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(出國類別：☐1 考察☐2 進修☐3 研究☑4 實習☐5 其他)

赴美國聯邦航空總署民航學院參加
「BASIC PANS/OPS/儀器飛航程序課程訓練」
報告書

服務機關： 民用航空局
出國人職稱： 管制員
姓名： 薛少怡

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BASIC PANS/OPS儀器飛航程序課程訓練

主辦機關:

交通部民用航空局

聯絡人／電話:

陳碧雲／(02)23496197

出國人員:

薛少怡 交通部民用航空局 航管組 管制員

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內容摘要: 配合業務需求，派薛員赴美國參加國際民航組織移航程序課程訓練，報告書內容包刮課程內容綱要、學習心得，並針對現行作業方式提出建議事項，包括持續人才培訓、查核機飛測能力隻擴充及盡速完成機場禁限建審核標準化等。

本文電子檔已上傳至出國報告資訊網

赴美國聯邦航空總署民航學院參加「BASIC PANS/OPS 儀器飛航程序課程訓練」報告書

目　　錄

壹、目　的

台北飛航情報區有關航路、離到場、進場及等待等儀航程序，係參照美國聯邦航空總署所頒布儀器飛航程序標準(UNITED STATES STANDARD FOR TERMINAL INSTRUMENT PROCEDURES , TERPS)之規範所訂定。儀器飛航程序事關飛航安全、駕駛員操作便利及管制員作業順暢，為了培訓儀器飛航程序設計人員，歷年來均編列預算派員前往美國聯邦航空總署民航學院參加儀器飛航程序訓練課程，今年因預算刪減並而未列入九十年度出國進修項目預算，但原項目第十二項區域航路程序發展(Rnav (GPS/FMS/LORAN-C)Procedures Development)因美國聯邦航空總署民航學院本年度未開課，經陳報交通部變更預算為「BASIC PANS/OPS 儀器飛航程序課程訓練」，而能夠有機會參加此訓練課程，藉實地研習瞭解國際民航組織有關儀器飛航程序(ICAO PROCEDURES FOR AIR NAVIGATION SERVICES - AIRCRAFT OPERATIONS , PANS-OPS)之設計規劃，以達到加強儀航飛航程序之基礎理論與實務設計技巧，有助於儀器飛航程序設計相關資訊之取得。而維護台北飛航情報區之國際地位，以提昇航管服務水準，則是需要儀器飛航程序之更新及配合，才能夠使整體作業達到更完美之境界。

貳、行 程 經 過 紀 要

職於九十年六月三十日搭乘中華航空公司班機啟程赴美國洛杉磯市，經由達拉斯市轉機至奧克拉荷馬市，於美國時間七月一日抵達當地。訓練課程於七月二日開始，為期六週，至八月十日結束。職於次日搭機離開奧克拉荷馬市，經達拉斯、洛杉磯，因時差及班機緣故於八月十三日凌晨返抵中正機場。

奧克拉荷馬市此時節氣候較台灣炎熱乾燥，平均溫度超過華氏一百度，約為攝氏三十九度，因屬高緯度地區，故白晝時間較長，日落時間經常在晚上九點以後，講師經常玩笑式提醒我們不要在外逗留太晚至夕陽下山，而忘記了晚餐時間，因為那時已經接近就寢了。職此行是第二次赴奧克拉荷馬市受訓，尚能適應當地氣候與環境。

參、訓 練 內 容 摘 要

本次美國聯邦航空總署民航學院之「基礎儀器飛航程序設計訓練班」(Course 12051，Basic Procedures for Air Navigation Services-Aircraft Operations，Basic PANS-OPS)係為首次開班，且為國際班，具有實驗性質，上課地點為美國 Oklahoma City 的 Mike Monroney Aeronautical Center。參加學員總計九人，除職之外，其餘均為非洲籍學員，包括納密比亞(NAMIBIA)、肯亞(KENYA)、喀麥隆(CAMEROON)、馬里(MALI)、坦尚尼亞(TANZANIA)及(CABO VERDE)等國家的飛航管制、飛航標準、助航設備及儀航程序設計等人員等。擔任全程課程講師者為 RALPH SEXTON，其學經歷令人咋舌，曾任美國聯邦航空總署飛航標準處處長，現任國際民航組織障礙物(Obstacle Clearance Panel) 、全天候作業委員會(All Weather Operations Panel)及隔離評議委員會(Review of General Concepts of Separation Panel)之顧問，教學經驗豐富而且非常認真，每年均定期受邀至新加坡民航學院、英國民航學院及 Wavionix 儀航程序設計自動化軟體公司等單位教授『ICAO PANS/OPS 儀器飛航程序設計』之基礎與進階課程。因為各國學員程度不一，遇到有學員不懂得地方，就會一再反覆的講解，並且引用一些較淺顯的例子，讓每位學員都能夠充份瞭解為止。職於上課時亦認真學習，遇有不懂處即隨時發問，特別是在分組練習時，更是經常與其他學員相互討論並予以指導，而獲得講師與學員間的稱讚，並被推派為簡報本小組設計程序之第一代表。結業證書如附件一。

訓練課程分為六週，實際上課二十九日，課程表及部分儀航程序訓練教材如附件二、三。主要課程內容可分為基礎課程(Basic Concepts , BC)、航路(En-Route , ER)、非精確進場程序(Non-precision Approach , NPA)、精確進場程序(Precision

Approach , PA)、碰撞風險模型(Collision Risk Model , CRM)、離場程序(Departures Procedures , DP)及全球衛星導航系統程序全球衛星導航系統程序(Global Navigation Satellite System Procedures , GNSS)等七個部分，惟全球衛星導航系統程序部份因時間不足，僅就定義部分做些許的介紹，甚是可惜，希望爾後對於課程時間之分配，能夠再規劃的更充分些。

一、 第一部分：基礎課程(BC)

(一) 介紹現行國際民航組織儀器飛航程序設計之起源及發展現況，課程進行方式、時數分配，課堂分組實做及報告，階段之關聯測驗，相關參考文件及輔助資料查詢。

(二) 介紹儀航程序設計一般之規範(Criteria)；包括三角函數之演算，各項空速之間轉換(Speed Conversion)、轉彎速率(Turn Rate)、轉彎半徑(Turn Radii)及轉彎角度(Bank Angle)之計算，不同定位點(Fixes)之設立及容許誤差(Tolerances)，助航設施之結構特性(Navigation Structures)及容許誤差，高度(Altitude)及溫度(Temperature)間相互影響等。

二、 第二部分：航路(ER)

多向導航台(VOR)及歸航台(NDB)航路結構之規劃及精確度，區域內障礙物之評估與隔離，最低安全區高度(Minimum Safe Altitude , MSA)之建立，最低航路高度(Minimum En-route Altitude , MEA)之決定，航路交叉點(Intersection Fix)、定位點(DME Fix)及等待點(Holding Pattern)之建立，其保護範圍較大及與地障之隔離為一千呎或三百公尺。包括：

(一) 航路(Airways)

(二) 過渡航路(Transition)

(三) 標準終端到場航路(Standard Terminal Arrival Route , STAR)

三、 第三部分：非精確性進場程序(NPA)

包括多向導航台進場程序及歸航台進場程序，另以助航設施位置則分為位於機場內的多向導航台/歸航台進場程序及非位於機場內的多向導航台/歸航台進場程序。

(一) 最初進場階段 (Initial Approach segment)

航空器自航路階段飛行脫離後，開始減速，下降高度，其保護範圍及隔離標準與航路階段完全一致(一千呎或三百公尺)。此階段包括：

1・ 直接進場 (Straight-in)

2・ 圓弧進場 (Arc)

3・ 回轉程序 (Course Reversal)

(二) 中間進場階段 (Intermediate Approach segment)

航空器自通過中間進場點(Intermediate Fix , IF)後即進入中間進場階段，而在此階段航空器準備攔截最後進場階段，因駕駛員必須調整之動作較多，如減速、放下襟翼、調整外型及擺正姿勢等，故此階段下降梯度(Descent Gradient DG)最小，其保護範圍開始縮小，而與地障隔離標準亦減少至五百呎或一百五十公尺。此階段包括：

1・ 直接進場 (Straight-in)

2・ 圓弧進場 (Arc)

3・ 回轉程序 (Course Reversal)

(三) 最後進場階段 (Final Approach segment)

此階段自最後進場點(Initial Approach Fix , IAF)開始

至誤失進場點(Missed Approach Point , MAP)為止，分為直接誤失進場急轉彎誤失進場兩種方式。航空器在此階段已準備好落地，若是在最低下降高度(Minimum Descent Altitude , MDA)或是誤失進場點可以目視跑道、進場燈光、跑道燈光等目視參考，就可順利落地。否則便必須保持最低下降高度至誤失進場點實施誤失進場。此階段而與地障隔離標準亦減少至二百五十呎或七十五公尺(包含最後進場點)及三百呎或九十公尺(不包含最後進場點)，包括：

1． 直接進場 (Straight-in)：進場航道與跑道中心線之夾角小於三十度，航道之對正(ALIGNMENT)與每一階段之下降率均符合標準之程序。
2． 環繞進場 (Circling)：按照直接進場程序至不同跑道降落，或者航道之對正與下降率不符合直接進場規範之程序。
3． 階梯下降點 (Step Down Fix)

(四) 誤失進場階段 (Missed Approach segment)

當航空器重飛之後即按照誤失進場程序爬昇，以確保與地障之隔離，繼續爬昇至誤失進場之安全高度(地障之隔離為一千呎或三百公尺)後，可以加入待命航線、航路或在重新安排進場。包括下列三階段：

1． 最初誤失進場階段(Initial Missed Approach Segment)
2． 中間誤失進場階段(Intermediate Missed Approach Segment)
3． 最後誤失進場階段(Final Missed Approach Segment)

四、 第四部分：精確性進場程序(PA)

包括儀器降落系統進場程序(Instrument Landing System , ILS)及微波降落系統進場程序(Microwave Landing System , MLS)。

(一) 標準條件 (Standard Conditions)

1． 航空器外形(Aircraft Dimensions)：最大半翼展(Max Wing Semi-span)不超過三十公尺及起落架與下滑角之距離不超過六公尺。

2． 依據飛行指導之第二類操作飛行。

3． 下滑角角度：最佳夾角為3° 角度，但第二類及第三類操作時，僅可使用3° 角度。

4． 跑道頭儀降系統之區段寬度(Sector Width)：二百一十公尺。

5． 儀降系統參考係數高度(Reference Datum Height , RDH)：十五公尺或五十呎。

6． 誤失進場程序之爬昇梯度(Climb Gradient)：百分之二．五。

7． 所有障礙物相對於跑道頭標高之高度。

8． 對於第二類及第三類操作時，附約十四所規定之內進場面(Inner Approach Surface)、內轉接面(Inner Transition Surface)及落地面(Balked Landing Surface)不得有障礙物穿越。

(二) 最初進場階段 (Initial Approach segment)

1． 直接進場 (Straight-in)

2． 圓弧進場 (Arc)

3． 回轉程序 (Course Reversal)

(三) 中間進場階段 (Intermediate Approach segment)

1． 直接進場 (Straight-in)

2． 圓弧進場 (Arc)

3・ 回轉程序 (Course Reversal)

(四) 最後進場階段 (Final Approach segment)

1・ 直接進場 (Straight-in)

2・ 環繞進場 (Circling)

3・ 階梯下降點 (Step Down Fix)

(五) 誤失進場階段 (Missed Approach segment)

1・ 最初誤失進場階段(Initial Missed Approach Segment)

2・ 中間誤失進場階段(Intermediate Missed Approach Segment)

3・ 最後誤失進場階段(Final Missed Approach Segment)

(1) 障礙物許可實際高度/高度(Obstacles Clearance Altitude/Height , OCA/H)之計算

(2) 基本儀降系統限制面(Basic ILS surfaces)

(3) 障礙物評估限制面(Obstacles Assessment surfaces , OAS)

(4) 碰撞風險模型(Collision Risk Model , CRM)

五、 第五部分：碰撞風險模型(CRM)

(一) 機場條件：

1・ 航空器外形(Aircraft Dimensions)：翼展(Wing Span)及起落架與下滑角之距離。

2・ 是否依據飛行指導之第二類操作飛行。

3・ 下滑角角度：介於2.5°~3.5°之間，但第二類及第三類操作時，僅可使用3°角度。

4・ 跑道頭儀降系統之區段寬度(Sector Width)。

5・ 儀降系統參考係數高度(Reference Datum Height , RDH)。

6・ 誤失進場程序之爬昇梯度(Climb Gradient)。

7・ 所有障礙物相對於跑道頭標高之高度。

8・ 對於第二類及第三類操作時，附約十四所規定之內進場面(Inner Approach Surface)、內轉接面(Inner Transition Surface)及落地面(Balked Landing Surface)是否有障礙物穿越。

(二) 機場周圍障礙物資料之建立，區分為障礙點(Spike)及障礙面(Wall)，但需注意屏障效應(Shield Effect)。

六、 第六部分：離場程序(DP)

(一) 直接離場程序 (Straight Departures)

(二) 轉彎離場程序 (Turning Departures)

(三) 多方向離場程序 (Omni-directional Departures)

(四) 標準儀器離場程序 (Standard Instrument Departures , SID)

七、 第七部分：全球衛星導航系統程序(GNSS)

全球衛星導航系統程序已是世界飛航之趨勢，利用衛星導航來建立空中交通之路徑，國際民航組織訂定之全球衛星導航系統，用以定義任何使用的衛星導航系統，亦即是使用者在航空器上的裝備接收衛星傳來的資料來決定其位置，目前大致包含美國的全球定位系統(Global Positioning System , GPS)、過去蘇聯的 GLONASS 系統、歐洲 GALEO 系統及日本的 MSAS：

(一) 定義介紹(Definitions)

(二) 最初進場階段 (Initial Approach segment)

(三) 中間進場階段 (Intermediate Approach segment)

(四) 最後進場階段 (Final Approach segment)

(五) 誤失進場階段 (Missed Approach segment)

(六) 等待航線 (Holding Pattern)

(七) 離場程序(Departure Procedures)

肆、心　得

一、國際民航組織的儀器飛航程序設計(PANS-OPS)規範基本上比較複雜，對於不同種類之機型有不同之規範，以精確性進場程序為例，在設計規劃之前必須先依照附約十四『機場設計與操作』之規範，評估機場四周之障礙物，若屬第二類精確性進場程序以上，則不得有任何障礙物穿越所有的限制面。而在設計完成程序之後，再經過碰撞風險模型(CRM)程式模擬測試，而所得之安全係數參考值均不可大於 10^{-7}，經過三重把關之後所設計之精確性進場程序，必然是安全性高。反觀目前國內各機場(包括軍民合用機場)因禁限建法規及取締辦法不完整，以致機場四周建築物經常穿越限制面，而儀航程序則因此也必須常做調整，而增加工作負擔，且標準的提高及航道的修改，也會造成管制單位及航空公司的困擾。

二、受訓期間非常幸運有機會參觀州立奧克拉荷馬大學(Oklahoma University)，該校電子研究所與美國聯邦航空總署合作研究發展衛星定位系統(GPS)部分計畫，目前負責 A 類及 B 類航空器有關衛星定位系統儀航程序資料之監控與收集，並定期向美國聯邦航空總署回報，所有經費由美國聯邦航空總署提供，而該研究所則負責裝備之裝置與架設，另外 C 類及 D 類航空器有關衛星定位系統儀航程序資料之監控與收集則由美國聯邦航空總署相關單位自行負責。經職詢問下方知，所有的裝備包括衛星定位系統之發射與接收器材，以及資料分析所需之軟硬體，在有限的經費之下，均由該所研究生自行不斷研發、改良後裝置在校區之機場內，而有效資料採樣則包含於二十五海浬半徑範圍內所有機場，全天候實施。民航局已完成衛星定位系統

非精確性進場程序(GPS-NPA)之規劃與設計，並將發布公告於本(九十)年十月四日開始啟用，進一步之區域航行(Area Navigation , RNAV)亦將於年底前完成規劃設計並公告實施。國內大學也有相關科所從事類似衛星定位系統之研究，但似乎都並未與民航局合作，若能夠建立適當之合作管道，協助收集相關之資料並作監控，對於目前發展中之衛星定位系統非精確性儀航程序(GPS-NPA)、區域航路(RNAV)，以及將來之衛星定位系統精確性儀航程序(GPS-PA)必有更多的幫助。

三、放眼望去，出入美國機場的安全檢查，是全球中眾所皆知的鬆散，而經歷慘絕人寰 911 恐怖爆炸事件，犧牲了無數的生命和財產損失慘重，付出慘痛的代價之後，終於喚醒美國政府對於機場安全檢查的重視，雖然是亡羊補牢，確也是為時不晚，不但減少了恐怖分子有機可乘，而造成對大眾交通安全的威脅，也讓一般犯罪機會大為降低。911 事件發生主要是因為恐怖份子以暴力方式劫持航空器之後，再使航空器飛向世貿大樓及五角大廈而至撞毀，造成大樓因燃燒產生高溫而快速傾倒坍塌，以致於機上乘客及大樓內多數人的傷亡。從航管人員發現航空器航線異狀到通報相關單位至戰機起飛攔截，在短短幾分鐘內，幾乎沒有足夠反應的時間，連續四起震驚全球的撞機悲劇就已經發生了。當航空器遭遇劫持時，無論是機上組員及乘客或是地面人員幾乎都是束手無策，在與劫持歹徒談判之際，即便想採取任何援救行動，也都因顧慮到機上人員生命，而有所忌諱不敢貿然執行，甚至於因為劫機而影響航管及其他航空公司的運作，更可能造成其他意外事件之發生，損失更多的生命財產。因此，如果未來能夠在航空器的操作軟體內研發出所謂的反劫機作業程式，經由設定的狀況

下自行啟動，例如當劫機事件發生時，駕駛員必須口頭報告相關單位及重置迴波器(Transponder)電碼,但這些動作可能因受制於劫機者而無法實施，若能經由其他簡易之方式，類似某種代字或是某個動作，系統即自行啟動而取代所有的飛行狀況，包括人為駕駛方式(Manual)或是自動駕駛(Auto-pilot)，不僅自動重置迴波器電碼，提醒地面之航管及相關單位，警告鄰近航空器自己已遭劫持，同時也開始變更高度至預設之安全高度，在不同航路階段則有預設之不同安全高度，並於設定之定位點開始盤旋待命，而這些所有的動作，亦已經把與其他航空器間之安全隔離考量在內。除非經過該航空器之所有人(經營者)或是相關之代理人，經過特定的密碼授權解除外，均不能變更任何動作，當然劫機者也就無法劫持該航空器至任何機場或任何國家作為犯罪工具。在航空器盤旋待命期間，地面相關應變單位可以一方面與劫機歹徒進行談判，另一方面則可以採取營救該航空器及機上人員生命之行動。最壞的結果即使談判失敗，或是劫機歹徒蓄意破壞航空器，而造成航空器毀損及機上人員的傷亡，但至少能夠讓那些計畫劫機之有心人知道，即使劫機成功卻無法運用該航空器為犯罪工具，最後則是落得同歸於盡，自己也無法脫身，如此或許可減少劫機事件之發生。

四、出國參加儀器飛航程序設計練課程之人員除了具有豐富之航管經驗，包含五年以上之雷達經驗，並兼具塔台、終端或航路執照，本身之語文及電腦能力必須足夠，如此在受訓期間才不致因語言問題，造成溝通不良，而無法適應課程。電腦能力則係課程配合分組實習，每個人都必須將設計完成之案例成果，完成簡報資料製作，而在全體學員及講師前做一完整之簡報，並接受大家的疑點詢問及討論。

伍、建　議

一、持續人才培訓

儀器飛航人力須長期培育並選派人員出國受訓，惟限於編制及經費問題，實際所需人力未能反映業務所需，以有限之人力負責台北飛航情報區現有近百個儀器飛航程序之複檢、修訂及新增程序之研發設計，實感不足。全球衛星導航系統(GNSS)已是國際潮流，本局已規劃本區的通信、導航及監視/飛航管理系統(CNS/ATM)之發展計畫與時程，而全球衛星定位系統(GPS)因為是一種便宜而易於部署的新空中導航設施，因此美國聯邦航空總署與國際民航組織決定將衛星導航系統列入未來空中航行系統之重要部份。本局目前參加過有關全球衛星定位系統(GPS)程序課程人員只有一人，且於本年初日以繼夜、排除萬難，完成衛星定位系統非精確性進場程序(GPS-NPA)之規劃與設計，並經美國聯邦航空總署查核機來台完成飛測。因應持續發展中之衛星定位系統非精確性儀航程序(GPS-NPA)、區域航路(RNAV)，以及將來之衛星定位系統精確性儀航程序(GPS-PA)，則應爭取參加相關課程訓練及國外研習之機會，如派員赴美國或其他國家之民航學院受訓及其他相關研習會議等。面對日益增加的飛航業務需要，除了人員專業素質需加強外，應儘速建立專業人才之養成系統，規劃與構建訓練之計畫與流程，加強儀器飛航程序專業知識之認知，以確保儀器飛航之絕對安全。

此次參加訓練課程學員多達九人，各國學員之經歷及程度均不同，根據前數期受過其他儀器飛航程序設計課程訓練之長官或同仁表示，每一次課程訓練均有他國之助航人員

及標準人員參加，如果這二類專業人員能夠參加此課程之訓練，對於本區飛航服務水準之提昇必有助益。

二、 查核機飛測能力之擴充

目前民航局已設計完成之衛星定位系統非精確性及區域航行儀器飛航程序於本(九十)年四月間，委託美國聯邦航空總署飛航檢查組之查核機來台完成飛測，該組擁有數十架不同機種之查核機，可以因應不同程序需求有效速完成飛測任務。如果衛星定位系統非精確性及區域航行儀器飛航程序所需之定期評估，甚至將來可發展於衛星定位系統精確性儀航程序需要即時的飛測時，若仍需委託美國聯邦航空總署飛航檢查組之查核機執行飛測方式，不但需大費周章做事前細節安排，且完成飛測後所有的飛測報告亦需等待較長時間。如民航局具有飛測衛星導航系統程序能力的查核機，則不但可以配合做定期的儀器飛航程序之飛測任務，對於新規劃設計的程序亦可做適時之飛測。

三、 儘速完成機場禁限建審核標準化

世界各國對於機場禁限建之標準，一般係依國際民航組織附約十四(ANNEX 14) 『機場設計與操作』規範，考慮機場運作、助航設備、通信狀況及飛航安全等因素訂定，以利機場之長期發展。至於航空器實際操作之範圍，則因航空器飛行速度、助導航設施種類及航空器機載裝備之差異性，實際飛航空域並不同，故儀器飛航程序實不宜用來作為控制機場附近建築物高度之標準。然而目前我國各機場有關禁限建的審核標準並不相同，在民用機場方面是以「飛航安全標準暨航空站飛行場助航設備四週禁止及限制建築

辦法」為依據，在軍用機場或軍民合用機場則是以軍方標準為依據。為考量機場發展及保障飛航安全，各機場禁限建辦法應儘速標準化並公告之。

陸、附 件

附件一　結業證書
附件二　儀航程序設計訓練課程表
附件三　儀航程序設計訓練教材
附件四　碰撞風險模型(CRM)
附件五　儀航程序設計訓練分組案例
附件六　附約十四『機場設計與操作』規範

附件1

U.S. DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

This is to certify that

SHAO-YI SHIUE

has satisfactorily completed the

BASIC ICAO PANS-OPS

INTERNATIONAL – COURSE 50047

conducted by the

FAA Academy

AUGUST 10, 2001

Date

William E. Taylor

Superintendent, FAA Academy

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Course/Exmination Number and Title 50047 BASIC ICAO PANS-OPS	Hours 240
Requirements for Certificate A COURSE GRADE OF PASS REQUIRES A SCORE OF 70% OR ABOVE ON ALL PHASES.	Grade PASS
Course/Examination Description or Remarks	

Name/Routing Symbol/Address	
SHIUE, SHAO-YI	Social Security Number
	Type of Course/Examination RESIDENT
	Region: Training Orginization: FAA ACADEMY

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FAA ACADEMY

Oklahoma City, Oklahoma

Accredited by the North Central Association of Colleges and Schools

AUGUST 10, 2001
Date of Completion

William E. Taylor
Superintendent, FAA Academy

FAA INTERNATIONAL TRAINING DIVISION

PANS-OPS Basic Workshop — Week 1

Date	02 Jul 2001	03 Jul 2001	04 Jul 2001	05 Jul 2001	06 Jul 2001
Day / Time	Monday	Tuesday	Wednesday	Thursday	Friday
0800-0930	Registration Administration and Orientation Introduction of Participants	General Criteria Speeds Categories IAS TAS Altitude Temperature Conversion	H O	Desk Exercise Intersection Fix Tolerances	Intermediate Approach Segment Straight Operational Considerations Area MOC Parameters
1000-1130	Executive Summary Organization of PANS Annexes	Turn Rate Turn Radii Speed (TAS) Bank Angle Calculations	L	Minimum Obstacle Clearance Primary Areas Principle of Secondary Areas Construction Calculations	Secondary MOC Calculations Width MOC Chart Application Exercise
1130-1215	L	U	I	C	H
1215-1345	Review of Mathematics for Procedure Design	Desk Exercise Turn Radius Calculations Plotting	D A	Initial Approach Segment Operational Considerations Areas MOC Parameters	Course Reversal Procedure Turn Base Turn Racetrack Templates
1415-1545	Review of Aviation Principles and Navigation Fundamentals for Procedures Design	Fixes NAV Tolerance VOR NDB DME Fix Tolerance Area Intersection Facility VOR/DME	Y	Desk Exercise Straight Initial Approach Segment	Altitude/Descent Calculations Area Construction Template Application Demonstration Racetrack Construction

FAA INTERNATIONAL TRAINING DIVISION

PANS-OPS Basic Workshop — Week 2

Date	09 Jul 2001	10 Jul 2001	11 Jul 2001	12 Jul 2001	13 Jul 2001
Day / Time	Monday	Tuesday	Wednesday	Thursday	Friday
0800-0930	Desk Exercise Racetrack Construction	Missed Approach Phase 2 MOC Climb Gradient OCA/H Adjustments	Non-Precision Approach Criteria Review	Non-Precision Approach Procedure Design Lab	Non-Precision Approach Procedure Design Lab
1000-1130	Final Approach Segment Parameters Area MOC OCA/H	Missed Approach Turning Turn Parameters Turn at Altitude Area MOC	Exam 1	Non-Precision Approach Procedure Design Lab	Non-Precision Approach Procedure Design Lab
1130-1215	L	U	N	C	H
1215-1345	Missed Approach Straight Parameters Phase 1 SOC MOC	Missed Approach Turning Turn at Point Area MOC Circling Bounding Circle	Non-Precision Approach Procedure Design Lab	Non-Precision Approach Procedure Design Lab	Non-Precision Approach Procedure Design Lab
1415-1545	Missed Approach Straight MAPt Fix Tolerance Distance Example	Missed Approach Turning Desk Exercise	Non-Precision Approach Procedure Design Lab	Non-Precision Approach Procedure Design Lab	Non-Precision Approach Procedure Design Lab

