EUROPEAN ORGANISATION FOR THE
SAFETY OF AIR NAVIGATION

EUROCONTROL

OPERATIONAL REQUIREMENTS FOR TRAJECTORY PREDICTION FOR EATCHIP PHASE III

OPR.ET1.ST03.1000-ORD-02-00

Edition	:	0.95
Edition Date	:	6 October 1998
Status	:	Working Draft
Class	:	EATCHIP

EUROPEAN AIR TRAFFIC CONTROL HARMONISATION AND INTEGRATION PROGRAMME

DOCUMENT IDENTIFICATION SHEET

DOCUMENT DESCRIPTION

Document Title

OPERATIONAL REQUIREMENTS FOR TRAJECTORY PREDICTION FOR EATCHIP

EWP DELIVERABLE REFERENCE NUMBER :	OPR.ET1.ST03.1000-ORD-02-00		
PROGRAMME REFERENCE INDEX		**EDITION :**	0.95
		EDITION DATE :	6 October 1998

Abstract

This document defines operational requirements for the prediction of aircraft trajectories to be included in Flight Data Processing Systems compliant with EATCHIP.

Keywords

Trajectory Prediction

CONTACT PERSON :	P.Bailey	**DIVISION :**	DED-2

DOCUMENT STATUS AND TYPE

STATUS		CATEGORY		CLASSIFICATION	
Working Draft	■	Executive Task		General Public	
Draft		Specialist Task		EATCHIP	■
Proposed Issue		Lower Layer Task	■	Restricted	
Released Issue					
Superseded					

DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

VERSION	Modified Paragraphs	Comments
0.2		Initial version for internal distribution
0.3 to 0.9	All	Working drafts circulated for development by TP Drafting Group.
0.95	Multi	Edition presented to Operational Requirements and ATM Data Processing Team for approval

Note

This document is a working draft and is in the course of development.

1. Introduction

1.1 Document Purpose

The Operational Requirements for Trajectory Prediction has been produced as part of the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) managed by the European Organisation for the Safety of Air Navigation (EUROCONTROL). It describes the concepts and principles and operational requirements applicable for trajectory prediction to be performed by Flight Data Processing Systems (FDPS's) introduced as part of EATCHIP Phase III in respect of area air traffic control service. It expands the requirements for trajectory prediction as outlined in the Operational Requirements for Flight Data Processing and Distribution Core Functions (Area Control).

The concepts advanced in this document are intended to be viewed in an operational context and are not intended to dictate design.

The operational concepts contained in this document are addressed to the following staff working in development of ATC systems:

- Staff responsible for development of functional specifications for EATCHIP functionality.
- ATM Service Provider staff responsible for FDPS planning and implementation.
- Operational and technical staff in National Administrations concerned with EATCHIP developments.
- Those in industry involved in the development and implementation of ATC systems.

1.2 Scope

This document describes the determination of the trajectory of a flight from take-off or entry to the AoI until landing or exit from the AoI, for the purpose of the support of Air Traffic Management (ATM) services and applies where the flight plan contains processable route and level data.

Functionally, the document addresses the development of the trajectory from receipt of flight data including the flight plan (or equivalent data) and amendments/updates and the identification of the airspace volumes associated with the trajectory. It does not address the subsequent manual manipulation of sector sequences or sector combination/ decombination. The document assumes compliance with ATC procedures and instructions and the trajectory may not be applicable to flights performing radio failure procedures.

The intention of the document is to address requirements of the function as seen from the perspective of the ATSU or area in which it is required. For example, it covers requirements seen from the point of view of an individual ACC, but it is equally applicable from the viewpoint of a state with multiple ACC's.

The domain of ground movement control is not addressed in this document, thus the determination of estimated take-off times from preceding events prior to take-off is not included.

This document is not intended to imply any technical system implementation.

1.3 Purpose of Trajectory Prediction

Within a FDPS, the majority of functions to be performed depend on the path through the airspace that each flight will follow and its expected progress along that path in terms of time. This data is referred to as the trajectory and is associated with the representation of the flight plan within the FDPS (the System Flight Plan (SFPL)). The trajectory includes the points on the route of flight and the level and time at each point, based upon a derived performance profile. Other data is associated with the trajectory such as speed data at each point and whether the flight is taxiing, is known to have departed, is holding in the air, etc. The definition and types of trajectory are at 3.2.4 and the functions that require the data are referred to in his document as the client functions.

1.4 Definitions

1.4.1 Trajectory

Definition A trajectory is a representation of the path of an aircraft, describing the horizontal and vertical profile over time.

The representation may also allow identification of points on the route such as sector boundaries and penetration of special use airspace. Typical ATM systems may represent trajectories as a sequence of annotated 4-D points, although this is not the only representation.

1.4.2 Predicted Trajectory

Definition A predicted trajectory is a representation of the expected trajectory of an aircraft, based on a set of input data and assumptions.

The predicted trajectory includes, inter alia, positional, level, and time data, and uncertainty data.

Within this document the term trajectory refers to a predicted trajectory generated by an FDPS; other predicted trajectories may exist, e.g. within a FMS or aircraft operator's ground system. Different types of trajectory are generated by the FDPS for different purposes and more than one of each may be produced for a flight based on different input data; the classes and statuses of trajectory are explained in section 3.2.4.

1.4.3 Trajectory Prediction

Definition Trajectory prediction is the process by which the predicted trajectory is determined.

1.4.4 Area of Responsibility (AoR)

Definition The volume of the airspace for which a service is provided by the ATSU.

1.4.5 Area of Interest (AoI)

Definition A defined volume of airspace not constrained by the AoR within which the flight trajectories shall be available for all eligible flights.

Many sub-functions require data related to aspects of the trajectory outside the AoR, e.g. to identify a destination airport outside the AoR for which a flight commences its descent within the AoR in order to calculate the Top of Descent (TOD). Whilst it is over-simplistic to assume that this area is the same for all such sub-functions, in general it is referred to in this document as the AoI and represents the set of data required for the performance of any given sub-function to meet the needs of the ATSU(s) concerned. The term 'sector AoI' is also used in this document to identify the volume of airspace in respect of which data is required to be made available to an ATC sector; unless qualified by the word sector, the term AoI refers to that of the unit.

1.4.6 Flight Levels

For the definitions of the different types of levels used in this document, see section 3.1.

1.5 Client Functions

This document takes its requirements from the following functions:

- Flight data management and distribution (including the determination of airspace volume penetration)
- Co-ordination (internal and external)
- SSR code assignment
- Correlation
- Controller requested alternative trajectory creation ('what-if?' probe)
- Monitoring aids
- Medium term conflict detection
- Departure manager
- Arrival manager
- Route conformance checking (AGDL flight plan consistency function)
- Conflict resolution assistant
- Statistical and post-flight analysis (support functions)

Within Flight Data Management and Distribution the following clients receive data based on the trajectory:

- Area unit HMI
- Adjacent/subjacent ATSU
- Aerodrome and approach control units
- Airport operators
- Aircraft
- Aircraft operators
- CFMU
- Military units

1.6 Data Sources

The main sources of data used by trajectory prediction are listed below:

- Initial Flight Plan Processing System (IFPS)
- Controller Input
- Central Flow Management Unit (TACT)
- External units
  - ⇒ Aerodrome and approach control units
  - ⇒ Adjacent area units
  - ⇒ Military units
- Environmental data
- System flight plan data
- Surveillance
- Aircraft operators
- Aircraft performance data
- Aircraft
- Added functions
  - ⇒ MONA
  - ⇒ DMAN
  - ⇒ AMAN

1.7 Organisation of the Document

Section 1 Introduction, gives a general description of the purpose and scope of this document, the purpose and clients of trajectory prediction and definitions of the most significant terms.

Section 2 Route Expansion contains requirements for consistency checking, the insertion of Standard Instrument Departures (SID's) and Standard Arrival Routes (STAR's), diversions and re-entrant flights.

Section 3 Determination of Trajectory details the requirements for trajectory prediction and includes subsections addressing the basic rules, uncertainty and updates to existing trajectories

Section 4 Data Requirements details the requirements for data received from aircraft operators and aircraft, aircraft performance and meteorological data.

Section 5 Performance contains requirements for accuracy and execution time.

<u>Conventions</u>

The specific operational requirements are preceded by explanatory text and are individually numbered. In the specific requirements the following conventions are used:

- The verb **shall** and the suffix M denotes a mandatory requirement.

- The verb **should** and the suffix R denotes a preferred requirement (recommendation).

- The verb **may** and the suffix O denotes an option.

The requirements are preceded by text which explains the context and gives reasoning for the requirements which follow. However, some justifications and explanations may be given in italics following the requirements text.

2. Route Expansion

This section describes requirements whereby the filed route data is expanded into a series of 2D points that make up the expected route. Points may be added or replaced by the application of departure and/or arrival routes.

2.1 Source of Flight Data

2.1.1 Flight Plan Route

The principal source of data in calculating the trajectory for a flight is the flight plan filed by or on behalf of the commander of the flight. Within the flight plan the main items of interest are the departure point, EOBT, destination, route, level, airspeed and aircraft type data. The data elements to be used in the determination of the trajectory and the checks that are to be applied are described in Appendix B.

2.1.2 Augmented Abbreviated Flight Data

Abbreviated flight data, locally entered or derived from co-ordination data for previously unknown flights, may be augmented by data required to perform trajectory prediction. Such data must be checked for consistency as described in Appendix B prior to the calculation of the trajectory.

2.2 Route Consistency Checking

The rules for the format checking of an ICAO flight plan route field are described in Appendix B. In addition to this logic the route must be checked for consistency with the data taken from the environmental database so that a complete trajectory can be determined.

Checks on the route consistency should include the following:

- The checking that all named route elements within the AoI exist.
- Filed fixes preceding or following ATS route elements can be associated with the ATS route.
- Speed level groups should be consistent with the aircraft performance and strategic constraints.

If encountered, cruise climb data suffixed to a significant point is ignored.

TP-01-M	If the route does not comply with consistency checks specified in Appendix B, it shall be referred to an appropriate working position.

2.3 Departures

Departure processing applies where the trajectory immediately after take-off affects the client functions.

Departure processing identifies whether a standard instrument departure (SID) is applicable and, if so, applies the correct one.

A SID consists of instructions specifying the route and optionally a set of speed and level constraints from take-off to a specified point, typically near the boundary of the TMA, at which the en-route ATS route structure may be joined. States normally prescribe whether or not a SID is to be specified in the flight plan; normally the SID exit point is to be specified and the requisite SID is automatically inserted using rules based on the runway of departure and the filed route; exceptionally, a state may require the SID to be specified in the flight plan.

2.3.1 Departure Runway Application

The departure runway to be used by a given flight frequently affects the selection of the SID and consequently the remainder of the trajectory. The determination of the runway to be used by a flight is specified in [EURO ADAPP].

In addition the departure runway can be explicitly specified for an individual flight by manual input.

TP-02-M	The departure runway expected to be used by the flight shall be used in the determination of the trajectory.
TP-03-M	A manually entered departure runway for a specified flight shall override any previously entered or derived departure runway.

2.3.2 Filed and Controller Entered SIDs

If a SID is filed in the flight plan, it is accepted as valid if it is consistent with the route and departure runway but subsequently it may be overridden manually.

A controller entered SID that is incompatible with the departure runway to be used by the flight is an inconsistent situation that is to be inhibited, preferably by the HMI.

A filed SID that is incompatible with the departure runway will be deemed invalid and one of the following options selected as required by operational procedures:

- the flight plan referred for manual modification;
- the correct SID inserted automatically, together with a warning to the operational positions concerned;
- the trajectory determined using the specified SID, together with a warning to the operational positions concerned.

TP-04-M	A filed SID shall be applied in the determination of the trajectory if it is consistent with the route and departure runway.
TP-05-M	A filed SID that is inconsistent with the departure runway shall be subject to one of the following as required by operational procedures: • automatic replacement with a warning; • automatic replacement without a warning; • apply the filed SID with a warning.
TP-06-M	A controller entered SID that does not conflict with the departure runway nor with the route shall override any filed or automatically generated SID.
TP-07-M	The entry of a SID that conflicts with the departure runway shall be inhibited.

TP-08-M	When the application of a SID is controller inhibited without specifying an alternative SID to be applied, the flight shall be ineligible for automatic SID insertion.

2.3.3 SID Insertion

Unless filed or manually inserted as described above, a SID is selected automatically by the FDPS on the basis of the runway expected to be used by the flight, route, type of aircraft, ETOT and SID availability status.

The reason for these criteria is as follows:

- The runway and route identifies the applicable SID or eligible SIDs if more than one.
- Time based selection allows for the availability of different SIDs at different times of day and night.
- Aircraft type selection allows for the selection of SIDs based on different noise levels and performance characteristics.
- SID status selection allows for the manual disabling of a SID for all flights.

The flight plan is referred for manual intervention if a SID cannot be automatically assigned to a flight and the aerodrome of departure requires all departures to be routed via SID's.

Example 1: PTA (Point A) is a point on a SID which is currently available from the departure runway from airport DEPT; PTA and PTB are points on ATS route ATS1.

A flight departing from the applicable runway at DEPT files in fields 13 and 15:

DEPT1500-N0280F210 PTA ATS1 PTB .....

The applicable SID is applied from departure to PTA (TP-09).

Example 2: From the same airport a flight files:

DEPT1500-N0280F210 PTX DCT PTY.......

where PTX is not on any currently active SID from the runway in use.

Depending on the procedures in force at the airport, the options are either to process the flight directly from departure to PTX (TP-10) or to refer the flight plan for manual intervention (TP-11).

TP-09-M	Where a valid SID has not been filed and a SID has not been manually entered, the SID shall be automatically derived from the departure runway, aircraft category, time of departure, SID status and filed route.
TP-10-M	Where a valid SID has not been filed and a SID has not been manually entered and a SID cannot be automatically derived and the aerodrome does not require all departures to be assigned a SID, the departure route shall be derived as a direct route from the runway to the first filed fix.
TP-11-M	Where a valid SID has not been filed and a SID has not been manually entered and a SID cannot be automatically derived and the aerodrome requires all departures to be assigned a SID, the flight plan shall be referred for manual correction.

2.3.4 Direct Routing After Departure

A first filed route segment (from take-off) filed as DCT is interpreted as the intention by the pilot to fly direct to the point without following a SID. If the airport is one where all flights are required to follow a SID, a SID will be applied; if not, the assignment of a SID will be inhibited.

The application of a SID may be inhibited by a controller in which case direct routing to the first specified point is assumed.

The initial climb out on runway heading is allowed for in the trajectory.

