What is B-RNAV?[1]

RNAV is a method of navigation which permits a/c operations on any desired flight path within the coverage of station referenced navigation aids or the limits of the capability of self-contained aids, or any combination thereof. Airborne RNAV equipment automatically determines a/c position by processing data from one or more sensors and guides the a/c in accordance with appropriate routing instructions. Additional navigation parameters such as distance and bearing to a preselected waypoint can also be computed from the a/c position and the location of the waypoint, depending upon the capability of the RNAV equipment. Position can be displayed to the pilot in various ways, most practically in terms of the a/c position relative to the precomputed desired track. Most RNAV equipment can employ any lateral displacementof the a/c from the desired track to generate track guidance signals to the auto-pilot. With other less sophisticated RNAV equipment manual corrective action is taken by the pilot.

B(asic)-RNAV defines European RNAV operations which satisfy a required track keeping accuracy of ±5NM for at least 95% of the flight time. This level of navigation accuracy is comparable with that which can be achieved by conventional navigation techniques on ATS routes defined by VOR/DME, when VORs are less than 100 NM apart.
The ability to achieve the required level of navigation performance in a given airspace depends not only on the accuracy and functionality of the a/c navigation equipment but also upon the adequate coverage of navigation aids and position co-ordinates accuracy provided by the navigation infrastructure of the region. For the determination of a/c position suitable input data can be derived from the following navigation sources:

- DME / DME
- VOR / DME (within 62 NM VOR range):
- INS (with radio updating or limited to 2 hour-use after last on-ground position update)
- LORAN C (with use limitations)
- GPS (with use limitations)

In the ECAC airspace the primary sources of navigation information will be VOR/DME, DME/DME and GPS until at least 2005. The availability and continuity of VOR and DME coverage have been evaluated for most of Europe and they are considered to be capable of meeting the requirements of the en-route phase of operations (EUROCONTROL - DEMETER 2000 studies refer). Furthermore, the introduction of WGS-84 as the standard geodetic reference system will provide a significant increase in the accuracy of co-ordinate data. Provision of the necessary B-RNAV infrastructure (e.g. aids to navigation, B-RNAV ATS routes, B-RNAV procedures, navigation co-ordinates) remains the responsibility of individual ECAC Member States. Each State must also ensure that supporting services (i.e. communications, navigation and surveillance) within their area of of

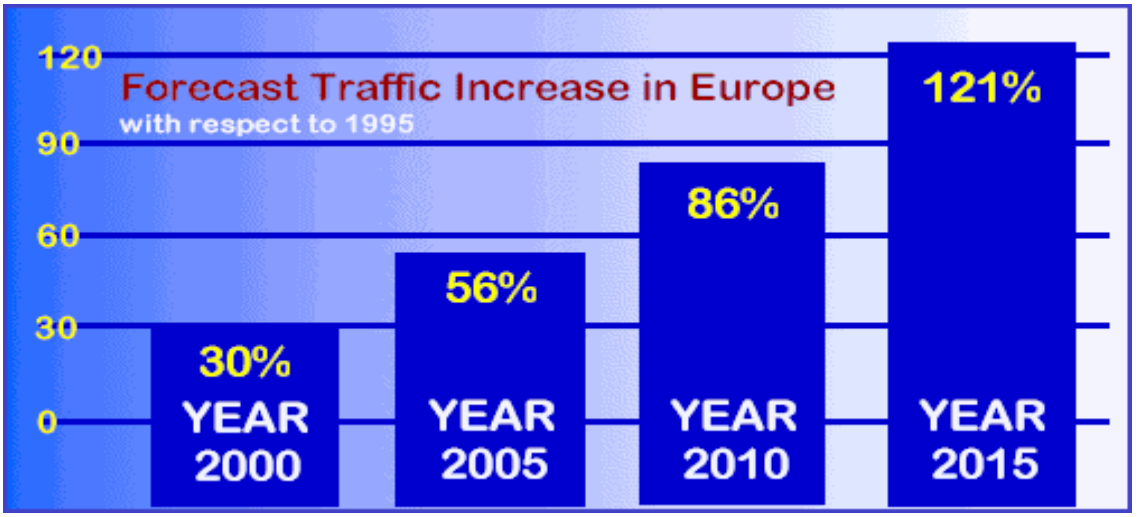
[1] Adaptado de http://users.forthnet.gr/ath/mpang/brnav.htm [2005 - 07 -31]

responsibility provide for the safe operation of the defined set of route-spacing standards.

