  

A NAVIGATOR'S TALES.

by OLE NIKOLAJSEN

When one as a passenger today flies over the Atlantic in a modern Boeing or the latest Airbus it is hard to imagine how such a flight was performed only thirty years ago.

Nowadays even the simplest of aircraft flying over the pond are equipped with sophisticated navigational systems and radios based on modern satellite technology. Most aircraft also fly so high that they avoid most weather which anyway has been thoroughly predicted.

In the late sixties the Royal Danish Air Force (RDAF) had the distinction (or maybe the pain) of being one of the last organisations to operate the Convair Catalina amphibian in its PBY-5A and 6A versions. These planes of 1938-40 vintage were mostly operated in the Arctic areas around Greenland and for such crossed the Atlantic several times a month.
The art of navigating is often defined of moving from A to B and knowing where you are in between all the time, but a Navigator usually did much more than that. He would be planning the flight in all details and prepare the documents like flight log and flight plans including points of no return and minimum heights. In the RDAF he would also supervise the loading of the aircraft and make the weight and balance documents. Then he would calculate fuel needs and instruct the Flight Engineer to fuel the aircraft. Together with the Aircraft Commander he would calculate take-off parameters. During the flight he would monitor and correct the flight path and prepare position reports for the Radio-operator to transmit every 20 minutes. If weather prevented further flight he would quickly prepare alternative routings or places of diversion.

Today the onboard computer does most of those things and the Navigator has been made redundant many years ago, shortly after the Radio-operator left the cockpit, but before the Flight-engineer was pushed out of his seat.

Navigating across the Atlantic or indeed over any stretch of water or un-populated land was based on one principle, the AIRPLOT. The Navigator would record, on a sheet of paper, mostly a chart, all the movements the aircraft made on its three axis, that is the height, the direction and the speed.

Today in a modern aircraft the computerised inertial navigation system (INS) does the same automatically.

After start he would mark a cross and the appropriate time on the chart, let us say at 10.00 hours, from there he would plot out a line in the direction the aircraft was flying. This information he got from his compass after having compensated for deviation and variation, that is inaccuracies of the compass and the earth's magnetic fields. He would then note the speed with which the aircraft was flying shown in nautical miles per hour also called knots. However, before he could use this he had to make a for the uninitiated complicated calculation compensating for the density of the air. This is caused by the height of the aircraft and the temperature of the air, so both had to be duly recorded. With a speed now at hand, let us say 120 knots (which was the cruising speed of a Catalina) he would plot out 20 minutes of flight on the line already on the chart, that is 40 N.M. He then makes another cross at this position and the time which is of course 10.20. This cross is called the Air Position and is where the aircraft is situated in the air after 20 minutes flight on a constant course (called heading by the Navigator) and with a constant speed, called true Airspeed. The Navigator now tries to establish his position over the ground, (if there had been no wind it would be the same as the Air Position) he could look out of the window, use various types of radio navigational aids, the observation of stars or the sun, ask a radar station where he is. That is called fixing your position and the place over the ground a fix. This „fix" is marked on the map as a small triangle. If he now makes a line connecting the Air Position and the Fix he now has the wind direction and the speed of the wind in 20 minutes. Multiplying this by three makes the wind speed something like 270°/28 knots. The Navigator now has the wind affecting his flight and he can calculate the direction to follow to any point and the time when he arrives there. THAT IS ALL THERE IS TO IT! Most operational units or Airlines and indeed the clever Navigator would tell to FIX yourself every 20 minutes and tell the ground (mostly Air Traffic Control) where you are at those intervals.