TP-12-M	Where DCT is filed as the first route element and the aerodrome does not require all departures to be assigned a SID, the departure route shall be derived as a direct route from the runway to the first filed fix.
TP-13-M	Where DCT is filed as the first route element and the aerodrome requires all departures to be assigned a SID, as required by operational procedures either: • a SID shall be assigned automatically and a warning generated, or • the flight plan shall be referred for manual correction.
TP-14-M	When the application of a SID is controller inhibited without specifying an alternative SID to be applied, direct routing to the first filed significant point shall be assumed.
TP-15-R	The climb profile should allow for the initial climb out on runway heading.

2.4 Lateral Entry

For flights entering the AoI laterally, special requirements for client functions include:

- Co-ordination; it must be possible to associate data received from the upstream unit;
- Monitoring aids; trajectory data must be available for entering flights to allow monitoring to take place prior to the co-ordination point if required by the unit concerned;
- MTCD; the function is required to operate for part of the flight in an adjacent AoR.

TP-16-M	For entering flights the trajectory shall be available from the AoI boundary.

2.5 Processing of Route Segments

2.5.1 General

The 2D points which define the track planned to be followed by the flight are determined. Such points may be derived from the description of an ATS route, a filed direct route segment, CWP input or other processes described in this document.

Ambiguity may exist due to the existence of significant points within or adjacent to the European ICAO region with the same identifier. If the point is filed on an ATS route, the correct one is determined from the ATS route definition; if it is filed on a direct route, an algorithm or rule is required to identify the one to be used.

TP-17-M	Where the identity of a filed significant point is duplicated within or adjacent to the European ICAO region, the point to be used in the determination of the trajectory shall be identified, either from ATS route data or, where a direct route segment is specified, by the use of an algorithm or rule.

2.5.2 ATS Route Processing

Filed ATS route segments are expanded to define the positional aspects of the trajectory by reference to the ATS route definition. Conditional Routes are included in the term ATS routes. The requirement is limited to that portion of an ATS route that is within the AoI.

TP-18-M	Within the AoI, ATS routes within the flight plan shall be expanded to define the positional aspects of the trajectory.

2.5.3 Direct Routes

Direct route processing occurs when a route segment is filed or entered between two points. The currently valid forms to specify a 2D location are a significant point name, bearing and distance from a significant point and latitude and longitude.

Positional data is required to be available for all significant points within the AoR and those outside the AoR to or from which flights route directly on leaving or entering the AoR respectively.

TP-19-M	The capability shall be provided for the trajectory to be determined from route segments expressed as a direct route between two specified positions.

2.6 Arrival Processing

Arrival processing consists of Arrival Runway Selection and STAR determination and is performed where the arrival runway is of interest to the unit concerned.

2.6.1 Arrival Runway Selection

The determination of the arrival runway to be used by a flight is specified in [EURO ADAPP].

Alternatively the arrival runway can be explicitly specified for an individual flight by manual input or AMAN.

Once the arrival runway is identified, the intermediate approach route from the IAF and ETA can be determined.

TP-20-M	The arrival runway expected to be used by the flight shall be used in the determination of the trajectory.
TP-21-M	A manually entered arrival runway for a specified flight shall override any previously entered or derived arrival runway.

2.6.2 Filed and Controller Entered STAR's

A Standard Arrival Route (STAR) is a published route from an ATS route to the IAF. In some cases a STAR applies only for a specified arrival runway; in others, a STAR also may be used for arrivals at minor aerodromes close to the airport for which they exist primarily. Each point on the STAR may be associated with a speed or level strategic constraint.

A controller entered STAR that is incompatible with the arrival runway to be used by the flight is an inconsistent situation that is to be inhibited, preferably by the HMI.

If a STAR is filed in the flight plan, it is accepted as valid if it is consistent with the route and arrival runway but subsequently it may be overridden manually.

A filed STAR that is incompatible with the arrival runway will be deemed invalid and one of the following options selected as required by operational procedures:

- the flight plan referred for manual modification;
- the correct STAR inserted automatically, together with a warning to the operational positions concerned;
- the trajectory determined using the specified STAR, together with a warning to the operational positions concerned.

TP-22-M	A filed STAR shall be applied in the determination of the trajectory if it is consistent with the route and arrival runway.
TP-23-M	A filed STAR that is inconsistent with the arrival runway shall be subject to one of the following as required by operational procedures: • automatic replacement with the correct STAR with a warning; • automatic replacement with the correct STAR without a warning; • apply the filed STAR with a warning.
TP-24-M	A manually entered STAR that does not conflict with the arrival runway nor with the route shall override any filed or automatically generated STAR.
TP-25-M	The entry of a STAR that conflicts with the arrival runway shall be inhibited.
TP-26-R	When the application of a STAR is controller inhibited, without specifying an alternative STAR to be applied, the flight should be ineligible for automatic STAR insertion.

2.6.3 STAR Insertion

Unless filed or manually inserted as described above, a STAR is selected automatically by the FDPS on the basis of the runway expected to be used by the flight, route, category of aircraft, ETA, aircraft operator and STAR availability status.

The reason for these criteria is as follows:

- The runway and route identifies the applicable STAR or eligible STARs if more than one.
- Time based selection allows for the availability of different STAR at different times of day and night.
- Aircraft category selection allows for the selection of STARs based on different noise levels and performance characteristics.

- Aircraft operator allow the application of special procedures agreed with individual operators.
- Status selection allows for the manual disabling of a STAR for all flights.

The flight plan is referred for manual intervention if a STAR cannot be automatically assigned to a flight and the aerodrome of departure requires all departures to be routed via STARs.

Subsequently the STAR may be overridden manually. The normal case is represented by requirement TP-27.

TP-27-M	Where a valid STAR has not been filed and a STAR has not been manually entered, the STAR shall be determined automatically from the arrival runway, aircraft category, aircraft operator, ETA, STAR status and filed route.
TP-28-M	Where no STAR can be automatically applied and none has been filed or entered and the aerodrome does not require all arrivals to be assigned a STAR, the arrival route shall be derived as a direct route from the last filed fix to an appropriate fix or the aerodrome as required by the operational procedures.
TP-29-M	Where a valid STAR has not been filed and a STAR has not been manually entered and a STAR cannot be automatically derived and the aerodrome requires all arrivals to be assigned a STAR, the flight plan shall be referred for manual correction.

2.6.4 Direct Route Prior to Arrival

A last filed route segment (to arrival) filed as DCT is interpreted as the intention by the pilot to fly direct from the point without following a STAR. If the airport is one where all flights are required to follow a STAR, a STAR will be applied; if not, the assignment of a STAR will be inhibited.

The application of a STAR may be inhibited by a controller in which case direct routing from the last specified point is assumed.

TP-30-M	Where DCT is filed as the last route element and the aerodrome does not require all arrivals to be assigned a STAR, the arrival route shall be derived as a direct route from the last filed fix to the runway.
TP-31-M	Where DCT is filed as the last route element and the aerodrome requires all arrivals to be assigned a STAR, as required by operational procedures either: • a STAR shall be assigned automatically and a warning generated, or • the flight plan shall be referred for manual correction.
TP-32-M	When the application of a STAR is controller inhibited without specifying an alternative STAR to be applied, direct routing from the last filed fix to an appropriate fix or the aerodrome as required by operational procedures shall be assumed.

2.7 Lateral Exit

For flights leaving the AoR laterally into the airspace of the next unit, special requirements for client functions include:

- Co-ordination; it must be possible to associate data received from the next unit;
- Monitoring aids; trajectory data must be available for exiting flights to allow monitoring to take place after the co-ordination point if required by the unit concerned;
- MTCD; the function may be required to operate for part of the flight in an adjacent AoR.

TP-33-M	For exiting flights the trajectory shall be available to the AoI boundary.

2.8 Diversion Processing

A diversion is the act of proceeding to an aerodrome other than the filed destination for the purpose of landing.

A diversion could be entered as a route amendment but, if a controller is busy, the entry of a complete route may be undesirable and time-consuming. It is therefore recommended that the route to the diversionary airport be determined automatically. This requirement applies where such a route from a point in the vicinity of the present position to the airport has been defined.

TP-34-R	Trajectory prediction should be able to construct a route and trajectory to any defined airport or defined exit point from the AoI on controller request.

2.9 Re-entrant Flights

Some flights pass more than once through an AoR, i.e. they are re-entrant. It is also possible for a flight to pass more than once through the AoI. Where the flight is re-entrant but remains within the AoI, a single trajectory is generated with information about each penetration of the AoR being separately provided. Where the aircraft passes more than once through the AoI, independent trajectories are generated for each AoI penetration.

Similarly, an aircraft may transition from IFR to VFR or back to IFR one or more times, while remaining in the AoI. In this case, an independent trajectory will be generated for each period of IFR flight.

TP-35-M	Where a flight re-enters an AoR, while remaining within the AoI any information related to the traversal of the AoR (e.g. co-ordination information) shall be determined for each traversal.
TP-36-M	When a flight re-enters an AoI, independent trajectories shall be determined for each period of operation within the AoI.
TP-37-M	When a flight has more than one period of IFR operation within the AoI, an independent trajectory shall be determined for each period of operation.

2.9.1 Aerial Manoeuvring Areas

Some flights require to proceed to and spend a period of time manoeuvring within a specified airspace. Such airspaces include aerial tactical, target towing and refuelling areas and those used for training and flight tests. Such areas are referred to in this section as aerial manoeuvring areas.

The requirements include the determination of the trajectory to the specified airspace and allowance for a period of time spent manoeuvring within it. The determination of trajectories within the areas is not performed.

The requirements assume that a suitable format exists for the inclusion in flight plan data of the period to be spent in the area but that such information is used only as a broad estimate, the actual time of leaving being determined at shorter notice in association with the authority responsible for operations in the area. The flight is considered re-entrant with the part after leaving the area in the notified state until the time is confirmed after which it becomes active.

TP-38-M	When a flight has indicated its intention to operate within an aerial manoeuvring area, the trajectory shall be determined to the boundary of the area prior to such manoeuvring and from the boundary of the area after such manoeuvring.
TP-39-M	When a flight has indicated its intention to operate within an aerial manoeuvring area and a leaving time has not been confirmed, the trajectory calculation shall end upon the entry to the area.
TP-40-M	Points on the trajectory after leaving an aerial manoeuvring area shall utilise a confirmed exit time from the area when available.

3. Determination of Trajectory

Trajectory prediction for a flight is performed when required by the functions to which it provides a service. It can be performed at any time after full flight plan[1] data is available and subsequently is carried out when significant changes are made to data used in the function.

The 4D trajectory prediction phase takes the list of 2D points and applies constraints such as LoA procedures, controller instructions, aircraft performance and meteorological data to produce the level, time and VRC at each point in the trajectory. The list of items which apply to the flight, except for the meteorological data, is referred to as the Flight Script.

Airspace volume penetration including sectors traversed is identified and additional points are created where necessary.

3.1 Definitions of Levels

Reference is made within this and subsequent sections to different types of level. These are normally flight levels but embrace altitudes.

Requested Flight Level (RFL): The level requested by the aircraft operator in the flight plan for the segment of the route under consideration.

IFR flight plan segments specify the level at which it is desired that the aircraft will fly; the RFL may be changed at significant points specified in the flight plan or by the crew directly to ATC either before or after take-off.

Enroute Cruising Level (ECL): The level that the flight is to maintain for a significant part of the flight after reaching TOC and prior to TOD.

The ECL is set initially to the RFL but may be changed automatically due to the presence of a strategic constraint (level limit) which applies to flights between the aerodromes of departure and destination. The ECL may be manually changed where the flight is to maintain a different cruising level, typically due to the proximity of a flight at the RFL on the same route. As with the RFL, the ECL can be changed for different segments of the route and, if different in the cruise phase, is changed to the XFL on passing the sector boundary. The ECL ceases to exist after the final TOD from cruising level.

Cleared Flight Level (CFL): The current flight level limit of the clearance acknowledged by the pilot of the flight.

The CFL is that to which the flight was last cleared by ATC and is either its current level or that to which it is cleared to descend or climb. Prior to TOC and after TOD, in many instances the CFL is of limited duration.

Exit Flight Level (XFL)

The level to which a flight is planned to be cleared on leaving the airspace volume.

The XFL applies equally to transfers between sectors or between units. This level defaults to the ECL or, if applicable, the level defined in a strategic constraint. It may be changed manually prior to co-ordination.

Exit Conditions

The XFL and optionally any associated supplementary level data where the flight is planned to be in vertical transition on leaving the airspace volume.

---

[1] A full flight plan contains enough information for trajectory prediction to be performed on it. An abbreviated flight plan does not contain enough information for trajectory prediction to be performed.

3.2 Trajectory Creation - General

3.2.1 Points Included in a Trajectory

The trajectory for a given flight will include data related to the following points within the AoI:

- Aerodromes of departure and destination
- Significant points derived from filed ATS route data, including points at which a transition takes place from/to an OAT or VFR segment
- Aerial manoeuvring areas
- Significant and turn points derived from inserted ATS route data such as SIDs
- Tactical constraint application points
- Entry and exit points of airspace volumes including
    - ⇒ ATC sectors
    - ⇒ Approach control AoR's
    - ⇒ AoR's of ACC's
    - ⇒ AoI's
    - ⇒ OAT AoR's
    - ⇒ Temporary Segregated Areas (TSA's)
- Top Of Climb
- Top of Descent

Speed, time, level, manoeuvre, uncertainty and other data are included at each significant and derived point.

The tactical constraint application points include those derived from the estimation of the future path of the flight where an open horizontal constraint has been issued.

A trajectory is calculated based on the data included in the flight script (see section 3.2.3).

TP-41-M	Each trajectory shall include the following points (where applicable) on the unexpired route of flight inside the AoR and those outside the AoR as required by the client functions: • departure runway or aerodrome; • destination runway or aerodrome; • filed fixes; • published fixes derived from filed ATS routes; • fixes derived from automatically inserted CDRs; • fixes derived from SIDs; • fixes derived from STARs; • tactical constraint application points derived from controller input; • points describing the intermediate and final approach path; • airspace penetration points; • points at which strategic constraints are applied or terminated; • inbound co-ordination points; • outbound co-ordination points; • position of TOC(s); • position of TOD(s).

3.2.2 Constraints

A predicted trajectory is derived from navigation elements of the filed flight plan (route and RFL) and ATC constraints. Such constraints applied to a flight include :

- strategic constraints (i.e. letters of agreement, sector/centre entry/exit points and levels, etc.)
- tactical control instructions

The navigational elements are described in [PANS-RAC] and Appendix B.

3.2.2.1 Strategic Constraints

Strategic constraints limit the trajectory in order to meet standard ATC procedures.