Note: in so far as the accuracy of the system is concerned, the term "Basic" can be considered to equate to the expression RNP5 (Required Navigation Performance) -see also ICAO Doc 9613- which is a statement of the navigation performance accuracy necessary for operation in a defined airspace. Thus simplistically: B-RNAV = RNP 5 RNAV. However the expected introduction of the RNP n RNAV concept (only from post-2005) will introduce functional and operational requirements for RNAV equipment (EUROCONTROL Standard refers) additional to those necessary for B-RNAV (1998) operations.

Why B-RNAV?

Conventional a/c navigation in European continental airspace is based on the use of ground-based navigation aids (i.e. VOR/DME/NDB) and the resultant ATS route structure is anchored on these point source aids, being totally dependent upon the location of the ground facilities. The system is inflexible in terms of both geography, which results in an inefficient use of airspace, and capacity, which means that it cannot easily be expanded to absorb the forecast growth in demand. Current forecasts indicate that air traffic movement will more than double by 2010.



This inherent inability of the present ATM service to continue to meet the users' expectations in terms of improved operational flexibility, punctuality and reduced costs, or to fully exploit current and emerging technologies, established the need for the development of a strategy for the introduction of new concepts for the operation of the future ECAC airspace, whilst maintaining the existing quality of ATS and associated safety standards.
One of these concepts is Area Navigation (RNAV) - a method of navigation which allows a/c to operate on tracks joining any two points, within prescribed accuracy tolerances, without the need for the overflight of specific ground facilities. RNAV was

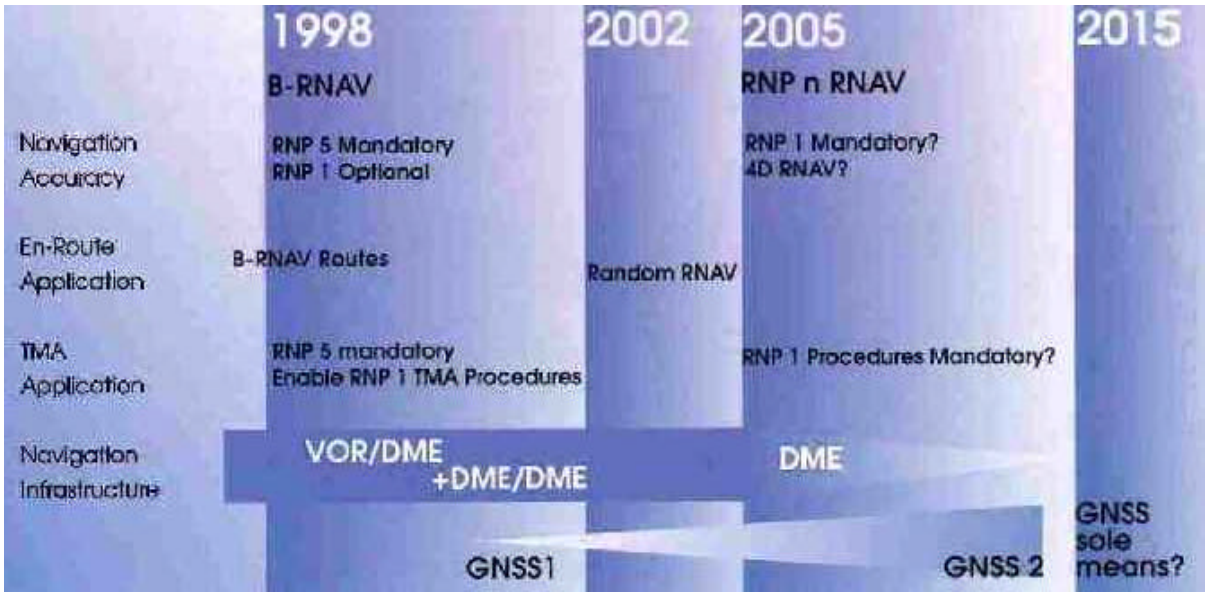
identified by ICAO FEATS as the future navigation system in the European region. In 1990 the ECAC Transport Ministers agreed a strategy for the air traffic control in Europe in accordance with ICAO FEATS. The strategy includes requirements for the mandatory carriage of on-board RNAV equipment from 1998. Aircraft not equipped and approved for RNAV operations will not be permitted in RNAV airspace.