FAA INTERNATIONAL TRAINING DIVISION

PANS-OPS Basic Workshop — Week 3

Date / Day / Time	16 Jul 2001 Monday	17 Jul 2001 Tuesday	18 Jul 2001 Wednesday	19 Jul 2001 Thursday	20 Jul 2001 Friday
0800-0930	Non-Precision Approach Procedure Design Lab	Precision Approach General Principles System Operation ILS MLS	Precision Approach Missed Approach Straight Height Loss Model	Precision Approach Turning Missed Approach Example	Precision Approach Criteria Review
1000-1130	Non-Precision Approach Procedure Design Lab	Precision Approach Precision Segment OAS Model Templates	Precision Approach Climb Gradient OCA/H Final Obstacle Final Approach Obstacle	Precision Approach Desk Exercise ILS Turning Miss	Exam 2
1130-1215	L	U	N	C	H
1215-1345	Non-Precision Approach Procedure Design Lab Presentations	Precision Approach Example OAS Application and Calculation	Precision Approach Missed Approach Beyond Precision Segment Straight Turning	Precision Approach Collision Risk Model Obstacle Models CRM Reports	Precision Approach Procedure Design Lab
1415-1545	Non-Precision Approach Procedure Design Lab Presentations	Precision Approach Desk Exercise Precision Segment	Precision Approach Turning Missed Approach Turn at Altitude Height	Precision Approach CRM Example CRM Exercise	Precision Approach Procedure Design Lab

FAA INTERNATIONAL TRAINING DIVISION

PANS-OPS Basic Workshop **Week 4**

Date	23 Jul 2001	24 Jul 2001	25 Jul 2001	26 Jul 2001	27 Jul 2001
Day / Time	Monday	Tuesday	Wednesday	Thursday	Friday
0800-0930	Precision Approach Procedure Design Lab	Precision Approach Procedure Design Lab	Precision Approach Procedure Design Lab Presentations	Departures General Criteria OIS MOC Performance Climb Gradients	Departure Turn Initiation Area Turn at a Point Turn Area
1000-1130	Precision Approach Procedure Design Lab	Precision Approach Procedure Design Lab	Precision Approach Procedure Design Lab Presentations	Departure Straight DR Area 1 Track Adjustment	Departure DR Track Interception of Track Guidance
1130-1215	*L*	*U*	*N*	*C*	*H*
1215-1345	Precision Approach Procedure Design Lab	Precision Approach Procedure Design Lab	Precision Approach Procedure Design Lab Presentations and Critique	Departure Track Guidance Alignment Area Obstacle Assessment	Departure Turning Example
1415-1545	Precision Approach Procedure Design Lab	Precision Approach Procedure Design Lab	Precision Approach Procedure Design Lab Presentations and Critique	Departure Turning Turn at Altitude Area Construction	Departure Turning Departure Exercise

FAA INTERNATIONAL TRAINING DIVISION

PANS-OPS Basic Workshop — Week 5

Date	30 Jul 2001	31 Jul 2001	01 Aug 2001	02 Aug 2001	03 Aug 2001
Day / Time	Monday	Tuesday	Wednesday	Thursday	Friday
0800-0930	Area Navigation (RNAV) General Principles Waypoints Tolerances Track Definition	Desk Exercise Geodetic Calculation	GNSS Final Segment Parameters Area Construction	RNAV Departures Criteria Construction Example	GNSS Procedure Design Lab
1000-1130	Area Navigation VOR/DME RNAV Tolerance Areas Area Widths Tables	GNSS System Performance Airborne Equipment Performance	GNSS Missed Approach Straight Turning	RNAV/GNSS Criteria Review	GNSS Procedure Design Lab
1130-1215	L	U	N	C	H
1215-1345	Missed Approach Phase 2 MOC Climb OCA/H Adjustments	GNSS Exercise Waypoint Calculations	Application of Reduced Areas Minimum Stabilization Distance	Exam 3	GNSS Procedure Design Lab
1415-1545	GNSS Geodesy for GNSS Procedures Geodetic Calculations	GNSS Criteria General Initial Intermediate	GNSS Procedure Construction Example Missed Approach Desk Exercise	GNSS Procedure Design Lab	GNSS Procedure Design Lab

FAA INTERNATIONAL TRAINING DIVISION

PANS-OPS Basic Workshop — Week 6

Date	06 Aug 2001	07 Aug 2001	08 Aug 2001	09 Aug 2001	10 Aug 2001
Time \ Day	Monday	Tuesday	Wednesday	Thursday	Friday
0800-0930	GNSS Procedure Design Lab	GNSS Procedure Design Lab	General Review	Introduction to Computer-Aided Procedure Design Tools	OCP Current Topics and Initiatives
1000-1130	GNSS Procedure Design Lab	GNSS Procedure Design Lab	General Review	GNSS Augmentation Systems Spaced-based (SBAS) Ground-based (GBAS)	Final Discussions and Course Evaluation
1130-1215	L	U	N	C	H
1215-1345	GNSS Procedure Design Lab	GNSS Design Lab Presentations and Critique	Final Exam	Helicopter Procedure Design Criteria Runway Cat H Heliport	Reserved
1415-1545	GNSS Procedure Design Lab	GNSS Design Lab Presentations and Critique	Final Exam	OCP Current Topics and Initiatives	Reserved

Doc 8168-OPS/611
Volume II

PROCEDURES

FOR

AIR NAVIGATION SERVICES

AIRCRAFT OPERATIONS

VOLUME II
CONSTRUCTION OF VISUAL AND INSTRUMENT FLIGHT PROCEDURES

FOURTH EDITION — 1993

This edition incorporates all amendments approved by
the Council prior to 4 March 1993 and supersedes,
on 11 November 1993, all previous editions of
PANS-OPS (Doc 8168), Volume II

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Chapter 3
DEPARTURE ROUTES

3.1 GENERAL

There are two basic types of departure route: straight and turning. Departure routes shall be based on track guidance acquired within 20.0 km (10.8 NM) from the DER on straight departures and within 10.0 km (5.4 NM) after completion of turns on departures requiring turns. Surveillance radar, when available, may be used to provide safe routing.

3.2 STRAIGHT DEPARTURES

3.2.1 *General.* A straight departure is one in which the initial departure track is within 15° of the alignment of the runway centre line. Wherever practical, the departure track should coincide with the extended runway centre line (see Figures II-3-1 to II-5-2).

3.2.2 Areas

3.2.2.1 In the construction of the areas it is assumed that any track adjustments will take place no further than a point corresponding to 120 m (394 ft) above the DER, or at a specified track adjustment point.

3.2.2.2 *Area without track guidance*

3.2.2.2.1 Area 1 begins at the DER and has an initial width of 300 m. It is centred on the extended runway centre line with a splay of 15° on each side when the initial departure track coincides with the extended runway centre line (see Figure II-3-1). The initial departure track may be adjusted by 15° or less. When so adjusted, the boundary of Area 1 on the side of the track adjustment shall be adjusted by the same amount (see Figure II-3-2). The length of Area 1 extends from the DER to 3.5 km (1.9 NM) measured along the extended runway centre line.

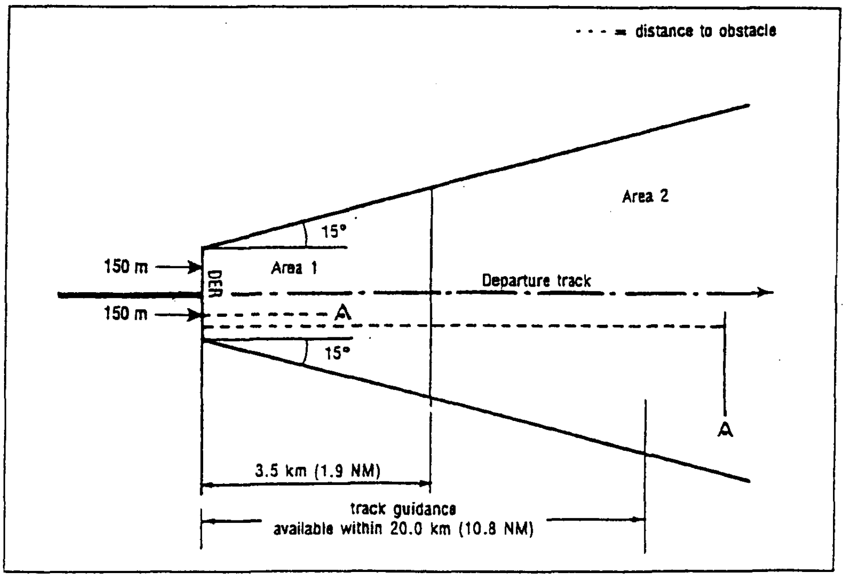


Figure II-3-1. Straight departure area without track guidance

3.2.2.2.2 Area 2 expands 15° either side of the departure track. Its initial width is defined by the width of the end of Area 1. Area 2 terminates at the end of the departure procedure and is as specified in 2.5.

3.2.2.2.3 If a track adjustment point is specified, the areas are adjusted as shown in Figure II-3-3. For appropriate track adjustment point tolerance criteria see Part III, 7.3 and Figure III-7-17.

3.2.2.3 *Area with track guidance*

3.2.2.3.1 Areas 1 and 2 are constructed as described in 3.2.2.2 above and extended to the point where the boundaries intercept the area associated with the navigation aid providing the track guidance (see Figures II-3-4 to II-3-9).

3.2.2.3.2 The areas associated with a navigation aid other than a localizer consist of appropriate portions of the trapezoids specified in Part III, 26.4.2 for VOR, 28.2 for NDB and 24.2.4.3 for surveillance radar. The general principle of secondary areas is applied.

3.2.3 *Obstacle identification surface.* A 2.5 per cent OIS measured in the direction of the departure overlies Areas 1 and 2. Area 1 OIS begins at the DER at a height of 5 m (16 ft) above the elevation of the DER. Area 2 OIS begins at the end of Area 1 OIS and rises therefrom. Distance measurements to an obstacle shall be made from the DER.

3.2.4 *Procedure design gradient (PDG).* The PDG is intended as an aid to the procedure designer, who should adjust the route used to minimize the PDG consistent with other constraints. If an obstacle penetrates the OIS and if it is proved impractical to define a departure track avoiding it, a procedure design gradient (PDG) computed from the elevation of the OIS at the DER, and providing the MOC over the obstacle (see 2.3) shall be promulgated, and the obstacle published. Gradients so promulgated shall be specified to an altitude/height after which the PDG of 3.3 per cent is considered to prevail (see Figure II-3-10). Gradients to a height of 60 m (200 ft) or less shall not be specified (see Figure II-3-11). These gradients would normally be caused by low, close-in obstacles. A note shall be published stating that the close-in obstacles exist (see Chapter 5).

3.2.5 Whenever a suitably located DME exists, or when suitably located RNAV fixes can be established, additional specific height/distance information intended for obstacle avoidance should be published to provide a means of monitoring aircraft position relative to critical obstacles.

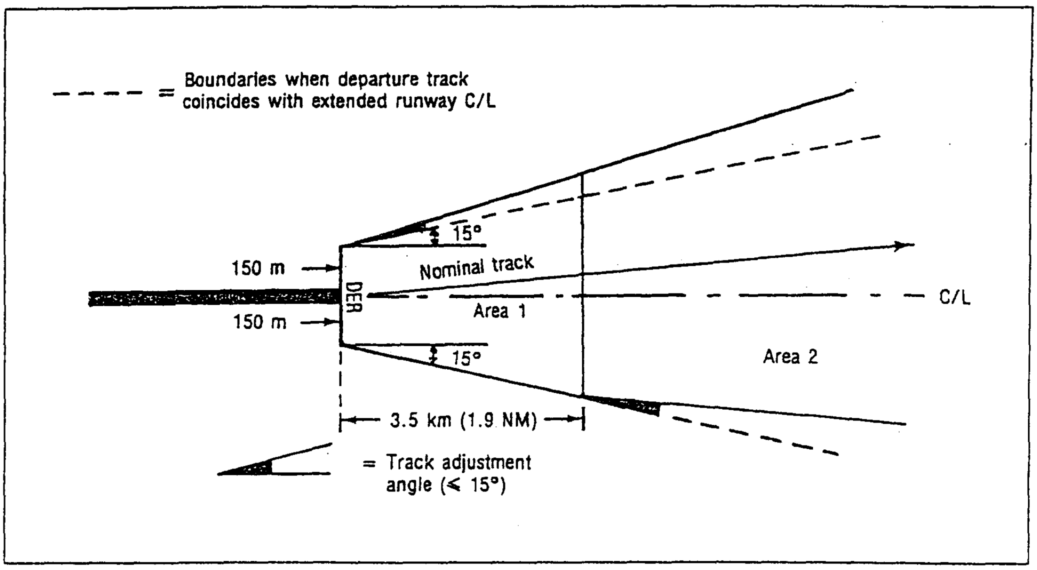


Figure II-3-2. Straight departure area with track adjustment (track adjustment point not specified)

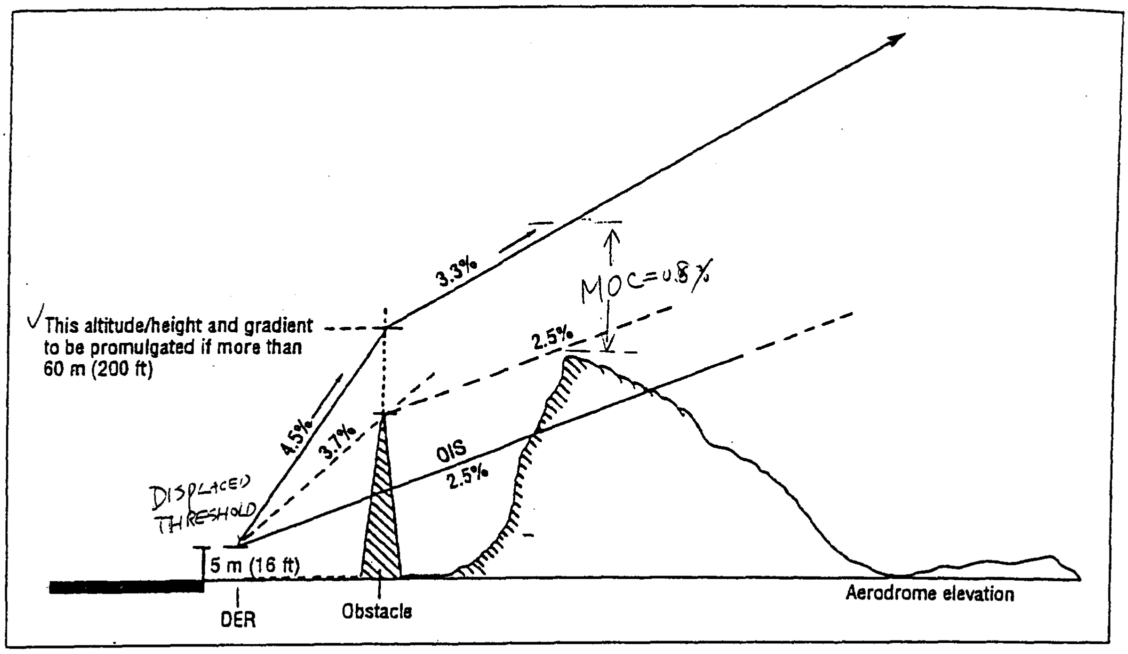


Figure II-3-10. Procedure design gradient

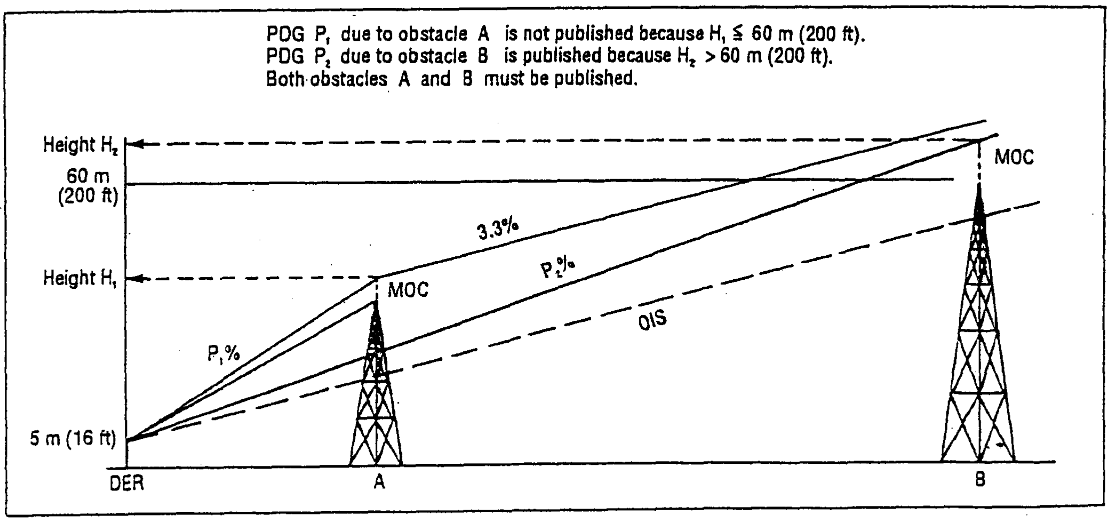


Figure II-3-11. Close-in obstacles

3.3 TURNING DEPARTURES

3.3.1 General

3.3.1.1 When a departure route requires a turn more than 15°, a turning area is constructed. Turns may be specified at an altitude/height, at a fix or at a facility. Straight flight is assumed until reaching a height of at least 120 m (394 ft) above the elevation of the DER. No provision is made in this document for turning departures requiring a turn below 120 m (394 ft) above the elevation of the DER. Where the location and/or height of obstacles precludes the construction of turning departures which satisfy the minimum turn height criterion, departure procedures should be developed on a local basis in consultation with the operators concerned.

3.3.1.2 Area 1 of the turning departure is identical to the straight departure area with no track guidance specified in 3.2.2.2. The areas terminate at the turning point (TP) chosen to allow the aircraft to climb to at least 120 m (394 ft) above the elevation of the DER.

3.3.1.3 Area 2 of the turning departure is constructed in the same manner as is the turning missed approach area (see Part III, 7.3). The following criteria apply:

Turn parameters: the parameters on which the turn areas are based are:

a) *altitude:*

   i) *turn designated at an altitude/height:* turn altitude/height;

   ii) *turn at a designated turning point:* aerodrome elevation plus the height based on a 10 per cent climb from the DER to the turning point;

b) *temperature:* ISA + 15°C corresponding to a) above;

c) *indicated air speed:* the speed tabulated for "final missed approach" in Tables III-1-1 and III-1-2 for the speed category for which the departure procedure is designed, increased by 10 per cent to account for the increased aircraft mass at departure. However, where operationally required to avoid obstacles, reduced speeds as slow as the IAS tabulated for "intermediate missed approach" in Tables III-1-1 and III-1-2 increased by 10 per cent may be used, provided the procedure is annotated "Departure turn limited to ________ km/h (kt) IAS maximum". In order to verify the operational effect of a desired speed limitation, the speed value should be compared with the statistical speed as published in Attachment A to Part II;

d) *true air speed:* the IAS in c) above adjusted for altitude a) and temperature b);

e) *wind:* maximum 95 per cent probability wind on an omnidirectional basis, where statistical wind data are available. Where no wind data are available, an omnidirectional 56 km/h (30 kt) wind should be used;

f) *bank angle:* 15° average achieved;

g) *fix tolerance:* as appropriate for the type of fix;

h) *flight technical tolerances:* pilot reaction time 3 s + bank establishment time 3 s equals 6 s (to calculate c));

i) *turn boundary:* Part III, 7.3.3 applies;

j) *secondary areas:* secondary areas are specified where track guidance is available.

3.3.2 Turn designated at an altitude/height

3.3.2.1 *General.* A turn is prescribed upon reaching a specified altitude/height to accommodate the situation where there is:

a) an obstacle located in the direction of the straight departure which must be avoided; and/or

b) another obstacle located abeam the straight departure track which must be overflown after the turn with the appropriate margin.

In such a case the procedure shall require a climb to a specified altitude/height before initiating the turn as specified (heading or track guidance).

3.3.2.2 A turning altitude or height is selected which shall result in a turning point that will ensure the aircraft avoids the straight ahead obstacle or overflies the abeam obstacle as appropriate. The straight departure criteria apply up to the TP. Turn height (TNH) is computed from the following relationship:

$$TNH = d_r PDG + 5 \text{ m } (16 \text{ ft})$$

GENERAL CRITERIA

Chapter 1
GENERAL

1.1 SCOPE

Chapters 1 to 9 contain information common to all types of instrument approach procedures which is to be used in the development of instrument approach procedures. Criteria which do not have general application are located in the individual sections concerned with the specific types of facilities. Because of the precision aspect of the ILS, some operational restrictions and advantages to these criteria are applicable in the development of ILS procedures. These variations are contained in Chapter 21 (ILS), and therefore, no reference to the ILS exceptions is made in the general criteria (Chapters 1 to 9). Where characteristics of radio facilities are provided in this document, they are intended solely for the construction of procedures, and they do not replace or supplement corresponding material in Annex 10.

1.2 PROCEDURE CONSTRUCTION

An instrument approach procedure may have five separate segments. They are the arrival, initial, intermediate, final and missed approach segments. In addition, an area for circling the aerodrome under visual conditions should be considered. The approach segments begin and end at designated fixes. However, under some circumstances certain segments may begin at specified points where no fixes are available (or necessary), e.g. the final approach segment of a precision approach may originate at the point of intersection of the designated intermediate flight altitude/height with the nominal glide path.

1.3 FIX NAMES

The fixes are named to coincide with the associated segment. For example, the intermediate segment begins at the intermediate fix and ends at the final approach fix. Where no fix is available as mentioned in 1.2, the segments begin and end at specified points (e.g. glide path intercept and missed approach point in ILS procedures). The order in which this document discusses the segments is the same order in which the pilot would fly them in a complete procedure, that is from arrival through initial and intermediate to a final approach, and if necessary the missed approach.

1.4 SEGMENT APPLICATION

Only those segments which are required by local conditions need be included in a procedure. In constructing the procedure the final approach track should be identified first because it is the least flexible and most critical of all the segments. When the final approach has been determined, the other necessary segments should be blended with it to produce an orderly manoeuvring pattern which is responsive to the local traffic flow. See Figure III-1-1.

1.5 AREAS

For each segment an associated area is provided and a minimum altitude/height is calculated by considering a minimum obstacle clearance. Normally the area is symmetrically disposed on each side of the intended track. In certain cases this area is subdivided into primary and secondary areas. When secondary areas are permitted, the outer half of each side of the area (normally 25 per cent of the total width) is designated as secondary area. See Figure III-1-2.

1.6 OBSTACLE CLEARANCE

Full obstacle clearance is provided throughout the entire area unless secondary areas are identified. In this case full obstacle clearance is provided in the primary area and in

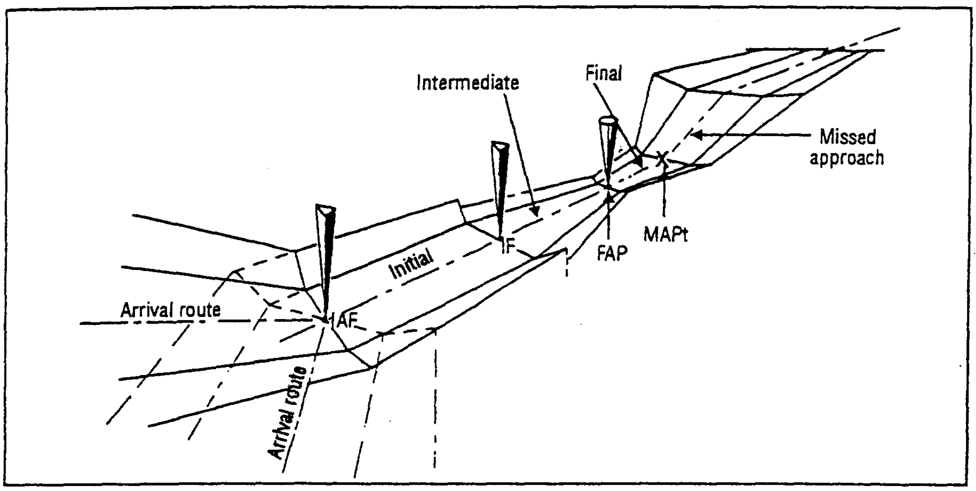


Figure III-1-1. Segments of instrument approach

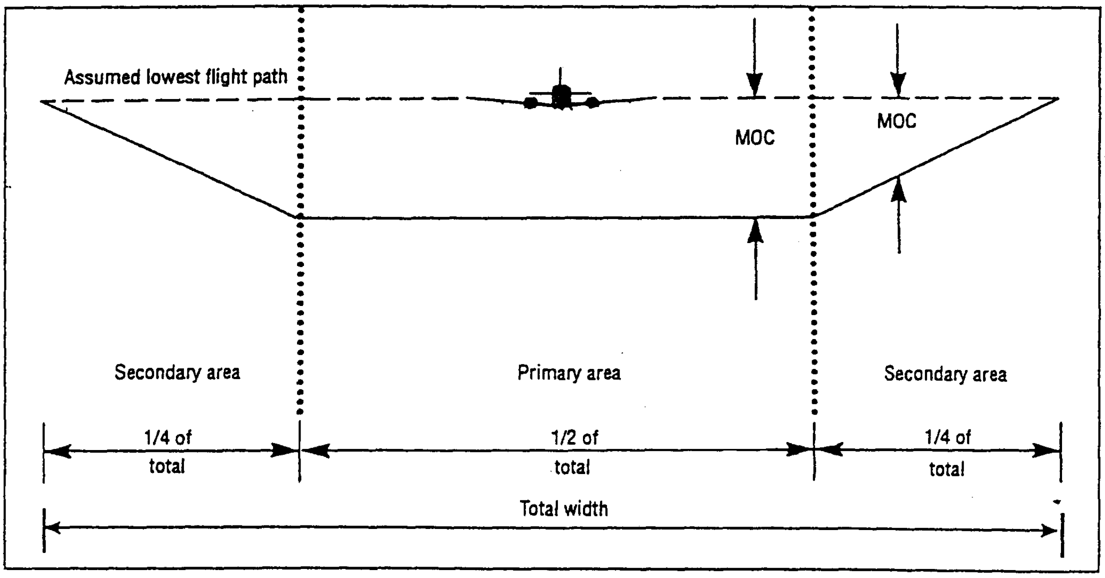


Figure III-1-2. Cross-section of straight segment area showing primary and secondary areas

the secondary area the obstacle clearance is reduced linearly from the full clearance at the inner edge to zero at the outer edge. See Figure III-1-2.