Such constraints may limit level, speed and route and normally depend on the airspace penetrated although they can depend on an ATS route being flown.

Examples of strategic constraints include the following:

- Agreed boundary crossing levels defined in the LoA between ATS units, either globally or based on flight characteristics such as the departure aerodrome or the boundary crossing points.
- Level constraints applicable to flights on departure routes including those resulting from ATC procedures.
- Speed constrained within a TMA airspace to a maximum value.
- Entry to an airspace within a specified level band restricted due to the presence of a TSA; the trajectories of flights that would climb or descend through the band must pass above or below it.
- A maximum enroute cruising level applicable to flights between two specified airports.

3.2.2.2 Tactical Constraints

Tactical constraints consist of those instructions that are issued to a flight or known in advance of such issue for the purpose of tactical control and include the following:

- Heading or track
- Proceed to point (not on route)
- Resume normal navigation
- CFL
- Speed
- Time at position (delay absorption)
- VRC
- Exit/entry level (XFL/PEL)
- Hold and hold cancellation (including orbit)
- Offset and end offset
- Missed Approach
- Route amendment

3.2.2.3 Types of Tactical Constraint

Open Constraint

When an *open constraint* is applied in isolation to a flight, the new trajectory is not known with certainty. Another instruction is needed to know the way the flight will resume its normal navigation, e.g. a heading instruction is an *open constraint* and is completed by an instruction to resume navigation or to proceed direct to a specified point.

Open constraints comprise the following :

- heading or track where the intended limit of the constraint is not known;
- indefinite hold (including orbiting) where the time at which the flight is to leave the holding pattern is not known;
- CFL in climb or descent phases;
- Speed restriction in climb or descent phases;
- vertical rate instruction.

All other constraints are considered to be closed.

Open Constraints may be of two types, as defined below:

Indeterminate Open Constraints: These relate to short term tactical manoeuvres where the flight profile, subsequent to the constraint, cannot be reliably predicted for client functions. No reliable assumptions can be made about how to close the constraint until a further, appropriate operator input is received. An example of an indeterminate open constraint is where a flight is put into an indefinite hold because of bad weather. Trajectory calculations are no longer feasible or sensible.

Determinate Open Constraints: These are constraints which allow for short term free tactical manoeuvring; an assumption about the most probable subsequent behaviour is possible, allowing a high degree of confidence in the most likely return to the planned profile. There are two main categories of closure for these constraints:

- **Determinate by application of an absolute limit** - In this case it is assumed that the flight will continue in its current progression without change until an absolute limit is reached. For example, for a vertical rate instruction during climb, the CFL, if not limited by aircraft performance, can be taken as the absolute limit to the manoeuvre.

- **Determinate by application of a high probability profile** - Reversion back to the planned profile, by application of a high probability closing profile, is possible. An open heading instruction can be closed by this means.

The optional Forecast Trajectory provides the capability to close for each of the determinate open constraints. It is envisaged that this option will be achieved by the selection and application of appropriate parameters, defining the closure criteria and profiles for each type of open constraint.

Closed Constraint

'Closed constraints' are those whose effect is completely predictable, e.g. to route direct from present position to a specified point on the planned trajectory or to apply a rate of climb until passing a specified level.

Target constraint

A *target constraint* is a constraint defined by an objective to reach for the aircraft without indication on its expected behaviour.

The *target constraint* list is the following :

- altitude constraint (to be at level xxx at point Y)
- time constraint (to be at time t at point Z)
- speed constraint (to be at speed v at point X)

All other constraints will be considered *non-target*.

3.2.3 Flight Script Creation

A flight script contains all available data required to compute the trajectories for a flight. A flight script includes the following attributes:

- the expanded route, expressed as a sequence of points and manoeuvres and their associated route elements;
- strategic constraints affecting the flight;
- ATC tactical constraints;
- entry level conditions (co-ordination data);
- the applicable rules for profile calculation as expressed by aircraft operators and in aircraft performance models;
- cruise speed(s);
- requested flight level(s);
- departure and arrival runways;
- time delay to be absorbed and method of absorption;
- current position of the aircraft (if applicable), otherwise the first point on the trajectory.

The flight script does not contain meteorological data.

The trajectories described below result from a single flight script and may include a number of local segments for re-entrant flights where applicable. Alternative trajectories may be produced using different flight scripts to satisfy AMAN criteria or “what-if?” scenarios.

3.2.4 Types of Trajectory

More than one trajectory can exist simultaneously for a flight in the Flight Data Processing System. Differing views on the behaviour of the flight result in the need for different trajectories. It may be noted also that others exist including those in the aircraft itself and in surveillance systems.

Within an ATM system, most trajectories are predicted trajectories, and this assumption is made in the definitions below. The distinctions made between planned/tactical trajectories (termed classes of trajectory) and between active/alternative trajectories (termed statuses of trajectory) are orthogonal, so a system which included both distinctions would have four trajectory types, for example “active planned trajectory” and “alternative tactical trajectory”.

3.2.4.1 Class of Trajectory

Up to three types of trajectory can exist - the planned, forecast and tactical trajectories. The planned trajectory is mandatory; the forecast and tactical trajectories are optional. For the purpose of this document all types are considered to exist simultaneously for the whole of each flight.

Planned Trajectory

A planned trajectory represents the expected behaviour of the aircraft, taking into account its planned route and requested vertical profile, strategic ATC constraints, closed tactical constraints, co-ordination conditions, downlinked or calculated data and the current state of the aircraft. Optionally it may include provision for short-term open constraints issued by tactical controllers.

The planned trajectory represents the stable medium to long term behaviour of the aircraft but may be inaccurate over the short term where tactical instructions issued to achieve the longer term plan are unknown or a probable trajectory has been calculated on the basis of assumptions of expected short term behaviour. In order to provide this view of the aircraft’s predicted behaviour, it will not always be appropriate to start the trajectory at the current position of the aircraft. The planned trajectory is re-computed whenever an open constraint is closed or a closed constraint is entered.

Forecast Trajectory

A Forecast Trajectory represents the expected behaviour of the aircraft taking into account clearances and other instructions issued to the aircraft and assumptions about how the Planned Trajectory can be rejoined.

The Forecast Trajectory is a hybrid trajectory merging the views on the expected aircraft behaviour as predicted in the Planned and Tactical Trajectories. It contains the current position of the aircraft and extends from that point onwards in accordance with tactical constraints until rules prevail that makes it rejoin the Planned Trajectory. From the rejoining point onwards, the route of the Forecast Trajectory is identical to that of the Planned Trajectory.

Tactical Trajectory

A tactical trajectory represents the expected tactical behaviour of the aircraft taking into account all clearances and other instructions issued to the aircraft but without making assumptions regarding how the constraint will be closed.

The tactical trajectory represents the expected behaviour of the aircraft in the absence of further controller instructions and starts from the current position of the aircraft. The tactical trajectory is useful for a relatively short prediction horizon, (e.g. 5-10 minutes) after which it is expected that further known tactical instructions would have been issued. This document does not describe how far the tactical trajectory extends as it depends on the requirements of the client function, particularly MTCD, although, where followed, it is limited to the extent of the planned trajectory.

3.2.4.2 Status of Trajectory

Each class of trajectory has one of the following statuses.

Active Trajectory

An active trajectory represents the expected behaviour of the aircraft based on the up-to-date information about the aircraft and clearances at the time of calculation.

A flight will have only one active trajectory of each class.

Alternative Trajectory

An alternative trajectory represents the behaviour of the aircraft which would be expected based on a modified version of the up-to-date information about the aircraft at the time of calculation.

Such modifications include a simulation of a possible new clearance (a “what-if?”), the resultant trajectory representing the behaviour of the aircraft which would be expected if the clearance were applied. A flight may have zero, one or more than one alternative trajectories.

Note 1- Design considerations may require the generation of alternative SFPLs to hold data associated with alternative trajectories; the description of alternative trajectories does not constrain such decisions.

Note 2- Within this document, reference to the planned trajectory and to the active trajectory is to be assumed unless reference to a tactical or alternative trajectory is made explicitly.

TP-42-M	A planned trajectory shall be produced in accordance with the rules described in this document.
TP-43-M	One active planned trajectory shall exist per flight for each separate period of operation within the AoI.
TP-44-O	A tactical trajectory may be produced in accordance with the rules described in this document.
TP-45-O	Not more than one active tactical trajectory may exist for a single flight.
TP-46-M	Multiple alternative planned and tactical trajectories shall be produced for a single flight as required.

Note - The SFPL itself may be in different life-cycle states, e.g. initial, active. It should be noted that such considerations do not affect the trajectory calculation requirements described in this document.

3.3 Tactical Trajectory

3.3.1 Route

Where the option to maintain a tactical trajectory is chosen, it is considered to exist from the present position of the flight.

Non-Constrained

If the flight is not subject to a horizontal tactical constraint:

1. If it has not deviated from the planned trajectory, the route follows the planned trajectory.
2. If it has deviated from the planned trajectory, the tactical trajectory routes from the present position to the next appropriate point on the planned trajectory and then follows the planned trajectory. For this the requirements are as described in 3.7.4 Heading and Track Related Tactical Constraint Processing for the planned trajectory.

Constrained

If the flight is subject to a closed horizontal tactical constraint, the route is calculated in accordance with the issued constraint after which it follows the planned trajectory. If necessary, the trajectory routes from the point at which the constraint is terminated to the next appropriate point on the planned trajectory.

If the aircraft has an active open heading (or track) constraint, the route is calculated in accordance with the issued constraint but no attempt is made to regain the planned trajectory. The applicable wind values will be applied to the heading to determine the track.

Next Appropriate Point

Rules are to be used to select a point on the planned trajectory to which the route is to converge as required.

Note:	*The following requirements exist only where the option to maintain a tactical trajectory is chosen.*
TP-47-O	The tactical trajectory shall extend from the present position of the flight.
TP-48-O	Where a horizontal constraint is not applicable and the flight is proceeding in conformance with the planned trajectory, the route of the tactical trajectory shall follow the route of the planned trajectory.
TP-49-O	Where an open horizontal constraint is not applicable and the position of the flight is not in conformance with the planned trajectory, the tactical trajectory shall route from the present position to the next appropriate point on the planned trajectory.
TP-50-O	Where an open horizontal constraint is applicable, the tactical trajectory shall route from the present position in accordance with the constraint.

3.3.2 Level

The tactical trajectory always respects the current CFL. The aircraft performance data used in determining the planned trajectory is used for the climb and descent performance.

Where a series of level instructions are given such as in the definition of a SID, the final level is maintained until a different CFL is issued.

Note:	*The following requirement exists only where the option to maintain a tactical trajectory is chosen.*
TP-51-O	The tactical trajectory shall maintain, climb or descend to the current CFL using performance data used in determining the planned trajectory.

3.3.2.1 Departure Clearance

For departing flights, a departure clearance may be issued which contains:

- the level to which the flight is cleared on take-off;
- a SID which includes level data in its definition;
- a SID plus a specified level.

Level restrictions included in the description of a SID or issued as part of the departure clearance are CFL's and must be respected by the tactical trajectory. The rules for the generation of departure clearance are given in reference [EURO ADAPP].

Note:	*The following requirement exists only where the option to maintain a tactical trajectory is chosen.*
TP-52-O	The tactical trajectory shall comply with level restrictions included in the description of a SID assigned to the flight or issued as part of the departure clearance unless a CFL has been entered.

3.4 Forecast Trajectory

3.4.1 Closure of Open Constraints

The forecast trajectory closes each of the determinate open constraints. It is envisaged that closures will be achieved by the selection and application of appropriate system parameters, defining the closure criteria and profiles for each type of open constraint.

TP-53-O	It may be possible to automatically identify and close determinate open constraints in accordance with pre-defined closure criteria and profiles.
TP-54-O	It may be possible to configure closure criteria for each type of determinate open constraint.
TP-55-O	It may be possible to configure closure profiles for each type of determinate open constraint.

3.4.2 Route

The route of a Forecast Trajectory contains the present position of the flight.

The route from the present position takes into account the horizontal tactical constraints, the observed aircraft behaviour and assumptions about when the flight will rejoin the Planned Trajectory in the case of open tactical constraints.

If the observed track of the flight is inconsistent with the current planned trajectory, the observed behaviour and assumptions about when the flight will rejoin the original trajectory may be applied in calculating an alternative trajectory for controller acceptance as an addition to the conformance warning.

Note:- The deviation parameter used in determining the above inconsistency would need to be greater than the lateral deviation parameter used by MONA.

Note:	*The following requirements exist only where the option to maintain a forecast trajectory is chosen.*
TP-56-O	The further route of the Forecast Trajectory shall start at the present position of the flight.
TP-57-O	From the present position, the Forecast Trajectory shall extend in accordance with horizontal tactical constraints, observed aircraft behaviour and assumptions about when the flight will rejoin the Planned Trajectory.
TP-58-O	If a flight is out of conformance horizontally, an alternative trajectory for controller acceptance may be generated in accordance with the observed track of the flight to rejoin the original trajectory.
TP-59-O	From the rejoining point, the route of the Forecast Trajectory shall be identical to that of the Planned Trajectory

3.4.3 Level

The Forecast Trajectory respects vertical constraints in the same way as the Planned Trajectory, from the next application point onwards.

The Forecast Trajectory contains the AFL and VRC of the aircraft at it's present position.

Note:	*The following requirements exist only where the option to maintain a forecast trajectory is chosen.*
TP-60-O	The Forecast Trajectory shall contain the AFL and VRC of the flight at the present position.
TP-61-O	From the AFL, the Forecast Trajectory shall be predicted to next vertical constraint, taking into account the observed behaviour of the aircraft.
TP-62-O	The vertical profile of the Forecast Trajectory shall be identical to Planned Trajectory from the next vertical constraint onwards.

3.5 Planned Trajectory - Basic Principles

The principles described in this section apply to all executions of the function. Those in section 3.7 apply when a tactical constraint is applied to or removed from a flight.

3.5.1 Application of Strategic Constraints

All strategic constraints as far as the point defining the end of the constraint have to be met by the trajectory unless overridden by a tactical constraint.

Strategic constraints based on the following criteria are applied to flights to which they are applicable:

- Flights through a specified fix;
- Flights on a specified route segment;
- Flights through a defined area;
- Flights climbing out from or descending into a specified aerodrome(s).

In some instances strategic constraints are applicable only at specified periods.

The application of a strategic constrains results in one or both of the following:

- The crossing of a point or area:
  - ⇒ at a specified level;
  - ⇒ at or below a specified level;
  - ⇒ at or above a specified level;
  - ⇒ between specified levels.
- A speed to be maintained during a specified procedure or in a defined airspace.

