A Robust Radionavigation Architecture is Essential to Our Critical Infrastructure

Radionavigation is a necessity in the 21st Century

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Essential Points

- The evaluation of Loran was *not* done because of its benefits to ***Loran users***.
- Our evaluation's purpose was to determine if a modernized Loran system could be used to mitigate the operational effects of a disruption in GPS services, thereby allowing ***GPS users*** to retain the benefits they derive from using GPS.
- Enhanced Loran (*eLoran*) is not yet defined and there has been no U.S. decision regarding Loran's future – there are, therefore, no *required* levels of modifications or new applications that Loran is expected to satisfy.

So how can I convince you that:

"A Robust Radionavigation Architecture is Essential to Our Critical Infrastructure?"

- I suggest by:
  - Describing the significance of radionavigation;
  - Explaining what I mean by enabling technology;
  - Defining the critical elements and architecture necessary for advancements in safety, surveillance, and security; and
  - Helping every one of you to become an advocate!

Four Elements are Critical to Applications that Involve Transportation Safety, Surveillance, and Security

1. Knowing where you are and where everyone/ everything else is at all times;
2. Being able to process, manage, and properly use the information in a timely manner;
3. Being able to reliably communicate data and/or information to those that need it when they need it; and
4. Gaining the acceptance and trust of the system by the targeted user community.

The right ***mix*** of radionavigation systems (e.g., GPS and Loran) can be the primary enablers for these advancements!!!

The Significance of Radionavigation as an Enabling Technology

- **Radionavigation** is ***the*** technology that has permeated all aspects of our lives in the 21st century – in many cases we don't even realize it is being used.
- Government/Corporate/Professional/All users are very dependent on radionavigation and reap considerable benefits from it thanks to:
  - The availability of low cost receivers
  - The integration of systems in consumer products
  - Innovative applications
  - The increasingly sophisticated, yet affordable s/w applications

The Significance of Radionavigation as an Enabling Technology

- Benefits are good, but “blind” dependence on a less than fully robust system is not the best course of action
  - Volpe Transportation System Center study on GPS vulnerability recommended backups for all safety of life and economically important applications
- Aspects of the 4 critical elements can be provided by relying on a mix of radionavigation systems like GPS and Loran.
- The full potential can be best achieved through the implementation of a robust radionavigation architecture

What is the meaning "Radionavigation" - an Evolving Understanding

- Radionavigation meaning now include:
  - (1) The science of ***plotting and following a course*** from one place to another and of ***determining the position*** of a moving ship, aircraft, or other vehicle
  - (2) The science of getting ships, aircraft, or spacecraft from place to place; *especially* **:** ***the method of determining position, course, and distance traveled***
  - (3) The ***plotting and directing of the course*** of a ship, aircraft, or other vehicle

To the layman, ***"Navigation"*** now includes all aspects of what has historically been referred to as Position and Navigation and Timing (PNT)

Radionavigation Today–
An All Encompassing Need

- Radionavigation is no longer a option– it is a ***necessity*** in the 21st century (whether you know its there or not)
  - **Transportation** – All modes of transportation (air, sea, & land) rely on accurate position, navigation, and timing for safety, for economic efficiency, and for customer services
  - **Communications** – Public and private communications systems rely on timing and time synchronization to maximize circuit bandwidth and secure their communication channels – for both hardwired and mobile cellular services
  - **Power Utilities** – Power companies rely on exact frequency and time synchronization to maximize power transmission through national electrical grids
  - **Recreational** – Personal use of positioning, navigation, and timing services continues to grow – unabated

Radionavigation –
The Good News … and the Bad News

- **The Good News**
  - Excellent positioning, navigation, and timing has become available to all levels of users with the advent of global navigation satellite systems (GNSS) such as the US Global Positioning System
  - Other GNSS services and capabilities are being planned and/or are being developed
  - GNSS technology continues to improve, costs continue to go down, and uses and users continue to increase every day
- **The Bad News**
  - Dependency on GNSS as a single source of position, navigation, and timing services provided by, will eventually lead to a loss in safety or economic benefits gained by using GNSS.

