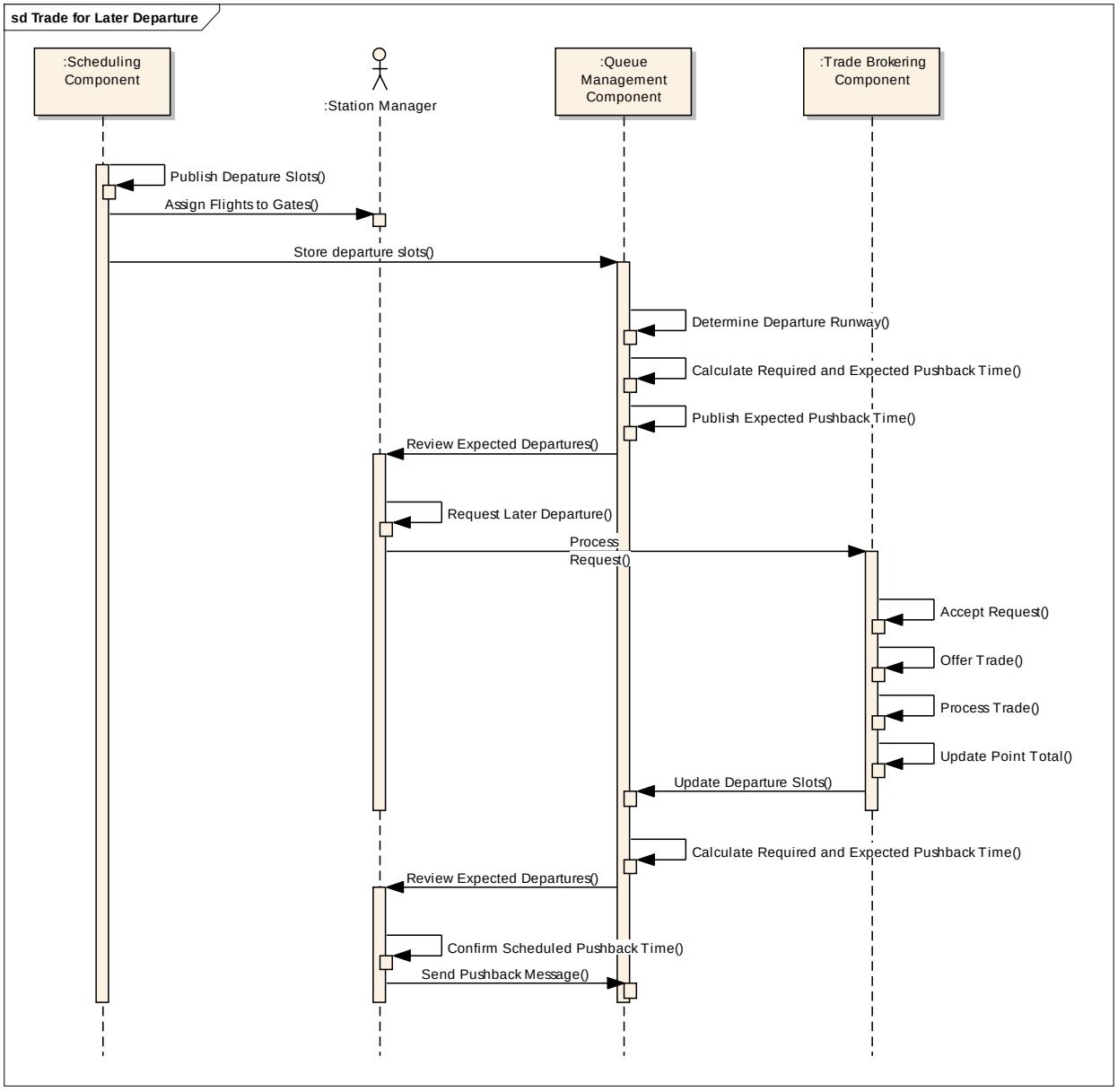


Figure 26 Trade for Later Departure Sequence Diagram

2.9 State Charts

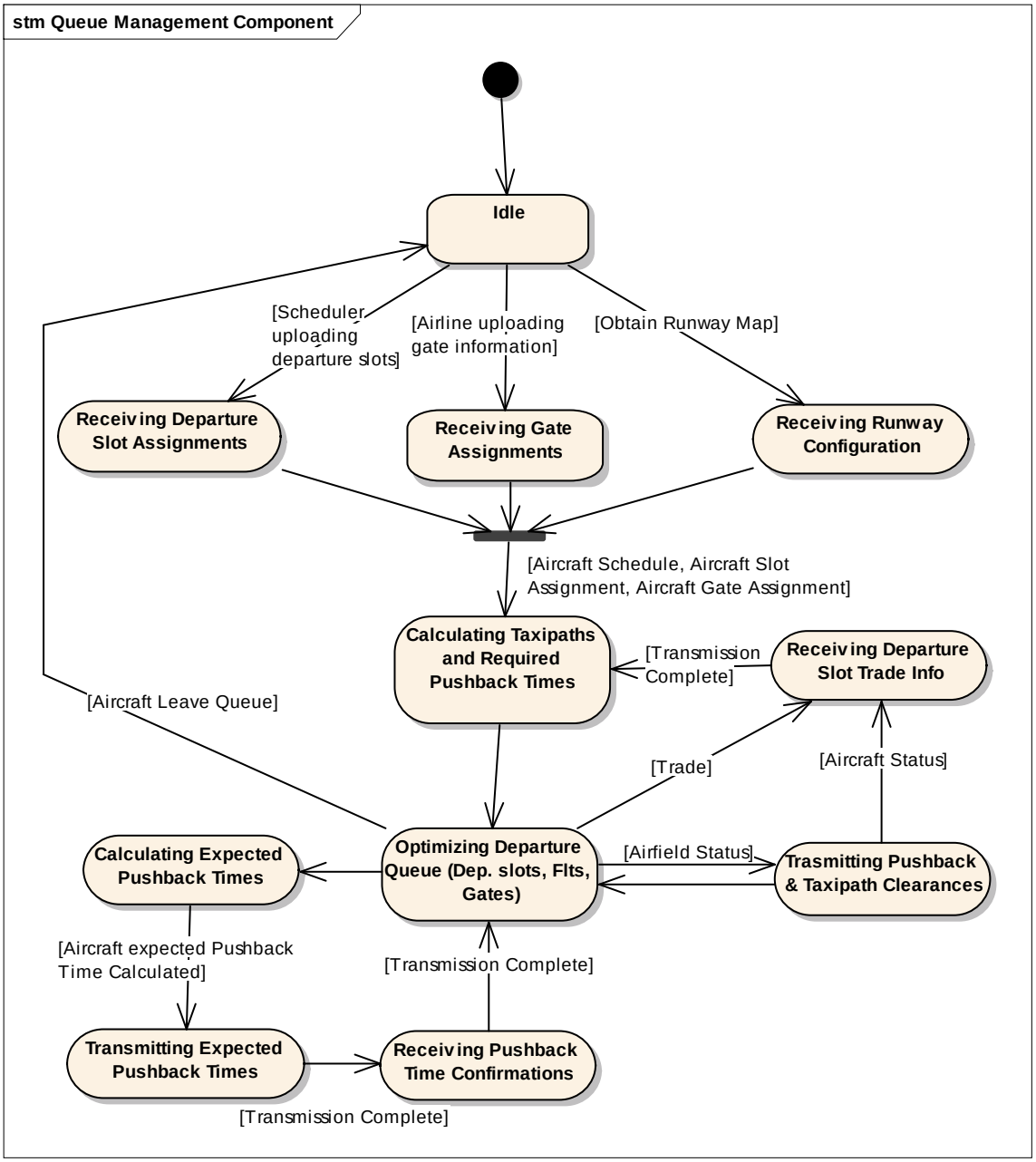