When a strategic constraint cannot be met by the flight due to a breach of the unconstrained flight envelope:

- The strategic constraint is met by changing the aircraft performance within the limits of the normal performance envelope to achieve the constraint;
- If it cannot be met, the strategic constraint is met as soon as possible after the start of the constraint and a warning is generated.

Level restrictions included in the description of a SID or issued as part of the departure clearance are considered as CFLs. If the planned trajectory is required to respect such level restrictions, they must be declared as strategic constraints.

For the purpose of this document, Conditional Routes (CDRs), Temporary Segregated Areas (TSAs) and Prohibited Areas are not in themselves strategic constraints as they do not constrain the calculation of the trajectory although a strategic constraint may exist which causes a TSA to be avoided vertically. The rules for the application of CDR's and TSA's are defined in sections 3.5.7 and 3.5.8 respectively.

TP-63-M	The planned trajectory shall comply with any applicable strategic constraint following the preferred economic profile if possible.
TP-64-M	When a strategic constraint cannot be met by following the preferred economic profile, the strategic constraint shall be met by modifying the aircraft performance within the achievable performance values.
TP-65-M	When a strategic constraint cannot be met within the achievable performance values, a warning shall be generated.

3.5.2 Determination of Track

The track is determined for that part of the route of flight required by the client functions. The capability is required to process route segments filed as ATS routes as either rhumb line or great circle tracks as required. In principle, great circle tracks are required for all segments filed as direct (off ATS) routes The requirement for great circle track calculation may be relaxed where the difference from a simpler calculation method is insignificant.

TP-66-M	Great circle processing shall be applied routes except where the difference from a simpler calculation method is insignificant.
TP-67-M	The capability shall be available to calculate tracks specified as ATS routes using great circle processing.

3.5.3 Level and Time Processing

The level, ground speed, time and Vertical Rate of Change (VRC) are calculated for all significant and derived points on the trajectory. It is required to be able to determine these values at any position in the trajectory between the significant and derived points, for example, where the ground speed or VRC is expected to change significantly between two points.

TP-68-M	The time, ground speed, level and VRC at all points in the trajectory shall be determined.
TP-69-M	It shall be possible to determine the correct time, ground speed, level and VRC (within specified tolerances) throughout the trajectory.

3.5.3.1 Time at Start Point

For the initial calculation, the time at each point on the trajectory is a function of the time at the start point and the time of flight to the point under consideration. The start points for the different types of entry are shown in Table 1.

Entry Type	Start of Trajectory
Departure	Runway or aerodrome of departure
Entering flights	Not later than the entry point to the AoI
Transitioning Flights	Point of transition between VFR and IFR
Airfile	Filed start point of flight plan

Table 1 - Start Points

3.5.3.1.1 Departing Flights

The most up to date departure time is used. For airborne flights the Actual Time of Departure (ATD) is used as received by the function, normally as a result of manual input or detection by surveillance. In the event of an erroneous departure time having been entered, a revised departure time overrides any previous departure time.

Prior to take-off the Estimated Take-off Time (ETOT) is used if available (the calculation of the ETOT is outside the scope of this document). If an ETOT has not been received, any calculated take-off time received from the CFMU is used, otherwise a time based on the EOBT plus an allowance for ground manoeuvring is used.

TP-70-M	Trajectory data prior to take-off shall be based on the following in descending order of priority: • Calculated Time of Departure (CTD) received from DMAN; • Received ETOT; • Slot time received from the CFMU (CTOT); • EOBT.
TP-71-M	The trajectory for an airborne departing flight shall be based on the ATD.

3.5.3.1.2 Other Flights

For entering flights, the time received for the co-ordination point in co-ordination and notification data (in descending priority) are used in the determination of trajectory time data.

It is assumed that the ETO for a transition point from a VFR to an IFR segment is entered manually.

If the trajectory is required prior to notification or manual entry, approximate time data may be extrapolated from the flight plan. Unless the elapsed time to a known point on the trajectory is filed, time data may be estimated using the EOBT and a calculated flying time from the departure aerodrome.

The initial point and the time at the point included in airfile flight plan data is used for trajectory calculation for such flights.

For all flights, data updated by flight plan monitoring aids supersedes any previously available data and overrides any received or entered time data, e.g. the time received in co-ordination data is ignored if the flight is being monitored following the earlier receipt of notification data and subsequent correlation. Eligibility rules within flight plan monitoring must ensure the avoidance of any undesirable consequences, e.g. where a flight is holding prior to entering the AoR.

TP-72-M	Time data shall be based on the following as applicable to the flight in decreasing order of priority: • Flight plan monitoring; • Manually entered time data; • Co-ordination data; • Notification data; • Time at airfile point; • Flight plan data.

3.5.3.2 Level Processing

3.5.3.2.1 Determination of the Enroute Cruising Level (ECL)

The achievement of the ECL is the objective of the climb phase and is the level at which the flight is processed until reaching Top of Descent. As with the RFL, the ECL can differ throughout the trajectory, even though for many flights, only a single cruising level is flown. In the absence of controller input, the ECL is determined using a set of priorities.

The ECL is determined as follows in descending priority order:

- Controller entered ECL;
- Strategic constraint limit;
- For flights which have not departed from specified aerodromes, typically close to the boundary, the entry flight level (EFL);
- The RFL.

A warning is provided if the ECL is below a minimum level available on a route.

TP-73-M	The ECL shall be determined as follows in descending priority order: • Controller entered ECL; • Strategic constraint limit; • For flights which have not departed from specified aerodromes, typically close to the boundary, the entry flight level; • RFL.
TP-74-M	If the ECL is below a strategic constraint which specifies the lowest level available for the flight, a warning shall be made available.

3.5.3.2.2 Climb Processing

Climb processing is based on the default profile being to climb as early as possible, thus for departing flights, the climb commences at the departure aerodrome and is limited only by the strategic constraints, if any. The climb is calculated to the Enroute Cruising Level (ECL).

The climb profile is determined using aircraft performance data or specific data received for the flight as described in section 4.2 in conjunction with the expected wind vectors and the strategic constraints such as those applicable to a SID and standard climb-out procedures.

The top of climb (TOC) is the point at which the flight is calculated to reach the ECL.

An exception case is where the TOC is calculated to occur after the TOD or within a short distance or time prior to it. In this case the trajectory is calculated to level out prior to the ECL being reached.

The level and VRC are calculated for each point on the trajectory.

TP-75-M	The planned trajectory shall be calculated to climb to the Enroute Cruising Level (ECL) following restriction (if any) by strategic constraints, except after a parameter distance or time before the resultant profile would intercept the descent profile.
TP-76-M	Where the climb profile intercepts the descent profile or the calculated distance or time between TOC and TOD is less than a parameter value, the TOC shall be established at a level prior to the attainment of the ECL.
TP-77-M	The climb profile shall be determined using the aircraft performance data for the climb between the aerodrome and the ECL taking into account the meteorological data and strategic constraints.

3.5.3.2.3 Airfiles and Transitions

Where a transition from VFR to IFR is filed prior to TOC and the regulations require all flights to be IFR above a specified lower level, the trajectory identifies the penetration of such lower airspace. It should be noted that the route between the aerodrome and the transition point cannot be estimated with any degree of accuracy.

Otherwise the filed level is applied to the point at which an airfile flight plan or an IFR segment commences.

TP-78-M	Where a transition from VFR to IFR is filed prior to TOC and the regulations require all flights to be IFR above a specified level lower than the ECL, the trajectory shall identify the penetration of such lower airspace.
TP-79-M	The level at the initial point filed in airfile flight plans shall be used in the determination of the trajectory.
TP-80-M	Except where TOC has not been reached, the filed level at the transition point shall be used for the determination of trajectory data for IFR flight segments which are preceded by a VFR segment.

3.5.3.2.4 Descent Processing

Descent processing applies where the descent phase of a flight is of interest to the client functions.

The default profile is to descend from TOD in accordance with standard operating procedures to reach the IAF, or a point related to it, at a specified level, such a procedure being a strategic constraint. The descent is limited only by any other strategic constraints and descent constraints may be included in the STAR definition, where applicable. A descent profile is determined for all flights which arrive in the AoR and for those outside the AoR for which the strategic constraint (at the IAF, or a level specified in the STAR) is known.

The descent profile is determined using aircraft performance data or specific data received for the flight as described in section 4.2 in conjunction with the expected wind vectors and the strategic constraints.

The level and VRC are calculated for each point on the descent trajectory.

TP-81-M	The descent profile shall be determined for flights arriving within the AoI and for those arriving outside the AoI for which a strategic constraint relating to the descent to the destination aerodrome exists.
TP-82-M	The descent profile shall be determined from the ECL using the aircraft performance data, meteorological data and strategic constraints.

3.5.3.2.5 Enroute Profile

The profile is determined between the TOC and TOD, if present, applying any applicable strategic constraints and meteorological data.

The enroute profile is determined using aircraft performance data or specific data received for the flight as described in section 4.2 in conjunction with the expected wind vectors and strategic constraints.

Where a speed/level group is suffixed to a significant point, the rules described in paragraph 3.5.3.2.1 are applied in determining the ECL after the point except that if an entered ECL is the same as the RFL before the point, the entered ECL is ignored in respect of the determination of the ECL after the point. If necessary, a transition to the new ECL is initiated at the point.

TP-83-M	The enroute trajectory shall be determined from TOC until TOD as applicable using the ECL and the filed cruising speed, taking into account meteorological data and strategic constraints.
TP-84-M	If a filed speed/level group is encountered suffixed to a point and an ECL different to the RFL before the point has not been entered, the ECL shall be recalculated with effect from the point.

3.5.4 Turn Processing

For accurate time calculation, the type of turn performed at turning points must be identified in association with the aircraft performance.

Two types of turn at are supported; a 'normal turn' is commenced before the waypoint such that the outbound track is achieved; a 'start turn' is commenced at the waypoint and continued to intercept and turn on to the outbound track (see Appendix C).

Errors in ignoring turns and the differences between them start to exceed five seconds for turns in excess of 50°. In addition to time considerations, turn processing gives a more accurate representation of the actual trajectory.

For departure routes, where significant turns may be made, the capability should be provided to specify the use of start turns. In other cases processing for normal turns should be performed.

TP-85-M	Allowance for the time delays due to turning shall be included in the determination of the trajectory.
TP-86-M	The capability to apply either a normal or start turn for a specified point on a specified ATS route shall be available.

3.5.5 Airspace Volume Penetration Determination

The entry and exit points of all defined airspace volumes that the trajectory penetrates is determined in 4D. These airspaces may be TSAs, sectors, approach control AoR's, etc.

It is required to produce penetration points for co-volumetric airspaces that may be coincident such as GAT and OAT sectors and to identify both airspaces. Controlling authorities responsible for OAT traffic in a given airspace may be within the same unit as the GAT element responsible for the provision of service in that airspace or at a separate unit.

Airspaces which are activated at specified times are detected.

Airspace penetrations detected by trajectory prediction include:

- GAT and OAT airspace sectors[2];

[2] Airspace sectors refer to those identifiable by airspace volume as distinct from those responsible for traffic on specified routes within a common airspace such as departure or arrival routes in a TMA.

- Sector areas of interest;
- TSAs;
- ATSU AoI's;
- ATSU AoR's;
- TMAs;
- Prohibited Areas;
- Area of Operation (MTCD);
- Area of Operation (MONA);
- Data Authority (AGDL);
- SSR Code Areas, e.g. participating areas, domestic and sub-domestic areas;
- Mode S Area.

Traversed Sectors

The traversed sectors together with the identity of any approach control areas or external FIRs can be determined from the airspace volume penetration processing.

The traversed sector list is made up of the sectors through which the trajectory passes; sectors may be combined to be under the control of a single CWP but this does not affect the list. Associated with each sector is the penetration point and the type of penetration (ascending, lateral or descending). Flights that are airfiled or which transition from VFR to IFR for which the trajectory originates in the middle of a sector will have the sector in which they appear as the first sector in the list.

Sectors to be notified of the flight and those directly involved in co-ordination are derived from the trajectory.

Data distribution and other functions relating to airspaces delegated to other units at specified times may be performed subsequent to the determination of the trajectory.

Equipment Requirements

Data is required to be available from the trajectory for flights planned to enter airspace for which they are not equipped (such as RVSM, 8.33kHz, etc.) to enable a warning to be generated at a sector prior to the penetration of the airspace.

TP-87-M	The entry point and time and the exit point and time for each of the airspace volumes penetrated by the planned trajectory shall be determined.
TP-88-M	Sector airspace penetrations shall be determined for uncombined sectors.
TP-89-R	Data should be provided in the trajectory to enable warnings to be made available at sectors prior to the airspace boundary for flights that will penetrate airspace for which they are not equipped.

3.5.6 Arrival Processing

3.5.6.1 Intermediate and Final Approach

When required by the unit concerned and where the arrival runway is known, the trajectory during the Intermediate and Final Approach phases is predicted (based on a standard default) in order to calculate the ETO at specified points for arrival management, both automatic (AMAN) and manual, if required, and the ETA. The ETA is available for use by aerodrome control and may be passed to the airport operator. Where arrival management facilities are provided, the application of subsequent constraints after the initial calculation may result in the ETA being amended.

TP-90-M	The trajectory from the IAF to the arrival runway shall be predicted (based on a standard default) in order to calculate the ETO at points of interest for the arrival manager and the ETA.
TP-91-M	The ETA shall be calculated.

3.5.6.2 Missed Approach Processing

Trajectory prediction should be able to produce an amended trajectory for a flight performing a missed approach procedure at its destination aerodrome in order to update displays and provide an arrival manager with enough information so that it can re-schedule the flight into the approach sequence.

The trigger for the missed approach will be manual from the HMI, or automatically from the surveillance system on detection of the track, climbing, or existing after the expected landing time.

The trajectory to be flown following a missed approach will be determined from the arrival runway. It would normally consist of a short fixed route, probably altitude and speed constrained, back to the initial approach fix.

TP-92-R	Upon manual input or automatic detection of a missed approach, a trajectory should be determined for the flight using the published missed approach procedure.

3.5.7 Conditional Route Processing

3.5.7.1 Types of Conditional Route

Conditional Routes (CDR) are classified into three types:

Category 1 - Permanently Plannable

Cat 1 CDRs are defined in the AIP of the State concerned together with the times of opening and closure. Air operators can file Cat 1 CDRs in flight plans, including RPL's.

