A CELESTIAL PARTNERSHIP

THE KEYNOTE ADDRESS

to

THE INTERNATIONAL LORAN ASSOCIATION

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I. THE GPS DILEMMA

Someone once wrote, "There are no second acts in life."

LORAN is proving him wrong. LORAN is entering a new and expanding role in the worlds of radionavigation and timing. LORAN lives and will prosper.

LORAN's future is assured because it will make a wonderful marriage with GPS. The combination of LORAN and GPS is elegantly logical and resolves all the doubts about GPS. GPS is a remarkable navigation, location, and timing system, but it is not perfect. We all now know that GPS is vulnerable to intentional and unintentional interference because its signal strength, one ten quadrillionth of a watt, is so weak. There is another less publicly discussed issue. The GPS satellites (or any similar sat nav systems) are controlled by the owner of the birds. The United States has reserved to itself the right to turn off the GPS signal whenever, and wherever, it chooses. Therefore, no country will voluntarily choose to become solely dependent on satellites for its military and civilian navigation, location, and timing.

Safety and sovereignty are the two issues that must be solved if the world is to take full advantage of this brand new, remarkable technology.

For aviation and marine navigation the solution is now crystal clear. GPS must be teamed with a secure ground based system that is controlled, and protected, by its owner.

The discussion of the best mix of navigation systems has just begun. For the aviation users, two systems must be retained: a navigation system for en route flight and for terminal maneuvering, and a precision approach system for landing. In the maritime world, only a navigation system is needed since vertical positioning is unnecessary.

II. THE CASE FOR LORAN

A. THE LORAN TRANSMITTERS

LORAN transmitting stations are relatively large, complex, and expensive compared to VOR/DME sites. The LORAN equipment is housed in a building approximately 30' x 90', which is full of electronic hardware. The station runs off commercial power (where it is available) and is backed up by on-site generators. The antennas are large, varying from 800' to 1300' in height. Because the signal follows the earth's surface the LORAN station can be located in relatively remote, and therefore non-sensitive, locations, away from congested urban areas.

A brand new LORAN station on a new site would cost about $7 million in an industrialized country. Very isolated sites, requiring staff accommodations and even a runway for access, cost more.

Modern LORAN stations are entirely solid state. Every element has a redundant back up. If a unit goes out, the hot spare goes on line and the attendant replaces the failed board. Like all modern ground transmitters, reliability is very high and maintenance costs are very low.

The good news is that very few stations are needed because of the long range of the LORAN signal. The entire North American continent and its coastal waters, from the Aleutians to Nova Scotia, is covered by 24 American and 5 Canadian stations. This compares favorably to the 1075 VOR/DME transmitters in the US alone.

B. LORAN RECEIVERS

The existing LORAN aircraft equipment is almost entirely old technology and has some limitations. The best known of these was the antenna design which made the receivers somewhat sensitive to precipitation static (p static). Today, modern H field antennas have eliminated this problem and lab and field testing is underway at Ohio University, with help from Ilgen Simulations, Locus and Megapulse, to prove once and for all that this issue is behind us.

Advances have been made in the avionics box as well. LORAN receivers are no longer tied to the three transmitters in a chain, the loss of any one of which could impede the navigation guidance. Sophisticated computers-on-a-chip now receive and analyze signals from multiple transmitters, and the loss of one or even two stations no longer interferes with navigation. To take full advantage of the performance of modern LORAN technology would require new receivers and antennas, which would involve some cost. But this is also true of all avionics in this fast moving, high performance era, including WAAS and LAAS.

C. RANGE

LORAN has always had a remarkably long range compared to line-of-sight transmitters such as VOR/DME. The development of modern receivers and aircraft antennas has dramatically increased the reach of LORAN. Over the CONUS, this merely adds to the security of the system since more transmitters can be received. But over the oceans the improvement can be dramatic. With the re-activation of the Icelandic and Greenland stations, almost all of the North Atlantic aviation tracks can be covered by a usable LORAN signal. Similar service improvements are possible for marine users.

D. COVERAGE

Since the LORAN signal follows the surface of the earth, it can be received almost everywhere and even on the airport runway. This contrasts to VOR/DME signals which are line of sight and which leave many gaps in coverage. LORAN's coverage is not absolute, since some geological conditions do affect the signal enough to prevent low decision height instrument approaches, but these conditions are extremely rare with new receiver technology.

