The Chart Clinic – Database Series

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Just imagine. Flying an approach where all the autopilot commands for heading select, VOR radial capture, descent to preset altitude, course capture, nav tracking, etc. are already in your database for your approach. And — what if not only all the autopilot commands were there, what if all the exact courses and altitudes were already there for your approach. You may ask, "Is that possible?"

Just thinking about that possibility, you can imagine that sometime in the way-out future, all that could be carried on board your airplane. But — the reality is that all of those autopilot commands are in the database and have been for some time. Today, all of the track and altitude information with the commands for the autopilot are there for virtually all the approaches, SIDs, and STARs in the world.

As a caveat, even though all the segments and approaches are in the master database, not all avionics systems have created the ability for all of the segments to be in airborne database. Additionally, not all autopilots have the connection to the avionics systems to implement all the commands.

Again, you ask, "How does all that work?"

Paths and Terminators

When RNAV was first introduced, the avionics systems only flew from point to point. This meant that every flight had to fly to a fix for every maneuver for an approach or other procedure. That eliminated the ability for an airplane to fly exactly the instructions prescribed in published approach procedures, DPs (SIDs), and STARs. As an example, the first systems were not able to fly a heading to an altitude before making a turn. And as you know, it is very common for departures from runways to maintain runway heading until you get to an altitude to clear obstacles or other ATC instructions to keep you separated from airspace used by other aircraft. It also was not possible to fly a heading or magnetic course until intercepting the next leg such as an airway or the inbound course for final approach.

In about 1977, a new concept was developed for database and airborne capability. It was called "air mass legs." This meant that the new systems would be able to fly exactly what was on the chart and what ATC wanted for departure and arrival procedures. ARINC 424, the worldwide navigation database standard, was revised in version three to enable navigation systems to fly without regard to predetermined fixes; but, in the same way they would be flown if the pilot was to do it all manually. Version three now made it possible for the navigation data to be loaded into the airborne systems and fly the procedures automatically with the flight management systems and the autopilot.

What is a path/terminator? In the simplest of terms, it is a means of prescribing the way in which a path is to be flown, and how the path is to be terminated. For every path/terminator, there are two characters in the database, the first column specifies the path to be flown and the second column specifies how the path should be stopped. As an example, the letters "CI" indicate that the equipment should *fly a course* and that it should *end when the next path is intercepted.*

In all, the ARINC 424 document has a total of 23 path/terminators. To implement all 23 path/terminators takes an incredible amount of programming for airborne avionics. As you can imagine, the number of implementations is much larger when you consider that each of the 23 path/terminators could be followed by each of the other 23 path/terminators. It is really significant when you know that most of the avionics systems actually are working with two path/terminators at a time because the next path/terminator has to be in memory for activation by the autopilot when the existing leg is completed. This requires significant programming and therefore not all avionics systems carry all of the path/terminators. Additionally, ARINC 424 document does not allow all legs to follow all other legs.

Track to a Fix (TF) Leg

The most common leg segment type is one that has been implemented in all avionics systems that have an aeronautical database. It is the great circle track between two fixes. In pilot "talk" that means the magnetic course between fixes. This path/terminator is called track to a fix and uses the letters "TF" in ARINC "talk." The TF leg starts at a fix and then proceeds direct **TO** the next fix via the track connecting the two fixes.

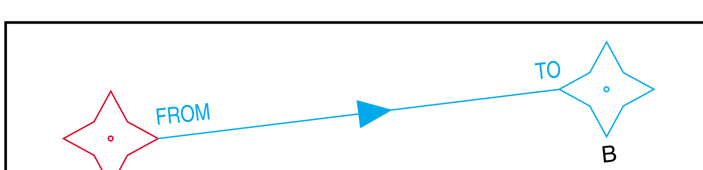
All airway segments in all databases are TF legs. This means that every turn point on every airway must be a fix in the database. And — each fix needs to have an identifier in the database. That is why you see so many computer navigation fixes (CNFs) on the enroute charts. Most intersections on the charts have names assigned to them that are used in pilot/controller communications, but those fixes not required for ATC communications show the name/identifier in brackets on the enroute charts. The CNFs are used for navigation only and are not part of the pilot/controller conversations.