Category 2 - Non Permanently Plannable

Cat 2 CDRs are subject to opening and closing on a much shorter time scale that Cat 1 CDRs and thus cannot be filed in RPLs; they can however be used in FPLs. Cat 2 CDR availability is notified to aircraft operators (AOs) by the use of the Conditional Route Availability Message (CRAM) sent from the CFMU. If processed correctly by the AOs there should be comparatively few occasions when an aircraft is filed on a closed Cat 2 CDR.

Category 3 - Not Plannable

Cat 3 CDRs are published but available on ATC instructions only. They are not permitted be filed and therefore trajectory prediction should not encounter a filed route using a Cat 3 CDR. However the TP function may be required to produce a trajectory using a Cat 3 CDR following the amendment of the route at an ATSU.

3.5.7.2 Category 1 and 2 Conditional Route Processing

Category 1 and 2 conditional routes (CDR's) should be processed as ATS routes. In addition, after time determination a check is recommended that a filed Cat 1 or 2 CDR will be open at the time that it is to be traversed. A warning should be provided if the flight will use a closed CDR. The location of the warning may relate to the position of the CDR in relation to the sectors on the traversed sector list (see section 3.5.6).

TP-93-R	A warning should be made available if a filed category 1 or 2 CDR is planned to be closed at the time of entry to the CDR or is planned to close whilst being traversed.
TP-94-M	If the CDR is planned to be closed whilst being traversed, an alternative route shall be applied automatically if available.
TP-95-M	If an alternative route is automatically inserted into the route, a warning shall be made available.

3.5.7.3 Insertion of CDRs

The availability of an open CDR to shorten the route of flight will be identified. The options then available are either automatic insertion or the creation of an alternative trajectory to be presented for controller acceptance.

Following insertion, the need to inform the flight would need to be identified before the flight arrived at the beginning of the CDR.

TP-96-R	A warning that a flight is eligible for a CDR which will shorten the trajectory and that the CDR is, or is expected to be, open, should be made available in advance of the flight reaching the start of the proposed CDR.
TP-97-M	Trajectory prediction shall automatically apply an open CDR to the route of flight if predefined operational criteria are met.
TP-98-M	If a CDR is automatically inserted into the route, a warning shall be made available.

3.5.8 TSA Processing

For the purposes of this document it is assumed that the penetration of an active TSA is not identified by IFPS. Requirements resulting from the proposed crossing of a TSA on a CDR are described in section 3.5.7.

3.5.8.1 TSA Crossing by Direct Route Processing

This section applies to direct (off-ATS) route processing across TSAs. It does not apply where the flight intends manoeuvring within the TSA.

In some instances, flight on a direct route across an inactive TSA is not permissible; in such cases the flight plan is referred to an editing position on reception. In cases where it is permissible, a warning is issued if a direct route segment crosses an active TSA.

Following the warning, options will be available as required at the unit concerned:

- for the manual specification of an avoiding route;
- to retain the current route;

- the calculation of an avoiding route on request for controller acceptance.

Following a request for the calculation of an avoiding route, such a route is determined in order to regain the filed route. A defined alternative route is inserted, if available; otherwise, where a choice exists, the shorter route around the TSA is identified. It may be possible in some instances to use or join ATS routes that circumnavigate the TSA, provided that the rules for selection of the route are specified. If the proposed option were not acceptable for the controller, the option for manual specification of the route would always exist, subject to the availability of suitable HMI facilities.

Where a frequently flown direct route segment which passes through a TSA is not available due to the TSA being active, a defined alternative avoiding route should be inserted.

TP-99-M	Where flight on a direct (off-ATS) route across a TSA is not permitted, a flight plan containing such a segment shall be referred for manual correction.
TP-100-M	Where flight on a direct (off-ATS) route across an active TSA is identified, one of the following shall be performed as required by the operational procedures at the unit concerned: • the flight plan is referred for manual correction; • the route is left unchanged but a warning is made available; • where an alternative avoiding route is defined, the avoiding route is inserted in place of the direct route segment and an indication made available of the route insertion.
TP-101-M	On controller request, an alternative trajectory shall be determined that avoids an active TSA.
TP-102-M	Where a route amendment is entered locally that would result in a direct (off-ATS) route across an active TSA, a warning shall be issued and confirmation required before the resultant trajectory becomes the active trajectory.

3.6 Uncertainty

Trajectory prediction is an inherently uncertain activity, affected by the uncertainty of available data including:

- aircraft weight and performance characteristics within its available performance envelope
- meteorological data (wind and temperature)
- pilot action, e.g. when controller instructions are enacted and other unknown future actions
- unknown future controller intentions, particularly in relation to forecast trajectories.

Uncertainty in the predicted trajectory will vary depending on the information known about the aircraft, its environment, and the route and profile flown by the aircraft, but in general it will increase as the prediction reaches further into the future.If controllers are usefully to interpret information presented to them based on a predicted trajectory, e.g. conflicts, it is essential that they can vary this interpretation based on the certainty with which the information is known. This variation may be achieved by presenting uncertainty information to the controller, or by algorithms using the uncertainty to attempt to distinguish and classify the situations based on the uncertainty. In either case, however, it is essential that accurate uncertainty information is available for presentation or analysis.

Trajectory prediction should therefore include an error model which enables uncertainty information to be propagated along a trajectory and provided with it. Such information represents the range of likely aircraft behaviour based on estimates of inaccuracy and of possible pilot or controller action. Input data uncertainty taken into account should include the items included in the first paragraph of this section.

Divergence in each of the dimensions is affected by different rules and therefore must be individually calculated.

Uncertainty data is to be generated from separate error models for climb, descent, cruise and turn, and is to model compound flight phases including possible combinations of these manoeuvres.

The error models should take into account uncertainty of how an aircraft flies within its available performance envelope, e.g. achieved true airspeed or bank angle, uncertainty in when manoeuvres take place, e.g. an early or late climb, and the probability of the flight following the trajectory predicted from an open constraint in a forecast trajectory.

TP-103-M	Each point in a predicted trajectory shall have associated uncertainty information.
TP-104-M	The uncertainty information shall be updated in accordance with the progress of the flight.
TP-105-M	Uncertainty on trajectory points shall represent, for a stated confidence level, the range of positions in which the aircraft is expected to be at any given moment in time.
TP-106-M	Uncertainty on trajectory points shall be based on uncertainty of input data and uncertainty generated by subsequent aircraft behaviour.
TP-107-M	In respect of forecast trajectories, uncertainty on trajectory points shall be based additionally on the probability associated with the closing of open constraints, where applied. *Note- The above requirement is mandatory only where the optional forecast trajectory is used.*TP-108-R The uncertainty due to possible wind error should be separately identifiable in the trajectory.

3.7 Amendments and Updates

Section 3.5 describes the basic principles applicable to all executions of trajectory prediction; this section identifies the processing required to be applied to an existing trajectory following the application and removal of specified constraints. Unless the flight has not yet reached the initial point, this results in partial recomputation of the trajectory.

3.7.1 General Requirements

3.7.1.1 Reason for Trajectory Update

Some processes require the reason for the trajectory update to be available for the application of processing rules or for display. Example reasons include: time, level, route.

TP-109-R	Where a trajectory has been re-calculated, the reason for it should be available.

3.7.1.2 Superseded Trajectory Data

Trajectory data that identifies airspaces to be penetrated may become obsolete as the result of an amendment, particularly to the route or a level which affects the trajectory. Some client functions temporarily require this data, e.g. to remove obsolete data from the HMI of bypassed sectors or to abrogate previously effected notification or co-ordination.

TP-110-M	When the trajectory of a flight is modified and, as a result, an airspace formerly penetrated is no longer penetrated, data shall be available to enable the removal of any obsolete displayed data and the abrogation of any notification and/or co-ordination which has taken place based on the original trajectory and is now no longer required.

3.7.1.3 Application of Tactical Constraints

Tactical constraints take effect from an application point which will normally be immediate but may be deferred. Options for deferred application include reference to:

- Specified point
- Distance or time from a specified point
- Time, either by reference to clock time or a time interval
- Level
- Time or distance after the application point of a previous constraint.

TP-111-M	Tactical constraints shall be applied with immediate effect unless deferred.
TP-112-M	Deferred tactical constraints shall be applied as specified.

3.7.2 Level Related Tactical Constraint Processing

Tactical constraints affecting level are the assignment of the following

- Cleared Flight Level (CFL)
- Enroute Cruising Level (ECL)
- Exit Flight Level (XFL)

3.7.2.1 Cleared Flight Level

This subsection addresses the issue of CFL's prior to the TOC and after the TOD.

If the CFL is within a strategic constraint currently applicable to the flight, the flight is considered to be complying with its planned trajectory and no modification to it is made. A typical application is a flight cleared to a standard level in accordance with normal ATC procedures.

If the CFL of a climbing flight is above the level of any current or subsequent strategic level constraint, the strategic level constraint is ignored.

If a climbing flight approaches within a vertical parameter distance of its CFL then the trajectory may be levelled out for a parameter distance or time which should be of comparatively short duration.

The relationship between the CFL and the ECL does not affect the trajectory.

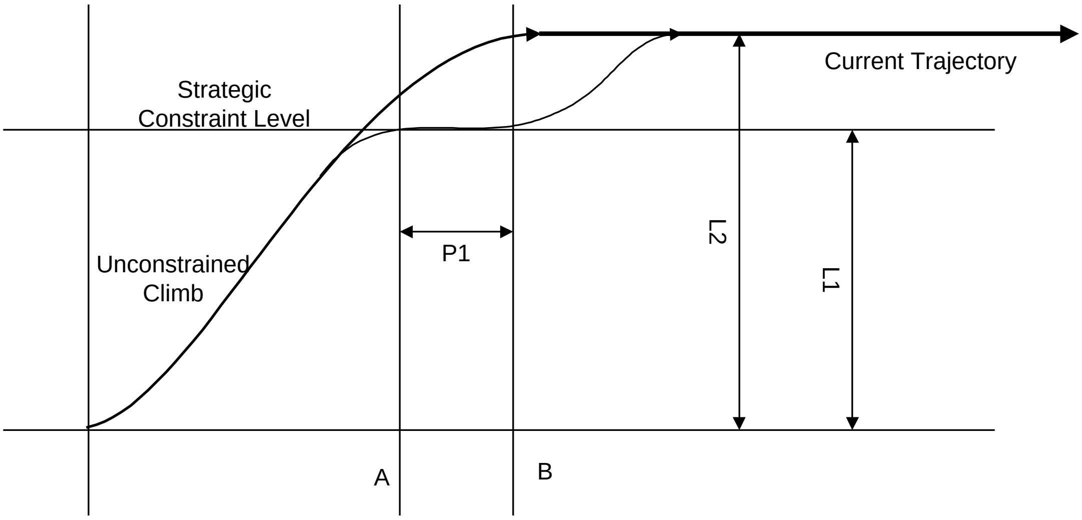

Figure 1 CFL and Strategic Constraints in the Climb Phase

In Figure 1, A represents the point at which a strategic level constraint of level L1 starts and P1 represents its duration. If a CFL is entered to level L1, no change to the trajectory is required; if a CFL is entered to level L2 (above L1), the trajectory is recalculated ignoring the strategic constraint. The planned trajectory will then assume an unconstrained climb to either to the ECL or to the level of the next higher strategic constraint above the CFL if applicable.

TP-113-M	If the CFL of a flight before TOC is above the level applicable before the expiry of any current or subsequent strategic level constraint, the constraint is ignored and the planned trajectory shall be calculated to climb to the ECL or the next strategic constraint, as applicable.
TP-114-O	If a flight approaches within a vertical parameter distance of its CFL then the trajectory may be levelled out for a parameter distance or time before resuming the climb or descent.

The converse applies to descending flights; if after TOD the CFL is the same or higher than a strategic constraint currently applicable to the flight, the flight is considered to be complying with its planned trajectory and no modification to it is made. If the CFL is below the level of any current or subsequent level constraint, the constraint is ignored.

TP-115-M	If the CFL of a flight after TOD is below the level of any current or subsequent strategic level constraint, the constraint is ignored and the trajectory shall be calculated to continue descent to the next strategic constraint level.

3.7.2.2 Requested Flight Level Amendment

The processing the TP function is to perform following an amendment to the RFL depends on the phase of the flight.

A change in the RFL prior to TOC being reached results in the trajectory being recalculated using the new RFL as the cruising level except if an ECL has been entered. Any XFL present shall continue to be respected.

If a change in the RFL after TOC is entered:

- If an ECL has been entered the new RFL is stored in the SFPL but does not result in the recalculation of the trajectory.
- If an ECL has not been entered, i.e. it is the same as the RFL, a vertical transition is made to the RFL at the specified point, if entered, otherwise at the present position, subject to strategic constraints and any XFL.

TP-116-M	A change in the RFL prior to TOC being reached shall result in the trajectory being recalculated using the new RFL as the cruising level except if an ECL has been entered.
TP-117-M	If an ECL has been entered the new RFL shall be stored for access and display.
TP-118-M	If an ECL has not been entered, a vertical transition shall be made to the RFL at the specified point, if entered, otherwise at the present position, subject to any strategic constraints and XFL.

3.7.2.3 En-route Cruising Level

When an ECL is entered, the flight is processed using the ECL and, if the flight has not reached TOC, it is recalculated accordingly but the RFL remains available for display in case the level becomes available later in the flight. The ECL remains applicable to TOD but can be changed. The entry of a new ECL after TOC results in a vertical transition to the new level from the present position unless the point at which the change is to take place is specified.

TP-119-M	When an ECL is entered which is different to the RFL, the trajectory shall be recalculated to climb/descend to the new ECL from the point at which the change is to take place if specified, otherwise from the present position.

3.7.2.4 Sector Exit Conditions

This paragraph describes the application of the exit conditions from a sector airspace. If the level is defined in the LoA, it is applied as a strategic constraint as described in sections 3.2.2.1 and 3.5.1.

3.7.2.4.1 Application of Exit Conditions

The general rules for the application of a manually entered XFL is for the trajectory to climb without delay within the sector or to descend to achieve the exit conditions by a point relative to the COP, e.g. 10 miles before it.

<u>Departures</u>

Subject to the application of strategic constraints, a climb to the XFL without delay shall be assumed. Where the XFL is below the ECL, the flight is assumed to climb not higher than the XFL before the sector boundary. The climb to the ECL continues immediately after the boundary.

Arrivals

Arrival processing calculates a TOD to meet strategic constraints, in particular the attainment of a specified level by the IAF. This requires to be modified only if the exit conditions are incompatible with the descent trajectory. In such a case, a descent to be at the XFL or the upper level of the crossing conditions if entered at a point relative to the COP shall be assumed and the TOD re-calculated accordingly.