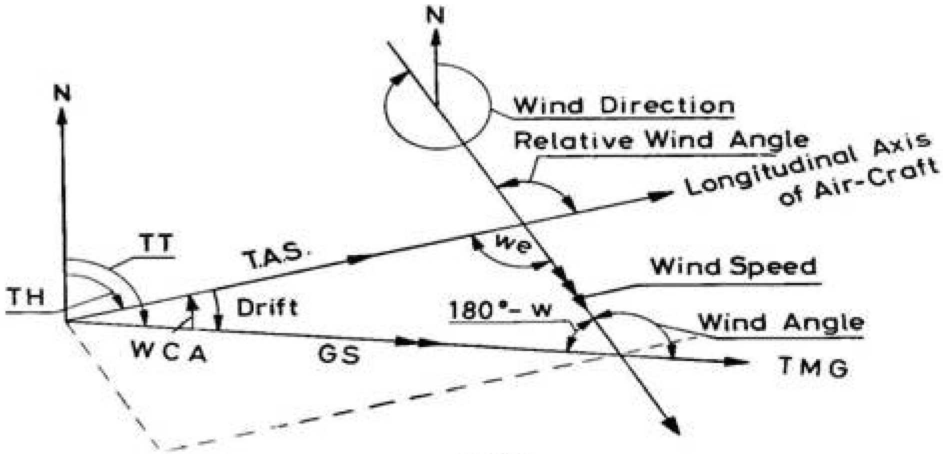

Fig. 64

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The "Wind Triangle" the basic principle behind the "Air plot"

The problems of course arrive when the pilot decides to turn for what ever reason (fly around a cloud was the most common as the aircraft then flew low, below 10.000 feet) or changed speed (due to icing or turbulence or indeed mountain tops) then the navigator would have to make a little line every time this happened. If the flight lasted 12 hours that could be an awful lot of small lines!

In real life, at low level over the sea or in the Arctic areas, the real problem was fixing the aircraft. Over the water looking out of the window did not help much, using the normal radio-navigational aids connected with flying in airways was not possible – they did not exist - and Radar Stations are mostly connected with land or within 200 miles thereof. This problem for us in the sixties had luckily been ALMOST solved during the 2nd World War. The Germans had constructed a large radio station at Sola near Stavanger in Norway and the British a similar one at Bush mills in Northern Ireland, they are called CONSOL stations (they were so important to both parties, that they NEVER considered destroying the other part's station). The Americans on the other hand had laid down a network of special navigational stations around the Northern Atlantic (in Canada, Greenland, Iceland, Norway and UK) called LORAN. Later Denmark and UK had made a similar but more accurate system in the North Sea and around the Shetland Isles called DECCA. The only problem with those stations, however, were that when you needed them most, that is during real bad weather or at night they did not work properly. In bad weather icing on the aircraft and the special antennas prevented reception, not to mention the danger of lightning strikes into the more than 1 mile long antennas trailing behind the aircraft. During night the special layers in the Ionosphere which made those systems work became unreliable or ceased to exist making reception difficult or impossible due to a phenomena called "Sky waves". When Northern light conditions existed in the arctic all reception and transmission of radio waves became near impossible.

Sometimes if clear skies existed, which is rare over the Atlantic, the rest of the crew would look with awe when the navigator took his Sextant and started to calculate like mad from columns of figures extracted from 3 or 4 large volumes of tables. In normal passenger aircraft observing the sun or the stars is not so difficult as aircraft then had a small Plexiglas bubble on top of the fuselage from where to do this. The Catalina flying boat did not have this facility as the front part of the upper fuselage was taken up by a radar radome and the mid-part by the pylon carrying the wing. The only place to "shoot the sun or the stars" from was the rear of the aircraft where there were two large Plexiglas blisters. Unfortunately those blisters had a total unpredictable refraction which made astronomical observations through them impossible. So there was only one way, open the blister during flight and then in open air at 120 knots speed at pitch black night observe the star through the sextant for one minute lining up the bubble in the sextant with the star. To get a good fix you needed to do this with three stars. Normally you would ask the Flight-engineer to grasp and hold your legs as no harness or other means of securing yourself existed. Few Catalina Navigators liked this procedure!

Using the Decca and Loran was a piece of cake. The Decca would display three different coloured figures, red, green and purple and those you copied to a special map, where they intersected was your fix. Unfortunately those figures intersect in many sectors on the chart so the fact was that you could only find were you were if you already knew where you were. Normally you did and then it was no problem.

The Loran was great fun, you had to line 3 sets of 2 curves up on a cathode ray tube and then got some figures which you found on a special chart as curves, where they intersected you had your fix. Unfortunately the curves on the cathode ray tube were usually a whole train of small and large sinus curves. Which ones to line up was the secret of the trade, especially at night. As usual it helped if you already knew where you were so you could confirm that with the fix.