1.7 TRACK GUIDANCE

Track guidance should normally be provided for all phases of flight through the arrival, initial, intermediate, final and missed approach segments. When track guidance is provided, the appropriate segment shall lie within the established coverage of the navigational facility on which the track guidance is based. When track guidance is not provided the obstacle clearance area shall be expanded as prescribed in Chapter 4. Terminal area surveillance radar (TAR), when available, may be used to provide vectors to the final approach (see 24.2). En-route surveillance radar (RSR) may be used to provide track guidance through initial approach segments up to and including the intermediate fix.

Note.— Detailed procedures regarding the use of primary radar in the approach control service are set forth in PANS-RAC, Doc 4444, Procedures for Air Navigation Services — Rules of the Air and Air Traffic Services.

1.8 VERTICAL GUIDANCE

Optimum and maximum descent gradients are specified depending on the type of procedure and the segment of the approach. At least in the case of the final approach segment for non-precision approach procedures, and, preferably, also for other approach segments where appropriate, the descent gradient(s) used in the construction of the procedure shall be published. Where distance information is available, descent profile advisory information for the final approach should be provided to assist the pilot to maintain the calculated descent gradient. This should be a table showing altitudes/heights through which the aircraft should be passing at each 2 km or 1 NM as appropriate.

1.9 CATEGORIES OF AIRCRAFT

1.9.1 Aircraft performance differences have a direct effect on the airspace and visibility needed to perform certain manoeuvres such as circling approach, turning missed approach, and final approach descent and manoeuvring to land, including base and procedure turns. The most significant factor in performance is speed. The following categories of typical aircraft are established, based on 1.3 times stall speed in the landing configuration at maximum certificated landing mass. These categories will be referred to throughout this document by their letter designations.

Category A — less than 169 km/h (91 kt) IAS
Category B — 169 km/h (91 kt) or more but less than 224 km/h (121 kt) IAS
Category C — 224 km/h (121 kt) or more but less than 261 km/h (141 kt) IAS
Category D — 261 km/h (141 kt) or more but less than 307 km/h (166 kt) IAS
Category E — 307 km/h (166 kt) or more but less than 391 km/h (211 kt) IAS

1.9.2 The ranges of speeds (IAS) in Tables III-1-1 and III-1-2 take account of the handling speeds when aircraft perform the manoeuvres specified and are to be used in calculating procedures. For conversion of these speeds to IAS see Attachment F to Part III.

1.9.3 Where airspace requirements are critical for a specific category of aircraft, procedures may be based on lower speed category aircraft, provided use of the procedure is restricted to those categories. Alternatively the procedure may be specified as limited to a specific maximum IAS for a particular segment without reference to category.

1.10 EXAMPLE CALCULATIONS

All example calculations in this document are based on an altitude of 600 m (2 000 ft) above MSL and a temperature of ISA + 15°C unless otherwise stated. For speed conversion the factors in Attachment F to Part III are used.

1.11 BEARINGS, TRACKS AND RADIALS

In planning procedures, degrees true shall be used. However, all published procedures shall be in degrees magnetic in accordance with Annex 4. Radials shall also be expressed in degrees magnetic, and shall further be identified as radials by prefixing the letter "R" to the magnetic bearing from the facility, for example, R-027 or R-310. The published radial shall be that radial which defines the desired flight track. In areas of magnetic unreliability (i.e. in the vicinity of the earth's magnetic poles) procedures may be established in degrees true.

Chapter 2
TERMINAL AREA FIXES

2.1 GENERAL

Terminal area fixes include, but are not limited to, the initial approach fix (IAF), the intermediate fix (IF), the final approach fix (FAF), the holding fix, and when necessary, a fix to mark the missed approach point (MAPt), or the turning point (TP). Terminal area fixes should be based on similar navigational systems. The use of mixed type (as VHF/LF) fixes should be limited to those intersections where no satisfactory alternative exists.

2.2 FIXES FORMED BY INTERSECTIONS

Because all navigation facilities have accuracy limitations, the geographic point which is identified is not precise, but may be anywhere within an area which surrounds the nominal point of intersection. Figure III-2-1 illustrates the intersection of an arc and a radial from the same VOR/DME facility, and the intersection of two radials or bearings from different navigation facilities. The area formed in these ways is referred to in this document as the "fix tolerance area".

2.3 FIXES FOR VOR OR NDB WITH DME

VOR/DME fixes use radial and distance information derived normally from facilities with collocated azimuth and DME antennae. However, where it is necessary to consider a VOR/DME fix derived from separate facilities the fix is only considered satisfactory where the angles subtended by the facilities at the fix results in an acceptable fix tolerance area. See Figure III-2-1. For the use of DME with ILS see 21.4.3. Where the DME antenna is not collocated with the VOR and NDB providing track guidance the maximum divergence between the fix, the tracking facility and the DME shall not be more than 23 degrees.

2.4 RADAR FIXES

Radar should not normally be the primary method of fix identification. However, where ATC can provide the service TAR within the limitations of 2.6.4.1 may be used to identify any terminal area fix. En-route surveillance radar (RSR) may be used for initial approach and intermediate approach fixes.

2.5 INTERSECTION FIX TOLERANCE AREAS

The intersection fix position accuracy areas obtained by using navigational information from either collocated or non-collocated facilities is shown at Figure III-2-1. The fix areas are formed by applying the plus and minus tolerances of the homing and intersecting radials or arcs as appropriate, to the nominal fix position.

2.6 FIX TOLERANCE FACTORS

2.6.1 *General.* The dimensions of the fix tolerance area are determined by the system use accuracy of the navigational system which supplies the information to define the fix. The factors from which the accuracy of a system is determined are: ground station tolerance; airborne receiving system tolerance; and flight technical tolerance. Based on statistical analysis of these system tolerances, the fix tolerance areas should be determined using the values shown in 2.6.2 through 2.6.5.2 (see also Table III-2-1). Difference between the over-all tolerance of the intersecting facility and the along track facility is accounted for by the fact that flight technical tolerance is not applied to the former.

2.6.2 Accuracy of facility providing track

2.6.2.1 *VOR.* ±5.2°. This value is the result of a combination, on a root sum square basis, of the following four values:

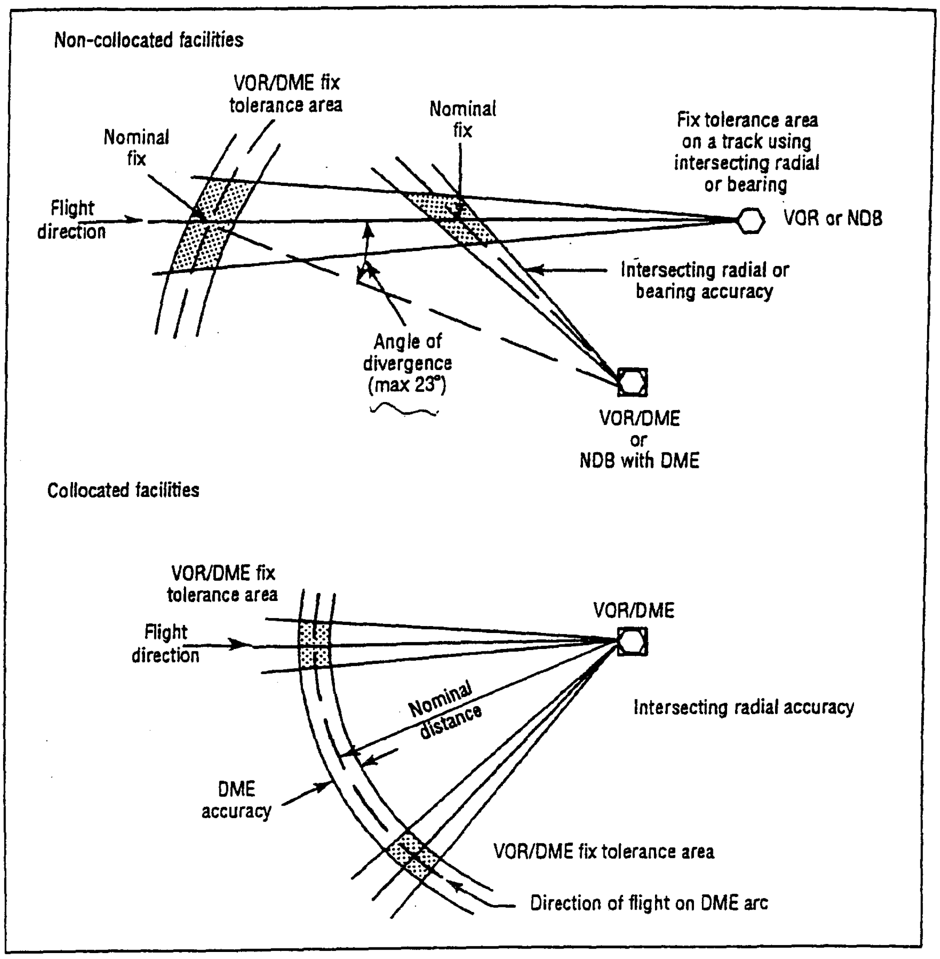


Figure III-2-1. Intersection fix tolerance areas

a) ± 3.5° ground system tolerance or as determined by flight test;

b) ± 1.0° monitor tolerance;

c) ± 2.7° receiver tolerance; and

d) ± 2.5° flight technical tolerance.

Note.— The value of ± 5.2° may be modified according to the value of a) above, resulting from flight tests.

2.6.2.2 *ILS localizer.* ± 2.4°. This value is the result of a combination, on a root sum square basis, of the following values:

a) ± 1° ground monitored equipment tolerance including beam bends;

b) ± 1° airborne equipment tolerance; and

c) ± 2° flight technical tolerance.

2.6.2.3 *NDB.* ± 6.9°. This value is the result of a combination, on a root sum square basis, of the following values:

a) ± 3° ground equipment;

b) ± 5.4° airborne equipment; and

c) ± 3° flight technical tolerance.

2.6.3 Over-all tolerance of the intersecting facility

2.6.3.1 *VOR.* ± 4.5°. This value is the result of a combination, on a root sum square basis, of the following three values:

a) ± 3.5° ground system tolerance or as determined by flight test;

b) ± 1.0° monitor tolerance; and

c) ± 2.7° receiver tolerance.

Note.— The value of ± 4.5° may be modified according to the value of a) above, resulting from flight tests.

2.6.3.2 *ILS localizer.* ± 1.4°.

2.6.3.3 *NDB.* ± 6.2°.

2.6.4 Fix tolerance factors for other facilities

2.6.4.1 *Terminal area radar.* Radar fix accuracies need to consider mapping accuracies (normally 150 m (492 ft) or 3 per cent of the distance to the antenna), azimuth resolutions of the radar (reduced to some extent to account for the controller interpretation of target centre), flight technical tolerance (which recognizes communication lag as well as speed of the aircraft) and controller technical tolerance (which recognizes sweep speed of the antenna and the speed of the aircraft). The total fix tolerance is the result of a combination, on a root sum square basis, as in Table III-2-2.

2.6.4.2 *DME.* The accuracy is ± 0.46 km (0.25 NM) + 1.25 per cent of the distance to the antenna. This value is the RSS total of minimum accuracy, monitor tolerance and flight technical tolerance, the latter two being so small as to be completely dominated by the larger airborne value.

Note 1.— No reduction can be justified based on flight test information.

Note 2.— Tolerance values assume that published procedures will take into account slant range distance.

Table III-2-1. Intersection fix tolerances and area splay angles for VOR and NDB

Facility	*VOR*		*NDB*	
Intersection fix tolerances	*Tracking tolerance*	*Intersecting tolerance*	*Tracking tolerance*	*Intersecting tolerance*
	5.2°	4.5°	6.9°	6.2°
Area splay angle	7.8°		10.3°	

Chapter 3
ARRIVAL SEGMENT

3.1 STANDARD INSTRUMENT ARRIVALS

3.1.1 General

3.1.1.1 In some cases it is necessary to designate arrival routes from the en-route structure to the initial approach fix. Only those routes which provide an operational advantage shall be established and published. These should coincide with the local air traffic flow. The length of the arrival route shall not exceed the operational service range of the facilities which provide navigational guidance.

3.1.1.2 STARs should be simple and easily understood and only those navigation facilities, fixes or way-points essential to define the flight path of an aircraft and for ATS purposes will be included in the procedure.

3.1.1.3 A STAR should be developed to accommodate as many aircraft categories as possible.

3.1.1.4 A STAR should commence at a fix, e.g. radio navigation facility, intersection, distance measurement equipment (DME) fix or way-point.

3.1.1.5 A STAR should permit transition from the en-route phase to the approach phase by linking a significant point normally on an ATS route with a point from which an instrument approach procedure is initiated.

3.1.1.6 A STAR should be designed so as to permit aircraft to navigate along the routes reducing the need for radar vectoring.

3.1.1.7 A STAR may serve one or more airports within a terminal area.

3.1.1.8 Airspeed and altitude/level restrictions, if any, should be included taking into account the operational capabilities of the aircraft category involved, in consultation with the operators.

3.1.1.9 Whenever possible, STARs should be designed with DME fixes or way-points in lieu of intersections.

Note 1.— Material relating to the principles governing the identification of standard arrival routes and associated procedures are contained in Annex 11, Appendix 3.

Note 2.— Material relating to the publication of The Standard Arrival Chart — Instrument (STAR) — ICAO is contained in Annex 4, Chapter 10.

3.1.1.10 A DME arc may provide track guidance for all or a portion of an arrival route. The minimum arc radius shall be 18.5 km (10.0 NM). An arc may join a straight track at or before the initial approach fix in this case, the angle of intersection of the arc and the track should not exceed 120°. When the angle exceeds 70°, a lead radial which provides at least a distance "d" of lead shall be identified to assist in leading the turn ($d = r.\tan \frac{(\alpha)}{2}$; r = radius of turn; α = angle of turn.

3.1.2 Area construction

3.1.2.1 When the length of the arrival route is greater than or equal to 46 km (25 NM), en-route criteria applies to the 46 km (25 NM) prior to the IAF. The area width decreases from the 46 km (25 NM) with a convergence angle of 30° each side of the axis, until reaching the width resulting from the initial approach criteria. See Figure III-3-1a.

3.1.2.2 When the length of the arrival route is less than 46 km (25 NM), the area width decreases from the beginning of the arrival route with a convergence angle of 30° each side of the axis, until reaching the width resulting from the initial approach criteria. See Figure III-3-1b.

3.1.2.3 Turns will be protected by using en-route criteria before 46 km (25 NM) to the IAF and the initial approach criteria of the last 46 km (25 NM) before the IAF.

3.1.2.4 In case of an arrival based on a DME arc, the decrease of the area width begins at the distance of 46 km

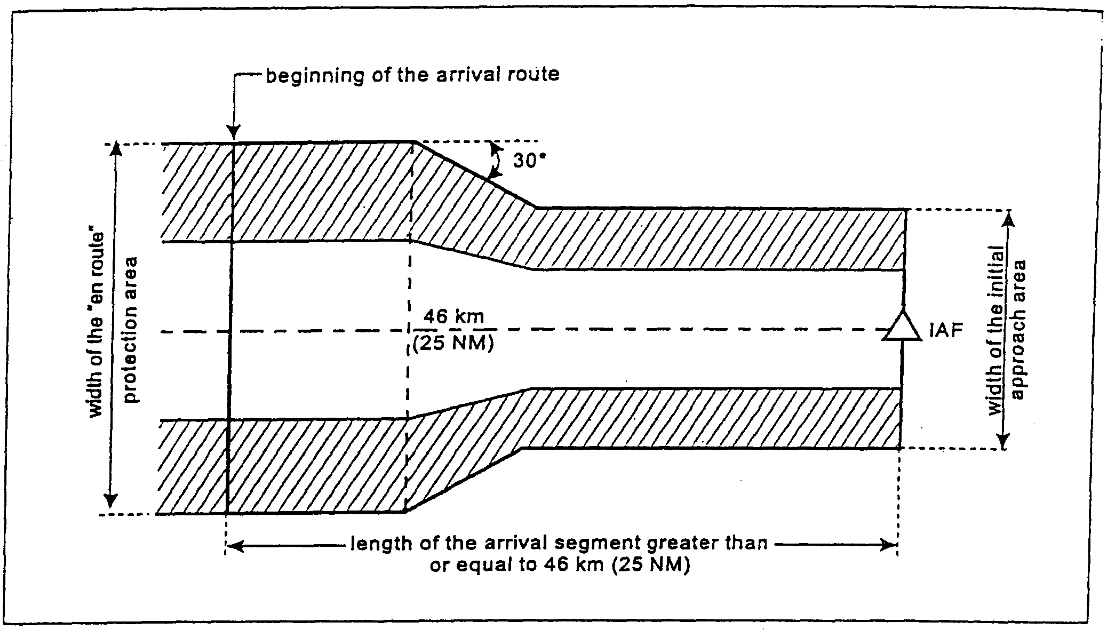


Figure III-3-1a. Arrival segment — protection area (length of the arrival segment greater than or equal to 46 km (25 NM))

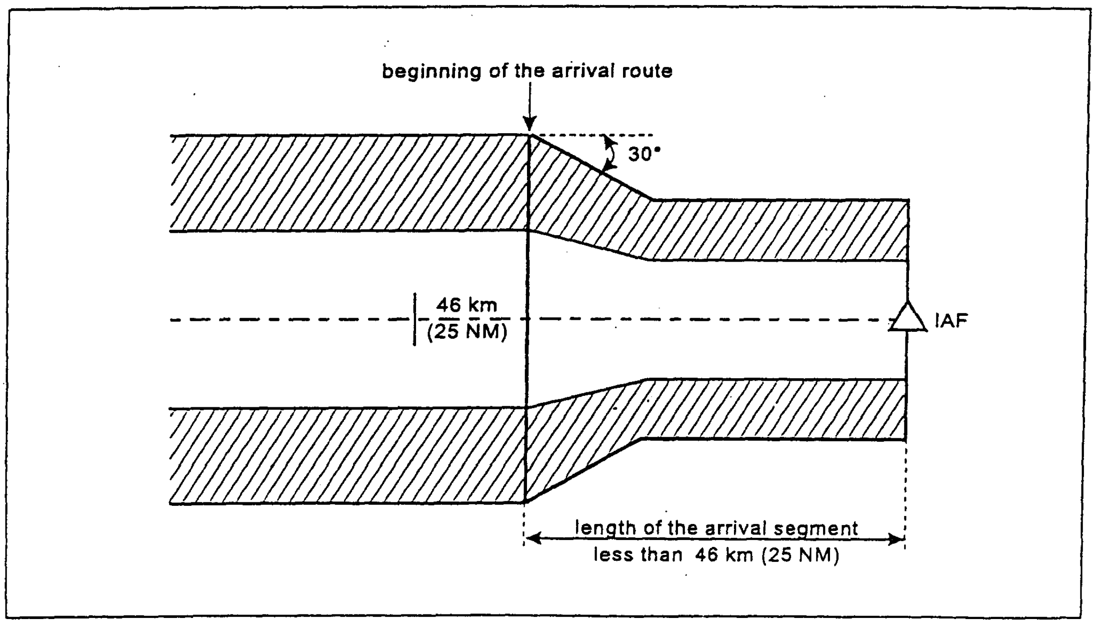


Figure III-3-1b. Arrival segment — protection area (length of the arrival segment less than 46 km (25 NM))

Chapter 4
INITIAL APPROACH SEGMENT

4.1 GENERAL

The initial approach segment commences at the initial approach fix (IAF). In the initial approach the aircraft is manoeuvring to enter the intermediate segment. When the intermediate fix is part of the en-route structure, it may not be necessary to designate an initial approach segment. In this case the instrument approach procedure commences at the intermediate fix and intermediate segment criteria apply. An initial approach may be made along a VOR radial, NDB bearing, specified radar vector or a combination thereof. Where none of these is possible a DME arc or a specified heading may be used. Reversal and racetrack procedures as well as holding pattern descents are initial segments until the aircraft is established on the intermediate approach track. Normally track guidance is required except that dead reckoning tracks may be used for distances not exceeding 19 km (10 NM). Although more than one initial approach may be established for a procedure, the number should be limited to that which is justified by traffic flow or other operational requirements. Where holding is required prior to entering the initial approach segment, the holding fix and initial approach fix should coincide. When this is not possible, the initial approach fix shall be located within the holding pattern on the inbound holding track.

4.2 ALTITUDE SELECTION

4.2.1 Minimum altitudes in the initial approach segment shall be established in 100 ft or 50 m increments as appropriate. The altitude selected shall not be below the reversal or racetrack procedure altitude where such a procedure is required. In addition, altitudes specified in the initial approach segment must not be lower than any altitude specified for any portion of the intermediate or final approach segments.

4.2.2 When different minimum altitudes are specified for different categories of aircraft, separate procedures shall be published.

4.3 INITIAL APPROACH SEGMENTS (OTHER THAN RADAR VECTORS) UTILIZING STRAIGHT TRACKS AND DME ARCS

4.3.1 *Tracks.* The angle of intersection between the initial approach track and the intermediate track should not exceed 120°. When the angle exceeds 70° a radial, bearing, radar vector or DME information providing at least 4 km (2 NM) of lead shall be identified to assist in leading the turn onto the intermediate track (see Figure III-4-1). When the angle exceeds 120° the use of a racetrack or reversal procedure (4.4 and 4.5) or DR track (4.3.3.1) should be considered.

4.3.2 *DME arcs.* An arc may provide track guidance for all or a portion of an initial approach. The minimum arc radius shall be 13 km (7 NM). An arc may join a track at or before the intermediate fix. When joining a track at or before the intermediate fix, the angle of intersection of the arc and the track should not exceed 120°. When the angle exceeds 70°, a radial which provides at least 4 km (2 NM) of lead shall be identified to assist in leading the turn onto the intermediate track.

4.3.3 *Area.* The initial approach segment has no standard length. The length shall be sufficient to permit the altitude change required by the procedure. The width is divided into a primary area which extends laterally 4.6 km (2.5 NM) on each side of the track, and a secondary area which extends laterally 4.6 km (2.5 NM) on each side of the primary area. (See Figure III-4-2.) Where, because of an operational requirement, any portion of the initial approach is more than 69 km (37 NM) from the VOR or 52 km (28 NM) from the NDB providing track guidance, the area will start splaying at these distances at an angle of 7.8° for VOR or 10.3° for NDB, the width of the primary area remaining one half of the total width of the area. (See Figure III-4-3.)

Note.— See also Attachment K to Part III for possible reduction of the width of straight initial approach area.

4.3.3.1 *Area associated with dead reckoning (DR) track procedures.* Where DR track procedures are utilized, the area shall be expanded to account for the maximum drift from an unrecognized beam wind component of ± 56 km/h (± 30 kt) in addition to ± 5° heading tolerance. The minimum length of the intermediate track being intercepted shall provide sufficient additional distance to accommodate these tolerances and the associated fix tolerances. See Attachment D to Part III.

4.3.4 *Obstacle clearance.* The obstacle clearance in the initial approach primary area shall be a minimum of 300 m (984 ft). In the secondary area 300 m (984 ft) of obstacle clearance shall be provided at the inner edge, reducing linearly to zero at the outer edge. The minimum obstacle clearance required at any given point in the secondary area is found by interpolation (see Figure III-5-2).

4.3.5 *Descent gradient.* The optimum descent gradient in the initial approach is 4.0 per cent. Where a higher descent gradient is necessary to avoid obstacles, the maximum permissible is 8.0 per cent.

OPTI = 4 %
MAX = 8 %

4.4 INITIAL APPROACH SEGMENT USING A RACETRACK PROCEDURE

4.4.1 *General.* Racetrack procedures are used where sufficient distance is not available in a straight segment to accommodate the required loss of altitude and when entry into a reversal procedure is not practical. Racetrack procedures may also be specified as alternative to reversal procedures to increase operational flexibility.

4.4.2 *Starting point.* The racetrack procedure starts at a designated facility or fix.

4.4.3 *Entry.* Entry into a racetrack procedure shall be similar to entry procedures for holding patterns as specified in Part IV, 1.2.1, with the following additional considerations:

a) Offset entry from Sector 2 shall limit the time on the 30° offset track to 1 min 30 s, after which the pilot is expected to turn to a heading parallel to the outbound track for the remainder of the outbound time. If the outbound time is only 1 min, the time on the 30° offset track shall be 1 min also.

b) Parallel entry shall *not* return directly to the facility without first intercepting the inbound track (when proceeding onto the final approach segment).

c) All manoeuvring shall be done in so far as possible on the manoeuvring side of the inbound track.

4.4.3.1 *Restricted entry.* Where necessary to conserve airspace (or for other reasons), entry may be restricted to specific routes. When so restricted, the entry route(s) shall be specified in the procedure. Examples of restricted entries are shown in Attachment C to Part III (3.4).

4.4.4 *Shape of a racetrack procedure.* The racetrack procedure has the same shape as a holding pattern but with different operating speeds and outbound timing. The inbound track normally becomes the intermediate or final segment of the approach procedure.