Flights En-route

If a flight has reached cruising level, the use of XFL may only be expected for the resolution of conflict situations. If an XFL different from the ECL is entered:

- a climb is initiated at the present position or at the sector entry point, whichever is the later;
- a descent is initiated to achieve the XFL by a point relative to the COP.

The ECL is then changed to the XFL on passing the boundary, i.e. the trajectory continues to be calculated at the XFL until TOD unless a further modification is entered.

Exit Conditions Unachievable

A warning is required to be generated if the exit conditions cannot be achieved within the maximum economic envelope for the flight.

TP-120-M	Where an XFL from a sector is higher than the current level of the flight, the planned trajectory shall assume a climb to the XFL from the sector entry point or present position, whichever is the later, whilst respecting any applicable strategic constraint.
TP-121-M	Where an XFL from a sector is lower than the current level of the flight, the planned trajectory shall assume a descent to comply with the crossing conditions at a point relative to the COP whilst respecting any applicable strategic constraint.
TP-122-M	The calculated climb/descent profile shall remain unchanged where the crossing conditions are compatible with it.
TP-123-M	Where the exit conditions cannot be achieved using the unconstrained climb or descent performance, the planned trajectory shall be determined so that the exit conditions can be attained using a performance profile between the unconstrained and the maximum economic.
TP-124-M	A warning shall be generated if the exit conditions cannot be met using the maximum economic climb/descent profile as applicable.
TP-125-M	Where a flight is between TOC and TOD at the sector boundary, the ECL after the boundary shall be set to the value of the XFL.

3.7.2.5 Vertical Rate of Change (VRC)

The trajectory is calculated using the economic VRC extracted either from company preferences or from default aircraft type data. Such a VRC may be overridden by instructions that implicitly or explicitly require the application of a different VRC.

Expedited climbs/descents require the application of an enhanced VRC until either a specified level or to the CFL. An entered minimum VRC shall be applied if the currently applied rate is less. An entered specified maximum VRC shall be applied if the currently applied rate is greater and an entered specified minimum VRC shall be applied if the currently applied rate is less.

TP-126-M	If the time or position is specified at which the CFL is to be achieved and it cannot be met using the economic performance, a greater VRC within the normal performance envelope shall be applied to achieve the constraint.
TP-127-M	Where an expedited climb or descent is issued, an increased VRC shall be applied to the trajectory.
TP-128-M	An entered minimum or maximum VRC shall be applied to the trajectory if the currently applied VRC is outside the specified limit.

3.7.3 Hold Related Tactical Constraint Processing

A flight enters a holding pattern when it is not cleared to proceed beyond a specified point. This occurs either:

- at the clearance limit (normally the Initial Approach Fix) prior to commencing intermediate approach, or
- enroute when so instructed by ATC.

The hold is either:

- definite: the time at which the flight is expected or instructed to leave the holding pattern is known and times at subsequent points can be calculated; or
- indefinite: times at subsequent points are indeterminate although flight times between them are known.

Note- Not all systems allow the existence of an indefinite hold.

An orbit is a circular path flown from the present position when instructed and is a special type of hold; the flight is considered to be delayed at the point at which the orbit is entered.
two cases exist:

– pre-defined holding, i.e. following a published hold pattern. In this case, the holding protection volume may be retrieved from environment data..

– non pre-defined holding including an instruction to orbit, i.e. following a procedure given by the controller. In this case, the volume is not known a priori but the turn direction may be known.

TP-129-M	Where an indefinite hold is applied, absolute time values for points on the trajectory shall be terminated beyond the holding point.

TP-130-M	Where the hold is definite, points on the trajectory beyond the holding point shall utilise the hold departure time.
TP-131-M	When a hold restriction is removed the trajectory shall be determined from the current location of the flight to the next appropriate significant point.
TP-132-M	Rules shall be applied to determine the next appropriate significant point at which the route is rejoined after the application of a hold.

3.7.4 Heading and Track Related Tactical Constraint Processing

Due to tactical control requirements flights may be instructed to take up a heading or track specified by the controller and therefore to deviate from the planned trajectory. This constraint is reflected if present in either of the tactical or forecast trajectories (see sections 3.3 and 3.4). The planned trajectory is recalculated when the constraint is closed (normal navigation is to be resumed, either immediately or at a specified point, level or time).

Track and Heading

A heading is an instruction to orientate the fore and aft axis of the aircraft on to a specified magnetic bearing; a track is an instruction to follow a path over the surface oriented at the specified magnetic bearing. They are the same if there is no wind vector. Requirements in this document referring to 'heading' are to be applied equally to the assignment of a track.

Rejoin Original Route

Any instruction to route to a specified point or to resume normal navigation terminates an assigned heading instruction. If the point is not specified by controller input, criteria are applied to determine the point at which the planned trajectory is expected to be rejoined. Examples include:

- First significant point in the next sector.
- Point at which the re-joining angle is less than a parameter value.

TP-133-O	An open heading or track constraint shall be applied to a forecast trajectory for a distance determined by the application of rules.
TP-134-O	After the application of an open heading or track constraint a forecast trajectory shall converge to the planned trajectory which existed prior to the application of heading or track constraints.
	Note- the above two requirements are options in that they apply only to the optional forecast trajectory.
TP-135-M	Longitudinal updates to the planned trajectory shall be performed for the duration of the open heading/track constraint, provided that the flight is within the lateral deviation threshold.
TP-136-M	When a heading constraint is terminated, the planned trajectory shall be recalculated including the segment from the current position of the flight to the specified point, if entered.

TP-137-M	When a heading constraint is terminated and the point to which the planned trajectory is to be rejoined is not specified, it shall be determined automatically by the application of criteria.

3.7.5 Speed Constraint Processing

Speed constraints may be applied either tactically by controller instruction or strategically in respect of specified airspaces. All refer to airspeed (as distinct from ground speed).

A controller issued constraint may specify the maintenance of the current or a specified speed. A typical example of a strategic constraint is the application of an airspeed limitation for flights at and below a specified level.

Tactical Speed Constraints

Entered constraints are applicable until the termination conditions (if entered) are met, e.g. until passing/reaching a specified level or until passing a specified point, or until explicitly cancelled. In respect of open speed constraints:

- those applied before TOC are closed at TOC;
- those applied before the final TOD are closed at TOD;
- those applied in the descent phase are closed at the IAF;
- those applied after the IAF are applied until a specified point on final approach.

Where a specified airspeed or a maximum or minimum airspeed constraint is entered and the speed used in the calculation of the trajectory is not compliant, the trajectory is recalculated to comply with the constraint by using the entered value.

Strategic Speed Constraints

Strategic speed constraints may be removed by controller instruction; this applies frequently in respect of departures within TMA airspace.

TP-138-M	Where an airspeed constraint is entered and the speed used in the calculation of any part of the trajectory to which the constraint applies is not compliant with the constraint, the trajectory shall be recalculated to comply with the constraint.
TP-139-M	A closed speed constraint shall be applied to the trajectory until the conditions for termination apply.
TP-140-M	A speed constraint shall be terminated on when manually specified.
TP-141-M	An open speed constraint shall be closed in accordance with definable conditions.

3.7.6 Offset Related Tactical Constraint Processing

Flights may be instructed to fly an offset left or right of a specified ATS route and later to resume normal navigation. This section describes the processing to be applied in respect of the planned trajectory in attaining and leaving the offset route.

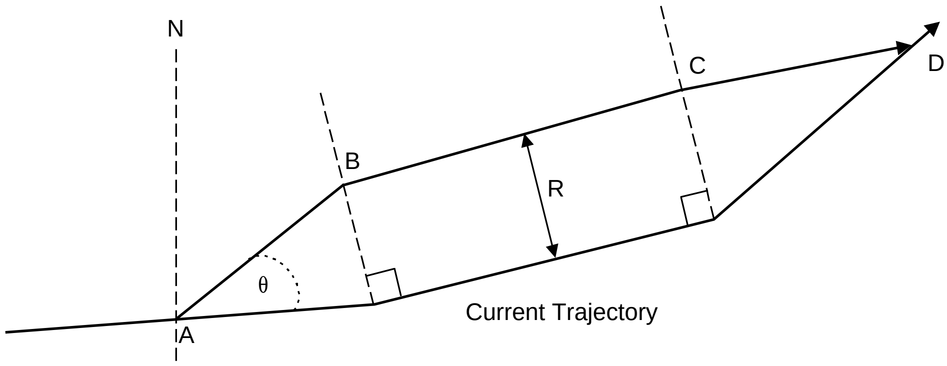

Figure 2

In Figure 2 the direction of offset is “left”. A represents the position at which the constraint is applied. R represents the offset distance. C represents the point at which the constraint is removed and D the point at which the original route is rejoined.

<u>Attaining the Offset</u>

The point to leave the original route in order to attain the offset may be specified in the constraint, however criteria must be applied in achieving it. If the point is not specified, criteria are required to be applied both in leaving the original route and attaining the offset. The angle of departure from the original route (θ in the example at Figure 2) must not be greater than 45° [RNAV].

<u>Rejoining the Original Route</u>

Similar criteria are used to determine the point at which the route is rejoined (point D in the example). Examples are as follows:

- It is specified in the constraint (rejoin by [position])
- It is derived from a time (and hence distance from point at which the constraint is removed)
- First significant point in the next sector.
- Point at which the re-joining angle is less than a parameter value.
- Point inside a parameter distance from the end of the offset.

TP-142-M	A trajectory parallel to the original trajectory shall be determined in the planned trajectory on application of an offset.
TP-143-M	When an offset constraint is applied or terminated, the trajectory to achieve the offset or to regain the original route respectively shall be determined.
TP-144-M	Rules shall be applied to determine the appropriate point at which the original route is left or rejoined after the application or termination respectively of a offset constraint.

3.7.7 Route Amendment Processing

This section describes the processing required when the route of flight is modified.

<u>Start of Amendment</u>

Two options exist:

- If the first point is on the route of flight, the amendment takes effect from the point;
- If the first point on the route amendment is not on the planned trajectory, a direct route from the present position to the first specified point represents the first route segment of the revised route.

End of Amendment

Two options exist:

- If the last point is on the route of flight, the amendment takes effect up to the point and the original route is resumed at the point;
- A new route is entered which replaces the remainder of the route within the AoI.

Specification of Route

Route amendments can be specified either by using direct route segments from one point on the route (or present position) to another, or by using ATS route identifiers (including CDRs). The modified route description is required to be confirmed as semantically correct and, if the route is error free, the trajectory is recalculated.

Diversions are a special case whereby the original route is not regained; the route to the diversionary aerodrome is specified or determined automatically (see section 2.8) and the new trajectory calculated.

TP-145-M	If the amendment starts at a point on the route of flight beyond the present position on the planned trajectory, the entered route data shall replace all or part of the original route from the specified point.
TP-146-M	If a route amendment starts at the present position, the entered route shall replace the route up to the point at which the planned trajectory is regained or entirely, as specified in the input data.
TP-147-M	With respect to the last entered route element, the amended route data shall either regain the original route at the point or replace the original route as specified in the input data.
TP-148-M	When a route amendment is entered by reference to significant points and ATS routes, the resultant route description shall be checked for correctness.
TP-149-M	If the route resulting from the entry of a route amendment is error free, a new trajectory shall be calculated.

3.7.8 Monitored Deviations

The detection of deviations of a flight from its planned trajectory is performed by Monitoring Aids (MONA). Where a flight is not in surveillance coverage, data may be entered to update the trajectory.

3.7.8.1 Longitudinal Deviation

When it is identified that a flight is ahead or behind its planned trajectory, the trajectory will be updated. Data for the flight currently observed through surveillance will be used to determine the time increment or decrement to be applied to subsequent points on the trajectory.

Longitudinal deviation data may be entered for a flight that is not in surveillance coverage or whose position is laterally out of conformance with the trajectory to the extent that longitudinal conformance cannot be determined automatically.

Longitudinal deviations for a flight that is time constrained result in the recalculation of delay absorption manoeuvres to meet the constraint time.

TP-150-M	The trajectory shall be updated as a result of a detected or entered longitudinal deviation.

3.7.8.2 Vertical Deviation

The trajectory is updated when a flight is significantly above or below its planned trajectory when it has been cleared to climb or descend during the climb or descent phase, i.e. prior to TOC or after TOD, and in the enroute phase when it is cleared to a different level from its current ECL, i.e. a new ECL or XFL .

The current 4D position is compared to the planned trajectory and the remainder of the trajectory is recalculated. A warning is provided if it is calculated that a level constraint cannot be achieved using the VRC used in the trajectory calculation.

TP-151-M	The planned trajectory for a flight in the climb or descent phase or which is performing a vertical transition to a new ECL or an XFL in the enroute phase shall be recalculated when a vertical deviation is identified.
TP-152-M	A warning shall be provided if a level constraint cannot be achieved using the performance criteria used in determining the trajectory.

3.8 Time Constraint Processing

Time constraints may be received from AMAN. Where such a constraint is applied at a specified point, the trajectory will be adjusted within the normal operating envelope of the flight to meet the constraint. The calculation is made using the current vertical profile, i.e. a vertical transition to a lower level to allow a greater speed reduction is not performed.

A warning is generated if the constraint cannot be met by speed adjustment.

The airspeeds used to meet (or attempt to meet) the constraint are required to be available for HMI purposes.

TP-153-M	When a time constraint is applied at a point that is different from the current calculated time at the point, a change of airspeed within the normal operating envelope and without any additional level change shall be applied in order to attempt to comply with the constraint.
TP-154-M	If a trajectory cannot be determined that complies with a time constraint, a trajectory shall be determined that attempts as far as possible to comply with the constraint and a warning issued.
TP-155-M	Controller instructions required to achieve a time constraint shall be retrievable from the trajectory.

3.8.1 Intermediate and Final Approach

An AMAN trajectory is any trajectory that results in the required landing time being met. Such trajectories are characterised by the desired ETA.

Between the IAF and the runway the controller will be assisted by means of system generated advisories that enable an AMAN trajectory to be flown. These advisories are equivalent to a set of manoeuvres that the controller will need to relay to the aircraft. These manoeuvres should be simple and efficient and it is recommended that trajectory prediction determines a speed change and/or a path stretch where necessary to meet the desired landing time.

TP-156-R	Where a time constraint has been received from the arrival manager, the trajectory should be recalculated in order to meet the constraint by the application of predefined path stretching/compression within the intermediate approach or speed control or both.

4. Data Requirements

4.1 Data Received from Operators and Aircraft

4.1.1 General

Depending on the aircraft operator and the equipment fit of the aircraft, data for a given flight may be available from the operator and/or the aircraft in order to enhance the accuracy of trajectory prediction.

