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Continuous Descent Operations (CDO) Manual

Approved by the Secretary General
and published under his authority

First Edition — 2010

International Civil Aviation Organization

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AMENDMENTS

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FOREWORD

The purpose of this manual is to provide guidance on continuous descent operations (CDO) and to harmonize its development and implementation. To achieve this, airspace design, instrument flight procedure design and air traffic control (ATC) techniques should all be employed in a cohesive manner. This will then facilitate the ability of flight crews to use in-flight techniques to reduce the overall environmental footprint and increase the efficiency of aircraft operations.

Note.— The generic term “continuous descent operations” has been adopted to embrace the different techniques being applied to maximize operational efficiency while still addressing local airspace requirements and constraints. These operations have been variously known as continuous descent arrivals, continuous descent approaches, optimized profile descent, tailored arrivals and 3D/4D path arrival management forming part of the business trajectory concept.

The implementation guidance in this manual is intended to support collaboration among the following stakeholders involved in implementing continuous descent operations:

a) air navigation service providers (ANSP), including;

- 1) policy/decision makers;
- 2) airspace designers;
- 3) procedure designers; and
- 4) operational ATC staff;

b) aircraft operators:

- 1) policy/decision makers;
- 2) senior pilots; and
- 3) technical (FMS expertise) staff;

c) airport operators including:

- 1) operations department; and
- 2) environment department;

d) aviation regulators.

Future developments

Comments on this manual would be appreciated from all parties involved in the development and implementation of CDO. These comments should be addressed to:

The Secretary General
International Civil Aviation Organization
999 University Street
Montréal, Quebec, Canada H3C 5H7

EXECUTIVE SUMMARY

This manual contains guidance material on the airspace design, instrument flight procedures, ATC facilitation and flight techniques necessary to enable continuous descent profiles. It therefore provides background and implementation guidance for:

- a) air navigation service providers;
- b) aircraft operators;
- c) airport operators; and
- d) aviation regulators.

The key objectives of this manual are to improve the:

- a) overall management of traffic and airspace in order to enable uninterrupted continuous descents, without disrupting departures;
- b) understanding of continuous descent profiles; and
- c) understanding and harmonization of associated terminology.

CDO is one of several tools available to aircraft operators and ANSPs to increase safety, flight predictability and airspace capacity, while reducing noise, fuel burn, emissions and controller-pilot communications. Over the years, different route models have been developed to facilitate CDO, and several attempts have been made to strike a balance between ideal fuel-efficient and environmentally friendly procedures and the capacity requirements of a specific airport or airspace.

It is expected that future developments will allow different means of realizing the performance potential of CDO without compromising the optimal airport arrival rate (AAR). The core CDO concept at the heart of this manual will also apply to increasingly sophisticated methods of facilitating CDO.

CDO is enabled by airspace design, procedure design and facilitation by ATC, in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix/final approach point (FAF/FAP). An optimum CDO starts from the top-of-descent (TOD) and uses descent profiles that reduce controller-pilot communications and segments of level flight. Furthermore it provides for a reduction in noise, fuel burn and emissions, while increasing flight stability and the predictability of flight path to both controllers and pilots.

The standardization of procedures is important for flight safety and needs to be designed and presented in an unambiguous manner. For the procedure designer, it is important to understand the flight characteristics, limitations and capabilities of aircraft expected to perform CDO, as well as the characteristics of the airspace and routes where it will be used. For airport operators and environmental entities, it is important to understand the extent and limitations of environmental benefits, aircraft performance and airspace limitations when proposing to introduce CDO. Considering the high cost of fuel and growing concerns about the environment and climate change, collaborating to facilitate CDO is an operational imperative for all stakeholders.

It is of paramount importance that safety be maintained during all phases of flight — nothing in this guidance shall take precedence over the requirement for the safe operation and control of aircraft at all times. To avoid doubt, all recommendations are to be read as being “subject to the requirements of safety”.