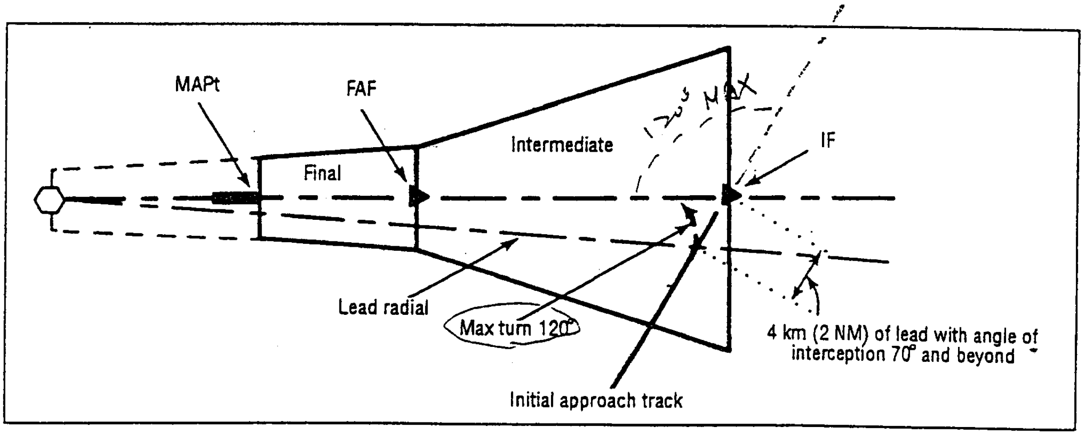


Figure III-4-1. Lead radial for turns greater than 70°

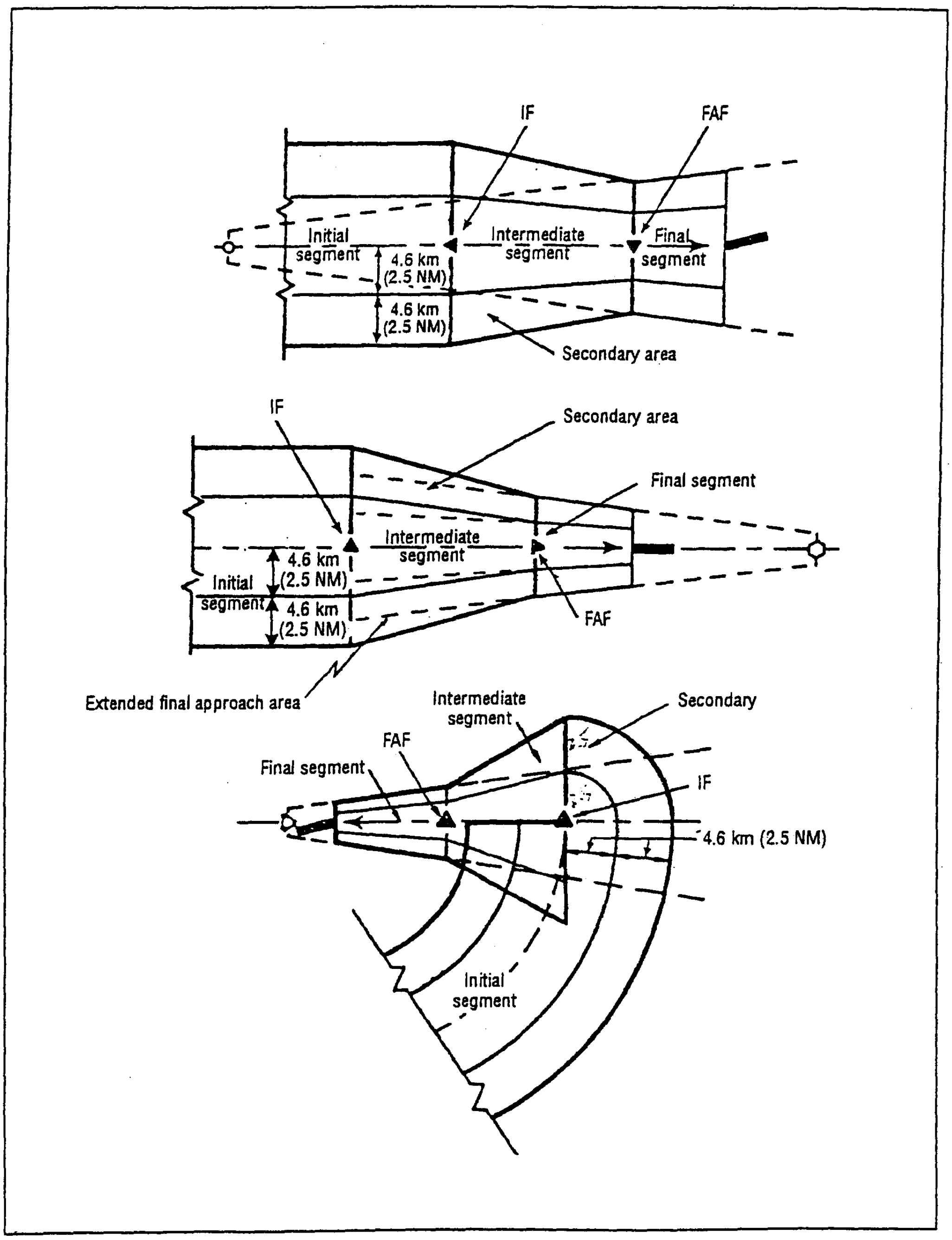


Figure III-4-2. Typical segments (plan view)

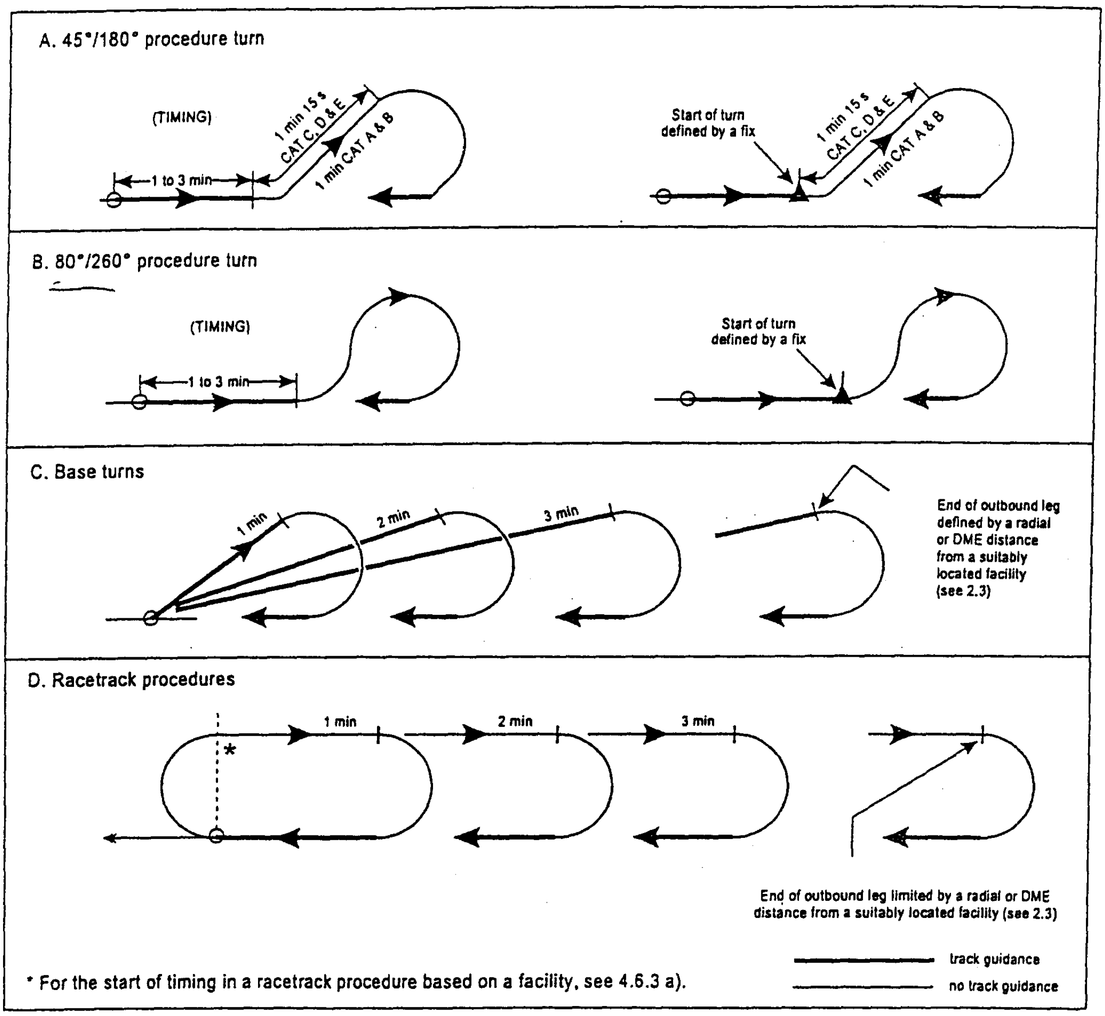


Figure III-4-7. Types of reversal and racetrack procedures

4.6 RACETRACK AND REVERSAL PROCEDURE AREAS

4.6.1 *General.* The areas required to accommodate both the racetrack and reversal procedures described in 4.4 and 4.5 shall be based on the application of the area parameters specified in 4.6.2 below. These may be applied either on an additive tolerance basis or using statistical methods.

4.6.2 *Area parameters.* The parameters on which both racetrack and reversal procedures are based are:

a) *altitude:* the specified altitude for which the area is designed;

b) *temperature:* ISA for the specified altitude plus 15°C;

c) *indicated air speed (IAS):* the highest procedural speed category for which the area is designed (see 1.9, Tables III-1-1 and III-1-2);

d) *true air speed (TAS):* the IAS in c) above adjusted for altitude a) and temperature b);

Chapter 5
INTERMEDIATE APPROACH SEGMENT

5.1 GENERAL

This is the segment which blends the initial approach segment into the final approach segment. It is the segment in which aircraft configuration, speed, and positioning adjustments are made for entry into the final approach segment. There are two types of intermediate approach segments, both of which end at the FAF: a) the segment begins at a designated IF, b) the segment begins upon completion of DR track, a reversal or racetrack procedure. In both cases, track guidance shall be provided inbound to the FAF. See Figure III-4-2 for typical intermediate approach segments.

5.2 ALTITUDE/HEIGHT SELECTION

The minimum altitude/height in the intermediate approach segment shall be established in 100 ft increments or 50 m increments as appropriate.

5.3 INTERMEDIATE APPROACH SEGMENT BASED ON A STRAIGHT TRACK ALIGNMENT

The track to be flown in the intermediate approach segment should normally be the same as the final approach track. Where this is not practicable and the final approach fix in a non-precision procedure is a navigational facility, the intermediate track shall not differ from the final approach track by more than 30°. Where the turn at the FAF is greater than 10° the final approach area should be widened on the outer side of the turn as in 7.3.5.3.2.

5.4 AREA

5.4.1 *Length.* The length of the intermediate approach segment shall not be less than 9.3 km (5.0 NM) (except as provided for in ILS, MLS and radar sections) nor more than 28 km (15 NM), measured along the track to be flown. The optimum length is 19 km (10 NM). A distance greater than 19 km (10 NM) should not be used unless an operational requirement justifies a greater distance. When the angle at which the initial approach track joins the intermediate approach track exceeds 90°, the minimum length of the intermediate approach track is as shown in Table III-5-1.

Table III-5-1. Minimum intermediate track length

Interception angle (degrees)	*Minimum track length*
91 — 96	11 km (6 NM)
97 — 102	13 km (7 NM)
103 — 108	15 km (8 NM)
109 — 114	17 km (9 NM)
115 — 120	19 km (10 NM)

5.4.2 *Width.* The total width of the intermediate approach segment is determined by joining the outer edges of the initial approach segment with the outer edges of the final approach segment by means of straight lines. For obstacle clearance purposes, the intermediate approach segment is divided into a primary and a secondary area. The primary area is determined by joining the primary initial approach area with the primary final approach area by means of straight lines. The secondary area is determined by joining the respective initial approach and final approach secondary areas by means of straight lines. The width of the secondary areas at any given point may be determined by using the graph shown in Figure III-5-1. See Figure III-4-2 for typical intermediate approach segments.

Note.— See also Attachment K to Part III for possible reduction of the width of the initial approach area.

5.5 OBSTACLE CLEARANCE

A minimum of 150 m (492 ft) of obstacle clearance shall be provided in the primary area of the intermediate approach segment. In the secondary area, 150 m (492 ft) of obstacle clearance shall be provided at the inner edge,

Chapter 6
FINAL APPROACH SEGMENT

6.1 GENERAL

This is the segment in which alignment and descent for landing are accomplished. The instrument part of the final approach segment begins at the final approach fix (see 2.7.3), and ends at the missed approach point (MAPt). In an ILS approach, the final approach is deemed to commence at the final approach point (see 21.4.2). Final approach may be made to a runway for a straight-in landing, or to an aerodrome for a circling approach. The final approach segment should be aligned with a runway whenever possible. Track guidance shall be provided for the instrument part of the final approach segment. Since the alignment and dimensions of the final approach segment and minimum obstacle clearance (MOC) vary with the location and type of navigational facility, applicable criteria are contained in the parts dealing with specific navigational facilities. See Chapters 21 to 31.

6.2 ALIGNMENT

6.2.1 *Straight-in approach.* The alignment criteria for precision approaches is contained in the specific chapters. The alignment criteria for non-precision approaches is as follows:

Maximum angle: For a straight-in approach, the angle formed by the final approach track and the runway centre line shall not exceed:

30° for procedures restricted to Cat A and B aircraft only
15° for other aircraft categories.

Minimum distance: The distance between the runway threshold and the point at which the final approach track intersects the runway centre line shall not be less than 1 400 m.

A final approach which does not intersect the extended centre line of the runway (θ equal to or less than 5°) may also be established, provided such track lies within 150 m laterally of the extended runway centre line at a point located at a distance of 1 400 m outward from the runway threshold (see Figure III-6-1).

Minimum OCH: For interception angles between the final approach and the runway centre line, comprised between 5° and the maximum value, the OCH of the procedure must be equal to or greater than the following values:

Aircraft category	*Lowest OCH (m (ft))* $5° < θ \le 15°$	$15° < θ \le 30°$
A	105 (340)	115 (380)
B	115 (380)	125 (410)
C	125 (410)	
D	130 (430)	
E	145 (480)	

These values were determined taking into account the maximum interception distance of 1 400 m, a runway threshold clearance height of 15 m, a descent gradient of 5 per cent, an indicated airspeed of V_{at}, a tail wind of 10 kt and an additional flight time of 5 s.

Minimum OCH = 15 m + Lxp%
with L = 1 400 m + r tan (θ/2) + 5 s of flight.

For nominal descent gradients above 5 per cent, increase by 18 per cent the values of the table for each per cent of gradient above 5 per cent.

6.2.2 *Circling approach.* When the final approach track alignment does not meet the criteria for a straight-in landing, only a circling approach shall be authorized and the track alignment should ideally be made to the centre of the landing area. When necessary, the final approach track may be aligned to pass over some portion of the usable landing surface. In exceptional cases, it may be aligned beyond the aerodrome boundary, but in no case beyond 1.9 km (1.0 NM) from the usable landing surface (see Figure III-6-2).

6.3 DESCENT GRADIENT

The optimum descent gradient is 5 per cent for the final approach segment of a non-precision approach with FAF (3° for a precision approach). The minimum descent gradient is 4.3 per cent for the final approach segment of a non-precision approach with FAF (2.5° for a precision approach). Descent gradients steeper than the optimum should not be used unless all other means to avoid obstacles have been attempted since these steeper descent gradients may result in rates of descent which exceed the recommended limits for some aircraft on final approach. The maximum descent gradient for standard procedures is 6.5 per cent for the final approach segment of a non-precision approach (3.5° for a Cat I precision approach; 3° for Cat II and III precision approaches). Where a stepdown fix is used in the final approach segment the descent gradient is applicable to the areas between the FAF and the stepdown fix, and between the stepdown fix and the approach runway threshold. The vertical distance applicable is the difference between the altitude specified at the fix(es) and the altitude corresponding to a height of 15 m (50 ft) above the runway threshold. For a non-precision approach with no FAF, see Table III-6-1.

Table III-6-1. Rate of descent in the final approach segment of a procedure with no FAF

Aircraft categories	*Rate of descent*	
	Minimum	*Maximum*
A, B	120 m/min (394 ft/min)	200 m/min (655 ft/min)
C, D, E	180 m/min (590 ft/min)	305 m/min (1 000 ft/min)

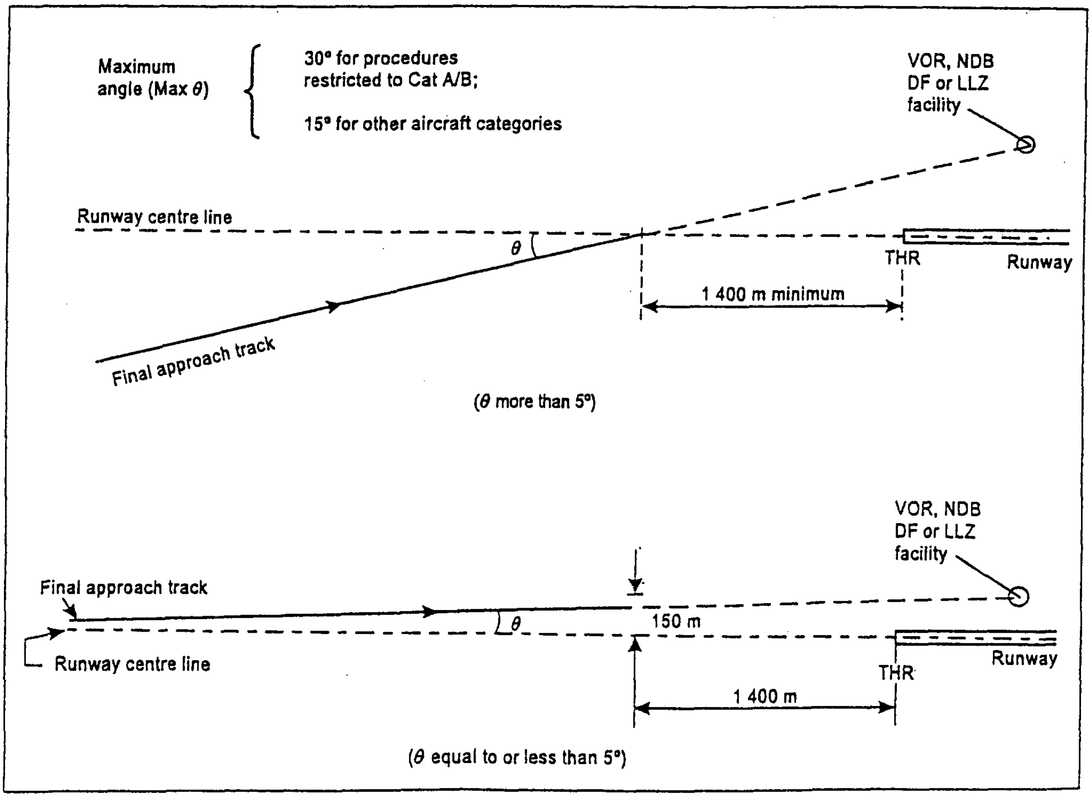


Figure III-6-1. Final straight-in approach alignment

Chapter 7
MISSED APPROACH SEGMENT

7.1 GENERAL

7.1.1 A missed approach procedure shall be established for each instrument approach and shall specify a point where the procedure begins and a point where it ends. The missed approach procedure is assumed to be initiated not lower than the OCA/H in precision approach procedures or at a specified point in non-precision approach procedures not lower than the OCA/H. The missed approach procedure shall terminate at an altitude/height sufficient to permit:

a) initiation of another approach; or

b) return to a designated holding pattern; or

c) resumption of en-route flight.

Only one missed approach procedure shall be published.

Note.— See ILS/PAR criteria for special provisions.

7.1.2 *Phases of missed approach segment.* In principle the missed approach procedure includes the initial, intermediate and final phases of the missed approach segment (see Figure III-7-1).

7.1.3 *Initial phase.* The initial phase begins at the missed approach point (MAPt) and ends at the start of climb point (SOC). It includes a longitudinal tolerance applied over the full width of the missed approach area for:

a) the longitudinal tolerance of the MAPt,

b) the distance an aircraft traverses during the 15 s transition from approach to missed approach climb, and

c) tail winds.

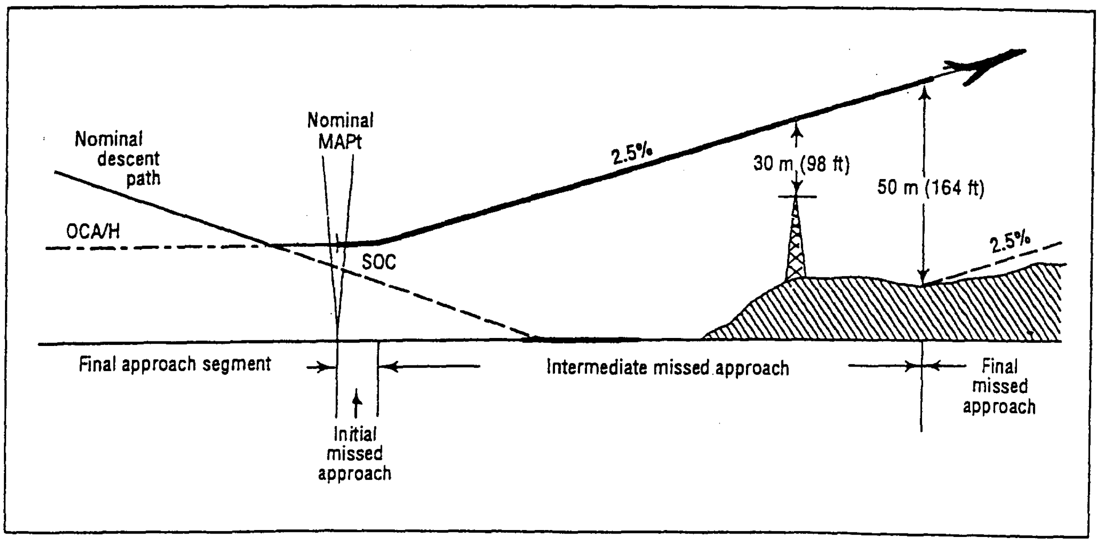


Figure III-7-1. Missed approach phases

The manoeuvre during this phase necessitates the concentrated attention of the pilot especially when establishing the climb and the changes in configuration, and it is assumed that the guidance equipment cannot be fully utilized during these manoeuvres. No requirements to change the flight direction are acceptable in this phase.

7.1.4 *Intermediate phase.* The intermediate phase is that during which the climb is continued at stabilized speeds up to the first point where 50 m (164 ft) obstacle clearance is obtained and can be maintained. Advantage may be taken of available navigational guidance. During the intermediate phase the missed approach track may be changed by a maximum of 15° from that of the initial phase.

7.1.5 *Final phase.* The final phase begins at the point where 50 m (164 ft) obstacle clearance is first obtained and can be maintained. It extends to the point at which a new approach, holding or return to en-route flight is initiated. Turns may be carried out during this phase.

7.1.6 *Climb gradient of the missed approach surface.* The nominal climb gradient of the missed approach surface is 2.5 per cent. A gradient of 2 per cent may be used if the necessary survey and safeguarding can be provided and with the approval of appropriate authority, gradients of 3, 4 or 5 per cent may be used for aircraft whose climb performance permits an operational advantage to be thus obtained. When a gradient other than the nominal gradient is used in the construction of the missed approach procedure this must be indicated in the instrument approach chart and, in addition to the OCA/H for the specific gradient the OCA/H applicable to the nominal gradient must also be shown.

Note.— In case of non-precision approach, any intermediate values (e.g. 3.4 per cent) between 2 and 5 per cent may be considered.

7.1.7 *Obstacle clearance.* The minimum obstacle clearance to be provided in the horizontal part of the initial missed approach area shall be the same as for the last part of the final approach area except where the extension of the missed approach surface towards the missed approach point requires less clearance. (See Figures III-7-2 and III-7-3.) In the intermediate missed approach phase the minimum obstacle clearance shall be 30 m (98 ft) in the primary area, and in the secondary area the minimum obstacle clearance shall be 30 m (98 ft) at the inner edge and shall reduce uniformly to zero at the outer edge. In the final missed approach phase the minimum obstacle clearance shall be 50 m (164 ft) in the primary area reducing linearly to zero at the outer edge of the secondary area.

Note.— MOC may be obtained by increasing the OCA/H or by a longitudinal adjustment of the MAPt or both.

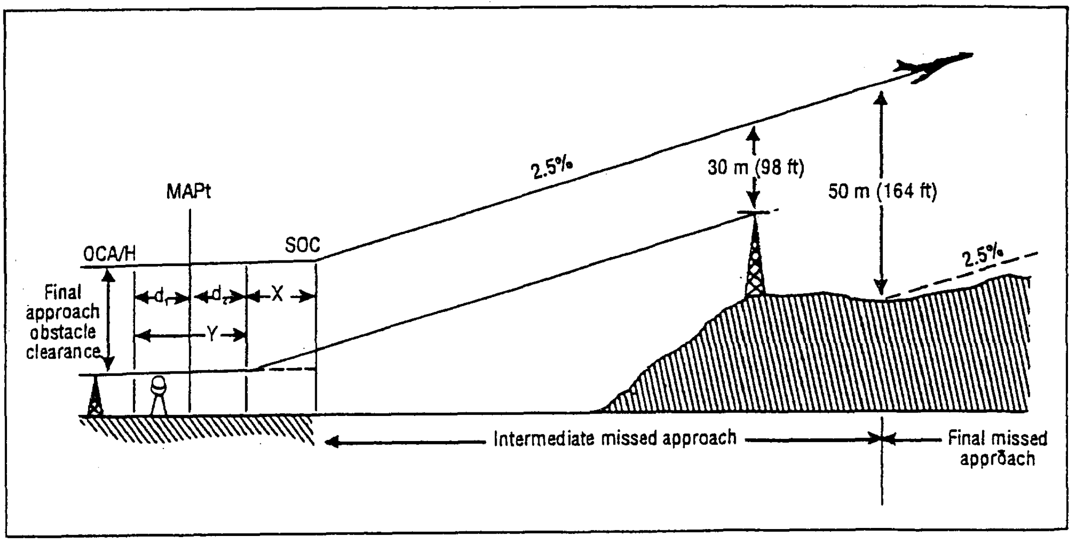


Figure III-7-2. Obstacle clearance for final missed approach phase

SPECIFIC INSTRUMENT APPROACH PROCEDURES

Chapter 21
ILS

21.1 INTRODUCTION

21.1.1 *Application.* The ILS criteria detailed in this chapter are related to the ground and airborne equipment performance and integrity required to meet the Category I, II and III operational objectives described in Annex 10.

21.1.2 *Procedure construction.* The procedure from en route to the precision segment of the ILS approach and in the final missed approach phase conforms with the general criteria. The differences are found in the physical requirements for the ILS precision segment which contains the final approach segment and initial/intermediate phases of the missed approach segment. These requirements are related to the performance of the ILS Cat I, II and III systems.

21.1.3 *Standard conditions.* The standard assumptions on which procedures are developed are:

- Aircraft dimensions; max 30 m semi span, max 6 m vertical distance between the flight paths of the wheels and GP antenna.
- Category II flown with flight director.
- Missed approach climb gradient 2.5 per cent.
- ILS sector width 210 m at threshold. ±105M
- Glide path angle:
  - minimum: 2.5°
  - optimum: 3.0°
  - maximum: 3.5° (3° for Cat II/III operations).
- ILS reference datum height 15 m (49 ft).
- All obstacle heights are referenced to threshold elevation.
- For Cat II and Cat III operations the Annex 14 inner approach, inner transitional and balked landing surfaces have not been penetrated.