From a navigation standpoint, as soon as any fix is passed, the navigation system switches to the next waypoint and then proceeds **TO** that next waypoint. You've noticed that I have emphasized the word **TO** a couple of times. Compared to VOR navigation where you frequently fly from the VOR until passing the cross over point, using the TF leg in airborne databases, you will never fly from a waypoint, but will always fly **TO** a waypoint. This means you *won't have diverging* tracks from a fix but will *always have converging* tracks to the next fix. Even though the outbound course from the previous fix is not used for navigation, in some avionics systems it is included in the database to display the published radial from a fix such as a VOR.

One of the advantages of the TF leg is that the magnetic variation makes no difference to the resultant track. One of the problems with some types of navigation is that there is an attempt to use magnetic variation to produce the magnetic course from a computed true course and then apply magnetic variation. That may sound good, except, if the magnetic course used by the avionics is different than that used by the government authorities who design procedures, the resultant magnetic course shown in the airplane will be different than on the chart which reflects the government values.

Because of the accuracy of the TF leg, the FAA specified that all final approach segments will be created using the TF leg. This ensures that all approaches will fly toward the landing runway (or missed approach point if not on the runway). This also helps the FAA ensure that there will not be any track differences because of magnetic variation.

The TF leg is one of the few legs that are allowed for new procedures that is designed for RNP RNAV. RNP (required navigation performance) is the new means used by ICAO and many countries to specify a type of navigation accuracy.



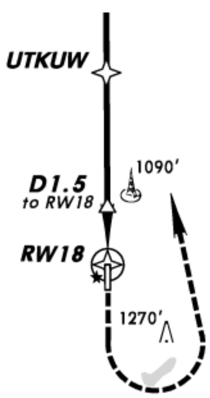
Track to a Fix (TF)

Fly-By Fixes

Technically, all fixes in the enroute environment are fly-by fixes. This means that when making any turns over a fix such as a navaid, waypoint, or intersection, you should start your turn before arriving at the fix. Another way of saying the same thing is that you should "lead the turn," or "anticipate the turn," and not wait until crossing the fix before initiating the turn.

In one sense the term "fly-by fix" seems a little misleading because when you fly over a fix on a straight line, you will fly over the fix and it might seem like that should be called a "fly- over fix." *By definition, a fly-over fix is one where there is to be no turn anticipation.* So when you fly over a fix on a straight line, turn anticipation is not relevant.

The only places where "fly-over fixes" are coded in the database are on SID (DP), STAR, and approach coding where the intent is to fly over a fix before making a turn. Whenever a fix is designated as a "fly-over fix," the fix will have a circle around it to positively identify the fix where turn anticipation is not allowed. The circle around the fix has been used in the United States since 1994 and is now the ICAO standard for fly-over fixes.



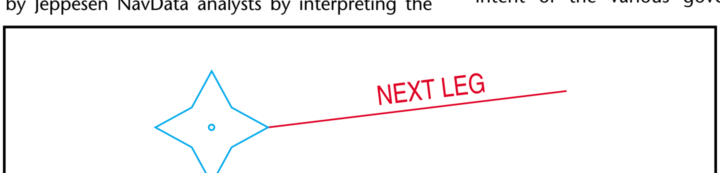
In the excerpt from the Fairfield, Iowa RNAV (GPS) approach chart, UTKUW is a fly-by fix and RW18 is a fly-over fix. At Fairfield, the fly-over fix at RW18 ensures your avionics doesn't start a turn before it passes over the runway threshold.

Initial Fix (IF) Leg

Since the TF leg is used to define the path **TO** the next waypoint (or fix), there must be a way to define the beginning fix for a leg segment. Since equipment that uses airborne databases doesn't work like setting an inbound course to a VOR, an "anchor" fix is established for the beginning of a leg.

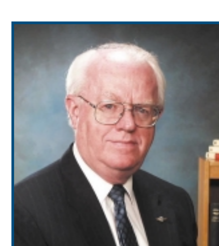
The leg segment is called an IF leg but really shouldn't be called a leg since it is a fix (initial fix) and not a defined leg. The "next leg" is shown with the IF leg (fix) for the purposes of illustration, but the next leg is not included with the coding of the IF leg in the database. It is only a point in space.

The determination of what leg types to code in the database for approaches, SIDs, and STARs is made by Jeppesen NavData analysts by interpreting the intent of the various government procedure designers who create the procedures.



Initial Fix (IF)

In the next article, we will continue the discussion of database leg types and the coding of SIDs (DPs), STARs, and approaches.



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