Using the Consol stations made the whole crew active. First the Flight-engineer would reel out the trailing antenna to about 1 mile and then the Navigator would delegate the two pilots and the radio-operator and himself to count dashes and dots from the two stations. You would then compare the result from the two counts of the stations and decide on the final result, find the special chart which was divided into zones of so many – or . s and plot the result. As with the Decca there were many sectors so you had to be careful. An American C-130 at the time was not careful and ended up over Northern Greenland instead of Southern Greenland using the system. Fortunately they had fuel enough. The usefulness of the Consol was that is was so powerful that when most other systems were blocked you could rely on it. Once on a flight north of Greenland it saved my honour (or maybe life) as is was the only possible means of fixing our position. At that distance the accuracy was probably less than 25 miles – but better than nothing! Still today my favourite drink is Bush mills Whiskey (unfortunately the area around Stavanger does not produce anything drinkable so I cannot celebrate that station).

When one of the above aids were not available you were in trouble or life became interesting depending on how you look at it.

The triangles of geometry works beautifully so when using the Air plot, that if you cannot get a fix you can still know where you are if you know how the wind makes you drift away from your heading and you know the speed you are making over the ground, the so-called Groundspeed. In the sixties well-equipped aircraft had an instrument called the "Drift meter", it was sticking out under the underside of the aircraft and with the help of a gyro and a grid you could measure how much you were drifting away from your course by looking at the ground or the waves on the ocean. If you knew your height over the ground or water, and we did by using a radio-altimeter, you could time, with a stopwatch, the time it took an object under the aircraft to pass between two gridlines and you could relatively easy calculate your groundspeed. You now knew to two of three sides and angles in a triangle and could calculate your wind. Sometimes over the Atlantic, but often over the Arctic Sea when radio aids were not useable we would drop below clouds and navigate for hours in this way. There was only one requirement, the skills of the navigator!

The last resort, if you could not climb above the clouds to take a celestial observation or fly below the clouds for using the drift meter, was to use pressure navigation.

This method was devised by the Americans during the war in order to fly the shortest route across the Atlantic regardless of the weather systems or actually using them. If you could measure the difference between your real height over the water and the one indicated by your pressure altimeter at regular intervals you could calculate, by using an awfully long mathematical formula, your drift exactly like with the drift meter. In this way you could make sure of staying on track and get to your destination. However, you had no indication of groundspeed and JUST had to wait for something to show up in your radar ahead of you, just as the Vikings did a thousand years ago. If you had luck you had fuel enough.

Do you know what Navigator's luck is? It is to make sure that you always had a little more fuel than needed. Actually it is the same as Flight-engineer's and Captain's luck so if we had a difficult mission ahead we would always be heavy on fuel!

The main problem we had with the Catalina was overweight. During its operations in the war the Catalina had a maximum operating weight of 28,000 lbs. The RDAF decided that the aircraft needed better equipment to fulfil its operational duties and installed radar, VOR, Loran, Decca, IFF and Tacan and topped up with ocean and arctic survival equipment. In the 6A type a new APU (a VW engine) was installed and new fuel burning heaters were added for wing de-icing. The result was that the maximum weight was increased to 36.000 lbs. Later it became a requirement to be able to fly IFR in the Arctic (all-weather blind flying) and for this the fuel reserves had to be increased. The result was that the aircraft was allowed, under certain conditions, to fly at 42.000 lbs. All this with the same engines! Needless to say that the aircraft would not keep flying on one engine. To loose an engine during flight meant immediate landing. It only happened once and that over Northern Greenland. As a miracle a hole in the sea ice appeared in front of the aircraft and a quick landing was made. A few minutes later the hole closed and the aircraft was screwed down by the ice. The crew saved itself on the ice and was later saved by an American Albatross aircraft which landed on the ice. Tales about Catalinas landing on ice are not true, to maintain any balance in such a landing would be impossible and lethal to the crew.

Another effect was that to get above 10.000 feet was only possible after many hours of flight. As the icecap of Greenland is more than 10.000 feet high it meant careful flight planning.