Before any CDO trials or operations commence, the proposed implementation needs to be the subject of a local safety assessment.

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REFERENCES

Note.— Documents referenced in this manual or affected by continuous descent operations.

ICAO documents

Annex 4 — *Aeronautical Charts*
Annex 6 — *Operation of Aircraft, Part I — International Commercial Air Transport — Aeroplanes*
Annex 6 — *Operation of Aircraft, Part II — International General Aviation — Aeroplanes*
Annex 8 — *Airworthiness of Aircraft*
Annex 10 — *Aeronautical Telecommunications, Volume I — Radio Navigation Aids*
Annex 11 — *Air Traffic Services*
Annex 15 — *Aeronautical Information Services*
Annex 17 — *Security — Safeguarding International Civil Aviation against Acts of Unlawful Interference*

Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM) (Doc 4444)
Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS) (Doc 8168)
Volume I — *Flight Procedures*
Volume II — *Construction of Visual and Instrument Flight Procedures*

Regional Supplementary Procedures (Doc 7030)
Manual on Testing of Radio Navigation Aids (Doc 8071)
Air Traffic Services Planning Manual (Doc 9426)
Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689)
Global Navigation Satellite System (GNSS) Manual (Doc 9849)
Safety Management Manual (SMM) (Doc 9859)

European Organisation for Civil Aviation Equipment (EUROCAE) documents

Minimum Operational Performance Specifications for Airborne GPS Receiving Equipment used for Supplemental Means of Navigation (ED-72A)
MASPS Required Navigation Performance for Area Navigation (RNAV) (ED-75B)
Standards for Processing Aeronautical Data (ED-76)
Standards for Aeronautical Information (ED-77)

RTCA, Inc. documents

Standards for Processing Aeronautical Data (DO-200A)
Standards for Aeronautical Information (DO-201A)
Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment using the Global Positioning System (DO-208)
Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation (DO-236B)

Aeronautical Radio, Inc. (ARINC) 424 documents

ARINC 424-15 Navigation System Database Specification
ARINC 424-16 Navigation System Database Specification
ARINC 424-17 Navigation System Database Specification
ARINC 424-18 Navigation System Database Specification

ACRONYMS

AAR	Airport arrival rate
ADS-B	Automatic dependent surveillance — Broadcast
ANSP	Air navigation service provider
ATC	Air traffic control
ATM	Air traffic management
ATS	Air traffic services
CDO	Continuous descent operations
CFIT	Controlled flight into terrain
CG	CDO collaborative implementation group
CIG	CDO implementation group
DTW	Downwind termination waypoint
EUROCAE	European Organisation for Civil Aviation Equipment
FAF/FAP	Final approach fix/final approach point
FM	Fix to manual termination
FMC	Flight management computer
FMS	Flight management system
IAF	Initial approach fix
ICAO	International Civil Aviation Organization
IF	Intermediate fix
ILS	Instrument landing system
LNAV	Lateral navigation
MSL	Mean sea level
NASA	National Aeronautics and Space Administration (United States)
NM	Nautical mile
OPD	Optimized profile descent
PBN	Performance-based navigation
PSR	Primary surveillance radar
RF	Radius to fix
RNAV	Area navigation
RNP	Required navigation performance
SID	Standard instrument departure
SSR	Secondary surveillance radar
STAR	Standard instrument arrival
TA	Transition altitude
TF	Track to fix
TL	Transition level
TOD	Top of descent
TOR	Terms of reference
VM	Heading to manual termination
VNAV	Vertical navigation

EXPLANATION OF TERMS

Approach procedure with vertical guidance (APV). An instrument approach procedure which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations.

Area navigation (RNAV). A method of navigation which permits aircraft operations on any desired flight path within the coverage of ground- or spaced-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Note.— Area navigation includes performance-based navigation as well as other operations that do not meet the definition of performance-based navigation.