Increasing Reliance, Costs of Radionavigation Systems and the Need for Reliable Service Dictates Adjustment in how we do Business

- Common metrics are essential to define Navigation services – Four basic metrics apply
  - Accuracy, Availability, Integrity, and Continuity
- Choosing to use or not use a navigation service should depend on the performance of a navigation system as defined by these metrics
- Lack of adequate reliability/robustness is problematic – could result in as little as an inconvenience or as much as a potential loss of life and/or property
- The robustness of the navigation system or mix of systems is a critical part of the application and that is often overlooked.

Radionavigation Must Fail-Soft / Fail-Safe

- At the FAA, there three levels of soft-fail capability for an application:
  - **Redundant Capability**
    - A failure of the GNNSS system has *no effect on operations*
    - "Other" Systems Capabilities are similar to those of GNSS
  - **Backup Capability**
    - A failure of the GNSS system *will affect operations*
    - Must ensure the ability to reach a safe location
  - **Operational Contingency**
    - *Ensures safety* at the onset of and during GNSS failure
    - *precludes or limits operations*

eLoran offers a potentially redundant solution for some, a backup solution for most FAA applications

Loran Metrics – Now and in the Future

A Means of Achieving the Necessary System Robustness

	Accuracy	Availability	Integrity	Continuity
Loran-C	0.25 nm (463 m)	0.997	10 second alarm/ 25 m error	0.997
eLoran	0.004 - 0.01 nm (8 – 20 m)	0.999 – 0.9999	0.9999999 (1 x 10-7)	0.999 - 0.9999 over 150 sec

- Radionavigation robustness can be achieved through the employment of disparate radionavigation systems with mutually exclusive failure modes (e.g., GPS and Loran)
- Ensures resilience against both unintentional and intentional interference sources

Having Achieved Robustness, What Benefits can be Realized?

Time and Frequency Standards
– *The Loran Clock*

- All North American Loran Stations and the Loran Support Unit have three new cesium clocks – ***87*** very high stability clocks ***geographically dispersed*** across North America
- Tests have shown that all 87clocks can be steered to UTC (USNO) with great accuracy
- Lays the groundwork for establishing a robust Loran clock akin to the GPS clock
- Penetrates into building cores – facilitates and lowers the cost of providing a robust time and frequency standard

Reliable Multi-Mode Receivers for Air, Sea, and Land Applications

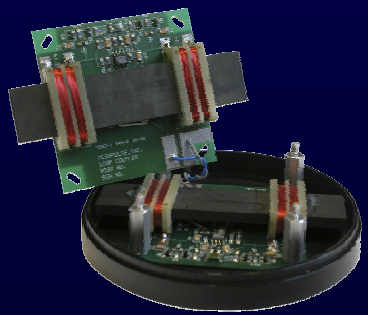
- Satellite navigation is good, but there can be availability problems in the canyons – both natural and man-made
- Satellite navigation stops at the front door or under the trees or in the tunnels
- Multi-mode receivers offer availability and continuity benefits not available with single-system units
- Availability of multi-mode units becoming a reality

