Chesapeake Chapter INCOSE
International Council on Systems Engineering

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Feature Article

Mission to Rapa Nui

By George Anderson

Easter Island or Rapa Nui is the most isolated inhabited location in the world today. Flying to a primitive airfield on the island is still risky business and reminds me of the challenges faced by earlier aviators such as Amelia Earhart in her doomed flight to Howland Island on July 2, 1937.

Today's Global Positioning System (GPS) creates a sense of complacency that appears to be the latest arena of concern in the struggle of man vs. nature. Airplanes have finite range and endurance and must land before these limits are exceeded. All current long-range aircraft must also land on reasonably prepared surfaces for the occupants to be assured of survival.

Remote islands cannot reliably be found using only visual cues. Some type of long-range navigation aid is always required. A failure modes and effects analysis (FMEA) study of navigation systems including current GPS must consider three major areas of failure. These are satellite or radio transmission system failure, propagation anomalies in the atmosphere and electrical and component failure onboard the aircraft. Some examples of events that can cause failure are lightning strikes, bird impact damage on antenna arrays, and component or bus failures due to issues ranging from substandard components and environmental induced failures to maintenance and operator error. To further establish the seriousness of this condition, most aircraft operators today have abandoned previously installed long-range navigation aids such as Celestial and LORAN(1). A few operators sensibly maintain inertial systems that are still useful if properly operated and maintained. Low frequency radio beacons can be installed at remote locations but suffer reliability problems. To add to the problem, an electrical failure on the aircraft can affect the radio receivers or related direction finding circuits even if a power failure does not take the destination transmitter down.

I piloted a mission to Easter Island in the early 1970's long before GPS existed or NASA had lengthened and graded the runway for an emergency Space Shuttle

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Mark your Calendars with these upcoming events:

Wednesday 19 January 2011

Engineering Clean Energy Systems

Dr. Alex Pavlak, PhD, PE, PMP -- Thales Research, Inc

>>download Jan flyer HERE<<

The Chesapeake Chapter is always looking for volunteers to speak at our upcoming meetings! Please contact our Programs Director, Mr. Donald York, if you would like the opportunity to speak or can recommend someone.

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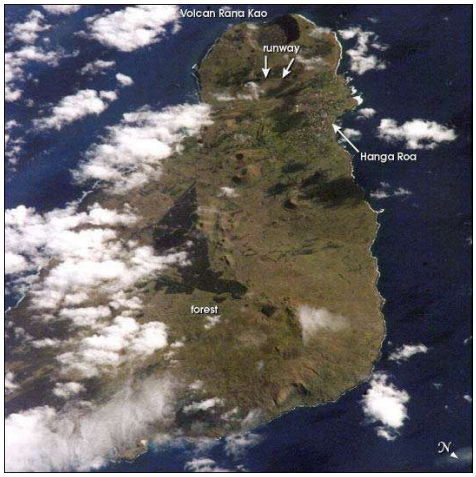
landing site. The aircraft was a Lockheed C-141 cargo aircraft operated by the USAF. The distance was 2336 nautical miles from Santiago, Chile to Easter Island and almost entirely over water. No inhabited islands are in the vicinity of Easter Island and no landing alternate was available. The mission either landed at Easter Island or ditched in the sea. Pitcairn, the closest inhabited island, is 1209 nautical miles to the west.

We had no GPS and due to the islands distance from established air routes, there was no LORAN radio signal coverage. Our only navigation tools were Celestial and pressure pattern.(2)

There was no modern satellite weather and no ships reporting weather in the seas over which we would operate so all wind and weather forecasts were essentially estimates.



Does this sound similar to the problem that Amelia Earhart faced with her navigator Fred Noonan flying 2300 miles to Howland Island? In the 36 years between our flights, several improvements had reduced the risk. Most important, were the range of our aircraft, airborne radar, and perhaps more disciplined flight planning. Other than this, there was no difference in the fundamental navigation problem of finding an island.

In 1970, we had to land in daylight because of the then primitive and challenging airstrip at Easter Island just as Amelia needed daylight to find her much smaller Howland island visually. Daylight flying limits the capability of Celestial navigation as it can provide only lines of position. This is much less accurate than night Celestial unless additional means can contribute data. We understood and employed pressure pattern methods that added a crosswind value to the navigation plot every hour of flight. Noonan did not and could not use pressure pattern.(3)

Both missions flew into the sun in the terminal phase of flight. We flew into a setting sun, they into a rising sun. This orientation allowed a check of distance traveled but not a position left or right of course.

