WSP072 Systems Architecture

Air Traffic Control System Tutorial II: *System Architecture and Behaviour*

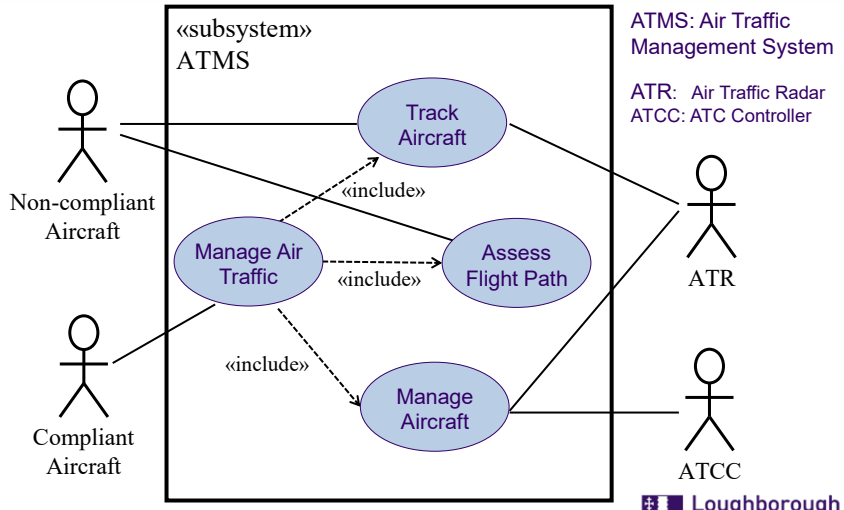
Lecture 10

Loughborough University

1

Use Case: Air Traffic Management Subsystem

Proposal: ATCS is comprised of ATR and ATMS

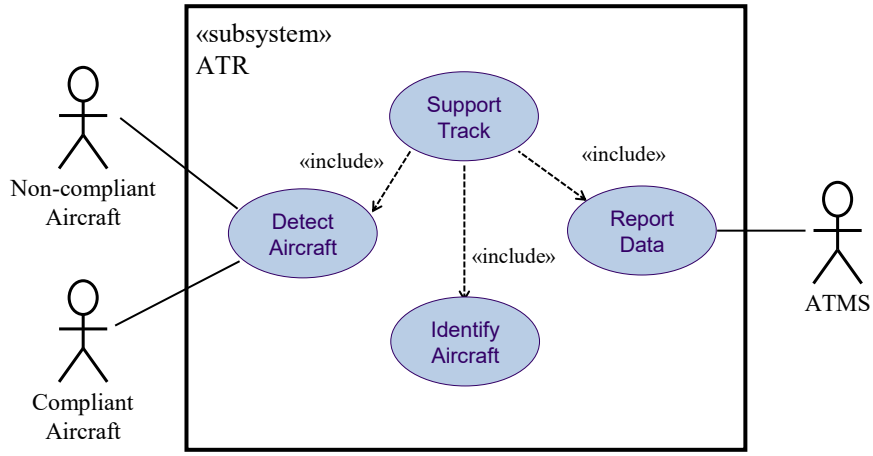


Loughborough University

2

Use Case: Air Traffic Radar Subsystem

Proposed functionality and interactions



The tracking functionality of the ATR has been allocated to ATMS in this use case.

Loughborough University

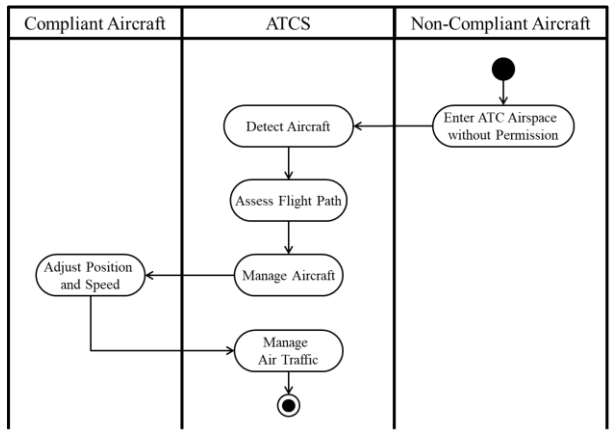
ATCS Use Case Description:

Manage Air Traffic (Case 2: Non-Compliant Aircraft)

Use Case Name	**Manage Air Traffic (Case 2)**
Description	Control existing Compliant Aircraft when Non-Compliant Aircraft enters ATC airspace
Actors	Non-Compliant Aircraft and Compliant aircraft, ATCC
Pre-conditions	Compliant Aircraft in the ATC airspace (simplifying assumption) Non-Compliant Aircraft enters ATC airspace without permission
Post-conditions	None
Extension points	None
List of Action for Basic Flow	1. Track Aircraft (both Non-Compliant Aircraft and Compliant aircraft) 2. Assess Flight Path 3. Manage Compliant Aircraft 4. Track Aircraft (both Non-Compliant Aircraft and Compliant aircraft)
Alternative Flow	None

Loughborough University

ATCS Black Box Activity Diagram:
Case 2: Non-Compliant Aircraft



Narrative (1 of 2):
Occasionally there are unintended aircraft in the airspace of the ATC.

Narrative (2 of 2):
... manage ... positions (iii) assess ... risk of air-to-air collisions

This is one architectural solution to the non-compliant aircraft problem. It addresses a gap in Tutorial 1.

Loughborough University

5

Structure of Tutorial

Key Concepts

Functional Allocation

Concurrent Definition

Collaboration

Interoperation

Key Topics

- Structure Modelling
- Behaviour Modelling
- Architectural Analysis
- System Specification

Loughborough University

6

Subsystem Structure Modelling: Classes, Attributes and Operations

System Elements
(system, subsystems, components)

System-level

ATCS
airSpace
manageAirTraffic( )

Subsystem-level

ATR
detectionRange location
reportData( ) detectAircraft( ) identifyAricraft( )

ATMS
airTrack flightPlan
assessFlightPath( ) manageAircraft( ) trackAircraft( )

Elements in the System Environment
(re-model actors as black-box classes)

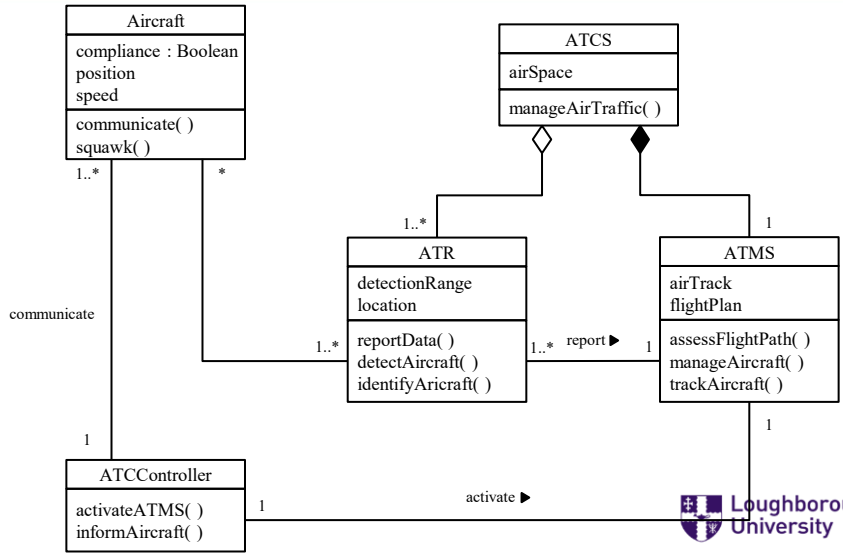
CompliantAircraft
compliance : Boolean position speed
communicate( ) squawk( )

'Squawk' is the response of the identification (ID)transponder.