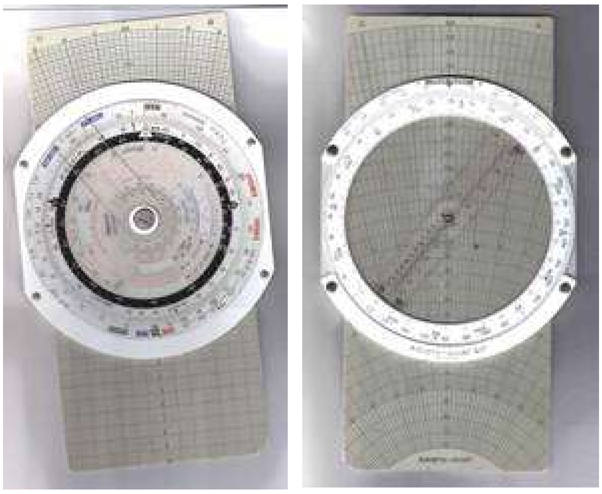
A third problem was special for the Navigator. As mentioned in the beginning he was in charge of calculating the weight of the aircraft. If you pick up a geological expedition in a fjord in North Greenland with all its equipment how do you estimate the load without using scales? Another time we had landed near a supply ship in East Greenland and had to take on a load of kerosene drums of 50 litres each. The manifest said a weight of 50 lbs per drum and that was used for the calculation. A little later when we took off it was almost impossible to get airborne. In the end, after a run on the water of almost 5 minutes and over-boosting the engines we made it just before the edge of the sea ice. I then realised that the weight of the drums were 50 Kg per drum. Our take-off weight had been more than 45.000 lbs.

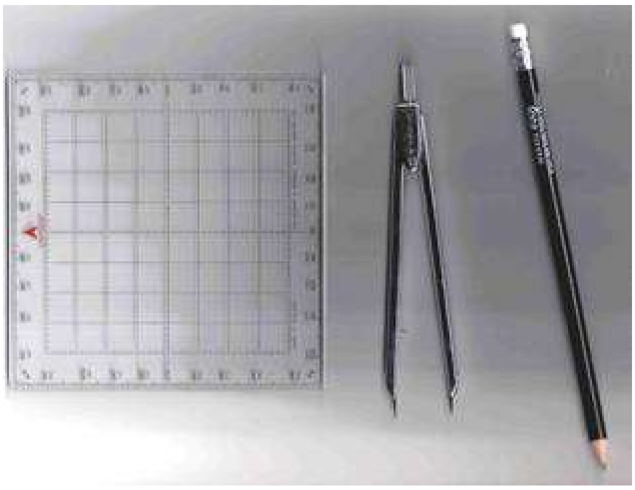
The above mentioned flight was not unusual. During summer time in Greenland the Catalina was used to position depots on the eastern and northern coastline of Greenland. Those depots

