Dnav: What's so different about it

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"Kennedy Clearance, Ransome 701 IFR to Washington National with Hotel."

"Ransome 701 cleared direct Washington National. After takeoff climb on course to 14,000. Expect Runway 33 at Washington to land at 1118."

"Kennedy Clearance, United 419 IFR to Chicago O'Hare with Hotel."

"United 419 cleared direct O'Hare. After takeoff climb on course to Flight Level 350. Expect Runway 4 Left at O'Hare to land at 1253."

DOES THE above exchange sound like a far-fetched dream? Being cleared direct from the departure runway to the destination runway, with a climb direct to cruise altitude, is surely nonsense. And then receiving an expected landing clearance is really stretching the limit. Or is it? Consider Dnav, a new aviation abbreviation representing the "database navigation system."

As Rnav systems become more sophisticated, applying the Rnav label to all area navigation systems causes much confusion. Coming upon a flight plan with the R suffix, ATC cannot tell whether the aircraft has a basic two-waypoint Rnav, an Omega/VLF or a GNS1000 with an NDB2 database. There is a big difference in your actual navigation capabilities depending on which system you have.

Prior to the installation of the Bendix Series 3 equipment in Ransome's Citation (October 1983 *Pro Pilot*) I used the Foster 612, a five-waypoint Rnav. Many times I asked for and received Rnav direct to a point 400 to 500 nm from my then present position, but it took considerable work to compute the Rho/Theta numbers for receivable VORs in relation to the final destination. Other aircraft need to find and plug in latitude and longitude, while still others need only type in the airport or VOR identifier. It's this last type of equipment that I refer to as Dnav.

Dnav is a multisensor navigation system that has a full alphanumeric keyboard, automatic nav radio tuning, course slewing, steering command, accurate groundspeed and wind information outputs, a large internal database and the affordability to be utilized widely. This internal database has continental VOR coverage.

Dnav uses the most accurate form of navigation available. The hierarchy for enroute navigation starts with VOR/VOR at the low end, then moves up to VOR/DME, VLF, Omega, Loran C, DME/DME and finally GPS, depending on the Dnav's sensor capability. For approaches the system uses ILS and, in the future, MLS, the most accurate sensor there is. Capabilities obviously depend on the sensors available to the Dnav plus the Dnav's configuration and ability to receive information.

Dnav could conceivably encompass all database navigation systems. This could progress from the Foster LNS616 to Universal Navigation's UNS1 to one of the expensive Sperry Flight Management Systems used in the Boeing 767 and other large aircraft.

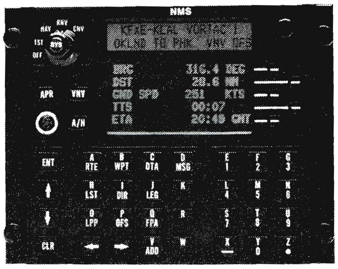
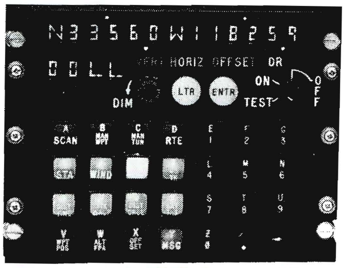
But only the systems that meet all the criteria will be considered here. The five systems outlined on the accompanying chart conform to the previous Dnav definition, especially the affordability requirement, which is the most important factor for widespread use and precludes the inclusion of many highly capable but costly systems. These systems also have enough growth potential to add functions like MLS, GPS, 4D and performance computer compatibility necessary in the future airspace system.

Navigation redefined

The proliferation of these new Dnav systems inevitably will change the way pilots navigate, though the transition may take place slowly. One main factor in utilizing this new airborne technology is the revamping of the air traffic control system. This reorganization, scheduled to take place over the next 10 to 15 yrs, will require new ground computers, software and procedures.