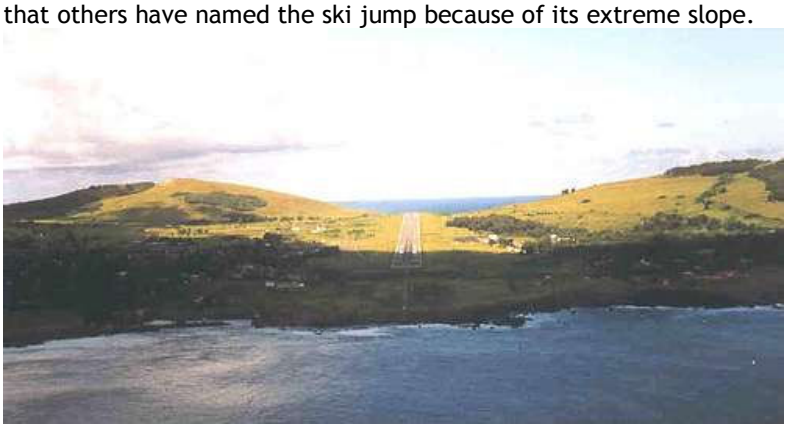
The bottom line in this comparison of two island flights is that we had some anxious moments as our estimated time of arrival came and no island appeared on the radar or was heard on the low frequency Automatic Radio Direction Finder (ADF). We had one advantage over Amelia in that we remained at cruise altitude where we kept our fuel consumption to a minimum. This produced about two hours of extra fuel in spite of higher than planned enroute fuel consumption. These two hours, however, could only give us more time to search for the island.

How would we search? What was our plan? An informed but very uncomfortable roll of the dice must be made. Very quickly, we must determine the most likely navigation error. Is the aircraft off course to left or right or ahead or behind the estimated time of arrival?

- **12 minutes** speed by with no island. The navigators are furiously checking their logs to prepare for the crucial decision.
- **16 minutes** pass as all eyes are looking at the sea searching for land and seeing only the shadows of the low clouds on the surface.
- **21 minutes** - the master navigator in almost a whisper informs the crew over the interphone that the most likely error is in groundspeed and we should not alter course.
- **22 minutes** - The Guard Voice Radio suddenly comes alive with a station calling our aircraft call sign. This radio has a range of around 150 -250 miles. We are

told that the island has had a power failure and the emergency generator has just been brought on line.
- **25 minutes** – Radar shows our destination at 48 miles dead on our nose.
- **25 minutes and 20 seconds** – Our twin radio direction finder needles swing to the nose showing that the beacon on Easter Island is again operating and we are now officially not lost.

Fear recedes and the crew begins to look forward to seeing this mysterious island while the pilots wonder if they are up to landing on the side of a volcano on a runway that others have named the ski jump because of its extreme slope.



Final Approach to Easter Island's 5 degree upwards sloping runway. Watch it on You Tube HERE

We overfly the welcome terrain at an altitude of 800 feet and see groups of people on foot and horseback headed to the airstrip to watch and probably critique our landing. I crash the aircraft onto the absurdly sloping runway and this embarrassing arrival takes our collective attention away from an inevitable appraisal of our mortality. Instead of 2 hours to live, we have been given many more. Who is to say why others were not granted the same.

I never flew to this remote island again but will never forget that small slice of my time when the island was not there.

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1 Long Range Radio Navigation and Ranging (LORAN) came in wide use during WWII. It is a forerunner of GPS in that it uses multiple radio transmitters to establish a geographic position. It was extensively used on ships and aircraft for long-range navigation. The U.S. Coast Guard, in accordance with the DHS Appropriations Act, terminated the transmission of all U.S. LORAN-C signals on February 8, 2010. http://en.wikipedia.org/wiki/LORAN

2 Pressure Pattern navigation is also known as Bellamy Drift. It uses the theory of air mass weather and the difference between Pressure Altitude and Radar Altitude when flying over water to compute an average crosswind value between observations. For further information see: http://propspistonsandoldairliners.blogspot.com/2010/02/navigating-on-b-29.html

3 Celestial navigation provides two main solutions to determining a location on the earth's surface. At night, when stars are visible, three stars can be sighted and their altitude above the horizon measured with a sextant. This reading provides three lines of position that when drawn on a chart will converge to create a small triangle. This triangle defines a position and is called a FIX. In the daytime, only the Sun is available and it's single line of position is not enough to establish a FIX. Instead, the aircraft is assumed to be located at any point on this line when plotted on the chart. Clearly, if the line is at right angles to course, it determines distance traveled. If it is parallel, the actual course of the aircraft is established.

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