were then used by the Danish Sirius sledge patrol during their winter patrols. At that time and probably today the Catalina was the only vehicle which could perform this job.
The fuselage of the Catalina was divided into six compartments, the nose-, the pilot-, the navigation-, the passenger-, the Blister- and the tail compartments each separated by a bulkhead with watertight doors. Any passengers and freight carried had to be placed in the Navigation, Passenger or Blister compartment the heavy items as far front as possible. The Navigation compartment was situated at the centre of gravity of the aircraft and therefore most heavy items such as black boxes were installed here. When the aircraft had to carry items such as fuel drums, sacks of coal or bales of dried fish they had to be manhandled into this compartment. Afterwards the two persons stationed there, the Navigator and the Radio-operator would sit on top of the load sometimes having to bow their heads under the ceiling. Human passengers would be placed on the benches in the passenger compartment, which were slightly more comfortable unless the APU was running. The APU was a normal VW car engine running a generator and it was installed totally unshielded next to the seats. It made a deafening noise and smelled of petrol and oil. It did not impress many passengers! If we were transporting sledge dogs they were normally placed in the blister together with their master. They usually got a couple of stone hard dried fish and kept quite.
Transporting coal was a history in itself. At the airfield of Mestersvig the supply ship would every second year unload a small mountain of coal on the small quay. The whole crew of the aircraft then had to fill the required amount of coal into jute sacks which were transported down to the gravel field and stored in the Navigation and passenger compartment. After landing on the water outside the small hut or near to the depot where the coal was needed it was loaded into a small glass fibre dinghy and sailed to shore. Here the crew carried the sacks (normally 50) to the depot. Afterwards the dinghy was squeezed into the Blister and we returned to the airstrip. It took an awful lot of beer to get that coal dust out of the lungs. There was an interesting side effect of transporting coal. The Catalina being a military transport aircraft did not have any covering on the inside of the metal fuselage, it was bare metal painted green, and the floor consisted of a rubber covered metal plank along the length of each compartment. After each mission to Greenland the aircraft were completely overhauled and cleaned, but some coal dust would always remain in the bottom of the aircraft under the floor planks. You could always see if a Catalina had been through medium or severe turbulence afterwards as both the Navigator and Radio-operator would be black in their faces of coal dust. Due to the static electricity and the sweat the coal particles would cling quite firmly to the skin. A similar thing happened when the Catalina flew into clouds with ice in them. In order to prevent ice to form on the propellers the blades had canals out of which alcohol would be injected so to remove any ice. Any ice thus released would be thrown by the propellers onto the fuselage of the aircraft. They hit right at the position where the Navigator and Radio-operator sat kicking loose small flakes of green paint from the inner of the cabin. These flakes also being loaded with static electricity would cling to the skin of your face. So turbulence meant a black face, icing a green spotted face and sometimes you got both. No wonder that sometimes passengers thought we were weird persons – the fact that our flying suit would sometimes smell of dried (rotten) fish didn’t make it easier.
Flying in the C-54 was of course more civilised and we flew many VVIP missions, but it also had its downs and dangers. One was that as a navigator your world was very restricted sitting behind a compartment separation that was behind the co-pilot with a small round window about 20 cm wide. That meant you had to rise from your seat whenever you had to look out. Not that leaving your set was that much as it was a so-called “Navigator’s stool” a moveable stool (because that there was an emergency exit at the position) without armrest or a back rest. The C-54G version had extra large tanks so flying in that could mean a 12 hours trip on that stool. The Danish Air Force C-54s initially had no cargo drop door so it meant that if you had to airdrop cargo (which you had to all the time when flying in Greenland) you had to de-install the aircraft main door before leaving on a flight. Flying at 10.000 feet over Greenland in the winter (but also often in the summer) meant an outside air temperature of -56C, within minutes that would also be the cabin temperature. Fortunately we had a door to the cockpit section so it was only the passengers who froze! At such times it was very popular for passengers to be

allowed to visit the cockpit, which because of the heating settings would have tropical conditions and the crew would be sitting in t-shirts. Dropping the cargo from the open door was very tricky as it really had to be pushed downward in order to clear the tail plane. It is still a mystery to me that nobody ever fell out as we had no kind of harness available and the aircraft usually was buffeting heavily during the drops. Needless to say we were not flying with parachutes! The Air Force made a big mistake in the sixties, it bought electronic ignition analysers for the C-54s, that was to improve safety. Before they were installed we rarely had to shut down an engine in flight, after that we REALLY knew how the engines were performing and that was bad for morale. I don’t know how many times we were flying on tree engines after that or had to abort take-offs.
Our squadron also flew C-47s, but it was only for tactical flying that a Navigator was on-board. Tactical flying was a kind of mission we trained extensively for during the cold war in the sixties. One of the squadron’s war missions was that of carrying special forces groups behind the front lines deep into Eastern Germany and Poland. We trained in flying at 300 feet at night with lights out zigzagging our way to fool the enemy of where we were going. Just before the drop point we would climb to 1000 feet (600 feet if at war) and drop the parachutist and then zigzag out. I wonder how many seconds we would have lived if it came to a war! I most say the C-47 was (is) a great aircraft, but when flying through clouds it rains on the Navigator and wets his charts.