Figure 27 Queue Management Component State Chart

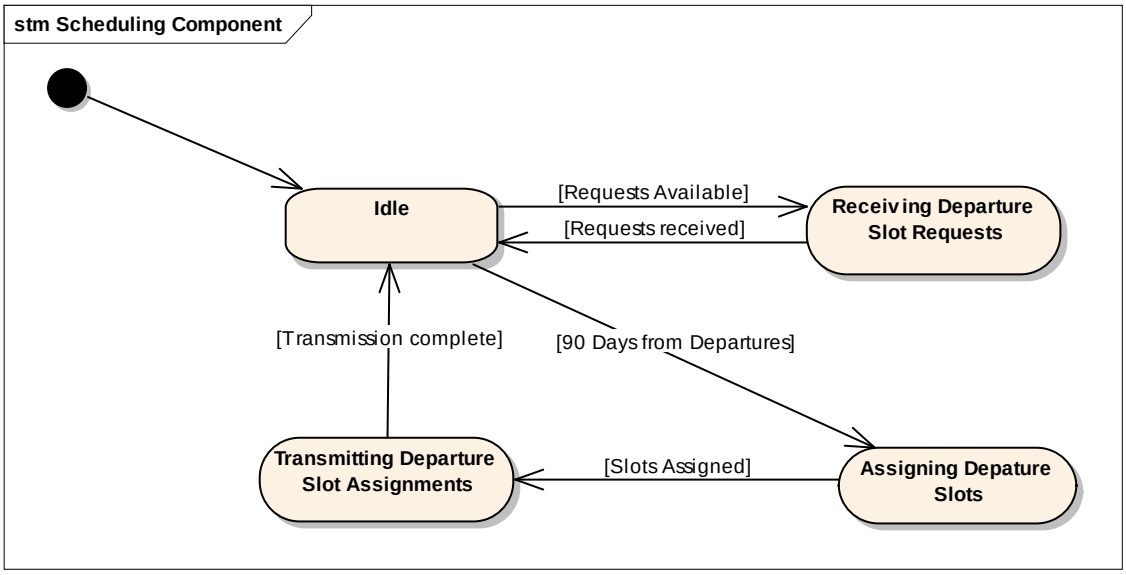


Figure 28 Scheduling Component State Chart