E. ACCURACY

LORAN provides a very accurate lateral locating signal. FAA has approved LORAN to RNP.3, that's three tenths of a mile. Flight management systems (FMS) driven by multiple DME's have the same highly accurate performance. The accuracy of basic (i.e., non-augmented) GPS is RNP.15, that's fifteen hundredths of a mile. For purposes of en route navigation and terminal maneuvering (called approach control in the US), all three systems are identical.

LORAN and FMS/DME do not provide vertical guidance and therefore rely on barometric altimeters which have an accuracy of +/- 50 feet – again, virtually identical to GPS.

In the aviation world, all these navigation systems – GPS, LORAN, INS/IRS, and FMS/DME – are capable of point to point (great circle) navigation and are interchangeable as to accuracy for en route and terminal maneuvering flight.

III. THE NEXT STEP IN LORAN'S DEVELOPMENT

In 1993 the US Government, and in particular, the Department of Transportation, announced that LORAN would be scrapped in the year 2000. This decision has been reversed for reasons which are now abundantly clear to all, and the DOT and the Congress will now undertake a program to repair the damage and to modernize LORAN.

When the 1994 FRP was announced sales of LORAN receivers stopped and government certification work has halted. Technical development work on LORAN, however, did not halt. Receivers and antennas now incorporate modern technology and are greatly improved.

Here's what is needed.

A. BURY THE P-STATIC ISSUE

Work is already underway to test H-field antennas under conditions of precipitation static. This should be concluded in 1999.

B. FINISH THE WORK OF RTCA SC159

Special Committee 159 of RTCA was part way through developing a Minimum Operating Performance Specifications (MOPS) for LORAN. In 1994, the work was halted. This committee should be re-activated to produce a standard against which LORAN navigation systems can be certificated.

This could be completed in seven months.

C. OUTLINE RECEIVER REQUIREMENTS

Like any navigation system, LORAN has different service applications. They include:

- a simple, low cost VFR receiver for general aviation pilots
- a sophisticated hard IFR receiver which would be used to complement GPS equipment independently.
- a combined GPS/LORAN navigation system which would cross check with and back up GPS.

D. CERTIFICATE THE RECEIVERS

As recent reports from Booz Allen and from the Volpe Center (as well as the GAO and the DOT's Inspector General) have found, LORAN receiver and antenna technology is literally sitting on the shelf awaiting an FAA MOPS. They will be immediately submitted for certification.

FAA should give receiver certification the highest priority: the sooner a way can be charted to allay the fears about GPS sole means, the better.

E. FAA SHOULD PUBLICLY ENDORSE LORAN

FAA's attitude toward LORAN has historically been ambivalent. This has exacted a high cost on public confidence in the GPS program, once its vulnerabilities come out in the open.

FAA should publicly endorse LORAN as one – repeat, one – method of backing up GPS. The market response, and the applause from the user community will be instantaneous.

F. ADOPT EUROFIX

The Europeans, under the leadership of Prof Durk van Willigen of the University of Delft, Holland, have developed an elegant, ultra low cost addition to LORAN that further advances the partnership with GPS. It is called Eurofix.

The Eurofix system adds GPS differential corrections to the LORAN signal. An aircraft equipped with a LORAN/EUROFIX receiver can feed correction data into its GPS receiver and the GPS is then capable of astonishing accuracy.

The NELS transmitters are now being fitted with Eurofix augmentation of GPS.

The US Coast Guard tested Eurofix at Wildwood, NJ, this summer. The GPS signal received in Boston, 500 km distant, was corrected to 3 meters accuracy! This is virtually identical to WAAS – except for the cost.

Adding Eurofix to all 24 US LORAN transmitters would cost a total of $10 million. This compares to a lifetime cost of WAAS of $3 billion.

IV. WHO WILL USE LORAN?

The use of GPS as a sole means of navigation is now a dead issue. The United States formally announced this to the ICAO CNS/ATM Convention in Rio de Janeiro in June. The current Applied Physics Lab study will report on the various ways of minimizing GPS interference, but it will not conclude the GPS sole means, where a back up is available, can be approved.

There are several systems which can back up GPS.

A. LORAN. Loran is one.

B. INS/IRS. Modern inertial systems are excellent. IRS has a lateral accuracy of 0.008 degree per hour of flight. Integrated GPS/IRS systems are certificated and in service with some sophisticated air carriers today. However, the present cost of IRS is too high for the small GA aircraft, which comprise 98% of the US fleet.