The time-scale for the availability of accurate data depends on the operator and the phase of flight. Data from ground based operations systems may be available some hours before departure. For some operators, the weight can be estimated at this time with a high degree of accuracy, where, for example, it is known that the flight will depart at maximum all up weight. In other cases an accurate trajectory can only be determined when the weight is known, shortly before engine start. For a trajectory to be usable before departure, the SID to be flown must be correct and strategic constraints applied. After take-off more accurate data may be available from a suitably equipped flight, however, for some operators, identical trajectory data is stored in the ground system and the FMS. In general, more accurate data for flights that have been airborne for some minutes would be available from the FMS.

Data may be received ground - ground from the aircraft operator, operations office or the flight (prior to push back) or via air ground datalink from the flight.

4.1.2 Application of Data

Trajectory data for individual flights may be available from aircraft operators and the aircraft themselves, although the format is not agreed. Items of interest include the following:

- Route/waypoints to be flown;
- Cruising level data including the RFL and the highest level acceptable;
- Climb, cruise and descent speeds;
- Position and time of TOD;
- Rates of climb and descent.
- Detailed type and engine fit;
- Take-off weight.
- The indication that the flight is airborne (wheels up).

The capability should be provided for the receipt and use of take-off weight and the ATD. Other events prior to departure such as ‘Doors Closed’ may be used for airport related calculations but are not within the scope of this document.

It should be noted that trajectory data received from aircraft and/or aircraft operators may not correctly reflect ATC procedures as in many instances such procedures are not promulgated. Nevertheless such data should be used to the greatest extent possible in order to provide added quality to the trajectory.

TP-157-M	The following data provided directly or extracted from the aircraft trajectory in respect of a given flight received from an aircraft operator and/or aircraft FMS shall be used in determining the FDPS trajectory: • RFL; • Maximum acceptable enroute level (not used directly); • Position and time of TOD; • Aircraft performance/operating parameters; • Aircraft type/version; • VRC profile. • Take-off indication; • Take-off weight.

4.1.3 Trajectory Negotiation

The process of trajectory negotiation via air ground datalink at the time of writing is still uncertain. If in the future it is possible to upload the constraints to which a flight will be subjected and allow the aircraft FMS to construct a trajectory that will obey those constraints, it may be possible to load the resultant trajectory into the FDPS. Requirements for such a function are not included in this document.

4.2 Aircraft Performance Data and Priorities

4.2.1 Aircraft Data

4.2.1.1 Aircraft Type

Aircraft performance, in particular climb performance, varies between aircraft types depending on many factors including type of engine and aircraft weight. The aircraft type is filed in the flight plan and consists (currently) of a 4 character text field containing a recognised identifier defined in ICAO Document 8643 (Aircraft Type Designators). Using the identifiers described in this document it is not always possible to distinguish between different versions of the same basic aircraft type, e.g. a B747-100 and a B747-300, both being assigned the identifier B74A. This makes trajectory prediction more inaccurate when considering any difference in aircraft performance between such variants.

4.2.1.2 Company Procedures

Aircraft operators operate their aircraft differently in accordance with individual company policy and priorities. Such differences in operating procedures affects the flight trajectory.

4.2.1.3 Take-Off Weight

Performance models are of limited use in the determination of the climb trajectory unless the take-off weight is available. The final value is normally calculated within a few minutes of engine start and adjustment can be made for fuel burn from engine start to take-off.

The alternative, which may be applicable to some types of aircraft in the service of the same operator, is to use a standard (average) model for each type/operator based on a representative weight.

The weight of the aircraft could be given to the FDPS from the aircraft via datalink, or from the aircraft operator directly.

TP-158-M	Aircraft performance data shall be used for the determination of climb and descent profiles in the trajectory.

TP-159-M	Aircraft performance data shall take into account standard operating procedures for the type of aircraft for all phases of flight including, for given temperature profiles and aircraft weights: • Preferred economic profiles; both company specific and default values. • Maximum and minimum values for normal aircraft operation.

4.2.2 Priority of Application

The priority for the use of performance data and specific data for the flight is as follows:

1. Specific performance/trajectory data received for the flight;
2. Application of specific data for the flight, e.g. aircraft weight, to an aircraft performance model reflecting company preferences;
3. Application of specific data to a generic aircraft performance model;
4. Aircraft operator preferences for the aircraft type;
5. Generic performance data for the aircraft type;
6. Default performance data (for unrecognised type).

Where the observed performance is different from that used in the determination of the trajectory, the recalculation takes into account the observed performance. Exactly how this is to be performed is not described in this document.

TP-160-M	Performance or specific flight data shall be applied in producing the trajectory in accordance with the following descending order of priority: • Specific performance/trajectory data received for the flight; • Preferred operating procedures for the specific aircraft operator utilising specific flight data; • Generic aircraft performance model using specific flight data; • Preferred operating procedures for the specific aircraft operator for the aircraft type; • Generic performance data for the aircraft type; • Default performance data
TP-161-M	Where a trajectory is observed through monitoring aids to be out of conformance vertically or longitudinally and the performance is observed through surveillance to differ significantly from that used in the calculation of the trajectory, the re-calculation shall take into account the performance data influenced by the observed performance.

4.3 Meteorological Aspects

4.3.1 Wind Profile

The wind profile is the direction and speed of the wind at a given level range for a given point or area.

Forecast wind data is available from national meteorological centres. In addition wind data for the whole world is supplied in a number of formats under the World Area Forecast System from Bracknell (UK) and Washington (USA) for 12, 18, 24 and 30 hours ahead, twice a day based on the operation 00 and 12 UTC of the global model. Within a 12 hour forecast, upper wind and temperature data are available at a lower level of granularity, e.g. 3 hours.

Wind data is required to be used in the calculation of aircraft trajectories.

TP-162-M	The calculation of aircraft trajectories shall take into account forecast wind data.

Note-Errors in forecast wind data is a major area of uncertainty in TP and further research is needed into its improvement. The joint EUROCONTROL, Meteorological Office (Bracknell) project WAFTAGE used wind information downloaded from aircraft to update the expected wind vectors. This led to a potential decrease in the size of the meteorological grid from 140km to 15km and a level of wind vector accuracy of 5kts for a range of altitudes from 5000ft to FL600 with an update period of 20 minutes. However there is currently no intention, i.e. business case, to implement the findings of the project.

4.3.2 Atmospheric Pressure

The atmospheric pressure converted to mean sea level (QNH) affects the geometric altitudes of flight levels, a spread of 100 Mb representing 3000ft.

For an accurate calculation of the climb and descent profiles, trajectory prediction must calculate the actual vertical displacement of flight levels.

TP-163-M	The calculation of aircraft trajectories shall take into account variability in the vertical displacement of flight levels due to fluctuations in air pressure.

4.3.3 Temperature Profile

The thrust from gas turbine engines varies with the air temperature. Most modern jet engines have a temperature range where performance does not change greatly; outside this range thrust decreases with increasing temperature which leads to a distinct non-linear behaviour of the climb performance as a function of ambient temperature.

The temperature profile is therefore be taken into account in determining the trajectory.

TP-164-M	The temperature profile shall be used in determining the trajectory in the climb phase.

5. Performance

5.1 Accuracy Requirements

Accuracy for trajectory prediction is defined by the difference in four dimensions between the predicted trajectory and the actual trajectory flown by the aircraft, both being based on the same flight script. The requirement for accuracy must meet the most exacting requirement of all the user functions.

Each dimension is addressed in the following paragraphs.

5.1.1 Granularity

Points derived by geometric calculation shall be calculated to within one hundredth of a nautical mile.

TP-165-M	Positional data shall be determined to within one hundredth of a nautical mile.

5.1.2 Longitudinal Accuracy

5.1.2.1 Estimated Time Over Points

Calculation of times at any point shall be to the nearest second.

Time accuracy will depend largely on the phase of flight and the distance to the point under consideration from the position of the aircraft.

After correlation the current position is known and the accuracy of the ETO at subsequent points will depend on the accuracy of the ground speed and track distance from the current point.

An accuracy of 2.5% of flying time, i.e. 1.5 minutes in an hour, is required.

Note- The calculation of the estimated take-off time based on ground movement handling is not part of the functionality described in this document.

5.1.2.2 Time at Top of Climb and Descent

TP-166-M	The difference between the actual and expected time at any point shall be less than or equal to 2.5% of the elapsed time from the present position for at least 95% of flights.
TP-167-M	In respect of a climb or descent, the difference between the actual and expected level at any point shall be less than or equal to 10% of the vertical distance from the present position within the limitation of the constraint defining where level flight is to be achieved for at least 95% of flights.

5.1.3 Lateral Accuracy

The aircraft track is required to be calculated laterally to within one nautical mile of its true position. Possibility for error exists where turn processing applies and where a heading is entered.

TP-168-M	Lateral accuracy of position prediction shall be 1NM or less for at least 95% of the cases.
TP-169-M	The accuracy of the predicted track resulting from the entry of a heading constraint shall be $\pm 1^{\circ}$ for at least 95% of the cases.

5.1.4 Vertical Accuracy

For a climbing or descending flight, the accuracy is required to be within 10% of the remaining vertical distance, within the limitation of the constraint defining the level at which level flight is to be achieved. In general the accuracy of the climb and descent levels will depend on the accuracy of the aircraft performance model and the wind data.

TP-170-M	In respect of a climb or descent, the difference between the actual and expected level at any point shall be less than or equal to 10% of the vertical distance from the present position within the limitation of the constraint defining where level flight is to be achieved for at least 95% of flights.

5.2 Execution Time

TP is an integral component of a FDPS for which overall availability and response time requirements will exist. The performance of trajectory prediction is required to allow the resultant data to be presented to the controller within 500 milliseconds from the entry causing the process.

TP-171-M	The performance of trajectory prediction shall allow the resultant data to be presented to the controller within 500 milliseconds from the entry causing the process for at least 95% of the cases.

Appendix A : Abbreviations and Glossary

A-1 Abbreviations

ACC	Area Control Centre
AFTN	Aeronautic Fixed Telecommunication Network
AGDL	Air Ground Data Link
AIP	Aeronautical Information Publication
AMAN	Arrival Manager
AoI	Area of Interest
AoR	Area of Responsibility
ATC	Air Traffic Control
ATM	Air Traffic Management
ATD	Actual Time of Departure
ATS	Air Traffic Services
ATSU	Air Traffic Services Unit
CFL	Cleared Flight Level
CFMU	Central Flow Management Unit
COP	Co-ordination Point
CRAM	Conditional Route Availability Message
CTD	Calculated Time of Departure
CTOT	Calculated Take Off Time
CWP	Controller Working Position
DCT	Direct (In relation to flight plan clearances and type of approach)
DMAN	Departure Manager
EATCHIP	European Air Traffic Control Harmonisation and Integration Program
ECL	Enroute Cleared Flight Level
eFDP	European Flight Data Processing
EOBT	Estimated Off Blocks Time
ETA	Estimated Time Of Arrival
ETO	Estimated Time Over
ETOT	Estimated Take Off Time
FDPS	Flight Data Processing System
FIR	Flight Information Region
FMS	Flight Management System

GAT	General Air Traffic
HMI	Human Machine Interface
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organisation
IDP	Initial Development Project
IFPS	Integrated Initial Flight Plan Processing System
IFR	Instrument Flight Rules
LoA	Letter of Agreement
MONA	Monitoring Aids
ms^{-1}	metres per second
MTCD	Medium Term Conflict Detection
OAT	Operational Air Traffic
OCD	Operational Concept Document
PEL	Planned Entry Level
RFL	Requested Flight Level
RNAV	Area Navigation
RNP	Required Navigation Performance
RPL	Repetitive Flight Plan
RVSM	Reduced Vertical Separation Minima
SFPL	System Flight Plan
SID	Standard Instrument Departure (Route)
SMAN	Surface Movement Manager
SSR	Secondary Surveillance Radar
STAR	Standard Arrival Route
TACT	Central Flow Management Unit Tactical System
TMA	Terminal Manoeuvring Area
TOC	Top Of Climb
TOD	Top of Descent
TP	Trajectory Prediction
TSA	Temporary Segregated Area
UTC	Universal Co-ordinated Time
VFR	Visual Flight Rules
VRC	Vertical Change Rate
WGS	World Geodetic System
XFL	Exit Flight Level

A-2 Glossary

Active Constraint	A constraint which is currently or will be executed by the flight.
Aircraft Classification	A grouping of specified types of aircraft to which a defined procedure applies.
AMAN Trajectory	A single trajectory produced using default SFPL data and constraints supplied from AMAN.
Area of Interest	The airspace volume including the AoR for which the function is required to have information to ensure its correct operation.
Area of Responsibility	The airspace volume in which a service is provided by the unit(s) for which the trajectory prediction function is being provided.
ATC Constraint	A limitation applied to a flight by the ATC organisation.
ATC Strategic Constraint	An ATC constraint defined by the airspace structure and associated operational rules. Such constraints normally apply to all flights.
ATC Tactical Constraint	An ATC constraint issued by a controller, e.g. CFL, heading.
Cleared Flight Level	The level to which a flight is currently cleared.
Conditional Route	An ATS route or part thereof which can be planned and used under conditions specified by an ATC unit
Correlation	A function which builds an association between a state vector and a system flight plan, based on SSR code recognition, geographical checks and timing checks with respect to the route of flight
Current trajectory segment	The part of the active planned trajectory currently being followed by the flight. Rules to determine this segment are similar to those used in current correlation processes to determine the flight progression along its route.
Derived Point	A point in a trajectory derived for the purposes of functions both inside and outside trajectory prediction. See Significant Point
Enroute Cruising Level	The level at which the flight is cleared for all or a significant proportion of the cruise phase of flight.
Estimated Off Blocks Time	The time supplied by the aircraft operator in the flight plan at which the flight is planned to leave its parking position.
Estimated Take-off Time	The expected take off time determined manually or automatically in advance.
Exit Flight Level	The flight level at which a flight is planned to leave a pre-defined airspace volume. A sector's XFL is the next sector's or unit's PEL.
Filed Point	A position filed in the route field of the flight plan.
Planned Trajectory	The single trajectory associated with an SFPL that the flight is expected to describe.
Letter of Agreement	A series of constraints and rules that define the agreement entered into by two ATSUs.
Levels	The types of level are described at section 3.1.
Notified Sector List	A list of sectors that are to be informed of a flight.
Operator	A generic human operator interacting with the FDPS. Specialised in various roles such as controller, supervisor, flight data assistant, etc.