Provisions are made for adjustments where appropriate. Adjustments are mandatory when conditions differ adversely from standard conditions and are optional when so specified (see 21.4.8.7).

21.1.4 *Obstacle clearance altitude/height (OCA/H).* The ILS criteria enable an OCA/H to be calculated for each category of aircraft. See 1.9.1. Where statistical calculations were involved, the OCA/H values were designed against an over-all safety target for risk of collision with obstacles of 1×10^{-7}, i.e. 1 in 10 million. The OCA/H ensures clearance of obstacles from the start of the final approach to the end of the intermediate missed approach segment.

Note.— This OCA/H is one of the factors to be taken into account in determining decision height as defined in Annex 6.

Additional material is included to allow operational benefit to be calculated for the improved beam holding performance of autopilots meeting national certification standards (as opposed to flight directors) in Cat II, and for improved missed approach climb performance in Cat I, II and III. Benefit may also be calculated for aircraft with dimensions other than the standard size assumed in the basic calculations. An OCA/H is not associated with Cat III operations. These are supported by the obstacle limitation surfaces defined in Annex 14, in association with overlapping protection from the Cat II criteria.

21.1.5 Calculation of OCA/H

21.1.5.1 *General.* Three methods of calculating OCA/H are presented, which in turn involve progressive increases in the degree of sophistication in the treatment of obstacles. Standard conditions specified in 21.1.3 are assumed to exist unless adjustments for non-standard conditions have been made.

21.1.5.2 *The first method* involves a set of surfaces derived from the Annex 14 precision approach obstacle limitation surfaces and a missed approach surface described in 21.4.7.2 hereafter termed "basic ILS surfaces". Where the standard conditions exist as specified in 21.1.3 and where the basic ILS surfaces are free of penetrations (see 21.4.7.1), the OCA/H for Cat I and Cat II is defined by aircraft category margins, and there are no restrictions on Cat III operations. If the basic ILS surfaces are penetrated, then the OCA/H is calculated as described in 21.4.7.3.

21.1.5.3 *The second method* involves a set of obstacle assessment surfaces (OAS) above the basic ILS surfaces (see 21.4.8.2). If the OAS are not penetrated, and provided the obstacle density below the OAS is operationally acceptable (see 21.4.8.9), the OCA/H for Cat I and Cat II is still defined by the aircraft category margins, and Cat III operations remain unrestricted. However, if the OAS are penetrated, the aircraft category related margin is added to the height of the highest approach obstacle, or the adjusted height of the largest missed approach penetration, whichever is greater. This value becomes the OCA/H.

21.1.5.4 *The third method*, using a collision risk model (CRM), is employed either as an alternative to the use of the OAS criteria (second method) or when the obstacle density below the OAS is considered to be excessive. The CRM accepts all objects as an input and assesses, for any specific OCA/H value, both the risk due to individual obstacles and the accumulated risk due to all the obstacles. In this way it assists operational judgement in the choice of an OCA/H value which will ensure that the hazard due to obstacles, both individually and collectively, can be contained within the over-all safety target.

21.1.6 *Attachments*. The following attachments relate to and amplify the material contained in this chapter:

a) Background information relating to the derivation of the OAS material (Attachment A to Part III, paragraph 1) and to airborne and ground equipment performance assumed in the derivation of the OAS (Attachment A to Part III, paragraph 2).

b) Examples of OCA/H calculation (Attachment B to Part III).

c) Constants for calculations of obstacle assessment surfaces (Attachment I to Part III).

√ 21.1.7 *ILS glide path inoperative*. The ILS with glide path inoperative is a non-precision approach procedure. The principles of Chapter 23 apply.

21.2 INITIAL APPROACH SEGMENT

21.2.1 *General*. The initial approach segment for ILS must ensure that the aircraft is positioned within the operational service volume of the localizer on a heading that will facilitate localizer interception. Consequently, the general criteria applicable to the initial segment (see Chapter 4) are modified in accordance with 21.2.2 and 21.2.3 below.

21.2.2 *Alignment*. The angle of interception between the initial approach track and the intermediate track should not exceed 90°. When the angle exceeds 70° a radial, bearing, radar vector, or DME information providing at least 4 km (2 NM) of lead shall be identified to assist the turn onto the intermediate track. When the angle exceeds 90°, the use of a reversal, racetrack, or DR track procedure (see Chapter 4) should be considered. In order to permit automatic pilot to couple on to the localizer, an interception angle not exceeding 30° is desirable.

21.2.3 *Area*. The area is as described in 4.3.3 except that the initial approach segment terminates at the IF, which must be located within the service volume of the ILS localizer course signal, and normally at a distance not exceeding 46 km (25 NM) from the localizer antenna. When radar is used to provide track guidance to the IF, the area shall be in accordance with 24.2.2.

21.3 INTERMEDIATE APPROACH SEGMENT

21.3.1 *General*. The intermediate segment for ILS differs from the general criteria in that the alignment coincides with the localizer course, the length may be reduced, and in certain cases the secondary areas may be eliminated. The primary and secondary areas at the FAP are defined in terms of the ILS surfaces. Consequently, the criteria in Chapter 5 are applied except as noted for alignment, area length and width, and for obstacle clearance, in 21.3.2 through 21.3.5 below.

21.3.2 *Alignment*. The intermediate segment of an ILS procedure shall be aligned with the localizer course.

21.3.3 *Length*. The optimum length of the intermediate approach segment is 9 km (5 NM). The distance between the point of interception with the localizer course and the interception with the glide path should be sufficient to permit the aircraft to stabilize and establish on the localizer course prior to intercepting the glide path, taking into consideration the angle of interception with the localizer course. Minimum values for that distance are specified in Table III-21-1; however, these minimum values should only be used if usable airspace is restricted. The maximum length of the segment is governed by the requirement that it be located wholly within the service volume of the localizer signal, and normally at a distance not exceeding 46 km (25 NM) from the localizer antenna.

21.3.4 *Area width.* The total width at the beginning of the intermediate approach segment is defined by the final total width of the initial approach segment and tapers uniformly to match the horizontal distance between the OAS X surfaces as defined in 21.4.8.2 at the FAP. For obstacle clearance purposes the intermediate approach segment is divided into a primary area bounded on each side by a secondary area (except that secondary areas are not applied where a DR track is used in the initial approach segment). The primary area is determined by joining the primary initial approach area with the final approach surfaces (at the FAP). At the interface with the initial approach segment the width of each secondary area equals half the width of the primary area. The secondary area width decreases to zero at the interface with the final approach surfaces. See Figures III-21-1, III-21-2 and III-21-3. Where a racetrack or reversal manoeuvre is specified prior to intercepting the localizer course, the provisions in 5.7.4 apply, the facility being the localizer itself and the FAF being replaced by the FAP. (See Figure III-21-4.)

21.3.5 *Obstacle clearance.* The obstacle clearance is the same as defined in Chapter 5 except that where the procedure permits a straight-in approach (in which the aircraft is stabilized on the localizer course prior to crossing the IF), the secondary areas need not be considered for the purpose of obstacle clearance.

21.4 PRECISION SEGMENT

21.4.1 *General.* The precision segment for ILS is aligned with the localizer course and contains the final descent for landing, the initial and the intermediate missed approach. See Figure III-21-5.

21.4.2 *Origin.* The precision segment starts at the final approach point (the intersection of the nominal glide path and the minimum altitude specified for the preceding segment). FAP should not normally be located more than 19 km (10 NM) before threshold, unless adequate GP guidance beyond the minimum specified in Annex 10 is provided.

21.4.3 *Outer marker fix.* An outer marker fix (OM or DME) is necessary so as to permit comparison between the indicated glide path and the aircraft altimeter information. The OM fix shall not have a fix tolerance exceeding ± 0.9 km (± 0.5 NM). When DME is used to identify the fix, the range shall be stated in whole numbers of kilometres (nautical miles).

21.4.4 *Descent fix.* A descent fix may be located at the FAP. When so located, it becomes the final approach fix linking the MOC in the preceding segment smoothly with the precision surfaces. The descent fix should not normally be sited more than 19 km (10 NM) before threshold, unless adequate GP guidance beyond the minimum specified in Annex 10 is provided. The maximum fix tolerance is ± 0.9 km (± 0.5 NM). Where DME is used to identify the fix, the range shall be stated in whole numbers of kilometres (nautical miles).

21.4.4.1 *Obstacle clearance at the descent fix.* When the descent fix is installed, the precision approach surfaces start at the earliest point of the FAF tolerance area (see Figure III-21-2). The provisions of 2.8.4 which allow obstacles close to the fix to be ignored, apply in the area below the 15 per cent gradient within the precision surfaces. Where a descent fix is not provided at the FAP, no curtailment of the precision surfaces is permitted (see Figure III-21-3). The precision surfaces, when extended into the preceding intermediate segment, shall not be extended beyond that segment.

Table III-21-1. Minimum distance between localizer and glide path interceptions

Intercept angle with localizer (degrees)	*Cat A/B*	*Cat C/D/E*
0 — 15	2.8 km (1.5 NM)	2.8 km (1.5 NM)
16 — 30	3.7 km (2.0 NM)	3.7 km (2.0 NM)
31 — 60	3.7 km (2.0 NM)	4.6 km (2.5 NM)
61 — 90 or within a racetrack or reversal procedure	3.7 km (2.0 NM)	5.6 km (3.0 NM)

21.4.5 *Missed approach point.* The missed approach point is defined by the intersection of the nominal glide path and the decision altitude/height (DA/H). The DA/H is set at or above the OCA/H, which is determined as specified in 21.4.7 to 21.4.9 and 21.5.

21.4.6 *Termination.* The precision segment normally terminates at the point where the final phase of the missed approach commences (see 7.1.5) or where the missed approach climb surface Z starting 900 m past threshold reaches a height of 300 m (984 ft) above threshold, whichever is lower.

21.4.7 Obstacle clearance of the precision segment — application of basic ILS surfaces

21.4.7.1 *General.* The area required for the precision segment is bounded over-all by the basic ILS surfaces defined in 21.4.7.2. In standard conditions (see 21.1.3) there is no restriction on objects beneath these surfaces. Objects or portions of objects that extend above these surfaces must be either:

a) minimum mass and frangible, or

b) taken into account in the calculation of the OCA/H.

21.4.7.2 *Definition of basic ILS surfaces.* The surfaces to be considered correspond to some Annex 14 obstacle limitation surfaces specified for precision approach runway code numbers 3 or 4, as follows (see Figure III-21-6).

a) The approach surface with the second section continuing at the 2.5 per cent gradient to the final approach point (FAP).

b) The runway strip assumed to be horizontal at the elevation of the threshold.

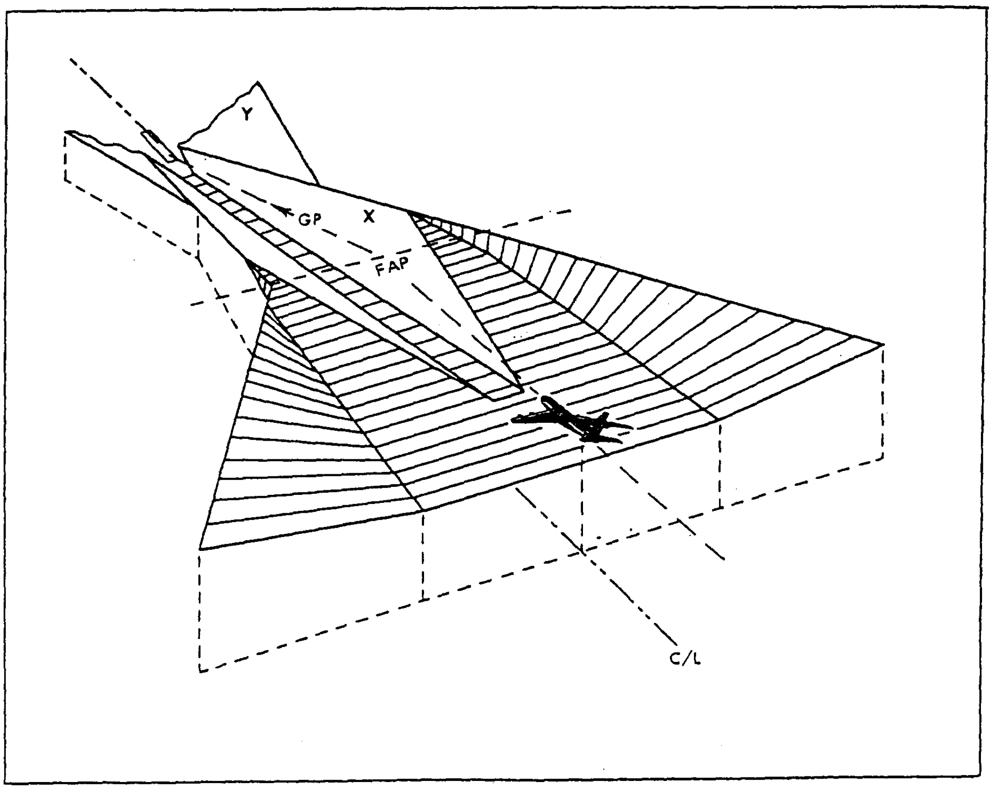


Figure III-21-1. Interface — final approach/preceding segment perspective view

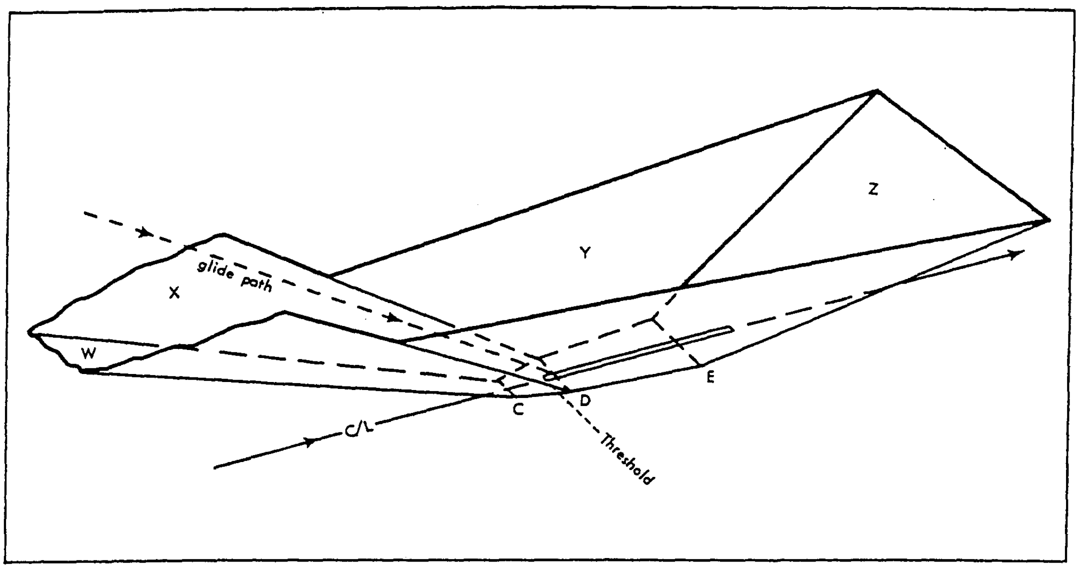


Figure III-21-9. Illustrations of ILS obstacle assessment surfaces — perspective view

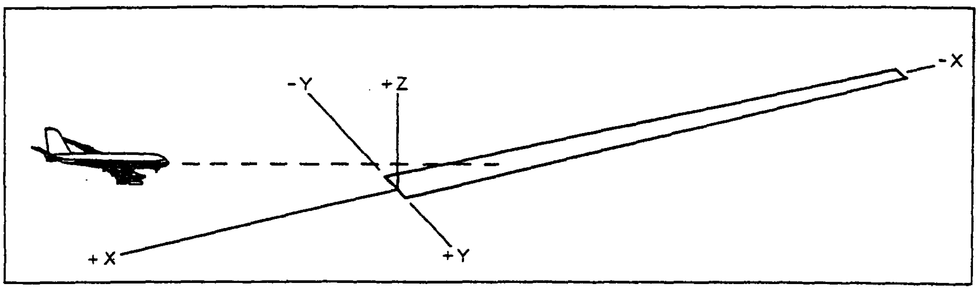
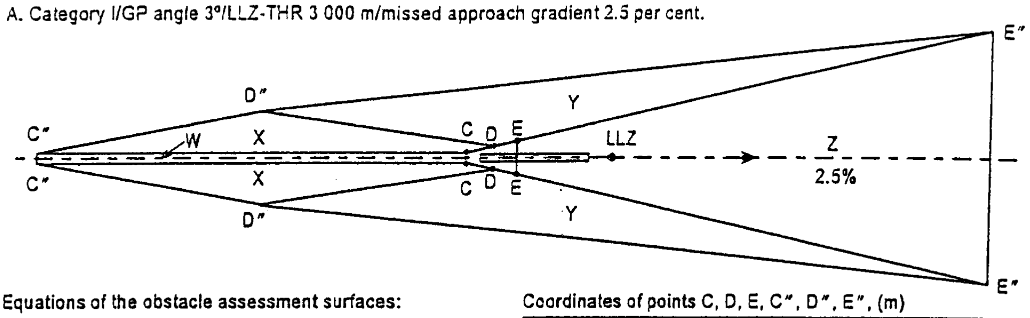


Figure III-21-10. System of coordinates

A. Category I/GP angle 3°/LLZ-THR 3 000 m/missed approach gradient 2.5 per cent.



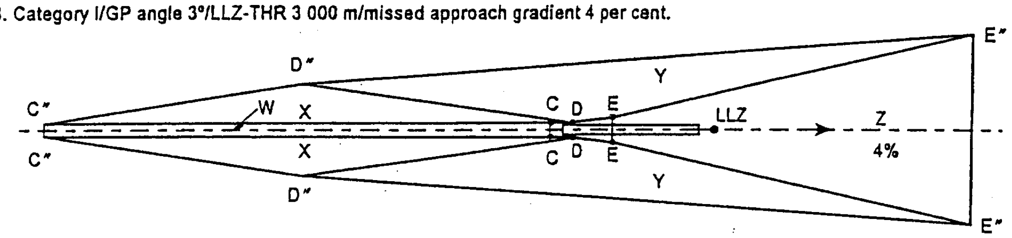
Equations of the obstacle assessment surfaces:

W I $z = 0.0285x - 8.01$
X I $z = 0.027681x + 0.1825y - 16.72$
Y I $z = 0.023948x + 0.210054y - 21.51$
Z I $z = -0.025x - 22.50$

Coordinates of points C, D, E, C", D", E", (m)

	C	D	E	C"	D"	E"
x	281	-286	-900	10 807	5 438	-12 900
y	49	135	205	96	910	3 001
z	0	0	0	300	300	300

B. Category I/GP angle 3°/LLZ-THR 3 000 m/missed approach gradient 4 per cent.



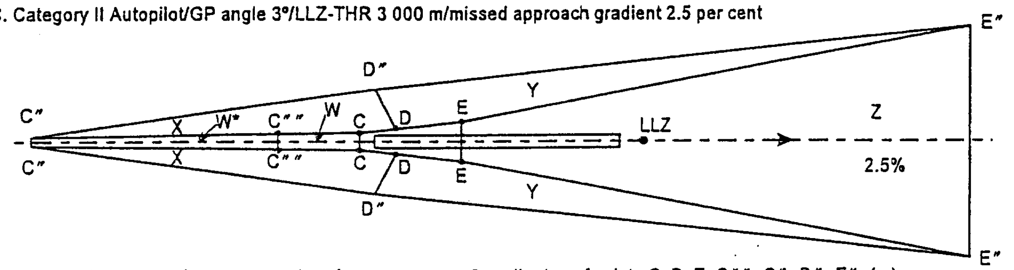
Equations of the obstacle assessment surfaces:

W I $z = 0.0285x - 8.01$
X I $z = 0.027681x + 0.1825y - 16.72$
Y I $z = 0.020158x + 0.238021y - 26.37$
Z I $z = -0.04x - 36.00$

Coordinates of points C, D, E, C", D", E", (m)

	C	D	E	C"	D"	E"
x	281	-286	-900	10 807	5 438	-8 400
y	49	135	187	96	910	2 082
z	0	0	0	300	300	300

C. Category II Autopilot/GP angle 3°/LLZ-THR 3 000 m/missed approach gradient 2.5 per cent



Equations of the obstacle assessment surfaces:

W I $z = 0.0358x - 6.19$
W* I $z = 0.042x - 12.39$
X I $z = 0.041370x + 0.2752y - 25.32$
Y I $z = 0.031955x + 0.280291y - 28.70$
Z I $z = -0.025x - 22.50$

Coordinates of points C, D, E, C"", C", D", E", (m)

	C	D	E	C""	C"	D"	E"
x	173	-286	-900	1 000	3 866	-13	-6 900
y	66	135	205	49	55	639	1 424
z	0	0	0	29.6	150	150	150

Figure III-21-11. Typical OAS contours for standard size aircraft

Table III-21-3. Sample of Attachment I to Part III — Constants for calculations of obstacle assessment surfaces

ILS OAS DATA GLIDEPATH ANGLE 3.00 LLZ/THR DISTANCE 3000.

ILS OAS CONSTANTS

	CAT I A	CAT I B	CAT I C	CAT II A	CAT II B	CAT II C	OAS CONSTANTS MODIFIED FOR CAT II AUTOPILOT A	B	C
W	.028500	.000000	-8.01	.035800	.000000	-6.19	.035800	.000000	-6.19
W*							.042000	.000000	-12.39
X	.027681	.182500	-16.72	.035282	.234700	-21.59	.041370	.275200	-25.32
Y 5.0P	.017858	.254997	-29.32	.025666	.366481	-42.13	.025666	.366481	-42.13
Z	-.050000	.000000	-45.00	-.050000	.000000	-45.00	-.050000	.000000	-45.00
Y 4.0P	.020158	.238021	-26.37	.028152	.332409	-36.82	.028152	.332409	-36.82
Z	-.040000	.000000	-36.00	-.040000	.000000	-36.00	-.040000	.000000	-36.00
Y 3.0P	.022585	.220112	-23.26	.030627	.298491	-31.54	.030627	.298491	-31.54
Z	-.030000	.000000	-27.00	-.030000	.000000	-27.00	-.030000	.000000	-27.00
✓ Y 2.5P	.023948	.210054	-21.51	.031955	.280291	-28.70	.031955	.280291	-28.70
Z	-.025000	.000000	-22.50	-.025000	.000000	-22.50	-.025000	.000000	-22.50
Y 2.0P	.025360	.199629	-19.70	.033287	.262031	-25.85	.033287	.262031	-25.85
Z	-.020000	.000000	-18.00	-.020000	.000000	-18.00	-.020000	.000000	-18.00

OAS TEMPLATE COORDINATES -M

THRESHOLD ELEVATION

	CAT I X	CAT I Y	CAT II X	CAT II Y	CAT II AUTOPILOT X	CAT II AUTOPILOT Y
C	281	49	173	66	173	66
D	-286	135	-286	135	-286	135
E 5.0P	-900	178	-900	178	-900	178
4.0P	-900	187	-900	187	-900	187
3.0P	-900	198	-900	198	-900	198
✓ 2.5P	-900	205	-900	205	-900	205
2.0P	-900	213	-900	213	-900	213

	300M HEIGHT CAT I X	Y	150M HEIGHT CAT II X	Y	150M HEIGHT ** CAT II AUTOPILOT X	Y
C"	10807	96	4362	75	3866	55
C""					1000	49
D"5.0P	5438	910	2576	343	1404	425
E"	-6900	1774	-3900	797	-3900	797
D"4.0P	5438	910	2576	343	1143	465
E"	-8400	2082	-4650	955	-4650	955
D"3.0P	5438	910	2576	343	605	546
E"	-10900	2587	-5900	1213	-5900	1213
✓ D"2.5P	5438	910	2576	343	-13	639
E"	-12900	3001	-6900	1424	-6900	1424
D"2.0P	5438	910	2576	343	-1462	856
E"	-15900	3671	-8400	1738	-8400	1738

P=PERCENTAGE
** NOTE ,
C"" COORDINATES APPLY TO TEMPLATE AT 29.6M HEIGHT
I.E. AT THE INTERSECTION OF THE W AND W* SURFACES(CAT II AUTOPILOT ONLY)

W : $Z = (0.0285)X + (0)Y + (-8.01)$
(SURFACE)

Chapter 33
AREA NAVIGATION (RNAV) APPROACH PROCEDURES FOR BASIC GNSS RECEIVERS

33.1 GENERAL

33.1.1 The general criteria in Chapters 1 to 9 as amplified or modified by the criteria in this chapter apply to area navigation (RNAV) approach procedures for basic GNSS receivers.

33.1.2 *Fix identification.* The fixes used are those in the general criteria. Each fix shall be determined as a way-point (latitude and longitude, with a minimum accuracy to the nearest one tenth of a second of arc or equivalent) referenced to the World Geodetic System of 1984 (WGS-84). No more than nine way-points shall be employed in an RNAV approach procedure based on GNSS, from the initial approach point to the way-point which concludes the missed approach segment.

33.1.3 *Secondary areas.* The general criteria for secondary areas apply (see 1.5 and 1.6).

33.1.4 The aircraft equipped with a basic GNSS receiver (described in Attachment Q to Part III) which have been approved by the State of the Operator for the appropriate level of GNSS operations may use these systems to carry out approaches provided they include:

a) integrity monitoring routines;

b) turn anticipation; and

c) read only electronic database.

33.1.5 *Glossary*

Fix names. Instrument approach fixes are identified as way-points: initial approach way-point (IAWP), intermediate way-point (IWP), final approach way-point (FAWP) and the missed approach way-point (MAWP). Further, a missed approach turning way-point (MATWP) is identified for turning missed approaches and a missed approach holding way-point (MAHWP) defines the end of the missed approach segment. Stepdown fixes incorporated between way-points in the procedure are identified as a distance to the next way-point.

33.2 GNSS RNAV SYSTEM ACCURACY

33.2.1 The agreed level of horizontal accuracy of the GNSS space segment is assumed to be 100 m (328 ft) at the 95 per cent confidence level.

33.2.2 Despite the inherent accuracy of the GNSS space segment position, the usability of a fix is also affected by the number of satellites available and their orientation with respect to the GNSS receiver. These factors vary from place to place and time to time. The ability of a receiver to detect and alert the pilot to these factors when they are unfavourable is a measure of the navigation system's operational capability. To qualify for use as a non-precision approach navigation system, GNSS receivers must incorporate an integrity monitoring routine which alerts the pilot when the fixing information is not to the required level of confidence. For integrity monitoring alarm limits see 33.2.3.1.

33.2.3 *Navigation system accuracy/tolerances.* The factors on which the navigational system accuracy of GNSS RNAV depends are:

a) inherent space segment accuracy;

b) airborne receiving system tolerance;

c) system computational tolerance; and

d) flight technical tolerance.