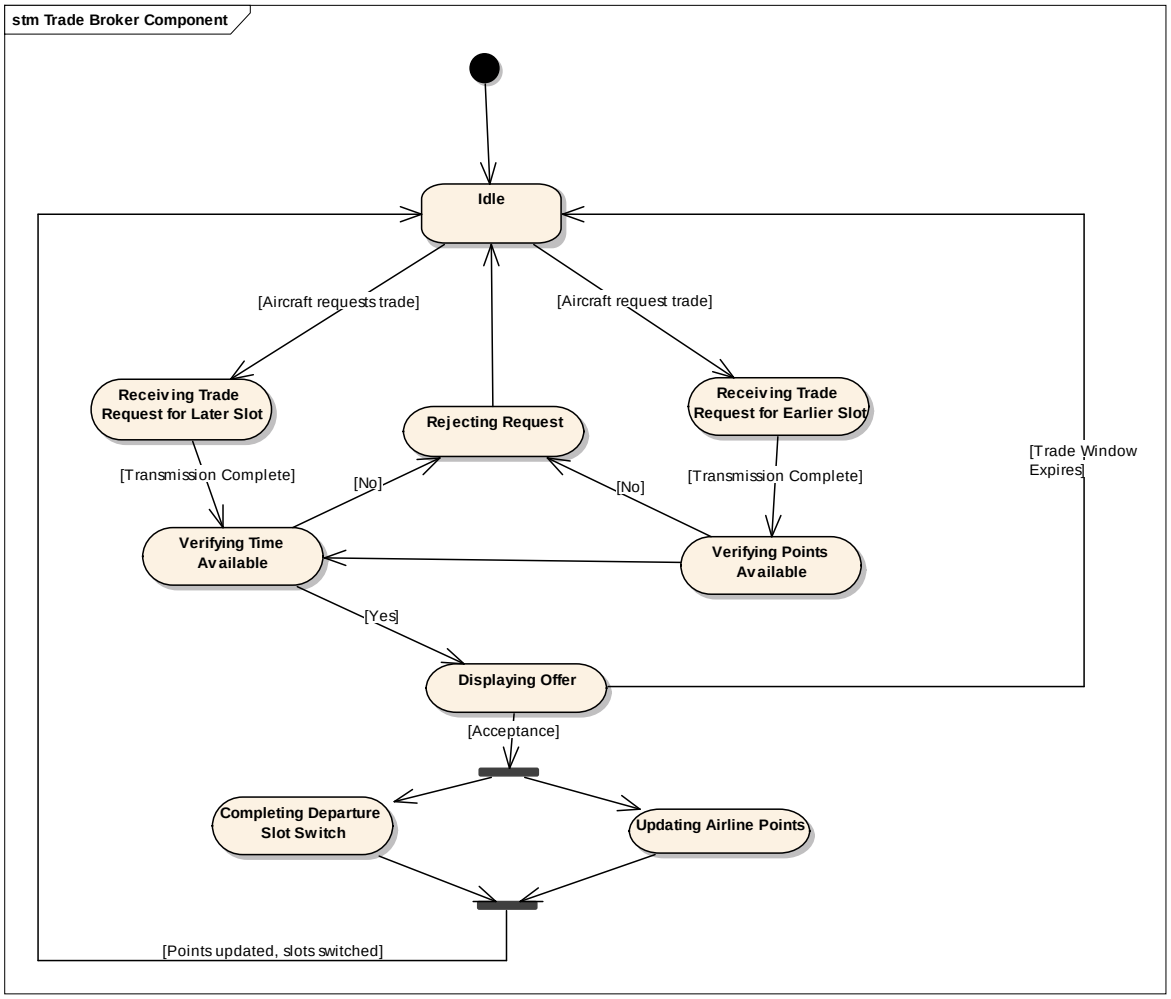


Figure 29 Trade Broker Component State Chart

2.10 Class Diagram

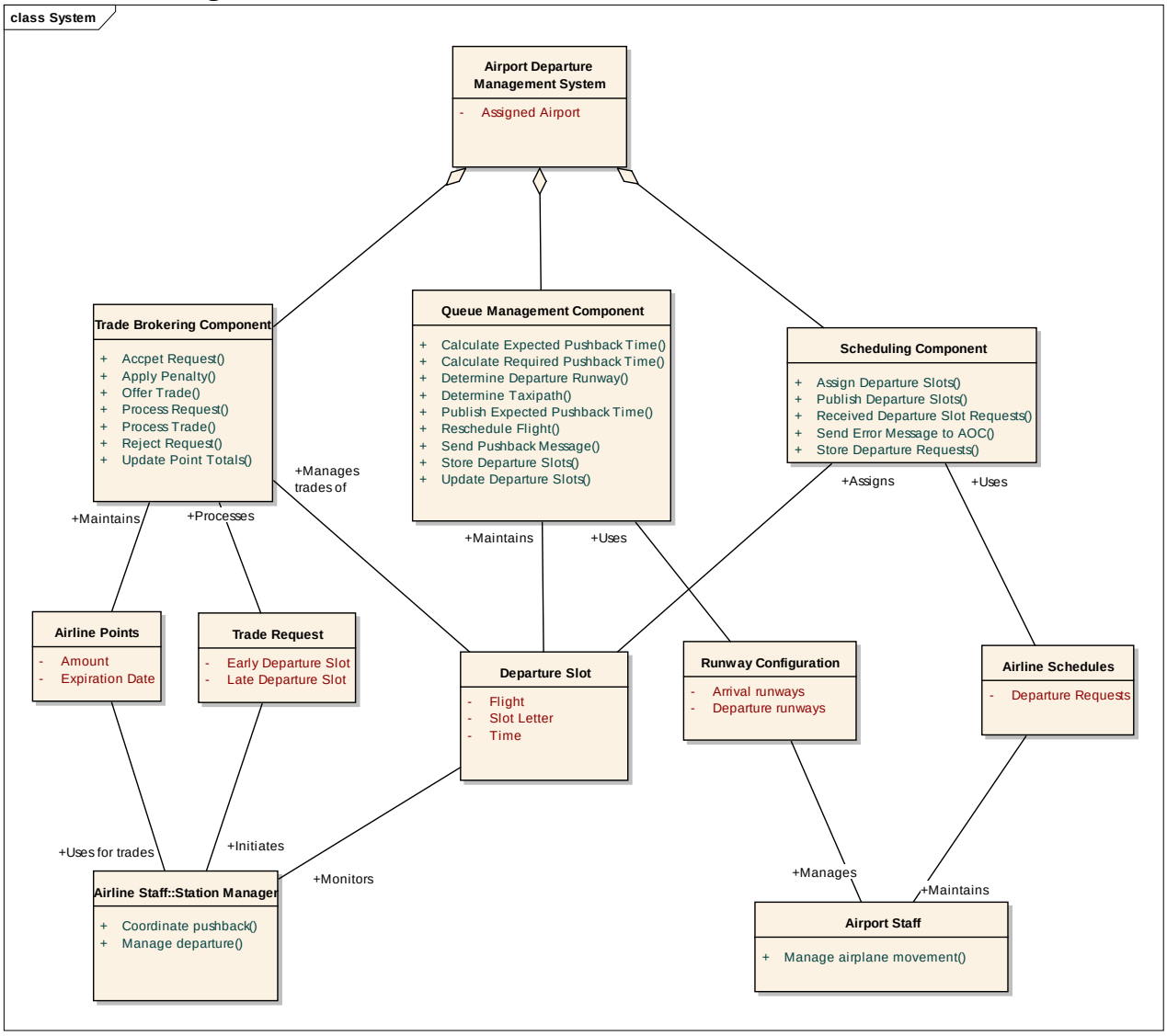


Figure 30 System Class Diagram