Out of conformance	A flight is out of conformance with its planned trajectory when its current position or level deviates in excess of a specified value in relation to the point at which it is expected to be.
Planned Entry Level	The flight level at which a flight is planned to enter a pre-defined airspace volume
Profile	The 3D trajectory of an aircraft comprising the route of flight with level information.
Projected Point	The projection of the actual position of the flight on to the current trajectory segment
Requested Flight Level	The level requested by the AO in the flight plan for the segment of the route under consideration.
Route	The 2D trajectory of an aircraft. Route can be expressed as significant points, ATS routes or geographical points.
Sector	A part of airspace controlled by a team of controllers, defined, notably, by its geographical co-ordinates and its assigned radio frequency.
Sector Area of Interest	The airspace volume encompassing the AoR of a sector within which data on all flights is required to be made available to the sector concerned.
Segment	A part of a route defined by initial and terminating points.
Significant Point	A point which is filed in the flight plan or derived from a published ATS route. See Derived Point
State Vector	A generic entity representing the surveillance data as transmitted by the surveillance system.
Strategic Constraint	A limitation on manoeuvring applicable to all flights which meet the specified conditions.
System Flight Plan	The entity within an FDPS containing the flight details, intentions and all applicable constraints during the flight life-cycle inside the AoI.
System Track	A generic entity representing the surveillance data as transmitted by the surveillance system. A track is composed of a sequence of state vectors.
Tactical Constraint	An instruction to manoeuvre or a limitation on manoeuvring issued or planned to be issued to an individual flight.
Temporary Segregated Area	Airspace of defined dimensions, within which activities require reservation of airspace for the exclusive use of specific users during a specified period of time.
Terminal Control Area	A control area normally established at the confluence of ATS routes in the vicinity of one or more major aerodromes.
Trajectory	A representation of the path of an aircraft, describing the horizontal and vertical profile over time Note- the types of trajectory are defined in paragraph 3.2.4.
Traversed Sector List	A list of sectors representing the airspace penetrated by a trajectory.
Waypoint	A specified geographical location used to define an Area Navigation Route or the flight path of an aircraft employing Area.
What-if Trajectory	A single trajectory produced using default SFPL data and other constraints.

A-3 Reference Documents

[OCD]	EUROCONTROL. Operational Concept Document for the EATCHIP Phase III, edition 1.1, 28.6.95.
[EURO FDP AREA]	Operational Requirements for Flight Data Processing and Distribution Core Functions (Area Control) (OPR.ET1.ST03.1000-ORD-01-00) Working Draft Edition 4.0 March 20 1997.
[EURO AMH]	EUROCONTROL Airspace Management Handbook for the application of The Concept of The Flexible Use of Airspace (ASM.ET1.ST08.500.HBK-01-00) Edition 1.0 05/02/1996
[PANS RAC]	ICAO. Rules of the Air and Air Traffic Services. (Doc 4444) 13th edition, 1996
[ADEXP]	EUROCONTROL ATS Data Exchange Presentation (ADEXP) Standard. (DPS-ET1-ST09-STD-01-00) Edition 1.1 24/01/97
[EURO ADDV0]	EUROCONTROL. Operational Requirements Document for EATCHIP Phase III ATM Added Functions Volume 0: - General (OPR.ET1.ST04.DEL01.01) Edition 1.3 14/05/97.
[EURO AMAN]	EUROCONTROL. Operational Requirements Document for EATCHIP Phase III Added Functions Volume 3: Arrival Manager (CIP Advanced Level) - (OPR.ET1.ST03.1000-ORD-01-00) Edition 1.5 27.3.97.
[EURO MTCD]	EUROCONTROL. Operational Requirements Document for EATCHIP Phase III Added Functions Volume 5: Medium Term Conflict Detection - (OPR.ET1.ST04.DEL01.02.5) Edition 1.4 11.4.97.
[EURO MONA]	EUROCONTROL. Operational Requirements Document for EATCHIP Phase III Added Functions Volume 1: Monitoring Aids - (OPR.ET1.ST04.DEL01.02.1) Edition 1.5 18.4.97.
[ECAC RL]	EUROCONTROL. ECAC Reference Levels for the ATM DPS Domain. Reference DPS.ET1.ST02.1000-REP-01-00 Edition1.3a 12 June 1996.
[EURO ENV]	EUROCONTROL. Operational Requirements Document for EATCHIP Phase III Environment Data Processing and Distribution, EUROCONTROL document OPR.ET1.ST03.3000, Edition 1.0, 20 June 1997
[EURO ADAPP]	Operational Requirements for Flight Data Processing and Distribution Core Functions (Aerodrome and Approach) (OPR.ET1.ST03.2000-ORD-02-00) Working Draft Edition 0.9 July 1 1998
[EURO RNAV]	EUROCONTROL Standard for Area Navigation (further details to be confirmed).

Appendix B - Route Acceptance

Flight plans received from IFPS should be free of errors. It is to cater for locally entered flight plans and route amendments and as a further safety net that the flight plan data relevant to the TP function is confirmed to be consistent and free from errors.

The format and content of flight plan data is described in [PANS RAC] and [ADEXP].

Format checking of the flight plan is not a TP function and will have been performed prior to receipt by TP.

B.1 Flight Plan Logic Checking

The following checks are pre-requisites to the operation of trajectory prediction.

- Recognition of the aircraft type in order to access performance data if available. If the aircraft type is not recognised, either a generic type could be used (with resultant inaccuracies) or the flight plan could be referred for manual intervention).
- If the flight identification represents an aircraft operator that has a specific aircraft performance model for the aircraft type and route, then this data is used in preference to the generic aircraft performance data.
- The elements of the filed route within the area of interest of the unit/system concerned are present in the fix and route database.
- The elements of the route conform to the logic of the route field.
- Filed points preceding or following an ATS route identifier are on the ATS routes they are intended to join/leave.
- A filed SID is valid for the departure aerodrome, departure runway and route.
- A filed STAR is valid for the arrival aerodrome and route.

A flight plan passing the checks is then able to be passed to the TP function for subsequent processing.

B.2 Route Field Logic Checking

Route processing extracts from the route field the route elements that are used in subsequent route processing.

In addition to processing the route field, the departure and destination aerodromes are extracted.

The first element is the speed level group from which the cruising airspeed and requested level to be applied are derived. This data is to be applied unless superseded by a significant point to which a speed level group is suffixed. The remaining elements comprise one of the following:

- Standard Instrument Departure Route
- ATS Route Designator
- Significant Point
- Significant Point/Cruising Speed and Cruising Level
- Change of Flight Rules[3]

---

[3] Change of Flight Rules and Cruise Climb indicators cannot exist on their own and must always be preceded by a speed level group.

- Cruise Climb[4]
- Indicators
- Standard Arrival Route

The preliminary processing for each element type is given in the following sections.

B.2.1 Standard Instrument Departure Route

Most states within Europe require that the SID is not included in the filed route as it is determined from the runway of departure and other aspects prior to departure; the requirement is for the first enroute point to be included from which the SID can be determined.

If filed, it must be the second element in the route field and is treated as a request by the FDPS for the SID specified. The identifier is located from a list associated with the departure aerodrome. It may be overridden by ATC closer to departure (see 2.3.2).

B.2.2 ATS Route Designator

Each individual ATS route designator is located in a list held in the environmental database.

B.2.2.1 Conditional Routes

The types of conditional route are described in section 3.5.7.1. Whilst category 1 and 2 CDR's are acceptable at the flight plan acceptance stage, a filed flight plan containing a category 3 CDR should be referred for manual processing.

B.2.3 Significant Point

A significant point may be a latitude/longitude, fix or bearing and distance from a fix. A fix has a unique identifier and its co-ordinates may be found in the environmental database.

B.2.4 Suffixed Significant Point

Significant Point/Cruising Speed and Cruising Level

This element identifies a point at which a change of enroute level and/or speed are planned. It also identifies the start of an IFR route segment immediately following a VFR segment. In such circumstances a new route segment is created for the flight, however the derivation of the time for the point is unclear. An estimate could be calculated by using the direct flying time from the last significant point.

Significant Point/Change of Flight Rules Indicator

A significant point suffixed with VFR, GAT or OAT identifies the intention to change the rules under which the flight is conducted at the point. Trajectory Prediction cannot be performed accurately for VFR route segments as the route and level are indeterminate.

Cruise Climb

The cruise climb suffix signifies the intention to request a gradual climb from the first specified level up to the second from the significant point onwards as the aircraft becomes lighter due to fuel burn.

---

[4] Cruise climb data suffixed to a significant point is ignored.

This facility is only allowed in specified airspace and not generally over Europe.

B.2.5 Indicators

DCT Indicator

The DCT indicator indicates that the next segment of the route is direct to the significant point immediately following the DCT indicator. Trajectory prediction will perform direct route processing between the two points.

T Indicator

The Truncation indicator indicates that the route is truncated at this point and the remainder is to be sought from a previous flight plan. It is not expected to be found in any messages within the ECAC area and should be treated as an error for manual resolution.

B.2.6 Standard Arrival Route

The Standard Arrival Route identifier is validated from environmental data associated with the arrival aerodrome. If present, it must be either the last element or precede the Initial Approach Fix.

Appendix C - Turn Processing

For a normal turn the reduction in distance flown compared to the nominal straight line segments is primarily a function of the angle of the turn, not of the radius.

For a start turn the additional distance flown is a function of the angle of the turn, the radius of the turn and the distance to the next waypoint.

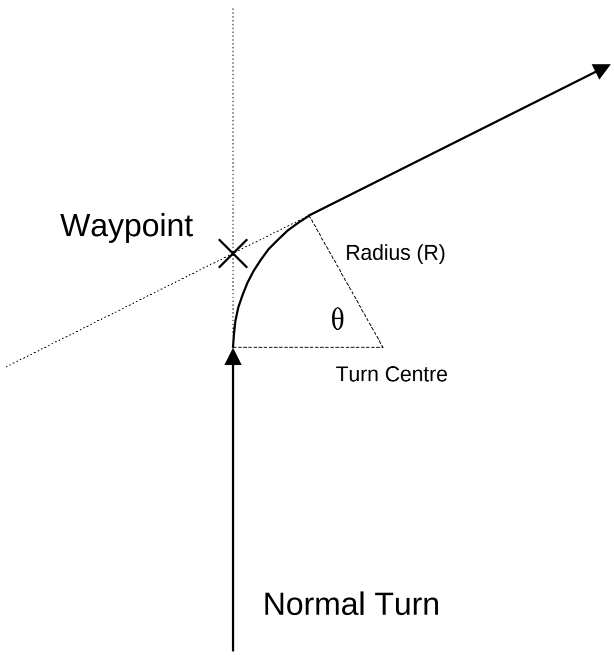

Figure 3

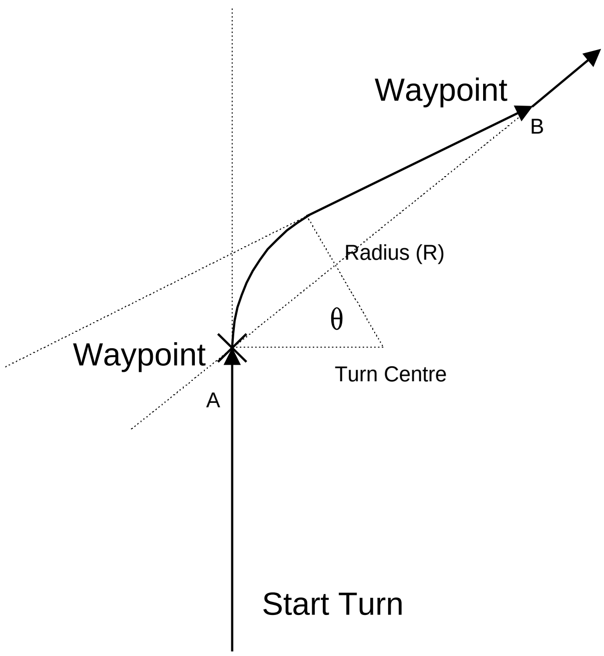

Figure 4

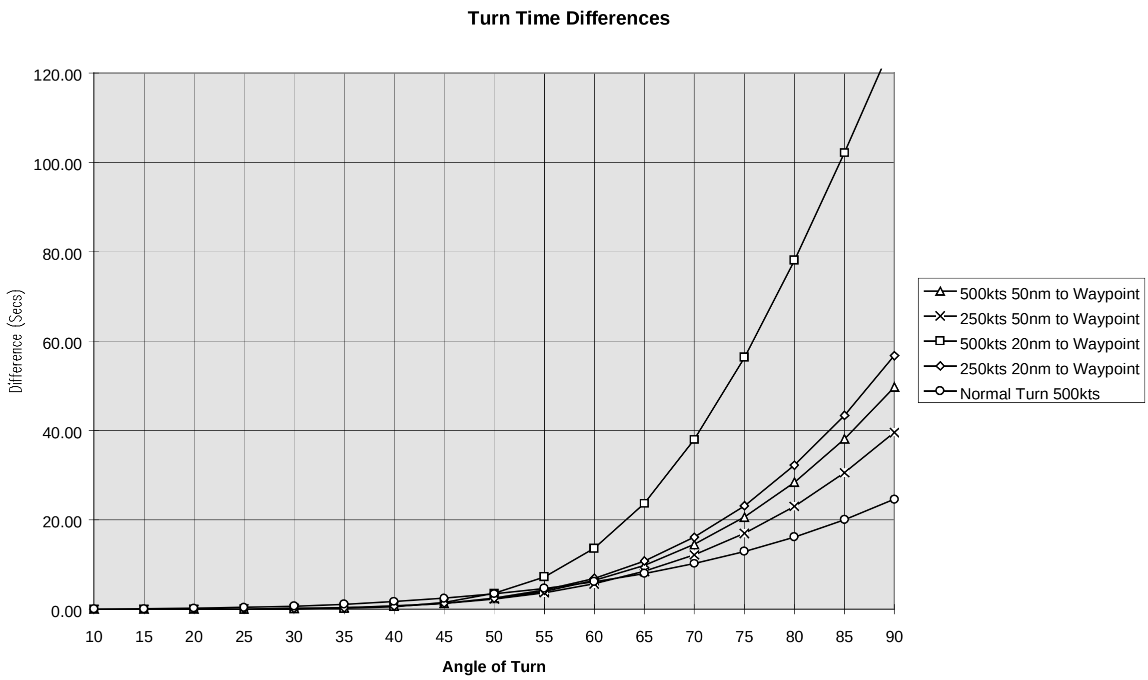

Figure 5

Figure 5 indicates that errors in excess of a very few seconds only start to occur for turns greater than 50 degrees but that errors of a minute are just possible under extreme circumstances. Note for turns of less than 30°, the difference in not performing the full turn geometry is less than 1 second.