As this new equipment is purchased and procedures are formulated, aircraft hopefully will be cleared by the most efficient routing. The ideal routing would entail turning on course after takeoff direct to the expected destination runway. Though this "ideal" routing will probably never materialize, we can come very close. Departure clearance probably will be pretty much on course, but arrival clearance will have to be off the ideal slightly to allow for merging of all inbound traffic

Database Navigation Systems (Dnav)

System	 Bendix NMS46	 Garrett AiRnav 400
Availability	March 1984	Currently available
Basic system cost	$16,840	$40,000
Basic nav sensors	VOR/DME, DME/DME	VOR/VOR, VOR/DME, DME/DME
Basic nav modes	Great circle, flat earth	Great circle
Options	Rack mount capability, processor for non-Arinc 429 sensors	None
Database	Worldwide VORs	Worldwide VORs or a more detailed regional database
Update method	Light wand	Cassette tape
Update cost per month/ Source	Approx $200/Jeppesen	$191/Garrett
Performance computer compatible (present/future)	No/Currently being evaluated	No/No
4D capable (present/future)	No/Currently being evaluated	No/No
Additional sensor inputs	VLF/Omega, Loran C, MLS	VLF/Omega, INS, Loran C
Data interface	Arinc 429, Arinc analog	Arinc 561 & 571, Arinc analog
Waypoint/Route storage	200/85	40 wps per route with capability in excess of 200 routes
Main processor	Intel 8086	AiResearch RF20
% of total computer capacity currently being used	48%	75%
Vnav/Offset capable	Yes/Yes	Yes/Yes
Usable display area	2.4" x 1.8" CRT	17 character incandescent

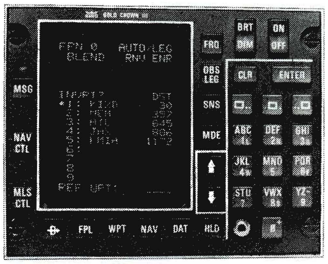
and for runway alignment.

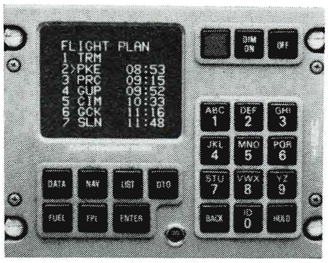
But why the new term Dnav? What makes this new equipment so different that it requires a new name? Typically Dnav equipment is much like current long range nav systems (Lnav) but is considerably easier to use. The alphanumeric keyboard and display screen, backed up by the VOR database, provide a system easily understood by both pilots and controllers. (I know I don't think in lat/lon coordinates and I doubt if many pilots or controllers do.)

Additionally controllers need to know the aircraft's intended course through their sectors. The local VOR inputs plus the new ATC computers and software will provide this information. These may seem like small points, but they make a big difference in the integration of air traffic within the current and future airspace system.

What ATC needs is for the pilot to maintain the navigation path as cleared. What the pilot needs is to be able to accomplish this without errors or undue effort. Dnav can accomplish both these tasks.

According to my definition Rnavs use local area VOR systems tuned by the pilot. They require the pilot to flight plan and then program the waypoints along the route and tune in the proper VORs. Long range navigation systems require initializing and programming of lat/lon, plus the difficult task of converting the aircraft's present position to local VORs for ATC purposes. Both Rnav and Lnav systems require steps which are cumbersome and ripe for