3. Structured Analysis

3.1 External Diagram

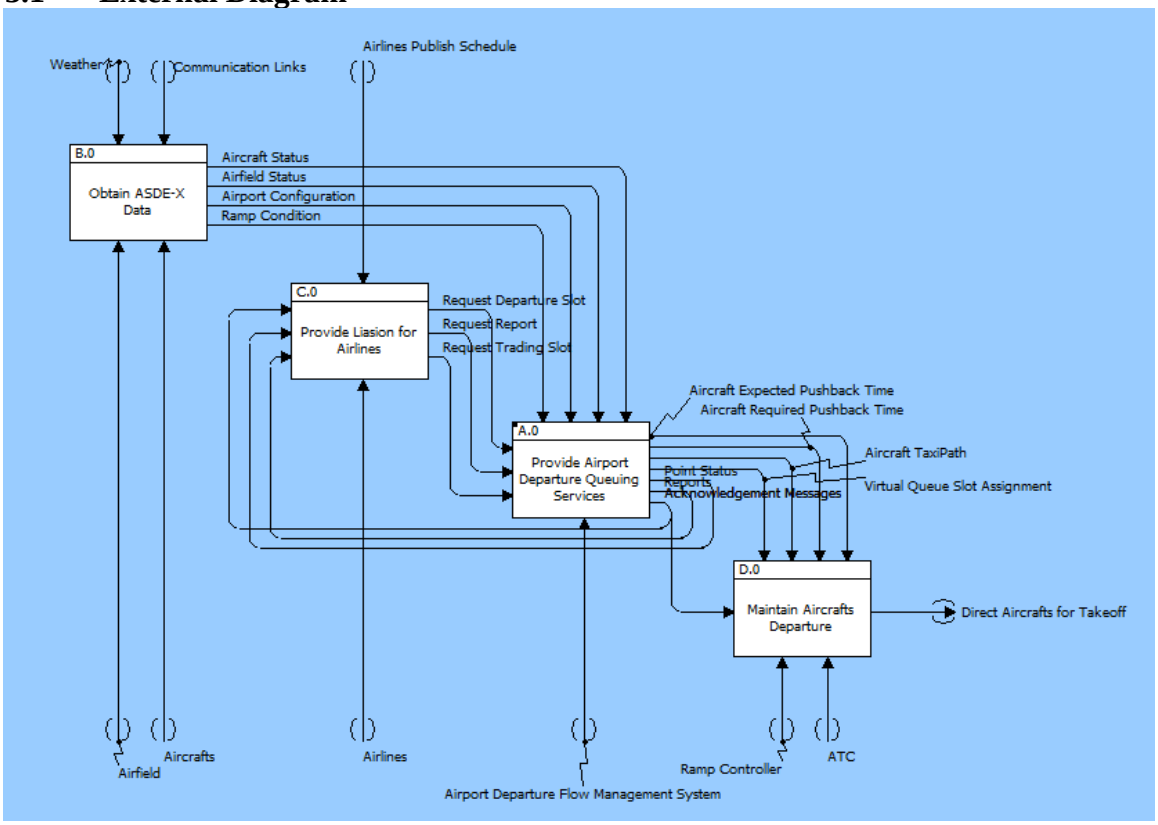


Figure 31 External Diagram

3.2 A-0 Diagram