33.2.3.1 The values of the space elements (including control element) and the airborne system tolerances (including system computation tolerance) are taken into account within the integrity monitoring alarm limits for basic GNSS systems. They are:

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Manual on the Use of the Collision Risk Model (CRM) for ILS Operations

First Edition — 1980

Approved by the Secretary General and published under his authority

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Part I

Instructions on the Use of the CRM

1 GENERAL

The material in this part contains instructions on the use of the ICAO CRM service.

2 BASIC CONCEPTS

2.1 General Concept of the CRM

The CRM is a computer programme that statistically predicts the position of an aeroplane in final parts of specified categories of ILS approaches and in the first parts of the missed approach in relation to the nominal flight path and based on this information calculates the probabilities for collision of an aeroplane with obstacles in a given obstacle environment and related OCA/H values. (For details see Part II, Chapter 2.) The CRM is valid for glide path angles between 2.5° and 3.5°.

2.2 Total Risk Concept

A risk of collision with one or more obstacles during an approach in a given obstacle environment is called total risk of collision. In order to calculate a value which has operational significance it is important that *all* affecting obstacles be considered in the risk computations. For obstacles which are likely to have an effect in the total risk value see 2.7 below. The total risk value can be used for example, to assess whether ILS operations with an associated OCA/H to a runway in a given obstacle environment meet a specified overall target level of safety.

2.3 Individual Risk Concept

A risk of collision with an individual obstacle is called the individual risk of collision. From a given obstacle environment only one obstacle is considered at a time and the others do not affect the computations. (The risk would be the same if there were no other obstacles.) The individual risk can be used in assessing the severity of a given obstacle, i.e., its contribution to the total risk value.

2.4 Minimum Acceptable OCA/H

The OCA or OCH value that corresponds to a total risk level of collision with obstacles of 1×10^{-7} is called the minimum acceptable OCA/H. If there are no obstacles this value is the same as that given in Table 21-4 of PANS-OPS, Volume II, Part III (height loss/altimeter margin). The minimum acceptable OCA/H can be calculated for each category of aeroplane if so requested.

2.5 Obstacle Clearance Altitude/Height (OCA/H)

In an ILS approach the OCA/H is the lowest altitude (OCA), or alternatively the lowest height above the relevant runway threshold (OCH), at which a missed approach must be initiated to ensure compliance with the appropriate obstacle clearance criteria. The OCA/H is taken into account in establishing operating minima, i.e., decision height/altitude (see PANS-OPS, Volume II, Part III, 6.3 and Figure 6-1a). The PANS-OPS criteria require that an OCA/H value be published on the instrument approach chart for each category of aeroplane for which the approach is designed (normally for categories A, B, C and D aeroplanes).

2.6 Aeroplane Categories

Aeroplanes are divided into categories based on their approach speed as follows (see PANS-OPS, Volume II, Part III, 1.9):

Category A: less than 91 kt
Category B: 91 to 120 kt
Category C: 121 to 140 kt
Category D: 141 to 165 kt
Category E: 166 to 210 kt

All the CRM computations can be made for categories A, B, C and D aeroplanes. For the time being information is not available on category E aeroplane missed approach distributions and therefore it is not possible to make computations for category E aeroplanes.

2.7 Information on Obstacles

2.7.1 Only obstacles within a specified area as indicated below have an effect on the risk values and the minimum acceptable OCA/H values. The CRM has been designed to exclude automatically those obstacles outside the specified area. Therefore, if it is not known where the borderline of the area is located or where obstacles are located in relation to this borderline, more obstacle information should be required.

2.7.2 The specified area is limited as follows:

a) *Longitudinally*, the area is limited by the start and end of the precision segment (see Part II, Figure II-2-1 and PANS-OPS, Volume II, Part II, 21.4). If the start end of the precision segment is not marked by a fix, the area shall be extended longitudinally beyond the start end of the precision segment (see Figures 21-3 and 21-4 of PANS-OPS, Volume II, Part III).
b) *Laterally*, the area is limited by the 300 m height contour of obstacle assessment surfaces (OAS). For typical OAS contours see PANS-OPS, Volume II, Part III, Figure 21-10.
c) *Vertically*, the area is limited by the refined Annex 14 surfaces (see PANS-OPS, Volume II, Part III, 21.4.7.2).

2.7.3 It is important that charting accuracies be considered when obstacle coordinates are submitted (see PANS-OPS, Volume II, Part III, 1.15).

2.7.4 Obstacles are modelled as a collection of "spikes" and/or "walls" depending on their shape (see Appendix A for obstacle modelling).

2.8 Height/Elevation/Altitude

The terms height, elevation and altitude are used in this document as defined and listed in PANS-OPS, Volume II. It should be noted that accordingly, elevation and altitude are always measured from mean sea level (MSL) and height from a specified datum (e.g., obstacle clearance height (OCH) from the threshold level).

3 CRM REQUEST

3.1 General

3.1.1 A request for a CRM run should be made to the following address by correspondence or by telex.

International Civil Aviation Organization
Operations/Airworthiness Section
1000 Sherbrooke Street West, Suite 400
Montreal, Quebec
Canada H3A 2R2

Telex: 05-24513 Attention OPS/AIR

3.1.2 The CRM information will be provided by ICAO to member States at no cost; all other users will be charged a nominal fee.

3.1.3 In case of a large number of obstacles, it is suggested that request should be made by correspondence. The request shall be submitted in a standard format. For this reason the Request Form has been developed (see Appendix B). Instructions for filling out the Request Form are given in Appendix C. If obstacle information is available in machine readable form, ICAO should be contacted for special instructions.

3.1.4 In each case, a telex message (see 4.3) containing a summary report will be transmitted to the requestor by telex if telex number is provided (see Appendix B, Item 06), followed by mailing of a full computer generated report. It is important that telex information be checked against the information on the final computer generated report before official use is made of it.

3.1.5 *It is emphasized that it will be necessary for the user to always check that the information submitted to ICAO agrees with that on the final computer generated report.* This check is necessary to ensure that no mistakes have been made in the process of inserting data into the computer.

3.2 Data Necessary for Running the CRM

3.2.1 The data required for running the CRM are listed below. The grouping and numbers are the same as those used in the Request Form (Appendix B).

A. ADMINISTRATIVE DATA

01 ICAO reference
02 User reference
03 Request title
04 Requestor
05 Address
06 Person to contact

B. GROUND DATA

07 ILS glide path angle (degrees)
08 ILS reference datum height (metres or feet)
09 Distance between ILS localizer antenna and runway threshold (metres or feet)
10 Localizer course width at threshold (metres or feet)
11 Threshold elevation (metres or feet)
12 Distance from final approach point to threshold (metres or feet)
13 Termination of precision segment (metres or feet)

C. AEROPLANE DATA

14 Aeroplane dimensions (metres or feet)
15 Missed approach climb gradient (per cent)

D. REQUESTED CASES

16 ILS approach category:
    Category I
    Category II
    Category I (radio altimeter only)
    Category II (autopilot only)
17 Choice of OCA or OCH
18 Unit of measurement for OCA/H (metres or feet)
19 Risk for a specified OCA/H and minimum acceptable OCA/H (for each category of aeroplane)

E. REPORT FORMAT

20 Language
21 Total number of obstacles to be processed
22 Obstacles for which obstacle risk is requested

F. OBSTACLE COORDINATE SYSTEM SPECIFICATIONS

23 Runway coordinate system
24 Grid coordinate system
25 Polar coordinate system
26 Geographical coordinate system

G. OBSTACLE DATA

27 Runway coordinate system
28 Grid coordinate system
29 Polar coordinate system
30 Geographical coordinate system

3.3 CRM Request Form and Instructions

CRM Request Forms are available from ICAO. A sample is given in Appendix B. The instructions for completion are given in Appendix C.

3.4 Subsequent and Special Requests

3.4.1 Subsequent requests

Data once submitted to ICAO can be reused for a period of a year (unless special arrangements for a longer storage time have been made) and referred to in subsequent correspondence. In this case, it is important to include in all correspondence the ICAO reference number appearing on the previous computer generated report (see Appendix E). Only those parts of the form containing information different from the previous submission need be submitted. The new submissions should be accompanied with a narrative description on a separate sheet of paper.

3.4.2 Special requests

If CRM information is needed for combinations not listed in the form or for combinations listed in the form but which because of other overriding selections cannot be used these cases should be explained in narrative form on a separate sheet of paper.

4 RESULTS AVAILABLE FROM THE CRM

The results from the CRM will appear on a computer generated report which is divided into an Edited Data Report, one or more Risk Reports, and a Telex Message (see below and Appendix E).

4.1 Edited Data Report

4.1.1 Each page of the report will contain a heading with a computer generated date and time as well as the entered ICAO reference, user reference, request title, and ILS approach category. The printed date and time will tell the actual time at which computer processing of this request was initiated, and they will provide a unique identification for each printed report.

4.1.2 All parameter data (Items 01 to 26 of the CRM Request Form) will be provided exactly as they were entered into the computer. It is the user's responsibility to verify that these data are correct.

4.1.3 A list of errors and warnings applying to the entered parameters will be provided. Errors, not warnings, prevent the use of the CRM.

4.1.3.1 Error messages will be provided whenever the CRM detects a non-valid or missing entry, a set of parameters which are not consistent with each other, or a parameter which is outside the limits of validity for this model. Error messages are given whenever parameters are not within the error limits contained in Table I-1. If an error message occurs, the user should first verify that the parameters referred to in the error message were entered correctly. If the parameters are correct and an error message occurs, then the CRM cannot be used to evaluate the given instrument approach procedure. This could occur, for example, if the ILS glide path angle is not between 2.5° and 3.5°.

4.1.3.2 Warning messages will be provided whenever the CRM detects a parameter which, while possibly correct, is outside the normal range of values. Warnings are given whenever parameters are not within the warning limits contained in Table I-1. The user should verify that the given value is correct for the given instrument approach procedure. If all parameter entries have been verified, warning messages will not interfere with the proper execution of the model.

4.1.3.3 Each error or warning message will contain a designation of whether it is an error or a warning, a reference to the item number on the CRM Request Form and a brief description of the error or possible error.

4.1.4 A summary of some of the entered and calculated parameters used in the CRM will be given with all values converted to metres. This summary will also contain the calculated distance from the localizer to the threshold for each of the coordinate systems used (Items 24, 25, and 26 of the CRM Request Form). If these distances do not agree with the entered localizer to threshold distance (Item 09 of the CRM Request Form), the user should verify the validity of the data for the various coordinate systems. (If the difference is more than 10 m a warning is provided; if it is more than 100 m an error message is provided.)

Table I-1. CRM Error and Warning Limits (related to input parameters)

Item No.	*Description*	*Error Limits*		*Warning Limits*	
		Minimum	*Maximum*	*Minimum*	*Maximum*
07	ILS glide path angle	2.5°	3.5°		
08	ILS reference datum height	0 m		12 m	20 m
09	Distance between LLZ and THR	900 m	6 000 m	2 000 m	4 500 m
10	LLZ course width at THR	60 m		170 m	250 m
10*	LLZ course sector angle				6°
11	THR elevation above MSL			-100 m	4 000 m
12	Distance from FAP to THR			2 400 m	18 520 m
13*	Glide path height at termination of precision segment				300 m
14A	Distance between flight paths of aeroplane wheels and GP antenna	0 m			10 m
14B	Aeroplane wing semi-span	0 m		7 m	50 m
15	Missed approach climb gradient	1%		2.5%	5%
19	OCH above THR elevation	0 m		PANS-OPS Vol II Part III Table 21-4	CAT I: 120 m CAT II: 60 m
21	Total number of obstacles	0		1	
23-26	THR height			-100 m	4 000 m
25C, F	Bearing	0°	360°		
25D, G	Distance	0 m			
26B, E	Latitude (North or South)	0°	85°		
26C, F	Longitude (East or West)	0°	180°		
24-26*	Difference between calculated and input LLZ to THR distance		100 m		10 m

* These values are not input; they are calculated within the CRM

** This warning will be provided also if the distance from FAP to THR is increased beyond 18 520 m because the FAP is not marked by a fix.

4.1.5 Obstacle data will be provided in the same form as it was entered into the computer and transformed into the runway coordinate system used by the CRM. An error message will be given if the computer detects an error in the data format. In this case, the user should correct all errors and re-submit the request. In addition one of the following messages will be printed in the edited data report whenever it is appropriate. In any of these cases, the specified obstacle will not be further considered in the risk calculations. However, the user should verify that the entered obstacle coordinates are correct.

1. The message "X NOT PRECISION SEG." will be given if the transformed obstacle x coordinate is too large or too small for consideration by the CRM. This message is given for an obstacle which is not located in the precision segment of the approach or the missed approach or, if applicable, in the area prior to the FAP (see Appendix C, paragraph 2, Item 12). If this message is received, the obstacle will not be considered further in risk calculations. However it may need to be considered in some other segment of the approach or the missed approach.
2. The message "EDIT — Y LARGE" will be given if the transformed obstacle y coordinate is too large in absolute value for the obstacle to be considered a risk. If this message is received, the indicated obstacle has a negligible risk, and it does not need to be considered further in risk calculations.
3. The message "EDIT — Z BELOW THR" will be given if the transformed obstacle z coordinate is not larger than zero, that is, if the elevation of the obstacle is below the elevation of the threshold. If this message is received, the indicated obstacle has a risk smaller than that of the ground plane (see 4.2.2/3.) and it does not need to be considered further in risk calculations.
4. The message "OFZ PENETRATED?" will be given if the obstacle penetrates the obstacle free zone (OFZ) specified in Annex 14 (the inner approach, inner transitional and balked landing surfaces) based on a horizontal runway.

When the conditions in 1 to 3 above occur the following will be given in the telex message: "_____ (number) obstacles are outside the precision segment and are not considered"; and when the condition in 4 above occurs the following will be given in the telex message "OFZ appears to be penetrated".

4.1.6 The number of obstacles entered and the number of obstacles included in the risk calculations will also appear on the Edited Data Report.

4.1.7 Obstacles modelled as "wall" in the grid, polar or geographical coordinate systems are subject to being "not perpendicular" to the extended runway centre line. Whether this is the case will be determined by the computer by comparison of the range (x coordinate) value of the end points of the wall after transformation to the runway coordinate system.

A warning is provided if the ratio of the range difference over the length of the wall is greater than 1 per cent but less than 10 per cent. In this case the range value nearest to the threshold is used for the "wall" model. If the above ratio exceeds 10 per cent an error message is provided and processing is discontinued.

4.2 Risk Reports

4.2.1 A separate risk report will be given for each Y (yes) entered under Item 19 of the CRM Request Form (see Appendix B). There are four separate types of risk report which might be obtained depending on the user's request and the risk calculations.

1. If the user requests a risk for a specified OCA/H, then a report for the "SPECIFIED OCA ABOVE SEA LEVEL" or the "SPECIFIED OCH ABOVE THRESHOLD" will be provided.
2. If the user requests a minimum acceptable OCA/H and the calculated OCH will be less than 300 m in CAT I and 150 m in CAT II, then a report for the "MINIMUM ACCEPTABLE OCA ABOVE SEA LEVEL" or the "MINIMUM ACCEPTABLE OCH ABOVE THRESHOLD" will be provided. This OCA/H is the minimum OCA or OCH, in even units of measurement (metres or feet), which achieves a total risk less than 1×10^{-7}.
3. If the user requests a minimum acceptable OCA/H but the calculated OCH would be more than 300 m in CAT I and 150 m in CAT II, then a report for the "HIGHEST OCA FOR WHICH RISKS CALCULATED" or the "HIGHEST OCH FOR WHICH RISKS CALCULATED" will be provided. In this case the minimum acceptable OCA/H cannot be calculated.
4. It should be noted that a higher OCA/H does not always result in a smaller risk. Although the risk of being vertically displaced below the obstacle height will always be smaller for a higher OCA/H, the risk of lateral displacement to the obstacle can in some cases increase with an increase in OCA/H. This occurs because of the assumption in the CRM that no lateral course guidance is available past the initiation of the missed approach. This increase would typically occur for a very high obstacle laterally displaced from the extended runway centre line in the missed approach. The CRM checks for the possibility in all cases in which a risk is requested for either a specified OCA/H or a minimum acceptable OCA/H, and it determines an approximate OCA/H for which the risk is maximized if this occurs. In this case, a

report for the "HIGHER OCA WITH GREATER CALCULATED RISK" or the "HIGHER OCH WITH GREATER CALCULATED RISK" will also be provided. The user should then either use an OCA/H higher than this value for which an acceptable risk can be obtained or restrict the instrument approach procedure by requiring, for example, the use of positive lateral course guidance past any early missed approach initiation point or the use of a turning missed approach away from the critical obstacle.

4.2.2 All of these risk reports will contain the information in the same format. Each of the risk reports will contain the following information.

1. Each page of the report will contain a heading with the same information as in the edited data report (see 4.1.1). In addition, the heading will specify the aeroplane speed category (see 2.6), the type of risk report (see 4.2.1), and the OCA or OCH.
2. The calculated total risk for these conditions is provided (see 2.2). This risk value is the one which should be compared with the target level of 1×10^{-7}.
3. A calculated risk of hitting the ground plane is provided. This represents the risk of an infinite level surface located at the runway threshold elevation. This is not the actual risk of hitting the ground, since the ground is not level and since ground effect is not considered by the CRM; however, it enables the CRM to calculate and to analyse an OCA/H in those cases where the ground is the controlling obstacle. Because this risk is always considered, it is not necessary to consider obstacles with elevations below that of the threshold (see 4.1.5/3.).
4. A description of the single obstacle with the highest individual risk and the risk for that obstacle are provided (see 2.3).
5. Individual obstacle risks are given for selected obstacles (Item 22 of the CRM Request Form). For each selected obstacle, the report contains the entered obstacle identification and description, the obstacle coordinates in the CRM runway coordinate system, and the individual obstacle risk. The obstacles will be ordered in decreasing range to the threshold (x coordinate).

4.3 Telex Message

The CRM will provide a summary telex message at the end of the risk reports. This message will contain the following information.

4.3.1 Administrative data sufficient for identification of the request will be provided. This will include the ICAO reference, the user reference, the request title and the requestors name.

4.3.2 A list of all error and warning messages from the CRM will be provided (see 4.1.3).

4.3.3 For each risk report generated (see 4.2.1), the aeroplane speed category, the type of risk report, the applicable OCA/H, the total risk, the identification of the obstacle with highest individual risk, and the risk for the obstacle with highest individual risk will be provided.

REPORT 1

ICAO COLLISION RISK MODEL/ EDIT REPORT PAGE 1

ICAO REFERENCE CRM EXAMPLE 1 DATE OCT 13, 1982
USER REFERENCE FANTASY AERODROME TIME 19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E ILS CATEGORY II
EXAMPLE 1

THE COLLISION RISK MODEL IS A COMPUTER PROGRAM THAT CALCULATES A NUMERICAL RISK FOR THE PRECISION SEGMENT OF AN ILS APPROACH. THIS RISK IS THEN COMPARED TO THE TARGET LEVEL OF SAFETY (1.0E-07) TO DETERMINE THE ACCEPTABILITY OF THE PROCEDURE. (SEE PANS-OPS, VOLUME II, PARAGRAPH 21.4.9)

ICAO TAKES NO RESPONSIBILITY FOR THE CORRECTNESS OF THE DATA ENTERED INTO THIS MODEL OR FOR THE APPLICABILITY OF THIS MODEL TO ANY SPECIFIC CASE. IT IS THE RESPONSIBILITY OF THE USER TO VERIFY ALL DATA USED BY THIS MODEL FOR THIS SPECIFIC ILS APPROACH.

ICAO COLLISION RISK MODEL/ EDIT REPORT PAGE 2

ICAO REFERENCE CRM EXAMPLE 1 DATE OCT 13, 1982
USER REFERENCE FANTASY AERODROME TIME 19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E ILS CATEGORY II
EXAMPLE 1

COLLISION RISK MODEL REQUEST FORM -- BASIC DATA

ICAO IDENTIFICATION (FOR ICAO USE ONLY)	3 FANTASY EXAMPLE1 6 10 82 ORIGINAL

ADMINISTRATIVE DATA

01 ICAO REFERENCE	CRM EXAMPLE 1
02 USER REFERENCE	FANTASY AERODROME
03 REQUEST TITLE	CRM MANUAL DOC 9274-AN904 PART I APP D/E EXAMPLE 1
04 REQUESTOR	DEPARTMENT OF AVIATION FANTASYLAND
05 ADDRESS	HILL ROAD 35 BIGCITY BOX 999 FANTASYLAND

06 PERSON TO CONTACT

NAME	MR JOHN OBSTACLE
PHONE	111-222-334
TELEX	44-555

```
ICAO COLLISION RISK MODEL/ EDIT REPORT                        PAGE    3

ICAO REFERENCE   CRM EXAMPLE 1                                DATE  OCT 13, 1982
USER REFERENCE   FANTASY AERODROME                            TIME  19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E                      ILS CATEGORY II
EXAMPLE 1



GROUND DATA

07 ILS GLIDE PATH ANGLE                                        3.00 DEGREES

08 ILS REFERENCE DATUM HEIGHT                                 15.0  M

09 DISTANCE BETWEEN ILS LOCALIZER
   ANTENNA AND RUNWAY THRESHOLD                             3000.   M

10 LOCALIZER COURSEWIDTH AT THRESHOLD                        210.   M

11 THRESHOLD ELEVATION                                         0.   M

12 DISTANCE FROM FINAL APPROACH POINT
   TO THRESHOLD                                            10807.   M

13 STANDARD TERMINATION OF
   PRECISION SEGMENT                                                Y
   IF NO THEN:
   A. TERMINATION POINT BEFORE THRESHOLD
   B. SPECIFY DISTANCE FROM TERMINATION
      POINT TO THRESHOLD


AIRCRAFT DATA

14 STANDARD DIMENSIONS                                              Y
   IF NO THEN SPECIFY:
   A. DISTANCE BETWEEN THE FLIGHTPATHS
      OF THE WHEELS AND THE GP ANTENNA
   B. WING SEMISPAN

15 STANDARD MISSED APPROACH CLIMB GRADIENT                          Y
   IF NO THEN SPECIFY CLIMB GRADIENT
```

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ICAO COLLISION RISK MODEL/ EDIT REPORT                                PAGE    4

ICAO REFERENCE    CRM EXAMPLE 1                                       DATE  OCT 13, 1982
USER REFERENCE    FANTASY AERODROME                                   TIME  19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E                              ILS CATEGORY II
EXAMPLE 1



REQUESTED CASES

16 ILS APPROACH CATEGORY                                                   2
   1  CATEGORY I
   2  CATEGORY II
   3  CATEGORY I (RADIO ALTIMETER ONLY)
   4  CATEGORY II (AUTOPILOT ONLY)

17 SELECT CHOICE OF OCA OR OCH                                             2
   1  OCA (ABOVE MEAN SEA LEVEL)
   2  OCH (ABOVE THRESHOLD)

18 SPECIFY UNIT OF MEASUREMENT FOR OCA/H                                   M

19 SPEED        RISK FOR SPECIFIED OCA/H REQUESTED    MINIMUM ACCEPTABLE
   CATEGORY                   IF YES THEN OCA/H        OCA/H REQUESTED

        A            N                                           Y

        B            N                                           Y

        C            Y                      30.                  Y

        D            Y                      30.                  Y
REPORT FORMAT

20 LANGUAGE                                                                1
   1  ENGLISH
   2  FRENCH
   3  RUSSIAN
   4  SPANISH

21 TOTAL NUMBER OF OBSTACLES TO BE PROCESSED                              14

22 INDIVIDUAL OBSTACLE RISK REQUESTED FOR                                  3
   2  OBSTACLES WITH INDIVIDUAL RISK HIGHER THAN 1.0E-10
   1  OBSTACLE WITH HIGHEST INDIVIDUAL RISK
   3  ALL OBSTACLES
```

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ICAO COLLISION RISK MODEL/ EDIT REPORT                      PAGE    5

ICAO REFERENCE   CRM EXAMPLE 1                              DATE  OCT 13, 1982
USER REFERENCE   FANTASY AERODROME                          TIME  19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E                    ILS CATEGORY II
EXAMPLE 1



OBSTACLE COORDINATE SYSTEM SPECIFICATIONS

23 RUNWAY COORDINATE SYSTEM USED                                  Y
   IF YES THEN SPECIFY:
   A. UNIT OF HORIZONTAL MEASUREMENT                              M
   B. UNIT OF  VERTICAL MEASUREMENT                               M
   C. HEIGHT OF THRESHOLD IN THIS SYSTEM                          0

24 GRID COORDINATE SYSTEM USED                                    N
   IF YES THEN SPECIFY:
   A. UNIT OF HORIZONTAL MEASUREMNT
   B. UNIT OF  VERTICAL MEASUREMENT
   C. FIRST COORDINATE OF THRESHOLD
   D. SECOND COORDINATE OF THRESHOLD
   E. HEIGHT OF THRESHOLD IN THIS SYSTEM
   F. FIRST COORDINATE OF LLZ ANTENNA
   G. SECOND COORDINATE OF LLZ ANTENNA

25 POLAR COORDINATE SYSTEM USED                                   N
   IF YES THEN SPECIFY:
   A. UNIT OF DISTANCE MEASUREMENT
   B. UNIT OF VERTICAL MEASUREMENT
   C. BEARING TO THRESHOLD
   D. DISTANCE TO THRESHOLD
   E. HEIGHT OF THRESHOLD IN THIS SYSTEM
   F. BEARING TO LLZ ANTENNA
   G. DISTANCE TO LLZ ANTENNA

26 GEOGRAPHICAL COORDINATE SYSTEM USED                            N
   IF YES THEN SPECIFY:
   A. UNIT OF VERTICAL MEASUREMENT
   B. LATITUDE OF THRESHOLD
   C. LONGITUDE OF THRESHOLD
   D. HEIGHT OF THRESHOLD IN THIS SYSTEM
   E. LATITUDE OF LLZ ANTENN
   F. LONGITUDE OF LLZ ANTEN
```

ICAO COLLISION RISK MODEL/ EDIT REPORT	PAGE 6
ICAO REFERENCE CRM EXAMPLE 1	DATE OCT 13, 1982
USER REFERENCE FANTASY AERODROME	TIME 19:39:56
CRM MANUAL DOC 9274-AN904 PART I APP D/E	ILS CATEGORY II
EXAMPLE 1	

SUMMARY OF ILS APPROACH PARAMETER INFORMATION

GROUND DATA

ILS GLIDE PATH ANGLE	3.00 DEGREES
ILS REFERENCE DATUM HEIGHT	15.00 METRES
DISTANCE FROM THRESHOLD TO ILS LOCALIZER ANTENNA	3000.00 METRES
LOCALIZER COURSEWIDTH AT THE THRESHOLD	210.00 METRES
LOCALIZER COURSE SECTOR ANGLE	4.01 DEGREES
THRESHOLD ELEVATION (ABOVE MEAN SEA LEVEL)	0.00 METRES
BEGINNING OF THE PRECISION SEGMENT	10807.00 METRES
TERMINATION OF THE PRECISION SEGMENT	-12900.00 METRES

AIRCRAFT DATA

DISTANCE BETWEEN WHEELS AND GLIDE PATH ANTENNA	6.00 METRES
WING SEMISPAN	30.00 METRES
MISSED APPROACH CLIMB GRADIENT	2.50 PERCENT

ICAO COLLISION RISK MODEL/ ECIT REPORT PAGE 7

ICAO REFERENCE CRM EXAMPLE 1 DATE OCT 13, 1982
USER REFERENCE FANTASY AERODROME TIME 19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E ILS CATEGORY II
EXAMPLE 1

		OBSTACLE DATA FILE IN USER RUNWAY COORDINATE SYSTEM				OBSTACLES IN CRM RUNWAY COORDINATE SYSTEM				
IDENT	DESCRIPTION	X METRES	Y1 METRES	Y2 METRES	Z METRES	X METRES	Y1 METRES	Y2 METRES	Z METRES	
OBS 01	GP ANTENNA	-250.	130.	130.	16.	-250.00	130.00	130.00	16.00	
OBS 02	LLZ ANT OPPOS	300.	0.	0.	5.	300.00	0.00	0.00	5.00	OFZ PENETRATED ?
OBS 03	AEROPLANE-2	-300.	-150.	-150.	22.	-300.00	-150.00	-150.00	22.00	
OBS 04	AEROPLANE-1	0.	-120.	-120.	22.	0.00	-120.00	-120.00	22.00	OFZ PENETRATED ?
OBS 05	BUILDING-1	-1860.	-780.	-820.	58.	-1860.00	-820.00	-780.00	58.00	
OBS 06	BUILDING-2	-2600.	-780.	-820.	56.	-2600.00	-820.00	-780.00	56.00	
OBS 07	CONTROL TOWER	-2840.	-340.	-340.	37.	-2840.00	-340.00	-340.00	37.00	
OBS 08	HANGAR	480.	240.	280.	17.	480.00	240.00	280.00	17.00	
OBS 09	POLE	740.	65.	65.	18.	740.00	65.00	65.00	18.00	OFZ PENETRATED ?
OBS 10	TREE	-3250.	-75.	-75.	23.	-3250.00	-75.00	-75.00	23.00	
OBS 11	APPR LIGHT	600.	0.	0.	10.	600.00	0.00	0.00	10.00	
OBS 12	APPR LIGHT	500.	0.	0.	8.	500.00	0.00	0.00	8.00	
OBS 13	APPR LIGHT	400.	0.	0.	6.	400.00	0.00	0.00	6.00	
OBS 14	APPR LIGHT	300.	0.	0.	4.	300.00	0.00	0.00	4.00	

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ICAO COLLISION RISK MODEL/ EDIT REPORT                          PAGE    8

ICAO REFERENCE   CRM EXAMPLE 1                                  DATE  OCT 13, 1982
USER REFERENCE   FANTASY AERODROME                              TIME  19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E                        ILS CATEGORY II
EXAMPLE 1


SUMMARY OF OBSTACLE INFORMATION

TOTAL NUMBER OF OBSTACLES ENTERED                                          14

ALL OBSTACLES ARE IN THE PRECISION SEGMENT.