When will B-RNAV be implemented?

From 23 April 1998 B-RNAV became mandatory as the primary means of navigation in all en-route airspace; VOR and DME will remain available* for reversionary navigation and some conventional Domestic ATS routes may be available in the lower airspace. Where beneficial, National Authorities may define B-RNAV TMA routes. However, they will remain optional in this timescale. Conventional SIDs, STARs and Holding procedures will continue to be provided.

From 2002, it is expected that Random Area Navigation (Free Route) will be introduced in selected areas. In these areas there will be a reduction in the availability of fixed routes. But there will be no change in required B - RNAV functionality.

In addition TMA procedures requiring P - RNAV (RNP1 accuracy or better) performance will be defined for use by suitably equipped aircraft. But they will not be mandatory.



Further developments are envisaged from 2005. RNP1 RNAV and increased use of RNAV in the TMA are foreseen for implementation.

* The availability of VOR and DME ground-based navaids and radar surveillance provides the potential for reversion to conventional navigation techniques in the event of system failure or reduced functionality. However, DME is expected to become the primary source of position fixing in the ECAC area and the maintenance of VOR beyond 2005 may not be guaranteed (FEATS Part 2, para 2.2.2 refers)

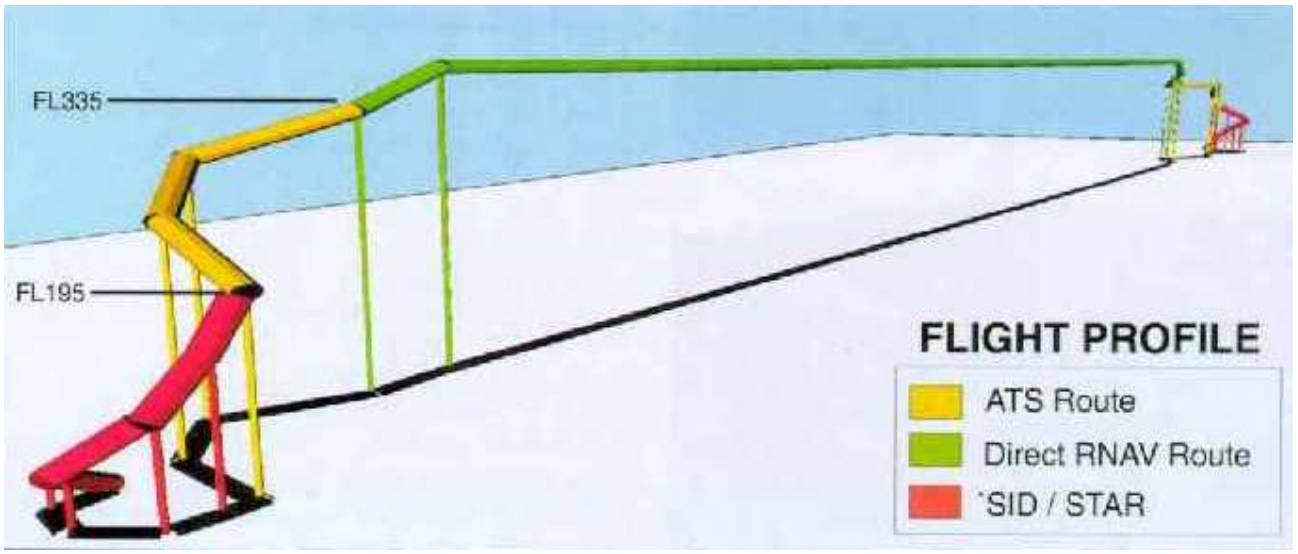
Where will B-RNAV be implemented?

Area of airspace concerned:
The entire ATS Route Network in the ECAC area, including designated feeder routes (SIDs & STARs) in and out of notified Terminal Areas.
However, National Authorities may designate domestic routes in the lower airspace which can be used by aircraft not equipped with RNAV but able to achieve RNP 5 navigation accuracy ?n these routes, i.e. VOR/DME defined routes.