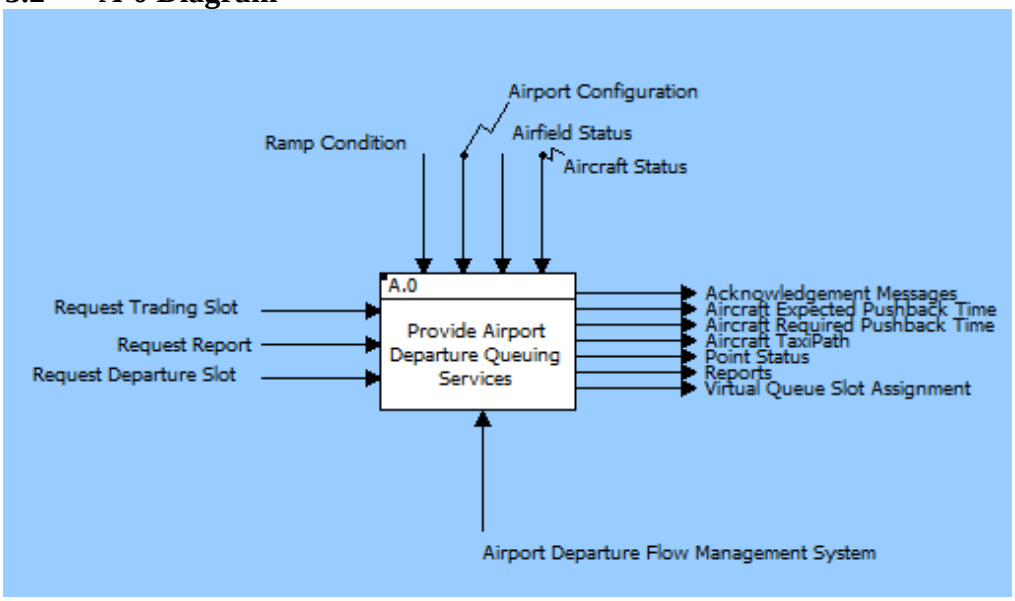


Figure 32 A-0 Diagram

3.3 A0 Diagram

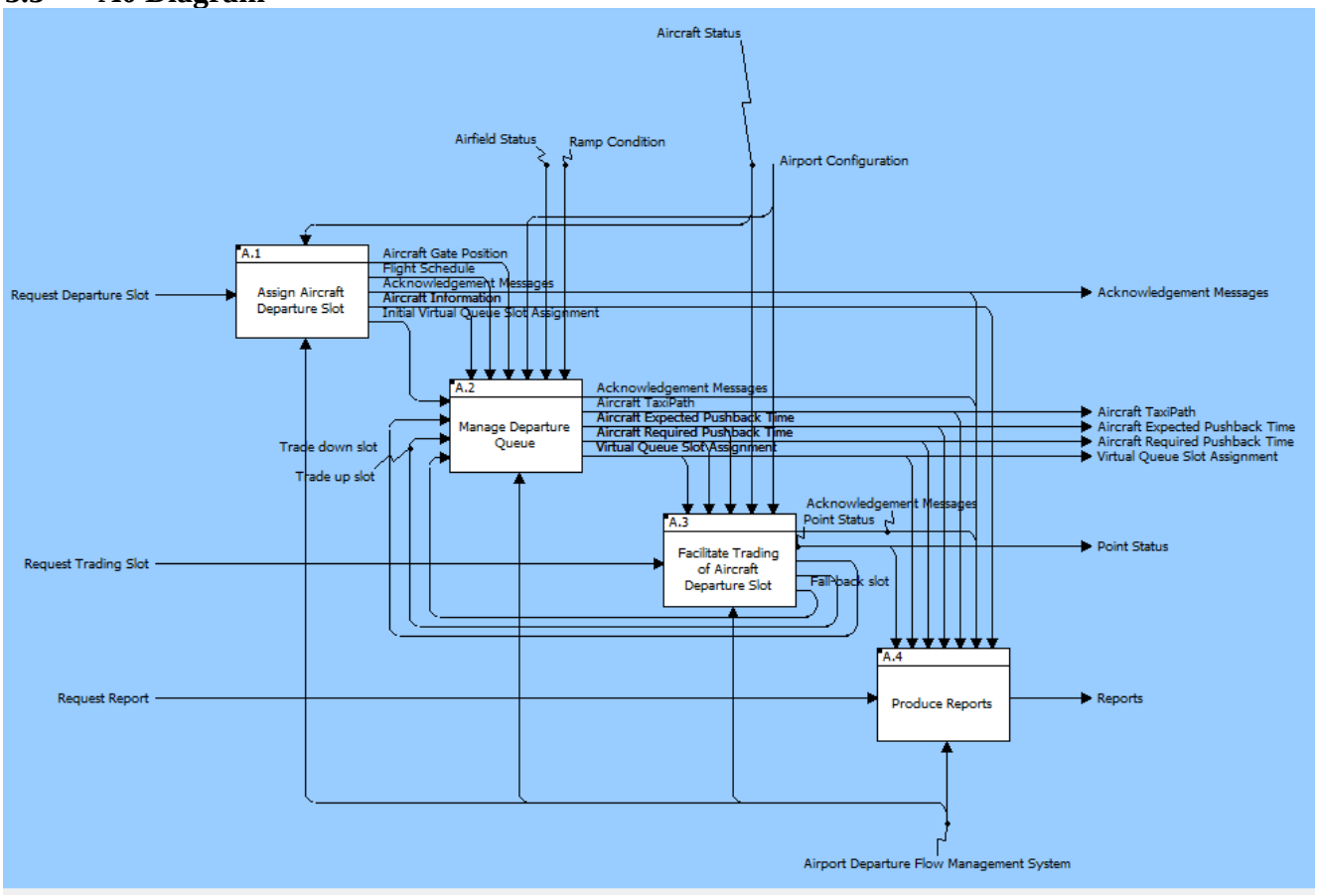
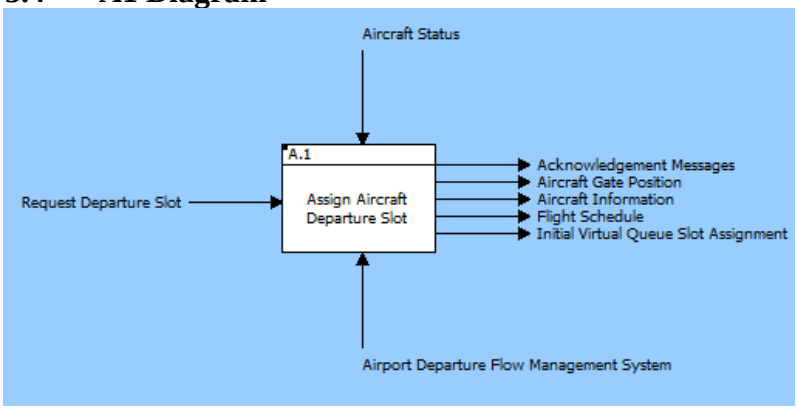