NO OBSTACLES WERE EDITED FROM THE ENTERED DATA.
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ICAO COLLISION RISK MODEL/ RISK REPORTS PAGE 9

ICAO REFERENCE CRM EXAMPLE 1 DATE OCT 13, 1982
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CRM MANUAL DOC 9274-AN904 PART I APP D/E ILS CATEGORY II
EXAMPLE 1

SPEED CATEGORY A MINIMUM ACCEPTABLE OCH ABOVE THRESHOLD 19 METRES

TOTAL RISK FOR THIS APPROACH 6.8E-08

RISK OF HITTING THE GROUND PLANE 2.2E-09

IDENT	DESCRIPTION	X METRES	Y1 METRES	Y2 METRES	Z METRES	RISK
OBSTACLE WITH HIGHEST INDIVIDUAL RISK						
OBS 04	AEROPLANE-1	0.00	-120.00	-120.00	22.00	4.2E-08
ALL OBSTACLES						
OBS 09	POLE	740.00	65.00	65.00	18.00	2.6E-09
OBS 11	APPR LIGHT	600.00	0.00	0.00	10.00	5.5E-10
OBS 12	APPR LIGHT	500.00	0.00	0.00	8.00	1.3E-09
OBS 08	HANGAR	480.00	240.00	280.00	17.00	*
OBS 13	APPR LIGHT	400.00	0.00	0.00	6.00	2.6E-09
OBS 02	LLZ ANT OPPOS	300.00	0.00	0.00	5.00	1.6E-08
OBS 14	APPR LIGHT	300.00	0.00	0.00	4.00	3.0E-09
OBS 04	AEROPLANE-1	0.00	-120.00	-120.00	22.00	4.2E-08
OBS 01	GP ANTENNA	-250.00	130.00	130.00	16.00	1.8E-10
OBS 03	AEROPLANE-2	-300.00	-150.00	-150.00	22.00	6.6E-11
OBS 05	BUILDING-1	-1860.00	-820.00	-780.00	58.00	1.4E-14
OBS 06	BUILDING-2	-2600.00	-820.00	-780.00	56.00	1.4E-15
OBS 07	CONTROL TOWER	-2840.00	-340.00	-340.00	37.00	3.2E-14
OBS 10	TREE	-3250.00	-75.00	-75.00	23.00	1.5E-14

REPRESENTS A RISK LESS THAN 1.0E-15.

ICAO COLLISION RISK MODEL/ RISK REPORTS PAGE 10

ICAO REFERENCE CRM EXAMPLE 1 DATE OCT 13, 1982
USER REFERENCE FANTASY AERODROME TIME 19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E ILS CATEGORY II
EXAMPLE 1

SPEED CATEGORY B MINIMUM ACCEPTABLE OCH ABOVE THRESHOLD 21 METRES

TOTAL RISK FOR THIS APPROACH 8.2E-08

RISK OF HITTING THE GROUND PLANE 1.0E-08

IDENT	DESCRIPTION	X METRES	Y1 METRES	Y2 METRES	Z METRES	RISK
OBSTACLE WITH HIGHEST INDIVIDUAL RISK						
OBS 02	LLZ ANT OPPOS	300.00	0.00	0.00	5.00	3.2E-08
ALL OBSTACLES						
OBS 09	POLE	740.00	65.00	65.00	18.00	2.1E-09
OBS 11	APPR LIGHT	600.00	0.00	0.00	10.00	8.9E-10
OBS 12	APPR LIGHT	500.00	0.00	0.00	8.00	2.8E-09
OBS 08	HANGAR	480.00	240.00	280.00	17.00	*
OBS 13	APPR LIGHT	400.00	0.00	0.00	6.00	5.5E-09
OBS 02	LLZ ANT OPPOS	300.00	0.00	0.00	5.00	3.2E-08
OBS 14	APPR LIGHT	300.00	0.00	0.00	4.00	8.4E-09
OBS 04	AEROPLANE-1	0.00	-120.00	-120.00	22.00	2.8E-08
OBS 01	GP ANTENNA	-250.00	130.00	130.00	16.00	4.4E-10
OBS 03	AEROPLANE-2	-300.00	-150.00	-150.00	22.00	1.8E-10
OBS 05	BUILDING-1	-1860.00	-820.00	-780.00	58.00	3.5E-14
OBS 06	BUILDING-2	-2600.00	-820.00	-780.00	56.00	7.3E-15
OBS 07	CONTROL TOWER	-2840.00	-340.00	-340.00	37.00	1.8E-13
OBS 10	TREE	-3250.00	-75.00	-75.00	23.00	9.5E-14

* REPRESENTS A RISK LESS THAN 1.0E-15.

ICAO COLLISION RISK MODEL/ RISK REPORTS PAGE 11

ICAO REFERENCE CRM EXAMPLE 1 DATE OCT 13, 1982
USER REFERENCE FANTASY AERODROME TIME 19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E ILS CATEGORY II
EXAMPLE 1

SPEED CATEGORY C SPECIFIED OCH ABOVE THRESHOLD 30 METRES

TOTAL RISK FOR THIS APPROACH 5.8E-09

RISK OF HITTING THE GROUND PLANE 7.9E-10

IDENT	DESCRIPTION	X METRES	Y1 METRES	Y2 METRES	Z METRES	RISK
OBSTACLE WITH HIGHEST INDIVIDUAL RISK						
OBS 04	AEROPLANE-1	0.00	-120.00	-120.00	22.00	3.4E-09
ALL OBSTACLES						
OBS 09	POLE	740.00	65.00	65.00	18.00	4.8E-11
OBS 11	APPR LIGHT	600.00	0.00	0.00	10.00	7.6E-12
OBS 12	APPR LIGHT	500.00	0.00	0.00	8.00	3.3E-11
OBS 08	HANGAR	480.00	240.00	280.00	17.00	*
OBS 13	APPR LIGHT	400.00	0.00	0.00	6.00	1.1E-10
OBS 02	LLZ ANT OPPOS	300.00	0.00	0.00	5.00	8.7E-10
OBS 14	APPR LIGHT	300.00	0.00	0.00	4.00	2.4E-10
OBS 04	AEROPLANE-1	0.00	-120.00	-120.00	22.00	3.4E-09
OBS 01	GP ANTENNA	-250.00	130.00	130.00	16.00	1.5E-10
OBS 03	AEROPLANE-2	-300.00	-150.00	-150.00	22.00	3.1E-10
OBS 05	BUILDING-1	-1860.00	-820.00	-780.00	58.00	3.8E-15
OBS 06	BUILDING-2	-2600.00	-820.00	-780.00	56.00	*
OBS 07	CONTROL TOWER	-2840.00	-340.00	-340.00	37.00	4.CE-15
OBS 10	TREE	-3250.00	-75.00	-75.00	23.00	*

* REPRESENTS A RISK LESS THAN 1.0E-15.

ICAO COLLISION RISK MODEL/ RISK REPORTS PAGE 12

ICAO REFERENCE CRM EXAMPLE 1 DATE OCT 13, 1982
USER REFERENCE FANTASY AERODROME TIME 19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E ILS CATEGORY II
EXAMPLE 1

SPEED CATEGORY C MINIMUM ACCEPTABLE OCH ABOVE THRESHOLD 25 METRES

TOTAL RISK FOR THIS APPROACH 5.3E-08

RISK OF HITTING THE GROUND PLANE 1.0E-08

IDENT	DESCRIPTION	X METRES	Y1 METRES	Y2 METRES	Z METRES	RISK
OBSTACLE WITH HIGHEST INDIVIDUAL RISK						
OBS 02	LLZ ANT OPPOS	300.00	0.00	0.00	5.00	2.3E-08
ALL OBSTACLES						
OBS 09	POLE	740.00	65.00	65.00	18.00	6.9E-10
OBS 11	APPR LIGHT	600.00	0.00	0.00	10.00	4.7E-10
OBS 12	APPR LIGHT	500.00	0.00	0.00	8.00	1.3E-09
OBS 08	HANGAR	480.00	240.00	280.00	17.00	*
OBS 13	APPR LIGHT	400.00	0.00	0.00	6.00	3.3E-09
OBS 02	LLZ ANT OPPOS	300.00	0.00	0.00	5.00	2.3E-08
OBS 14	APPR LIGHT	300.00	0.00	0.00	4.00	7.0E-09
OBS 04	AEROPLANE-1	0.00	-120.00	-120.00	22.00	1.2E-08
OBS 01	GP ANTENNA	-250.00	130.00	130.00	16.00	9.8E-10
OBS 03	AEROPLANE-2	-300.00	-150.00	-150.00	22.00	8.6E-10
OBS 05	BUILDING-1	-1860.00	-820.00	-780.00	58.00	4.9E-14
OBS 06	BUILDING-2	-2600.00	-820.00	-780.00	56.00	6.1E-15
OBS 07	CONTROL TOWER	-2840.00	-340.00	-340.00	37.00	2.6E-14
OBS 10	TREE	-3250.00	-75.00	-75.00	23.00	4.1E-15

* REPRESENTS A RISK LESS THAN 1.0E-15.

ICAO COLLISION RISK MODEL/ RISK REPORTS PAGE 13

ICAO REFERENCE CRM EXAMPLE 1 DATE OCT 13, 1982
USER REFERENCE FANTASY AERODROME TIME 19:39:56

CRM MANUAL DOC 9274-AN904 PART I APP D/E ILS CATEGORY II
EXAMPLE 1

SPEED CATEGORY D SPECIFIED OCH ABOVE THRESHOLD 30 METRES

TOTAL RISK FOR THIS APPROACH 4.7E-08

RISK OF HITTING THE GROUND PLANE 1.0E-08

IDENT	DESCRIPTION	X METRES	Y1 METRES	Y2 METRES	Z METRES	RISK
OBSTACLE WITH HIGHEST INDIVIDUAL RISK						
OBS 04	AEROPLANE-1	0.00	-120.00	-120.00	22.00	1.7E-08
ALL OBSTACLES						
OBS 09	POLE	740.00	65.00	65.00	18.00	5.8E-10
OBS 11	APPR LIGHT	600.00	0.00	0.00	10.00	1.3E-10
OBS 12	APPR LIGHT	500.00	0.00	0.00	8.00	4.2E-10
OBS 08	HANGAR	480.00	240.00	280.00	17.00	
OBS 13	APPR LIGHT	400.00	0.00	0.00	6.00	1.6E-09
OBS 02	LLZ ANT OPPOS	300.00	0.00	0.00	5.00	1.0E-08
OBS 14	APPR LIGHT	300.00	0.00	0.00	4.00	2.4E-09
OBS 04	AEROPLANE-1	0.00	-120.00	-120.00	22.00	1.7E-08
OBS 01	GP ANTENNA	-250.00	130.00	130.00	16.00	3.3E-09
OBS 03	AEROPLANE-2	-300.00	-150.00	-150.00	22.00	3.9E-09
OBS 05	BUILDING-1	-1860.00	-820.00	-780.00	58.00	7.1E-14
OBS 06	BUILDING-2	-2600.00	-820.00	-780.00	56.00	2.8E-14
OBS 07	CONTROL TOWER	-2840.00	-340.00	-340.00	37.00	1.7E-13
OBS 10	TREE	-3250.00	-75.00	-75.00	23.00	3.4E-14

* REPRESENTS A RISK LESS THAN 1.0E-15.

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PROCEDURE DESIGN LABORATORY EXERCISE
NON-PRECISION APPROACH
VOR 27R

1. The design is a VOR instrument approach procedure to runway 27R
2. The final approach guidance is provided by VOR CAA.
3. CAA is located 11300 meters from the runway threshold and 150 meters north of the centerline.
4. The missed approach will be to VOR KAV and hold.
5. Suggested MAPt is by a crossing radial from KAV.
6. Suggested sequence:
   - A. Lay out the final approach track.
   - B. Construct the final approach area
   - C. Evaluate the final area and establish the OCA/H
   - D. Construct the missed approach point tolerance area
   - E. Determine the earliest and latest MAPt tolerance point.
   - F. Construct the missed approach area to the SOC.
   - G. Construct the Straight missed approach area.
   - H.]Determine the required turn altitude/height.
   - I. Deal with the problem obstacle(s).
   - J. Construct the turn area and area to KAV
   - K. Construct the intermediate segment.
   - L. Evaluate the intermediate segment for the minimum altitude.
   - M. Construct the racetrack reversal area at CAA.
   - N. Establish reversal altitudes for all categories.
   - O. Construct the initial segment from the airway along the R127 KAV.
   - P. Prepare a draft approach plate from the template provided.
   - Q. Prepare a briefing showing your construction and major calculations.
7. Present a briefing on your design.

PROCEDURE DESIGN LABORATORY EXERCISE
NON-PRECISION APPROACH VOR 27R

GROUP A: DANIEL
OMBASA
ENGLEBERT

1. CALCULATE ANGLE OF THE FINAL APPRAOCH TRACK AND RWY27R CENTERLINE EXTENSION.

   $\alpha = SIN^{-1}$ (150M / 11300M) = 0.76°<5°

   ∴ IT IS OK FOR STRAIGHT-IN APPOACH.

2. THE LENGHTH OF FINAL APPROACH SEGMENT IS 11300M ≅ 6.1NM

   W / 2 = 1NM + 6.1NM * TAN 7.8=1.84NM
   Ws = 1.84NM / 2 = 0.92NM

   CONSTRUCT THE FINAL APPROCH AREA.

3. CONTROLLING OBSTACLE = 46 MSL.

   MOC = 75M + 1.5M (1) = 76.5M ≅ 77M MSL
   OCA = 46M +77M = 123M ≅ 403FT → 410FT MSL ≅ 125M MSL
   OCH = 125M – 16M = 109M

4. CONSTRUCT THE MISSED APPROACH POINT TOLERANCE AREA.

   VOR : TRACKING : ±5.2°,
   CROSSING : ±4.5°

5. DETERMINE THE EARLIEST AND LAEST MAPt TOLERANCE POINT.

6. CONSTRUCT THE MISSED APROACH AREA TO SOC.

   CAT D IAS = 185KT (TABLE III – 1 – 2)
   ISA + 15° = 1.0411 (ATTACH. – F – 3)
   TAS = IAS * 1.0411 = 185KT * 1.0411 ≅ 193KT
   10KT WIND → 10KT + 193KT = 203KT

   d + x = (203KT * 18S) / 3600 ≅ 1.01NM

MAPt → SOC = 1.01NM + 0.75NM   (MEASURED a = 0.75NM)
= 1.76NM

7. CONSTRUCT THE STRAIGHT MISSED APPROACH AREA.

(1) THREE OBSTACLES

	MSL	MOC	RH	dz +do
O1	170M	50M	= 220M	
O2	200M	50M	= 250M	
O3	84M	50M	= 134M	

(2) AIRCRAFT ALTITUDE

SOC →O1 = 4.7NM (MEASURED)
A/C H OF O1 = 125M + (4.7NM * 0.025 * 1852) = 342.61 ≅ 342M
RH OF O1 = 170M + 50M = 220M ≅ 342M   ∴ O1 IS OK.

O3 IS IN AREA JUST NEAR TO SOC
∴ RH O3 = 84M + 50M = 134M
OCA = 125M → 134M – 125M = 9M STILL NEEDED

MEASURED dO2 = 1.4NM
∴ dO2 CLIMB = 1.4NM * 0.025 * 1852 = 64.8M ≅ 64M
dz CLIMB = 250M (NEEDED) – 125M (OCA) – 64M (dO2 CLIMB)
= 61M

dz = dz CLIMB / (0.025 * 1852) = 61M / (0.025 * 1852) = 1.317M
≅ 1.32NM
TNA = 125M + 61M = 186M ≅ 610.08FT → 700FT
∴ ADJUST dz = 700FT / (0.025 * 6076) ≅ 1.9NM

(3) CALCULATE "C", R, r, & E

IAS = 265KT (CAT D) ISA + 15°C (+ 1000FT) = 1.0567
TAS = IAS * 1.0567 = 265KT * 1.0567 ≅ 280KT
30KT TAILWIND → 30KT + 280KT = 310KT

C = (310KT * 6S) / 3600 = 0.5166NM ≅ 0.52NM
R = (3431 * TAN15) / (π * 280KT) = 1.045 ≅ 1.04°/ SEC

$r = 280KT / (20 * \pi * 1.04) = 4.284NM \cong 4.29NM$
$E = W / (30 * R) = 30 / (40 * 1.04) \cong 0.72NM$
$((E)^2 + (r)^2)^{1/2} = ((4.29)^2 + (0.72)^2)^{1/2} \cong 4.35NM$

@ BUT AREA TOO WIDE TO COVER THE FACILITY
∴ REDUCE THE SPEED

IAS = 185KT (INTERMEDIAT MISSED APPROACH SPEED)
ISA + 15°C (+ 1000FT) = 1.0567
TAS = IAS * 1.0567 = 185KT * 1.0567 195.489 ≅ 196KT
30KT TAILWIND → 30KT + 196KT = 226KT

$C = (226KT * 6S) / 3600 = 0.3766NM \cong 0.38NM$
$R = (3431 * TAN15) / (\pi * 196KT) = 1.493 \cong 1.49°/ SEC$
$r = 196KT / (20 * \pi * 1.49) = 2.0935NM \cong 2.10NM$
$E = W / (30 * R) = 30 / (40 * 1.49) \cong 0.50NM$
$((E)^2 + (r)^2)^{1/2} = ((0.50)^2 + (2.10)^2)^{1/2} \cong 4.35NM$

8. CONSTRUCT THE TURN AREA AND AREA TO KAV (VOR) BASED ON THE "C", R, r & E.

9. CONSTRUCT THE INTERMEDIATE SEGMENT AND EVALUATE THE MINIMUM ALTITUDE.

O1 : 199M IN THE PRIMARY AREA
O2 : 299M IN THE EDGE OF THE PRIMARY AREA
MOC = 150M
∴ OCA = 299M + 150M = 449M MSL ≅ 1472FT → 1500FT

ALT. OF FINAL = 16M + 49FT + 6.1NM * 0.05 * 6076
= 53FT + 49FT +1853FT = 1955FT → 1500FT
∴ INTERMEDIATE SEGMENT ALTIUDE = 2000FT (FLAT)

10. CONSTRUCT THE RACKTRACK REVERSAL AREA AT CAA (VOR) AND ESTABLISH REVERSAL ALTITUDE FOR ALL CATEGORY.

ALT TO DESCEND : HEIGHT – 2000FT
CAT A/B → t = 1MIN. = (H – 2000FT) / 804FT + 492FT
∴ H = (804FT + 492FT) * 1 + 2000FT = 3296FT → 3300FT
CAT C/D → t = 1MIN. = (H – 2000FT) / 1197FT + 755FT
∴ H = (1197FT + 755FT) * 1 + 2000FT = 3952FT → 4000FT

ENTRY ALT :

CAT A/B → 3300FT – 804FT = 2496FT → 2500FT

CAT C/D → 4000FT – 1197FT = 2803FT → 2900FT

11. CONATRUCT THE INITIAL SEGMENT FROM THE AIRWAY ALONG THE R127 KAV.

IF = 13.8NM (MEASURED)

DME TOL. = 0.25NM + 0.0125 * 138.NM ≅ 0.43NM

O1 : 300M IN THE SECONDARY AREA JUST NEAR THE PRIMARY AREA

O2 : 299M IN THE SECONDARY AREA 2.2NM TO THE PRIMARY AREA

O1 : MOC = 300M (CONTROLLING OBSTACLE)

O2 : MOC = 300M – 300M * (2.2 / 2.5) ≅ 36M

∴ OCA = 300M + 300M = 600M MSL ≅ 1968FT → 2000FT

ALT. OF FINAL = 2000FT

ALT OF INTERM. = 2000FT (FLAT)

→ ALT OF INITIAL = 2000 FT + 10NM * 0.04 * 6076 (OPTIMUM)

= 4500FT

GRAD. = (4500FT – 2000FT) / 10NM * 6076 ≅ 0.041= 4.1%

12. MISSED APROACH INSTRUCTION

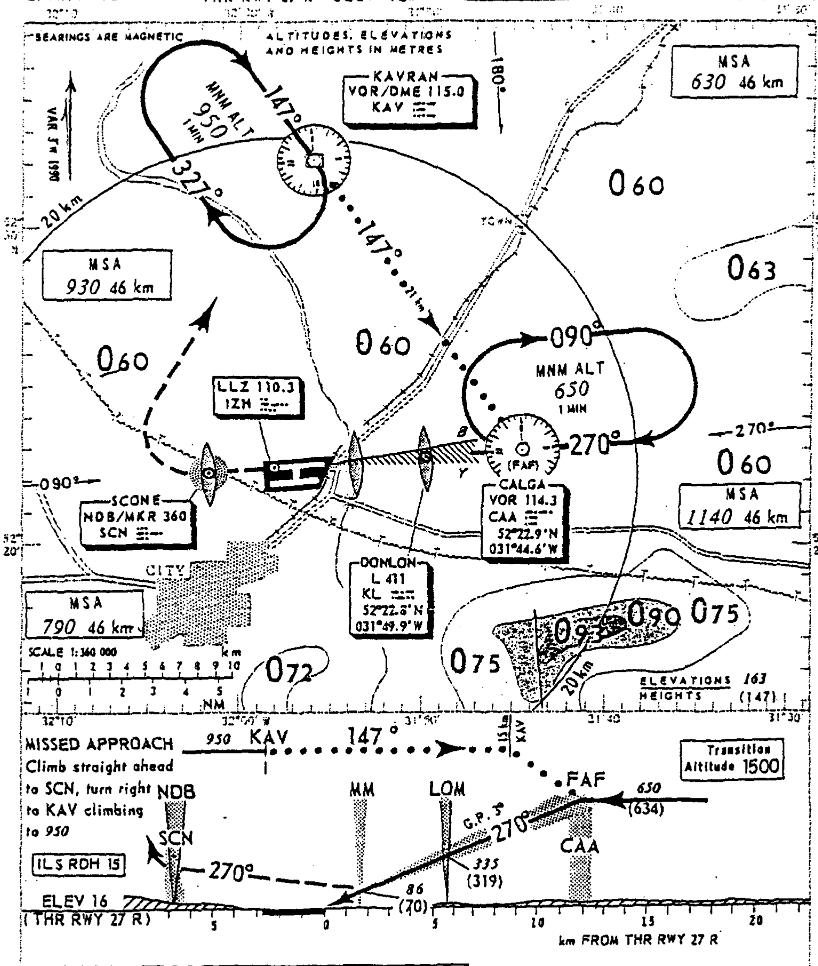
" CLIMB ON HEADING 268°UNTIL LEAVING 700FT, THEN TURN RIGHT DIRECT TO KAV, MAINTAIN 4,000FT AND HOLD "

INSTRUMENT APPROACH CHART - ICAO

AERODROME ELEV. 30m
HEIGHTS RELATED TO THR RWY 27 R - ELEV 16m

APP 119.1
TWR 118.1

CITY/AERODROME
ILS
RWY 27 R



OCA/H		A	B	C	D
Straight-in Approach	Cat I	64 (48)	67 (51)	70 (54)	73 (57)
	Cat II	(13)	(18)	(22)	(26)
	GP INOP	140 (124)			
Circling		385	465	630	680

	km/h	100	150	200	250
FAF-MAPT 10.6 km	min:s	6.22	4.14	3.11	2.33
Rate of descent	m/s	1.7	2.5	3.3	4.1

DATE OF AERONAUTICAL INFORMATION

PRODUCING ORGANIZATION

REFERENCE NUMBER
5/2/90

附件六

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I
AERODROME DESIGN AND OPERATIONS

THIRD EDITION — JULY 1999

This edition incorporates all amendments to Annex 14, Volume I, adopted by the Council prior to 6 March 1999 and supersedes on 4 November 1999 all previous editions of Annex 14, Volume I.