Note: Studies show that successful use of B-RNAV capabilily requires a uniform structure of aircraft population (not mixed RNAV/ n?n-RNAV equipped), performing ?n a dedicated ATS RNAV route network in a uniform airspace structure (with n? upper/lower division).

Types of flights concerned:
? ll IFR flights operating as GAT, in conformity with the procedures of the ICAO.

Note: State aircraft (as defined by the Chicago Convention) are exempted.



What does B-RNAV offer?

The introduction of B-RNAV operations in ECAC airspace will provide a number of advantages over the conventional ground-based navigation whilst maintaining existing safety standards. These advantages and their related benefits include:

- improved management in the flow of traffic by repositioning of intersections;
- application of the Flexible Use of Airspace (FUA) concept, permitting the establishment of:

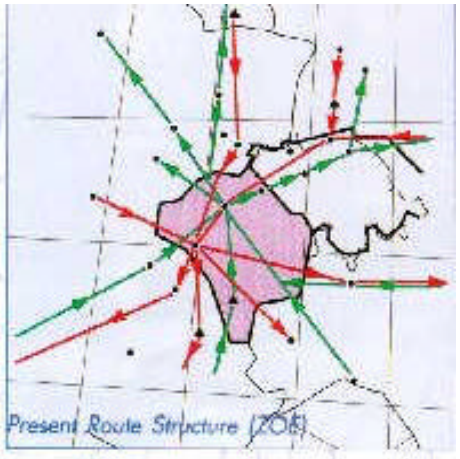
1. more direct conditional routes (dual or parallel) to accommodate a greater flow
2. of en-route traffic;
3. alternative or contingency routes on either a planned or an ad hoc basis;
4. establishment of optimum locations for holding patterns;
5. optimised feeder routes (SIDs and STARs);

- reduction in flight distances resulting in fuel savings;
- reduction in the number of ground navigation facilities.

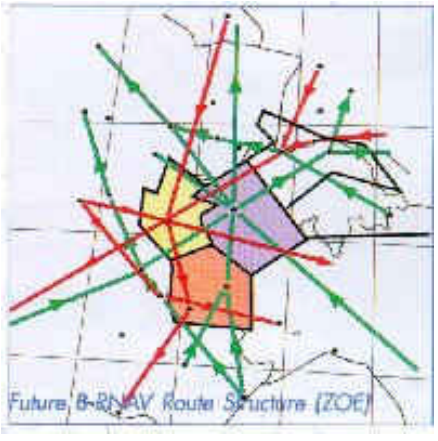
All these are easily achievable, as one of the main objectives of this initial application of RNAV has been to ensure that **full use** is made of the already existing on-board RNAV systems. Many of them have been fitted for some time and are capable of performance better than RNP 5 accuracy. The requirements were therefore established such that they could be satisfied by the majority of existing types of RNAV equipment and full benefit was derived from their capabilities.

Simulations demonstrated that capacity gains up to 30% can be achieved only by a uniform application of B-RNAV, in parallel with the revised ATS route network and the implementation of the FUA concept.

Present Route Structure



Future B-RNAV Route Structure



What will happen when B-RNAV is implemented?

B-RNAV Route Network:

Initially, the regional route network will continue to bear a strong resemblance to the existing structure. However, RNAV will make it possible to modify the hitherto fixed route network in order to remove bottlenecks and to introduce additional routes because aircraft will no longer be required to overfly ground navigation aids. The principles and criteria for designing the new route network are set out in EUROCONTROL document: "Concept and Criteria for Medium-Term European Route Network and Associated Airspace Sectorisation/ARN Version 3".

The safety analysis (EUROCONTROL studies) has demonstrated that, in the ECAC area, in a B-RNAV environment, route spacing requirements will remain unchanged from those set out in ICAO Annex 11 for VOR defined routes. National Administrations are required to publish the coverage and to notify the status of their navigation aids and to have the WGS-84 geodetic reference system in place throughout their FIRs/UIRs. Manufacturers, operators, and data base suppliers, are responsible for ensuring. the RNAV systems transition to the WGS-84 system on or prior to the 1st of January 1998.

