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Back then we thought we were pretty sophisticated! Not by today's standards, but with the technology that was available then, maybe we were. Back in 1968, just the idea of not having to fly over nav aids on an IFR cross country was brand new. Narco first sold their CLC-60 RNAV computer in 1968 and it was an amazing tool. It worked, but there was a lot of effort to create an RNAV flight plan. To create each waypoint, the bearing and distance had to be computed or plotted so the RNAV system knew where to electronically move a VORTAC.

That first RNAV computer used the existing VOR and DME receivers in the airplane as its input and then the user entered the radial and distance where to move the VORTAC. In the first RNAV computer, the system allowed an offset of only 42 nautical miles, but it was a computer which could be used to create and fly direct routes without having to fly over any existing nav aid facilities.

This concept was so new, the use of RNAV would also create interesting discussions with controllers. While en route, there were times you wanted to go to an intersection via present position direct and the controller would ask, "Can you really do that in that little airplane?"

## Off-Airway Navigation

In the previous article, we discussed flying shorter distances by flying off the airways. There are two series of Jeppesen charts that can be used to draw direct routes. The Jeppesen high and low altitude enroute charts are one of the ways to make it happen. The easiest is the RNAV enroute series which uses 11 charts to cover the entire U.S. Most of these charts are drawn to a scale of 30 nautical miles to the inch, so it is easy to place adjacent charts next to each other and have a straight line go across more than one chart. The Area Navigation Enroute Charts were first published in 1968 when Narco introduced their CLC-60 RNAV computer to the marketplace.

To look at the charts in a way they would typically be used, let's look at a flight from Centennial Airport just southwest of Denver, Colorado to Westcliffe Airport toward the bottom of the illustration.

For most airports on the chart, there is a tabular listing in front of the chart subscription series that gives detailed information for establishing a waypoint at an airport. As an example, look at

## The Chart Clinic – Tenth in a Series

the entry for Centennial. It lists the airport as "CENTENNIAL/DENVER" to include both the airport and city name. To the right of the airport name is the airport elevation of 5,880 feet. The next line includes Centennial's coordinates for those systems which can use coordinates but do not have a stored database of airport coordinates. To the right of the coordinates is the airport identifier.

CENTENNIAL/DENVER		APA	5880
N39 34.2	W104 51.0		
116.3	FQF	224.9/12.8	5789
115.4	BJC	135.8/24.5	5730

Following the coordinates are two VORTACs or VORDMEs that are within 40 nautical miles of the airport with the bearings and distances to the airport reference point (ARP). At Centennial, the two nav aids and their bearings and distances are Falcon (FQF) and Jeffco (BJC). With the RNAV systems that electronically move VORTACs, a waypoint can be created at Centennial by tuning to FQF's frequency of 116.3 and setting the bearing to 224.9° and the distance to 12.8 nautical miles and activating the RNAV function. Some RNAV systems have the ability to input the VORTAC elevation to automatically compensate for the DME's slant range distance. For those systems the FQF elevation of 5,789 feet would be entered.

Note that Jeffco is listed as the second nav aid but it is not the second closest VORTAC to Centennial. The second nav aid is selected for the listing at a location that may provide a better nav aid if approaching from the west rather than having both VORTACs located very close to each other.

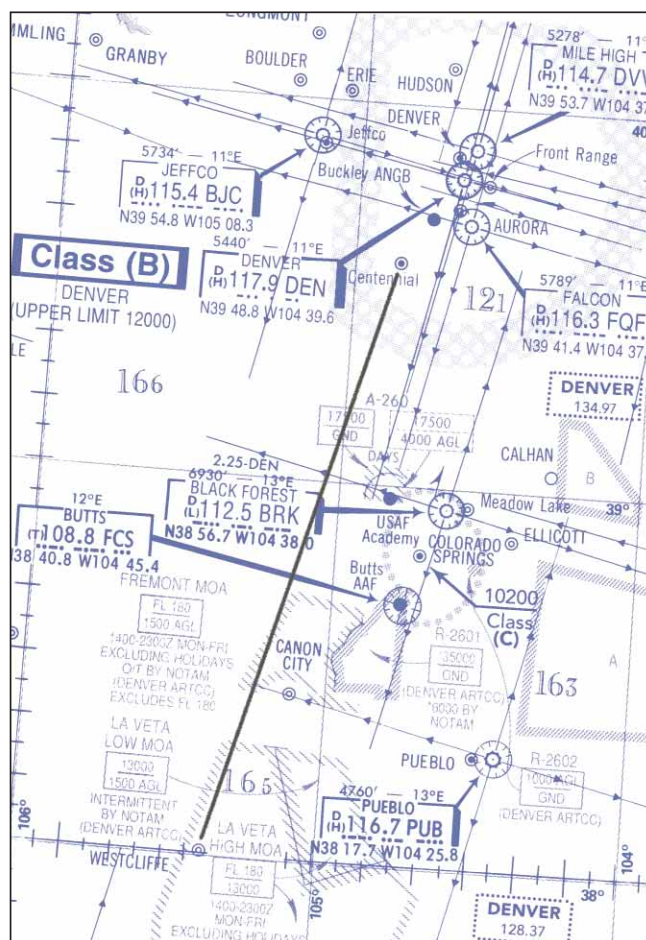
Since the flight is going to the south, the best nav aid to tune when departing Centennial Airport is the Falcon VOR because it is the most southern of the nav aids that are within reception range. Before departure, you would tune the VOR frequency to 116.3 MHz and enter 224.9 degrees and 12.8 NM into the RNAV computer. The magnetic course to set from Centennial is 185°. With the RNAV set up this way, you would fly with a FROM indication when departing Centennial.