King KNS660	Sperry FMZ604	UNS1
April 1984	October 1985	Currently available
$25,000	Approx $35,000	$40,000
VOR/DME, DME/DME	VOR/DME, DME/DME	DME/DME
Great circle, flat earth	Great circle	Great circle
VLF/Omega, split alphanumeric keyboard	Expanded database	Expanded database
VOR, runways, intersections, runway ends, etc. Although available for the world on an update disc, aircraft memory can only hold regional info. Additional regions must be loaded if required.	Worldwide VORs and runways over 4000 ft or a regionalized database with more detailed information.	Worldwide VORs and airports with 4000-ft runways
Floppy disc	Floppy disc	Light wand
Approx $100/King	To be determined/Sperry	$85/Universal Navigation
No/Currently being evaluated	NA/Yes	No/Currently being evaluated
No/Currently being evaluated	NA/Yes	No/Currently being evaluated
VLF/Omega, Lasernav	VLF/Omega, GPS, IRS, MLS, TACAN, Loran C	VLF/Omega, IRS, Loran C
Arinc 429, Arinc analog	Arinc 429, Collins Pro Line 2 Buss	Arinc 429, Arinc analog
800/80	990/80	750/100
Zilog Z8002	Intel 8086	Zilog Z8010
75%	NA	50%
Yes/Yes	Yes/Yes	Yes/Yes
3.1" x 2.5" CRT	2.5" x 3.9" CRT	2.5" x 2.0" CRT

errors. These difficulties, along with ATC's reluctance to clear flights direct because of coordination problems, have really slowed the development and therefore the benefits of these types of systems.

It's human nature to use the simplest procedure available—or at least the simplest procedure that one understands. This fact has been evident in Ransome's Rnav program. On the pilot side, the easier it is to access and use the JET DAC7000 Rnav system, the more the system is utilized. The more use it gets, the more familiar the pilots and ATC become with its capabilities. The more familiar everyone is with its capabilities, the more direct clearances are received.

On the ATC side, controllers were initially reluctant to clear Ransome's Dash 7s for direct routings or simultaneous approaches and if things got busy, the controllers put the Dash 7 in line with everyone else. This becomes less of a problem as controllers gained confidence that the Dash 7s would maintain the programmed course. But direct routings are difficult, especially in the northeast corridor, due to coordination requirements along the route.

The new computers and software should solve the coordination problems now encountered, however. Hopefully this new ATC equipment will finally allow for separation of airplanes from airplanes and not airplanes from airspace.

What can today's Dnav system do for you, what are its general characteristics and basically how does it work?

First of all it really doesn't matter what navigation system the Dnav is operating from, be it VOR/DME, DME/DME, GPS, Omega/VLF or Loran C. All the pilot need really care about is that he is navigating correctly and can readily determine the aircraft's present position.

Let's take a hypothetical trip from PHL (Philadelphia) to PIA (Peoria IL). The characteristics of the Dnav on this trip are generic in nature and don't reflect any particular equipment brand. The comments refer to what should be possible in the next couple of years.

The first thing required is the flight plan. With a little work this could be done on a personal/business computer. Some of the computers will provide the flight plan for you, but if access to the aircraft prior to filing is difficult, the new ProStar navigation computer from Jeppesen is an inexpensive and excellent aid. The ProStar allows programming the lat/lon coordinates of PHL and PIA to find a great circle route. Then by programming the lat/lon of VORs every 100 nm along the route, you can get the local VOR Rho/Theta information for filing purposes.

As an aside the new ProStar, although seemingly expensive at $225, is worth the price. This computer will quickly pay for itself in fuel savings when used by itself or in conjunction with a normal Rnav. I recently used it to get a direct routing between two VORs 445 nm apart without having an Rnav on board or struggling with charts or plotters. I had the correct heading and course in approximately 1 minute while in flight.

Once filed, the next item is to get the Dnav system up and ready. This is a relatively painless procedure which involves little more than turning it on. The computer will run a quick self test to assure that the system is operating properly. Then all that is needed is to verify that the system is still at the same position (ie, airport) as it was when last turned off.

Next type in the destination VOR or destination airport, or the destination airport defined from a local VOR. (VOR Rho/Theta information for airports is found in the Rnav section of the Jeppesen plates.)

In the air

Unfortunately PHL clearance only gives you "Cleared to PIA after departure (Rwy 27), maintain runway heading, vectors Modena (MXE), Modena 270 radial to intercept J-110 to Bellaire (AIR), then direct PIA, maintain 2000, expect FL350 10 minutes after departure."