ATS surveillance service. A term used to indicate a service provided directly by means of an ATS surveillance system.

ATS surveillance system. A generic term meaning variously, ADS-B, PSR, SSR or any comparable ground-based system that enables the identification of aircraft.

Note. — A comparable ground-based system is one that has been demonstrated, by comparative assessment or other methodology, to have a level of safety and performance equal to or better than monopulse SSR.

Closed path CDO procedures. Procedures coded with track to fix (TF) legs and fly-by waypoints. STARs that terminate with a link to an instrument approach procedure should terminate at a fly-by waypoint. STARs that terminate with vector-based legs may be coded with fix to manual termination (FM) or heading to manual termination (VM) path terminators.

Continuous descent operation (CDO). An operation, enabled by airspace design, procedure design and ATC facilitation, in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix /final approach point.

Note 1.— An optimum CDO starts from the top of descent and uses descent profiles that reduce segments of level flight, noise, fuel burn, emissions and controller/pilot communications, while increasing predictability to pilots and controllers and flight stability.

Note 2.— A CDO initiated from the highest possible level in the enroute or arrival phases of flight will achieve the maximum reduction in fuel burn, noise and emissions.

Mixed navigation environment. An environment where different navigation specifications may be applied within the same airspace (e.g. RNP 10 routes and RNP 4 routes in the same airspace) or where operations using conventional navigation are allowed in the same airspace with RNAV or RNP applications.

Navigation aid (navaid) infrastructure. Space-based and/or ground-based navigation aids available to meet the requirements in the navigation specification.

Navigation application. The application of a navigation specification and the supporting navaid infrastructure, to routes, procedures, and/or defined airspace volume, in accordance with the intended airspace concept.

Note.— The navigation application is one element, along with communication, surveillance and ATM procedures which meet the strategic objectives in a defined airspace concept.

Navigation function. The detailed capability of the navigation system (such as the execution of leg transitions, parallel offset capabilities, holding patterns, navigation databases) required to meet the airspace concept.

Note.— Navigational functional requirements are one of the drivers for the selection of a particular navigation specification. Navigation functionalities (functional requirements) for each navigation specification can be found in the Performance-based Navigation (PBN) Manual (Doc 9613), Volume II, Parts B and C.

Navigation specification. A set of aircraft and flight crew requirements needed to support performance-based navigation operations within a defined airspace. There are two kinds of navigation specifications:

Required navigation performance (RNP) specification. A navigation specification based on area navigation that includes the requirement for performance monitoring and alerting, designated by the prefix RNP, e.g. RNP 4, RNP APCH.

Area navigation (RNAV) specification. A navigation specification based on area navigation that does not include the requirement for performance monitoring and alerting, designated by the prefix RNAV, e.g. RNAV 5, RNAV 1.

Note 1.— The Performance-based Navigation (PBN) Manual (Doc 9613), Volume II, contains detailed guidance on navigation specifications.

Note 2.— The term RNP, previously defined as “a statement of the navigation performance necessary for operation within a defined airspace”, has been removed (...) as the concept of RNP has been overtaken by the concept of PBN. The term RNP (...) is now solely used in the context of navigation specifications that require performance monitoring and alerting, e.g. RNP 4 refers to the aircraft and operating requirements, including a 4 NM lateral performance with on-board performance monitoring and alerting that are detailed in the PNB Manual (Doc 9613).

Open path CDO procedures. Procedures which require that after the DTW, an FM path terminator should be coded. In contrast, if ATC requires a defined path, a VM path terminator can be used instead.

Optimized profile descent (OPD). A descent profile normally associated with a published arrival (STAR) and designed to allow maximum practical use of a CDO. It starts from top of descent, taking into consideration the limitations of the local airport, airspace, environment, traffic and aircraft capabilities, and ATC. To the extent possible the descent profile is comprised of idle-power performance descent profile segments and geometric descent profile segments that maximize altitude, minimize the thrust required to remain on the path, terminate the path at the desired end location and satisfy the altitude and speed constraints along the closed path design.