C. VOR/DME. The VOR based system, usually combined with DME, is a satisfactory back up for GPS and is very safe. But the lateral accuracy of VOR is very poor and it is doubtful that aircraft navigating with VOR can operate in high density free flight service.

D. FMS/DME. The world's airline fleet is rapidly equipping with modern, sophisticated flight management systems. FMS is highly accurate and is capable of RNAV. FMS relies on multiple DME's for guidance, not VOR.

FMS/DME is a perfectly good back up for GPS. <u>There is no need for air carriers to acquire LORAN if</u> they are FMS/DME equipped.

V. LORAN AROUND THE WORLD

A. LORAN NOW

The United States and Canada, Northern Europe, Eastern and Western Russia (the Chayka system), Saudi Arabia, parts of India, China, Korea, and Japan are served by operating LORAN chains. At present, LORAN is mainly a Northern Hemisphere service.

LORAN was originally installed as a military system and, as the Cold War abated, Coast Guard support for the stations outside the US was withdrawn. The Northern European LORAN System (NELS) was taken over by the host countries and is flourishing.

In the Mediterranean, the story is different. The LORAN stations were handed over to the host countries, but have not been kept in service.

In the North Atlantic, the LORAN stations on Greenland and Iceland were decommissioned by the Coast Guard, so the North Atlantic aviation and marine routes are not covered by ground wave LORAN signals.

In the Central Pacific, the Coast Guard has also turned off the stations in Hawaii, Johnson Island, and Kure.

B. IMMEDIATE CAPITAL IMPROVEMENTS

1. <u>In the U.S.</u>

The 24 operating stations in the US are in dire need of upgrades because little work has been done since 1994. DOT plans to budget approximately $100 million for this in 2000 and subsequent years.

2. <u>In the Mediterranean</u>

The stations in the Mediterranean that are now out of service should be modernized and brought back on line. This can be achieved for a relatively low price and would immediately alleviate fears in the region that GPS navigation, positioning, and timing services are not under local control and can be blocked by terrorists or turned off by the US.

The cost of re-establishing LORAN service in the Mediterranean could easily be borne by the European Community and would not require protracted discussions with the US.

3. In the Caribbean/Gulf of Mexico

A new station in Yucatan, Mexico would complete coverage in the Southern Gulf of Mexico.

4. In the North Atlantic

The LORAN stations in Greenland and Iceland should be modernized and brought back into service.

Modern LORAN receivers have extended the usable range of the signal so that all North Atlantic aviation and marine routes would be served. This would provide an accurate radionavigation back up to GPS in the busiest oceanic routes in the world.

The one time cost of reactivating these two stations would be very small – about $20 million, and would easily be within reach of the US DOT. Alternatively, the US and the EC could share the cost.

5. In the Central Pacific

The Central Pacific system should be brought back on line. The deactivated stations are all on US territory and the US would pay for the cost.

For the US, the priority of the Central Pacific service is certainly lower than upgrading the North American stations and is probably lower than re-establishing service on the North Atlantic.

C. NEW SERVICES

1. In Eastern Europe

There is an active discussion between the EC, Russia, and the former Soviet States of Eastern Europe about establishing modern LORAN/CHAYKA stations on the Eastern Europe land mass.

The need is obvious: there is a requirement for a locally controlled, accurate navigation, positioning, and timing service. Existing services are woefully inadequate. LORAN/CHAYKA provides excellent coverage compared to other secure, land based systems, and is very much less expensive.

But there are obstacles. Russia and the Eastern European nations are short of cash and international agreements are hard to conclude.

2. Southeast Asia

The Pacific Rim and Southeast Asian countries are rapidly moving towards membership in the technologically advanced, developed world. There is an acute need for infrastructure of all kinds. Locally controlled, ground-based navigation, positioning, and timing are in short supply almost everywhere.

Moreover, the region includes some of the most congested and dangerous transportation corridors in the world. Since the unwise termination of the VLF-OMEGA system, the Straits of Malacca have been sole means with the GPS signal. Considering the presence of terrorism in the region, this may be the highest risk transportation hot spot in the world.

A regional LORAN system would provide sovereign control, reduce the risk of deliberate interception of service, and improve safety.

VI. CONCLUSION

There is an emerging awareness that the secure, accurate, and familiar LORAN system makes a perfect partner with GPS. Together, these two complementary systems will increase safety, promote economic growth, and stabilize international relations throughout the world.

The future of the GPS/LORAN combination is bright.