Figure 33 A0 Diagram

3.4 A1 Diagram



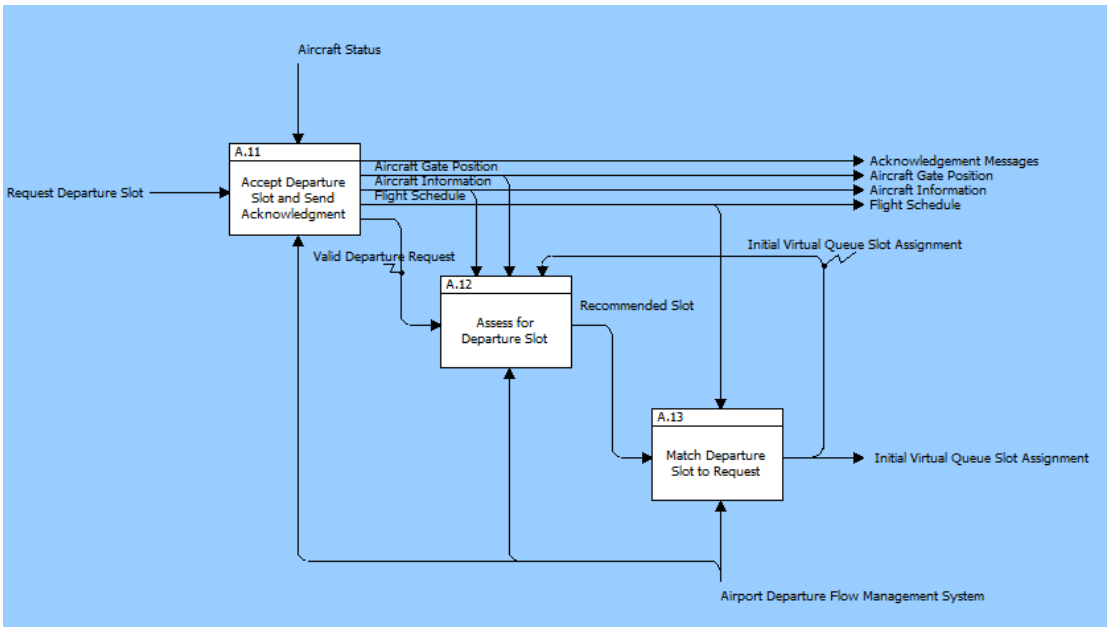
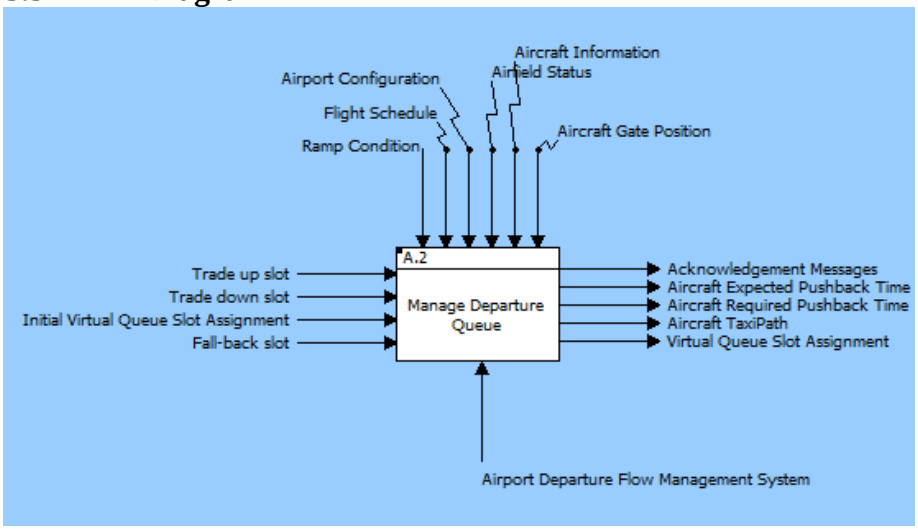