THE TOOLS OF TRADE

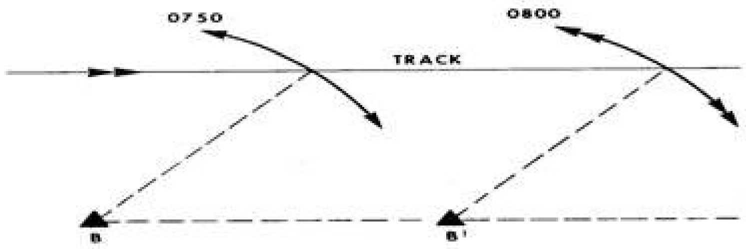




The Navigator’s computer Protractor Dividers The Pencil

In order to navigate properly (then and now) the Navigator had a bag full of tools. The most important was a very pointed graphite **pencil**, the survival knife was excellent for keeping it pointed. For measuring angles, to offset parallel lines and drawing lines a **Protractor** was essential, sometimes combined with a ruler. In order to measure distances and lengths of lines a good **pair of dividers** was needed, with pointed legs please, pencil ends just too inaccurate (actually a strip of paper could easily substitute the dividers, but in films showing navigators one always sees dividers, but never protractors). Yes, we had what we called a **“Computer”** it was a slide rule made round so it was unending and with that we could calculate and convert almost anything imaginable in aviation. Combined with this computer was a sliding and rotating part graduated into a compass rose and for various speeds. This magic devise made it possible to calculate winds, expected drift, point of no return and many, many more interesting things. In tactical flying – like interceptions, search patterns and Para drop - it was used instead of a chart.
The Protractor was the most invaluable of the tools without this aid nothing would be possible. Every little line on the chart had to be measured and set out with that tool. The protractor was specially useful for parallel offsetting lines which happened all the time. You used that in making a so-called “running fix”. If you were over water and wanted to fix your position you could make a bearing of a Cape, mountain top, fjord inlet or some other distinct feature at certain fixed intervals (3 minutes or 6 minutes was the easiest to calculate- see next section “The Navigator’s mind”) and then transfer those lines ahead using the speed of the aircraft. After a

while 3 of those lines would make up a triangle of position and you knew exactly where you were. For short range, like up to 30 miles you could use visual bearings, up to 200 miles you could use the radar (if you had one and if it was working) and beyond that radio bearings of VOR's (VHF OMNI-Directional Ranges) , NDB's (Non-Directional Radio Beacon's) or most powerful of all Commercial Radio Stations.



A "Running Fix" obviously drawn by a "non-navigator" as there is 10 minutes between lines instead of 6 or 12 which is easier to calculate.

Most of the space of the Navigator's Bag was taken up by Maps and Charts of all kinds and Astronomical Tables for calculating (according to St. Hillarie's system) sun, planet and star fixes. You would have to have planning maps, plotting charts, detailed maps of the parts of the flight flown at low altitude, sea charts covering the areas of water landings and approach charts for all the airports and airfields of landing. ALL those had to be of latest version and failing to comply could be deadly. We lost a Catalina on Greenland with all souls hitting a mountain top in clouds probably due to faulty charts.
Apart from the Astro-tables, including tables for sun and moon rises and sets you had to have tables showing ebb and tides of the area going to.

THE NAVIGATOR'S MIND

The Navigators mind works differently than layman's. The layman thinks in hundreds, ten and ones whereas the navigator's world is divided into segments of sixty and fractions thereof. The compass scale is divided into 360 degrees, an hour is divided into 60 minutes and they into 60 seconds. The Earth's graticule has 90 degrees of Northern and Southern Latitude degrees each divided into 60 minutes and they into 60 seconds. The longitudes have 180 degrees eastern and western longitude again divided into sixty and sixty. The Earth rotates in 24 hours so it rotate 15 degrees an hour. No DECIMAL calculations here! Speed is calculated in KNOTS that is Nautical Miles per hour so if an aircraft flies an airspeed of 120 knots (that what a Catalina does!) you will in a Navigator's mind break it down into how much in half an hour (60) how much in 6 minutes (that is 1/10 of 120 =12) and 3 minutes (that is half of 1/10 =6) no decimals here!
The sky and celestial bodies all move in degrees (Earth's rotation) and are measured in degrees, minutes and seconds. One Earth rotation is 24 hours so the clock works with 24 hours (no AM and PM here), but amazingly very few languages has a word for a 24 hour period (English, German and French does not). The Nordic languages extraordinary has such a word (DØGN in Danish) and it is used there by everyone. This make me think that the Norse are the only real navigators by birth. Also you would never use AM and PM in expressing time in Scandinavia.
When compared to a Pilot who navigates (or try to) a Navigator does "Duck tracking" where a Pilot does "Dog tracking". Let me explain: If a duck has to swim across a stream with a strong current it will offset its course to take account for the current and will thus be seen to swim a straight line to the other bank always at an angle to the current, never against it. A dog on the other hand will jump in and fix at a point on the other bank thus constantly correcting its course to compensate for the current and making a long curve, ending up almost swimming against the current. There is no discussion about what is shortest and more efficient. By the way the pilots call their course "homing".

It was rarely boring to be a Navigator in the sixties.