For information regarding the applicability of the Standards and Recommended Practices, *see* Chapter 1, 1.2 and Foreword.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

CHAPTER 1. GENERAL

Introductory Note.— This Annex contains Standards and Recommended Practices (specifications) that prescribe the physical characteristics and obstacle limitation surfaces to be provided for at aerodromes, and certain facilities and technical services normally provided at an aerodrome. It is not intended that these specifications limit or regulate the operation of an aircraft.

To a great extent, the specifications for individual facilities detailed in Annex 14, Volume I, have been interrelated by a reference code system, described in this chapter, and by the designation of the type of runway for which they are to be provided, as specified in the definitions. This not only simplifies the reading of Volume I of this Annex, but in most cases, provides for efficiently proportioned aerodromes when the specifications are followed.

This document sets forth the minimum aerodrome specifications for aircraft which have the characteristics of those which are currently operating or for similar aircraft that are planned for introduction. Accordingly, any additional safeguards that might be considered appropriate to provide for more demanding aircraft are not taken into account. Such matters are left to appropriate authorities to evaluate and take into account as necessary for each particular aerodrome. Guidance on some possible effects of future aircraft on these specifications is given in the Aerodrome Design Manual, *Part 2.*

It is to be noted that the specifications for precision approach runways categories II and III are only applicable to runways intended to be used by aeroplanes in code numbers 3 and 4.

Annex 14, Volume I, does not include specifications relating to the overall planning of aerodromes (such as separation between adjacent aerodromes or capacity of individual aerodromes) or to economic and other non-technical factors that need to be considered in the development of an aerodrome. Information on these subjects is included in the Airport Planning Manual, *Part 1.*

Aviation security is an integral part of aerodrome planning and operations. Annex 14, Volume I, contains several specifications aimed at enhancing the level of security at aerodromes. Specifications on other facilities related to security are given in Annex 17 and detailed guidance on the subject is contained in the ICAO Security Manual.

1.1 Definitions

When the following terms are used in this Annex they have the following meanings:

Accuracy. A degree of conformance between the estimated or measured value and the true value.

Note.— For measured positional data the accuracy is normally expressed in terms of a distance from a stated position within which there is a defined confidence of the true position falling.

Aerodrome. A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

Aerodrome beacon. Aeronautical beacon used to indicate the location of an aerodrome from the air.

Aerodrome elevation..The elevation of the highest point of the landing area.

Aerodrome identification sign. A sign placed on an aerodrome to aid in identifying the aerodrome from the air.

Aerodrome reference point. The designated geographical location of an aerodrome.

Aerodrome traffic density.

a) *Light.* Where the number of movements in the mean busy hour is not greater than 15 per runway or typically less than 20 total aerodrome movements.

b) *Medium.* Where the number of movements in the mean busy hour is of the order of 16 to 25 per runway or typically between 20 to 35 total aerodrome movements.

c) *Heavy.* Where the number of movements in the mean busy hour is of the order of 26 or more per runway or typically more than 35 total aerodrome movements.

Note 1.— The number of movements in the mean busy hour is the arithmetic mean over the year of the number of movements in the daily busiest hour.

CHAPTER 2. AERODROME DATA

2.1 Aeronautical data

2.1.1 Determination and reporting of aerodrome related aeronautical data shall be in accordance with the accuracy and integrity requirements set forth in Tables 1 to 5 contained in Appendix 5 while taking into account the established quality system procedures. Accuracy requirements for aeronautical data are based upon a 95 per cent confidence level and in that respect, three types of positional data shall be identified: surveyed points (e.g. runway threshold), calculated points (mathematical calculations from the known surveyed points of points in space, fixes) and declared points (e.g. flight information region boundary points).

Note.— Specifications governing the quality system are given in Annex 15, Chapter 3.

2.1.2 Contracting States shall ensure that integrity of aeronautical data is maintained throughout the data process from survey/origin to the next intended user. Aeronautical data integrity requirements shall be based upon the potential risk resulting from the corruption of data and upon the use to which the data item is put. Consequently, the following classification and data integrity level shall apply:

a) *critical data, integrity level* 1×10^{-8}: there is a high probability when using corrupted critical data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe;

b) *essential data, integrity level* 1×10^{-5}: there is a low probability when using corrupted essential data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe; and

c) *routine data, integrity level* 1×10^{-3}: there is a very low probability when using corrupted routine data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe.

2.1.3 Protection of electronic aeronautical data while stored or in transit shall be totally monitored by the cyclic redundancy check (CRC). To achieve protection of the integrity level of critical and essential aeronautical data as classified in 2.1.2 above, a 32 or 24 bit CRC algorithm shall apply respectively.

2.1.4 **Recommendation.** — *To achieve protection of the integrity level of routine aeronautical data as classified in 2.1.2 above, a 16 bit CRC algorithm should apply.*

Note.— Guidance material on the aeronautical data quality requirements (accuracy, resolution, integrity, protection and traceability) is contained in the World Geodetic System — 1984 (WGS-84) Manual *(Doc 9674). Supporting material in respect of the provisions of Appendix 5 related to accuracy and integrity of aeronautical data, is contained in RTCA Document DO-201A and European Organization for Civil Aviation Equipment (EUROCAE) Document ED-77, entitled* Industry Requirements for Aeronautical Information.

2.1.5 Geographical coordinates indicating latitude and longitude shall be determined and reported to the aeronautical information services authority in terms of the World Geodetic System — 1984 (WGS-84) geodetic reference datum, identifying those geographical coordinates which have been transformed into WGS-84 coordinates by mathematical means and whose accuracy of original field work does not meet the requirements in Appendix 5, Table 1.

2.1.6 The order of accuracy of the field work shall be such that the resulting operational navigation data for the phases of flight will be within the maximum deviations, with respect to an appropriate reference frame, as indicated in tables contained in Appendix 5.

2.1.7 In addition to the elevation (referenced to mean sea level) of the specific surveyed ground positions at aerodromes, geoid undulation (referenced to the WGS-84 ellipsoid) for those positions as indicated in Appendix 5, shall be determined and reported to the aeronautical information services authority.

Note 1.— An appropriate reference frame is that which enables WGS-84 to be realized on a given aerodrome and with respect to which all coordinate data are related.

Note 2.— Specifications governing the publication of WGS-84 coordinates are given in Annex 4, Chapter 2 and Annex 15, Chapter 3.

2.2 Aerodrome reference point

2.2.1 An aerodrome reference point shall be established for an aerodrome.

2.2.2 The aerodrome reference point shall be located near the initial or planned geometric centre of the aerodrome and shall normally remain where first established.

2.2.3 The position of the aerodrome reference point shall be measured and reported to the aeronautical information services authority in degrees, minutes and seconds.

CHAPTER 3. PHYSICAL CHARACTERISTICS

3.1 Runways

Number and orientation of runways

Introductory Note.— Many factors affect the determination of the orientation, siting and number of runways.

One important factor is the usability factor, as determined by the wind distribution, which is specified hereunder. Another important factor is the alignment of the runway to facilitate the provision of approaches conforming to the approach surface specifications of Chapter 4. In Attachment A, Section 1, information is given concerning these and other factors.

When a new instrument runway is being located, particular attention needs to be given to areas over which aeroplanes will be required to fly when following instrument approach and missed approach procedures, so as to ensure that obstacles in these areas or other factors will not restrict the operation of the aeroplanes for which the runway is intended.

3.1.1 **Recommendation.—** *The number and orientation of runways at an aerodrome should be such that the usability factor of the aerodrome is not less than 95 per cent for the aeroplanes that the aerodrome is intended to serve.*

3.1.2 Choice of maximum permissible cross-wind components

Recommendation.— *In the application of 3.1.1 it should be assumed that landing or take-off of aeroplanes is, in normal circumstances, precluded when the cross-wind component exceeds:*

- *37 km/h (20 kt) in the case of aeroplanes whose reference field length is 1 500 m or over, except that when poor runway braking action owing to an insufficient longitudinal coefficient of friction is experienced with some frequency, a cross-wind component not exceeding 24 km/h (13 kt) should be assumed;*
- *24 km/h (13 kt) in the case of aeroplanes whose reference field length is 1 200 m or up to but not including 1 500 m; and*
- *19 km/h (10 kt) in the case of aeroplanes whose reference field length is less than 1 200 m.*

Note.— In Attachment A, Section 1, guidance is given on factors affecting the calculation of the estimate of the usability factor and allowances which may have to be made to take account of the effect of unusual circumstances.

3.1.3 Data to be used

Recommendation.— *The selection of data to be used for the calculation of the usability factor should be based on reliable wind distribution statistics that extend over as long a period as possible, preferably of not less than five years. The observations used should be made at least eight times daily and spaced at equal intervals of time.*

Note.— These winds are mean winds. Reference to the need for some allowance for gusty conditions is made in Attachment A, Section 1.

Location of threshold

3.1.4 **Recommendation.—** *A threshold should normally be located at the extremity of a runway unless operational considerations justify the choice of another location.*

Note.— Guidance on the siting of the threshold is given in Attachment A, Section 10.

3.1.5 **Recommendation.—** *When it is necessary to displace a threshold, either permanently or temporarily, from its normal location, account should be taken of the various factors which may have a bearing on the location of the threshold. Where this displacement is due to an unserviceable runway condition, a cleared and graded area of at least 60 m in length should be available between the unserviceable area and the displaced threshold. Additional distance should also be provided to meet the requirements of the runway end safety area as appropriate.*

Note.— Guidance on factors which may be considered in the determination of the location of a displaced threshold is given in Attachment A, Section 10.

Actual length of runways

3.1.6 Primary runway

Recommendation.— *Except as provided in 3.1.8, the actual runway length to be provided for a primary runway*

CHAPTER 4. OBSTACLE RESTRICTION AND REMOVAL

Note 1.— The objectives of the specifications in this chapter are to define the airspace around aerodromes to be maintained free from obstacles so as to permit the intended aeroplane operations at the aerodromes to be conducted safely and to prevent the aerodromes from becoming unusable by the growth of obstacles around the aerodromes. This is achieved by establishing a series of obstacle limitation surfaces that define the limits to which objects may project into the airspace.

Note 2.— Objects which penetrate the obstacle limitation surfaces contained in this chapter may in certain circumstances cause an increase in the obstacle clearance altitude/height for an instrument approach procedure or any associated visual circling procedure. Criteria for evaluating obstacles are contained in Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS) *(Doc 8168).*

Note 3.— The establishment of, and requirements for, an obstacle protection surface for visual approach slope indicator systems are specified in 5.3.5.41 to 5.3.5.45.

4.1 Obstacle limitation surfaces

Note.— See Figure 4-1.

Outer horizontal surface

Note.— Guidance on the need to provide an outer horizontal surface and its characteristics is contained in the Airport Services Manual, *Part 6.*

Conical surface

4.1.1 *Description.— Conical surface.* A surface sloping upwards and outwards from the periphery of the inner horizontal surface.

4.1.2 *Characteristics.—* The limits of the conical surface shall comprise:

a) a lower edge coincident with the periphery of the inner horizontal surface; and

b) an upper edge located at a specified height above the inner horizontal surface.

4.1.3 The slope of the conical surface shall be measured in a vertical plane perpendicular to the periphery of the inner horizontal surface.

Inner horizontal surface

4.1.4 *Description.— Inner horizontal surface.* A surface located in a horizontal plane above an aerodrome and its environs.

4.1.5 *Characteristics.—* The radius or outer limits of the inner horizontal surface shall be measured from a reference point or points established for such purpose.

Note.— The shape of the inner horizontal surface need not necessarily be circular. Guidance on determining the extent of the inner horizontal surface is contained in the Airport Services Manual, *Part 6.*

4.1.6 The height of the inner horizontal surface shall be measured above an elevation datum established for such purpose.

Note.— Guidance on determining the elevation datum is contained in the Airport Services Manual, *Part 6.*

Approach surface

4.1.7 *Description.— Approach surface.* An inclined plane or combination of planes preceding the threshold.

4.1.8 *Characteristics.—* The limits of the approach surface shall comprise:

a) an inner edge of specified length, horizontal and perpendicular to the extended centre line of the runway and located at a specified distance before the threshold;

b) two sides originating at the ends of the inner edge and diverging uniformly at a specified rate from the extended centre line of the runway; and

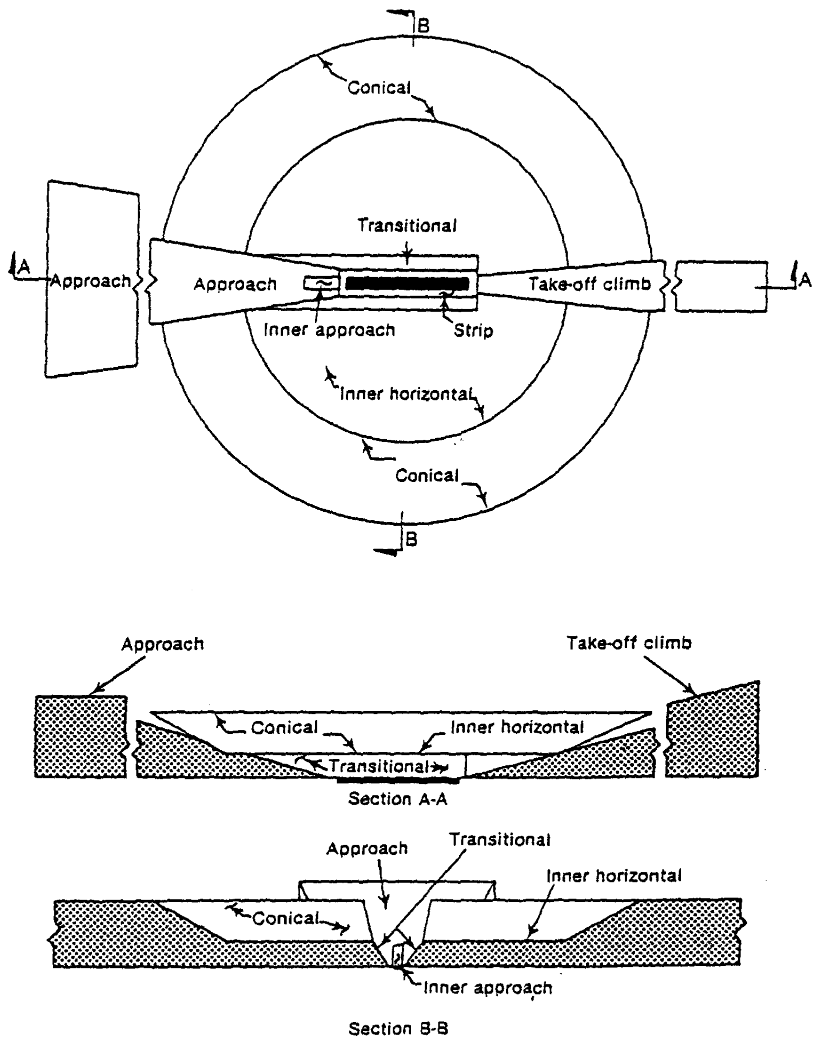
c) an outer edge parallel to the inner edge.

4.1.9 The elevation of the inner edge shall be equal to the elevation of the mid-point of the threshold.

4.1.10 The slope(s) of the approach surface shall be measured in the vertical plane containing the centre line of the runway.

Inner approach surface

4.1.11 *Description.— Inner approach surface.* A rectangular portion of the approach surface immediately preceding the threshold.



See Figure 4-2 for inner transitional and balked landing obstacle limitation surfaces and Attachment B for a three-dimensional view

Figure 4-1. Obstacle limitation surfaces

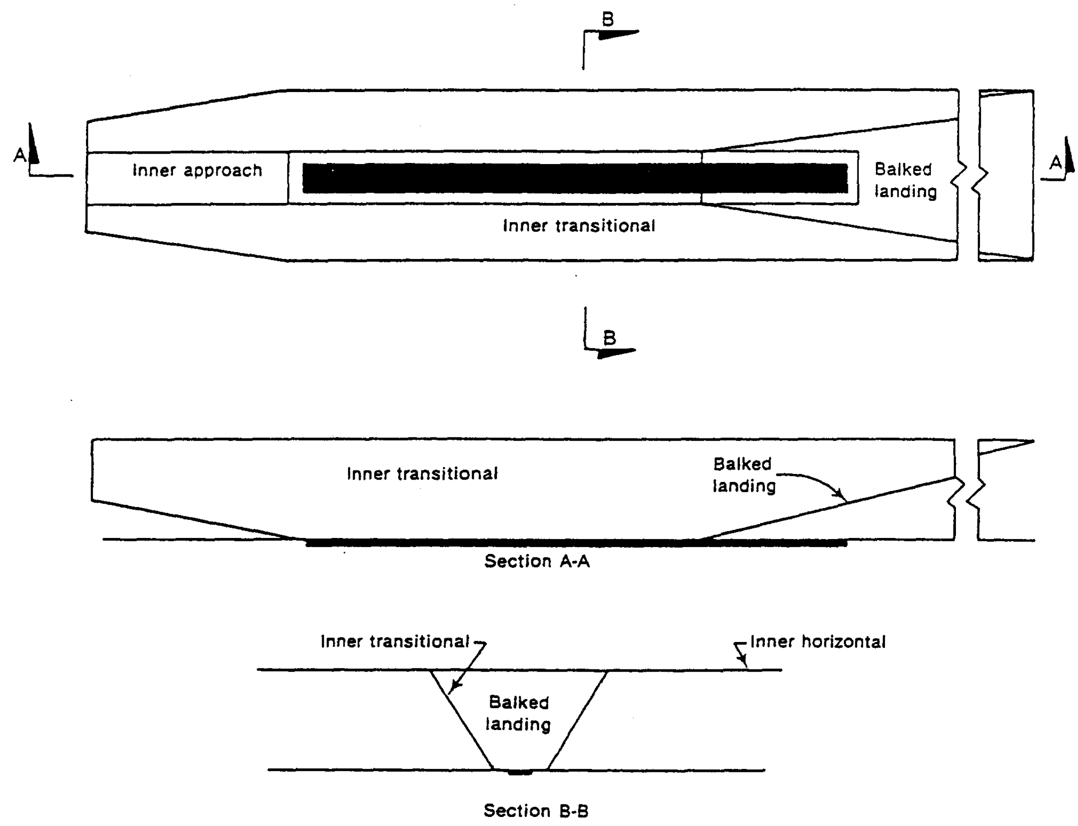


Figure 4-2. Inner approach, inner transitional and balked landing obstacle limitation surfaces

4.1.12 *Characteristics.—* The limits of the inner approach surface shall comprise:

a) an inner edge coincident with the location of the inner edge of the approach surface but of its own specified length;

b) two sides originating at the ends of the inner edge and extending parallel to the vertical plane containing the centre line of the runway; and

c) an outer edge parallel to the inner edge.

Transitional surface

4.1.13 *Description.— Transitional surface.* A complex surface along the side of the strip and part of the side of the approach surface, that slopes upwards and outwards to the inner horizontal surface.

4.1.14 *Characteristics.—* The limits of a transitional surface shall comprise:

a) a lower edge beginning at the intersection of the side of the approach surface with the inner horizontal surface and

Table 4-1. Dimensions and slopes of obstacle limitation surfaces —Approach runways

APPROACH RUNWAYS

	RUNWAY CLASSIFICATION									
	Non-instrument Code number				Non-precision approach Code number			Precision approach category I Code number		Precision approach category II or III Code number
Surface and dimensions[a]	1	2	3	4	1,2	3	4	1,2	3,4	3,4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CONICAL										
Slope	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Height	35 m	55 m	75 m	100 m	60 m	75 m	100 m	60 m	100 m	100 m
INNER HORIZONTAL										
Height	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m
Radius	2 000 m	2 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m
INNER APPROACH										
Width	—	—	—	—	—	—	—	90 m	120 m[e]	120 m[e]
Distance from threshold	—	—	—	—	—	—	—	60 m	60 m	60 m
Length	—	—	—	—	—	—	—	900 m	900 m	900 m
Slope								2.5%	2%	2%
APPROACH										
Length of inner edge	60 m	80 m	150 m	150 m	150 m	300 m	300 m	150 m	300 m	300 m
Distance from threshold	30 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m
Divergence (each side)	10%	10%	10%	10%	15%	15%	15%	15%	15%	15%
First section										
Length	1 600 m	2 500 m	3 000 m	3 000 m	2 500 m	3 000 m	3 000 m	3 000 m	3 000 m	3 000 m
Slope	5%	4%	3.33%	2.5%	3.33%	2%	2%	2.5%	2%	2%
Second section										
Length	—	—	—	—	—	3 600 m[b]	3 600 m[b]	12 000 m	3 600 m[b]	3 600 m[b]
Slope	—	—	—	—	—	2.5%	2.5%	3%	2.5%	2.5%
Horizontal section										
Length	—	—	—	—	—	8 400 m[b]	8 400 m[b]	—	8 400 m[b]	8 400 m[b]
Total length	—	—	—	—	—	15 000 m	15 000 m	15 000 m	15 000 m	15 000 m
TRANSITIONAL										
Slope	20%	20%	14.3%	14.3%	20%	14.3%	14.3%	14.3%	14.3%	14.3%
INNER TRANSITIONAL										
Slope	—	—	—	—	—	—	—	40%	33.3%	33.3%
BALKED LANDING SURFACE										
Length of inner edge	—	—	—	—	—	—	—	90 m	120 m[e]	120 m[e]
Distance from threshold	—	—	—	—	—	—	—	c	1 800 m[d]	1 800 m[d]
Divergence (each side)	—	—	—	—	—	—	—	10%	10%	10%
Slope	—	—	—	—	—	—	—	4%	3.33%	3.33%

a. All dimensions are measured horizontally unless specified otherwise.
b. Variable length (see 4.2.9 or 4.2.17).
c. Distance to the end of strip.
d. Or end of runway whichever is less.
e. Where the code letter is F (Column (3) of Table 1-1), the width is increased to 155 m.

CHAPTER 5. VISUAL AIDS FOR NAVIGATION

5.1 Indicators and signalling devices

5.1.1 Wind direction indicators

Application

5.1.1.1 An aerodrome shall be equipped with at least one wind direction indicator.

Location

5.1.1.2 A wind direction indicator shall be located so as to be visible from aircraft in flight or on the movement area and in such a way as to be free from the effects of air disturbances caused by nearby objects.

Characteristics

5.1.1.3 **Recommendation.—** *The wind direction indicator should be in the form of a truncated cone made of fabric and should have a length of not less than 3.6 m and a diameter, at the larger end, of not less than 0.9 m. It should be constructed so that it gives a clear indication of the direction of the surface wind and a general indication of the wind speed. The colour or colours should be so selected as to make the wind direction indicator clearly visible and understandable from a height of at least 300 m, having regard to background. Where practicable, a single colour, preferably white or orange, should be used. Where a combination of two colours is required to give adequate conspicuity against changing backgrounds, they should preferably be orange and white, red and white, or black and white, and should be arranged in five alternate bands, the first and last bands being the darker colour.*

5.1.1.4 **Recommendation.—** *The location of at least one wind direction indicator should be marked by a circular band 15 m in diameter and 1.2 m wide. The band should be centred about the wind direction indicator support and should be in a colour chosen to give adequate conspicuity, preferably white.*

5.1.1.5 **Recommendation.—** *Provision should be made for illuminating at least one wind indicator at an aerodrome intended for use at night.*

5.1.2 Landing direction indicator

Location

5.1.2.1 Where provided, a landing direction indicator shall be located in a conspicuous place on the aerodrome.

Characteristics

5.1.2.2 **Recommendation.—** *The landing direction indicator should be in the form of a "T".*

5.1.2.3 The shape and minimum dimensions of a landing "T" shall be as shown in Figure 5-1. The colour of the landing "T" shall be either white or orange, the choice being dependent on the colour that contrasts best with the background against which the indicator will be viewed. Where required for use at night the landing "T" shall either be illuminated or outlined by white lights.

5.1.3 Signalling lamp

Application

5.1.3.1 A signalling lamp shall be provided at a controlled aerodrome in the aerodrome control tower.

Characteristics

5.1.3.2 **Recommendation.—** *A signalling lamp should be capable of producing red, green and white signals, and of:*

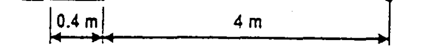


Figure 5-1. Landing direction indicator

CHAPTER 6. VISUAL AIDS FOR DENOTING OBSTACLES

6.1 Objects to be marked and/or lighted

Note.— The marking and/or lighting of obstacles is intended to reduce hazards to aircraft by indicating the presence of the obstacles. It does not necessarily reduce operating limitations which may be imposed by an obstacle.

6.1.1 **Recommendation.—** *A fixed obstacle that extends above a take-off climb surface within 3 000 m of the inner edge of the take-off climb surface should be marked and, if the runway is used at night, lighted, except that:*

a) such marking and lighting may be omitted when the obstacle is shielded by another fixed obstacle;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

c) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

d) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.2 **Recommendation.—** *A fixed object, other than an obstacle, adjacent to a take-off climb surface should be marked and, if the runway is used at night, lighted if such marking and lighting is considered necessary to ensure its avoidance, except that the marking may be omitted when:*

a) the object is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m; or

b) the object is lighted by high-intensity obstacle lights by day.

6.1.3 A fixed obstacle that extends above an approach or transitional surface within 3 000 m of the inner edge of the approach surface shall be marked and, if the runway is used at night, lighted, except that:

a) such marking and lighting may be omitted when the obstacle is shielded by another fixed obstacle;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

c) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

d) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.4 **Recommendation.—** *A fixed obstacle above a horizontal surface should be marked and, if the aerodrome is used at night, lighted except that:*

a) such marking and lighting may be omitted when:

1) the obstacle is shielded by another fixed obstacle; or

2) for a circuit extensively obstructed by immovable objects or terrain, procedures have been established to ensure safe vertical clearance below prescribed flight paths; or

3) an aeronautical study shows the obstacle not to be of operational significance;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

c) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

d) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.5 A fixed object that extends above an obstacle protection surface shall be marked and, if the runway is used at night, lighted.

Note.— See 5.3.5 for information on the obstacle protection surface.