Figure 34 A1 Diagram

3.5 A2 Diagram



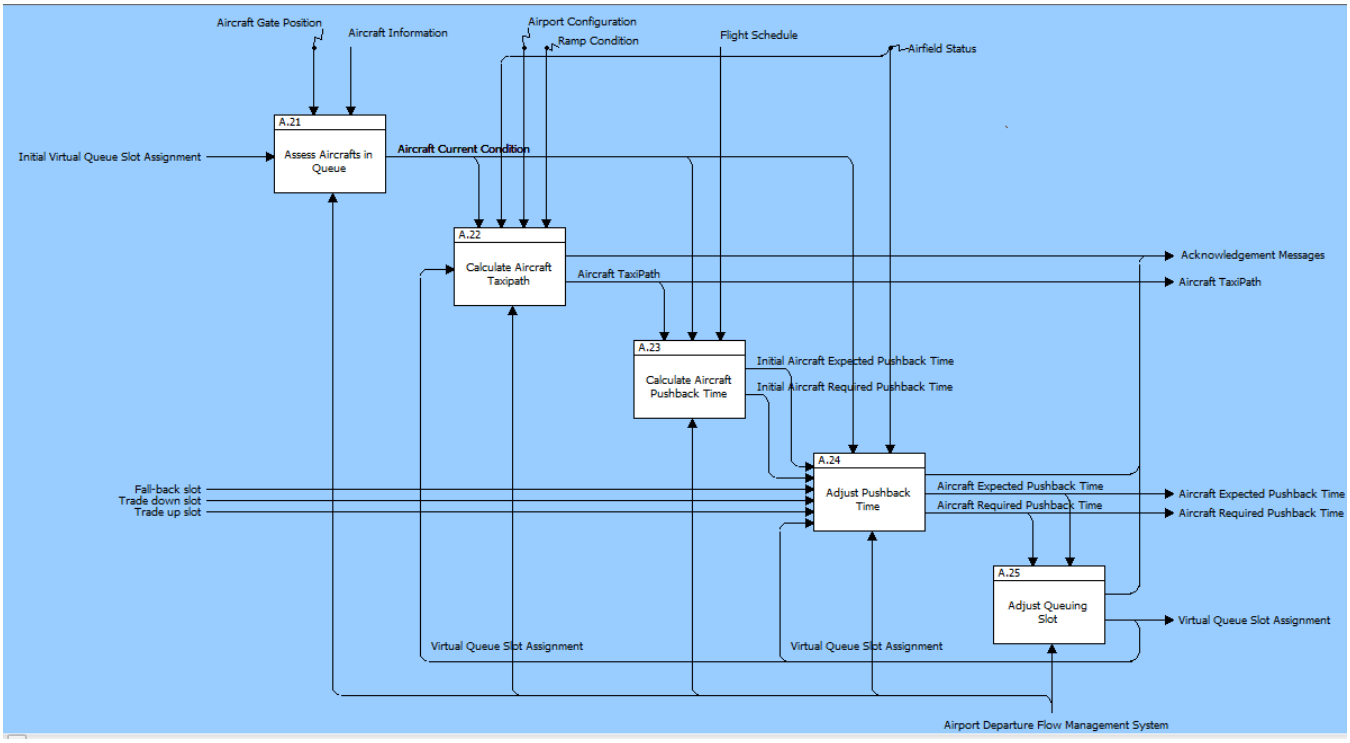
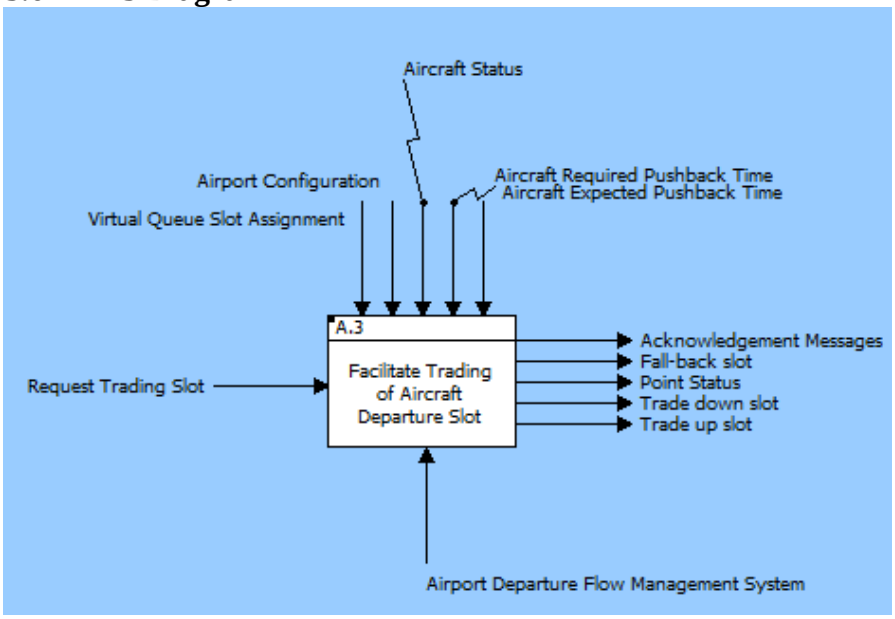