There is another method for determining the RNAV bearing and distance offset that works better if the RNAV has a distance capability of 199 nautical miles or more. Since Westcliffe Airport is not that far away, you could calculate the bearing and distance from FQF all the way to Westcliffe and be able to depart Centennial with a TO indication and the distance to

go would read the distance remaining to the Westcliffe. Since the bearing and distance from FQF to Westcliffe is 185° and 106.6 NM, these values set into the RNAV make it much easier to fly the route. Typically when departing an airport, the departure pattern is not on a straight line out of the airport. With the destination set in the RNAV, as soon as you are out of the pattern, you can set in the bearing to Westcliffe and that becomes the new magnetic course. *It's easier this way!*

## Determining Magnetic Courses

The magnetic course from Centennial to Westcliffe can be determined by a number of methods. The easiest method, of course, is a computer flight planning software package. But, since that is not always convenient when sitting at the airport or in the airplane, there is a Jeppesen plotter included with the RNAV charts that can be used to plot the course. If there is a GPS receiver in the airplane, the destination airport would be set in the GPS receiver and the magnetic course is automatically computed. In the VORTAC RNAV systems, the course has to



be pre-determined and set in the course selector before departing the airport to provide course guidance right after takeoff when the VOR is within navaid reception range.

Since the Falcon VOR can't be used for the *entire* flight, you will need to tune to the next VOR sometime after leaving Centennial. The first RNAV waypoint is easy to determine by looking at the route of flight and the location where it crosses the 270° radial of the Black Forest VOR. There are four cardinal compass points on the VOR which have radials extended 40 nautical miles from each VOR. The 40 miles is based on the FAA's service volume for "L" class nav aids. Even though the VORs can be electronically moved much farther than 40 nautical miles, the reception range still is 40 NM for "L" class nav aids. The service volume of the different classes of nav aids is shown in a graphic on the RNAV charts.

On each of the four extended radials of the VORTACs, there are small tick marks spaced at 10 nautical mile intervals. By looking at the route of flight, you can see the route crosses the 270° radial at 19 miles. You can create a waypoint by tuning to Black Forest on 112.5 MHz, setting the RNAV bearing to 270° and the RNAV distance to 19 NM and engaging the RNAV function. When filing the flight plan, the waypoint description would be written as BRK270019.

For the **altitude** on this flight, it is easiest to use the grid MORAs (minimum off-route altitudes) that are included at one-degree intervals. There is a number just to the east of Centennial Airport which contains a large number "12" and the smaller number "1." This MORA indicates the minimum flight altitude of 12,100 feet which will clear all terrain and obstacles by at least 2,000 feet. We will discuss more details regarding altitudes in the next article.

## Long-Distance Flights

One of the most important items on the RNAV charts is the graphic portrayal of the special use airspace (SUA). One of the biggest problems in creating a direct route is trying to determine if the route will go through a prohibited or restricted area or MOAs. For most direct routes, the chances of going through special use airspace are good. The FAA says that all direct routes should be planned to avoid prohibited or restricted airspace by at least three nautical miles. If a bend in a direct route is required to avoid SUA, the turning point needs to be part of the flight plan.

For all random RNAV flights, there needs to be a least one waypoint in each ARTCC through whose area the random route will be flown. These waypoints must be located within 200 NM of the preceding center's boundary. When specifying these waypoints, they can be communicated in the flight plan using the frequency/bearing/distance format or latitude and longitude. All aircraft flying with latitude and longitude systems flying above FL 390 must use latitude and longitude to define the

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turning point. The format for latitude and longitude is four numbers for the latitude and five numbers for the longitude separated by a forward slash "/." As an example, a turning point at N39° 28.0' W104° 54.5' would be stated as 3928/10455 on the flight plan.

In the next article, we will look at the high altitude charts and some international charts.



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