Note.— OPD is one method of facilitating CDO.

Performance-based navigation (PBN). Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.

Note.— Performance requirements are expressed in navigation specifications (RNAV specification, RNP specification) in terms of accuracy, integrity, continuity, availability and functionality needed for the proposed operation in the context of a particular airspace concept.

Procedural control. Term used to indicate that information derived from an ATS surveillance system is not required in the provision of air traffic control service.

RNAV operations. Aircraft operations using area navigation for RNAV applications.

RNAV system. A navigation system which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these. An RNAV system may be included as part of a flight management system (FMS).

RNP operations. Aircraft operations using an RNP system for RNP navigation applications.

RNP route. An ATS route established for the use of aircraft adhering to a prescribed RNP navigation specification.

RNP system. An area navigation system which supports on-board performance monitoring and alerting.

Standard instrument arrival (STAR). A designated instrument flight rule (IFR) arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced.

Standard instrument departure (SID). A designated IFR departure route linking the aerodrome or a specified runway of the aerodrome with a specified significant point, normally on a designated ATS route, at which the en-route phase of a flight commences.

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Part A

**CONTINUOUS DESCENT OPERATIONS
OVERVIEW**

Chapter 1

DESCRIPTION OF CONTINUOUS DESCENT OPERATIONS

1.1 INTRODUCTION

1.1.1 Continuous descent operations (CDO)

1.1.1.1 CDO is an aircraft operating technique aided by appropriate airspace and procedure design and appropriate ATC clearances enabling the execution of a flight profile optimized to the operating capability of the aircraft, with low engine thrust settings and, where possible, a low drag configuration, thereby reducing fuel burn and emissions during descent. The optimum vertical profile takes the form of a continuously descending path, with a minimum of level flight segments only as needed to decelerate and configure the aircraft or to establish on a landing guidance system (e.g. ILS).

1.1.1.2 The optimum vertical path angle will vary depending on the type of aircraft, its actual weight, the wind, air temperature, atmospheric pressure, icing conditions and other dynamic considerations. A CDO can be flown with or without the support of a computer-generated vertical flight path (i.e. the vertical navigation (VNAV) function of the flight management system (FMS)) and with or without a fixed lateral path. However, the maximum benefit for an individual flight is achieved by keeping the aircraft as high as possible until it reaches the optimum descent point. This is most readily determined by the onboard FMS.

1.1.2 Facilitating continuous descent operations

1.1.2.1 Air traffic controllers are required to provide safe and efficient management of arriving aircraft. However, the term "efficiency" can mean different targets to different stakeholders and may vary depending on traffic density levels, aircraft mix or weather. To achieve overall arrival and departure efficiency, a balance should be struck between expediting traffic, meeting airport capacity, and reducing flight times, flight distances, fuel burn, emissions and noise within the overall requirement for safe operations. Environmental impact is a significant issue for aviation in general and should be considered both when designing airspace and instrument flight procedures, and when managing aircraft operations. Specifically, techniques that enable a fuel-efficient (minimum thrust) optimum descent and approach should be used wherever and whenever possible. The total energy of the aircraft at high altitude can be used most efficiently during descent with minimum thrust and drag. The pilot should however have the maximum flexibility to manage the aircraft's speed and rate of descent.

1.1.2.2 Ideally, to maximize the benefit of a CDO it should start at the top of descent and continue through to the final approach fix (FAF)/final approach point (FAP) or establishment on the landing guidance system. Traffic sequencing could be achieved by small speed interventions during the cruise or early phases of descent, thereby minimizing sequencing manoeuvres at lower altitudes with the consequent benefit on fuel burn and noise. The level and speed windows of standard instrument arrivals (STARs) and approach procedures must be designed to take account of aircraft performance limits and be executed with a good knowledge of the wind data available to the pilot by manual entry or data link.