Prototype Locus Loran Card in Rockwell Collins Multi-Mode Receiver

FreeFlight/Locus GA Multi-Mode Receiver

- **Phase II Prototype will be available for testing Spring 2005**

Megapulse/Reelektronika/Si-Tek Multi-Mode Marine Receiver



Signal Processor
77 x 51 mm

Front End & ADC
77 x 47 mm

GPS – WAAS

Prototype will be available for testing Spring 2004

New Loran/GPS/WAAS Megapulse/Reelektronika Receiver

Applications Enabled by Robust Radionavigation

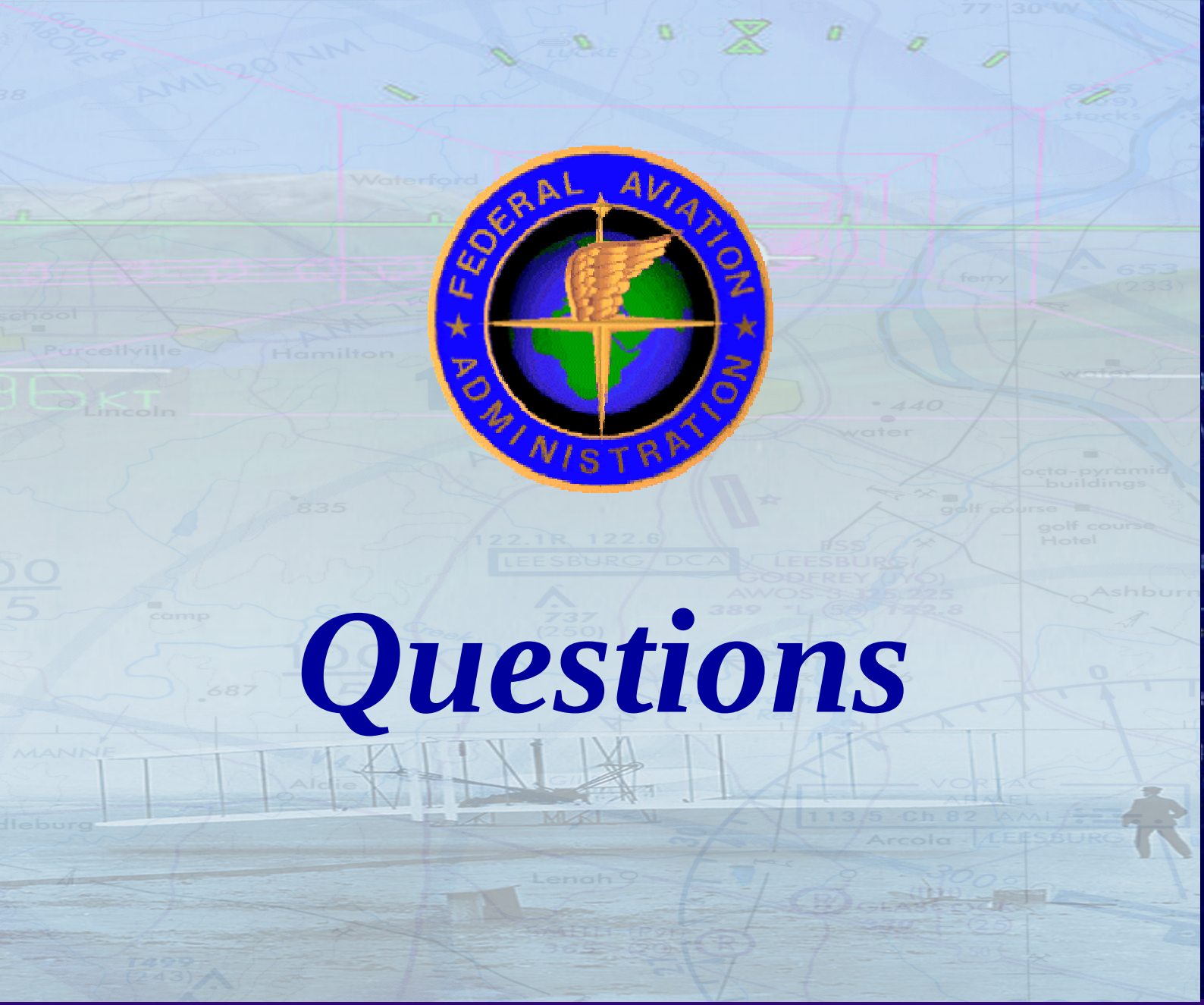
- Tracking vehicles in the inner cities to derive information regarding
  - Traffic patterns and congestion
  - Best real-time routing for emergency vehicles
  - Tracking of hazardous cargo and overweight vehicles
  - School Bus and sensitive cargo vehicle tracking
  - Mobile sensors to accumulate data on
    - Temperature
    - Air pollution
    - Pollen
    - Chemical/biological agents

Applications Enabled by Robust Radionavigation

- Tracking of maritime vessels in and around harbors and sensitive locations
  - Sensitive and hazardous cargo
  - Entry into and out of Security zones
  - Container movement identification between transport modes
  - Identification, location, and speed of all vessels in the shipping channel
  - Mobile sensors to accumulate data on
    - Temperature
    - Currents
    - Pollution
    - Chemical/biological agents
- Maritime domain awareness

Open Season for New and Innovative Ideas

- Radionavigation of the 21st Century offers potential benefits never before available
- Reliance on the technology demands respect for its capabilities as well as its limitations
- Building and maintaining a robust infrastructure is not only prudent, but essential to ensure the continued of safety, security and economic support services.



Questions