Once initialized and positioned the Dnav can begin its navigational task, accurately determining the correct great circle course to any point in the world. Also the Dnav can now locate local VORs in order to navigate as accurately as possible. Because PHL has no receivable VOR on the field, the system will search until airborne to find a receivable navaid.

Just after leaving ground the Dnav commands the navigation radio to tune Woodstown. Using Woodstown VOR it updates its position using VOR/DME information while simultaneously searching for and tuning Yardley DME. Upon receiving Yardley the Dnav switches modes to DME/DME navigation, giving a highly accurate aircraft position. Once cleared direct to MXE the pilot keys in MXE and pushes the Direct command. The system computes the position of the Modena VOR and slews the CDI on the pilot's HSI to the proper course, even though not using MXE for navigation.

After MXE, climbing through FL330, the pilot negotiates with New York Center for direct KPIA. This may be stretching ATC's current capabilities, but the more we request and use the direct routings, the more ATC will structure the procedures to provide them. The pilot types in PIA 97.8/4.7 (Peoria airport defined by the Peoria VOR) and defines it as KPIA waypoint, or just types in KPIA depending on the database. Pushing the Direct entry starts the Dnav system searching for PIA from its database and plots KPIA internally with lat/lon coordinates. This information is used to compute the great circle routing to KPIA. The CDI slews automatically, providing course information on the pilot's HSI.

Typically the Dnav system works by setting up a geographical area around its position. This area is approximately a 150-nm to 200-nm circle around the aircraft. It pulls all the VORs in this circle from its memory so they are readily available for use. The system then continually recalculates the VORs to automatically tune for the best DME/DME navigation. If the desired VOR is off the air, a new one is tuned automatically. If dual DME reception is lost, the computer uses the next most accurate available sensor, VOR/DME in this example. The computer does all its calculations in lat/lon coordinates although it usually won't display this information unless asked.

Enroute a Pirep requires giving present position. A quick push of a button shows present position defined from a local VOR, although it may not be currently in use for navigation. Also, the groundspeed allows accurate fuel and time enroute calculations.

Around Rosewood thunderstorms force a 30-nm north deviation. The pilot quickly sets up and flys a 30-nm offset to the present great circle course. Once clear the pilot receives direct KPIA from ATC, recalls the KPIA waypoint direct and again receives the shortest route from present position to KPIA.

After receiving ATIS the pilot sets up for a visual approach to Rwy 30. This is easily done by defining a new waypoint from KPIA. Simply use the destination waypoint of KPIA to define the KPIA 120/3.0. This will set the aircraft up on a 3-nm final to the correct runway. If the pilot links the two waypoints together, the Dnav will automatically slew the CDI to show final approach course guidance on the pilot's HSI. This should prevent pilots from landing at the wrong airport.

What's next?

Manufacturers are feverishly working to upgrade the capabilities of present Dnav equipment. These added capabilities will allow 4D navigation, use of a performance computer and more control of the aircraft through a single control display unit. In fact Dnav is probably the most important piece of avionics equipment in the new integrated cockpit concept.

Second generation Dnavs will integrate with any sensor available and ensure that the aircraft arrives at the runway end at a specific time, while using the least amount of fuel possible. Setting up minimum fuel or minimum time to destination will be easily accomplished through the Dnav control head. Since the navigation computer knows the routing, it is the natural control computer over the performance calculations.

The whole objective of Dnav is to provide the safest, easiest, most accurate and most efficient navigation system possible. By using alphanumerics the pilot has much less potential for inputing erroneous data. The point the pilot is cleared to is exactly what is inputed into the computer and exactly what is on the charts. No more typing strings of numbers or filling the cockpit with charts to determine the proper course. Two or three inputs for an entire flight will provide complete navigational guidance. If the jet routes are assigned, the pilot can easily input these points as a string of alphanumeric waypoints.

The ideal routing described earlier is very possible and certainly desirable, though to achieve it will take considerable work by pilots, controllers and their respective managements. The airspace system will change rapidly in the next 10 yrs. Let's make sure it's a change for the better.