ATCController
activateATMS( ) informAircraft( )

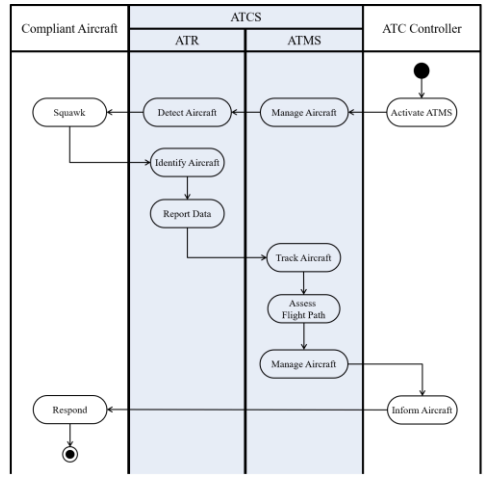
Loughborough University

Subsystem Structure Modelling: Associations and Hierarchy



Loughborough University

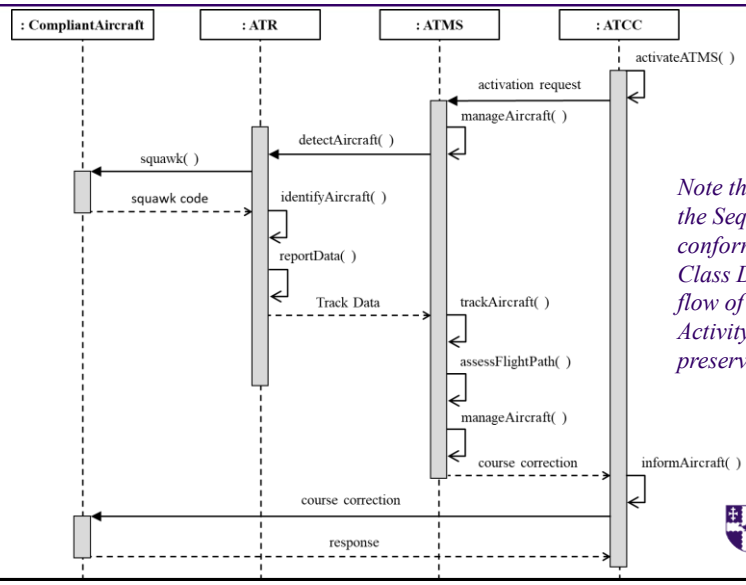
ATCS System Activity Diagram:
Case 1: Compliant Aircraft



Note: this Activity Diagram (from Tutorial I) for the ATCS synthesises subsystem actions with those of both actors. Again, the flow is only an ordering of events.

Loughborough University

ATCS Behavior Modelling (Case 1):
Interactions, Calls, Exchange of Messages



Note that each object of the Sequence Diagram conforms to the ATCS Class Diagram; and the flow of actions in the Activity Diagram is preserved.

Loughborough University

Analysis of Aircraft Critical Flow Density

- Assume the following for sequenced aircraft in the landing pattern:
  - Runway maximum landing / take-off rate of **1 aircraft per min**
    - ***Safety Rule 1: an aircraft cannot touch down whilst another is on the runway***
    - ***Safety Rule 2: each pair of aircraft must have 500 ft altitude separation***
  - Aircraft approach ATC airspace uniformly at max speed of **240 nmi/h**
- Calculated critical spacing for compliant aircraft in the pattern:

$$s = \frac{240\ nmi/h}{1\ aircraft/min} = \mathbf{4nmi/aircraft}$$

- The safety spacing must always be met by compliant aircraft; but must be managed when non-compliant aircraft are in the ATC airspace.
- Critical density = inverse of critical spacing:

$$k_c = 1/s = \mathbf{0.25\ aircraft/nmi}$$

- Safety issues (next tutorial): for the pattern density k, when $k > k_c$
  - How does ATCS manage: (i) aircraft approaching the ATC airspace, and (ii) non-compliant aircraft?

Loughborough University

Summary and System Specification [1]

- ✓ An elaborated system description has been completed:
  - ✓ Elements with functions and attributes
  - ✓ Sequences of functional exchanges
- ✓ System architecture definition: structure and behaviour
  - ✓ Subsystems: Radar and Management Subsystem
  - ✓ 4 external exchanges and 4 internal exchanges
- ✓ System structure and behaviours have been specified and integrated
- ✓ System architecture has been analysed
  - ✓ Behaviour (system processes) proposed for both types of aircraft
  - ✓ Safety analysis started: air traffic critical spacing and density
  - → Ready to seek next agreement between stakeholders & engineering
- ✓ System architecture has been modelled in UML to facilitate precision and communication and prepare for deployment of software

[1] Refer to EA&PSE 6.6.1 Refinement of the System Concept for a textual description of a system specification. The models are part of a technical package; some more for the customer, others for the engineering team.

Loughborough University