COMING TO TERMS WITH

THE GNSS SOLE MEANS PROBLEM

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I. ATC ARCHITECTURE

How appropriate that this panel on ATC architecture should be held in Vienna where the classics of past building architecture co-exist with the work of the first Austro-German modernists.

So it will be with the architecture of air traffic control. The established with the new: the earth with the heavens: terrestrial with satellite.

At the dawn of the space era it was thought that satellite radionavigation would make all terrestrial navaids unnecessary – Deus ex satellite. It hasn't worked out that way. Satellite navigation via GNSS is a useful technology but it has opened up political and military questions which we technologists had not foreseen.

II. SAFETY

a. The Single Thread Issue

In aviation we have learned a hard lesson: sooner or later, every element will fail. If those failures can be catastrophic, we make the system redundant. It is the prudent adoption of back-up systems that has brought our aircraft home safely so often.

The redundancy principle applies to radionavigation. And sole means GNSS – meaning that there is no navigation and landing system available on the aircraft but GNSS – is a single thread system and cannot be adopted, except in very limited circumstances. This rule applies regardless of steps taken to solve the vulnerability problem.

B. Signal Vulnerability

By now nearly everyone knows that the GPS signal is ultra weak at 1^{-16} watt – in words, one ten quadrillionth of a watt. GPS receivers work fine with this signal, but it can be interfered with. Simple noise jammers can overpower it. The famous Moscow jammer kills military and civilian GPS frequencies to a range of 200 kilometers with just five watts of power. You can make a noise jammer with parts costing 40 EUROS from your local radio store.

"Spoofing" jammers are even more effective. A one watt spoofing jammer confuses a GPS receiver at any line of sight distance which, at 40,000 feet, is about 350 miles. Spoofing jammers are complex and expensive and the NAVWAR types don't like to talk about them – understandably.

FAA is trying to define and deal with the interference problem. For the latest update you should read the Johns Hopkins University/Applied Physics Laboratory report, which optimistically concludes that the interference problem can potentially be "managed." For a discussion of the cost and complexity of "managing" interference, read the paper by Vic Strachan of Litton.

III. SOVEREIGNTY

The sovereignty issue is military and political in nature, and is harder for technocrats to understand and deal with. A present, the only fully operational Sat Nav system is GPS. GPS is owned and controlled by the US. The US can turn off or degrade the GPS signal and, for good military reasons, has publicly reserved the right to do so.

This creates a dilemma for all other nations: should other nations become totally dependent on GPS for navigation by adopting a "sole means" policy? No nation that has a choice will do so, including the US.

IV. THE SOLUTION – A MIXED SYSTEM

The solution is obvious. The ultimate navigation architecture will include a mix of satellite and terrestrial navaids. This assures the continuation of safe flight in case of total loss of GNSS. Equally significant, a mixed system removes the incentive for military forces or terrorists to interfere.

Obvious though the solution may be, it is not simple in execution. We must retain a terrestrial system that is safe, comprehensive, and cost effective. What to do?

For aviation, two modes must be provided, en route and terminal navigation, and precision approach.

A. Navigation

Both EUROCONTROL and FAA will, in the future, require high accuracy point to point (great circle) navigation – RNP1. DME-DME radionavigation will meet the high accuracy RNAV performance standard and will be retained and, in Europe, expanded. VOR is not a high accuracy system and should be withdrawn as soon as possible.

LORAN C is fascinating. LORAN C has the best performance of any radionavigation system – high accuracy (RNP.3), coverage to the ground, and negligible cost. The University of Delft, Holland, under the leadership of Prof. Durk Van Willigen, has developed the EUROFIX addition to LORAN C. EUROFIX adds GPS augmentation messages to

LORAN C and, when integrated with GPS receivers, may avoid the cost and complexity of WAAS and EGNOS. And it provides a back-up when GPS is lost! The GPS/LORAN C marriage is, as George Donohue said, elegant.

In April EUROFIX was added to a Russian CHAYKA transmitter at Bryansk and demonstrated a corrected GPS and GLONASS accuracy of three meters.

LORAN C is not widely used in Europe for aviation, but this technology should not be overlooked.

B. Landing

Precision approach in foul weather is absolutely mandatory and a comprehensive system of terrestrial navaids must be maintained. ILS – probably the greatest aviation safety device in history – is pervasive. MLS is to be installed at the bigger airports, and both ILS and MLS will be retained in significant numbers.

Augmented GPS was recently demonstrated in Iceland to provide a precision approach. Where ILS/MLS is installed, augmented GNSS is duplicative. But the vast majority of runways have no precision approach and in these cases augmented GNSS is a breakthrough, providing a lower decision height and improved safety. GNSS is here to stay.

V. CONCLUSION

The different types of navigation systems now available are dazzling in their coverage, accuracy and routing flexibility. We haven’t figured out how best to use them yet, and it will take time.

But it will also be exciting. Because we are entering the golden age of navigation!

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