Figure35 A2 Diagram

3.6 A3 Diagram



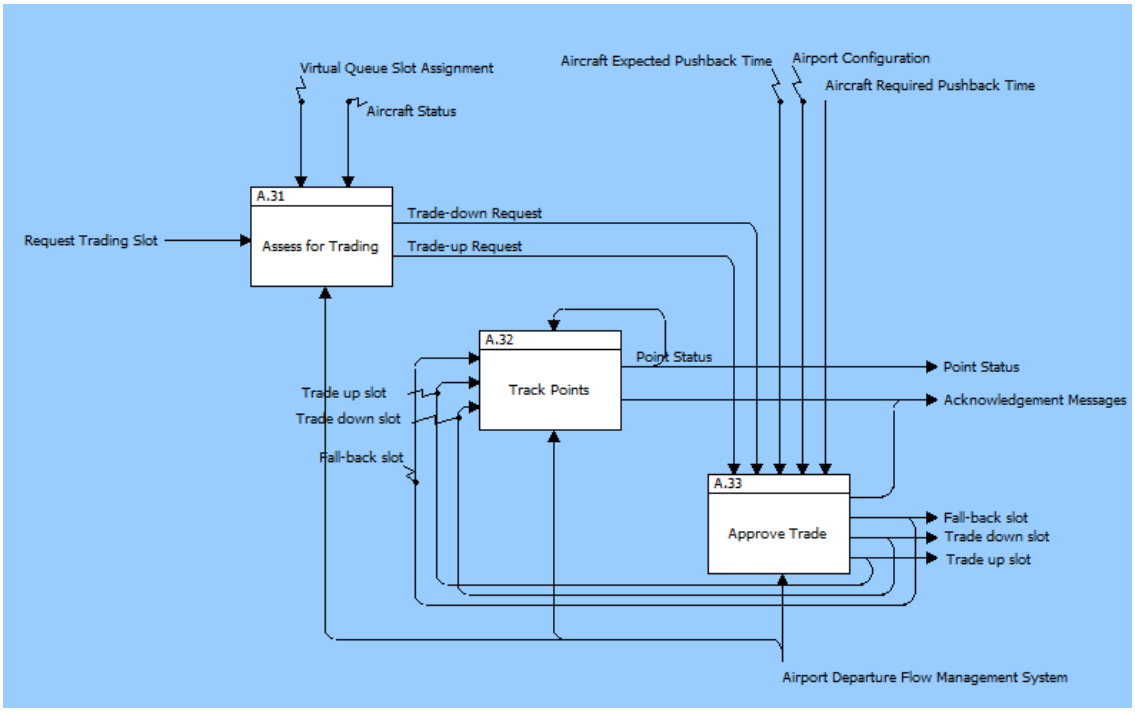
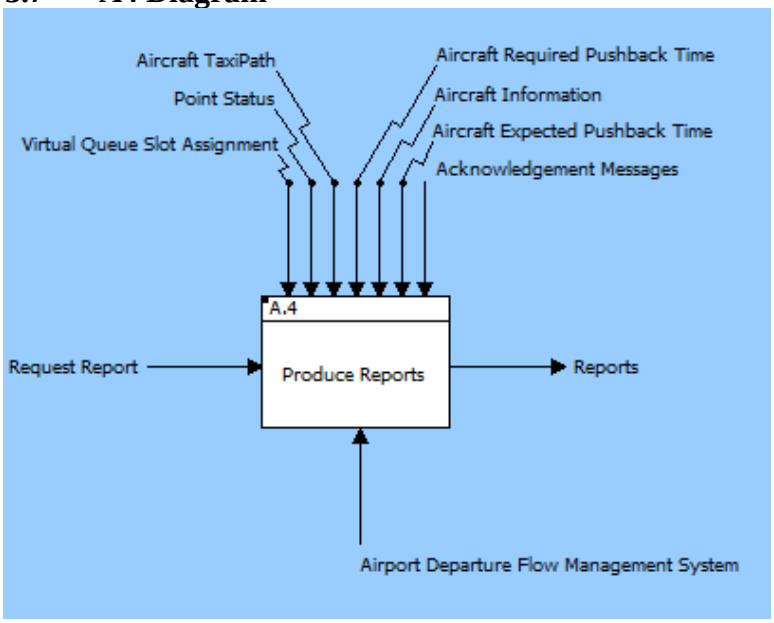


Figure 36 A3 Diagram

3.7 A4 Diagram



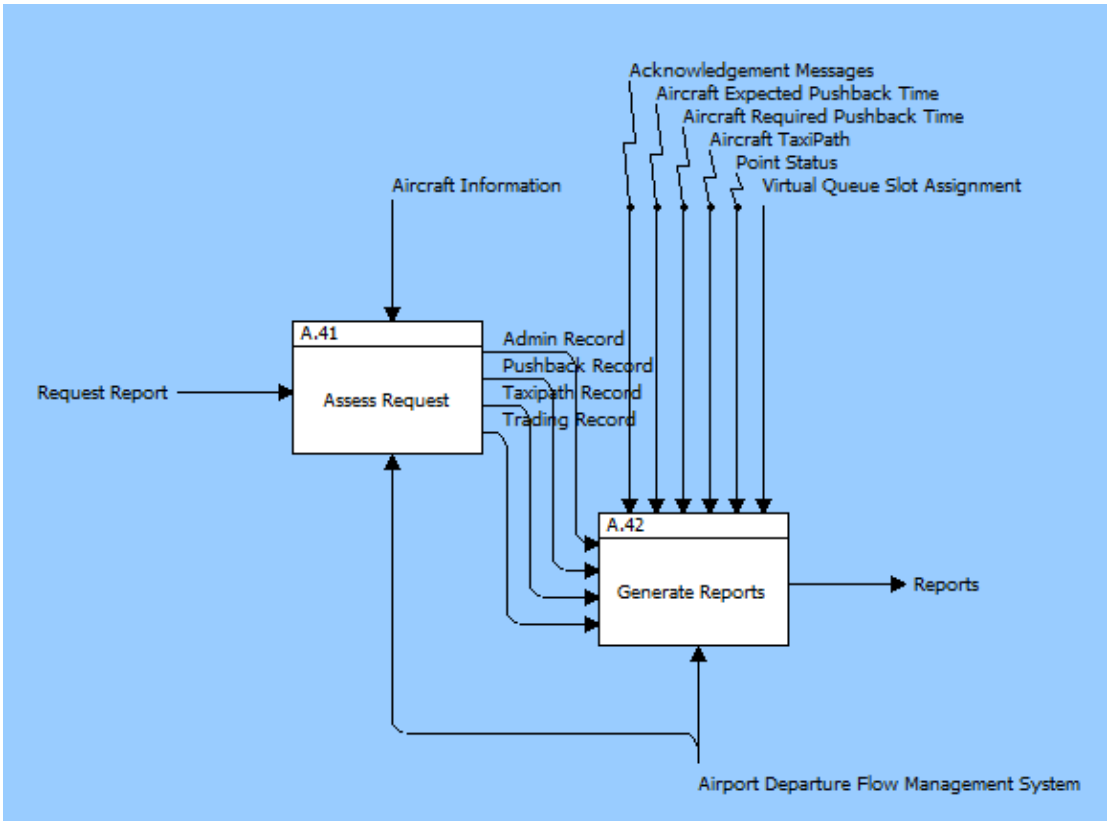


Figure 37 A4 Diagram