Operational Procedures

The specific RNAV procedures have been incorporated in ICAO Doc 7030/4 Ed.1997, Para 14 - 'Procedures for Area Navigation (RNAV) Operations'*

Airworthiness Procedures

The procedures for obtaining approval for operations in B-RNAV airspace are detailed in "TGL-2 - 'JAA Guidance Material for the Airworthiness Approval of Navigation Systems for use in European Airspace designated for Basic RNAV Operations". The document provides references to the detailed capability requirements which will enable manufacturers, operators and national administrations to grant RNAV certification and operational approval.

On-Board Requirements

Aircraft operating in RNAV airspace shall be equipped with, as a minimum, B-RNAV equipment providing a system use accuracy equal to, or better than, ± 5 NM (±9.26 Km) for 95% of flying time**. For the period until at least 2005, or until such a time as VOR, DME or NDB facilities cease to be available, the carriage of a single RNAV system meeting RNP 5 accuracy but not meeting the above continuity of service requirements may be approved for B-RNAV operation if the aircraft is also carrying VOR and DME equipment.

ATC Training

The relevant State Authorities are responsible for ensuring that adequate provision is made for the training of air traffic controllers in RNAV operations. From the ATC point of view, the traffic handling along B-RNAV routes will show little difference from traffic handling on routes defined by VOR/DME (conventional ATS routes). It is likely, therefore, that the requirement for additional specific ATC training will be minimal. The revised route structure will be designed to ensure that ATC workload is not increased and where possible it is reduced in spite of increased traffic.

The introduction of systematic RNAV operations off ATS routes (Random RNAV), projected for 2002, may, however, introduce significant changes to ATC operating procedures which wouldmake additional training necessary (EUROCONTROL Standard refers).

Flight Crew Training

It is the responsibility of the appropriate National Administrations to approve the operators RNAV training programme. The programme should ensure that the pilots have a thorough understanding of the equipment and the necessary operational procedures.

Should the flight crew have reason to believe that their RNAV equipment is no longer capable of maintaining the required level of accuracy and integrity, they should advise ATC.

Unlike conventional navigation which requires only the ability to follow tracks defined by a ground navigation aid, RNAV additionally requires a knowledge of the navigation aid coordinates and coverage, and the coordinates of the waypoints defining the route. Both are mission critical and their availability needs to be verified in accordance with RTCA Do2OO/ EUROCAE ED76.

***Note:** In the unlikely event of the RNAV system no longer being able to maintain the required level of navigation performance the pilot shall advise the ATC.

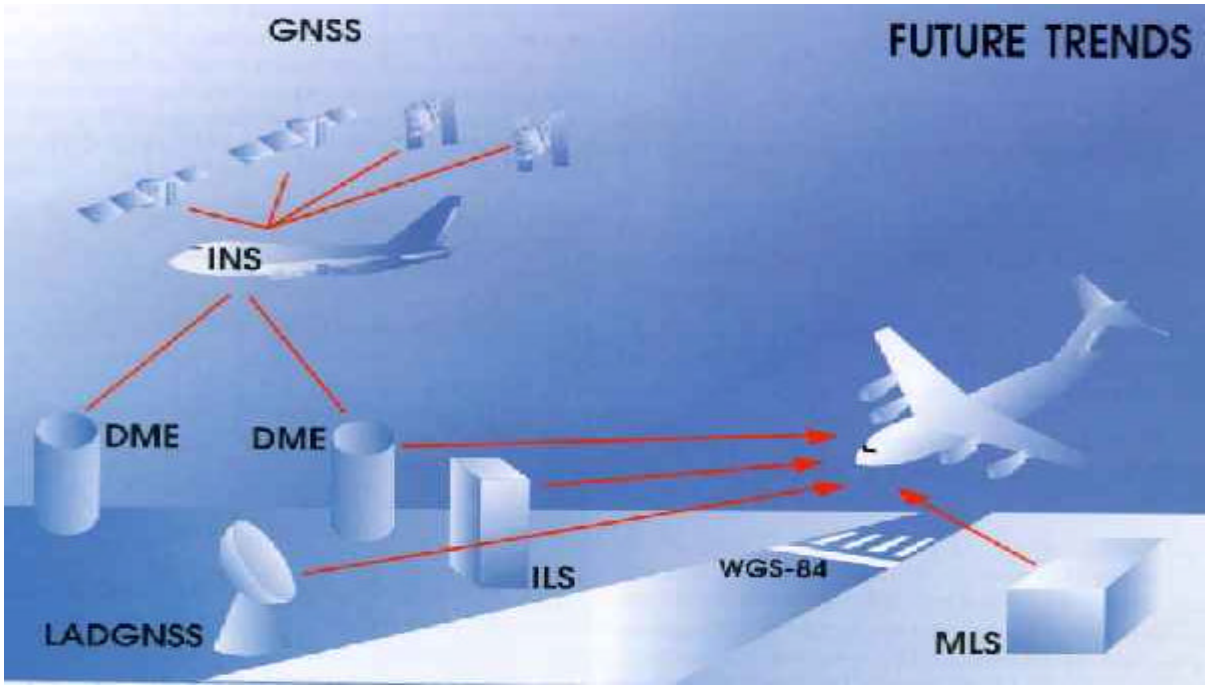
****Note:** Aircraft performing to RNP 5 navigation accuracy but not equipped with B-RNAV approved

What follows after B-RNAV?

It should be noted that whilst only B-RNAV is required for en-route operations, this minimum system may not be suitable for terminal operations (where P-RNAV will be required for many RNAV SIDs and STARs). It is also expected that some of the simpler equipment available today to meet the B-RNAV requirements will not be suitable for operation post-2005, once VOR starts to be removed and the reversion to conventional operations in the event of RNAV failure is no longer possible.

Whilst the present applications are restricted to 2D RNAV, as capacity benefits can be demonstrated, they will extend to 3D navigation, enabling profile management to be employed and a resulting modification to the structure of TMA. Ultimately full 4D (3D plus time) is expected to be required in accordance with the proposed developments within the air/ground integrated ATM environment of the future European ATM System(EATMS).

It is anticipated that a decision on the mandatory carriage of RNAV equipment meeting RNP 1 requirements (±1 NM 95% of flight time) will be made by ECAC Member States in 1998. A transition from ground to space based navigation infrastructure is expected. However, the implementation of RNP 1 RNAV is not foreseen before 2005.



List of abbreviations:

ARN: ATS Route Network
ATC: Air Traffic Control
? ? ? : Air Traffic Managemenr
ATS: Air Traffic Services
? -RNAV: Basic Area Navigation
DME: Distance Measuring Equipment
ECAC: European Civil Aviation Conference
FEATS: ICAO Future European Air Traffic Management System
FIR: Flight Information Region
FUA: Flexible Use of Airspace
GAT: General Air Traffic
GNSS: Global Navigation Satellite System
GPS: Global Positioning System
ICAO: International Civil Aviation Organization
IFR: Instrument Flight Rules
INS: Inertial Navigation System
JAA: Joint Aviation Authorities
LADGNSS: Landing GNSS
LORAN-C: Hyperbolic Navigation System
MASPS: Minimum Aviation System Perfo?mance Standards
MLS: Microwave Landing System
NDB: ? ?n Directional Beacon
?-RNAV: Precision Area Navigation
RNAV: Area Navigation
RNP: Required Navigation Performance
SID: Standard Instrument Departure
STAR: Standard Arrival Route
? ? ? : Terminal Cont?ol Area
TGL: Temporary Guidance Leaflet
UIR: Upper Flight Information Region
VOR: Very High Frequency Omnidirectional Radio Range
WGS: World Geodetic System

If you want more details:

- ICAO Annex 11 - "Air Traffic Services", 1994
- ICAO Doc 9613-? ? /937 - ? anual ?n Required Navigation Performance (RNP);
- ICAO PANS-RAC Doc 4444 - "Rules of the Air and Air Traffic Services", 1985
- ICAO Doc 7030 - "Regional Supplementary Procedures", 1987
- ICAO Doc 8168 - "Procedures for Air Traffic Services - Aircraft Operations (PANS-OPS)
- SPECIMEN AIC - Implementation of ? -RNAV in the Airspace of the Member States of ECAC;

- EUROCONTROL Doc 003-93 - Area Navigation Equipment - Operational Requirements and Functional Requirements;
- Implementation Strategy of the Future Air Traffic Management System in the European Region (FEATS), 1990
- ECAC Strategy for the 1990s- Relieving Congestion ?n And Around Airports, 1992
- TGL-2 - "Advisory Material for the Airworthiness Approval of Navigation Systems for use in European Airspace designated for Basic RNAV Operations", 1996;

RTCA. Do236/EUROCAE ED75 - Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation, 1996